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Transport, Aging, and Disposal Canister System Preliminary Performance Specifications Report

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Transport, Aging, and Disposal Canister System
Preliminary Performance Specifications Report

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CHANGE HISTORY

Revision Number	Interim Change No.	Date	Description of Change
000		June 2006	Initial issue
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EXECUTIVE SUMMARY

In the fall of 2005, the U.S. Department of Energy (DOE) directed the Management and Operating Contractor for the Yucca Mountain Project (YMP) to develop a new repository design that primarily uses canisters for containing spent nuclear fuel (SNF) from commercial nuclear utilities. Bechtel SAIC Company, LLC (BSC) subsequently received direction to prepare performance specifications for the transport, aging, and disposal canister (TAD) system and compile them into a single document. This report presents the TAD concept, background information, and an overview of TAD operations. The preliminary performance specifications are included in the appendices.

Utilization of a canister system with components suitable for geologic disposal is a concept that will simplify SNF waste handling operations at the Yucca Mountain repository. The concept envisions TADs that are loaded, sealed, inerted, and tested at nuclear utility sites. The TAD is then placed within an appropriate transportation overpack and ultimately shipped to the repository where it can be placed into a waste package for geologic disposal or an aging overpack for additional aging. The concept is beneficial for handling commercial SNF since bare SNF assemblies do not require direct handling again after the assemblies have been sealed inside a TAD.

Preliminary performance specifications have been developed to provide performance objectives for TAD system components. The preliminary performance requirements presented herein are generally not prescriptive of specific design features but rather are performance based to allow maximum flexibility and potential for innovation on the part of potential TAD vendors. The performance requirements given in this specifications report are intended to support the initiation of conceptual design activities and/or to obtain informal quotes or proposals from prospective TAD suppliers. These limited uses reflect the lack of either the TAD or associated requirements in the baseline.

These preliminary performance specifications cannot be used immediately for design, procurement, or fabrication purposes until the TAD-based system is formally documented in the project's technical baseline, and the performance and regulatory requirements are allocated to the specific structures, systems, and components (SSCs). This technical baseline implementation will allow completion of a basis of design that addresses the TAD-based system SSCs. A basis of design and subsequent engineering will then allow development of a performance specification that would be appropriate for procurement of the TAD-based system SSCs. Additionally, all specific values prescribed in the requirements must be verified for use as design input by DOE, BSC, or potential TAD vendors. Based on DOE direction, the scope of this document does not include performance requirements that are unique to use for specific storage sites.

The specifications, with a description of the components, are listed in Table ES-1 below.

Table ES-1. TAD System Preliminary Performance Specifications

Specification	Description
Preliminary Performance Specification: Transport, Aging, and Disposal Canister *Appendix A*	The specification in Appendix A describes the standard TAD. The canister contains either pressurized water reactor (PWR) or boiling water reactor (BWR) fuel assemblies. The canisters are loaded at utility sites, DOE sites, the repository, or other locations. The TAD is eventually loaded into a waste package and placed underground at the Yucca Mountain repository.
Preliminary Performance Specification: Transportation Overpack *Appendix B*	A transportation overpack is necessary for transporting the TAD safely between licensed nuclear facilities. The transportation overpack ensures that radionuclides within the TAD are contained during normal and accident conditions.
Preliminary Performance Specification: Transportation Skid *Appendix C*	The transportation skid is a cradle that secures the transportation overpack. It interfaces with a railcar or heavy-haul truck, if used. The skid is utilized for tie-down of the transportation overpack and facilitates rotation of the transportation overpack to a vertical orientation. The preliminary performance specification in Appendix C ensures that the skid is designed to perform all necessary functions while handling the transportation overpack and TAD.
Preliminary Performance Specification: Transport, Aging, and Disposal Canister System Ancillary Equipment *Appendix D*	Ancillary equipment such as lifting yokes and grapples will be needed to handle overpacks, impact limiters, and TADs. The performance of these items is documented in Appendix D.
Preliminary Performance Specification: Shielded Transfer Cask *Appendix E*	At the repository, the TAD will be moved inside and among various waste handling facilities. A shielded transfer cask (STC) is needed for safe handling and to ensure that radiation exposures are minimized. The performance requirements of the STC are found in Appendix E.
Preliminary Performance Specification: Aging Overpack *Appendix F*	If a TAD must be aged at the repository, it will be housed in an aging overpack. The preliminary performance specification in Appendix F establishes the performance objectives for the aging overpack.
Preliminary Performance Specification: Site Transporter *Appendix G*	The TADs are placed on aging pads at the repository site when needed to allow the SNF within the canisters to cool prior to emplacement underground. A site transporter moves the canisters (within an STC or aging overpack) from the handling facilities to the pad or between handling facilities. The specification in Appendix G describes that transporter.

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ACRONYMS

ALARA	as low as is reasonably achievable
BSC	Bechtel SAIC Company, LLC
BWR	boiling water reactor
DCRA	disposal control rod assembly
DOE	U.S. Department of Energy
DPC	dual-purpose canister
GROA	geologic repository operations area
HLW	high-level radioactive waste
HVAC	heating, ventilation, and air-conditioning
ISFSI	independent spent fuel storage installation
MTHM	metric tons of heavy metal
MTU	metric tons of uranium
NRC	U.S. Nuclear Regulatory Commission
NWPA	Nuclear Waste Policy Act
OCRWM	Office of Civilian Radioactive Waste Management
PWR	pressurized water reactor
SNF	spent nuclear fuel
SSCs	structures, systems, and components
STC	shielded transfer cask
TAD	transport, aging, and disposal canister
YMP	Yucca Mountain Project

ABBREVIATIONS

°C	degrees centigrade
°F	degrees fahrenheit
cm	centimeter
cm^2	centimeter square
ft	feet
g	acceleration due to gravity
GWd	gigawatt-day
h	hour
hr	hour
in.	inches
k_{eff}	maximum calculated effective multiplication factor
kg	kilogram
kW	kilowatt
lb	pound(s)
lb/ft^2	pounds per square foot
$lb/in^2/sec$	pounds per square inch per sec
m	meter
m/second	meter per second
m^2	square meter(s)
mho	Conductance in mho being the reciprocal of resistance in ohms
mm	millimeter
mph	miles per hour
mrem	milli roentgen equivalent man
pH	concentration of hydrogen ions
ppm	parts per million
psi, lb/in^2	pounds per square inch
sec	second
torr	pressure that causes the Hg column to rise 1 millimeter
yr	year

1. INTRODUCTION

This report presents the preliminary performance specifications that have been developed for the TAD system. The purpose of this document is to produce a single source for the performance specifications that the DOE can utilize. Preliminary performance specifications have been developed to provide performance objectives for TAD system components. The preliminary performance requirements presented herein are generally not prescriptive of specific design features but rather are performance-based to allow maximum flexibility and potential for innovation on the part of potential TAD vendors. The performance requirements given in this specifications report are intended to support the initiation of conceptual design activities and/or obtain informal quotes or proposals from prospective TAD suppliers. These limited uses reflect the lack of either the TAD or associated requirements in the baseline.

These preliminary performance specifications cannot be used immediately for design, procurement, or fabrication purposes until the TAD-based system is formally documented in the project's technical baseline and the performance and regulatory requirements are allocated to the specific SSCs. This technical baseline implementation will allow completion of a basis of design that addresses the TAD-based system SSCs. A basis of design and subsequent engineering will then allow development of a performance specification that would be appropriate for procurement of the TAD-based system SSCs. Additionally, all specific values prescribed in the requirements must be verified for use as design input by DOE, BSC, or potential TAD vendors. Based on DOE direction, the scope of this document does not include performance requirements that are unique to use for specific storage sites.

The scope of the TAD system preliminary performance specifications is limited to high-level performance objectives for the major system components. Requirements for the TAD system design, procurement, detailed quality assurance requirements, or deployment are beyond the scope of the specifications herein.

The quality assurance program was applied to the development of this report as explained in Section 2.

Background information on nuclear waste disposal and the TAD system concept is presented in Section 3. Since the TAD concept and geologic disposal are a first-of-a-kind system, the regulatory concept for the system is presented in Section 4. Section 5 is a summary of TAD operations, and Section 6 introduces the preliminary performance specification appendices and provides concluding remarks. Supporting references that provide additional details on the concepts presented in this report are listed in Section 7.

2. QUALITY ASSURANCE

This report was prepared in accordance with LP-3.11Q-BSC, *Technical Reports*. The TAD has not been classified on the current *Q-List* (BSC 2005 [DIRS 175539]); however, this document identifies functions that are important to safety and important to waste isolation. Therefore, this report is subject to the requirements of *Quality Assurance Requirements and Description* (DOE 2006 [DIRS 176927], Section 2.2.2.A).

Governing quality assurance regulations for operations such as TAD loading at nuclear utility sites, transportation, independent spent fuel storage installations, and operations at the repository are listed below:

- TAD loading and handling operations at nuclear utilities will be subject to the quality assurance provisions of 10 CFR Part 50, Domestic Licensing of Production and Utilization Facilities [DIRS 176567], Appendix B to Part 50, Quality Assurance Criteria for Nuclear Power Plants and Fuel Reprocessing Plants.

- The quality assurance provisions of 10 CFR Part 71, Packaging and Transportation of Radioactive Material [DIRS 176575], Subpart H, Quality Assurance, will apply to the components associated with the transportation program (i.e., canister, transportation overpack, transportation skid).

- If TADs are stored by utilities at independent spent fuel storage installation (ISFSI) sites, the quality assurance requirements in 10 CFR Part 72, Licensing Requirements for the Independent Storage of Spent Nuclear Fuel, High-Level Radioactive Waste, and Reactor-Related Greater than Class C Waste [DIRS 176577], Subpart G, Quality Assurance, will be applicable.

- Quality assurance requirements for aging at the repository will be governed by 10 CFR Part 63, Disposal of High-Level Radioactive Wastes in a Geologic Repository at Yucca Mountain, Nevada [DIRS 176544], Subpart G, Quality Assurance. Activities such as transfer, aging, and disposal at the repository involving TAD components (the canister, STC, aging overpack, and site transporter) will also be controlled by the quality assurance provisions of 10 CFR Part 63, Subpart G, Quality Assurance.

The regulations previously mentioned mandate the formal control of requirements, designs, reviews, acceptance criteria, purchasing, fabrication, testing, maintenance, and many other aspects for safety significant SSCs. Requirements for the TAD system concept have been identified and documented in *Transport, Aging, and Disposal Canister System Basis of Specification Requirements Document* (BSC 2006 [DIRS 176593], Section 3), which is the document source for TAD system component preliminary performance specifications (included as Appendices A through G in this report).

3. TAD SYSTEM BACKGROUND

This section presents relevant background applicable to the TAD system concept. The information for this section was extracted primarily from *Yucca Mountain Project Conceptual Design Report* (DOE 2006 [DIRS 176937]).

In 1982, the U.S. Congress acted to establish a comprehensive federal policy to address the accumulation of the nation's nuclear waste. The policy centers on deep geologic disposal and defines the original project mission need. In passing the Nuclear Waste Policy Act of 1982 (NWPA) [DIRS 101681], Congress assigned the primary responsibility for implementing this national policy to the DOE. Congress also identified specific actions to be taken by the Secretary of Energy, including characterizing several sites and deciding whether to recommend any of the sites for approval by the President. In 1987, Congress amended the NWPA to specify that only Yucca Mountain would be characterized as a potential repository site (Nuclear Waste Policy Amendments Act of 1987 [DIRS 100016]). In 2002, the open, orderly, and legally specified process in the NWPA was completed for designating the Yucca Mountain site as qualified for the submittal of a license application to the U.S. Nuclear Regulatory Commission (NRC). On February 15, 2002, the President recommended Yucca Mountain as the site for the first permanent geologic repository for high-level radioactive waste (HLW) and SNF. On July 23, 2002, the U.S. Congress upheld the presidential action (DOE 2006 [DIRS 176937], Section 1.3).

The Yucca Mountain repository will allow the consolidation of nuclear material that is temporarily stored at 130 sites around the nation to a single secure disposal site. In addition to ensuring the safety and security of nuclear materials, the repository will enable the federal government to fulfill contractual obligations to dispose of SNF from commercial nuclear power plants, meet the waste disposal needs of the Naval Nuclear Propulsion Program, and complete the clean-up and closure of former nuclear weapons production facilities (DOE 2006 [DIRS 176937], Section 2.1.1).

The United States has generated approximately 45,000 metric tons of heavy metal (MTHM) of SNF at commercial nuclear power plants around the country, all of which is destined for geologic disposal. This amount could more than double by 2035 if all currently operating nuclear power plants complete their 40-year license period. By 2035, the United States will also have about 2,500 MTHM of SNF from research reactors, naval reactors, reactor prototypes, and reactors that produce nuclear weapons materials (DOE 2006 [DIRS 176937], Section 2.1.1).

The NWPA, as amended [DIRS 100016], limits the amount of SNF and HLW that can be emplaced in the first geologic repository to 70,000 MTHM until a second repository is in operation. The materials that are currently planned for disposal at the repository include approximately 63,000 MTHM of commercial SNF, approximately 2,300 MTHM of DOE SNF, and approximately 4,700 MTHM of DOE HLW. All the waste forms transported to and received at the repository will be solid materials.

Yucca Mountain is located on federal land in a remote area of Nye County in southern Nevada, one of the most arid regions of the United States, approximately 90 miles northwest of Las Vegas. The federal government controls nearly all of the land in the region. The area needed for the repository encompasses land controlled by three federal agencies: the U.S. Department of Defense (U.S. Air Force, Nellis Test and Training Range, formerly known as the Nellis Air Force Range), the DOE (Nevada Test Site), and the U.S. Bureau of Land Management.

As required by the NWPA, as amended [DIRS 100016], the DOE Office of Civilian Radioactive Waste Management (OCRWM) will prepare a license application for submittal to the NRC for authorization to construct the Yucca Mountain repository. After receiving a license and constructing the repository, the DOE will apply to the NRC for a license to receive and possess 70,000 metric tons of nuclear waste and, upon receipt of that license, will begin operations.

In an October 2005 letter from DOE to the Management and Operating Contractor, a mostly canistered system with minimum handling of uncanistered SNF was directed (Arthur 2005 [DIRS 175743]). The objective is to simplify the design, licensing, construction, and operation of the repository surface facilities. For this approach, TADs are used to minimize the handling of uncanistered SNF by sealing commercial SNF in TADs at reactor sites. The TAD will be designed to accommodate both PWR and BWR SNF with only minor modifications for each type.

The TAD is then used for transport, aging (or storage at a licensed ISFSI), and disposal. In all three modes, the TAD is placed inside another vessel (overpack) that provides other necessary functions such as shielding, heat dissipation, structural strength, and corrosion resistance. For transportation to the repository, the overpacks for the TADs are the transportation overpacks; while at the repository, the overpacks for TADs are the STCs, aging overpacks, and ultimately the waste packages for disposal. The relatively small amount of uncanistered commercial SNF that arrives at the repository will be packaged into TADs.

The conceptual design described in *Yucca Mountain Project Conceptual Design Report* (DOE 2006 [DIRS 176937]) is based on receiving mostly canistered SNF. A large majority of the commercial SNF is received in TADs and the balance is received as individual assemblies in either casks or dual-purpose canisters (DPCs). Uncanistered commercial SNF assemblies are unloaded and repackaged in TADs under water in the Wet Handling Facility. TADs, including those loaded in the Wet Handling Facility and other disposal canisters (naval canisters, HLW canisters, and DOE SNF canisters), are loaded into waste package overpacks in a Canister Receipt and Closure Facility. Closing (welding) waste packages and transferring them to the emplacement system is done in the Canister Receipt and Closure Facility.

Surface Facilities—The repository's surface facilities will be located in the geologic repository operations areas (GROA), South Portal development area, North Construction Portal development area, Balance of Plant area, and surface shaft areas. The repository operations areas, supporting areas, utilities, and roads are expected to require the active use of as much as 1,500 acres of land (DOE 2006 [DIRS 176937], Section 2.1.2).

The surface portion of the repository comprises the facilities necessary to receive, package, and support emplacement of waste in the repository. Waste transfer operations will be conducted inside reinforced concrete and metal frame buildings that will be designed and constructed to withstand earthquakes and other natural phenomena. Protected from radiation by shielded transfer equipment and/or shield walls, workers will use remotely controlled equipment to remove the waste forms from transportation overpacks and insert them into waste packages.

The primary waste handling facilities in the surface designs are:

- **Receipt Facility**—Rail transportation overpacks containing DPCs or TADs are received into the Receipt Facility. The material handling system in the Receipt Facility provides the capability to receive and inspect the transportation overpack, remove the overpack from the carrier, prepare the overpack for unloading, and unload the TAD or DPC into either an STC for transfer to another waste handling facility or to an aging overpack for transfer to an aging pad. Unloaded transportation overpacks are prepared for return to the National Transportation System in the Receipt Facility (DOE 2006 [DIRS 176937], Section 2.1.2).

- **Wet Handling Facility**—In the Wet Handling Facility, the loaded truck and rail casks containing uncanistered commercial SNF assemblies are received in the entrance vestibule and moved inside to the heating, ventilation, and air-conditioning (HVAC) confinement area where they are inspected and the impact limiters are removed. The cask is then moved into the poolroom where it is upended and placed in the cask preparation area. In the cask preparation area, the cask is cooled (if required), sampled, and vented, and the cover bolts are removed. The cask is then moved to the pool where the commercial SNF assemblies are transferred underwater by a spent fuel transfer machine to staging racks in the pool or alternatively directly to an empty TAD previously staged in the pool. The unloaded cask is then moved to the cask restoration pit where it is decontaminated, as required; the lid and lid bolts are reinstalled; and it is inspected, surveyed, and ultimately returned (DOE 2006 [DIRS 176937], Section 2.1.2).

  An STC containing an empty TAD is brought into the Wet Handling Facility by the site transporter through the entrance vestibule. The STC and TAD are placed into the pool, and the TAD is loaded underwater with commercial SNF assemblies directly from the cask or staging racks by the spent fuel transfer machine. When the TAD is loaded, the TAD lid, which also functions as a shield plug, is installed. The lid of the STC is then installed and closed and the STC and enclosed TAD are moved to the TAD closure area. In the TAD closure area, the TAD is sealed, drained of water, dried, and backfilled with helium. The lid is installed on the STC. The STC and TAD are transferred to the Canister Receipt and Closure Facility for loading the TAD into a waste package. Alternatively, the TAD can be loaded into an aging overpack prior to being transferred to an aging pad. Additionally, the Wet Handling Facility can receive DPCs in rail transportation overpacks and STCs vertically from the Receipt Facility or the aging pads. DPCs that are received welded closed at the repository and must be cut open to remove the commercial SNF assemblies inside. The Wet Handling Facility can open and unload DPCs.

- **Canister Receipt and Closure Facility**—The Canister Receipt and Closure Facility houses SSCs for receiving all canistered waste forms, loading disposal canisters (DOE, naval, and TADs) into waste packages, closing waste packages, and downending waste packages for transfer to the emplacement transporter.

After the canisters are loaded into waste packages, the waste packages are welded closed, evacuated, and backfilled with helium; they are loaded onto the shielded waste package transporter in a horizontal orientation in the Canister Receipt and Closure Facility. The rail-based transport locomotive moves the waste package through the North Portal and down the north ramp to the appropriate emplacement drift. The waste package transporter docks against a transfer dock at the emplacement drift where the waste package is pushed out of the waste package transporter onto a rolling bedplate. The waste package emplacement gantry in the drift then straddles the waste package, lifts it, and moves it to its location in the drift (DOE 2006 [DIRS 176937], Section 2.1.2).

- **Aging Pads**—The aging pads provide space for aging and staging waste. This aging capability will enable commercial SNF to be aged, as necessary, to meet waste package thermal limits, while the staging capability will provide a surge capacity for additional flexibility in waste processing operations. Approximately 2,500 aging spaces for 21,000 MTHM of commercial SNF are provided in the design (DOE 2006 [DIRS 176937], Section 2.1.2).

Other surface facilities in the radiologically controlled area include the Central Control Center Facility, Heavy Equipment Maintenance Facility, Low-Level Waste Facility, and Warehouse and Non-Nuclear Receipt Facility. These facilities provide support to waste processing operations.

The infrastructure facilities together with the balance of plant area includes: an administration building, a medical center, a fire station, a central warehouse, central shops, a motor pool service station, a visitor center, a utility building, the North Portal entrance structure, a training facility, and security facilities.

The South Portal development area and the North Construction Portal development area will support the phased construction of the repository, even as the North Portal area accepts and prepares waste for underground emplacement in the first emplacement drifts.

Provisions are included in the conceptual design to permit retrieval of emplaced waste packages as required.

The surface facilities will be designed for eventual decommissioning and to minimize the generation of radioactive waste. Repository decommissioning criteria will meet the requirements of 10 CFR Part 63 [DIRS 176544]. The federal government will maintain institutional control of the site. Active and passive security systems and monitoring will prevent deliberate or inadvertent human intrusion and any other human activity that could adversely affect the repository.

After the operations in the repository and the performance confirmation program have been completed, the DOE will file a request with the NRC to amend the license to permit closure of the repository. After the license amendment has been received from the NRC, the DOE will permanently close the repository.

