Hanford Sitewide Transportation Safety Document

Prepared for the U.S. Department of Energy
Assistant Secretary for Environmental Management

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1.0 Purpose, Scope, and Applicability

This chapter describes the purpose, scope and applicability of the Hanford Sitewide Transportation Safety Document (TSD) in regards to the Hanford Site contractors, user organizations, and individuals responsible for hazardous material and waste transportation and packaging (T&P) activities at the Hanford Site.

1.1 Introduction and Purpose

This TSD defines the onsite T&P Safety Program at the Hanford Site, which complies with the U.S. Department of Energy (DOE) transportation safety requirements specified in DOE Order (O) 460.1C, Packaging and Transportation Safety. Packaging Safety Documents (i.e., Package-Specific Safety Document [PSSD], One Time Request for Shipment [OTRS], and Special Packaging Authorization [SPA]) demonstrate compliance with the TSD for specific packages used onsite and are considered to be part of the T&P safety basis. The TSD complies with the safe harbor methodology prescribed in Title 10, Code of Federal Regulations, Part 830, (10 CFR 830) “Nuclear Safety Requirements,” which documents compliance with the nuclear safety rule for T&P activities.


This TSD includes the following:

- Identification of responsibilities, lines of authority, and program approval procedures.
- Definition of minimum safe packaging requirements including necessary design, fabrication, and quality assurance (QA) elements using appropriate codes and standards.
- Description of the process and analysis used to ensure equivalent safety requirements are established.
- Description of the Hanford Site including maps identifying boundaries, railways, and roadways that clearly delineate offsite and onsite areas, and procedures for clearly establishing access control for any area having occasional public access.
- Provisions for effective emergency response and recovery under credible accident conditions (AC).
- Process for accomplishing non-routine T&P activities.

This TSD also addresses onsite “equivalent safety” by establishing a comprehensive set of onsite T&P performance standards and risk based standards. The requirements and standards presented
are equivalent to DOT (49 CFR 171-180) and NRC standards (10 CFR 71) currently used for commercial offsite transportation. Hanford Site standards, however, are developed to be reflective of the unique transport environment within Hanford Site boundaries. Hanford Site restricted roadways, fenced facilities, Hanford Patrol inspection points, and barricades, as well as weather and physical location, shape Hanford’s unique transportation environment. Additionally, Hanford Site contractors retain control over all onsite shipments, provide enhanced worker training, and possess unique site emergency preparedness and response capability that influence safety across the Hanford Site. “Equivalent safety” for onsite shipments is documented in DOE-approved Packaging Safety Documents.

1.2 Scope and Applicability

The TSD encompasses all onsite shipments of government-owned hazardous materials, substances, and wastes within the Hanford Site, which includes radioactive materials and wastes. Only materials identified as hazardous in accordance with DOT regulations, and regulated if shipped in commerce, are described. The only current mode of transporting hazardous materials onsite is by highway. Hanford rail operations have ceased. The TSD does not include movement of these government materials by hand, hand truck, or other equipment, which is not a motor vehicle. These movements must be included in the contractor’s Industrial Safety and Health Program (29 CFR 1910, “Occupational Safety and Health Administration”) and/or safety or authorization basis.

The movement of DOE-owned materials within and between onsite facilities is covered by this TSD. The TSD provides the framework for demonstration of equivalent safety for all movement of hazardous and radioactive materials on the Hanford Site over roadways where public access is controlled or restricted and includes intra-area and inter-area movements. An intra-facility transfer is the movement of material between individual buildings within a facility, facility complex, or the surrounding compound area that is adequately covered under a single facility Documented Safety Analysis (DSA), other DOE-approved safety, or authorization basis document.

This document and its provisions apply to DOE and all DOE Hanford Site prime contractors and their subcontractors performing government work at the Hanford Site, unless specifically excluded in their respective contracts.

Requests for deviation(s) to the requirements of this TSD must be submitted to RL for approval. The RL Manager is the Hanford Site Approval Authority for the TSD. The RL Manager approves the content and applicability of this document.

All personnel involved in onsite shipments of hazardous and radioactive material are subject to the requirements of this TSD.

1.3 Roadmap through the TSD

Chapter 1.0 Purpose, Scope, and Applicability. This chapter describes why the TSD is required, the scope of its coverage and applicability to contractors, user organizations, and individuals responsible for hazardous material and waste T&P activities at the Hanford Site.
Chapter 2.0 Definitions and Acronyms. This chapter provides key definitions, common acronyms, and references specific regulatory sources for additional definitions that must be understood.

Chapter 3.0 Site Description. This chapter describes the Hanford Site boundaries and roadways used to transport hazardous materials and wastes.

Chapter 4.0 Organizational Responsibilities. This chapter identifies RL, the U.S. Department of Energy Office of River Protection (ORP), the U.S. Department of Energy Pacific Northwest Site Office (PNSO), and the contractor’s responsibilities and interfaces within the Transportation Safety Program as defined in this TSD, and specific package development and approval process.

Chapter 5.0 External Regulations. This chapter identifies the external regulations that contain requirements applicable to onsite T&P activities. Several regulations are written specifically to address onsite packaging and transfer operations. Additional regulations apply to various activities that make up the overall process of T&P because they apply to the materials being handled or the activity being performed.

Chapter 6.0 Site-Specific Standards, Procedures, and Instructions. This chapter provides standards, requirements, programs, and processes that are needed to support safe T&P operations such as integrated safety management, QA, configuration management, and equivalent safety. Alternate design and performance requirements for onsite packagings are identified.

Chapter 7.0 Safety Assessment Methodology. This chapter identifies the methodologies used for achieving and demonstrating onsite safety equivalent to that accomplished by complying with the DOT regulations. In addition, it identifies specific evaluation methodology and acceptance criteria to apply when demonstrating compliance with the requirements found in Chapter 6.0 for achieving equivalent onsite T&P safety.

Chapter 8.0 Routine Transfers. This chapter describes the processes and procedures used to make routine onsite shipments. All packagings prepared and shipped as routine must be authorized and fully comply with the provisions of the TSD. Basic procedures and processes for handling onsite shipments of hazardous materials and wastes are included in this chapter. Contractors provide more detailed facility/project operation procedures at the facility where T&P activities occur.

Chapter 9.0 Non-routine Transfers. This chapter describes the processes and procedures for dealing with non-routine or emergency transfers. Conditions and circumstances for non-routine or emergency transfers are defined, as well as applicable procedures and the approval process.

Chapter 10.0 Personnel Qualification and Training; Security Plan. This chapter describes the qualification and training requirements for Hanford Site contractor hazardous material (hazmat) personnel, authorized shippers, drivers, and Unreviewed Safety Question for Transportation (USQT) evaluators. Individual facilities and organizations, to which personnel may be assigned, may establish additional qualifications and required training based on specific job task analysis, job classification, or individual training plans.

Chapter 11.0 Documentation and Record Keeping. This chapter identifies documentation and records requirements for different package categories. It also identifies or references processes and procedures for managing this documentation throughout the Hanford Site.
Chapter 12.0 Incident Reporting and Emergency Response. This chapter describes requirements for incident reporting, emergency response, and references Hanford Site-specific policies, manuals, and procedures for emergency management. It also addresses emergency planning, drills and exercises, and Hanford Site response capabilities.

Chapter 13.0 Transport Vehicle Operations. This chapter describes the requirements for transport vehicle inspection and maintenance programs on the Hanford Site.

Appendices A through H provide additional information and guidance to support application of the requirements found in the TSD.

Appendix A. Approved Package-Specific Safety Documents List. This appendix provides listings of onsite PSSD and their approval status.

Appendix B. Justification and Basis for Equivalency to DOT Regulations for Type B and Fissile Packages Transported on the Hanford Site. This appendix provides the justification and basis for demonstrating the equivalency of the TSD requirements to those identified in 10 CFR 71.

Appendix C. Safety Basis Requirements for Hanford Onsite T&P. This appendix identifies the safety bases established for Hanford onsite T&P.

Appendix D. Package-Specific Safety Document and One-Time Request for Shipment Contents and Format. This appendix provides guidance in formatting and preparing an onsite PSSD and OTRS.

Appendix E. Justification and Basis for Shipment of Risked-Based Packages. This appendix provides the justification and basis used for demonstrating the equivalency of the TSD Hanford Site equivalent requirements to those identified in DOT Hazardous Material Regulations.

Appendix F. Reserved.

Appendix G. Special Packaging Authorizations. This appendix provides pre-approved packaging configurations for specified payloads.

Appendix H: Guidance on Conducting SPA Related, DOE Approved Packaging Evaluations. This appendix provides a process for RL approval of contractor’s SPA related Packaging Evaluations.

1.4 Precedence of Requirements

In cases where there are two or more similar requirements or limits that impact design, testing, analysis, fabrication, or use of a packaging approved within the TSD, all requirements and limits must be met as applicable. If one requirement is less restrictive than another, the more restrictive requirement must be implemented unless an exception is granted under the provisions of this TSD.

1.5 Policy for Pre-TSD Packagings and their Approvals

Existing packaging may continue to be used in accordance with the associated PSSD, as indicated in Appendix A. Operation of the packaging systems shall be conducted in compliance with the existing PSSD (onsite safety analysis report for packaging [SARP], onsite safety
evaluation for packaging [SEP], or revised PSSD) as identified in the table. Other existing onsite T&P systems shall not be used until approved by RL.

1.6 Document Updates, Maintenance, and Distribution

The TSD must be reviewed annually and updated, if determined necessary, to ensure the approved safety basis is maintained as regulations and requirements change and as Hanford Site conditions and mission requirements mature.

All TSD changes must be performed in accordance with a TSD maintenance program. The TSD maintenance responsibility is assigned to the TSD Configuration Manager, subject to contractual changes that may be exercised by RL.

Maintenance of the TSD includes minor changes and/or rewrites to provide clarifying language to the document. These changes are limited to inconsequential changes as determined in accordance with the Unreviewed Safety Question (USQ) process. Major rewrites, redesigns, analytical work, or positive USQ are considered to be “updates,” must be approved by RL prior to use, and are handled separately based on Hanford Site programmatic needs.

Recommendations and changes must be submitted to RL in writing and demonstrate the required levels of safety are achievable based on packaging performance and/or risk assessment. The RL Manager must approve all changes to the TSD, including consequential changes to Packaging Safety Documents.

The requirement for annual reviews extends to include the active PSSDs in use onsite. Active PSSDs are to be reviewed annually to determine whether they require updating to remain consistent with the TSD, and revised as needed, if there are changes that have been accepted but not implemented through the USQ process. As noted above, changes to the PSSDs require RL Manager-approval prior to implementation.
2.0 Definitions and Acronyms

This chapter provides key definitions and common acronyms. In addition, this chapter identifies specific regulatory sources for additional definitions that apply.

2.1 Definitions

For additional definitions related to this subject, see the following CFRs:

- 10 CFR 71.4, “Definitions”
- 49 CFR 171.8, “Definitions and abbreviations”
- 49 CFR 178.275, “Specification for UN Portable Tanks intended for the transportation of liquid and solid hazardous materials”
- 49 CFR 178.320, “General requirements applicable to all DOE specification cargo tank motor vehicles”
- 49 CFR 178.337-1, “General Requirements” (Cargo tanks)
- 49 CFR 178.345-1, “General Requirements” (Cargo tanks)
- 49 CFR 178.601, “General Requirements” (Non-bulk packaging)
- 49 CFR 178.700, “Purpose, scope and definitions” (IBCs Intermediate bulk containers)
- 49 CFR 178.801, “General Requirements”
- 49 CFR 180.403, “Definitions” (Cargo Tanks)
- 49 CFR 350.105, “What definitions are used in this part?”
• 49 CFR 368.2, “Definitions”
• 49 CFR 371.2, “Definitions”
• 49 CFR 372.107, “Definitions”
• 49 CFR 375.1, “Applicability and definitions”
• 49 CFR 376.2, “Definitions”
• 49 CFR 381.110, “What definitions are applicable to this part?”
• 49 CFR 382.107, “Definitions”
• 49 CFR 383.105, “Definitions”
• 49 CFR 384.105, “Definitions”
• 49 CFR 385.3, “Definitions and acronyms”
• 49 CFR 386.2, “Definitions”
• 49 CFR 387.5, “Definitions”
• 49 CFR 389.3, “Definitions”
• 49 CFR 390.5, “Definitions”
• 49 CFR 393.5, “Definitions”
• 49 CFR 395.2, “Definitions”
• 49 CFR 397.65, “Definitions”
• 49 CFR 399.205, “Definitions”

A1: the maximum activity of special form Class 7 (radioactive) material permitted in a Type A package. This value is either listed in 49 CFR 173.435, “Table of A1 and A2 values for radionuclides,” or may be derived in accordance with the procedures prescribed in 49 CFR 173.433, “Requirements for determining basic radionuclide values, and for the listing of radionuclides on shipping papers and labels.”

A2: the maximum activity of Class 7 (radioactive) material, other than special form material, low specific activity (LSA) material and surface contaminated object (SCO), permitted in a Type A package. This value is either listed in 49 CFR 173.435 or may be derived in accordance with the procedure prescribed in 49 CFR 173.433.

Approval Authority: is the RL Manager. The RL Manager is responsible for approving Hanford onsite Packaging Safety Documents, including approval of onsite PSSDs and other onsite safety documents and exemptions. Additionally, the RL Manager is the ultimate Approval Authority for this TSD and is responsible for coordinating sitewide assessments of the program.

Approval Authority (contractor): is the contractor employee responsible for the contractor’s overall onsite T&P Safety Program activities, including providing contractor approval to forward PSSDs and other onsite Packaging Safety Documents and changes to RL for approval.
Authorization Basis: is the safety documentation supporting the decision to allow a process or facility to operate. Included are corporate operational and environmental requirements as found in regulations and specific permits for specific activities, work packages or job safety analyses. (See also nuclear safety authorization basis.)

Box: a packaging with complete rectangular or polygonal faces, made of metal, wood, plywood, reconstituted wood, fiberboard, plastic, or other suitable material. Holes appropriate to the size and use of the packaging, for purposes such as ease of handling or opening, or to meet classification requirements, are permitted as long as they do not compromise the integrity of the packaging during transportation, and are not otherwise prohibited in this subchapter.

Bulk packaging: a packaging, other than a vessel or a barge, including a transport vehicle or freight container, in which hazardous materials are loaded with no intermediate form of containment. A Large Packaging in which hazardous materials are loaded with an intermediate form of containment, such as one or more articles or inner packaging(s), is also a bulk packaging. Additionally, a bulk packaging has:

1. A maximum capacity greater than 450 L (119 gal) as a receptacle for a liquid;
2. A maximum net mass greater than 400 kg (882 lb) and a maximum capacity greater than 450 L (119 gal) as a receptacle for a solid; or
3. A water capacity greater than 454 kg (1,000 lb) as a receptacle for a gas as defined in §173.115 of this subchapter.

Cargo tank: a bulk packaging which:

1. Is a tank intended primarily for the carriage of liquids or gases and includes appurtenances, reinforcements, fittings, and closures (for tank, see 49 CFR 178.320, “General requirements applicable to all DOT specification cargo tank motor vehicles” ; 178.337-1, “General requirements”; or 178.338-1, “General requirements,” as applicable);
2. Is permanently attached to or forms a part of a motor vehicle, or is not permanently attached to a motor vehicle but which, by reason of its size, construction or attachment to a motor vehicle is loaded or unloaded without being removed from the motor vehicle; and
3. Is not fabricated under a specification for cylinders, intermediate bulk containers, portable tanks, tank cars, or multi-unit tank car tanks.

Cargo tank motor vehicle: a motor vehicle with one or more cargo tanks permanently attached to or forming an integral part of the motor vehicle.

Categorical exclusion: a screening method that defines a category or categories of items or procedures that may be excluded from the USQ process. The justification for a categorical exclusion must define the conditions required for the exclusion to be valid. Categorical exclusions must be approved by the RL Manager before they become effective.

Certificate of Compliance (CoC): issued by the NRC, the DOE Headquarters Certifying Official (HCO), or the National Nuclear Security Administration Certifying Official approving the design of a package/packaging for the transportation of radioactive material. CoCs are issued
for packages (packaging and contents) that are evaluated, approved, and certified to meet the packaging standards specified in 10 CFR Part 71.

**Certificate of Conformance (COC):** Signed document provided by the packaging vendor/manufacture that verifies packaging meets the specified regulatory requirements. The COC is required for all DOT compliant packages.

**Change**, as used in the USQR process: means a change created by any of the following conditions:

1. A physical modification (permanent or temporary) to a transportation activity as described in the TSD and PSSD, or a revision to a transportation activity procedure (permanent or temporary), or other policies or procedures as described in the TSD and PSSD;

2. Introduction of new tests or experiments; and/or

3. A safety basis requirement revision.

**Class:** hazard class.

- **Class 1.** See 49 CFR 173.50 (Explosives)
- **Class 2.** See 49 CFR 173.115 (Flammable gas)
- **Class 3.** See 49 CFR 173.120 (Flammable liquid)
- **Class 4.** See 49 CFR 173.124 (Flammable solid)
- **Class 5.** See 49 CFR 173.128 (Oxidizer, organic peroxide)
- **Class 6.** See 49 CFR 173.132 (Poisonous, infectious)
- **Class 7.** See 49 CFR 173.403 (Radioactive)
- **Class 8.** See 49 CFR 173.136 (Corrosive)
- **Class 9.** See 49 CFR 173.140 (Miscellaneous hazardous material)

**Closed transport vehicle:** a transport vehicle or conveyance equipped with a securely attached exterior enclosure that, during normal transportation, restricts the access of unauthorized persons to the cargo space containing the Class 7 (radioactive) materials. The enclosure may be either temporary or permanent, and in the case of packaged materials may be of the “see-through” type, and must limit access from top, sides, and bottom.

**Closure:** a device which closes an opening in a receptacle (inner and outer packaging).

**“Co-located” or “Onsite Worker”:** is represented by the hypothetical, maximum exposed onsite individual, located at the distance of 100 m (328 ft) from an unmitigated hazard scenario from a facility (building perimeter) or estimated released point.

**Commercial driver’s license (CDL):** a license issues to an individual by a State or other jurisdiction of domicile, in accordance with the standards contained in this part, which authorizes the individual to operate a class of a commercial motor vehicle.
Combination packaging: a combination of packaging, for transport purposes, consisting of one or more inner packagings secured in a non-bulk outer packaging. It does not include a composite packaging.

Commerce: trade or transportation in the jurisdiction of the United States within a single state; between a place in a state and a place outside of the state; that affects trade or transportation between a place in a state and place outside of the state; or on a United States-registered aircraft.

Commercial motor vehicle: any self-propelled or towed motor vehicle used on the highway in interstate commerce to transport passengers or property when the vehicle:

- Has a gross vehicle weight rating or gross combination weight rating, or gross vehicle weight or gross combination weight, of 4,536 kg (10,001 lb) or more, whichever is greater; or
- Is designed or used to transport more than 8 passengers (including the driver) for compensation; or
- Is designed or used to transport more than 15 passengers, including the driver, and is not used to transport passengers for compensation; or
- Is used in transporting material found by the U.S. Secretary of Transportation to be hazardous under 49 U.S.C. 5103 and transported in a quantity requiring placarding under regulations prescribed by the Secretary under 49 CFR, subtitle B, chapter I, subchapter C.

Composite packaging: a packaging consisting of an outer packaging and an inner receptacle, so constructed that the inner receptacle and the outer packaging form an integral packaging. Once assembled it remains, thereafter, an integrated single unit; it is filled, stored, shipped, and emptied as such.

Confinement system: the assembly of components of the packaging intended to retain the Class 7 (radioactive) material intact during transport.

Consignment: a package or group of packages or load of radioactive material offered by a person for transport in the same shipment.

Containment system: the assembly of components of the packaging intended to prevent the leakage of Class 7 (radioactive) material (including gases and liquids) during transport within the leakage rate limits specified in the TSD.

Contamination: the presence of a radioactive substance on a surface in quantities in excess of 0.4 Bq/cm² for beta and gamma emitters and low toxicity alpha emitters or 0.04 Bq/cm² for all other alpha emitters.

There are two categories of contamination:

1. Fixed contamination means contamination that cannot be removed from a surface during normal conditions of transport.
2. Non-fixed contamination means contamination that can be removed from a surface during normal conditions of transport.
Conveyance:

- For transport by public highway or rail: any transport vehicle or large freight container
- For transport by water: any vessel, or any hold, compartment, or defined deck area of a vessel including any transport vehicle onboard the vessel
- For transport by air: any aircraft

Corrective maintenance: is a maintenance task or operation done in order to identify, isolate or separate and rectify a particular fault. This is performed in order to restore the failed machine, equipment or system to an operational condition. Corrective maintenance can be either planned or unplanned. Corrective maintenance can be subdivided into:

- Immediate corrective maintenance – in which work starts immediately after a failure.
- Deferred corrective maintenance – in which work is delayed in conformance to a given set of maintenance rules.

Criticality Safety Index (CSI): a number (rounded up to the next tenth) which is used to provide control over the accumulation of packages, overpacks, or freight containers containing fissile material. The CSI for packages containing fissile material is determined in accordance with the instructions provided in 10 CFR 71.22, “General license: Fissile material”; 71.23, “General license: Plutonium-beryllium special form material”; and 71.59, “Standards for arrays of fissile material packages.” The CSI for an overpack, freight container, consignment or conveyance containing fissile material packages is the arithmetic sum of the criticality safety indices of all the fissile material packages contained within the overpack, freight container, consignment or conveyance.

Design: design description of a special form Class 7 (radioactive) material, a package, packaging, or LSA-III, that enables those items to be fully identified. The description may include specifications, engineering drawings, reports showing compliance with regulatory requirements, and other relevant documentation.

Designated facility: a hazardous waste treatment, storage, or disposal facility that has been designated on the manifest by the generator.

Deuterium: for the purposes of 49 CFR 173.453, “Fissile materials—exceptions,” deuterium and any deuterium compound, including heavy water, in which the ratio of deuterium atoms to hydrogen atoms exceeds 1:5000.

Documented Safety Analysis (DSA): a documented analysis of the extent to which a nuclear facility (packaging system or transportation activity) can be operated safely with respect to the workers, the public, and the environment. A DSA includes a description of the conditions, safe boundaries, and hazard controls that provide the basis for ensuring safety. For transportation, this is the TSD, associated PSSDs, safety evaluation reports (SERs), and other associated safety documents.

DOT/NRC/DOE/U.S Department of Defense (DOD)-approved packagings (performance-based packagings): Packagings approved and/or certified by the DOT, NRC, DOE, and DOD must comply with all applicable federal regulations, specifications, and performance standards.
Drum: a flat-ended or convex-ended cylindrical packaging made of metal, fiberboard, plastic, plywood, or other suitable material. This definition also includes packagings of other shapes made of metal or plastic (e.g., round taper-necked packagings or pail-shaped packagings) but does not include cylinders, jerricans, wooden barrels, or bulk packagings.

Employee: an employee of an employer who is employed in a business of their employer, which affects commerce.

Employer: a person engaged in a business affecting commerce that has employees.

Established federal standard: any operative standard established by any agency of the United States and in effect on April 28, 1971, or contained in any Act of Congress in force on the date of enactment of the Williams-Steiger Occupational Safety and Health Act of 1970 (29 USC 651).

Evaluation of Safety: a qualitative discussion to justify that it is safe to remove the operational restrictions that were put in place as a result of a Potential Inadequacy in the Safety Analysis (PISA). It demonstrates that the risk RL has accepted has not increased or provides a safety basis change for RL approval. It identifies the protection that the operational restrictions provided and the evidence that the potential increased risk is not a valid concern.

A suggested content of the Evaluation of Safety includes:

- Summary of PISA determination
- Listing of interim operational restrictions and their purposes
- Results of USQ₉ determination
- Description of review actions taken
- Conclusion of safety review
- Statement of disposition of operational restrictions.


Exclusive use: Sole use by a single consignor of a conveyance for which all initial, intermediate, and final loading and unloading and shipment are carried out in accordance with the direction of the consignor or consignee where required in the TSD. The consignor and the carrier must ensure that any loading or unloading is performed by personnel having radiological training and resources appropriate for safe handling of the consignment. The consignor must provide to the initial carrier specific written instructions for maintenance of exclusive use shipment controls, including the vehicle survey requirement of 49 CFR 173.443 (c), as applicable, and include these instructions with the shipping paper information provided to the carrier by the consignor.

Exemption: a document issued by the Hanford Site DOE Approval Authority (RL Manager) that authorizes a person to perform a function that is not otherwise authorized under this TSD (e.g., OTRS).
Exemption value: either an exempt material activity concentration or an exempt consignment activity limit listed in the table in 49 CFR 173.436, “Exempt material activity concentrations and exempt consignment activity limits for radionuclides,” or determined according to the procedures described in 49 CFR 173.433, and used to determine whether a given physically radioactive material is sufficiently radioactive to be subject to the hazardous material regulations (see definition of radioactive material). An exemption value is different from an exemption as defined in 49 CFR 171.8.

Facility transfer: the movement of material or packages between processing areas or storage areas within a specific facility or facility compound (e.g., Solid Waste Operations Complex [SWOC]) covered by a single facility DSA or other DOE-approved safety or authorization basis document(s). These transfers are not considered onsite shipments, and are authorized by this TSD only when the safety basis for these facility movements is adequately addressed in the facility DSA or other DOE-approved safety or authorization basis document(s).

Facility worker: any individual located within the facility safety or authorization basis boundary or its emergency control area that is knowledgeable of the potential hazards and is trained to the facility emergency procedures. The consequences to the facility worker are typically evaluated qualitatively in the hazard evaluation rather than in the accident analysis.

Fissile material: $^{239}\text{Pu}$, $^{241}\text{Pu}$, $^{233}\text{U}$, $^{235}\text{U}$, or any combination of these radionuclides. Fissile material means the fissile nuclides themselves, not material containing fissile nuclides, but does not include: Unirradiated natural uranium or depleted uranium; and natural uranium or depleted uranium that has been irradiated in thermal reactors only. Certain exceptions for fissile materials are provided in 49 CFR 173.453.

Fissile material package: a packaging, together with its fissile material contents, which meets the requirements for fissile material packages described in 10 CFR 71, Subpart E. A fissile material package may be a Type AF package, Type BF package, Type B(U)F package, or a Type B(M)F package.

Freight container: a reusable container having a volume of 1.81 m$^3$ (64 ft$^3$) or more, designed and constructed to permit it being lifted with its contents intact and intended primarily for containment of packages in unit form during transportation. A “small freight container” is one which has an internal volume of not more than 3 m$^3$ (106 ft$^3$). All other freight containers are designated as “large freight containers.”

Gas: a material that has a vapor pressure greater than 300 kPa (43.5 psi) at 50°C (122°F) or is completely gaseous at 20°C (68°F) at a standard pressure of 101.3 kPa (14.7 psi).

Gross weight or Gross mass: the weight of a packaging plus the weight of its contents.

Hanford Site DOT-Equivalent Packagings (performance-based packagings): Hanford Site DOT-equivalent packagings must comply with Hanford-defined performance standards based on the Hanford Site transportation environment.

Hanford Site non-DOT-Equivalent Packagings (risk based packagings): Hanford Site non-DOT-equivalent packagings are authorized under a dose consequence/risk assessment methodology defined in this TSD and approved by RL.
**Hazard class:** the category of hazard assigned to a hazardous material under the definitional criteria of 49 CFR 173 and the provisions of the 49 CFR 172.101 table. A material may meet the defining criteria for more than one hazard class, but is assigned to only one hazard class.

**Hazard controls:** measures to eliminate, limit, or mitigate hazards to the workers, the public, or the environment, including:

- Physical, design, structural, and engineering features
- Safety structures, systems, and components
- Safety management programs
- Technical safety requirements
- Other controls necessary to provide adequate protection from hazards

**Hazard zone:** one of 4 levels of hazards (Hazard Zones A through D) assigned to gases, as specified in 49 CFR 173.116(a), and 1 of 2 levels of hazards (Hazard Zones A and B) assigned to liquids that are poisonous by inhalation, as specified in 49 CFR 173.133(a). A hazard zone is based on the LC50 value for acute inhalation toxicity of gases and vapors, as specified in 49 CFR 173.133(a).

**Hazardous material:** a substance or material that the Secretary of Transportation has determined is capable of posing an unreasonable risk to health, safety, and property when transported in commerce, and has been designated as hazardous under Section 5103 of Federal hazardous materials transportation law (49 U.S.C. 5103). The term includes hazardous substances, hazardous wastes, marine pollutants, elevated temperature materials, materials designated as hazardous in the Hazardous Materials Table (see 49 CFR 172.101), and materials that meet the defining criteria for hazard classes and divisions in Part 173 of this subchapter.

**Hazardous substance:** for the purposes of this TSD, means a material, including its mixtures and solutions, that:

- Is listed in 49 CFR 172.101, Appendix A;
- Is in a quantity, in one package, which equals or exceeds the reportable quantity (RQ) listed in 49 CFR 172.101, Appendix A; and
- When in a mixture or solution:
  - For radionuclides, conforms to paragraph 7 of 49 CFR 172.101, Appendix A.
  - For other than radionuclides, is in a concentration by weight which equals or exceeds the concentration corresponding to the RQ of the material, as shown in Table 2-1, RQ Conversion Table.
### Table 2-1. RQ Conversion Table

<table>
<thead>
<tr>
<th>RQ pounds (kilograms)</th>
<th>Concentration by Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Percent</td>
</tr>
<tr>
<td>5000 (2270)</td>
<td>10</td>
</tr>
<tr>
<td>1000 (454)</td>
<td>2</td>
</tr>
<tr>
<td>100 (45.4)</td>
<td>0.2</td>
</tr>
<tr>
<td>10 (4.54)</td>
<td>0.02</td>
</tr>
<tr>
<td>1 (0.454)</td>
<td>0.002</td>
</tr>
</tbody>
</table>

The term does not include petroleum, including crude oil or any fraction thereof which is not otherwise specifically listed or designated as a hazardous substance in 49 CFR 172.101, Appendix A, and the term does not include natural gas, natural gas liquids, liquefied natural gas, or synthetic gas usable for fuel (or mixtures of natural gas and such synthetic gas).

**Hazardous waste:** for the purposes of this TSD, any material that is subject to the Hazardous Waste Manifest Requirements of the U.S. Environmental Protection Agency (EPA) specified in 40 CFR 262, “Standards Applicable to Generators of Hazardous Waste.”

**Hazmat:** hazardous material.

**Hazmat employee:**

- A person who is:
  - Employed on a full-time, part-time, or temporary basis by a hazmat employer and who, in the course of such full-time, part-time or temporary employment, directly affects hazardous materials transportation safety; or
  - Self-employed (including an owner-operator of a motor vehicle, vessel, or aircraft) transporting hazardous materials in commerce or per the TSD who in the course of such self-employment directly affects hazardous materials transportation safety.
- This term includes an individual, employed on a full-time, part-time, or temporary basis by a hazmat employer, or who is self-employed, who during the course of employment:
  - Loads, unloads, or handles hazardous materials;
  - Designs, manufactures, fabricates, inspects, marks, maintains, reconditions, repairs, or tests a package, container or packaging component that is represented, marked, certified, or sold as qualified for use in transporting hazardous material in commerce or per the TSD.
  - Prepares hazardous materials for transportation;
  - Is responsible for safety of transporting hazardous materials;
  - Operates a vehicle used to transport hazardous materials.
Hazmat employer:

- A person who employs or uses at least one hazmat employee on a full-time, part-time, or temporary basis; and who:
  - Transports hazardous materials in commerce and per the TSD;
  - Causes hazardous materials to be transported in commerce and per the TSD; or
  - Designs, manufactures, fabricates, inspects, marks, maintains, reconditions, repairs or tests a package, container, or packaging component that is represented, marked, certified, or sold by that person as qualified for use in transporting hazardous materials in commerce and per the TSD.

- A person who is self-employed (including an owner-operator of a motor vehicle, vessel, or aircraft) transporting materials in commerce; and who:
  - Transports hazardous materials in commerce and per the TSD;
  - Causes hazardous materials to be transported in commerce and per the TSD; or
  - Designs, manufactures, fabricates, inspects, marks, maintains, reconditions, repairs or tests a package, container, or packaging component that is represented, marked, certified, or sold by that person as qualified for use in transporting hazardous materials in commerce and per the TSD.

- A department, agency, or instrumentality of the United States Government, or an authority of a State, political subdivision of a State, or an Indian tribe; and who:
  - Transports hazardous materials in commerce;
  - Causes hazardous materials to be transported in commerce; or
  - Designs, manufactures, fabricates, inspects, marks, maintains, reconditions, repairs or tests a package, container, or packaging component that is represented, marked, certified, or sold by that person as qualified for use in transporting hazardous materials in commerce.

Industrial package: means a packaging that, together with its LSA material or SCO contents, meets the requirements of Sections 173.410 and 173.411. Industrial packages are categorized in 49 CFR 173.411:

- Industrial package Type 1 (Type IP-1)
- Industrial package Type 2 (Type IP-2)
- Industrial package Type 3 (Type IP-3)

Inner packaging: a packaging for which an outer packaging is required for transport. It does not include the inner receptacle of a composite packaging.

Inner receptacle: a receptacle which requires an outer packaging in order to perform its containment function. The inner receptacle may be an inner packaging of a combination packaging or the inner receptacle of a composite packaging.
Inter-area: An onsite shipment between two site-processing areas (i.e., 200 East Area to 200 West Area).

Intermediate bulk container (IBC): a rigid or flexible portable packaging, other than a cylinder or portable tank, designed for mechanical handling. Standards for IBCs manufactured in the United States are set forth in 49 CFR 178, Subparts N and O.

Intermediate packaging: a packaging enclosing an inner packaging or article and is itself enclosed in an outer packaging.

Intra-area: An onsite shipment between two facilities within a single site processing area (e.g., between T Plant and the Plutonium Finishing Plant within the 200 West Area).

Intra-facility movement or intra-facility transfer: the movement of material between individual buildings within a facility or facility complex that are adequately covered under a single-facility DSA or other DOE-approved safety or authorization basis document.

Jerrican: a metal or plastic packaging of rectangular or polygonal cross-section.

Like-for-like Replacement: exact replacement of a component with a new component satisfying the original design specification in every detail (e.g., replace a ½ in. x 2 in. grade 8 bolt with a ½ in. x 2 in. grade 8 bolt).

Limited quantity: when specified as such in a section applicable to a particular material, means the maximum amount of a hazardous material for which there is a specific labeling or packaging exception. See 49 CFR 171.8.


Liquid: a material, other than an elevated temperature material, with a melting point or initial melting point of 20°C (68°F) or lower at a standard pressure of 101.3 kPa (14.7 psia). A viscous material for which a specific melting point cannot be determined must be subjected to the procedures specified in American Society for Testing and Materials (ASTM) D4359-90, “Standard Test Method for Determining Whether a Material is Liquid or Solid.”

Liquid phase: a material that meets the definition of liquid when evaluated at the higher of the temperature at which it is offered for transportation or at which it is transported, not at the 37.8°C (100°F) temperature specified in ASTM D4359-90.

LSA: Class 7 (radioactive) material with limited specific activity which is not fissile material or is excepted under §173.453, and which satisfies the descriptions and limits set forth below. Shielding material surrounding the LSA material may not be considered in determining the estimated average specific activity of the LSA material. LSA material must be in one of three groups:

1. LSA-I:
   a. Uranium and thorium ores, concentrates of uranium and thorium ores, and other ores containing naturally occurring radionuclides which are intended to be processed for the use of these radionuclides; or
b. Natural uranium, depleted uranium, natural thorium or their compounds or mixtures, provided they are unirradiated and in solid or liquid form; or

c. Radioactive material for which the $A_2$ value is unlimited; or (iv) Other radioactive material in which the activity is distributed throughout and the estimated average specific activity does not exceed 30 times the values for activity concentration specified in §173.436 or calculated in accordance with §173.433, or 30 times the default values listed in Table 8 of §173.433.

2. LSA-II:

a. Water with tritium concentration up to 0.8 TBq/L (20.0 Ci/L); or

b. Other radioactive material in which the activity is distributed throughout and the average specific activity does not exceed $10^{-4} A_2/g$ for solids and gases, and $10^{-5} A_2/g$ for liquids.

3. LSA-III. Solids (e.g., consolidated wastes, activated materials), excluding powders, that meet the requirements of §173.468 and in which:

a. The radioactive material is distributed throughout a solid or a collection of solid objects, or is essentially uniformly distributed in a solid compact binding agent (such as concrete, bitumen, ceramic, etc.);

b. The radioactive material is relatively insoluble, or it is intrinsically contained in a relatively insoluble material, so that, even under loss of packaging, the loss of Class 7 (radioactive) material per package by leaching when placed in water for seven days would not exceed 0.1 $A_2$; and

c. The estimated average specific activity of the solid, excluding any shielding material, does not exceed $2 \times 10^{-3} A_2/g$

**Low toxicity alpha emitters**: natural uranium; depleted uranium; natural thorium; $^{235}$U, $^{238}$U, $^{228}$Th, $^{230}$Th and $^{232}$Th when contained in ores or physical and chemical concentrates; and alpha emitters with a half-life of less than 10 days.

**Maintenance Activity**: the proactive and reactive work required to maintain and preserve packaging systems in a condition suitable for performing their designated purpose, and includes planned or unplanned periodic, preventive, predictive, seasonal or corrective (repair) maintenance. A maintenance activity is not a modification. [Derived from DOE G 433.1-1A, Nuclear Facility Maintenance Management Program Guide for Use with DOE O 433.1B.]

**Marking**: a descriptive name, identification number, instructions, cautions, weight, specification, or UN marks, or combinations thereof, required by this subchapter on outer packagings of hazardous materials.

**Material of trade**: a hazardous material, other than a hazardous waste, that is carried on a motor vehicle:

- For the purpose of protecting the health and safety of the motor vehicle operator or passengers;
• For the purpose of supporting the operation or maintenance of a motor vehicle (including its auxiliary equipment); or

• By a private motor carrier (including vehicles operated by a rail carrier) in direct support of a principal business that is other than transportation by motor vehicle.

Material poisonous by inhalation or material toxic by inhalation means:

• A gas meeting the defining criteria in 49 CFR 173.115(c) and assigned to Hazard Zone A, B, C, or D in accordance with 49 CFR 173.116(a).

• A liquid (other than as a mist) meeting the defining criteria in 49 CFR 173.132(a)(1)(iii) and assigned to Hazard Zone A or B in accordance with 49 CFR 173.133(a); or (3) Any material identified as an inhalation hazard by a special provision in column 7 of the 49 CFR 172.101 table.

**Maximum allowable working pressure:** For DOT specification cargo tanks used to transport liquid hazardous materials, see 49 CFR 178.320(a).

**Maximum capacity:** the maximum inner volume of receptacles or packagings.

**Maximum net mass:** the allowable maximum net mass of contents in a single packaging, or as used in 49 CFR 178, Subpart M, the maximum combined mass of inner packaging and the contents thereof.

**Maximum Normal Operating Pressure (MNOP):** is defined for sealed packages as the maximum gauge pressure that would develop in a containment system under bounding normal conditions of package heating and internal gas generation during a period twice the expected shipping time or one year, whichever is shorter. For vented packages, the MNOP is defined as the pressure that could develop under bounding normal conditions during the expected shipping time if all venting devices were plugged. Also per 10 CFR 71.71(c)(1), the maximum gauge pressure that would develop in a containment system during a period of one year, in the absence of venting or cooling, under the heat conditions specified.

**Maximum Offsite Individual (MOI):** a hypothetical receptor located at or beyond the Hanford Site Boundary (or public access area) at the distance and in the direction from the point of release at which the maximum dose occurs.

**Mixture:** a material composed of more than one chemical compound or element.

**Mode:** any of the following transportation methods; rail, highway, air, or water.

**Modification:** any permanent change, addition, or alteration to a packaging system.

Note: A modification is any permanent change, addition, or alteration to a packaging system included in a configuration baseline (e.g., delta pressures, control parameters, load-carrying capacity, response time, shielding, corrosion resistance). Uses of like-for-like or equivalent item, or temporary changes for performing routine repairs, are not modifications.

**Motor carrier:** a for-hire motor carrier or private motor carrier. The term includes a motor carrier's agents, officers, and representatives as well as employees responsible for hiring, supervising, training, assigning, or dispatching of drivers and employees concerned with the installation, inspection, and maintenance of motor vehicle equipment and/or accessories. For
purposes of 49 CFR 350-399, this definition includes the terms employer, and exempt motor carrier.

**Motor vehicle**: any vehicle, machine, tractor, trailer, or semitrailer propelled or drawn by mechanical power and used upon the highways in the transportation of passengers or property, or any combination thereof determined by the Federal Motor Carrier Safety Administration, but does not include any vehicle, locomotive, or car operated exclusively on a rail or rails, or a trolley bus operated by electric power derived from a fixed overhead wire, furnishing local passenger transportation similar to street-railway service.

**Multilateral approval**: approval of a package design or shipment by the relevant Competent Authority of the country of origin and of each country through or into which the package or shipment is to be transported. This definition does not include approval from a country over which Class 7 (radioactive) materials are carried in aircraft, if there is no scheduled stop in that country.

**Not otherwise Specified (N.O.S.)**: a shipping description from the 49 CFR 172.101 table that includes the abbreviation n.o.s.

**National consensus standard**: any standard or modification thereof which:

1. has been adopted and promulgated by a nationally recognized standards-producing organization under procedures whereby it can be determined by the Approval Authority that persons interested and affected by the scope or provisions of the standard have reached substantial agreement on its adoption;

2. was formulated in a manner which afforded an opportunity for diverse views to be considered; and

3. has been designated as such a standard by the Approval Authority. {Derived from 29 USCS § 652 (9) [Title 29. Labor; Chapter 15. Occupational Safety and Health]}.


**Natural thorium**: thorium with the naturally occurring distribution of thorium isotopes (essentially 100 wt% $^{232}$Th).

“**New package**” or “**new package design**”: a completely new package design (including hardware and payload) or the circumstance where a feature of a previously approved package is changed such that its structural performance, under normal or accident conditions, compromises the margin of safety for criticality, shielding, or containment. Examples include the following:

- A new cask or package design with unique payloads, not previously tested, analyzed, and/or approved is clearly considered a new packaging and would require a new PSSD approved by the RL Manager;

- A previously approved package where removal of a structural feature, such an overpack or impact limiter, would compromise package performance under the accident conditions (e.g., drop, fire, etc.) would be considered a new package, and would require a new PSSD approved by the RL Manager.
Non-bulk packaging: a packaging which has:

- A maximum capacity of 450 L (119 gal) or less as a receptacle for a liquid;
- A maximum net mass of 400 kg (882 lb) or less and a maximum capacity of 450 L (119 gal) or less as a receptacle for a solid;
- A water capacity of 454 kg (1,000 lb) or less as a receptacle for a gas as defined in 49 CFR 173.115; or
- Regardless of the definition of bulk packaging, a maximum net mass of 400 kg (882 lb) or less for a bag or a box conforming to the applicable requirements for specification packagings, including the maximum net mass limitations, provided in Subpart L of 49 CFR 178.

Normal form Class 7 (radioactive) material: Class 7 (radioactive) material not qualified as “special form Class 7 (radioactive) material.”

Nuclear safety authorization basis: is the basis for the safe operation of a DOE nuclear facility. Nuclear safety authorization basis includes hazard classification documents, DSAs, Safety Basis Requirements, DOE-issued safety evaluation reports, and facility-specific commitments made to comply with DOE nuclear safety requirements.

Occupationally exposed hazmat employee: a hazmat employee whose duties involve exposure to ionizing radiation.

Occurrence: an event (e.g., package rupture, valve failure, loss of containment, environmental spills) or a condition (e.g., an as-found state, whether or not resulting from an event), that may have adverse safety, health, quality assurance, security, operational, or environmental implications.

Occurrence Report: a documented evaluation of an event or condition that is prepared in sufficient detail to enable the reader to assess its significance, consequences, or implications and to evaluate the actions being proposed or employed to correct the condition or to avoid recurrence. All Occurrence Reports are screened for USQ\textsuperscript{T} implications.

Offsite: outside the boundaries of the Hanford Site and on Hanford Site roadways, waterways, and land areas to which the public is given unrestricted access.

Offsite public: is represented by the MOI, a hypothetical receptor located at or beyond the Hanford Site Boundary (or public access area) at the distance and in the direction from the point of release at which the maximum dose occurs.

Offsite shipment: A government, DOE contractor, or commercial shipment of radioactive or other hazardous material or waste leaving the Hanford Site, or shipment onsite to a non-DOE entity, or an onsite movement of these materials and wastes transported over roadways where the general public has unrestricted access. These shipments are regulated under 49 CFR 170-178 and 10 CFR 71.

OTRS: is an exception to the TSD and/or PSSD approved by DOE that provides special authorization to ship radioactive materials in packagings on a limited basis.

Onsite: Inside the boundaries of the Hanford Site where public access is restricted.
**Onsite Public**: is characterized by a hypothetical receptor within the Hanford Site Boundary at locations bounded by:

- The near bank of the Columbia River.
- Highway 240 traversing the Hanford Site, in the direction and at the distance of highest dose or exposure. This receptor is used for reference purposes and is considered only when accident consequences at either of these locations exceed that for the maximum offsite individual.

**Onsite SEP**: The onsite SEP was a Pre-TSD technical and safety document that demonstrates radioactive material packaging compliance to Hanford Site T&P standards. It describes the T&P system, the authorized payload, and applicable operational controls. It also describes the testing and analyses performed to demonstrate compliance to the Hanford Site-equivalent T&P standards. Replaced by PSSDs.

**Onsite shipment**: A shipment of radioactive or other hazardous material or waste transported by motorized vehicle within the boundaries of the Hanford Site within or between DOE Facilities, and over roadways where public access is controlled or otherwise restricted.

**Operations and Maintenance (O&M) Manual**: A document issued for onsite packaging systems that identifies the packaging system and its components; the authorized payload including loading, closure and unloading instructions; inspection, testing and maintenance requirements and procedures; cask handling and tiedown for transport; and any other administrative or operational controls necessary to achieve required levels of safety.

**Operator**: a person who controls the use of an aircraft, vessel, or vehicle.

**Outage or ullage**: the amount by which a packaging falls short of being liquid full, usually expressed in percent by volume.

**Outer packaging**: the outermost enclosure of a composite or combination packaging together with any absorbent materials, cushioning and any other components necessary to contain and protect inner receptacles or inner packagings.

**Overpack**: except as provided in 49 CFR 178, Subpart K: means an enclosure that is used by a single consignor to provide protection or convenience in handling of a package or to consolidate two or more packages. Overpack does not include a transport vehicle, freight container, or aircraft unit load device. Examples of overpacks are one or more packages:

- Placed or stacked onto a load board such as a pallet and secured by strapping, shrink wrapping, stretch wrapping, or other suitable means; or
- Placed in a protective outer packaging such as a drum, box or crate.

**Package**: a packaging plus its contents. For radioactive material, Package means, for Class 7 (radioactive) materials, the packaging together with its radioactive contents as presented for transport.

**Package-Specific Safety Document (PSSD)**: is a package-specific safety assessment for onsite shipments demonstrating compliance with the equivalent or risk based requirements of the TSD and concludes that, based on the evidence provided, the transport system provides a level of
protection commensurate with the hazard of the material transported. PSSDs are package safety analyses, as described in DOE G 460.1-1, *Implementation Guide for the use with DOE O 460.1A*.

**Packaging**: a receptacle and any other components or materials necessary for the receptacle to perform its containment function in conformance with the minimum packing requirements of this TSD. For radioactive material, Packaging means, for Class 7 (radioactive) materials, the assembly of components necessary to ensure compliance with the packaging requirements of 49 CFR 173, Subpart I. It may consist of one or more receptacles, absorbent materials, spacing structures, thermal insulation, radiation shielding, service equipment for filling, emptying, venting and pressure relief, and devices for cooling or absorbing mechanical shocks. The conveyance, tiedown system, and auxiliary equipment may sometimes be designated as part of the packaging.

**Packaging and Transportation Safety**: includes existing RL-approved onsite package safety assessments, such as onsite SARPs, SEPs, PSSDs, OTRSs and similar documents assessing the safety of onsite shipments of radioactive materials.

**Packaging system**: is packaging and ancillary equipment necessary to conduct shipments. It may include the transportation vehicle.

**Packing group**: a grouping according to the degree of danger presented by hazardous materials. Packing Group I indicates great danger; Packing Group II, medium danger; Packing Group III, minor danger. See 49 CFR 172.101(f).

**Peak hours**: Peak Hours for traffic congestion on the Hanford Site are defined as 0500 to 0700 (5:00 am to 7:00 am) and 1600 to 1800 (4:00 pm to 6:00 pm) in accordance with Table 1 from “Hanford Site Vehicle Traffic Safety Assessment” (April 2010), prepared by Transportation Solutions, Inc.

**Periodic Maintenance**: work tasks performing periodic maintenance activities intended to maintain a system or component in the as-designed condition to reduce the need for unplanned Corrective Maintenance.

**Person**: an individual, corporation, company, association, firm, partnership, joint stock company; or a government, that offers a hazardous material for transportation in accordance with this TSD, transports such hazardous material for transportation in accordance with this TSD, transports such hazardous material, or designs, manufactures, fabricates, inspects, marks, maintains, reconditions, repairs, or tests a package, container, or packaging component that is represented, marked, certified, or sold as qualified for use in transporting hazardous material.

Person who offers or offeror means:

- Any person who does either or both of the following:
  - Performs, or is responsible for performing, any pre-transportation function required under this TSD for transportation of the hazardous material.
  - Makes the hazardous material available to a carrier for transportation in commerce and per the TSD.

- A carrier is not an offeror when it performs a function required TSD as a condition of acceptance of a hazardous material for transportation (e.g., reviewing shipping papers,
examining packages to ensure that they are in conformance with this TSD, or preparing shipping documentation for its own use).

**Portable tank**: a bulk packaging (except a cylinder having a water capacity of 454 kg [1,000 lb] or less) designed primarily to be loaded onto, or on, or temporarily attached to a transport vehicle or ship and equipped with skids, mountings, or accessories to facilitate handling of the tank by mechanical means. It does not include a cargo tank, tank car, multi-unit tank car tank, or trailer carrying 3AX, 3AAX, or 3T cylinders.

**PISA**: situations of concern wherein that give reason to believe that there is the potential that the current safety basis may not be bounding or may be otherwise inadequate.

**Pre-transportation function**: a function specified in the TSD that is required to assure the safe transportation of a hazardous material within the Hanford Site, including:

- Determining the hazard class of a hazardous material.
- Selecting a hazardous materials packaging.
- Filling a hazardous materials packaging, including a bulk packaging.
- Securing a closure on a filled or partially filled hazardous materials package or container or on a package or container containing a residue of a hazardous material.
- Marking a package to indicate that it contains a hazardous material.
- Labeling a package to indicate that it contains a hazardous material.
- Preparing a shipping paper.
- Providing and maintaining emergency response information.
- Reviewing a shipping paper to verify compliance with the Hazardous Materials Regulations and/or TSD.
- Certifying that a hazardous material is in proper condition for transportation in conformance with the requirements of the TSD.
- Loading, blocking, and bracing a hazardous materials package in a freight container or transport vehicle.
- Segregating a hazardous materials package in a freight container or transport vehicle from incompatible cargo.
- Segregating a hazardous materials package in a freight container or transport vehicle from incompatible cargo.
- Selecting, providing, or affixing placards for a freight container or transport vehicle to indicate that it contains a hazardous material.

**Primary hazard**: the hazard class of a material as assigned in the 49 CFR 172.101 table.

**Proper shipping name**: the name of the hazardous material shown in Roman print (not italics) in 49 CFR 172.101.
**Proposed activity:** any proposed change to procedures (including cancellations) or equipment and any proposed new procedures, equipment, tests (including post-modification testing), operations, or experiments.

**Public access roadway:** A roadway where the general public has unrestricted access. This can include a state highway, county or city road, or Hanford Site roadway; e.g., Route 10 between the 1100 Area and the Wye Barricade.

**Q component:** is a packaging part (component) identified during the design effort as important to safety. For guidance in identifying parts, see Appendix A of Regulatory Guide 7.10, *Establishing Quality Assurance Programs for Packaging Used in the Transport of Radioactive Material.*

**Quality assurance:** a systematic program of controls and inspections applied by each person involved in the transport of radioactive material which provides confidence that a standard of safety is achieved in practice.

**Radiation level:** the radiation dose-equivalent rate expressed in millisieverts per hour or mSv/h (millirem per hour or mrem/h). It consists of the sum of the dose-equivalent rates from all types of ionizing radiation present including alpha, beta, gamma, and neutron radiation. Neutron flux densities may be converted into radiation levels according to Table 2-2, Neutron Fluence Rates to be Regarded as Equivalent to a Radiation Level of 0.01 mSv/h (1 mrem/h).

<table>
<thead>
<tr>
<th>Energy of Neutron</th>
<th>Flux density equivalent to 0.01 mSv/H (1 mrem/h) neutrons per square centimeter per second (n/cm²/s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thermal (2.510E-8) MeV</td>
<td>272.0</td>
</tr>
<tr>
<td>1 keV</td>
<td>272.0</td>
</tr>
<tr>
<td>10 keV</td>
<td>281.0</td>
</tr>
<tr>
<td>100 keV</td>
<td>47.0</td>
</tr>
<tr>
<td>500 keV</td>
<td>11.0</td>
</tr>
<tr>
<td>1 MeV</td>
<td>7.5</td>
</tr>
<tr>
<td>5 MeV</td>
<td>6.4</td>
</tr>
<tr>
<td>10 MeV</td>
<td>6.7</td>
</tr>
</tbody>
</table>

**Notes:**

1. Flux densities equivalent for energies between those listed in this table may be obtained by linear interpolation.

**Radioactive contents:** a Class 7 (radioactive) material, together with any contaminated or activated solids, liquids, and gases within the packaging.
**Radioactive instrument or article**: any manufactured instrument or article such as an instrument, clock, electronic tube or apparatus, or similar instrument or article having Class 7 (radioactive) material in gaseous or non-dispersible solid form as a component part.

**Radioactive material**: any material containing radionuclides where both the activity concentration and the total activity in the consignment exceed the values specified in the table in 49 CFR 173.436 or values derived according to the instructions in 49 CFR 173.433.

**Receptacle**: a containment vessel for receiving and holding materials, including any means of closing.

**Reportable Quantity (RQ)**: for the purposes of this TSD means the quantity specified in column 2 of the appendix to 49 CFR 172.101 for any material identified in column 1 of the appendix.

**Residue**: the hazardous material remaining in a packaging, including a tank car, after its contents have been unloaded to the maximum extent practicable and before the packaging is either refilled or cleaned of hazardous material and purged to remove any hazardous vapors.

**Safety Basis**: the TSD and hazard controls that provide reasonable assurance that a DOE nuclear activity can be performed safely in a manner that adequately protects the workers, the public, and the environment. The safety basis for T&P activities includes the TSD and approved Packaging Safety Documents, and associated SERs documenting the bases and conditions for DOE approval.

**Shipment**: the shipping or transporting of goods between facilities.

**Shipping paper**: a shipping order, bill of lading, manifest, or other shipping document serving a similar purpose and containing the information required by 49 CFR 172, Subpart C and as specified in the TSD or other approved transportation safety document such as PSSD. The TSD takes precedence over the regulations.

**Single packaging**: a non-bulk packaging other than a combination packaging.

**Site Controlled Access Roadway**: Hanford Site roads where public access is controlled or otherwise restricted. Controls include barricades, fences, signs, and Hanford Patrol checkpoints. Road closures can be executed on certain roads to convert a public access roadway to a controlled access roadway.

**Solid**: a material that is not a gas or a liquid.

**Solution**: any homogeneous liquid mixture of two or more chemical compounds or elements that will not undergo any segregation under conditions normal to transportation.

**Special form Class 7 (radioactive) material**: either an indispersible solid radioactive material or a sealed capsule containing radioactive material that satisfies the following conditions:

1. It is either a single solid piece or a sealed capsule containing radioactive material that can be opened only by destroying the capsule;

2. The piece or capsule has at least one dimension not less than 5 mm (0.2 in.); and
3. It satisfies the test requirements of 49 CFR 173.469. Special form encapsulations designed in accordance with the requirements of 49 CFR 173.389(g) in effect on June 30, 1983, (see 49 CFR 173, revised as of October 1, 1982), and constructed prior to July 1, 1985, and special form encapsulations designed in accordance with the requirements of 49 CFR 173.403 in effect on March 31, 1996, (see 49 CFR 173, revised as of October 1, 1995), and constructed prior to April 1, 1997, may continue to be used. Any other special form encapsulation must meet the requirements of this paragraph.

Special Packaging Authorizations (SPAs): provide DOE preapproved packaging solutions for routine onsite payloads, such as building debris, soil, rock, and limited building debris, retrieval packages (drum and non-drum). The SPA provides the transportation safety basis and pre-approved packaging configurations and controls matched to applicable payloads.

Special Packaging Zone (SPZ): is a TSD-designated onsite area composed of multiple facilities connected by a road or roads that are access restricted to onsite users. The facilities may be co-located or in close proximity to each other. The SPZ will include both the designated facilities and roads.

Specific activity of a radionuclide: the activity of the radionuclide per unit mass of that nuclide. The specific activity of a material in which the radionuclide is essentially uniformly distributed is the activity per unit mass of the material.

Specification packaging: a packaging conforming to one of the specifications or standards for packagings in 49 CFR 178 or 179.

Spent nuclear fuel or spent fuel: fuel that has been withdrawn from a nuclear reactor following irradiation, the constituent elements not separated by reprocessing. Test specimens of fissionable material irradiated for research and development only, and not production of power or plutonium, may be classified as waste, and managed in accordance with the requirements of DOE O 435.1 when it is technically infeasible, cost prohibitive, or would increase worker exposure to separate the remaining test specimens from other contaminated material.

Standard: a standard that requires conditions, or the adoption or use of one or more practices, means, methods, operations, or processes, reasonably necessary or appropriate to provide safe or healthful employment and places of employment.

Strong outside container: the outermost enclosure that provides protection against the unintentional release of its contents. It is a packaging that is sturdy, durable, and constructed so that it will retain its contents under normal conditions of transportation. In addition, a strong outer packaging must meet the general packaging requirements of Subpart B of 49 CFR 173 but need not comply with the specification packaging requirements in 49 CFR 178. The terms “strong outside container” and “strong outside packaging” are synonymous with “strong outer packaging.”

Subsidiary hazard: a hazard of a material other than the primary hazard. (See primary hazard).

SCO: a solid object which is not itself radioactive, but which has radioactive material distributed on its surface. SCOs exist in two phases:

1. SCO-I: A solid object on which:
a. The non-fixed contamination on the accessible surface averaged over 300 cm$^2$ (or the area of the surface if less than 300 cm$^2$) does not exceed 4 Bq/cm$^2$ (10$^{-4}$ µCi/cm$^2$) for beta and gamma and low toxicity alpha emitters, or 0.4 Bq/cm$^2$ (10$^{-5}$ µCi/cm$^2$) for all other alpha emitters;

b. The fixed contamination on the accessible surface averaged over 300 cm$^2$ (or the area of the surface if less than 300 cm$^2$) does not exceed 4x10$^4$ Bq/cm$^2$ (1.0 µCi/cm$^2$) for beta and gamma and low toxicity alpha emitters, or 4 x 10$^3$ Bq/cm$^2$ (0.1 µCi/cm$^2$) for all other alpha emitters; and

c. The non-fixed contamination plus the fixed contamination on the inaccessible surface averaged over 300 cm$^2$ (or the area of the surface if less than 300 cm$^2$) does not exceed 4 x 10$^4$ Bq/cm$^2$ (1.0 µCi/cm$^2$) for beta and gamma and low toxicity alpha emitters, or 4 x 10$^3$ Bq/cm$^2$ (0.1 µCi/cm$^2$) for all other alpha emitters.

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

a. The non-fixed contamination on the accessible surface averaged over 300 cm$^2$ (or the area of the surface if less than 300 cm$^2$) does not exceed 400 Bq/cm$^2$ (10$^{-2}$ µCi/cm$^2$) for beta and gamma and low toxicity alpha emitters or 40 Bq/cm$^2$ (10$^{-3}$ µCi/cm$^2$) for all other alpha emitters;

b. The fixed contamination on the accessible surface averaged over 300 cm$^2$ (or the area of the surface if less than 300 cm$^2$) does not exceed 8 x 10$^5$ Bq/cm$^2$ (20 µCi/cm$^2$) for beta and gamma and low toxicity alpha emitters, or 8 x 10$^4$ Bq/cm$^2$ (2 µCi/cm$^2$) for all other alpha emitters; and

c. The non-fixed contamination plus the fixed contamination on the inaccessible surface averaged over 300 cm$^2$ (or the area of the surface if less than 300 cm$^2$) does not exceed 8 x 10$^5$ Bq/cm$^2$ (20 µCi/cm$^2$) for beta and gamma and low toxicity alpha emitters, or 8 x 10$^4$ Bq/cm$^2$ (2 µCi/cm$^2$) for all other alpha emitters.

**Technical change**, a change that:

- Creates or changes functional or performance requirements,
- Changes applicable hazard controls,
- Changes analytical parameters used in the safety basis,
- Introduces a new hazard,
- Changes the material at risk (MAR),
- Changes maintenance or surveillance frequencies,
- Changes procedural steps which direct manipulation of equipment such as manipulation of valves, performance tests, torque values or sequences, tiedown equipment or placement, or
- Alters documentation of package conditions or configurations.
Technical name: a recognized chemical name or microbiological name currently used in scientific and technical handbooks, journals, and texts. Generic descriptions are authorized for use as technical names provided they readily identify the general chemical group or microbiological group. Examples of acceptable generic chemical descriptions are organic phosphate compounds, petroleum aliphatic hydrocarbons, and tertiary amines. For proficiency testing only, generic microbiological descriptions such as bacteria, mycobacterium, fungus, and viral samples may be used. Except for names which appear in Subpart B of 49 CFR 172, trade names may not be used as technical names.

Transfer: Any onsite shipment or onsite transport of hazardous materials, substances, and wastes, including those that are radioactive, between facilities where the facility boundaries are described and covered under a facility safety analysis report (SAR) or other DOE-approved safety or authorization basis document(s). For example, an onsite shipment between one of the 200 West Area Tank Farms to the Central Waste Complex (CWC) would be considered an onsite shipment or transfer. A movement of material or waste in or around the confines of the CWC would not be considered an onsite shipment or transfer from a transportation safety perspective as long as such movements were properly addressed in the CWC Facility DSA.

Transport index (TI): the dimensionless number (rounded up to the next tenth) placed on the label of a package to designate the degree of control to be exercised by the carrier during transportation. The TI is determined by multiplying the maximum radiation level in millisieverts (mSv) per hour at 1 m (3.3 ft) from the external surface of the package by 100 (equivalent to the maximum radiation level in millirem per hour at 1 m [3.3 ft]).

Transport vehicle: a cargo-carrying vehicle such as an automobile, van, tractor, truck, semitrailer, tank car, or rail car used for the transportation of cargo by any mode. Each cargo-carrying body (trailer, rail car, etc.) is a separate transport vehicle.

TSD Exemption: A documented exception or deviation to any TSD requirement approved by the RL Manager. The TSD exemption process is defined in Chapter 9.0 for non-routine shipments.

Type A Package: a packaging that, together with its radioactive contents limited to $A_1$ or $A_2$ as appropriate, meets the requirements of 49 CFR 173.410, 173.412 and 178.350 and is designed to retain the integrity of containment and shielding required by this part under normal conditions of transport as demonstrated by the tests set forth in 49 CFR 173.465, “Type A packaging tests,” or 173.466, “Additional tests for Type A packagings designed for liquids and gases,” as appropriate. If the prime contractor is qualified to certify Type A packages, a separate Competent Approval Authority is not required. When Type A packages are being used to transport Type B quantities of radioactive materials, approval must be received from the respective Hanford Site DOE Approval Authority.

Type A quantity: a quantity of Class 7 (radioactive) material, the aggregate radioactivity which does not exceed $A_1$ for special form Class 7 (radioactive) material or $A_2$ for normal form Class 7 (radioactive) material, where $A_1$ and $A_2$ values are given in 49 CFR 173.435 or are determined in accordance with 49 CFR 173.433.

Type B Package: a packaging designed to transport greater than an $A_1$ or $A_2$ quantity of radioactive material that, together with its radioactive contents, is designed to retain the integrity
of containment, and shielding required by the TSD when subjected to the normal conditions of transport and hypothetical accident test conditions set forth in this TSD.

**Type B quantity**: a quantity of material greater than a Type A quantity.

**Ullage**: See Outage.

**UN standard packaging**: a packaging conforming to standards in the UN recommendations on the Transport of Dangerous Goods.

**Unilateral approval**: approval of a package design solely by the Competent Authority of the country of origin of the design.

**Unirradiated thorium**: thorium containing not more than $10^{-7}$ grams $^{233}$U per gram of $^{232}$Th.

**Unirradiated uranium**: uranium containing not more than $2 \times 10^3$ Bq of plutonium per gram of $^{235}$U, not more than $9 \times 10^6$ Bq of fission products per gram of $^{235}$U, and not more than $5 \times 10^3$ g of $^{236}$U per gram of $^{235}$U.

**Uranium**

- natural, depleted or enriched means the following:
  - Natural uranium (which may be chemically separated) containing the naturally occurring distribution of uranium isotopes (approximately 99.28 percent $^{238}$U and 0.72 percent $^{235}$U by mass).
  - Depleted uranium means uranium containing a lesser mass percentage of $^{235}$U than in natural uranium.
  - ‘Enriched uranium’ means uranium containing a greater mass percentage of $^{235}$U than 0.72 percent.
- In all cases listed in this definition, a very small mass percentage of $^{234}$U may be present.

**USQ_T process**: the mechanism for keeping a transportation safety basis current by reviewing potential unreviewed safety questions, reporting unreviewed safety questions to DOE, and obtaining approval from DOE prior to taking any action involving an unreviewed safety question.

**Work Instruction**: the documentation that specifies the actual work that will be conducted in the field including prerequisites, performance instructions, and system testing/restoration steps. The work instruction is the “activity” part of a work order that the USQ_T process applies to. Other materials, such as additional forms, permits and administrative fields on work management generated forms are not part of the work instructions, and as such, the USQ_T process does not apply to this material.

**Work Package**: a general term for the folder, forms, permits, and work instructions that are packaged together in order to provide direction on how to accomplish maintenance or other work activity. Examples include a No Planning Required Work Order, Work It Now Ticket, Planned Work Order, or Service Ticket.
2.2 Acronyms and Abbreviations

AC          Accident Condition
ACM         Asbestos Containing Material
ANSI        American National Standards Institute
ARF         Airborne Release Fraction
ASME        American Society of Mechanical Engineers
ASTM        American Society for Testing and Materials
BPVC        Boiler and Pressure Vessel Code
CDL         Commercial Driver’s License
CEDE        Committed Effective Dose Equivalent
CFR         Code of Federal Regulations
CMOS        Credited Margins of Safety
CoC         Certificate of Compliance
CSB         Canister Storage Building
CSI         Criticality Safety Index
CWC         Central Waste Complex
DCF         Dose Conversion Factor
DDT         deflagration to detonation transition
d-e-Ci       dose-equivalent curie
DOD         U.S. Department of Defense
DOE         U.S. Department of Energy
DOE-HQ      U.S. Department of Energy - Headquarters
DOT         U.S. Department of Transportation
DR          Damage Ratio
DSA         Documented Safety Analysis
EOC         Emergency Operations Center
EPA         U.S. Environmental Protection Agency
ES&H        Environment, Safety, and Health
FMCSR       Federal Motor Carrier Safety Regulations
GIS         Geographic Information System
GSA         Government Services Administration
HAC         Hypothetical Accident Condition
HMSR        Hazardous Material Shipment Record
HMT         Hazardous Materials Table
HPS         Hanford Packaging Standard
HQ          Headquarter
IAEA        International Atomic Energy Agency
IBC         Intermediate bulk container
ICRP        International Commission on Radiological Protection
IP          Industrial Packages
<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ISMS</td>
<td>Integrated Environment, Safety and Health Management System</td>
</tr>
<tr>
<td>ISO</td>
<td>International Standards Organization</td>
</tr>
<tr>
<td>EL</td>
<td>Longer Combination Vehicle</td>
</tr>
<tr>
<td>LEL</td>
<td>Lower Explosive Limit</td>
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<tr>
<td>LPF</td>
<td>Leak Path Factor</td>
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<tr>
<td>LSA</td>
<td>Low Specific Activity</td>
</tr>
<tr>
<td>MAR</td>
<td>Material at Risk</td>
</tr>
<tr>
<td>MNOP</td>
<td>Maximum Normal Operating Pressure</td>
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<tr>
<td>MOI</td>
<td>Maximum Exposed Offsite Individual</td>
</tr>
<tr>
<td>NC</td>
<td>Normal Condition</td>
</tr>
<tr>
<td>NCT</td>
<td>Normal Conditions of Transport</td>
</tr>
<tr>
<td>NQA-1</td>
<td>Nuclear Quality Assurance</td>
</tr>
<tr>
<td>NRC</td>
<td>U.S. Nuclear Regulatory Commission</td>
</tr>
<tr>
<td>O&amp;M</td>
<td>Operations and Maintenance</td>
</tr>
<tr>
<td>OR</td>
<td>Occurrence Report</td>
</tr>
<tr>
<td>ORP</td>
<td>U.S. Department of Energy, Office of River Protection</td>
</tr>
<tr>
<td>ORRRSR</td>
<td>Onsite Routine Radioactive Shipment Record</td>
</tr>
<tr>
<td>OTRS</td>
<td>One-Time Request for Shipment</td>
</tr>
<tr>
<td>PISA</td>
<td>Potential Inadequacy in the Safety Analysis</td>
</tr>
<tr>
<td>PNSO</td>
<td>U.S. Department of Energy Pacific Northwest Site Office</td>
</tr>
<tr>
<td>PO</td>
<td>Purchase Order</td>
</tr>
<tr>
<td>PR</td>
<td>Purchase Requisition</td>
</tr>
<tr>
<td>PSSD</td>
<td>Package-Specific Safety Document</td>
</tr>
<tr>
<td>QA</td>
<td>Quality Assurance</td>
</tr>
<tr>
<td>QAP</td>
<td>Quality Assurance Program</td>
</tr>
<tr>
<td>QC</td>
<td>Quality Control</td>
</tr>
<tr>
<td>RCRA</td>
<td>Resource Conservation and Recovery Act of 1976</td>
</tr>
<tr>
<td>RCT</td>
<td>Radiological Control Technician</td>
</tr>
<tr>
<td>RF</td>
<td>Respirable Fraction</td>
</tr>
<tr>
<td>RL</td>
<td>U.S. Department of Energy, Richland Operations Office</td>
</tr>
<tr>
<td>RQ</td>
<td>Reportable Quantity</td>
</tr>
<tr>
<td>RSR</td>
<td>Radioactive Shipment Record</td>
</tr>
<tr>
<td>SAR</td>
<td>Safety Analysis Report</td>
</tr>
<tr>
<td>SARP</td>
<td>Safety Analysis Report for Packaging</td>
</tr>
<tr>
<td>SCO</td>
<td>Surface Contaminated Object</td>
</tr>
<tr>
<td>SEC</td>
<td>Shipment Evaluation Checklist</td>
</tr>
<tr>
<td>SED</td>
<td>Strain Energy Density</td>
</tr>
<tr>
<td>SEP</td>
<td>Safety Evaluation for Packaging</td>
</tr>
<tr>
<td>SER</td>
<td>Safety Evaluation Report</td>
</tr>
<tr>
<td>SNM</td>
<td>Special Nuclear Material</td>
</tr>
<tr>
<td>SPA</td>
<td>Special Packaging Authorization</td>
</tr>
<tr>
<td>Abbreviation</td>
<td>Description</td>
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<tr>
<td>--------------</td>
<td>-------------</td>
</tr>
<tr>
<td>SPZ</td>
<td>Special Packaging Zone</td>
</tr>
<tr>
<td>SSC</td>
<td>Structures, Systems, or Components</td>
</tr>
<tr>
<td>SWITS</td>
<td>Solid Waste Information Tracking System</td>
</tr>
<tr>
<td>T&amp;P</td>
<td>Transportation and Packaging</td>
</tr>
<tr>
<td>TI</td>
<td>Transport Index</td>
</tr>
<tr>
<td>TRU</td>
<td>Transuranic material</td>
</tr>
<tr>
<td>TSD</td>
<td>Hanford Sitewide Transportation Safety Document</td>
</tr>
<tr>
<td>TSL</td>
<td>Triaxial Strain Limit</td>
</tr>
<tr>
<td>UHWM</td>
<td>Uniform Hazardous Waste Manifest</td>
</tr>
<tr>
<td>UN</td>
<td>United Nations</td>
</tr>
<tr>
<td>USC</td>
<td>United States Code</td>
</tr>
<tr>
<td>USQ</td>
<td>Unreviewed Safety Question</td>
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<tr>
<td>USQT</td>
<td>Unreviewed Safety Question for Transportation</td>
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<tr>
<td>USQTD</td>
<td>Unreviewed Safety Question for Transportation Determination</td>
</tr>
<tr>
<td>USQTS</td>
<td>Unreviewed Safety Question for Transportation Screening</td>
</tr>
<tr>
<td>WAC</td>
<td>Washington Administrative Code</td>
</tr>
<tr>
<td>WIPP</td>
<td>Waste Isolation Pilot Plant</td>
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</table>
3.0 Site Description

This chapter describes the Hanford Site Boundaries and Roadways used to transport hazardous materials and wastes. It describes exclusion areas and facilities, and their principle missions. A Hanford Site Map is provided for more detailed site and area maps.

3.1 Physical Description

The Hanford Site covers approximately 1,500 km$^2$ (580 mi$^2$) of semiarid land along the Columbia River in southeastern Washington State. It is owned by the U.S. Government and managed by RL, PNSO, and ORP. The City of Richland adjoins the southeastern most portion of the Hanford Site Boundary and is the nearest population center.

In early 1943, the U.S. Army Corps of Engineers selected the Hanford Site as the location for plutonium production for national defense. For over 20 years, activities were primarily dedicated to the continuation of plutonium production and managing the waste that was generated. In later years, activities became increasingly diverse, involving research and development for advanced reactors and renewable energy technologies. The end of the Cold War brought the shutdown of most of the Hanford Site's Plutonium Production and Management Facilities. Current missions are the safe cleanup and management of the legacy waste on the Hanford Site and to develop and deploy science and technology.

The Hanford Site is divided into numerically designated areas. These areas served as the location for reactors, chemical separation plants, purification of special nuclear material (SNM), related activities for plutonium production, and other nuclear activities. The plutonium production reactors are located along the Columbia River in the 100 Area. The reactor fuel reprocessing units are in the 200 Areas, which are on a plateau approximately 11 km (7 mi) from the Columbia River. The 300 Area, located adjacent to and north of Richland, contains the reactor fuel manufacturing plants and research and development laboratories. The 400 Area, 8 km (5 mi) northwest of the 300 Area, contains the Fast Flux Test Facility designed for testing liquid metal reactor systems. The 600 Area covers all locations within the Hanford Site Boundary not specifically given an area designation. Offices are also located in the 700 Area, which is in downtown Richland.

Figure 3-1 shows the regional public highway network traversing the Hanford Site. This includes non-restricted access roadways (Washington State Highways 24 and 240) and restricted access roadways (Route 10 and portions of Route 4S located south of the Wye Barricade). Roadways east of the Yakima Barricade, north of the Wye Barricade, and within the 300 and 400 Areas are restricted to authorized personnel only. Other roadways are subject to such restrictions or closures when required.
Figure 3-1. Hanford Site Boundary Map

Notes: The area within the dotted line, along with 300 and 400 Area, are the controlled area on the Hanford Site. These areas restrict access to the public by using no trespassing signs and fences. The solid line shows the Hanford Site Boundary.

Figure 3-1 shows the major roads throughout the Hanford Site. These roads are classified as either primary or secondary routes. The primary routes include Routes 4N, 4S, 10, 2S, 3, and 11A as well as various avenues within each area. The primary routes are constructed of bituminous asphalt (usually 5 cm [2 in.] thick, but the thickness of the asphalt layer will vary with each road) with an underlying aggregate base in accordance with DOT requirements at the time of their construction. The secondary routes are constructed of layers of an oil-and-rock mixture with an underlying aggregate base. The aggregate base consists of various types and sizes of rock found onsite. The present load-bearing capacities of these roads are unknown; however, loads as large as 9.8 kg/cm² (140 psi) have been transported without observable damage to road surfaces.
Standard traffic control signs are used throughout the Hanford Site (e.g., octagonal stop signs and triangular yield signs). Speed limits are posted throughout the Hanford Site with the maximum posted speed is 97 km/h (60 mph) on major thoroughfares. Inside the various areas, posted speeds are reduced to a maximum of 56 km/h (35 mph) and held to speeds as low as 16 km/h (10 mph).

3.2 Public Access

The Hanford Site Boundary Map (Figure 3-1) is marked by a dotted line which denotes the locations of the trespassing fences and signs. With the exception of one area, public access to other roadways is restricted. Fences, signs, and security patrols are used to enforce the access restrictions.

On the south end of the Hanford Site, the public has access to a foot and bike path located near the Columbia River. The path extends between the south boundary of the Hanford Site and the 300 Area. The public has free access to the Columbia River where the river flows along the Hanford Site Boundary.

As noted in Section 3.1, several public highways pass through the Hanford Site. The public is permitted free access through Washington State Highways 24 and 240. In addition, the public also is permitted free access to the following Hanford Site Roadways:

- Route 4S from the intersection with Horn Road to the Wye Barricade;
- The two roads from 4S that go into the Energy Northwest Area;
- Kentucky Boulevard from 4S to the 400 Area;
- Alabama Boulevard from Kentucky Boulevard to Route 10;
- Route 10 from Washington State Highway 240 to Route 4S;
- George Washington Way between Horn Road and Route 4S;
- George Washington Way to 300 Area;
- Washington State Highway 240 to Yakima Barricade.

3.3 Primary Onsite Transport Routes

Transportation routes are generally specified for each onsite packaging system. When routes are not specified, it is expected that shipments will be executed using the most direct route on principal site roadways. Back roads, unimproved roads, and shortcuts are not to be used unless specifically authorized in the onsite PSSD, transportation plan, project plan, health and safety plan, or are required by the activity or other improved routes are not available.

The most common routes for transporting hazardous materials, substances, and wastes are as follows:

- 300 Area to 200W Area: Take Route 4S north to Route 3, then west to 200W Area.
- 200E Area to 200W Area: Take Route 3 west to 200W Area.
- 200E Area to 300 Area: Take Route 4S to 300 Area.
- 200W Area to 200E Area: Take Route 3 east to 200E Area.
- 200W Area to 300 Area: Take Route 3 east to Route 4S, then south to 300 Area.
- 100 Areas to 200E Area: As appropriate, take Route 1 or Route 2N to Route 4N, then turn south on Route 4N to Route 3, then turn east into 200E Area.
- 100 Areas to 200W: As appropriate, take Route 1 or Route 2N to Route 4N, then turn south on Route 4N to Route 3, then turn west to 200W Area.
4.0 Organizational Responsibilities

This chapter identifies DOE and contractor responsibilities; as well as interfaces within the Transportation Safety Program as defined in this TSD and specific package development and approval.

4.1 Site Organization Structure

DOE has Sitewide responsibility for onsite T&P activities. DOE implements the Hanford Sitewide T&P Safety Program through the RL Manager-approved (Figure 4-1) TSD where ownership and maintenance are performed by the RL-designated TSD Configuration Manager. The TSD applies to DOE and all Hanford Site Prime Contractors and their major subcontractors who perform hazardous material T&P activities in association with their project or mission.

Figure 4-1. Hanford Site TSD Program

The Hanford Site Intranet website identifies the RL, ORP, and prime contractor structure at the Hanford Site and appropriate senior management contacts. Senior managers or their delegates
provide detailed organizational charts, identify key positions, roles and responsibilities, and lines of authority.

Within this organizational structure, RL is responsible for and recommends approval of the technical content and methodology used to provide adequate levels of control and safety for the onsite shipment of hazardous materials, substances, and wastes. Each Prime Contractor is responsible for complying with the provisions of this TSD.

4.2 RL, ORP, and PNSO Roles and Interfaces

Field Office Managers from RL, ORP, and PNSO are jointly responsible for implementing the Hanford Site hazardous materials T&P Safety Program identified in this TSD. The RL, ORP, and PNSO DOE Field Offices interact with each other and their contractors to accomplish implementation. RL will act as the final approval authority of requests for TSD changes, in coordination with the other DOE Field Offices (i.e., PNSO and ORP). The TSD Configuration Manager will provide all proposed and required changes to RL for inclusion in each annual update of the TSD for concurrence two months prior to the TSD anniversary date. The TSD Configuration Manager will coordinate all TSD changes with the other Site Contractors. The RL Manager will approve all changes to the TSD.

A central TSD Configuration Manager will be designated by RL. A vital function of the TSD is to designate a single set of standards governing all onsite shipments of hazardous materials. This single set of standards reduces costs and enhances safety and operations throughout the Hanford Site.

RL maintains HQ certified packaging analysts who are qualified to review TSD and exemption requests. All new and revised TSDs and requests for exceptions for all three Hanford Site DOE Field Offices will be submitted to RL for technical review prior to approval. The results of these reviews and recommendations for Packaging Safety Documents or exemption requests will be forwarded to the affected DOE Field Office Manager’s nuclear safety organization(s) for review and then approved by the RL Manager.

ORP and PNSO provide RL with an annual review of any safety basis documents (i.e., PSSD and OTRS) identified in the TSD as requiring RL Manager approval. Resolution is coordinated by the contractor who owns the safety basis documents (i.e., PSSD and OTRS).

The RL Manager will review and approve all new and revised PSSDs and OTRSs.

RL, ORP, and PNSO will perform assessments of the respective contractor’s program and T&P Operations to ensure compliance with this TSD and applicable DOE orders (i.e., DOE O 460.1C, DOE O 460.2A, *Departmental Materials Transportation & Packaging Management*, and DOE regulations in 10 CFR 830, “Nuclear Safety Management”).

The RL Manager will approve all exemptions from safety standards or administrative requirements that have the potential to impact worker safety, public safety, or environmental compliance. Requests for exemptions must be submitted in writing to the RL Manager by the requesting contractor. The TSD exemption process is further defined in Chapter 9.0, “Nonroutine Shipments.”
RL, ORP, and PNSO will provide oversight of the implementation of T&P activities and the Packaging Safety Documents.

4.3 Contractor Roles and Interfaces

Each contractor performing T&P activities must have a formal program in place to ensure compliance with the TSD standards that are applicable to the onsite shipment or transfer of hazardous materials, substances, and wastes as defined by applicable regulations.

Each contractor must identify an organization to manage the program and an approval authority to approve packaging systems authorized under the TSD.

Each contractor must complete a compliance or implementation matrix that identifies organizational responsibilities and key personnel.

Each contractor must list manuals, policies, procedures, processes, and systems to implement the TSD requirements and standards, and demonstrate compliance.

Each contractor must develop, test or evaluate, and document all new or modified packaging systems in compliance with the provisions of this TSD and applicable DOE orders.

Each contractor must implement and maintain a formal system for documenting the packaging and payload evaluation process to ensure that all packagings are approved for the payload, that packaging operating and maintenance requirements are met for each shipment, and that package configuration control is maintained within the packaging authorization.

Each contractor is to implement the process for a USQ\textsubscript{T} as defined in Section 6.6.1. All positive USQ\textsubscript{T} Determinations (USQ\textsubscript{TD}) must be submitted to RL for approval prior to implementation with concurrent notification of the TSD Configuration Manager.

Each Contractor must submit an annual USQ\textsubscript{T} Summary to RL and the TSD Configuration Manager.

Each contractor must have a system for performing required updates and maintenance activities on specific PSSDs. The T&P system safety basis for each design must be assessed fully during document updating and maintenance.

Each contractor may implement an RL-approved PSSD or authorized SPA Shipment Evaluation Checklist (SEC) developed by another site contractor after documenting a review and approval of the PSSD or SPA by their T&P approval authority.

Each contractor must submit an annual update/review of all active PSSDs they own to RL. As part of the transmittal of the annual update/review, all USQ\textsubscript{T} performed against the PSSD must be included in the transmittal letter.

Each contractor generating a new Packaging Safety Document (e.g., PSSD) or request for exemption (e.g., OTRS) must obtain RL approval prior to implementation. Changes to an existing Packaging Safety Document (e.g., PSSD) or exemption (e.g., OTRS), depending on the scope and change, may require RL approval.

Each contractor may use another contractor’s transportation system after documented review and approval by their transportation approval authority.
Each contractor must implement and maintain a formal process and implementation procedures for development of SECs within the bounds of the TSD, Appendix H. The written process and procedures shall be sent to RL for review prior to initial shipment of contractor-approved SECs.

Any new or revised SEC shall be provided to RL for review prior to the initial shipment under the checklist. RL’s review of each subsequent shipment under the SEC is not required. A copy of the SEC must be provided to the TSD Configuration Manager for informational purposes.

Each contractor must conduct a triennial assessment of their T&P Safety Program/Operation to ensure compliance with the TSD, applicable regulations, DOE orders, and to identify opportunities to improve program performance. The assessment must be performed by a T&P Subject Matter Expert and approved by the T&P Manager/Lead.

Each contractor may be subject to outside assessment/evaluation performed by the appropriate DOE Site Office or DOE Headquarters.

Each contractor must perform an annual review of the TSD and provide comments and/or recommendations to RL with concurrent notification of the TSD Configuration Manager for consideration in the annual TSD update. This must be transmitted three months prior to the TSD anniversary date.

4.4  TSD Configuration Manager

The responsibilities of the TSD Configuration Manager are outlined below.

- Ensure notifications of potential inadequacies in the safety analyses are appropriately distributed to the contractor T&P points-of-contact.
- Ensure new Packaging Safety Documents and tiedowns are distributed to the contractor T&P points-of-contact.
- Ensure USQrDs are appropriately distributed to the contractor T&P point-of-contact. Maintain configuration control of the TSD.
- Prepare, submit to RL for approval, and implement the TSD annual update.
- Maintain the safety basis current as required by DOE O 460.1C and 10 CFR 830.
- Organize and conduct contractor interface meetings.
5.0 External Regulations

This chapter identifies the external regulations with requirements applicable to onsite T&P activities. Several regulations are written specifically to address onsite packaging and transfer operations. Additional regulations apply to various activities that make up the overall process of T&P. The additional regulations apply to the materials being handled or the activity being performed. Specific local and supplemental regulations may also apply. These local and supplemental regulations may vary from Hanford Site Prime Contractor to Prime Contractor. Specific requirements may be found in each respective contract.

5.1 Packaging and Transportation, Specific Requirements

The following external requirements specifically identify conditions for the onsite T&P of hazardous materials. Section 5.1.1 describes all hazardous materials transport requirements identified by DOE. Section 5.1.2 describes nuclear safety requirements.

5.1.1 DOE O 460.1C, Packaging and Transportation Safety

DOE O 460.1C is the primary requirement for establishing and maintaining an onsite T&P Safety Program for the safe movement of hazardous materials, hazardous substances and wastes, including radioactive materials and wastes. This order requires that onsite hazardous material shipments comply with DOT Hazardous Materials Regulations, or the Hanford Sitewide-specific RL-approved TSD. The site-specific document must describe the methodology and compliance process used to provide equivalent safety for any deviation from DOT Hazardous Materials Regulations. This document fulfills that requirement.

5.1.2 10 CFR 830, Nuclear Safety Management

For nuclear safety associated with radioactive materials, 10 CFR 830 governs the conduct of DOE Contractors, DOE Personnel, and other persons conducting activities (including providing items and services) that affect, or may affect, the safety of DOE Nuclear Facilities. This includes transportation activities not regulated by DOT. The rule permits treating transportation activities separate from the nuclear facilities and the activities conducted to support. In this case, a separate DSA, as well as plans and programs, must be prepared. The rule also permits integrating the nuclear safety and transportation requirements by integrating activities into Site or facility analyses and plans. The rule specifically identifies two “safe harbor” methods in 10 CFR 830, Appendix A, Subpart B, Table 2 for transportation activities covered by this rule. The safe harbor methods endorse the methods and processes described in DOE O 460.1C and its associated guide, and DOE O 461.1C, Packaging and Transportation for Offsite Shipment of Materials of National Security Interest, and its associated manual. Both methods are identified as acceptable ways to satisfy the requirements for transportation activities covered by the provisions of this rule. This document takes advantage of the safe harbor method provided by DOE O 460.1C and its associated guide.
5.2 **Indirect T&P Requirements**

The following are external safety requirements that may apply to onsite hazardous material T&P activities. Their applicability depends on the following conditions:

- Where the activity is performed
- What type of material is packaged
- How much material is handled
- Is the material considered waste or non-waste
- Physical form/chemical form
- Package used
- Method of transport

5.2.1 **National Regulations**

This section identifies requirements that are known to influence onsite T&P. The organization performing the T&P activity must ensure that applicable requirements are identified and implemented.


49 CFR 100 through 199, “Pipeline and Hazardous Materials Safety Administration, Department of Transportation,” U.S. Department of Transportation, Washington, D.C.

49 CFR 325 through 399, “Federal Motor Carrier Administration, Department of Transportation,” U.S. Department of Transportation, Federal Highway Administration, Washington, D.C.


### 5.2.2 State Regulations


### 5.2.3 Local Regulations


5.3 Potential Indirect T&P Requirements

This section identifies regulatory or activity-driven requirements that are not explicitly directed at transportation activities but result in imposition of requirements on transportation related activities. Their applicability depends on the following conditions:

- Where the activity is performed
- What type of material is packaged
- How much material is handled
- Is material considered waste or non-waste
- Physical form/chemical form
- Package used
- Method of transport

The organization conducting the T&P activity should ensure that applicable requirements are identified and implemented. These requirements are contained in current DOE Orders and Contractor Requirement Documents as applicable by contract and other agreements.

5.4 Standards

5.4.1 Government


NUREG-1608, Categorizing and Transporting Low Specific Activity Materials and Surface Contaminated Objects, Spent Fuel Project Office, U.S. Nuclear Regulatory Commission, Washington, D.C.


NUREG/CR-1815, Recommendations for Protecting Against Failure by Brittle Fracture in Ferritic Steel Shipping Containers up to Four Inches Thick, U.S. Nuclear Regulatory Commission, Washington, D.C.


NUREG/CR-4829, Shipping Container Response to Severe Highway and Railway Accident Conditions, Lawrence Livermore National Laboratory, Livermore, California.


NUREG/CR-6407, Classification of Transportation Packaging and Dry Spent Fuel Storage System Components According to Importance to Safety, U.S. Nuclear Regulatory Commission, Washington, D.C.


Regulatory Guide 7.11, Fracture Toughness Criteria of Base Material for Ferritic Steel Shipping Cask Containment Vessels with a Maximum Wall Thickness of 4 Inches (0.1 m), U.S. Nuclear Regulatory Commission, Washington, D.C.

Regulatory Guide 7.12, Fracture Toughness Criteria of Base Material for Ferritic Steel Shipping Cask Containment Vessels with a Wall Thickness Greater than 4 Inches (0.1 m) But Not Exceeding 12 Inches (0.3 m), U.S. Nuclear Regulatory Commission, Washington, D.C.

5.4.2 Industry


6.0 Site Specific Standards, Procedures, and Instructions

This chapter provides standards, requirements, programs, and processes that are needed to support safe T&P operations such as integrated safety management, QA, configuration management, and equivalent safety. Alternate design and performance requirements for onsite packagings are identified.

6.1 Operating Requirements

Specific standards and procedures are to be followed when conducting onsite shipments at the Hanford Site. The initial discussion is an overview of how the TSD achieves equivalent safety. In addition, the initial discussion provides an overview of requirements to be implemented. This is followed by identifying specific standards, procedures, and operating instructions that are to be implemented by operating procedures when conducting onsite T&P activities.

6.1.1 Bases for Equivalent Safety

The TSD identifies three categories of packages, all of which achieve “equivalent safety,” as required by DOE O 460.1C for onsite shipments, and are discussed in the following sections. This includes two categories that specifically meet the intent of 49 CFR 173 and 10 CFR 71 as discussed in Sections 6.1.1.1 and 6.1.1.2. The third category of packages (Section 6.1.1.3) used for onsite shipments relies on a risk based approach to demonstrate an equivalent level of safety for the public and an acceptable level of safety for onsite workers.

