SECTION C

ATTACHMENT C-A-E

PRELIMINARY DESIGN SPECIFICATION FOR DOE STANDARDIZED SNF CANISTERS

Application of the Standardized DOE SNF Canister Preliminary Design Specification To the INEEL SNF Dry Storage Project

Specification Premise:

The DOE SNF canisters will be used by different DOE sites using a variety of storage facilities and (potentially) a variety of transportation systems. This preliminary design specification for the DOE SNF canisters was written without detailed design information from the interim storage or transportation stages of use. Therefore, this preliminary specification provides only part of the canister design requirements. Other information identifying design requirements from the storage and transportation systems being used must be considered before the complete Design Specification (per the ASME Boiler and Pressure Vessel Code, Section III requirements) can be issued. However, this preliminary design specification establishes a common basis for all standardized DOE SNF canisters so that they can be accepted for disposal at the repository.

Application to the INEEL SNF Dry Storage Project:

1. The INEEL SNF Dry Storage Project requires the use of only the 18-inch nominal OD canisters in either the long or short length for Peach Bottom and TRIGA fuels. Either the 18-inch or 24-inch canisters may be used for the Shippingport LWBR fuel.

2. The INEEL SNF Dry Storage Project requires that the DOE SNF canister internals include provisions that will help protect the structural integrity of the DOE SNF canisters during accident events. These provisions include internals with large bearing surfaces and energy absorption features that minimize point loads imposed directly on the interior surface of the DOE SNF canister shell pressure boundary. The goal is to reduce excessive strains in the pressure boundary. At this time, a full-length interior sleeve (or equivalent), approximately 0.375 inches thick with an outer diameter approximately equal to the DOE SNF canister inner diameter, is envisioned. The Contractor is responsible for designing the canister internals for the specific fuels under this contract.

DOE/SNF/REP-011
REVISION 3

Preliminary Design Specification for Department of Energy Standardized Spent Nuclear Fuel Canisters

Volume I – Design Specification

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Revision 3
August 17, 1999

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DOE/SNF/REP-011
Revision 3

United States Department of Energy

National Spent Nuclear Fuel Program

Preliminary Design Specification for Department of Energy Standardized Spent Nuclear Fuel Canisters

Volume I – Design Specification

August 17, 1999

U.S. Department of Energy
Assistant Secretary for Environmental Management
Office of Spent Fuel Management and Special Projects

ABSTRACT

This document (Volume I) is the preliminary design specification for the canisters to be used during the handling, storage, transportation, and repository disposal of Department of Energy (DOE) spent nuclear fuel (SNF). This document contains no procurement information, such as the number of canisters to be fabricated, explicit timeframes for deliverables, etc. A companion document (Volume II) provides background information and design philosophy in order to help engineers better understand the established design requirements for these DOE SNF canisters.

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ACRONYMS, ABBREVIATIONS, AND DEFINITIONS

ANS	American Nuclear Society
ANSI	American National Standards Institute
ASME	American Society of Mechanical Engineers
B&PV	Boiler and Pressure Vessel
can	a smaller structure surrounding SNF or other highly radioactive components that can be placed into a canister
canister	a large structure (approximately 18 to 24-inch diameter) surrounding SNF or other highly radioactive components (bare or in cans) that facilitates handling, storage, transportation, and/or disposal and can be placed into a disposal container or cask
cask	a structure used for the transportation or storage of SNF and/or HLW comprised of components intended to provide radiation shielding and retention of spent nuclear fuel and radioactive material contents during storage or transportation that meets all applicable regulatory requirements
CFR	Code of Federal Regulations
confinement	retention of a material within an area from which releases or leakage are permitted but controlled, and leakage of other substances into the area may also occur
containment	the complete and absolute retention of any substance within a closed area and no other substance may gain access inside the closed area
damaged SNF	SNF with cladding defects greater than hairline cracks or pinhole leaks (per Draft NUREG-1617)
disposal container	the container in which the DOE SNF canisters are to be placed at the geologic repository for disposal, prior to acceptance of the final barrier weld, at which time the disposal container becomes a waste package
DOE	Department of Energy
failed SNF	SNF with hairline cracks or pinhole leaks in the cladding (as defined for this document only)
HEPA	high efficiency particulate air
HLW	high-level radioactive waste means (1) the highly radioactive material resulting from the reprocessing of spent nuclear fuel and (2) other highly radioactive material that the NRC determines by rule requires permanent isolation
intact SNF	SNF with no hairline cracks or pinhole leaks in the cladding (as defined for this document only)
INEEL	Idaho National Engineering and Environmental Laboratory