An overview of the TAD system operations is presented in Chapter 5.

4. TAD SYSTEM REGULATORY CONCEPT

The TAD system will be reviewed, evaluated, and approved by the NRC. Though many components of the canister system have been approved for use in similar applications, the TAD will be the first canister that is approved for transport, aging, and disposal in a geologic repository. The primary new issue for the canister system that the NRC will have to evaluate is the disposal aspect. Nuclear utilities have already canisterized SNF and placed it in storage locations and transported canisters. The DOE and Naval Nuclear Propulsion Program have also successfully canisterized, transported, and placed SNF in storage.

The DOE will likely assign more detailed operational requirements for TAD activities as they become clearer as the repository design and safety analyses evolve. The operational requirements will be expected to include areas such as records, training, and quality assurance. The DOE may also prescribe more specific operational limits for the TAD after additional waste package emplacement thermal analyses have been completed.

The TAD concept is unique for handling SNF since it will combine a variety of regulatory reviews that will examine SNF handling operations from an operating utility site to TAD emplacement underground inside a waste package at the Yucca Mountain repository. The regulations and plans discussed in this section reflect the expected requirements and guidelines that the NRC may use for their licensing and certification review. Details of regulatory framework for the TAD system are not currently available and the NRC will be developing their approaches as the repository and TAD designs evolve. This section presents a possible regulatory framework for TAD design, storage, loading, transportation, and disposal.

Capability for Reactor Site Storage

The nuclear utility industry has obtained approval from the NRC to use canister and overpack systems to load, handle, and store SNF in dry installations. The designs of these systems have evolved considerably over the past few years and include both horizontally and vertically oriented SNF storage systems. The cask systems are certified as part of obtaining a license in accordance with 10 CFR Part 72 [DIRS 176577]. Similar systems would be designed and licensed by DOE per 10 CFR Part 63 [DIRS 176544] for use at the repository site as aging components. Just as vendors and utilities work together to ensure that the dry storage systems are certified in accordance with 10 CFR Part 72 for storage at reactor sites, vendors and the DOE (and DOE contractors) will collaborate to ensure that the provisions of 10 CFR Part 63 are met for aging at Yucca Mountain.

A significant difference between 10 CFR Part 72 [DIRS 176577] and 10 CFR Part 63 [DIRS 176544] that will affect the TAD involves the methodology for demonstrating preclosure nuclear safety. Even though the SNF cask storage designs will most likely be very similar, 10 CFR Part 72 approval allows a deterministic approach for demonstrating nuclear safety of the storage system alone, and licensing for use under 10 CFR Part 63 requires a probabilistic approach that addresses the entire repository system. The difference will require vendors and DOE to develop nuclear safety analyses using the probabilistic methodology.

The NRC reviews the dry cask storage system design in accordance with NUREG-1536, *Standard Review Plan for Dry Cask Storage Systems* (NRC 1997 [DIRS 101903]). The facility design for dry storage is reviewed in accordance with NUREG-1567, *Standard Review Plan for Spent Fuel Dry Storage Facilities* (NRC 2000 [DIRS 149756]). It is likely that the review criteria for the TAD system will be very similar to these criteria already utilized by the NRC for the review of dry storage systems but will include probabilistic factors.

TAD Loading

TAD loading and handling operations at utilities are expected to follow the licensing requirements from 10 CFR Part 50 [DIRS 176567]. Each utilities' safety analysis report will include fuel handling requirements and loading. TADs will be similar to the process being followed today. The NRC reviews the utilities' safety analysis report in accordance with NUREG-0800, *Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants* (NRC 1987 [DIRS 103124]), and the TAD system is likely to be examined in a very similar manner.

TAD Transportation

The requirements in 10 CFR Part 71 [DIRS 176575] establish guidance for the transportation effort, and NUREG-1617, *Standard Review Plan for Transportation Packages for Spent Nuclear Fuel* (NRC 2000 [DIRS 154000]), provides guidance and other information to ensure that the TAD system can safely transport SNF on the nation's transportation system. In addition to the NRC requirements, U.S. Department of Transportation rules in 49 CFR Part 173, Shippers--General Requirements for Shipments and Packagings [DIRS 176026], will also be a part of the regulatory review.

TAD Disposal

TAD handling and disposal operations, including aging at the repository, will be reviewed against the criteria in 10 CFR Part 63 [DIRS 176544]. The NRC review criteria for the Yucca Mountain repository site are presented in NUREG-1804, *Yucca Mountain Review Plan, Final Report* (NRC 2003 [DIRS 163274]). Even though nuclear safety will be demonstrated using a probabilistic approach, long term disposal design features are the only elements that have not been previously implemented by the nuclear utility industry.

Regulatory Concepts—Conclusion

The TAD and associated loading, aging, transportation, and disposal SSCs will be subjected to a design environment that is, apart from the disposal aspect, fairly well known. The NRC and 10 CFR Part 63 [DIRS 176544] require a probabilistic approach for demonstrating nuclear safety rather than a deterministic approach utilized per 10 CFR Part 72 [DIRS 176577], but it is anticipated that only analyses and calculations will change substantially and designs can remain relatively the same.

5. OVERVIEW OF TAD SYSTEM OPERATIONS

The TAD system requires integrated operations that occur in the fuel handling buildings at nuclear power plants and in the waste handling facilities at the Yucca Mountain repository. Though only the canister shell and SNF within the TAD are the primary common components that travel from the reactor sites to Yucca Mountain, other system components such as overpacks, transfer casks, and transporters will also be utilized during waste handling operations. This section describes the major functions that are anticipated for TAD operations at the utilities and Yucca Mountain repository site.

5.1 MAJOR FUNCTIONS FOR TAD PROCESSING AT THE UTILITIES

5.1.1 Functions for TAD Loading

Empty TADs will be loaded with commercial SNF in a 10 CFR Part 50 [DIRS 176567] licensed facility in accordance with 10 CFR Part 71 [DIRS 176575] or 10 CFR Part 72 [DIRS 176577] and 10 CFR Part 63 [DIRS 176544] loading requirements. The loading will be performed in and around a fuel pool that is serviced by an overhead crane and fuel transfer machine.

5.1.2 Functions for TAD Dry Storage

Upon completion of loading and sealing, the utility may choose to place the loaded TADs in dry storage until they are scheduled for shipment to the repository or until thermal characteristics and other conditions support acceptance of the TADs at the repository.

5.1.3 Functions for TAD Transportation

For transportation to the repository, a loaded TAD must be inserted into its transportation overpack at a 10 CFR Part 50 [DIRS 176567] licensed facility and in accordance with loading requirements under 10 CFR Part 71 [DIRS 176575]. The transportation overpack is loaded onto the transportation skid and secured. Impact limiters are installed and the loaded transportation skid is lifted and loaded onto its railcar conveyance. The skid is secured to the conveyance, and the transportation package is then shipped to the repository.

5.2 MAJOR FUNCTIONS FOR TAD PROCESSING AT THE REPOSITORY

This section is derived from information contained in *Yucca Mountain Project Conceptual Design Report* (DOE 2006 [DIRS 176937], Section 2.4.2).

Upon arrival at the repository, the railcar conveyance and transportation overpack will be received at the Cask Receipt Security Station where custody of the cargo will be transferred to the repository operator and required inspections will be performed. After custody transfer and inspections have been completed, a site prime mover locomotive will move the conveyance to a railcar staging area. When the TAD is needed, the conveyance will be moved to one of the repository waste handling facilities.

Waste handling, aging, and preparation for disposal take place in a suite of repository surface facilities that will be designed to process loaded TADs for normal and off-normal event sequences. As shown on Figure 5-1, Repository Concept of Operations Flow Diagram, TAD operations take place in the Receipt Facility, Wet Handling Facility, and Canister Receipt and Closure Facility. The facilities will be constructed in phases; therefore, the diagram represents the facilities and all available flow paths at the end of construction.

The operations described below are based on vertically moving a loaded TAD between buildings while protected inside an STC. In addition, a loaded TAD is moved to and from the aging pad while protected inside a vertical aging overpack for the purpose of aging in vertical mode. Alternatively the TAD could also be designed for aging in a horizontal mode inside an aging overpack that may be of another style than the one used for vertical aging. In either mode of aging the design objectives will be the same. However, operating procedures and functional requirements applicable to horizontal onsite transport and horizontal aging, depending on proposed design concepts, will be quite different than those for a vertical mode.

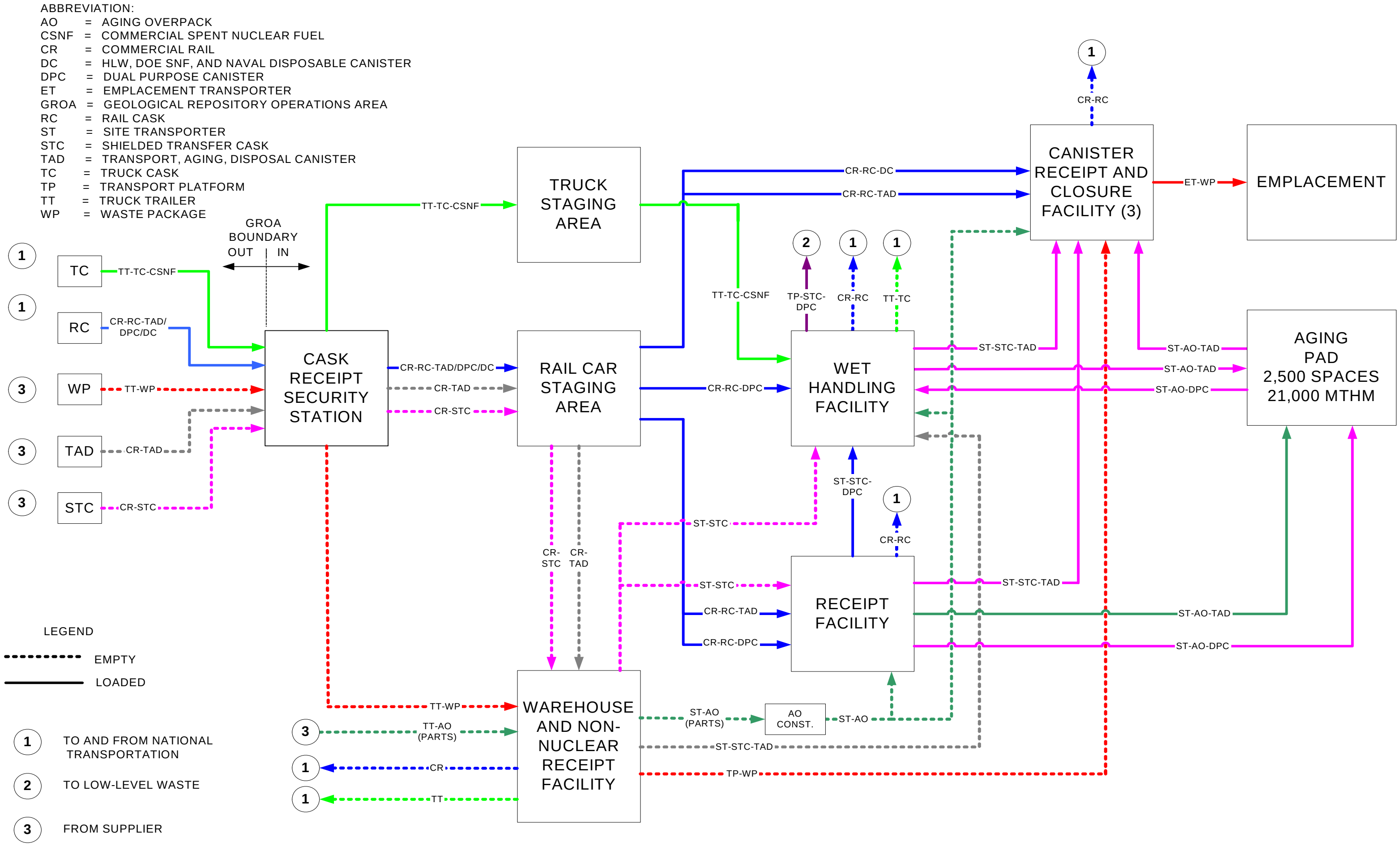
Most TAD movements between these facilities will be satisfied using the site transporter, as it will have to satisfy inter-facility movements of the STC and aging overpack. Preliminary designs for TAD operations at the repository utilize a standard STC configuration that includes a shielded right cylindrical cask with an integral shielded bottom and lift trunnions near the top end of the cask. The primary shielding on top of the commercial SNF inside a TAD is provided by the TAD's shielded top closure lid.

The aging overpack is a right cylindrical overpack that is shielded. If constructed of steel and concrete, it would be equipped with air ventilation ports for passive cooling of the TAD during aging. This aging overpack is lifted and moved by the gantry type site transporter that will engage the aging overpack via fittings at its top. The aging overpacks will be fitted with instruments to monitor the temperature of passive cooling air leaving the exhaust ports of the aging overpack.

In addition to the TADs, the repository waste handling facilities will also accommodate other waste forms including DPCs and disposal canisters containing HLW, DOE and naval fuel. The primary facility functions outlined below are for processing the TAD only.

5.2.1 Functions for TAD Processing in the Receipt Facility

This facility will receive and process loaded TADs and DPCs from the utilities for unloading and transferring to either the Canister Receipt and Closure Facility, Wet Handling Facility, or aging pad. TADs and DPCs are delivered in rail transportation overpacks, while the site transporter delivers empty STCs and aging overpacks from the Warehouse and Non-Nuclear Receipt Facility. A TAD with commercial SNF that has cooled sufficiently for immediate emplacement will be inserted into an empty STC for transfer to the Canister Receipt and Closure Facility. A DPC that is to be opened for SNF transfer is inserted into an empty STC for transfer to the Wet Handling Facility. All other TADs, and DPCs delivered to the Receipt Facility, will be inserted into empty aging overpacks for transfer to the aging pad.



Source: DOE 2006 [DIRS 176937], Figure 2-10.

Figure 5-1. Repository Concept of Operations Flow Diagram

Functions in the Receipt Facility include:

- Receiving, inspecting, and staging empty STCs
- Receiving and inspecting transportation overpacks with a TAD or DPC
- Off-loading the transportation overpack and preparing them for unloading
- Unloading TADs and DPCs to either an empty STC or empty aging overpack
- Preparing unloaded transportation overpacks for return to the National Transportation System.

5.2.2 Functions for TAD Processing in the Wet Handling Facility

The Wet Handling Facility receives uncanistered commercial SNF in a truck or rail transportation cask. The Wet Handling Facility also receives DPCs in an STC for opening operations. The fuel assemblies in truck and rail transportation casks, as well as those inside DPCs, must be unloaded and inserted into TADs and then transported to the Canister Receipt and Closure Facility for subsequent transfer to the aging pad.

The following functions are performed to meet these requirements:

- Receiving and off-loading truck and rail transportation casks containing uncanistered commercial SNF
- Receiving site transporter with an STC containing a DPC
- Receiving the site transporter with an STC and an empty TAD in the entrance vestibule for pickup by the overhead crane
- Cutting open the DPCs to provide access to the commercial SNF for extraction
- Managing commercial SNF for staging, queuing, and blending
- Transferring commercial SNF from truck or rail transportation overpacks, opened DPCs, and in-pool staging racks into empty TADs
- Closing, drying, and inerting loaded TAD while in the STC.

STCs with loaded TADs that are within the waste package 11.8 kW thermal limit are placed in the entrance vestibule for pick-up and transfer by the site transporter to the Canister Receipt and Closure Facility for placement into a waste package and subsequent emplacement in an underground drift.

Functions for the case where a TAD loaded at the Wet Handling Facility must go to the aging pad include:

- Closing, drying, and inerting loaded TAD while in the STC
- Transferring loaded TADs from the STC into aging overpacks
- Placing the loaded aging overpacks in the crawler vestibule for pick up by the site transporter
- Preparing unloaded transportation overpacks for return to the National Transportation System.

5.2.3 Functions for TAD Processing in the Canister Receipt and Closure Facility

The Canister Receipt and Closure Facility has been designed to receive all waste forms in canisters that are disposable and load these canisters into waste packages. The waste forms include TADs delivered in rail transportation overpacks, STCs from the Receipt Facility and the Wet Handling Facility, and aging overpacks from the aging pad.

Other waste forms that the Canister Receipt and Closure Facility will also receive for transfer into waste packages are HLW canisters, DOE SNF canisters, and naval canisters.

The following functions are performed:

- Receiving and off-loading a rail transportation overpack containing a TAD or disposal canister containing HLW/DOE/naval waste
- Receiving a site transporter with an STC or aging overpack containing a loaded TAD
- Receiving the empty waste packages from the Warehouse and Non-Nuclear Receipt Facility
- Transferring TADs and other disposal canisters into waste packages
- Closing and sealing loaded waste packages
- Transferring the loaded waste packages to the emplacement transporter
- Preparing unloaded transportation overpacks for return to the National Transportation System.

TADs coming from the aging pad are moved to the Canister Receipt and Closure Facility inside their aging overpack in which they were aged. TADs coming from the Receipt Facility and the Wet Handling Facility are delivered inside STCs. The Canister Receipt and Closure Facility also has capabilities to receive and process TADs, as well as other disposal canisters, in transportation overpacks that are delivered directly from the rail staging area to the Canister Receipt and Closure Facility.

5.2.4 TAD Processing at the Aging Pad

There are several aging pads, with a total of 2,500 aging and staging spaces to accommodate the aging or staging of aging overpacks. The design of the pads and the layout of aging spaces permit maneuvering a site transporter for placement and retrieval of the aging overpacks. The top surface of each pad is level with its surrounding area for ready roll-on and roll-off of the site transporter.

The primary functions that are satisfied at and with the aging pad are as follows:

- Receiving aging overpacks
- Placing or retrieving aging overpacks by the site transporter
- Monitoring aging overpacks in accordance with appropriate procedures.

After a period of cooling, an aging overpack with a TAD is moved using a site transporter to the Canister Receipt and Closure Facility for loading into a waste package and subsequent emplacement in an underground drift. When the Wet Handling Facility needs commercial SNF assemblies from staged DPCs on the aging pad, an STC with a DPC is delivered to the Wet Handling Facility using a site transporter. The DPC is opened and the commercial SNF is removed and transferred into a TAD.

6. CONCLUSIONS

In October 2005 the DOE directed BSC to revise the design for the Yucca Mountain repository to facilitate the utilization of primarily canisterized commercial SNF (Arthur 2005 [DIRS 175743]). The initial direction was followed up in November 2005 with further guidance to prepare performance specifications for the TAD system components (Arthur 2005 [DIRS 176432]).

Requirements analysis sheets containing performance-based requirement statements, identification of requirement sources, and rationale for the requirement statements were first developed and reviewed by subject matter experts and compiled into a basis of specification requirements document for the TAD system components. The *Transport, Aging, and Disposal Canister System Basis of Specification Requirements Document* (BSC 2006 [DIRS 176593], Section 3) provides the suite of requirements that affect the TAD system components and was used as the primary central source document for the performance specification development effort.

The DOE requirements for the TAD program originate in the *Civilian Radioactive Waste Management System Requirements Document (CRD)* (DOE 2006 [DIRS 176715]) and *U.S. Department of Energy Spent Nuclear Fuel and High-Level Radioactive Waste to the Monitored Geologic Repository,* Volume 1 of *Integrated Interface Control Document* (DOE 2002 [DIRS 158398]). Additional requirements are given in the *Monitored Geologic Repository Systems Requirements Document* (DOE 2006 [DIRS 177007]), *Waste Acceptance System Requirements Document* (DOE 2002 [DIRS 158873]), and *Transportation System Requirements Document* (DOE 2004 [DIRS 172491]).

At the time this report was developed, spring 2006, the primary requirements from DOE for the TAD program were documented by technical direction letters (Arthur 2005 [DIRS 175743] and [DIRS 176432]). As the TAD program matures, the DOE technical baseline requirements are subject to revision to reflect the progression of the TAD system conceptual design as it is received from TAD vendors.

The preliminary performance specifications are included in this report as Appendices A through G. These preliminary performance specifications were prepared by BSC for use by the DOE OCRWM.

The scope of the preliminary performance specifications is limited to performance within the OCRWM system. Specific requirements that would be unique at non-repository individual storage sites (e.g., nuclear power plants) are outside the scope of this set of specifications (Arthur 2005 [DIRS 176432]).

The preliminary performance specifications are intended to facilitate a market-driven approach for the development and deployment of TADs. This approach relies upon the private sector to design and certify the TAD based transportation systems that meet DOE performance specifications. Market forces are anticipated to determine the flexibility in the canister designs to serve specific industry needs. The performance objectives in the specifications are intended to allow flexibility and potential for innovation by qualified TAD vendors (Arthur 2005 [DIRS 176432]).

Table 6-1 summarizes the suite of seven (7) preliminary performance specifications that reflect the current state of the TAD program. The content of each of these specifications is briefly described in Table 6-1.