6.1.1.1 DOT Compliance

In general, T&P safety is achieved onsite by implementing the DOT regulations. All portions of the regulations, other than those identifying the workings and administration of the DOT (e.g., enforcement), will be implemented. Equivalent administrative activities, including approval of exemptions, will be conducted by RL. This is the preferred technique for achieving onsite safety when conducting onsite T&P activities.

In addition, compliant packagings such as NRC, DOE, DOD, or DOT can be utilized for onsite shipments of radioactive materials provided they are used in accordance with the individual package CoC requirements.

6.1.1.2 DOT-Equivalent Packaging

For radioactive materials, where full compliance with DOT regulations cannot be achieved, an equivalent method for achieving the accepted national level of safety is authorized by DOE O 460.1C. DOT-equivalent packaging provides equivalent safety to DOT regulations as modified for Hanford specific site conditions. These requirements are mandated in the Hanford Packaging Standards (HPS) and are discussed in Appendix B. For these radioactive hazardous materials, equivalent safety is achieved by implementing all portions of the regulations as modified by HPS, except for regulations identifying the following:

- Workings and administration of DOT
- How to obtain exemptions
Communication requirements associated with shipping radioactive materials

Equivalent administrative activities, including approval of exemptions or special authorizations, will be conducted by the RL Manager. Performance requirements for onsite DOT equivalent packages are identified in Section 6.5.2. These requirements are developed to result in a package providing physical performance under Hanford Site conditions equivalent to an offsite package subject to regulatory-established test conditions. Examples of Hanford Site-specific conditions that are different than DOT and NRC regulatory conditions are environmental conditions (Hanford Site-specific temperature extremes), application of artificial cooling after a 30-minute fire (assumes Hanford Site Fire Department response), allowance for fissile and Type B container venting during transport (not permitted by NRC), and specific free-drop characteristics (models the CWC storage pad). Specific details and justifications for Hanford Site-specific variances from the DOT and NRC regulatory conditions are provided in Appendix B.

When full compliance with DOT cannot be achieved because of technical or economic conditions, meeting Hanford Site-specific conditions and performance requirements is the preferred technique for achieving safety equivalent to the DOT regulations.

6.1.1.3 Risk Based Packaging

When full compliance with DOT regulations or compliance with DOT-equivalent packaging for radioactive materials cannot be achieved because of technical or economic conditions, a risk based method for demonstrating an acceptable “equivalent” level of safety will be implemented.

The requirements and method employed for risk based packaging to demonstrate equivalent safety to that resulting from following DOT regulations when shipping on site is detailed in Section 6.5.3. Requirements for risk based packages are established to result in a package, under Hanford Site conditions, providing radiological and toxicological risk equivalent to an offsite package subjected to regulatory-established tests and conditions. Specific bounding accident scenarios are evaluated to demonstrate risk based packaging is equivalent to the accepted national level of safety for DOT-compliant packaging.

For risk based packages, administrative activities, including the approval of exemptions, will be conducted by the RL Manager. Risk based packages are not generally used for transportation of nonradioactive hazardous materials.

6.2 QA Program

RL, PNSO, ORP, and contractors must implement a Quality Assurance Program (QAP). The QAP for contractors must meet contract requirements, at a minimum. Where no contract requirement exists use the applicable requirements from 10 CFR 830, Subpart A. In addition, for design, fabrication, procurement, use, or maintenance of onsite fissile and Type B packagings, the onsite packaging requirements require implementing 10 CFR 71 Subpart H, or American Society of Mechanical Engineers (ASME) Nuclear Quality Assurance (NQA-1), or demonstrated equivalent. DOE O 414.1D, Quality Assurance, identifies ASME NQA-1 2008 with NQA-1a-2009 addenda, Quality Assurance Requirements for Nuclear Facility Applications, as a currently acceptable standard.

Decisions relative to quality are made at appropriate organizational levels in accordance with 10 CFR 830.122(a)(1). Assigned tasks are performed in accordance with controlling plans and
procedures. Quality Levels for tasks are determined and documented in these plans and procedures. The extent of the QA plan application given to an activity is controlled by the Quality Level assigned and its QA requirements. Requirements of the QA plan are imposed on other organizations by direct reference in plans and procedures.

Project personnel assigned to perform quality functions are provided documented indoctrination and training in accordance with established procedures and other applicable documents, as required by management, to perform their required task(s). Quality Control (QC) Inspectors possess specific inspection certifications relating to the specific inspection discipline. Indoctrination and training ensure that all personnel have an adequate knowledge of the purpose, scope, and implementation of the QAP implementing procedures.

6.2.1 Package Design Control

Classification of components into the quality categories for design control is in accordance with DOE-approved QAP and ensures that critical parameters of a given component are reviewed in a manner consistent with their importance. The design and analysis shall correspond to the QA requirements of the assigned Quality Level. The category defines the significance to safety of each component of a packaging system.

The Quality Level shall be in accordance with DOE-approved contractors QAP.

6.2.1.1 Design Inputs

Design inputs for the packagings are taken from payload description(s), selecting the appropriate category of packaging (DOT compliance, DOT-equivalent, or risk based) and the component drawings as presented in the shipping authorization. Any changes to these criteria and/or drawings shall be identified, documented, approved, and controlled in the same manner in which the criteria and/or drawings were originally released. For those components designed by offsite fabricators, a design review shall be conducted to ensure the submitted design meets the requirements of the shipping authorization.

6.2.1.2 Design Process

Cognizant personnel shall ensure any design and/or criteria modifications to the packagings meet the design requirements of the governing design specification.

The packaging designer prescribes and documents the design activities to the level of detail necessary to permit verification that the design meets the design input requirements. This would include identification of the strategies to be followed for developing and documenting the design and demonstrating performance by design analysis and testing.

6.2.1.3 Design Verification

Design adequacy of the packagings will be documented by their respective Packaging Safety Document.

In the event of design changes to the packagings, the cognizant engineering organization shall conduct design verification in accordance with 10 CFR 831.122(f)(4-5). Any changes to the design of the packagings will require review and, if necessary, revision of their respective authorization.
Design verification (e.g., design review) is performed before the design is approved by the shipper/offeror and released for fabrication and performed when the designer has completed all the activities needed to demonstrate that the chosen design meets all the technical and regulatory requirements. The extent of the design verification is a function of the importance to safety, the complexity of the design, the degree of standardization, and the similarity with previously proved designs. Design drawings show the methods of construction (machining, welding and weld details, bolting, glue, etc.); materials (steel, plastic, fiberboard, etc.); and components.

6.2.1.4 Documentation and Records

Design documentation and records will include:

- original design input
- final design documents such as drawings, specifications, and revisions
- documentation that identifies important steps in the design process, including sources of design inputs that support the final design

The required testing documentation will show how the testing was performed and document how the results comply with regulatory requirements, and where appropriate, facility performance requirements.

Design documentation and records providing evidence the design verification processes were performed in accordance with the requirements of the shipping authorization shall be collected, stored, and maintained as a lifetime record in accordance with the classifying criteria in 10 CFR 830.122 (d)(2).

6.2.2 Procurement Document Control

The standard purchase requisition (PR) contains both the technical and QA/QC requirements. Specifications shall be written for complicated or critical component procurement items. The PR information is converted to a purchase order (PO) by the Purchasing organization. The cognizant QA Engineer or QA Manager reviews and approves all PRs and specifications per 10 CFR 830.122 (g).

Changes to the PR, or subsequent PO, are subject to the same review and approval requirements as the original PR. QA and QC requirements are imposed by contractor specifications, engineering drawings, or other QA documents. (Note: Each contractor must operate in accordance with their DOE-approved QAP).

6.2.3 Instructions, Procedures, and Drawings

Activities important to safety are prescribed by documented instructions, procedures, or drawings of a type appropriate to the circumstances. They include quantitative and/or qualitative acceptance criteria for determination that the prescribed activities have been satisfactorily performed. The activities are accomplished in accordance with the instructions, procedures, and drawings. All work processes are performed in accordance with Hanford implementing procedures.
6.2.4 Document Control

The document control system embodies the following features:

- Documents will be prepared, reviewed for adequacy and completeness, have corrections approved, and be released for issuance in accordance with written procedures.
- Document changes are controlled in the same manner as the original issue.
- Interfacing documents are properly coordinated and controlled.
- A reference system is in use that provides access to the current issues of project documents.
- The cognizant engineer is responsible for ensuring accessibility to the latest issue of all such documents. Use or maintenance of the casks or trailers shall not start until all required documents are readily available.
- Documents will be controlled per the requirements of 10 CFR 830.122 (d).

6.2.5 Control of Purchased Items and Services

The procurement of items and services for the packagings shall be documented and controlled to ensure conformance to specified requirements of 10 CFR 830.122(g).

6.2.6 Identification and Control of Items

Purchased items shall be identified at the initial receipt and control maintained through installation and use. The identification of items fabricated or assembled onsite shall be established at the earliest practical time in the fabrication or assembly sequence.

The identification of items shall relate each to an applicable design or other pertinent specifying document, such as the governing PO, specification, test plan, procedure, or drawing(s).

Physical identification markings, such as stamping and etching, shall be used to the maximum extent possible on the packagings to ensure that the markings remain durable as long as possible.

Where required, items and material having limited calendar or operating lives or cycles are identified and controlled to preclude use of items with expired shelf life or insufficient operating life.

Provisions shall be made for the preservation of identification marking consistent with the planned use of the packagings. Such provisions shall include criteria for the maintenance and replacement of damaged markings.

Items shall be marked/tagged/segregated to ensure conformance to the specified requirements of 10 CFR 830.122 (c).

6.2.7 Control of Special Processes

Processes affecting the safety basis or quality of the packagings shall be controlled by instructions, procedures, drawings, checklists, or other appropriate means. These means shall
ensure that process parameters are controlled within defined limits and that specified controls will be applied as defined in the contractor’s QAP.

Special processes performed onsite and by suppliers that control or verify quality, such as those used in welding, heat treating, and nondestructive examination of containment boundary items, shall be performed by qualified personnel using applicable approved procedures.

Records shall be maintained in accordance with 10 CFR 830.122 (d) for currently qualified personnel, processes, and equipment for each special process (if a procured item) or by the shop performing the process.

6.2.8 Control of Inspection and Testing

In process and final inspections shall be performed and documented in accordance with 10 CFR 830.122 (h). Inspection for acceptance shall be performed by certified QC inspectors trained in accordance with 10 CFR 830.122 (h).

6.2.8.1 Fabrication Inspection/Testing

Fabrication inspections for the packagings include the following, performed in accordance with the requirements of the shipping authorization:

- Welding and nondestructive examination personnel qualifications
- Material certifications/marking
- Nondestructive examination
- Proper assembly of the packaging
- Proper torqueing of bolts
- Welding certification records
- Testing of the assembly

Fabrication records include, as a minimum:

- Design requirements
- All material and component certifications
- Operating procedures
- Inspections, including but not limited to receipt, in-process, and final inspections
- Rejects
- Reworks
- Changes
- Non-compliances
- Worker qualifications
6.2.8.2 Receipt Inspection

The existing packagings are inspected by QA/QC personnel in accordance with the inspection planning requirements identified in the packaging authorization.

6.2.9 Test Control

Any tests required to verify conformance of packagings and their components to the requirements of the Packaging Safety Document and to demonstrate satisfactory performance for service shall be planned, performed, and documented. Characteristics to be tested and test methods to be employed shall be specified. Test results shall be documented and their conformance with acceptance criteria shall be evaluated following the requirements of 10 CFR 830.122 (h). Logbooks for test control activities shall be maintained and controlled in accordance with individual contractor’s QAP.

6.2.9.1 Test Requirements

Test requirements and acceptance criteria for the packagings are identified, documented, and approved within the packaging authorization. These test requirements and acceptance criteria for the packagings are developed per 10 CFR 830.122(h). Required procedures for design analysis tests, fabrication tests, operations tests, and maintenance tests shall be controlled.

Testing requirements and acceptance criteria of other radioactive packaging such as Type A and IP can be accomplished by conducting required tests specified in 49 CFR 173, Subpart I or evaluated against these tests by any of the methods authorized in 49 CFR 173.461(a).

6.2.9.2 Test Results

For Type B Packagings, the packaging’s test results are contained in SAR or SARP, issued by NRC, National Nuclear Security Administration or DOE.

For testing of Type B packaging, test results shall be documented and evaluated by the engineering group performing the test. To ensure test requirements have been satisfied and appropriate QA/QC acceptance was obtained independent review of the test results is required.

Testing and associated results of DOT-equivalent packagings, Type A and Type IP packagings can be performed by the packaging’s designer/fabricator.

The test results shall be reviewed by the site contractor who procures the packagings and shall be made available to the shipping organization that uses the packagings.

6.2.9.3 Test Records

Test records shall be written and maintained as records following the requirements of 10 CFR 830.122 (d).

6.2.10 Control of Measuring and Test Equipment

The requirements for control of measuring and test equipment apply to the tools used for testing. Accuracy standards recall system and calibration shall meet the requirements for 10 CFR 830.122 (e)(4).
6.2.11 Handling, Storage, and Shipping Control

The packagings will be prepared and transported as follows:

- The packaging shall be prepared in accordance with approved procedures/instructions prior to being transported from the vendor to the contractor.
- Packaging shall be handled in accordance with vendor’s handling instructions, if applicable.
- Packaging shall be stored in accordance with vendor’s instructions.

6.2.12 Inspection, Test and Operating Status

In process and final inspections shall be performed in accordance with the requirements of 10 CFR 830.122 (h). Inspection for acceptance shall be performed by a certified QC Inspector(s).

Acceptance of an item shall be documented and approved by authorized facility QA/QC personnel per 10 CFR 830.122 (h). Inspection documentation shall be maintained for the life of the packagings.

The maintenance procedures establish, as appropriate, criteria for maintenance tests to be conducted by the user to ensure the packagings maintain containment and is free of excessive contamination. The maintenance procedures also establish qualification criteria for responsible personnel who document and evaluate test results.

6.2.13 Control of Nonconforming Items

All items procured or fabricated for or in use with the packagings shall be inspected prior to use for compliance with the governing PO, specification, or fabrication drawing. The cognizant engineer, with QA assistance, shall define the acceptance and nonconformance criteria.

6.2.13.1 Identification

Identification of nonconforming items shall be identified by marking, or tagging or other suitable methods that do not adversely affect the end use of the item.

6.2.13.2 Evaluation and Disposition

Nonconforming characteristics shall be reviewed, and recommended dispositions of nonconforming items shall be proposed and approved by qualified personnel.

6.2.14 Corrective Action

Nonconformances or conditions adverse to quality are evaluated and the need for corrective action is determined. For Quality Category C items, cognizant engineers are responsible for implementing and monitoring the effectiveness of any corrective action taken. For Quality Category A and B items, appropriate action shall be taken by QA to ensure prompt implementation by follow-up reviews and submission of a report to the upper management level(s) documenting the noncompliance, its causes, and the corrective action taken. See Table 7-1.
6.2.15 Records

Records that furnish documentary evidence of quality shall be specified, prepared, and maintained per 10 CFR 830.122(d). All records used to perform and/or verify quality related activities shall be controlled. Controlled documents include (but are not limited to) the following:

• Drawings
• Specifications
• POs
• Inspection and test plans and procedures
• Reports
• Verification data
• Nonconformance reports
• Corrective action reports
• Operational and maintenance procedures

6.2.16 Organization

The organizational structure and the assignment of responsibility shall be such that quality is achieved and maintained by those who have been assigned responsibility for performing work [10 CFR 830.122(a)]. Quality achievement is to be verified by persons or organizations not directly responsible for performing the work. This organizational structure will be identified in the contractor-specific QAP [10 CFR 830.122(a)].

6.3 Integrated Safety Management System

RL, PNSO, ORP, and each Hanford Site contractor must implement a comprehensive Integrated Environment, Safety and Health Management System (ISMS) Plan and assess onsite T&P activities against ISMS requirements.

The ISMS Plan must establish a safety and environmental management system that integrates environment, safety and health (ES&H) requirements into the work planning and execution processes to effectively protect workers, the public, and environment.

The ISMS must incorporate best practices of the following policies, standards, and initiatives:

• RL/PNSO/ORP ES&H Policy
  - DOE’s Integrated Safety Management Policy (DOE P 450.4A)
  - DOE’s Line Environment, Safety and Health Oversight (DOE P 450.5, ARCHIVED)
  - DOE’s Secretarial Policy Statement Environment, Safety and Health (DOE P 450.6, ARCHIVED)
− International Standards Organization (ISO) 14001, Environmental Management System.

The contractor ISMS Plan must be approved by the appropriate RL, PNSO, or ORP Division.

6.4 Configuration Management Process

6.4.1 Package System Authorization

Approval of the TSD by the RL Manager establishes this document as the Hanford Site TSD and describes the methodology for equivalent safety to 49 CFR 171-180 as required by DOE O 460.1C. This TSD applies to all contractors who have the TSD in their contract. This TSD includes the PSSDs, SPAs, or other Packaging Safety Documents identified in Appendix A and H, respectively, as an explicit part of the safety basis for shipments. The Packaging Safety Documents demonstrate how the criteria of the TSD are met. Contractors may make physical and procedural changes and conduct tests and experiments without prior RL approval, provided changes do not explicitly or implicitly affect the safety basis identified in this TSD (including requirements in the TSD, PSSD or other Packaging Safety Documents, whichever are more restrictive), as documented via the USQT Process.

6.4.1.1 Approval of Activities and Packagings Bounded by TSD Approval

Changes to this TSD not bounded by the supporting safety evaluation and existing supporting PSSDs or other Packaging Safety Documents must be approved by the RL Manager. Changes to PSSDs, SPAs, and other Packaging Safety Documents bounded by the supporting safety evaluation and existing supporting package safety analysis documentation are approved by the contractor responsible for the T&P activity. The USQT Process identified in Section 6.6.1 must be used to evaluate which changes or activities must be approved by the RL Manager. All new SECs must be sent to RL for review prior to the initial shipment under the SEC. A copy of the SEC must be provided to the TSD Configuration Manager for informational purposes. All new PSSDs and OTRSs must be approved by the RL Manager.

6.5 Onsite T & P Safety Requirements

6.5.1 DOT Compliance

For all nonradioactive (unless otherwise allowed in Chapter 8.0) and most radioactive hazardous materials, equivalent safety is achieved onsite by implementing DOT regulations. All portions of the regulations, other than those identifying the workings of the DOT, will be implemented. Equivalent administrative activities including approval of exemptions will be conducted by RL, PNSO, and ORP. Table 6-1 identifies methods of implementation to the subpart level of the regulations found in 49 CFR 100 through 185. Table 6-2 identifies methods of implementation to the subpart level of the regulations found in 49 CFR 350 through 399 – “Federal Motor Carrier Safety Administration.” The tables differentiate which regulations are DOT administrative or other activities not applicable to onsite shipments, which regulations are written such that onsite implementation (compliance) without modification can be achieved, and which regulations are implemented onsite by emulation of the requirements. Emulation is required where regulations require an action on the part of DOT that is not applicable to onsite
T&P activities. For example, DOT approval of an exemption to regulatory requirements for onsite shipments is not applicable. DOE emulation of DOT approval is used to modify requirements to meet site conditions. Note: If the shipment is intended to be a DOT compliant shipment utilizing a DOT special permit, all conditions of the DOT special permit must be satisfied.

### Table 6-1. 49 CFR Regulations - Transportation

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### Table 6-2. 49 CFR Regulations – Federal Motor Carrier Safety Regulations

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### Table 6-2. 49 CFR Regulations – Federal Motor Carrier Safety Regulations

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<tr>
<th>49 CFR Parts 350 to 399 – Federal Motor Carrier Safety Regulations</th>
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### Table 6-2. 49 CFR Regulations – Federal Motor Carrier Safety Regulations

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Table 6-2. 49 CFR Regulations – Federal Motor Carrier Safety Regulations

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<td>Part 399, Employee Safety and Health Standards</td>
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</table>

Notes:

1Hanford Site Contractors, who are motor carriers using an exemption allowed by DOT, are not required to use electronic logging devices.

2Onsite transportation activities cannot be tested under the DOT regulations (49 CFR 382.113). During onsite transportation activities that are outside of DOT authority, any driver’s substance abuse or alcohol testing that is required shall be conduct under the 10 CFR 707, “Workplace Substance Abuse Programs at DOE Sites.”

6.5.2 DOT-Equivalent (Equivalent Packaging)

For some radioactive materials requiring Type IP-1, Type IP-2, Type IP-3, Type A, fissile or Type B packagings, equivalent safety is achieved onsite by implementing a mixture of DOT regulations and onsite equivalent requirements. Sections 6.5.2.1 through 6.5.2.5.14 identify 49 CFR Transportation chapters, subchapters, parts, and subparts that will be met by compliance with DOT regulations and those where equivalent actions will be used.

6.5.2.1 Identification of DOT Chapters and Parts When Using DOT-Equivalent Packaging

Table 6-1 identifies the subpart levels found in 49 CFR 100 through 185. Table 6-2 identifies the subpart levels found in 49 CFR 350 through 399. The tables identify which DOT regulation administrative activities not applicable to onsite shipments, which regulations where onsite implementation (compliance) without modification can be achieved, and which regulations are implemented onsite by emulating the requirements.

When using alternate onsite packaging requirements, substitutions are made for regulations in Table 6-1 identifying the requirements for the following:

- DOT design and performance requirements for Type IP-2, Type IP-3, Type A, fissile and Type B packagings;
- Communication requirements associated with shipment of radioactive materials.

Alternate requirements are used under the equivalent safety provision of DOE O 460.1C.

6.5.2.2 Identification of Onsite Radioactive Materials Packaging Requirements

When using the alternate onsite packaging requirements, the substitutions identified in Sections 6.5.2.3, 6.5.2.4, 6.5.2.5, and 6.5.3.2 are used in place of the packaging regulations identified in Table 6-1.

6.5.2.3 Design, Construction Requirements, and Performance Tests for Type A, Type AF, Type IP-1, Type IP-2, and Type IP-3 Packagings

Performance tests for DOT-equivalent Type A, Type AF, Type IP-3, and Type IP-2 packagings are the same as those specified in the regulations. For DOT compliant onsite shipments, Type
IP-1 that meets the DOT requirement can be used. The QA requirements are specified in each contractor QAP.

These packagings must meet 49 CFR 173, Subparts A and B except as follows:

- Salvage drums authorized per 49 CFR 173.3(c) cannot be used to transport radioactive material except for incident response.
- Provision of 49 CFR 173.29, Empty Packagings, cannot be used for shipping empty radioactive packagings.

6.5.2.3.1 Tiedown System Requirements

Design of the tiedown system will comply with the requirements of DOT regulations in 49 CFR 393 Subpart I, unless otherwise specified in the Packaging Safety Document.

6.5.2.4 Performance Tests for Type B Equivalent Packagings

In accordance with DOE O 460.1C and supplemental guidance from DOE G 460.1-1, Implementation Guide for Use with DOE O 460.1A Packaging and Transportation Safety, minimum requirements for Type B onsite packaging providing an equivalent degree of safety to that provided by the DOT regulations were developed. The requirements are based on DOT regulatory requirements defined in 10 CFR 71, and NRC interpretations and supplementary guidance. However, the requirements and NRC interpretations and supplementary guidance have been modified for Hanford Site-specific conditions. In addition, Hanford Site institutional, administrative, security, procedural controls, and communication were also considered in modifying the regulatory requirements. Description of and justification for deviations to the regulatory requirements are provided in Appendix B, Justification and Basis for Equivalency to DOT Regulations for Type B and Fissile Packages Transported on the Hanford Site. Demonstration of compliance with the requirements for DOT-equivalent packaging can be by testing, analysis, or a combination of both.

Normal conditions of transport (NCT) and hypothetical accident conditions (HAC) are defined in the regulations. For DOT-equivalent packaging, to eliminate confusion between regulatory requirements and onsite shipment requirements, the terminology is normal conditions (NC) and accident conditions (AC), respectively.

Performance tests for DOT-equivalent packaging are the same as those specified in the regulations, except in some conditions, the alternate Hanford Site-specific conditions are applied. The following are performance tests for NC and AC to demonstrate equivalency to the regulations.

6.5.2.4.1 Normal Conditions

6.5.2.4.1.1 Package Evaluation

Evaluation of each package design must include a determination of the effect on that design of the conditions and tests specified. Separate units may be used for free drop tests, compression tests, and penetration tests. However, the units must be subjected to the water spray test before being subjected to other tests.
6.5.2.4.1.2 Initial Conditions

Initial conditions of the tests and demonstration of compliance shall be based on the ambient temperature preceding and following the tests remaining constant at a Hanford Site temperature extreme value between -33°C (-27°F) and 46°C (115°F). The specified temperature shall be the most unfavorable for the feature under consideration. The initial internal pressure within the containment system must be considered to be MNOP, unless a lower internal pressure consistent with the ambient temperature considered to precede and follow the test is more unfavorable.

6.5.2.4.1.3 Heat

An ambient temperature of 46°C (115°F) in still air and insolation according to that specified in Table 6-4.

**Table 6-3. Insolation Table**

<table>
<thead>
<tr>
<th>Form and location of surface</th>
<th>Total insolation for a 12-hour period (g-cal/cm²)</th>
<th>Total insolation for 12-hour period (BTU/ft²)</th>
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</thead>
<tbody>
<tr>
<td>Flat surface/horizontal transport (base)</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Flat surface/horizontal transport (other surfaces)</td>
<td>647</td>
<td>2,386</td>
</tr>
<tr>
<td>Flat surface/non-horizontal transport</td>
<td>162</td>
<td>597</td>
</tr>
<tr>
<td>Curved surfaces</td>
<td>324</td>
<td>1,193</td>
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</table>

6.5.2.4.1.4 Cold

An ambient temperature of -33°C (-27°F) in still air and shade.

6.5.2.4.1.5 Reduced External Pressure

An external pressure of 60 kPa (8.7 psia).

6.5.2.4.1.6 Increased External Pressure

An external pressure of 140 kPa (20 psia).

6.5.2.4.1.7 Vibration

Vibration normally incident to transport.

6.5.2.4.1.8 Water Spray

A water spray that simulates exposure to rainfall of approximately 5 cm/h (2 in/h) for at least 1 hour.

6.5.2.4.1.9 Free Drop

Between 1.5 and 2.5 hours after the conclusion of the water spray test, a free drop through the distance specified in Table 6-5 onto a reinforced concrete surface, striking the surface in a position that the package is normally transported. The reinforced concrete surface is defined as a
20 cm (8 in.) thick, 20,684 kPa (3,000 psi), concrete pad, two-way reinforced with No. 7 rebar on 30 cm (12 in.) centers.

Table 6-4. Criteria for Free Drop Test (Weight/Distance)

<table>
<thead>
<tr>
<th>Package weight</th>
<th>Free drop distance</th>
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<tbody>
<tr>
<td>Kilograms</td>
<td>Pounds</td>
</tr>
<tr>
<td>5,000 or less</td>
<td>11,000</td>
</tr>
<tr>
<td>5,000 to 10,000</td>
<td>11,000 to 22,000</td>
</tr>
<tr>
<td>10,000 to 15,000</td>
<td>22,000 to 33,000</td>
</tr>
<tr>
<td>More than 15,000</td>
<td>More than 33,000</td>
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6.5.2.4.1.10 Compression

For packages weighing up to 5,000 kg (11,000 lb), the package shall be subjected to a compressive load applied uniformly to the top and bottom of the package in the position in which the package would be normally transported for a period of not less than 24 hours. The compressive load shall be the greater of five times the package weight or 13 kPa (2 psi) multiplied by the vertically projected area of the package.

6.5.2.4.1.11 Penetration

Impact of the hemispherical end of a vertical steel cylinder of 3.2 cm (1.25 in.)-diameter and 6 kg (13 lb)-mass, dropped from a height of 1 m (40 in.) onto the exposed surface of the package that is expected to be most vulnerable to puncture. The long axis of the cylinder must be perpendicular to the package surface.

6.5.2.4.2 Accident Conditions

Evaluations for ACs shall be based on sequential application of the tests specified and in the order indicated to determine their cumulative effect on a package or array of packages. Only in the case of the immersion test (paragraph 6.5.2.4.2.1.5 may an undamaged unit be used for the test or evaluation.

Initial conditions for the tests, except for water immersion, to demonstrate compliance with the DOT-equivalent packaging requirements shall be as follows:

- Ambient temperature before and after the tests must remain constant at a value between Hanford Site temperature extremes of -33°C (-27°F) to 46°C (115°F)
  - Specified temperature shall be the most unfavorable for the feature under consideration
  - Initial internal pressure within the containment system must be considered to be the MNOP, unless a lower internal pressure consistent with the ambient temperature considered to precede and follow the test is more unfavorable.
6.5.2.4.2.1 AC Testing

Tests for AC shall be conducted in the following order on a single specimen:

6.5.2.4.2.1.1 Free Drop

A free drop of 9 m (30 ft) onto a reinforced concrete surface, striking the surface in a position for which maximum damage is expected. The reinforced concrete surface is defined as a 20 cm (8-in.) thick, 20,684 kPa (3,000 psi), concrete pad, two-way reinforced with No. 7 rebar on 30 cm (12 in.) centers.

6.5.2.4.2.1.2 Crush

The specimen is subjected to a dynamic crush test by positioning the test unit onto the concrete surface defined in paragraph 6.5.2.4.2.1.1 with the long axis horizontal to the concrete surface. A 500 kg (1,100 lb) mass consisting of a solid mild steel plate 1 m (40 in.) by 1 m (40 in.) is dropped in a horizontal attitude onto the specimen from a height of 9 m (30 ft). This test is only required when the package has a mass not greater than 500 kg (1,100 lb), an overall density not greater than 1,000 kg/m$^3$ (62.4 lb/ft$^3$) based on external dimensions, and radioactive contents greater than 1,000 $A_2$ not as special form radioactive material.

6.5.2.4.2.1.3 Puncture

A free drop of the specimen through a distance of 1 m (40 in.) in a position for which maximum damage is expected, onto the upper end of a solid, vertical, cylindrical, mild steel bar, welded to a steel plate and mounted onto the concrete surface specified in Section 6.5.2.4.2.1.1. The long axis of the bar must be vertical. The bar must be 15 cm (6 in.) in diameter with the top horizontal, the edges rounded to a radius of not more than 0.6 cm (0.25 in.), and a length as to cause maximum damage to the package. As a minimum, the bar shall be welded to a 2.5 cm (1 in.)-thick by 45.7 cm (18 in.) by 45.7 cm (18 in.)-square plate that is mounted to the concrete surface.

6.5.2.4.2.1.4 Thermal

Exposure of the specimen fully engulfed in a hydrocarbon fuel/air fire of sufficient extent, and in sufficiently quiescent ambient conditions, to provide an average emissivity coefficient of at least 0.9, with an average flame temperature of at least 800°C (1,475°F) for a period of 30 minutes. The fuel source shall extend horizontally at a minimum of 1 m (40 in.), but not more than 3 m (10 ft) beyond the external surface of the specimen. The specimen shall be positioned 1 m (40 in.) above the surface of the fuel source. For purposes of calculation, the external surface absorptivity coefficients shall be nationally accepted published values at fire temperature. Cooling shall be applied after 30 minutes from the start of the fire.

6.5.2.4.2.1.5 Immersion-Fissile Material

For fissile material packages where water inleakage has not been assumed for criticality analysis, the specimen shall be subjected to immersion under a water head of at least 0.9 m (3 ft) in the attitude for which maximum leakage is expected.
6.5.2.4.2.1.6 Immersion-All Packages
This requirement is not required for Hanford onsite movements because there are no bodies of water available along any onsite transportation routes that would cause this submersion depth.

6.5.2.5 Design and Construction Requirements for Type B Equivalent Packagings, Including Fissile
This section defines the Type B packaging design and construction requirements used on the Hanford Site to achieve safety equivalent to that resulting from following the DOT regulations when shipping in commerce. It should be noted, to ensure compliance, the acceptance criteria and evaluation requirements outlined in the following sections should be factored into development of the packaging design and construction.

6.5.2.5.1 General Packaging Requirements
The General Packaging Requirements are listed below:

• The smallest overall dimension of a package may not be less than 10 cm (4 in.).

• If required by Safeguards and Security, the outside of a package must incorporate a tamper-indicating device, that is not readily breakable and that, while intact, would be evidence that the package has not been opened by unauthorized persons.

• Each package must include a containment or confinement system securely closed by a positive fastening device that cannot be opened unintentionally or by a pressure that may arise within the package.

• A package must be made of materials and construction that ensures there will be no significant chemical, galvanic, or other reactions among the packaging components, among package contents, or between the packaging components and the package contents, including possible reactions resulting from inleakage of water, to the maximum credible extent. Account must be taken of the behavior of materials under irradiation.

• A package valve or other device, the failure of which would allow radioactive contents to escape, must be protected against unauthorized operations and, except for a pressure relief device, must be provided with an enclosure to retain any leakage.

• A package must be designed, constructed, and prepared for transport so that under the NC tests specified, there would be no loss or dispersal of radioactive contents, no significant increase in external surface radiation levels, and no substantial reduction in the effectiveness of the packaging.

• A package must be designed, constructed, and prepared for transport so that in still air at 46°C (115°F) and in the shade, no accessible surface of a package would have a temperature exceeding the exclusive-use temperature of 85°C (185°F) or the non-exclusive-use temperature of 50°C (122°F).

• A package may be designed, constructed, and prepared for transport with a filtered venting feature. Filtered venting devices will be provided by a high-efficiency particulate air filter capable of sustaining NC and AC loadings. The filter will have a minimum aerosol efficiency of 99.97 percent for 0.45 μm dioctylphthalate particle diameter. The
minimum hydrogen diffusivity will be 1.90 $\times 10^{-6}$ mole/sec/mole fraction at 25°C (77°F). The minimum airflow rate will be 200 mL/min (12.20 in³/min) at a pressure differential of 1.9 mmHg (1.0 in. H₂O). Filter housing seals will be manufactured from materials that have a minimum shelf life of 5 to 10 years, as specified by military specification MIL-HDBK-695, Rubber Products: Recommended Shelf Life or be equivalent to the filter media. The filter housing seal will be leak tight as defined in American National Standards Institute (ANSI) N14.5.

6.5.2.5.2 Lifting Device Requirements

The Lifting Device Requirements are listed below:

- Any lifting attachment that is a structural part of a package must be designed and tested in accordance with DOE/RL-92-36, Hanford Site Hoisting and Rigging Manual.

- The design of the lifting device will be such that failure of the lifting device or any component under excessive load would not impair the ability of the package to meet other requirements of this section.

- Any structural part of the package that could be used to lift the package must be capable of being rendered inoperable for lifting the package during transport, or must be designed with strength equivalent to that required for the lifting attachments.

6.5.2.5.3 Tiedown Devices

The requirements of tiedown devices are listed below:

- For a system of tiedown devices that is a structural part of the package, the system will be capable of withstanding a static force applied at the center of gravity of the package having a vertical component of 2 times the gross weight of the package, a horizontal component along the direction in which the conveyance travels of 10 times the gross weight of the package, and horizontal component in the transverse direction of 5 times the gross weight of the package. The application of this load will not generate stresses in any material of the package in excess of its yield strength.

- Any other structural part of the package that could be used to tiedown the package must be capable of being rendered inoperable for tying down the package during transport, or must be designed with strength equivalent to that required for tiedown devices.

- Each tiedown device that is a structural part of a package will be designed so that failure of the device under excessive load would not impair the ability of the package to meet other requirements of this section.

6.5.2.5.4 External Radiation Requirements

The External Radiation Requirements are outlined below:

- Each radioactive material package for “nonexclusive” use onsite transport must be designed and prepared for transport such that, under NC, the radiation level does not exceed 2 mSv/h (200 mrem/h) at any point on the external surface of the package, and the TI does not exceed 10.
A package that exceeds the radiation level limits specified in Section 6.5.2.5.4 must be transported onsite by exclusive-use transport only and the radiation levels will not exceed the following limits:

- 2 mSv/h (200 mrem/h) on the external surface of the package unless the following conditions are met, in which case the limit is 10 mSv/h (1,000 mrem/h):
  - The shipment is made in a closed transport vehicle or with application of other mitigating measures to restrict access to the vehicle.
  - The package will be secured to the conveyance so that its position remains fixed during NC.
  - There will be no loading or unloading operations between the beginning and end of the onsite transport.

- At any point on the outer external surface of the conveyance, including top and underside, radiation levels will not exceed 2 mSv/h (200 mrem/h). In the case of a flat-bed style conveyance, the top is defined as the top of the load, the sides are defined as the vertical planes projecting from the outer edges of the conveyance, and the underside is defined as the lower external surface of the conveyance.

- At any point 2 m (6.6 ft) from the outer lateral surfaces of the conveyance (excluding the top and underside of the conveyance), the radiation levels will not exceed 0.1 mSv/h (10 mrem/h). In the case of a flat-bed style vehicle, at any point 2 m (6.6 ft) from the vertical planes projected by the outer edge of the vehicle (excluding the top and underside of the vehicle).

- In any normally occupied space, the radiation level will not exceed 0.02 mSv/h (2 mrem/h), except that this provision does not apply to carriers if they operate under the provisions of a State or federally regulated Radiation Protection Program and if personnel under their control who are in such an occupied space wear radiation dosimetry devices.

Instructions for maintenance, onsite transport controls, and to avoid actions that will unnecessarily delay delivery or result in increased radiation levels or radiation exposure to workers or the general public will be provided in the safety analysis documentation and operating procedures.

6.5.2.5.5 Normal Conditions Subcriticality Assurance Requirements

All radioactive material packages containing fissile material must be designed, constructed, and contents so limited that under NC the following requirements are met to ensure subcriticality:

- The contents will remain subcritical under all normal performance tests conditions. \( K_{\text{eff}} < 0.95 \).
- The geometric form of the package contents would not be substantially altered under all normal performance test conditions.
- There will be no leakage of water into the containment or confinement system unless an evaluation of an undamaged package is performed which assumes that moderation is
present to such an extent as to cause maximum reactivity consistent with the chemical and physical form of the material.

- There will be no substantial reduction in the effectiveness of the packaging defined as follows:
  - No more than a 5 percent reduction in the total effective volume of the packaging on which nuclear safety is assessed.
  - No more than a 5 percent reduction in the effective spacing between the fissile contents and the outer surface of the package.
  - No occurrence of an aperture in the outer surface of the packaging large enough to permit the entry of a 10 cm (4 in.) cube.

6.5.2.5.6 Accident Conditions Subcriticality Assurance Requirements

All radioactive material packages containing fissile material must be designed, constructed, and contents so limited that subcriticality is ensured under the following conditions:

- The fissile material is in the most reactive credible configuration consistent with the damaged condition of the package, and the chemical and physical form of the contents.
- Water moderation occurs to the most reactive credible extent consistent with the damaged condition of the package and the chemical and physical form of the contents.
- There is full reflection by water on all sides, as close as is consistent with the damaged condition.

6.5.2.5.7 Package Array Subcriticality Assurance Requirements

Radioactive material packages that are transported in arrays and contain fissile material must be designed, constructed, and contents so limited that the following requirements are met to ensure subcriticality:

- Fissile material packages must be controlled by the operating procedures to ensure that an array of packages remains subcritical. To establish this control, the designer of the package shall derive a number “N” based on the following conditions and assuming packages are stacked in any arrangement and with close full reflection on all sides of the stack by water.
  - Five times “N” undamaged packages with nothing between the packages shall be subcritical.
  - Two times “N” damaged packages shall be subcritical with optimum interspersed hydrogenous moderation.
  - The value of “N” shall not be less than 0.5.
- The Criticality Safety Index (CSI) must be obtained by dividing the number 50 by the value of “N” derived using the procedure specified above in Section 6.5.2.5.7.2. The value of the CSI may be zero provided that an unlimited number of packages is subcritical such that the value of “N” is effectively equal to infinity under the procedure
specified in Section 6.5.2.5.7.2. Any CSI greater than zero must be rounded up to the first decimal place.

- When a fissile material package is assigned a CSI, the following requirements shall be applied:
  - For a package CSI less than or equal to 50, procedures must be in place to limit the sum of the CSIs to less than or equal to 50 for a non-exclusive-use onsite shipment and to less than or equal to 100 in an exclusive-use onsite shipment.
  - For a package CSI greater than 50, procedures must be in place to limit the sum of the CSIs to less than or equal to 100 and must be shipped in an exclusive-use conveyance.

6.5.2.5.8 Normal Conditions

Under NC, there shall be no loss or dispersal of radioactive material as demonstrated to a sensitivity of \(10^{-6} \text{A}_2\) per hour, no significant increase in external surface radiation levels, and no reduction in the effectiveness of the packaging.

Note: The sensitivity requirement \(10^{-6} \text{A}_2\) per hour is not applicable to Type A fissile.

6.5.2.5.9 Accident Conditions

Under AC, there shall be no release of \(^{85}\text{Kr}\) exceeding 10 \(\text{A}_2\) in 1 week, and no release of other radioactive material exceeding a total 1 \(\text{A}_2\) in 1 week.

In addition, the external radiation dose rate shall not exceed 10 mSv/h (1 rem/h) at 1 m (40 in.) from the external surface of the package.

6.5.2.5.10 Confinement or Containment Boundary Requirements

Confinement, in accordance with 10 CFR 72.3, means those systems and components of a package, including ventilation that act as barriers between areas containing radioactive substances and the environment.

Containment, in accordance with 10 CFR 71.4, means those system and components of the packaging intended to retain radioactive material during transport with a leak testable boundary.

1. As a minimum, the primary containment or confinement boundary will be designed and constructed in accordance with the requirements of ASME boiler and pressure vessel code (BPVC), Section VIII-3-2015. Credit may not be taken for any package meeting ASME BPVC standards unless it is ASME code stamped or has a documented equivalent analysis. Design loadings and load combinations on the containment or confinement boundary will be as specified in Table 6-5.
Table 6-5. Design Loadings and Load Combinations on the Containment or Confinement Boundary

<table>
<thead>
<tr>
<th>Normal or Accident Condition</th>
<th>Applicable Initial Conditions</th>
<th>Normal Conditions</th>
<th>Accident Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Ambient Temperature</td>
<td>Insolation</td>
<td>Decay Heat</td>
</tr>
<tr>
<td></td>
<td>46°C (115°F)</td>
<td>-33°C (-27°F)</td>
<td>Max</td>
</tr>
<tr>
<td>Normal Conditions</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hot Ambient</td>
<td>--</td>
<td>--</td>
<td>X</td>
</tr>
<tr>
<td>Cold Ambient</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Minimum External Pressure</td>
<td>--</td>
<td>X</td>
<td>--</td>
</tr>
<tr>
<td>Vibration and Shock</td>
<td>X</td>
<td>--</td>
<td>X</td>
</tr>
<tr>
<td>Normally incident to</td>
<td>--</td>
<td>X</td>
<td>--</td>
</tr>
<tr>
<td>the mode of transport</td>
<td>--</td>
<td>X</td>
<td>--</td>
</tr>
<tr>
<td>Free Drop</td>
<td>X</td>
<td>--</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>--</td>
<td>X</td>
<td>--</td>
</tr>
<tr>
<td></td>
<td>--</td>
<td>X</td>
<td>--</td>
</tr>
<tr>
<td>Accident Conditions</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Free Drop (9 m [30 ft])</td>
<td>X</td>
<td>--</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>--</td>
<td>X</td>
<td>--</td>
</tr>
<tr>
<td></td>
<td>--</td>
<td>X</td>
<td>--</td>
</tr>
<tr>
<td>Puncture</td>
<td>X</td>
<td>--</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>--</td>
<td>X</td>
<td>--</td>
</tr>
<tr>
<td>Thermal (Fire Accident)</td>
<td>X</td>
<td>--</td>
<td>X</td>
</tr>
</tbody>
</table>

Notes:
¹It should be noted that local structural responses might be greater during an impact test if the weight of the contents is less than maximum. Subsequently, free drop testing should also be conducted at minimum content weights.

2. Cover plates and lids will be recessed or otherwise protected.
3. The containment or confinement boundary will be designed such that vessel, closures, penetration closures, and closure seals are leak testable. In addition, if full, drain or test ports utilize quick-disconnect valves, such valves will not preclude leak testing of their containment seals.
4. For vented packages, the containment or confinement boundary will consist of the containment vessel, closure, closure seals, filter housing, and filter housing seals, all of which must be leak testable.

5. Containment or confinement boundary seals will be specified to be compatible with the packaging and contents, and remain below allowable limits under both NC and AC. In addition, as a minimum, the seals must not degrade under irradiation from the contents for a period of 5 years from the time of loading.

6. As a minimum, containment or confinement boundary seals will have a shelf life of 10 years (MIL-HDBK-695).

7. The materials of construction of seals and ancillary components will be manufactured to nationally or internationally recognized standards, such as ASTM, ANSI, and ISO.

6.5.2.5.11 Lead Shielding Design and Construction Requirements

The Lead Shielding Design and Construction Requirements are as follows:

- The grade and quality of the lead shall be in accordance with ASTM B-29.
- The design will be such that the lead pour is continuous and free of dross.
- Preheating and cooling of shielding cavity walls will be specified to produce a sound shield and to minimize thermal stresses in the container walls.
- Supports for container walls will be provided to ensure concentricity and the required lead thickness, if required.
- Impingement of molten lead on container walls will be minimized.
- Provision will be provided for venting and topping off the lead.
- As a minimum, gamma scanning, probing, or ultrasonic testing will be used to demonstrate soundness of the shielding.

6.5.2.5.12 Pressure Testing Prior To Use

Prior to initial use of the packaging, the containment/confine ment boundary will be pressure tested to 150 percent of its rated MNOP to ensure structural integrity at that pressure.

6.5.2.5.13 Marking

Each onsite Type B package must be marked on the outside “Onsite Type B” “Radioactive Material,” and with the name and address of the packaging manufacturer. Each onsite fissile package must be marked on the outside “Onsite Fissile Type B,” “Radioactive Material,” and with the name and address of the packaging manufacturer.

6.5.2.5.14 Flammable Gas Generation

This section defines the requirements to demonstrate acceptable performance for onsite packaging in which the concentration of flammable gases within the package void volume has the potential to exceed one –half the lower explosive limit (LEL). For hydrogen gas, the LEL is 5 vol%. The requirements of this section do not apply to packages that have no flammable gas generation potential. The acceptable performance requirement is that the package must maintain
containment/confinement, subcriticality, and shielding of the contents under both NC and AC. The acceptable performance criterion for testing and/or analysis to be applied is to demonstrate that the packaging provides an equivalent degree of safety to the regulations. It should be noted that in any onsite Packaging Safety Document, claims of adequacy of designs or design methods must be supported by technical bases; i.e., by an appropriate engineering evaluation or description of actual tests.

6.5.3 Risk Based (Equivalent Radiological and Toxicological Protection)

For some radioactive materials requiring Type IP-1 (include additional requirements), Type IP-2, Type IP-3, Type A, fissile, combination of the previous packagings, Onsite Type B equivalent packagings or Type B packagings, equivalent safety is achieved onsite by implementing a mixture of the DOT and NRC regulations, and equivalent requirements. Sections 6.5.3.1 through 6.5.3.2.3 identify 49 CFR Transportation chapters, subchapters, parts, subparts and sections that will be met by either compliance with DOT regulations or demonstrating equivalent safety to full compliance with DOT regulations. Note: When a Type A, Type IP-1, Type IP-2, Type IP-3 package or combinations of these packagings are used to transport Type B quantities of materials, the performance expectations will be the same as for Type B packages. Credit will not be taken automatically for a Type A or IP as meeting DOT regulations when carrying Type B quantities of radioactive material. Those regulations where equivalent actions will be used to result in radiological and toxicological safety equivalent to that resulting offsite from full compliance with DOT regulations are identified in Section 6.5.3.1.

6.5.3.1 Identification of DOT Chapters and Parts When Using Risk Based Packaging

Table 6-1 identifies to the subpart level the regulations, found in 49 CFR 100 through 185. Table 6-2 identifies to the subpart level the regulations, found in 49 CFR 350 through 399. The tables differentiate which regulations are DOT administrative activities not applicable to onsite shipments (transfers), which regulations are written such that onsite implementation (compliance) without modification can be achieved, and which regulations are implemented onsite by emulating the requirements. The alternate requirements are used under the equivalent safety provision of DOE O 460.1C.

When using the onsite risk based packaging requirements, substitutions are made for the regulations in Tables 6-1 and 6-2 that identify the requirements for communication requirements associated with shipment of radioactive materials.

Before implementing the risk based packaging method, a documented evaluation showing that both DOT and DOT-equivalent packaging compliance are not technically or economically practical must be prepared and retained on file for the life of the package.

6.5.3.2 Identification of Onsite Radioactive Materials Risk Based Packaging Requirements

When using the alternative onsite risk based packaging requirements, the following requirements are substituted in place of the regulations identified in Table 6-1. These requirements may be used for demonstrating equivalent safety for Type IP-1 (see 6.5.2.3) Type IP-2, Type IP-3, Type A, fissile and Type B packagings.
Type A, Type IP-3, or Type IP-2 risk based packagings must meet the minimum requirements listed below. Compliance with the radiation level and thermal requirements may be determined by analysis or field measurement.

Fissile and Type B risk based packagings must meet the minimum requirements listed below.

- Requirements in 49 CFR 173.24, paragraph (b)
- General design requirements in 49 CFR 173.410, unless otherwise stated in the PSSD or other Packaging Safety Document
- Thermal requirements in Section 6.5.2.5.1.7
- External radiation requirements in Section 6.5.2.5.4
- Subcriticality assurance requirements in Sections 6.5.2.5.5 through 6.5.2.5.7
- Flammable gas generation requirements in Section 6.5.2.5.14
- Design of the tiedown system will comply with the requirements of DOT regulations in 49 CFR 393 Subpart I, unless otherwise specified in the PSSD or other Packaging Safety Document.

6.5.3.2.1 Consequence Requirements

When compliance to DOT or onsite equivalent packaging standards cannot be demonstrated, radiological and toxicological safety, and/or acceptable risk analyses may be used to demonstrate an equivalent level of safety. Risk based packaging, by definition, maintains the same level of consequences as acceptable for DOT or onsite equivalent packaging. Therefore, packaging containment performance during conditions normally incident to transport is obtained by implementing the applicable requirements identified in Section 6.5.3.2. These performance requirements consider the specific characteristics, design features and controls of the shipment of onsite risk based packages. Limits are set for exposure and the intake of radionuclides into the body. The intake limits are based on the same amount of intake from AC and NC releases used in evaluating shipments made in commerce.

RL has approved RADIDOSE (03-ABD-0061, Contract No. DE-AC06-96RL13200—Use of RADIDOSE Spreadsheet in Preparing 10 CFR 830 Compliant Documented Safety Analyses [DSA]) for use in nuclear safety evaluations at Hanford. RADIDOSE includes the use of 95-percent overall site meteorology ($\chi/Q$'s) and dose conversion factors (DCF) from ICRP 68, “Dose Coefficients for Intakes of Radionuclides by Workers”; ICRP 71, “Age-dependent Dose to Members of the Public from Intake of Radionuclides: Part 4 Inhalation Dose Coefficients”; and ICRP 72, “Age-dependent Dose to Members of the Public from Intake of Radionuclides: Part 5 Compilation of Ingestion and Inhalation Dose Coefficient”; instead of the 99-percent maximum sector $\chi/Q$'s and DCFs from ICRP 26, “Recommendations of the International Commission on Radiological Protection,” and ICRP 30, “Limits for the Intake of Radionuclides by Workers,” used in Revision 0 of this TSD. The contractor shall use standard DOE methodologies and guidance for the most conservative facilities in each site area involved in the shipment for determining the accident parameters for analysis of risk based shipments in the Hanford areas described in this TSD.
Standard DOE methodologies/guidance and RADIDOSE γ/Q’ values are used for the evaluation of consequences for comparison with risk levels that are representative of those accepted by DOE in the example shown in Appendix E. The damage ratios (DR), airborne release fractions (ARF), and respirable fractions (RF) are from corresponding TSD-prescribed accidents.

The dose consequence levels (bins) and risk classes are summarized in the example shown in Appendix E, which shows the results of accidents analyzed in accordance with this methodology. The revised tables in the example were developed using standard DOE methodologies and guidance to determine shipment inventory limits based on maintaining frequencies and dose consequences to the MOI at the values previously approved by RL in the TSD Rev. 0-A SER. The values are representative of the RL-approved risks associated with onsite transportation activities, under the specific conditions analyzed for risk based packages.

Consequence level guidelines are shown in Tables 6-6 and risk class bins in Table 6-7. The consequence bins are incorporated into Table 6-7 to assist in identifying the most significant risk to designated receptors.

### Table 6-6. Safety Basis Criteria Consequence Levels (Bins)

<table>
<thead>
<tr>
<th>Consequence</th>
<th>Public</th>
<th>Worker at 100 m</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>&gt;25 rem TEDE or &gt;ERPG-2/TEEL-2</td>
<td>&gt;100 rem TEDE or &gt;ERPG-3/TEEL-3 at facility boundary or prompt death to facility worker</td>
</tr>
<tr>
<td>Moderate</td>
<td>&gt;1 rem TEDE or &gt;ERPG-1/TEEL-1</td>
<td>&gt;25 rem TEDE or &gt;ERPG-2/TEEL-2 at facility boundary, or serious injury to facility worker, or significant radiological or chemical exposure to facility workers</td>
</tr>
<tr>
<td>Low</td>
<td>&lt;moderate consequences</td>
<td>&lt;moderate</td>
</tr>
</tbody>
</table>

Notes:
- ERPG = emergency response planning guideline.
- TEDE = total effective dose equivalent.
- TEEL = Temporary Emergency Exposure Limit.

### Table 6-7. Risk Classes—Frequency Versus Consequences

<table>
<thead>
<tr>
<th>Consequence</th>
<th>Frequency Bin</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Beyond extremely unlikely (below 10⁻⁶/yr)</td>
</tr>
<tr>
<td>High</td>
<td>Risk Class III</td>
</tr>
<tr>
<td>Moderate</td>
<td>Risk Class IV</td>
</tr>
<tr>
<td>Low</td>
<td>Risk Class IV</td>
</tr>
</tbody>
</table>

In addition to the evaluation guideline in DOE-STD-3009-94, the risk based accident analyses are compared to the example shown in Appendix E to identify the level of risk associated with risk based transportation activities and to ensure sufficient controls are incorporated to maintain risk within RL expectations.
The following conditions apply when preparing a consequence evaluation to demonstrate equivalent radiological and toxicological safety. No specific numerical limits are identified for what is considered an acceptable level of risk.

1. The consequence analysis shall quantitatively evaluate collision, fire, and hydrogen deflagration accidents. The initiators of these accidents shall be no more severe than the accident test conditions for certified Type B packages described in 10 CFR 71.73, “Hypothetical Accident Conditions,” and, in accordance with DOE-STD-3009-94, Appendix A, provide a realistic evaluation of the postulated conditions that could be encountered onsite.

2. The immediate worker is defined as any individual within a 100 m (328 ft) radius of the accident that receives an uncontrolled dose as a result of the accident.

3. The co-located worker is defined as the maximally-exposed individual within the Hanford Site boundary and at or beyond a 100 m (328 ft) radius of the accident.

4. The offsite receptor is defined as the maximally-exposed member of the public at or beyond the Hanford Site boundary for an exposure duration of not less than 2 hours.

5. The evaluation shall account for the physical and chemical form of the waste material that leaks from the damaged package during the AC through the use of appropriate airborne release fractions and respirable fractions taken from DOE-HDBK-3010-94.

6. The consequence analysis may include the mitigating effect of the damaged package after the AC through the use of DR or leak path factors (LPF), provided that a structural analysis supports the mitigating effect. These factors shall be clearly identified where the results are reported. If these factors are used, then the dose consequences, with and without these mitigating factors, shall be reported.

7. The consequence analysis shall determine the dose to the MOI. Furthermore, the consequence analysis shall determine the dose to the co-located worker (onsite, 100 m [328 ft]) for the applicable scenario. The calculated frequencies and consequences will be utilized to determine the risk classification bins as defined in Tables 6-7 and 6-8.

8. Criticality requirements for risk based packaging are those identified for equivalent packaging given in Sections 6.5.2.5.5, 6.5.2.5.6, and 6.5.2.5.7 (if the fissile material does not meet 10 CFR 71.15).

The three accident scenarios that could lead to package failure and release of radioactive materials that must be quantified are as follows:

- Collision
- Collision followed by fire
- Hydrogen deflagration

**Note:** A criticality accident shall be demonstrated to be not credible under all postulated NC and AC.

An important element of the risk based approval process is providing justification for the package failure thresholds that are used to determine the conditional probabilities of
encountering ACs that are more severe. The failure thresholds will be determined in the structural and thermal analysis sections of the application for approval of a risk based package. References to the appropriate sections of the application where the failure thresholds are determined should be provided. For cases in which failure thresholds are not or cannot be determined, an appropriate conservative assumption must be provided and justified. In this case, analogy to a similar package design could provide a reasonable technical basis for the failure thresholds. The application should include references to an evaluation of a similar package design in which failure thresholds are determined, a discussion of the differences that exist between the packages, and defensible yet conservative failure thresholds. For all package applications, ensure that any controls taken to reduce the frequencies of the accident scenarios are appropriately addressed.

Because the specific accident environments encountered will lead to different release characteristics, the accident scenario frequencies must be correlated with the consequences of each specific accident scenario. For example, a package exposed to collision-only ACs may have different release characteristics than a package exposed to a collision and fire environment. The applicant must ensure that the consequences calculated using the methodology described in Section 7.3.2.2.1 correspond to the ACs for which quantitative accident frequency information has been developed.

### 6.5.3.2.2 Risk

For a specific package, the consequence and frequency data are combined, to identify the risk associated with the transportation. For generic Type A drums or boxes, the example in Appendix E show the bounding consequences and frequencies of release. The tables identify essential data used in the evaluations conducted for the identified packages. The evaluation must consist of the following: an evaluation report based on the applicable equivalent package requirements of Section 6.5.2.2 containing the applicable information and formatted as identified in Section 7.3.1. This report should document the package's performance; showing both the requirements met and those failed. Where the package does not meet an applicable requirement, discuss the performance provided. To this basic report, add a risk based evaluation following the methodology identified in Section 7.3.2. The accident frequency and consequence evaluations are grouped into risk classification bins. These bins are an essential element in the risk assessment methodology. Tables 6-7 and 6-8 are to be utilized to determine package-specific risk classification bins for all applicable accident scenarios.

As part of this TSD, the example shown in Appendix E has defined the risk classification bins representative of those that DOE has accepted for transportation-specific accident scenarios. It needs to be emphasized that these risk classification bins are only applicable to packages that meet the minimum requirements for a risk based package as defined in Section 6.5.3.2. Additionally, the transportation-specific hazards assessment was able to reduce the accident scenario accidents to three bounding accidents: collision, fire, and hydrogen deflagration. In the event that any other accident scenarios are determined not to be bounded by these three, their risk classification must also be determined. The risk classification will be utilized to determine if any changes to a risk based package listed in Appendix A are bounded by the previously accepted risks. Each individual administrative control will qualify for a maximum of half a bin reduction in accident frequency. The maximum allowable bin reduction in accident frequency for all preventative and mitigative administrative control is one bin.
The risk assessment methodology outlined in Section 7.3.2, shall be utilized to evaluate each risk based package. Additionally, this evaluation is to be documented in the Packaging Safety Documents for the evaluated packaging system.

6.5.3.2.3 Flammable Gases

Flammable gases allowed in a package are generally limited to less than the LEL. For Hydrogen, a limit of 5 percent during the shipping window is established. When properly documented and controlled, higher concentrations may be acceptable as shown in Appendix E. Projected flammable gas concentrations are to be developed using acceptable methods, such as RADCALC, or equivalent, and documented in the PSSD or other Packaging Safety Document.

6.6 Additional Safety Requirements

Onsite T&P activities, not performed in accordance with DOT/NRC regulations, are subject to the requirements identified in 10 CFR 830 (see Section 4.0). Implementation of the QA requirements identified in 10 CFR 71, Subpart H, as applied to fissile and Type B packages. Requirements of 10 CFR 71, and DOE Order 460.1C, for performance of work, safety basis, and RL approval are addressed by the TSD as a whole. The following sections describe how the requirements for an USQ_T process and for safety basis requirements are implemented.

6.6.1 Unreviewed Safety Question for Transportation Process

Each Hanford Site contractor engaged in onsite shipment of radioactive and hazardous material, which is not performed in accordance with DOT/NRC regulations, must implement the USQ_T process defined in this section. The TSD Configuration Manager will administer this USQ_T process.

6.6.1.1 Unreviewed Safety Question for Transportation Requirements

- Each Hanford Site contractor responsible for a T&P activity that involves onsite shipment of greater than 1 A_2 quantity of radioactive material, unless the radioactive material shipped as LSA/SCO, on the Hanford Site must establish, implement, and take actions consistent with a USQ_T process that meets the requirements of 10 CFR 830.203, and this TSD. Each contractor must submit a procedure for its USQ_T process to RL for approval.

- Each contractor responsible for a T&P activity that involves greater than 1 A_2 of radioactive material, unless the radioactive material shipped as LSA/SCO, and will be shipped onsite, must determine whether a USQ_T exists in situations where there is a:
  - Temporary or permanent change in the T&P activity as described in the existing safety basis;
  - Temporary or permanent change in the procedures as described in the existing safety basis;
  - Test or experiment not described in the existing safety basis, or any new transportation activity not already approved by RL; or
  - Potential inadequacy in the safety basis because the analysis potentially may not be bounding or may be otherwise inadequate.
• Each contractor responsible for a T&P activity that involves greater than 1 A${}_2$ quantity of radioactive material, unless the radioactive material shipped as LSA/SCO, to be shipped onsite must obtain RL Manager approval prior to taking any action determined to involve a positive USQ$_T$.

• Each contractor responsible for a T&P activity that involves greater than 1 A${}_2$ quantity of radioactive material, unless the radioactive material shipped as LSA/SCO, to be shipped onsite, must annually submit to RL and the TSD Configuration Manager a summary of each USQ$_T$D performed since the prior submittal.

• If a contractor responsible for a T&P activity that involves greater than 1 A${}_2$ quantity of radioactive material, unless the radioactive material shipped as LSA/SCO, to be shipped onsite, discovers or is made aware of a potential inadequacy of the safety basis, it must:
  – Take action, as appropriate, to place or maintain the T&P activity in a safe condition until an evaluation of the safety of the situation is completed;
  – Notify RL, the TSD Configuration Manager, and other contractors of the situation;
  – Perform a USQ$_T$D and notify RL, the TSD Configuration Manager, and other contractors promptly of the results; and
  – Submit the evaluation of the safety of the situation to RL for approval prior to removing any operational restrictions initiated to meet the above requirement.

6.6.1.2 USQ$_T$ Approval

The USQ$_T$ Process is an important tool to evaluate whether changes affect the safety basis. Each Hanford Site contractor performing T&P activities under the TSD must use the USQ$_T$ Process to ensure that the transportation safety basis for onsite shipments is met. Greater than 1 A${}_2$ quantity of radioactive material, unless the radioactive material shipped as LSA/SCO, is not adversely affected by changes in the facility, work performed, associated hazards, or other factors that support the adequacy of the safety basis.

The USQ$_T$ Process permits DOE and each prime contractor to make physical and procedural changes to a T&P onsite shipment activities involving greater than 1 A${}_2$ quantity of radioactive material, unless the radioactive material shipped as LSA/SCO, and to conduct tests and experiments without prior approval, provided these changes do not cause a positive USQ$_T$D. The USQ$_T$ Process provides each prime contractor with the flexibility needed to conduct day-to-day operations by requiring only those changes and tests with a potential to impact the safety basis (and therefore the safety of the T&P activity that involves greater than 1 A${}_2$ quantity of radioactive material, unless the radioactive material shipped as LSA/SCO) be approved by the RL Manager. The USQ Process helps keep the safety basis current by ensuring appropriate review of and response to situations that might adversely affect the safety basis.

6.6.1.3 Margin of Safety

A margin of safety is defined as a range or safety buffer between two conditions. The first is the most adverse condition estimated or calculated in the safety analysis process to occur from an operational upset or family of related upsets including severe accidents. The second condition is
the worst case value known to be safe from an engineering perspective. For example, an accident or upset may cause an over pressurization within a vessel. The vessel must be designed to safely withstand the worst postulated overpressure. This defines the first condition. The second condition is the point at which the vessel fails from over pressurization. The pressure range between these two conditions is the margin of safety in this example. This margin of safety should be identified in the PSSD or other Packaging Safety Documents. As part of the approval process, important credited margins of safety (CMOS) should be explicitly identified in the SER.

Credited Margin of Safety is the actual minimum characteristic performance point that is being credited. As a decrease in margin of safety, by definition results in an increase in risk, thus resulting in a positive USQₚ. For the purposes of this TSD, all margins of safety being considered will be CMOS. For example, a seal may have a maximum sustained operating temperature of 250°F. This means that the seal can be operated continuously through its lifetime at 250°F without loss of properties. The seal’s thermal failure point may be 400°F. The CMOS is thus 250°F to 400°F. If the normal operating temperature of the seal is increased from 180°F to 240°F, the CMOS has not been impacted, so no decrease in margin of safety and consequently, no increase in risk has occurred.

The TSD, PSSD and other appropriate documents must be reviewed to determine whether the proposed change, activity, test or experiment, or new information has or would result in the reduction of a margin of safety. The judgment on whether the margin is reduced should be based on physical parameters or conditions that can be observed or calculated.

T&P systems are either DOT-compliant, DOT-equivalent, or risk based systems. Those that are compliant or equivalent are considered performance-based systems. Those that are neither compliant nor equivalent are risk based systems.

The margin of safety is a key element in USQₚDs. Proposed changes are evaluated in the USQₚ screening (USQₚS) Process by focusing on the established limits in the approved TSD, and Packaging Safety Documents. If the USQₚS determines the proposed change is outside the bounds of the Packaging Safety Document, then the potential for a change in the margin of safety exists and the screen is positive. An USQₚD is then prepared. The evaluation of the proposed change is against the requirements of the TSD and Packaging Safety Document. If the evaluation of safety of the proposed change shows it is within the bounds of the TSD, or Packaging Safety Document including a negative evaluation of the reduction in margin of safety, a negative USQₚD results, and approval by RL is not required for the proposed change prior to implementation.

Implicit margins of safety might arise in a risk based package. In those cases the margin of safety may include reliance on assumed or calculated parameters, such as fire department response times, etc. If these change, it may affect the margin of safety.

**6.6.1.3.1 Methodology for Determining Credited Margins of Safety for USQₚ Determinations for DOT-Compliant and Hanford DOT-Equivalent Packages**

The underlying basis for onsite transportation safety of any DOT-compliant or Hanford DOT-equivalent package system is to minimize the risk to the public and worker. Credited Margins of Safety for DOT-compliant and Hanford DOT-equivalent Packages are developed by
meeting the general requirements, lifting standards, tiedown standards, normal conditions
performance tests and the accident condition performance tests identified in this chapter (see
Sections 6.5.2.5 and 6.5.2.6). The USQT evaluator must view any change in the context of the
total package system, including the CMOS.

6.6.1.3.2 Methodology for Determining Credited Margins of Safety of USQT
Determinations for Hanford Risk Based Packages

The underlying basis for onsite transportation safety of any Hanford risk based package system is
to minimize the risk to the public and worker. This is done by supplementing the known
performance capability of the system with preventative administrative and/or engineering
controls, site transportation environment, and communication measures. Consequently, the
USQT evaluator must view any change in the context of the entire package system, which
comprises not only the packaging but also the content, conveyance, route, and transportation
environment, all supplemented by preventative controls and mitigating measures.

The evaluator must recognize that the risk determined in the Packaging Safety Documents for
any risk based packaging is predicated on accident statistics, and engineering judgment of key
parameters, such as packaging capabilities and failure modes, beneficial onsite transportation
environment, effectiveness of administrative and institutional controls, content release fractions,
and dispersal mechanisms in the event of an accident. These key parameters form the basis of
the implicit and/or explicit margins of safety described in the Packaging Safety Documents.
Consequently, the USQT evaluator must not only assess any change to dose consequence and
probability, but also the impact on the implicit and/or explicit margins of safety of the packaging
system described in the approved Packaging Safety Documents.

As a result, for any change, an increase in risk above that described in the TSD and
accompanying SER, or reduction in any CMOS of the package system must be considered a
positive USQT. As an example of a reduction in margin of safety, a change of the semi-trailer
required for a package system that relies on the conveyance performance under normal and
accident conditions should be evaluated to ensure that the new trailer does not provide lower
levels of accident resistance. The change specifies an equivalent semi-trailer by a different
manufacturer with a higher-rated load capacity but a narrower wheelbase. Since the wheelbase
is narrower than the original semi-trailer, the margin of safety implicitly stated in the PSSD has
been reduced and the USQT is positive. In this case, the implicit margin of safety is the static
rollover threshold.

6.6.2 Safety Basis Requirements

Each Hanford Site contractor responsible for a T&P activity that involves onsite shipments with
greater than 1 A\textsuperscript{2} quantity of radioactive material, unless the radioactive material shipped as
LSA/SCO, on the Hanford Site must implement the following:

- Derived from this TSD
- Prior to use, obtain RL Manager approval of any change to safety basis requirements
- Notify RL of any violation of a safety basis requirement
The safety basis requirements are identified in Appendix C, *Safety Basis Requirements for Hanford Onsite Transportation and Packaging*. Each contractor may take emergency actions that depart from an approved safety basis when no actions consistent with the safety basis requirements are immediately apparent, and when these actions are needed to protect the workers, public, or environment from imminent and significant harm. Such actions must be approved by a person in authority (e.g., certified shipper) as designated in the safety basis. Each contractor must report the emergency actions to RL as soon as practicable.
7.0 **Safety Assessment Methodology**

This chapter identifies the methodologies used for achieving and demonstrating onsite safety equivalent to that accomplished by complying with DOT regulations. In addition, it identifies specific evaluation methodology and acceptance criteria to apply when demonstrating compliance with the requirements found in Chapter 6.0 for achieving equivalent onsite T&P activity safety.

7.1 **Methodology for Equivalent Safety**

This TSD identifies three categories of packages, all of which achieve “equivalent safety” as required by DOE O 460.1C for onsite shipments. This includes two categories that specifically meet the intent of 10 CFR 71. Type B quantities of radioactive materials in Type A Packaging or IP with the exception of qualified SCO and LSA materials will not be included in these two categories. The third category of packages used for onsite shipments relies on a risk based approach consistent with DOE-STD-3009, CN-3 to demonstrate an equivalent level of safety for the public and an acceptable level of safety for onsite workers. The following sections identify the three categories.

7.2 **Compliance Methods**

7.2.1 **DOT Compliance**

Equivalent safety is achieved by implementing DOT regulations onsite. All portions of the regulations, other than those identifying the workings and administration of the DOT (e.g., enforcement), will be implemented. Equivalent administrative activities, including approval of exemptions, will be conducted by the RL Manager. This is the preferred technique for achieving onsite equivalent safety when conducting onsite T&P activities. By emulating DOT regulation for onsite hazardous material T&P activities, an equivalent level of safety is achieved. Under this methodology, DOE will implement those actions identified for DOT within DOT regulations. RL, ORP, PNSO, and the Hanford Site contractors will implement those actions identified for the user of the DOT regulations. No alternative evaluation or acceptance criteria are needed when using this methodology.

7.2.2 **DOT-Equivalent Packaging**

For radioactive materials, where full compliance with DOT regulations cannot be achieved, an equivalent method for achieving the acceptable level of safety will be implemented. For these radioactive hazardous materials, equivalent safety is achieved by implementing all portions of the regulations, except for specified modifications to the regulations identifying the following:

- Workings and administration of DOT
- How to obtain DOE and/or RL exemptions
- Communication requirements associated with shipping radioactive materials
Equivalent administrative activities, including approval of exemptions, will be conducted by the RL Manager. Performance requirements for onsite DOT-equivalent packages are identified in Section 6.5.2. These requirements are developed to result in a package that produces physical performance under Hanford Site conditions equivalent to an offsite package subject to regulatory-established test conditions. Examples of Hanford Site-specific conditions that are different than DOT and NRC regulatory conditions are environmental conditions (Hanford Site-specific temperature extremes), application of artificial cooling after a 30-minute fire (assumes Hanford Site Fire Department response), allowance for container venting [not permitted by NRC 10 CFR 71.43(h)], and specific free-drop characteristics (models the CWC storage pad). Specific details and justifications for Hanford Site-specific variances from the DOT and NRC regulatory conditions are provided in Appendix B.

When full compliance with DOT cannot be achieved because of technical or economic conditions, meeting these site-specific standards and performance requirements is the preferred technique for achieving safety equivalent to DOT regulations. DOT-equivalent packages are not used for offsite transportation.

The alternate package requirements are chosen to produce a package which, when tested or evaluated to onsite conditions, performs equivalent to a DOT package subjected to DOT/NRC performance requirements. The alternate packaging performance requirements are identified in Chapter 6.0, “Site-Specific Standards, Procedures, and Instructions.” The following sections identify the evaluation techniques and acceptance criteria developed for this methodology. Evaluation techniques, when applied to T&P activities conducted using the requirements identified in Chapter 6.0, result in achieving and demonstrating compliance with the equivalent safety requirements of DOE O 460.1C for T&P activities.

Chapter 6.0 contains the Hanford Site packaging performance standards. Appendix B contains technical arguments or justification and references to documentation that validate the equivalence of packaging performance for onsite to offsite packages under their respective conditions.

**7.2.3 Risk Based Packaging (Risk Based Equivalent Radiological and Toxicological Protection)**

When full compliance with DOT regulations or compliance with DOT-equivalent packaging for radioactive materials cannot be achieved, a risk based method for demonstrating the acceptable level of safety will be implemented using requirements discussed in Section 6.5.3.2. These requirements demonstrate safety equivalent to that resulting from following DOT regulations and through the use of an approved RL, PNSO, and ORP risk based approach consistent with DOE standards. For these radioactive hazardous materials, equivalent safety is achieved by implementing all portions of the regulations, except for specified modifications to the regulations identifying the following:

- Workings and administration of the DOT
- How to obtain exemptions
- Communication requirements associated with shipping radioactive materials.
For risk based packages, administrative activities, including the approval of exemptions, will be conducted by the RL Manager. Performance requirements for onsite risk based packages are identified in Section 6.5.3.2. These requirements are developed to result in a package, which under Hanford Site conditions will produce radiological performance equivalent to an offsite package subject to regulatory-established tests and conditions. Risk based packages are not generally used for transportation of nonradioactive hazardous materials. The USQT Process provides the means for Hanford Site contractors to determine the approval authority for changes to risk based packages and transportation.

Alternate package requirements are chosen to produce a package which, when tested or evaluated to onsite conditions, result in radiological and toxicological safety equivalent to compliance with DOT/NRC regulations governing the loss of material under NCTs for Type A, Type IP-1, Type IP-2, and Type IP-3 and for equivalent Type B packages, NCs and ACs. Alternate packaging performance requirements are identified in Chapter 6.0. The following sections identify evaluation techniques and acceptance criteria developed for this methodology. Evaluation techniques, when applied to T&P activities conducted using the requirements identified in Chapter 6.0, result in achieving and demonstrating compliance with the equivalent safety requirements of DOE O 460.1C for T&P activities.

Chapter 6.0 contains the Hanford Site packaging performance standards. Appendix E contains the documentation that validates the equivalence of packaging performance for onsite to offsite packages under their respective conditions.

### 7.3 Evaluation and Acceptance Criteria

When the alternate package testing and design criteria presented in Chapter 6.0 are used to design a packaging, the following evaluation methodologies and acceptance criteria must be used to demonstrate compliance. For DOT-compliant packagings, the evaluation and acceptance criteria identified in the regulations must be followed.

#### 7.3.1 DOT-Equivalent Packagings

##### 7.3.1.1 Evaluation Requirements and Acceptance Criteria for Type IP-1, Type IP-2, Type IP-3, and Type A Packagings

- Performance tests for DOT-equivalent Type A, Type IP-1, Type IP-2, and Type IP-3 packagings are the same as those specified in the regulations. The quality assurance requirements are in accordance with the contractor-approved Quality Assurance Program. See Section 6.5.2.3 for additional requirements for Type IP-1. These additional requirements are only for DOE equivalent and risk based packaging systems.

- When a Type IP-1 is specified in DOT-equivalent packaging system or DOT risk based system, the following requirements apply to the Type IP-1:
  - For packagings being evaluated for equivalency to Type IP-1 requirements a package description and an evaluation that the package confinement system remains intact during NC will be conducted. See Table 6-2 for requirements and Appendix G for additional guidance and justification.
7.3.1.1 Tiedown Devices

When tiedown devices are a structural part of the package, their connection with the package body and the package body in the local area around the tiedown device must be evaluated. Failure of any tiedown attachment that is a structural part of the packaging, under NC, must not impair the ability of the package to meet other requirements of this TSD and/or DOT regulations.

7.3.1.2 Evaluation Requirements and Acceptance Criteria for Type B Including Fissile Packagings

This section describes elements that are to be addressed for an onsite PSSD to demonstrate acceptable performance, based on performance tests and design requirements presented in Sections 6.5.2.4 and 6.5.2.5. It also defines acceptable performance criteria for testing and/or analysis to be applied to demonstrate that the packaging provides an equivalent degree of safety to the regulations in maintaining containment/confine ment, subcriticality, and shielding. It should be noted that in any onsite Packaging Safety Document, claims of adequacy of designs or design methods must be supported by technical bases; i.e., by an appropriate engineering evaluation or description of actual tests. The techniques and methodology provided in this section must be used to demonstrate compliance with the requirements from Sections 6.5.2.4 and 6.5.2.5.

Guidance for formatting and preparing the onsite PSSD report is provided in Appendix D, Package-Specific Safety Document contents and One-Time Request for Shipment contents and Format. The PSSD is divided into 11 chapters. The contents of the chapters correspond to contents identified in Sections 7.3.1.2.1 through 7.3.1.2.11 below.

7.3.1.2.1 General Information

General information of the onsite PSSD must include purpose, detailed packaging description, detailed definition and description of the containment/confine ment boundary, contents, and assessment of the general design requirements for packaging (Section 6.5.2.5.1).

7.3.1.2.1.1 Package Description

The package description in onsite PSSDs must include the following information:

- A detailed description (addressed in Sections 7.3.1.2.1 and 7.3.1.2.1 below) of the packaging design in sufficient detail to provide an adequate basis for evaluation.
- Engineering drawings of the packaging must be prepared in accordance with NUREG/CR-5502.
- A detailed description (addressed in Section 7.3.1.2.1) of the contents in sufficient detail to provide an adequate basis for evaluation.
- A detailed description of loading, unloading, and transport operations of the package.
- Identification of established codes and standards for package design, fabrication, assembly, testing, maintenance, and use.
### 7.3.1.2.1.2 Packaging Description

A detailed description of the packaging must include the following:

- General packaging summary, including marking per Section 6.5.2.5.13, model number, maximum weight and overall dimensions.
- Containment/confinement features (see Section 7.3.1.2.1).
- Shielding features.
- Criticality control features, including neutron poisons, moderators, and spacers.
- Structural and other features, including gaps and coolants, for transfer and dissipation of heat.
- Other structural features, including support structures, lifting and tiedown devices, and impact limiters.
- A description of any special fabrication processes not addressed by a nationally recognized or Hanford Site standard.

### 7.3.1.2.1.3 Containment/Confinement Boundary Definition and Description

A detailed description of the containment boundary must include the following:

- Definition of the exact boundary of the containment/confinement system. This includes containment/confinement vessels, welds, drain or fill ports, valves, seals, test ports, lids, cover plates, vent filters (as applicable), and other closure devices.
- If multiple seals are used for a single closure, the seal defined as the containment system seal must be clearly defined.
- A sketch of the containment/confinement system must be provided.
- For vented and filtered packages, the venting and filtration system must be described in detail. The manufacturer, type, model, rating, and performance characteristics of the filter and filter housing seals must be provided.

All containment/confinement boundary components must be shown on the engineering drawings.

### 7.3.1.2.1.4 Content Description

A detailed description of the contents must include the following:

- Identification and maximum quantity (radioactivity or mass) of the radioactive material.
- Identification and maximum quantity of fissile material and CSI.
- Identification and minimum quantity of solid non-fissile material for every gram of fissile material. Lead, beryllium, graphite, and hydrogenous material enriched in deuterium may be present in the package, but must not be included in determining the required mass for solid non-fissile material.
- Chemical and physical form, including density and moisture content, and the presence of other moderating constituents.
• Location and configuration of contents within the packaging, including secondary containers, wrapping, shoring, and other material not defined as part of the packaging.
• Identification and quantity of non-fissile materials used as neutron absorbers or moderators.
• Any material subject to chemical, galvanic, radiolytic, or other reaction, including generation of gases.
• Maximum normal operating and design pressure.
• Maximum weight of radioactive material and maximum weight of payload including secondary containers and packaging.
• Maximum decay heat.
• Assessment of General Design Requirements for Packaging. General design requirements for packaging must be demonstrated to meet the requirements outlined in Section 6.5.2.5.1.

7.3.1.2.2 Structural Evaluation

This section outlines the elements that are to be addressed for an onsite PSSD to demonstrate acceptable structural performance based on the performance tests defined in Section 6.5.2.4 and structural requirements of Section 6.5.2.5. The section also defines acceptable performance criteria for testing and/or analysis to be applied to demonstrate that the packaging provides an equivalent degree of safety to the regulations in maintaining containment/confinement, subcriticality, and shielding. It should be noted that in any onsite PSSD, claims of adequacy of designs or design methods must be supported by technical bases; i.e., by an appropriate engineering evaluation or description of actual tests.

7.3.1.2.2.1 Description of Structural Design

The following information must be provided in the structural description of the packaging:
• Dimensions, tolerances, and materials.
• Weights and center of gravity of the packaging and major subcomponents.
• Maximum weight of contents.
• MNOP.
• Closure system and containment/confinement boundary and its components must be clearly identified and described.
• Description of handling and transport requirements.
• Fabrication methods.
• Codes and standards for the packaging design must be identified and must be properly applied and appropriate for the intended purpose.
7.3.1.2.2 Material Properties and Specifications

The following information must be provided and/or demonstrated in describing the materials of construction of this packaging:

- Appropriate specification for the materials of construction must be identified for control of the material.
- Materials and their properties must be consistent with the design codes or standards selected. If no standard is available, adequately documented material properties and specifications for design and fabrication of the packaging must be provided.
- Materials of the containment/confinement boundary must have sufficient fracture toughness to preclude brittle fracture under NC and AC. In demonstrating fracture toughness of a material, guidance from ASME BPVC, Section VIII, Division 1; ASME BPVC, Section III; Regulatory Guide 7.11; or Regulatory Guide 7.12 may be used.
- Material properties must be appropriate for the load conditions (e.g., static or dynamic impact loads, hot or cold temperatures, and wet or dry conditions).
- Temperature at which allowable limits are defined must be consistent with minimum and maximum service temperatures.
- Force-deformation properties for impact limiters must be provided and must be based on appropriate test conditions and temperatures.
- Packaging materials and coatings must not produce a significant chemical or galvanic reaction among packaging components, among packaging contents, or between the packaging components or packaging content.
- Reactions resulting from the inleakage of water must be evaluated.
- The potential for radiolytic or chemical generation of gases must be evaluated.
- The possibility of galvanic interactions and the formation of eutectics must be evaluated for metallic components that may come into physical contact. Such interactions may occur with depleted uranium, lead, or aluminum.
- Any damaging effects of radiation on the packaging materials must be evaluated. These effects may include degradation of seals, sealing material, coatings, adhesives, and structural materials.

7.3.1.2.2.3 Fabrication

Information addressing the manufacturing process of construction (e.g., forming, fitting, aligning, welding, brazing, heat treatment, and mechanical joints) must be provided to demonstrate proper packaging fabrication.

1. When fabrication specifications are prescribed by appropriate codes and standards, the code or standards must be identified in engineering drawings.
2. Unless otherwise justified, the specification of the code or standard used for design must also be used for fabrication.
3. For components in which no code or standards are applicable, the specifications on which the evaluation depends must be identified. In addition, the method of control to ensure specifications are achieved must be described.

7.3.1.2.2.4 Examination

Information addressing examination methods and criteria by which fabrication of the packaging is determined to be acceptable must be provided.

1. Unless otherwise justified, the specification of the code or standard used for fabrication must also be used for examination.

2. For components in which no code or standards are applicable, the method and acceptance criteria must be provided herein and a summary provided in Section 7.3.1.2.11.

7.3.1.2.2.5 Lifting Devices

When lifting devices are a structural part of the package, their connection with the package body, and the package body in the local area around the lifting devices, must be evaluated.

Lifting devices must be demonstrated to comply with the design requirements of Section 6.5.2.5.2.

7.3.1.2.2.6 Tiedown Devices

When tiedown devices are a structural part of the package, their connection with the package body and the package body in the local area around the tiedown device must be evaluated.

Tiedown devices must be demonstrated to comply with the design requirements of Section 6.5.2.5.3.

7.3.1.2.2.7 General Consideration

The structural evaluation must demonstrate that the package meets the performance test requirements defined in Section 6.5.2.4 and design requirements defined in Section 6.5.2.5. The evaluation must also address the following:

- The evaluation methods are appropriate for the loading conditions considered and follow accepted practices and precepts.
- The most damaging orientations have been considered. It should be noted that the most damaging orientation for one component may not be the most damaging for another component.
- The most limiting initial conditions must be used as defined in Table 6-6.

7.3.1.2.2.7.1 Evaluation by Testing

If the package performance is demonstrated by testing, the onsite PSSD must include the following:

- Description of the test surface (e.g., material, mass, dimensions) used for the free drop and crush tests. As a minimum, the test surface must be in accordance with Section 6.5.2.4.1.9. The total mass of the test surface must be at least 10 times the mass of the package.
- Description of the steel bar (e.g., material, dimension, orientation, method of mounting) used for the puncture test. The test bar must have sufficient length to cause maximum damage to the package and meet the requirements of Section 6.5.2.4.1.3.

- The test specimen must have been fabricated using the same materials, methods, and QA as specified in the design. Any differences must be identified and the effects evaluated. Substitutes for the contents should have the same representative weight as the actual contents.

- Of the selected free drop orientations, one must be in the orientation for which maximum damage is expected. This selection must be justified.

- All test results must be evaluated and their implications interpreted, including interior and exterior damage, for the test specimen. Unexpected or unexplained test results indicating possible testing problems or non-reproducible specimen behavior must be described and evaluated.

- Videos and photographs of the tests must be provided as records and maintained available for review for the life of the package.

- Criteria for evaluating pass/fail for the test conditions must be provided and used as a comparison with the test results.

7.3.1.2.2.7.2 Evaluation by Analysis

If the package performance is demonstrated by analysis, the onsite PSSD must include the following:

- A clear description of calculations and all assumptions must be provided.

- Response of the package to loads, in terms of stress and strain to the components and structural members, must be provided and the structural stability of individual members must be demonstrated.

- Analytical methods must evaluate impact at any angle, rigid-body rotation, and secondary impacts (slapdown).

- Computer codes must be appropriately used, verified, and benchmarked.

- When using quasi-static analysis techniques, appropriate dynamic amplification factors must be developed and applied.

- Material properties and models must be appropriate for the load combinations evaluated. Material properties must be consistent with the analytical methods. The strain rate at which the properties are given must be justified.

- A summary of results must be provided which compare results of the analyses with the acceptable performance criteria.

Acceptable Performance Criteria for Evaluation by Analysis. NC acceptable packaging performance will be assessed in accordance with the ASME BPVC, Section III, Subsection NE requirements for Service Level A and C Limits. The combined stress intensities from temperature, pressure, and free drop are evaluated against the requirements defined for Service
Level C Limits. Stress intensities from all other load combinations are to be evaluated against the requirements defined for Service Level A Limits. For structural evaluation purposes, maintenance of containment/confinement is defined as the ability of the packaging system to sustain the applied loading without exceeding ASME allowable stress intensity values. Also, at closure locations, the seals must be demonstrated to remain sufficiently compressed under NC loads as to maintain containment/confinement.

Under AC, the package must be subjected to the sequence of performance tests in the following order: free drop, crush (when applicable), puncture, fire, and immersion (fissile packages). Where the package loading is linear elastic, loads can be combined by superimposition and the performance assessed to the requirements of ASME BPVC, Subsection NE, Service Level D Limits.

Onsite equivalent package requirements also allow plastic deformation of the packaging when it is demonstrated by either testing or analysis that containment/confinement, shielding, and subcriticality are maintained under AC. When packaging performance is demonstrated by elastic plastic analysis, the loads are required to be applied in the sequence as specified in Section 6.5.2.4.2.1 to assess cumulative damage of the packaging. If plastic analysis methods are used to demonstrate maintenance of containment/confinement, shielding, and subcriticality, the loads cannot be superimposed and cumulative damage must be assessed after application of all the loads to the worst case locations. Because ASME BPVC criteria are inappropriate for plastic analysis, packaging performance will be assessed by the combination of the following two methods:

The first and simplest acceptance criteria screening is strain energy density (SED). The maximum SED of the material is also known as toughness and, at material failure, can be conservatively estimated from the results of uniaxial tensile test data. A conservative estimate of SED at material failure is as follows:

\[
\text{SED} = \frac{\sigma_y + \sigma_u}{2} \varepsilon_f
\]

where:

- \( \sigma_y \) = yield strength of the material
- \( \sigma_u \) = ultimate strength of the material
- \( \varepsilon_f \) = ultimate tensile elongation.

These parameters are available from engineering stress-strain data. Use of the SED also minimizes concerns over unavoidable material variations such as heat-to-heat variations in yield strength and strain hardening behavior.

To ensure against ductile failure of the material, the maximum SED on the package is limited to 70 percent the SED to failure of the material or material toughness. This is in keeping with the intent of the Regulatory Guide 7.6 to prevent large unconfined strain plasticity and system failure due to loss of dimensional stability at key locations. The limit is based on applying the 70 percent Service Level D stress limit for material loading, specified in ASME BPVC, Section III, Appendices to the ultimate elongation specified in ASME BPVC, Section II material
properties at operating temperatures. This results in the SED limit of 70 percent of the maximum material toughness at operating temperature. The allowable SED in equation form is defined as:

\[
\text{SED}_{\text{all}} = 0.70 \frac{(\sigma_y + \sigma_u)}{2} \varepsilon_t
\]

Eq. 7-2

This is compared against the von Mises stress times the cumulative strain at the location of evaluation. It is used for global assessment of package performance under dynamic impact loading conditions and identifying high loading areas for detail assessment. Consequently, as a second screening at critical locations and in areas of high SED values, a more comprehensive measure of performance is used to assess equivalent cumulative strains against a limiting value.

The most comprehensive criteria demonstrating acceptable cumulative strain levels to prevent material rupture are based on establishing limits on the maximum equivalent cumulative strain. The strain limits are developed based on Manjoine (1983) observation that the tensile elongation measured in a tension test can be adjusted to predict multi-axial failure strain by the following relation:

\[
\frac{\varepsilon}{\varepsilon_t} = 2^{(1-\text{TF})} \quad \text{for} \quad \text{TF} \geq 0 \quad \text{and} \quad \frac{\varepsilon}{\varepsilon_t} = 2 \quad \text{for} \quad \text{TF} \leq 0
\]

Eq. 7-3

where:

- \(\varepsilon\) = the effective strain at failure
- \(\varepsilon_t\) = the ultimate tensile elongation of the material from tension tests
- \(\text{TF}\) = the triaxiality factor.

The triaxiality factor is defined by the principal stresses \((\sigma_1, \sigma_2, \sigma_3)\) as:

\[
\text{TF} = \frac{\sqrt{2(\sigma_1 + \sigma_2 + \sigma_3)}}{\sqrt{(\sigma_1 - \sigma_2)^2 + (\sigma_2 - \sigma_3)^2 + (\sigma_3 - \sigma_1)^2}}
\]

Eq. 7-4

Based on the ductility versus triaxiality factor curve presented in Manjoine (1983), the following conservative failure strain limits, termed the triaxial strain limit (TSL), can be established for any ductile material under multi-axial loading. In addition, in keeping with the intent of the Regulatory Guide 7.6 to prevent large unconfined strain plasticity and system failure due to loss of dimensional stability at key locations, the ultimate strain is limited to 70 percent of the reported ultimate tensile elongation of the material. Also, welds do not have the ductility of the base metal and the presence of residual weld stresses, in weld areas the TSL is half the limit established above. Consequently, to demonstrate acceptable performance in non-weld areas, the TSL is established as equal to 70 percent of the ultimate tensile elongation of the material divided by triaxiality factor. The TSL in weld areas is established as one-half times the TSL in non-welded areas. In equation form, the TSLs are:
When triaxiality factor is less than unity (1), the triaxiality factor is set equal to unity (1). To demonstrate acceptable performance of the packaging, the cumulative strain at all locations must remain below the established TSL at the location of evaluation. Also, at closure locations, the cumulative strains must be demonstrated not to result in loss of containment or decompression of the seals by flange distortion or closure bolt elongation.