internals	items (baskets, spacers, sleeves, dividers, cans, etc.) placed inside the DOE SNF canister along with the SNF for supporting and positioning the SNF and to also prevent criticality if necessary
ISFSI	independent spent fuel storage installation
LMITCO	Lockheed Martin Idaho Technologies Company
MNIP	Maximum Normal In-Plant Handling Pressure (Section III, Division 3 definition)
MNOP	Maximum Normal Operating Pressure (Section III, Division 3 definition)
NRC	Nuclear Regulatory Commission
NSNFP	National Spent Nuclear Fuel Program
OCRWM	Office of Civilian Radioactive Waste Management (DOE)
OD	outer diameter
package	the packaging together with its radioactive contents as presented for transport
packaging	assembly of components necessary to ensure compliance with the requirements of 10 CFR Part 71
psig	pounds per square inch gage pressure
QA	quality assurance
QAPM	quality assurance program manager
repository	synonymous with geologic repository, a system that is intended to be used for the disposal of radioactive wastes in excavated geologic media
RT	radiographic test
SNF	spent nuclear fuel is fuel that has been withdrawn from a nuclear reactor following irradiation, the constituent elements of which have not been separated by reprocessing
SRS	Savannah River Site
SST	stainless steel
storage industry canister	large outer container (approximately 5 or 6 feet in diameter) used in storage of SNF
U.S.	United States
USNRC	United States Nuclear Regulatory Commission
UT	ultrasonic testing
waste package	the name of the disposal container after the final barrier weld is accepted (formal definition in 10 CFR Part 60.2)

Preliminary Design Specification for the Department of Energy Standardized Spent Nuclear Fuel Canisters

Volume I – Design Specification

1. INTRODUCTION

The Department of Energy's National Spent Nuclear Fuel Program (NSNFP) is working with the Department's Office of Civilian Radioactive Waste Management (OCRWM), the Idaho National Engineering and Environmental Laboratory (INEEL), Hanford, Oak Ridge National Laboratory, Argonne National Laboratory, and the Savannah River Site (SRS) to develop a set of standard canisters for handling, interim storage, transportation, and disposal in the national repository of Department of Energy (DOE) spent nuclear fuel (SNF). This resulting preliminary specification is written in two volumes. Volume I contains design parameters for the standardized SNF canisters. Volume II provides background information and associated reasons for specifying certain design parameters for these standard canisters.

1.1 Objective

The objective of this specification is to provide the requirements and necessary information to design the standardized canisters to be used for handling, interim storage, transportation, and disposal in the national repository of DOE SNF. This design specification addresses two different outer diameter (OD) sizes of DOE SNF standardized canisters, including two different lengths for each canister OD, resulting in a total of four unique canister geometries. This design specification does not consider using these DOE SNF canisters for either U.S. Navy or commercial SNF or HLW (either commercial or defense) materials. This design specification does not provide any procurement-specific information.

Although using the same terminology, the standardized DOE SNF canister must not be confused with the containers used in current interim SNF storage systems for commercial spent nuclear fuels. Many independent spent fuel storage installation (ISFSI) or dry storage system vendors also call their SNF container a canister. However, the commercial nuclear industry storage canister (hereafter referred to as the storage industry canister) is typically 5 to 6 feet in diameter. The DOE SNF canisters are approximately 1.5 to 2 feet in diameter.