Table 6-1. TAD System Preliminary Performance Specifications

Specification	Description
Preliminary Performance Specification: Transport, Aging, and Disposal Canister *Appendix A*	The specification in Appendix A describes the standard TAD. The canister contains either PWR or BWR fuel assemblies. The canisters are loaded at utility sites, DOE sites, the repository, or other locations. The TAD is eventually loaded into a waste package and placed underground at the Yucca Mountain repository.
Preliminary Performance Specification: Transportation Overpack *Appendix B*	A transportation overpack is necessary for transporting the TAD safely between licensed nuclear facilities. The transportation overpack ensures that radionuclides within the TAD are contained during normal and accident conditions.
Preliminary Performance Specification: Transportation Skid *Appendix C*	The transportation skid is a cradle that secures the transportation overpack. It interfaces with a railcar or heavy-haul truck, if used. The skid is utilized for tie-down of the transportation overpack and facilitates rotation of the transportation overpack to a vertical orientation. The preliminary performance specification in Appendix C ensures that the skid is designed to perform all necessary functions while handling the transportation overpack and TAD.
Preliminary Performance Specification: Transport, Aging, and Disposal Canister System Ancillary Equipment *Appendix D*	Ancillary equipment such as lifting yokes and grapples will be needed to handle overpacks, impact limiters, and TADs. The performance of these items is documented in Appendix D.
Preliminary Performance Specification: Shielded Transfer Cask *Appendix E*	At the repository, the TAD will be moved inside and among various waste handling facilities. An STC is needed for safe handling and to ensure that radiation exposures are minimized. The performance requirements of the STC are found in Appendix E.
Preliminary Performance Specification: Aging Overpack *Appendix F*	If a TAD must be aged at the repository, it will be housed in an aging overpack. The preliminary performance specification in Appendix F establishes the performance objectives for the aging overpack.
Preliminary Performance Specification: Site Transporter *Appendix G*	The TADs are placed on aging pads at the repository site when needed to allow the SNF within the canisters to cool prior to emplacement underground. A site transporter moves the canisters (within an STC or aging overpack) from the handling facilities to the pad or between handling facilities. The specification in Appendix G describes that transporter.

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8. GLOSSARY

Aging—Placing commercial SNF in a site-specific cask on an aging pad for a long period of time (years) for radioactive decay. Radioactive decay results in a cooler waste form to ensure thermal limits can be met.

Burnup—A measure of nuclear-reactor fuel consumption expressed either as the percentage of fuel atoms that have undergone fission or the amount of energy produced per initial unit weight of fuel.

Canister—The structure surrounding the waste form (e.g., HLW immobilized in borosilicate glass logs) that facilitates handling, storage, and/or transportation.

1. For solidified HLW, the canister is a pour mold and provides confinement of radionuclides.

2. For SNF, the canister may provide structural support for intact SNF, loose rods, non-fuel components, and confinement of radionuclides.

3. Canistered waste will be placed in waste packages prior to emplacement. For the purposes of the TAD system, a TAD is a canister suited for transport, aging, and disposal.

Cladding—The metallic outer sheath of a fuel rod element generally made of a zirconium alloy. It is intended to isolate the fuel element from the external environment.

Dual-purpose canister (DPC)—A sealed metal container used to transfer, store, and transport SNF and HLW from a reactor site to a storage site or the repository site. The container and its shipping cask are licensed by the NRC pursuant to 10 CFR Part 71 [DIRS 176575] and 10 CFR Part 72 [DIRS 176577] for transportation and storage, respectively. Thus, the term dual-purpose canister.

Event sequence—A series of actions and/or occurrences within the natural and engineered components of a GROA that could potentially lead to exposure of individuals to radiation. An event sequence includes one or more initiating events and associated combinations of repository system component failures, including those produced by the action or inaction of operating personnel. Those event sequences that are expected to occur one or more times before permanent closure of the GROA are referred to as Category 1 event sequences. Other event sequences that have at least one chance in 10,000 of occurring before permanent closure are referred to as Category 2 event sequences

Fuel assembly—A number of fuel rods held together by plates and separated by spacers used in a reactor. This assembly is sometimes called a fuel bundle or fuel element.

Geologic repository operations area (GROA)—An HLW facility that is part of a geologic repository, including both surface and subsurface areas, where waste handling activities are conducted.

High-level radioactive waste (HLW)—(1) The highly radioactive material resulting from the reprocessing of SNF, including liquid waste produced directly in reprocessing, and (2) any solid material derived from such liquid waste that contains fission products in sufficient concentrations and other highly radioactive material that the NRC rules must receive permanent isolation.

Important to safety—A term used to define geologic repository SSCs, those engineered features of the GROA whose function is: (1) to provide reasonable assurance that HLW can be received, handled, packaged, stored, emplaced, and retrieved without exceeding the requirements of 10 CFR 63.111(b)(1) [DIRS 176544] for Category 1 event sequences, or (2) to prevent or mitigate Category 2 event sequences that could result in radiological exposures exceeding the values specified at 10 CFR 63.111(b)(2) to any individual located on or beyond any point on the boundary of the site.

Important to waste isolation—Those engineered and natural barriers whose function is to provide a reasonable expectation that HLW can be disposed of without exceeding the requirements in 10 CFR 63.113 [DIRS 176544].

Neutron absorber—A material (such as boron or gadolinium) that captures neutrons; used in nuclear reactors, transportation casks, and waste packages to control neutron activity by making neutrons unavailable for other reactions.

Off-normal—A term used to define radioactive waste, operations, and processes that are not expected during normal activities. Usually associated with damaged or failed materials, equipment, or processes.

Overpack—A secondary container that is used to package or hold canisters containing SNF or HLW. An overpack also provides a means for transporting or storing canisters while dissipating heat and providing radiological shielding. The TAD system contains three overpacks: (1) an aging overpack to contain the TAD while in storage at the Yucca Mountain repository on an aging pad, (2) a transportation overpack to hold the TAD during transportation from offsite nuclear utilities or other storage locations to the repository, and (3) an STC that provides protection during TAD transfer operations at the repository.

Postclosure—The period of time after closure of the repository system.

Preclosure—The period of time before and during closure of the repository system.

Site—Area surrounding the GROA for which the DOE exercises authority over its use in accordance with the provisions of 10 CFR Part 63 [DIRS 176544].

Site transporter—A large, heavy, shielded, self-powered vehicle used to haul transportation casks, STCs, and aging overpacks in a vertical orientation to and from the repository surface facilities.

Shielded transfer cask (STC)—A heavily shielded container system that meets applicable regulatory requirements for the transfer of SNF or HLW among surface waste transfer and aging facilities.

Spent nuclear fuel (SNF)—Used fuel elements and the associated hardware withdrawn from a nuclear reactor following irradiation, the constituent elements of which have not been separated by reprocessing; used fuel elements that have been irradiated (burned) in a reactor to the extent that they no longer make an efficient contribution to a nuclear chain reaction. Used fuel is highly radioactive compared to unused fuel, and it generates significant decay heat.

TAD System—The set of components consisting of TADs, transportation overpacks, transportation skids, ancillary equipment, shielded transfer casks, aging overpacks, and site transporters.

Total effective dose equivalent—For purposes of assessing doses to workers, the sum of the deep-dose equivalent (for external exposures) and the committed effective dose equivalent (for internal exposures).

Transportation overpack—The assembly of components of the packaging intended to retain the radioactive material during transport.

Trunnion—A knob shaped means for lifting on the outside of a cylinder (waste package, canister).

Waste form—A generic term that means radioactive waste materials and any encapsulating or stabilizing matrix.

Waste package—The container that is designed to isolate emplaced waste from its environment. The waste package includes the waste form and any containers, spacing structures, or baskets, and other absorber materials immediately surrounding an individual waste container placed internally to the container or attached to the outer surface of the waste container.

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APPENDIX A
PRELIMINARY PERFORMANCE SPECIFICATION: TRANSPORT, AGING, AND DISPOSAL CANISTER

This appendix contains the *Preliminary Performance Specification: Transport, Aging, and Disposal Canister*.

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1. SCOPE/BACKGROUND

1.1 This preliminary performance specification applies to a TAD that may be approved for use and licensed by the NRC for confining commercial SNF.

1.2 The TAD includes the canister shell, lid(s), and other components (basket for holding fuel assemblies, thermal shunts, and neutron absorbers).

1.3 When necessary, the following TAD system components will work in conjunction with the canister to meet the performance objectives of this specification:

- Transportation Overpack (Appendix B)
- Ancillary Equipment (Appendix D)
- Shielded Transfer Cask (Appendix E)
- Aging Overpack (Appendix F).

1.4 The TAD system design effort will utilize as guidance the following NRC NUREGs that may be used by the NRC to review the TAD system designs: *Standard Review Plan for Transportation Packages for Spent Nuclear Fuel* (NRC 2000 [DIRS 154000]), *Standard Review Plan for Dry Cask Storage Systems* (NRC 1997 [DIRS 101903]), and *Yucca Mountain Review Plan, Final Report* (NRC 2003 [DIRS 163274]), as applicable.

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2.4 OTHER REFERENCES

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168553 BSC (Bechtel SAIC Company) 2004. *Criticality Model.* CAL-DS0-NU-000003 REV 00A. Las Vegas, Nevada: Bechtel SAIC Company. ACC: DOC.20040913.0008; DOC.20050728.0007.

176593 BSC (Bechtel SAIC Company) 2006. *Transport, Aging, and Disposal Canister System Basis of Specification Requirements Document.* 000-30R-MGR0-01400-000-000. Las Vegas, Nevada: Bechtel SAIC Company.

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3. PERFORMANCE REQUIREMENTS

The performance requirements for the TAD system at the Yucca Mountain repository have been compiled into a single source: *Transport, Aging, and Disposal Canister System Basis of Specification Requirements Document* (BSC 2006 [DIRS 176593], Section 3). The performance requirements in this specification for the canister shell, internal baskets, and other canister components are a subset of the overall requirements for the entire TAD system. In many instances the TAD must function with other system components in order to satisfy performance objectives.

Background information, with sources and rationale for the performance requirements, is found in the basis of the specification requirements document. Performance requirements cite the requirement number from the TAD requirements document. For example, the citation MH-10 or the citation defined in FP-1 refers to *Transport, Aging, and Disposal Canister System Basis of Specification Requirements Document* (BSC 2006 [DIRS 176593], Section 3) and requirement number MH-10 or definition of a fully engulfing fire in requirement number FP-1 in that document.

3.1 GENERAL PERFORMANCE REQUIREMENTS

3.1.1 The TAD shall conform to the dimensional envelope (e.g., tolerance, stackup, thermal expansion) based on a right-circular cylinder with a length of $212.0\ in.\left(\frac{+0.0\ in.}{-0.5\ in.}\right)$ and a diameter of $66.5\ in.\left(\frac{+0.0\ in.}{-0.5\ in.}\right)$. (TAD-1)

3.1.2 The TAD maximum loaded weight shall be 54.25 short tons. (TAD-1)

3.1.3 The capacity of the TAD shall be either 21 spent fuel assemblies from a PWR or 44 spent fuel assemblies from a BWR. (TAD-1)

3.1.4 The cumulative height of the TAD; the open STC, or open transportation overpack, or open aging overpack (i.e., lids removed); and associated grapple shall be limited such that maximum lift height limits of Yucca Mountain repository lifting equipment are not exceeded. The limit under-the-hook height is less than 42 ft as shown in Figure A3.1-1. (MH-1)

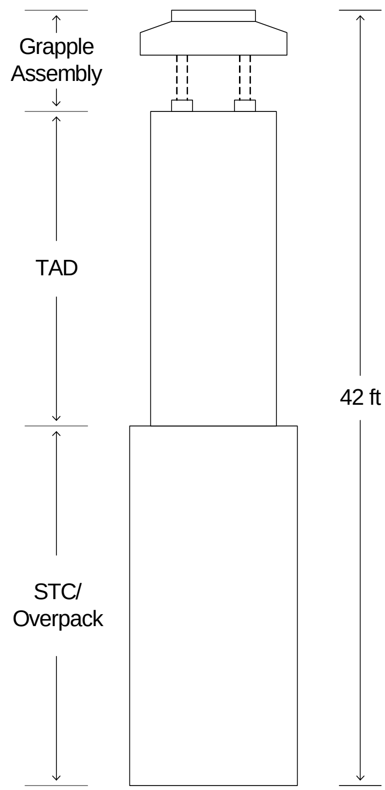

Figure A3.1-1. TAD Component Cumulative Height

3.1.5 The loaded and closed TAD shall be capable of being reopened such that the waste may be repackaged. The design shall demonstrate the methodology for opening while submerged in a pool. (MH-5)

3.1.6 The TAD for PWR fuel shall accept fuel assemblies with the characteristics bounded by the maximum source specification of 5% initial enrichment, 80 GWd/MTU burn up, and 5 years out-of-reactor cooling time. (NU-5)

3.1.7 The TAD for BWR fuel shall accept fuel assemblies with the characteristics bounded by the maximum source specification of 5% initial enrichment, 75 GWd/MTU burnup, and 5 years out-of-reactor cooling time. (NU-6)

3.1.8 A TAD shall be capable of being loaded with SNF from one or more facilities that are licensed by the NRC and hold one or more contracts with the DOE for the disposal of SNF. (TRO-1)

3.1.9 The combined size and weight of the loaded TAD and STC (in a water-filled condition), and the combined size and weight of the loaded TAD and aging overpack, shall be limited to ensure that they can be handled at the Yucca Mountain repository. These limits are provided in Table A3.1-1. (MH-12):

Table A3.1-1. Combined Size and Weight Limits

Maximum envelope diameter	135 in.
Maximum length	240 in.
Maximum loaded weight	200 tons (hook weight, including lifting devices)

3.1.10 The TAD shall be designed so that dropping a TAD lid or shield plug onto an open TAD shall not result in damage to fuel within the TAD. (PCSA-9)

3.1.11 All external edges shall have a minimum radius of curvature of one-quarter inch to ensure the minimization of stress risers and line-stress loads on the inner surface of the inner vessel of the waste package that might result in adverse performance of the waste package outer corrosion barrier. To the extent practicable, projections or protuberances from reasonably smooth adjacent surfaces shall be avoided or smoothly blended into the adjacent smooth surfaces. (TAD-1)

3.1.12 The TAD shall be designed for a 50-year service life. (PCSA-10)

3.2 STRUCTURAL

3.2.1 A TAD in an STC, a TAD in an aging overpack, a TAD within a transportation overpack with impact limiters, and a TAD within a transportation overpack without impact limiters shall be designed to maintain confinement (normal leakage rate specified in PCSA-1 and within the normal operations temperature limits specified in PCSA-3) following a seismic event defined by the 2,000-year seismic return period. The STC, the aging overpack, and the transportation overpack, if used for a direct transfer to a stationary aging overpack, may be on a site transporter. The normal leakage rates and the off-normal cladding temperatures provided in PCSA-3 shall be demonstrated following a seismic event defined by the 10,000-year seismic return period. Seismic data for the 2,000- and 10,000-year return period seismic events are provided in *Transport, Aging, and Disposal Canister System Basis of Specification Requirements Document* (BSC 2006 [DIRS 176593], Attachment A of Appendix C). (PCSA-4)

3.2.2 For use at the repository, a TAD within a transportation overpack with impact limiters, a TAD within an STC and a TAD within an aging overpack shall be designed to maintain confinement (normal leakage rate specified in PCSA-1 and within temperature limits specified in PCSA-3) during and following exposure to the environmental conditions listed below. The STC and an aging overpack may be on a site transporter. (PCSA-5)

For TAD transfers directly from the transportation overpack to a stationary aging overpack, the configuration shall be designed to maintain confinement (normal leakage rate specified in PCSA-1 and within temperature limits specified in PCSA-3) during and following exposure to the environmental conditions listed below. The TAD within a transportation overpack without impact limiters may be on a site transporter. (PCSA-5)

The cladding temperature requirement is identified as normal (400°C) or off-normal (570°C) following the environmental condition listed below:

These environmental conditions are not cumulative but occur independently (PCSA-5):

- Outdoor average daily temperature of 2ºF to 116ºF with insolation as specified in 10 CFR Part 71 [DIRS 176575] (normal)
- An extreme wind of a 3-sec 90 mph gust (normal)
- Maximum tornado wind speed of 189 mph with a corresponding pressure drop of 0.81 lb/in^{2}and a rate of pressure drop of 0.30 lb/in^2/sec (off-normal)
- The spectrum of missiles from the maximum tornado are provided in Table A3.2-1 (off-normal):

Table A3.2-1. Spectrum of Missiles

Missile	Mass (kg)	Dimensions (m)	Horizontal Velocity (m/second)
Wood Plank	52	0.092 × 0.289 × 3.66	58
6 in. Schedule 40 pipe	130	0.168D × 4.58	10
1 in. steel rod	4	0.0254D × 0.915	8
Utility Pole	510	0.343D × 10.68	26
12 inch Schedule 40 pipe	340	0.32D × 4.58	7
Automobile	1810	5 × 2 × 1.3	41

- Annual precipitation of 20 inches/year (normal)
- The spectrum of rainfall is provided in Table A3.2-2 (normal):

Table A3.2-2. Spectrum of Rainfall

Parameter and Frequency	Nominal Estimate	Upper Bound 90% Confidence Interval*
Maximum 24-hr precipitation (50-year return period)	2.79 in./day (7.1 cm)	3.30 in./day (8.4 cm)
Maximum 24-hr precipitation (100-year return period)	3.23 in./day (8.2 cm)	3.84 in./day (9.8 cm)
Maximum 24-hr precipitation (500-year return period)	4.37 in./day (11.1 cm)	5.25 in./day (13.3 cm)
Precipitation 1-hr intensity (50-year return period)	1.35 in./hr (3.4 cm)	1.72 in./hr (4.4 cm)
Precipitation 1-hr intensity (100-year return period)	1.68 in./hr (4.3 cm)	2.15 in./hr (5.5 cm)

*Use the values for upperbound 90% confidence interval.

- Maximum daily snowfall of 6.0 in. (15.2 cm) (normal)
- Maximum monthly snowfall of 6.6 in. (16.8 cm) (normal)
- A lightning strike with a peak current of 250 kiloamps over a period of 260 microseconds and a continuing current of up to 2 kiloamps for 2 seconds (off-normal).

  (PCSA-5)

3.2.3 The TAD within a transportation overpack with impact limiters, an STC or an aging overpack shall be designed to maintain confinement (normal leakage rate specified in PCSA-1 and the off-normal cladding temperature provided in PCSA-3) following 4 inches of volcanic ash accumulation. The STC and an aging overpack may be on a site transporter. (PCSA-6)

3.2.4 For TAD transfers directly from the transportation overpack to a stationary aging overpack at the Aging Pad, a TAD within a transportation overpack without impact limiters shall be designed to maintain confinement (normal leakage rate specified in PCSA-1 and within off-normal temperature limit specified in PCSA-3) following 4 in. of volcanic ash accumulation. The TAD within a transportation overpack without impact limiters may be on a site transporter. (PCSA-6)

The ash fall loads are estimated at 21 lb/ft^2 (PCSA-6)

3.3 THERMAL

3.3.1 In accordance with ISG-11 (NRC 2003 [DIRS 170332]) for normal operations during transportation and storage, the maximum SNF cladding temperature in TADs shall not exceed 400°C. The requirement applies to all cladding materials in accordance with ISG-11. Normal operations include storage at reactors and aging at Yucca Mountain repository surface facilities, transportation from reactors to the repository, and transportation by on-site transporters at the repository. (TH-1)

3.3.2 During accidents or off-normal operation for durations lasting up to 30 days (such as fires or loss of HVAC systems in surface facilities), the maximum SNF cladding temperature in TADs shall not exceed 570°C (PCSA-3). This requirement applies to all cladding materials in accordance with ISG-11 (NRC 2003 [DIRS 170332]). (TH-1)

3.33 Cooling features and mechanisms in TADs shall be passive in nature. (TH-1)

3.3.4 For normal operations in the repository emplacement drifts, the maximum temperature of cladding for SNF contained in a TAD shall not exceed 350°C. This includes both preclosure and postclosure time periods. For purposes of demonstrating that a TAD meets this requirement, Table A3.3-1 specifies boundary conditions and assumptions to be used to calculate fuel pin temperatures. This correlation is valid for TAD thermal power values ranging from 11.8 kW to 25 kW. (TH-1)

Table A3.3-1. Boundary Conditions for Calculating Fuel Pin Temperatures

For a Uniform Radial Surface Temperature of:	Minimum Peak Heat Flux Through Surface:	Minimum Average Heat Flux Through Radial Surface:
274°C	0.78 kW/m^2	0.42 kW/m^2
232°C	1.19 kW/m^2	0.64 kW/m^2
181°C	1.65 kW/m^2	0.89 kW/m^2

(TH-1)

3.3.5 The TAD system shall be designed to maintain cladding temperature for SNF below 400ºC during normal operations and 570ºC during off-normal and accident conditions in accordance with ISG-11 (NRC 2003 [DIRS 170332]. The requirement for the TAD is applicable in any TAD configuration: a TAD within an STC, an aging overpack, a transportation overpack with impact limiters, or a transportation overpack without impact limiters. (PCSA-3)

3.4 SHIELDING AND RADIATION

3.4.1 The TAD, the transportation overpack, the STC, the aging overpack, site transporter, and ancillary equipment shall contain features that are designed to reduce worker (individual and collective) radiation exposures to as low as is reasonably achievable (ALARA). Worker dose assessments based on specified operating procedures and associated operating environments shall be provided for each operation. These assessments shall demonstrate the effectiveness of the design features to meet ALARA objectives at the repository.