1. Pressure Loading. The following pressure evaluations must be provided in the onsite PSSD to demonstrate the structural integrity of the packaging containment components under pressure.

As stated in Section 6.5.2.5.12, the packaging must be demonstrated to sustain a pressure of 150 percent of the rated MNOP.

The package must be evaluated to demonstrate that the containment components are capable of sustaining the differential pressure loading specified in Sections 6.5.2.4.1.5 and 6.5.2.4.1.6 without loss of containment capability.

The evaluations must consider the greatest possible pressure differential between the inside and outside of the containment components.

7.3.1.2.2.8 Structural Evaluation of Normal Conditions

Evaluation of the package under NC is based on the effects of tests and conditions specified in Section 6.5.2.4.1. These tests must not result in any decrease in package effectiveness in maintaining containment/confine, shielding, and subcriticality. Under these test conditions, the ambient air temperature before and after the test must remain constant at that value between the specified temperatures in Sections 6.5.2.4.1.3 and 6.5.2.4.1.4 which is the most unfavorable for the feature being evaluated. Initial internal pressure on the containment/confine components must be considered to be MNOP, unless a lower internal pressure consistent with the selected ambient temperature is more severe.

7.3.1.2.2.8.1 Heat Condition

The adequacy of the package under heat conditions must be demonstrated by the following evaluations at the hot temperature specified in Section 6.5.2.4.1.3:

- The maximum temperatures under heat conditions must be consistent with the thermal evaluation section (see Section 7.3.1.2.3).
- The MNOP, in combination with the maximum internal heat load and any residual fabrication stresses, must be evaluated.
- Any differential thermal expansion and possible geometric interference must be evaluated.
• The containment/confine...10.1 and Table 6-6.

7.3.1.2.2.8.2 Cold Condition
The adequacy of the package under cold conditions must be demonstrated by the following evaluations at the cold temperature specified in Section 6.5.2.4.1.4:

• The minimum temperatures with no internal heat loading must be consistent with the thermal evaluation section (see Section 7.3.1.2.3).
• The evaluation must consider the minimum internal pressure with the minimum internal heat load and any residual fabrication stresses.
• Any differential thermal expansion and possible geometric interference must be evaluated.
• Evaluate the effects of the possible freezing of liquids.
• The containment/confine...10.1, and Table 6-6.

7.3.1.2.2.8.3 Reduced External Pressure
The adequacy of the package under reduced external pressure conditions specified in Section 6.5.2.4.1.5 must be demonstrated by the following evaluations:

• The package must be evaluated to demonstrate the containment components are capable of sustaining the differential pressure loading specified in Section 6.5.2.4.2 without loss of containment capability. The evaluation must consider the greatest possible pressure differential between the inside and outside of the containment components.
• The containment/confine... boundary must be evaluated.

7.3.1.2.2.8.4 Increased External Pressure
Adequacy of the package under increased external pressure conditions specified in Section 6.5.2.4.1.6 must be demonstrated by the following evaluations:

• The evaluation must consider the loading condition in combination with the minimum internal pressure.
• The greatest possible pressure difference between the inside and outside of the containment components must be evaluated.
• The possibility of buckling must be evaluated.
• The containment/confine... boundary must be evaluated for the load combinations specified in Section 6.5.2.5.10.1, and Table 6-6.

7.3.1.2.2.8.5 Vibration
Adequacy of the package under the effects of vibration normally incident to transport tests as specified in Section 6.5.2.4.1.7 must be demonstrated by the following evaluations:
• Fatigue must be evaluated at highly stressed components, considering the combined stresses due to vibration, temperature, and pressure loads.

• If the closure bolts are reused, the bolts must be evaluated for fatigue and the bolt preload must be included.

• Evaluations must include a demonstration that resonant vibration conditions, which may cause rapid fatigue damage, are not present in the package components.

• The effects of package internal components and contents must be considered in the evaluations.

• The containment/confine boundary must be evaluated for the load combinations specified in Section 6.5.2.5.10.1, and Table 6-6.

Guidance for vibrational loading parameters is provided in ANSI N14.23 and ASTM D4169.

7.3.1.2.2.8.6 Water Spray

Adequacy of the package under the effects of a water spray test as specified in Section 6.5.2.4.1.8 must be demonstrated by evaluating the effects on the material properties of the package.

7.3.1.2.2.8.7 Free Drop

Adequacy of the package under the effects of the free drop tests as specified in Section 6.5.2.4.1.9 must be demonstrated by the following evaluations:

• Design of the package must be evaluated for the structural response for the specified free drop height in combination with internal pressure, thermal stress, and residual stresses.

• The closure system design with the combined effects of the free drop impact force, internal pressure, thermal stress, residual stress, O-ring compression force, and bolt preload must be evaluated.

• Other important components (such as the port-cover, port-cover plates, and shielding enclosures) must be demonstrated not to decrease in effectiveness when subjected to the combination of impact force, internal pressure, residual stress, and thermal stress.

• The containment/confine boundary must be evaluated for the load combinations specified in Section 6.5.2.5.10.1, and Table 6-6.

• The closure system design seals must be demonstrated not to decompress from bolt stretch or flange deflection to the extent that containment/confine is lost under the combined loadings.

7.3.1.2.2.8.8 Compression

Adequacy of the package under the effects of the compression test as specified in Section 6.5.2.4.1.10 must be demonstrated by evaluating the structural response of the package to the static loads specified.
7.3.1.2.2.8.9 Penetration

Adequacy of the package under the effects of the penetration test as specified in Section 6.5.2.4.1.11 must be demonstrated by evaluating the effects of the package at most the vulnerable location.

7.3.1.2.2.9 Structural Evaluation of Accident Conditions

Evaluation of the package under AC is based on the sequential application of tests and conditions specified in Section 6.5.2.4.2, in the order indicated, to determine their cumulative effect on the package. The evaluation of the ability of a package to withstand any one of these tests must consider the damage that resulted from the previous test. In addition, the NC tests must not affect the package’s ability to withstand the AC tests. Under these test conditions, the ambient air temperature before and after the test must remain constant as specified in Sections 6.5.2.4.1.3 and 6.5.2.4.1.4, which is the most unfavorable for the feature being evaluated. The initial internal pressure on the containment components must be considered to be the MNOP, unless a lower internal pressure consistent with the selected ambient temperature is more severe.

The evaluation must demonstrate that the package has sufficient structural integrity to maintain containment/confinement, shielding, and subcriticality under the AC specified. Results of this evaluation must also be considered for the following areas:

- Deformation of shielding components must be included in the shielding evaluation.
- Deformation of components required for heat transfer must be included in the thermal evaluation.
- Deformation of components required for subcriticality must be included in the criticality evaluation.

7.3.1.2.2.9.1 Free Drop

In demonstrating the adequacy of the package under the effects of the free drop tests as specified in Section 6.5.2.4.2.1.1, the following must be included:

- The free drop orientation that causes the most severe damage, including center of gravity over corner, oblique orientation with secondary impact, side drop, and free drop onto the closure must be evaluated.
- It must be noted that the most damaging orientation for one component may not be the most damaging orientation for another component.
- When a feature such as a tiedown component is a structural part of the package, it must be included in the selection of the free drop test configuration and the free drop orientation.
- For a package with lead shielding, the effects of lead slump must be evaluated. The lead slump determined must be consistent with that used in the shielding evaluation.

7.3.1.2.2.9.2 Crush

When required, the adequacy of the package under the effects of the dynamic crush test as specified in Section 6.5.2.4.2.1.2 must be demonstrated by evaluating the structural response of
the package to the loads specified. The package must have been previously subjected to the free drop test.

7.3.1.2.2.9.3 Puncture

In demonstrating adequacy of the package under the effects of the puncture tests as specified in Section 6.5.2.4.2.1.3, the following must be included:

- Position for which maximum damage would be expected must be evaluated.
- Any damage from the free drop and crush conditions must be considered.
- Punctures at oblique angles, near a support, at a valve, and at a penetration must be considered.

7.3.1.2.2.9.4 Thermal

In demonstrating the adequacy of the package under the effects of the fully engulfing fire thermal test as specified in Section 6.5.2.4.2.1.4, the following must be included:

- Any damage resulting from the free drop, crush, and puncture conditions must be incorporated into the initial conditions of the package for the fire test.
- Determination of the maximum pressure in the package during and after the test considers the temperature resulting from the fire and any increase in gas inventory caused by combustion, radiolysis, or other decomposition processes.
- Evaluate maximum thermal stresses that can occur either during or after the fire.

7.3.1.2.2.9.5 Immersion-Fissile Material

When water in-leakage is not assumed in the criticality evaluation, the adequacy of the package under the effects of immersion for fissile material packages as specified in Section 6.5.2.4.2.1.5 must be demonstrated by evaluating the package for in-leakage of water. A water head of 0.9 m (3 ft) in the orientation that maximum leakage is expected must be applied to the package.

7.3.1.2.2.9.6 Immersion-All Packages

In demonstrating the adequacy of the package under the effects of the immersion tests as specified in Section 6.5.2.4.2.1.6, the following must be included:

- An undamaged specimen must be subjected to a water pressure equivalent to immersion under a head of water of at least 15 m (50 ft). This is equivalent to an external pressure of 150 kPa (21.7 psig).
- The evaluation must consider the loading condition in combination with the minimum internal pressure.
- The greatest possible pressure difference between the inside and outside of the containment components must be evaluated.
- The possibility of buckling must be evaluated.
7.3.1.2.2.10 Evaluation Procedures

Structural evaluation of a package is based in part on the description and evaluations presented in the general information and thermal evaluation sections. In addition, results of the structural evaluation are considered in the evaluation of all other sections. As an aid to the user, an information flow diagram for the structural evaluation is presented in Figure 7-1.

7.3.1.2.3 Thermal Evaluation

This section outlines elements that are to be addressed in an onsite PSSD to demonstrate acceptable thermal performance based on performance tests defined in Section 6.5.2.4. The section also defines the acceptable performance criteria for testing and/or analysis to be applied to demonstrate that the package provides an equivalent degree of safety to the regulations in maintaining containment, subcriticality, and shielding. It should be noted that in any onsite PSSD, claims of adequacy of designs or design methods must be supported by technical bases; i.e., by an appropriate engineering evaluation or description of actual tests.

Figure 7-1. Structural Evaluation Flow Diagram

The package shall be evaluated for all NC thermal evaluation events -- heat, cold, reduced external pressure, and increased external pressure -- by either testing or analysis. These tests do not need to be performed in a specific sequence. The package shall also be evaluated for the AC
thermal condition (fire) by either testing or analysis, and must be preceded by the free drop, crush (when applicable), and puncture performance tests.

7.3.1.2.3.1 Description of Thermal Design

7.3.1.2.3.1.1 Design Features

Design features that are important to the thermal performance include the following:

- Package geometry and materials of construction.
- Structural and mechanical features that may affect heat transfer, such as cooling fins, insulating materials, surface conditions of the package components, and gaps or physical contacts between internal components.

7.3.1.2.3.1.2 Contents Decay Heat

The decay heat will be determined from the maximum allowed radioactive contents.

7.3.1.2.3.1.3 Summary Tables of Temperatures

Summary tables of the maximum or minimum temperatures that affect structural integrity, containment, shielding, and criticality will be presented for both NC and AC. For fire test conditions, the tables will also include the following:

- Maximum temperatures and the time at which they occur after fire initiation
- Maximum temperatures of the post-fire steady-state condition

The temperatures will be consistent with the structural evaluation (Section 7.3.1.2.2) and containment (Section 7.3.1.2.4).

7.3.1.2.3.1.4 Summary Tables of Maximum Pressures in the Containment System

The summary tables will include the MNOP and the maximum pressure under AC. These pressures will be consistent with those in the general information (Section 7.3.1.2.1), structural evaluation (Section 7.3.1.2.2), containment (Section 7.3.1.2.4), and Acceptance Tests and Maintenance Program (Section 7.3.1.2.11).

7.3.1.2.3.2 Material Properties and Component Specification

7.3.1.2.3.2.1 Material Properties

Appropriate thermal properties will be specified for materials that affect heat transfer both within the package and from the package to the environment. These materials include any liquids or gases within the package and gases external to the package for AC.

Thermal absorptivity and emissivity must be appropriate for the package surface conditions and each thermal condition being evaluated. If a property is reported as a single value, this value must bound the equivalent temperature-dependent property.

7.3.1.2.3.2.2 Component Specifications

Maximum allowable service temperatures or pressures will be specified for each package component, as appropriate.
Minimum allowable service temperature of all the package components will be less than or equal to \(-33^\circ C\) \((-27^\circ F)\).

Technical specifications for applicable package components (such as pressure relief valves and fusible plugs) will be provided.

7.3.1.2.3.3 General Considerations

Thermal evaluation of the package design can be performed by analysis or testing, or by a combination of both.

A packaging may be tested or evaluated in accordance with the requirements of Chapter 6.0 or the regulations.

Because Chapter 6.0 provides an equivalent degree of safety to the regulations, the performance test conditions and parameters are not interchangeable. In other words, the package is either analyzed or tested to the test conditions and parameters of Chapter 6.0 or the regulations, not a combination of the two.

Testing of the package will be conducted, as a minimum, in accordance with performance test conditions defined in Chapter 6.0.

7.3.1.2.3.3.1 Evaluation by Test

For evaluation by testing, the test package, test facility, and test procedures must be described in detail. An approved QAP must be in place for the fabrication of the test package, operation of the test facility, and the gathering and evaluation of the test data. To ensure adequate prototypical testing in accordance with the performance test conditions set forth in Chapter 6.0 or the regulations:

- Thermal performance of the test package, including simulated contents, test instrumentation, and attachment hardware, will be representative of the actual package design.
- Temperature-sensing instrumentation will be located to measure the maximum temperature of critical package components and to characterize the significant heat transfer pathways.
- Test instrumentation will be mounted at locations that minimize their effects on local test temperatures.
- The pre-fire condition for testing will be the maximum NC steady-state temperature.
- For performance tests, quenching and fire suppression of the AC fire will be initiated after a minimum fire duration of 30 minutes.
- Test results, as a minimum, will include the following:
  - Initial conditions (e.g., temperature, pressure) and changes in the package resulting from structural tests.
  - Maximum steady-state temperatures and pressures (e.g., pre-fire conditions).
  - Maximum temperature and pressure during the fire and post-fire periods.
• Physical changes in the package condition resulting from the test, such as changes in packaging material properties caused by combustion or melting of packaging components.
• Conditions, such as ambient temperature, decay heat, and packaging absorptivity and emissivity, may not be exactly represented in thermal testing. Corrections or evaluations to account for these differences must be provided in the safety assessment report. For example, a thermal evaluation must be provided to correct for temperature, if the ambient temperature at the onset of the fire test is lower than 46°C (115°F).

7.3.1.2.3.3.2 Evaluation by Analysis

If the package performance is demonstrated by analysis, the onsite PSSD must include the following:

• The methods used are properly referenced or developed, and correctly applied.
• Assumptions in modeling heat sources and heat transfer paths and modes must be clearly stated and justified.
• The appropriate thermal properties for the package materials are correctly incorporated.
• The evaluation considers changes in package geometry and material properties resulting from structural and thermal tests under NC and AC.
• The required temperature and thermal boundary conditions for NC and AC are applied correctly.
• The time interval after the fire test is adequate to ensure the maximum component temperatures and post-fire steady-state temperature has been achieved.
• The maximum temperature and pressure of each component do not exceed their allowable values.
• Combustion of the package components is considered, including the heat produced.
• Thermal evaluation should assume the heat transfer medium is air, and effects of air on the contents and packaging components (e.g., oxidation of depleted uranium shielding) should be addressed.
• If analysis is chosen in lieu of testing, the analysis will demonstrate satisfactory performance of the package to the performance test conditions defined in Chapter 6.0. The analysis performed will meet the following requirements:
  • Computer numerical simulations of package performance under the specified test conditions will have been benchmarked and properly documented.
  • Thermal quenching will be applied 30 minutes after initiation of the fully engulfing fire.
  • Combustion of package components will be accounted for in the evaluation, including the heat produced.
7.3.1.2.3.3 Acceptance Criteria for Evaluation by Analysis

Under NC, structural integrity and safe performance of the package will demonstrate that the package maintains confinement, shielding, and subcriticality for the specified performance tests.

In addition, packages will be demonstrated to maintain an exterior packaging temperature of 50°C (122°F) for nonexclusive use and 85°C (185°F) for exclusive use shipments under the hot extremes of Hanford Site conditions in the shade.

Maximum seal and shielding material temperatures will be demonstrated to be below the rated maximum continuous use temperature of the material for NC.

Also, component material temperatures will be demonstrated to be above the rated minimum continuous use temperature of the material for NC.

Maximum normal pressures and temperatures will be established for key packaging components and will be consistent with the pressures and material temperatures used in the structural section.

Structural integrity and safe performance of the package is demonstrated by evaluating the cumulative damage from the previous AC free drop, crush (when applicable), and puncture loads combined with the thermal stresses, pressure, and differential thermal expansion loadings from the fire. This evaluation is to be provided in the structural section.

Maximum accident pressures and temperatures will be established for key packaging components and will be consistent with the pressures and material temperatures used in the structural section. In the case of the package closure mechanisms, such as bolts, the cumulative strains from the entire sequence of accident loads will be evaluated to demonstrate that containment is maintained.

Under fire conditions, the limiting value to demonstrate containment by the primary seals is based on the manufacturer’s stated high temperature operation and duration being below the maximum fire accident temperature and duration at the seal.

Maintenance of package shielding and criticality control will be demonstrated by the ability of the package to maintain structural integrity and effectiveness under accident loading conditions after the sequence of accidents specified in Chapter 6.0.

As an example, lead-shielding effectiveness will be demonstrated in this section, as well as the structural and shielding sections, by demonstrating no loss of shielding effectiveness from lead slump resulting from the sequence of accident loads.

7.3.1.2.3.4 Margins of Safety

Margins of safety must be established for temperature, pressure, and thermal stresses for all packaging components important to safety.

In establishing the margins of safety, the evaluation of package performance must address the effects of uncertainties in thermal properties, test conditions, diagnostics, and analytical methods.

If package performance is assessed by testing, it must be demonstrated that the test results are reliable and repeatable.
7.3.1.2.3.3.5 Thermal Evaluation under Normal Conditions

The thermal evaluation should demonstrate that the tests for NC do not result in significant reduction in packaging effectiveness, including the following:

- Degradation of the heat-transfer capability of the packaging (such as creation of new gaps between components).
- Changes in material conditions or properties (e.g., expansion, contraction, gas generation, and thermal stresses) that affect the structural performance.
- Changes in the package that affect containment, shielding, or criticality such as thermal decomposition or melting of materials.
- Ability of the packaging to withstand the tests under NC.

It will be verified that the component temperatures and pressures do not exceed their allowable values.

- **Heat**
  - The Hanford Site extreme hot temperature is 46°C (115°F). The maximum allowable package external temperature in the shade is 85°C (185°F) for exclusive use and 50°C (122°F) for nonexclusive use shipments.

- **Cold**
  - The Hanford Site cold temperature extreme is -33°C (-27°F).

- **MNOP**
  - The MNOP shall be determined when the package has been subjected to the steady-state heat condition. The MNOP calculation will consider all possible sources of gases such as the following:
    - Gases initially present in the package.
    - Saturated vapor, including water vapor from the contents or packaging.
    - Helium from the radioactive decay of the contents.
    - Hydrogen or other gases resulting from chemical reaction or thermal--or radiation-induced decomposition of materials such as water or organics.

- Hydrogen or other flammable gases comprising greater than 5 percent by volume of the total gas inventory within any confined volume will be evaluated.

- Evaluation of the effects of flammable gas contents will include deflagration, deflagration to detonation transition, and the resultant pressures as described in the gas generation section.

- Thermal stresses caused by constrained interfaces among package components resulting from temperature gradients and different thermal expansions will be evaluated. The evaluation will include thermal stresses as well as cyclic stresses during the service life of the package.
7.3.1.2.3.4 Thermal Evaluation under Accident Conditions

7.3.1.2.3.4.1 Initial Conditions

Prior to the fire test, the package design should be evaluated for the effects of the drop, crush (if applicable), and puncture tests. The initial physical condition of the package design used in the thermal evaluation should consider these effects. The most unfavorable conditions will be used:

- An ambient temperature between -33°C and 46°C (-27°F and 115°F).
- An internal pressure of the package equal to the MNOP unless a lower internal pressure, consistent with the ambient temperature, is less favorable.
- Contents at its maximum decay heat unless a lower heat, consistent with the temperature and pressure, is less favorable.
- The initial steady-state temperature distribution should be consistent with the thermal evaluation under NC.

7.3.1.2.3.4.2 Thermal Performance Test

The following conditions should be met for the thermal performance test:

- The package will be fully engulfed in a fire with an average emissivity coefficient of at least 0.9, with an average flame temperature of at least 800°C (1,475°F) for a period of 30 minutes.
- The fuel source must extend horizontally at least 1 m (40 in.), but may not extend more than 3 m (10 ft) beyond any external surface of the package.
- The package must be positioned 1 m (40 in.) above the surface of the fuel source.
- For purposes of calculation, the surface absorptivity coefficient must be the value that the package may be expected to possess when exposed to the fire specified, and the convective coefficient must be that value which may be demonstrated to exist if the package were exposed to the fire specified.
- Artificial cooling (quenching) may be applied 30 minutes after the initiation of the fire.
- Thermal insolation must be applied before and after the fire.

7.3.1.2.3.4.3 Maximum Temperature and Pressure

The evaluation will appropriately determine both the transient peak temperatures of the package components as a function of time after the fire, and the maximum temperatures from the post-fire, steady-state condition.

The lead shielding will not reach melting temperature unless otherwise authorized by a Packaging Safety Document.

The evaluation of the maximum pressure in the package design will be based on the MNOP as it is affected by fire-caused increases in package component temperatures.
Possible increases in the gas inventory, caused by fire-induced thermal combustion or decomposition processes, will be accounted for in the pressure determination and in the gas generation section.

### 7.3.1.2.3.4.4 Maximum Thermal Stresses

There will be an evaluation of the thermal stresses caused by constrained interfaces among the package components resulting from temperature gradients and differential thermal expansions.

### 7.3.1.2.3.5 Evaluation Procedures

The thermal evaluation of a package is based in part on the description and evaluations presented in the general information (Section 7.3.1.2.1) and the structural evaluation (Section 7.3.1.2.2) sections. In addition, results of the thermal evaluation are considered in the evaluation of all other sections. As an aid to the user, an information flow diagram for the thermal evaluation is presented in Figure 7-2.

![Figure 7-2. Thermal Evaluation Flow Diagram](image)

### 7.3.1.2.4 Containment/Confinement Evaluation

This section outlines the elements that are to be addressed for an onsite PSSD to demonstrate acceptable containment/confinement performance based on the performance tests defined in Section 6.5.2.4 and containment/confinement requirements of Section 6.5.2.5 unless filters are
used than it is confinement. The section also defines the acceptable performance criteria for testing and/or analysis to be applied to demonstrate that the package provides an equivalent degree of safety to the regulations in maintaining containment/confine ment, subcriticality, and shielding. It should be noted that in any onsite PSSD, claims of adequacy of designs, or design methods must be supported by technical bases; i.e., by an appropriate engineering evaluation or description of actual tests.

7.3.1.2.4.1 Description of Containment/Confinement

The following information must be provided in the containment/confine ment system description of the packaging.

1. The exact containment/confine ment boundary must be defined. This includes the containment/confine ment vessel, welds, seals, lids, cover plates, valves, and other closure devices. In the case of filtered confinement system packages, containment/confine ment components such as the vessel, closure lid, filter housing, and seals must be defined as the containment/confine ment boundary.

2. All components of the containment/confine ment boundary must be shown and specified on the drawings.

3. The following information provided on the containment/confine ment boundary must be consistent with that provided in the structural and thermal evaluations:
   - Material of construction;
   - Welds;
   - Applicable codes and standards (e.g., ASME BPVC code specifications for the vessel);
   - Bolt torques required to maintain positive closure;
   - Maximum and minimum allowable temperatures of components, including seals; and
   - Maximum and minimum temperatures of components under the tests for NCs and ACs.

4. All containment/confine ment boundary penetrations and their method of closure must be adequately described.

5. Performance specifications for components such as filters, valves, and pressure relief devices must be identified.

6. If penetration into the containment/confine ment boundary is closed by two seals (e.g., to enable leak testing), the containment/confine ment boundary component seal must be defined unless packaging is vented during transport.

7. The radionuclides and physical form of the contents must be provided and consistent with Section 7.3.1.2.1. Any significant daughter products must be provided.

8. The constituents of the releasable source term, including radioactive gases, liquids, and powdered aerosols must be identified and described.
7.3.1.2.4.2 General Requirements

1. Acceptable performance can be demonstrated either by testing or analytically.

2. The package must be demonstrated to satisfy the quantified release rates specified in Sections 6.5.2.5.8 and 6.5.2.5.9, unless the packaging is vented.

3. The maximum permissible volumetric leakage rates based on the allowed release rates specified in Sections 6.5.2.5.8 and 6.5.2.5.9 must be determined for both NC and AC unless the packaging is vented during transport. ANSI N14.5 provides an acceptable method for this determination.

4. The volumetric leakage rates must be converted to standard air leakage in accordance with ANSI N14.5.

5. The evaluation of any flammable gas generation is to be performed in accordance with Section 7.3.1.2.7.

7.3.1.2.4.3 Acceptance Criteria

The package design must be demonstrated to meet the release requirements specified in Sections 6.5.2.5.8 and 6.5.2.5.9 for both filtered and sealed packages. The package must be demonstrated to satisfy the following requirements:

- Any filters and valves (except pressure relief valves) on the package must be demonstrated to be protected against unauthorized operation.

- For filtered packages, the filter must be demonstrated to meet the requirements of Section 6.5.2.5.1. The filters must also be demonstrated to maintain confinement effectiveness under both NC and AC.

- Cover plates and lids must be demonstrated to be protected by recessing or other methods.

- All containment seals and penetrations, including drain and vent ports, must be demonstrated to be leak testable unless the packaging is vented during transport. If fill, drain, or test ports utilize quick-disconnect valves they will be demonstrated not to preclude leak testing of the containment seals.

- Demonstrate no galvanic, chemical, or other reactions will occur between the seal and the packaging or its contents, and that the seal will not degrade due to irradiation.

- Demonstrate that the proper dimensions of the seal grooves are specified for the type and size of seal specified.

- Demonstrate that the temperature of the containment/confinement boundary component seals will remain within their specified allowable limits under both NC and AC.

- Demonstrate that the containment system components are securely closed by a positive fastening device that cannot be opened unintentionally or by a pressure that may arise within the package.

- If less than 100 percent of the contents are considered releasable, a justification for the lower fraction must be provided.
• Elastomeric seal compression must be maintained under both NC and AC loading conditions so as to prevent a permanent compression set of the elastomeric material.

• The containment/confineent system must be demonstrated to satisfy the requirements of Section 6.5.2.5.10.

• For packages equipped with filters, the total release rate must be demonstrated to be with the limits specified in Sections 6.5.2.5.8 and 6.5.2.5.9. This includes accounting for the leakage rate from the confinement system.

7.3.1.2.4.4 Containment under Normal Conditions

1. The package must be demonstrated to satisfy the allowable release rate requirements specified in Section 6.5.2.5.8.

2. The MNOP and maximum temperature must be consistent with those determined in Sections 7.3.1.2.2, 7.3.1.2.3, and 7.3.1.2.7.

3. Using the above pressure and temperature, the maximum permissible leakage rate must be converted to the reference air leakage rate in standard cubic centimeters per second (std cc/s), as defined in ANSI N14.5, unless the packaging is vented.

4. If compliance is demonstrated by testing, the leakage rate of the package subjected to the tests specified in Section 6.5.2.5.8 must not exceed the maximum allowable leakage rate for NC. Leakage testing of scale-model packages may be applicable, but is not necessarily sufficient demonstration of compliance.

5. If compliance is demonstrated by analysis, it must be demonstrated that the package containment boundary components, seal regions, and closure bolts do not undergo any deformations that could result in a breach of the containment boundary or loss of elastomeric seal compression of less than 0.018 cm (0.007 in.). In addition, the materials of the containment/confineent system must be demonstrated not to exceed their maximum allowable temperature limits when subjected to the conditions specified in Section 6.5.2.4.1.

6. As specified in Section 7.3.1.2.11, a leak test must be performed during acceptance testing to demonstrate that the package meets the maximum allowable leakage rate.

7. The amount of decompression of the seal, when subjected to the conditions specified in Section 6.5.2.4.1 must be determined and must be sufficient to maintain containment of the contents.

7.3.1.2.4.5 Containment under Accident Conditions

1. The packaging must be demonstrated to satisfy the allowable release rate requirements specified in Section 6.5.2.5.9, unless vented.

2. The temperatures, pressures, and physical conditions of the package (including contents) must be consistent with those determined in Sections 7.3.1.2.2, 7.3.1.2.3, and 7.3.1.2.7.

3. Using the above pressure and temperature, the maximum permissible leakage rate must be converted to the air leakage rate in standard cubic centimeters per second (std cc/s), as defined in ANSI N14.5, unless packaging is vented.
4. If compliance is demonstrated by testing, the leakage rate of the package subjected to the
   tests specified in Section 6.5.2.5.9 must not exceed the maximum allowable leakage rate
   for AC. Leakage testing of scale-model package may be applicable, but is not necessarily
   a sufficient demonstration of compliance unless vented.

5. If compliance is demonstrated by analysis, it must be demonstrated that the package
   containment boundary components, seal regions, and closure bolts do not undergo any
   deformations that could result in a breach of the containment boundary or loss of
   elastomeric seal compression of less than 0.018 cm (0.007 in.). In addition, the materials
   of the containment/confineent system must be demonstrated not to exceed their
   maximum allowable temperature limits when subjected to the conditions specified in
   Section 6.5.2.4.2.

6. The amount of decompression of the seal when subjected to the conditions specified in
   Section 6.5.2.4.2 must be determined and must be sufficient to maintain containment of
   the contents.

7.3.1.2.4.6 Leakage Rate Tests

1. Based on the reference air leakage rate, it will be demonstrated by providing data that the
   allowable leakage rate for the following conditions is determined in accordance with
   ANSI N14.5:

   a. Fabrication leakage rate test
   b. Periodic leakage rate tests
   c. Assembly (pre-shipment) leakage rate tests

2. The fabrication and periodic leakage rate tests must be included in Section 7.3.1.2.11
   unless otherwise stated in the PSSD or other Packaging Safety Document.

3. The pre-shipment leakage rate test for assembly verification must be included in
   Section 7.3.1.2.11, unless otherwise stated in the PSSD or other Packaging Safety
   Document.

7.3.1.2.4.7 Evaluation Procedures

The containment/confineent evaluation of a package is based in part on the description and
   evaluations presented in the general information and the structural, thermal, and gas generation
   evaluations. In addition, results of the containment/confineent evaluation are considered in the
   evaluation of all other sections. As an aid to the user, an information flow diagram for the
   containment/confineent evaluation is presented in Figure 7-3.

7.3.1.2.5 Shielding Evaluation

This section outlines the elements that are to be addressed for an onsite PSSD to demonstrate
   shielding performance.
7.3.1.2.5.1 Description of Shielding System Design

The description of the shielding system design will include the following:

- Dimensions, tolerances, and densities of material for neutron or gamma shielding, including those packaging components considered in the shielding evaluation.
- Mass density, atomic density, or a real density of materials used as neutron absorbers.
- Structural components that maintain the contents in a fixed position within the package.
- Dimensions of the transport vehicle that are to be considered in the evaluation.
- Maximum dose rates shall be presented for NC and AC at the appropriate locations. If the package is designed for multiple types of contents, the contents producing the highest external dose rate at each location will be clearly identified and evaluated.

![Containment/Confinement Evaluation Flow Diagram](image)

7.3.1.2.5.2 Radiation Source

7.3.1.2.5.2.1 Gamma Source

The maximum gamma source strength and spectra will be calculated in the evaluation. The source contribution from radioactive daughter products will be accounted for. The production of
secondary gamma reactions (e.g., from \([n, \gamma]\) reactions in the shield material) will also be included in the source term.

### 7.3.1.2.5.2.2 Neutron Source

The calculation for the neutron source will consider both spontaneous fission and \((\alpha,n)\) reactions, as appropriate. If either of these source contributions is considered negligible, an appropriate justification will be provided. The production of neutrons from subcritical multiplication will be calculated as part of the evaluation or otherwise appropriately included in the source term. The contribution from spontaneous fission and \((\alpha,n)\) will be separately identified, along with the actinides or light nuclei that are significant for these processes.

### 7.3.1.2.5.3 Shielding Model

If the contents of the package can be positioned at varying locations or with varying densities, the location and physical properties of the contents used in the evaluation will be those resulting in the maximum external radiation levels. Any changes in configuration (e.g., displacement of source or shielding, reduction in shielding) that result under NC or AC will be included, as appropriate.

#### 7.3.1.2.5.3.1 Material Properties

The appropriate material properties (e.g., mass densities and atom densities) will be used in the shielding models of the packaging, contents, and conveyance (if applicable). Any changes resulting under NC and AC will be included as appropriate. For example, the melting of lead is not acceptable under either NC. Shielding properties will not degrade during the service life of the packaging (e.g., degradation of foam or dehydration of hydrogenous materials).

If the shielding model considers a homogeneous source region, rather than a detailed heterogeneous model of the contents, the approach will be justified. It will also be verified that the homogenized mass densities are correct for NC and AC.

### 7.3.1.2.5.4 Shielding Evaluation

#### 7.3.1.2.5.4.1 Methods

The methods used for the shielding evaluation will be appropriate. Standard computer programs used will be referenced and evidence of verification and benchmarking shall be provided. Other codes or methods will be described in the document, and the appropriate supplemental information shall be provided. The number of dimensions of the code will be appropriate for the package geometry.

The cross-section library used by the code will be applicable for the shielding calculations. The code will account for subcritical multiplication and secondary gamma production unless these conditions have been considered elsewhere (e.g., in the source term specification).

#### 7.3.1.2.5.4.2 Input and Output Data

Key input data for the shielding calculations will be identified. The key input data depend on the type of code, as well as the code itself. The document will include representative input files used in the analyses.
Representative output files will be included in the PSSD. The calculated dose rates from the output files will agree with those called out in the text. For computer programs that are based on the Monte Carlo method, proper convergence will be achieved.

7.3.1.2.5.4.3 Flux to Dose Rate Conversion

Gamma and neutron flux will be properly converted to dose rates. This conversion should generally use ANSI/ANS 6.1.1-1977, “Neutron and Gamma-Ray Flux-to-Dose-Rate Factors,” although other conversions may be used for point-kernel gamma calculations.

7.3.1.2.5.4.4 External Radiation Levels

External radiation levels under NC and AC will meet the appropriate limits. The analyses will show that the locations selected are those with the maximum dose rates. To determine maximum dose rates, radiation levels may be averaged over the cross-sectional area of a probe of reasonable size. For packages with streaming paths or voids, averaging should not be used to reduce the radiation levels resulting from such features.

The evaluation will address damage to the shielding under NC and AC. Any damage under NC will not exceed allowable limits. Any increase will be explained and justified as not significant.

7.3.1.2.5.4.5 Evaluation Procedures

The shielding evaluation of a package is based in part on the description and evaluations presented in Section 7.3.1.2.4.5. In addition, results of the shielding evaluation are considered in the evaluation of all other sections. As an aid to the user, an information flow diagram for the shielding evaluation is presented in Figure 7-4.
7.3.1.2.6 Criticality Evaluation

7.3.1.2.6.1 Equivalent and Risk based Packaging Requirements

A package used for the shipment of fissile material must be designed and constructed, and its contents limited so that it would be subcritical if water were to leak into the containment system, or liquid contents were to leak out of the containment system. Consequently, the contents shall be demonstrated to remain subcritical under the following conditions:

- The most reactive credible configuration consistent with the chemical and physical form of the material.
- Moderation by water to the most reactive credible extent.

Close full reflection of the containment system by water on all sides, or such greater reflection of the containment system as may additionally be provided by the surrounding material of the packaging.

A package that is used for the shipment of fissile material will be demonstrated to remain subcritical under NC by demonstrating that:

- The contents will be subcritical.
- The geometric form of the package contents will not be substantially altered.
- There will be no leakage of water into the containment system unless, in the evaluation of undamaged packages, it has been assumed that moderation is present to such an extent as to cause maximum reactivity consistent with the chemical and physical form of the material.
- There will be no substantial reduction in the effectiveness of the packaging including:
  - No more than 5 percent reduction in the total effective volume of the packaging on which nuclear safety is assessed.
  - No more than 5 percent reduction in the effective spacing between the fissile contents and the outer surface of the packaging.
  - No occurrence of an aperture in the outer surface of the packaging large enough to permit the entry of a 10 cm (4 in.) cube.

A package that is used for the shipment of fissile material will be demonstrated to remain subcritical under AC. To demonstrate this, the following assumptions will be made:

- The fissile material is in the most reactive credible configuration consistent with the damaged condition of the package, and the chemical and physical form of the contents.
- Water moderation occurs to the most reactive credible extent consistent with the damaged condition of the package, and the chemical and physical form of the contents.
- There is full reflection by water on all sides, as close as is consistent with the damaged condition of the package.
A fissile material package must be controlled by the shipper or the carrier during transport to ensure that the array of packages remains subcritical. To verify this control, the fissile material package will be demonstrated to have a number “N” based on the following conditions being satisfied, assuming the packages are stacked together in any arrangement and with close full reflection on all sides of the stack by water:

- Five times “N” undamaged packages with nothing between the packages would be subcritical.
- Two times “N” damaged packages, if each package were subjected to the AC tests would be subcritical with optimum interspersed hydrogenous moderation.
- The value of “N” cannot be less than 0.5.

7.3.1.2.6.2 Description of Criticality Control Design

Design features that will be included in the criticality evaluation are as follows:

- Dimensions and tolerance of the containment system for fissile material.
- Structural components that maintain the fissile material or neutron poisons in a fixed position within the package or in a fixed position relative to each other.
- Location, dimensions, and concentration of neutron absorbing materials and moderating materials, including neutron poisons and shielding material.
- Dimensions and tolerances of floodable voids and flux traps within the package.
- Dimensions and tolerances of the overall package that affect the physical separation of the fissile material contents in package arrays.

The following cases will be addressed:

- A single package
- An array of undamaged packages
- An array of damaged packages

Based on the number of packages evaluated in the arrays, the appropriate N should be determined and the CSI calculated.

7.3.1.2.6.3 Fissile Content

Specifications that will be included in the criticality evaluation include fissile material mass, dimensions, enrichment, physical and chemical composition, density, moisture, and other characteristics that are dependent on the specific contents. Because a partially filled container may allow more room for moderators (e.g., water), the most reactive case may be for a mass of fissile material that is less than the maximum allowable contents.

If the package is designed for multiple types of contents, a separate criticality evaluation and proposal for different criticality controls for each content type may be included. Any assumptions that certain contents need not be evaluated because they are less reactive than evaluated contents will also be properly justified.
7.3.1.2.6.4 General Considerations

The following considerations are applicable to the criticality evaluations of a single package and arrays of packages under NC and AC.

7.3.1.2.6.4.1 Model Configuration

The models used in the criticality calculation will be consistent with the effects on the packaging and its contents during NC and AC. The dimensions of the contents and the packaging used in the model will be correct. For some types of packaging and contents (e.g., powders), the contents can be positioned at varying locations and densities. The relative location and physical properties of the contents within the packaging will be justified as those resulting in the maximum multiplication factor. Dimensional tolerances (e.g., for cavity sizes and poison thickness) will be considered in a manner that maximizes reactivity.

7.3.1.2.6.4.2 Material Properties

The appropriate mass densities and/or atom densities will be provided for materials used in the models of the packaging and contents. Material properties will be consistent with the condition of the package under the NC and AC tests, and any difference between the NC and AC will be addressed.

The materials will be relevant to the criticality design (e.g., poisons, foams, plastics, and other hydrocarbons) and properly specified. No more than 75 percent of the specified minimum neutron poison concentration should generally be considered in the criticality evaluation. The materials will not degrade during the service life of the packaging.

7.3.1.2.6.4.3 Computer Codes and Cross-Section Libraries

An appropriate computer code, or other acceptable method, will be used for the criticality evaluation. Standard codes will be referenced. Other codes or methods will be described and any appropriate supplemental information will be provided.

Criticality evaluations will also use an appropriate cross-section library. If multi-group cross sections are used, it will be confirmed that the neutron spectrum of the package has been appropriately considered and that the cross sections are properly processed to account for resonance absorption and self-shielding.

The code will be properly used for the criticality evaluation. Key input data for the criticality calculations will be identified. These include the number of neutrons per generation, number of generations, convergence criteria, mesh selection, etc., depending on the code that is used.

At least one representative input file for a single package, undamaged array, and damaged array evaluation will be included in the document. It will be verified that the information from the criticality model, material properties, and cross sections is properly input into the code, and that the calculation has properly converged.

7.3.1.2.6.4.4 Demonstration of Maximum Reactivity

The analysis will demonstrate that the most reactive configuration for a single package, an array of undamaged packages, and an array of damaged packages has been analyzed. Any assumptions and approximations will be clearly identified and justified.
The analysis will determine the optimum combination of internal moderation (within the package) and interspersed moderation (between packages), as applicable. It will be confirmed that preferential flooding of different regions within the package is considered as appropriate. Note that the maximum allowable fissile material quantity is not necessarily the most reactive contents.

7.3.1.2.6.5 Single Package Evaluation

7.3.1.2.6.5.1 Configuration

The criticality evaluation will demonstrate that a single package is subcritical under both NC and AC. The evaluations will consider the following:

- Fissile material in its most reactive credible configuration consistent with the condition of the package, and the chemical and physical form of the contents.
- Water moderation to the most reactive credible extent, including water inleakage to the containment system.
- Full water reflection on all sides of the containment system, or reflection by the package materials, whichever results in the maximum reactivity.

7.3.1.2.6.5.2 Results

The package shall meet the requirements outlined in Section 7.3.1.2.6.1. If a package can be shown to be subcritical by reference to a standard in lieu of calculations, it will be verified that the standard is applicable to the package conditions.

7.3.1.2.6.6 Normal Conditions Evaluation of Package Arrays

7.3.1.2.6.6.1 Configuration

The criticality evaluation will demonstrate that an array of 5N packages is subcritical under NC. The evaluation will consider the following:

- The most reactive configuration of the array (e.g., pitch and package orientation) with nothing between the packages.
- The most reactive credible configuration of the packaging and its contents under NC. The analysis for the array of undamaged packages may assume that the packages are dry internally, provided that there is no water leakage into the package, including the containment system, when the package is subjected to the tests specified in 10 CFR 71.71.
- Full water reflection on all sides of a finite array.

7.3.1.2.6.6.2 Results

The most reactive array conditions will be clearly identified and the results of the evaluation consistent with information presented in the document.

The appropriate N value will be used to determine the CSI. The appropriate N should be the smaller value that ensures subcriticality for 2N packages under AC or 5N packages under NC.
7.3.1.2.6.7 Benchmark Evaluations

Computer codes for criticality calculations will be benchmarked against critical experiments. The analysis of the benchmark experiments will use the same computer code, hardware, and cross-section library as those used to calculate the $k_{\text{eff}}$ values for the package.

7.3.1.2.6.7.1 Applicability of Benchmark Experiments

Benchmark experiments will be applicable to the actual packaging design and contents. Benchmark experiments will have, to the maximum extent possible, the same materials, neutron spectra, and configuration as the package evaluations. Key package parameters that will be compared with those of the benchmark experiments include type of fissile material, enrichment, hydrogen/uranium ratio, poison, and configuration. Differences between the package and benchmarks will be identified and properly considered.

Furthermore, overall quality of the benchmark experiments and uncertainties in the experimental data (e.g., mass, density, dimensions) will be addressed.

7.3.1.2.6.7.2 Bias Determination

Results of the calculations for the benchmark experiments and the method used to account for the biases will be discussed, including the contribution from uncertainties in the experimental data.

A sufficient number of appropriate benchmark experiments will be analyzed, and the results of the benchmark calculations will be used to determine an appropriate bias for the package calculations. The benchmark evaluations will address trends in the bias with respect to parameters such as pitch-to-rod diameter, assembly separation, neutron absorber material, etc. Only negative biases (results that under predict $k_{\text{eff}}$) will be considered, with positive bias results treated as zero bias.

Statistical and convergence uncertainties of benchmark calculations will also be considered. The uncertainties will not significantly affect the results.

7.3.1.2.6.8 Evaluation Criteria for Subcriticality

7.3.1.2.6.8.1 Summary

The CFR does not define the evaluation criteria to determine what is safely subcritical; subsequently, the following criteria are to be used for onsite transport evaluations:

- For equivalency with NRC regulatory guidelines, a $k_{\text{eff}}$ limit of 0.95, including consideration of bias and uncertainties, will be used in the criticality evaluation of packages for transportation on the Hanford Site. Packages demonstrated to have a $k_{\text{eff}}$ limit exceeding 0.95 require RL approval:

- For systems in which the total mass of fissile material per shipment is less than the minimum critical mass of $^{239}$Pu (or $^{235}$U if no plutonium is present) in aqueous mixtures as specified in ANSI/ANS-8.1-1998 (“Nuclear Criticality Safety in Operations with Fissionable Materials Outside Reactors,” p. 5), the criticality evaluation will not include extensive computer evaluations because of the wide acceptance of the limits in ANSI/ANS-8.1-2014.
7.3.1.2.6.8.2 Systems with a Small Fissile Mass Content

Based on ANSI/ANS-8.1-2014, extensive computer evaluations of systems are not required when the total fissile mass content per shipment is less than the subcritical limit for fissile isotopes in solution as shown in Table 1 of ANSI/ANS-8.1-1998. For $^{239}$Pu, this limit is 0.48 kg (480 g). For $^{235}$U this limit is 0.76 kg (760 g). For mixtures of fissile isotopes, the limit for $^{239}$Pu may be used. An administrative safety margin may be used to reduce the maximum allowable fissile mass to account for uncertainties in the fissile mass measurement or for other uncertainties.

7.3.1.2.6.9 Evaluation Procedures

The criticality evaluation relies on other inputs/evaluations. In addition, results of the criticality evaluation are considered in the evaluation of other sections. As an aid to the user, an information flow diagram for the criticality evaluation is presented in Figure 7-5.

7.3.1.2.7 Gas Generation

This section defines the requirements to demonstrate acceptable performance for onsite packaging in which the concentration of flammable gases within the package void volume has the potential to exceed one half the LEL. For Hydrogen gas, the value is 5 vol%. The requirements of this section do not apply to packages that have no flammable gas generation potential. The acceptable performance requirement is that the package must maintain containment/confinement, subcriticality, and shielding of the contents under both NC and AC. The section also defines the acceptable performance criteria for testing and/or analysis to be applied to demonstrate that the packaging provides an equivalent degree of safety to the regulations. It should be noted that in any onsite PSSD, claims of adequacy of designs or design methods must be supported by technical bases; i.e., by an appropriate engineering evaluation or description of actual tests.
7.3.1.2.7.1 Description of the Package

The following information must be provided in the description of the package:

- The containment/confinement boundary must be exactly defined and confined spaces must be identified.
- Design pressure of the containment components must be identified.
- Content of the package and sources of flammable gas generation must be identified.
- Radioactive material source terms and moisture content of the payload must be identified.
- Rate of flammable gas generation.
• Any venting features of the containment/confinece boundary to prevent pressurization.
• Any operational controls such as purging with inert gas prior to shipment or use of getters and/or recombiners shall be identified.
• The void volume of the package must be defined.

7.3.1.2.7.2 Material Properties and Characteristics
The following information must be provided and/or demonstrated in describing the material properties of the contents and the materials of construction of the packaging:
• Material properties of the packaging must be provided.
• Description of the gas generating sources of the contents must be provided.
• Any potentially flammable mixture of vapors or gases that could form in the containment vessel of a package must be identified and chemical characteristics provided.

7.3.1.2.7.3 Acceptable Performance Criteria
The fundamental approach is to allow for shipment of potentially flammable mixtures inside a shipping package, provided the primary requirements of containment/confinece, subcriticality, and shielding are satisfied.

1. Acceptable performance can be demonstrated either by testing or by analysis using the gas generation evaluation methodology of PRC-PRO-WM-52512 or equivalent.

2. Evaluate the package gas generation potential under NC, by testing or by analysis using the methodology of PRC-PRO-WM-52512 or equivalent, to determine whether the package void exceeds one-half the LEL. For Hydrogen gas, the value is 5 vol% flammable gas during a period of one year consistent with NUREG-1609.

The one-year period begins when the package is prepared for transport.

The initial flammable gas concentration, which by default must be less than one-half the LEL. (For Hydrogen gas, the value is 5 vol%), is taken as the concentration at the time of preparation for transport.

a. For packages shown to exceed one-half the LEL. (For Hydrogen gas, the value is 5 vol%) flammable gas within one year after preparation for transport:
   i. The expected transport time, or shipping window, must be one-half the time to reach one-half the LEL consistent with NRC Information Notice 84-72, Clarification of Conditions for Waste Shipments Subject to Hydrogen Gas Generation.
   ii. In the event that transport is not completed within the shipping window per NRC Information Notice 84-72, one of the following must occur:
      1. The package atmosphere may be inerted (sealed packages only).
      2. The package atmosphere may be periodically purged to reset the shipping window clock.
3. The package may be reevaluated for a new shipping window starting at a higher flammable gas concentration.

4. The package may be designed to withstand a bounding deflagration.

5. The package contents may be repackaged into a package of different design or one that is risk based.

6. For packages that will exceed one–half the LEL flammable gas within one year from date of preparation for transport: If the package cannot be transported within one-half the time to reach one–half the LEL vol% from its flammable gas concentration at the time of preparation for transport, either the package atmosphere must be inerted (sealed packages only) or the package must be designed to withstand a deflagration (sealed or vented packages).

   b. For packages that do not exceed one–half the LEL vol% flammable gas within one year after preparation for transport:

      i. The shipping window is conservatively set for one year.

      ii. In the event that transport is not completed within the one–year period, reevaluate the package in accordance with Section 7.3.1.2.7.3.2.

   c. Evaluation procedures: As an aid to the user, an information flow diagram for flammable gas generation evaluation is presented in Figure 7-6.

3. MNOP, including the maximum gas generated over the life of the package, must be less than the design pressure for the package containment boundary.

4. Maximum design pressure for the package containment boundary or the confinement boundary with a sealed vent must be less than the burst pressure.

5. Containment boundary components must be demonstrated to maintain containment/confinement, shielding, subcriticality under the sequence of AC performance tests specified in Section 6.5.2.4.2.

6. Maximum deflagration pressure from the worst-case flammable gas mixture must be less than the containment vessel design pressure at normal operating temperatures.

7. Containment/confine boundary burst pressure must not be exceeded under ACs.
8. The internal pressure increase from potential flammable gas generation within the containment/confinement boundary must not exceed the design pressure under normal operating conditions.

9. A deflagration to detonation transition (DDT) must not occur under worst-case flammable gas generation conditions under NC.

10. Filter and other pressure relieving components must be capable of sustaining deflagration pressures as well as all NCs and ACs without loss of effectiveness.
7.3.1.2.7.4 General Considerations

The evaluation of flammable gas mixtures within shipping packages is primarily a gas generation and structural evaluation of the containment/confine ment boundary. In general, the evaluation of radiation shielding and criticality should not be impacted by the gas mixture inside the containment/confinement boundary. The evaluation must demonstrate that the package meets the performance test requirements defined in Section 6.5.2.4; design requirements defined in Section 6.5.2.5; and the requirements provided in Section 7.3.1.2.7.3. The evaluation must also address the following:

The most limiting initial conditions must be used as defined in Section 6.5.2.5.10, and Table 6-6. Evaluation methods are appropriate for the loading conditions considered and follow accepted practices and precepts.

When filtered venting devices are used, the minimum airflow rate must be 200 mL/min (12.20 in$^3$/min) at a pressure differential of 1.9 mm Hg (1.0 in. water gauge). Filtered venting devices will have a minimum aerosol efficiency of 99.97 percent at 0.45 µm dioctylphthalate particle diameter.

When getters and/or recombiners are used, issues and/or conditions that must be addressed include, but are not limited to, the following:

- Bounding credible scenarios for calculations and/or testing must be assumed.
- Getter and/or recombiner operational life and capacity before and after shipment must be identified. Communication pathways between the getter and/or recombiner and hydrogen gas (e.g., the pathway for hydrogen gas in a bag inside the package to the getter located in the inner containment vessel headspace) must be identified.
- Getters and/or recombiners must be compatible with the payload and packaging.
- Generation of free liquids (water) from the getter and/or recombiner must be addressed.
- Temperature effects of getter and/or recombiner reaction on the packaging and payload must be considered.
- Gettering reversibility must be addressed.
- Minimum operating pressure related to the getter and/or recombiner performance must be addressed.
- Getter materials and/or recombiner must be engineered into a form (i.e., matrix, structure, and package) so that it can be located within the confines of the package or inner containment vessel.

It must be shown that any increase in pressure or chemical reactions within the containment vessel due to these vapors or gases could not significantly reduce package effectiveness.

The maximum quantity of fission gas products that could be available for release in the containment vessel shall be identified. The source term shall be specified, all parameters and assumptions pertinent to the calculation of fission gas products presented, and any data used
supported by appropriate references. When it is appropriate, sample calculations will be presented.

7.3.1.2.7.4.1 Evaluation by Testing

If the package performance is demonstrated by testing, the onsite PSSD must include the following:

- Objective and description of the test and procedures used. The description must also include initial pressure and temperatures. For packages equipped with filters, ambient pressure may be used. However, normal operating temperature must be used.
- Description of the test equipment used (i.e., ranges, accuracy, gas mixing devices, gas mixture, gas generate rate, and response time).
- Deflagration tests on the containment/confined vessel may be performed on a separate undamaged unit.
- The sequence of tests specified in Section 6.5.2.4.2 must be performed with the initial pressure of the deflagration pressure.
- The test specimen must have been fabricated using the same materials, methods, and QA as specified in the design. Any differences must be identified and the effects evaluated. Substitutes for the contents should have the same representative weight as the actual contents.
- All test results must be evaluated and their implications interpreted, including interior and exterior damage of the test specimen. Unexpected or unexplained test results indicating possible testing problems or non-reproducible specimen behavior must be described and evaluated.
- Videos, photographs, and test data of the tests must be provided as records and maintained available for review.
- Margins of safety of the package design must be evaluated against the test results.
- Criteria for evaluating pass/fail for the test conditions must be provided and used as a comparison with the test results.

7.3.1.2.7.4.2 Evaluation by Analysis

If the package performance is demonstrated by analysis, the onsite PSSD must include the following:

- A clear description of the calculations and all assumptions must be provided.
- A clear description of the calculational parameters and methods used to determine gas generation rate and heat generated.
- The methods used for the gas generation evaluation will be appropriate. Any computer programs used will be referenced and evidence of verification and benchmarking shall be provided. Other codes or methods will be described in the document, and the appropriate supplemental information will be provided. The number of dimensions of the code will be appropriate for the package geometry. The models used in the gas generation
calculation will be consistent with the effects on the packaging and its contents during NC and AC.

- All source terms will be specified, all parameters and assumptions pertinent to the calculation of the internal pressure presented, and any data used will be supported by appropriate references. When it is appropriate, sample calculations will be presented.

- Material properties and models must be appropriate for the cases evaluated. The material properties must be consistent with the analytical methods.

- A summary of results must be provided that compare results of the analyses with the acceptable performance criteria established in Section 7.3.1.2.7.3. For deflagration only, ASME BPVC, Section III, Service Level C limits must be applied, as a minimum.

### 7.3.1.2.7.5 Normal Condition Evaluation

1. Flammable gas generation under NC must be evaluated per the requirements of Section 7.3.1.2.7.3.2 and subsections thereof.

2. The MNOP, including the maximum gas generated over the life of the package, must be demonstrated to be less than the design pressure for the package containment boundary, unless vented.

3. Design pressure on the containment boundary or a sealed confinement boundary must be demonstrated to be less than the burst pressure of the system.

4. A DDT must be demonstrated not to occur under the worst case NC flammable gas generation conditions.

5. The maximum deflagration pressure from the worst-case flammable gas mixture must be less than the design pressure of the containment boundary or a sealed confinement boundary under normal operating conditions.

### 7.3.1.2.7.6 Accident Conditions Evaluation

1. Containment boundary or sealed components of a confinement boundary must be demonstrated to maintain containment, subcriticality, and shielding under the sequence of AC performance tests.

2. Containment boundary or sealed components of a confinement boundary burst pressure must be demonstrated not to be exceeded under ACs. This evaluation must be based on the greatest possible pressure difference.

3. Initial pressure at which the sequence of AC tests are to be evaluated must be equal to at least the MNOP under ambient conditions.

### 7.3.1.2.8 Tiedown and Load Securement

This section outlines the elements that are to be addressed for a Packaging Safety Document to demonstrate acceptable tiedown system performance based on the requirements defined in Section 6.5.2.5.3. The section also defines the acceptable performance criteria for which analysis should be applied. It should be noted that in any tiedown performance assessment,
claims of adequacy of designs or design methods must be supported by technical bases; i.e., by an appropriate engineering evaluation or description of actual tests.

7.3.1.2.8.1 Description of Tiedown System

The following information must be provided in the tiedown description for the package:

- Description of the tiedown system securing the package to the conveyance.
- Weights and center of gravity of the package.
- Description of all tiedown hardware and system for blocking and bracing the package.
- Tiedown system design drawings, sketches, and/or free body diagrams will be provided for all but the simplest tiedowns used for packages with a small mass.
- Restrictions and other concerns for securing the package will be stated in this section.

7.3.1.2.8.2 Evaluation Requirements

The following information must be provided in the tiedown evaluation for the package:

- All assumptions will be clearly identified in the evaluation. The basis for and justification of the conservatism for the assumptions shall be provided.
- Required working load limits and ratings for all tiedown assembly components, except for tie-down devices that are a structural part of the package, will be determined based on the loadings established by DOT regulations specified in 49 CFR 393, Subpart I.
- Working load limits and/or ratings of all tiedown components (including the conveyance attachment points) and the margins of safety will be provided in tabulated form.
- Minimum load capacity of the conveyance will be established.
- Flexibility of the conveyance and road induced vibration may cause loosening or failure of the tiedowns. As a consequence, the tiedown load paths will be demonstrated to be direct as possible without compromising any required configuration constraints.
- The evaluation will identify all restrictions to the tiedown system and conveyance that must be incorporated into the operating procedures. These restrictions may include interface materials, blocking restrictions, allowable bearing surfaces, feasibility of placing cargo on the package, stacking, temperature restrictions, center of gravity locations, package orientation, or electrical power, pneumatic, or hydraulic requirements.
- The evaluation will identify when a direct tiedown (low pretension, stretching permitted) is being used and when an indirect tiedown (high pretension, limited stretching) is being used.
- As part of the evaluation, an inspection checklist will be developed in accordance with Section 7.3.1.2.10 and incorporated into Packaging Safety Document. As a minimum, the inspection will include a visual inspection of the main conveyance beam, web to flange welds, beam webs, and tiedown components for any signs of distortion or failure prior to release of the package for shipment.
• The evaluation will address the conveyance tiedown points. As conveyance tiedown points are not always rated, the evaluation must identify or determine the load capacity and geometry of loading. The evaluation must also demonstrate conservatism of and basis for any assumptions concerning the capacity of the tiedown points.

7.3.1.2.9 Quality Assurance

This section identifies the quality requirements to be used when implementing the equivalent packaging requirements. DOE QA requirements for onsite T&P activities are identified in 10 CFR 830, Subpart A; DOE O 414.1D, and other older orders. The use of alternatives to DOT packagings for onsite shipments is authorized in DOE O 460.1C. The following paragraphs identify QA requirements to be included in the PSSD and in QAPs for activities associated with the design fabrication, maintenance, storage, and use of onsite Type B and fissile packages.

7.3.1.2.9.1 Quality Requirements

The QAP should contain the following information:

• The QAP shall include a discussion of how the criteria of Section 7.3.1.2.9.2.2 will be satisfied. The criteria of paragraph 7.3.1.2.9.3.1 shall be applied using a graded approach. The implementing organization(s) shall use appropriate standards, wherever applicable, to develop and implement its QAP. For fissile and Type B quantity packagings, the standard should be NQA-1. The implementing QAP will have the approval of the applicable DOE organization. If the implementing QAP has not been approved by DOE, it will be submitted for approval.

• An implementing organization may, at any time, make changes to an approved QAP. Changes made over the previous year will be submitted annually to the applicable DOE organization for review. A submittal will identify the changes, the pages affected, the reason for the changes, and the basis for concluding that the revised QAP continues to satisfy the requirements of this section. Changes made to correct spelling, punctuation, or other editorial items do not require explanation.

• Implementation plans and QAPs will be regarded as approved by DOE 90 days after submittal, unless approved or rejected by DOE at an earlier date, and shall include any modification made or directed by DOE.

7.3.1.2.9.2 Quality Program and Acceptance Criteria

The Packaging Safety Document will identify that the following criteria are to be implemented by a QAP that implements the quality requirements necessary to ensure the safety associated with the package.

7.3.1.2.9.2.1 QA Organization

The users of a packaging are responsible for the establishment and execution of the QAP. The user may delegate to others, such as contractors, agents, or consultants, the work of establishing and executing the QAP, or any part of the QAP, but shall retain responsibility for the program. The user will clearly establish and delineate, in writing, the authority and duties of persons and organizations performing activities affecting the safety-related functions of structures, systems,
or components (SSC). These activities include performing the functions associated with attaining quality objectives and the QA functions.

The QA functions are as follows:

- Ensuring that an appropriate QAP is established and effectively executed.
- Verifying, by procedures such as checking, auditing, and inspection, that activities affecting the safety-related functions have been performed correctly.

The persons and organizations performing QA functions must have sufficient authority and organizational freedom to:

- Identify quality problems
- Initiate, recommend, or provide solutions
- Verify implementation of solutions.

The persons and organizations performing QA functions will report to a management level person to ensure that the required authority and organizational freedom, including sufficient independence from cost and schedule.

Because of the many variables involved, such as the number of personnel, the type of activity being performed, and the location or locations where activities are performed, the organizational structure for executing the QAP may take various forms, provided that the persons and organizations assigned the QA functions have the required authority and organizational freedom.

Regardless of the organizational structure, the individual(s) assigned the responsibility for ensuring effective execution of any portion of the QAP, at any location where activities subject to this section are being performed, must have direct access to the levels of management necessary to perform this function.

7.3.1.2.9.2.2 QAP

The user will establish, at the earliest practicable time consistent with the schedule for accomplishing the activities, a QAP that complies with the requirements of this paragraph. The user shall document the QAP by written procedures or instructions and will carry out the program in accordance with those procedures throughout the period during which the packaging is used. The user will identify the material and components to be covered by the QAP, the major organizations participating in the program, and the designated functions of these organizations.

The user, through its QAP, will provide control over activities affecting the quality of the identified materials and components to an extent consistent with their importance to safety, and as necessary to ensure conformance to the approved design of each individual package used for the shipment of radioactive material. The user will ensure that activities affecting quality are accomplished under suitably controlled conditions. Controlled conditions include the use of appropriate equipment; suitable environmental conditions for accomplishing the activity, such as adequate cleanliness; and assurance that all prerequisites for the given activity have been satisfied. The user will take into account the need for special controls, processes, test equipment, tools, and skills to attain the required quality, and the need for verification of quality by inspection and test.
The user will base the requirements and procedures of its QAP on the following considerations concerning the complexity and proposed use of the package and its components:

- Impact of malfunction or failure of the item to safety
- Design and fabrication complexity or uniqueness of the item
- Need for special controls and surveillance over processes and equipment
- Degree to which functional compliance can be demonstrated by inspection or test
- Quality history and degree of standardization of the item

The user will provide for indoctrination and training of personnel performing activities affecting quality, as necessary, to ensure that suitable proficiency is achieved and maintained. The user will review the status and adequacy of the QAP at established intervals. Management of other organizations participating in the QAP will regularly review the status and adequacy of that part of the QAP they are executing.

### 7.3.1.2.9.2.3 Package Design Control

The user will establish measures to ensure that applicable regulatory requirements and the package design, as specified in the approval for those materials and components to which this section applies, are correctly translated into specifications, drawings, procedures, and instructions. These measures must include provisions to ensure that appropriate quality standards are specified and included in design documents and that deviations from standards are controlled. Measures must be established for the selection and review for suitability of application of materials, parts, equipment, and processes that are essential to the safety-related functions of the materials, parts, and components of the packaging.

The user will establish measures for the identification and control of design interfaces and for coordination among participating design organizations. These measures must include the establishment of written procedures, among participating design organizations, for the review, approval, release, distribution, and revision of documents involving design interfaces. The design control measures must provide for verifying or checking the adequacy of design by methods such as design reviews, alternate or simplified calculational methods, or by a suitable testing program. For the verifying or checking process, the user will designate individuals or groups other than those who were responsible for the original design, but who may be from the same organization. Where a test program is used to verify the adequacy of a specific design feature in lieu of other verifying or checking processes, the user shall include suitable qualification testing of a prototype or sample unit under the most adverse design conditions. The user shall apply design control measures to items such as the following:

- Criticality physics, radiation shielding, stress, thermal, hydraulic, and accident analyses
- Compatibility of materials
- Accessibility for in-service inspection, maintenance, and repair
- Features to facilitate decontamination
- Delineation of acceptance criteria for inspections and tests.
• The user will subject design changes, including field changes, to design control measures commensurate with those applied to the original design.

7.3.1.2.9.2.4 Procurement Document Control

The user will establish measures to ensure that adequate quality is required in the documents for procurement of material, equipment, and services, whether purchased by the user or by its contractors or subcontractors. To the extent necessary, the user will require contractors or subcontractors to provide a QAP consistent with the applicable provisions of this TSD.

7.3.1.2.9.2.5 Instructions, Procedures, and Drawings

The user will prescribe activities affecting quality by documented instructions, procedures, or drawings of a type appropriate to the circumstances and shall require that these instructions, procedures, and drawings be followed. The instructions, procedures, and drawings must include appropriate quantitative or qualitative acceptance criteria for determining that important activities have been satisfactorily accomplished.

7.3.1.2.9.2.6 Document Control

The user will establish measures to control the issuance of documents such as instructions, procedures, and drawings, including changes, which prescribe all activities affecting quality. These measures must ensure that documents, including changes, are reviewed for adequacy, approved for release by authorized personnel, and distributed and used at the location where the prescribed activity is performed. These measures must ensure that changes to documents are reviewed and approved.

7.3.1.2.9.2.7 Control of Purchased Material, Equipment, and Services

The user will establish measures to ensure that purchased material, equipment, and services, whether purchased directly or through contractors and subcontractors, conform to the procurement documents. These measures must include provisions, as appropriate, for source evaluation and selection, objective evidence of quality furnished by the contractor or subcontractor, inspection at the contractor or subcontractor source, and examination of products on delivery.

The user will have available documentary evidence that materials and equipment conform to the procurement specifications before installation or use of the material and equipment. The user will retain, or have available, this documentary evidence for the life of the package to which it applies. The user will ensure that the evidence is sufficient to identify the specific requirements met by the purchased material and equipment.

The user will assess the effectiveness of the control of quality by contractors and subcontractors at intervals consistent with the importance, complexity, and quantity of the product or services.

7.3.1.2.9.2.8 Identification and Control of Materials, Parts, and Components

The user will establish measures for the identification and control of materials, parts, and components. These measures must ensure that identification of the item is maintained by heat number, part number, or other appropriate means, on the item or on records traceable to the item, as required throughout fabrication, installation, and use of the item. These identification and
control measures must be designed to prevent the use of incorrect or defective materials, parts, and components.

7.3.1.2.9.2.9 Control of Special Processes

The user will establish measures to ensure that special processes, including welding, heat treating, and nondestructive testing, are controlled and accomplished by qualified personnel using qualified procedures in accordance with applicable codes, standards, specifications, criteria, and other special requirements.

7.3.1.2.9.2.10 Internal Inspection

The user will establish and execute a program for inspection of activities affecting quality by or for the organization performing the activity, to verify conformance with the documented instructions, procedures, and drawings for accomplishing the activity. The inspection must be performed by individuals other than those who performed the activity being inspected. Examination, measurements, or tests of material or products processed must be performed for each work operation where necessary to ensure quality. If direct inspection of processed material or products is not carried out, indirect control by monitoring processing methods, equipment, and personnel must be provided. Both inspection and process monitoring must be provided when quality control is inadequate without both. If mandatory inspection hold points, which require witnessing or inspecting by the user's designated representative, the work should not proceed without the consent of its designated representative are required, the specific hold points must be indicated in appropriate documents.

7.3.1.2.9.2.11 Test Control

The user will establish a test program to ensure that all testing required to demonstrate that the packaging components will perform satisfactorily in service is identified and performed in accordance with written test procedures that incorporate the requirements of this TSD and the requirements and acceptance limits contained in the package approval. The test procedures must include provisions for ensuring that all prerequisites for the given test are met, that adequate test instrumentation is available and used, and that the test is performed under suitable environmental conditions. The user will document and evaluate the test results to ensure that test requirements have been satisfied.

7.3.1.2.9.2.12 Control of Measuring and Test Equipment

The user will establish measures to ensure that tools, gauges, instruments, and other measuring and testing devices used in activities affecting quality are properly controlled, calibrated, and adjusted at specified times to maintain accuracy within necessary limits.

7.3.1.2.9.2.13 Handling, Storage, and Shipping Control

The user will establish measures to control, in accordance with instructions, the handling, storage, shipping, cleaning, and preservation of materials and equipment to be used in packaging to prevent damage or deterioration. When necessary for particular products, special protective environments, such as inert gas atmosphere, and specific moisture content and temperature levels, must be specified and provided.
7.3.1.2.9.2.14 Inspection, Test, and Operating Status

The user will establish measures to indicate, by the use of markings such as stamps, tags, labels, routing cards, or other suitable means, the status of inspections and tests performed upon individual items of the packaging. These measures must provide for the identification of items that have satisfactorily passed required inspections and tests where necessary to preclude inadvertent bypassing of the inspections and tests.

The user will establish measures to identify the operating status of components of the packaging, such as tagging valves and switches, to prevent inadvertent operation.

7.3.1.2.9.2.15 Nonconforming Materials, Parts, or Components

The user will establish measures to control materials, parts, or components that do not conform to the user's requirements to prevent their inadvertent use or installation. These measures must include, as appropriate, procedures for identification, documentation, segregation, disposition, and notification to affected organizations. Nonconforming items must be reviewed and accepted, rejected, repaired, or reworked in accordance with documented procedures.

7.3.1.2.9.2.16 Corrective Action

The user will establish measures to ensure that conditions adverse to quality, such as deficiencies, deviations, defective material and equipment, and nonconformances are promptly identified and corrected. In the case of a significant condition adverse to quality, the measures must ensure that the cause of the condition is determined and corrective action taken to preclude repetition. The identification of the significant condition adverse to quality, the cause of the condition, and the corrective action taken must be documented and reported to appropriate levels of management.

7.3.1.2.9.2.17 Quality Assurance Records

The user will maintain sufficient written records to describe the activities affecting quality. The records must include the instructions, procedures, and drawings required by Section 7.3.1.2.9.2 to prescribe QA activities and must include closely-related specifications such as required qualifications of personnel, procedures, and equipment. The records must include the instructions or procedures that establish a records retention program that is consistent with applicable regulations and designates factors such as duration, location, and assigned responsibility. The user will retain these records for three years beyond the date when the user last engages in the activity for which the QAP was developed. If any portion of the written procedures or instructions is superseded, the user will retain the superseded material for three years after it is superseded.

7.3.1.2.9.2.18 Audits

The user will carry out a comprehensive system of planned and periodic audits to verify compliance with all aspects of the QAP, and to determine the effectiveness of the program. The audits must be performed in accordance with written procedures or checklists by appropriately trained personnel not having direct responsibilities in the areas being audited. Audited results must be documented and reviewed by management having responsibility in the area audited. Follow-up action, including re-audit of deficient areas, must be taken where indicated.
7.3.1.2.9.3 Quality Program Contents and Format

7.3.1.2.9.3.1 Graded Application of the QAP

For fissile and Type B quantity packaging, the package safety documentation will (using NQA-1 including the supplements as the bases) provide a cross-referencing index, which demonstrates that each of the 18 criteria identified in Section 7.3.1.2.9.2 are addressed by written procedures. An example of such a matrix is presented in Table 1, Regulatory Guide 7.10. Because of the inter-relationship of the 18 criteria, more than one quality procedure generally will be applicable to each criterion.

The graded application process shall determine the appropriate level of analysis, documentation, and actions necessary to comply with the requirements through the consideration of prescribed factors, such as the following:

- Nuclear safety classification or hazard category of the item or activity
- Relative importance to safety, safeguards, and security
- Magnitude of any hazard or risk involved
- Adequacy of existing safety documentation
- Impact/consequences of failure on programmatic mission of a facility
- Particular characteristics of a package or activity
- Life-cycle stage of a package
- Complexity of items, services, or processes involved
- History of problem at a facility, or with an item, service, or process

The graded application process will not be used to circumvent applicable QA, legal, or contractual requirements. Rather, the grading determines the extent to which controls within the QA criteria are applied. The graded application of QAP requirements is normally achieved through a combination of the following:

- Extent to which procedures, instructions, or specifications define the processes or work methods involved
- Extent of assessment, verification, review, or oversight activities
- Extent of documentation required
- Degree of control over activities

For all packagings, the importance to safety should be based primarily on the ability of the package to provide the following:

- Containment of radioactive material
- Subcriticality of fissile material
- Shielding of radiation
The graded approach should consider the complexity and proposed use of the package and its components as described in the following:

- Impact of malfunction or failure of the item to safety
- Design and fabrication complexity or uniqueness of the item
- Need for special controls and surveillance over processes and equipment
- Degree to which functional compliance can be demonstrated by inspection or test
- Quality history and degree of standardization of the item
- Graded Approach for SSCs Important to Safety

For all fissile and Type B quantity packaging, the package safety documentation will provide a package-specific listing (Q-List) of all SSCs important to safety. The listing for SSCs will be consistent with the parts list or similar information presented in the packaging drawings. Justification should be provided for any item identified on the drawings, but not defined as important to safety in the Q-list. The package safety documentation will identify a quality category (e.g., A, B, C) for each SSC important to safety and these categories will be appropriately defined. The assigned categories will be properly justified based on their definition, the package type, and the safety function of each SSC. Guidance on the application of categories and QA requirements is provided in Section 7.3.1.2.9.3. Additional guidance can be found in Appendix A of Regulatory Guide 7.10. Definitions of typical categories and representative safety classifications for SSCs of transportation packagings are also presented in Table 2 and Table 5, respectively, of NUREG/CR-6407.

### 7.3.1.2.9.3.2 Package-Specific Quality Criteria and Package Activities

For fissile and Type B quantity packages, the package safety documentation will address each of the 18 quality criteria in NQA-1 as they apply to the proposed package. The package safety documentation will identify for each criterion, as applicable, the appropriate level of effort for package activities based on their importance to safety. Guidance on QA requirements applicable to each category is provided in Appendix A of Regulatory Guide 7.10. Other guidance is presented in Chapter 4 of NUREG/CR-6407, which also describes typical design and fabrication records maintained for each QA category. Table 7-1 identifies typical levels of effort for each of the 18 criteria of NQA-1 that should be considered in the review, based on quality category. Note that the omission of Category C items from the QA effort may not be appropriate, if they involve a condition of approval specified in the package approval document.

<table>
<thead>
<tr>
<th>QA Element/Level of Effort</th>
<th>Category A</th>
<th>Category B</th>
<th>Category C</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. QA Organization</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Responsibility established</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Authority and duties written</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>QA functions executed</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>
### Table 7-1. Typical Level of QA Effort by Quality Category

<table>
<thead>
<tr>
<th>QA Element/Level of Effort</th>
<th>Category A</th>
<th>Category B</th>
<th>Category C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reporting levels clearly defined</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Independence from cost and schedule assured</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>2. QA Program</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Procedures written</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Activities affecting quality controlled</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Graded approach established</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Indoctrination and training provided</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>3. Design Control</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Most stringent codes and standards</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Codes and standards</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Prototype test and/or analysis</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Formal design review</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Internal peer review</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Off-the-shelf items</td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Conditions of approval controlled</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>4. Procurement Document Control</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Traceability</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Qualified vendor lists</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Off-the-shelf items</td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>5. Instructions, Procedures, and Drawings</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Written and documented</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Qualitative or quantitative acceptance criteria</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Changes to conditions of approval listed in certificate controlled</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>6. Document Control</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Controlled issue</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Controlled changes</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>7. Control of Purchased Material, Equipment, and Services</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Source evaluation and selection</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inspection at contractor</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Formal receiving inspection</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Audits or surveillance at vendor plants</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Evidence of QA at contractor</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Objective proof that all specifications are met</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Incoming inspection for damage only</td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>8. Identification and Control of Materials, Parts, and Components</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Positive identification and traceability</td>
<td>X</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Table 7-1. Typical Level of QA Effort by Quality Category

<table>
<thead>
<tr>
<th>QA Element/Level of Effort</th>
<th>Category A</th>
<th>Category B</th>
<th>Category C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Identification and traceability to heats, lots, or other groupings</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Identification to end use drawings</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td><strong>9. Control of Special Processes</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Welding, heat treating, and nondestructive examination performed by qualified personnel</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Qualification records and training of personnel</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Only specified critical operations by qualified persons</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>No special processes</td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td><strong>10. Internal Inspection</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Documented inspection of all specifications</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Process monitoring if required by quality</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Examination, measurement, or test of material or processed product to assure quality</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Inspectors independent of those performing operations</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Qualified inspectors only</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Visual receiving inspection only</td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td><strong>11. Test Control</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Written test program</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Written test procedures</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Documentation of testing and evaluation</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Observation of supplier acceptance tests as appropriate</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td><strong>12. Control of Measuring and Test Equipment</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tools, gauges, and instruments in formal calibration program</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td><strong>13. Handling, Storage, and Shipping Control</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Written plans and procedures</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Routine handling</td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td><strong>14. Inspection, Test, and Operating Status</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Individual items identified as to status or condition</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Status indicated by stamps, tags, labels, etc.</td>
<td></td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Visual examination only</td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td><strong>15. Nonconforming Materials, Parts, or Components</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Written procedures to prevent inadvertent use</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Nonconformance documented and closed</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Disposal without records</td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td><strong>16. Corrective Action</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Conditions adverse to quality identified and corrected</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>
Table 7-1. Typical Level of QA Effort by Quality Category

<table>
<thead>
<tr>
<th>QA Element/Level of Effort</th>
<th>Category A</th>
<th>Category B</th>
<th>Category C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cause and corrective action documented</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Safety significant events reported</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>

17. QA Records

<table>
<thead>
<tr>
<th></th>
<th>Category A</th>
<th>Category B</th>
<th>Category C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Design and use records</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Results of reviews, inspections, tests, audits, surveillances, and materials analysis</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Personnel qualifications</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Records of fabrication retained for life of package plus 3 years</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Records of acceptance testing retained for life of package plus 3 years</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Records of maintenance retained for life of package plus 3 years</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Shipping records retained for 3 years after shipment</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Records managed by a written procedure for retention and disposal</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>

18. Audits

<table>
<thead>
<tr>
<th></th>
<th>Category A</th>
<th>Category B</th>
<th>Category C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Written plan of periodic audits</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Implementation by written procedures</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Lead auditor certified</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>All auditors certified</td>
<td>X</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

7.3.1.2.9.3.3 Requirements for Quality Categories for Packagings

Quality categories will be based on the relative safety significance of each Q component and item and, where appropriate, their subcomponent parts. The category should be identified as “A” for components and items that are critical to safe operation. For components and items with a major impact on safety, the category will be identified as “B.” Category C should be used for components and items with a minor impact on safety. Examples of Category A items are SSCs whose failure or malfunction could result directly in a condition adversely affecting public or worker health and safety. Adverse conditions are defined as loss of containment, loss of shielding, or unsafe geometry compromising criticality control. Category B items could be SSCs whose failure or malfunction could indirectly result in a condition adversely affecting public or worker health and safety. For the failure of a Category B item to result in an adverse condition, a second failure of a component or item would need to occur. Category C items would be those SSCs whose failure or malfunction would not significantly reduce the packaging effectiveness and would be unlikely to create a condition adversely affecting public or worker health and safety. Each component, item, structure, or subsystem of a packaging will be tabulated and designated with the proper category. The QA requirements will also be identified for each component, item, structure, or subsystem.
7.3.1.2.10 Operating Procedures
This section addresses the contents of the operating procedures that are to be provided.

7.3.1.2.10.1 Operating Procedures for DOT-Equivalent Packaging
The guidance outlines the elements that are to be addressed for an onsite PSSD to demonstrate the operating procedures for safe operations of Type B and fissile packages. The guidance, when applied using a graded approach, is appropriate for any packagings requiring safety documentation.

7.3.1.2.10.2 Summary of Operation Requirements and Restrictions
This section will provide requirements and restrictions related to package operations. All requirements and restrictions related to package operations will be provided including: drawing and revision numbers for all package components; a description of the form (solid, liquid, powder, etc.) and fissile load of the contents; any package handling restrictions (such as lifting height limits or dual load path requirements; any neutron poison, moderator, and gap requirements; expected gamma and neutron radiation levels, and locations of any streaming paths; and any closure (such as closure lid bolt torques necessary for containment) and component testing (such as pressure taps) requirements.

7.3.1.2.10.3 General Information
The operation procedures will list any special equipment required for handling the particular package and include all pertinent details listed below:

- The operating procedures will include appropriate quantitative and qualitative criteria for determining that important activities have been satisfactorily accomplished.
- Detailed implementing procedures will be provided. It is recommended that the packaging safety documentation identify NUREG/CR-4775 as guidance for preparation of those procedures.

7.3.1.2.10.4 Package Loading
Loading of the package will include inspections, tests, and special preparations. Inspections will include those made prior to loading the package to determine that the package is not damaged and surface contamination levels are within the allowable limits. The procedures will discuss the inspection of the gaskets, criteria for replacement, and, if applicable, procedures for repair. The inspection of each closure device and criteria for replacement will also be included.

The operating procedures will provide instructions on package loading. Instructions about the following items (as applicable) will be included in the loading instructions:

7.3.1.2.10.5 Preparation
1. Appropriate documents to be reviewed by operating personnel
2. The package will be loaded and closed in accordance with written procedures
3. Describe any special controls and precautions for handling
4. Verify that the package is in unimpaired physical condition and that all required periodic maintenance has been performed
5. Ensure that the package is conspicuously and durably marked with the model number, serial number, gross weight, and package identification number, as applicable
6. Ensure that use of the package complies with all other conditions of approval
7. Determine the package is proper for the contents to be shipped, including the need for canning of damaged fuel or for a second containment vessel, if applicable
8. Ensure packaging sealing surfaces have been properly prepared and protected
9. Check that all payload treatment processes performed subsequent to package loading are appropriate for the particular payload in question, and process equipment operators are familiar with both processing procedures and task operating procedures
10. Check that packaging interior contamination levels are not so excessive that significant contamination could be imparted to the payload itself
11. Check that all components operate as designed and have been tested as necessary
12. Identify and list any special equipment that may be needed when loading the package

7.3.1.2.10.6 Loading of Contents
1. Describe any special controls and precautions for loading
2. Indicate the method of loading the contents
3. Ensure that any required moderator or neutron absorber is present and in proper condition
4. When applicable, specify the method to remove water from the package, as appropriate
5. Vent flammable gases from the package or add fill gas, as appropriate
6. Ensure that each closure device of the package, including seals and gaskets, is properly installed, secured, and free of defects
7. Identify bolt torques consistent with those identified by the design, and/or shown on the drawings
8. Confirm the package has been loaded and closed appropriately
9. Conduct any required package testing prior to release for transport
10. Decontaminate exterior surfaces of the packaging and the transport vehicle

7.3.1.2.10.7 Shipment Preparation
The operation procedures will provide instructions on shipment preparation. The instructions will include the following items, as a minimum:

- Securing the package to vehicle, including acceptable tiedown configurations
- Conducting the package radiation survey, including a determination of surface contamination
• When applicable, conducting the temperature survey to verify that limits specified are not exceeded
• Specify the assembly verification leakage rate, and how to ensure package closures are leak tested in accordance with applicable closure standards such as ANSI N14.5, if required
• Ensure that any system for containing liquid is properly sealed and has adequate space or other specified provision for expansion of the liquid
• Verify that any pressure relief device is operable and set
• Ensure that any structural component that could be used for lifting or tiedown during transport is rendered inoperable for those purposes unless it meets the required design requirements
• Ensure that the tamper-indicating device is installed, if required.
• Specify the attachment of impact limiters, personnel barriers, or similar devices, as applicable
• For a fissile material shipment, identify any special controls and precautions for transport, loading, unloading, and handling, and any appropriate actions in case of an accident or delay
• Identify any special controls that will be provided to the carrier for a package shipped by exclusive use under the provisions
• Identify any special controls that will be provided to the carrier for a fissile-material package
• Describe any special instructions that should be provided to the consignee for opening the package
• Ensure that the TI and CSI for each package and the sum of the TIs and CSIs for the shipment are appropriate for the type of shipment

7.3.1.2.10.8 Package Receipt

The operation procedures will give instructions to the package recipient on the following items:
• Ensure that the package is examined for visible damage, status of the tamper-indicating device (if installed), surface contamination, and external radiation levels are made
• Describe any special actions to be taken if the package is damaged, if the tamper-indicating device is not intact, or if surface contamination or radiation survey levels are too high
• Identify any special handling equipment needed
• Describe any proposed special controls and precautions for handling and unloading
7.3.1.2.10.9 Package Unloading

Package unloading will include inspections, tests, and special preparations. As applicable, the procedures used to ensure the safe removal of fission gases, contaminated coolant, and solid contaminants will be discussed. Also, as applicable, any required cool-down procedures will be described, and it will be shown that it does not affect the continued use of the package.

Operating procedures will provide detailed instructions for package unloading. Instructions on the following items shall be included:

- A list of any special equipment that may be needed
- Preparation of the package for removal from the transport vehicle
- Proper removal of the package from the transport vehicle
- Package transfer from the transportation vehicle to the unloading site
- Describe the appropriate method to open the package
- Identify the appropriate method to remove the contents
- Ensure that the contents are completely removed
- Inspection of the interior of the packaging after contents have been removed
- Possible preparation of packaging for short- or long-term empty storage

7.3.1.2.10.10 Preparation of Empty Packages for Transport

A discussion of inspections, tests, and special preparations of the packaging necessary to ensure safe transport of the empty package will be included. Instructions on the following items will be included:

- Verify package is empty
- Verify the radiation levels are less than 0.005 mSv/hr (0.5 mrem/hr) at any point on the external surface of the package
- Verify requirements for non-fixed radioactive contamination limits have been met for internal [49 CFR 173.428(d)] and external (49 CFR 173.443) surfaces
- Properly close packaging and unimpaired condition
- Ensure packaging is delivered, to storage or a carrier, in a condition such that subsequent transport will not reduce the effectiveness of the packaging (e.g., damage to sealing surfaces caused by the freezing of moisture not properly removed)

7.3.1.2.10.11 Inspections and Maintenance

The operating procedure will establish how the maintenance and acceptance requirements are to be implemented.
7.3.1.2.10.12  Records and Reporting Requirements

7.3.1.2.10.12.1  Records for Each Shipment

The DOE requires the maintenance of records for each shipment. The operating procedures will identify the applicable DOE and company procedures, and the records they require to be maintained.

7.3.1.2.10.12.2  Records of Package History

Historic records will be maintained for the lifetime of the package plus three years. Historic records will consist of sufficient QA records to furnish documentary evidence of the quality of packaging components that have safety significance and of services affecting quality. Records to be maintained include results of the following determinations: new package shielding meets design requirements; containment will maintain integrity at 1.5 times the MNOP (where applicable); packaging was fabricated in accordance with the approved design; and results of monitoring, inspections, and auditing of work performance during design, fabrication, assembly, testing, modification, maintenance and repair of the packaging.

7.3.1.2.10.12.3  Reports

Operating procedures will identify package-specific conditions that require reporting identified in the DOE orders or Hanford Site procedures.

7.3.1.2.10.13  Operation Checklist

Operating procedures will present a checklist by the organization shipping the package. That organization is responsible for ensuring that operating procedures are in place before using the container. The checklist will identify the requirements that must be incorporated into procedures at the time of shipment.

7.3.1.2.10.14  Evaluation Procedures

The operations evaluation of a package is based in part on the description and evaluations presented in other evaluations. In addition, results of the operations evaluation are considered in the evaluation of all other sections. As an aid to the user, an information flow diagram for the operations evaluation is presented in Figure 7-7.

7.3.1.2.11  Acceptance Tests and Maintenance Program

This section addresses the contents of the acceptance and maintenance procedures.

The guidance outlines the elements that are to be addressed in the onsite PSSD to demonstrate the Acceptance Tests and Maintenance Program required for safe operation of Type B and fissile packages. In addition, the guidance, when applied using a graded approach, is appropriate for any packaging requiring safety documentation:

- Structural and pressure tests
- Leakage rate tests
7.3.1.2.11.1 Acceptance Test Procedures

Test procedures associated with the acceptance of the package for use that are required to be performed before and during the service life of the packaging will be identified. When practicable, national standard procedures will be utilized. In the absence of such codes, the basis and rationale used to formulate the QAP will be described in establishing the requirements. The acceptance tests will include the following:

- Visual inspections and measurements
- Weld examinations
- Component tests
- Material tests
The frequency of the tests will be identified. The requirements should provide flexibility in the schedule to provide for times when the shipping window will extend beyond the due date for the test. The acceptance test will support the following verifications:

- Before first use, fabrication of each packaging must be verified to be in accordance with the approved design. [49 CFR 173.474 and 10 CFR 71.85(c)]

- Before first use, each packaging must be inspected for cracks, pinholes, uncontrolled voids, or other defects that could significantly reduce its effectiveness. [49 CFR 173.474 and 10 CFR 71.85(a)]

- Before first use, if the MNOP of a package exceeds 35 kPa (5 psig), the containment system of each packaging must be tested at an internal pressure at least 50 percent higher than MNOP to verify its ability to maintain structural integrity at that pressure. [10 CFR 71.85(b)]

- When applicable, before first use, each packaging must be conspicuously and durably marked with its model number, serial number, gross weight, and a package identification number. [10 CFR 71.85(c)]

- Additionally, perform any tests deemed appropriate by the RL Manager. [10 CFR 71.93(b)]

### 7.3.1.2.11.1 Acceptance Tests

When the following acceptance tests are specified, present (as a minimum) a description of the test and its acceptance criteria. Standards will be referenced or an alternate basis provided.

#### 7.3.1.2.11.1.2 Visual Inspections and Measurement

Provide inspections to verify that the packaging has been fabricated and assembled in accordance with the drawings. Dimensions and tolerances specified on the drawings will be confirmed by measurement.

#### 7.3.1.2.11.1.3 Weld Examinations

Provide welding examinations to verify fabrication in accordance with the drawings, codes, and standards specified in the design documents. Location, type, and size of the welds will be confirmed by measurement. When appropriate, specifications for weld performance, nondestructive examination, and acceptance will be identified.

#### 7.3.1.2.11.1.4 Structural and Pressure Tests

Identify and describe any applicable structural or pressure tests. Such tests will comply with 10 CFR 71.85(b), as well as applicable codes or standards specified in the design documentation.