1.2 Standardized Canister Design Approach

According to the Foreword in ANSI/ANS-57.9-1992, "...the safe storage of spent fuel assemblies is achieved by maintaining a minimum of two independent barriers between the fuel and the environs. The fuel cladding is considered the primary barrier for undamaged fuel. ...In addition, the complete confinement system for the stored fuel is conservatively designed to withstand damaging events... so that there is an effective secondary barrier(s) to the release of radioactive materials under all credible conditions." The storage industry canister is intended to provide the secondary barrier for the commercial SNF. The DOE SNF canisters are intended to provide the primary barrier (cladding replacement) for damaged DOE SNF during interim storage and transportation to the repository. Intact, failed, and damaged DOE SNF can be placed directly into the standardized DOE SNF canisters.

Although details regarding SNF loading, interim storage, and transportation are not yet finalized, the NSNFP is establishing a design for the DOE SNF canisters. The approach taken by the NSNFP is to specify a design[a] for the DOE SNF canister. This design must be robust. Robust is defined herein to mean a design that has significant safety margins for the known loads and safety margins for the loads that have been estimated.

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a. The mention of any specific products and/or manufacturers in this document implies neither endorsement or preference, nor disapproval by the U. S. Government, any of its agencies, or LMITCO, of the use of a specific product for any purpose.

2. REFERENCES

Federal Regulations:

A.	10 CFR Part 60 January 1, 1998 Edition	Disposal of High-Level Radioactive Waste in Geologic Repositories
B.	10 CFR Part 71 January 1, 1998 Edition	Packaging and Transportation of Radioactive Material
C.	10 CFR Part 72 January 1, 1998 Edition	Licensing Requirements for the Independent Storage of Spent Nuclear Fuel and High-Level Radioactive Waste

National Standards:

A.	ANSI/ANS-57.9 1992	Design Criteria for an Independent Spent Fuel Storage Installation (Dry Type)
B.	ANSI N14.5 1987	American National Standard for Radioactive Materials - Leakage Tests on Packages for Shipment
C.	ANSI N14.6 1993	American National Standard for Special Lifting Devices for Shipping Containers Weighing 10,000 Pounds (4500 kg) or More for Nuclear Materials
D.	ASME B&PV Code, Section II, 1995 Edition, 1997 Addenda*	Materials
E.	ASME B&PV Code, Section III, Division 1, Subsection NB, 1989 Edition*	Rules for Construction of Nuclear Power Plant Components Class 1 Components
F.	ASME B&PV Code, Section III, Division 3, 1997 Edition*	Containment Systems and Transport Packagings for Spent Nuclear Fuel and High Level Radioactive Waste
G.	ASME B&PV Code, Section V, 1995 Edition, 1997 Addenda*	Nondestructive Examination
H.	ASME B&PV Code, Section IX, 1995 Edition, 1997 Addenda*	Welding and Brazing Qualifications.

*The most current edition of the ASME B&PV Code (approved by the NRC) may be used for design purposes provided the proposed changes described in Section 3.2.1 have been incorporated.

3. DESIGN REQUIREMENTS FOR THE DOE SNF CANISTERS

This preliminary design specification establishes a common basis for all standardized DOE SNF canisters so that they can be accepted for disposal at the repository. It is recognized that the DOE SNF canister final design must be integrated with the total system design, including storage and transportation requirements. Different groups of DOE SNF canisters may be stored in a variety of facilities and these same groups of DOE SNF canisters may even be transported in a variety of transportation casks.

Each unique group of DOE SNF canisters will require Design Specifications and Design Reports [per the ASME Boiler & Pressure Vessel (B&PV) Code]. The Design Report must establish the design bases and establish the specified uses of the DOE SNF canister. The Design Reports may also have to be updated as necessary when design information changes.

3.1 NSNFP Specified Canister Design

The specified standardized DOE SNF canister designs for the four unique geometries are shown on the engineering drawings (see Appendix A). The storage system vendor and the transportation cask designer must incorporate the specified DOE SNF canister design into their respective system designs. For clarification, the design loads defined in 10 CFR Part 71.71 and 71.73 shall be applied to the DOE SNF canister and the outer transportation cask as a combined system (canister and cask), not individually. The same combined system design philosophy applies to the DOE SNF canister and the applicable storage system.