Examples of the ALARA design and operational features: radiation shielding; simplified operations that reduce time and the number of workers required; isolating and maintaining clean water in the annulus between a TAD and its transfer cask; vent, backfill, and test penetrations located and oriented to facilitate access and reduce radiation streaming; smooth surfaces for ease of decontamination; use of standard tools and equipment; and use of long reach tools. (NU-1)

3.4.2 The TAD shall provide axial shielding (i.e., shield plug(s)) to allow limited personnel access during closure and handling operations. The combined neutron and gamma dose rate at the top surface of the loaded canister shall not exceed 80 mrem/hr. (NU-4)

3.4.3 A TAD and associated components shall be designed such that removable external surface contamination of radioactive material is controlled in conjunction with specified operating procedures to limit the potential for contamination in worker areas, airborne contamination of repository facilities such as HVAC, onsite and offsite radioactive releases, and cross contamination of equipment in contact with TADs. (NU-7)

3.4.4 The TAD shall withstand a blast wave, projectiles, or thermal radiation resulting from a site transporter fuel, lubricating or hydraulic tank or system explosion, without failure of shielding functions as defined in NU-2, and NU-3, respectively. (FP-2) "The aging overpack shall limit the combined maximum neutron and gamma dose rate to less than 40 mrem/hr at contact with any exterior surface of the overpack". (NU-2) "The on-site STC shall limit the combined neutron and gamma dose rate to less than 80 mrem/hr at contact with any exterior surface of the STC". (NU-3)

3.5 CRITICALITY

3.5.1 Preclosure Criticality

To ensure criticality control to the extent reasonably possible in TAD systems, the maximum calculated effective multiplication factor (k_{eff})[1] for a TAD containing the most reactive SNF for which the design is approved shall not exceed the upper subcritical limit (USL)[2] for the three archetypical proxy configurations[3]. These proxy configurations are surrogates for the configurations from event sequences that are important for criticality and have a probability greater than 1 chance in 10,000 of occurring during the preclosure period. (PRCC-1)

3.5.2 Postclosure Criticality

3.5.2.1 The TAD design shall ensure that the probability of criticality occurring within a waste package is less than 1 chance in 100,000,000 per package over the first 10,000 years after permanent closure. This is to be accommodated by one of the following means:

1. Include the following features in the TAD internals:

   a. Neutron absorber plates or tubes made from Ni-Cr-Mo-Gd Alloy (ASTM B932-04 [DIRS 168403] [DIRS 176830]).

   b. Minimum thickness of the neutron absorber plates or tubes is 7/16 in. (11.1125 mm) [DIRS 176831]. The maximum and nominal thickness can be based on structural requirements.

   c. Neutron absorber plates or tubes must extend the full axial length of the canister internals within 1/2 in. (12.7 mm) [DIRS 176832] or less at room

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[1] The maximum k_{eff} for a configuration is the value at the upper limit of a two-sided 95% confidence interval (YMP 2003 [DIRS 165505], Section 3.5.3.2.9).

[2] The USL is a value of k_{eff} that accounts for biases and uncertainties for the configurations and includes an administrative margin to provide added assurance of subcriticality (BSC 2004 [DIRS 168553], Section 6.3.1).

[3]The *Criticality Input to Canister Based System Performance Specification for Disposal* (BSC 2006 [DIRS 176841] Section 3.1)provides a set of considerations for determining the proxy configurations based upon analyses of different, but similar, waste package designs. A summary of the three proxy configurations are:

(1) Nominal fully loaded TAD configurations that are open and fully flooded in the Wet Handling Facility pool with no soluble neutron absorber present in the pool water;
(2) Off-normal TAD configurations where a fuel assembly, normal or deformed, are lying across an open, fully loaded, TAD in the Wet Handling Facility pool with no soluble neutron absorber present in the pool water;
(3) Off-normal configurations where the TAD shell, TAD internals, and SNF assemblies are reconfigured in accordance with a 50g impact in the orientation that would result in the greatest force transfer to the TAD and its contents [DIRS 176829] while inside the transfer cask and in the Wet Handling Facility pool (i.e., the TAD is fully flooded with no soluble neutron absorber present in the pool water).

temperature. This feature addresses the issue of fissile materials shifting to the ends of a canister during disruptive events.

d. Neutron absorber plates or tubes must cover all four longitudinal sides and corners of each fuel assembly. This feature is to provide a closed cell that prevents neutronic and physical interactions between adjacent cells [DIRS 176833].

e. Surface(s) of the neutron absorber plates or tubes that could contact a fuel assembly or other zircaloy component must have inserts or liners of Stainless Steel 316NG plate or tube of minimum 5/16 in. (7.9375 mm) [DIRS 176834] thickness. The insert or liner (or their corrosion products in the case of long-term corrosion) is to prevent direct contact and potential eutectic formation between Ni-Zr and Fe-Zr materials during an igneous intrusive event.

f. The ratio of the fuel assembly cross-sectional area (area from the outer edges of the spacer grids or channel) to the area within the inner edges of the neutron absorber plate or tube (subtracting the cross-sectional area of stainless steel insert or liner [i.e., item e] and any other solid components [e.g., thermal shunts]) in the region of the active fuel must be 0.80 or less. This ratio limit reflects the current extent of postclosure criticality analyses performed. Reasons to go beyond may be considered but will require additional analyses to confirm if a greater ratio is acceptable [DIRS 176835].

g. The TAD design for pressurized water reactor (PWR) fuel assemblies must be able to accommodate PWR fuel assemblies loaded with disposal control rod assemblies (DCRAs), i.e., extra weight and possibly extra length, if the TAD design is to accept fuel assemblies with characteristics outside the limits set in the postclosure criticality loading curves for the features described in items (a) through (f). DCRAs are similar to the control rod assemblies, reactivity control assemblies, reactivity control cluster assemblies, or burnable poison rod assemblies placed in fuel assemblies during irradiation in reactors. The main differences are that they have extra thick zircaloy cladding, the absorber materials extend beyond the active fuel length, and the spiders that hold the rod have thick zircaloy or titanium locking mechanism(s). The TAD postclosure criticality control design features, described in items (a) through (f), do not necessarily allow loading of the entire SNF inventory. Initial loading curves based on the postclosure criticality control design features are available (*Criticality Input to Canister Based System Performance Specification for Disposal* (BSC 2006 [DIRS 176841], Section 4.1, Figures 5 and 6); but these loading curves will need to be adjusted for the specific TAD design; and further loading restriction may be necessary for the transportation license (i.e., criticality, shielding, and thermal limits). The fuel assemblies shown unacceptable for postclosure criticality on the final TAD loading curve will require additional criticality control features [DIRS 176836].

These features will ensure postclosure criticality control to the extent reasonably possible without a fully detailed postclosure criticality evaluation of a specific design using the methods described in the Topical Report (YMP 2003 [DIRS 165505]) and input document (BSC 2006 [DIRS 176841]). Alternatives to the above may be proposed with sufficient analyses to demonstrate the intents expressed above.

2. Perform the following analyses of TAD systems:

   The maximum calculated effective neutron multiplication factor (k_{eff})[4] for a TAD containing the most reactive SNF for which the design is approved shall not exceed the critical limit[5] for the four archetypical proxy configurations[6]. These proxy configurations are surrogates for the configurations from event sequences that are important for criticality and that have a probability of occurrence greater than the screening threshold for inclusion in performance assessments[7]. (POCC-1)

3.6 CONFINEMENT

3.6.1 The TAD shall be designed to facilitate helium leak testing of closure features using methods that can demonstrate that the leak-tightness requirements of PCSA-1 have been met. Leak testing should be performed in accordance with industry standards and regulatory guidance, such as ANSI N14.5-97 [DIRS 145735]. (CC-1)

3.6.2 If TAD closure welds are used, they shall be designed in accordance with standard nuclear industry practice. The *2004 ASME Boiler and Pressure Vessel Code* (ASME 2004 [DIRS 171846]) is required for design, procedure, and qualification requirements. (CC-2)

3.6.3 The TAD shall be designed to facilitate:

- Draining and vacuum drying to remove water vapor and oxidizing material to an acceptable level. The objective is to demonstrate the ability of the loaded TAD to maintain a 3 Torr vacuum for 30 minutes after vacuum pump operation ceases.

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[4]The maximum k_{eff} for a configuration is the value at the upper limit of a two-sided 95% confidence interval (YMP 2003 [DIRS 165505], Section 3.5.3.2.9).

[5]The critical limit is the value of k_{eff} at which a configuration is considered potentially critical including biases and uncertainties (BSC 2004 [DIRS 168553], Section 6.3.1).

[6]The *Criticality Input to Canister Based System Performance Specification for Disposal* (BSC 2006 [DIRS 176841], Section 3.1) provides a set of considerations for determining the proxy configurations based upon analyses of different, but similar, waste package designs. A list of the four proxy configuration cases are:

a. Nominal case, basket assembly degraded, SNF intact.
b. Seismic case-I, basket assembly intact, SNF degraded.
c. Seismic case-II, basket assembly degraded, SNF degraded.
d. Igneous intrusion case, basket assembly degraded, SNF degraded, waste package and TAD structural deformation.

[7]A system performance assessment is a comprehensive analysis that estimates the dose incurred by the reasonably maximally exposed individual, including the associated uncertainties, as a result of releases from the repository caused by all significant features, events, processes, and sequences of events and processes, weighted by their probability of occurrence (YMP 2003 [DIRS 165505], Appendix B).

- Filling with helium to atmospheric pressure, or greater as required to meet leak test procedural requirements.

- Sampling of the gas space to verify helium purity. The objective is to limit the maximum allowable oxidizing gas concentration within the loaded and sealed TAD to 0.20% by volume, based on the free volume of the TAD at atmospheric pressure.

These operations should be assumed to be performed in accordance with industry standards and regulatory guidance, such as NUREG-1536 (NRC 1997 [DIRS 101903]). (CC-3)

3.6.4 The design/qualification of the final closure on the TAD shall comply with Interim Staff Guidance-18 (NRC 2003 [DIRS 164538]) if applicable for the purposes of demonstrating no credible leakage *or* shall be designed to a maximum leak rate of 1.5×10^{-12} fraction of canister free volume per second during normal operations under repository environmental conditions as defined in PCSA-5. (PCSA-1)

3.6.5 The TAD within an STC and a TAD within an aging overpack shall be designed to a maximum accident leak rate of 9.3×10^{-10} fraction of canister free volume per second under the applicable repository environmental conditions following a 3-ft drop or tipover. The drop or tip over may be from the transporter. During potential events involved with unloading the transportation overpack from the conveyance, the TAD within the transportation overpack must be capable of sustaining the same g-loadings as those incurred during potential 10 CFR Part 71 [176575] transportation events, that is, a TAD within a transportation overpack shall be designed to a maximum accident leak rate of 9.3×10^{-10} fraction of canister free volume per second under the applicable repository environmental conditions defined in PCSA-5 following drop events during the unloading from the transportation conveyance. (PCSA-2)

3.6.6 For TAD transfers from a transportation overpack to a stationary aging overpack at the Aging Pad, the TAD within transportation overpack without removable impact limiters located outside a heating, ventilation, and air-conditioning (HVAC) serviced area shall be designed to a maximum accident leak rate of 9.3×10^{-10} fraction of canister free volume per second under the applicable repository environmental conditions defined in PCSA-5 following a drop or tip-over from the railcar or site transporter. The TAD shall be designed to the maximum accident leak rate of 9.3×10^{-10} fraction of canister free volume per second following the drop or tip-over from the maximum potential height of the TAD during the transport and transfer operations. (PCSA-2)

3.6.7 The TAD within an STC or an aging overpack while on a site transporter shall be designed to maintain confinement (normal leakage rate specified in PCSA-1 and the off-normal cladding temperature limits provided in PCSA-3) following a fire (as defined in FP-1) or explosion from the site transporter. (PCSA-7)

3.6.8 For TAD transfers directly from the transportation overpack to a stationary aging overpack at the aging pad, a TAD within a transportation overpack without impact limiters shall be designed to maintain confinement (normal leakage rate specified in

PCSA-1 and within the off-normal temperature limits specified in PCSA-3) following a fire (as defined in FP-1) or explosion from the site transporter. (PCSA-7)

3.6.9 The TAD, while inside a building, shall be designed to maintain confinement (normal leakage rate specified in PCSA-1 and within the off-normal cladding temperature limit provided in PCSA-3) following a fire (as defined in FP-1) within the building. (PCSA-7)

3.6.10 The TAD shall withstand a fully engulfing fire (as defined in FP-1) without failure of its confinement functions as defined in PCSA-7. (FP-1)

3.6.11 The TAD including its confinement systems shall withstand a blast wave, projectiles, or thermal radiation resulting from a site transporter fuel, lubricating or hydraulic tank or system explosion, without failure of confinement functions as defined in PCSA-7. (FP-2)

3.7 OPERATIONS

3.7.1 An integral lifting feature for lifting a vertically oriented, loaded TAD from the top lid, without requiring manual installation and removal of lifting devices and adapters, shall be provided. (MH-2)

3.7.2 Integral lifting features shall be provided that allow an empty TAD, resting vertically with internal basket but without lid, to be lifted by an overhead handling system and lowered into an STC. (MH-3)

3.7.3 The TAD and lid shall be designed for handling under water with the TAD in a vertical orientation. The TAD body and lid shall have features that center and seat a lid that is being installed on the TAD body while submerged in a pool. These features shall accommodate a lid that is off-center by 1/2 in. while being inserted. (MH-4)

3.7.4 The TAD shall be designed so that it maintains confinement (normal leakage rate specified in PCSA-1 and normal cladding temperature limits provided in PCSA-3) following the transfer of a TAD to or from a stationary aging overpack at the aging pad. (PCSA-8).

3.8 LICENSING

3.8.1 The TAD shall be designed so that it is compatible with 10 CFR Part 63 [DIRS 176544] preclosure and postclosure performance requirements for SNF aging and emplacement in the repository. (LIC-1)

3.8.2 The TAD shall be designed so that it will qualify for a 10 CFR Part 71 [DIRS 176575] transportation Certificate of Compliance. (LIC-1)

3.8.3 The TAD shall be designed so that reactor licensees can successfully obtain any needed 10 CFR Part 50 [DIRS 176567] license amendments to the reactor operating license, or would be able to perform safety evaluations that would demonstrate the absence of a change requiring NRC review and approval, under 10 CFR 50.59. Such regulatory actions under 10 CFR Part 50 are needed to permit the loading of SNF in TADs at individual reactor sites. (LIC-1)

3.8.4 The movement of a TAD within the geologic repository operations area in a transportation overpack, aging overpack, STC, or waste package, the transfer of a TAD from the transportation overpack to the aging overpack or a waste package and from the aging overpack to a waste package, and aging of a TAD in an aging overpack must be conducted within the requirements of 10 CFR Part 63 [DIRS 176544], in accordance with NRC endorsed or accepted industry standards and regulatory guidance, and within the requirements of any applicable technical specifications and license conditions for the repository license to receive and possess SNF. (LIC-2)

4. MATERIALS

4.1 REQUIRED MATERIALS

4.1.1 The TAD and structural internals (i.e., basket), other than thermal shunts and criticality control materials, will be constructed of AISI 300-series stainless steels (e.g., 316 L) as listed in ASTM A-276-06, *Standard Specification for Stainless Steel Bars and Shapes* [DIRS 176774]. (PC-1)

4.1.2 The TAD and its basket materials shall be designed to be compatible with the repository pool water in Table A4.1-1. For example, there shall be no adverse chemical interactions between these materials and the pool water. (MH-6)

Table A4.1-1. Repository Pool Water Specifications

Average annual pool water temperature	< 90°F (Pool water temperature may exceed 110°F for no more than 5% of the time during June, July, August, and September.)
Average annual pool water conductivity	< 3 micro mho per cm
Pool water chloride concentration	< 0.5 ppm
Pool water pH	5.3 to 7.5 (unborated water)

4.2 PROHIBITED OR RESTRICTED MATERIALS

4.2.1 The TAD shall not have organic components. The capability to remove residues prior to use shall be provided. (PC-2)

4.2.2 The TAD design shall not include pyrophoric materials (uranium metal) that might initiate rapid exothermic chemical reaction in the emplacement drift environment. (PC-3)

4.2.3 The TAD, including the steel matrix, gaskets, seals, adhesives, and solder, shall not be constructed with materials that would be regulated as hazardous wastes under the Resource Conservation and Recovery Act (RCRA) [DIRS 103936] and prohibited from land disposal under RCRA if declared to be waste. (DR-1)

APPENDIX B
PRELIMINARY PERFORMANCE SPECIFICATION: TRANSPORTATION OVERPACK

This appendix contains the Preliminary Performance Specification*: Transportation Overpack.*

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1. SCOPE/BACKGROUND

1.1 This preliminary performance specification applies to a TAD transportation overpack that is certified by the NRC. The transportation overpack is loaded with a TAD that contains SNF at an origin site for delivery to the Yucca Mountain repository in Nevada.

1.2 The transportation overpack is conceptually similar to certified transportation overpacks for existing DPC-based systems for the transportation of commercial SNF.

1.3 The transportation overpack interfaces physically and functions directly with the following TAD system components:

- Transport, Aging, and Disposal Canister (Appendix A)
- Transportation Skid (Appendix C)
- Transport, Aging, and Disposal Canister System Ancillary Equipment (Appendix D).

2. REFERENCED DOCUMENTS

The following documents are referenced in this performance specification and provide additional information on the applicable subjects.

2.1 REGULATIONS

176575 10 CFR 71. 2006 Energy: Packaging and Transportation of Radioactive Material. Internet Accessible.

176026 49 CFR 173. 2005 Transportation: Shippers--General Requirements for Shipments and Packagings. ACC: MOL.20060116.0146.

176544 10 CFR 63. 2006 Energy: Disposal of High-Level Radioactive Wastes in a Geologic Repository at Yucca Mountain, Nevada. Internet Accessible.

2.2 U.S. NUCLEAR REGULATORY COMMISSION DOCUMENTS

104939 NRC (U.S. Nuclear Regulatory Commission) 1980. *Control of Heavy Loads at Nuclear Power Plants.* NUREG-0612. Washington, D.C.: U.S. Nuclear Regulatory Commission. TIC: 209017.

164538 NRC (U.S. Nuclear Regulatory Commission) 2003. *Interim Staff Guidance - 18. The Design/Qualification of Final Closure Welds on Austenitic Stainless Steel Canisters as Confinement Boundary for Spent Fuel Storage and Containment Boundary for Spent Fuel Transportation*. ISG-18. Washington, D.C.: U.S. Nuclear Regulatory Commission. TIC: 254660.

170332 NRC (U.S. Nuclear Regulatory Commission) 2003. *Interim Staff Guidance - 11, Revision 3. Cladding Considerations for the Transportation and Storage of Spent*

Fuel. ISG-11, Rev. 3. Washington, D.C.: U.S. Nuclear Regulatory Commission. ACC: MOL.20040721.0065.

2.3 INDUSTRY STANDARDS

None.

2.4 OTHER REFERENCES

176593 BSC (Bechtel SAIC Company) 2006. *Transport, Aging, and Disposal Canister System Basis of Specification Requirements Document.* 000-30R-MGR0-01400-000-000. Las Vegas, Nevada: Bechtel SAIC Company.

3. PERFORMANCE REQUIREMENTS

The performance requirements for the TAD system have been compiled in a single source: *Transport, Aging, and Disposal Canister System Basis of Specification Requirements Document* (BSC 2006 [DIRS 176593], Section 3). The performance requirements in this specification for the transportation overpack are a subset of the overall requirements for the entire TAD system. In many instances the transportation overpack must function with other TAD system components in order to satisfy performance objectives.

Background information, with sources and rationale for the performance requirements, is found in the basis of the specification requirements document. Performance requirements cite the requirement number from the TAD requirements document. For example, the citation MH-10 refers to *Transport, Aging, and Disposal Canister System Basis of Specification Requirements Document* (BSC 2006 [DIRS 176593], Section 3) and requirement number MH-10 in that document.