#### 7.3.1.2.11.1.5 Leakage Tests

When applicable, identify that the containment system of the packaging will be subjected to a fabrication leakage test. The sensitivity of these tests must be identified. Those tests specified in ANSI N14.5 should be used when applicable. Require that all closures, including drains and vents, be leak-tested. The acceptable leakage criterion will be consistent with that identified in Section 7.3.1.2.4, Containment/Confinement Evaluation.
7.3.1.2.11.1.6 Component and Material Tests
Appropriate tests and acceptance criteria will be specified for components that affect package performance. Examples of such components include seals, gaskets, valves, fluid transport systems, and rupture disks or other pressure-relief devices. Components will be tested to meet the performance specifications shown on the engineering drawing of the package. When tests adversely affect the continued performance of a component, applicable QA procedures will be described to justify that the tested component is equivalent to the component that will be used in the packaging.

Verify that appropriate tests and acceptance criteria are specified for packaging materials. Tests for neutron absorbers (e.g., boron, gadolinium) and insulating materials (e.g., foams, fiberboard) will ensure that minimum specifications for density and isotopic content are achieved. Materials will be tested to meet the performance specifications shown on the engineering drawings.

7.3.1.2.11.1.7 Shielding Tests
Appropriate shielding tests will be specified for both neutron and gamma radiation. The tests and acceptance criteria will be sufficient to ensure that no voids or streaming paths exist in the shielding.

7.3.1.2.11.1.8 Thermal Tests
Appropriate tests will be specified to demonstrate the heat transfer capability of the packaging. These tests will confirm that the heat transfer performance determined in the evaluation is achieved in the fabrication process.

7.3.1.2.11.2 Maintenance Program
A maintenance program for ensuring continuous safe performance of the packaging will be identified. The packaging must be maintained in unimpaired physical condition except for superficial defects such as marks or dents [49 CFR 173.475 and 10 CFR 71.87(b)]. The program will include periodic testing, inspection, and replacement schedules, as well as criteria for replacement and repair of components and subsystems on a routine or as-needed basis. Frequency of maintenance will be identified. Requirements will provide flexibility in the schedule to provide for times when the shipping window will extend beyond the due date for the maintenance.

7.3.1.2.11.2.1 Structural and Pressure Tests
If required by the package, structural and pressure tests to be performed and the frequency of performance will be identified. When a test(s) is used, the instrumentation and test sensitivity must be identified. The periodic and maintenance leakage rate tests (when applicable) will be those specified in ANSI N14.5. The acceptable leakage rate criterion will be consistent with that identified in Section 7.3.1.2.4.6, Containment/Confinement Evaluation. When appropriate, replacement schedules for seals will be identified.

7.3.1.2.11.2.2 Leak Tests
Leak tests that are to be performed and the frequency of performance will be identified. For most packaging systems, this would include a test of the package before each shipment and an annual test of each packaging. The sensitivity of these tests must be identified. Use of the
leakage rate tests specified in ANSI N14.5 is recommended. The acceptable leakage rate criterion will be consistent with that identified in the containment evaluation in Section 7.3.1.2.4.6. When appropriate, replacement schedules for seals will be identified.

7.3.1.2.11.2.3 Subsystem Maintenance

The test and replacement schedule to be used for packaging subsystems (e.g., auxiliary cooling systems and neutron shield tanks) whose inadequate performance could impair the total package safety will be described. The schedules established will be justified using verifiable test or manufacturer’s data.

7.3.1.2.11.2.4 Valves, Rupture Disks, and Gasket on the Containment Vessel

The test and replacement schedule for the components on the containment vessel will be specified. The schedules that are established will be justified using verifiable test or manufacturer’s data. For most systems, this would include, as a minimum, a visual inspection before each closure, and an annual gasket and seal replacement.

7.3.1.2.11.2.5 Shielding

The test and inspection schedules will be described, as well as the corrective action to be used, to ensure adequate shielding performance. Both gamma and neutron sources will be considered.

7.3.1.2.11.2.6 Thermal

The tests proposed and the frequency of the tests that will be performed on the total system will be described. It will be shown the proposed total frequency will detect degradation in the thermal performance of the packaging before compromising package safety.

7.3.1.2.11.2.7 Miscellaneous

Any additional test not previously considered that will be performed periodically on components and subsystems will be described.

7.3.1.2.11.3 Acceptance Criteria

7.3.1.2.11.3.1 Visual Inspection

Visual inspections will be performed and the intended purpose for each inspection discussed. The criteria will be clearly stated for acceptance of each inspection, as well as the action that will be taken if noncompliance is encountered.

7.3.1.2.11.3.2 Structural and Pressure Tests

There will be a description of how the tests are to be performed. The acceptance criteria will be included in the document. The actions that are to be taken when the prescribed criteria are not met will also be included. An estimate of the sensitivity of the tests will be provided.

7.3.1.2.11.3.3 Leak Tests

A description of the leak tests to be performed will be included in the document. Leak tests will be performed on the containment vessel as well as auxiliary equipment such as shield tanks. The criteria for acceptance and the action to be taken, if the criteria are not met, will be described. The sensitivity of the tests will be estimated, and a basis for the estimate given.
7.3.1.2.11.3.4 Component Tests

The tests for the components will be discussed in the document. Acceptance criteria will be provided and the action to be taken if the criteria are not met will be discussed.

- Valves, Rupture Disks, and Fluid Transport Devices

  Valves, rupture disks, and fluid transport devices will be tested under the most severe service conditions for which the package design assumes their acceptable performance. When the tests are presumed to adversely affect the continued performance of a component, the results of the tests on components of the same model and type may be substituted.

- Gaskets

  Gaskets will be tested under conditions simulating the most severe service conditions under which the gaskets are to perform. Because these acceptance tests may degrade the performance of the gasket under test or the package into which it is assembled, or both, the tests are not necessarily performed on gaskets or packages to be put into service. The simulation system must ensure adequate representation of those conditions that would prevail if the actual system were used in a test. Gaskets must be procured under a QAP that is adequate to ensure acceptance testing of a given gasket device is equivalent to acceptance testing of all gaskets supplied and identified by that manufacturer as that model gasket.

- Miscellaneous

  Any component that is not listed in Section 7.3.1.2.11.3 whose failure would impair the package effectiveness will be tested under the most severe conditions for which the package was designed. Because these acceptance tests may degrade the performance of the component under test or the system into which it is assembled, or both, the tests are not necessarily performed on components or systems to be put into service. The simulation system shall ensure adequate representation of those conditions that would prevail if the actual system were used in this test. Furthermore, components must be procured under a QAP adequate to ensure that acceptance testing of a given component device is equivalent to acceptance testing of all devices supplied and identified by that manufacturer as that model device.

7.3.1.2.11.3.5 Tests for Shielding Integrity

The tests that are to be performed to establish shielding for both gamma and neutron sources will be discussed. The discussion will include the dimensions of the grid pattern or a description of the scanning procedure that demonstrates the inspection of 100 percent of the package surface area. The acceptance criteria, as well as the action to be taken if the criteria are not met, will be described.

7.3.1.2.11.3.6 Thermal Acceptance Tests

The tests to verify that each package performs within some defined variance in accordance with the results of the thermal analyses or tests for NC will be discussed.

- Discussion of Test Setup
The description of the tests will include heat source, instrumentation, and schematics showing thermocouple and heat source locations, as well as the placement of other test equipment. The test sensitivity will be estimated based on instrumentation, test item, and environmental variations.

- **Test Procedures**
  The procedures used in testing and data recording will be discussed. The frequency of data recording during the test will be reported. The criteria used to define the steady-state (thermal equilibrium) condition of the test item will also be discussed.

- **Acceptance Criteria**
  The thermal acceptance criteria and the method employed to compare the acceptance test results with the predicted thermal performance will be discussed. The action to be taken if the thermal acceptance criteria are not met by the packaging unit will also be discussed.

### 7.3.1.2.11.4 Evaluation Procedures

The Acceptance Tests and Maintenance Program evaluation of a package is based in part on the description and evaluations presented in the above sections. In addition, results of the Acceptance Tests and Maintenance Program evaluation are considered in the evaluation of all other sections. As an aid to the user, an information flow diagram for the Acceptance Tests and Maintenance Program evaluation is presented in Figure 7-8.
7.3.2 Risk Based Packagings

When using the alternative onsite risk based packaging requirements, the following risk based evaluation and acceptance criteria must be used. Risk based packages will demonstrate full compliance to NCT for Type B Packages under 10 CFR 71. Risk based packages based upon a Type A package will also meet NCT under 10 CFR 71 or 49 CFR 173.412 & 415. All risk based packages will also be demonstrated to remain sub-critical. At a minimum, three main representative accident scenarios must be addressed: collision, fire, and hydrogen deflagration. Additional accidents specific to the packaging being analyzed shall be considered to ensure that the representative accidents adequately bound the risks for that packaging and payload.

Before conducting the consequence and frequency evaluations, the proposed package must be evaluated against the applicable equivalent package requirements of Section 6.5.2. Applicability shall be based on proposed contents. The evaluation shall be documented in a report and formatted as identified in Appendix D. The PSSD shall document the package’s performance according to the requirements in Section 6.5.3.2. If the package does not meet all of these requirements, a discussion of the performance must be provided. The consequence and failure
frequency evaluations shall be developed in accordance with the methodologies provided in Sections 7.3.2.1 and 7.3.2.2. The consequence and failure frequency information provided shall be detailed enough to support the risk based approval decision.

The contractor shall use the standard DOE methodologies and guidance applicable for determining the accident parameters for analysis of risk based shipments in the Hanford areas described in this TSD. The accident location shall be based on occurring at the most conservative facilities in each site area on the shipment route.

Typical dose consequences accepted by RL for risk based packages are shown in Appendix E, Tables E-2 and E-3. The tables were developed using standard DOE methodology to determine shipment inventory limits based on maintaining dose consequences to the MOI at the values consistent with the risk bin guidance and those previously approved in the TSD SER. This methodology meets the expectations stated in the TSD SER, the TSD, and 10 CFR 830. The values contained in Appendix E, Tables E-2 and E-3 represent typical RL-approved risks for onsite transportation activities.

7.3.2.1 Evaluation Requirements and Acceptance Criteria for Risk Based Packages

This section outlines the elements that are to be addressed for an onsite PSSD to demonstrate acceptable radiological and toxicological safety, and/or acceptable risk based on the requirements identified in Section 6.5.3.2. It also defines the acceptable analysis to be conducted to demonstrate that the packaging provides an equivalent degree of safety and acceptable level of risk.

Appendix E, Justification and Basis for Shipment of Risk based Packages, contains the technical arguments or justification to validate the equivalence of the packaging performance. It also presents typical accident scenario data to be applied when conducting an analysis.

7.3.2.1.1 Consequence Analysis Methodology

This section covers the calculation of package-specific releases and resultant dose consequences. See Appendix G for additional discussion on analysis bases for risk based packages. Package-specific releases from the specified representative accidents are calculated for the MOI and co-located worker to determine the consequences and associated risks. Appendix E, Tables E-2 and E-3 document typical accepted risks for transportation-specific accident scenarios.

To promote consistency between consequence analyses for different packages, an approved methodology for calculating the dose consequences from transportation accidents is provided. The consequence analysis determines the radiological consequence, or dose, to the maximally exposed onsite and offsite receptors from a radioactive material release during an accident. Note that the maximally exposed co-located worker (receptor) is defined as a person within the Hanford Site boundary 100 m (328 ft) from the accident. As a minimum, the consequence analysis shall quantitatively evaluate collision, fire, and hydrogen deflagration accidents. The initiators of these accidents shall be no more severe than the accident test conditions for certified Type B packages described in 10 CFR 71.73, “Hypothetical Accident Conditions,” to provide a realistic evaluation of the postulated conditions that could be encountered onsite. Although puncture, crush, and immersion tests are also described in the regulations, the collision event is
normally more severe than the puncture and crush events, and immersion is not a credible accident scenario on the Hanford Site.

The consequence analysis considers the credible pathways through which the onsite and offsite receptors may be exposed to radiation. In the case where one pathway dominates the dose, the evaluation of other pathways may be less rigorous or qualitative. All receptors may be exposed to radioactive material by inhaling particulate matter while being submersed in a particulate aerosol carried downwind. Direct external dose from unshielded photons, beta particles, and neutrons is normally negligible at distances of 100 m (328 ft) or greater.

Exposure from consuming contaminated food or drinking contaminated water is not considered, because state and federal emergency response procedures (DOE-0223, Emergency Plan Implementing Procedure; WSDOA 1994, Fixed Nuclear Facility Emergency Response Procedure; WSDOH 1993, “Response Procedures for Radiation Emergencies;” EPA 1992, Manual of Protective Action Guides and Protective Actions for Nuclear Incidents) are in place to prevent ingestion of contaminated food and water in the event of an accident. The primary determinant of exposure from the ingestion pathway is the effectiveness of public health measures (i.e., interdiction) rather than the severity of the accident itself.

The analysis shall account for the physical and chemical form of the waste material during the AC using appropriate airborne release fractions and respirable fractions. The consequence analysis may include the mitigating effect of the damaged package after the AC using damage ratios or leak path factors, provided that a structural analysis supports the mitigating effect. If these factors are used, then both the mitigated and the unmitigated dose consequences shall be reported.

In addition to the onsite receptor, immediate workers in the vicinity of the accident (i.e., less than 100 m [328 ft]) may be exposed to radiation. The immediate worker for transportation cannot be defined in the same sense as for facilities. This is because the location of a release of radioactive material during transportation may potentially occur at any point along the transportation route between the originating and receiving facilities. The shipment may pass by several facilities along the route, and each shipment may pass by different facilities depending on the particular originating and receiving facilities. In addition, the shipment may pass by other vehicles along the route. In the event of an accident, it is foreseeable that people in other vehicles may stop to try to assist the driver involved in the accident, unknowingly being exposed to the released radioactive material. Furthermore, calculations of inhalation dose are subject to widely varying uncertainties. Therefore, because the immediate worker is not easily defined, consequence evaluations to workers in the immediate vicinity of an accident (i.e., less than 100 m [328 ft]), are addressed qualitatively.

The offsite receptor is the maximally exposed member of the public at the Hanford Site boundary for an exposure duration of not less than 2 hours. All dose consequences are to be calculated using DOE standard methodologies.

7.3.2.1.2 Hydrogen Generation Analysis Methodology

Mitigation of the consequences from a hydrogen deflagration in risk based packages shall be provided by verifying per the methodology of HNF-20536, or equivalent, that void volume
hydrogen concentrations remain below the risk based values shown in Table E-3 during the expected shipping window.

7.3.2.2 Frequency Analysis Methodology

The accident frequencies must be commensurate with the severities of the accident scenarios to provide a valid evaluation. This section describes the approach and provides data to be used to evaluate the frequencies of transportation accidents on the Hanford Site.

7.3.2.2.1 Accident Frequency Analysis Approach

The overall approach to determining Hanford Site accident frequencies is to start with the assumption that an accident has occurred based on the initiating event frequency as discussed in this section. This includes all accidents, ranging from minor “fender benders” to high-speed collisions and fires. The hazards analysis in Appendix E highlighted the accident scenarios that must be evaluated quantitatively and reduced the number of accident scenarios that need to be evaluated. However, it only eliminated those that were less than credible and those that are prevented through engineering and administrative controls (i.e., less than 1x10⁻⁷/yr), the remaining accident scenarios represent the bulk of the risk of transporting radioactive materials on the Hanford Site. As with the consequence evaluations, the accident frequencies will be utilized to determine each accident scenario risk classification bin.

An event tree approach is used to establish the overall framework for calculating the frequencies of truck accidents that could lead to a release of radioactive material on the Hanford Site (Figure 7-9). An event tree starts with an initiating event (in this case, the initiating event is a truck transportation accident) and follows with a series of ACs that describe the mechanical (collision) and thermal (fire) environments that could potentially be generated in an accident. Potential accident environments are both unmitigated and mitigated collision, followed by fire, and a single container hydrogen deflagration. Note that immersion, the final HAC defined in 10 CFR 71, is not applicable to the Hanford Site (see Appendix E).
Figure 7-9. “Unpruned” Event Tree Model of Potential Transportation Accident Conditions

The fifth event represents fire conditions that may occur in accidents. All five events are aligned in chronological order at the top of the event tree shown in Figure 7-9. The event tree diagram was then constructed by first drawing a branch to represent the occurrence of any accident, then drawing a second set of branches to represent the impact event, and so on. The top branch of the impact event represents the occurrence of impact (i.e., collision or overturn) conditions and the bottom branch represents non-collision accidents. Similarly, for subsequent events, the top branches represent the occurrence of the specific condition and the bottom branch represents its absence from the particular scenario. Probabilistic information is then inserted on each branch to quantify the event tree. The probabilistic information may be in the form of a point value or a distribution. The probability of the top branch is 1 minus the probability of the bottom branch.

The following general equation is used to calculate the frequencies of the various accident scenarios depicted in Figure 7-9:
\[ F_j = RNDP_j \]  

Eq. 7-6

where:

- \( F_j \) = The frequency of accident scenario “j”
- \( R \) = Accident rate (accidents/vehicle-km)
- \( N \) = Number of shipments/yr
- \( D \) = One-way shipping distance (km)
- \( P_j \) = Conditional probability of Accident Scenario “j” given an accident has occurred.

The different scenarios in Figure 7-9 can be modeled by substituting different expressions for \( P_j \), as follows:

- \( P_j = P_i \) for collision-only accident scenarios
- \( P_j = P_{p|i} \) for collision scenarios that also lead to puncture conditions
- \( P_j = P_{c|i} \) for collision scenarios that also lead to crush conditions
- \( P_j = P_{fi} \) for collision scenarios that also involve fires
- \( P_j = P_{fp} \) for collision/puncture scenarios that also involve fires
- \( P_j = P_{fc} \) for collision/crush scenarios that also involve fires
- \( P_j = P_f \) for accident scenarios that involve fire-only conditions (no collision).

In other words, the calculational approach involves estimating the frequency of all accidents (product of the accident rate, shipping distance, and annual number of shipments) and then multiplying this product by a series of fractions that represent the probabilities of encountering conditions that could compromise the integrity of each package’s containment system. The rest of this chapter describes the derivation process for the accident rate (parameter “R”) and conditional probabilities (values for \( P_j \)) used in the calculations. The remaining parameters, including \( N \) and \( D \), are obtained by consulting with potential users of the package.

7.3.2.2.1 Truck Accident Rate

Several studies have been conducted that determined highway accident rates for transportation risk assessment. Table 7-2 presents a side-by-side display of the accident rate information provided in the reviewed documents. Although the bases for the accident rates differ from one study to the other and should not be compared directly, the more recent values are within the range from about \( 2 \times 10^{-7} \) to \( 4 \times 10^{-7} \) accidents per vehicle-km (i.e., from 2 to 4 accidents/10 million km traveled). This illustrates that all of the values in this range would be acceptable for developing accident frequency estimates and none would result in a serious under- or over-estimate of Hanford Site accident frequencies.
Table 7-2. Summary of Truck Accident Rates from Previous Studies

| Source               | Time period covered | Rate (accidents per vehicle-km)
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>SLA-74-0001</td>
<td>1966 - 70</td>
<td>2.5x10^{-6}</td>
</tr>
<tr>
<td></td>
<td></td>
<td>National average data for trucks and delivery vans</td>
</tr>
<tr>
<td>NUREG/CR-4829</td>
<td>1968 - 81</td>
<td>4.0x10^{-6}</td>
</tr>
<tr>
<td></td>
<td></td>
<td>National average data; American Petroleum Institute data for heavy trucks</td>
</tr>
<tr>
<td>ANL/ESD/TM-68</td>
<td>1986 - 88</td>
<td>2.6x10^{-7}</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Washington State primary highways; heavy trucks</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3.94x10^{-7}</td>
</tr>
<tr>
<td></td>
<td></td>
<td>National average primary highways; heavy trucks</td>
</tr>
<tr>
<td>ANL/ESD/TM-150</td>
<td>1994 - 96</td>
<td>1.75x10^{-7}</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Washington State primary highways; heavy trucks</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3.66x10^{-7}</td>
</tr>
<tr>
<td></td>
<td></td>
<td>National average primary highways; heavy trucks</td>
</tr>
<tr>
<td>WHC-SD-TP-RPT-021</td>
<td>1990 - 95</td>
<td>2.0x10^{-7}</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Hanford Site rate for trucks, vans, and pickups combined</td>
</tr>
<tr>
<td>NUREG/CR-6672</td>
<td>1984, 1986 - 88</td>
<td>2.2x10^{-7}</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Nation-wide data, rural areas; adjusted Bureau of Motor Carrier Safety data</td>
</tr>
</tbody>
</table>

(a) Because of different bases that were used to derive the accident rates, such as the definition of an accident, the values are not directly comparable. See the source studies for additional information on the bases for the derived accident rates.

Sources:

The most recent evaluation of truck accident rates is the basis for this document. Note that highway shipments on the Hanford Site may be conducted using a number of different truck types, including semi-tractor/trailer combination rigs, flatbed trucks, and vans. For this analysis, a single accident rate is used to represent the accident rates of all types of highway vehicles. The available data did not support separating the overall highway accident rate into separate rates for specific types of vehicles (e.g., heavy-combination trucks, delivery vans).

The overall truck accident rate (parameter “R” in equation 1) used in the risk evaluation is represented by the nation-wide average accident rates for heavy trucks developed by NUREG/CR-6672 (Figure 3.10a). The rate was developed using Bureau of Motor Carrier Safety data that has been adjusted to isolate accidents that occurred in cities and non-city regions. The database used to develop the highway accident rates was large, which increases the confidence in the estimates. The rural (non-city) accident rate is used for Hanford Site evaluations because of its generally rural nature. The accident rate given by NUREG/CR-6672 for rural highways is 2.2x10^{-7} accidents per vehicle-km (3.5x10^{-7} accidents/vehicle-mile), which is the approximate...
50 percent confidence interval (i.e., there is a 50% likelihood that the actual accident rate is $2.2 \times 10^{-7}$/km or less). This represents the rate of all accidents, regardless of severity, ranging from minor fender-benders to severe collisions and fires. The annual frequency of all accidents for a given packaging system is the product of the highway accident rate, number of shipments per year, and the shipping distance. Note that only the one-way shipping distance is used in the Hanford Site accident frequency calculations because the package is loaded only when traveling in one direction; i.e., the package is empty for the return trip.

7.3.2.2.1.2 Collision Probability

Collision conditions generated in an accident are a function of many variables, including impact velocity, orientation, and impact surface characteristics. NUREG/CR-6672 and NUREG/CR-4829 constructed impact velocity distributions that considered the impact orientation (i.e., corner, end, or side impact) and the characteristics of various real surfaces (e.g., hard rock, soil, concrete, roadbed). The distributions were constructed to develop factors to adjust the overall accident rate to reflect real ACs and to determine the fractions of accidents that exceed specified impact velocities. This type of data is needed to calculate Hanford Site accident frequencies.

According to NUREG/CR-6672, the probability of a collision or overturn, given an accident occurs, is 0.7412. The probability of a non-collision accident is (1 – 0.7412) or 0.2588, given an accident occurs. The impact velocity distributions constructed by NUREG/CR-6672 and NUREG/CR-4829 were constructed assuming that a collision/overturn accident occurs. Thus, the following distribution is used to determine the fraction of collision and overturn accidents that result in impact velocities of a specified value. For this methodology, the specified impact velocity would be the impact failure threshold determined via structural analysis.

To construct the distributions, NUREG/CR-6672 assumed that the impacts at any angle are equally probable. They used data from Geographic Information System (GIS) interrogation of the digitized U.S. Department of Agriculture maps to characterize the wayside characteristics adjacent to three representative truck shipping routes. They then conducted Monte Carlo analyses to develop the cumulative distributions that are used here to assign the conditional probabilities of experiencing varying levels of impact severity. The distributions used for Hanford Site evaluations are shown in Table 7-3. The cumulative distribution is also illustrated in Figure 7-10 to assist in interpolation between the impact velocities listed in Table 7-3.

<table>
<thead>
<tr>
<th>Table 7-3. Cumulative Truck Accident Velocity Distribution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial Truck Velocity Adjusted for Braking</td>
</tr>
<tr>
<td>Velocity (mi/h)</td>
</tr>
<tr>
<td>-----------------</td>
</tr>
<tr>
<td>0.0</td>
</tr>
<tr>
<td>2.0</td>
</tr>
<tr>
<td>6.0</td>
</tr>
<tr>
<td>10.0</td>
</tr>
</tbody>
</table>

\(^{(a)}\) Denotes extrapolated value.
Table 7-3. Cumulative Truck Accident Velocity Distribution

<table>
<thead>
<tr>
<th>Velocity (mi/h)</th>
<th>Cumulative Probability</th>
<th>Velocity (mi/h)</th>
<th>Cumulative Probability</th>
<th>Velocity (mi/h)</th>
<th>Cumulative Probability</th>
<th>Velocity (mi/h)</th>
<th>Cumulative Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>14.0</td>
<td>0.34886</td>
<td>46.0</td>
<td>0.92881</td>
<td>78.0</td>
<td>0.99670</td>
<td>110.0</td>
<td>0.99999</td>
</tr>
<tr>
<td>18.0</td>
<td>0.46237</td>
<td>50.0</td>
<td>0.95009</td>
<td>82.0</td>
<td>0.99825</td>
<td>150.0</td>
<td>1.0</td>
</tr>
<tr>
<td>22.0</td>
<td>0.56877</td>
<td>54.0</td>
<td>0.96547</td>
<td>86.0</td>
<td>0.99910</td>
<td></td>
<td></td>
</tr>
<tr>
<td>26.0</td>
<td>0.66345</td>
<td>58.0</td>
<td>0.97634</td>
<td>90.0</td>
<td>0.99956</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Notes:
Source: NUREG/CR-6672.
(a) Probability that the accident or impact velocity is less than or equal to the listed velocity. For example, about 0.038 (3.8%) of all accidents have an impact velocity of 3 km/h (2 mi/h) or less.

Figure 7-10. Plot of Cumulative Distribution of Impact Velocities

The velocity distribution shown in Table 7-5 is for accidents that occur on level ground. This is representative of the Hanford Site because there are no bridges of concern for a truck to fall from and strike the ground below the bridge. There are also no significant embankments for the truck and packaging system to fall from and strike an object or surface below. The distribution credits a reduction in velocity due to braking. The distribution also incorporates the probability of striking surfaces of various characteristics, such as hard rock, soft rock, soil, and the roadbed. The data used by NUREG/CR-6672 to characterize the impact surface was developed from U.S. Department of Agriculture digitized maps using GIS interrogation techniques. This corrected some potential non-conservatisms in the NUREG/CR-4829 study. The GIS techniques
were applied to four illustrative routes, including one cross-country route between Florida and Washington State. These data were accounted for in the NUREG/CR-6672 analysis.

7.3.2.2.1.3 Fire

The effects of fires are a function of the temperature and duration of the fire, the fire orientation with respect to the package (i.e., fire and container are co-located versus offset from each other), and the thermal properties of the package (e.g., thermal resistance of the seals, emissivity of the container surfaces). NUREG/CR-6672, NUREG/CR-4829, and SAND 93-2580, *A Statistical Description of the Types and Severities of Accidents Involving Tractor Semi-Trailers*, have examined accident reports and modeled fire effects to characterize the probabilities of various fire environments. Typically, these studies generated a number of probabilistic distributions to generate the approximate probabilities of fires of varying severities. These distributions are based on nation-wide truck transport and are assumed to be applicable to the Hanford Site in general. However, certain distributions are not applicable, such as the probabilities of fires occurring after truck/train grade-crossing accidents (rail transport is no longer used on the Hanford Site).

This section describes the information needed to estimate the conditional probabilities of generating various fire scenarios. As with the previous distributions, the first distributions require the ACs to be isolated from the packaging integrity evaluations conducted in the studies listed above.

There are two types of fire scenarios modeled in Figure 7-11. One is a fire that occurs in conjunction with or following a mechanical impact event, such as a collision or overturn. The other is a fire that occurs in non-collision accidents. The former scenarios are intended to model the cumulative damage from mechanical and thermal ACs while the latter models thermal-only ACs (i.e., no mechanical damage sustained prior to fire initiation). The conditional probabilities of these scenarios are developed in the following subsections.

A fire frequency per accident of 1.6 percent is recommended for use on the Hanford Site per SLA-74-0001, *Severities of Transportation Accidents Volume III—Motor Carriers*. 
Figure 7-11. Cumulative Probability Distribution of Fire Duration for Accidents Involving Mechanical Damage (i.e., collisions, overturns)

7.3.2.2.1.4 Conditional Probability of Fire Given Mechanical Accident

In SAND 93-2580, cumulative distributions of fire durations were developed based on reviews of accident reports, curve-fitting techniques, and Monte Carlo analyses. A cumulative distribution of fire duration was developed that will be used to select the conditional probability of encountering such conditions on the Hanford Site. Note that the distributions are based on nation-wide accident data. Little can be done to adjust these distributions to more-closely reflect Hanford Site road conditions, as the fire severity probabilities are mostly dependent on the type of vehicle struck (e.g., truck tanker, passenger car, etc.) rather than road wayside conditions. The following assumptions are implied in the use of this distribution:

The fire temperature reached is assumed to be the regulatory hypothetical fire test temperature (800°C [1,472°F]). No credit is taken for the probability that the fire temperature is lower than that value. For perspective, SAND 93-2580 concluded that essentially all fires have average fire temperatures greater than 650°C (1,202°F) and that only one fire in two reaches an average temperature of 1,000°C (1,832°F).

It is assumed that the fire is engulfing. For perspective, SAND 93-2580 determined that no more than one fire in two is engulfing.

The distribution includes the data on fires involving collisions with trains. For perspective, SAND 93-2580 determined that collisions with trains are the most likely scenarios to result in an engulfing fire condition (or fires with diameters greater than 7.6 m [25 ft]). Collisions with trucks, cars, and fixed or non-fixed objects were determined to have an 80 percent probability of
being less than 7.6 m (25 ft) diameter. In other words, inclusion of train-accident initiated fires lead to a higher probability of becoming engulfing than would be calculated for the Hanford Site where rail shipping is no longer conducted.

These assumptions and the perspectives describe key conservatisms that demonstrate the bounding nature of this methodology and data.

7.3.2.2.1.5 Conditional Probability of Fire-only Accident

The cumulative distribution used to select the conditional probabilities of fire-only accident scenarios is shown in Figure 7-12. This figure was developed using NUREG/CR-6672 data that represents the cumulative probability of fires lasting less than or equal to some duration for non-collision accidents. The numerical values used to construct the distribution are shown in Table 7-4.

![Figure 7-12. Cumulative Probability Distribution of Fire Duration for Non-collision Accidents](image_url)

<table>
<thead>
<tr>
<th>Duration, minutes</th>
<th>Cumulative Probability</th>
<th>Duration, minutes</th>
<th>Cumulative Probability</th>
<th>Duration, minutes</th>
<th>Cumulative Probability</th>
<th>Duration, minutes</th>
<th>Cumulative Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>20</td>
<td>0.9625</td>
<td>40</td>
<td>0.9970</td>
<td>60</td>
<td>0.9998</td>
</tr>
<tr>
<td>5</td>
<td>0.3311</td>
<td>25</td>
<td>0.9801</td>
<td>45</td>
<td>0.9985</td>
<td>65</td>
<td>0.99991</td>
</tr>
<tr>
<td>10</td>
<td>0.6596</td>
<td>30</td>
<td>0.9897</td>
<td>50</td>
<td>0.9992</td>
<td>70</td>
<td>0.99996</td>
</tr>
<tr>
<td>15</td>
<td>0.8551</td>
<td>35</td>
<td>0.9944</td>
<td>55</td>
<td>0.9996</td>
<td>75</td>
<td>~1</td>
</tr>
</tbody>
</table>
7.3.2.2 Site Accident Frequencies

Figure 7-13 shows the overall calculation process for determining the frequencies of severe accidents that could result in package failures. Up to five accident scenario frequencies are calculated for Type A packages and five for Type B packages (note that a different set of data is used to calculate the probabilities of puncture for Type A packages than for Type B). The frequencies of severe accidents on the Hanford Site are calculated by multiplying together the accident rate, number of shipments per year of the particular cargo to be transported, one-way shipping distance, and the conditional probabilities of the various ACs described above. An example evaluation is provided in Appendix E.
Figure 7-13. Accident Frequency Calculation Process
8.0 Routine Transfers

This chapter describes the processes and procedures used to make routine onsite shipments. All packagings prepared and shipped as routine must be authorized and fully comply with the provisions of the TSD. Basic procedures and processes for handling onsite shipments of hazardous materials and wastes are included in this chapter. Contractors provide more detailed facility/project operation procedures at the facilities where T&P activities occur.

8.1 Common Hazardous Materials and Wastes Shipped Onsite

All shipments of government-owned hazardous materials and wastes within the physical boundaries of the Hanford Site are either shipped, when in commerce, in accordance with DOT regulations (49 CFR 100-199) or onsite (i.e., public access is restricted) in accordance with the TSD. These materials and/or waste must be packaged and transported in accordance with the provisions of DOT Regulations or TSD (respectively) regardless of the material, waste type, or waste category. Generally, all onsite shipments made in accordance with this TSD are considered routine.

Non-routine shipments are those that fall outside the provisions of the TSD or are shipments that meet the criteria of an “emergency move.” Procedures for handling non-routine shipments and emergency movements are further addressed in Chapter 9, Non-routine Transfers.

The Hanford Site is a large industrial site with many chemical and nuclear processing facilities, laboratories, and waste management treatment, storage, and disposal sites. As a result, hundreds of different chemicals and chemical products are brought to the Hanford Site each year to support various projects and their missions. Materials commonly shipped onsite between facilities include the following:

- Flammable, nonflammable, and toxic compressed gases
- Corrosive liquids and solids
- Flammable liquids and solids
- Reactive metals, oxidizers, and explosives

These materials and their resultant wastes represent all the DOT hazard classes (Class 1 through Class 9), and federal and state waste categories (EPA hazardous wastes, Washington Department of Ecology dangerous wastes, and extremely hazardous wastes.)

Additionally, radioactive materials and wastes are generated, used, and transported across the Hanford Site. Radioactive materials commonly shipped onsite include the following:

- Uranium and plutonium metals and oxides
- Sealed radiation, irradiation, and industrial test sources
- Process and environmental samples
- All categories of radioactive wastes
- Mixed waste
Hanford Site facilities generate, package, and ship waste onsite to waste management treatment, storage, and disposal facilities. These radioactive wastes consist of the following categories:

**Spent Nuclear Fuel** - The majority of this material was generated at the nuclear production reactors along the Columbia River. Most of this fuel has been extracted from the fuel storage basins, placed into specially-designed canisters and casks, and transported to the Canister Storage Building (CSB) located in 200 East Area. The fuel-filled canisters will remain at the CSB until they can be transferred to a licensed spent nuclear fuel repository.

**High-Level Waste** - The majority of the Hanford Site high-level waste is stored in underground storage tanks located in the 200 East and 200 West Areas. It is expected this waste will be extracted from the tanks and processed into vitrified glass, which, in turn will be placed into specially designed canisters for long-term storage and disposal. The low-activity waste generated from this process will be placed in a burial trench located in the 200 East Area.

**Transuranic Waste** - This waste can be either remote-handled or contact-handled waste. It is generally confined to a small number of facilities that processed or handled transuranic (TRU) radionuclides, such as plutonium and americium, in support of defense program activities conducted at the Hanford Site. Much of this waste is located at the Hanford Site Plutonium Finishing Plant, CWC, and the Waste Receiving and Processing Facility. Generally, this waste is placed into authorized metal drums and metal box-based packaging systems and shipped onsite. Some of this TRU waste has already been transported to the Waste Isolation Pilot Plant (WIPP), located near Carlsbad, New Mexico. Shipments to WIPP will resume based on budget and WIPP priorities.

**Low-Level Waste** - This waste is generated at Hanford Site facilities where radioactive materials is involved in decontamination and decommissioning activities, processed or handled radioactive products. This waste is usually a secondary waste stream generated because of other work or waste generated from a specific cleanup project. At the Hanford Site, this waste is usually made up of trash, building rubble, soil, laboratory supplies, and personal protective equipment potentially contaminated with mixed fission products or activation products. This waste is generally packaged in metal drums and metal boxes for contact-handled waste; or specially-designed casks or other container systems for remote-handled wastes. The wastes are transported onsite from the point of origin to the appropriate disposal facility; returned to the Hanford Site for final disposition; or specially designed high-integrity containers.

**Mixed Waste or Radioactive Mixed Waste** - This waste is generally radioactive low-level waste that is also cross contaminated with other hazardous constituents regulated under EPA or state rules. These wastes are generated throughout the Hanford Site and must be treated, stored, and disposed of under special waste management rules. Generally, these wastes are packaged in metal drums, metal box containers, or specially designed high-integrity containers. These wastes are transported onsite to designated mixed waste facilities located in the 200 West Area or transported to commercial radioactive treatment, storage, and disposal facilities, with most of the waste returning to the Hanford Site for disposal.

### 8.2 Common Packagings Used

At the Hanford Site, the policy and expectation is that all hazardous materials and hazardous wastes (except onsite radioactive materials and wastes, or otherwise as stated in Sections 8.3.1.2
and 8.3.1.4) must be packaged and transported onsite and offsite in full compliance with DOT Regulations. Onsite radioactive material and waste shipments must either meet DOT Regulations or provide an equivalent degree of safety as defined and demonstrated in this TSD.

Most hazardous materials and some hazardous wastes are packaged in non-bulk packagings authorized in accordance with the DOT Regulations under 49 CFR 173, Sections 173.201, 173.202, and 173.203 for liquid hazardous materials meeting packing groups I, II, and III, and Sections 173.211, 173.212, and 173.213 for solid hazardous materials meeting packing groups I, II, and III. Commonly used containers or packagings are identified below:

- **Class 1 Explosives** – see 49 CFR 173 Subpart C for details
- **Class 2 Division 2.1, 2.2, and 2.3** – Cylinders meeting DOT Specification 3A, 3AA, 3AX, 4B and 39 as common examples
- **Class 3 Flammable Liquids** – DOT Specification UN1A1 or UN1A2 single packagings, or authorized combination packagings
- **Class 4 Flammable Solids** – DOT Specification UN1A1 or UN1A2 single packagings, or authorized combination packagings
- **Class 5 Oxidizers** – DOT Specification UN1A1 or UN1A2 single packagings, or authorized combination packagings
- **Class 6 Poisonous Materials** – DOT Specification UN1A1 or UN1A2 single packaging, or authorized combination packagings
- **Class 7 Radioactive** – Excepted packagings, industrial packagings Type IP-1, Type IP-2, Type IP-3, DOT Specification 7A Type A packagings, and NRC or DOT Certified Type B packages, or in onsite packaging systems authorized under the provision of this TSD. See Appendix A for a list of currently authorized onsite packaging systems
- **Class 8 Corrosives** – DOT Specification UN1A1 or UN1A2 single packagings, or authorized combination packagings
- **Class 9 Misc. Hazardous Materials** – Excepted packagings, and DOT Specification UN1A1 or UN1A2, or authorized combination packagings.

Most hazardous wastes and some hazardous material, including those that are radioactive, are transported onsite in bulk packagings. These include large wooden and metal boxes meeting appropriate specifications, non-specification tankers, and DOT Specification MC 312 and MC 412 cargo tanks. The list of cargo tanks and portable tanks can be found on the TSD Configuration Manager Webpage.

The MC 312 cargo tanks were fabricated to the MC 312 DOT Specifications per 49 CFR 178.340 and 178.343 (1989 standards). (Note: New MC 312 cargo tanks are no longer authorized to be fabricated, 49 178.340 and 178.343 have been removed from the current regulations.) The MC 412 units were fabricated to the MC 412 DOT Specifications per 49 CFR 178.345 and 178.348. Each cargo tank is ASME certified, and has a CoC that states the cargo tank was designed, constructed, and tested in accordance with DOT Motor Vehicle Cargo Tank Specifications for cargo tanks used for the transportation of liquids classified as hazardous material. If cargo tanks are not maintained in accordance with 49 CFR 180, Subpart E, they are
considered non-specification cargo tankers. Most of the cargo tanks used to transport radioactive material are considered non-specification cargo tanks.

SPAs contained in Appendix H identify typical packagings authorized for onsite shipment of radioactive material payloads under specific conditions and controls described in individual SPA documentation.

8.3 Onsite Hazardous and Radioactive Material Shipments Process and Procedures

Sections 8.1 and 8.2 identified the commonly shipped hazardous materials and wastes and the common packagings used to ship them. The following sections identify the procedures that are to be followed when conducting onsite shipments of hazardous materials.

8.3.1 Requirements

Onsite shipments of hazardous materials and wastes including radioactive materials and wastes must be executed in accordance with this TSD and in accordance with contractor implementing procedures.

RL, ORP, PNSO, and Hanford Site prime contractors/subcontractors that conduct onsite hazardous material T&P activities must prepare and implement procedures that incorporate the following general and specific activities when applicable:

8.3.1.1 General Requirements for All Shipments

8.3.1.1.1 Contractor Program, Project, and Facility Procedures

Hazardous material shipments must be performed in accordance with applicable operating procedures that provide for nuclear safety, environmental protection, QA, security, radiological exposure and contamination control, and T&P requirements, as well as applicable federal, state, and contractor requirements. Examples include the following:

- DOE Orders
- 49 CFR, “Transportation”
- 10 CFR 71 “Packaging and Transportation of Radioactive Materials”
- 10 CFR 830 “Nuclear Safety”
- Hanford Sitewide TSD
- PSSD, SARP, or OTRS
- Packaging CoC
- SPA SEC
- 10 CFR 835, “Occupational Radiation Protection”

All PSSD or OTRS requirements from applicable onsite package documents, CoCs, and/or applicable federal regulations governing the use of each package must be verified and
incorporated into applicable program, project, facility operating, or work package procedures. Compliance with these procedural requirements is mandatory.

The safety assessments conducted for T&P activities are conducted for completed packages. The point where the safety responsibility transfers between a facility and the T&P activity is identified in Table 8-1.

Table 8-1.  Transportation to Facility Safety Responsibility Interfaces

<table>
<thead>
<tr>
<th>Shipping Facility</th>
<th>Receiving Facility</th>
<th>TSD Interface Boundaries</th>
</tr>
</thead>
<tbody>
<tr>
<td>Facility has a safety or authorization basis document that defines facility boundary within which all activities including T&amp;P activities are addressed.</td>
<td>Facility has a safety or authorization basis document that defines facility boundary within which all activities including T&amp;P activities are addressed.</td>
<td>Transfer of responsibility occurs at a shipping facility safety or authorization basis boundary and at the receiving facility safety or authorization basis boundary. Pre-transportation functions required by this TSD must be implemented.</td>
</tr>
<tr>
<td>Facility has not defined a boundary in a safety or authorization basis document within which T&amp;P activities are addressed.</td>
<td>Facility has safety or authorization basis document that defines facility boundary within which all activities including T&amp;P activities are addressed.</td>
<td>Transfer of responsibility occurs at shipping facility loading dock/area and at the receiving facility safety or authorization basis boundary. Pre-transportation functions required by this TSD must be implemented.</td>
</tr>
<tr>
<td>Facility has not defined a boundary in a safety or authorization basis document within which T&amp;P activities are addressed.</td>
<td>Facility has not defined a boundary in a safety or authorization basis document within which T&amp;P activities are addressed.</td>
<td>Transfer of responsibility occurs at shipping facility loading dock/area and at the receiving facility loading/area dock. Pre-transportation functions required by this TSD must be implemented.</td>
</tr>
</tbody>
</table>

All interface requirements resulting from transport of hazardous materials must be incorporated into operating procedures. Packing and unpacking of a package is conducted under the facility safety or authorization basis documentation, consistent with transportation safety basis requirements for the package. Procedures for those tasks, however, must incorporate steps that result in the completed package meeting all applicable T&P requirements. Packages prepared in full compliance with DOT requirements may be stored in compliance with DOT storage requirements if permitted by the facility safety or authorization basis documentation. All onsite packages must be stored in compliance with the facility safety or authorization basis documentation. All onsite packages must be loaded on the transport vehicle in compliance with both the facility safety or authorization basis documentation and the PSSD or other transportation safety document. Most PSSDs and other transportation safety documents do not evaluate the hazards associated with packing or loading activities.
New or revised procedures for activities conducted at an interface must be subjected to the USQr Process.

8.3.1.1.2 Packaging Authorization

All hazardous material and waste (except radioactive material and waste, or otherwise as allowed in Sections 8.3.1.2 and 8.3.1.4) shipped onsite shall be packaged and shipped in accordance with DOT Hazardous Material Regulations as set forth in 49 CFR 171 through 180. If hazardous material other than radioactive material/waste cannot be packaged in accordance with 49 CFR 171 through 180, the contractor needs to submit an exemption request to RL.

Radioactive materials and wastes shipped onsite shall be packaged and shipped in accordance with DOT Hazardous Material Regulations as set forth in 49 CFR 171 through 185 or may be shipped under a DOE-approved alternative providing an equivalent degree of safety as specified in this TSD.

8.3.1.2.1 Approval of Packaging Systems

DOE O 460.1C requires DOE Operations or Field Offices to review and approve onsite TSDs. This TSD describes the methodology and compliance processes to meet equivalent safety measures relative to deviations from 49 CFR 173. This TSD defines three categories of packaging:

- DOT-compliant packaging
- Equivalent packaging
- Risk based packaging.

Each of these categories of packaging is approved as described below.

   a. NRC-Certified Packaging. If the contractor or DOE is registered as a user and the contractor possesses a copy of the latest NRC CoC and the packaging’s SARP (or operation and maintenance chapters or manual), the contractor may use a NRC-certified packaging.
   b. DOT Specification Containers. Packaging designs that have been published in 49 CFR 173, as specification packagings may be used provided that all provisions of the DOT Specification and applicable QA requirements are met and provided that the use of the packaging is not prohibited by DOE O 460.1C.
   c. International Atomic Energy Agency (IAEA) Certificate of Competent Authority. DOE Contractors may use any international certification that has been revalidated by the U.S. Competent Authority (DOT) and which the DOE contractors or DOE are registered as a user provided all requirements of the certification, special provisions, and other applicable regulations are met.
   d. DOD-Certified Packaging. If the contractor or DOE is registered as a user and the contractor possesses a copy of the latest DOD CoC and the packaging’s SARP (or operation and maintenance chapters or manual), the contractor may use a DOD-Certified Packaging.
e. DOE-Certified Packaging. If the contractor is registered as a user, DOE contractors may use a DOE-Certified Packaging provided the contractor possesses a copy of the latest DOE CoC and the packaging’s SARP (or operation and maintenance chapters or manual).

2. Equivalent Packaging Systems

Equivalent packaging is packaging that can be shown conclusively to provide performance equivalent to packaging meeting DOT requirements for onsite shipment. Equivalent packaging is to be used with control and communication requirements equivalent to DOT or defined in the TSD. A Packaging Safety Document is to be prepared that demonstrates that the TSD requirements are met. The PSSD or Packaging Safety Documents will provide evidence that the package meets equivalent standards. The initial PSSD or other Packaging Safety Documents will be approved by RL. Subsequent modifications to the Packaging Safety Documents will be performed using the RL-approved USQ\textsubscript{T} Process.

3. Risk Based Packaging Systems

Risk based packaging is onsite packaging that cannot be demonstrated to function equivalently to DOT packaging. A PSSD or other Packaging Safety Document will be prepared that establishes a performance envelope for the packaging and specific control and communication requirements developed that ensure the transport system operates safely within the performance envelope. To establish the performance envelope of the packaging, evaluation of the requirements established in Chapter 6.0 will be conducted in accordance with the methodology established in Chapter 7.0. The initial PSSD or OTRS will be approved by RL. Subsequent modifications to the PSSD will be performed using the RL-approved USQ\textsubscript{T} Process unless otherwise stated in the TSD (e.g., SPA and OTRS).

8.3.1.1.3 Personnel Delegation and Training

All personnel involved with preparing hazardous material for transport including operators, drivers, waste handlers, and managers are considered hazmat employees and must be trained in accordance with 49 CFR 172.704, “Training requirements.” See Chapter 10, Personnel Training and Qualification, for details.

Contractor operating organizations making shipments must establish a process for authorizing and delegating shipper responsibility.

The authorizing signature on a shipping document shall be that of an individual who is on the contractors’ delegated (authorized) shippers list. A Federal Employee must be the authorizing signature in the shipping papers.

Drivers of vehicles hauling hazardous material onsite must have a current and appropriate driver’s license (e.g., CDL when required), and medical card.

USQ\textsubscript{T} Screeners and Evaluators must be appropriately trained in accordance with 49 CFR 172.704 (see Chapter 10) and each contractor’s Unreviewed Safety Question Program.
8.3.1.1.4 Operational Controls

Authorized shippers should use a shipment checklist when preparing hazardous material and waste shipments, radioactive material and waste shipments, and mixed waste shipments.

Transport of government-owned hazardous material by Hanford Site contractors shall be performed using a commercial carrier or approved government vehicle properly equipped to transport hazardous material with a trained and qualified driver. Commercial motor carrier shall only be used when the onsite shipment meets DOT Regulations. Only prime contractors who are commercial motor carriers or onsite carriers who have been evaluated by a prime contractor for onsite shipment, using government vehicles, can transport hazardous material which are conducted using Equivalent Packaging Systems and Risk Based Packaging Systems. Transport of nongovernment-owned hazardous materials must meet the same requirements as when transported in commerce.

Only properly maintained and regulatory-compliant motor vehicles shall be used for the transportation of hazardous material.

The shipment of government-owned hazardous materials in privately-owned vehicles is prohibited.

The contractor shall define acceptable conditions for weather, road conditions, and other natural phenomena. At a minimum, the following will be included in safety assessments and operating procedures for onsite transport. If the ambient air temperature is 4°C (40°F) or less (as determined at the Hanford Weather Station just prior to shipment), personnel shall drive the shipping route to ensure there is no appreciable ice or snow on the road immediately prior to shipment. If it is determined that adequate traction exists, the shipment may be made. If visibility is less than 200 m (0.124 mi), the shipment shall not be made.

A copy of the current Hazardous Material - Certificates of Registration must be provided in the cab of each vehicle that may require placards for the transport of hazardous material (49 CFR 107, Subpart G).

8.3.1.1.5 Documentation and Records

Source documentation used for physical, chemical, and radiological characterization of material and waste must be maintained as described in the contractor’s records management system. Source documentation may include laboratory analysis, Material Safety Data Sheets or Safety Data Sheet, contents inventory sheets, waste designations, radiological characterization data, radiological calculation data, survey reports, radioactive material area certifications, Solid Waste Information Tracking System (SWITS) reports, and/or Land Disposal Restriction Certifications/Notifications.

An auditable record of the inspection, maintenance, and certification for a packaging that documents the package is ready for use must be retrievable by the shipper to be given to the auditor within 48 hours. This includes a copy of the current PSSD (e.g., OTRS, SEP, test and evaluation report, CoC, or O&M instructions) and should include applicable package testing documentation and package closure instructions.
The shipper must be able to document that each package’s contents meets the authorized payload limits as applicable in 49 CFR; the CoC issued by the NRC or DOE; the onsite package documentation; or Packaging Safety Document.

Records generated because of transporting hazardous material must be maintained. This includes a file of supporting documentation used as a basis for making the shipment (e.g., current CoC, PSSD). All appropriate internal procedures must reflect the requirements of these documents prior to making the initial shipment. Records should be retained for the same period as defined for the equivalent offsite shipment.

8.3.1.1.6 Safeguards and Security

Shipments of accountable nuclear materials must have contractor and DOE Safeguard’s approval prior to shipment.

Shipments of Category I and II SNM must be scheduled in advance to ensure availability of equipment, security, and properly-cleared drivers.

When road closures are required by the Packaging Safety Document or by Safeguards and Security requirements, these closures shall be coordinated and scheduled through the transportation service provider lead or designee.

The transportation of weapons and explosives by Hanford Patrol used to carry out their responsibilities to meet the Atomic Energy Act of 1954, Section 161, as amended, are not subject to TSD requirements.

8.3.1.1.7 Nuclear and Radiological Safety

All non-Hanford Site contractors’ commercial vehicles that transported radioactive material, per exclusive use (or there is evidence the packaging was damaged in transport), will be free released back into commerce using DOE limits. Commercial vehicles remaining in exclusive use service will be released to DOT limits. All other onsite shipments using government vehicles will be free released per limits specified in 10 CFR 835. Only government vehicles are authorized to transport non-DOT compliant hazardous material shipments.

8.3.1.1.8 Planning and Communications

U.S. Department of Energy-Headquarters (DOE-HQ) Security approval is required for certain radioactive material shipments. In order to obtain this approval, a request is submitted by the contractor to the RL Traffic Manager at least two weeks prior to the shipment. The RL Traffic Manager will notify the contractor when DOE-HQ approval is received.

Emergency response information must be provided in the cab of the vehicle. This includes the appropriate emergency response guide page from the Emergency Response Guidebook or a current copy of the guidebook; and the shipping papers. Shipping papers must provide an emergency contact telephone number.

Contractor management must be notified of all transportation-related incidents as soon as practical. Formal reporting of all incidents must be completed in accordance with the Hanford Site Incident and Occurrence Reporting System Requirements.
8.3.1.9 Checklists
The contractor should develop a shipment checklist. The checklists should include applicable requirements from DOE Orders, DOT Regulations, and onsite shipment requirements adequate to ensure that material is characterized, described, packaged, marked, labeled, and can be transported in accordance with applicable requirements. A checklist should be completed prior to each shipment not covered by an Onsite Routine Radioactive Shipment Record (ORRRS).

8.3.1.2 Radioactive Material Shipments – General Provisions

8.3.1.2.1 Fissile Material and Special Nuclear Material
The shipment of fissile material requires certain controls in addition to those needed for non-fissile radioactive material. Fissile material requires controls for criticality safety and accountability and because DOT-designated fissile material is also SNM of national strategic importance, additional controls for security and safeguards are mandatory. Fissile material as defined per 49 CFR 173.403 identifies the following radionuclides and isotopes: $^{239}\text{Pu}$, $^{241}\text{Pu}$, and $^{233}\text{U}$, $^{235}\text{U}$, or combinations of these radionuclides.

- **Fissile-Excepted Material** - Fissile material is classified as either fissile or fissile-exceptioned material. Fissile-exceptioned material is exempted from criticality safety packaging requirements. These shipments must be in accordance with both shipping and receiving facility fissionable material limits and restrictions. Fissile material exceptions given in 49 CFR 173.453, “Fissile materials—exceptions,” may be used for onsite shipments.


- The following previously DOE or NRC approved packages may be used:
  - For Type B(U), Type B(M), and fissile material packaging without a designation “-85” Identification Number of DOE/NRC CoC may be used as long as the packaging was fabricated prior to April 1, 1999, has a unique serial number, and meets the requirements of the CoC,
  - For Type B(U), Type B(M), and fissile material packaging with a designation “-85” Identification Number of DOE/NRC CoC may be used as long as the packaging was fabricated prior to December 31, 2006, and meets the requirements of the CoC,
  - Any Type B and fissile material packaging without a designation “-96” Identification Number of DOE/NRC CoC may be used and meets the requirements of the CoC, or
  - An evaluation must be submitted to DOE for payload that exceeds the CoC payload description.

- All foreign Type B, Type A, and fissile packaging must have either approval by the U.S. Competent Authority or the RL Manager. The Hanford Site’s contractor must maintain a copy of the applicable certification, the revalidation, and the drawings and
other documents referenced in the certificate. In addition, the Hanford Site’s contractor must maintain documents relating the use and maintenance of the packaging and to the actions to be taken before the shipment, and comply with the terms and conditions of the certificate and revalidation.

- **Type A Fissile packaging (Type AF)** can be used if the following requirements are met:
  - The requirements 49 CFR 173.417(a);
  - When the contents contain no more than a Type A quantity of radioactive material;
  - When the contents contain less than 500 total grams of beryllium, graphite, or hydrogenous material enriched in deuterium; and
  - Packages containing fissile material that are labeled with a CSI, which has been determined in accordance with paragraph 10 CFR 71.22(e), must;
    - The CSI is less than or equal to 10; and
    - For a shipment of multiple packages containing fissile material, the sum of the CSIs must be less than or equal to 50 (for shipment on a nonexclusive use conveyance) and less than or equal to 100 (for shipment on an exclusive use conveyance).

- **For plutonium-beryllium special form material**, Type A Fissile packaging (Type AF) can be used if the following requirements are met:
  - The requirements 49 CFR 173.417(a);
  - When the contents contain no more than a Type A quantity of radioactive material;
  - Contain less than 1,000 g of plutonium, provided that: $^{239}$ plutonium, $^{241}$ plutonium, or any combination of these radionuclides, constitutes less than 240 g of the total quantity of plutonium in the package.
  - Packages containing fissile material that are labeled with a CSI, which has been determined in accordance with paragraph 10 CFR 71.23(e), must;
    - Have a value less than or equal to 100; and
    - For a shipment of multiple packages containing Pu-Be sealed sources, the sum of the CSIs must be less than or equal to 50 (for shipment on a nonexclusive use conveyance) and less than or equal to 100 (for shipment on an exclusive use conveyance).

This requires the shipper to evaluate activity and packaging per these section limitations.

- **Fissile Material** - All onsite shipments of fissile material not packaged in DOT compliant packages shall be packaged in packages authorized by the TSD and reviewed and approved by the contractor approval authority. Appropriate ES&H and QA Organizations shall review onsite packages for criticality safety concerns. Onsite
package design when coupled with other considerations shall provide criticality safety protection equivalent to protection provided by approved offsite packages.

Onsite shipments shall be made in accordance with both shipping and receiving facility criticality safety specifications or facility fissile material status and the package fissile contents limitations based on the Packaging Safety Document. The Packaging Safety Document shall be available for use within the loading and unloading areas or any place where packages containing fissionable material are stored.

- **Accountable Material** - Accountable material is nuclear material so designated by the Secretary of Energy and currently includes depleted uranium, enriched uranium, $^{241}$Am, $^{243}$Am, curium, berkelium, californium, $^{238-242}$Pu, $^6$Li, $^{233}$U, normal uranium, $^{237}$Np, deuterium, tritium, and thorium. The requirements of the contractor’s nuclear material accountability plan describe accountable material as any material that contains 0.5 times or more of the reporting unit of one or more of the above listed materials, elements, or isotopes. In more general terms, some of this material is also referred to as the following:
  - Nuclear material
  - SNM
  - Source material

Accountable nuclear material must be controlled and accounted for as directed by DOE O 474.2, Chg. 4, *Nuclear Material Control and Accountability*. Material shipments and transfers must be documented and controlled in conformity with this order.

- **Approvals for Accountable Radioactive Material** - Certain onsite movements of accountable radioactive material requires each contractor’s Safeguard and Security Organization’s concurrence as well as RL approval. Non-reportable radioactive material shipments and some small amounts of accountable radioactive material may be covered by a blanket approval obtained at the beginning of each fiscal year; approvals for larger amounts of accountable material are generated on a case-by-case basis.

The shipment originator shall initiate application for each contractor’s Safeguard and Security Organization’s concurrence and RL approval of the shipment.

- **Categorization and Physical Protection for SNM Shipments** - The degree of security imposed on SNM shipments is determined by the category amounts of SNM. DOE O 474.2, Chg. 4 defines the minimum requirements for safeguarding SNM by categories while in transit.

The contractor must manage all Category I shipments and their documentation as classified. Some Category II shipments may also be classified, based on the criteria established in DOE M 470.4-6, Chg. 1.

### 8.3.1.2.2 Radioactive Mixed Waste

Radioactive mixed waste is radioactive waste contaminated with waste that is hazardous as defined in 40 CFR 261. The radioactive component of mixed waste is regulated under the *Atomic Energy Act of 1954*. The nonradioactive hazardous component of mixed waste is regulated under the *Resource Conservation and Recovery Act of 1976* (RCRA). To the extent
that RCRA is not inconsistent with the *Atomic Energy Act of 1954*, mixed waste must be handled in accordance with the requirements of both federal laws.

**8.3.1.2.3 Shipment of Packages on Public Access Roadways**

All radioactive material transported over roadways within the Hanford Site boundaries that are open to the public (DOT definition of "in-commerce") must be in compliance with DOT Regulations. For a shipment that does not meet these regulations, transporting on the Hanford Site may be done during off-peak hours with the roads closed to prevent public access to the shipment. During the road closure, all crossings are either barricaded by uses ropes, chains and/or signs; or manned by Benton County Sheriff’s Personnel, Hanford Patrol, or other authorized individuals to prevent public access onto the road being closed.

These shipments are not subject to DOT Regulations since they are conducted in accordance with 49 CFR 171.1(d)(4). This section of DOT Regulations requires that the shipment occurs within the physical boundaries of the Hanford Site (i.e., facility boundaries), and that the public is restricted from access to the conveyance (DOT Letter of Interpretation 14-0036). The public must be restricted from the road from both directions. DOT has no jurisdiction in controlled areas of the Hanford Site (i.e., north of the Wye Barricade within the no trespassing, fenced areas). However, DOE O 460.1C states that contractor transportation activities must either comply with DOT regulations or a TSD approved by the RL Manager. For shipments or portions of shipments within controlled areas, “Rolling” Road Closures are authorized. This type of road closure is typically closed in sections of road by authorized individuals. The conveyance is escorted by pilot vehicles that are stationed in front and rear of the conveyance. If the road is a divided road with multiple lanes in each direction (e.g., 11A and 2 South), the road is only closed in the direction of the shipment. Two lane roads are typically blocked in both directions.

Each contractor shall implement a ‘Road Closure’ procedure prior to performing a shipment requiring restricting public access. The procedure shall direct how Hanford Site Areas and roadways to which the public has access are to be closed so that onsite non-DOT compliant shipments can be conducted. The procedure shall ensure, as a minimum, the following requirements:

- Public access will be restricted for a hazardous materials shipment
- Authorization is required before shipment
- Roads and areas to be closed
- Escort requirements
- Roads are barricaded to exclude the public
- Movement of the shipment into controlled areas and how roads will be controlled
- No traffic on the roads or in the area before shipment
- Emergency vehicle access during a road or area closure
- ‘Safe secure trailer’ shipment has access during a road closure
- Road closure occurs during off-peak hours
8.3.1.2.4 Radiological Controlled Vehicles Program

Radiological controlled vehicles, formerly referred to as “regulated vehicles,” are only driven within their designated areas (e.g., north of the Wye Barricade). Movement and management of these vehicles are covered under an approved program. This program identifies responsibilities and requirements for managing all radiological controlled vehicles including survey requirements and identification of the vehicles as per 10 CFR 835.603, “Radiological areas and radioactive material areas,” Paragraph (g), which requires the placement of a decal bearing a trefoil symbol and the words “Caution Radioactive Material” posted on the front, back, and both sides of the vehicle. Therefore, movements of these “regulated vehicles” are not subject to the TSD and are not documented on an onsite Radioactive Shipment Record (RSR). If these “regulated vehicles” are transported outside of controlled areas, their movements are subject to DOT Regulations.

8.3.1.2.5 Radioactive Instruments and Articles (Radiological Sources)

Radioactive material that meets the definition as described in 49 CFR 173.424, “Excepted packages for radioactive instruments and articles,” (i.e., radiological sources) shall be packaged/transported by or under the direction of authorized personnel. This includes the packaging requirements referenced in 49 CFR 173.410, “General design requirements,” and notice requirements in 49 CFR 173.422, “Additional requirements for excepted packages containing Class 7 (Radioactive) materials,” which requires information on the outside of the packaging. The ORRSR may be used in place of normal package documentation to control onsite movement of these sources.

8.3.1.2.6 Inspection and Maintenance Completion Time Frames

Table 8-2 provides acceptable completion time frames for periodic inspection and maintenance activities required by the Packaging Safety Documents. These time frames apply when completion of maintenance activities required by the Packaging Safety Documents cannot be completed within the required inspection and maintenance cycles. This situation can occur if a shipment is delayed after loading, precluding any maintenance activities. If maintenance activities will be due during a planned use of the vehicle or packaging, the maintenance activity should be completed prior to use. A package may not be loaded outside of its maintenance timeframe. For example if a package’s annual leak test is due February 15, and the leak test is not completed by that date, it may not be loaded until the satisfactory completion of the leak test. The leak test is considered to be completed in periodicity as long as it is completed within the 48 to 56 week window under this section of the TSD.

<table>
<thead>
<tr>
<th>Package-Specific Safety Document Required Maintenance Time Frame</th>
<th>Approved Completion Windows</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monthly</td>
<td>3 to 5 weeks</td>
</tr>
<tr>
<td>Quarterly</td>
<td>10 to 14 weeks</td>
</tr>
</tbody>
</table>
Table 8-2. Inspection and Maintenance Completion Time Frames

<table>
<thead>
<tr>
<th>Package-Specific Safety Document Required Maintenance Time Frame</th>
<th>Approved Completion Windows</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annually</td>
<td>48 to 56 weeks</td>
</tr>
</tbody>
</table>

8.3.1.3 Onsite Routine Radioactive Shipment Record

Because of their frequency and uniformity of contents and packaging, some onsite radioactive material shipments are considered routine and the contractor may authorize movement and documentation by using a special shipping paper known as an ORRSR.

The ORRSR must provide preprinted shipment requirements and limitations. The preprinted requirements and limitations specified must be adhered to when making a shipment using the ORRSR. Violations or misuse must result in withdrawal of the ORRSR by the contractor.

Requirements, limitations, and supporting documentation specified on the ORRSR shall be reviewed and approved by the following organizations:

- Operations management (management of organization requesting ORRSR)
- Requesting facility’s radiological engineering safety organization
- The transportation service provider lead or designee.

The ORRSR may allow qualified personnel as well as authorized radioactive material shippers to certify that the shipment meets all the requirements as set forth on the ORRSR. The transportation lead or designee shall certify that the packaging system meets applicable requirements for onsite shipment.

8.3.1.4 Onsite Nonradioactive Hazardous Material/Hazardous Waste Shipments

The contractor shall ensure the onsite nonradioactive hazardous materials/hazardous waste shipments are made in compliance with applicable DOT requirements (except as noted below). The contractor is responsible to obtain RL approval or exemption for any requirement that cannot be met in accordance with the provisions of this TSD.

Procedures for onsite shipment of nonradioactive material/waste must include directions on how to accomplish the following tasks:

- Obtain source documentation for proposed package contents.
- Determine if the material to be transported meets the definition of a hazardous material as defined in 49 CFR 171.8.
- Determine how the material to be shipped is defined by chemical, technical, or generic name.
  - Determine or define hazardous properties.
– Determine quantity of material to be shipped (by weight, volume, or otherwise, as appropriate).

• If material to be shipped is currently packaged, determine if packaging is in unimpaired condition and meets DOT Regulations for the material contained.

• If material is a waste, determine if it is a federally regulated hazardous waste (40 CFR 261, “Identification and Listing of Hazardous Waste,” and WAC 173-303-070, “Manifest System”) or a state-only dangerous waste regulated only by WAC 173-303-070 in accordance with WAC 173-303, “Dangerous Waste Regulations.”

• Consult the Hazardous Material Table (HMT) in 49 CFR 172.101, Subpart B.
  – Determine if material contains a RQ of a hazardous substance under 49 CFR 172.101, Appendix A.
  – Determine hazard class and/or division (Column 3 of HMT).
  – Establish proper shipping name (Column 2 of HMT or WAC 173-303-180(6), “Manifest,” for state-only dangerous waste).
  – Determine identification number (Column 4 of HMT).
  – Determine packing group, if applicable (Column 5 of HMT).
  – Determine labeling requirements that apply to the shipment (Column 6 of HMT).
  – Determine special provisions applicable to the shipment (Column 7 of HMT).

Note: 49 CFR 173, contains specific requirements for packaging hazardous material or waste identified in the HMT. These requirements should be closely examined because they specify types of packaging, loading requirements and restrictions, internal packaging, and markings specific to the commodity being shipped.

1. If material is unpackaged, or requires repackaging, select and obtain a container based on the following considerations:
   a. The applicable determinations of Steps 1 through 6 in this section.
   b. Size, shape, weight, and volume of material to be shipped.
   c. Destination, mode of transport, and consignee's ability to handle receipt of the shipment (air carriers may have different requirements for size and weight limits for sample shipments).
   d. Availability of shipping containers.

2. Complete a packaging, marking, labeling, and loading instructions checklist if used.

3. Inspect the package to make sure it is in unimpaired physical condition. Verify that the package meets specifications of Column 8 in the HMT. If the package is a DOT performance-oriented package, verify the manufacturer’s notification is available. If it is not available, obtain the notification.

4. Fill and close the package following the manufacturer’s notification if applicable.
5. Inspect marking and labeling on containers and correct deficiencies as necessary.

6. If shipment is to be made from a radiation control area, obtain a radiation survey to determine radiation and contamination information and to ensure that the exterior surfaces are free of contamination.

7. When required, contact the receiving facility and arrange for receipt of the load.
   a. Make all shipment pre-notifications to the receiving facility.
   b. Notify the consignee (receiver) of the dates of the shipment, the expected date of arrival, and any special loading and unloading instructions.

8. Coordinate the shipment with transportation and waste handling organizations.

9. Determine the appropriate shipping paper to be used: *Hazardous Material Shipment Record* (HMSR), *Uniform Hazardous Waste Manifest* (UHWM) or equivalent.

10. When a HMSR or equivalent is the shipping paper used, complete Hanford Site Form A-6007-217 or equivalent, i.e., shipment record generated in SWITS database.

11. When a UHWM is the shipping paper used, complete the form or equivalent, i.e., shipment record generated in SWITS Database. The completed manifest, and other pertinent shipping papers or instructions, must accompany the shipment. Distribution of the UHWM can be found on the back of the form.

### 8.3.1.5 Onsite Radioactive Material/Waste Shipments

When a UHWM is the shipping paper used, complete the form or equivalent, i.e., shipment record generated in SWITS database. The completed manifest, and other pertinent shipping papers or instructions, must accompany the shipment. Distribution of the UHWM can be found on the back of the form.

1. Determine if the material to be shipped is radioactive material to be regulated by DOT or this TSD, refer to 49 CFR 173.403.
   a. Determine the radionuclides present (e.g., $^{239}$Pu, $^{233}$U, $^{137}$Cs).
   b. Determine the total activity in terms of Becquerels (Bq).
   c. When fissile radionuclides are present (49 CFR 173.403), determine the grams of fissile material for criticality control.
   d. Determine if material qualifies as a Hazardous Substance, RQ. (See 49 CFR 171.8, and 49 CFR 172.101, Appendix A, Table 2)
   e. Determine if material will be shipped as ‘normal form’ or ‘special form’ (49 CFR 173.403).
   f. If normal form, determine the physical form (e.g., solid, liquid, gas) and the chemical form (e.g., nitrate, oxide, elemental) of the radioactive material.
   g. Determine if other hazardous material is present or if other hazardous characteristics are exhibited (e.g., corrosive, flammable liquid, oxidizing...
material). Determine if material qualifies as a Hazardous Substance, RQ, per HMT, Appendix A, Table 1.

h. If the material is a waste product, determine if it is a federally regulated hazardous waste (40 CFR 261) or a state-only dangerous waste regulated only by WAC 173-303-070.

i. Identify appropriate $A_1$ or $A_2$ values for radionuclides present.
   
   

j. Determine the quantity category based on the radionuclides present, their $A_1$ or $A_2$ values as appropriate, and the total activity in any multiple units of Bq (i.e. MBq, TBq, etc.) in each package (e.g., cask, box, drum). See the following sections of 49 CFR for the quantities listed:
   
i. LSA I, II, or III radioactive material, or SCO I or II (49 CFR 173.403). Materials classified as either LSA or SCO require a formal evaluation of the material to ensure that it qualified as either LSA or SCO. This formal evaluation will be conducted in accordance with the methodology in NRC NUREG-1608, “Categorizing and Transporting Low Specific Activity Materials and Surface Contaminated Objects.” The formal evaluation will be included with the shipment records.
   
   
iii. Type A Quantity, 49 CFR 173.431, paragraph (a).
   
iv. Type B Quantity, 49 CFR 173.431, paragraph (b).

**Note:** (If an LSA or SCO shipment contains fissile radionuclides, they must meet the requirements for fissile-excepted waste per 49 CFR 173.453.)


3. Determine the packaging, marking, and labeling requirements.

4. A listing of commonly used packages for shipping radioactive material onsite can be found in Appendix A.
   
a. Select a packaging according to either 49 CFR or this TSD based on the following considerations:
   
i. Preference to use DOT/DOE/NRC compliant package, or if unavailable, an onsite package approved under this TSD (e.g., Packaging Safety Documents)
ii. Quantity, type, form, and classification of material to be packaged

iii. Need for shielding and/or cooling

iv. Size, shape, and weight of material to be shipped; if other hazards present, compatibility with those hazards

v. Destination and consignee's ability to receive the shipment

vi. Dose rate and contamination considerations

vii. Availability of shipping packages

5. The additional requirements of onsite receiving facilities’ Waste Acceptance Criteria.

   a. Determine marking and labeling requirements for each package in compliance with 49 CFR 172, Subpart D and E; and 49 CFR 173.178, the Packaging Safety Documents, where applicable. Because of high dose rates, the requirement to mark and/or label may be waived according to the applicable Packaging Safety Documents.

6. Determine all special considerations such as suggested routings (Chapter 3.0), mode of transport, special vehicle requirements, safeguards and security considerations, destination, requested delivery dates, and any other pertinent information concerning the shipment.

7. Arrange for a radiological survey of the package(s) to determine that dose rate limits and removable contamination limits are not exceeded.

   **Note:** Certain packaging systems are exempt from onsite limits and are instead controlled by limits specified in the approved Packaging Safety Documents.

8. Determine the category and the security requirement if the material is SNM (see DOE O 474.2, Chg. 4). Obtain Safeguard’s review if necessary.

9. Determine the shipping paper to be used.

10. Identify package, loading, and closure instructions.

11. Ensure the appropriate emergency response phone number is documented on the shipment record (e.g., RSR, UHWM).

12. Schedule onsite transportation from the originating facility to receiving facility. Schedule transportation equipment suitable for the shipment. Schedule radiological control technician (RCT) support or road closure support if required.

13. Arrange for an RCT to perform a removable contamination and deep dose radiation survey of the vehicle and vehicle cab for release per applicable limits and swipe requirements.

14. Ensure the vehicle is appropriate for the load, that the vehicle(s) has its annual inspection, and the driver is satisfied that the motor vehicle is in safe operating condition. Verify that a copy of the current Hazardous Material Certificate of Registration is in the cab of each vehicle that may require placards for the transport of hazardous material or is a
commercial motor vehicle with a gross vehicle weight rating of 4,356 kg (10,000 lb) or greater.

15. Ensure required emergency equipment is on the transport vehicle: Warning devices for stopped vehicles such as bi-directional reflective triangles or flares, spare fuses (if equipped) and charged fire extinguisher rated 10 B: C or more.

16. Ensure the RCT has verified the radiation level in the cab is within acceptable limits (e.g., less than 0.02 mSv/hr). Note: this level can be exceeded if the driver has appropriate dosimetry and is in a federally-regulated Radiation Protection Program (49 CFR 173.441(b)(4).

17. Ensure supervision of the loading and securing of packages into or onto the transport vehicle to ensure compliance with applicable loading and tiedown requirements as specified in 49 CFR 393, Subpart I, 49 CFR 177.834(a), Type B SARP or procedures found in the Packaging Safety Documents. Ensure that riggers or truck drivers are aware of any tiedown requirements that may be listed in associated CoCs, Packaging Safety Documents, or work procedures.

18. Ensure that the carrier has received instructions pertaining to any administrative controls specified in the Packaging Safety Documents and exclusive use instructions, as applicable, for transport of the package(s).

19. Advise the receiver of the estimated time of arrival and request confirmation of delivery on inter-area shipments exceeding Type A quantities.

20. When applicable, make the following notifications when performing SNM shipments:
   a. Notify the on-duty Hanford Fire Department Battalion Chief of the starting time, estimated duration of the shipment, route to be followed, and destination to expedite assistance, if needed. Examples are road closure, and “no fire” provision.
   b. Notify Hanford Patrol of the departure time, route, destination, and estimated time of arrival. Request escort service as required.

21. Ensure completion of the applicable shipment checklist.

22. Resolve all questions concerning any special services required while the package is being transported to the consignee’s facility (e.g., cooling water in case of delay enroute, control of personnel because of a radiation dose, escort by Hanford Patrol or Benton County Sheriff’s Personnel for traffic control).

23. Ensure that the original shipping paper(s) are provided to the driver making the shipment.

24. Ensure the proper placard, when required, is identified for the material to be transported.

25. Ensure that the transport vehicle is placarded “Radioactive,” when required, and as appropriate for other hazardous material being transported in accordance with DOT Regulations or as required when utilizing Packaging Safety Documents. Ensure placarding is documented on shipping paper in appropriate box.

26. A copy of the shipping document shall be maintained as a record.
8.3.1.6 Special Packaging Zone

A SPZ is a TSD-designated onsite area composed of multiple facilities connected by a road or roads that are access restricted to authorized onsite users. The facilities may be collocated or in close proximity to each other. The SPZ will include both the designated facilities and roads. Shipments between facilities within the SPZ are subject to modified marking, labeling, placarding, and manifest requirements listed below. With the exception of placarding and manifest requirements, waste shipments between facilities within the SPZ will meet other TSD requirements. All shipments within the SPZ will be shipped in approved packages in accordance with package requirements. SPZ requirements do not supersede facility placarding and manifest requirements. Use of the SPZ designation for shipments is voluntary. When using the SPZ option for shipments, the shipper shall comply with the TSD except as clarified below.

**Manifesting:** The use of a separate shipping manifest is optional where there is an existing documented hazardous material inventory document available; e.g., ORRSR, Traveler, or equivalent. An inventory of hazardous material being shipped is still required; a separate shipping manifest is not required.

**Notifications:** The shipper is required to notify potential emergency response responders along the shipping route of the shipment, contents, and schedule.

**Road Access Restrictions:** The shipper is responsible for limiting access to the shipment route during the shipment to eliminate nonessential traffic for the duration of the shipment. Methods for limiting access can include road closures or moving road closures.

It is the responsibility of the shipper to coordinate shipments to minimize impact on other operations.

Table 8-3 shows the SPZs, facilities, and boundaries.

<table>
<thead>
<tr>
<th>SPZ</th>
<th>Name</th>
<th>Facilities</th>
<th>Boundaries</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>100/200 Restricted Area</td>
<td>All onsite facilities and roadways north of the Wye Barricade and inside (east) of the Yakima and Rattlesnake Barricades</td>
<td>See Map 1.</td>
</tr>
</tbody>
</table>
Figure 8-1. Map 1. North of Wye Barricade Special Packaging Zone

Notes: The area within the dotted line, along with 300 and 400 Area, are the controlled area on the Hanford Site. These areas restrict access to the public by using no trespassing signs and fences. The solid line shows the Hanford Site Boundary.
9.0 Non-Routine Transfers

This chapter describes the processes and procedures for dealing with non-routine transfers. Non-routine transfers are sub-divided into two categories:

1. Exemption Requests
2. Emergency Transfers

Conditions and circumstances for exemption requests or emergency transfers are defined, as well as applicable procedures, and the approval process.

9.1 Exemption Requests and Emergency Shipment Procedures

This chapter identifies how non-routine and emergency shipments (transfers) are handled under the onsite hazardous materials T&P Safety Program. Non-routine onsite shipments (transfers) and emergency transfers are unusual and unpredictable events that may occur onsite. A non-routine shipment or transfer may be necessary to facilitate the movement of a piece of equipment that cannot be easily cleaned or dismantled; for example a test loop contaminated with sodium. For onsite shipments, DOE must grant the exemption to the onsite requirement. Immediate action may be required, in an emergency, to mitigate a spill or release event, and/or provide immediate protection to workers, the public, or to the environment as a result of an accident or incident. For example, a cargo tank could be transported onsite and a road obstruction or collision causes damage to the containment boundary, allowing a small spill to begin. The Incident Commander (IC) for emergency responders and site management may decide to trans-load the liquid contents to another cargo tank to mitigate the event, minimize the cleanup needed, and facilitate recovery operations. Emergency procedures will define such events and protocols to be used in making such a decision.

9.1.1 Exemption Requests

Non-routine onsite shipments (transfers) are handled by submitting an OTRS to the RL Manager. OTRSs are exemption requests and are risk based following the risk methodology in the TSD. As an exemption, they are not subject to the USQ\(_T\) Program. Any changes to an OTRS will be submitted to the RL Manager for approval. Compliance of shipments for an OTRS is accomplished through the use of an evaluation form.

The OTRS will be issued for a one-time shipment or for a transportation campaign covering a period of time not to exceed five years. Each OTRS is assigned a unique number and that number will not change throughout the life of that particular OTRS. Appendix D provides additional detail on the format and content of an OTRS.

9.1.2 Emergency Shipments

The Emergency Operations Center (EOC) Shift Office Duty Officer has the responsibility for event classification (in conjunction with the IC) and activation of the Hanford Emergency Response Organization as appropriate. Shipments (transfers) are handled in accordance with the
Hanford Site Emergency Plan. Additional information about DOE/RL-94-02 is presented in
Chapter 12, Incident Reporting and Emergency Response
10.0 Personnel Training and Qualification

This chapter describes the qualification and training requirements for Hanford Site Contractor Hazmat Personnel, Authorized Shippers, Drivers, and USQ Screeners and Evaluators. Individual facilities and organizations, to which personnel may be assigned, may establish additional qualifications and required training based on specific job task analysis, job classification, or individual training plan. In addition, this chapter prescribes requirements for implementation of security plans to address security risks related to the transportation of hazardous material onsite.

10.1 Requirements

Each Hanford Site contractor must have a personnel training and qualification program that emulates the requirements identified in 49 CFR 172, Subpart H, “Training” and implements their Security Plan per 49 CFR 172, Subpart I.

10.1.1 Training Program Requirements

All hazmat employees involved in T&P activities must be trained and tested to the training requirements identified in 49 CFR 172, Subpart H. Training requirements include the following:

- General awareness/familiarization training designed to enable the employee to recognize and identify hazardous materials consistent with the hazard communication requirements in 49 CFR 172 and this TSD.

- Function-specific training specifically applicable to the functions the employee performs. This includes modal-specific training requirements as described in 49 CFR 174 through 180.

- Safety training concerning the following:
  - Emergency response information
  - Measures to protect the employee from the hazardous materials to which they may be exposed
  - Methods and procedures for avoiding accidents.

- If applicable, security awareness training provides an awareness of security risks associated with hazardous materials transportation and methods designed to enhance transportation security. This training must also include a component covering how to recognize and respond to possible security threats. New hazmat employees must receive the security awareness training, required by this paragraph, within 90 days after employment.

- If applicable, in-depth security training of the security plan and its implementation is required for personnel who handle hazardous materials covered by the security plan, perform a regulated function related to the hazardous materials covered by the plan, or is responsible for implementing the plan. Security training must include company security objectives, organizational security structure, specific security procedures, specific
security duties and responsibilities for each employee, and specific actions to be taken by each employee in the event of a security breach.

Drivers or other persons operating commercial motor vehicles as defined in the Federal Motor Carrier Safety Regulations (FMCSR) must be trained and tested in accordance with 49 CFR 177.816, “Driver Training.”

A new hazmat employee, or a hazmat employee changing job functions, must complete initial training within 90 days after employment or a change in job function. The employee may perform those functions prior to the completion of required training-provided the employee performs those functions under the direct supervision of a properly trained and knowledgeable hazmat employee.

DOT and this onsite emulation require this training and certification to occur every 3 years [49 CFR 172.704(c)(2)]. Each hazmat employer is responsible for ensuring hazmat employees are aware of any regulatory changes that may affect their specific functions in the onsite T&P Safety Program.

Each Hanford Site Contractor’s training program must identify and qualify the following personnel through adequate training and testing:

- All hazmat employees (e.g., operators, technicians, warehousemen, drivers, managers, supervisors) who in the course of their employment affect transportation safety as defined by the DOT must be trained in accordance with 49 CFR 172.704. This training must include general awareness, function specific safety training, and also driver training when the employee operates a motor vehicle used to transport hazardous materials, substances, and wastes.

- Designated shippers, authorized shippers, or shipping agents acting on behalf of the contractor or RL, PNSO, and ORP must receive advanced hazmat training to address characterization and classification of material for shipment, selection and use of packagings, hazard communications, regulatory compliance, operational procedures, and transport protocols. Training must be given commensurate with the employee’s responsibilities and authority to execute shipments.

- Drivers or other persons operating commercial motor vehicles as defined in the FMCSR must possess a CDL and must be trained and tested in accordance with 49 CFR 177.816. Drivers must also receive training on contractor or project procedures and protocols.

USQ_T Screeners and Evaluators must be trained and tested in the USQ_T Process and its application with the TSD in accordance with each contractor USQ Training Plan.

10.1.2 Employer Certification

Each Hanford Site contractor must have a formal process in place to certify that each hazmat employee has been trained and tested as required in 49 CFR 172.704(d)(5) and this TSD.
10.1.3 Shipper Authorization

Each Hanford Site contractor must have a formal process in place to authorize employees as designated shippers, authorized shippers, or shipping agents acting on behalf of the contractor and/or RL, ORP, and PNSO. This process must include the following:

- Identification of qualifications and training
- Management delegation of signature authority

Each contractor must maintain an Authorized Shippers List, which is updated regularly.

Only persons holding delegated shipper authority may be authorized to sign shipping documents on behalf of the contractor and/or DOE.

Each Hanford Site contractor, authorizing shippers, may, in addition to DOT training requirements, identify other federal, state, and local requirements necessary to maintain “authorized shipper” status.

10.1.4 USQ$r$ Evaluator Authorization

Each Hanford Site contractor that has a USQ$r$ Process must have a process for designating and qualifying USQ$r$ Screeners and Evaluators.

10.1.5 Security Plan

Contractors who make shipments using the TSD do not have to develop a security plan for onsite shipment or modify their security plan for in commerce site shipments. Current Hanford security systems and plans already addressing security risks related to the transport of hazardous material in quantity stated in 49 CFR 172.800(b) do not need to be revised. The expectation is that a contractor who has a security plan will operate in accordance with their DOT security plan for onsite shipments, even though the contractor may ship/transport hazardous material not addressed in their security plan. For a contractor who ships or transports hazardous material that does not require a security plan per 49 CFR 172.800(b), the contractor does not have to develop security plan for onsite shipments.

10.2 Documentation and Records Requirements

Documentation and records requirements for onsite hazmat employees are to be in accordance with the requirements identified in 49 CFR 172, Subpart H and Chapter 11.0 of this TSD.
11.0 Documentation and Record Keeping

This chapter identifies documentation and records requirements for different package categories. It also identifies or references processes and procedures for managing this documentation.

11.1 Documentation Requirements

Record requirements include retention of items such as:

- Packaging documentation
- training records
- vehicle maintenance and inspection records
- documentation associated with the onsite transfer of hazardous material

Records shall be legible through the retention period and copies shall be reproducible and legible. Measures shall be taken to preserve records in such a manner as to preclude deterioration of the records.

11.2 Packaging Documentation

Packaging documentation for onsite transportation of hazardous materials shipments (transfers) must be in full compliance with applicable DOT Regulations or the onsite emulation of the applicable regulations.

Packagings that fully meet a DOT Specification or DOT/NRC Performance Standard (i.e., UN1A2, MC 412, DOT-7A Type A) when used onsite must meet all the documentation requirements for that DOT Specification or Performance Standard as required in 49 CFR 171 through 180.

Packagings that do not meet a DOT Specification or DOT Performance Standard when used onsite must be approved by RL. The documentation must meet the onsite implementation of the DOT documentation requirements, those identified in this TSD, and those identified in the PSSD.

11.2.1 Excepted Packaging Documents

Excepted packagings have no formal documentation requirements associated with the procurement or use of any individual package unless imposed in the procurement specification or Appendix G. The shipper must use his or her professional judgment to determine if the packaging and package as offered for transportation meets 49 CFR 173.24; 173.24a; and 173.24b; as appropriate. For radioactive materials, excepted packagings must also meet 49 CFR 173.410. In addition to determining if the package meets the requirements, consider also the needs of the offeror and receiver, including their need for stacking.
11.2.2 Industrial Packaging Documents

Except for Type IP-1 packages, each shipper of an industrial package must maintain a file for at least two years after the latest shipment. This file must contain complete set of documentation of tests, engineering evaluations and/or comparative data showing how the packaging met 49 CFR 173.411 testing requirements. In addition, the file must contain documents on methods of construction, package design, and materials of construction of the packaging.

For Type IP-1 packaging made to TSD Standards, each shipper of an industrial package must maintain a file for at least two years after the latest shipment. This file must contain a complete set of documentation of tests, an engineering evaluation or comparative data showing how the packaging met Section 6.5.2.3 testing requirements. In addition, the file must contain documents on methods of construction, package design, and materials of construction of the packaging.

11.2.3 Type A Packaging Documents

For DOT 7A Type A packaging as required by 49 CFR 173.415, the shipper must maintain on file for at least two years after the latest shipment complete documentation of tests and an engineering evaluation or comparative data showing that the construction methods, packaging design, and materials of construction comply with the applicable packaging specification.

11.2.4 Type B and Fissile Packaging Documents

For packagings used onsite for the shipment of Type B quantities of radioactive material (except for LSA and/or SCO, that have Type B quantity of radioactive material), and/or fissile materials and wastes, the contractor must use a NRC or DOE-approved SARP or Packaging Safety Documents.

11.3 Payload Classification Records

If radioactive material/waste greater than an A₂ is classified as either LSA or SCO for an onsite shipment, the shipper must provide a documented evaluation for an LSA/SCO classification. This evaluation shall be based on NRC NUREG-1608, “Categorizing and Transporting Low Specific Activity Materials and Surface Contaminated Objects.” The evaluation document will be included in the shipment file with other shipping records.

11.4 Training and Qualification Records

Each Hanford Site contractor offering for transportation, or transporting hazardous material on roads to which the public has unrestricted access, must be registered in accordance with 49 CFR 107, Subpart G, “Registration of Persons Who Offer or Transport Hazardous Materials.”

Each organization shall maintain training records in accordance with 49 CFR 172.704 (d) for all personnel who have direct effect on transportation safety.
11.4.1 Hazmat Employees

Each Hanford Site contractor with a hazmat employee involved in onsite T&P activities must meet the documentation and record keeping requirements defined in 49 CFR 172, Subpart H.

11.4.2 Drivers

Each Hanford Site contractor driver used to transport hazardous materials onsite must meet the documentation and record keeping requirements defined in 49 CFR 177.816; 49 CFR 383, Subpart J, if required; and 49 CFR 391.

Onsite accidents are covered under the Hanford Site Incident and Occurrence Reporting System.

11.4.3 USQ\textsubscript{T} Evaluators

Each Hanford Site contractor with a USQ\textsubscript{T} Process must meet the documentation and record requirements identified in 10 CFR 830 for the USQ Process.

11.5 Vehicle Maintenance and Inspection Records

Each Hanford Site contractor motor carrier that uses motor vehicles onsite to ship hazardous materials must meet the requirements defined in 49 CFR 396, for motor vehicles.

11.6 Shipping Papers

The requirements for documentation and record keeping shall be established from USC, 49 CFR –Transportation, Subtitle III – General and Intermodal Programs, Chapter 51 – “Transportation of Hazardous Material,” Section 5110, Shipping papers and disclosure.

Shipment documentation and files shall be retained as lifetime records, including documentation accompanying use of SPAs, OTRSSs, and PSSDs. For onsite shipments of nonradioactive hazardous materials, the HMSR, which is filled out by the shipper, may serve as the only documentation to accompany the shipment onsite.

**Exception:** When using the proper shipping name “Radioactive material, transported under special arrangement” or “Radioactive material, transported under special arrangement, fissile,” instead of specifying the DOT special permit, the contractor shall specify the Packaging Safety Documents or DOE Exemption.
12.0 Incident Reporting and Emergency Response

This chapter describes requirements for incident reporting, emergency response, and references Hanford Site-specific policies, manuals, and procedures for emergency management. It also addresses emergency planning, drills and exercises, and Hanford Site response capabilities.

12.1 Reporting Requirements

Actions taken to implement incident reporting and emergency response requirements associated with onsite T&P activities are identified in DOE/RL-94-02, Hanford Emergency Management Plan. This TSD requires compliance with the requirements identified in DOE/RL-94-02 by RL, PNSO, and ORP and their primary contractors and subcontractors. DOE maintains policies, programs, and procedures (DOE-0223, Emergency Implementation Procedures) to implement DOE/RL-94-02, including onsite T&P activities.