This preliminary design specification (Volume I) identifies the requirements necessary to construct (design, fabricate, examine) the DOE SNF canisters. Additional background information, functionality requirements, intended canister use details, or an explanation of imposed requirements can be found in Volume II of this document.

3.2 Design Requirements

3.2.1 Acceptance Criteria

The DOE SNF canisters shall be designed, fabricated, and examined per the requirements of the ASME B&PV Code, Section III, Division 3, Subsections WA and WB, 1997 Edition (or most current edition approved by the NRC provided the specific code changes explained below have been incorporated) for the loads and environments identified in this design specification.

Certain changes to Section III, Division 3 need to be made in order for the DOE SNF canisters to be fabricated as N-stamped vessels. First, Division 3 must be changed to allow field operations in order to complete construction (e.g., perform the final closure weld) at locations other than the Code shop. Division 3 must also be changed to allow the actual N-stamping prior to the SNF being loaded into the DOE SNF canisters. In addition, clarifications that allow the use of ultrasonic examination for the final closure weld must be made. Due to the presence of the SNF after loading, the DOE SNF canisters shall not be required to satisfy pressure test requirements of Section III, Division 3, Subsection WB, after loading the SNF and final closure welding. Changes permitting helium leak testing (per ASME Code, Section V requirements) in lieu of pressure testing for low design pressure vessels must be made to Division 3 rules. The DOE SNF canisters shall not contain any pressure relief devices. The DOE SNF canisters shall be considered N-stamped (with the Data Report signed) after the authorized nuclear inspector has accepted the final closure weld.

Depending on how the DOE SNF canister is used for interim storage, there could exist the possible requirement to demonstrate DOE SNF canister structural adequacy. If this occurs, it may be necessary to demonstrate compliance with the requirements of the ASME B&PV Code, Section III, Division 1, Subsection NB. However, this is achievable because the DOE SNF canisters are already Section III vessels.

3.2.2 Geometry

All of the DOE SNF canisters shall be right circular cylinders that are able to stand vertically when placed on a flat surface after being loaded with SNF. The large canister shall have a nominal OD of 610 mm (24.00 inches) and a nominal wall thickness of 12.7 mm (0.500 inches). The small canister shall have a nominal OD of 457 mm (18.00 inches) and a nominal wall thickness of 9.53 mm (0.375 inches). Both of these canisters shall be designed for a maximum overall length of either 3,000 mm (118.11 inches) or 4,570 mm (179.92 inches). Appendix A of this design specification contains the engineering drawings showing the specified NSNFP canister design. Dimensional tolerances and fabrication processes (including weld grinding where necessary) shall be controlled so that the maximum dimensions are not exceeded.

Typical fabrication tolerances are indicated on the engineering drawings. Since the material specification is SA-312 (for seamless and welded austenitic stainless steel pipes), certain dimensional tolerances (from material specification SA-530 in Section II of the ASME B&PV Code) associated with the exterior canister shell are already specified. Outer diameter variations shall not be over by more than 3.2 mm (0.125 inches) for the 610 mm (24.00 inches) canister and 2.4 mm (0.093 inches) for the 457 mm (18.00 inches) canister. For ovality, the difference in extreme outside diameter readings in any one cross-section shall not exceed 1.5% of the specified nominal outside diameter. Straightness tolerances for each canister shall not exceed 3.2 mm (0.125 inches) maximum deviation for every 3.0 m (10 feet) of pipe length (both ends of a 3.0-m (10-foot) straightedge used for the measurement are in contact with the surface). In addition to the above mentioned mill tolerances, provisions must be made for the as-welded condition of the final canister weld (attaching the top head to the canister shell). Therefore, an additional diameter increase of 4.76 mm (0.1875 inches) shall be considered acceptable for the crown of the final canister weld.

In order to ensure that certain contents can be placed inside these canisters and that the canister can be placed in the repository waste package, the following dimensions shall be incorporated into the canister design:

Table 3.1. DOE SNF canister dimensions.