3.1 GENERAL PERFORMANCE REQUIREMENTS

3.1.1 The transportation overpack shall accommodate a TAD that is formed as a right-circular cylinder with a length of $212.0\ in.\left(\dfrac{+0.0\ in.}{-0.5\ in.}\right)$ and a diameter of $66.5\ in.\left(\dfrac{+0.0\ in.}{-0.5\ in.}\right)$. (TAD-1)

3.1.2 The transportation overpack shall function with a TAD that has a maximum loaded weight of 54.25 short tons. (TAD-1)

3.1.3 The cumulative height of the TAD; the open STC, open transportation overpack, or open aging overpack (i.e., lids removed); and associated grapple shall be limited such that maximum under-the-hook height is less than 42 ft as shown in Figure B3.1-1. (MH-1)

3.1.4 The transportation overpack without external impact limiters shall be designed to be lifted in a vertical orientation by an overhead crane and to stand upright when set down upon a flat horizontal surface without requiring the use of auxiliary supports. (MH-8)

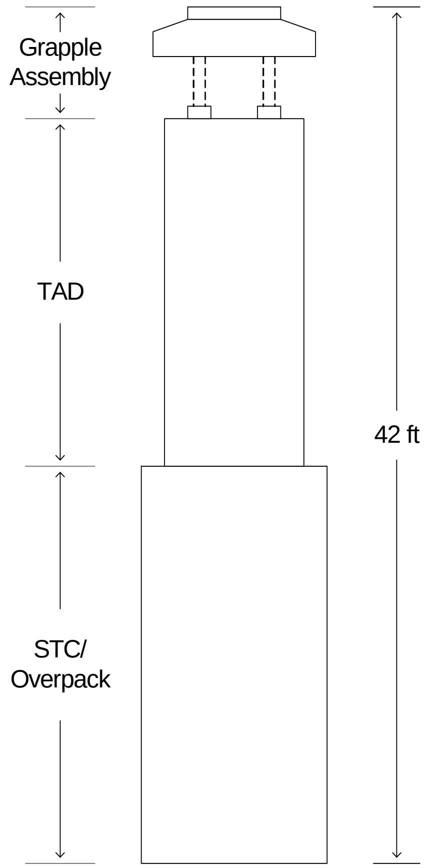

Figure B3.1-1. TAD Component Cumulative Height

Table B3.1-1. Transportation Overpack Characteristics

Characteristic	Value
Maximum cask length without impact limiters (in.)	225
Maximum cask length with impact limiters (in.)	333
Maximum cask diameter without impact limiters (in.)	98
Maximum distance across upper trunnions (in.)	108
Maximum cask closure lid diameter (in.)	79
Maximum cask closure lid weight (lb.)	15,000
Maximum diameter of impact limiters (in.)	128
Maximum cask weight when fully loaded (lb)	280,000
Impact limiter maximum weight, pair (lb)	25,000
Minimum available crane under-hook clearance (in.) (Height above the rails to which the hook would need to be raised in order to remove the transportation overpack from the conveyance)	480

NOTE: This table applies to transportation overpacks without impact limiters installed. (TRO-6).

3.1.5 The size and weight of the loaded transportation overpack, and under-the-hook height of the crane required to lift it, shall be limited to ensure that it can be handled at the Yucca Mountain repository. The limiting characteristics are provided in Table B3.1-1 from TRO-6. (MH-9)

3.1.6 Lifting attachments and appurtenances on transportation overpacks, cask lids, transportation skids, personnel barriers, and impact limiters shall be designed, documented, and fabricated in accordance with *Control of Heavy Loads at Nuclear Power Plants* (NRC 1980 [DIRS 104939], Section 5.1.1). (MH-15)

3.1.7 The TAD or transportation overpack, as appropriate, shall be designed so that the TAD maintains confinement (normal leakage rate specified in PCSA-1 and the normal cladding temperature limit provided in PCSA-3) following the transfer of the TAD to or from the stationary aging overpack at the aging pad. (PCSA-8)

3.2 STRUCTURAL

3.2.1 A loaded TAD contained within a transportation overpack assembled with any other components included in the packaging, as that term is defined in 10 CFR Part 71 [DIRS 176575], shall meet the requirements for a Type B cask as specified in 10 CFR Part 71, as evidenced by a valid Certificate of Compliance. (TRO-2)

3.2.2 Transportation overpacks shall have bolted closures that can be bolted and unbolted using standard tools. Standard tools are those that can be found in industrial tool catalogs. (TRO-3)

3.2.3 For use at the repository, a TAD within a transportation overpack with impact limiters shall be designed to maintain confinement (normal leakage rate specified in PCSA-1 and within temperature limits specified in PCSA-3) during and following exposure to the environmental conditions listed below. (PCSA-5)

The cladding temperature requirement is identified as normal (400°C) or off-normal (570°C) following the environmental condition listed below.

These environmental conditions are not cumulative but occur independently (PCSA-5):

- Outdoor average daily temperature of 2ºF to 116ºF with insolation as specified in 10 CFR Part 71 [DIRS 176575] (normal)

- An extreme wind of a 3-sec 90 mph gust (normal)

- Maximum tornado wind speed of 189 mph with a corresponding pressure drop of 0.81 lb/in^2 and a rate of pressure drop of 0.30 $lb/in^2/sec$ (off-normal)

- The spectrum of missiles from the maximum tornado are provided in Table B3.2-1 (off-normal):

Table B3.2-1. Spectrum of Missiles

Missile	Mass (kg)	Dimensions (m)	Horizontal Velocity (m/second)
Wood Plank	52	0.092 × 0.289 × 3.66	58
6 in. Schedule 40 pipe	130	0.168D × 4.58	10
1 in. steel rod	4	0.0254D × 0.915	8
Utility Pole	510	0.343D × 10.68	26
12 inch Schedule 40 pipe	340	0.32D × 4.58	7
Automobile	1810	5 × 2 × 1.3	41

- Annual precipitation of 20 inches/year (normal)
- The spectrum of rainfall is provided in Table B3.2-2 (normal):

Table B3.2-2. Spectrum of Rainfall

Parameter and Frequency	Nominal Estimate	Upper Bound 90% Confidence Interval*
Maximum 24-hr precipitation (50-year return period)	2.79 in./day (7.1 cm)	3.30 in./day (8.4 cm)
Maximum 24-hr precipitation (100-year return period)	3.23 in./day (8.2 cm)	3.84 in./day (9.8 cm)
Maximum 24-hr precipitation (500-year return period)	4.37 in./day (11.1 cm)	5.25 in./day (13.3 cm)
Precipitation 1-hr intensity (50-year return period)	1.35 in./hr (3.4 cm)	1.72 in./hr (4.4 cm)
Precipitation 1-hr intensity (100-year return period)	1.68 in./hr (4.3 cm)	2.15 in./hr (5.5 cm)

*Use the values for upperbound 90% confidence interval.

- Maximum daily snowfall of 6.0 in. (15.2 cm) (normal)
- Maximum monthly snowfall of 6.6 in. (16.8 cm) (normal)
- A lightning strike with a peak current of 250 kiloamps over a period of 260 microseconds and a continuing current of up to 2 kiloamps for 2 seconds (off-normal).

(PCSA-5)

3.2.4 The TAD within a transportation overpack with impact limiters shall be designed to maintain confinement (normal leakage rate specified in PCSA-1 and the off-normal cladding temperature provided in PCSA-3) following 4 in. of volcanic ash accumulation. The ash fall loads are estimated at 21 lb/ft^2. (PCSA-6)

3.2.5 For TAD transfers directly from the transportation overpack to a stationary aging overpack at the aging pad, a TAD within a transportation overpack without impact limiters shall be designed to maintain confinement (normal leakage rate specified in

PCSA-1 and within off-normal temperature limit specified in PCSA-3) following 4 in. of volcanic ash accumulation. The TAD within a transportation overpack without impact limiters may be on a site transporter. (PCSA-6)

3.2.6 A TAD in a transportation overpack shall be designed to maintain confinement (normal leakage rate specified in PCSA-1 and within the normal operations temperature limit specified in PCSA-3) following a seismic event defined by the 2,000-year seismic return period. The transportation overpack, if used for a direct transfer to a stationary aging overpack, may be on a site transporter. The normal leakage rates and the off-normal cladding temperature provided in PCSA-3 shall be demonstrated following a seismic event defined by the 10,000-year seismic return period Seismic data for the 2,000 and 10,000-year return period seismic events are provided in Attachment A of Appendix C of *Transport, Aging, and Disposal Canister System Basis of Specification Requirements Document* (BSC 2006 [DIRS 176593]). (PCSA-4)

3.2.7 For TAD transfers from a transportation overpack to a stationary aging overpack at the Aging Pad, the TAD within transportation overpack without removable impact limiters located outside a heating, ventilation, and air-conditioning (HVAC) serviced area shall be designed to a maximum accident leak rate of 9.3×10^{-10} fraction of canister free volume per second under the applicable repository environmental conditions defined in PCSA-5 following a drop or tip-over from the railcar or site transporter. The TAD shall be designed to the maximum accident leak rate of 9.3×10^{-10} fraction of canister free volume per second following the drop or tip-over from the maximum potential height of the TAD during the transport and transfer operations. (PCSA-2)

3.3 THERMAL

3.3.1 In accordance with ISG-11 (NRC 2003 [DIRS 170332]) regarding normal operations during transportation, the maximum SNF cladding temperature in TADs shall not exceed 400ºC. The requirement applies to all cladding materials in accordance with ISG-11. Normal operations include transportation from loading sites to the repository and transportation on site transporters at the repository. (TH-1)

3.3.2 During accidents or off-normal operation for durations lasting up to 30 days (such as fires or loss of HVAC systems in surface facilities), the maximum SNF cladding temperature in TADs shall not exceed 570°C (PCSA-3). This requirement applies to all cladding materials in accordance with ISG-11 (NRC 2003 [DIRS 170332]). (TH-1)

3.3.3 The TAD system shall be designed to maintain cladding temperature for SNF below 400ºC during normal operations and 570ºC during off-normal and accident conditions in accordance with ISG-11 (NRC 2003 [DIRS 170332]. The requirement for the TAD is applicable in any TAD configuration: a TAD within an STC, an aging overpack, a transportation overpack with impact limiters, or a transportation overpack without impact limiters. (PCSA-3)

3.3.4 Cooling features and mechanisms in TADs and transportation overpacks shall be passive in nature. (TH-1)

3.4 SHIELDING AND RADIATION

3.4.1 The TAD, the transportation overpack, the STC, the aging overpack, site transporter, and ancillary equipment shall contain features that are designed to reduce worker (individual and collective) radiation exposures to as low as is reasonably achievable (ALARA). Worker dose assessments based on specified operating procedures and associated operating environments shall be provided for each operation. These assessments shall demonstrate the effectiveness of the design features to meet ALARA objectives at the repository.

Examples of the ALARA design and operational features: radiation shielding; simplified operations that reduce time and the number of workers required; isolating and maintaining clean water in the annulus between a TAD and its transfer cask; vent, backfill, and test penetrations located and oriented to facilitate access and reduce radiation streaming; smooth surfaces for ease of decontamination; use of standard tools and equipment; and use of long reach tools. (NU-1)

3.4.2 A TAD and associated components (including the transportation overpack) shall be designed such that removable external surface contamination of radioactive material is controlled in conjunction with specified operating procedures to limit the potential for contamination in worker areas, airborne contamination of repository facilities such as HVAC, onsite and offsite radioactive releases, and cross contamination of equipment in contact with TADs. (NU-7)

3.5 CRITICALITY

No specific requirements beyond those of 10 CFR Part 71 [DIRS 176575].

3.6 CONFINEMENT

3.6.1 For TAD transfers directly from the transportation overpack to a stationary aging overpack at the aging pad, a TAD within a transportation overpack without impact limiters shall be designed to maintain confinement (normal leakage rate specified in PCSA-1 and within the off-normal temperature limits specified in PCSA-3) following a fire (as defined in FP-1) or explosion from the site transporter. (PCSA-7)

3.6.2 For TAD transfers directly from the transportation overpack to a stationary aging overpack, the configuration shall be designed to maintain confinement (normal leakage rate specified in PCSA-1 and within temperature limits specified in PCSA-3) during and following exposure to the environmental conditions listed under Section 3.2.3 of this appendix. (PCSA-5)

3.6.3 The design/qualification of the final closure on the TAD system shall comply with Interim Staff Guidance-18 (NRC 2003 [DIRS 164538]) if applicable for the purposes of demonstrating no credible leakage *or* shall be designed to a maximum leak rate of 1.5×10^{-12} fraction of canister free volume per second during normal operations under repository environmental conditions as defined in PCSA-5. (PCSA-1)

3.7 OPERATIONS

3.7.1 The design of transportation systems for TADs and procedures for their operation shall not require submergence of those transportation overpacks in SNF handling pool water at either the repository or loading site. (TRO-4)

3.7.2 The transportation overpack and any accompanying conveyance (including the transportation skid) shall be designated for transportation under the provisions of "exclusive-use" as defined in 49 CFR 173.403 [DIRS 176026]. (TRO-5)

3.7.3 The transportation overpack and transportation skid shall be designed to permit the transportation overpack, without removable impact limiters, to be upended and removed from the transportation skid in a vertical orientation using an overhead crane while the transportation skid remains on the railcar conveyance. The transportation overpack shall have upper lifting trunnions with dual seats and lower turning trunnions. Trunnions shall remain attached to the cask body during transportation. (MH-7)

3.7.4 The transportation overpack shall be designed such that a loaded transportation overpack without removable impact limiters is not required to be lifted or transported at a height greater than that for which it is designed to maintain confinement following a drop. (MH-14)

3.7.5 Loaded transportation overpacks shall be delivered on a transportation skid. (TS-1)

3.8 LICENSING

3.8.1 The TAD transportation overpack shall be designed so that it will obtain a 10 CFR Part 71 [DIRS 176575] transportation Certificate of Compliance. (LIC-1)

3.8.2 The movement of a TAD within the geologic repository operations area in a transportation overpack, aging overpack, STC, or waste package, the transfer of a TAD from the transportation overpack to the aging overpack or a waste package and from the aging overpack to a waste package, and aging of a TAD in an aging overpack must be conducted within the requirements of 10 CFR Part 63 [DIRS 176544], in accordance with NRC endorsed or accepted industry standards and regulatory guidance, and within the requirements of any applicable technical specifications and license conditions for the repository license to receive and possess SNF. (LIC-2)

4. MATERIALS

Materials selections shall be as necessary to meet requirements of 10 CFR Part 71 [DIRS 176575] and other requirements of this specification.

APPENDIX C
PRELIMINARY PERFORMANCE SPECIFICATION: TRANSPORTATION SKID

This appendix contains the Preliminary Performance Specification*: Transportation Skid*.

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1. SCOPE/BACKGROUND

1.1 This preliminary performance specification only documents performance requirements for the transportation skid designed to carry the transportation overpack. In many instances the TAD system components must interface with each other in order to satisfy performance objectives. The transportation skid interfaces with the transportation overpack, transporter (railcar), and any ancillary transportation skid equipment, such as transportation skid lifting devices.

1.2 To fulfill the DOE preference for shipping nuclear waste by rail, the transportation skid allows pickup and delivery of transportation overpacks at locations lacking railroad tracks, such as some commercial nuclear reactors and ISFSIs. Integral parts of this specification include the transportation skid-to-railcar securement and the fixture used to lift and transfer the transportation skid using overhead cranes of sufficient capacity.

1.3 A key feature of the transportation skid is its interface with the transporter (railcar) so that any transportation skid would mate to any DOE transporter (railcar) in a standardized fashion. The transportation skid with the loaded transportation overpack can be transferred between the railcar and another transport conveyance, such as a heavy-haul truck trailer or barge.

1.4 The transportation skid interfaces physically and functions directly with the following TAD system components:

- Transportation Overpack (Appendix B)
- Transport, Aging, and Disposal Canister System Ancillary Equipment (Appendix D).

2. REFERENCED DOCUMENTS

The following documents are referenced in this performance specification and provide additional information on the applicable subjects.

2.1 REGULATIONS

176026 49 CFR 173. 2005 Transportation: Shippers--General Requirements for Shipments and Packagings. ACC: MOL.20060116.0146.

176575 10 CFR 71. 2006 Energy: Packaging and Transportation of Radioactive Material. Internet Accessible.

2.2 U.S. NUCLEAR REGULATORY COMMISSION DOCUMENTS

None.

2.3 INDUSTRY STANDARDS

176662 ISO 1161:1984/Cor.1:1990(E). 1990. *Series 1 Freight Containers — Corner Fittings — Specification (including Technical Corrigendum 1).* 4th Edition. [Geneva], Switzerland: International Organization for Standardization. TIC: 258256; 258247.

2.4 OTHER REFERENCES

176593 BSC (Bechtel SAIC Company) 2006. *Transport, Aging, and Disposal Canister System Basis of Specification Requirements Document.* 000-30R-MGR0-01400-000-000. Las Vegas, Nevada: Bechtel SAIC Company.

3. PERFORMANCE REQUIREMENTS

The performance requirements for the TAD system have been compiled in a single source: *Transport, Aging, and Disposal Canister System Basis of Specification Requirements Document* (BSC 2006 [DIRS 176593], Section 3). The performance requirements in this specification for the transportation skid are a subset of the overall requirements for the entire TAD system. In many instances the transportation skid must function with other TAD system components in order to satisfy performance objectives.

Background information, with sources and rationale for the performance requirements, is found in the basis of specification requirements document. Performance requirements cite the requirement number from the TAD requirements document. For example, the citation MH-10 refers to *Transport, Aging, and Disposal Canister System Basis of Specification Requirements Document* (BSC 2006 [DIRS 176593], Section 3) and requirement number MH-10 in that document.

3.1 GENERAL PERFORMANCE REQUIREMENTS

3.1.1 The transportation skid shall be designed to permit the transportation overpack with impact limiters removed to be upended and removed from the transportation skid in a vertical orientation using an overhead crane while the transportation skid remains on the railcar conveyance. (MH-7)

3.1.2 The transportation skid features designed to support and secure the transportation overpack against the normal conditions of transport, as described in 10 CFR 71.71 [DIRS 176575], shall be described in the transportation overpack safety analysis report and shall be reviewed by the NRC against the applicable lifting and tie-down standards for all packages in 10 CFR 71.45. Service lifetime of the transportation skid is 50 years. (TS-3)

3.1.3 The transportation overpack and any accompanying conveyance (including the transportation skid) shall be designated for transportation under the provisions of "exclusive-use" as defined in 49 CFR 173.403 [DIRS 176026]. (TRO-5)

3.2 STRUCTURAL

3.2.1 Loaded transportation overpacks shall be delivered on a transportation skid. The skid tiedown to the railcar shall be via approved corner fittings, which meet corner fitting standards in ISO 1161, *Series 1 Freight Containers — Corner Fittings — Specification* [DIRS 176662]. (TS-1)

3.2.2 The dimensions of the transportation skid shall not exceed the bounding dimensions listed in Table C3.2-1: (TS-1)

Table C3.2-1. Transportation Skid Bounding Characteristics

Characteristic	Maximum
Width	124 in.
Length (between lift points)	318 in.
Length (overall)	360 in.
Height (to top of personnel barrier)	150 in.
Number of transportation skid lifting points	4 (exactly)

3.2.3 A transportation skid lifting fixture shall be provided that can lift the fully loaded transportation skid from above by crane and maintain it in an essentially horizontal orientation throughout any lift with a load safety factor of no less than 5 times the maximum transportation skid weight without exceeding the yield strength of the materials of construction of the skid lifting fixture in any portion of the load path. (TS-2)

3.2.4 Mechanical stress in structures of the loaded transportation skid, transportation skid lifting fixture and associated transportation skid securing devices, when subjected to the forces encountered in normal handling and under the normal conditions of transportation shall not exceed the offset yield stress of the materials of construction. (TS-5)

3.3 THERMAL

Not Applicable.

3.4 SHIELDING/CONFINEMENT/RADIATION PROTECTION

3.4.1 The TAD, the transportation overpack, the STC, the aging overpack, site transporter, and ancillary equipment shall contain features that are designed to reduce worker (individual and collective) radiation exposures to as low as is reasonably achievable (ALARA). Worker dose assessments based on specified operating procedures and associated operating environments shall be provided for each operation. These assessments shall demonstrate the effectiveness of the design features to meet ALARA objectives at the repository.

Examples of the ALARA design and operational features: radiation shielding; simplified operations that reduce time and the number of workers required; isolating and maintaining clean water in the annulus between a TAD and its transfer cask; vent, backfill, and test penetrations located and oriented to facilitate access and reduce radiation streaming; smooth surfaces for ease of decontamination; use of standard tools and equipment; and use of long reach tools. (NU-1)

3.4.2 Each transportation skid shall avoid features that would trap water and shall incorporate finishes and coatings that facilitate the removal of non-fixed radiological contamination and surface dirt using hand-wiping methods. (TS-6)

3.5 CRITICALITY

Not applicable.

3.6 CONFINEMENT

Not applicable.

3.7 OPERATIONS

3.7.1 Each transportation skid shall consider normal operation over a range of temperatures from -40^{o}F to 131^{o}F, rain, snow accumulation of no less than 6 in, wind speeds of no less than 3-sec 90 mph gust (normal), and a lightening strike with a peak current of 250 kiloamps over a period of 260 microseconds and a continuing current of up to 2 kiloamps for 2 seconds (off-normal). (TS-4)

3.8 LICENSING

Not Applicable.

4. MATERIALS

4.1 REQUIRED MATERIALS

4.1.1 Materials of transportation skid construction shall be readily commercially available and shall meet current national requirements and standards. Specialty materials or processes should be avoided. (TS-5)

APPENDIX D
PRELIMINARY PERFORMANCE SPECIFICATION: TRANSPORT, AGING, AND DISPOSAL CANISTER SYSTEM ANCILLARY EQUIPMENT

This appendix contains the Preliminary Performance Specification: *Transport, Aging, and Disposal Canister System Ancillary Equipment.*

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1. SCOPE/BACKGROUND

1.1 The TAD system ancillary equipment interfaces physically and functions directly with the following TAD system items:

1.1.1 Lifting yokes used at the nuclear waste repository operations area and lifting yokes used at a nuclear power plant to lift:

- Loaded (containing loaded TADs) and unloaded transportation overpacks
- Loaded and unloaded STCs
- Loaded and unloaded aging overpacks (repository only).