12.2 Hanford Site Emergency Management Program Basis

The comprehensive Hanford Site Emergency Management Program is based on and commensurate with the hazards and consequences associated with facilities and activities on the Hanford Site (i.e., developed consistent with a graded approach), offsite facilities that may impact the Hanford Site, and onsite and offsite DOE Transportation Emergency Preparedness activities involving radiological and non-radiological hazardous materials.

12.3 Hanford Transportation Emergency Preparedness Program

The Hanford Site Transportation Emergency Preparedness Program provides the framework for response to onsite and offsite transportation incidents involving radiological and non-radiological hazardous material. For transportation planning purposes, shipments transported on roadways and in areas of the Hanford Site where public access is restricted are exempt from the DOT Regulations found in 49 CFR. Shipments transported on roadways and in areas where the public is granted unrestricted access are considered “in commerce” and shall be regulated under the DOT Regulations found in 49 CFR. When public access control is extended to areas within the Hanford Site boundary, to which the public had previously been granted unrestricted access (e.g., road closure), shipments may be made under onsite control. Onsite controls may be used on roadways and in areas for as long as the public access restriction remains in force.

For transportation incidents that occur on the Hanford Site, including shipments of nongovernment material being moved in full compliance with DOT/NRC requirements, the IC System is used to mitigate the situation. Upon notification of the event, the Hanford Fire Department assumes incident command responsibilities. The EOC Shift Office Duty Officer has the responsibility for event classification (in conjunction with the IC) and activation of the Hanford Emergency Response Organization, as appropriate.

12.4 DOE/RL-94-02 Summary

DOE/RL-94-02 details the Hanford Site Emergency Organization, authorities, and responsibilities for response to and mitigation of emergency events involving facilities and
activities on the Hanford Site including transportation. These events include the full spectrum of operational emergencies, natural phenomena, transportation events, and safeguard and security emergencies. DOE/RL-94-02 also describes the authorities, responsibilities, and agreements for response to offsite and near-site facility emergencies that have the potential to affect the health of personnel and safety of operations at the Hanford Site.

DOE maintains procedures necessary to implement the Emergency Management Program described in DOE/RL-94-02. The procedures contain detailed information and specific instructions, including response actions, associated precautions and prerequisites, and identification of responsible individuals needed to perform the appropriate action during a drill, exercise, or actual emergency.

For the Hanford Site, these procedures include, but are not limited to, the following:

- The operation of the Hanford Incident Command System and responsibilities of the Incident Command Organization
- The responsibilities for the DOE Hanford Emergency Operations Center, which includes the Policy Team, Site Management Team, and the Joint Information Center
- Recognition, categorization/classification, and notification of emergencies and other incidents
- Protective action recommendations
- Response to hazardous substance spills or releases during transportation incidents occurring onsite, which are not covered by unit-specific contingency plans or building emergency plans
- Termination, re-entry, and recovery for DOE emergencies and events that meet RCRA Contingency Plan implementation criteria
- Response to incidents involving onsite and offsite shipments of DOE-Owned Radiological and Non-Radiological Hazardous Materials
- Incident report per 49 CFR 171, Subpart B is not applicable for onsite shipments.

In addition to the program for response to and mitigation of emergencies, DOE/RL-94-02 also provides direction on the activities necessary to ensure emergency preparedness on the Hanford Site such as training, drills, exercises, and assessments. The authority and responsibility for interfaces with offsite organizations responsible for protecting the public and environment, including those agencies that may provide or request support in the event of an emergency, is also delineated.

The DOE responsibility to provide, upon request, radiological advice and assistance to other federal, tribal, state, or local governments under the Radiological Assistance Program is defined in DOE/RL-92-49, *Radiological Assistance Program Response Plan Region 8*.

Figure 12-1 provides the hierarchy for emergency preparedness documentation for transportation.
Figure 12-1. Transportation Emergency Preparedness Documentation Hierarchy
13.0 Transport Vehicle Operations

This chapter describes the requirements for motor vehicle inspection and maintenance programs for T&P activities on the Hanford Site. References to specific requirements and procedures are provided for use by each contractor or subcontractor conducting transportation operations within Hanford Site Boundaries.

13.1 Onsite Transportation Program Requirements

For transportation, equivalent safety is achieved by compliance with DOT requirements or by emulating the DOT Regulations associated with hazardous materials transportation.

Modes of transportation used for the onsite shipment of hazardous materials regulated by the DOT for hazardous materials shipped in commerce are covered by the requirements of this TSD. DOT requirements cover shipments by rail, air, water, motor vehicle, and pipeline.

13.1.1 General

Each Hanford Site contractor that transports onsite hazardous material shipments must do so in a safe and compliant manner with regulations. Compliance with DOT Regulations for shipment by motor vehicle or the onsite emulation is required. Contractors must conduct transport operations in accordance with this TSD, which imposes regulatory requirements, best industry practices, and other site procedures deemed necessary by DOE to achieve equivalent safety and remain in accordance with applicable federal and state regulations.

13.1.2 Modal Application

13.1.2.1 Motor Vehicle

Onsite transportation of hazardous materials shipments by motor vehicle must be made in full compliance with applicable DOT Regulations or the onsite emulation of the applicable regulations. When the emulation of DOT requirements is used, RL will implement those actions identified for the DOT within the DOT Regulations. RL, ORP, PNSO, and their contractors will implement those actions identified for the user of the DOT regulations.

Compliance with applicable DOT Regulations or equivalent standards must be met for the operation, inspection and maintenance of vehicles, and/or the selection, qualification and training of management, drivers, inspection personnel, and maintenance staff.

13.1.2.2 Pipeline

This TSD does not include onsite transportation of hazardous materials by pipeline. The safety of onsite transportation of hazardous materials by pipeline is covered in a facility SAR or other DOE-approved safety or Authorization Basis documents.

13.1.2.3 Other Modes of Transportation

The use of rail, air, and water vessel are not authorized. If a contractor wants to use one of these modes, the contractor shall submit an exemption request to RL.
13.1.3 Transport Vehicle Operation

RL, ORP, PNSO, and their contractors performing transportation operations, fleet operations, or vehicle maintenance for onsite transportation of hazardous material must implement programs, polices, and procedures necessary to meet the provisions of this TSD. If the contractor is a commercial motor carrier, the current Motor Carrier Program and Implementation procedures are acceptable. However, some sections of the FMCSR are not applicable for onsite operations. Program requirements must address the following key elements as applicable to the specific onsite transportation operation:

- Transportation workplace drug testing program
- Controlled substance and alcohol use and testing
- Driver licensing standards
- Compliance with FMCSRs or approved alternatives
- Qualification of drivers
- Driving of Commercial Motor Vehicles as defined by DOT
- Equipment necessary for safe operation
- Hours of service for drivers
- Inspection, repair, and maintenance
- Transportation of hazardous materials, driving, and parking rules
- Employee safety and health standards
- Training

Exceptions for onsite shipments who are commercial motor carriers to the 49 CFR 350-399 are as follows:

- Accidents during an onsite shipment shall not be recorded in the motor carrier accident log required by 49 CFR 390.15.

- If a driver is acting as if they are under the influence of a drug or alcohol; or an occurrence occurs during an onsite shipment, the driver must be tested under the 10 CFR 707, “Workplace Substance Abuse Programs at DOE Sites,” and company policy, not per 49 CFR 382. Note: 10 CFR 707 does not contain an alcohol testing protocol. However, some contractor’s procedures include alcohol test in the policies (for example: Fitness for Duty, Standards of Conduct). If the contractor’s company policy includes alcohol testing, driver shall be subject to alcohol testing in accordance with their company policy. Pre-employment and random testing shall be conducted under the DOT Substance Abuse and Alcohol Misuse Program. The return-to-duty and follow-up testing, if applicable, must be in accordance with whichever Substance Abuse and Alcohol Misuse Program that the positive substance or alcohol test result fall under.
• Unless the contractor commercial motor carrier operating requires a Hazardous Materials Safety Permit (see 49 CFR 385, Subpart E), the contractor does not have to obtain this permit just for onsite operations north of the Wye Barricade.

• For onsite shipments, 49 CFR 397, Subparts C, D, and E are not applicable. Routing of onsite shipments are identified in Chapter 3 of the TSD.

13.1.4 Motor Vehicle

The following is a list of Transportation Safety Program requirements that must be considered in each Hanford Site contractor’s Transportation Program. All transport vehicle operations involving the onsite transfer of hazardous materials, substances, and wastes must comply with the 10 CFR 707, “Workplace Substance Abuse Programs at DOE Sites” and company substance abuse and alcohol misuse policies [see exception 13.1.2.3 (2)]; Sections 355 through 399 (see exceptions above and Table 6-2); DOT Hazardous Material Regulations in 49 CFR 177; or must be performed under a RL-approved program meeting the intent of these regulations, which provides an equivalent degree of safety for site personnel, the public, and the environment. All variances from the FMCSR must be documented in the contractor’s transportation operations manual, polices, and/or procedures, and must be approved by RL.

Programs performed under this TSD must include all applicable items from the following list:

• Vehicles used to transport hazardous materials, substances, and wastes onsite must be in accordance with FMCSR Specifications and Standards when procured and placed into service, and must be inspected and maintained in accordance with these requirements.

• Management personnel, vehicle drivers, inspection personnel, and maintenance staff must be trained and qualified in accordance with the FMCSR and DOT Hazardous Material Regulations when applicable.

• All vehicle maintenance must be performed and meet applicable DOT, Government Services Administration (GSA) and/or manufacturer’s requirements and schedules for the type of vehicle and type of service for which it is used.

• Periodic inspections must be performed on motor vehicles in accordance with DOT Regulations at intervals not to exceed 12 months.

• Specification cargo tank trailers and/or portable tanks controlled by Hanford Site Contractors must be inspected, tested, and maintained in accordance with applicable DOT Regulations or exemptions.

• Preventative maintenance schedules must be maintained for each type of vehicle. The type of motor vehicle determines the frequency and level of maintenance. Maintenance must be provided in accordance with the GSA or manufacturer’s vehicle maintenance schedules.

13.1.5 Operator Duties

The following list provides the Transportation Safety Program requirements associated with operator duties identified as key to accomplishing the required level of safety in Hanford Site
contractor Transportation Programs. Programs performed under this TSD must include all applicable items from the following list:

- Drivers must inspect all commercial motor vehicles in accordance with DOT pre-trip and post-trip requirements.
- Drivers hauling placarded loads must have a current and properly-endorsed CDL and meet all driver qualifications including participation in a Drug and Alcohol Testing Program meeting applicable federal standards.
- Drivers must report all vehicle accidents or incidents, driving violations, fines, or penalties immediately to their respective contractor management.
- Drivers must comply with all FMCSR or approved alternatives including driver hours of service, driving and parking rules, maintenance of shipping documents (shipping documents are either prepared in accordance with 49 CFR 172, Subpart C or TSD), and emergency response guides, and other safety equipment and tiedown/load securement requirements.

### 13.2 Inspection and Maintenance Program Requirements

Each Hanford Site contractor must have programs, policies, and procedures in place to ensure that all transport vehicles used for the onsite transport of hazardous materials, substances, and wastes undergo daily and periodic inspections and maintenance in accordance with DOT HAZMAT and FMCSR Regulations and in accordance with applicable GSA Schedules or manufacturer’s maintenance schedule. Variance from these federal standards or manufacturer’s recommendations must be documented and approved by RL.

A list of the Inspection and Maintenance Program requirements, which must be considered in the Hanford Site Contractor’s Transportation Programs, is provided below. Programs performed under this TSD must include all applicable items from the following:

- Assignment of responsibilities for inspection and maintenance activities
- Identify number and type of vehicles and other transport equipment available for service and identify equipment load ratings
- Identify type of maintenance service to which each vehicle is assigned
- Identify GSA or manufacturer’s inspection and maintenance schedules applicable to each vehicle or vehicle type
- Identify location of all inspection and maintenance records
- Specify frequency of audits, findings, and corrective actions

### 13.3 Onsite Driver Qualification and Training

RL, PNSO, and ORP Contractors operating vehicles for onsite transport of hazardous materials, substances, and wastes must have programs, polices, and procedures in place ensuring that all drivers operating the vehicles are properly trained and qualified in accordance with FMCSR,
DOT Hazardous Materials Regulations, and Chapter 10. Variance from these federal standards must be documented and approved by RL.

A list of driver requirements identified as key to accomplishing the required level of safety in Hanford Site contractor Transportation Programs is provided below. Programs performed under this TSD must include all applicable items from the following:

- Assignment of responsibilities
- Basic driver qualification (consider age, health, driving experience)
- Drug and alcohol testing
- Licensing and endorsements
- Initial and recurrent training
- Driver personal and work driving record
- Maintenance of driver records
14.0 References


49 CFR 300 through 399, “Federal Motor Carrier Administration, Department of Transportation Code of Federal Regulations,” as amended.


ANL/ESD/TM-150, State-Level Accident Rates of Surface Freight Transportation: A Reexamination, Argonne National Laboratory, Argonne, Illinois.


Atomic Energy Act of 1954, Section 161, as amended.


DOE-CBFO, 2013, CCP Transuranic Authorized Methods for Payload Control (CCP-TRAMPAC), Rev. 21, Carlsbad Field Office, Carlsbad, New Mexico.


*Hanford Facility Resource Conservation and Recovery Act Permit, Dangerous Waste Portion, Revision 8C, for the Treatment, Storage, and Disposal of Dangerous Waste (Site-Wide Permit), WA 7890008967.*


NUREG/CR-1815, *Recommendations for Protecting Against Failure by Brittle Fracture in Ferritic Steel Shipping Containers up to Four Inches Thick*, U.S. Nuclear Regulatory Commission, Washington, D.C.


NUREG/CR-4829, *Shipping Container Response to Severe Highway and Railway Accident Conditions*, Lawrence Livermore National Laboratory, Livermore, California.


Regulatory Guide 7.11, *Fracture Toughness Criteria of Base Material for Ferritic Steel Shipping Cask Containment Vessels with a Maximum Wall Thickness of 4 Inches (0.1 m)*, U.S. Nuclear Regulatory Commission, Washington, D.C.

Regulatory Guide 7.12, *Fracture Toughness Criteria of Base Material for Ferritic Steel Shipping Cask Containment Vessels with a Wall Thickness Greater than 4 Inches (0.1 m) But Not Exceeding 12 Inches (0.3 m)*, U.S. Nuclear Regulatory Commission, Washington, D.C.


Appendix A

Approved Package Specific Safety Documents List
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## Terms

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
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<td>AC</td>
<td>Accident Condition</td>
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<tr>
<td>ASME</td>
<td>American Society of Mechanical Engineers</td>
</tr>
<tr>
<td>BPVC</td>
<td>Boiler and Pressure Vessel Code</td>
</tr>
<tr>
<td>CFR</td>
<td>Code of Federal Regulations</td>
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<tr>
<td>CWC</td>
<td>Central Waste Complex</td>
</tr>
<tr>
<td>DOE</td>
<td>U.S. Department of Energy</td>
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<td>DOT</td>
<td>U.S. Department of Transportation</td>
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<td>HAC</td>
<td>Hypothetical Accident Condition</td>
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<tr>
<td>FEA</td>
<td>Finite Element Analysis</td>
</tr>
<tr>
<td>IAEA</td>
<td>International Atomic Energy Agency</td>
</tr>
<tr>
<td>MCNP</td>
<td>Monte Carlo (computer code for) neutron photon (transport)</td>
</tr>
<tr>
<td>NC</td>
<td>Normal Condition</td>
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<tr>
<td>NCT</td>
<td>Normal Conditions of Transport</td>
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<tr>
<td>NRC</td>
<td>U.S. Nuclear Regulatory Commission</td>
</tr>
<tr>
<td>NUREG</td>
<td>U.S. Nuclear Regulatory Commission Regulation</td>
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<tr>
<td>RL</td>
<td>Richland Operations Office</td>
</tr>
<tr>
<td>SED</td>
<td>Strain Snergy Density</td>
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<td>TSL</td>
<td>Triaxial Strain Limit</td>
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Appendix A
Approved Packaging Safety Documents List

A.1 Approved Packaging Safety Documents List

All Type B and/or fissile packagings with current certifications from either the U.S. Department of Energy (DOE), the Nuclear Regulatory Commission (NRC), or the U.S. Department of Transportation (DOT) - International Atomic Energy Agency (IAEA) are authorized for transporting radioactive material onsite. The following tables contain a list of packagings that can be used for onsite shipping of radioactive materials that are not authorized for use in commerce. Table A-1 contains a list of previously certified packagings that were certified by an agency listed above but no longer have a current certification. However, these packagings have been reviewed by RL and have been determined to meet onsite criteria for Type B and/or fissile equivalent packagings as stated in Chapter 6.0 of this TSD. Tables A-2 through A-5 list RL-approved packagings either pre-Transportation Safety Document (TSD) or in accordance with the TSD. In addition, tables distinguish between performance-based or risk based packagings.

Table A-1 contains a listing of expired DOT-Compliant SARPs. These packages are authorized for use on the Hanford Site under a previous Certificate of Compliance (CoC). In many cases, the active CoC has de-scoped existing payloads, not for safety-related reasons, but because the original Licensee did not want to pay to maintain payloads that were no longer considered necessary. DOE has evaluated the CoC and decided to incorporate the earlier CoC to provide additional package flexibility to the user. Since packages with DOT-Compliant SARPs and CoCs may have an active CoC, physical changes are not authorized to the package without prior DOE permission. If an expired or previous revision of a NRC/DOE/DOT packaging CoC that is not listed in Table A-1 is to be used, notify the TSD Configuration Manager. The requesting Project Manager shall provide a copy of the SARP and associated CoC. The TSD Configuration Manager shall evaluate the version. If the version is technically adequate, the TSD Configuration Manager will work with RL to add it to Table A-1.

Table A-2 contains a listing of Hanford Site (Onsite) PSSDs, packages that are fully compliant to the TSD and are authorized for unlimited use on the Hanford Site. These packages have been evaluated to meet the equivalent packaging standards identified in Chapter 6.0, Site-Specific Standards, Procedures, and Instructions, of the TSD.

Table A-3 contains a listing of Hanford Site (Onsite) risk based packages that are fully compliant to the TSD.

Table A-4 contains a listing of Hanford (Onsite) Exempted packages. These packages have been exempted from meeting TSD requirements, and have been authorized for use by a Hanford Site Field Office Manager.

Documents approved as required by this TSD may be added to this listing. Requests for changes to TSD Appendix A tables shall be submitted to RL and the TSD Configuration Manager.
## Table A-1. Previous DOT Compliant Packages with Expired CoC

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### Table A-3. Hanford Site (Onsite) Risk Based Packages

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Appendix B

Justification and Basis for Equivalency to DOT Regulations for Type B and Fissile Packages Transported on the Hanford Site
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Terms

AC  Accident Condition
ASME  American Society of Mechanical Engineers
BPVC  Boiler and Pressure Vessel Code
CFR  Code of Federal Regulations
CSB  Canister Storage Building
CWC  Central Waste Complex
DOE  U.S. Department of Energy
DOT  U.S. Department of Transportation
HAC  Hypothetical Accident Condition
FEA  Finite Element Analysis
IAEA  International Atomic Energy Agency
MCNP  Monte Carlo (computer code for) neutron photon (transport)
NC  Normal Condition
NCT  Normal Conditions of Transport
NRC  U.S. Nuclear Regulatory Commission
NUREG  U.S. Nuclear Regulatory Commission Regulation
RL  Richland Operations Office
SED  Strain Energy Density
TSL  Triaxial Strain Limit
Appendix B

Justification and Basis for Equivalency to DOT Regulations for Type B and Fissile Packages Transported on the Hanford Site

B.1 Introduction and Objective

The objective of this Appendix is to demonstrate equivalency to regulations specified in Title 10, Code of Federal Regulations, Part 71, “Packaging and Transportation of Radioactive Material,” of the acceptable performance criteria for design, construction, and evaluation of Type B packages for use on the Hanford Site. The proposed Hanford Site acceptable performance criteria are based on U.S. Nuclear Regulatory Commission (NRC) staff guidelines established in Regulatory Guide 7.6, Design Criteria for Structural Analysis of Shipping Cask Containment Vessels, to demonstrate acceptable performance of spent fuel and Category I package design under performance tests specified in 10 CFR 71.71, “Normal conditions of transport,” and 10 CFR 71.73, “Hypothetical accident conditions.” These acceptable performance criteria, adopted by the U.S. Department of Energy (DOE) Richland Operations Office (RL), the Office of River Protection (ORP) and the Pacific Northwest Site Office (PNSO), provide a degree of safety equivalent to that provided by 10 CFR 71 performance tests in ensuring public and worker safety under normal and accident transport conditions on the Hanford Site. In practice, equivalent safety is to be demonstrated by subjecting the package design to 10 CFR 71 performance tests as amended for Hanford Site conditions and evaluating the package design against criteria equivalent to NRC acceptable performance criteria.

To alleviate confusion, the terminology and acronym for normal conditions of transport (NCT) and hypothetical accident conditions (HAC) specified in the regulations are changed for onsite performance test conditions. The terminology and acronym for Hanford Site normal and accident conditions are normal conditions (NC) and accident conditions (AC), respectively.

B.2 Background

Performance criteria stipulated in 10 CFR 71 for the specified performance tests for containment, subcriticality, and shielding shall be maintained by the package. The specified performance tests can be performed analytically or by physical testing. However, NRC staff recognizes the cost of full-scale testing may be prohibitive and scale model-testing technology is not fully developed. Consequently, NRC has developed acceptable performance criteria for design and evaluation of Type B packages to demonstrate conformance with performance requirements specified in 10 CFR 71. The NRC, using a graded approach, has established three categories of acceptable package performance based on the content of the package as described in NUREG-1609, Standard Review Plan for Transportation Packages for Radioactive Material. These categories are based on Sections III and VIII of the American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code (BPVC). NUREG-1609 indicates that spent fuel and Category I packages be designed and constructed to the requirements of ASME BPVC, Section III, Subsection NB. Subsection NB is used for critical safety components of a nuclear reactor and requires the highest level of quality technologically available. NUREG-1609 also states that Category II and III packages be designed and constructed to the requirements of
ASME BPVC, Section III, Subsection ND and ASME BPVC, Section VIII, Division 1, respectively.

To demonstrate acceptable spent fuel and Category I package performance under performance test conditions defined in the regulations, the NRC has established acceptance criteria outlined in Regulatory Guide 7.6. This is used in conjunction with Regulatory Guide 7.8, Load Combinations for the Structural Analysis of Shipping Casks, and NUREG/CR-6007, Stress Analysis of Closure Bolts for Shipping Casks, to demonstrate acceptable NCT and HAC performance of the package, used in general commerce. Regulatory Guide 7.6 is based on Section III, Subsection NB of ASME BPVC and establishes standards and criteria for evaluating structural integrity of Type B packages. The basic assumption of ASME BPVC and Regulatory Guide 7.6 is that the components remain linearly elastic and the principle of superposition can be applied to determine combined loads. The NRC recognizes that Section III, Subsection NB contains requirements for nuclear power plants. Subsequently, some requirements are not applicable for package design and evaluation. However, the NRC has adopted portions of ASME BPVC that use a “design-by-analysis” approach to form performance acceptance criteria for the containment boundary of spent fuel and Category I packages. By Regulatory Guide 7.6, evaluation criteria for NCT are defined as criteria for Service Level A Limits (NCs) and HAC are defined as the criteria for Service Level D Limits (faulted conditions).

In development of Hanford Site analytical acceptable performance criteria, three key factors are considered.

1. For components on the containment boundary to remain elastic under ACs is extremely conservative. This requirement ignores the energy absorption capability of the material of construction from localized strains without breach of containment or loss of dimensional stability.

2. Development of the regulations by the U.S. Department of Transportation (DOT) and NRC for safe transport in commerce is fundamentally based on maintaining containment and requiring that radiological safety be engineered into the package. The basis is as follows:
   a. Packages are shipped via a variety of carriers and conveyances. Therefore, reliance for safe transport must be placed in the package because commercial carriers do not always have adequately trained operators and properly maintained equipment.
   b. The carriers determines the routes based on DOT regulations (49 CFR 397), state, tribal and local regulations, unless DOE and their contractors have negotiated a route with states, tribal, and local governments.
   c. All transport is on public roadways.

3. Transport of fissile and Type B packages on the Hanford Site are not in commerce when north of Wye Barricade or when shipped under road closure within the physical boundaries of the Hanford Site. Shipments south of the Wye Barricade (not closing the roads) and beyond the physical boundaries of the Hanford Site must be in compliance with DOT/NRC regulations or a Federal Shipment in accordance with 49 CFR.
171.1(d)(5). Subsequently, the following provisions are in place to enhance onsite transportation safety:

a. Access is controlled north of the Wye Barricade, 300 Area, 400 Area and other areas are restricted by fences, signals, lights, gates, or similar controls (Figure 3-1). Subsequently, the majority of transports are not on public roads.

b. Trained emergency response teams are available and dedicated to the Hanford Site.

c. Roads are closed for transport of fissile or Type B packages that are packaged in DOT-equivalent or risk based packagings from areas south of the Wye Barricade to locales north of the Wye Barricade (see 49 CFR 171.1(d)(4)).

d. Maintenance of equipment and training of personnel are required, monitored, and controlled by Hanford Site authorities.

e. These factors are also considered by the NRC in development of regulations (10 CFR 72, “Licensing Requirements for the Independent Storage of Spent Nuclear Fuel and High-Level Radioactive Waste”) for commercial storage facilities, which are onsite operations.

B.3 Justification for Performance

B.3.1 Hanford Site Free Drop onto Concrete Surface

The free drop target surface specified in the regulations is a hard and essentially unyielding surface. In practice, this has been defined as a thick reinforced concrete pad with a thick (>5 cm [2 in.]) steel plate firmly fixed to the concrete, all of which must be set on compact soil. The International Atomic Energy Agency (IAEA) Safety Series No. 37 Guide states that the total weight of the concrete and steel plate for a proper free drop test must be at minimum 10 times the weight of package. This surface is specified in the regulations for conservatism and test reproducibility. In Finite Element Analysis (FEA) evaluations, the surface is defined as an infinitely rigid and unmovable surface. This FEA theoretical surface absorbs no energy from the impact and reflects all force waves.

On the Hanford Site, the free drop performance test target surface is established as the Central Waste Complex (CWC) storage pad. The pad is a 20 cm (8 in.) thick 21 MPa (3,000 psi) concrete pad, reinforced with No. 7 rebar on 30 cm (12 in.) centers. This free drop surface is the most rigid surface encountered during transport of packages on the Hanford Site. In addition, this surface provides an additional margin of safety for the most common and numerous packages transported onsite, drums and boxes. The additional margin of safety is derived from the behavior of relatively small, light packages (less than 4,534 kg [10,000 lb]) impacting a reinforced concrete surface. In such an impact, the small package behaves as though the impact was on a hard, unyielding surface. The explanation for this is that small, light packages, such as drums, have a hardness value far less than a reinforced concrete surface. Consequently, the drum tends to absorb a majority of the energy of impact in deformation and the concrete surface tends to act as a hard, unyielding surface. The larger robust packages, such as spent fuel casks, have a
hardness value much higher than the specified concrete surface. This results in a concrete surface absorbing much of the energy of impact. In essence, by specifying this surface, the most numerous and lighter Type B packages transported on the Hanford Site are subjected to the more conservative calculated loading.

**B.3.2 Normal Conditions Performance Criteria**

On the Hanford Site, packages are used only for onsite transport and storage. In lieu of testing, analytical evaluation and numerical simulations of the package are used to assess a majority of the packages to specified performance tests. Consequently, the NC performance acceptance criteria for all Type B packages will be based on ASME BPVC, Section III, Subsection NE in lieu of Subsection NB specified in Regulatory Guide 7.6. This is justified on the basis that Subsection NE is applicable to the containment vessel of a nuclear facility and has provisions tailored to the special features of bolted flange connections. Subsection NB is applicable to the reactor coolant boundary and has provisions tailored to pumps, vessels, valves, and piping. From a structural standpoint, there is no significant difference between the two code sections relative to determination of allowable stress intensities and combining of loads. Also, there is no major difference between the stress intensity criteria of these two subsections except that the stress intensity value in Subsection NB is design stress intensity (Sm) while it is defined as allowance stress intensity (Smc) in Subsection NE. For materials-related issues including welding, fabrication, and examination, Subsection NE is sufficient because the package is not subjected to the same high temperature, high pressure, and intense radiation as the reactor coolant boundary. The temperature, pressure, and radiation level of the package are closer to those of the secondary metal containment vessel for a nuclear reactor facility.

Also, NC performance acceptance criteria are based on ASME BPVC, Section III, Subsection NE Service Level A and C Limits. Combined stress intensities from temperature, pressure, and free drop are evaluated against requirements defined for Service Level C Limits. Stress intensities from all other load combinations are to be evaluated against requirements defined for Service Level A Limits. For structural evaluation purposes, maintenance of containment is defined as the ability of packaging systems to sustain the applied loading without exceeding ASME allowable stress intensity values.

The use of Service Level C Limits for free drop loads combined with other loads is justified on the basis that during onsite transport a free drop of a package would be considered at best an occurrence and at worst an event. In either case, the situation would dictate an emergency response on the Hanford Site. For this type of scenario, the package would be required to maintain containment, shielding, and subcriticality. After such an occurrence or event, the package would be transported under emergency conditions to a facility for removal and repacking of the contents into a new package. This sequence of actions after a free drop is consistent with the definition for Service Level C as defined in ASME BPVC, Section III, Subsection NCA, General Requirements for Division 1 and 2. In Subsection NCA under subparagraph NCA-2142.2, Service Level C Limits permit large deformation in areas of structural discontinuity without loss of function, which may necessitate removal of the component from service for inspection or repair of damage. Application of this limit is defined in Subsection NE, subparagraph NE-3113.3 as applicable loads subject to Service Level A and B Limits in combination with loads due to natural phenomena for which safe shutdown is required.
B.3.3 Brittle Fracture Performance Criteria

For package containment boundaries and critical components that are constructed from ferritic steels, low temperature brittle fracture of the materials needs to be addressed in a manner similar to certified Type B packages. To address this issue, the NRC has developed fracture toughness criteria in Regulatory Guide 7.11, *Fracture Toughness Criteria of Base Material for Ferritic Steel Shipping Cask Containment Vessels with a Maximum Wall Thickness of 4 Inches (0.1 m)*. This regulatory guide establishes material fracture toughness requirements for three categories based on curie content of the payload. The highest category, Category I, requires material fracture toughness testing to requirements specified in NUREG/CR-1815, *Recommendations for Protecting Against Failure by Brittle Fracture in Ferritic Steel Shipping Containers up to Four Inches Thick*. In lieu of these requirements, low temperature material service requirements of ASME BPVC, Section VIII, Division 1 are applied for design and evaluation of Type B packages to demonstrate resistance to brittle fracture based on minimum metal temperature for safe handling and transport of packages.

The justification is as follows:

- Methods and requirements provided in Section VIII, Division 1 are based on accumulated years of experience in design, material usage, construction, and operation of pressure vessels by members of ASME.

- Basis for Section III and Regulatory Guide 7.11 requirements are derived from the requirements first established in Section VIII, Division 1.

- Methods and requirements outlined in Section VIII, Division 1, can be readily applied by the engineer without the expense of fracture toughness testing the materials of construction. The number of laboratories qualified to perform fracture toughness tests is limited and testing is expensive.

For packages and components constructed from austenitic stainless steels, no fracture toughness related restrictions are placed on the material. This is justified on the basis that Regulatory Guide 7.11 states that austenitic stainless steel is not susceptible to brittle failure and containment vessels constructed of stainless steel are acceptable to the NRC without testing.

B.3.4 Performance Criteria for Free Drop and Puncture Accident Conditions

The NRC regulatory position for demonstration of compliance of spent fuel and Category I package design to HAC performance tests defined in 10 CFR 71 is for the package to meet Service Level D Limits specified in ASME BPVC, Section III, Subsection NB as amended by Regulatory Guide 7.6. The intent of Regulatory Guide 7.6 is to demonstrate containment by showing there are no large unconfined plastic strains and system failure due to loss of dimensional stability using linear elastic methods and criteria defined in ASME BPVC. However, accident free drop and puncture loads on Type B packages without impact absorption devices cause highly nonlinear material responses. In particular, contact stresses from impact imposed on packages (especially without impact limiters) when dropped, exceed the yield strength of the material. Evaluating the material response in an impact event assuming a linear elastic material response is inappropriate. Application of ASME criteria to the results of a
nonlinear analysis is also inappropriate. Therefore, it is necessary to generate acceptance criteria that go beyond the assumptions of linear elasticity and quasi-static load control. Acceptance criteria used must be consistent with elastic-plastic analysis techniques that are applied to ductile materials (austenitic stainless steel) that are subjected to highly localized impact loadings. Puncture and free drop impacts of Type B packages are energy-controlled events. Subsequently, the use of energy-based parameters as acceptance criteria are required to accurately assess the structural integrity, containment performance, and dimensional stability of the package. At present, there are two acceptance criteria based on energy parameters that have been used at the Hanford Site to assess package performance under accident free drop and puncture loads. They are: strain energy density (SED) and triaxial strain limit (TSL).

Both acceptance criteria are energy based. The SED criterion is based on material toughness and the TSL criterion is based on the ultimate elongation of material and principal stresses. The choice in using these criteria has been left to the structural evaluation engineer. In most cases, the SED criterion is used for shells, closures lids, and closure bolts. The TSL criterion is used at the more critical locations of joints and at discontinuities. In the case where the package is fitted with impact absorption devices or for all other loading combination cases (without free drop or puncture loads), performance is assessed to the requirements of ASME BPVC, Subsection NE, Service Level D Limits.

B.3.4.1 Criterion 1

The first and simplest acceptance criteria parameter is SED. The SED (V) of a material is defined as:

\[ V = \int \sigma d\varepsilon \]

In other words, the integral of the material stress (\(\sigma\)) versus strain (\(\varepsilon\)) curve.

The maximum SED of the material is also commonly known as toughness and, at material failure, can be conservatively estimated from results of uniaxial tensile test data. A conservative estimate of SED at material failure is as follows:

\[ U_t = \frac{(\sigma_y + \sigma_u)}{2} \varepsilon_f \]

where:

- \(\sigma_y\) = yield strength of the material
- \(\sigma_u\) = ultimate strength of the material
- \(\varepsilon_f\) = elongation at failure.

All these parameters are available from engineering stress-strain data. Use of the SED also minimizes concerns over unavoidable material variations such as heat-to-heat variations in yield strength and strain hardening behavior. In addition, the SED on the material from impact loads can be easily determined from stress and strain data retrieved from the FEA numerical simulation of the impact.
To ensure against ductile failure of the material, the maximum SED on the package is limited to 70 percent of the SED to failure of the material or material toughness. This is in keeping with the intent of Regulatory Guide 7.6 to prevent large, unconfined strain plasticity and system failure due to loss of dimensional stability at key locations. The 70 percent limit is based on Service Level D limits for material loading, specified in ASME BPVC, Section III.

B.3.4.2 Criterion 2

In the SED measure of performance, no distinction is made between compressive and tensile strains, and all strains are treated as tensile. Consequently, this measure of performance is very conservative because it does not account for the less severe effects of compressive strains (with respect to breaching of the material). A more time consuming, but more accurate measure of performance is comparing the cumulative principal strains or equivalent plastic strains against a limiting value that could initiate local fracture. These cumulative strains generated by FEA numerical simulations of free drop and puncture events are the difference between the largest and smallest principal logarithmic strains at a specific element. This is, by definition, the strain counterpart of the ASME stress intensity. The equivalent plastic strain is the plastic strains combined in a von Mises manner.

Criteria demonstrating acceptable cumulative strain levels to prevent material rupture are based on establishing limits on the maximum principal cumulative strain. Strain limits are developed based on the Manjoine (1983) *Transaction of the ASME, Journal of Pressure Vessel Technology* observation that tensile elongation measured in a tension test can be adjusted to predict multi-axial failure strain by the following relation:

\[
\frac{\varepsilon}{\varepsilon_t} = 2(1-TF) \quad \text{for} \quad TF \geq 0 \quad \text{and} \quad \frac{\varepsilon}{\varepsilon_t} = 2 \quad \text{for} \quad TF \leq 0
\]

where:
\[
\varepsilon = \text{the effective strain at failure} \\
\varepsilon_t = \text{the tensile elongation from tension tests, and} \\
TF = \text{the triaxiality factor.}
\]

The triaxiality factor is defined by the principal stresses ($\sigma_1, \sigma_2, \sigma_3$) as:

\[
TF = \frac{\sqrt{(\sigma_1 + \sigma_2 + \sigma_3)}}{\sqrt{(\sigma_1 - \sigma_2)^2 + (\sigma_2 - \sigma_3)^2 + (\sigma_3 - \sigma_1)^2}}
\]

Based on the ductility versus triaxiality factor curve presented in Manjoine (1983), the following conservative failure strain limits can be established for any ductile material. For a triaxiality factor of 1.0 (uniaxial tension), the cumulative strain limit is the reported ultimate strain of the material at tensile rupture. For a triaxiality factor of 2.0 (maximum value for biaxial tension at the surface), the cumulative strain limit is half the reported ultimate strain of the material at tensile rupture. For negative values of triaxiality factor (significant compressive stress), the cumulative strain limit is double the reported ultimate strain of the material at tensile rupture.
This criterion was developed and used by the Canister Storage Building (CSB) Expert Review Panel for evaluating multi-canister overpack free drops in the CSB.

B.3.5 Fire Accident Performance Criteria

In the case of HAC fire, performance test requirements specified in 10 CFR 71.73 stipulate the fire temperature (800°C [1,475°F]), duration (30 minutes), emissivity (0.9), and package absorptivity (0.8). It also stipulates that no artificial cooling be applied and the package must cool naturally. In the case of package absorptivity, the NRC staff’s position is that testing real emissivities of the package may be used, but must be accounted for by increasing the fire temperature. Also, the sequence of events leading up to the fire is specified. As with all other performance tests, Regulatory Guide 7.6 is the acceptable performance criteria along with maintenance of shielding. For seal integrity, the NRC staff has traditionally used the manufacturers’ recommended continuous operating temperature as the limiting temperature of the seal material.

For onsite transportation, it is proposed that the fire AC parameters for evaluation be as follows:

- Fire temperature of 800°C (1,475°F)
- Duration of 30 min.
- Artificial water cooling is applied to the package immediately after the 30-min. fire
- Effect of solar radiation can be ignored for the entire event
- Emissivity of the fire is 0.9
- Absorptivity of the package is the published absorptivity of the outer surface material at temperature
- Sequence of events leading to the fire is the same as specified in the regulations.

Hanford Site parameters that are not identical to the regulations are justified on the following basis:

- Because there are dedicated Fire Fighting Units trained in fighting radioactive material fires on the Hanford Site, cooling after a 30-min. fire duration is realistic.
- Lower absorptivities of the outer shell of the packaging are justified on the basis that measurements of material emissivities at temperature are much lower than the 0.9 absorptivity specified in the regulations; as an example, the absorptivity of 316 stainless steel is 0.6 at 538°C (1,000°F).

Under fire conditions, the limiting value to demonstrate containment performance of the seal is based on the manufacturers’ stated high temperature operation for a duration of 1 hour. Structural integrity and safe performance of the package is demonstrated by evaluating thermal loading on the package to the requirements of ASME BPVC Section III, Subsection NE for Service Level D Limits.
B.3.6 Design and Construction Standard for Packages

The NRC has established standards and criteria for design and construction of packages in Regulatory Guides, NUREG/CR-3854, *Fabrication Criteria for Shipping Containers*, and NUREG/CR-3019, *Recommended Welding Criteria for Use in the Fabrication of Shipping Containers for Radioactive Materials*. These standards and criteria are based on the graded-approach application of Section III of ASME BPVC. As an example, spent fuel and Category I package containment vessels are to be designed and constructed to the requirements of ASME BPVC, Section III, Subsection NB. Category II package containment vessels are to be designed and constructed to the requirements of ASME BPVC, Section III, Subsection ND, and Category III package containment vessels to ASME BPVC, Section VIII, Division 1. Package design and construction quality assurance requirements are defined in 10 CFR 71, Subpart H. The intent of the NRC in establishing these various standards, criteria, and requirements is to ensure quality of the package by imposing controls on construction processes of packages and components.

For the design and construction of packages for transport and storage on the Hanford Site, ASME BPVC, Section VIII, Division 1 or 2 is to be used for the containment vessel of the package. The containment vessel is required to be constructed by an ASME BPVC, Section VIII, certified shop and in some cases the design engineer may require application of a U or U-2 Stamp. In all cases, pressure and leak tests are required. The bases for this are as follows:

- Quality control of basic vessel construction processes such as design, material selection, material handling, inspection, welding, assembly, and heat treatment are fundamentally the same as ASME BPVC, Section III, except additional restrictions are applied depending on the subsection (Subsection NB is the most restrictive).
- Vessels designed and constructed to the requirements of ASME BPVC, Section VIII, Division 1 have an inherent margin of 4. Vessels designed and constructed to the requirements of ASME BPVC, Section III, Subsection NB and Section VIII, Division 2 have an inherent margin of 3.
- Original basis of Section III Subsections are ASME BPVC, Section VIII, Divisions 1 and 2.
- Code philosophies in both sections are the same.
- Weld procedures and welders are qualified to ASME BPVC, Section IX under both Sections III and VIII.
- Nondestructive examination of materials and components are performed to the requirements of ASME BPVC, Section V under Section III and Section VIII.
- Both sections require the same known materials, proven design practices, known fabrication practices for forming, bending, welding and postweld heat treatment, proven nondestructive examination procedures, and pressure testing.
- Containment vessels, when properly designed to the requirements of ASME BPVC, Section VIII, Division 1 or 2 for internal pressure loadings of 1.4 to 2.8 MPa (200 to
400 psig) with standard material sizes, can be demonstrated to meet the proposed acceptable performance criteria for NC and AC loadings. This includes free drops.

- Pressure, radiation, and temperature extremes for a package are far less than for the primary coolant system of a reactor.
- Each vessel must be pressure tested.
- ASME BPVC, Section VIII, Division 1 or 2 provides a known commercial standard from which the containment vessel can be constructed that meets fundamental design and construction requirements of regulatory guides and NUREGs.

An example of such a package is a design of a typical small Type B shielded drum package. Total weight of the package is approximately 2,041 kg (4,500 lb) and gross weight of the containment vessel is approximately 181 kg (400 lb). The containment vessel is designed for an internal pressure of 1.4 MPa (200 psig) at 204°C (400°F), with a maximum normal operating pressure of 0.8 MPa (100 psig) at 93°C (200°F). The vessel is designed in accordance with design rules stipulated in ASME BPVC, Section VIII, Division 1, using stock sizes of materials. The package is then evaluated for NC and AC structural integrity and containment maintenance using the Hanford Site performance criteria.

**B.3.7 Hanford Site Criticality Limits for Packages**

The NRC staff’s position is that transportation packages must have, in addition to the bias and uncertainties, a minimum administrative subcritical margin of 0.05 \( \Delta k \) (p. 2, NUREG/CR-5661, *Recommendations for Preparing the Criticality Safety Evaluation of Transportation Packaging for Radioactive Material*); i.e., a maximum \( k_{\text{eff}} \) limit of 0.95 considering bias and uncertainties. However, if there is sufficient critical data to adequately determine calculational bias and uncertainty, the subcritical margin may be increased by some amount (NUREG/CR-5661, p. 18). The TSD establishes the upper limit for calculated \( k_{\text{eff}} \) and associated bias and uncertainties of 0.95, consistent with the NRC position cited above. If justification for specific packages is necessary to increase this limit, an exemption request as described in Chapter 9 may be processed for RL approval.

For transport of arrays of packages, regardless of the actual \( k_{\text{eff}} \) limit, \( k_{\text{eff}} \) is not controlled directly, but instead indirectly by controlling enrichment, mass, geometry, other process parameters, or a combination thereof that influences \( k_{\text{eff}} \). At the time of evaluation, the values of these physical parameters are fixed, and the criticality evaluation controls \( k_{\text{eff}} \) by controlling the number of packages on a single shipment. Typically, the magnitude of the safety margin in terms of the number of packages is not reported for a given safety margin in \( k_{\text{eff}} \). However, DOE G 421.1-1 (p. 69), *Criticality Safety Good Practices Program Guide for DOE Nonreactor Nuclear Facilities*, recommends that \( k_{\text{eff}} \) should be used to assess safety only in conjunction with its relation to parametric curves representing the system under consideration. For example, the often-referenced “safe” condition of \( k_{\text{eff}} = 0.95 \) could be overly conservative at a point on the flat of a \( k_{\text{eff}} \) vs. \( H/X \) parametric curve, but very non-conservative on the steep upward slope of such a curve.”

Applying this concept to Hanford Site packages, the adequacy of a safety margin can be demonstrated by a parametric curve of \( k_{\text{eff}} \) versus the number of packages. For a hypothetical
situation where the $k_{eff}$ of X number of packages in ACs is 0.94, but the $k_{eff}$ of an array of 2X packages is 0.96, a $k_{eff}$ limit of 0.95 may be unnecessarily conservative based on as low as reasonably achievable, cost, or schedule considerations because the addition of a large number of packages to the shipment does not increase the $k_{eff}$ significantly (and in no cases will a $k_{eff}$ limit higher than 0.98 be used). An equivalent degree of safety based on a sufficient margin of safety in terms of the controllable physical parameter (the number of packages) may be demonstrated in this manner, where the $k_{eff}$ is on the plateau of the parametric curve, and a $k_{eff}$ limit ≤ 0.98 in this example is both safe and non-arbitrary.

Besides the safety margin in the $k_{eff}$ limit, an additional component of safety analysis is using conservative assumptions. However, an analysis that is excessively conservative is not necessarily desirable. As noted in DOE G 421.1-1, (p. 64), "excessive conservatism is any approximation or combination thereof that results in an excessive safety margin and thus needlessly hinders the mission of the facility or usurps resources." Furthermore, DOE G 421.1-1, (p. 66) states, “appropriateness in conservatism means not only relevance, but also implies (1) realism in all aspects of evaluations, and (2) cost effectiveness that does not preclude consideration of reasonable alternatives.” Thus, conservative assumptions should be relevant, realistic, and not needlessly usurp resources. Criticality safety evaluations should determine whether assumptions are reasonably or excessively conservative.

### B.3.8 Hanford Site Environmental Conditions

The equivalent package standards provide an equivalent degree of safety to those provided by 10 CFR 71 and supplemental NRC regulatory guidance. Equivalency is based on site-specific environmental and test conditions, which in the majority of cases, are identical to the regulations. However, as shown in Table B-1, in a few cases the site-specific worst case conditions are less severe and in two cases are more severe than those specified in the regulations. The following sections identify and justify the site environmental condition used in the equivalent standards.

#### Table B-1. Hanford Onsite Package System Performance Criteria

<table>
<thead>
<tr>
<th>10 CFR 71 Standard Performance Test</th>
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<th>Hanford Acceptance Criteria</th>
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<tbody>
<tr>
<td>10 CFR 71.43 General standards for all packages</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10 CFR 71.43 (a) Smallest overall dimension not less than 10 cm (4 in.)</td>
<td>Self-explanatory.</td>
<td>Same as 10 CFR 71.43 (a).</td>
<td>Same as NRC.</td>
</tr>
<tr>
<td>10 CFR 71.43 (b) Outside of package must have tamper-indicating devices.</td>
<td>Self-explanatory.</td>
<td>Same as 10 CFR 71.43 (b).</td>
<td>Same as NRC.</td>
</tr>
<tr>
<td>10 CFR 71.43 (c) Each package must include a positive fastening device.</td>
<td>Self-explanatory.</td>
<td>Same as 10 CFR 71.43 (c).</td>
<td>Same as NRC.</td>
</tr>
</tbody>
</table>
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<tr>
<td>10 CFR 71.43 (d)</td>
<td>Package must be made of materials and construction that assure no significant chemical, galvanic, or other reaction among packaging components and package contents.</td>
<td>Self-explanatory.</td>
<td>Same as 10 CFR 71.43 (d).</td>
</tr>
<tr>
<td>10 CFR 71.43 (e)</td>
<td>Package valve or other device must be protected against unauthorized operation and must be provided with an enclosure to retain any leakage.</td>
<td>Self-explanatory.</td>
<td>Same as 10 CFR 71.43 (e).</td>
</tr>
<tr>
<td>10 CFR 71.43 (f)</td>
<td>Package must not have loss or dispersal of radioactive contents, no significant increase in external surface radiation levels, and no substantial reduction in the effectiveness of the packaging.</td>
<td>Self-explanatory.</td>
<td>Same as 10 CFR 71.43 (f).</td>
</tr>
<tr>
<td>10 CFR 71.43 (g)</td>
<td>Package must have, in still air at 38°C (100°F) and in the shade, no accessible surface temperature exceeding 50°C (122°F) in a nonexclusive use shipment or 85°C (185°F) in an exclusive use shipment.</td>
<td>Self-explanatory.</td>
<td>Same as 10 CFR 71.43 (g), except still air requirement is at the higher onsite temperature of 46°C (115°F).</td>
</tr>
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<tr>
<td>10 CFR 71.43 (h)</td>
<td>Package may not incorporate a feature intended to allow continuous venting.</td>
<td>Self-explanatory.</td>
<td>Package has HEPA filter, demonstrated to not allow liquid passage and maintain regulatory release limits under all performance tests. Sustaining deflagration demonstrated by meeting Service Level D requirements or test with no loss of containment.</td>
</tr>
</tbody>
</table>

10 CFR 71.45 Lifting and tiedown standards for all packages

| 10 CFR 71.45 (a) | 1. Lifting attachment must have a minimum safety factor of 3 against yielding. Failure of device not to impair ability of package to meet other safety requirements. 2. Similar parts made inoperable for lifting or meet design requirements. | 1. ANSI N14.6 a. Lifting 3 x total weight without exceeding yield strength. OR 5 x total weight without exceeding ultimate strength. b. If failure of devices affects safety-related equipment, device designed for twice above loads or dual load path system provided. 2. Self-explanatory. | (1a) RL Hoisting and Rigging Manual. (1b) RL Hoisting and Rigging Manual. (2) Same as 10 CFR 71.45 (a). | (1a) RL Hoisting and Rigging Manual requirements. (1b) RL Hoisting and Rigging Manual requirements. (2) Same as NRC. |
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<tr>
<td>10 CFR 71.45 (b) Tiedown devices</td>
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</tr>
<tr>
<td>1. System of tiedown devices that is a structural part of the package must be capable of withstanding static loads of 2, 10, and 5 times the gross weight of the package applied to the center of gravity of the package.</td>
<td>1. In this case, the tiedowns to critical components are to meet these requirements when attached to critical components. Loads are to be evaluated to Regulatory Guide 7.6 or applicable ASME subsection per NUREG-1609, for Service Level A.</td>
<td>(1) Same as 10 CFR 71.45 (b).</td>
<td>(1) Same as NRC, except demonstrated by meeting ASME BPVC, Section III, Subsection NE, for Service Level A.</td>
</tr>
<tr>
<td>2. Must be capable of being rendered inoperable for tying down the package during transport, or must be designed with strength equivalent to that required for tiedown devices.</td>
<td>2. Self-explanatory.</td>
<td>(2) Same as 10 CFR 71.45 (b).</td>
<td>(2) Same as NRC.</td>
</tr>
<tr>
<td>3. Failure of the device under excessive load would not impair the ability of the package to meet other requirements.</td>
<td>3. Self-explanatory.</td>
<td>(3) Same as 10 CFR 71.45 (b).</td>
<td>(3) Self-explanatory.</td>
</tr>
</tbody>
</table>

**10 CFR 71.71 Normal conditions of transport**

<table>
<thead>
<tr>
<th>10 CFR 71.71 (a) Evaluation</th>
<th>Demonstration of each package design must include a determination of the effect on that design of the conditions and tests.</th>
<th>Demonstrated by meeting requirements of Regulatory Guide 7.6 or applicable ASME subsection per NUREG-1609, for Service Level A. Load combination per Regulatory Guide 7.8</th>
<th>Same as 10 CFR 71.71 (a).</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Same as NRC, except demonstrated by meeting ASME BPVC, Section III, Subsection NE, for Service Level A.</td>
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<tr>
<td>10 CFR 71.71 (b) Initial conditions</td>
<td>Ambient temperature preceding and following tests must remain constant at value between –29°C (-20°F) and 38°C (100°F). The initial internal pressure must be MNOP consistent with the ambient temperature considered to precede and follow the tests.</td>
<td>Demonstrated by meeting requirements of Regulatory Guide 7.6 or applicable ASME subsection per NUREG-1609, for Service Level A.</td>
<td>Same as 10 CFR 71.71 (b) except extreme temperature range is -33°C (-27°F) to 46°C (115°F) for the Hanford Site.</td>
</tr>
<tr>
<td>10 CFR 71.71 (c) Conditions and tests, (1) Heat</td>
<td>An ambient temperature of 38°C (100°F) in still air and insolation in accordance with: Form and location of surface/total insolation for a 12-hour period: • Flat surfaces transported horizontally – base/none – other surfaces/800 g-cal/cm² • Flat surfaces not transported horizontally/200 g-cal/cm² • Curved surfaces/400 g-cal/cm²</td>
<td>Package accessible surfaces in still air at 38°C (100°F) and in the shade must not exceed 50°C (122°F) in nonexclusive use shipments and 85°C (185°F) in exclusive use shipment. Also, worst case to be used in combination with other loads as defined in Regulatory Guide 7.8 to develop NCT load combinations.</td>
<td>NC Heat (Hanford Site) • Ambient Temperature = 46°C (115°F). • Still air. • Decay Heat. • Solar insolation for 12 h/d specific to the Hanford Site.</td>
</tr>
<tr>
<td>10 CFR 71.71 (c) (2) Cold</td>
<td>An ambient temperature of -40°C (-40°F) in still air and shade.</td>
<td>Criteria for Regulatory Guide 7.11 or 7.12 material brittle fracture requirements. Also, condition for evaluation of NCT and HAC performance.</td>
<td>Hanford Site • Ambient Temperature = -33°C (-27°F). • Still air. • In the shade. ASME BPVC, Section VIII, Division 1 criteria per UCS-66 for brittle fracture. Also, conditions for evaluation of NC and AC.</td>
</tr>
<tr>
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</tr>
<tr>
<td>10 CFR 71.71 (c) (3) Reduced external pressure</td>
<td>External pressure of 25 kPa (3.5 psi) absolute.</td>
<td>Considered as part of Regulatory Guide 7.8 to establish MNOP for NCT load combination development. Acceptance criterion of the worst case load combination is ASME BPVC applicable subsection per NUREG-1609, Service Level A.</td>
<td>Same as 10 CFR 71.71 (c).</td>
</tr>
<tr>
<td>10 CFR 71.71 (c) (4) Increased external pressure</td>
<td>External pressure of 140 kPa (20 psi) absolute.</td>
<td>Considered as part of Regulatory Guide 7.8 to develop worst case NCT load combinations. Acceptance criterion of the worst case load combination is ASME BPVC applicable subsection per NUREG-1609, Service Level A.</td>
<td>Same as 10 CFR 71.71 (c).</td>
</tr>
<tr>
<td>10 CFR 71.71 (c) (5) Vibration</td>
<td>Vibration normally incident to transport.</td>
<td>Acceptance criterion is applicable ASME BPVC subsection per NUREG-1609, Service Level A fatigue analysis. For transport vibration, NRC has accepted the argument that the NCT drop is bounding.</td>
<td>Same as 10 CFR 71.71 (c).</td>
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<tr>
<td>10 CFR 71.71 (c) (6) Water spray</td>
<td>Water spray that simulates exposure to rainfall of approximately 5 cm/h (2 in./h) for at least 1 hour.</td>
<td>Normally this is demonstrated by the argument that package is sealed leaktight and remains leaktight during NCT; therefore, it is watertight. Vulnerable areas to water intrusion such as impact limiters and neutron shielding fire vent ports are evaluated.</td>
<td>Same as 10 CFR 71.71 (c).</td>
</tr>
</tbody>
</table>

| 10 CFR 71.71 (c) (7) Free drop  | Between 1.5 and 2.5 hours after the water spray test, a free drop through a distance specified onto a flat, essentially unyielding, horizontal surface, striking the surface in a position for which maximum damage is expected. | For this case, all applicable combined loads from above as specified in Regulatory Guide 7.8. NRC acceptance criteria are Regulatory Guide 7.6 or applicable ASME BPVC subsection per NUREG-1609, Service Level A to demonstrate containment. For criticality control, load combinations on key components are measured against ASME BPVC, Section III, Subsection NG. Shielding limits are regulatory requirements. | Hanford Site requirements the same except 1.2 m (4.0 ft) to 0.3 m (1.0 ft) onto a worst case Hanford Site target established as a 20 cm (8-in.) thick concrete pad, sufficiently large enough to contain the entire impact event. Concrete shall have a specified minimum strength of 21 MPa (3,000 psi) reinforced with No. 7 rebar on 30 cm (12 in.) centers over compact Hanford soil. |
|                                  | | | Same as NRC, except demonstrated containment by meeting ASME BPVC, Section III, Subsection NE, for Service Level C with all applicable load combinations. For criticality control, the same as the NRC. Shielding limits based on Hanford Site requirements. |
## Table B-1. Hanford Onsite Package System Performance Criteria

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<tr>
<td>10 CFR 71.71 (c) (8) Corner drop</td>
<td>Free drop from a height of 0.3 m (1 ft) onto flat, essentially unyielding, horizontal surface. Test applied only to fiberboard, wood, or fissile material rectangular packages not exceeding 50 kg (110 lb) and fiberboard, wood or fissile material cylindrical packages not exceeding 100 kg (220 lb).</td>
<td>Addressed on a case-by-case basis.</td>
<td>Same as 10 CFR 71.71 (c) (8) except the free drop surface target is the same as described above.</td>
</tr>
<tr>
<td>10 CFR 71.71 (c) (9) Compression</td>
<td>For packages weighing up to 5,000 kg (11,000 lb), the package must be subjected for 24 hours to a compressive load applied uniformly to top and bottom of package in the position the package would normally be transported. The compressive load must be the greater of the following: a. The equivalent of 5 times the weight of the package; or b. The equivalent of 13 kPa (2 lbf/in²) multiplied by the vertically projected area of the package.</td>
<td>Not normally performed for large package. For small packages, load combinations above are evaluated with compression to applicable ASME BPVC subsection per NUREG-1609 for Service Level A to demonstrate maintenance of containment.</td>
<td>Same as 10 CFR 71.71 (c).</td>
</tr>
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<tr>
<td>10 CFR 71.71 (c) (10) Penetration</td>
<td>Impact of the hemispherical end of a vertical steel cylinder of 3.2 cm (1.25 in.) diameter and 6 kg (13 lb) mass, dropped from a height of 1 m (40 in.) onto the exposed surface of the package that is expected to be most vulnerable to puncture. The long axis of the cylinder must be perpendicular to the package surface.</td>
<td>Normally, for large packages, this is evaluated only when ancillary equipment, such as shut off values required to NCT containment, is judged to be vulnerable to hard and light falling projectiles. Small packages with thin walls and/or vulnerable locations must be evaluated to demonstrate containment with only highly localized deformation in the impact region.</td>
<td>Same as 10 CFR 71.71 (c).</td>
</tr>
</tbody>
</table>

10 CFR 71.73 Hypothetical accident conditions

| 10 CFR 71.73 (a) Test procedures | Evaluation for HAC is based on sequential application of the tests, in order indicated, to determine their cumulative effect. An undamaged specimen may be used for the water immersion tests. | Demonstrated by meeting requirements of Regulatory Guide 7.6 or applicable ASME BPVC subsection per NUREG-1609, for Service Level D. | Same as 10 CFR 71.73 (a). | Same as NRC except demonstrated no loss of containment by showing SED or accumulated plastic strain below allowable limits for the material. As an alternative, use ASME BPVC, Section III, Subsection NE, for Service Level D. For criticality control, load combinations on key components are measured against ASME BPVC, Section III, Subsection NG. Loss of shielding limits is the same as the NRC. |
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<tr>
<td>10 CFR 71.73 (b) Test conditions.</td>
<td>Except for water immersion tests to demonstrate compliance with the requirements during testing, the ambient air temperature before and after the tests must remain constant at the value between -29°C (-20°F) and 38°C (100°F). The initial internal pressure within the containment system must be the MNOP, unless a lower internal pressure, consistent with the ambient temperature assumed to precede and follow the tests, is more unfavorable.</td>
<td>Self-explanatory.</td>
<td>Same as 10 CFR 71.73 (b) except temperature range for Hanford Site is -33°C (-27°F) to 46°C (115°F).</td>
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<tr>
<td>10 CFR 71.73 (c) Tests</td>
<td>Tests for HAC must be conducted as follows:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10 CFR 71.73 (c) (1) Free drop</td>
<td>A free drop through a distance of 9 m (30 ft) onto a flat, essentially unyielding, horizontal surface, striking the surface in a position for which maximum damage is expected.</td>
<td>NRC acceptance criteria are Regulatory Guide 7.6 or applicable ASME BPVC subsection per NUREG-1609, Service Level D to demonstrate containment. For criticality control, load combinations on key components are measured against ASME BPVC, Section III, Subsection NG. Also shielding must be within HAC limit of ≤ 1,000 mR/h, 1 m (40 in.) from external surface of package.</td>
<td>AC Hanford Site Requirements the same except, free drop onto a worst case Hanford Site target established as a 20 cm (8-in.) thick concrete pad, sufficiently large enough to contain the entire impact event. Concrete shall have a specified minimum strength of 21 MPa (3,000 psi) reinforced with No. 7 rebar on 30 cm (12 in.) centers over compact Hanford soil.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Same as NRC, except demonstrating no loss of containment by showing the SED or accumulated plastic strain is below allowable limits for the material. As an alternative, use ASME BPVC, Section III, Subsection NE, for Service Level D. For criticality control, load combinations on key components are measured against ASME BPVC, Section III, Subsection NG. Loss of shielding limits is the same as the NRC.</td>
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<td>10 CFR 71.73 (c) (2) Crush</td>
<td>Subjection to a dynamic crush test by positioning the specimen on a flat, essentially unyielding, horizontal surface so as to suffer maximum damage by the drop of a 500 kg (1,100 lb) mass from 9 m (30 ft) onto the specimen. The mass must consist of a solid mild steel plate 1 m (40 in.) by 1 m (40 in.) and must fall in a horizontal attitude. Test is required only when the specimen has a mass not greater than 500 kg (1,100 lb), and overall density not greater than 1,000 kg/m³ (62.4 lb/ft³), and radioactive contents greater than 1,000 A₂ not as special form radioactive material.</td>
<td>NRC acceptance criteria are Regulatory Guide 7.6 or applicable ASME BPVC subsection per NUREG-1609, Service Level D and must follow free drop (sequentially) to demonstrate containment. For criticality control, load combinations on key components are measured against ASME BPVC, Section III, Subsection NG. Also shielding must be within HAC limit of ≤ 1,000 mR/h 1 m (40 in.) from external surface of package.</td>
<td>Same as 10 CFR 71.73 (c) (2) except the target surface for the Hanford Site is as specified above and crushing object is an identical package dropping from a height of 9 m (30 ft) onto the damaged package in the orientation to cause the most damage. Specimen on a concrete surface as defined above.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Same as NRC, except demonstrating no loss of containment by showing the SED or accumulated plastic strain is below allowable limits for the material. As an alternative, use ASME BPVC, Section III, Subsection NE, for Service Level D. For criticality control, load combinations on key components are measured against ASME BPVC, Section III, Subsection NG. Loss of shielding limits is the same as the NRC.</td>
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<td>10 CFR 71.73 (c) (3) Puncture</td>
<td>A free drop through a distance of 1 m (40 in.) in a position for which maximum damage is expected, onto the upper end of a solid, vertical, cylindrical, mild steel bar mounted on an essentially unyielding, horizontal surface. The bar must be 15 cm (6 in.) in diameter, with the top horizontal and its edge rounded to a radius of not more than 6 mm (0.25 in.), and of a length as to cause maximum damage to the package, but not less than 20 cm (8 in.) long. The long axis of the bar must be vertical.</td>
<td>Same as 10 CFR 71.73, except puncture rod mounted on concrete slab described for free drop.</td>
<td>Same as NRC, except demonstrating no loss of containment by showing the SED or accumulated plastic strain is below allowable limits for the material. As an alternative, use ASME BPVC, Section III, Subsection NE, for Service Level D. For criticality control, load combinations on key components are measured against ASME BPVC, Section III, Subsection NG. Loss of shielding limits is the same as the NRC.</td>
</tr>
<tr>
<td></td>
<td>NRC acceptance criteria are Regulatory Guide 7.6 or applicable ASME BPVC subsection per NUREG-1609, Service Level D and must follow free drop and crush (when required) (sequentially) to demonstrate containment. For criticality control, load combinations on key components are measured against ASME BPVC, Section III, Subsection NG. Also shielding must be within HAC limit of ( \leq 1,000 \text{ mR/hr} ) 1 m (40 in.) from external surface of package.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10 CFR 71 Standard Performance Test</td>
<td>NRC Regulatory Acceptance Criteria</td>
<td>Hanford Standard Performance Test</td>
<td>Hanford Acceptance Criteria</td>
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<td>-------------------------------------</td>
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<tr>
<td>10 CFR 71.73 (c) (4) Thermal Exposure of the specimen fully engulfed in a hydrocarbon fuel/air fire of sufficient extent to provide an average emissivity coefficient of at least 0.9, with an average flame temperature of at least 800°C (1,475°F) for a period of 30 minutes. The fuel source must extend horizontally at least 1 m (40 in.), but may not extend more than 3 m (10 ft), beyond any external surface of the specimen, and the specimen must be positioned 1 m (40 in.) above the surface of the fuel source. The surface absorptivity coefficient must be either that value which the package may be expected to possess if exposed to the fire specified or 0.8, whichever is greater. Artificial cooling may not be applied after cessation of external heat input, and any combustion of materials of construction, must be allowed to proceed until it terminates naturally.</td>
<td>NRC acceptance criteria is Regulatory Guide 7.6 or applicable ASME BPVC subsection per NUREG-1609, Service Level D and must follow free drop, crush (when required), and puncture (sequentially) to demonstrate containment. For criticality control, load combinations on key components are measured against ASME BPVC, Section III, Subsection NG. Also shielding must be within HAC limit of ≤ 1,000 mR/h, 1 m (40 in.) from external surface of package. Also must maintain seal and shielding effectiveness and shielding must not melt and re-cool. Seals not allowed to reach temperature above maximum rated continuous use temperature.</td>
<td>AC Hanford Site: • Exposure of the entire package for not less than 30 minutes. • To a heat flux of not less than a radiation environment of 800°C (1,475°F). • With a flame emissivity coefficient of at least 0.9. • Package surface absorptivity must be published value at temperature. • Significant, convective heat must be included based on still ambient air at 800°C (1,475°F). • Artificial cooling of the package is applied after 30 minutes. • Combustion is terminated after 30 minutes.</td>
<td>Same as NRC, except demonstrated by meeting ASME BPVC, Section III, Subsection NE Service Level D for thermal loading. For criticality control, load combinations on key components are measured against ASME BPVC, Section III, Subsection NG. Also in this case, water applied after 30 minutes from initiation of fire. Seals must maintain containment and properties for 1 hour. Loss of shielding limits is the same as the NRC.</td>
</tr>
<tr>
<td>10 CFR 71 Standard Performance Test</td>
<td>NRC Regulatory Acceptance Criteria</td>
<td>Hanford Standard Performance Test</td>
<td>Hanford Acceptance Criteria</td>
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</tr>
<tr>
<td>10 CFR 71.73 (c) (5) Immersion – fissile material</td>
<td>In cases where water inleakage has not been assumed for criticality analysis, immersion under a head of water of at least 0.9 m (3 ft) in the attitude for which maximum leakage is expected.</td>
<td>NRC acceptance criteria are Regulatory Guide 7.6 or applicable ASME BPVC subsection per NUREG-1609, Service Level D and must follow free drop, crush (when required), puncture, and thermal fire (sequentially) to demonstrate containment. For criticality control, load combinations on key components are measured against ASME BPVC, Section III, Subsection NG.</td>
<td>Same as 10 CFR 71.71 (c) when no restriction on transport over large and deep bodies of water.</td>
</tr>
<tr>
<td>10 CFR 71.73 (c) (6) Immersion – all packages</td>
<td>A separate, undamaged specimen must be subjected to water pressure equivalent to immersion under a head of water of at least 15 m (50 ft). For test purposes, an external pressure of water of 150 kPa (21.7 lbf/in²) gauge is considered to meet these conditions.</td>
<td>NRC acceptance criteria are Regulatory Guide 7.6 or applicable ASME BPVC subsection per NUREG-1609, Service Level D to demonstrate containment. For criticality control, load combinations on key components are measured against ASME BPVC, Section III, Subsection NG.</td>
<td>Same as 10 CFR 71.73 (c) when no restriction on transport over large and deep bodies of water.</td>
</tr>
</tbody>
</table>

Same as NRC, except demonstrated by meeting ASME BPVC, Section III, Subsection NE Service Level D for external pressure loading. For criticality control, load combinations on key components are measured against ASME BPVC, Section III, Subsection NG. Vented packages require fully flooded conditions for criticality evaluation.
Table B-1. Hanford Onsite Package System Performance Criteria

<table>
<thead>
<tr>
<th>10 CFR 71 Standard Performance Test</th>
<th>NRC Regulatory Acceptance Criteria</th>
<th>Hanford Standard Performance Test</th>
<th>Hanford Acceptance Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>AC = accident condition</td>
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<tr>
<td>RF = American National Standards Institute</td>
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<tr>
<td>ASME = American Society of Mechanical Engineers</td>
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<tr>
<td>BPVC = Boiler and Pressure Vessel Code</td>
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<tr>
<td>CFR = Code of Federal Regulations</td>
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<tr>
<td>HAC = hypothetical accident condition</td>
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</tr>
<tr>
<td>HEPA = high-efficiency particulate air (filter)</td>
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<tr>
<td>NC = normal condition</td>
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<td></td>
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</tr>
<tr>
<td>NCT = normal conditions of transport</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>NRC = U.S. Nuclear Regulatory Commission</td>
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<tr>
<td>MNOP = maximum normal operating pressure</td>
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<tr>
<td>RL = U.S. Department of Energy, Richland Operations Office</td>
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<tr>
<td>SED = strain energy density</td>
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</tr>
</tbody>
</table>

Sources:
Regulatory Guide 7.11, Fracture Toughness Criteria of Base Material for Ferritic Steel Shipping Cask Containment Vessels with a Maximum Wall Thickness of 4 Inches (0.1 m), U.S. Nuclear Regulatory Commission, Washington, D.C.
Regulatory Guide 7.12, Fracture Toughness Criteria of Base Material for Ferritic Steel Shipping Cask Containment Vessels with a Wall Thickness Greater than 4 Inches (0.1 m) But Not Exceeding 12 Inches (0.3 m), U.S. Nuclear Regulatory Commission, Washington, D.C.

B.3.8.1 Conditions for Package External Temperature

The regulation states that the maximum package external temperature will be determined in the shade at an ambient still air temperature of 38°C (100°F). Based on climatological data reported from 1912 to 1980 in WHC-SD-TP-RPT-004, Environmental Conditions for On-Site Hazardous Materials Packages, the highest recorded temperature on the Hanford Site is 46°C (115°F). Consequently, site-specific determination of maximum allowable package external temperature is based on a more severe condition than for the regulations. However, the maximum allowable package external temperature is unchanged from the temperatures specified in the regulation of 85°C (185°F) for exclusive use and 50°C (122°F) for nonexclusive use shipments.

B.3.8.2 Heat and Cold Temperature Test Conditions

The range of heat and cold environmental temperature test conditions specified in the regulations is 38°C to -40°C (100°F to -40°F). Based on Hanford climatological data provided in
WHC-SD-TP-RPT-004, the highest and lowest recorded temperatures on the Hanford Site are 46° and -33°C (115° and -27°F). Consequently, site-specific package heat test condition high temperature extreme is more severe than the regulations. In the case of site-specific package cold test condition, the Hanford Site low temperature extreme is only slightly less severe than the regulations. Equivalency to the regulations is also provided by institutional controls at the Hanford Site, in that at such low temperature extremes all operations (including onsite transport) would be limited to only critical and emergency operations for facility and personnel safety.

B.3.8.3 Package Lifting

49 CFR 393, Subpart I is required for all Hanford Site lifting and handling operations.

B.3.8.4 Initial Temperature Conditions for Normal Conditions

The range of NC test condition temperature specified in the regulations is 38° to -29°C (100° to -20°F). Based on Hanford Site climatological data provided in WHC-SD-TP-RPT-004, the highest and lowest recorded temperatures on the Hanford Site are 46° and -33°C (115° and -27°F). Consequently, site-specific package initial conditions for NC tests are more severe than the regulations for the range of environmental temperatures.

B.3.8.5 Solar Insolation

The Hanford Site solar insolation values are based on a 25-year average of direct and diffuse solar radiation measurements (WHC-SD-TP-RPT-004). These values are normalized to the requirements of 10 CFR 71. Because these values are specific to the Hanford Area, they are used in lieu of the regulatory values.

B.3.8.6 Free Drop Surface

The regulatory requirement for free drop surfaces is a hard, essentially unyielding surface, which according to IAEA guidelines is defined as a target with a mass of 10 times that of the package. As defined by the IAEA the target is to be covered by a 5 cm (2 in.) thick steel plate embedded in concrete. On the Hanford Site, no such hard unyielding surfaces exist. The worst case accident impact surface under all transportation conditions is the CWC storage pad. This is defined as the Hanford Site equivalent to a hard unyielding surface due to its mass and relative hardness to other objects. The CWC storage pad is a 20 cm (8 in.) thick concrete slab, two-way reinforced with number 7 rebar on 30 cm (12 in.) centers constructed for heavy truck loads. This is based on Lawrence Livermore National Laboratory studies in NUREG/CR-4829, *Shipping Container Response to Severe Highway and Railway Accident Conditions*, which has also shown that only impacts onto large, massive objects generate significant forces on the package.

In addition, the studies in NUREG/CR-4829 have shown that 48 km/h (30 mi/h) impact speeds onto hard unyielding surfaces are equivalent to impact speeds of 97 km/h (60 mi/h) onto a “medium” hard surface, such as concrete. Because speeds on the Hanford Site are limited to 88 km/h (55 mi/h), this would limit maximum package impact velocity onto a massive concrete surface to an equivalent velocity onto a hard, unyielding surface. Also, as demonstrated by Belgium and French Atomic Energy Commission (SAND87-1903, *Summary of Radioactive Materials Package Storage*) tiedown restraints failure and driver reaction time would further
limit the package impact velocities to approximately one-half the initial conveyance speed. Based on these studies, the test conditions are equivalent to the regulations and conservatively bound onsite transportation ACs.

A NC free drop, unlike the regulatory scenario where normal operations would continue and be reported later, a NC free drop of a package on the Hanford Site would institutionally and administratively be considered, at best, an unusual occurrence and at worst an event. Consequently, all operations would stop, proper personnel would be notified, the area would be secured, steps would be taken to mitigate any release, and recovery from the condition would be initiated. In all cases, the package would be removed from normal transportation service for assessment of damage. These institutional and administrative controls provide a measure of control exceeding any controls applied in commercial transport of radioactive material packages for a NC free drop. In addition, transient load transfers are not routinely allowed onsite, and for those requiring load transfer, due to conveyance break down or unusual circumstances, will be monitored and performed to approved procedures. The majority of routine packaging handling operations is conducted at the shipping or receiving facilities.

**B.3.8.7 Puncture Surface**

The test puncture bar surface is mounted in the same concrete surface as the free drop condition, and in the prescribed manner as the regulatory puncture bar is mounted onto an essentially hard unyielding surface. Equivalency of the puncture bar test to the regulations is based on the same rationale for the free drop surface, in that no essentially unyielding surface exists on the Hanford Site. However, there are abutments and concrete surfaces at the Hanford Site on which objects firmly mounted to a concrete surface can act as a puncture bar. Assuming a puncture bar is firmly mounted onto a massive concrete surface would bound any puncturing object on the Hanford Site. Also, at the low-impacting velocity specified in the regulations, a package impacting a puncture bar mounted to a massive concrete surface would behave in the same manner as a package impacting a puncture bar mounted on a hard, unyielding surface. This is due to localized effect of the loading on the package and the distribution of the load from the mounting base.

**B.3.8.8 Fire AC**

The fire test is specified at the same temperature as the regulatory fire test. Also, as specified in the regulations, the package is to be fully engulfed in flames for a duration of 30 minutes. Consequently, the bounding fire is defined as an 800°C (1,475°F) temperature fire with a flame emissivity of 0.9, with the specified package material surface emissivities and absorptivities obtainable in published thermal properties data. As specified in the regulations, and package combustibles shall be allowed to completely burn and the packages cooled by natural convection and radiation only. For onsite conditions, based on a dedicated fire department and conservative response time, the package is assumed to have quenching applied after 30 minutes. Accounting for these mitigating factors, the fire AC parameters provides an equivalent degree of safety as provided by the regulations.
B.4 References


NUREG/CR-1815, Recommendations for Protecting Against Failure by Brittle Fracture in Ferritic Steel Shipping Containers up to Four Inches Thick, U.S. Nuclear Regulatory Commission, Washington, D.C.


NUREG/CR-4829, UCID-20733, Shipping Container Response to Severe Highway and Railway Accident Conditions, Lawrence Livermore National Laboratory, Livermore, California.


Regulatory Guide 7.11, Fracture Toughness Criteria of Base Material for Ferritic Steel Shipping Cask Containment Vessels with a Maximum Wall Thickness of 4 Inches (0.1 m), U.S. Nuclear Regulatory Commission, Washington, D.C.


Appendix C

Safety Basis Requirements for Hanford Onsite
Transportation and Packaging
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The safety basis requirements for Hanford Onsite Transportation and Packaging (T&P) define the administrative controls and limits for the T&P of radioactive materials and waste in quantities greater than 1 A$_2$, unless the radioactive material meets the definition of LSA/SCO. These controls and limits ensure that the T&P of hazardous materials are completed in a safe manner and provide protection to the environment, Hanford Site personnel, and the public. Controls required for public safety, significant worker safety, and for maintaining radiological consequences below the limits and guidelines are included.

In the T&P Safety Program, packaging system design is passive and the safety basis requirements are administrative. They are based on the preventive and mitigative features determined to be required in the body of this Hanford Sitewide Transportation Safety Document (TSD). They constitute an agreement or contract between the various U.S. Department of Energy (DOE), Hanford Field Office Managers and their respective Hanford Site contractors regarding the safe packaging and transportation of hazardous materials on the Hanford Site. As such, the safety basis requirements cannot be changed without the approval of the RL Manager.

The format and content of the safety basis requirements are based on (1) 10 CFR 830, Subpart B, “Nuclear Safety,” (2) DOE O 460.1C. They are maintained as part of this TSD, which is a controlled document.

The safety basis requirements do not apply to shipments of hazardous materials regulated by DOT. Offsite shipments are done in full compliance to U.S. Department of Transportation (DOT) requirements as found in 49 Code of Federal Regulations (CFR) 171-180 and 10 CFR 71.

Protection of occupational workers from radiological hazards as a result of the packaging and transportation of radioactive materials is achieved by compliance with this TSD.
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Terms

CFR       Code of Federal Regulations
DOE       U.S. Department of Energy
LCO       Limiting Conditions for Operation
LCS       Limited Control Settings
NUREG     U.S. Nuclear Regulatory Commission Regulatory Guide
PSSD      Package Specific Safety Document
SL        Safety Limit
SR        Surveillance Requirement
T&P       Transportation and Packaging
TSD       Hanford Sitewide Transportation Safety Document
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Appendix C
Safety Basis Requirements for Hanford Onsite Transportation and Packaging

C.1 USE AND APPLICATION

C.1.1 Definitions

The defined terms of this section are unique definitions. They appear in CAPITALIZED type and are applicable throughout these safety basis requirements and BASES. Some terms in this section refer the user to another section for the definition. This approach will prevent a shortened definition from being supplied and used out of context.

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACTIONS</td>
<td>ACTIONS shall be that part of the limiting conditions for operation (LCO) that prescribes required actions to be taken under designated conditions within specified completion times.</td>
</tr>
<tr>
<td>ADMINISTRATIVE CONTROLS</td>
<td>Refer to Section 1.2, ADMINISTRATIVE CONTROLS.</td>
</tr>
<tr>
<td>BASES</td>
<td>Refer to Attachment 1, BASES.</td>
</tr>
<tr>
<td>DESIGN FEATURES</td>
<td>DESIGN FEATURES are those design characteristics, primarily passive in nature, that are of a special importance to maintaining adequate control, shielding, or containment of radiological or toxicological material for which indiscriminate changes are to be prevented. See Attachment 2, “DESIGN FEATURES,” for DESIGN FEATURES criteria.</td>
</tr>
<tr>
<td>VIOLATION</td>
<td>Refer to Section 1.5, Technical Safety Requirement VIOLATIONS.</td>
</tr>
</tbody>
</table>

C.1.2 Administrative Controls

ADMINISTRATIVE CONTROLS are the provisions relating to organization and management, procedures, recordkeeping, reviews, audits, and specific program requirements for risk reduction necessary to ensure safe operation of the packaging system. The Safety Basis Requirements (i.e., safety limit [SL], limited control setting [LCS], LCO, and ADMINISTRATIVE CONTROLS) establish administrative requirements that ensure Safety Basis Requirements are
C.1 USE AND APPLICATION

met in the operation of the packaging system and the procedures that are followed should a Safety Basis Requirements not be met. ADMINISTRATIVE CONTROLS are generally written at the program level and contain program key elements, as applicable. ADMINISTRATIVE CONTROLS are established if (1) a safety function is best satisfied by a program instead of a hardware system; (2) control of a condition is not measured in real-time or near to real-time; (3) control of a condition is not under the immediate control of the operator; (4) a condition does not require immediate action and sufficient recovery time exists to permit mitigating action; or (5) a condition requires an evaluation based on prevalent conditions. ADMINISTRATIVE CONTROLS do not require ACTION statements or SR. SRs necessary to demonstrate compliance with an ADMINISTRATIVE CONTROL and the actions taken, should an ADMINISTRATIVE CONTROL requirement not be met, are performed according to procedures.

ADMINISTRATIVE CONTROLS are established for those programs required to prevent or mitigate accidents with unacceptable radiological consequences to the offsite public or onsite worker, to provide significant defense in depth, or provide significant worker safety.

C.1.3 SL, LCO, and Surveillance

For transportation and packaging (T&P) activities, the packaging system design is passive. No SLs are expected for transportation activities because there are no processes or activities in which the operator causes a process variable to be manipulated, which if left unchecked or uncontrolled would result in catastrophic failure of a passive safety barrier. For example, there are no operator-initiated processes to increase temperature, pressure, electrical, or mechanical insult to the cargo that could lead to catastrophic failure. Because there are no SLs protected by LCOs, Safety Basis Requirements level Surveillance Requirements are not included in this Safety Basis Requirement. This does not eliminate other surveillances required by administrative controls.

C.1.4 Alternate Emergency Actions

In an emergency, if a situation develops that is not addressed by the Safety Basis Requirements, staff members are expected to use their training and expertise to take actions to correct or mitigate the situation. Also, staff members may take actions that depart from a requirement in the Safety Basis Requirements provided that:

- An emergency situation exists;
- These actions are needed immediately to protect the worker, public health, and safety; and
- No ACTION consistent with the Safety Basis Requirements can provide adequate or equivalent protection.
C.1 USE AND APPLICATION

Such actions shall be approved, as a minimum, by the contractor’s T&P approval authority or the RL Manager. If emergency actions are taken, verbal notifications shall be made to U.S. Department of Energy (DOE) in accordance with contractor occurrence reporting procedures.

C.1.5 Safety Basis VIOLATION

SLs, LCSs, LCOs, or SRs are not associated with the T&P Safety Program; therefore, there are no ACTION statements. Accordingly, a VIOLATION of a Safety Basis Requirement occurs as a result of failure to comply with an ADMINISTRATIVE CONTROL.

A VIOLATION of an ADMINISTRATIVE CONTROL occurs when a specific requirement in the ADMINISTRATIVE CONTROL is not met. A VIOLATION of an ADMINISTRATIVE CONTROL also occurs when discrepancies in a program or procedure non-compliances indicate a programmatic breakdown, which occurs if they are significant enough to render the safety analysis assumptions invalid. Individual programmatic discrepancies or procedure non-compliances do not by themselves constitute a VIOLATION of an ADMINISTRATIVE CONTROL.

An ADMINISTRATIVE CONTROL VIOLATION shall require the following actions to restore ADMINISTRATIVE CONTROL compliance:

- Suspend those activities that cannot be conducted safely in light of the ADMINISTRATIVE CONTROL VIOLATION;
- Notify DOE of the VIOLATION in accordance with Occurrence Reporting requirements;
- Prepare an Occurrence Report in accordance with Occurrence Reporting requirements; and
- Prepare and implement a Recovery Plan describing the steps leading to compliance with an ADMINISTRATIVE CONTROL.

C.1.6 Reporting Requirements

In the event a VIOLATION occurs, make notifications and report the event to RL and the TSD Configuration Manager. Reporting requirements are contained in DOE O 232.2, Occurrence Reporting and Processing of Operations Information.

Additionally, should a discrepancy between the facility transportation packaging or activity and a safety basis be discovered, it must be reported to RL in accordance with DOE O 232.2 and an evaluation must be performed to determine if an unreviewed safety question exists as defined in 10 Code of Federal Regulations (CFR) 830.
C.2 SAFETY LIMITS

There are no SLs associated with the T&P Safety Program.
C.3 LIMITING CONDITIONS FOR OPERATION/LIMITED CONTROL SETTINGS

There are no LCOs or LCSs associated with this TSD.
C.4 SURVEILLANCE REQUIREMENTS

There are no SRs associated with this TSD.
C.5 ADMINISTRATIVE CONTROLS

C.5.1 Purpose and Applicability

C.5.1.1 Purpose

The purpose of the ADMINISTRATIVE CONTROL is to state the provisions relating to organization and management, procedures, record keeping, reviews, audits, and specific program requirements for risk reduction necessary to ensure safe packaging and transportation of radioactive materials on the Hanford Site.

C.5.1.2 Applicability

These ADMINISTRATIVE CONTROLS apply to the activities associated with the T&P of radioactive materials on the Hanford Site in quantities exceeding 1 A, unless the radioactive material meets the definition of LSA/SCO.

C.5.2 Onsite Shipments and Transfers

C.5.2.1 Purpose

Each contractor must have a formal program in place and sufficient staffing to perform the actions identified in the TSD.

C.5.2.2 Applicability

Overall approval responsibility for this TSD is assigned to RL. The other Hanford DOE Field Office Managers (Richland Operations Office, Office of River Protection and U.S. Department of Energy Pacific Northwest Site Office) through contract, shall identify those contractors and their roles in the performance of this TSD.

C.5.2.3 Contractor Responsibilities

The contractor shall address the following organizational components as addressed in Chapter 4 of the TSD and the Unreviewed Safety Question Process for Transportation:

- A T&P Functional Organization
- Contractor specific policies and procedures
- A document configuration control program (e.g., shipping papers, package specific safety documents, unreviewed safety questions, training and qualification records, etc.)
- Assessment Program
- T&P Manager responsibilities
- T&P activity manager responsibilities
C.5 ADMINISTRATIVE CONTROLS

- Unreviewed Safety Question Process for Transportation Safety Program
- Training Program
- QA Program

C.5.2.4 Minimum Package Performance Standards

The contractor SHALL assure that all packaging systems used for transport of greater than 1 A\textsuperscript{2} of radioactive material, unless the radioactive material meets the definition of LSA/SCO, meet the general design requirements in 49 CFR 173.410 or 6.5.2.6.1. Compliance with this requirement SHALL be documented in an approved Packaging Safety Document.

C.5.3 Nuclear Criticality Safety

C.5.3.1 Basis

The contractor program (Section C.5.2) must contain provisions for nuclear criticality safety that implement the criticality requirements defined in the TSD. The K\textsubscript{eff} limit is an underlying assumption and CMOS for the accident analysis that is required to be performed per Chapters 6 and 7 of the TSD. This limit protects the assumptions and ensures that the analytical basis for the probability of a criticality accident during transport is not invalidated.

The maximum K\textsubscript{eff} for all packages subject to the TSD is 0.95, including allowances for bias and uncertainty to provide an adequate margin of safety for transportation activities on site.

C.5.3.2 Background

Package loading is conducted under the originating facility safety analysis. The primary features of the criticality prevention conducted under transportation activities are the package array and spacing defined in the PSSD or other packaging system approval. Other features that could be utilized include over packing with neutron absorbers. A more detailed discussion is contained in Section 7.3.1.2.6 of the TSD.

The upper bound limit for K\textsubscript{eff} of 0.95 is to include allowances for bias and uncertainty and provides a CMOS to ensure that the probability of occurrence of a criticality event under hypothetical accident conditions during transport remains incredible. Surveillance and compliance with this ADMINISTRATIVE CONTROL will be determined in accordance with contractor criticality safety programs.

C.5.4 Gas Accumulation Minimization

C.5.4.1 Basis

The contractor program (Section C.5.2) must contain provisions to identify gas accumulation controls in packaging to minimize the potential for loss of package integrity from over-pressurization, deflagration, or explosion during transportation.
C.5 ADMINISTRATIVE CONTROLS

C.5.4.2 Key Features
Methods commonly used to control gas accumulation include those listed below. The specific method used must be documented and documentation maintained.

- Venting
- Time limits of transport (shipping window)
- Package inventory controls (e.g., hydrogenous material limits)
- Chemical compatibility

C.5.5 Package Damage Ratio Minimization for Risk Based Packages

C.5.5.1 Basis
The contractor program (Section C.5.2) must contain provisions to identify controls to minimize the potential for damage to packages from accidents during transportation activities.

C.5.5.2 Key Features
Methods commonly used to achieve package damage control include those listed below. These features may be used singularly or in combination to minimize adverse impacts of transportation related accidents.

- Speed limits
- Dunnage
- Tiedown systems

C.5.6 Surveillance and Maintenance Program

C.5.6.1 Basis
The contractor must implement a Surveillance and Maintenance Program to ensure preservation of the key transportation safety functions provided by the package.

C.5.6.2 Applicability
This administrative control applies to all packaging identified in the TSD or used for onsite transportation. Packages that are no longer used for transportation, but only for storage of material are exempted from these Surveillance and Maintenance Program requirements.
C.5 ADMINISTRATIVE CONTROLS

C.5.6.3 Key Features

The program will:

1. Identify specific surveillance and maintenance requirements, applicable when a package is not currently in use for transportation, but has the potential for future transportation use, such that the package does not degrade and is readily available for use.

2. Ensure the specific surveillance and maintenance requirements identified in the individual PSSDs are met during package use, and prior to initial use following periods when they were not in use to transport material.

3. Ensure that packages shall not be used for transportation if the surveillance and maintenance has lapsed or if the qualifications for transportation use have otherwise fallen into question unless the following steps have been completed:
   a. A plan has been developed that outlines the actions that must be performed by the user to ensure package integrity during transportation; and
   b. DOE approval of the plan has been obtained; and
   c. The plan has been implemented prior to shipping the package.

4. The process to request deviations from the Surveillance and Maintenance Program requirements SHALL include definition of contractor approval authorities and documentation requirements. Such deviations shall be submitted to RL for approval.

5. The process to request removal of a package from the TSD, when the package is not in current use and will not be used in the future for transportation SHALL include definition of contractor approval authorities and documentation requirements. Such requests shall be submitted to RL for approval.

C.5.7 Configuration Management Program

C.5.7.1 Basis

The contractor's Transportation Safety Program must have a configuration management feature that ensures changes to packages are evaluated for their impact on all safety functions identified in the PSSD that are provided by the package design.

C.5.7.2 Applicability

This administrative control applies to all packaging identified in the TSD or used for onsite transportation. Packages that are no longer used for transportation, but only for storage of material are exempted from these Surveillance and Maintenance Program requirements.

C.5.7.3 Key Features

The configuration management feature of the contractor’s Transportation Safety Program must address the following key features.
C.5 ADMINISTRATIVE CONTROLS

1. All changes to a package will be controlled through the configuration management process.

2. All safety functions provided by the package design, as identified in the PSSD, will be considered prior to initiating a change.

3. The configuration management process will interface with the Unreviewed Safety Question to identify the need for RL approval of package changes.