Canister Size	Nominal Outer Diameter	Long Canister Max. External Length	Short Canister Max. External Length	Min. Internal Diameter	Long Canister Min. Internal Length	Short Canister Min. Internal Length
Large	610 mm (24.00 in.)	4,570 mm (179.92 in.)	3,000 mm (118.11 in.)	579 mm (22.80 in.)	4,038.6 mm (159 in.)	2,470.2 mm (97.25 in.)
Small	457 mm (18.00 in.)	4,570 mm (179.92 in.)	3,000 mm (118.11 in.)	430 mm (16.93 in.)	4,114.8 mm (162 in.)	2,540.0 mm (100 in.)

3.2.3 Materials

The DOE SNF canisters shall be made of SA-312, type 316L stainless steel for the shell and SA-240, type 316L for all other parts, including the heads, labels, and lifting rings. The optional plugs and plug thread plates shall be SA-479 type 316L stainless steel. All stainless steel materials shall be annealed and pickled. A total value of 1.27 mm (0.050 inches) of pressure boundary wall thickness reduction has been established as the erosion and corrosion value to be used for canister design purposes. This corrosion/erosion value reflects the full design lifetime of 100 years. Therefore, prior to acceptance at the repository, the DOE SNF canisters shall be protected from adverse environmental conditions in such a manner as to prevent the total wall thickness corrosion/erosion limit from being exceeded. A 50-year interim storage and transportation interval shall be assumed for this specific wall thickness reduction evaluation. The assumption is made that once the DOE SNF canister is placed inside the waste package, insignificant corrosion or erosion will occur for the next 50-year interval.

The canisters will be subjected to a radiation environment. Radiation fields (10^7 rad/hr or less) are expected but no significant material damage or degradation is anticipated for the stainless steel material.

Both the inner and outer surfaces of the canisters shall have a finished condition such that acceptable nondestructive examinations can be performed in order to satisfy ASME B&PV Code, Section III, Division 3, Subsection WB requirements. However, no specific surface finish is specified for the DOE SNF canisters. Any burrs, sharp edges, and weld edges shall not exceed 0.5 mm (0.0197 inches). The interior surfaces shall be smooth enough to allow easy loading of any DOE SNF or internals (baskets, spacers, sleeves, dividers, cans, etc.) so as to not damage the SNF.

3.2.4 Contents

The DOE SNF canisters shall be designed for the total maximum allowable weights (canister plus contents) listed in the table below:

Table 3.2. DOE SNF canister maximum total allowable weights.

Canister Size	Nominal Outer Diameter	Long Canister Maximum Total Weight	Short Canister Maximum Total Weight
Large	610 mm (24.00 in.)	4,535 kg (10,000 lb_f)	4,080 kg (8996 lb_f)
Small	457 mm (18.00 in.)	2,721 kg (6,000 lb_f)	2,270 kg (5,005 lb_f)

When loading the DOE SNF, the center-of-gravity of the entire contents (SNF, baskets, spacers, sleeves, dividers, etc.) shall be within 127.0 mm (5 inches) of the canister centerline for the 457 mm (18.00 inches) nominal OD canister and within 203.2 mm (8 inches) of the canister centerline for the 610 mm (24.00 inches) nominal OD canister. These loading restrictions are to avoid excessive lop-sided loading situations and to limit resulting stresses in the lifting ring and adjacent skirt portion of the canister to stress limits that satisfy the requirements of ANSI N14.6. When possible, the center-of-gravity of the loaded DOE SNF canister will be as close to the canister centerline as reasonably achievable. The axial location of the center-of-gravity of a loaded DOE SNF canister shall be within 609.6 mm (24.0 inches) of the canister centroid. Sites performing SNF loading may make separate evaluations of center-of-gravity locations if the indicated center-of-gravity limitations are exceeded. However, all acceptance criteria shall still be satisfied.