1.1.2 Other devices for lifting and lifting attachments and appurtenances on:

- Transportation casks
- Transportation, transfer, and aging overpack cask lids
- Loaded and unloaded TADs and associated components
- STCs
- Aging overpacks
- Transportation skids
- Personnel barriers
- Impact limiters
- Cask lifting yokes and associated components
- Other heavy components used at the Yucca Mountain repository or a nuclear power plant for transferring, transporting, or aging TADs containing commercial SNF.

1.1.3 Special tools for installing, removing, torquing, and detorquing bolts and fasteners on TADs, transfer casks, transportation overpacks (including impact limiters), transportation skids, and aging overpacks.

1.1.4 Special tools and equipment for use of TADs, including tools and equipment for:

- Installing and securing the shield plug in a TAD (as required)
- Closing and sealing a TAD
- Drying and backfilling a TAD with inert gas
- Inspecting and leak testing a TAD.

1.1.5 Special tools and equipment for loading, testing, inspecting, and preparing transportation overpacks, aging overpacks, and transfer casks (if applicable) for use:

- Closing and sealing
- Drying and backfilling with inert gas (as applicable)
- Inspecting, leak testing, and other safety-related testing for transport
- Installing impact limiters
- Securing transportation skid or transporter.

1.2 Ancillary equipment performs with other components of the TAD system to meet respective performance objectives:

- TAD
- STC
- Transportation overpack
- Aging overpack
- Transportation skid.

1.3 Ancillary equipment will interface with the following SSCs:

1.3.1 TAD System Interfaces

- TAD
- STC
- Transportation overpack
- Aging overpack
- Transportation skid.

1.3.2 Yucca Mountain Repository Interfaces

- Receipt Facility
- Canister Receipt Closure Facility
- Wet Handling Facility.

1.3.3 Nuclear Power Facilities

- Spent fuel pool
- Cask handling crane
- Ancillary equipment cranes
- Ventilation and air filtration system
- Various plant safety systems.

2. REFERENCED DOCUMENTS

The following documents are referenced in this performance specification and provide additional information on the applicable subjects.

2.1 REGULATIONS

None.

2.2 U.S. NUCLEAR REGULATORY COMMISSION DOCUMENTS

104939 NRC (U.S. Nuclear Regulatory Commission) 1980. *Control of Heavy Loads at Nuclear Power Plants.* NUREG-0612. Washington, D.C.: U.S. Nuclear Regulatory Commission. TIC: 209017.

101903 NRC (U.S. Nuclear Regulatory Commission) 1997. *Standard Review Plan for Dry Cask Storage Systems.* NUREG-1536. Washington, D.C.: U.S. Nuclear Regulatory Commission. ACC: MOL.20010724.0307.

2.3 INDUSTRY STANDARDS

145735 ANSI N14.5-97. 1998. *American National Standard for Radioactive Materials — Leakage Tests on Packages for Shipment.* New York, New York: American National Standards Institute. TIC: 247029.

2.4 OTHER REFERENCES

176593 BSC (Bechtel SAIC Company) 2006. *Transport, Aging, and Disposal Canister System Basis of Specification Requirements Document.* 000-30R-MGR0-01400-000-000. Las Vegas, Nevada: Bechtel SAIC Company.

3. PERFORMANCE REQUIREMENTS

The performance requirements for the TAD system are compiled in a single source: *Transport, Aging, and Disposal Canister System Basis of Specification Requirements Document* (BSC 2006 [DIRS 176593], Section 3). The performance requirements in this specification for ancillary equipment are a subset of the requirements for the TAD system. Ancillary equipment must function with other TAD system components and with components of facilities at the Yucca Mountain repository GROA and at nuclear power plant facilities.

Background information, with sources and rationale, for the performance requirements may be found in the basis of specification requirements document. Performance requirements cite the requirement number from the TAD requirements document. For example, the citation MH-07 refers to *Transport, Aging, and Disposal Canister System Basis of Specification Requirements Document* (BSC 2006 [DIRS 176593], Section 3) and requirement number MH-07 in that document.

3.1 GENERAL PERFORMANCE REQUIREMENTS

3.1.1 The ancillary equipment shall contain features that are designed to reduce worker (individual and collective) radiation exposures to ALARA. Worker dose assessments based on specified operating procedures and associated operating environments shall be provided for each operation. These assessments shall demonstrate the effectiveness of the design features to meet ALARA objectives at the repository.

Examples of the ALARA design and operational features, radiation shielding; simplified operations that reduce time and the number of workers required; smooth surfaces for ease of decontamination; use of standard tools and equipment; and use of long reach tools where applicable. (NU-1)

3.1.2 The cumulative height of the TAD; the open STC, open transportation overpack, or open aging overpack (i.e., lids removed); and associated grapple shall be limited such that maximum under-the-hook height is less than 42 ft as shown in Figure D3.1-1. (MH-1)

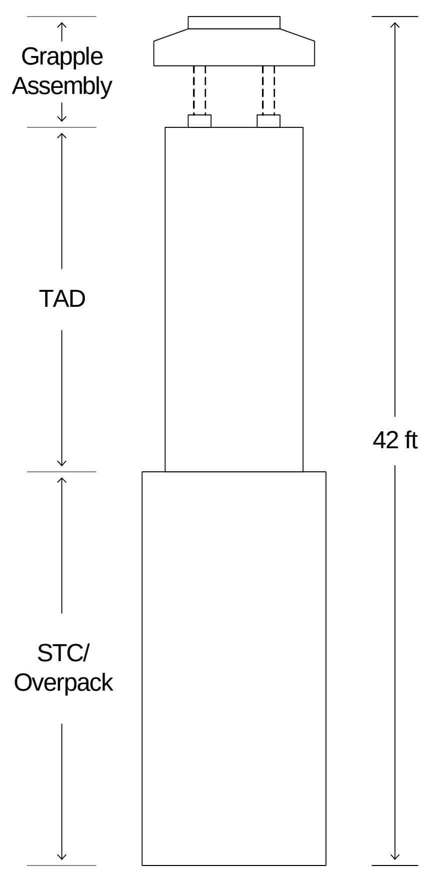

Figure D3.1-1. TAD Component Cumulative Height

3.1.3 A TAD and associated components shall be designed such that removable external surface contamination of radioactive material is controlled in conjunction with specified operating procedures to limit the potential for contamination in worker areas, airborne contamination of repository facilities such as HVAC, onsite and offsite radioactive releases, and cross contamination of equipment in contact with TADs. (NU-7)

3.1.4 Ancillary lifting devices shall be designed to interface with the limits that can be handled at the Yucca Mountain repository. These limits are provided in Table E3.1-1. (MH-12):

Table D3.1-1. Combined Size and Weight Limits

Maximum envelope diameter	135 in.
Maximum length	240 in.
Maximum loaded weight	200 tons (hook weight, including lifting devices)

3.2 STRUCTURAL

3.2.1 Devices for lifting attachments and appurtenances on transportation overpacks; cask lids; loaded and unloaded TADs and associated components; transportation skids; personnel barriers; impact limiters; cask-lifting-yokes and associated components; and other heavy components used in transporting TADs containing SNF shall be designed, documented, and fabricated in accordance with *Control of Heavy Loads at Nuclear Power Plants*, NUREG-0612 (NRC 1980 [DIRS 104939], Section 5.1.1). (MH-15)

3.2.2 A transportation skid lifting fixture shall be provided that can lift the fully loaded transportation skid from above by crane and maintain it in an essentially horizontal orientation throughout any lift with a load safety factor of no less than five times the maximum transportation skid weight without exceeding the yield strength of the materials of construction of the skid-lifting fixture in any portion of the load path. (TS-2)

3.3 THERMAL

Not applicable

3.4 SHIELDING AND RADIATION

Related performance requirements were considered and included in Section 3.1 above.

3.5 CRITICALITY

Not applicable

3.6 CONFINEMENT

Not applicable

3.7 OPERATIONS

3.7.1 To interface with Yucca Mountain repository facility crane hooks and hoists, these devices shall provide for secured pin-type connections between the repository cranes and the lifting fixture/appurtenances. (MH-15)

3.7.2 Design of a lifting device for the TAD shall consider the following design feature requirement for the TAD. "An integral lifting feature for lifting a vertically oriented, loaded TAD from the top lid, without requiring manual installation and removal of lifting devicesand adapters, shall be provided." (MH-2)

3.7.3 Integral lifting features shall be provided that allow an empty TAD, resting vertically with internal basket but without lid, to be lifted by an overhead handling system and lowered into an STC. (MH-3)

3.7.4 Devices for lifting TAD system components shall accommodate the size and weight of the loaded transportation overpack, and under-the-hook height of the crane required to lift it, to ensure that it can be handled at the Yucca Mountain repository. Bounding transportation overpack characteristics (TRO-6) are listed in Table D3.7-1. (MH-9)

Table D3.7-1. Transportation Overpack Characteristics

Characteristic	Value
Maximum cask length without impact limiters (in.)	225
Maximum cask length with impact limiters (in.)	333
Maximum cask diameter without impact limiters (in.)	98
Maximum distance across upper trunnions (in.)	108
Maximum cask closure lid diameter (in.)	79
Maximum cask closure lid weight (lb.)	15,000
Maximum diameter of impact limiters (in.)	128
Maximum cask weight when fully loaded (lb)*	280,000
Impact limiter maximum weight, pair (lb)	25,000
Minimum available crane under-hook clearance (in.) (Height above the rails to which the hook would need to be raised in order to remove the transportation overpack from the conveyance)	480

Note: This Table applies to transportation overpacks without impact limiters installed. (TRO-6)

3.7.5 Failure of ancillary equipment during the transfer of a TAD at the aging pad to or from a stationary aging overpack shall not lead to the TAD loss of confinement. (PCSA-8)

3.7.6 Tools and equipment used for draining and vacuum drying of a TAD shall facilitate removal of water vapor and oxidizing material to an acceptable level. The objective is to demonstrate the ability of the loaded TAD to maintain a 3 Torr vacuum for 30 minutes after vacuum pump operation ceases. (CC-3)

3.7.7 Tools and equipment shall facilitate filling a loaded TAD with helium to atmospheric pressure or greater, as required, to meet leak test procedural requirements. (CC-3)

3.7.8 Tools and equipment shall facilitate sampling the gas space to verify helium purity. (CC-3)

3.7.9 Tools and equipment for leak testing shall be in accordance with industry standards and regulatory guidance, such as ANSI N14.5-97 [DIRS 145735]. (CC-1)

3.7.10 These (tool) operations should be assumed to be performed in accordance with industry standards and regulatory guidance, such as NUREG-1536 (NRC 1997 [DIRS 101903]). (CC-3)

3.8 LICENSING

Not applicable

4. MATERIALS

4.1 REQUIRED MATERIALS

4.1.1 Ancillary equipment shall be designed to be compatible with the repository pool water (Table D4.1-1). For example, there shall be no adverse chemical interactions between these materials and the pool water. (MH-6)

Table D4.1-1. Repository Pool Water Specification

Average annual pool water temperature	< 90ºF (Pool water temperature may exceed 110ºF for no more than 5% of the time during June, July, August and September.)
Average annual pool water conductivity	< 3 micro mho per cm
Pool water chloride concentration	< 0.5 ppm
Pool water pH	5.3 to 7.5 (unborated water)

(MH-6)

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APPENDIX E
PRELIMINARY PERFORMANCE SPECIFICATION: SHIELDED TRANSFER CASK

This appendix contains the Preliminary Performance Specification*: Shielded Transfer Cask.*

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1. SCOPE/BACKGROUND

1.1 This preliminary performance specification applies to a potential TAD STC that maybe approved for use and licensed by the NRC. The STC functions with a TAD and a site transporter to transfer a loaded TAD among repository facilities.

1.2 The STC is a right circular cylinder that stands upright with shielding on the sides and bottom. The TAD shield plug lid provides shielding at the top. Neutron and gamma shielding is an integral part of the STC design.

1.3 Transfer cask performance requirements are similar to provisions for currently designed and in-service transfer casks that have been licensed for transfer operations at nuclear utility sites in accordance with 10 CFR Part 72 [DIRS 176577].

1.4 The TAD system will meet the performance objectives of this specification. When necessary, the following TAD system components will work in conjunction with the STC to meet the performance objectives.

- Transport, aging, and disposal canister
- Site transporter
- Ancillary equipment.

1.5 The TAD system design effort will use *Standard Review Plan for Dry Cask Storage Systems*, NUREG-1536 (NRC 1997 [DIRS 101903]) and *Yucca Mountain Review Plan, Final Report*, NUREG-1804 (NRC 2003 [DIRS 163274]), as guidance when applicable. These NUREGs may be used by the NRC to review the TAD system designs.

2. REFERENCED DOCUMENTS

The following documents are referenced in this performance specification and provide additional information on the applicable subjects.

2.1 REGULATIONS

176544 10 CFR 63. 2006 Energy: Disposal of High-Level Radioactive Wastes in a Geologic Repository at Yucca Mountain, Nevada. Internet Accessible.

176575 10 CFR 71. 2006 Energy: Packaging and Transportation of Radioactive Material. Internet Accessible.

176577 10 CFR 72. 2006 Energy: Licensing Requirements for the Independent Storage of Spent Nuclear Fuel, High-Level Radioactive Waste, and Reactor-Related Greater than Class C Waste. Internet Accessible.

2.2 U.S. NUCLEAR REGULATORY COMMISSION DOCUMENTS

163274 NRC (U.S. Nuclear Regulatory Commission) 2003. *Yucca Mountain Review Plan, Final Report.* NUREG-1804, Rev. 2. Washington, D.C.: U.S. Nuclear Regulatory Commission, Office of Nuclear Material Safety and Safeguards. TIC: 254568.

101903 NRC (U.S. Nuclear Regulatory Commission) 1997. *Standard Review Plan for Dry Cask Storage Systems.* NUREG-1536. Washington, D.C.: U.S. Nuclear Regulatory Commission. ACC: MOL.20010724.0307.

164538 NRC (U.S. Nuclear Regulatory Commission) 2003. *Interim Staff Guidance - 18. The Design/Qualification of Final Closure Welds on Austenitic Stainless Steel Canisters as Confinement Boundary for Spent Fuel Storage and Containment Boundary for Spent Fuel Transportation.* ISG-18. Washington, D.C.: U.S. Nuclear Regulatory Commission. TIC: 254660.

170332 NRC (U.S. Nuclear Regulatory Commission) 2003. *Interim Staff Guidance - 11, Revision 3. Cladding Considerations for the Transportation and Storage of Spent Fuel.* ISG-11, Rev. 3. Washington, D.C.: U.S. Nuclear Regulatory Commission. ACC: MOL.20040721.0065.

2.3 INDUSTRY STANDARDS

None.

2.4 OTHER REFERENCES

176593 BSC (Bechtel SAIC Company) 2006. *Transport, Aging, and Disposal Canister System Basis of Specification Requirements Document.* 000-30R-MGR0-01400-000-000. Las Vegas, Nevada: Bechtel SAIC Company.

3. PERFORMANCE REQUIREMENTS

The performance requirements for the TAD system at the Yucca Mountain repository have been compiled into a single source: *Transport, Aging, and Disposal Canister System Basis of Specification Requirements Document* (BSC 2006 [DIRS 176593], Section 3). The performance requirements in this specification are a subset of the overall requirements for the entire TAD system. In many instances the STC must function with other TAD system components in order to satisfy performance objectives.

Background information, with sources and rationale for the performance requirements, is found in the *Transport, Aging, and Disposal Canister System Basis of Specification Requirements Document*. Performance requirements cite the requirement number from the TAD requirements document. For example, the citation "(MH-10)" refers to the *Transport, Aging, and Disposal Canister System Basis of Specification Requirements Document* (BSC 2006 [DIRS 176593], Section 3) and requirement number MH-10 in that document.

3.1 GENERAL PERFORMANCE REQUIREMENTS

3.1.1 The STC shall accommodate a TAD that is formed as a right-circular cylinder with a length of $212.0\ in.\left(\frac{+0.0\ in.}{-0.5\ in.}\right)$ and a diameter of $66.5\ in.\left(\frac{+0.0\ in.}{-0.5\ in.}\right)$. (TAD-1)

3.1.2 The STC shall function with a TAD that has a maximum loaded weight of 54.25 short tons. (TAD-1)

3.1.3 The cumulative height of the TAD; the open STC, open transportation overpack, or open aging overpack (i.e., lids removed); and associated grapple shall be limited such that maximum under-the-hook height is less than 42 ft as shown in Figure E3.1-1. (MH-1)

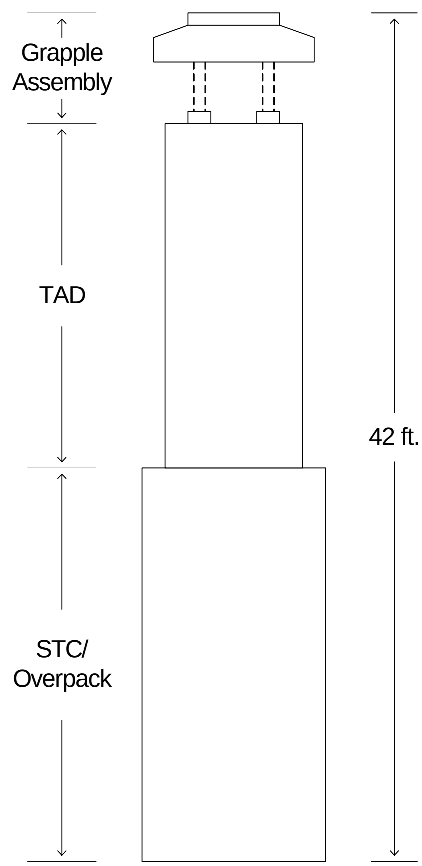

Figure E3.1-1. TAD Component Cumulative Height

3.1.4 Integral lifting features shall be provided that allow an empty TAD, resting vertically with internal basket but without lid, to be lifted by an overhead handling system and lowered into an STC. (MH-3).

3.1.5 The STC shall be reusable and capable of being transported by a site transporter in a vertical or horizontal orientation. If transported in a horizontal orientation, the STC shall have upper lifting trunnions with dual seats and lower turning trunnions, and shall be designed to be upended and removed from the site transporter in a vertical orientation using an overhead crane. (MH-10)

3.1.6 The STC shall be designed to be lifted in a vertical orientation by an overhead crane and to stand upright when set down upon a flat horizontal surface without requiring the use of auxiliary supports. (MH-8)

3.1.7 The combined size and weight of the loaded TAD and STC (in a water-filled condition) shall be limited to ensure that they can be handled at the Yucca Mountain repository. These limits are provided in Table E3.1-1. (MH-12):

Table E3.1-1. Combined Size and Weight Limits

Maximum envelope diameter	135 in.
Maximum length	240 in.
Maximum loaded weight	200 tons (hook weight, including lifting devices)

3.2 STRUCTURAL

3.2.1 A TAD in an STC shall be designed to maintain confinement (normal leakage rate specified in PCSA-1 and within the normal operations temperature limit specified in PCSA-3) following a seismic event defined by the 2,000-year seismic return period. The STC, if used for a direct transfer of a TAD to a stationary aging overpack, may be on a site transporter. The normal leakage rates and the off-normal cladding temperature provided in PCSA-3 shall be demonstrated following a seismic event defined by the 10,000-year seismic return period. Seismic data for the 2,000 and 10,000-year return period seismic events are provided in Attachment A of Appendix C of *Transport, Aging, and Disposal Canister System Basis of Specification Requirements Document* (BSC 2006 [DIRS 176593]). (PCSA-4)

3.2.2 For use at the repository, a TAD within an STC shall be designed to maintain confinement (normal leakage rate specified in PCSA-1 and within temperature limits specified in PCSA-3) during and following exposure to the environmental conditions listed below. The STC may be on a site transporter. (PCSA-5)

The cladding temperature requirement is identified as normal (400°C) or off-normal (570°C) following the environmental condition listed below.

These environmental conditions are not cumulative but occur independently (PCSA-5):

- Outdoor average daily temperature of 2ºF to 116ºF with insolation as specified in 10 CFR Part 71 [DIRS 176575] (normal)

- An extreme wind of a 3-sec 90 mph gust (normal)
- Maximum tornado wind speed of 189 mph with a corresponding pressure drop of 0.81 lb/in^{2}and a rate of pressure drop of 0.30 lb/in^2/sec (off-normal)
- The spectrum of missiles from the maximum tornado are provided in Table E3.2-1 (off-normal):

Table E3.2-1. Spectrum of Missiles

Missile	Mass (kg)	Dimensions (m)	Horizontal Velocity (m/second)
Wood Plank	52	0.092 × 0.289 × 3.66	58
6 in. Schedule 40 pipe	130	0.168D × 4.58	10
1 in. steel rod	4	0.0254D × 0.915	8
Utility Pole	510	0.343D × 10.68	26
12 inch Schedule 40 pipe	340	0.32D × 4.58	7
Automobile	1810	5 × 2 × 1.3	41

- Annual precipitation of 20 inches/year (normal)
- The spectrum of rainfall is provided in Table E3.2-2 (normal):

Table E3.2-2. Spectrum of Rainfall

Parameter and Frequency	Nominal Estimate	Upper Bound 90% Confidence Interval*
Maximum 24-hr precipitation (50-year return period)	2.79 in./day (7.1 cm)	3.30 in./day (8.4 cm)
Maximum 24-hr precipitation (100-year return period)	3.23 in./day (8.2 cm)	3.84 in./day (9.8 cm)
Maximum 24-hr precipitation (500-year return period)	4.37 in./day (11.1 cm)	5.25 in./day (13.3 cm)
Precipitation 1-hr intensity (50-year return period)	1.35 in./hr (3.4 cm)	1.72 in./hr (4.4 cm)
Precipitation 1-hr intensity (100-year return period)	1.68 in./hr (4.3 cm)	2.15 in./hr (5.5 cm)

*Use the values for upperbound 90% confidence interval.