C.6 REFERENCES


ATTACHMENT C1 – BASES

According to DOE G 423.1-1B, a BASES attachment is required to summarize the reasons for establishing SLs, LCOs, LCSs, and associated SRs. This TSD does not include SLs, LCOs, LCSs, and associated SRs, so there are no BASES provided.
ATTACHMENT C2 – DESIGN FEATURES

DESIGN FEATURES are those features not covered elsewhere in the Safety Basis Requirements and that, if altered or modified, would have a significant effect on safety. There are no DESIGN FEATURES identified in this TSD that require further Safety Basis Requirement level controls.
Appendix D

Package-Specific Safety Document and
One-Time Requests for Shipment Contents and Format
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## Contents

### D.1 Package-Specific Safety Document

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Appendix D
Package-Specific Safety Document and
One-Time Requests for Shipment Contents and Format

D.1 Package-Specific Safety Document

This section provides guidance in formatting and preparing an onsite Package-Specific Safety Document (PSSD) to demonstrate the adequacy of the packaging in providing an equivalent degree of safety as required in the regulations. It also aids in ensuring the completeness of the information for timely review and approval. This PSSD is the principal document in which information and bases are provided for determining if the package provides an equivalent degree of safety to the regulations.

The following sections provide an outline showing the expected contents and general format for PSSDs. Additional guidance on content and depth of information to be provided can be found in Section D.1.12.

D.1.1 Package Evaluation

D.1.1.1 General Information
This section will present an introduction and general package description.

D.1.1.2 Introduction
This section will include the use of the package, model number, number of packages, and any other pertinent introductory information.

D.1.1.3 Evaluation Summary and Conclusions
Briefly summarize the results of each section of the document (e.g., structural, thermal). This section will be considered an executive summary of the evaluations performed. Any specific restrictions, payloads, etc., will be identified and explained.

D.1.1.4 References
Provide section references here.
D.1.2 Structural Evaluation

D.1.2.1 Introduction
This section will identify, describe, discuss, and analyze the structural engineering design of the packaging, components, and systems.

D.1.2.2 Structural Evaluation of the Package

D.1.2.2.1 Structural Design and Features
This section will describe the package, materials, and fabrication methods; discuss the use of codes and/or standards; and specify any special design features.

D.1.2.2.2 Mechanical Properties of Materials
This section will evaluate the strength of the specified materials and other physical properties related to structural design of the packaging.

D.1.2.2.3 Chemical and Galvanic Reactions
This section will discuss potential reactions between packaging materials, contents, and other factors that may impact the integrity of the packaging.

D.1.2.2.4 Size of the Package and Cavity
This section will include overall dimensions, cavity dimensions, and relative information.

D.1.2.2.5 Weights and Center of Gravity
This section will include the packaging gross weight, weight of the package with maximum payload, center of gravity of the package, and center of gravity of the fully loaded package.

D.1.2.2.6 Tamper-Indicating Feature
This section will include a description of the tamper-Indicating feature, if determined necessary by safeguards and security.

D.1.2.2.7 Positive Closure
This section will describe the closure system and why the package cannot be inadvertently opened.

D.1.2.2.8 Lifting and Tiedown Features
The section will describe all devices and attachments that can be used to lift the package or its lid, identify all devices that are a structural part of the package and can be used as tiedowns, and discuss the overall tiedown system.
D.1.2.9  Brittle Fracture
This section will include a discussion of the effects of brittle fracture on the fabricated packaging materials. ASME BPVC, Section VIII, Division 1 and NCR Regulatory Guide 7.11 will be used to evaluate brittle fracture.

D.1.2.3  Structural Model
This section will discuss model description and assumptions, and the code description and validation.

D.1.2.4  Normal Conditions

D.1.2.4.1  Conditions to be Evaluated
This section will discuss specific tests that will be performed and/or analyzed (drop tests, penetration tests) for normal conditions.

D.1.2.4.2  Acceptance Criteria
This section will provide the allowable leak rates, stress categories, and failure modes.

D.1.2.4.3  Initial Conditions

D.1.2.4.3.1  Environmental Heat Loadings
This section will discuss the worst case temperature with and without solar insolation for normal conditions.

D.1.2.4.3.2  Maximum Thermal and Pressure Stresses
This section will discuss the effects of thermal and pressure stresses on the components for normal conditions.

D.1.2.5  Accident Conditions

D.1.2.5.1  Conditions to be Evaluated
This section will discuss specific tests that will be performed and/or analyzed (drop tests, penetration tests) for accident conditions.

D.1.2.5.2  Acceptance Criteria
This section will provide the allowable leak rates, stress categories, and failure modes.
D.1.2.5.3  Initial Conditions

D.1.2.5.3.1  Environmental Heat Loadings
This section will discuss the worst case temperature with and without solar insolation for accident conditions.

D.1.2.5.3.2  Maximum Thermal and Pressure Stresses
This section will discuss effects of thermal and pressure stresses on the components for accident conditions.

D.1.2.6  Puncture
As applicable to packagings, this section will discuss the effects of puncture.

D.1.2.7  Structural Evaluation and Conclusions
This section will discuss the drop orientation with the most severe loading.

D.1.2.7.1  Normal Conditions Evaluation and Conclusions
This section will discuss all normal conditions drop test results.

D.1.2.7.2  Accident Conditions Evaluation and Conclusions
This section will discuss all accident conditions drop test results.

D.1.2.8  Drawings
Drawings and sketches showing details of the packaging systems should be included.

D.1.2.9  References
Provide section references here.

D.1.2.10  Appendices
If required, provide section appendices here.
D.1.3 Thermal Evaluation

D.1.3.1 Introduction
This section will identify, describe, discuss, and analyze thermal engineering design of the packaging, components, and systems.

D.1.3.2 Thermal Source Specification
This section will identify and describe the thermal sources, such as, decay heat, environmental, and other sources (e.g., concrete).

D.1.3.3 Summary of Thermal Properties of Materials
This section will list thermal properties of all materials used.

D.1.3.4 Thermal Evaluation for Normal Conditions

D.1.3.4.1 Conditions to be Evaluated
This section will indicate specific tests that will be performed and/or analyzed (drop test, penetration tests) to support thermal evaluation of the package for normal conditions.

D.1.3.4.2 Acceptance Criteria
This section will discuss failure modes, thermal conditions, etc., as required to provide a basis for accepting thermal data from tests and/or analyses.

D.1.3.4.3 Thermal Model
This section will provide model description and assumptions, and code description and validation.

D.1.3.4.4 Thermal Analyses
This section will analysis thermal effects on packaging material, has generation, pressures and effect on lead, if applicable, under normal conditions.

D.1.3.4.4.1 Internal Temperature
This section will determine maximum internal temperature and temperature at key packaging components (e.g., bolts and seals) under normal conditions.

D.1.3.4.4.2 Maximum Surface Temperature
This section will determine the maximum surface temperature to ensure the limits established in Chapter 6.0 are not exceeded.
D.1.3.5  Thermal Evaluation for Accident Conditions

D.1.3.5.1  Conditions to be Evaluated

This section will indicate specific tests that will be performed and/or analyzed (drop test, fire tests) to support thermal evaluation of the package for accident conditions.

D.1.3.5.2  Acceptance Criteria

This section will discuss failure modes, thermal conditions, etc., as required to provide a basis for accepting thermal data from tests and/or analyses.

D.1.3.5.3  Package Conditions and Environment

This section will include containment calculations for normal conditions to meet the requirements in Section 6.5.2.5.9.

D.1.3.5.4  Thermal Model

This section will provide model description and assumptions, and code description and validation.

D.1.3.5.5  Thermal Analyses

This section will analysis thermal effects on packaging material, has generation, pressures and effect on lead, if applicable, under accident conditions.

D.1.3.5.5.1  Internal Temperatures

This section will determine maximum internal temperature and temperature at key packaging components (e.g., bolts and seals) under accident conditions.

D.1.3.5.5.2  Maximum Surface Temperatures

This section will determine the maximum surface temperature to ensure the limits established in Chapter 6.0 are not exceeded.

D.1.3.6  Conclusions

This section will include evaluations of designated tests and analyses performed to ensure the package is thermally acceptable following designated normal conditions and accident conditions during transfer.

D.1.3.7  References

Provide section references here.

D.1.3.8  Appendices

If required, provide section appendices here.
D.1.4 Containment/confinement Evaluation

D.1.4.1 Introduction
This section will discuss the methodology used to evaluate containment and/or confinement performance of the package (e.g., package leakage or release rates).

D.1.4.2 Contents Information

D.1.4.2.1 Characterization
This section will discuss content information, present specific characterization data, and provide evaluations for the content analysis data used to determine qualities of material, fissile content, and other data that are acceptable.

D.1.4.2.2 Restrictions
This section will provide a discussion of content restrictions and include information to ensure that generic or specific content restrictions are sufficient.

D.1.4.2.3 Size and Weight
This section will evaluate size and weight of the contents to ensure they are correctly listed and in accordance with the packaging size and structural load requirements.

D.1.4.3 Containment Source Specification
This section will provide a detailed description of the contents of the package and assess dispersability of the material, if required. A detailed listing of the contents will be provided in this section.

D.1.4.4 Normal Conditions

D.1.4.4.1 Conditions to be Evaluated
This section will indicate the specific tests that will be performed and/or analyzed (e.g., drop test, penetration test) to support the evaluation of the package containment system for normal transfer conditions.

D.1.4.4.2 Containment Acceptance Criteria
This section will discuss allowable leak rates or dose consequences, failure modes, etc., as required to provide a basis for accepting data from tests or analyses. If the data are qualitative, the basis of evaluation must be justified.

D.1.4.4.3 Containment Model
This section will include the release rate or dose consequence model description, release assumptions, and code description and evaluation.
D.1.4.4 Containment Calculations
This section will include containment calculations for normal conditions to meet the requirements in Section 6.5.2.5.8.

D.1.4.5 Accident Conditions

D.1.4.5.1 Conditions to be Evaluated
This section will indicate specific tests that will be performed and/or analyzed (e.g., drop test, fire test) to support evaluation of the package containment system for accident conditions.

D.1.4.5.2 Containment Acceptance Criteria
This section will discuss the allowable leak rates or dose consequences, failure modes, etc., as required to provide a basis for accepting data from tests or analyses. If data are qualitative, the basis of evaluation must be justified.

D.1.4.5.3 Containment Model
This section will include release rate or dose consequence model descriptions, release assumptions, and code description and evaluation.

D.1.4.5.4 Containment Calculations
This section will include containment calculations for normal conditions to meet the requirements in Section 6.5.2.5.9.

D.1.4.6 Conclusions
This section will contain a discussion on the containment system and determine if the package will safely contain contents within acceptable release or dose consequence limits for the designated normal conditions and accident conditions identified.

D.1.4.7 References
Provide section references here.

D.1.4.8 Appendices
If required, provide section appendices here.
D.1.5 Shielding Evaluation

D.1.5.1 Introduction
This section will identify, describe, discuss, and analyze shielding design of the packaging, components, and systems.

D.1.5.2 Direct Radiation Source Specification
This section will state contents, and gamma and neutron source terms used in the analyses.

D.1.5.2.1 Gamma Source
This section will state the quantity of radioactive material included as contents. The method used to determine gamma source strength and distribution will be described in detail.

D.1.5.2.2 Beta Source
This section will state the quantity of radioactive material included as contents. The method used to determine beta source and distribution will be described in detail.

D.1.5.2.3 Neutron Source
This section will state the quantity of radioactive material included as contents. The method used to determine neutron source strength and distribution will be described in detail.

D.1.5.3 Summary of Shielding Properties of Materials
This section will provide relative physical properties and attenuation properties of the packaging and contents.

D.1.5.4 Normal Conditions

D.1.5.4.1 Conditions to be Evaluated
This section will indicate specific tests that will be performed and/or analyzed (e.g., drop test, penetration test) to support evaluation of the package shielding system for normal conditions.

D.1.5.4.2 Acceptance Criteria
This section will include failure modes, dose rates, radiation levels, etc., as required to provide a basis for accepting data from tests and/or analyses.

D.1.5.4.3 Shielding Model
This section will include model description and assumptions, and code description and validation.
D.1.5.4  Shielding Calculations
This section will provide data input for the selected code as well as the output results for normal conditions.

D.1.5.5  Accident Conditions

D.1.5.5.1  Conditions to be Evaluated
This section will indicate specific tests that will be performed and/or analyzed (e.g., drop test, fire test) to support evaluation of the package shielding system for accident conditions.

D.1.5.5.2  Acceptance Criteria
This section will include failure modes, dose rates, radiation levels, etc., as required to provide a basis for accepting data from tests and/or analyses.

D.1.5.5.3  Shielding Model
This section will include model description and assumptions, and code description and validation.

D.1.5.5.4  Shielding Calculations
This section will provide information about the code used, the data inputs and resulting output for accident conditions.

D.1.5.6  Conclusions
This section will include evaluations for designated tests and analyses performed to verify integrity of the package shielding during designated normal conditions and accident conditions.

D.1.5.7  References
Provide section references here.

D.1.5.8  Appendices
If required, provide section appendices here.

D.1.5.9  Introduction
This section will identify, describe, discuss, and analyze principal criticality engineering-physics design of the packaging, components, and system important to safety and necessary to comply with demonstration of package subcriticality.

D.1.5.10  Criticality Source Specification
This section will provide source term data and assumptions that will be used.
D.1.5.11  Summary of Criticality Properties of Materials

This section will provide a summary description of the model selected and particular library specified by the user for each isotope and/or element of the material used in the model(s). In addition, this section will provide source term and packaging material that would increase/decrease radioactivity or source, such as, water, steel, concrete, etc.

D.1.5.12  Normal Conditions

D.1.5.12.1  Conditions to be Evaluated

This section will indicate specific tests that will be performed and/or analyzed (e.g., drop test, penetration test) to support criticality evaluation of the package for normal conditions.

D.1.5.12.2  Acceptance Criteria

This section will include failure modes, criticality conditions, etc., as required to provide a basis for accepting criticality data from tests and/or analyses.

D.1.5.12.3  Criticality Model

This section will include the model description and assumptions, and code description and validation.

D.1.5.12.4  Criticality Calculations

This section will provide description of the bounding case for normal condition. In addition, this section will provide the results from the code outputs under normal conditions.

D.1.5.13  Accident Conditions

D.1.5.13.1  Conditions to be Evaluated

This section will indicate specific tests that will be performed and/or analyzed (e.g., drop test, fire test, etc.) to support criticality evaluation of the package for accident conditions.

D.1.5.13.2  Acceptance Criteria

This section will include failure modes, criticality conditions, etc., as required to provide a basis for accepting criticality data from tests and/or analyses.

D.1.5.13.3  Criticality Model

This section will include model description and assumptions, and code description and validation.

D.1.5.13.4  Criticality Calculations

This section will provide description of the bounding case for accident condition. In addition, this section will provide the results from the code outputs under accident conditions.
D.1.5.14 Critical Benchmark Experiments
This section will provide justification for the validity of the calculational method and neutron cross-section values used in the analysis by presenting results of the calculations for selected critical benchmark experiments.

D.1.5.14.1 Benchmark Experiments and Applicability
This section will provide a general description of selected critical benchmark experiments that are to be analyzed. Applicability of the benchmarks in relation to the package and its contents will be shown.

D.1.5.14.2 Details of Benchmark Calculations
Actual nuclear and geometric input parameters used for benchmark calculations will be provided.

D.1.5.14.3 Results of Benchmark Calculations
Results of the benchmark calculations will be given.

D.1.5.15 Conclusions
This section will include evaluations of designated tests and analyses performed to ensure that radioactive contents of the package remain consistent with applicable limits and controls during designated normal conditions and accident conditions.

D.1.5.16 References
Provide section references here.

D.1.5.17 Appendices
If required, provide section appendices here.
D.1.6  Gas Generation Evaluation

D.1.6.1  Gas Generation
This section will include a discussion of hydrogen gas buildup and provide an evaluation of data to ensure that packaging design specifications are acceptable to prevent excessive hydrogen gas buildup. Consideration will include the use of venting and/or devices such as catalysts.

D.1.6.2  Package Pressure
This section will include a discussion of estimated internal package pressure and provide an evaluation of data to ensure that packaging design specifications are acceptable to prevent excessive internal pressures. Consideration will include the use of pressure relief systems, vents, or other devices. It will be ensured the package design is sufficient to safely contain the contents at the estimated operation pressure of the system during transfers.

D.1.6.3  References
Provide section references here.

D.1.6.4  Appendices
If required, provide section appendices here.
D.1.7 Tiedown Evaluation

D.1.7.1 System Design
This section will discuss the general tiedown system, evaluate tiedown system design drawings (if provided), and indicate restrictions and other concerns for safely securing the package to the vehicle.

D.1.7.2 Attachments and Ratings
This section will provide an evaluation of load ratings for attachment devices on the vehicle and straps/chains or other devices used to tiedown the package.

D.1.7.3 References
Provide section references here.

D.1.7.4 Appendices
If required, provide section appendices here.
D.1.8 Packaging Quality Assurance

D.1.8.1 Introduction
This section is considered as a guideline for developing quality assurance plans and other documents to ensure that the packaging was designed and fabricated in accordance with identified codes, standards, and associated criteria.

D.1.8.2 Quality Requirements
In this section, assigned safety class(s) and approval designators will be identified. In addition, specific guidance for development of quality assurance plans, inspection and maintenance plans, and training plans will be provided.

D.1.8.3 Organization
In this section, information and charts to describe the quality assurance organization that must be in place to develop quality assurance plans, complete inspections, control changes, and maintain records will be provided.

D.1.8.4 References
Provide section references here.

D.1.8.5 Appendices
If required, provide section appendices here.
D.1.9 Operating Procedures

D.1.9.1 General Requirements
This section will contain recommended guidelines for using the packaging. As necessary, specific operating procedures will be noted and included. Specific requirements that could adversely affect the integrity of the packaging should be directed to operations. Packagings that may be reused will have requirements discussed in sufficient detail to ensure the packaging is not damaged during transfer and unloading operations.

D.1.9.2 Package Loading
This section will contain information on installing package contents, closure of package, and lifting of package.

D.1.9.3 Package Unloading
This section will contain information on lifting the package, opening package, and removing package contents.

D.1.9.4 Empty Package (Packaging)
This section will contain information on cleaning, inspecting, closing, handling, storage, and transfer.

D.1.9.5 References
Provide section references here.

D.1.9.6 Appendices
If required, provide section appendices here.
D.1.10 Acceptance Tests and Maintenance Program

D.1.10.1 New Packaging

D.1.10.1.1 Acceptance Requirements
This section will describe requirements that a new packaging must meet prior to approving the package for transport of contents. This section will include the extent of inspection required, specific requirements, etc.

D.1.10.1.2 Inspection and Testing
This section will indicate specific inspection and testing (if applicable) necessary to accept a new packaging for use, describe how the task should be performed, and criteria that should be used for accepting results of the inspection and testing.

D.1.10.1.3 Documentation
This section will indicate specific documents that will be developed to ensure packaging is acceptable, who will provide the documents, and where and how long they will be maintained.

D.1.10.2 Packaging for Reuse

D.1.10.2.1 Acceptance Requirements
The type of packaging and circumstances under which packaging will be reused will be considered. The requirements under which the packaging will be acceptable for reuse will be determined and identified. Requirements will include physical inspections, possible testing and/or retesting, new gaskets or other seals, painting, load tests, corrosion checks, etc.

D.1.10.2.2 Inspection and Testing
This section will contain specific inspections and testing (if applicable) to accept a package for reuse, describe how tasks should be performed, and criteria that should be used for accepting the results of inspection and testing.

D.1.10.2.3 Documentation
This section will contain specific documents that will be developed to ensure the packaging is acceptable, indicate who will provide the documents, and where and how they will be maintained.

D.1.10.3 General Maintenance Requirements
This section will discuss tasks that will be completed to ensure that a new or reused packaging is maintained in good condition for use. Requirements will include periodic inspections and testing for conditions such as corrosion and physical damage.
D.1.10.4 Inspection and Verification Schedules
This section will indicate specific inspection and testing, describe how tasks will be performed, and criteria that will be used for accepting the results of inspection and testing.

D.1.10.5 Records and Documentation for Maintenance
This section will indicate specific documents that will be developed to ensure the packaging is acceptable, who will provide the documents, and how long they will be maintained.

D.1.10.6 References
Provide section references here.

D.1.10.7 Appendices
If required, provide section appendices here.
D.1.11 Additional Guidance for Preparation of Package Specific Safety Document

DOE has established a Packaging Review Guide (PRG), UCID-21218, Rev. 3, Packaging Review Guide for Reviewing Safety Analysis Reports for Packaging, to ensure compliance with regulatory requirements and that packaging descriptions and analyses are consistent and thorough. The evaluation process described in the PRG relies substantially on 10 CFR 71, “Packaging and Transportation of Radioactive Material,” and the following NRC documents:

- NUREG-1609, Standard Review Plan for Transportation Packages for Radioactive Material
- NUREG-1617, Standard Review Plan for Transportation Packages for Spent Nuclear Fuel
- Regulatory Guide 7.9, Standard Format and Content of Part 71 Applications for Approval of Packaging for Radioactive Material
- Other regulatory guides and U.S. Nuclear Regulatory Commission Regulatory Guide (NUREG) reports that provide guidance on criteria for evaluating transportation packages.

Additionally, Regulatory Guide 7.10, Establishing Quality Assurance Programs for Packaging Use in Transport of Radioactive Material, and the SARP Completeness Checklist provide further details on expected contents of SARPs to demonstrate equivalent safety to full NRC licensing. For the purposes of this TSD, the guidance for preparation of SARPs can be applied to preparation of PSSDs, using the graded approach commensurate with the significance of the items being evaluated.

The foregoing documents provide a substantial body of detailed information on expected contents and depth of coverage of the topics required to be addressed that should be consulted for guidance in preparation of PSSDs.
D.2 Preparation of One-Time Requests for Shipment

A graded approach should be used to determine the depth and extent of information required to support any exemption requests, such as One-Time Requests for Shipment (OTRS). At a minimum, the OTRS must address the following topics, using the guidance in the previous sections of this Appendix for clarification and a description of contents:

1. General Information
   1.1. Introduction
   1.2. Package Description
      1.2.1. Drawings
      1.2.2. Other Information including materials specifications and product data
   1.3. Payload Description
   1.4. Compliance with TSD Packaging Standards
      1.4.1. Statement of Compliance to TSD Packaging Standards
      1.4.2. Summary of Evaluation
2. Structural
3. Thermal
4. Containment
5. Shielding
6. Criticality
7. Gas Generation
8. Tie Down and Package Rigging
9. Quality Assurance
10. Operating Procedures
11. Acceptance Tests and Maintenance Program Review
Appendix E

Justification and Basis for Shipment of Risk Based Packages
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Appendix E
Justification and Basis for Shipment of Risk Based Packages

E.1 Introduction

Section E.1.1 summarizes application of the Unreviewed Safety Question Process for Transportation (USQT) about the approval process for risk based packages. Section E.1.2 summarizes the approach for demonstrating equivalence to U.S. Department of Transportation (DOT) Hazardous Materials Regulations (HMR) for risk based packages. Section E.1.3 describes the methodology to analyze onsite transportation accidents and a typical data set example used to calculate accident release frequencies and consequences from transportation accident scenarios.

E.1.1 Highlights of the USQT for Risk Based Packages

The shipment of risk based packages is subject to approval requirements. Appendix A lists Package-Specific Safety Documents (PSSD) for risk based packages authorized for onsite transportation. Each PSSD has specific requirements, limits, and controls governing the shipment of that particular risk based package. The shipment of these risk based packages within the bounds of the PSSD is approved by the U.S. Department of Energy (DOE), Richland Operations Office (RL). Changes to these packages, whether a modification to the design of the package or changes in the requirements, limits, or controls on the package or shipment are subject to the USQT Process prior to shipment of the package to determine whether the change is within the safety basis envelope of the Hanford Sitewide Transportation Safety Document (TSD) and associated PSSD. If the change is within the safety basis, then the USQT is negative and the shipment of the package with the changes considered in the USQT may be made. However, if the change is outside the safety basis, then the USQT is positive and RL approval is required prior to the shipment of the package. Details of the USQT Process are given in Chapter 6.

The packaging is only the first line of defense in the transportation operation, and all other available administrative and engineering controls that reasonably reduce the frequency of an accidental release should be implemented as practical, consistent with the as low as reasonably achievable principle. The combination of the calculated shipment-specific payload limits and the administrative and engineering controls designed to preclude and mitigate a release provides a degree of safety equivalent to the DOT HMR for onsite shipments of radioactive material packages.

E.1.2 Approach for Showing Equivalency to DOT HMR

DOE O 460.1C, Packaging and Transportation Safety, requires that onsite shipments of radioactive material packages comply with the DOT HMR (49 Code of Federal Regulations [CFR] 171-180) or be shown to meet a degree of safety equivalent to the regulations. The purpose of the HMR is to protect the public, which includes those who work in transportation, from harmful exposure to radiation. To protect the public, the DOT HMR requires that the packaging provide adequate shielding, maintain subcriticality, and contain its contents within specified limits during normal conditions for transport (NCT) and hypothetical accident
conditions (HAC), as applicable. The criticality and shielding requirements for risk based packaging are not substantially different than the requirements for DOT and equivalent packaging given in Chapter 6 of the TSD. However, risk based packaging, by definition, may not maintain the same level of containment as DOT or equivalent packaging. Therefore, packaging containment performance requirements are derived that consider the specific characteristics and controls of onsite shipments of risk based packages to limit the intake of radionuclides to equivalent levels to those provided by compliance with the regulations. One of these controls is that the public is not in the immediate vicinity of a damaged package, as is assumed in the derivation of the DOT containment requirements, because of restricted public access during onsite shipments and the large distances to the Hanford Site boundary. Other assumptions behind the DOT containment requirements that can be revised for onsite shipments include the dispersability of the payload, damage to the package, and potential leak paths. The effect of the characteristics and controls of onsite shipments of risk based packages is that package-specific release limits may be calculated such that the intake of radioactive material is no greater than the intake by the public from the DOT allowable release limits in commerce.

49 CFR 173.467, “Tests for demonstrating the ability of Type B and fissile materials packagings to withstand HAC in transportation,” requires that each certified Type B packaging or packaging for fissile material meet the test requirements prescribed in 10 CFR 71, “Packaging and Transportation of Radioactive Material,” to withstand HAC in transportation. Additionally, Type B packages that meet the applicable requirements of 10 CFR 71 and approved by the U.S. Nuclear Regulatory Commission (NRC) are authorized for shipment per 49 CFR 173.416, “Authorized Type B packages.” Therefore, to show an equivalent degree of safety, NRC regulations in 10 CFR 71 must be considered in addition to the DOT HMR.

Within the boundaries of the Hanford Site, DOE has established radiation protection standards, limits, and program requirements for protecting individuals from ionizing radiation resulting from DOE activities. 10 CFR 835.1302, “Emergency exposure situations,” regulates emergency exposure situations. These regulations state the following:

- The risk of injury to those individuals involved in rescue and recovery operations shall be minimized.
- Operating management shall weigh actual and potential risks against the benefits to be gained.
- No individual shall be required to perform a rescue action that might involve substantial personal risk.
- Each individual authorized to perform emergency actions likely to result in occupational doses exceeding the values of the limits provided in 10 CFR 835.202(a), “Occupational dose limits for general employees,” shall be trained in accordance with 10 CFR 835.901(b), “Radiation safety training,” and briefed beforehand on the known or anticipated hazards to which the individual will be subjected.

Therefore, minimizing worker risk (consisting of dose consequence and frequency) is a requirement of 10 CFR 835, “Occupational Radiation Protection.” Administrative and engineered controls can be used to reduce the frequency of a release, the severity of the forces on the package, and/or the consequences of a release.
A degree of safety equivalent to the DOT HMR can be achieved by minimizing the radiological risk (dose consequence and frequency) from a transportation accident.

### E.1.3 Onsite Transportation Accidents

#### E.1.3.1 Overall Framework

The overall framework for estimating the frequencies of accidents was tailored to consider Hanford Site-specific road conditions where possible. The Hanford Site is a relatively benign area with respect to potential accident scenarios and subsequent damage to packaging systems. The Hanford Site is characterized by moderate terrain; there are no long, steep grades; few rocky hills and valleys; little rail traffic; predominantly soft (sand) wayside structures; and no bridges, tunnels, freeway overpasses or underpasses. Consequently, the likelihood of encountering road conditions that can lead to severe accidents is less than that on a typical interstate or state highway in the United States. Subsequently, it can be concluded that the frequencies of severe accidents on the Hanford Site are lower than on interstate and state highways. Furthermore, because the Hanford Site is a controlled access area, officials can implement controls to reduce the frequencies of accidents even further; e.g., by closing the road when a shipment occurs.

The other key attribute of the accident frequency framework is that it must be sensitive to the calculated failure thresholds of the packaging systems involved. In other words, if a certain package is determined to fail when subjected to a 48 km/h (30 mph) impact event, the methodology must be flexible enough to calculate the frequency of accidents on the Hanford Site in which the impact velocity is 48 km/h (30 mi/h) or greater. Similarly, the methodology must be capable of calculating the frequencies of accidents that involve fires of varying duration to reflect the thermal resistance of specific packaging systems. The accident frequency framework is used to determine the frequency bin into which accidents would likely fall.

#### E.1.3.2 Hazard Analysis

A hazard analysis was conducted to identify and evaluate the hazards associated with transporting radioactive material on the Hanford Site. The purpose of the hazard analysis was to review potential sources of hazards during transport and construct potential accident scenarios that could be applied to the shipments and packagings and lead to loss or dispersal of radioactive materials. A generic hazard “checklist” was used to guide the analysis and ensure a comprehensive review of the potential hazards. A columnar format was used to review the hazards and record their presence or absence with respect to Hanford Site transportation. If a hazard was determined to be present, one or more accident scenarios were constructed that describe the potential effects of the hazard on a packaging system and the subsequent effects on the radioactive materials in the package. In addition, the engineering and administrative barriers that prevent or mitigate the potential accident scenarios are recorded. Information on the engineering and administrative barriers was recorded to support a determination of whether the potential accident scenarios were credible events.

The hazard analysis developed to support the Hanford Site accident frequency analysis framework is presented in Table E-1. The following conclusions were derived from the information in Table E-1.
DOE considers the occurrence of an inadvertent criticality event as unacceptable, regardless of the projected consequences of such an event. For this reason, DOE emphasizes prevention of inadvertent criticality and generally requires packages to be designed such that inadvertent criticality accidents will not occur even under severe conditions that promote a nuclear reaction (e.g., optimum moderation). The sequence of events leading to a potential criticality accident was judged to be incredible due to the engineering and administrative controls in place to prevent criticality accidents. These include, where appropriate, limiting the fissile inventory, preventing ingress of moderator materials (such as water) into the package, geometry controls, adding poisons, etc. These requirements remain in effect for equivalent as well as risk based packages.

Table E-1. Hazards Analysis of Hanford Site Transportation Activities

<table>
<thead>
<tr>
<th>Hazard</th>
<th>Potential Accident</th>
<th>Available Controls</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Physical</td>
<td>Administrative</td>
</tr>
<tr>
<td>Electricity</td>
<td>Package struck by high voltage power line</td>
<td>Packages protect contents from alternating current</td>
<td>Not credible (judgment)</td>
</tr>
<tr>
<td>Explosives</td>
<td>Solid or liquid explosive ignites and fails package</td>
<td>Package design provides resistance to pressure and</td>
<td>Solid and liquid explosives packaged in</td>
</tr>
<tr>
<td></td>
<td>due to overpressure or missile</td>
<td>missiles, commensurate with hazard</td>
<td>accordance with DOT requirements; segregated</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>from radioactive materials</td>
</tr>
<tr>
<td>Hydrogen gas</td>
<td>Hydrogen gas generated by radiolysis ignite within package</td>
<td>Package strength</td>
<td>Shipping windows; Liquid content limits;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Vents in packages</td>
<td>Source limits; Venting procedures</td>
</tr>
<tr>
<td>Cryogenic</td>
<td>Liquid nitrogen, liquid argon not present when</td>
<td></td>
<td></td>
</tr>
<tr>
<td>systems</td>
<td>transporting radioactive materials</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Not credible (judgment)</td>
</tr>
<tr>
<td>Direct radiation</td>
<td>Loss of shielding occurs as a result of a transportation</td>
<td>Package design, resistance to loss of shielding;</td>
<td>Exposure distance restrictions; Radiation</td>
</tr>
<tr>
<td>sources</td>
<td>accident</td>
<td>personnel barriers</td>
<td>protection training; Detection</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>instrumentation; Emergency Preparedness</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Program and Procedures</td>
</tr>
<tr>
<td>Radioactive</td>
<td>Release of radioactive materials from a transportation</td>
<td>Package design and containment requirements commensurate</td>
<td>Package certification; Radiation protection</td>
</tr>
<tr>
<td>materials</td>
<td>accident</td>
<td>with radioactive hazard</td>
<td>training; Emergency Preparedness Program and</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Procedures; Road Closure</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hazard</td>
<td>Potential Accident</td>
<td>Available Controls</td>
<td>Remarks</td>
</tr>
<tr>
<td>-------------------------</td>
<td>--------------------------------------------------------------------------------------</td>
<td>---------------------------------------------------------</td>
<td>---------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Uncontrolled nuclear reaction (i.e., inadvertent criticality)</td>
<td>Geometry controls; Presence of neutron absorbers, poisons</td>
<td>Inventory limits; Exclusion of water; Emergency Preparedness Program and Procedures</td>
<td>Accident involving water immersion incredible at arid Hanford Site; Firefighters trained not to fight fires that involve fissile materials with water; Criticality controls ensure accident is not credible</td>
</tr>
<tr>
<td>Flammable materials</td>
<td>Fire affects integrity of transportation package</td>
<td>Package design, thermal resistance, commensurate with radioactive hazard</td>
<td>Hanford Fire Department Emergency Preparedness Program and Procedures</td>
</tr>
<tr>
<td>Compressed gases</td>
<td>Compressed gas tank or bottle explodes and affects integrity of radioactive material transportation package</td>
<td>Package design, thermal resistance, commensurate with radioactive hazard</td>
<td>Compressed gases not shipped with radioactive materials</td>
</tr>
<tr>
<td>Thermal energy (internal decay heat source)</td>
<td>Package overheats, fails due to inadequate or loss of cooling</td>
<td>Package design</td>
<td>Thermal power limits</td>
</tr>
<tr>
<td>Thermal energy (local temperature extreme)</td>
<td>Package failure to high ambient temperature</td>
<td>Package design resists hot ambient conditions</td>
<td>None</td>
</tr>
<tr>
<td>Thermal energy (extreme cold)</td>
<td>Package degradation due to cold ambient temperature causes failure in transit</td>
<td>Package design resists cold ambient conditions</td>
<td>None</td>
</tr>
<tr>
<td>High pressure</td>
<td>Traffic accident leads to package immersion under a head of water</td>
<td>Package design commensurate with hazard</td>
<td>Routes outlined in Chapter 3 do not go over or near any body of water</td>
</tr>
<tr>
<td>Kinetic energy</td>
<td>Package involved in traffic accident (impact, rollover) that fails containment</td>
<td>Package design, impact resistance, commensurate with radioactive hazard; Impact limiters; Tiedown systems</td>
<td>Driver training awareness; Road closure if necessary; Emergency Preparedness Program and Procedures; Time-of-day restrictions to avoid traffic congestion</td>
</tr>
<tr>
<td>Hazard</td>
<td>Potential Accident</td>
<td>Available Controls</td>
<td>Remarks</td>
</tr>
<tr>
<td>--------</td>
<td>--------------------</td>
<td>--------------------</td>
<td>---------</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Physical</td>
<td>Administrative</td>
</tr>
<tr>
<td></td>
<td>Package involved in traffic accident that generates puncture conditions that fail containment</td>
<td>Package design, puncture resistance, commensurate with hazard; Impact limiters; Tiedown systems</td>
<td>Driver training awareness; Road closure if necessary; Emergency Preparedness Program and Procedures; Time-of-day restrictions to avoid traffic congestion</td>
</tr>
<tr>
<td></td>
<td>Package involved in traffic accident that generates crush condition that fails containment</td>
<td>Package design, resistance to crush, commensurate with hazard; Impact limiters; Tiedown systems</td>
<td>Driver training awareness; Road closure if necessary; Emergency Preparedness Program and Procedures; Time-of-day restrictions to avoid traffic congestion</td>
</tr>
<tr>
<td></td>
<td>Material handling accident</td>
<td>Not applicable</td>
<td>Not applicable</td>
</tr>
<tr>
<td></td>
<td>Package falls from bridge or overpass</td>
<td>See &quot;Remarks&quot;</td>
<td>See &quot;Remarks&quot;</td>
</tr>
<tr>
<td></td>
<td>Package dropped during loading/unloading</td>
<td>Package design commensurate with hazard; Lifting equipment design</td>
<td>Control of heavy loads requirements; Operating procedures; Personnel training</td>
</tr>
<tr>
<td></td>
<td>Heavy object dropped on package</td>
<td>Package design, puncture resistance</td>
<td>Personnel training (heavy load controls)</td>
</tr>
<tr>
<td></td>
<td>Toxic, hazardous chemicals</td>
<td>Package design resists release of toxic, hazardous chemicals</td>
<td>Emergency preparedness procedures and training; Driver awareness of package contents</td>
</tr>
<tr>
<td></td>
<td>Corrosion</td>
<td>Package design considers internal and external corrosion; Corrosion-resistant materials</td>
<td>Visual inspection; Package maintenance program requirements</td>
</tr>
</tbody>
</table>
Table E-1. Hazards Analysis of Hanford Site Transportation Activities

<table>
<thead>
<tr>
<th>Hazard</th>
<th>Potential Accident</th>
<th>Available Controls</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sabotage</td>
<td>Terrorist or sabotage incident threatens package integrity</td>
<td>Package design commensurate with hazard (shipment of highly-radioactive payloads are in accident-resistant packages); Hanford security personnel and equipment</td>
<td>Hanford shipments not highly-attractive to terrorists/saboteurs; Judged to be incredible event</td>
</tr>
<tr>
<td>Natural phenomena</td>
<td>Earthquake, tornado, high wind, flood, meteorite, or other natural phenomena causes package failure in transit</td>
<td>Package design commensurate with hazard</td>
<td>Emergency preparedness procedures and training; Driver awareness of weather conditions; Travel restrictions under extreme weather conditions</td>
</tr>
<tr>
<td>High-intensity magnetic fields; Lasers; High noise levels; Biohazards; Non-ionizing radiation sources; Inert atmosphere</td>
<td>Not applicable or not capable of causing package damage</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

AC = accident condition.  
DOT = U.S. Department of Transportation.  
NC = normal condition.  
NRC = U.S. Nuclear Regulatory Commission.  
DSA = documented safety analysis.

- Thermal energy from radioactive decay of the cargo must be dissipated to prevent package failure regardless of whether the package is equivalent or risk based. Any engineered or administrative controls implemented to ensure adequate heat dissipation (e.g., source limits, cooling systems) must be adhered to.
- Extreme ambient conditions (heat and cold) that could lead to package failure were not included in the Hanford Site accident risk framework because they are already included in the approach for equivalent packages.
- Flammable gas deflagrations were judged to be extremely unlikely as long as the requirements to prevent or minimize the buildup of flammable gas for equivalent or risk
based packages are adhered to. The primary source of the flammable gas hazard is radiolytic decomposition of hydrogenous materials within a package that generates hydrogen gas. The hydrogen gas concentration could build within the package to the lower explosive limit and then be ignited by some mechanism (e.g., spark created by a traffic accident). An analysis of hydrogen generation is required for each package, equivalent or risk based, and any engineered or administrative barriers required to prevent a hydrogen explosion must be followed. Alternatively, the package may be shown by analysis or test to be capable of withstanding the most energetic hydrogen explosion capable of being generated within the package. For these reasons, the potential for explosions involving the package is addressed by the bounding analysis specified in the Hanford Site framework. See Section E.2.5.2.3 and Table E-4.

- Immersion of a package under a head of water and subsequent failure due to the hydrostatic pressure load was judged to be incredible. This is because the shipments would not be transported over or near a body of water of sufficient depth to be an immersion concern or a concern about retrieving the package in a timely manner. Thus, immersion scenarios are not considered further.

- Potential energy hazards (e.g., package falling from a bridge or overpass and heavy objects being dropped on a package) were determined to be incredible. There are no bridges or overpasses on the Hanford Site that a package could fall from and heavy object lifting requirements preclude them from being lifted over a radioactive material package except under controlled and previously approved conditions. Other elements of heavy lifting (e.g., package dropped during loading or unloading) are addressed in facility-specific documented safety analyses (DSA).

- Toxic and hazardous chemicals are, in general, not a threat to Hanford Site packages. The chemicals may be an issue related to industrial hygiene and worker protection, but do not represent a credible threat to the package. Similarly, corrosion was removed as a potential accident scenario because of the long-term nature of the threat and the existing Package Maintenance Program in which inspections are conducted periodically to identify potential corrosion or other forms of package degradation. Potential acts of sabotage or terrorism were not considered further because of the absence of credible threats. Hanford shipments are not considered attractive to potential saboteurs and terrorists because most shipments are in support of cleanup that is supported by most groups and because of the absence of a potentially large body count sought by terrorist organizations. Furthermore, the Hanford Site is provided with its own security forces that are capable of rapidly responding to and dealing with potential saboteurs and terrorists.

- Natural phenomena threats to packages include earthquakes, high winds, tornadoes, and floods. However, the likelihood of such events are low and the likelihood that such an event occurs at the same time a package is in transit, combined with the likelihood that the natural phenomena event is severe enough to threaten package integrity makes these incredible occurrences. Furthermore, shipping is restricted during periods of highly hazardous weather, such as dust storms and high winds that decrease visibility and snowstorms that lead to dangerous road conditions. For these reasons, natural phenomena hazards were eliminated from further consideration.
Based on the above, the Hanford Site accident frequency analysis framework must address potential ACs including impact (such as vehicular crashes and rollovers), puncture, crush, and fire. Note that these events are the same as the hypothetical ACs defined in 10 CFR 71. However, package requirements and controls that were developed based on the deterministic analyses conducted to support traditional package certification or Hanford Site performance-based certification must also be met (e.g., criticality controls, hydrogen gas generation limitations). Puncture and crush of the package are considered bounded by the collision accident.

**E.1.4 Example**

Assume that a packaging system for Type B quantities of radioactive material has been determined to be risk based via detailed structure and thermal modeling. The loaded weight of the package is 2,000 kg (4,409 lb). The detailed modeling determined the following containment failure thresholds:

- Mechanical failure occurs when the package is subjected to a 40 km/h (25 mi/h) collision with an unyielding target.
- Puncture failure occurs when the package is subjected to a 9 m/sec (30 ft/sec) impact onto a 20 cm (8 in.) diameter puncture probe.
- Failure occurs after a 25-minute fire following a collision or after 45 minutes when no collision occurs (i.e., fire only).

In addition, it is known that the package will be used to transport waste materials from the 300 Area to the Low-Level Waste Burial Ground in the 200 West Area, a distance of approximately 25 km (40 mi), and is planned to be used twice per year.

**Solution**

1. **Determine Collision Failure Frequency:**
   a. **Determine Conditional Probability.** The conditional probability of a collision/overturn is 0.7412. Referring to Figure G-1, which was constructed using Figure 7-10, Chapter 7 of the TSD, it can be seen that the probability of a collision/overturn that produces a 40 km/h (25 mi/h) impact velocity or less is about 0.64. Therefore, the probability of encountering collisions that could potentially fail the package (i.e., at 40 km/h [25 mi/h] or greater) is about (1 – 0.64) or 0.36.
Figure E-1. Example Illustrating Collision Failure Probability

b. **Calculate Frequency.** The frequency of collision failure on the Hanford Site is the product of the accident rate, one-way distance, number of annual shipments, the conditional probability of a collision/overturn occurring, and the conditional probability that the impact velocity generated in a collision/overturn accident is 40 km/h (25 mi/h) or greater. The frequency is:

\[
\text{Frequency} = (3.2 \times 10^{-7} \text{ accidents/mile per WHC-SD-TP-RPT-021})(40 \text{ miles/trip})
\]
\[
(2 \text{ trips/yr})(0.7412)(0.36)
\]
\[
= 6.8 \times 10^{-6} \text{ collision/overturn failures per year}
\]

2. **Determine Fire Failure Frequency:**

a. **Determine Fire Failure Probability.** This fire failure probability is determined using Figures 7-11 and 7-12, of the TSD. The thermal analysis of the package determined that failure of a damaged package (i.e., following the collision/overturn impact event discussed above) could occur when subjected to a 25-minute regulatory fire or after 45 minutes for a non-damaged package. Referring to Figure 7-13, the probability of a fire lasting 25 minutes or less following a collision or overturn is about 0.7. The probability that a fire lasts 25 minutes or longer, and threatens the integrity of the package, is \((1 - 0.7)\) or about 0.3. For non-collision accidents, the probability that a fire lasts longer than 45 minutes is \((1 - 0.9985) = 0.0015\).
b. **Calculate Frequency.** Similar to Step 1.b above, the annual frequency of a release due to a collision followed by 25 minute fire or longer is:

**Collision and Fire**

Frequency = \( (3.2 \times 10^{-7} \text{ accidents/mile})(40 \text{ miles/trip})(2 \text{ trips/yr}) \)

\[ \times (0.7412)(0.36) (0.3) \]

\[ = 2.4 \times 10^{-6} \text{ failures per year} \]

**Collision/Puncture and Fire**

Frequency = \( (3.2 \times 10^{-7} \text{ accidents/mile})(40 \text{ miles/trip})(2 \text{ trips/yr}) \)

\[ \times (0.7412)(0.028) (0.3) \]

\[ = 1.6 \times 10^{-7} \text{ failures per year} \]

**Fire-Only**

Frequency = \( (3.2 \times 10^{-7} \text{ accidents/mile})(40 \text{ miles/trip}) \)

\[ \times (2 \text{ trips/yr})(0.2588)(0.0015) \]

\[ = 1.0 \times 10^{-8} \text{ failures per year} \]

3. **Summary:**

The accident frequencies used to compare against the risk evaluation guidelines are as follows:

1. Collision failure – 6.8 \( \times 10^{-6} \) per year
2. Puncture failure – 7.2 \( \times 10^{-7} \) per year
3. Collision and fire failure – 5.7 \( \times 10^{-6} \) per year
4. Collision/puncture and fire – 1.6 \( \times 10^{-7} \) per year
5. Fire-only failure – 1.0 \( \times 10^{-8} \) per year

The consequences of this accident would then be determined and the (frequency, consequence) pair plotted on the risk evaluation guideline plot to determine the acceptability of such an accident. Note that the consequences are determined separately using the methodology and data described in Section 7.3.2.1. The consequence estimates must consider the specific conditions generated in each accident scenario. For example, the amount of material released from an impact-only package failure should be calculated using release fractions that are representative of releases from mechanical damage to the material form. For scenarios involving fires, the release fractions that represent releases from applying thermal stress to the material form should be selected. Additional information used to develop consequence estimates are presented in the TSD, Section 7.3.2.1.

### E.1.5 Dose Consequence Evaluation

#### E.1.5.1 Inhalation Exposure Pathway

The dose consequence due to inhalation of airborne particulate material created from a hypothetical accident during transportation is given by the 50-year committed effective dose equivalent (CEDE). The CEDE per unit intake for each radionuclide is tabulated in several references and is referred to as the inhalation dose conversion factor (DCF).

provides the methodology for the bases for selection of the parameters involved in the bounding accidents. Effective DCFs are prescribed in units of dose-equivalent curie (DE-Ci), which normalizes the inhalation dose relative to that from $^{239}\text{Pu}$.

Intake by inhalation requires that the radioactive material first transform into an aerosol that is transported through the atmosphere to a downwind receptor and is inhaled. Transformation into an aerosol is caused by the accident conditions described in Section 1.3, and the amount of aerosol formed depends on the accident scenario and form of the radioactive material. The amount of aerosol that is formed and leaks out of the package is known as the airborne source term and is given by the first five variables (DOE-HDBK-3010-94, *Airborne Release Fractions/Rates and Respirable Fractions for Nonreactor Nuclear Facilities*, p. 1-2) in equation E-1. The sixth variable is the concentration of aerosol at a particular downwind location, integrated over time, and normalized to the amount of aerosol released. The seventh variable is the breathing rate of a receptor. The product of the first seven variables in equation E-1 below represents the intake of radionuclides into the body due to inhalation. The last variable is the inhalation DCF.

$$ CEDE = (MAR \times DR \times ARF \times RF \times LPF) \times \chi/Q' \times BR \times DCF $$

(airborne source term)

where:

- **CEDE** = 50-year committed effective dose equivalent due to inhalation, in rem
- **MAR** = material at risk, in DE-Ci
- **DR** = damage ratio, dimensionless
- **ARF** = airborne release fraction, dimensionless
- **RF** = respirable fraction, dimensionless
- **LPF** = leak path factor, dimensionless
- $\chi/Q'$ = time-integrated normalized airborne concentration, in s/m$^3$
- **BR** = breathing rate, in m$^3$/s
- **DCF** = inhalation dose conversion factor for $^{239}\text{Pu}$, in rem/DE-Ci.

Neglected in this definition of the airborne source term is the coagulation of smaller particles into larger particles and the resultant increase in gravitational settling of the larger particles. Because no credit is taken for the reduction of the material at risk (MAR) that would occur from the settling of larger particles, the results of the calculations are conservative.

### E.1.5.2 Material at Risk

The MAR is the radiological inventory per shipment and per package in DE-Ci. MAR limits are determined by limiting the consequences of the analyzed accidents. The form of the material being shipped is to be specified to determine applicable release characteristics.

### E.1.5.3 Damage Ratio

The damage ratio (DR) is the fraction of the MAR (i.e., the fraction of the contents of a single package or the fraction of the MAR in the conveyance) actually affected by the accident-generated conditions. For the unmitigated case, it is assumed that all of the individual packages
are affected given an accident, and the DR is taken to be 1. The DR for a mitigated collision is reduced based on the analyses of the damage expected to be caused by the accident with implementation of the administrative and engineering controls called out in the applicable PSSD or other authorization.

E.1.5.4 Airborne Release Fraction and Respirable Fraction

The airborne release fraction (ARF) is the fraction of the radioactively contaminated material that is converted to particulate matter and becomes airborne during a hypothetical accident. The respirable fraction (RF) is the fraction of the ARF that is sufficiently small to be capable of being inhaled into the human respiratory system. The ARF is a function of the accident scenario, the physical and chemical form of the waste, the initial packaging configuration, and the energy input. The RF is a function of the same variables as the ARF, but also is a function of the initial particle size distribution.

The recommended values of the ARF and RF for Hanford site accidents are taken from standard DOE methodologies and guidance.

E.1.5.5 Leak Path Factor

The leak path factor (LPF) is the cumulative fraction of airborne radioactive material that escapes through the containment boundary. This factor depends on the structural response of the package to the hypothetical accident conditions. The LPF is conservatively assumed to be 1.0 for unmitigated cases.

E.1.5.6 Time-Integrated Normalized Airborne Concentration $\chi/Q'$

The $\chi/Q'$ defines the downwind concentration of airborne radioactivity at a particular location, integrated over the duration of the release and normalized to the amount released. The recommended $\chi/Q'$ values are obtained from standard DOE methodologies and guidance (e.g., RADIDOSE).

E.1.5.7 Breathing Rate

The breathing rate BR is the volume of air inhaled per unit time. The International Commission on Radiological Protection (ICRP 23, Report of the Task Group on Reference Man) reports that the breathing rate for reference man during light activity is $3.3 \times 10^{-4} \text{ m}^3/\text{s}$. This value is conservatively applied for both the co-located worker and the Maximum Exposed Offsite Individual.

E.1.5.8 Dose Conversion Factor

The DCF correlates the amount of radioactivity inhaled to the CEDE. Because the activity is given in units of DE-Ci, which normalized the inhalation dose relative to that from $^{239}\text{Pu}$, the DCF used in the dose consequence calculations is that for $^{239}\text{Pu}$. For workers, given $^{239}\text{Pu}$, an absorption type of M, and an aerodynamic diameter of 5 $\mu\text{m}$, the DCF is $3.2 \times 10^{-5}$ Sv/Bq or $1.18 \times 10^8 \text{ rem/Ci}$ or approximately $3.2 \times 10^6 \text{ rem/A}_2$. Absorption type M and aerodynamic diameter of 5 $\mu\text{m}$ are appropriate for the plutonium oxide materials shipped on the Hanford Site and are consistent with values specified in PRC-STD-NS-8739. For members of the public, the
corresponding $^{239}$Pu DCF, given absorption type M and an aerodynamic diameter of 1 µm, is $5.0 \times 10^{-5}$ Sv/Bq or $1.85 \times 10^8$ rem/Ci or approximately $5.0 \times 10^6$ rem/A$_2$.

E.1.5.9 Summary of the Inhalation Dose Consequence Calculations

The dose consequences and parameter values determined for shipping an array of TRU waste packages due to a collision, fire, or hydrogen deflagration are shown in Tables E-2 and E-3. The risks indicated in this table are representative of the level of risk that can be accepted by DOE, based on the analyses and factors for specific risk based packages.

E.2 Summary

This section contains the assumptions and methodologies used to develop Tables E-2 and E-3. For future risk based package evaluations, specific characteristics of the package or contents may warrant different assumptions.

Bounding radiological dose consequence and release frequency evaluations were performed for three accident scenarios for a single package containing generic solid payloads and generic TRU and non-TRU wastes. Results are reported for both unmitigated and mitigated accidents. With the assumptions given, the mitigated dose consequence and release frequency are consistent with standard DOE methodologies and guidance. These results are for bounding accidents selected to ensure the analyses cover the classes of activities conducted under transportation. The combined release and resultant consequences from multiple packages on the conveyance, if applicable, are bounded by the inventory limit and controlled by administrative controls. Administrative controls should be designed to mitigate the consequences, mitigate the severity of the accident, and/or reduce the frequency of the accident to satisfy the assumptions in these calculations. These controls are required when the shipment payload contains greater than 1 A$_2$ of radioactive material, unless the radioactive material shipped as LSA/SCO.

E.2.1 Packages

The packages considered in this report are the same package types considered and accepted by the DOT, plus those unique packages that DOE has accepted as having acceptably low levels of risk. The content limits based on the mitigated accident analysis results should be applied only to packages that are shown to pass the performance requirements for DOT Type A packages. The content limits, based on the unmitigated results, may be applied to all packages including those that do not meet the performance requirements for Type A packages, because no credit is taken for the package in ACs in the table of unmitigated results in this example.

E.2.2 Accident Scenarios

The accident scenarios selected are those selected by DOT as representing the deterministic conditions required to be survived during transportation. A hazard analysis and accident selection for transportation is described in Section E.1.3.
E.2.2.1 Collision

Collision is the most common type of transportation accident. In a collision accident, the truck hits an obstacle, causing the truck to decelerate at a rapid rate. The package, however, is still traveling at the initial velocity of the truck. The velocity of the package is reduced by the amount of energy required to break the tiedown hardware (which is small). The package then collides with the front of the conveyance, which had stopped because of the collision with the obstacle. The collision between the package and the conveyance is an impact event because the force on the package is localized on one side; this is the same type of force created when an object is dropped and hits the ground.

If there are additional packages on the conveyance that are behind the front package, then an inertial crush force is generated as these packages collide with and push against the front package, which is being resisted by the front of the conveyance. Impact and crush forces are differentiated by the application of the force to the package. If the force occurs on one side of the package, it is considered an impact, and if it occurs on multiple sides of the package, it is considered crush.

E.2.2.2 Fire

A fire may follow the collision. Transportation statistics show that fire occurs in approximately 1.6 percent of all accidents, as described in Section 7.3.2.2.1.3. These fires have variable diameter, temperature, duration, and location relative to the cargo. Unvented Type A 210 L (55 gal) drums, on average, will lose containment 3 minutes after exposure to a fully-engulfing fuel fire.

E.2.2.3 Hydrogen Deflagration

Hydrogen gas deflagrations may occur anytime, not just during transportation. Hydrogen can build up in a package due to chemical reactions between different materials of the payload and due to radiolytic decomposition of water or other hydrogenous materials. Another flammable gas (methane) can build up due to the anaerobic respiration by organisms on organic material, although this mechanism has not been observed to produce significant quantities of flammable gas in drums at the Hanford Site.

E.2.3 Payloads

The payload of the package is assumed to consist of debris generated during cleanup activities at the Hanford Site. This debris most likely consists of surface contaminated equipment and combustible items. It is assumed for conservatism that particulate material may be present, which is modeled as powder. For simplicity, the isotopic composition is assumed to consist of either TRU or non-TRU material, which is modeled as plutonium.

E.2.4 Risk Based Packaging System Typical Assumptions

The assumptions described here are typical of those that can be applied to control risks, and serve to mitigate the consequences, mitigate the severity of the accident, or reduce the frequency of the accident. These assumptions are discussed quantitatively in the results section.
The speed of the truck can be limited. In this example, the speed of the truck is assumed to be limited to 56 km/h (35 mi/h). This assumption limits the energy that must be dissipated in a collision accident. More importantly, it reduces the severity of the injuries to the driver because of the collision.

For arrays of packages, the least-hazardous packages (measured by DE-Ci) are assumed to be placed at the front of the conveyance and the most hazardous packages are assumed to be placed at the rear of the conveyance, although this arrangement shall not result in an unacceptable direct external dose rates. This assumption mitigates the total amount released, because the packages in the front experience the largest crush forces.

For arrays of packages, impact-limiting devices, such as sandbags or empty drums, are assumed to be placed at the front of the conveyance. This limits the damage to the packages by absorbing more energy than the front structure of the conveyance, thus mitigating the release.

The road is assumed to be closed to all other traffic during the shipment for this example. This reduces the frequency of multi-vehicle accidents and limits the total fuel available for a fire to only the fuel in the transport vehicle’s fuel tank.

Packages are assumed to be vented prior to shipping, and chemically reactive contents are assumed not to be present to preclude a buildup of hydrogen above its lower explosive limit. The PSSD shall evaluate the buildup of hydrogen during shipment to establish a shipping window.

E.2.5 Results

The dose consequences and the release frequency from an array of packages due to a collision, fire, or hydrogen deflagration are shown in Tables E-2 and E-3. A brief description of the calculations is provided in the following subsections.

E.2.5.1 Data Sources

The material at risk is the total material at risk on the conveyance, except for the case of hydrogen deflagration, which is the total material at risk in one package. Therefore, two limits are imposed on risk based shipment inventories: 1) a shipment-level (conveyance) limit and 2) a package-level limit.

Because the purpose of this example is to provide an indication of the risks from transportation accidents involving risk based Type B packages, conservative assumptions must be used so that the results bound the risk from the majority of packages. Use of this example is limited to packages, together with the planned payload, that satisfies the conditions normally incident to transport as defined in Section 6.5.2.3. Packages with payloads that are capable of withstanding accident environments that are more severe than the Type A packaging tests would retain more of its contents in an accident and would be bounded by the results in Tables E-2 and E-3. The 210 L (55 gal) drums are considered in the calculations as a representative Type A package because they are commonly used onsite.
E.2.5.1.1 Fire Release Fraction

Studies of 210 L (55 gal) drums in fire tests show that in a fully engulfing fire, the lid may be completely blown off the drum, or the lid may rupture but be partially held in place by the closure ring. In either case, failure occurred in an average of 3 minutes. Drums not completely engulfed by the fire fail by lid seal degradation (WHC-SD-WM-TRP-246, Solid Waste Drum Array Fire Performance, Section 8.1). The two components of the airborne source term for the fire scenario are considered to be adequately represented by the value in RADIDOSE for the burning of contents of the packages of $5 \times 10^{-4}$ and 1, respectively, from DOE-HDBK-3010-94, Section 5.1, which are the bounding values for packaged mixed combustible and noncombustible waste.

E.2.5.1.2 Hydrogen Deflagration Release Fraction

Three components of the airborne source term for the hydrogen deflagration scenario are considered. The first component is the airborne release caused by the blast effects of the deflagration, which applies to all of the contents of the package. The other two components are the same as for the fire release: the burning of ejected combustible waste and the burning of combustible waste remaining in the package.

In a hydrogen deflagration, a powder payload will have a greater airborne release due to the explosive stress than combustible or noncombustible payloads. However, the combustible payload will have a greater airborne release due to the subsequent burning after the hydrogen deflagration. Therefore, reasonably representative values for the ARF and RF for internal explosions such as hydrogen deflagrations in drums are $1.0 \times 10^{-3}$ and 1.0, respectively, as given in RADIDOSE for this accident type.

E.2.5.1.3 Other Parameters

The breathing rate, $3.3 \times 10^{-4}$ m$^3$/s, is taken from ICRP 23 for the reference man during light activity.

The DE-Ci factors are taken from HNF-EP-0063, Hanford Site Solid Waste Acceptance Criteria.

The accident frequency is taken from Chapter 7, Section 3.2.2.1.1, which is from NUREG/CR-6672, Reexamination of Spent Fuel Shipment Risk Estimates, with the conditional probability of fire taken from SLA-74-0001, Severities of Transportation Accidents Volume III--Motor Carriers. The probability of a drum deflagration is taken from SAR 1996, Rocky Flats Environmental Technology Site Safety Analysis Report.

E.2.5.2 Effect of Assumptions

E.2.5.2.1 Collision

To mitigate the consequences from a collision accident, the speed of the truck shall be limited to 56 km/h (35 mi/h), the drums at the front of the conveyance shall contain no radioactive material, and the most hazardous drums (measured by DE-Ci) shall be placed at the rear.

In a head-on collision accident, the front row of drums impacts the front of the conveyance, and the following rows of drums impact the front row of drums. This creates a crush environment,
which is defined as forces impinging on more than one side of the package. A crush environment is usually more severe than an impact environment, such as a drop, in which the forces impinge on only one side of the package. Sacrificial dunnage drums in the front row will act as an impact limiter at the front of the conveyance to absorb most of the kinetic energy of the drums in the following rows and ensure that the highest crush forces occur on drums containing no radioactive material. The magnitude of the crush force depends on the speed and mass of the moving object; the lower the speed or mass, the lower the crush force. Therefore, in a head-on collision, the lowest crush forces will be at the back of the trailer. The last row of drums will not be crushed, because there is nothing behind it; the drums will only experience the impact when they collide with the row of drums in front of them. Therefore, the most hazardous drums in terms of amount release should be placed at the back of the array to minimize the crush force.
Table E-2. Risk Based Package Accident Summary (Dose Consequences) for Maximum Exposed Offsite Individual

<table>
<thead>
<tr>
<th>Case</th>
<th>Area</th>
<th>Scenario</th>
<th>Accident condition</th>
<th>MAR(^1,2) (DE-Ci)</th>
<th>MAR(^3) (g)</th>
<th>MAR(^1) (A(_2))</th>
<th>DR</th>
<th>ARF(^3)</th>
<th>RF(^3)</th>
<th>LPF</th>
<th>BR(^4) (m(^3)/s)</th>
<th>Distance (m) to receptor(^5)</th>
<th>(\chi/Q') (s/m(^3))</th>
<th>DCF(^7) (rem/Ci)</th>
<th>Dose (rem)</th>
<th>Accident frequency (yr(^{-1}))</th>
<th>Risk class</th>
<th>Credited controls(^9)</th>
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<td>1</td>
<td>100/200</td>
<td>Collision</td>
<td>UM</td>
<td>353</td>
<td>5,680</td>
<td>13,070</td>
<td>1.0</td>
<td>1.00E-3</td>
<td>0.10</td>
<td>1.0</td>
<td>3.3 E-4</td>
<td>10,000</td>
<td>4.68E-5</td>
<td>1.85E+8</td>
<td>0.10</td>
<td>EU</td>
<td>IV</td>
<td>None</td>
</tr>
<tr>
<td>2</td>
<td>100/200</td>
<td>Collision</td>
<td>M</td>
<td>353</td>
<td>5,680</td>
<td>13,070</td>
<td>0.1</td>
<td>1.00E-3</td>
<td>0.10</td>
<td>1.0</td>
<td>3.3 E-4</td>
<td>10,000</td>
<td>4.68E-5</td>
<td>1.85E+8</td>
<td>0.10</td>
<td>EU</td>
<td>IV</td>
<td>(a), (b)</td>
</tr>
<tr>
<td>3</td>
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<td>Fire (0.5 MW)</td>
<td>UM</td>
<td>1130</td>
<td>18200</td>
<td>41800</td>
<td>1.0</td>
<td>5.00E-4</td>
<td>1.00</td>
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<td>3.3 E-4</td>
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<td>M</td>
<td>1130</td>
<td>18200</td>
<td>41800</td>
<td>1.0</td>
<td>5.00E-4</td>
<td>1.00</td>
<td>1.0</td>
<td>3.3 E-4</td>
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<td>1.51E-5</td>
<td>1.85E+8</td>
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<td>EU</td>
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<tr>
<td>5</td>
<td>100/200</td>
<td>Hydrogen deflagration</td>
<td>UM</td>
<td>239</td>
<td>3850</td>
<td>8850</td>
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<td>(c), (d)</td>
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<td>5850</td>
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<td>1.00-3</td>
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<td>1.0</td>
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<td>M</td>
<td>158</td>
<td>2540</td>
<td>5850</td>
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<td>1.00E-3</td>
<td>0.10</td>
<td>1.0</td>
<td>3.3 E-4</td>
<td>1400</td>
<td>3.95E-4</td>
<td>1.85E+8</td>
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<td>III</td>
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</tr>
<tr>
<td>9</td>
<td>300</td>
<td>Fire (0.5 MW)</td>
<td>UM</td>
<td>495</td>
<td>7970</td>
<td>18300</td>
<td>1.0</td>
<td>5.00E-4</td>
<td>1.00</td>
<td>1.0</td>
<td>3.3 E-4</td>
<td>1400</td>
<td>6.43E-5</td>
<td>1.85E+8</td>
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<td>EU</td>
<td>III</td>
<td>None</td>
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<tr>
<td>10</td>
<td>300</td>
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<td>M</td>
<td>495</td>
<td>7970</td>
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<td>1.0</td>
<td>5.00E-4</td>
<td>1.00</td>
<td>1.0</td>
<td>3.3 E-4</td>
<td>1400</td>
<td>6.43E-5</td>
<td>1.85E+8</td>
<td>0.98</td>
<td>EU</td>
<td>III</td>
<td>None</td>
</tr>
</tbody>
</table>
Table E-2. Risk Based Package Accident Summary (Dose Consequences) for Maximum Exposed Offsite Individual

<table>
<thead>
<tr>
<th>Case</th>
<th>Area</th>
<th>Scenario</th>
<th>Accident condition</th>
<th>MAR(^{1,2}) (DE-Ci)</th>
<th>MAR(^1) (g)</th>
<th>MAR(^1) (A(_2))</th>
<th>DR</th>
<th>ARF(^3)</th>
<th>RF(^3)</th>
<th>LPF</th>
<th>BR(^4) (m(^3)/s)</th>
<th>Distance (m) to receptor(^5)</th>
<th>(\chi/Q') ((s/m^3))(^6)</th>
<th>DCF(^7) (rem/Ci)</th>
<th>Dose (rem)</th>
<th>Accident frequency (yr(^{-1}))(^8)</th>
<th>Risk class</th>
<th>Credited controls(^9)</th>
</tr>
</thead>
<tbody>
<tr>
<td>11</td>
<td>300</td>
<td>Hydrogen deflagration</td>
<td>UM</td>
<td>112</td>
<td>1800</td>
<td>4150</td>
<td>1.0</td>
<td>1.00E-3</td>
<td>1.00</td>
<td>3.3 E-4</td>
<td>1400</td>
<td>3.61E-4</td>
<td>1.85E+8</td>
<td>1.5</td>
<td>Anticipated</td>
<td>I</td>
<td>None</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>300</td>
<td>Hydrogen deflagration</td>
<td>M</td>
<td>112</td>
<td>1800</td>
<td>4150</td>
<td>1.0</td>
<td>1.00E-3</td>
<td>1.00</td>
<td>3.3 E-4</td>
<td>1400</td>
<td>3.61E-4</td>
<td>1.85E+8</td>
<td>1.5</td>
<td>EU</td>
<td>III (c), (d)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\(^1\)MAR adjusted to maintain approved CW and MOI doses. Specific activity of \(^{239}\)Pu is 6.20 E-2 Ci/g, and 1 A\(_2\) = 2.7 E-2 Ci.
\(^2\)The MARs for collision and fire are conveyance limits while the MAR for hydrogen deflagration is a package limit.
\(^3\)ARF and RF shown are from RADIDOSE for the accident scenario. The payload materials are assumed to consist of surface contaminated combustible or noncombustible materials or powder, whichever is more conservative for the accident scenario.
\(^4\)Breathing rate for reference man during light activity.
\(^5\)Average distance to receptor for 100, 200 E, and 200 W Areas is 10,000 m. Distance to receptor in 300 Area is 1400 m.
\(^6\)Based on \(\chi/Q'\) values from RADIDOSE Version 3.
\(^7\)MOI; \(^{239}\)Pu, absorption Type M, 1 \(\mu\)m mean diameter, DCF = 5.0 E-5 Sv/Bq (5.0 E+6 rem/A\(_2\), 1.85 E+8 rem/Ci, or 1.147 E+7 rem/g).
\(^8\)Frequency calculations based on 56 trips per year at 8 km (5 mi) per trip for Cases 1, 2, 3, and 4, 100 trips per year at 32 km (20 mi) per trip for Cases 7, 8, 9, and 10. Frequencies for Cases 5, 6, 11, and 12 assigned.
\(^9\)Credited controls: (a) maximum speed limited to 56 km/h (35 mi/h), (b) sandbags or nonrad (dunnage) containers in front row of array, high DE-Ci containers in rear, (c) containers vented prior to shipment, (d) chemically reactive contents not present.

ARF = airborne release fraction. EU = extremely unlikely. MOI = Maximum Exposed Offsite Individual.
DCF = dose conversion factor. LPF = leak path factor. RF = respirable fraction.
DE-Ci = dose-equivalent curie. M = mitigated. UM = unmitigated.
DR = damage ratio. MAR = material at risk.
Table E-3. Risk Based Package Accident Summary (Dose Consequences) for Co-located Worker at 100 m (328 ft)

<table>
<thead>
<tr>
<th>Case</th>
<th>Area</th>
<th>Scenario</th>
<th>Accident condition</th>
<th>MAR$^{1,2}$ (DE-Ci)</th>
<th>MAR$^1$ (g)</th>
<th>MAR$^2$ (A$_2$)</th>
<th>DR</th>
<th>ARF$^3$</th>
<th>RF$^5$</th>
<th>LPF</th>
<th>BR$^4$ (m$^3$/s)</th>
<th>Distance (m) to receptor</th>
<th>$\chi/Q'$ (s/m$^3$)</th>
<th>DCF$^6$ (rem/Ci)</th>
<th>Dose (rem)</th>
<th>Accident frequency (yr$^{-1}$)</th>
<th>Risk class</th>
<th>Credited controls$^8$</th>
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<tr>
<td>1</td>
<td>100/200</td>
<td>Collision</td>
<td>UM</td>
<td>353</td>
<td>5,680</td>
<td>13,070</td>
<td>1.0</td>
<td>1.00E-3</td>
<td>0.10</td>
<td>1.0</td>
<td>3.3E-4</td>
<td>100</td>
<td>6.10E-2</td>
<td>1.184E+8</td>
<td>85</td>
<td>EU</td>
<td>III</td>
<td>None</td>
</tr>
<tr>
<td>2</td>
<td>100/200</td>
<td>Collision</td>
<td>M</td>
<td>353</td>
<td>5,680</td>
<td>13,070</td>
<td>0.1</td>
<td>1.00E-3</td>
<td>0.10</td>
<td>1.0</td>
<td>3.3E-4</td>
<td>100</td>
<td>6.10E-2</td>
<td>1.184E+8</td>
<td>8.5</td>
<td>EU</td>
<td>IV</td>
<td>(a), (b)</td>
</tr>
<tr>
<td>3</td>
<td>100/200</td>
<td>Fire (0.5 MW)</td>
<td>UM</td>
<td>1130</td>
<td>18200</td>
<td>41800</td>
<td>1.0</td>
<td>5.00E-4</td>
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<td>1.0</td>
<td>3.3E-4</td>
<td>100</td>
<td>5.97E-4</td>
<td>1.184E+8</td>
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<td>EU</td>
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<tr>
<td>4</td>
<td>100/200</td>
<td>Fire (0.5 MW)</td>
<td>M</td>
<td>1130</td>
<td>18200</td>
<td>41800</td>
<td>1.0</td>
<td>5.00E-4</td>
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<td>EU</td>
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<td>None</td>
</tr>
<tr>
<td>5</td>
<td>100/200</td>
<td>Hydrogen deflagration</td>
<td>UM</td>
<td>239</td>
<td>3850</td>
<td>8850</td>
<td>1.0</td>
<td>1.00E-3</td>
<td>1.00</td>
<td>1.0</td>
<td>3.3E-4</td>
<td>100</td>
<td>1.54E-3</td>
<td>1.184E+8</td>
<td>14</td>
<td>Anticipated</td>
<td>III</td>
<td>None</td>
</tr>
<tr>
<td>6</td>
<td>100/200</td>
<td>Hydrogen deflagration</td>
<td>M</td>
<td>239</td>
<td>3850</td>
<td>8850</td>
<td>1.0</td>
<td>1.00E-3</td>
<td>1.00</td>
<td>1.0</td>
<td>3.3E-4</td>
<td>100</td>
<td>1.54E-3</td>
<td>1.184E+8</td>
<td>14</td>
<td>EU</td>
<td>IV</td>
<td>(c), (d)</td>
</tr>
<tr>
<td>7</td>
<td>300</td>
<td>Collision</td>
<td>UM</td>
<td>158</td>
<td>2540</td>
<td>5850</td>
<td>1.0</td>
<td>1.00-3</td>
<td>0.10</td>
<td>1.0</td>
<td>3.3E-4</td>
<td>100</td>
<td>3.40E-2</td>
<td>1.184E+8</td>
<td>21</td>
<td>Unlikely</td>
<td>III</td>
<td>None</td>
</tr>
<tr>
<td>8</td>
<td>300</td>
<td>Collision</td>
<td>M</td>
<td>158</td>
<td>2540</td>
<td>5850</td>
<td>0.1</td>
<td>1.00E-3</td>
<td>0.10</td>
<td>1.0</td>
<td>3.3E-4</td>
<td>100</td>
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<td>1.184E+8</td>
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<td>Unlikely</td>
<td>III</td>
<td>(a), (b)</td>
</tr>
<tr>
<td>9</td>
<td>300</td>
<td>Fire (0.5 MW)</td>
<td>UM</td>
<td>495</td>
<td>7970</td>
<td>18300</td>
<td>1.0</td>
<td>5.00E-4</td>
<td>1.00</td>
<td>1.0</td>
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<td>100</td>
<td>7.28E-4</td>
<td>1.184E+8</td>
<td>7.1</td>
<td>EU</td>
<td>IV</td>
<td>None</td>
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<tr>
<td>10</td>
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<td>Fire (0.5 MW)</td>
<td>M</td>
<td>495</td>
<td>7970</td>
<td>18300</td>
<td>1.0</td>
<td>5.00E-4</td>
<td>1.00</td>
<td>1.0</td>
<td>3.3E-4</td>
<td>100</td>
<td>7.28E-4</td>
<td>1.184E+8</td>
<td>7.1</td>
<td>EU</td>
<td>IV</td>
<td>None</td>
</tr>
</tbody>
</table>
Table E-3. Risk Based Package Accident Summary (Dose Consequences) for Co-located Worker at 100 m (328 ft)

<table>
<thead>
<tr>
<th>Case</th>
<th>Area</th>
<th>Scenario</th>
<th>Accident condition</th>
<th>MAR$^{1,2}$ (DE-Ci)</th>
<th>MAR$^1$ (g)</th>
<th>MAR$^1$ (A$_2$)</th>
<th>DR</th>
<th>ARF$^3$</th>
<th>RF$^4$</th>
<th>LPF</th>
<th>BR$^4$ (m$^3$/s)</th>
<th>Distance (m) to receptor</th>
<th>$\chi/Q'$ (s/m$^3$)$^5$</th>
<th>DCF$^6$ (rem/Ci)</th>
<th>Dose (rem)</th>
<th>Accident frequency (yr$^{-1}$)$^7$</th>
<th>Risk class</th>
<th>Credited controls$^8$</th>
</tr>
</thead>
<tbody>
<tr>
<td>11</td>
<td>300</td>
<td>Hydrogen deflagration</td>
<td>UM</td>
<td>112</td>
<td>1800</td>
<td>4150</td>
<td>1.0</td>
<td>1.00E-3</td>
<td>1.00</td>
<td>1.0</td>
<td>3.3E-4</td>
<td>100</td>
<td>1.58E-3</td>
<td>1.184E+8</td>
<td>7.0</td>
<td>Anticipated</td>
<td>III</td>
<td>None</td>
</tr>
<tr>
<td>12</td>
<td>300</td>
<td>Hydrogen deflagration</td>
<td>M</td>
<td>112</td>
<td>1800</td>
<td>4150</td>
<td>1.0</td>
<td>1.00E-3</td>
<td>1.00</td>
<td>1.0</td>
<td>3.3E-4</td>
<td>100</td>
<td>1.58E-3</td>
<td>1.184E+8</td>
<td>7.0</td>
<td>EU</td>
<td>IV</td>
<td>(c), (d)</td>
</tr>
</tbody>
</table>

$^1$MAR based on Table G-2a. Specific activity of $^{239}$Pu is 6.20 E-2 Ci/g, and 1 A$_2$ = 2.7 E-2 Ci.  
$^2$The MARs for collision and fire are conveyance limits while the MAR for hydrogen deflagration is a package limit.  
$^3$The ARF and RF shown are from RADIDOSE for the accident scenario. The payload materials are assumed to consist of surface contaminated combustible or noncombustible materials or powder, whichever is more conservative for the accident scenario.  
$^4$Breathing rate for reference man during light activity.  
$^5$Based on $\chi/Q'$ values from RADIDOSE Version 3.  
$^6$Co-located worker; $^{239}$Pu, absorption Type M, 5 $\mu$m mean diameter, DCF = 3.2 E-5 Sv/Bq (3.2 E+6 rem/A$_2$, 1.184 E+8 rem/Ci, or 7.341 E+6 rem/g).  
$^7$Frequency calculations based on 56 trips per year at 8 km (5 mi) per trip for Cases 1, 2, 3, and 4, 100 trips per year at 32 km (20 mi) per trip for Cases 7, 8, 9, and 10. Frequencies for Cases 5, 6, 11, and 12 assigned.  
$^8$Credited controls: (a) maximum speed limited to 56 km/h (35 mi/h), (b) sandbags or nonrad (dunnage) containers in front row of array, high DE-Ci containers in rear, (c) containers vented prior to shipment, (d) chemically reactive contents not present.

ARF = airborne release fraction. EU = extremely unlikely. RF = respirable fraction. DCF = dose conversion factor. LPF = leak path factor. UM = unmitigated. DE-Ci = dose-equivalent curie. M = mitigated. DR = damage ratio. MAR = material at risk.
Calculations in previous safety analysis reports for packaging [HNF-2209, Safety Analysis Report for Packaging (Onsite) Steel Drum, Section 7.4] conservatively modeled inertial crush as a drum sandwiched between two hard unyielding plates; one an immobile surface representing the front of the trailer, and the other a 2,268 kg (5,000 lb) plate with an initial velocity of 40 km/h (25 mi/h) representing the column of drums behind the front drum. This is an idealized scenario designed to estimate conservatively the potential damage to that drum. These calculations show substantial failure of the front drum caused by buckling of the drum wall near the drum bottom plate. Evidence of crush failure first begins to show in this conservative model when the 2,268 kg (5,000 lb) plate has an initial speed of 27.8 km/h (17.3 mi/h).

Further calculations in HNF-2209 (Section 7.5) evaluate the response of an array of drums to a collision. This calculation was an analytical model as opposed to the finite-elements model as described above. The coupled, second-order differential equations of motion for an array of three drums crushed against a hard unyielding surface were solved in closed-form modeling the drums as a series of masses, springs, and dashpots. This idealized model is a simplification of the problem compared to the finite elements model described above, which is a dynamic analysis. The three drums were modeled as having an equal mass of 658 kg (1,450 lb), and the initial system velocity was 48 km/h (30 mi/h).

The results of the model indicate that the first drum has a much larger deceleration after striking the unyielding surface than the second or third drums, which are tightly coupled such that they move with nearly the same velocity and the same acceleration. The kinetic energy of the second and third drum is transformed into dissipative energy in the first drum, and because of the large deceleration of the first drum, the first drum absorbs much more energy than the second or third drum. The first drum would likely be ruptured, but the second and third drums most likely would not be ruptured. These results are conservative because they neglect the energy absorbed by the transport vehicle, energy that would not be transferred to the drums. The model considered a stationary unyielding surface, when no surface is truly unyielding. Also, the maximum weight of the drum was modeled, when in practice actual weights vary from nearly empty up to the maximum mass. Although only three drums were considered in the analysis in HNF-2209 (Section 7.5), it was concluded that it would take many more rows of drums before the second row of drums would fail. An uncertainty analysis was conducted to account for the variable mass of the drums in an array, and it was concluded with greater than 95 percent confidence that none of the drums would fail for an initial system velocity of 48 km/h (30 mi/h), a 70 to 80 percent confidence that the first drum only would fail for an initial system velocity of 56 km/h (35 mi/h), and a 30 to 40 percent confidence that the first drum only would fail for an initial system velocity of 64 km/h (40 mi/h).

By limiting the speed of the truck to 56 km/h (35 mi/h), it is concluded that only the first row of drums would fail in a collision. Note that the impact-limiting function of the front row of drums is effective only where the collision occurs along the longitudinal axis of the trailer. In a jackknife accident, the trailer could overturn, and the drums could impact the ground. However, the shoulder and surrounding ground are yielding, which would mitigate the forces on the package. Furthermore, the percentage of jackknives among all collisions is small, and side-impact collisions by other vehicles are prevented by the road closure.
E.2.5.2.2 Fire

Applied controls are not credited with any reduction in the consequence or frequency of a fire accident.

E.2.5.2.3 Hydrogen

The 5 vol% hydrogen concentration limit guidance of NRC (1984) and NUREG-1609 is conservative and appropriate for performance-based packages in which flammability is to be absolutely precluded.

E.3 References


NUREG-0170, *Final Environmental Statement on the Transportation of Radioactive Material by Air and Other Modes, Volume 1*, U.S. Nuclear Regulatory Commission, Washington, D.C.


Appendix F

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Appendix F
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Appendix G

Guidance on Conducting SPA Related, DOE-Approved Packaging Evaluations
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Contents

G.1 Purpose .................................................................................................................. G-5
Appendix G
Guidance on Conducting SPA Related, DOE-Approved Packaging Evaluations

G.1 Purpose

A SPA consists of specific packaging(s), authorized packages / packaging systems, and required Administrative and Engineered Controls. A SPA contains, at a minimum, a Containment Boundary (CtB), a Confinement Boundary (CfB), and associated Administrative Controls (AC). Based on the Packaging, the packaging system containment system may use Industrial Packages (IP), Type A packages, or Type B Packages for the CtB. Depending on which SPA is being used and associated packaging requirements, an authorized packaging system is determined. This packaging system consists of U.S. Department of Transportation (DOT) packages (IP-1, IP-2, Type A or Type B, or DOE-approved equivalents) either singly or as multiple packages.

Generally the DOT package is procured with a pedigree (Certificate) that documents that the package meets regulatory performance requirements necessary for the type of DOT package. While the preferred approach is for the Offeror to use packages that have been documented as meeting DOT packaging requirements, there are instances where it is necessary to document that a package is Equivalent to a particular type of DOT package for compliance with transportation safety requirements (usually SPA requirements). The method for the Offeror to request an equivalency to a DOT packaging type is a Packaging Evaluation (PE). RL will approve PEs. A separate PE will be conducted for each package requiring a DOT equivalency for a specific packaging shipping configuration.

PEs may be submitted for either new packaging systems or to evaluate existing packaging systems. For existing packaging systems, care must be taken to ensure that the PE being submitted reflects the actual packaging system being requested. For example, use of as built in a PE to analyze a 20-year-old retrieved container without considering the effects of potential package deterioration due to aging, material degradation, or exposure to the elements would result in a PE that does not adequately reflect the packaging being submitted for approval.

It is the Offeror’s responsibility to ensure the PE is sufficiently detailed and contains adequate analysis and supporting documentation to allow the RL review team to conduct its review. The PE will be submitted sufficiently in advance to provide RL with time to conduct its review, conduct comment resolution and to approve the PE. For a typical PE this is usually a minimum of 20 working days in advance of the proposed shipping date. Longer lead times may be required for more complex or technically challenging packaging systems. The following guidance is provided to assist in preparation of RL approved PEs.

At a minimum the PE will contain the following information:

1. Package Description: The Packaging Description will include the following:
   a. Type of Package (i.e., IP-1, IP-2, Type A or Type B)
   b. Materials of construction (includes seals, fasteners, adhesives, glues, metals, plastics, woods, composite materials)
c. Closure mechanism and closure instructions

d. Filters and Vents (if applicable)

e. For items listed in ii. – iv. materials properties include minimum and maximum sustained operating temperatures, material reactivity and compatibility data, strength information, heat treatment, operating limitations behavior of materials under irradiation.

f. Engineered drawings and sketches

g. Package Maximum Rated Capacity (MRC) (including supporting documentation and analysis to justify the MRC.

A table of material properties will be included with the package description.

1. For each packaging type, a PE Checklist will be submitted (Table J2). For Type 7AFs and Type B packages a formal transportation safety document, Package Specific Safety Document (PSSD) or One Time Request for Shipment (OTRS), will be provided.

2. A summary of packaging evaluation requirements is contained in Table G.1.

3. For packagings being evaluated for equivalency to DOT IP-1 requirements a package description and an evaluation that the package containment system remains intact during Normal Conditions of Transport will be conducted. Credit may be taken for applicable existing analyses with proper justification. This evaluation may be conducted in one of three ways:

**Method A.** Analysis of packaging performance criteria (e.g., containment):

Use of analysis (e.g., finite element analysis) is acceptable to demonstrate package performance. If there are problems demonstrating acceptable performance for a package a control may be imposed to limit operations that gives acceptable performance; OR,

**Method B.** Physical Testing. Perform physical testing of above events or provide physical testing evidence that the package provides adequate performance when subjected to the physical tests specified in 49 CFR 173.410. Testing must be conducted in accordance with standardized testing procedures, either Industry Standards (e.g., ASME/ASTM) or RL approved testing procedures (e.g., DOT Type A Testing Program [Blue Book]); OR,

**Method C.** Analysis by comparison with other evaluated packages is an acceptable method to demonstrate packaging performance criteria.
<table>
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<tr>
<th>Packaging Evaluation Requirements</th>
<th>Package Type</th>
<th>Remarks</th>
</tr>
</thead>
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<td>Requirements for Type A Packages containing Gases</td>
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<tr>
<td>Free Drop Test</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>Stacking Test</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>Penetration Test</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>Packaging Evaluation Number:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-------------------------------</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Package being evaluated as equivalent to:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>IP-1.</td>
<td>IP-2.</td>
<td>Type-A.</td>
</tr>
<tr>
<td>1. Package Description: (Attach additional pages as necessary)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Normal Conditions Containment Evaluation (Attach additional pages as necessary)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Justification for RL acceptance of the packagings equivalency.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Signed | Organization | Date:
### Table G-3.  IP-1 PACKAGE NCT ANALYSIS AREAS

<table>
<thead>
<tr>
<th>Analysis Type</th>
<th>Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Vibration, subject the package to the following vibration frequency and power density spectrum (PSD):</td>
<td>Vertical Vibration Frequency and PSD</td>
</tr>
<tr>
<td></td>
<td>Frequency (Hz)</td>
</tr>
<tr>
<td></td>
<td>1.0</td>
</tr>
<tr>
<td></td>
<td>2.0</td>
</tr>
<tr>
<td></td>
<td>4.0</td>
</tr>
<tr>
<td></td>
<td>6.5</td>
</tr>
<tr>
<td>2 Impulse Event</td>
<td>Package will be subjected to a vertical acceleration pulse of 2gs of simple harmonic motion for a duration of 0.5 seconds.</td>
</tr>
<tr>
<td>3 Braking Event</td>
<td>The package will be subjected to a 1g acceleration in the forward and lateral directions.</td>
</tr>
<tr>
<td>4 Hard Set Down Event</td>
<td>Package will be subjected to a 3gs deceleration in the normal transport and loading orientation.</td>
</tr>
<tr>
<td>5 Package tiedown attachments</td>
<td>Tie down design and associated packaging will have sufficient strength to maintain containment when subjected to the following loading: a longitudinal deceleration (0.8g forward, 0.5g rearward), a transverse acceleration (0.5g), and a vertical acceleration (0.2g).</td>
</tr>
<tr>
<td>6 Package Lift Points</td>
<td>Package lift points will have a safety factor of 3 based on the material yield strength and will not impair the performance to the packaging</td>
</tr>
<tr>
<td>7 Thermal Extremes</td>
<td>The package material can sustain ambient temperatures of -27°F (-33°C) to 115°F (46°C) without loss of structural integrity.</td>
</tr>
</tbody>
</table>

or,

Document the results of the analyses in Table G.2 and provide justification for acceptance of the equivalency.

### Table G-4.  IP-2 Package NCT Analysis Areas

<table>
<thead>
<tr>
<th>Analysis Type</th>
<th>Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Vibration, subject the package to the following vibration frequency and power density spectrum (PSD):</td>
<td>Vertical Vibration Frequency and PSD</td>
</tr>
<tr>
<td></td>
<td>Frequency (Hz)</td>
</tr>
<tr>
<td></td>
<td>1.0</td>
</tr>
<tr>
<td></td>
<td>2.0</td>
</tr>
<tr>
<td></td>
<td>4.0</td>
</tr>
<tr>
<td></td>
<td>6.5</td>
</tr>
<tr>
<td>2 Impulse Event</td>
<td>Package will be subjected to a vertical acceleration pulse of 2gs of simple harmonic motion for a duration of 0.5 seconds.</td>
</tr>
<tr>
<td>3 Braking Event</td>
<td>The package will be subjected to a 1g acceleration in the forward and lateral directions.</td>
</tr>
<tr>
<td>Analysis Type</td>
<td>Standard</td>
</tr>
<tr>
<td>-------------------------------------</td>
<td>---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>4 Hard Set Down Event</td>
<td>Package will be subjected to a 3gs deceleration in the normal transport and loading orientation.</td>
</tr>
<tr>
<td>5 Package tiedown attachments</td>
<td>Tie down design and associated packaging will have sufficient strength to maintain containment when subjected to the following loading a longitudinal deceleration (0.8g forward, 0.5g rearward), a transverse acceleration (0.5g), a vertical acceleration (0.2g).</td>
</tr>
<tr>
<td>6 Package Lift Points</td>
<td>Package lift points will have a safety factor of 3 based on the material yield strength and will not impair the performance of the packaging</td>
</tr>
<tr>
<td>7 Thermal Extremes</td>
<td>The package material can sustain ambient temperatures of -27°F (-33°C) to 115°F (46°C) without loss of structural integrity.</td>
</tr>
<tr>
<td>8 Free Drop Test</td>
<td>The specimen must drop onto the target so as to suffer maximum damage to the safety features being tested, and:</td>
</tr>
<tr>
<td></td>
<td>1. The height of the drop measured from the lowest point of the specimen to the upper surface of the target may not be less than the distance specified in the table below, for the applicable package mass. The target must be as specified in 49 CFR 173.465(c)(5).</td>
</tr>
<tr>
<td></td>
<td>2. For packages containing fissile material, the free drop test specified in paragraph (c)(1) of this section must be preceded by a free drop from a height of 1 foot (0.3 m) on each corner, or in the case of cylindrical packages, onto each of the quarters of each rim.</td>
</tr>
<tr>
<td></td>
<td>3. For fiberboard or wood rectangular packages with a mass of 110 pounds (50 kg) or less, a separate specimen must be subjected to a free drop onto each corner from a height of 1 foot (0.3m).</td>
</tr>
<tr>
<td></td>
<td>4. For cylindrical fiberboard packages with a mass of 220 pounds (100kg) or less, a separate specimen must be subjected to a free drop onto each of the quarters of each rim from a height of 0.3 m (1 ft).</td>
</tr>
<tr>
<td></td>
<td>5. The target for the free drop must be a flat, horizontal surface of such mass and rigidity that any increase in its resistance to displacement or deformation upon impact by the specimen would not significantly increase the damage to the specimen.</td>
</tr>
<tr>
<td>9 Stacking Test</td>
<td>1. The specimen must be subjected for a period of at least 24 hours to a compressive load equivalent to the greater of the following:</td>
</tr>
<tr>
<td></td>
<td>a. Five times the mass of the actual package; or</td>
</tr>
<tr>
<td></td>
<td>b. The equivalent of 1.9 psi (13kilopascals) multiplied by the vertically projected area of the package.</td>
</tr>
</tbody>
</table>

### Table G-4. IP-2 Package NCT Analysis Areas

<table>
<thead>
<tr>
<th>Packaging Mass</th>
<th>Free Drop Distance</th>
</tr>
</thead>
<tbody>
<tr>
<td>M&lt;11000 lbs (5000 kg)</td>
<td>4 Feet 1.2 Meters</td>
</tr>
<tr>
<td>11000 lbs (5000 kg) &lt;M&lt;220000 lbs 10000 kg</td>
<td>3 Feet 0.9 Meters</td>
</tr>
<tr>
<td>22000 lbs (10000 kg)&lt;M&lt;330000 lbs (15000 kg)</td>
<td>2 Feet 0.6 Meters</td>
</tr>
<tr>
<td>M&gt; 33000 lbs (15000 kg)</td>
<td>1 Foot 0.3 Meters</td>
</tr>
</tbody>
</table>

2. For packages containing fissile material, the free drop test specified in paragraph (c)(1) of this section must be preceded by a free drop from a height of 1 foot (0.3 m) on each corner, or in the case of cylindrical packages, onto each of the quarters of each rim.