3.2.5 Canister Sealing

Sealing of the DOE SNF canisters may be required for interim storage, depending on the type of storage system utilized. However, if the storage system permits it, the DOE SNF canisters may be sealed after interim storage. Incorporated into the DOE SNF canister design is the option of a threaded plug in the top and bottom head. However, prior to transportation and repository disposal, the DOE SNF canister must be seal-welded closed. The DOE SNF canisters shall be backfilled with an inert cover gas (e.g., helium) inside of the canister at a pressure of 13.8 to 27.6 kPa (2 to 4 psig). The final canister weld shall implement a welding procedure that can be qualified to yield leaktight welds. A leaktight weld shall be considered equal to or better than the required leak rate necessary to satisfy the applicable 10 CFR Parts 71 and 72 requirements. At a minimum, in order to demonstrate compliance with the ASME Code and obtain the Code stamp per the proposed Code changes, the DOE SNF canister shall be helium leak tested per the requirements identified in Section V, Article 10, Appendix IV to verify that no leakage is detected that exceeds the rate of 1×10^{-4} std cm^3/sec.

When using the optional threaded plugs, it is necessary to seal-weld the threaded plugs in order to establish an acceptable containment boundary per ASME B&PV Code, Section III requirements. The seal weld shall cover any exposed threads on the plug.

3.2.6 Shielding

For the purposes of this design specification, it is assumed that the DOE SNF canisters do not require additional shielding beyond that provided by the canisters themselves or in conjunction with shielding provided by the facilities handling the DOE SNF canisters or the storage or transportation systems.

3.2.7 Criticality

For the purposes of this design specification, it is assumed that adequate attention to the types and amounts (proper fissile limits) of SNF to be loaded into the canisters or proper configuration using properly designed internals (baskets, spacers, sleeves, dividers, cans, etc.) will preclude any criticality concerns.

3.2.8 Weight

The weight considerations listed in Table 3.2 are for all of the DOE SNF canister geometries. The DOE canisters shall not be horizontally or vertically stacked at any time with any other canisters without a proper evaluation of all possible consequences. Interim storage, transportation, and disposal scenarios are situations where the canisters are within other enclosures or facilities and these canister placements shall be properly evaluated.

The lifting fixture is not part of the canister design specification. However, the design of the lifting fixture does have an affect on the resulting design of the canister. Therefore, some insights regarding design requirements of the lifting fixture should be indicated. The lifting fixture shall provide at least three locations to engage the canister lifting ring, with the capability to engage and disengage remotely. The lifting fixture shall be capable of engaging and disengaging while remaining within the projected perimeter of the DOE SNF canisters. The lifting fixture must also allow the reading of the canister label appearing on the lifting ring while the lifting fixture is engaged. The amount of engagement provided by the lifting fixture shall be determined so that ANSI N14.6 stress criteria for the canister are satisfied. With a proper lifting fixture available, the DOE SNF canister shall be designed so that the canisters can be lifted and moved safely.

1. The DOE SNF canisters shall be designed to be vertically lifted with a lifting fixture that remotely engages underneath the 12.7-mm (1/2-inch) thick lifting ring. Material temperature limits for lifting the canisters shall be 148.9°C (300°F). Due to the symmetry of the specified DOE SNF canister design (see the engineering drawings Appendix A), either end shall be capable of being used to lift the canister. The Maximum Normal In-Plant Handling Pressure (MNIP) shall be considered to be acting coincidentally.

2. With respect to recovering from an accidental canister drop or tip-over (regardless of severity), the canisters shall be designed to be picked up from both extreme ends or tilted back upright from a horizontal position. Stresses resulting from this action shall satisfy normal operating condition stress limits defined in the ASME B&PV Code, Section III, Division 3, Subsection WB. Worst case temperatures and pressures shall be considered to

be acting coincidentally. The weight of the contents shall be assumed to be lumped at the centroid of the canister.

3.2.9 Pressure

The following specified pressure loadings are listed for all of the DOE SNF canister geometries.