- Maximum daily snowfall of 6.0 in. (15.2 cm) (normal)
- Maximum monthly snowfall of 6.6 in. (16.8 cm) (normal)
- A lightning strike with a peak current of 250 kiloamps over a period of 260 microseconds and a continuing current of up to 2 kiloamps for 2 seconds (off-normal). (PCSA-5)

3.2.3 The TAD within an STC shall be designed to maintain confinement (normal leakage rate specified in PCSA-1 and within off-normal temperature limit specified in PCSA-3) following 4 in. of volcanic ash accumulation. The STC may be on a site transporter. The ash fall loads are estimated at 21 lb/ft^2. (PCSA-6)

3.2.4 The STC shall be designed such that a drop of the lid of an STC onto an open STC shall not result in damage of the TAD within the STC. (PCSA-9)

3.3 THERMAL

3.3.1 In accordance with ISG-11 (NRC 2003 [DIRS 170332]) for normal operations during transportation and storage, the maximum SNF cladding temperature in TADs shall not exceed 400°C. The requirement applies to all cladding materials in accordance with ISG-11. Normal operations include storage at reactors and aging at repository surface facilities, transportation from reactors to the repository, and transportation by on-site transporters at the repository. (TH-1)

3.3.2 During accidents or off-normal operation for durations lasting up to 30 days (such as fires or loss of HVAC systems in surface facilities), the maximum SNF cladding temperature in TADs shall not exceed 570°C (PCSA-3). This requirement applies to all cladding materials in accordance with ISG-11 (NRC 2003 [DIRS 170332]). (TH-1)

3.3.3 Cooling features and mechanisms in TADs and STCs shall be passive in nature. (TH-1)

3.3.4 The TAD within an STC shall be designed to maintain cladding temperature for SNF below 400ºC during normal operations and 570ºC during off-normal and accident conditions in accordance with ISG-11 (NRC 2003 [DIRS 170332]). (PCSA-3)

3.4 SHIELDING AND RADIATION

3.4.1 The TAD, the transportation overpack, the STC, the aging overpack, site transporter, and ancillary equipment shall contain features that are designed to reduce worker (individual and collective) radiation exposures to as low as is reasonably achievable (ALARA). Worker dose assessments based on specified operating procedures and associated operating environments shall be provided for each operation. These assessments shall demonstrate the effectiveness of the design features to meet ALARA objectives at the repository.

Examples of the ALARA design and operational features, radiation shielding; simplified operations that reduce time and the number of workers required; isolating and maintaining clean water in the annulus between a TAD and its transfer cask; vent, backfill, and test penetrations located and oriented to facilitate access and reduce radiation streaming; smooth surfaces for ease of decontamination; use of standard tools and equipment; and use of long reach tools. (NU-1)

3.4.2 The on-site STC shall limit the combined neutron and gamma dose rate to less than 80 mrem/hr at contact with any exterior surface of the STC. (NU-3)

3.4.3 A TAD and associated components shall be designed such that removable external surface contamination of radioactive material is controlled in conjunction with specified operating procedures to limit the potential for contamination in worker areas, airborne contamination of repository facilities such as HVAC, onsite and offsite radioactive releases, and cross contamination of equipment in contact with TADs. (NU-7)

3.4.4 The TAD STC shall withstand a fully engulfing fire (as defined in FP-1) without loss of its shielding function as described in NU-3. (FP-1)

3.4.5 The STC shall withstand a blast wave, projectiles, or thermal radiation resulting from a site transporter fuel, lubricating or hydraulic tank or system explosion, without failure of shielding functions as defined in as defined in NU-3. (FP-2)

3.5 CRITICALITY

There are no criticality requirements that apply to the STC. The STC provides radiological shielding and protection of the TAD from natural phenomena such as tornado driven missiles, but the STC does not play a direct role in preventing or mitigating criticality of the SNF contained within the TAD.

3.6 CONFINEMENT

3.6.1 The TAD within an STC shall be designed to the maximum accident leak rate of 9.3×10^{-10} fraction of canister free volume per second following a 3-ft drop or tipover during the transport and transfer operations. (PCSA-2)

3.6.2 The TAD within an STC while on a site transporter shall be designed to maintain confinement (normal leakage rate specified in PCSA-1 and the off-normal cladding temperature limits provided in PCSA-3) following a fire (as defined in FP-1) or explosion from the site transporter. (PCSA-7)

3.6.3 The TAD shall withstand a fully engulfing fire (as defined in FP-1) while inside the STC without failure of its confinement function as defined in PCSA-7. (FP-1)

3.6.4 The TAD including its confinement systems shall withstand a blast wave, projectiles, or thermal radiation resulting from a site transporter fuel, lubricating or hydraulic tank or system explosion, without failure of confinement or shielding functions as defined in PCSA-7. (FP-2)

3.6.5 The STC shall be designed so that the TAD maintains confinement (normal leakage rate specified in PCSA-1 and the normal cladding temperature limit provided in PCSA-3) following the transfer of the TAD to or from the stationary aging overpack at the aging pad. (PCSA-8)

3.6.6 The design/qualification of the final closure on the TAD shall comply with Interim Staff Guidance-18 (NRC 2003 [DIRS 164538]) if applicable for the purposes of demonstrating no credible leakage *or* shall be designed to a maximum leak rate of 1.5×10^{-12} fraction of canister free volume per second during normal operations under repository environmental conditions as defined in PCSA-5. (PCSA-1)

3.6.7 For TAD transfers from the STC to the aging overpack, the configuration shall be designed to maintain confinement (normal leakage rate specified in PCSA-1 and within temperature limits specified in PCSA-3) during and following exposure to the environmental conditions listed in Section 3.2.2 of this appendix. The TAD within an STC may be on a site transporter. (PCSA-5)

3.7 OPERATIONS

3.7.1 The STC and lid shall be designed for handling under water with the STC in a vertical orientation. The STC body and lid shall have features that center and seat a lid that is being installed on the STC body while submerged in a pool. These features shall accommodate a lid that is off-center by up to 1/2 in. while being inserted. (MH-11)

3.7.2 The STC shall be designed so that water in any annular volume between the STC and the TAD can be drained following removal of the STC from the pool. (MH-13)

3.7.3 A horizontal STC shall be designed to permit the STC to be upended to a vertical orientation using a overhead crane. (MH-14)

3.8 LICENSING

3.8.1 The movement of a TAD within the geologic repository operations area in a transportation overpack, aging overpack, STC, or waste package, the transfer of a TAD from the transportation overpack to the aging overpack or a waste package and from the aging overpack to a waste package, and aging of a TAD in an aging overpack must be conducted within the requirements of 10 CFR Part 63 [DIRS 176544], in accordance with NRC endorsed or accepted industry standards and regulatory guidance, and within the requirements of any applicable technical specifications and license conditions for the repository license to receive and possess SNF. (LIC-2)

4. MATERIALS

4.1 REQUIRED MATERIALS

4.1.1 The STC shall be designed to be compatible with the repository pool water (see Table E4.1-1). For example, there shall be no adverse chemical interactions between these materials and the pool water. (MH-6)

Table E4.1-1. Repository Pool Water Specification

Average annual pool water temperature	< 90°F [Pool water temperature may exceed 110°F for no more than 5% of the time during June, July, August, and September]
Average annual pool water conductivity	< 3 micro mho per cm
Pool water chloride concentration	< 0.5 ppm
Pool water pH	5.3 to 7.5 (unborated water)

(MH-6)

4.2 PROHIBITED OR RESTRICTED MATERIALS

No material prohibitions or restrictions have been developed at this time for addressing performance of the STC. Standard industry practices and materials will provide adequate protection for STC performance.

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APPENDIX F
PRELIMINARY PERFORMANCE SPECIFICATION: AGING OVERPACK

This appendix contains the Preliminary Performance Specification*: Aging Overpack*.

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1. SCOPE/BACKGROUND

1.1 This preliminary performance specification applies to an aging overpack, which is a part of the TAD system that would be approved for use and licensed by the NRC. The aging overpack provides the necessary functions (i.e., shielding, heat dissipation, structural strength, and corrosion resistance).

1.2 The aging overpack will be used to thermally age SNF contained within a TAD at the Yucca Mountain site. Aging overpack performance requirements are similar to provisions for currently designed and in service overpacks that have been licensed for storage in accordance with 10 CFR Part 72 [DIRS 176577].

1.3 When necessary, the following TAD system components will work in conjunction with the canister to meet the performance objectives of this specification.

- Transport, Aging and Disposal canister (Appendix A)
- TAD System Ancillary Equipment (Appendix D)
- Site Transporter (Appendix G)

1.4 The TAD system design effort will use *Standard Review Plan for Dry Cask Storage Systems*, NUREG-1536 (NRC 1997 [DIRS 101903]) and *Yucca Mountain Review Plan, Final Report*, NUREG-1804 (NRC 2003 [DIRS 163274]), as applicable. These NUREGs may be used by the NRC to review the TAD system designs.

2. REFERENCED DOCUMENTS

The following documents are referenced in this performance specification and provide additional information on the applicable subjects.

2.1 REGULATIONS

176544 10 CFR 63. 2006 Energy: Disposal of High-Level Radioactive Wastes in a Geologic Repository at Yucca Mountain, Nevada. Internet Accessible.

176575 10 CFR 71. 2006 Energy: Packaging and Transportation of Radioactive Material. Internet Accessible.

176577 10 CFR 72. 2006 Energy: Licensing Requirements for the Independent Storage of Spent Nuclear Fuel, High-Level Radioactive Waste, and Reactor-Related Greater than Class C Waste. Internet Accessible.

2.2 U.S. NUCLEAR REGULATORY COMMISSION DOCUMENTS

163274 NRC (U.S. Nuclear Regulatory Commission) 2003. *Yucca Mountain Review Plan, Final Report.* NUREG-1804, Rev. 2. Washington, D.C.: U.S. Nuclear Regulatory Commission, Office of Nuclear Material Safety and Safeguards. TIC: 254568.

101903 NRC (U.S. Nuclear Regulatory Commission) 1997. *Standard Review Plan for Dry Cask Storage Systems.* NUREG-1536. Washington, D.C.: U.S. Nuclear Regulatory Commission. ACC: MOL.20010724.0307.

164538 NRC (U.S. Nuclear Regulatory Commission) 2003. *Interim Staff Guidance - 18. The Design/Qualification of Final Closure Welds on Austenitic Stainless Steel Canisters as Confinement Boundary for Spent Fuel Storage and Containment Boundary for Spent Fuel Transportation*. ISG-18. Washington, D.C.: U.S. Nuclear Regulatory Commission. TIC: 254660.

170332 NRC (U.S. Nuclear Regulatory Commission) 2003. *Interim Staff Guidance - 11, Revision 3. Cladding Considerations for the Transportation and Storage of Spent Fuel.* ISG-11, Rev. 3. Washington, D.C.: U.S. Nuclear Regulatory Commission. ACC: MOL.20040721.0065.

2.3 INDUSTRY STANDARDS

None.

2.4 OTHER REFERENCES

176593 BSC (Bechtel SAIC Company) 2006. *Transport, Aging, and Disposal Canister System Basis of Specification Requirements Document.* 000-30R-MGR0-01400-000-000. Las Vegas, Nevada: Bechtel SAIC Company.

3. PERFORMANCE REQUIREMENTS

The preliminary performance requirements for the TAD system at the Yucca Mountain repository have been compiled into a single source document titled *Transport, Aging, and Disposal Canister System Basis of Specification Requirements Document* (BSC 2006 [DIRS 176593], Section 3). The performance requirements in this specification for the aging overpack are a subset of the overall requirements for the entire TAD system. In many instances the TAD must function with other system components in order to satisfy performance objectives.

Background information, with sources and rationale for the performance requirements, is found in *Transport, Aging, and Disposal Canister System Basis of Specification Requirements Document*. Performance requirements cite the requirement number from the TAD requirements document. For example, the citation MH-10 refers to the document *Transport, Aging, and Disposal Canister System Basis of Specification Requirements Document* (BSC 2006 [DIRS 176593], Section 3) and the requirement number MH-10 in that document.

3.1 GENERAL PERFORMANCE REQUIREMENTS

3.1.1 The aging overpack shall accommodate a TAD that is based on a right-circular cylinder with a length of $212.0\ in.\left(\frac{+0.0\ in.}{-0.5\ in.}\right)$ and a diameter of $66.5\ in.\left(\frac{+0.0\ in.}{-0.5\ in.}\right)$. (TAD-1)

3.1.2 The aging overpack shall function with a TAD that has a maximum loaded weight of 54.25 short tons. (TAD-1)

3.1.3 The cumulative height of the TAD; the open STC, open transportation overpack, or open aging overpack (i.e., lids removed); and associated grapple shall be limited such that maximum under-the-hook height is less than 42 ft as shown in Figure F3.1-1. (MH-1)

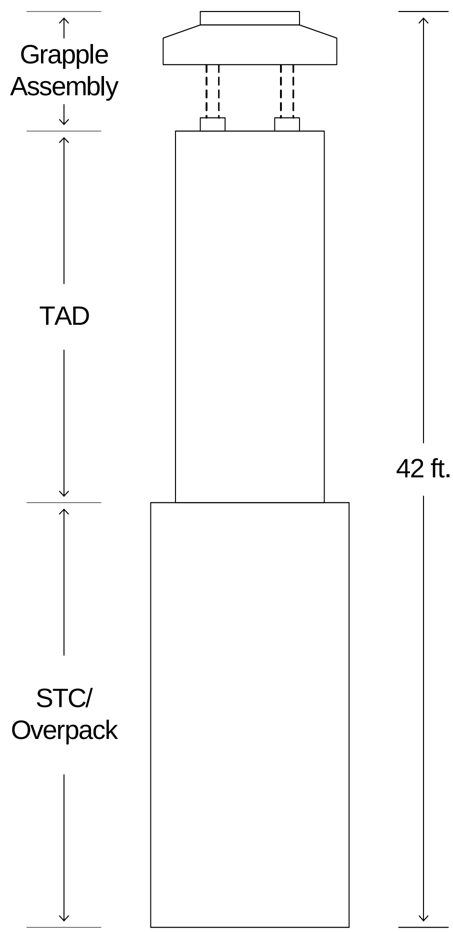

Figure F3.1-1. TAD Component Cumulative Height

3.1.4 A transportable aging overpack shall be capable of being transported by an overhead crane or site transporter. It shall be designed to remain in its transport orientation when set down on a flat horizontal surface, without requiring the use of auxiliary supports. (MH-20)

3.1.5 A transportable aging overpack designed to be moved in a vertical orientation and shall also be capable of being transported by the use of an air pallet. (MH-20)

3.1.6 The combined size and weight of the loaded TAD and aging overpack, shall be limited to ensure that they can be handled at the Yucca Mountain repository. These limits are provided in Table F3.1-1 (MH-12):

Table F3.1-1. Combined Size and Weight Limits

Maximum envelope diameter	135 in.
Maximum length	240 in.
Maximum loaded weight	200 tons (hook weight, including lifting devices)

3.1.7 The aging overpack shall be designed for a 50-year service life. (PCSA-10)

3.2 STRUCTURAL

3.2.1 A TAD in an aging overpack shall be designed to maintain confinement (normal leakage rate specified in PCSA-1 and within the normal operations temperature limit specified in PCSA-3) following a seismic event defined by the 2,000-year seismic return period. The aging overpack, may be on a site transporter. The normal leakage rates and the off-normal cladding temperature provided in PCSA-3 shall be demonstrated following a seismic event defined by the 10,000-year seismic return period. Seismic data for the 2,000- and 10,000-year return period seismic events are provided in *Transport, Aging, and Disposal Canister System Basis of Specification Requirements Document* (BSC 2006 [DIRS 176593], Attachment A of Appendix C). (PCSA-4)

3.2.2 For TAD transfers directly to a stationary aging overpack from a transportation overpack, the configuration shall be designed to maintain confinement (normal leakage rate specified in PCSA-1 and within temperature limits specified in PCSA-3) during and following exposure to the environmental conditions listed below. The TAD within a transportation overpack without impact limiters may be on a site transporter. (PCSA-5)

The cladding temperature requirement is identified as normal (400°C) or off-normal (570°C) following the environmental condition listed below:

These environmental conditions are not cumulative but occur independently (PCSA-5):

- Outdoor average daily temperature of 2ºF to 116ºF with insolation as specified in 10 CFR Part 71 [DIRS 176575] (normal)

- An extreme wind of a 3-sec 90 mph gust (normal)
- Maximum tornado wind speed of 189 mph with a corresponding pressure drop of 0.81 lb/in^{2}and a rate of pressure drop of 0.30 lb/in^2/sec (off-normal)
- The spectrum of missiles from the maximum tornado are provided in Table F3.2-1 (off-normal):

Table F3.2-1. Spectrum of Missiles

Missile	Mass (kg)	Dimensions (m)	Horizontal Velocity (m/second)
Wood Plank	52	0.092 × 0.289 × 3.66	58
6 in. Schedule 40 pipe	130	0.168D × 4.58	10
1 in. steel rod	4	0.0254D × 0.915	8
Utility Pole	510	0.343D × 10.68	26
12 inch Schedule 40 pipe	340	0.32D × 4.58	7
Automobile	1810	5 × 2 × 1.3	41

- Annual precipitation of 20 inches/year (normal)
- The spectrum of rainfall is provided in Table F3.2-2 (normal):

Table F3.2-2. Spectrum of Rainfall

Parameter and Frequency	Nominal Estimate	Upper Bound 90% Confidence Interval*
Maximum 24-hr precipitation (50-year return period)	2.79 in./day (7.1 cm)	3.30 in./day (8.4 cm)
Maximum 24-hr precipitation (100-year return period)	3.23 in./day (8.2 cm)	3.84 in./day (9.8 cm)
Maximum 24-hr precipitation (500-year return period)	4.37 in./day (11.1 cm)	5.25 in./day (13.3 cm)
Precipitation 1-hr intensity (50-year return period)	1.35 in./hr (3.4 cm)	1.72 in./hr (4.4 cm)
Precipitation 1-hr intensity (100-year return period)	1.68 in./hr (4.3 cm)	2.15 in./hr (5.5 cm)

*Use the values for upperbound 90% confidence interval.

- Maximum daily snowfall of 6.0 in. (15.2 cm) (normal)
- Maximum monthly snowfall of 6.6 in. (16.8 cm) (normal)
- A lightning strike with a peak current of 250 kiloamps over a period of 260 microseconds and a continuing current of up to 2 kiloamps for 2 seconds (off-normal).

  (PCSA-5)

3.2.3 For use at the repository, a TAD within an aging overpack shall be designed to maintain confinement (normal leakage rate specified in PCSA-1 and within temperature limits specified in PCSA-3) during and following exposure to the environmental conditions listed in Section 3.2.2 of this appendix. The aging overpack may be on a site transporter. (PCSA-5)

3.2.4 The TAD within an aging overpack shall be designed to maintain confinement (normal leakage rate specified in PCSA-1 and the off-normal cladding temperature provided in PCSA-3) following 4 inches of volcanic ash accumulation. The aging overpack may be on a site transporter. The ash fall loads are estimated at 21 lb/ft^2. (PCSA-6)

3.2.5 For TAD transfers directly from the transportation overpack to a stationary aging overpack at the aging pad, a TAD within a transportation overpack without impact limiters shall be designed to maintain confinement (normal leakage rate specified in PCSA-1 and the off-normal cladding temperature provided in PCSA-3) following 4 inches of volcanic ash accumulation. The TAD within a transportation overpack without impact limiters may be on a site transporter. (PCSA-6)

3.3 THERMAL

3.3.1 In accordance with ISG-11 (NRC 2003 [DIRS 170332]) for normal operations during transportation and storage, the maximum SNF cladding temperature in TADs shall not exceed 400°C. The requirement applies to all cladding materials in accordance with ISG-11. Normal operations include storage at reactors and aging at repository surface facilities, transportation from reactors to the repository, and transportation by on-site transporters at the repository. (TH-1)

3.3.2 During accidents or off-normal operation for durations lasting up to 30 days (such as fires or loss of HVAC systems in surface facilities), the maximum SNF cladding temperature in TADs with an aging overpack shall not exceed 570°C (PCSA-3). This requirement applies to all cladding materials in accordance with ISG-11 (NRC 2003 [DIRS 170332]). (TH-1)

3.3.3 Cooling features and mechanisms in TADs and aging overpack shall be passive in nature. (TH-1)

3.3.4 The TAD in an aging overpack shall be designed to maintain cladding temperature for SNF below 400ºC during normal operations and 570ºC during off-normal and accident conditions in accordance with ISG-11 (NRC 2003 [DIRS 170332]). (PCSA-3)

3.4 SHIELDING AND RADIATION

3.4.1 The TAD, the transportation overpack, the STC, the aging overpack, site transporter, and ancillary equipment shall contain features that are designed to reduce worker (individual and collective) radiation exposures to as low as is reasonably achievable (ALARA). Worker dose assessments based on specified operating procedures and associated operating environments shall be provided for each operation. These assessments shall demonstrate the effectiveness of the design features to meet ALARA objectives at the repository.