3. For fiberboard or wood rectangular packages with a mass of 110 pounds (50 kg) or less, a separate specimen must be subjected to a free drop onto each corner from a height of 1 foot (0.3m).

4. For cylindrical fiberboard packages with a mass of 220 pounds (100kg) or less, a separate specimen must be subjected to a free drop onto each of the quarters of each rim from a height of 0.3 m (1 ft).

5. The target for the free drop must be a flat, horizontal surface of such mass and rigidity that any increase in its resistance to displacement or deformation upon impact by the specimen would not significantly increase the damage to the specimen.
Table G-4. IP-2 Package NCT Analysis Areas

<table>
<thead>
<tr>
<th>Analysis Type</th>
<th>Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>2. The compressive load must be applied uniformly to two opposite sides of the specimen, one of which must be the base on which the package would normally rest. Note: In cases where the package will not be stacked, an administrative control prohibiting package stacking will be implemented and the Staking Test will not be required.</td>
<td></td>
</tr>
</tbody>
</table>

Table G-5. Type A Package NCT Analysis Areas

<table>
<thead>
<tr>
<th>Analysis Type</th>
<th>Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Vertical Vibration Frequency and PSD</strong></td>
<td></td>
</tr>
<tr>
<td>Frequency (Hz)</td>
<td>PSD (G²/Hz)</td>
</tr>
<tr>
<td>1.0</td>
<td>4.0E-03</td>
</tr>
<tr>
<td>2.0</td>
<td>3.0E-02</td>
</tr>
<tr>
<td>4.0</td>
<td>3.0E-02</td>
</tr>
<tr>
<td>6.5</td>
<td>2.0E-03</td>
</tr>
<tr>
<td>2. Impulse Event</td>
<td>Package will be subjected to a vertical acceleration pulse of 2gs of simple harmonic motion for a duration of 0.5 seconds.</td>
</tr>
<tr>
<td>3. Braking Event</td>
<td>The package will be subjected to a 1g acceleration in the forward and lateral directions.</td>
</tr>
<tr>
<td>4. Hard Set Down Event</td>
<td>Package will be subjected to a 3gs deceleration in the normal transport and loading orientation.</td>
</tr>
<tr>
<td>5. Package tiedown attachments</td>
<td>Tie down design and associated packaging will have sufficient strength to maintain containment when subjected to the following: loading a longitudinal deceleration (0.8g forward, 0.5g rearward), a transverse acceleration (0.5g), a vertical acceleration (0.2g).</td>
</tr>
<tr>
<td>6. Package Lift Points</td>
<td>Package lift points will have a safety factor of 3 based on the material yield strength and will not impair the performance to the packaging</td>
</tr>
<tr>
<td>7. Thermal Extremes</td>
<td>The package material can sustain ambient temperatures of -27°F (-33°C) to 115°F (46°C) without loss of structural integrity.</td>
</tr>
<tr>
<td>8. Tamper Indicator</td>
<td>The outside of the packaging incorporates a feature, such as a seal, that is not readily breakable, and that, while intact, is evidence that the package has not been opened. In the case of packages shipped in closed transport vehicles in exclusive use, the cargo compartment, instead of the individual packages, may be sealed.</td>
</tr>
<tr>
<td>9. Minimum External Dimensions</td>
<td>The smallest external dimension of the package is not less than 4 inches (10 cm).</td>
</tr>
</tbody>
</table>
**Table G-5. Type A Package NCT Analysis Areas**

<table>
<thead>
<tr>
<th>Analysis Type</th>
<th>Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 Containment and shielding</td>
<td>Containment and shielding is maintained during transportation and storage in a temperature range of -27°F (-33°C) to 115°F (46°C). Special attention shall be given to liquid contents and to the potential degradation of the packaging materials within the temperature range.</td>
</tr>
<tr>
<td>11 Containment System</td>
<td>The packaging must include a containment system securely closed by a positive fastening device that cannot be opened unintentionally or by pressure that may arise within the package during normal transport. Special form Class 7 (radioactive) material, as demonstrated in accordance with 49 CFR 173.469, may be considered as a component of the containment system. If the containment system forms a separate unit of the package, it must be securely closed by a positive fastening device that is independent of any other part of the package.</td>
</tr>
<tr>
<td>12 Gas Generation</td>
<td>For each component of the containment system account is taken, where applicable, of radiolytic decomposition of materials and the generation of gas by chemical reaction and radiolysis.</td>
</tr>
<tr>
<td>13 Reduced Pressure</td>
<td>The containment system will retain its radioactive contents under the reduction of ambient pressure to 3.6 psi (25 kPa).</td>
</tr>
<tr>
<td>14 Valves</td>
<td>Each valve, other than a pressure relief device, is provided with an enclosure to retain any leakage.</td>
</tr>
<tr>
<td>15 Shielding</td>
<td>Any radiation shield that encloses a component of the packaging specified as part of the containment system will prevent the unintentional escape of that component from the shield.</td>
</tr>
<tr>
<td>16 Tie Down</td>
<td>Failure of any tie-down attachment that is a structural part of the packaging, under both normal and accident conditions, must not impair the ability of the package to meet other requirements of this subpart.</td>
</tr>
<tr>
<td>17 Containment / Dose Rate</td>
<td>When evaluated against the performance requirements of this section and the tests specified in 49CFR 173.465 or using any of the methods authorized by 49 CFR 173.461(a), the packaging will prevent— 1. Loss or dispersal of the radioactive contents; and 2. A significant increase in the radiation levels recorded or calculated at the external surfaces for the condition before the test.</td>
</tr>
</tbody>
</table>
### Table G-5. Type A Package NCT Analysis Areas

<table>
<thead>
<tr>
<th>Analysis Type</th>
<th>Standard</th>
</tr>
</thead>
</table>
| 18 Requirements for Type A Packages containing Liquids | Each packaging designed for liquids will--  
1. Be designed to provide for ullage to accommodate variations in temperature of the contents, dynamic effects and filling dynamics;  
2. Meet the conditions prescribed in 49 CFR 173.412(j) when subjected to the tests specified in 49 CFR 173.466 or evaluated against these tests by any of the methods authorized by 49 CFR 173.461(a); and  
3. Either--  
a. Have sufficient suitable absorbent material to absorb twice the volume of the liquid contents. The absorbent material must be compatible with the package contents and suitably positioned to contact the liquid in the event of leakage; or  
b. Have a containment system composed of primary inner and secondary outer containment components designed to assure retention of the liquid contents within the secondary outer component in the event that the primary inner component leaks. |
| 19 Requirements for Type A Packages containing Gases | Each package designed for gases, other than tritium not exceeding 40 TBq (1080Ci) or noble gases not exceeding the A2 value appropriate for the noble gas, will be able to prevent loss or dispersal of contents when the package is subjected to the tests prescribed in 49 CFR 173.466 or evaluated against these tests by any of the methods authorized by 49 CFR 173.461(a) |
| 20 Free Drop Test | The specimen must drop onto the target so as to suffer maximum damage to the safety features being tested, and:  
1. The height of the drop measured from the lowest point of the specimen to the upper surface of the target may not be less than the distance specified in the table below, for the applicable package mass. The target must be as specified in 49 CFR 173.465(c)(5). |

<table>
<thead>
<tr>
<th>Packaging Mass</th>
<th>Free Drop Test</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Feet</td>
</tr>
<tr>
<td>M&lt;11000 lbs (5000 kg)</td>
<td>4</td>
</tr>
<tr>
<td>11000 lbs (5000 kg) &lt;M&lt;22000 lbs 10000 kg</td>
<td>3</td>
</tr>
<tr>
<td>22000 lbs (10000 kg)&lt;M&lt;33000 lbs (15000 kg)</td>
<td>2</td>
</tr>
<tr>
<td>M&gt; 33000 lbs (15000 kg)</td>
<td>1</td>
</tr>
</tbody>
</table>
Table G-5. Type A Package NCT Analysis Areas

<table>
<thead>
<tr>
<th>Analysis Type</th>
<th>Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2. For packages containing fissile material, the free drop test specified in paragraph (c)(1) of this section must be preceded by a free drop from a height of 1 foot (0.3m) on each corner, or in the case of cylindrical packages, onto each of the quarters of each rim.</td>
</tr>
<tr>
<td></td>
<td>3. For fiberboard or wood rectangular packages with a mass of 110 pounds (50kg) or less, a separate specimen must be subjected to a free drop onto each corner from a height of 1 foot (0.3m).</td>
</tr>
<tr>
<td></td>
<td>4. For cylindrical fiberboard packages with a mass of 220 pounds (100kg) or less, a separate specimen must be subjected to a free drop onto each of the quarters of each rim from a.</td>
</tr>
<tr>
<td></td>
<td>5. The target for the free drop must be a flat, horizontal surface of such mass and rigidity that any increase in its resistance to displacement or deformation upon impact by the specimen would not significantly increase the damage to the specimen.</td>
</tr>
<tr>
<td>21 Stacking Test</td>
<td>1. The specimen must be subjected for a period of at least 24 hours to a compressive load equivalent to the greater of the following:</td>
</tr>
<tr>
<td></td>
<td>a. Five times the mass of the actual package; or</td>
</tr>
<tr>
<td></td>
<td>b. The equivalent of 1.9psi (13kilopascals) multiplied by the vertically projected area of the package.</td>
</tr>
<tr>
<td></td>
<td>2. The compressive load must be applied uniformly to two opposite sides of the specimen, one of which must be the base on which the package would normally rest.</td>
</tr>
<tr>
<td></td>
<td>Note: In cases where the package will not be stacked, an administrative control prohibiting package stacking will be implemented and the Staking Test will not be required.</td>
</tr>
<tr>
<td>22 Penetration Test</td>
<td>Penetration test. For the penetration test, the specimen must be placed on a rigid, flat, horizontal surface that will not move significantly while the test is being performed.</td>
</tr>
<tr>
<td></td>
<td>1. A bar of 3.2 cm (1.25 in.) in diameter with a hemispherical end and a mass of 6 kg (13.2 pounds) must be dropped and directed to fall with its longitudinal axis vertical, onto the center of the weakest part of the specimen, so that if it penetrates far enough, it will hit the containment system. The bar may not be significantly deformed by the test; and</td>
</tr>
<tr>
<td></td>
<td>2. The height of the drop of the bar measured from its lower end to the intended point of impact on the upper surface of the specimen must be 1 m (3.3 feet) or greater.</td>
</tr>
<tr>
<td>23 Water Spray Test</td>
<td>Not required by the TSD for onsite packagings.</td>
</tr>
</tbody>
</table>
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Special Packaging Authorizations
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Terms

AASHTO American Association of State Highway and Transportation Officials
CE Contaminated Equipment
CfB Confinement Boundary
CFR Code of Federal Regulations
CtB Containment Boundary
DBGB Dirt & Burial Ground Debris
DOE U.S. Department of Energy
DOT U.S. Department of Transportation
ERDF Environmental Restoration Disposal Facility
F Fuel
FGE Fissile Gram Equivalent
FRP Fiberglass Reinforced Plywood
HDPE High-Density Polyethylene
IP Industrial Package
IM Immobilization Media
ISO International Organizations for Standardization
LDPE Low-Density Polyethylene
LLDPE Low Density Polyethylene/Linear Low Density Polyethylene
M Monolith
OTRS One Time Request for Shipment
PC Prohibited Condition
PETE Polyethylene Terephthalate
PSE Payload Specific Evaluation
PSSD Package-Specific Safety Document
PVDC Polyvinylidene chloride
R Retrieval
RL U.S. Department of Energy, Richland Operations Office
RP Retrieval Package
SPA Special Packaging Authorization
TSD Hanford Sitewide Transportation Safety Document
USQ\textsubscript{T} Unresolved Safety Question Transportation
VOC Volatile Organic Compound
VS Vicat Softening
Appendix H
Special Packaging Authorizations

H.1 Special Packaging Authorization Definitions and Usage

The Hanford Sitewide Transportation Safety Document (TSD) evaluated Special Packaging Authorization (SPA) is a specific class of U.S. Department of Energy (DOE) pre-approved packages/packaging systems where the hazard and transportation safety analyses have been conducted and the results included in the TSD as the authorization basis document. SPAs are intended to eliminate the need and cost of conducting multiple One Time Request for Shipments (OTRS) for either similar shipments of low-activity / high-volume payloads, or high-activity/high-volume payloads where a Type B package is either unavailable or would not be cost effective to produce (e.g., SPAs are risk based). A SPA consists of specific payload(s), authorized packages/packaging systems, and required administrative and engineered controls.

The SPAs are a risk based package system that has been determined, in accordance with TSD criteria, to be equivalent to the U.S. Department of Transportation (DOT) requirements. Changes to any SPA are not subject to evaluation and contractor approval under the USQ1 Program.

The Shipper conducts an evaluation to ensure the payload meets SPA requirements for use. If the payload meets the SPA criteria the Shipper selects the appropriate SPA from the available authorized packages and completes the Shipment Evaluation Checklist (SEC). Any changes to waste characteristics or packagings that are not consistent with the existing SEC and its supporting documentation require a new checklist. For example, payload increases that move the shipment to a new payload bin, exceed thermal or dose rate limits, or a shipping configuration different from that described in the existing checklist require preparation and submittal of a new (revised) checklist.

The initial SEC for a particular bounding payload description will be submitted to RL for review. RL review of each subsequent shipment under the SEC for a given waste stream is not required. The SEC will be sent to the TSD Configuration Manager for informational purposes. If an SEC exceeds the bounds or is not addressed within the SPA, as stated in this TSD, the SEC and associated supporting documentation, including a risk analysis, shall be submitted to RL for approval and a revision to the TSD. Compliance with the SPA is documented by the appropriate SEC and supporting documentation. The SPA is intended to give the Shipper greater flexibility in package and control selection. As the authorized SPAs are an integral part of the TSD, their payloads and configurations are promulgated by RL as part of the TSD. Use of the SPA does not relieve the Shipper from the responsibility of meeting the requirements of the TSD.

The following SPAs are currently authorized:

- Contaminated Equipment (CE) (Section H.2)
- Retrieval Packages (R) (Section H.3)
- Dirt & Burial Ground Debris (DBGD) (Section H.4)
- Monolith (M) (Section H.5)
- Fuel (F) (Section H.6)
The basic general concept of these SPAs is that the payload to be shipped is contained in multiple packages or confinement layers sufficient to meet normal conditions of transport without failure. Additional layers of confinement are then added to the package to reduce the risk of releases under accident conditions that may be encountered onsite.

The TSD defines containment and confinement as follows:

**Confinement system**: the assembly of components of the packaging intended to retain the Class 7 (radioactive) material intact during transport.

**Containment system**: the assembly of components of the packaging intended to prevent the leakage of all Class 7 (radioactive) material (including gases and liquids) during transport within the leakage rate limits specified in the TSD.

Each SPA is based on DOE-approved safety analyses that establish the boundaries and limits of applicability. Shippers must ensure that the payloads shipped under the SPA meet established requirements and limits. Completed SECs are to be retained by the Shipper for a period of at least one year following the last shipment made using the SEC. The SEC will be kept with the other shipping papers and dispositioned in accordance with facility records disposition requirements. The contractor may include additional information and procedural requirements on the checklists.

### H.1.1 General SPA Requirements

The below section outlines general requirements that pertain to all five SPAs (CE, R, DBGD, M, and F). Any requirement specific to a SPA can be found in Sections H.2, H.3, H.4, H.5, and H.6 for CE, R, DBGD, M and F, respectively.

- The shipping papers shall reference which SEC is used for that waste stream with an assigned designation identifying the shipment and payload as part of the specific waste stream. The Shipper is responsible for maintaining copies of all SECs in accordance with TSD requirements. This designation will contain an identifying element for each individual package to facilitate an audit of the SPA implementation. SECs and supporting documentation will be maintained for not less than two years after shipments. Supporting documents include Payload Specific Evaluations (PSEs), SECs, payload analyses and documentation, analyses supporting the evaluations documented on the SEC, packaging specifications, design data, and tie down analyses.

- The Shipper is responsible for evaluating and documenting the shipping configuration to ensure compliance with the SPA requirements. For the purposes of any SPA, waste being transported can include Type B payloads. Packages shipped under any SPA also must meet the acceptance requirements at the receiving facility.

- The use of International Organizations for Standardization (ISO) Freight Containers as IP-2 packagings is not permitted unless supported by proper analyses, tests, and certification to meet IP-2 requirements and authorized by RL.

- The use of vented packages is authorized for all confinement boundaries (CfB), unless otherwise stated.

- No shipments during inclement weather, slick or icy conditions, or limited visibility.
• SPA packaging composed of subcomponents of transportation packages listed in 49 CFR 171-180, must meet the dimensions and allowed weights for design values that the packages were originally certified to, or analyzed under the subcomponent engineering analysis.

• The use of external shielding or engineered stand offs is authorized.

• The transport trailer will be suitable for the load and proposed route.

• Payload within packaging shall be properly restrained within the packaging to prevent damage to confinement boundaries.

• Immobilization media approved by RL is authorized.

• When shipping packages containing liquids under the provisions of SPAs, the packaging shall, as a minimum, meet the following requirements of 49 CFR 173.412 (k)(3):
  
  – Have sufficient suitable absorbent material to absorb twice the volume of the liquid contents. The absorbent material must be compatible with the package contents and suitably positioned to contact the liquid in the event of leakage; or
  
  – Have a containment/confinement system composed of primary inner and secondary outer containment/confinement components designed to enclose the liquid contents completely and ensure retention of the liquid within the secondary outer component in the event that the primary inner component leaks.

The method of compliance with the above requirement for packages containing liquids shall be described in the applicable SEC t or payload specific evaluation.

The General Entry Bounding Requirements are found in Table H1-1, below.
Table H1-1. General Entry Bounding Requirements

<table>
<thead>
<tr>
<th>Area</th>
<th>Bounding Value</th>
<th>Remarks</th>
</tr>
</thead>
</table>
| Structural         | Meets the General Design Requirements of 49 CFR 173.410 and Type A (49 CFR 173.412). | Industrial Packaging (IP)-1 and IP-2 containers constructed in accordance with 49 CFR 173.411 are satisfactory provided that the following elements 49 CFR 173.412 for a Type A container are met:
1. Confinement and shielding is maintained during transportation and storage over a temperature range of –40°C (-40°F) to 70°C (158°F).
2. The packaging must include a confinement system securely closed by a positive fastening device that cannot be opened unintentionally or by pressure that may arise within the package during normal transport. If the confinement system forms a separate unit of the package, it must be securely closed by a positive fastening device that is independent of any other part of the package.
3. For each component of the confinement system account is taken, where applicable, of radiolytic decomposition of materials and the generation of gas by chemical reaction and radiolysis.
4. Any radiation shield that encloses a component of the packaging specified as part of the confinement system will prevent the unintentional escape of that component from the shield.
5. Failure of any tiedown attachment that is a structural part of the packaging, under normal, must not impair the ability of the package to meet other requirements specified in the TSD.  |
2. Confinement and shielding is maintained during transportation and storage over a temperature range of -40°C (-40°F) to 70°C (158°F). |
| Shielding          | Meets 49 CFR 173 requirements                                                  | 1. Allowable dose rate for non-exclusive-use shipments is 2 mSv/h (200 mrem/h) on contact and 0.1 mSv/h (10 mrem/h) at 2 m from the vehicle surface and meets TSD requirements.
2. The use of external shielding or engineered stand offs is authorized if it does not impair design features of the package. |
| Containment/       | Meets 49 CFR 173 requirements                                                  | Package specific containment system based on hazard and meets TSD requirements.                                                                                                                          |
| Confinement        |                                                                                |                                                                                                                                                                                                         |
| Criticality        | CE-, R-, DBGD-, M- and F-SPA specific, see Sections H.2, H.3, H.4, H.5 and H.6, respective |                                                                                                                                                                                                         |
## Table H1-1. General Entry Bounding Requirements

<table>
<thead>
<tr>
<th>Area</th>
<th>Bounding Value</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gas Generation</td>
<td>Hydrogen gas concentration does not exceed 5% by volume in the sealed package over a period of time twice that of the expected shipment time under normal operating conditions.</td>
<td>If venting is required and the shipment cannot be completed within the established shipping window, provisions shall be made before loading the package for venting and purging to reestablish a new shipping window before the original shipping window expires.</td>
</tr>
<tr>
<td>Total Payload</td>
<td>CE-, R-, DBGD-, M- and F-SPA specific, see Sections H.2, H.3, H.4, H.5 and H.6, respective</td>
<td></td>
</tr>
<tr>
<td>Waste Heat</td>
<td>CE-, R-, DBGD-, M- and F-SPA specific, see Sections H.2, H.3, H.4, H.5 and H.6, respective</td>
<td></td>
</tr>
<tr>
<td>Tiedown</td>
<td>Meets 49 CFR 393, Subpart I</td>
<td>--</td>
</tr>
<tr>
<td>Restrictions/Prohibited Materials</td>
<td>CE-, R-, DBGD-, M- and F-SPA specific, see Sections H.2, H.3, H.4, H.5 and H.6, respective</td>
<td></td>
</tr>
</tbody>
</table>
H.2 Contaminated Equipment Special Packaging Authorization

The Contaminated Equipment – Special Packaging Authorization (CE-SPA) is limited to packages that meet the requirements for contaminated equipment waste packages to package and transport waste generated as a result of operation, demolition, repair and/or maintenance of DOE-operated facility systems. The CE-SPA is intended to move equipment that was contaminated incidental to operations, not process equipment whose purpose is to collect contamination, and could be easily changed/replaced as part of its normal function (e.g., ion exchange columns, ion exchange modules, glove boxes, tanks, filters, cold traps, sand filters). The currently authorized payloads (including the addition of Tank Waste Samples) under the CE-SPA are listed in Table H2-4.

Use of multiple layers of flexible material (e.g., plastic sheeting) as the CfB can account for only one layer of confinement. The flexible material will consist of multiple layers that are at least 10 mils thick and placed around the package in a manner that the placement of the seams does not reduce the strength of the two layers providing confinement of the payload during transport. The flexible material must be continuously sealed in such a manner that it allows maintenance of the CfB during handling and transportation activities. When flexible materials are used, the effects of softening and other types of loss of physical properties throughout the anticipated range of transportation environments (e.g., temperature, wind, and weather conditions) must be considered in the supporting documentation.
## Table H2-1. CE SPA Entry Bounding

<table>
<thead>
<tr>
<th>Area</th>
<th>Bounding Value</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Structural</td>
<td>See Table H1-1</td>
<td></td>
</tr>
<tr>
<td>Thermal</td>
<td>See Table H1-1</td>
<td></td>
</tr>
<tr>
<td>Shielding</td>
<td>See Table H1-1</td>
<td></td>
</tr>
<tr>
<td>Containment/Confinement</td>
<td>See Table H1-1</td>
<td></td>
</tr>
<tr>
<td>Criticality</td>
<td>Keff (&lt;0.95)</td>
<td></td>
</tr>
<tr>
<td>Gas Generation</td>
<td>Hydrogen gas concentration does not exceed 5% by volume in the sealed package over a period of time twice that of the expected shipment time under normal operating conditions.</td>
<td>If venting is required and the shipment cannot be completed within the established shipping window, provisions shall be made before loading the package for venting and purging to reestablish a new shipping window before the original shipping window expires.</td>
</tr>
<tr>
<td>Total Payload</td>
<td>(&lt;100) DE-Ci</td>
<td>--</td>
</tr>
<tr>
<td>Fissile Payload</td>
<td>(&lt;450) FGEs</td>
<td>--</td>
</tr>
<tr>
<td>Waste Heat</td>
<td>(&lt;50) Watts</td>
<td>--</td>
</tr>
<tr>
<td>Tiedown</td>
<td>See Table H1-1</td>
<td>--</td>
</tr>
<tr>
<td>Restrictions/Prohibited Materials</td>
<td>No explosive materials, free liquids, pressurized gas containers, or chemically inter-reactive components.</td>
<td>--</td>
</tr>
</tbody>
</table>
Table H2-2. CE SPA Authorized Package Configuration

<table>
<thead>
<tr>
<th>Payload</th>
<th>CE-1</th>
<th>CE-2</th>
<th>CE-3</th>
<th>CE-4</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0 DE-Ci &lt; Payload ≤ 5 DE-Ci</td>
<td>5 DE-Ci &lt; Payload ≤ 25 DE-Ci</td>
<td>25 DE-Ci &lt; Payload ≤ 50 DE-Ci</td>
<td>50 DE-Ci &lt; Payload ≤ 100 DE-Ci</td>
</tr>
<tr>
<td></td>
<td>CtB</td>
<td>CfB</td>
<td>Speed</td>
<td>CtB</td>
</tr>
<tr>
<td>≤ 1 DE-Ci</td>
<td>IP-1</td>
<td>Required</td>
<td>15 mph</td>
<td>Two IP-1</td>
</tr>
<tr>
<td>&gt; 1 DE-Ci</td>
<td>IP-1</td>
<td>Required</td>
<td>10 mph</td>
<td>Two IP-1</td>
</tr>
<tr>
<td>≤ 1 DE-Ci</td>
<td>Two IP-1</td>
<td>Not Required</td>
<td>15 mph</td>
<td>Two IP-1</td>
</tr>
<tr>
<td>&gt; 1 DE-Ci</td>
<td>Two IP-1</td>
<td>Not Required</td>
<td>10 mph</td>
<td>IP-2</td>
</tr>
<tr>
<td>≤ 1 DE-Ci</td>
<td>Two IP-2</td>
<td>Not Required</td>
<td>20 mph</td>
<td>Two IP-2</td>
</tr>
<tr>
<td>&gt; 1 DE-Ci</td>
<td>Two IP-2</td>
<td>Not Required</td>
<td>20 mph</td>
<td>Two IP-2</td>
</tr>
<tr>
<td>≤ 1 DE-Ci</td>
<td>Type A</td>
<td>Not Required</td>
<td>30 mph</td>
<td>Type A</td>
</tr>
<tr>
<td>&gt; 1 DE-Ci</td>
<td>Type A</td>
<td>Not Required</td>
<td>25 mph</td>
<td>Type A</td>
</tr>
<tr>
<td>N/A</td>
<td>Type B</td>
<td>N/A</td>
<td>30 mph</td>
<td>Type B</td>
</tr>
</tbody>
</table>
H.2.1 Contaminated Equipment Packages SPA: Authorized Packaging Configurations/ Administrative Controls

Table H2-3. CE SPA Administrative Controls

<table>
<thead>
<tr>
<th>Road Closure required.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Rolling road closure is acceptable within controlled areas (North of the Wye barricade, 300 Area and 400 Area).</td>
</tr>
<tr>
<td>2. Road closures within controlled areas are optional for payloads containing Sealed Sources with an ANSI N43.6 Certification that meet payload bin CE-1 or CE-2. These Sealed sources may be transported at safe speeds of up to 30 MPH.</td>
</tr>
<tr>
<td>3. Road closures within controlled areas are optional for payloads containing Tank Samples packaged in Hanford Equivalent Type B Packages (e.g., Sample Pig PSSDs) that meet payload bin CE-1 or CE-2. This is an interim authorization until a permanent shipping option can be implemented.</td>
</tr>
<tr>
<td>4. Road closures within controlled areas are optional for payloads &lt; 5 DE-Ci containing Tank Samples packaged in the former Sample Pig Transport System. Due to credit taken for package configuration and payload form, these payloads may be transported at safe speed (not to exceed posted speed).</td>
</tr>
</tbody>
</table>

Contaminated Equipment (CE) to be decontaminated to the extent practicable prior to packaging.
### Table H2-4. Contents Authorized by the CE-SPA

<table>
<thead>
<tr>
<th>Items Covered</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Metal Racks, rack pieces, z-brackets, lead shielding, washed metal debris</td>
<td>Long pole tools</td>
</tr>
<tr>
<td>Metal working tools: saws, drill presses, milling machines, lathes, cutters, mixers, bending presses, extrusion presses, forming presses, material feeders, crushers, and formers. (All hydraulic fluids must be drained.)</td>
<td>Ducting, filter housings, HEPA filters, test equipment, light fixtures, Plexiglas/glass panels, paper, metal, leather, cloth, glass, hoods (various configurations), tanks, filter boxes, glove boxes/hoods, glove box manipulators, and gloves. North Loadout Pit equipment and miscellaneous equipment. Metal piping including joints, tanks, valves, valve covers, valve hand wheels, paper, plastic, wood, metal, absorbents, rubber, leather, cloth, tank sections, drums, rubber hose, air hoses, hydraulic lines &amp; fittings, furnaces, motors, wiring,</td>
</tr>
<tr>
<td>Miscellaneous non-fuel reactor components and hardware¹</td>
<td>Ducting, filter housings, HEPA filters, test equipment, light fixtures, Plexiglas/glass panels, paper, metal, leather, cloth, glass, hoods (various configurations), tanks, filter boxes, glove boxes/hoods, glove box manipulators, and gloves. North Loadout Pit equipment and miscellaneous equipment. Metal piping including joints, tanks, valves, valve covers, valve hand wheels, paper, plastic, wood, metal, absorbents, rubber, leather, cloth, tank sections, drums, rubber hose, air hoses, hydraulic lines &amp; fittings, furnaces, motors, wiring,</td>
</tr>
<tr>
<td>Job Control and Packaging Waste</td>
<td>Associated materials used in packaging (rigging cables &amp; ropes), cloth , plastic (containment control), cribbing (wood) and absorbent</td>
</tr>
<tr>
<td>Empty bottles and other containers including punctured aerosol cans. Empty, crushed DOT Type A, Specification 7A packages packaged in DOT Type A, Specification 7A packages,²</td>
<td>Ducting, filter housings, HEPA filters, test equipment, light fixtures, Plexiglas/glass panels, paper, metal, leather, cloth, glass, hoods (various configurations), tanks, filter boxes, glove boxes/hoods, glove box manipulators, and gloves. North Loadout Pit equipment and miscellaneous equipment. Metal piping including joints, tanks, valves, valve covers, valve hand wheels, paper, plastic, wood, metal, absorbents, rubber, leather, cloth, tank sections, drums, rubber hose, air hoses, hydraulic lines &amp; fittings, furnaces, motors, wiring,</td>
</tr>
<tr>
<td>Instrumentation &amp; Control devices</td>
<td>Tank Farm Instrument Trees, gages, detectors</td>
</tr>
<tr>
<td>Neutralized rags and cleaning materials used with DOE authorized cleaning solutions</td>
<td></td>
</tr>
<tr>
<td>Zircaloy, Zirconium clad metal debris (no fuel, dust or fines), size &gt; 1mm subject to conditions in footnote³.</td>
<td></td>
</tr>
<tr>
<td>Neutralized rags and cleaning materials used with DOE authorized cleaning solutions⁴</td>
<td></td>
</tr>
<tr>
<td>Sealed Sources</td>
<td>DOT certified Sealed Source Special Form Certification, ANSI 43.6 certified sources, other sources, BF3 type detector tubes, medical isotopes.</td>
</tr>
<tr>
<td>Canyon floor waste including residual from all pans.</td>
<td>Waste from the canyon floor including residues from all the pans located on the canyon floor meeting CE-SPA limits.</td>
</tr>
<tr>
<td>Tritium-producing burnable absorber rods, processed</td>
<td></td>
</tr>
<tr>
<td>Tank and Borehole Samples</td>
<td>105KE boreholes, sample pig transport system and Onsite Transfer Cask.</td>
</tr>
<tr>
<td>Lab and hot cell waste</td>
<td>Solid LLW/transuranic/mixed</td>
</tr>
</tbody>
</table>
Table H2-4. Contents Authorized by the CE-SPA

<table>
<thead>
<tr>
<th>Items Covered</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Glove boxes and parts of glove boxes are authorized for shipment under the CE SPA provided the parts being shipped were/are not process equipment whose purpose is to collect radionuclides for processing.</td>
<td></td>
</tr>
<tr>
<td>2 For the purposes of the CE SPA, former DOT 17C and 17H Spec packages (although no longer authorized as spec packages under 49CFR170-180) that are Legacy packages are authorized for shipment under this SPA.</td>
<td></td>
</tr>
<tr>
<td>3 Due to concerns over possible toxicity and pyrophoricity of zircaloy/zirconium, debris or fragment size is limited to pieces greater than 1mm in size and not in either a respirable form or other form that may produce an airborne suspension.</td>
<td></td>
</tr>
<tr>
<td>4 This authorization does not permit shipment of free liquids, nor rags that have not been neutralized (i.e. considered to be reactive materials).</td>
<td></td>
</tr>
</tbody>
</table>
### Contaminated Equipment Packages SPA (CE SPA) Shipment Evaluation Checklist

**Required Packaging System Configuration**

Enter Total payload DE-Ci inventory

**Package Configuration (check one):**

- **CE-1 Total Payload is between 0 and 5 DE-Ci**
  A minimum of an IP-1 package (or authorized equivalent) and additional 1 confinement boundary.

- **CE-2 Total Payload is between 5 and 25 DE-Ci**
  A minimum of 2 IP-1 packages (or authorized equivalent) and no confinement boundary.

- **CE-3 Total Payload is between 25 and 50 DE-Ci**
  A minimum of 2 IP-1 packages (or authorized equivalent) and 1 confinement boundary.

- **CE-4 Total Payload is between 50 and 100 DE-Ci**
  A minimum of 1 Type A package (or authorized equivalent) and 1 confinement boundary.

**Package Evaluation:**

Description of packaging system being used and method of transport: (include description of packages used to meet containment / confinement requirements Package Certification Data including material of construction, who and how certified.

---

**Package Requirements:**

<table>
<thead>
<tr>
<th>Requirements</th>
<th>Yes</th>
<th>No</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Package meets CE SPA Structural Requirements</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Package meets CE SPA Thermal Requirements</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Package meets CE SPA Shielding Requirements</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Package meets CE SPA Containment Requirements</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Package meets CE SPA Tie Down / Load Restraint Requirements</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Copies of Package Tie Down / Restraint Plans will be provided to DOE Traffic Manager at least one week prior to shipping.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Payload Evaluation**

<table>
<thead>
<tr>
<th>Area</th>
<th>Limits</th>
<th>Yes</th>
<th>No</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Payload</td>
<td>&lt; 100 DE-Ci</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fissile Payload</td>
<td>&lt; 450 FGEs</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Criticality</td>
<td>$K_{eff} &lt; 0.95$</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Waste Heat</td>
<td>&lt;50 Watts</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gas Generation Acceptable</td>
<td>&lt; 5 Volume % Flammable Gases</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flammable Gas Limit applies to time duration of loading and transportation activities until received at receipt facility. Inner package may be vented using HEPA filter.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**No Prohibited Materials**

- [ ]

**Administrative Controls**

- [ ] Speed Restriction (30 mph road for Type B or equivalent package, 10 mph for Type A or equivalent Package).
- [ ] Road Closure

**Signed**

| Organization | Date: |
H.3 Retrieval Package Special Packaging Authorization

The Retrieval Package – Special Packaging Authorization (R-SPA) is limited to packages that meet the definition of retrieval packages (RPs). Disposition procedures for RPs that do not meet, at a minimum, Type A (or equivalent) requirements, or that contain Prohibited Conditions (PCs) are included within the R-SPA (H3-2). The Shipper will be given flexibility in selecting the packaging components to meet the containment and confinement requirements and Administrative Controls of this SPA. The R-SPA is intended to allow the efficient packaging and transportation of RPs either using the existing packages or placing the RPs inside IPs, and/or DOT Type A Specification 7A packagings. These packages also are referred to as Legacy Waste Packages. At its simplest, the R-SPA provides shipping authorization to permit RPs to be transported to a disposal facility, characterization/treatment/process facility or to storage facility. If transported to a storage facility, the RP can be transported one time to a characterization/treatment/process facility. Any additional shipment made using the R-SPA is not authorized. As analyzed under the R-SPA, RPs shall be configured to ensure that there will be no loss or dispersal of contents from the package under normal transport conditions.

The R-SPA is intended to allow shipment of existing RPs and not newly generated waste except for those instances where the newly generated waste is the result of remediating RPs. For the purposes of this SPA, RPs also include packages containing payloads that have been in long-term storage in facilities under controlled conditions (i.e., not necessarily buried).

The R-SPA seeks to minimize the number of packages being shipped that require being place inside another radioactive packaging. RPs meeting specified R-SPA requirements may be shipped by the most direct approved route with no intermediate stops to a remediation facility as is (i.e., without being place inside another qualified CfB). R-SPA payloads can be designated into the following Payload Types (Table H3-1):

1. Payloads that may be shipped without being placed inside another qualified CfB and that do not contain PCs are designated as payload R-1. RPs with questionable integrity and containing no known PCs may be shipped by the most direct approved route with no intermediate stops to a remediation facility within another qualified CfB. This payload is designated as Payload R-2.

2. RPs containing PCs are designated as (depending on PCs present) payload R-3 through R-6. RPs containing PCs may be shipped by the most direct approved route with no intermediate stops to a remediation facility inside another qualified CfB with additional engineered and administrative controls on a one-time basis. RPs containing multiple types of PCs will be shipped based on specific controls for the most restrictive PC present.

3. RPs that have no creditable package (i.e., the original package has either deteriorated or been damaged to the point where it is deemed unsafe to ship) are designated as payload R-7.

These payloads may be shipped by the most direct approved route with no intermediate stops to a remediation facility with the original contents placed inside another qualified CfB with additional engineered and administrative controls. It is assumed for the purpose of the R-SPA that any...
known PCs will be removed from the payload contents prior to being inside another qualified CfB and shipment for separate handling and disposition.

Payload designations are summarized in Table H3-1. Designations under this SPA are to be based on the best available knowledge concerning payload contents. This SPA credits the controls and limitations that existed at the time the packages were originally shipped. This means that previous shipping records and databases, such as the Solid Waste Information and Tracking System, can provide data in making appropriate designations of payload contents and types for the single authorized shipment to the remediation facility under this SPA.

The R-SPA uses a hierarchical approach to develop the packaging system authorized configurations and controls. The intent is to determine if a RP can be safely transported to a disposal facility, characterization/treatment/process facility or to storage facility. To make this determination, the RP integrity is first evaluated (Figure H3-1). Points will be assigned to a RP to determine if the package requires another qualified CfB prior to shipment (i.e., is there an unacceptable level of risk of loss of containment during transport without additional engineered and administrative controls). Secondly, the known contents of the RP are evaluated. For payloads containing PCs the R-SPA uses a scoring system (Table H3-5) to assign each RP a score that can be converted into a package configuration and supporting administrative controls. This methodology permits the evaluation of retrieved packages containing non-PC contents, single type PCs, and multiple type PCs. As the risk from the potential release of a particular package’s payload increases, additional engineered and administrative controls will be required in a graded approach.

In accordance with a graded approach, this SPA authorizes the use of various packaging configurations and administrative controls. The R-SPA packaging systems consist of, at a minimum, a Containment Boundary (CtB) and a CfB (if required) and associated administrative controls to meet the requirements of a Risk Based package under the TSD. Based on the payload, the packaging system may use Industrial Packages (IP), Type A packages or Type B Packages for the CtB; and IP, Type A, Type B packages or other analyzed effective CfBs (e.g., multiple layers of heat sealed or taped heavy gage plastic). Packaging sub-containers (e.g., failed fuel rod containers) may be credited as either a CtB or CfB provided they have been approved by RL. For the purposes of this SPA, waste being transported can include Type B payloads. The use of ISO Freight Containers as IP-2 packages is not permitted unless supported by proper analyses, tests, and certification to meet IP-2 requirements, and authorized by RL.

Use of multiple layers of flexible material (e.g., plastic sheeting) as the CfB can account for only one layer of confinement. The flexible material will consist of multiple layers that are at least 10 mils thick each and placed around the package in a manner that the placement of the seams does not reduce the strength of the two layers providing confinement of the payload during transport. The flexible material must be continuously sealed in such a manner that it allows maintenance of the confinement boundary during handling and transportation activities. When flexible materials are used, the effects of softening and other types of loss of physical properties throughout the anticipated range of transportation environments (e.g., temperature, wind, and weather conditions) must be considered in the supporting documentation (see definition for flexible confinement materials in the attached Annex A).
<table>
<thead>
<tr>
<th>Payload</th>
<th>Description</th>
<th>Shipping Configuration</th>
<th>Determination</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>R-1</td>
<td>RETRIEVED TYPE A PACKAGES WITH STRUCTURAL INTEGRITY AND NO PCs</td>
<td>SHIP AS IS WITHOUT BEING PLACED INSIDE ANOTHER CIB IN ACCORDANCE WITH ANNEX C AND TABLE H3-4</td>
<td>LESS THAN 100 POINTS PER PACKAGE SCORE CARD (TABLE H3-5)</td>
<td></td>
</tr>
<tr>
<td>R-2</td>
<td>RETRIEVAL PACKAGES ARE PLACED WITHIN ANOTHER CIB – NO PCs.</td>
<td>RP ARE PLACED WITHIN ANOTHER CIB AND SHIP IN ACCORDANCE WITH ANNEX C AND TABLE H3-4</td>
<td>100 POINTS OR MORE PER PACKAGE SCORE CARD (TABLE H3-5)</td>
<td></td>
</tr>
<tr>
<td>R-3</td>
<td>HIGH FISSION GRAM TYPE A PACKAGES</td>
<td>RP ARE PLACED WITHIN ANOTHER CIB AND SHIP IN ACCORDANCE WITH ANNEXES B &amp; C AND TABLE H3-4</td>
<td>1. &gt;250 FGE TO &lt; 300 FGE - IP-1 CIB 2. &gt;300 FGE TO &lt; 350 FGE - IP-2 CIB 3. &gt;350 FGE TO &lt; 450 FGE – TYPE A CIB 4. &gt; 450 FGES - OTRS</td>
<td></td>
</tr>
<tr>
<td>R-4</td>
<td>FLAMMABLE GAS CONCENTRATION TYPE A PACKAGES</td>
<td>RP ARE PLACED WITHIN ANOTHER CIB AND SHIP IN ACCORDANCE WITH ANNEXES B &amp; C AND TABLE H3-4</td>
<td>FLAMMABLE GASES&lt; LEL LOWER FLAMMABILITY LIMIT</td>
<td></td>
</tr>
<tr>
<td>R-5</td>
<td>PC TYPE A PACKAGES</td>
<td>RP ARE PLACED WITHIN ANOTHER CIB AND SHIP IN ACCORDANCE WITH ANNEXES B &amp; C AND TABLE H3-4</td>
<td>1. CORROSIVES PRESENT? 2. CORROSIVES ARE PRESENT. 3. CHEMICAL REACTIONS?</td>
<td></td>
</tr>
<tr>
<td>R-6</td>
<td>AQUEOUS FREE LIQUIDS</td>
<td>RP ARE PLACED WITHIN ANOTHER CIB AND SHIP IN ACCORDANCE WITH ANNEXES B &amp; C AND TABLE H3-4</td>
<td>AQUEOUS FREE LIQUIDS &lt; 2% BY VOLUME</td>
<td></td>
</tr>
<tr>
<td>R-7</td>
<td>NO CREDITABLE PACKAGE</td>
<td>RP ARE PLACED WITHIN ANOTHER CIB AND SHIP IN ACCORDANCE WITH ANNEX C AND TABLE H3-4</td>
<td>VISUAL INSPECTION REVEALS NO CREDITABLE PACKAGE</td>
<td></td>
</tr>
</tbody>
</table>
Figure H3-1. Proposed Retrieval Package SPA (R-SPA) Process Flow
### Table H3-2. R-SPA Entry Bounding Requirements

<table>
<thead>
<tr>
<th>Area</th>
<th>Bounding Value</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Structural</td>
<td>See Table H1-1</td>
<td></td>
</tr>
<tr>
<td>Thermal</td>
<td>See Table H1-1</td>
<td></td>
</tr>
<tr>
<td>Shielding</td>
<td>See Table H1-1</td>
<td></td>
</tr>
<tr>
<td>Containment/Confinement</td>
<td>See Table H1-1</td>
<td></td>
</tr>
<tr>
<td>Criticality</td>
<td>$k_{\text{eff}} &lt; 0.95$</td>
<td></td>
</tr>
<tr>
<td>Gas Generation</td>
<td>$&lt; \text{LEL Flammable Gases}$</td>
<td></td>
</tr>
<tr>
<td>Total Payload</td>
<td>$&lt; 100 \text{DE-Ci}$</td>
<td></td>
</tr>
<tr>
<td>Fissile Payload</td>
<td>$&lt; 450 \text{FGEs per package and conveyance}$</td>
<td></td>
</tr>
<tr>
<td>Waste Heat</td>
<td>$&lt; 50 \text{Watts}$</td>
<td></td>
</tr>
<tr>
<td>Tiedown</td>
<td>See Table H1-1</td>
<td></td>
</tr>
<tr>
<td>Other Payload Restrictions / Other Prohibited Materials</td>
<td>No explosive materials.</td>
<td></td>
</tr>
<tr>
<td>Table H3-3. R-SPA SEC</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-----------------------</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Required Packaging System Configuration**

Enter bounding package payload DE-Ci

<table>
<thead>
<tr>
<th>Payload Type</th>
<th>Shipping Configuration</th>
</tr>
</thead>
<tbody>
<tr>
<td>R</td>
<td></td>
</tr>
<tr>
<td>R-1</td>
<td></td>
</tr>
<tr>
<td>R-2</td>
<td></td>
</tr>
<tr>
<td>R-3</td>
<td></td>
</tr>
<tr>
<td>R-4</td>
<td></td>
</tr>
<tr>
<td>R-5</td>
<td></td>
</tr>
<tr>
<td>R-6</td>
<td></td>
</tr>
<tr>
<td>R-7</td>
<td></td>
</tr>
</tbody>
</table>

**Package Evaluation**

Description of packaging system being used: (include description of packages used to meet containment / confinement requirements, Package Certification Data including material of construction, who and how certified.)

<table>
<thead>
<tr>
<th>Package Requirements</th>
<th>Yes</th>
<th>No</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Package meets R SPA Structural Requirements</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Package meets R SPA Thermal Requirements</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Package meets R SPA Shielding Requirements</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Package meets R SPA Containment Requirements</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Package meets R SPA Tie Down / Load Blocking and Bracing</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Requirements</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Payload Evaluation**

<table>
<thead>
<tr>
<th>Area</th>
<th>Limits</th>
<th>Yes</th>
<th>No</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Payload</td>
<td>&lt; 100 DE-Ci</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fissile Payload</td>
<td>&lt; 450 FGEs</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Criticality</td>
<td>$k_{eff} &lt; 0.95$</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Waste Heat</td>
<td>&lt; 50 Watts</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gas Generation</td>
<td>&lt; LEL Flammable Gases</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Flammable Gas Limit applies to time duration of loading and transportation activities until received at receipt facility. Inner package may be vented using approved filter.

**Prohibited Materials**

<table>
<thead>
<tr>
<th>Administrative Controls</th>
</tr>
</thead>
<tbody>
<tr>
<td>· Speed Restriction (20 mph for all Payload Types except Payload Type R-5, which is limited to 10 mph).</td>
</tr>
<tr>
<td>· Route Control · Road Closure</td>
</tr>
</tbody>
</table>

Signed Organization Date:
Table H3-4. R-SPA Shipment Controls

<table>
<thead>
<tr>
<th>R-SPA Controls</th>
<th>R-1</th>
<th>R-2</th>
<th>R-3</th>
<th>R-4</th>
<th>R-5</th>
<th>R-6</th>
<th>R-7</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Enclosed conveyance&lt;sup&gt;a&lt;/sup&gt;</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td></td>
</tr>
<tr>
<td>Packages Stacking Not Permitted</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Speed restrictions</td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>10</td>
<td>20</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td>Spill containment devices&lt;sup&gt;b&lt;/sup&gt;</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>AR</td>
<td>AR</td>
<td>N</td>
<td></td>
</tr>
<tr>
<td>Neutralization agents&lt;sup&gt;b&lt;/sup&gt;</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>AR</td>
<td>N</td>
<td>N</td>
<td></td>
</tr>
<tr>
<td>Sorbents&lt;sup&gt;b&lt;/sup&gt;</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>AR</td>
<td>AR</td>
<td>N</td>
<td></td>
</tr>
<tr>
<td>Reactive Material Resistant Seals, O-rings, gaskets and fittings, minimum 10 mil thickness agent resistant liner&lt;sup&gt;b&lt;/sup&gt;</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>AR</td>
<td>N</td>
<td>N</td>
<td></td>
</tr>
<tr>
<td>Shipping Window</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td></td>
<td></td>
<td></td>
<td>Inorganic Acids 15</td>
</tr>
<tr>
<td></td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td></td>
<td></td>
<td></td>
<td>Bases 30 days (B.3.2)</td>
</tr>
<tr>
<td></td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td></td>
<td></td>
<td></td>
<td>Other 30 days (B.3.3-5)</td>
</tr>
</tbody>
</table>

AR As Required, depending on package characteristics  
O Optional  
X Required  
N Not Required

Footnotes:
<sup>a</sup> If enclosed conveyance meets requirements, it may be credited as an overpack.
<sup>b</sup> Required for liquid contents.
<sup>c</sup> Low temperature limit applicable to credited packaging components using mild steel or temperature sensitive sealing materials (tape, adhesives), High range applicable to containments using plastics.
Table H3-5. Package Score Card

<table>
<thead>
<tr>
<th>Package Number</th>
<th>Seal Type</th>
<th>Time since Package was sealed (Years)</th>
</tr>
</thead>
</table>

Packages that score 100 or more total points in cumulative degradation points will require over packaging and may require additional mitigation features.

Known PCs Present: (Describe)

<table>
<thead>
<tr>
<th>Type</th>
<th>Amount</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Loss of Containment</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Percent Surface Corrosion</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flammable Gases</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aerosol Cans</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Free Liquids</td>
<td></td>
<td></td>
</tr>
<tr>
<td>High Fissile Grams</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reactive Materials- Acid</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reactive Materials – Bases</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reactive Materials – Organic Solvents</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reactive Materials – Other</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Does Package Exhibit?</th>
<th>Criteria</th>
<th>Points</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Holes, tears, severe dents?</td>
<td></td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>2 Percent Surface Area Degradation (corrosion from General Attack)</td>
<td>&lt;10%</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td></td>
<td>&gt; 10% (per additional 5%)</td>
<td>25</td>
<td></td>
</tr>
<tr>
<td>3 Fissile Gram Equivalents (FGEs)</td>
<td>&lt; 200 FGEs</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td></td>
<td>&gt; 200 FGEs, per each additional 50 FGEs</td>
<td>50</td>
<td></td>
</tr>
<tr>
<td>4 Free Liquids – Water</td>
<td>&lt; 1%</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td></td>
<td>&gt;1%, additional 1%</td>
<td>50</td>
<td></td>
</tr>
<tr>
<td>5 Reactive Materials – Acids</td>
<td>&gt; 2 years since seal time</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>6 Reactive Materials – Bases</td>
<td>&gt; 4 years since seal time</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>7 Reactive Materials – Organic Solvents</td>
<td>&gt; 5 years since seal time</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>8 Reactive Materials – Other</td>
<td>&gt; 5 years since seal time</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>9 Aerosol Cans</td>
<td>Per Can</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>10 Flammable Gases &gt; LEL</td>
<td>Not Authorized for Shipment</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Total Points

Notes: For guidance on scoring packages, see Annex K. For wooden/FRP and concrete packages, use the evaluation criteria and scoring from Table K.2.1 for Package Surface Area Degradation and enter the points in the Total column for rows above corresponding to the criteria for metal packages.
ANNEX OUTLINE (R-SPA)

Annex A: Definitions
Annex B: Prohibited Item Evaluations
  B.1 Flammable Gas Evaluation
    B.1.1 Flammable Gas – General Evaluation
    B.1.2 Aerosol Can Evaluation
  B.2 Criticality Evaluation
    B.2.1 Package Limits
    B.2.2 Conveyance Limits
  B.3 Reactive Materials
    B.3.1 Inorganic Acids
    B.3.2 Bases
    B.3.3 Organic Acids
    B.3.4 Organic Solvents
    B.3.5 Other Reactive Materials
  B.4 Free Liquid Water Evaluation
Annex C: Packaging Evaluation
Annex D: Payload Evaluation
Annex E: Structural Evaluation
Annex F: Thermal Evaluation
Annex G: Containment Evaluation
Annex H: Shielding Evaluation
Annex I: Quality Assurance, Operating Procedures and Acceptance Tests and Maintenance Program Requirements
Annex J: Deleted
Annex K: Guidelines for Determining Package Surface Deterioration
  K.1 Metal Packaging
  K.2 Wooden / Glass Reinforced Plastic Packaging
  K.3 Concrete
Annex L: Guidance on Allowed Repairs to Retrieval Packages (RPs)
  L.1 Metal Packages
  L.2 Wood FRP Packages
  L.3 Concrete Packages
Annex M: Sample Shipment Log
Annex N: References
Annex A to Retrieval SPA -- Definitions

**Confinement System**: the assembly of components of the packaging intended to retain the Class 7 (radioactive) material intact during transport.

**Containment System**: the assembly of components of the packaging intended to prevent the leakage of all Class 7 (radioactive) material (including gases and liquids) during transport within the leakage rate limits specified in the TSD.

**Container**: a receptacle for holding or storing material. As used in Packaging and Transportation activities, containers generally have not been evaluated as meeting DOT requirements for packaging.

**Degraded Package**: a package where, through the action of use, or environmental and operating conditions, the package no longer meets as-built DOT requirements for that type of package.

**Enclosed Conveyance**: To be credited under the R-SPA, an enclosed conveyance must be demonstrated to meet the 49 CFR 173 package performance requirements for at least an Industrial Package 2 (IP-2) when credited as a CtB, or IP-1 as a CfB.

**Flexible Confinement Material**: Depending on the Payload Type, the use of plastic sheeting, liners, and other flexible materials as a confinement boundary is authorized under this SPA. Flexible materials used under the R-SPA must each be at least 10 mils thick with a Minimum Vicat Softening (VS) Point value of 200°F (93.33°C). Multiple layers of flexible materials must be placed in the package in a manner that placement of the seams does not reduce the strength of the two layers and provides confinement of the payload during transport. The flexible material must be sealed in such a manner that it allows maintenance of the confinement boundary during handling and transportation activities (e.g., continuous seal). Spot seals are not authorized. When flexible materials including tapes and glue are used, the effects of softening and other types of loss of physical properties throughout the anticipated range of transportation environments (e.g., temperature, wind, and weather conditions, chemical environment) will have to be considered. For cold temperature operation, effects of cold and possible brittle fracture of the plastic sheeting and sealing surfaces will be considered. Effects of solar insolation will be considered. The thermal analysis will consider the VS temperature, total waste heat balance and performance of the flexible containment material under the conditions anticipated for shipment and will include at least a 20 percent Margin of Safety in the analysis. To minimize the chance of use of flexible materials with degraded properties, all such materials used under the R-SPA will be inspected to ensure they are within the manufacturer's shelf life requirements.

Common plastics that have been evaluated include:

1. PETE - Polyethylene Terephthalate (PET) includes Mylar.
2. HDPE - High-Density Polyethylene.
3. LDPE - Low-Density Polyethylene includes LDPE/LLDPE (low density polyethylene/linear low density polyethylene).
4. PVDC – Polyvinylidene chloride.

**Free Liquid**: unconstrained materials in the liquid phase in the package. It may be present due to being separated from the package payload, or the package introduced to the environment.
(e.g., rain or water ingress). Free liquids are a concern as far as their potential to impact the packaging’s containment boundary or their ability to impair the structural performance of the packaging. Incidental accumulations of small amounts of water (i.e., less than 1 percent of the package volume) are not considered to be free liquids for the purpose of the R-SPA.

**Prohibited Conditions:** For the purposes of the R-SPA, PCs are defined as those portions of a Retrieval Package’s payload that contain the following types of materials:

1. High Fissile Gram Content (HFGC)  
   
2. Flammable Gas Content  
   
3. Reactive Materials  
   
4. Free Liquids (Water Only)

**Reactive Materials:** Materials present in the payload whose interaction with each other, other packaging components, or the environment could affect either the packaging system’s containment or confinement boundaries. For the purpose of the R-SPA, reactive materials include explosive compounds, corrosive materials (acids and bases), oxidizers, pyrophoric materials and organic solvents.

**Retrieval Packages:** Retrieval packages are waste containers being retrieved for the purpose of characterization, transfer, or other operations that were stored in belowground or aboveground storage prior to May 1, 2010. Due to the conditions in storage environments, their condition may be degraded structurally from that of a package that meets the specification requirements. Packages placed in storage after January 1, 2010, will be compliant with the requirements for storage at the facility and should be candidates for compliant transport under the provisions and requirements of the TSD.
Operating Instructions for the TL-2000 and TL-2001

1. Unplug the TL-2000 or TL-2001 from the power source before any service is performed.

2. Refer to the instructions for service and repair as outlined in the operating manual provided with the equipment.

3.doi.org/10.1111/j.1748-7737.2011.00609.x

Preliminary Study

The preliminary study was conducted to assess the feasibility of using the TL-2000 and TL-2001 for various applications. The results of the study are summarized below:

A. TL-2000

1. Accuracy: 0.1% of reading
2. Resolution: 0.01 units
3. Range: 0-1000 units

B. TL-2001

1. Accuracy: 0.2% of reading
2. Resolution: 0.02 units
3. Range: 0-2000 units

The TL-2000 and TL-2001 were found to be suitable for the intended applications. Further testing and evaluation were recommended to confirm the results of the preliminary study.

References

1. doi.org/10.1111/j.1748-7737.2011.00609.x

Appendix A

Test Results

A1. TL-2000 Test Results

<table>
<thead>
<tr>
<th>Test</th>
<th>Accuracy</th>
<th>Resolution</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.1%</td>
<td>0.01</td>
<td>1000</td>
</tr>
<tr>
<td>2</td>
<td>0.2%</td>
<td>0.02</td>
<td>2000</td>
</tr>
</tbody>
</table>

A2. TL-2001 Test Results

<table>
<thead>
<tr>
<th>Test</th>
<th>Accuracy</th>
<th>Resolution</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.1%</td>
<td>0.01</td>
<td>1000</td>
</tr>
<tr>
<td>2</td>
<td>0.2%</td>
<td>0.02</td>
<td>2000</td>
</tr>
</tbody>
</table>

The test results indicate that the TL-2000 and TL-2001 meet the specified performance criteria. Further testing and evaluation are recommended to confirm the results.
that it is reasonable to expect that packages containing VOCs may have flammable concentrations in the void volume depending on prevailing ambient conditions and the vapor pressure of the VOC(s) in question.


HNF-25634 and S-CLC-F-00533 provide a substantial basis on which to bound the probability and consequences of a VOC deflagration with those of a hydrogen deflagration. Both documents base their calculations on the adiabatic, isochoric, complete combustion model that yields highly conservative results for container internal pressures resulting from deflagration. S-CLC-F-00533 examines these conservative results and adjusts them for actual conditions to obtain more realistic, but still conservative, estimates of drum pressures resulting from VOC deflagrations.

S-CLC-F-00533 demonstrates VOC deflagration pressures for stoichiometric (i.e., worst case) mixtures of various VOCs in air are bounded by the hydrogen deflagration pressures measured in WSRC-TR-90-165 for drums whose lids were not ejected during deflagration testing.

S-CLC-F-00533 further notes the following:

- The presence of waste in a container dampens the effect of a deflagration by absorbing or cushioning a significant portion of the deflagration energy and by diminishing the completeness of the deflagration reaction due to isolated pockets of the fuel/air mixture. This applies equally to both hydrogen and VOC deflagrations. Results reported in Gordon (1986) show that even with a stoichiometric hydrogen-air mixture (30 vol% hydrogen), drum lids were not blown off as long as the drums were more than half-full of waste.

Both HNF-25634 and S-CLC-F-00533 contain substantial additional information. However, the points noted above demonstrate that a hydrogen deflagration is bounding and that the presence of waste and the container geometry (length-to-diameter ratio) are partial mitigating factors for deflagrations in general.

1. Package failure by Detonation is incredible. Based on the information above, and specifically as discussed in S-CLC-F-00533: A VOC deflagration inside a waste drum will not transition to a detonation because the minimum required length-to-diameter ratio for a deflagration-to-detonation transition is approximately 7; i.e., the height or length of the void volume must be greater than 7 times its width. Neither drums nor boxes have length-to-diameter ratios of this magnitude.

2. Package fails deflagration (Unmitigated), Containment maintained (Mitigated). Based on DOE-STD-5506-2007, Preparation of Safety Basis Documents for Transuranic (TRU) Waste Facilities, the RP could suffer loss of containment from a deflagration event initiated from the combustible gases from either the waste payload or from breeched aerosol cans (Unmitigated). The application of engineered and administrative controls; e.g., over packing, temperature limits, use of awnings or shades would reduce the risk of
failure of the package causing the release of the radioactive payload by reducing potential
ignition sources.

3. Package failure by over pressurization occurs at pressures greater than 12 psig
   (DOE-STD-5506-2007).

4. Aerosol can breech modes are mechanical and thermal.

5. Ignition sources are mechanical, thermal, and electrical.

For a Deflagration to occur, three things are necessary:

- Fuel,
- Oxygen (or an oxidizer) and
- An ignition source is required to initiate the combustion process.

Once the combustible gas has escaped from the can, the fuel air mixture can be ignited in one of
three ways:

- Mechanical: Interaction of package internal components generates a spark.
- Thermal: Temperatures within the package cause auto ignition of fuel (860°F for
  Isobutane) and reach high enough temperature to cause spontaneous combustion of
  other waste materials (e.g., rags, paper etc.).
- Electrical: Discharge of built up static electricity or electrical discharge from
  discarded electrical components (batteries, capacitors etc.) causes ignition.

6. Package Void Fraction in package is at least 40 percent.

The Solid Waste Operations Complex Master Documented Safety Analysis (MDSA), HNF-14741
Rev. 10, models the void fraction of a retrieval drum as 50 percent of the drum’s volume. This
evaluation assumes Package (includes boxes and drums) Void fraction is conservatively assumed
to be 40 percent.

7. Flammable gas mixture present in package can be modeled as an ideal gas.
Table B.1.2-1. Aerosol Can Propellants

<table>
<thead>
<tr>
<th>Name</th>
<th>Formula</th>
<th>Heat of combustion (kJ/mol)</th>
<th>Flammability limits in Air</th>
<th>Moles O₂ reacted per mole gas</th>
<th>Heat of combustion per mol O₂ (kJ/mol)</th>
<th>NFPA instability rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>n-Butane</td>
<td>C₄H₁₀</td>
<td>2632</td>
<td>1.8% - 8.4%</td>
<td>6.5</td>
<td>404.9</td>
<td>0</td>
</tr>
<tr>
<td>1,1- Difluoroethane</td>
<td>C₂H₄F₂</td>
<td>Not found</td>
<td>3.7% -18.0%</td>
<td>2.5</td>
<td>-----</td>
<td>0</td>
</tr>
<tr>
<td>Dimethyl ether</td>
<td>C₂H₆O</td>
<td>1277</td>
<td>2.0% - 50%</td>
<td>3</td>
<td>425.7</td>
<td>1</td>
</tr>
<tr>
<td>Isobutane</td>
<td>C₄H₁₀</td>
<td>2625</td>
<td>1.8% - 8.4%</td>
<td>6.5</td>
<td>403.8</td>
<td>0</td>
</tr>
<tr>
<td>Methyl ethyl ether</td>
<td>C₃H₈O</td>
<td>Not found</td>
<td>2.0% - 10.1%</td>
<td>4.5</td>
<td>-----</td>
<td>1</td>
</tr>
<tr>
<td>Propane</td>
<td>C₃H₈</td>
<td>2039</td>
<td>2.2% - 9.5%</td>
<td>5</td>
<td>407.8</td>
<td>0</td>
</tr>
</tbody>
</table>

Source: Table is adapted from HNF-31228, Table A-2.

Assumptions:
- Cans are full
- Can propellants are bounded by case for isobutane which in turn is bounded by hydrogen
- Sufficient oxygen is present to support deflagration
- Package failure by detonation is incredible (BEU)
- Package failure by deflagration is extremely unlikely (EU)
- Package fails deflagration (unmitigated), containment maintained (mitigated)
- Package failure by overpressurization occurs at pressures greater than 12 psig
- Can breech modes are mechanical and thermal
- Ignition sources are thermal, mechanical, and static electricity
- Void fraction in package is at least 40%
- Flammable gas mixture present in package can be modeled as an ideal gas.

Figure B.1.2-1. R-SPA Aerosol Can Accident Basis
B.2 Criticality Evaluation

B.2.1 Package Limits

This SPA has established an unmitigated baseline criticality limit for packages of 450 Fissile Gram Equivalents (FGE). This value is low enough to guarantee that criticality is not an issue during transportation or as a result of anticipated accidents because less than a minimum critical mass is involved in the shipment. Standard FGE conversion factors given in Contact Handled Transuranic Waste Authorized Methods for Payload Control (CHTRAMPAC), Rev. 2, May 2005, HNF-EP-0063, or RADCALC shall be used to determine the unmitigated total package FGEs for this SPA.

B.2.2 Conveyance Limits

This SPA has established an unmitigated baseline criticality limit per conveyance of 450 FGE. While a criticality event is theoretically possible in an accident event that results in complete rubblization of the payload into an optimum fissile material enrichment within the resulting debris with optimal moderation and reflection, the review team concluded that rubblization of the fuel would not occur due to package configuration and engineered and administrative controls during Normal Conditions of Transport and Accident Conditions.

B.3 Reactive Materials

The approach taken with the R-SPA for the PC of the presence of Reactive Materials is to allow a limited one-time shipment of the original payload utilizing engineered and administrative controls that minimize the risk of package loss of containment and release of radioactive materials to the environment. These controls are established in the R-SPA. However, due to a wide variety and potentially severe effects of these materials, the Shipper will be required to select and justify some of the controls (including which agent resistant seal will be used to seal the package, absorbents and neutralizing agents) on the R-SPA SEC submitted to RL and TSD Configuration Manager for review.
# Reactive Materials

<table>
<thead>
<tr>
<th>Reactive Materials</th>
<th>Vulnerable Package Component</th>
<th>Severity</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Metal Components</td>
<td>Seals</td>
<td>Other</td>
<td></td>
</tr>
<tr>
<td>1. Inorganic Acids</td>
<td>![check] ![check] ![check]</td>
<td>![check]</td>
<td>UNKN</td>
</tr>
<tr>
<td>2. Bases</td>
<td>![check] ![check]</td>
<td></td>
<td>UNKN</td>
</tr>
<tr>
<td>3. Organic Acids</td>
<td>![check] ![check]</td>
<td></td>
<td>UNKN</td>
</tr>
</tbody>
</table>

1 The degree of severity for a particular agent is dependent on numerous factors including, actual agent, concentration, amount present, ambient temperatures and potential catalyzing or sensitizing agents.

<table>
<thead>
<tr>
<th>Severity</th>
<th>Definition</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extreme</td>
<td>Agent could cause loss of containment on the order of days</td>
<td></td>
</tr>
<tr>
<td>Major</td>
<td>Agent could cause loss of containment on the order of weeks</td>
<td></td>
</tr>
<tr>
<td>Minor</td>
<td>Agent could cause loss of containment on the order of months</td>
<td></td>
</tr>
<tr>
<td>![check] ![check] ![check]</td>
<td>Major Sensitivity</td>
<td></td>
</tr>
<tr>
<td>![check] ![check]</td>
<td>Moderate Sensitivity</td>
<td></td>
</tr>
<tr>
<td>![check]</td>
<td>Minor Sensitivity</td>
<td></td>
</tr>
</tbody>
</table>

## B.3.1 Inorganic Acids

An inorganic acid is any acid containing no carbon atoms. Examples of inorganic acids that typically could be found in retrieval packages include hydrochloric, nitric and sulfuric acids. Due to their potential for causing package failure and loss of containment on a short-term basis (on the order of days), RPs containing inorganic acids will be required to be placed into a qualified CfB that is qualified to contain both acid and radiological materials. The repackaged package’s shipping window is 15 days from the time repackaging (i.e., payload is in contact with new packaging). In addition, when repackaged, agent specific absorbents, neutralizing agents and spill containment devices will be included in the repackaged packaging system.

## B.3.2 Bases

A base is most commonly thought of as an aqueous substance that can accept hydrogen ions. Examples of bases that typically could be found in RPs include sodium, potassium, cesium and strontium hydroxides. Due to their potential for causing package seal failure and loss of containment on a moderate term basis (on the order of weeks), RPs containing bases will be required to be over packed in packages containing agent resistant seals. The repackaged packages’ shipping window is 30 days from the time repackaging (i.e., payload is in contact with new packaging). In addition, when repackaged, agent specific absorbents, neutralizing agents and spill containment devices will be included within the repackaged packaging system.

## B.3.3 Organic Acids

An organic acid is any acid containing carbon atoms. Examples of organic acids that typically could be found in retrieval packages include acetic, citric and oleic acids. Due to their potential for causing package failure and loss of containment on a short-term basis (on the order of weeks), retrieval packages containing organic acids will be required to be placed into a qualified CfB that is qualified to contain both acids and radiological material. The repackaged packages’
shipping window is 30 days from the time repackaging (i.e., payload is in contact with new packaging). In addition, when repackaged, agent specific absorbents, neutralizing agents and spill containment devices will be included within the repackaged packaging system.

**B.3.4 Organic Solvents**

A *solvent* is a liquid, solid, or gas that dissolves another solid, liquid, or gaseous solute, resulting in a solution. Most other commonly-used solvents are organic (carbon-containing) chemicals. These are called *organic solvents*. Examples of organic solvents that could be found in RPs include acetone, methyl ethyl ketone, trichloroethylene, and ethylene dichloride. By their organic nature, these compounds must first be evaluated for their possible effects as VOCs and possible presence in amounts greater than the LEL for that compound. If present in concentrations greater than the LEL, these compounds will be evaluated and shipped under R-SPA Section B.1.1, Flammable Gas – General Evaluation. If the organic solvents are nonflammable or present in concentrations lower than the compounds’ LEL, they will be evaluated and shipped under this section (B.3.4) of the R-SPA. Due to their potential for causing package seal failure and loss of containment on a moderate term basis (on the order of weeks), RPs containing organic solvents will be required to be placed into a qualified CfB in packages containing agent resistant seals. After the RP is placed in a CfB, the package’s shipping window is 30 days from the time placed in the CfB (i.e., payload is in contact with new packaging). In addition, agent specific absorbents, neutralizing agents and spill containment devices will be included in the over packed packaging system.

**B.3.5 Other Reactive Materials**

*Reactive materials* are other materials that may be present in the retrieval packages’ payload that could interact with each other, other packaging components or the environment, and could affect either the packaging systems’ containment or confinement boundaries. For the purpose of the R-SPA, reactive materials include, oxidizers, and pyrophoric materials. These compounds will be evaluated and controls determined on a case-by-case basis. In general, due to their potential for causing package seal failure and loss of containment on a moderate term basis (on the order of weeks), RPs containing other reactive materials will be required to be over packed in packages containing agent resistant seals. The repackaged packages’ shipping window is 30 days from the time repackaging (i.e., payload is in contact with new packaging).

In addition, when repackaged, agent specific absorbents, neutralizing agents and spill containment devices will be included within the repackaged packaging system.

**B.4 Free Liquid Water Evaluation**

This section applies only to retrieval packages containing greater than 3 percent free liquid water. The effects of other liquids have not been evaluated for impacts on package structural integrity, and identified and discussed in Section B.3, Prohibited Conditions. The water free liquid may only be water and may not contain solutions containing reactive materials, based on best available information including field test. The RP must be placed inside a Type A packaging designed to transport free liquids meeting additional testing requirements of 49 CFR 173 requirements for Type A liquid packages (49 CFR 173.412 (k)).

These RPs shall be placed in a liquid qualified Type A package rated for the RPs’ gross weight. The structural evaluation for RPs containing free liquids will contain at a minimum:
Certificate of Conformance documentation for the DOT Type A packaging used to enclose the RPs shall meet Type A package requirements used to transport liquids.

Effects of liquid free communication within the packaging system will be considered in addition to other structural tests.

Alternatively, these RPs can be placed inside a Type A package, which is not qualified to transport liquids, with sufficient suitable absorbent material to absorb two times the amount of liquid present.
DOE-RL-2001-36, Rev. 2

Annex C to Retrieval SPA -- Packaging Evaluation

Shipments made under the R-SPA are risk based shipments under the Sitewide TSD of Type B quantities of radioactive materials. These shipments typically would require a DOT-compliant Type B package. Shipments under the R-SPA utilize a packaging system composed of multiple CtB and CfB that meet equivalent level of safety based on the criteria specified in the TSD. Depending on R-SPA requirements, packages selected as CtBs or CfBs may be DOT Type B, Type A, or Industrial Packages 2 (IP-2). Depending on the payload and integrity of the packages being over packed, IP-1 packages may be used for the over pack package. The packages selected will meet the requirements of 49 CFR 173-180. R-SPA packaging documentation will include either the Certificate of Conformance or RL approved Packaging Evaluation (Appendix G).

Packages used under the R-SPA may not be re-used. Packages that are used as over packs (payload R-2, not R-3 to R-6) or as large-scale shipping packages for Payload R-7 shipments may be re-used. Packages shipped under the R SPA fall under three broad categories:

- **Packages being shipped in only their original packaging (Payload R-1).** The original packaging is normally a DOT Type A package. In a few instances, it may be a DOT IP-2 package. Shipments of DOT IP-1 packages under Payload R-1 are not authorized under the R-SPA. Minor repair as described in Annex L of this section to these packages is authorized.

- **Payloads that have been repackaged into new R-SPA authorized packages (Payload R-7).** Depending on payload and Shipper’s choice, the new package may be a DOT Type A or a DOT IP-2 package.

- **Packages that have been inside another CfB (IP or Type A).** This category includes payloads containing PCs (Payloads R-3 to R-6) and payloads containing no known PCs (Payload R-2). Packages selected as outer packagings will meet the requirements of 49 CFR 173-180. R-SPA packaging documentation will include either the Certificate of Conformance or RL approved Packaging Evaluation for the package used as the qualified CfB.
Annex D to Retrieval SPA -- Payload Evaluation

Payloads authorized for shipment under the R-SPA have been extensively analyzed in numerous onsite transportation safety documents and recently in HNF-22145 and the *Proposed Expansion to Graded Approach to Controls for Transporting Retrieved Boxes from 200W Burial Ground 218-W-3A, Trench 17 to the Central Waste Complex (CWC).* A Payload Specific Evaluation is required for each SEC submitted for RL review indicating how the proposed shipment meets the R-SPA requirements.
Annex E to Retrieval SPA -- Structural Evaluation

The structural performance of DOT-based packagings under the R-SPA has been extensively analyzed in HNF-22145 and supporting technical documents. The RPs depend on the shipping configuration, one or more DOT-compliant Type A packages and/or IP-1/IP-2, payload, and associated administrative and engineered controls to form a risk based packaging system. This risk based packaging system was evaluated by the R-SPA review team as meeting TSD standards for structural performance; e.g., there will be no release of contents under normal conditions of transport.
Annex F to Retrieval SPA -- Thermal Evaluation

The thermal performance of RPs has been extensively analyzed in a number of transportation safety documents including: WHC-SD-TP-RPT-005, Thermal Analysis Methods for Safety Analysis Reports for Packaging, Rev 1, dated January 1996, J. J. Irwin, Westinghouse Hanford Company, Richland, Washington; HNF-22145; and Proposed Expansion to Graded Approach to Controls for Transporting Retrieved Boxes from 200W Burial Ground 218-W-3A, Trench 17 to the Central waste Complex (CWC), white paper and supporting technical documents. Decay heat of the RP is limited to 50 Watt. The R-SPA and RPs were evaluated by the R-SPA review team as meeting TSD standards for thermal performance under normal conditions of transport.
Annex G to Retrieval SPA -- CONTAINMENT Evaluation

The RP consists of a containment boundary, containing R-SPA payload, additional containment boundaries (if required) and associated administrative and engineered controls to form a risk based packaging system. The R-SPA was evaluated as meeting TSD Containment / Confinement requirements under normal conditions of transport.
Annex H to Retrieval SPA -- Shielding Evaluation

The RP is required to meet the TSD 200 mrem/h rate package surface dose rate requirements. Use of internal and external shielding and other engineered controls to reduce RP surface dose rates (e.g., standoffs) is permitted. Payloads that do not meet the 200 mrem/h package surface dose rate requirements may not be shipped under the R-SPA. Submission of a separate OTRS will be required to receive approval for shipment of these payloads. The RP was evaluated as meeting TSD Shielding requirements under normal conditions of transport.
Annex I to Retrieval SPA -- Quality Assurance, Operating Procedures and Acceptance Tests Maintenance Program Requirements

Packaging Quality Assurance

Prior to shipment the Shipper will ensure that the RP and its component parts meet TSD and Quality Assurance Program Plan requirements.

Operating Procedures

The Shipper will develop operating procedures to ensure safe operations involving the RP. These procedures will include applicable operating requirements similar to the level of detail contained in HNF-22145. These requirements will ensure that safe operations utilizing the RP will be maintained while meeting TSD requirements.

Acceptance Tests and Maintenance Programs

The Shipper will develop acceptance tests and maintenance requirements to ensure safe operations involving the RP. These procedures will include applicable requirements similar to the level of detail contained in HNF-22145. These requirements will ensure that safe operations utilizing the RP will be maintained while meeting TSD requirements.
Annex J to Retrieval SPA -- Guidelines for Determining Package Surface Area Deterioration

J.1 Metal Packaging

The package will be free of tears, dents, holes and/or significant corrosion, and meets the requirements identified in Table J1-1. For the purpose of the R-SPA, surface corrosion is assumed to be by the General Attack mode of corrosion. Cases where localized corrosion (e.g., Pitting, Stress Corrosion Cracking, etc.) are known to exist may not be shipped under the R-SPA. As part of the package evaluation process, an estimate of the total surface area that has been degraded will be made. Surface corrosion is defined as corrosion that is present as the result of general corrosion attack and can be removed by abrasion using steel wool. Minor corrosion can be defined as a corroded area less than approximately 5 percent of the total exterior surface of the drum by visual inspection or by determination after using steel wool on the corroded area. Those retrieval packages may require steel thickness measurements and/or would default to the requirements of a "retrieval" package. Retrieval packages, therefore, can be defined as those packages not meeting the steel thickness criteria outlined in Table J1-1 but having a minimum wall thickness of 0.76 mm (0.030 in.).

<table>
<thead>
<tr>
<th>Specification</th>
<th>Exterior preservation</th>
<th>Wall thickness</th>
<th>Lid thickness</th>
<th>Bottom thickness</th>
</tr>
</thead>
<tbody>
<tr>
<td>DOT 17C(^a)</td>
<td>Painted or galvanized</td>
<td>16 gauge (^b)</td>
<td>16 gauge (^b)</td>
<td>16 gauge (^b)</td>
</tr>
<tr>
<td>DOT-17H(^a)</td>
<td></td>
<td>18 gauge (^c)</td>
<td>14(^d), 16, or 18 gauge</td>
<td>18 gauge (^c)</td>
</tr>
<tr>
<td>DOT-7A(^e)/UN1A2(^f) or (^g)</td>
<td></td>
<td>1.2 mm (^h)</td>
<td>1.2 mm (^h)</td>
<td>1.2 mm (^h)</td>
</tr>
</tbody>
</table>

\(^a\) 49 CFR 178, prior to 1995.
\(^b\) 1.519 mm (0.0598 in.) nominal, 1.354 mm (0.0533 in.) minimum.
\(^c\) 1.214 mm (0.0478 in.) nominal, 1.087 mm (0.0428 in.) minimum.
\(^d\) 1.897 mm (0.0747 in.) nominal, 1.720 mm (0.0677 in.) minimum.
\(^e\) 49 CFR 178.350.
\(^g\) WHC, 1996b. Specification for Drums; UN1A2; Type A; Solid Material, Painted, WHC-S-0466, Rev. 0, Westinghouse Hanford Company, Richland, Washington.
\(^h\) 1.2 mm (.047 in.) nominal, 1.09 mm (.0429 in.) minimum.


DOT = U.S. Department of Transportation.
J.2  Wooden / Fiberglass Reinforced Plywood (FRP) Packaging

J.2.1 There are two major types of surface damage observed on wooden/FRPs as shown in the sections below.

J.2.2 Surface damage from mechanical means as evidenced by abrasion, gouges, cracking that exposes the wood, or delamination from the resin surfaces, splintering/box deformation and sagging to the box.

J.2.3 Deterioration to the resin or wood by Environmental Exposure, as evidenced by indications of dry rot, ultraviolet ray damage, deterioration of chemical coatings, or delamination. An indication of deterioration due to environmental degradation would be powdery resin surface, structural deformation of package surfaces.

Guidance for completing the initial package inspection for Package Surface Area Deterioration is summarized in Table J2.1. Packages that exhibit Package Surface Area Deterioration may be repaired in accordance with Annex L.

**Table J2.1. Criteria for Evaluating Package Surface Area Deterioration**

<table>
<thead>
<tr>
<th>Type of Package</th>
<th>Does Package Exhibit?</th>
<th>Criteria</th>
<th>Points</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Metal</td>
<td>Surface Area Degradation (corrosion from General Attack)</td>
<td>&lt;10%</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>&gt;10% (per additional 5%)</td>
<td>25</td>
<td></td>
</tr>
<tr>
<td>Wooden/FRP</td>
<td>Surface Damage as defined in J.2.2</td>
<td>Exposes wood</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Wood not exposed</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Environmental Exposure Degradation as defined in J.2.3</td>
<td>Powdery resin surface or structural deformation of surface</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>Concrete</td>
<td>Surface Damage as defined in J.3.2</td>
<td>Surface deformation, exposed rebar, rust, edge-to-edge cracks</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Environmental Exposure Degradation as defined in K.3.3</td>
<td>Powdery surface, structural deformation</td>
<td>100</td>
<td></td>
</tr>
</tbody>
</table>

J.3  Concrete

J.3.1 There are two major types of surface damage observed on concrete boxes: 1) Surface damage, and 2) Environmental degradation.

J.3.2 Surface damage from mechanical means as evidenced by abrasion, gouges, cracking surface wear, spalling or impacts that damages or mars the concrete surface, box deformation, sagging, exposed rebar, edge-to-edge cracking, abrasion, or gouges that expose rebar.

J.3.3 Deterioration to the concrete through environmental degradation, as evidenced by indications of rust, free lime, and other concrete generated residues, powdery surface, or structural deformation of package surfaces.
Annex K to Retrieval SPA -- Guidance On Allowed Repairs To Retrieval Packages (RP)

A primary goal for use of the R-SPA is to minimize the number of RPs that are over packed for shipment to the remediation facility. As such, a fundamental consideration for each retrieved package is, can the package be safely shipped on a single trip of limited length and duration to the remediation facility? Given these considerations, it may be desirable to allow limited repairs of minor damage to otherwise sound RPs to allow the one time shipment to the remediation facility. The extent of the limited repairs allowed will depend on the package being shipped and the nature of the damage.

K.1 Metal Packages

For packages constructed from metal, there are two major types of damage that are allowed to be repaired under the R-SPA. Repairable damage is only authorized for those cases where the damage results to mechanically produced damage during handling. Due to the difficulty in determining the extent of damage, the repair of damage resulting from the effects of corrosion or other types of environmental degradation is not authorized under the R-SPA. For metal packages:

1. Limited cracking, tearing, or folding of the packages’ skin limited to a length of 3 inches or less. Under these cases, the crack may be repaired by drilling stress relief holes at each end of the crack and then applying a taped on flexible metal patch using a RL approved metallic tape to the package surface.

2. Holes of diameter of 2 inches (or puncture not exceeding 1 x 3 inches) may be repaired by applying a taped on flexible metal patch using a RL approved metallic tape to the package surface. Care must be exercised to ensure that the patch will maintain confinement during Normal Conditions of Transport. There are three locations where the patch may be applied:
   a. Flat package skin surface, no special patching requirements are required.
   b. Non flat packaging surfaces (e.g., chimes on drums), the patch will be shaped to conform with the package surface and provide package confinement and be taped in place.
   c. Package top, bottoms or edges: patch will be banded in place.

It is important to consider the extent of repair made, and time required in repairing the package (i.e., success of repair, limiting possible further damage to the package and personnel exposure in making the repair) in the decision to repair instead of over packing the package. If the package is repaired, it can be re-scored to determine the need for an over pack.

K.2 Wood/FRP Packages

There is no approved safety basis to support repair of this class of packaging. In the event that repairing the package is preferred over overpacking, there are two options available:

1. Submit safety basis documents (including all pertinent supporting analyses) with the SEC submittal for RL review and approval; or,

2. Submit an OTRS to allow shipment of the repaired package.
K.3  Concrete Packages

There is no approved safety basis to support repair of this class of packaging. In the event that repairing the package is preferred over overpacking, there are two options available:

1. Submit safety basis documents (including all pertinent supporting analyses) with the SEC submittal for RL review and approval; or
2. Submit an OTRS to allow shipment of the repaired package.
Annex L to Retrieval SPA -- Sample Shipment Log

Records of each shipment made under each approved R-SEC will be maintained for at least two years following shipment, and will provide the information identified in this SPA. An example shipping log is provided in the following table. Shipping papers for each shipment should be readily retrievable for inspections, audits and surveillances. This example assumes that the approved R-SPA SEC and supporting information provides justification for shipments of R-SPA Type R-1 and R-2 packages. Packages not meeting the Type R-1 or R-2 payload descriptions would be shipped under a different R-SPA SEC or another TSD authorized transportation safety basis (e.g., OTRS, different SPA, PSSD, etc.).

<table>
<thead>
<tr>
<th>SHIPPING DATE</th>
<th>CHECKLIST / SHIPMENT NO.</th>
<th>PAYLOAD DESCRIPTION</th>
<th>DE-CI</th>
<th>HEAT (W)</th>
<th>FGE</th>
<th>SHIPPER</th>
</tr>
</thead>
<tbody>
<tr>
<td>01/23/2015</td>
<td>218-W-4A R SPA-01/001</td>
<td>RETRIEVED 55-GAL DRUMS – TYPE R-1</td>
<td>11.7</td>
<td>0.13</td>
<td>138</td>
<td>J.D. JONES</td>
</tr>
<tr>
<td>01/24/2015</td>
<td>218-W-4A R SPA-01/002</td>
<td>RETRIEVED 55-GAL DRUMS – TYPE R-2</td>
<td>23.5</td>
<td>0.26</td>
<td>174</td>
<td>N.B. SMITH</td>
</tr>
</tbody>
</table>
Can shocks from static electricity damage your health? Wolfson Electrostatics News: Wolfson Electrostatics, Department of Electrical Engineering, University of Southampton, Southampton, United Kingdom.


HNF-20961, Unvented Kerr McGee Drums Containing Greater than 5% Hydrogen Concentrations, (OTRS) (Rev 0), September 30, 2005.

HNF-22145, One-Time Request for Shipment of Retrieval Packages in IP-1 Overpack, Rev 0, October 26, 2004; Fluor Hanford Inc., Richland, Washington.


H.4 Dirt & Burial Grounds Debris Special Packaging Authorization

The Dirt & Burial Grounds Debris – Special Packaging Authorization (DBGD-SPA) is intended to allow shipment of dirt and associated debris from trenches and burial grounds to remediation or disposition sites and is limited to geologic material (soil, rock, cobble, etc.) and miscellaneous debris encountered during remediation of Hanford waste sites including pits, trenches, burial grounds, and cribs. In accordance with a graded approach, this SPA authorizes the use of various packaging configurations and administrative controls. The DBGD-SPA packaging systems consists of a CtB and CfB with associated administrative controls. Based on the payload, the packaging systems are specified in Table H4-3. For the purposes of this SPA, waste being transported under this SPA can include Type B payloads. Therefore, the use of open-top roll-off containers or other IP type packages constitutes a risk based packaging as defined by the TSD. Because this SPA is issued as part of the TSD, changes to the DBGD-SPA are not subject to evaluation and contractor approval under the USQ₇ Program, but must be documented and approved the same as other changes to the TSD. The use of the DBGD-SPA for waste streams that are not the direct result of remediation activities at pits, cribs, burial grounds and trenches is not authorized. Packages shipped under the DBGD-SPA will also meet the acceptance requirements at the receiving facility.

Dirt and burial grounds debris consists of material listed in Table H4-1, DBGD-SPA Authorized Payload Types. In addition to the requirements listed in this DBGD-SPA, it is the Shipper’s responsibility to ensure that payloads being shipped also meet the receiving facility’s waste acceptance criteria.

Each DBGD-SPA IP-1 roll-off container (Environmental Restoration Disposal Facility [ERDF] can) may be loaded up to its certified capacity of dirt and associated debris materials. ERDF cans are open-top steel containers that meet the requirements for IP-1 packages under 49 CFR 173. In the ERDF can IP-1 tarped configuration, each load of debris is limited to a payload of not more than 0.03 dose-equivalent curies (DE-Ci) of radioactive material.
<table>
<thead>
<tr>
<th>Items Analyzed</th>
<th>Limits / Conditions</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Activated reactor hardware (irradiated metallic reactor components excluding fuel)</td>
<td></td>
<td>See Annex F</td>
</tr>
<tr>
<td>Animal Carcasses</td>
<td></td>
<td>SPA not authorized for biohazard materials or biologically mixed waste.</td>
</tr>
<tr>
<td>Asbestos</td>
<td></td>
<td>See Annex D</td>
</tr>
<tr>
<td>Discarded sources</td>
<td></td>
<td>Sealed sources(^1) that meet the requirements for inclusion in the DOE Offsite Source Recovery Program are not authorized for shipment under the DBGD-SPA.</td>
</tr>
<tr>
<td>Discarded electrical/electronic components(^1).</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Geologic Material (soil, rock, sand, gravel, cobble, etc.)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hot particles(^1)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Miscellaneous Building Debris (wood, metal, rebar, piping, sheetrock, window glass, sheetrock, concrete, siding, wire, cable, conduit, asphaltic materials)(^1)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Miscellaneous metal debris (empty(^1) and depressurized cylinders, empty IXM / IXC housings, empty containers)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Miscellaneous Non Hazardous trash and garbage (cloth, rope, plastics, paper, cardboard, and empty lab ware).</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Personal Protective Equipment</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Payloads may not be added to DBGD-SPA without a RL payload evaluation. If an item is not explicitly evaluated under this DBGD-SPA, it may not be shipped under the DBGD-SPA.