Examples of the ALARA design and operational features, radiation shielding; simplified operations that reduce time and the number of workers required; vent, backfill, and test penetrations located and oriented to facilitate access and reduce radiation streaming; smooth surfaces for ease of decontamination; use of standard tools and equipment; and use of long reach tools. (NU-1)

3.4.2 The aging overpack shall limit the combined maximum neutron and gamma dose rate to less than 40 mrem/hr at contact with any exterior surface of the overpack. (NU-2)

3.4.3 The TAD aging overpack shall withstand a fully engulfing fire (as defined in FP-1) without loss of its shielding function as described in NU-2. (FP-1)

3.4.4 The TAD and the aging overpack shall withstand a blast wave, projectiles, or thermal radiation resulting from a site transporter fuel, lubricating or hydraulic tank or system explosion, without failure of shielding functions as defined in PCSA-7. (FP-2)

3.5 CRITICALITY

There are no critical requirements that apply to the aging overpack. The aging overpack provides radiological shielding and protection of the TAD from natural phenomena such as tornado driven missiles, but the aging overpack does not play a direct role in preventing or mitigating criticality of the TAD's SNF.

3.6 CONFINEMENT

3.6.1 The TAD within an aging overpack shall be designed to the maximum accident leak rate of 9.3×10^{-10} fraction of canister free volume per second following the drop or tip-over from the maximum potential height of the TAD during the transport and transfer operations. (PCSA-2)

3.6.2 For TAD transfers from a transportation overpack to a stationary aging overpack at the aging pad, the TAD within transportation overpack without removable impact limiters located outside an HVAC serviced area shall be designed to a maximum accident leak rate of 9.3×10^{-10} fraction of canister free volume per second under the applicable repository environmental conditions defined in PCSA-5 following a drop or tip-over from the railcar or site transporter. The TAD shall be designed to the maximum accident leak rate of 9.3×10^{-10} fraction of canister free volume per second following the drop or tip-over from the maximum potential height of the TAD during the transport and transfer operations. (PCSA-2)

3.6.3 The TAD within an aging overpack shall be designed to a maximum accident leak rate of 9.3×10^{-10} fraction of canister free volume per second under the applicable repository environmental conditions following a 3-ft drop or tipover. The drop or tip over may be from the site transporter. (PCSA-2)

3.6.4 The TAD within an aging overpack while on a site transporter shall be designed to maintain confinement (normal leakage rate specified in PCSA-1 and the off-normal cladding temperature limits provided in PCSA-3) following a fire (as defined in FP-1) or explosion from the site transporter. (PCSA-7)

3.6.5 For TAD transfers directly from the transportation overpack to a stationary aging overpack at the aging pad, a TAD within a transportation overpack without impact limiters shall be designed to maintain confinement (normal leakage rate specified in PCSA-1 and within the off-normal temperature limits specified in PCSA-3) following a fire (as defined in FP-1) or explosion from the site transporter. (PCSA-7)

3.6.6 The TAD shall withstand a fully engulfing fire (as defined in FP-1) while inside the aging overpack without failure of its confinement functions as defined in PCSA-7. (FP-1)

3.6.7 The TAD and the aging overpack shall withstand a blast wave, projectiles, or thermal radiation resulting from a site transporter fuel tank explosion, without failure of confinement as defined in PCSA-7. (FP-2)

3.6.8 The design/qualification of the final closure on the TAD system shall comply with Interim Staff Guidance-18 (NRC 2003 [DIRS 164538]) if applicable for the purposes of demonstrating no credible leakage *or* shall be designed to a maximum leak rate of 1.5×10^{-12} fraction of canister free volume per second during normal operations under repository environmental conditions as defined in PCSA-5. (PCSA-1)

3.7 OPERATIONS

3.7.1 The aging overpack shall be designed to receive, age, and discharge a loaded TAD. The aging overpack may be transportable or stationary and may be designed to perform these functions with the TAD in either a vertical or horizontal orientation. (MH-19)

3.7.2 The TAD, stationary aging overpack at the aging pad, the STC or transportation overpack, as appropriate, and the ancillary equipment used for transfer of the TAD to or from the stationary aging overpack at the aging pad shall be designed so that the TAD maintains confinement (normal leakage rate specified in PCSA-1 and the normal cladding temperature limit provided in PCSA-3) following the transfer. (PCSA-8).

3.8 LICENSING

3.8.1 The movement of a TAD within the geologic repository operations area in a transportation overpack, aging overpack, STC, or waste package, the transfer of a TAD from the transportation overpack to the aging overpack or a waste package and from the aging overpack to a waste package, and aging of a TAD in an aging overpack must be conducted within the requirements of 10 CFR Part 63 [DIRS 176544], in accordance with NRC endorsed or accepted industry standards and regulatory guidance, and within the requirements of any applicable technical specifications and license conditions for the repository license to receive and possess SNF. (LIC-2)

4. MATERIALS

4.1 PROHIBITED OR RESTRICTED MATERIALS

No material requirements, prohibitions, or restrictions have been developed at this time for addressing performance of the aging overpack. Standard industry practices and materials that will be developed in the design and procurement specifications will provide adequate protection for aging overpack performance.

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APPENDIX G
PRELIMINARY PERFORMANCE SPECIFICATION: SITE TRANSPORTER

This appendix contains the Preliminary Performance Specification*: Site Transporter*.

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1. SCOPE/BACKGROUND

1.1 This preliminary performance specification applies to a site transporter that would be approved for use and licensed by the NRC for conveying a loaded TAD inside an STC or aging overpack.

1.2 Site transporter performance requirements are similar to provisions for currently designed and in-service site transporters.

1.3 When necessary, the following site transporter system components will work in conjunction to meet the performance objectives of this specification.

- Ancillary Equipment (Appendix D)
- Shielded Transfer Cask (Appendix E)
- Aging Overpack (Appendix F).

1.4 The site transporter system design effort will use *Standard Review Plan for Dry Cask Storage Systems*, NUREG-1536 (NRC 1997 [DIRS 101903]), and *Yucca Mountain Review Plan, Final Report*, NUREG-1804 (NRC 2003 [DIRS 163274]), as guidance when applicable. These NUREGs may be used by the NRC to review site transporter system designs.

2. REFERENCED DOCUMENTS

The following documents are referenced in this performance specification and provide additional information on the applicable subjects.

2.1 REGULATIONS

176544 10 CFR 63. 2006 Energy: Disposal of High-Level Radioactive Wastes in a Geologic Repository at Yucca Mountain, Nevada. Internet Accessible.

176575 10 CFR 71. 2006 Energy: Packaging and Transportation of Radioactive Material. Internet Accessible.

2.2 U.S. NUCLEAR REGULATORY COMMISSION DOCUMENTS

101903 NRC (U.S. Nuclear Regulatory Commission) 1997. *Standard Review Plan for Dry Cask Storage Systems.* NUREG-1536. Washington, D.C.: U.S. Nuclear Regulatory Commission. ACC: MOL.20010724.0307. (Provides Guidance Only).

163274 NRC (U.S. Nuclear Regulatory Commission) 2003. *Yucca Mountain Review Plan, Final Report.* NUREG-1804, Rev. 2. Washington, D.C.: U.S. Nuclear Regulatory Commission, Office of Nuclear Material Safety and Safeguards. TIC: 254568.

170332 NRC (U.S. Nuclear Regulatory Commission) 2003. *Interim Staff Guidance - 11, Revision 3. Cladding Considerations for the Transportation and Storage of Spent Fuel.* ISG-11, Rev. 3. Washington, D.C.: U.S. Nuclear Regulatory Commission. ACC: MOL.20040721.0065.

2.3 INDUSTRY STANDARDS

None.

2.4 OTHER REFERENCES

176593 BSC (Bechtel SAIC Company) 2006. *Transport, Aging, and Disposal Canister System Basis of Specification Requirements Document.* 000-30R-MGR0-01400-000-000. Las Vegas, Nevada: Bechtel SAIC Company.

3. PERFORMANCE REQUIREMENTS

The preliminary performance requirements for the TAD system at the Yucca Mountain repository have been compiled into a single source document titled *Transport, Aging, and Disposal Canister System Basis of Specification Requirements Document* (BSC 2006 [DIRS 176593], Section 3). The performance requirements in this specification for the site transporter are a subset of the overall requirements for the entire TAD system. In many instances the site transporter must function with other system components in order to satisfy performance objectives.

Background information, with sources and rationale for the performance requirements, is found in the *Transport, Aging, and Disposal Canister System Basis of Specification Requirements Document*. Performance requirements cite the requirement number from the TAD requirements document. For example, the citation "(MH-10)" refers to the document *Transport, Aging, and Disposal Canister System Basis of Specification Requirements Document* (BSC 2006 [DIRS 176593], Section 3) and the requirement number MH-10 in that document.

3.1 GENERAL PERFORMANCE REQUIREMENTS

3.1.1 Site transporters of one or more designs shall be used to transport empty or loaded STCs, empty or loaded transportable aging overpacks (if applicable), and empty or loaded transportation overpacks (if applicable). If feasible, the same site transporter shall be capable of carrying either an STC or a transportable aging overpack. (MH-14)

3.1.2 The site transporter shall be capable of transporting an aging overpack containing a loaded TAD from one repository location to a second location and returning to its starting point (without load) without requiring refueling. It shall be designed for a roundtrip distance of 5 miles, with the elevation of the second location 150 feet greater than the elevation of the starting point. (MH-21)

3.1.3 The site transporter shall be an all-weather vehicle capable of operating under repository environmental conditions provided in Table G3.1-1. (MH-16)

Table G3.1-1. Environmental Conditions for Site Transporter

Maximum/minimum temperatures	116°F / 2°F
Maximum daily/yearly rainfall	3.3 inches / 20 inches
Maximum snowfall	6 inches
Maximum wind	72 mph (sustained)/ 3-sec 90 mph gust (normal)
Relative humidity	11% to 58%

3.1.4 The site transporter shall be capable of negotiating roadways with a 5% grade and up to a 2% cross-slope. (MH-17)

3.1.5 The site transporter shall not damage concrete floors in the surface nuclear facilities and minimize damage to roadways between the facilities. The facility floors can be assumed to be 4,000 psi concrete. Damage is defined to include spalling or gouging of the concrete surface or roadway. (MH-18)

3.1.6 In the design of the site transporter consideration shall be given to the implication of the following requirement “The TAD including its confinement and shielding systems shall withstand a blast wave, projectiles, or thermal radiation resulting from a site transporter fuel, lubricating or hydraulic tank or system explosion, without failure of confinement or shielding functions as defined in PCSA-7, NU-2, and NU-3, respectively.” (FP-2). “The aging overpack shall limit the combined maximum neutron and gamma dose rate to less than 40 mrem/hr at contact with any exterior surface of the overpack”. (NU-2) “The on-site STC shall limit the combined neutron and gamma dose rate to less than 80 mrem/hr at contact with any exterior surface of the STC”. (NU-3)

3.1.7 The TAD within an STC or an aging overpack while on a site transporter shall be designed to maintain confinement (normal leakage rate specified in PCSA-1 and the off-normal cladding temperature limits provided in PCSA-3) following a fire (as defined in FP-1) or explosion from the site transporter. (PCSA-7)

3.2 STRUCTURAL

3.2.1 The site transporter must accommodate the combined size and weight of the loaded TAD and STC and the combined size and weight of the loaded TAD and aging overpack as limits as defines in Table G3.2-1. (MH-12):

Table G3.2-1. Combined Size and Weight Limits

Maximum envelope diameter	135 in.
Maximum length	240 in.
Maximum loaded weight	200 tons (hook weight, including lifting devices)

3.2.2 The STC or an aging overpack may be on a site transporter. The TAD within an STC, or an aging overpack shall be designed to maintain confinement (normal leakage rate specified in PCSA-1 and the off-normal cladding temperature provided in PCSA-3) following 4 inches of volcanic ash accumulation. The ash fall loads are estimated at 21 lb/ft^2. (PCSA-6)

3.2.3 The site transporter shall be capable of withstanding all environmental conditions listed below. The environmental conditions in PCSA-5 shall not lead to the failure of the site transporter that could lead to a failure of confinement and temperature limits of its load (TAD in aging overpack or TAD in STC). (PCSA-5)

The cladding temperature requirement is identified as normal (400°C) or off-normal (570°C) following the environmental condition listed below.

These environmental conditions are not cumulative but occur independently (PCSA-5):

- Outdoor average daily temperature of 2ºF to 116ºF with insolation as specified in 10 CFR Part 71 [DIRS 176575] (normal)
- An extreme wind of a 3-sec 90 mph gust (normal)
- Maximum tornado wind speed of 189 mph with a corresponding pressure drop of 0.81 lb/in^2 and a rate of pressure drop of 0.30 lb/in^2/sec (off-normal)
- The spectrum of missiles from the maximum tornado are provided in Table G3.2-2 (off-normal):

Table G3.2-2. Spectrum of Missiles

Missile	Mass (kg)	Dimensions (m)	Horizontal Velocity (m/second)
Wood Plank	52	0.092 × 0.289 × 3.66	58
6 in. Schedule 40 pipe	130	0.168D × 4.58	10
1 in. steel rod	4	0.0254D × 0.915	8
Utility Pole	510	0.343D × 10.68	26
12 inch Schedule 40 pipe	340	0.32D × 4.58	7
Automobile	1810	5 × 2 × 1.3	41

- Annual precipitation of 20 inches/year (normal)
- The spectrum of rainfall is provided in Table G3.2-3 (normal):

Table G3.2-3. Spectrum of Rainfall

Parameter and Frequency	Nominal Estimate	Upper Bound 90% Confidence Interval*
Maximum 24-hr precipitation (50-year return period)	2.79 in./day (7.1 cm)	3.30 in./day (8.4 cm)
Maximum 24-hr precipitation (100-year return period)	3.23 in./day (8.2 cm)	3.84 in./day (9.8 cm)
Maximum 24-hr precipitation (500-year return period)	4.37 in./day (11.1 cm)	5.25 in./day (13.3 cm)
Precipitation 1-hr intensity (50-year return period)	1.35 in./hr (3.4 cm)	1.72 in./hr (4.4 cm)
Precipitation 1-hr intensity (100-year return period)	1.68 in./hr (4.3 cm)	2.15 in./hr (5.5 cm)

*Use the values for upperbound 90% confidence interval.

- Maximum daily snowfall of 6.0 in. (15.2 cm) (normal)
- Maximum monthly snowfall of 6.6 in. (16.8 cm) (normal)
- A lightning strike with a peak current of 250 kiloamps over a period of 260 microseconds and a continuing current of up to 2 kiloamps for 2 seconds (off-normal).

(PCSA-5)

3.2.4 The site transporter shall be designed so that its failure following a seismic event defined by the 2,000-year seismic return period does not lead to its load (a TAD in an STC or a TAD in an aging overpack) not maintaining confinement (normal leakage rate specified in PCSA-1 and within normal operations temperature limit specified in PCSA-3). Seismic data for the 2,000 and 10,000-year return period seismic events are provided in Attachment A of Appendix C of *Transport, Aging, and Disposal Canister System Basis of Specification Requirements Document* (BSC 2006 [DIRS 176593]). (PCSA-4)

3.3 THERMAL

3.3.1 A fire or explosion of the site transporter fuel tank may affect the SNF clad temperature inside the TAD and therefore the site transporter shall be designed to limit the effect on TADs carried in a aging overpack or STC as defined below:

The TAD system shall be designed to maintain cladding temperature for SNF below 400ºC during normal operations and 570ºC during off-normal and accident conditions in accordance with ISG-11 (NRC 2003 [DIRS 170332]). The requirement for the TAD is applicable in any TAD configuration: a TAD within an STC, an aging overpack, a transportation overpack with impact limiters, or a transportation overpack without impact limiters. (PCSA-3)

3.4 SHIELDING AND RADIATION

3.4.1 The TAD, the transportation overpack, the STC, the aging overpack, site transporter, and ancillary equipment shall contain features that are designed to reduce worker (individual and collective) radiation exposures to as low as is reasonably achievable

(ALARA). Worker dose assessments based on specified operating procedures and associated operating environments shall be provided for each operation. These assessments shall demonstrate the effectiveness of the design features to meet ALARA objectives at the repository.

Examples of the ALARA design and operational features: radiation shielding; simplified operations that reduce time and the number of workers required; isolating and maintaining clean water in the annulus between a TAD and its transfer cask; vent, backfill, and test penetrations located and oriented to facilitate access and reduce radiation streaming; smooth surfaces for ease of decontamination; use of standard tools and equipment; and use of long reach tools. (NU-1)

3.5 CRITICALITY

Does not apply to the site transporter.

3.6 CONFINEMENT

Does not apply to the site transporter.

3.7 OPERATIONS

The first two operating requirement directly apply to the site transporter. Requirements 3.7.3 through 3.7.6 indirectly apply and are given for consideration since the design of the site transporter may have an adverse impact on the ability of other TAD system components to comply with performance specifications.

3.7.1 The site transporter for STCs and transportable aging overpacks that are transported in a vertical orientation shall be capable of lifting the empty or loaded STC/aging overpack, transporting it to another surface location on the Yucca Mountain repository site, and setting it down on a platform whose height above the travel surface is nominally 30 inches. It shall be physically impossible for the site transporter to lift a loaded STC/aging overpack to a height greater than 3 ft. (MH-14)

3.7.2 The site transporter for transportable aging overpacks that are transported in a horizontal orientation shall be capable of lifting the empty or loaded aging overpack, transporting it to another surface location on the Yucca Mountain repository site, and setting it down on a horizontal surface. It shall be physically impossible for the site transporter to lift a aging overpack to a height greater than 3 feet. (MH-14)

3.7.3 The site transporter for STCs that are transported in a horizontal orientation shall be capable of receiving the empty or loaded STC and transporting it to another surface location on the Yucca Mountain repository site. The site transporter shall be designed to permit the STC to be upended and removed from the site transporter in a vertical orientation using an overhead crane. The site transporter shall be designed so that the STC is not required to be lifted or transported at a height greater than 3 feet. (MH-14)

3.7.4 The site transporter for transportation overpacks (e.g., for transportation from a repository receipt facility to stationary aging overpacks) shall be designed such that a loaded transportation overpack without removable impact limiters is not required to be lifted or transported at a height greater than that for which it is designed to maintain confinement following a drop. (MH-14)

3.7.5 The STC shall be capable of being transported by a site transporter in a vertical or horizontal orientation. If transported in a horizontal orientation, the STC shall have upper lifting trunnions with dual seats and lower turning trunnions and be designed to be upended and removed from the site transporter in a vertical orientation using an overhead crane. (MH-10)

3.7.6 For TAD transfers from a transportation overpack to a stationary aging overpack at the Aging Pad, the TAD within transportation overpack without removable impact limiters located outside a HVAC serviced area shall be designed to a maximum accident leak rate of 9.3×10^{-10} fraction of canister free volume per second under the applicable repository environmental conditions defined in PCSA-5 following a drop or tip-over from the railcar or site transporter. The TAD shall be designed to the maximum accident leak rate of 9.3×10^{-10} fraction of canister free volume per second following the drop or tip-over from the maximum potential height of the TAD during the transport and transfer operations. (PCSA-2)

3.7.7 For TAD transfers directly from the transportation overpack to a stationary aging overpack at the aging pad, a TAD within a transportation overpack without impact limiters shall be designed to maintain confinement (normal leakage rate specified in PCSA-1 and within the off-normal temperature limits specified in PCSA-3) following a fire (as defined in FP-1) or explosion from the site transporter. (PCSA-7)

3.7.8 The TAD within a transportation overpack without impact limiters may be on a site transporter. For TAD transfers directly from the transportation overpack to a stationary aging overpack, the configuration shall be designed to maintain confinement (normal leakage rate specified in PCSA-1 and within temperature limits specified in PCSA-3) during and following exposure to the environmental conditions listed in Section 3.2.3 of this appendix. (PCSA-5)

3.8 LICENSING

3.8.1 Design of the site transporter shall take into consideration that movement of a TAD within the geologic repository operations area in a transportation overpack, aging overpack, STC, or waste package, the transfer of a TAD from the transportation overpack to the aging overpack or a waste package and from the aging overpack to a waste package, and aging of a TAD in an aging overpack must be conducted within the requirements of 10 CFR Part 63 [DIRS 176544], in accordance with NRC endorsed or accepted industry standards and regulatory guidance, and within the requirements of any applicable technical specifications and license conditions for the repository license to receive and possess SNF. (LIC-2).

4. MATERIALS

4.1 PROHIBITED OR RESTRICTED MATERIALS

Does not apply to the site transporter.