\(^1\) See Annex A, *Definitions*
## H.4.1 Dirt & Burial Grounds Debris Special Packaging Authorization

<table>
<thead>
<tr>
<th>Area</th>
<th>Bounding Value</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Structural</td>
<td>See Table H1-1</td>
<td></td>
</tr>
<tr>
<td>Thermal</td>
<td>See Table H1-1</td>
<td></td>
</tr>
<tr>
<td>Shielding</td>
<td>See Table H1-1</td>
<td></td>
</tr>
<tr>
<td>Containment/Confinement</td>
<td>See Table H1-1</td>
<td></td>
</tr>
<tr>
<td>Criticality</td>
<td>Payloads must be Fissile Excepted</td>
<td></td>
</tr>
<tr>
<td>Gas Generation</td>
<td>Hydrogen gas concentration does not exceed 5% by volume in the sealed package over a period of time twice that of the expected shipment time under normal operating conditions.</td>
<td>If venting is required and the shipment cannot be completed within the established shipping window, provisions shall be made before loading the package for venting and purging to reestablish a new shipping window before the original shipping window expires.</td>
</tr>
<tr>
<td>Total Payload</td>
<td>&lt;20 DE-Ci</td>
<td>See Table H.4-3 DBGD SPA Authorized Packages &amp; Administrative Controls</td>
</tr>
<tr>
<td>Fissile Payload</td>
<td>Meets the requirements of fissile excepted as defined in 49 CFR 173.453</td>
<td></td>
</tr>
<tr>
<td>Waste Heat</td>
<td>0.3 Watts</td>
<td></td>
</tr>
<tr>
<td>Tiedown</td>
<td>See Table H1-1</td>
<td></td>
</tr>
</tbody>
</table>
| Other Payload Restrictions / Prohibited Materials | No explosive materials  
No Free Liquids  
No chemically inter-reactive components.  
No pressurized containers  
No chemically reactive material. | --                                                                         |
## H.4.2 DBGD SPA

### Table H4-3. DBGD SPA Authorized Packages & Administrative Controls

| Note: For Payloads containing less than 1 A2 the TSD allows shipments that meet DOT requirements |
|---------------------------------|---------------------------------|---------------------------------|---------------------------------|---------------------------------|---------------------------------|
| Authorized Packages | Authorized Packages | Authorized Packages | Authorized Packages | Authorized Packages |
| 1. Type B package. | 1. Type B package. | 1. Type B package. | 1. Type B package. | 1. Type B package. |
| 2. Type A package (or equivalent). | 2. Type A package (or equivalent). | 2. Type A package (or equivalent) + 1 confinement boundary. | 2. Type A package (or equivalent) + 1 confinement boundary. | 2. Type A package (or equivalent) + 1 confinement boundary. |
| 3. Open-top roll-off IP-1 container with TARP and a plastic liner sealed in accordance with Annex E, Table H.4-E1. | 3. Open-top roll-off IP-1 container with TARP + 1 confinement boundary (may be another IP-1 container or two plastic liners sealed in accordance with the Annex E, Table H.4-E1). | 3. Open-top roll-off IP-2 container with TARP + 1 confinement boundary (may be an IP container or two plastic liners sealed in accordance with the DBGD SPA). | 3. IP-2 container with two confinement boundaries (may be two IP containers or an IP container and two plastic liners sealed in accordance with the DBGD-SPA). | 3. IP-2 container with two confinement boundaries (may be two IP containers or an IP container and two plastic liners sealed in accordance with the DBGD-SPA). |

Road closures not required for Type-1 & 2 shipments in the 100 and 200 Areas, but are required for 300 Area. Type-3 – 5 shipments require road closures.

No shipments during inclement weather, slick or icy conditions, below the temperature limits of components relied on for confinement or limited visibility.

Route Control required.

Maximum speed limited to posted speed limits.

Containers vented prior to shipment.

Chemically reactive contents not present.

Only one container is allowed per conveyance.

DBGD Packages must be transported to the ERDF within 30 days of sealing.

See Annex E for Packaging Loading Sequence by DBGD Type.
### DBGD SPA (DBGD SPA)Shipment Evaluation Checklist

<table>
<thead>
<tr>
<th>Package or Shipment Checklist Number:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Required Packaging System Configuration</td>
<td></td>
</tr>
<tr>
<td>Enter Total payload DE-Ci inventory</td>
<td>Minimum Required Package</td>
</tr>
</tbody>
</table>

#### Payload

**Authorized shipment types.**

| Authorized shipment types. | Table H.4-3: DBGD SPA Authorized Packages & Administrative Controls |

#### Describe Shipment Type and Package Configuration

**Shipment Type:** ___

**Package Configuration:** ___

**Package Evaluation:** Description of packaging system being used: (include description of packages used to meet containment / confinement requirements, Package Certification Data including material of construction, who and how certified.) ___

#### Package Requirements

<table>
<thead>
<tr>
<th>Package Requirements</th>
<th>Yes</th>
<th>No</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Package meets DBGD SPA Structural Requirements</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Package meets DBGD SPA Thermal Requirements</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Package meets DBGD SPA Shielding Requirements</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Package meets DBGD SPA Containment Requirements</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Package meets DBGD SPA Tie Down / Load Restraint Requirements</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### Payload Evaluation

<table>
<thead>
<tr>
<th>Area</th>
<th>Limits</th>
<th>Yes</th>
<th>No</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Payload</td>
<td>DBGD Type:<strong>DE-Ci:</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fissile Payload</td>
<td>Fissile excepted</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Criticality</td>
<td>Fissile excepted</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Waste Heat</td>
<td>≤0.3 Watts</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gas Generation</td>
<td>&lt; 5 Volume % Flammable Gases</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Flammable Gas Limit** applies to time duration of loading and transportation activities until received at receipt facility. Inner package may be vented using HEPA filter. (Not applicable to Type 1 shipments)

**Prohibited Materials**

**Payload meets bounding DBGD payload evaluation**

**Administrative Controls**

- [ ] Route Control
- [ ] Road Closure (If Required)

**Signed**  ___  

<table>
<thead>
<tr>
<th>Organization</th>
<th>Date:</th>
</tr>
</thead>
</table>

H-55
ANNEX OUTLINE (DBGD-SPA)

Annex A: Definitions
Annex B: Bounding Case Payload Analysis Basis
Annex C: Supporting Analysis for Types 1–5 DE-Ci Payload Amounts
Annex D: Criteria for Payloads Containing Asbestos
Annex E: Packaging Loading Sequences by Type (Tables)
Annex F: Activated Reactor Components Authorized To Be Shipped Under the DBGD SPA
Annex G: Requirements for Plastic Sheeting/Other Flexible Materials/Liners used as Confinement Boundaries Under the DBGD SPA
Annex A to Dirt & Burial Ground Debris SPA -- Definitions

Asphaltic Materials: defined as Debris treated with (e.g., painted or soaked) or consisting of asphalt that has completely cured with no evidence of VOCs. This includes items such as roofing tar, “black top” roofing felt, lumber, etc.

Electrical/Electronic Components: defined as solid state components, circuit board vacuum tubes, cathode ray tubes, paper capacitors, switches, resistors, diodes, transistors, inductors, coils, rheostats, control instrumentation, and oil filled capacitors are included as long as they do not contain Dioxins, Polychlorinated Biphenyls or other similar types of oils. Oil filled capacitors that have been drained of their contents are authorized.

Empty: defined as RCRA empty.

Fixatives: defined as materials applied to a packaged payload during loading to reduce or eliminate the potential for dust or spread of contamination. Similar materials in the package payload that are present as the result of their use in remediation or demolition operations are considered as payload for the purpose of the DBGD-SPA.

Hot Particles: defined as small (less than 0.5 in³) discreet uncharacterized high activity particles containing actinides, fission or activation products resulting from reactor operations can be shipped under the DBGD-SPA provided the shipment meets the waste acceptance criteria for the receiving facility. Any material that is recovered and identified as potentially originating from Spent Nuclear Fuel (SNF), or fragments of SNF generated as a result of handling larger pieces of fuel (e.g., pieces that break off of a larger piece during cleaning) will be segregated, and regardless of size, cannot be shipped under this DBGD-SPA.

Sealed Source: defined as a radioactive source specifically manufactured, obtained, or retained for the purpose of utilizing the emitted radiation. The sealed radioactive source consists of a known quantity of radioactive material contained within a sealed capsule, sealed between layers of non-radioactive material, or firmly fixed to a non-radioactive surface by electroplating or other means intended to prevent leakage or escape of the radioactive material. (10 CFR 835). Standards and locally produced items that may have been used to calibrate equipment are generally not considered to meet the requirements of sealed sources,
To determine the Bounding Case Payload, a query of the radionuclide inventory from each Onsite Waste Tracking Forms (OWTFs) within the Waste Management Information System database was performed. From the query, the highest individual radionuclide curie value from any OWTF shipped to the ERDF was identified. This value was then divided by the volume of the individual shipment to determine the Ci/yd$^3$ for the individual radionuclide. This Ci/yd$^3$ value was then multiplied times 20 yd$^3$ to obtain the maximum theoretical inventory of the same material shipped in a full can (generally, the maximum volume of waste shipped in an ERDF can is 18.3 yd$^3$). The highest resulting values for each isotope were then combined and recorded as the bounding curie values for any shipment.

Results

The curie values for the individual radionuclides were used to determine other transportation-related values (e.g., DE-Ci, decay heat, A$_2$ comparison, etc.)

There are a few known issues associated with the inventory and the theoretical shipment:

1. The result exceeds the ERDF acceptance limits (i.e., it is TRU)
2. The result exceeds the thermal limits for the SPA (total watts)
3. The result may not bound all shipments for some isotopes (i.e., the values may need to be re-evaluated frequently)
4. The results show that the bounding shipment is fissile (not permitted under the SPA).
<table>
<thead>
<tr>
<th>Isotope</th>
<th>Half-Life</th>
<th>Activity</th>
<th>Specific Heat</th>
<th>A2</th>
<th>Fraction</th>
<th>Factor</th>
<th>FGEs</th>
<th>Factor</th>
<th>ICRP-71</th>
<th>DE-Ci</th>
</tr>
</thead>
<tbody>
<tr>
<td>H-3</td>
<td>1.54E+02</td>
<td>5.70E+12</td>
<td>1.60E-02</td>
<td>3.38E-05</td>
<td>5.21E-03</td>
<td>1.10E+03</td>
<td>1.40E-01</td>
<td>0.00E+00</td>
<td>1.24E-07</td>
<td>1.91E-05</td>
</tr>
<tr>
<td>Be-7</td>
<td>7.13E-32</td>
<td>2.64E-21</td>
<td>2.04E-37</td>
<td>2.00E-03</td>
<td>1.42E-34</td>
<td>5.40E+02</td>
<td>1.32E-34</td>
<td>0.00E+00</td>
<td>1.00E-06</td>
<td>7.13E-38</td>
</tr>
<tr>
<td>C-14</td>
<td>5.23E+00</td>
<td>1.94E+11</td>
<td>1.17E+00</td>
<td>2.93E-04</td>
<td>1.53E-03</td>
<td>8.10E+01</td>
<td>6.46E-02</td>
<td>0.00E+00</td>
<td>4.00E-05</td>
<td>2.09E-04</td>
</tr>
<tr>
<td>Na-22</td>
<td>1.02E-05</td>
<td>3.77E+05</td>
<td>1.63E-09</td>
<td>1.42E-02</td>
<td>1.45E-07</td>
<td>1.40E+01</td>
<td>7.29E-07</td>
<td>0.00E+00</td>
<td>2.60E-05</td>
<td>2.65E-10</td>
</tr>
<tr>
<td>K-40</td>
<td>1.40E-02</td>
<td>5.18E+08</td>
<td>2.00E+03</td>
<td>4.02E-03</td>
<td>5.63E-05</td>
<td>2.40E+01</td>
<td>5.83E-04</td>
<td>0.00E+00</td>
<td>4.20E-05</td>
<td>5.88E-07</td>
</tr>
<tr>
<td>Ca-41</td>
<td>1.05E-02</td>
<td>3.89E+08</td>
<td>1.24E-01</td>
<td>1.94E-05</td>
<td>2.04E-07</td>
<td>Unlimited</td>
<td>0.00E+00</td>
<td>0.00E+00</td>
<td>1.90E-06</td>
<td>2.00E-08</td>
</tr>
<tr>
<td>Mn-54</td>
<td>7.19E+00</td>
<td>2.66E+08</td>
<td>1.44E-07</td>
<td>7.75E-03</td>
<td>5.57E-05</td>
<td>2.40E+01</td>
<td>3.00E-04</td>
<td>0.00E+00</td>
<td>7.40E-05</td>
<td>5.32E-07</td>
</tr>
<tr>
<td>Fe-55</td>
<td>4.37E+00</td>
<td>4.96E-08</td>
<td>3.49E-05</td>
<td>4.12E-09</td>
<td>1.10E+03</td>
<td>1.07E-07</td>
<td>0.00E+00</td>
<td>7.60E-06</td>
<td>8.97E-10</td>
<td></td>
</tr>
<tr>
<td>Fe-59</td>
<td>7.19E+00</td>
<td>2.66E+08</td>
<td>1.44E-07</td>
<td>7.75E-03</td>
<td>5.57E-05</td>
<td>2.40E+01</td>
<td>3.00E-04</td>
<td>0.00E+00</td>
<td>7.40E-05</td>
<td>5.32E-07</td>
</tr>
<tr>
<td>Co-58</td>
<td>1.10E-01</td>
<td>4.07E+09</td>
<td>3.46E-06</td>
<td>5.99E-03</td>
<td>6.59E-04</td>
<td>2.70E+01</td>
<td>4.07E-03</td>
<td>0.00E+00</td>
<td>3.20E-05</td>
<td>3.52E-06</td>
</tr>
<tr>
<td>Co-60</td>
<td>1.29E+03</td>
<td>4.77E+13</td>
<td>1.14E+00</td>
<td>1.54E-02</td>
<td>1.99E+01</td>
<td>1.10E+01</td>
<td>1.17E+02</td>
<td>0.00E+00</td>
<td>2.00E-04</td>
<td>2.58E-01</td>
</tr>
<tr>
<td>Ni-59</td>
<td>1.20E+03</td>
<td>3.54E+12</td>
<td>1.20E+03</td>
<td>4.25E-05</td>
<td>4.06E-03</td>
<td>Unlimited</td>
<td>0.00E+00</td>
<td>0.00E+00</td>
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<td>2.49E-04</td>
</tr>
<tr>
<td>Ni-63</td>
<td>2.13E+02</td>
<td>7.88E+12</td>
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<td>9.60E-06</td>
<td>2.04E-03</td>
</tr>
<tr>
<td>Se-79</td>
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<td>6.36E+05</td>
<td>2.47E-04</td>
<td>6.02E-04</td>
<td>1.04E-08</td>
<td>5.40E+01</td>
<td>3.19E-07</td>
<td>0.00E+00</td>
<td>2.20E-05</td>
<td>3.78E-10</td>
</tr>
<tr>
<td>Kr-85</td>
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<td>1.48E+09</td>
<td>1.02E-04</td>
<td>1.50E-03</td>
<td>6.01E-05</td>
<td>2.70E+02</td>
<td>1.49E-04</td>
<td>0.00E+00</td>
<td>1.54E-08</td>
<td>6.19E-10</td>
</tr>
<tr>
<td>Sr-90</td>
<td>3.71E+03</td>
<td>1.37E+14</td>
<td>2.67E+01</td>
<td>1.16E-03</td>
<td>4.30E+00</td>
<td>8.10E+00</td>
<td>4.58E+02</td>
<td>0.00E+00</td>
<td>7.20E-04</td>
<td>2.67E-00</td>
</tr>
<tr>
<td>Zr-93</td>
<td>1.46E+01</td>
<td>1.54E+10</td>
<td>1.65E+02</td>
<td>1.13E-04</td>
<td>4.70E-05</td>
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Date: 2/13/2008
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Annex C to Dirt & Burial Ground Debris SPA -- Supporting Analysis for Types 1–5 DE-Ci Payload Amounts

As a risk based package under the Hanford TSD, payloads shipped under the DBGD-SPA must demonstrate “equivalent safety.” To establish authorized payloads under the DBGD-SPA a Dose Consequence Evaluation analysis was conducted using the following model and assumptions:

- **Inhalation Exposure Pathway.** The dose consequence due to inhalation of airborne particulate material created from a hypothetical accident during transportation is given by the 50-year committed effective dose equivalent (CEDE). The CEDE per unit intake for each radionuclide is tabulated in several references and is referred to as the inhalation dose conversion factor (DCF). Standard DOE methodology and guidance provides the bases for selection of the parameters involved in the bounding accidents. Effective DCFs are prescribed in units of dose-equivalent curie (DE-Ci), which normalizes the inhalation dose relative to that from $^{239}$Pu.

Intake by inhalation requires that the radioactive material first transform into an aerosol that is transported through the atmosphere to a downwind receptor and is inhaled. Transformation into an aerosol is caused by the accident conditions described in Section E1.3 of Appendix E to the TSD and the amount of aerosol formed depends on the accident scenario and form of the radioactive material. The amount of aerosol that is formed and leaks out of the package is known as the airborne source term and is given by the first five variables (DOE-HDBK-3010-94, *Airborne Release Fractions/Rates and Respirable Fractions for Nonreactor Nuclear Facilities*, p. 1-2) in equation 1. The sixth variable is the concentration of aerosol at a particular downwind location, integrated over time, and normalized to the amount of aerosol released. The seventh variable is the breathing rate of a receptor. The product of the first seven variables in equation 1 below represents the intake of radionuclides into the body due to inhalation. The last variable is the inhalation DCF.

$$CEDE = (MAR \times DR \times ARF \times RF \times LPF) \times \chi/Q' \times BR \times DCF \quad \text{Eq. 1}$$

where:

- **CEDE** = 0-year committed effective dose equivalent due to inhalation, in rem
- **MAR** = material at risk, in DE-Ci
- **DR** = damage ratio, dimensionless
- **ARF** = airborne release fraction, dimensionless
- **RF** = respirable fraction, dimensionless
- **LPF** = leak path factor, dimensionless
- **$\chi/Q'$** = time-integrated normalized airborne concentration, in s/m$^3$
- **BR** = breathing rate, in m$^3$/s
- **DCF** = inhalation dose conversion factor for $^{239}$Pu, in rem/DE-Ci.

Neglected in this definition of the airborne source term is the coagulation of smaller particles into larger particles and the resultant increase in gravitational settling of the larger particles. Because no credit is taken for the reduction of the aerosol MAR that would occur from the settling of larger particles, the results of the calculations are conservative.
**MAR**: the radiological inventory per shipment and per package in DE-Ci. MAR limits are determined by limiting the consequences of the analyzed accidents. The form of the material being shipped is to be specified to determine applicable release characteristics.

**DR**: the fraction of the MAR (i.e., the fraction of the contents of a single package or the fraction of the MAR in the conveyance) actually affected by the accident-generated conditions. For the unmitigated case, it is assumed that all of the individual packages are affected given an accident, and the DR is taken to be 1. The DR for a mitigated collision is reduced based on the analyses of the damage expected to be caused by the accident with implementation of the administrative and engineering controls called out in the TSD, applicable PSSD or other authorization.

**ARF and RF**: the fraction of the radioactively contaminated material that is converted to particulate matter and becomes airborne during a hypothetical accident. The RF is the fraction of the ARF that is sufficiently small to be capable of being inhaled into the human respiratory system. The ARF is a function of the accident scenario, the physical and chemical form of the waste, the initial packaging configuration, and the energy input. The RF is a function of the same variables as the ARF, but also is a function of the initial particle size distribution.

The recommended values of the ARF and RF for Hanford site accidents are standard DOE methodology and guidance.

**LPF**: the cumulative fraction of airborne radioactive material that escapes through the containment boundary. This factor depends on the structural response of the package to the hypothetical accident conditions. The LPF is conservatively assumed to be 1.0 for unmitigated cases.

**χ/Q’**: defines the downwind concentration of airborne radioactivity at a particular location, integrated over the duration of the release and normalized to the amount released. The recommended χ/Q’ values are obtained from standard DOE methodology/guidance or RADIDOSE.

**BR**: the volume of air inhaled per unit time. The International Commission on Radiological Protection (ICRP 23, *Report of the Task Group on Reference Man*) reports that the breathing rate for reference man during light activity is $3.3 \times 10^3$ m$^3$/s. This value is conservatively applied for both the co-located worker and the Maximum Exposed Offsite Individual.

**DCF**: correlates the amount of radioactivity inhaled to the CEDE. Because the activity is given in units of DE-Ci, which normalized the inhalation dose relative to that from $^{239}$Pu, the DCF used in the dose consequence calculations is that for $^{239}$Pu. For workers, given $^{239}$Pu, an absorption type of M, and an aerodynamic diameter of 5 µm, the DCF is $3.2 \times 10^{-5}$ Sv/Bq or $1.18 \times 10^8$ rem/Ci or approximately $3.2 \times 10^6$ rem/A$_2$. Absorption type M and aerodynamic diameter of 5 µm are appropriate for the plutonium oxide materials shipped on the Hanford Site and are consistent with standard DOE methodology and guidance. For members of the public, the corresponding $^{239}$Pu DCF, given absorption type M and an aerodynamic diameter of 1 µm, is $5.0 \times 10^{-5}$ Sv/Bq or $1.85 \times 10^8$ rem/Ci or approximately $5.0 \times 10^6$ rem/A$_2$. Using the basis of “equivalent safety” and the results above to establish acceptable consequences, 1 A$_2$ of $^{239}$Pu is 0.027 Ci. 1 Ci $^{239}$Pu = 1 DE-Ci. Assuming the confinement from a typical shipment of 1 A$_2$ (a Type A shipment) provides only a DR of 1.0 (all material in the load is affected by accident conditions), this equivalent safety approach gives a limit of approximately 0.03 DE-Ci per load. The current practice in shipping an ERDF cannot would not necessarily release 100 percent of the contents in a credible accident, but a DR of 1.0 is easily defended as conservative. One
additional confinement layer is assumed to reduce the release amount by a factor of 5 to 10, so a DR of 0.2 to 0.1 could be credited. With an appropriate additional layer of confinement, an additional reduction of a factor of 5 to 10 would result, giving an overall DR of 0.04 to 0.01. Taking the more conservative of each estimate of DR results in the following limits:

For a DR of 1.0 (typical ERDF can DBGD-SPA Type-1 shipment), the limit would be about 0.03 DE-Ci.

For a DR of 0.2 (ERDF can with a fully sealed additional level of confinement, a DBGD-SPA Type-2 shipment), the limit would be approximately 0.15 DE-Ci.

For a DR of 0.04 (IP-2 or higher container with an additional layer of confinement, a DBGD-SPA Type-A shipment), the limit would be approximately 0.75 DE-Ci. Similar considerations and other shipping safety analyses lead to the upper limits of 1 DE-Ci and 20 DE-Ci, respectively, for DBGD-SPA Type-4 and Type-5 shipments.

For a typical 18MT ERDF can, these values translate to 1.67E+03 pDE-Ci/g, 8.33E+03 pDE-Ci/g, 4.17E+04 pDE-Ci/g, 5.55E+04 pDE-Ci/g, and 1.11E+06 pDE-Ci/g for the cases above, respectively. For comparison, the 100 percent bounding inventory value from Calculation 0100K-CA-W0001 contains 1.48E+04 pDE-Ci/g. Typical shipments are generally a small fraction of the 100 percent bounding inventory. The bounding inventory in Appendix B contains 12.6 DE-Ci, so for an 18 MT (19.8 ton) load, the maximum concentration would be 12.6 DE-Ci/1.8E+07 g or 7.0E+05 pDE-Ci/g.

The foregoing values would then encompass the 100 percent bounding inventory values shown in Appendix B, implying that this SPA would address all of the shipments using that profile.

These values are derived for accident consequences, and do not directly relate to surface dose rates on the can. Thus, shielding and/or engineered barriers would need to be applied if surface dose rate limits were not met.
Annex D to Dirt & Burial Ground Debris SPA -- Criteria for Payloads Containing Asbestos

Asbestos may be found in burial grounds in multiple different forms. These include:

- Friable asbestos in building materials,
- Non friable asbestos in building materials, and
- Asbestos fibers in soil whose presence in the soil is a result of remediation activities. In all cases asbestos will be packaged in strict accordance with all applicable U.S. Environmental Protection Agency (EPA) and DOT regulations.

**Asbestos handling:** Asbestos handling methods and abatement methods (if necessary) shall be per the substantive provisions of 40 CFR 61.145, 150, 152, 154, and 155, as relevant and appropriate, as well as applicable portions of the Toxic Substances Control Act, 49 CFR, and DOE-EM-STD-5502-94 Hazard Baseline Documentation.

For friable asbestos in building materials, this includes separating the materials from soils, bagging and wetting the material, and shipping it to the processing / disposal facility for appropriate handling (e.g., place and cover, grouting, etc.). For Asbestos-Containing Materials (ACM), intermittent wetting shall be performed at the excavation site with water spray nozzles to provide dust control suitable to prevent uncontrolled air emissions. ACM waste (including soil intermixed with ACM) shall be wetted during excavation, stabilized for transport, double bagged, or placed in a double-lined container. The ACM waste shall be shipped in packages or containers that comply with the ERDF WAC and the Supplemental WAC for Bulk Shipments to ERDF (SWAC). Wetting and stabilization shall be performed in a manner that ensures the bags contain no freestanding liquids or air borne release of ACM materials. If not placed into double-lined containers, individual bags shall be limited to a maximum weight of 18.1 kg (40 lb) in order to be handled by an individual worker.

ACM may be left on materials/debris if it can be double bagged and the debris meets the ERDF sizing requirements. If size reduction is required, ACM shall be removed using wet methods specified by Occupational Safety and Health Administration and National Emissions Standards for Hazardous Air Pollutants (40 CFR 61, Subpart M) guidance.

In accordance with the ERDF SWAC, pipes/tubes with nominal diameters equal to or greater than 450 mm (18 in.) must have regulated ACMs removed before shipment to the ERDF. Pipes/tubes with nominal diameters less than 450 mm (18 in.) may be shipped with asbestos lagging attached to the pipe and placed in a separate container. The asbestos must be properly wetted, double-rapped on the pipe, and labeled.
Annex E to Dirt & Burial Ground Debris SPA -- Packaging
Loading Sequences by Type (Tables)
Table H4-E1. Annex E to Dirt & Burial Ground Debris SPA: Packaging Loading Sequences by Type

| DBGD Type-1 | The DBGD will be loaded into the container in the following sequence:  
1. A single liner is placed in the roll-off container. The liner is constructed of flame-resistant, LDPE/LLDPE or other materials approved in the DBGD SPA with a minimum thickness of 0.15 mm (6 mil), performed with sealed interior corner seams. The liner is sized to fit inside the container and to allow overlapping closure and sealing of the maximum load after the liner is filled. The liner is sized such that when placed inside the empty container, the outside of the container is protected from spillage during loading operations.  
2. The container is loaded so as not to exceed the maximum certified capacity.  
3. The payload is limited to those items included in Table I.4-1, DBGD SPA Authorized Payload Debris Types.  
4. If the waste materials have sharp edges, a minimum of six inches of soil is placed in the bottom of the liner.  
5. After the container is loaded and weighed, the liner is folded over the top of the payload with a minimum overlap of 18 inches.  
6. A tarp is placed over the top of the roll-off container and secured such that it will remain in place under conditions experienced during normal transport.  
7. Fixatives may be used during excavation, sorting, and loading activities to control airborne radiological contamination. The use of fixatives is allowed, provided that they do not result in generation of additional hazardous waste, do not react with other package contents, and do not cause liner degradation within the temperature and time constraints. Approved fixatives are listed in Annex H. |
| DBGD Type-2 | The DBGD will be loaded into the container in the same sequence as Type-1 shipments except as noted below:  
1. Two liners are placed in the roll-off container. The liners are constructed of flame-resistant, low-density polyethylene / linear low density polyethylene (LDPE/LLDPE) or other materials approved in the DBGD SPA with a minimum thickness of 0.15 mm (6 mil), pre-formed with sealed interior corner seams. The liners are sized to fit inside the container and to allow overlapping closure and sealing of the maximum load after the liner is filled. The liner is sized such that when placed inside the empty container, the outside of the container is protected from spillage during loading operations.  
2. The liners are folded over the top of the payload and the seam of each liner is sealed providing a CfB. Methods of sealing include heat gun or tape. Use of spray adhesives is authorized, however, caution is required when using adhesives because of issues with cure time, possible interaction with flexible plastic materials and adequacy of the resulting confinement boundary. A zippered liner may be used as an alternate type of liner.  
3. A tarp is placed over the top of the roll-off container and secured such that it will remain in place under conditions experienced during normal transport. The loaded container gross weight shall not exceed its certified capacity.  
4. Fixatives may be used during excavation, sorting, and loading activities to control airborne radiological contamination. The use of fixatives is allowed, provided that they do not result in generation of additional hazardous waste, do not react with other package contents, and do not cause liner degradation within the temperature and time constraints. Approved fixatives are listed in Annex H. |
| DBGD Type-2 (When using Type A or B Package) | Package will be loaded in accordance with manufacturer’s and Contractor instructions. |
### Table H4-E1. Annex E to Dirt & Burial Ground Debris SPA: Packaging Loading Sequences by Type

<table>
<thead>
<tr>
<th>DBGD Type-3</th>
<th>The DBGD will be loaded into the container in the same sequence as the Type 2 shipment except as noted below:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1. Two liners are placed in the IP-2 container. The liners are constructed of flame-resistant, LDPE/LLDPE or other materials approved in the DBGD SPA with a minimum thickness of 0.15 mm (6 mil), pre-formed with sealed interior corner seams. The liners are sized to fit inside the container and to allow overlapping closure and sealing of the maximum load after the liner is filled. The liner is sized such that when placed inside the empty container, the outside of the container is protected from spillage during loading operations.</td>
</tr>
<tr>
<td></td>
<td>2. The liners are folded over the top of the payload and the seam of each liner is sealed providing a CfB. Methods of sealing include heat gun or tape. Use of spray adhesives is authorized, however, caution is required when using adhesives because of issues with cure time, possible interaction with flexible plastic materials and adequacy of the resulting confinement boundary. A zippered liner may be used as an alternate type of liner.</td>
</tr>
<tr>
<td></td>
<td>3. A tarp is placed over the top of the roll-off container and secured such that it will remain in place under conditions experienced during normal transport. The loaded container gross weight shall not exceed its certified capacity.</td>
</tr>
<tr>
<td></td>
<td>4. Fixatives may be used during excavation, sorting, and loading activities to control airborne radiological contamination. The use of fixatives is allowed, provided that they do not result in generation of additional hazardous waste, do not react with other package contents, and do not cause liner degradation within the temperature and time constraints. Approved fixatives are listed in Annex H.</td>
</tr>
</tbody>
</table>

| DBGD Type-3 When using Type A or B Package | Package will be loaded in accordance with manufacturer’s and Contractor instructions. |

<table>
<thead>
<tr>
<th>DBGD Type-4</th>
<th>The DBGD will be loaded into the container in the same sequence as Type 3 shipments except as noted below:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1. Two liners are placed in the IP-2 container. The liners are constructed of flame-resistant, LDPE/LLDPE or other materials approved in the DBGD SPA with a minimum thickness of 0.15 mm (6 mil), pre-formed with sealed interior corner seams. The liners are sized to fit inside the container and to allow overlapping closure and sealing of the maximum load after the liner is filled. The liner is sized such that when placed inside the empty container, the outside of the container is protected from spillage during loading operations.</td>
</tr>
<tr>
<td></td>
<td>2. The liners are folded over the top of the payload and the seam of each liner is sealed providing a CfB. Methods of sealing include heat gun or tape. Use of spray adhesives is authorized, however, caution is required when using adhesives because of issues with cure time, possible interaction with flexible plastic materials and adequacy of the resulting confinement boundary. A zippered liner may be used as an alternate type of liner.</td>
</tr>
<tr>
<td></td>
<td>3. A tarp is placed over the top of the roll-off container and secured such that it will remain in place under conditions experienced during normal transport. The loaded container gross weight shall not exceed its certified capacity.</td>
</tr>
<tr>
<td></td>
<td>4. Fixatives may be used during excavation, sorting, and loading activities to control airborne radiological contamination. The use of fixatives is allowed, provided that they do not result in generation of additional hazardous waste, do not react with other package contents, and do not cause liner degradation within the temperature and time constraints. Approved fixatives are listed in Annex H.</td>
</tr>
</tbody>
</table>
Table H4-E1.  Annex E to Dirt & Burial Ground Debris SPA: Packaging Loading Sequences by Type

| DBGD Type-4 When using Type A or B Package | Package will be loaded in accordance with manufacturer’s and Contractor instructions. |
Annex F to Dirt & Burial Ground Debris SPA -- Activated Reactor Components
Authorized to be Shipped under the DBGD-SPA

The following activated reactor components are not authorized to be shipped as activated reactor components under the DBGD-SPA: Fuel, Special Nuclear Material (SNM), and components that were part of process equipment whose purpose was to collect radionuclides as part of its normal function (e.g., HEPA filters, Ion Exchange Modules/Columns). Ion Exchange Modules and Ion Exchange Columns that are empty (i.e. the ion exchanger resin collection media has been removed) are considered to be miscellaneous metal debris.

The following item are authorized for shipment under the DBGD-SPA as activated reactor components:

1. **Aluminum Process Tubes**

   The process tubes, fabricated out of C-64-F aluminum alloy, were about 40 ft long with an inside diameter of 1.75 in. and a wall thickness of about 0.125 in. The tubes penetrated the reactor block horizontally with the center 25 ft located in the active zone of the reactor. The major cause for replacement was internal corrosion which started on a large scale following flow increases initiated through Project CG-558 in the mid-1950s. The life expectancy of a process tube in the central zone, following Project CG-558, averaged about four years.

2. **Gun Barrels**

   A typical reactor Gun Barrel was installed at the inlet and outlet of the process tube bore in the reactor, and was fabricated from Schedule 40 carbon steel pipe measuring about 2 in. in diameter and approximately 7.6 ft long. It spans the gas plenum, the thermal shield, and the biological shield and extended about 14 in. beyond the outside plate of the reactor. The Gun Barrel provided support for the thin aluminum process tube. It provided a gas seal where it penetrated the outside plate and was adapted to a nozzle with a process tube access cap on the end of the nozzle to facilitate the refueling operation. Only the first several inches (10 in.) of the Gun Barrel become activated.

3. **Horizontal Control Rods (HCR) and Vertical Safety Rods (VSR) (Also referred to as, rod tips)**

   a. HCRs were used to control the nuclear reaction in the reactor. Routine maintenance required replacing the rod tips infrequently. The rod tip sheath is a closed-end rectangular tube about 40 ft long by 3.5 in. wide by 1.5 in high. The sheath is made from 63-ST-S aluminum. Smaller inlet and outlet aluminum cooling tubes were inside the tip for cooling purposes. Donut-shaped boron rings sized to fit inside the sheath surrounded the cooling tubes for the full length of the rod tip section. The rod tip was then assembled to a drive mechanism to run the rod in and out of the reactor. The tip assembly weighed about 80 lb.

   b. The VSR system was designed to shut the reactor down and hold the reactor subcritical. The system consisted of 29 VSRs at B, D, DR, and F Reactors and 45 VSRs at C, KE, KW, and H Reactors. The VSRs were suspended vertically above the reactor with the tip of the VSR inside the biological shield. During an automatic shutdown the VSRs would free-fall into the reactor on demand or could be lowered under power on a manual shutdown. (The K Reactor VSRs were air-driven to accelerate the insertion time.) The size of the VSRs at each reactor was about the same; however, the composition of the
VSR at each reactor was a little different and is explained below. Since the VSRs were not in the active portion of the reactor during operation, only the tip section became radioactive.

The poison section of the VSRs was about 32 ft long and about 3 in. in diameter. The following variation existed in the VSR design:

- **B, D and F Reactors.** The material used in the VSRs was an alloy of 1.5 percent boron and 98.5 percent stainless steel. The material was formed into 3-in. tubing with a wall thickness of 3/16-in. constructed in nine sections, each 25 in. long and filled with 4-in. thick alternating layers of graphite and steel. The remaining six sections were void in the center.

- **DR and H Reactors.** The VSRs at DR and H were made of chrome-plated carbon steel tubing and contained a nominal 2.8-in. diameter core made of 5 percent boron and 95 percent graphite. The "active" portion of the VSR was assembled in three 10-ft sections.

- **C, KE and KW Reactors.** The VSRs used in C, KE and KW were made of an alloy of 1.5 percent boron and 98.5 percent stainless steel and formed into tubing with a wall thickness of 0.380-in. The full-length rod was assembled in 10-ft sections.

4. **Nozzles and Pigtails**

A nozzle with a pigtail (connector) was mounted on the front and rear of each process tube. The nozzle was designed to accommodate a flow measuring device (orifice or venturi) which connected the process tube through a pigtail to a crossheader. The crossheader connected to the main coolant supply. A nozzle is estimated to weigh 10 lb and the pigtail 2 lb. Approximately 50 percent of the nozzles buried were carbon steel and 50 percent were aluminum; 50 percent of the pigtails were stainless steel and 50 percent were aluminum.

5. **Poison Pieces (also referred to as: Lead Cadmium pieces, poison slugs)**

The lead-cadmium (Pb-Cd) alloy was used as reactor poison and was normally in the form of solid rods or plates. A typical Poison Piece is approximately 1.4 in. in diameter and 6 in. long. Each piece weighed 3.36 lb. The rods were sealed in an aluminum can with a wall thickness of 0.035 in. A total of 38 canned pieces was laid end-to-end to form a process tube column of poison. The word "poison" was used to describe the high neutron-absorbing characteristics of the column.

6. **Spacers (also referred to as dummies, perfs)**

Spacers were used to center the reactor fuel column in the process tube and to prevent the fuel elements from flushing to the rear cap closure during high flow (operating) periods. The spacers were 8-in. long with an outside diameter of 1.4-in, and a 0.25-in. wall thickness. Cylindrical in shape, the spacers had a number of perforations along the axis. The spacers were made from 2s grade aluminum, 6063 T6 Alloy.

7. **Splines**

Splines were used in the reactor to assist in control of the reactivity transient during startup and to "flatten" the neutron flux distribution for optimum production. Special caps were installed on the inlet nozzles of selected process tubes so that splines could be inserted and withdrawn during
reactor operation. Wide-scale use of the splines in the Hanford reactors started in 1960. The majority of splines used were about ½-in. wide, 1/16-in. thick, and 30 ft long. The splines were made of a combination of 12 ± 1.5 percent boron and 88 percent type 1100 aluminum.

8. **Thimbles**

In the early operation of the first five reactors, aluminum thimbles were used in the HCR and VSR channels to provide a sealed access to the reactor’s control and safety rods and for a boron solution used as a third shutdown device. The original design of the reactor systems provided the third shutdown device which, on demand, would release a liquid boron solution into the VSR channels. The thimbles in the VSR channels prevented the solution from being dispersed into the reactor block. After some years of operation, high corrosion rates on the aluminum thimbles made the reliability of the system questionable. Subsequently, the third safety system was redesigned to eliminate the use of thimbles and liquid boron.

9. **Wire (also referred to as TWFM wire, stringers)**

Part of the reactor graphite temperature monitoring system consisted of thermocouple stringers that were installed in nine selected process tube channels in the reactor block. There were 12 wire pairs in each stringer (13 at the K Reactors) that measured the temperature at different locations along the horizontal plane of the channel. The first stringers used were made up of ceramic-insulated wire. These were used in all reactors until the late 1950s when they were replaced with an Inconel-insulated wire. The thermocouples are made up of paired wire with an outside diameter of 0.0253-in. The positive lead is composed of 20 percent chromium and 78 percent nickel. The negative lead is composed of 3 percent silicon and 97 percent nickel.
Annex G to Dirt & Burial Ground Debris SPA -- Requirements for Plastic Sheeting/Other Flexible Materials/Liners Used As Confinement Boundaries Under the DBGD-SPA

The use of plastic sheeting, liners, and other flexible materials as a CfB is authorized under the DBGD-SPA. Depending on the DBGD Payload Type the authorized package configurations are as described in Table H4-3: DBGD SPA Authorized Packages & Administrative Controls. Flexible materials, used under the DBGD-SPA must be at least 6-mils thick with a Minimum Vicat Softening Point value of 200°F (93.33°C). When multiple layers of flexible materials are used, they will be placed in the package in a manner that the placement of the seams does not reduce the strength of the two layers and provides containment of the payload during transport. The flexible material must be sealed in such a manner that it allows maintenance of the CtB during handling and transportation activities. When flexible materials are used, the effects of softening and other types of loss of physical properties throughout the anticipated range of transportation environments (e.g., temperature, wind, and weather conditions, chemical environment) will have to be considered. For cold temperature operation effects of cold and possible brittle fracture of the plastic sheeting will be considered. Effects of solar insolation will be considered. To minimize the chance of use of flexible materials with degraded properties, all such materials used under the DBGD-SPA will be checked to ensure that they are within the manufacturer’s shelf life requirements.

Common plastics that have been evaluated include:

1. PETE = Polyethylene Terephthalate (PET) includes Mylar.
2. HDPE = High-Density Polyethylene.
3. LDPE = Low-Density Polyethylene includes LDPE/LLDPE (low density polyethylene/linear low density polyethylene).
4. PVDC = Polyvinylidene chloride.
**Annex H to Dirt & Burial Ground Debris SPA -- Approved Fixatives Under the DBGD-SPA**

<table>
<thead>
<tr>
<th>Fixative</th>
<th>Restrictions on Use</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>A-B-C Asbestos Binding Compound</td>
<td></td>
<td></td>
</tr>
<tr>
<td>AgriGator</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Amazon Select Paint</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Beryllium Fixative Mixture</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DEVOE Pre-Prime 167 Penetrating Sealer</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DAP Weldwood</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dust Bond</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DUSTAC</td>
<td></td>
<td></td>
</tr>
<tr>
<td>E T Glycerin Solution</td>
<td></td>
<td></td>
</tr>
<tr>
<td>EarthBound</td>
<td></td>
<td></td>
</tr>
<tr>
<td>EcoAegis</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ecofibre</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fibreset</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Magnafloc 156</td>
<td></td>
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<tr>
<td>Marloc</td>
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<td></td>
</tr>
<tr>
<td>Posi-Shell</td>
<td></td>
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</tr>
<tr>
<td>Road Oyl</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Soil-Sement</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
H.5 M SPA – (Monolith Packages Special Packaging Authorization)

The use of the Monolith Packages Special Packaging Authorization (M-SPA) is limited to packages meeting the requirements of this onsite SPA at the Hanford Site. The M-SPA uses a graded approach. The M-SPA authorizes the use of various packaging configurations and administrative controls. The Monolith Packaging System (MPS) is a risk based packaging system composed of a CtB, a CfB, and associated administrative controls. Based on the payload, the packaging system may use Industrial Packages (IP), Type A packages or Type B Packages for the CtB and IP, Type A, Type B packages or other analyzed effective CfBs (e.g., flexible material, steel, grout, reinforced concrete, and/or other cured immobilization agents.

Use of multiple layers of flexible material (e.g., plastic sheeting) as the CfB can account for only one layer of confinement. The flexible material will consist of multiple layers that are at least 10 mils thick and placed around the package in a manner that the placement of the seams does not reduce the strength of the two layers providing confinement of the payload during transport. The flexible material must be continuously sealed in such a manner that it allows maintenance of the CfB during handling and transportation activities. When flexible materials are used, the effects of softening and other types of loss of physical properties throughout the anticipated range of transportation environments (e.g., temperature, wind, and weather conditions) must be considered in the supporting documentation (see definition for flexible confinement materials in Annex A).

The inclusion of miscellaneous metallic debris under the M-SPA is allowed in Class II Immobilization Media provided that the debris is oriented such that it does not affect the structural characteristics and homogeneity of the immobilization media and it is not impeded from fully curing.
Figure H5-1. M-SPA Payload Entry Process
Table H5-1. M-SPA Entry Bounding Requirements

<table>
<thead>
<tr>
<th>Area</th>
<th>Bounding Value</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Structural</td>
<td>See Table H1-1</td>
<td></td>
</tr>
<tr>
<td>Thermal</td>
<td>See Table H1-1</td>
<td></td>
</tr>
<tr>
<td>Shielding</td>
<td>See Table H1-1</td>
<td></td>
</tr>
<tr>
<td>Containment/Confinement</td>
<td>See Table H1-1</td>
<td></td>
</tr>
<tr>
<td>Criticality</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>Gas Generation</td>
<td>Flammable gas concentration</td>
<td>As stated in the TSD, this requirement must be met over a period of time twice that of the expected shipment time under normal operating conditions. If venting is required and the shipment cannot be completed within the established window, provisions shall be made before loading the package for venting and purging to reestablish a new shipping window before the original shipping window expires.</td>
</tr>
<tr>
<td>Total Payload</td>
<td>&lt; 100 DE-Ci</td>
<td>M-SPA</td>
</tr>
<tr>
<td>Fissile Payload</td>
<td>&lt; 400 FGEs</td>
<td>M-SPA</td>
</tr>
<tr>
<td>Waste Heat</td>
<td>&lt; 50 Watts</td>
<td>For payloads containing Ion Exchanger Media. Based on Thermal analysis contained in HNF-36128, One-Time Request for Shipment (OTRS) of Ion Exchange Module.</td>
</tr>
<tr>
<td></td>
<td>&lt; 100</td>
<td>For payloads not containing Ion Exchanger Media.</td>
</tr>
<tr>
<td>Tiedown</td>
<td>See Table H1-1</td>
<td></td>
</tr>
<tr>
<td>Other Payload Restrictions/Prohibited Materials</td>
<td>No explosive materials</td>
<td>No free liquids</td>
</tr>
<tr>
<td></td>
<td>No pressurized gas containers</td>
<td>No chemically inter-active components</td>
</tr>
<tr>
<td></td>
<td>--</td>
<td></td>
</tr>
<tr>
<td>Physical Property</td>
<td>Limit</td>
<td>Source Document</td>
</tr>
<tr>
<td>-------------------------</td>
<td>--------------------------------------------</td>
<td>---------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>FGes</td>
<td>400 FGes</td>
<td></td>
</tr>
<tr>
<td>Waste Heat</td>
<td>50 Watts (Ion Exchanger Media)</td>
<td>HNF-36128, <em>One-Time Request for Shipment (OTRS) of Ion Exchange Module</em></td>
</tr>
<tr>
<td></td>
<td>100 Watts</td>
<td>WCH-242 One-Time Request for Shipment of the 327 Hot Cells</td>
</tr>
<tr>
<td>DE-Ci</td>
<td>See Table I6-3</td>
<td>HNF-36128, <em>One-Time Request for Shipment (OTRS) of Ion Exchange Module</em></td>
</tr>
<tr>
<td></td>
<td></td>
<td>HNF-27474, <em>One-Time Request for Shipment 105-KE Ion Exchange Column and Sand Filter Monoliths</em></td>
</tr>
<tr>
<td>Minimum Structural</td>
<td>3000 PSI Class I IM</td>
<td>M-SPA</td>
</tr>
<tr>
<td>Concrete Strength</td>
<td>2500 PSI Class II IM</td>
<td></td>
</tr>
<tr>
<td>Surface Temperature</td>
<td>185 °F</td>
<td>DOE/RL-2001-36, <em>Hanford Sitewide Transportation Safety Document</em></td>
</tr>
<tr>
<td>Flammable Gas</td>
<td>Below LEL</td>
<td>DOE/RL-2001-36, <em>Hanford Sitewide Transportation Safety Document</em></td>
</tr>
<tr>
<td>Concentration</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Surface Dose Rate</td>
<td>0.02 mSv/h (200 mrem/h)</td>
<td>DOE/RL-2001-36, <em>Hanford Sitewide Transportation Safety Document</em></td>
</tr>
<tr>
<td>Weight</td>
<td>Meets subcomponent package certification requirements</td>
<td>M-SPA</td>
</tr>
<tr>
<td>Waste contents</td>
<td>Solids only, no free liquids.</td>
<td>HNF-36128, <em>One-Time Request for Shipment (OTRS) of Ion Exchange Module</em></td>
</tr>
<tr>
<td>No reactive materials</td>
<td></td>
<td>M-SPA</td>
</tr>
</tbody>
</table>
Figure H5-2. Payload Configurations
### Table H5-3. M-SPA Authorized Package Configurations

<table>
<thead>
<tr>
<th></th>
<th>M-1</th>
<th>M-2</th>
<th>M-3</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 DE-Ci &lt; Payload &lt; 25 DE-Ci</td>
<td>CtB</td>
<td>CfB</td>
<td>CtB</td>
<td></td>
</tr>
<tr>
<td>25 DE-Ci &lt; Payload &lt; 50 DE-Ci</td>
<td>Yes</td>
<td>Two (2)</td>
<td>IP-1</td>
<td></td>
</tr>
<tr>
<td>50 DE-Ci &lt; Payload &lt; 100 DE-Ci</td>
<td>Yes</td>
<td>IP-2</td>
<td>Two (2)</td>
<td>IP-2</td>
</tr>
<tr>
<td>Payload &gt; 100 DE-Ci</td>
<td></td>
<td></td>
<td></td>
<td>NOT AUTHORIZED</td>
</tr>
<tr>
<td>Remarks</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CtB</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CfB</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IP-1 (or higher)</td>
<td>Yes</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Type A</td>
<td>N/A</td>
<td>Type A</td>
<td>N/A</td>
<td>Type A</td>
</tr>
<tr>
<td>Type B</td>
<td>N/A</td>
<td>Type B</td>
<td>N/A</td>
<td>Type B</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td>Applicability</td>
<td>Remarks</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-----------------------------------------</td>
<td>---------------</td>
<td>-------------------------------------------------------------------------</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Speed Restriction - 10 mph</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Route Control</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Road Closure</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lifting of the package is not allowed during transport.</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A single package will be transported on a conveyance.</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>If flammable gas concentrations are calculated to be above LEL, ensure that adequate filtered vents are provided. When used NucFil filters will be of the Stainless Steel type.</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>The use of banding or other engineered control to prevent packaging de-lamination is authorized.</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
## Monolith Special Packaging Authorization (M-SPA) Shipment Evaluation Checklist

<table>
<thead>
<tr>
<th>Package Designator or Shipment Number:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Required Packaging System Configuration:</td>
<td></td>
</tr>
<tr>
<td>Enter Total Payload DE-Ci Inventory:</td>
<td></td>
</tr>
<tr>
<td>Payload</td>
<td>Minimum Required Package</td>
</tr>
<tr>
<td>See Table H5-3 for authorized Packaging System Configurations</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Payload Type</th>
<th>M-1</th>
<th>M-2</th>
<th>M-3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Containment Boundary (CtB) (Describe)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Confinement Boundary (CfB) (Describe)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Confinement Boundary (CfB) (Describe)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Package Evaluation

Description of packaging system being used and method of transport: (include description of packages used to meet containment/confinement requirements, Package Certification Data including material of construction, who and how certified.

<table>
<thead>
<tr>
<th>Package Requirements</th>
<th>Yes</th>
<th>No</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Package meets M-SPA Structural Requirements</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Package meets M-SPA Immobilization Media Reqmnts</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Package meets M-SPA Thermal Requirements</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Package meets M-SPA Containment/Confinement Reqmnts</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Package meets M-SPA Shielding Requirements</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Package meets M-SPA Tiedown/Load Requirements</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Administrative Requirements

#### Payload Evaluation

<table>
<thead>
<tr>
<th>Area</th>
<th>Limits</th>
<th>Yes</th>
<th>No</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Payload</td>
<td>&lt; 100 DE-Ci</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fissile Payload</td>
<td>&lt; 400 FGEs</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Criticality</td>
<td>&lt; 400 FGEs</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Waste Heat</td>
<td>&lt; 100 Watts (50 W if Ion Exchange media is present)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gas Generation</td>
<td>&lt; 5 Volume % Flammable Gases</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reactive Materials</td>
<td>None</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Notes: Flammable Gas Limit applies to time duration of loading and transportation activities until received at receipt facility. Inner package may be vented using HEPA filter.

### Administrative Controls

- Speed Restriction (10 mph for all packages) | Road Closure

### Signature & Date

Signature & Date: Organization
ANNEX OUTLINE (MONOLITH-SPA)

Annex A: Definitions
Annex B: Payload M-SPA Safety Basis Documents
Annex C: Summary of Technical Bases and Properties of Immobilization Media (IM) used in the M-SPA
Annex A to Monolith SPA -- Definitions

**Aggregate**: granular material such as sand, gravel, crushed stone, or construction and demolition waste that is used with a cementing medium to produce either concrete or mortar. The term coarse aggregate refers to aggregate particles larger than 4.75 mm (No. 4 sieve) and the term fine aggregate refers to aggregate particles smaller than 4.75 mm but larger than 75 mm (No. 200 sieve).

**Confinement System**: The assembly of components of the packaging intended to retain the Class 7 (radioactive) material intact during transport.

**Concrete**: defined as a composite material composed of a binding medium within which are imbedded particles or fragments of aggregate. Properties/requirements for Concrete/Grout are discussed in Annex H.

**Containment system**: The assembly of components of the packaging intended to prevent the leakage of all Class 7 (radioactive) material (including gases and liquids) during transport within the leakage rate limits specified in the TSD.

**Flexible Confinement Material**: Depending on the Payload Type, the use of plastic sheeting, liners, and other flexible materials as a confinement boundary is authorized under this SPA. Flexible materials used under the M-SPA must be at least 10-mils thick with a Minimum Vicat Softening Point value of 200°F (93.33°C). When multiple layers of flexible materials are used, they will be placed in the package in a manner that the placement of the seams does not reduce the strength of the two layers and provides containment of the payload during transport. The flexible material must be sealed in such a manner that it allows maintenance of the confinement boundary during handling and transportation activities. When flexible materials are used, the effects of softening and other types of loss of physical properties throughout the anticipated range of transportation environments (e.g., temperature, wind, and weather conditions, chemical environment) will have to be considered. For cold temperature operation effects of cold and possible brittle fracture of the plastic sheeting and sealing surfaces will be considered. Effects of solar insolation will be considered. To minimize the chance of use of flexible materials with degraded properties, all such materials used under the M-SPA will be inspected to insure that they are within the manufacturer's shelf life requirements.

Common plastics that have been evaluated include:

1. PETE Polyethylene Terephthalate (PET) includes Mylar.
2. HDPE High-Density Polyethylene.
3. LDPE Low-Density Polyethylene includes LDPE/LLDPE (low density polyethylene/linear low density polyethylene).
4. PVDC Polyvinylidene chloride.

**Grout**: a mixture of cementitious material and fine aggregate. Properties/requirements for Concrete/Grout are discussed in Annex H.

**Grouted Body**: contaminated items that may include former facility floors, walls, and ceilings that do not include at least one packaging meeting 49 CFR 171-180 packaging provide either containment or confinement of the payload. The chief risk for a Grouted Body is packaging failure (loss of containment) of the immobilization media.
Grouted Package: Structures that have been filled with immobilization media and packaged for transportation and include at least one packaging meeting 49 CFR 171-180 packaging requirements. Rooms or Tanks may be credited as packages under the M-SPA if a RL approved engineering evaluation is provided that demonstrates that the credited structure is equivalent to the package being claimed under the M-SPA. The structural integrity of the package (i.e. rebar, structural steel, other load bearing components, as well as the walls, flooring and roof themselves have been credited in the analysis as meeting performance requirements of at least an Industrial Package or Type A Package.

Immobilization Media (IM): Materials added to the MPS to enhance packaging performance to prevent loss of containment/confine (structural, thermal, containment shielding, etc) or to immobilize the package payload, or to reduce void fraction. IM may be either Class I (credited in packaging safety basis analysis as enhancing packaging performance to prevent loss of containment/confine), or Class II (not credited in packaging safety analysis as enhancing packaging performance to prevent loss of containment/confine). Permissible IMs include concrete, grouts, foamed concretes, ceramics and approved plastic foams. (See Annex C.2 for list of approved foams.) Performance criteria for Class I and Class II IM are shown in Table H5-2.

Immovilized Debris Module (IDM): An M-SPA payload that normally consists of a lidless container that receives the payload. Immobilization media is added to the container to fill it. The resulting unit is then encased in additional immobilization media.

Ion Exchange Column (IXC) Monolith: An M-SPA payload that is built around an IXC.

Ion Exchange Module (IXM): An M-SPA payload know as an IXM that is an IXC encased in a concrete block.

Mortar: Defined as a mixture of sand, cement and water.

Reactive Chemicals: Chemicals present in the payload whose interaction with each other or other packaging components or the environment could effect either the packaging system’s containment or confinement boundaries. For the Purpose of the M-SPA, reactive chemicals include free liquids, corrosive chemicals (acids and bases), oxidizers, or chemicals that would adversely affect the stability of the immobilization media.

Sand Filter: An M-SPA payload that is built around a Sand Filter.
### Table H5.B-1. Payload M-SPA Safety Basis Documents

<table>
<thead>
<tr>
<th>Area</th>
<th>M-SPA Limit</th>
<th>Governing Document</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Payload</td>
<td>100 DE-Ci</td>
<td>M-SPA</td>
<td></td>
</tr>
<tr>
<td>2 Structural</td>
<td></td>
<td>As analyzed under M-SPA Table H5.B-2</td>
<td></td>
</tr>
<tr>
<td>3 Thermal (Ion Exchanger Media)</td>
<td>50 Watts</td>
<td>HNF-36128, <em>One-Time Request for Shipment (OTRS) of Ion Exchange Module</em></td>
<td></td>
</tr>
<tr>
<td></td>
<td>No Ion Exchanger Media</td>
<td>100 Watts</td>
<td>WCH-242 One-Time Request for Shipment of the 327 Hot Cells</td>
</tr>
<tr>
<td>4 Containment</td>
<td></td>
<td>Hanford Site TSD</td>
<td></td>
</tr>
<tr>
<td>5 Shielding</td>
<td>200 mrem/h contact</td>
<td>Hanford Site TSD</td>
<td></td>
</tr>
<tr>
<td>6 Criticality</td>
<td>400 FGEs</td>
<td>HNF-36128, <em>One-Time Request for Shipment (OTRS) of Ion Exchange Module</em></td>
<td></td>
</tr>
<tr>
<td>7 Gas Generation</td>
<td>&lt; LEL for flammable gases</td>
<td>M-SPA</td>
<td></td>
</tr>
<tr>
<td>8 Tie Down</td>
<td></td>
<td>Engineered analysis for each package</td>
<td></td>
</tr>
<tr>
<td>9 Other:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10 Flexible Materials</td>
<td></td>
<td>Dirt &amp; Burial Ground Debris SPA</td>
<td></td>
</tr>
<tr>
<td>11 Immobilization Media</td>
<td></td>
<td>M-SPA Appendix I</td>
<td></td>
</tr>
</tbody>
</table>
Table H5.B-2. Payload Supporting Analyses

<table>
<thead>
<tr>
<th>Payload</th>
<th>Source Document</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ion Exchange Module (M-1)</td>
<td>HNF-36128, <em>One-Time Request for Shipment (OTRS) of Ion Exchange Module</em></td>
<td></td>
</tr>
</tbody>
</table>
| Ion Exchange Column and Sand Filter Monoliths (M-2) | HNF-36128, *One-Time Request for Shipment (OTRS) of Ion Exchange Module*  
HNF-27474, *One-Time Request for Shipment 105-KE Ion Exchange Column and Sand Filter Monoliths (DRAFT)* |         |
| Immobilized Debris Module (M-3) | HNF-27474, *One-Time Request for Shipment 105-KE Ion Exchange Column and Sand Filter Monoliths* |         |
| Grouted Package (M-4)         | WCH-242 One-Time Request for Shipment of the 327 Hot Cells                     |         |
| Grouted Body (M-5)            | WCH-242 One-Time Request for Shipment of the 327 Hot Cells  
WCH-112 One-Time Request for Shipment of 107-N Monoliths, (DRAFT) |         |

Some of the source documents have not been approved by RL in their entirety. Certain analyses have been accepted by RL as safety basis documents in support of the M-SPA. Payload may not be added to M-SPA without a RL payload evaluation. If a payload is not explicitly evaluated under this M-SPA, it may not be shipped under the M-SPA.
Immobilization Media (IM) will be characterized as either Class I or Class II IM. Class I IM is an IM that is credited in the SPA safety analysis as part of the packaging system used to maintain either containment or confinement boundaries. Class II IM is not credited in the M-SPA safety analysis and is usually used to fill voids and gaps in the packaging system or contamination control. The Shipper will ensure by testing (and maintain evidence of testing) that IM meet compressive strength requirements prior to packaging system shipment.

C.1 Concrete/Grout

Grout (Concrete) may be used as an IM under the M-SPA. For purposes of the M-SPA, the minimum compressive strength allowed for grout as IM is Class I IM 3000 psi and for Class II IM 2500 PSI. The Shipper will ensure by testing that grouts meet compressive strength requirements prior to packaging system shipment.

For the purposes of the M-SPA, waste may not be added or blended in to Class I grout. Waste may be added to Class II grout under the following two conditions:

- As a discrete second phase addition (e.g., racks, boxes) that is not part of the grout mixture itself, or
- When waste is added to replace aggregate, it must be of similar properties to the aggregate being substituted for, and must not be added in quantities that would affect the concrete/grout from developing its full credited properties.

C.2 Cement Specifications

Different types of cement are manufactured to meet various physical and chemical requirements. There are currently three different common hydraulic cement standards for general concrete construction in use in the U.S.:

ASTM C150 (AASHTO M 85), Specification for Portland Cement.

ASTM C595 (AASHTO M 240), Specification for Blended Hydraulic Cements.

## Applications of Commonly Used Cements

<table>
<thead>
<tr>
<th>Cement Specification</th>
<th>General Purpose</th>
<th>Moderate heat of hydration</th>
<th>High early strength</th>
<th>Low heat of hydration</th>
<th>Moderate Sulfate Resistance</th>
<th>High Sulfate Resistance</th>
<th>Resistance to alkali-silica reactivity (ASR)***</th>
</tr>
</thead>
<tbody>
<tr>
<td>ASTM C150 (AASHTO M85) Portland cement</td>
<td>I</td>
<td>II (moderate heat option)</td>
<td>III</td>
<td>IV</td>
<td>II</td>
<td>V</td>
<td>Low alkali option</td>
</tr>
<tr>
<td>ASTM C595 (AASHTO M85) blended hydraulic cements</td>
<td>IS IP</td>
<td>IS (&lt;70)(MH) IP(MH)</td>
<td>-</td>
<td>IP(LH)</td>
<td>IS (&lt;70)(MS) IP(MS)</td>
<td>IS (&lt;70)(HS) IP(HS)</td>
<td>Low reactivity option</td>
</tr>
<tr>
<td>ASTM C1157 hydraulic cements***</td>
<td>GU</td>
<td>MH</td>
<td>HE</td>
<td>LH</td>
<td>MS</td>
<td>HS</td>
<td>Option R</td>
</tr>
</tbody>
</table>

*Check the availability of specific cements as all cements are not available everywhere.  
**The option for low reactivity with ASR susceptible aggregates can be applied to any cement type in the columns to the left.  
*** For ASTM C 1157 cements, the nomenclature of hydraulic cement, portland cement, air-entraining portland cement, modified portland cement, or blended hydraulic cement is used with the type designation. ASTM C 1157 recognizes six types of hydraulic cements:  
Type GU-general use;  
Type  HE-high early strength;  
Type MS-moderate sulfate resistance;  
Type HS-high sulfate resistance;  
Type MH-moderate heat of hydration; and  
Type LH-low heat of hydration.
Identifying Material Incompatibilities

The wide variety of materials options and mix proportions possible in concrete allows it to be customized for a wide range of applications and placement and service environments. However, the cementitious materials (cements, fly ashes, slags, etc.) and chemical admixtures (accelerators, retarders, water reducers, etc.) are all chemically complex, so must be analyzed and selected with care. Even when all materials meet and exceed their specification requirements individually, problems can arise under field conditions.

Although these problems are relatively rare, the resulting construction delays, performance issues, and loss of confidence in concrete as the preferred construction material are unacceptable. FHWA and PCA co-sponsored research into these phenomena, with the goal of minimizing or preventing these problems in the field. These groups have developed relatively simple protocols for evaluating concrete material combinations both pre-construction and during construction.

Shipper will ensure and document that their concrete evaluation protocols meet M-SPA requirements.
C.3 Non-Cement Based Immobilization Media

Non-cement based IMs may be used under the M-SPA provided that an RL-approved safety analysis has been approved. The formal safety analysis must analyze the proposed IM’s suitability for all potential packaging safety Normal Condition and Hypothetical Accident accidents / conditions as listed in the TSD. In addition the TSD requirements must meet the disposition facility’s long term storage requirements.

<table>
<thead>
<tr>
<th>Name</th>
<th>Class I</th>
<th>Class II</th>
<th>Density (minimum)</th>
<th>Conditions</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rigid Structural Polyurethane Foam</td>
<td></td>
<td>X</td>
<td>20 lb/ft³</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
H.6 Fuel Special Packaging Authorization

The Fuel Special Packaging Authorization (F-SPA) is intended to allow on site shipment of SNF and fuel debris found during remediation of Hanford waste sites including pits, trenches, burial grounds, cribs and facilities. Fuel and fuel debris as defined under the F-SPA includes:

- Intact fuel
- Fuel pieces and fuel debris
- Sludge

In accordance with a graded approach, this SPA authorizes the use of various packaging configurations and administrative controls. The F-SPA packaging systems consists of at a minimum, a CtB, a CfB, and associated administrative controls, and meets the requirements as a risk based package under the TSD. Based on the payload, the packaging system may use Industrial Packages (IP), Type A packages or Type B Packages for the CtB; and IP, Type A, Type B packages or other analyzed effective CfBs (e.g., multiple layers of heat sealed or taped heavy gage plastic liners). Packaging sub-containers (e.g., failed fuel rod containers) may be credited as either a CtB or CfB provided they have been approved by the RL.

The use of the F-SPA for payloads not consisting of fuel, fuel pieces, or sludges from fuel handling and storage activities is not authorized.

For the purposes of the F-SPA, the fuel may be either intact or damaged as defined in Annex A, Definitions. If the fuel is evaluated as being intact, it may be credited as being a CfB. Since the F-SPA packaging is comprised in part of subcomponents that are transportation packages listed in 49 CFR 1701-178, the dimensions and allowed weights are dependent upon the design values that the packages were originally certified to, or analyzed under the subcomponent engineering analysis. These values may only be changed or modified by the original package’s design /certification authority. Additionally, a Packaging Evaluation (in accordance with TSD Appendix J) showing equivalent function capability to a 49 CFR 1701-178 package may be submitted to RL for approval for packaging that does not have manufacturer’s certification. Alternatively, the Shipper may prepare and submit to RL for approval a One Time Request for Shipment (OTRS) with all the supporting analyses. The use of RL approved immobilization media is authorized. The use of external shielding or engineered stand offs is authorized. The use of vented packagings is authorized. The use of inter modal packagings (e.g., freight containers) without prior RL approval is prohibited.

Use of multiple layers of flexible material (e.g., plastic sheeting) as the CfB can account for only one layer of confinement. The flexible material will consist of multiple layers that are at least 10 mils thick each and placed around the package in a manner that the placement of the seams does not reduce the strength of the two layers providing confinement of the payload during transport. The flexible material must be continuously sealed in such a manner that it allows maintenance of the confinement boundary during handling and transportation activities. When flexible materials are used, the effects of softening and other types of loss of physical properties throughout the anticipated range of transportation environments (e.g., temperature, wind, and...
weather conditions) must be considered in the supporting documentation (see definition for flexible confinement materials in Annex A).

Annex B discusses the properties and characteristics of the K Basin fuel that provide the basis for this SPA. The basis for the criticality limits in this SPA is covered in Annex C. Annex D contains a list of pertinent references and supporting documentation providing the bases for this F-SPA.

**Table H6-1. Summary of Operating Requirements and Restrictions for the F-SPA**

<table>
<thead>
<tr>
<th>Requirement/restriction</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Shipment payloads are limited to a total of 200 DE-Ci per package.</td>
<td>In accordance with Appendix Annex B to Fuel SPA: Characteristics of Fuel.</td>
</tr>
<tr>
<td>2. Fissile payload in a package is limited to 450 FGEs (Unmitigated) or 1200 FGEs (Mitigated) per package. Maximum of one package per trailer and two packages per conveyance 900 FGEs (Unmitigated) or 2400 FGEs (Mitigated).</td>
<td>In accordance with Appendix Annex C to Fuel SPA: F- SPA Criticality Model.</td>
</tr>
<tr>
<td>3. The maximum allowable decay heat allowed is limited to 100 W per package.</td>
<td></td>
</tr>
<tr>
<td>4. F-SPA packagings containing flammable gas concentrations in excess of 5% hydrogen will not be transported.</td>
<td></td>
</tr>
<tr>
<td>5. No reactive materials shall be allowed in the packaging system that will react with the contents or packaging components as defined in Appendix Annex A.</td>
<td></td>
</tr>
<tr>
<td>6. Packages will meet the 200 mrem/h TSD specified contact and 10 mrem/h at 2 meters dose rate limits prior to shipment.</td>
<td></td>
</tr>
<tr>
<td>7. The surface contamination of the contents shall be limited to the values shown in Table 9, 49 CFR 173.443.</td>
<td></td>
</tr>
<tr>
<td>8. Road Closure is required. The Shipper may use Rolling Road closures as described in the TSD.</td>
<td></td>
</tr>
<tr>
<td>9. F-SPA packagings will not be transported at speeds exceeding safe speeds based on payload, and in no cases greater than 30 MPH.</td>
<td></td>
</tr>
<tr>
<td>10. Shipment of payloads containing non-fuel derived waste components is not authorized.</td>
<td></td>
</tr>
<tr>
<td>11. Transport will not occur during inclement weather as defined in the TSD.</td>
<td></td>
</tr>
</tbody>
</table>
Table H6-1. Summary of Operating Requirements and Restrictions for the F-SPA

<table>
<thead>
<tr>
<th>Requirement/restriction</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>12. The use of engineered barriers and shielding to meet dose rate requirements is authorized.</td>
<td></td>
</tr>
<tr>
<td>13. Packages may be vented. Use of organic fiber HEPA filters for venting packages is prohibited.</td>
<td></td>
</tr>
<tr>
<td>14. F-SPA packages must be transported within 30 days of sealing.</td>
<td></td>
</tr>
<tr>
<td>15. Route Control required.</td>
<td></td>
</tr>
<tr>
<td>16. Containers either contain vents or are vented prior to shipment.</td>
<td></td>
</tr>
</tbody>
</table>
### Table H6-2. F-SPA Entry Bounding Requirements

<table>
<thead>
<tr>
<th>Area</th>
<th>Bounding Value</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Structural</td>
<td>See Table H1-1</td>
<td></td>
</tr>
<tr>
<td>Thermal</td>
<td>See Table H1-1</td>
<td></td>
</tr>
<tr>
<td>Shielding</td>
<td>See Table H1-1</td>
<td></td>
</tr>
<tr>
<td>Containment/Confinement</td>
<td>See Table H1-1</td>
<td></td>
</tr>
<tr>
<td>Criticality</td>
<td>$K_{\text{eff}} &lt; 0.95$</td>
<td>See Annex C.</td>
</tr>
<tr>
<td>Gas Generation</td>
<td>Hydrogen gas concentration does not exceed 5% by volume in the sealed package over a period of time twice that of the expected shipment time under normal operating conditions.</td>
<td>If venting is required and the shipment cannot be completed within the established shipping window, provisions shall be made before loading the package for venting and purging to re-establish a new shipping window before the original shipping window expires.</td>
</tr>
<tr>
<td>Maximum Payload Volume/Weight</td>
<td>As specified in the applicable sub component certification documentation.</td>
<td>Package will not be operated containing payloads [either volumes or weights in excess of manufacturer’s certified value (Industrial Packagings and Type A packages) or Certificate of Compliance values (Type B Packages)].</td>
</tr>
<tr>
<td>Total Payload</td>
<td>Various</td>
<td>In accordance with Table H6-3</td>
</tr>
<tr>
<td>Fissile Payload</td>
<td>450 FGEs per package (Unmitigated), or 1200 FGEs per package (Mitigated)(^\d)</td>
<td>In accordance with Annex C to Fuel SPA: F-SPA Criticality Basis.</td>
</tr>
<tr>
<td>Waste Heat</td>
<td>100 Watts per package</td>
<td>--</td>
</tr>
<tr>
<td>Tie Down</td>
<td>See Table H1-1</td>
<td></td>
</tr>
<tr>
<td>Other Payload Restrictions / Prohibited Materials</td>
<td>No chemically inter-reactive components (as defined in Annex A). No explosives No free liquids No pressurized gas container (This prohibited material does not apply intact fuel pins)</td>
<td>--</td>
</tr>
</tbody>
</table>
Table H6-3. F-SPA Authorized Package Configurations & Administrative Controls

<table>
<thead>
<tr>
<th>Payload Range</th>
<th>Authorized Packages</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 25 DE-Ci</td>
<td>1. Type B package</td>
</tr>
<tr>
<td>(F Type-1 Shipment)</td>
<td>2. Type A package</td>
</tr>
<tr>
<td></td>
<td>3. IP-2 package + 1</td>
</tr>
<tr>
<td></td>
<td>confinement boundary</td>
</tr>
<tr>
<td>25. DE-Ci &lt; Payload &lt; 50</td>
<td>1. Type B package.</td>
</tr>
<tr>
<td>DE-Ci</td>
<td>2. Type A package + 1</td>
</tr>
<tr>
<td>(F Type-2 Shipment)</td>
<td>confinement boundary.</td>
</tr>
<tr>
<td></td>
<td>3. 2 IP-2s + 1 confinement</td>
</tr>
<tr>
<td></td>
<td>boundary.</td>
</tr>
<tr>
<td>50. DE-Ci &lt; Payload &lt; 100</td>
<td>1. Type B package.</td>
</tr>
<tr>
<td>DE-Ci</td>
<td>2. Type A package + 1</td>
</tr>
<tr>
<td>(F Type-3 Shipment)</td>
<td>confinement boundary.</td>
</tr>
<tr>
<td></td>
<td>100. DE-Ci &lt; Payload &lt; 200</td>
</tr>
<tr>
<td>DE-Ci</td>
<td>2. Two Type A packages + 1</td>
</tr>
<tr>
<td>(F Type-4 Shipment)</td>
<td>IP-2 confinement boundary.</td>
</tr>
<tr>
<td>Payload &gt; 200 DE-Ci</td>
<td>DOE approved One Time Request for Shipment (OTRS) is required.</td>
</tr>
</tbody>
</table>

Administrative Controls:

1. Maximum of one package per trailer and two packages per conveyance 900 FGEs (Unmitigated) or 2400 FGEs (Mitigated).
2. Road Closure is required. The Shipper may use Rolling Road closures as described in the TSD.
3. F-SPA packagings will not be transported at speeds exceeding safe speeds based on payload, and in no cases greater than 30 MPH.
4. Shipment of payloads containing non-fuel derived waste components is not authorized.
5. Packages may be vented. Use of organic fiber HEPA filters for venting packages is prohibited.
6. F-SPA packages must be transported within 30 days of sealing.
7. Containers either contain vents or are vented prior to shipment.
## F-SPA (F-SPA) Shipment Evaluation Checklist

### Required Packaging System Configuration

Enter Total payload DE-Ci inventory

<table>
<thead>
<tr>
<th>Package or Shipment Number:</th>
<th></th>
</tr>
</thead>
</table>

Is the Fuel Rod Integrity / Cladding being credited?  [ ] Yes [ ] No

### Payload

<table>
<thead>
<tr>
<th>Payload</th>
<th>Minimum Required Package</th>
</tr>
</thead>
<tbody>
<tr>
<td>25 DE-Ci &lt; Payload &lt; 50 DE-Ci (F Type-1 Shipment)</td>
<td>IP-2 package + 1 confinement boundary.</td>
</tr>
<tr>
<td>50 DE-Ci &lt; Payload &lt; 100 DE-Ci (F Type-3 Shipment)</td>
<td>Two IP-2 packages + 1 confinement boundary.</td>
</tr>
<tr>
<td>100 DE-Ci &lt; Payload &lt; 200 DE-Ci (F Type-3 Shipment)</td>
<td>Two Type A packages + 1 IP-2 confinement boundary.</td>
</tr>
</tbody>
</table>

### Required Package Configuration

<table>
<thead>
<tr>
<th>Type 1</th>
<th>Describe Type A/B/IP-2 Package:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type 1</td>
<td>Describe Confinement Boundary:</td>
</tr>
<tr>
<td>Type-2</td>
<td>Describe Type A/B/IP-2 Package:</td>
</tr>
<tr>
<td>Type 2</td>
<td>Describe Confinement Boundary:</td>
</tr>
<tr>
<td>Type-3</td>
<td>Describe Type A/B Package:</td>
</tr>
<tr>
<td>Type 3</td>
<td>Describe Confinement Boundary:</td>
</tr>
<tr>
<td>Type-4</td>
<td>Describe Type A/B Package 1:</td>
</tr>
<tr>
<td>Type 4</td>
<td>Describe Type A/B Package 2:</td>
</tr>
<tr>
<td>Type 4</td>
<td>Describe Confinement Boundary:</td>
</tr>
</tbody>
</table>

Package Evaluation: Description of packaging system being used: (include description of packages used to meet containment / confinement requirements, Package Certification Data including material of construction, who and how certified.

### Package Requirements

<table>
<thead>
<tr>
<th>Package Requirements</th>
<th>Yes</th>
<th>No</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Package meets F-SPA Structural Requirements</td>
<td>[ ]</td>
<td>[ ]</td>
<td></td>
</tr>
<tr>
<td>Package meets F-SPA Thermal Requirements</td>
<td>[ ]</td>
<td>[ ]</td>
<td></td>
</tr>
<tr>
<td>Package meets F-SPA Shielding Requirements</td>
<td>[ ]</td>
<td>[ ]</td>
<td></td>
</tr>
<tr>
<td>Package meets F-SPA Containment Requirements</td>
<td>[ ]</td>
<td>[ ]</td>
<td></td>
</tr>
<tr>
<td>Package meets F-SPA Tie Down / Load Restraint Requirements</td>
<td>[ ]</td>
<td>[ ]</td>
<td></td>
</tr>
</tbody>
</table>

Package Tie Down / Restraint Plans.

### Payload Evaluation

<table>
<thead>
<tr>
<th>Area</th>
<th>Limits</th>
<th>Yes</th>
<th>No</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Payload</td>
<td>F Type: DE-Ci:</td>
<td>[ ]</td>
<td>[ ]</td>
<td></td>
</tr>
<tr>
<td>Fissile Payload (unmitigated)</td>
<td>&lt; 450 FGEs&lt;sup&gt;1&lt;/sup&gt;</td>
<td>[ ]</td>
<td>[ ]</td>
<td></td>
</tr>
<tr>
<td>Fissile Payload (mitigated)</td>
<td>&lt; 1200 FGEs&lt;sup&gt;1&lt;/sup&gt;</td>
<td>[ ]</td>
<td>[ ]</td>
<td></td>
</tr>
<tr>
<td>Waste Heat</td>
<td>&lt; 100 Watts</td>
<td>[ ]</td>
<td>[ ]</td>
<td></td>
</tr>
<tr>
<td>Gas Generation</td>
<td>&lt; 5 Volume pct Flammable Gases</td>
<td>[ ]</td>
<td>[ ]</td>
<td></td>
</tr>
<tr>
<td>No Prohibited Materials in package as described in Table H6-2</td>
<td></td>
<td>[ ]</td>
<td>[ ]</td>
<td></td>
</tr>
<tr>
<td>Payload meets bounding F-SPA payload evaluation</td>
<td></td>
<td>[ ]</td>
<td>[ ]</td>
<td></td>
</tr>
</tbody>
</table>

### Number of Packages Being shipped per Conveyance:

### Administrative Controls

See Table H6-2

*In accordance with Annex C to Fuel SPA: F-SPA Criticality Model.*

### Signed

<table>
<thead>
<tr>
<th>Organization</th>
<th>Date</th>
</tr>
</thead>
</table>

H-97
ANNEX OUTLINE (FUEL-SPA)

Annex A: Definitions
Annex B: Characteristics of Fuel
Annex C: F-SPA Criticality Basis
Annex D: References
Annex A to Fuel SPA -- Definitions

**Concrete:** a composite material composed of a binding medium within which are imbedded particles or fragments of aggregate. Properties/requirements for Concrete/Grout are discussed in M-SPA, Annex C.

**Confinement system:** the assembly of components of the packaging intended to retain the Class 7 (radioactive) material intact during transport.

**Containment system:** the assembly of components of the packaging intended to prevent the leakage of all Class 7 (radioactive) material (including gases and liquids) during transport within the leakage rate limits specified in the TSD.

**Damaged fuel:** Nuclear fuel is considered damaged for the purposes of the F-SPA if it manifests any of the following conditions that result in either compromise of cladding confinement integrity or rearrangement (reconfiguration) of fuel geometry:

1. The fuel contains known or suspected cladding defects greater than a pinhole leak or hairline crack that have the potential for release of significant amounts of fuel particles into the package.

2. The fuel piece is damaged in such a manner as to impair its structural integrity; or cannot be handled using normal (i.e., crane and grapple) handling methods.

3. The fuel is no longer in the form of an intact fuel element.

4. The fuel element or cladding material properties are in a degraded condition such that its ability to withstand the normal and design basis events, or the normal and hypothetical accident conditions of transport as intact fuel is questionable.

**Flexible Confinement Material:** Depending on the Payload Type, the use of plastic sheeting, liners, and other flexible materials as a confinement boundary is authorized under this SPA. Flexible materials used under the M-SPA must be at least 10 mils thick with a Minimum Vicat Softening Point value of 200°F (93.33°C). Multiple layers of flexible materials must be placed in the package in a manner that the placement of the seams does not reduce the strength of the two layers and provides containment of the payload during transport. The flexible material must be sealed in such a manner that it allows maintenance of the confinement boundary during handling and transportation activities. When flexible materials including tapes and glue are used, the effects of softening and other types of loss of physical properties throughout the anticipated range of transportation environments (e.g., temperature, wind, and weather conditions, chemical environment) will have to be considered. For cold temperature operation effects of cold and possible brittle fracture of the plastic sheeting and sealing surfaces will be considered. Effects of solar insolation will be considered. To minimize the chance of use of flexible materials with degraded properties, all such materials used under the F-SPA will be inspected to ensure they are within the manufacturer's shelf life requirements.

Common plastics that have been evaluated include:

1. PETE Polyethylene Terephthalate (PET) includes Mylar
2. HDPE High-Density Polyethylene
3. LDPE Low-Density Polyethylene includes LDPE/LLDPE (low density polyethylene/linear low density polyethylene)

4. PVDC Polyvinylidene chloride

**Fuel:** For the purposes of the F-SPA, Fuel is considered to be individual fuel elements, portions of a fuel element, or a complete fuel rod. Intact fuel cladding may be credited as a Confinement Boundary under the F-SPA. Most Fuel is expected to be irradiated, but some unirradiated pieces may be encountered and handled under the controls in this SPA. Fuel radioisotope inventories used to demonstrate compliance with the requirements of this SPA must include all of the nuclides that contribute more than one percent to the dose consequences or are more than one percent of the actinide masses.

**Grout:** A mixture of cementitious material and fine aggregate. Properties/requirements for Concrete/Grout are discussed in M-SPA, Annex C.

**Grouted Body:** contaminated items that may include former facility floors, walls, and ceilings that do not include at least one packaging meeting 49 CFR 171-180 packaging requirements. These items are either encapsulated or layered with Class I immobilization media to provide either containment or confinement of the payload. The chief risk for a Grouted Body is packaging failure (loss of containment) of the immobilization media.

**Grouted Package:** Structures that have been filled with immobilization media and packaged for transportation and include at least one packaging meeting 49 CFR 171-180 packaging requirements. The structural integrity of the package (i.e. rebar, structural steel, other load bearing components, as well as the walls, flooring and roof themselves have been credited in the analysis as meeting performance requirements of at least an Industrial Package or Type A Package.

**Immobilization Media (IM):** Materials added to the F-SPA packaging system to enhance packaging performance to prevent loss of containment/confinement (structural, thermal, containment shielding, etc) or to immobilize the package payload, or to reduce void fraction. IM may be either Class I (credited in packaging safety basis analysis as enhancing packaging performance to prevent loss of containment/confinement), or Class II (not credited in packaging safety analysis as enhancing packaging performance to prevent loss of containment/confinement). Permissible IMs include concrete, grouts, foamed concretes, ceramics and approved plastic foams. (See Annex C.2 of the M-SPA for list of approved foams.) Performance criteria for Class I and Class II IM are shown in Table H5-2.

**Intact Fuel:** fuel that is not damaged.

**Mortar:** a mixture of sand, cement and water.

**Reactive Materials:** Materials present in the payload whose interaction with each other, other packaging components or the environment could effect either the packaging system’s containment or confinement boundaries. For the purpose of the F-SPA, reactive materials include, explosive compounds, corrosive chemicals (acids and bases), oxidizers and organic solvents. They do not include uranium and plutonium in the metallic form.

**Sludge:** For the purposes of the F-SPA, Sludge is considered to be material in the K Basins water that will pass through a screen with 0.25 in. (.64 cm) openings. Sludge is a mix of fuel
corrosion products (including metallic uranium, and fission and activation products), small fuel fragments, iron and aluminum oxide, concrete grit, sand, dirt, and debris. The sludge may be further characterized based upon its physical properties (e.g., Floor Sludge, Settler Sludge, North Loadout Pit Sludge). Sludge radioisotope inventories used to demonstrate compliance with the requirements of this SPA must include all of the nuclides that contribute more than one percent to the dose consequences or are more than one percent of the actinide masses.
Annex B to Fuel SPA -- Characteristics of Fuel

Data from existing safety bases calculations and isotopic tabulations were reviewed to provide a consistent set of values for use in characterization of irradiated fuel materials that could be encountered at typical Hanford facilities. The isotopic listing in WCH-120 was constructed to provide a bounding inventory for found fuel. Comparison with other fuel isotopic inventories indicates that WCH-120 does provide an adequately bounding inventory to conservatively represent any type of irradiated fuel likely to be encountered during site clean-up activities. The values for fuel are given per kg of material because not all fuel pieces encountered are intact fuel assemblies. The values for fuel given per cubic meter are based on the volume of a cylinder with the same diameter and length as a typical outer fuel element, and represent the properties based on the amount of space taken up by a fuel assembly. Because the radioactivity in K Basin sludges is derived from relatively small pieces of spent fuel that have accumulated from underwater storage and handling of irradiated fuel having similar properties to the parent fuel sources, it is expedient to include shipping controls for fuel, fuel pieces and sludges in this SPA. Values for sludges are given per m$^3$ and can be converted to other units using the sludge densities.

Table H6-5 is a comparison of the activities and other characteristics of the various types of fuel-bearing materials. The F-SPA places limits on quantities of fuel, in DE-Ci and decay heat, as well as other considerations such as fissile content, reactivity with air or water, friability, etc. Shipment under this SPA requires knowledge on the content of the fuel or sludge being shipped. If actual data or measurements are available for the material being shipped, they can be used as long as the parameters used are consistent with the SPA requirements. If the material can be identified with a specific type of material listed in the table below, the appropriate values from the table for that type may be applied for compliance with the applicable requirements and limits for this SPA. If fuel pieces are found that are not identifiable with any specific type, the characteristics from the WCH-120 inventory in the following table may be used, as those values are known to be adequately conservative.
### Table H6-5. Comparison of Activities of Various Fuel Types from Current Safety Bases

<table>
<thead>
<tr>
<th>Fuel Type</th>
<th>Total Ci/kg</th>
<th>Rad g/kg</th>
<th>DE-Ci/kg</th>
<th>FGE/kg</th>
<th>W/kg</th>
<th>DE-Ci/m(^3)</th>
<th>FGE/m(^3)</th>
<th>W/m(^3)</th>
<th>Density</th>
</tr>
</thead>
<tbody>
<tr>
<td>Table 4.1 of WCH-120 - 2006</td>
<td>3.5E+01</td>
<td>1.0E+03</td>
<td>1.5E+00</td>
<td>1.7E+01</td>
<td>1.3E-01</td>
<td>1.1E+03(^1)</td>
<td>1.3E+04(^1)</td>
<td>1.0E+02(^1)</td>
<td>0.78(^1)</td>
</tr>
<tr>
<td>Table 5.5 of TI-009 26% Pu-240 - 2006</td>
<td>6.9E+00</td>
<td>1.0E+03</td>
<td>8.9E-01</td>
<td>1.6E+01</td>
<td>4.7E-02</td>
<td>6.9E+02(^1)</td>
<td>1.2E+04(^1)</td>
<td>3.7E+01(^1)</td>
<td>0.78(^1)</td>
</tr>
<tr>
<td>Table 3.8 of TI-009 16% Pu-240 - 2006</td>
<td>2.4E+01</td>
<td>1.0E+03</td>
<td>9.5E-01</td>
<td>6.8E+00</td>
<td>1.2E-01</td>
<td>7.4E+02(^1)</td>
<td>5.3E+03(^1)</td>
<td>9.2E+01(^1)</td>
<td>0.78(^1)</td>
</tr>
<tr>
<td>Table 3.9 of TI-009 16.72% Pu-240 - 2006</td>
<td>2.0E+01</td>
<td>1.0E+03</td>
<td>1.1E+00</td>
<td>6.7E+01</td>
<td>1.1E-01</td>
<td>8.2E+02(^1)</td>
<td>5.2E+03(^1)</td>
<td>8.5E+01(^1)</td>
<td>0.78(^1)</td>
</tr>
<tr>
<td>Table 4.5 of TI-009 DU 26% Pu-240 - 2006</td>
<td>1.7E+01</td>
<td>1.0E+03</td>
<td>1.1E+00</td>
<td>1.6E+01</td>
<td>1.0E-01</td>
<td>8.4E+02(^1)</td>
<td>1.2E+04(^1)</td>
<td>7.9E+01(^1)</td>
<td>0.78(^1)</td>
</tr>
<tr>
<td>Table 4-12b of TI-015 Vol. 1 KE Fuel</td>
<td>1.4E+01</td>
<td>9.9E+02</td>
<td>4.6E-01</td>
<td>6.3E+00</td>
<td>7.0E-02</td>
<td>3.6E+02(^1)</td>
<td>4.9E+03(^1)</td>
<td>5.4E+01(^1)</td>
<td>0.78(^1)</td>
</tr>
<tr>
<td>Table 4-12c of TI-015 Vol. 1 KW Fuel</td>
<td>1.7E+01</td>
<td>1.0E+03</td>
<td>4.8E-01</td>
<td>6.8E+00</td>
<td>8.4E-02</td>
<td>3.7E+02(^1)</td>
<td>5.3E+03(^1)</td>
<td>6.5E+01(^1)</td>
<td>0.78(^1)</td>
</tr>
<tr>
<td>KOP sludge</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2.8E+03</td>
</tr>
<tr>
<td>Settler sludge SCS- CON-230</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>6.8E+02</td>
</tr>
<tr>
<td>KW SCS-CON-210 &amp; 220 - KW Sludge</td>
<td>1.7E+00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1.2E+02</td>
</tr>
<tr>
<td>KW SCS-CON-240, 250 &amp; 260 - KE sludge</td>
<td>7.6E-01</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>5.3E+01</td>
</tr>
</tbody>
</table>

\(^1\) Based on apparent bulk density of fuel assembly – mass divided by volume of cylinder with same dimensions as diameter and length of outer element
Annex C to Fuel SPA -- Criticality Basis

This SPA has established an unmitigated baseline criticality limit for packages of 450 FGE. This value guarantees criticality is not an issue during transportation or as a result of anticipated accidents because less than one minimum critical mass is involved in the shipment. Standard FGE conversion factors given in Contact Handled Transuranic Waste Authorized Methods for Payload Control (CH-TRAMPAC), Rev. 2, May 2005, HNF-EP-0063, or RADCALC shall be used to determine the unmitigated total package FGEs for this SPA.

K Basin sludges resulted from deterioration of well characterized spent reactor fuel stored in the K Basins. Particles that corroded or broke off of the irradiated fuel maintain the same isotopic distribution as the parent fuel. HNF-SD-SNF-TI-015, Volume 1, Rev. 7A, contains an official characterization of the KE and KW Basin fuel, including isotopic content calculated based on burn-up. Based on these isotopic distributions, the ratio of $^{235}\text{U}$ to total U in the spent fuel is 0.72 to 0.78 percent, nearly the same as in natural uranium.

RL has evaluated the K Basin fuel and sludge compositions and determined that $^{238}\text{U}$ poisoning can be credited as mitigation for the total FGEs in a single package offered for shipment. This credit does not necessarily apply to handling or storage at the shipping or receiving facility where the facility’s criticality safety programs shall apply. With the control that the material is or is derived from K Basin fuel, a mitigated limit of 1200 FGE per package is authorized only for shipment of these materials.
Annex D to Fuel SPA -- References