1. The Maximum Normal In-Plant Handling Pressure (MNIP) is the maximum pressure that would develop in a DOE SNF canister during initial handling, interim storage, transportation, or initial repository handling or disposal container loading prior to actual emplacement in a repository drift under the most severe conditions of normal in-plant handling operations. The DOE SNF canister shall be designed for a MNIP not to exceed 344.8 kPa (50 psig) per the criteria of the ASME B&PV Code, Section III, Division 3, Subsection WB. (For potential ASME B&PV Code, Section III, Division 1, Subsection NB evaluations, the MNIP shall be considered to be the design pressure.)

2. The Maximum Normal Operating Pressure (MNOP) is the maximum pressure that would develop in a DOE SNF canister during initial handling, interim storage, transportation, or initial repository handling or disposal container loading prior to actual emplacement in a repository drift without venting. The DOE SNF canister shall be designed for a MNOP not to exceed 151.7 kPa (22 psig) per the criteria of the ASME B&PV Code, Section III, Division 3, Subsection WB. (For potential ASME B&PV Code, Section III, Division 1, Subsection NB evaluations, the MNOP shall be considered to be the operating pressure.)

3.2.10 Thermal

The DOE SNF canisters are assumed to have adequate room (diameter and length) for stress-free thermal expansion during all uses.

1. The Primary Service Temperature for a DOE SNF canister when it is not inside any other container (by itself, in a 25°C (77°F) calm air environment) is 176.7°C (350°F), and 343.3°C (650°F) after placement within another enclosed container (e.g., a storage industry canister for interim storage or a transportation cask), possibly with other heat generating DOE SNF canisters or HLW canisters. (For potential ASME B&PV Code, Section III, Division 1, Subsection NB evaluations, the Primary Service Temperature shall be considered to be the design temperature.)

2. The maximum operating temperature for a DOE SNF canister when it is not inside any other container (by itself, in a 25°C (77°F) calm air environment) is 148.9°C (300°F), and 315.5°C (600°F) after placement within another enclosed container (e.g., a storage industry canister for interim storage or a transportation cask), possibly with other heat generating DOE SNF canisters or HLW canisters.

3. The DOE SNF canisters shall be designed for 20 full MNIP and temperature cycles of a canister achieving its maximum steady state operating temperature of 315.5°C (600°F) inside of another container and then suddenly being exposed to an external calm air temperature environment of 10°C (50°F) while the canister simultaneously loses its internal pressure. The maximum thermal gradient associated with this event shall be evaluated per the criteria of the ASME B&PV Code, Section III, Division 3, Subsection WB. If the canisters are subjected to any other significant fatigue loads due to initial SNF loading, interim storage, transportation, or loading into a disposal container at the repository, a detailed fatigue analysis shall be performed per WB-3221.9(e). If necessary, cumulative usage factors from all uses (SNF loading, canister handling, storage, or transportation) shall be evaluated once these values are known.

4. The DOE SNF canisters shall be capable of maintaining containment in temperature environments that range from -40°C to 343.3°C (-40°F to 650°F), excluding accidental drop scenarios or other accidental events when being handled by itself or inside of the waste package at the repository.

3.2.11 Other Normal Operating Condition Loads

1. For situations requiring specific design evaluations where significant compressive stresses occur in the canister, the buckling stress shall be taken into account. Acceptance criteria for buckling evaluations shall be obtained from the ASME Nuclear Code Case N-284 or other appropriate methodology acceptable to ASME Code requirements and the regulatory agency. Buckling situations need to be considered in terms of being able to remove the canister from the enclosing container (either the storage industry canister or the transportation cask).

2. The DOE SNF canisters shall be designed for any other normal operating condition loads resulting from initial handling, interim storage, transportation, or handling and loading into a disposal container at the repository once the loads and environments have been defined.

3.2.12 Hypothetical Accident Loads and Environmental Conditions

Anytime a DOE SNF canister is being handled by itself, the canister shall be within a high efficiency particulate air (HEPA) filtered building or facility. This eliminates the requirement of specifically designing the DOE SNF canisters to any specific ASME B&PV Code stress limits for accidental drop events. However, when the DOE SNF canister is enclosed within a storage industry canister for interim storage purposes or within a transportation cask, the DOE SNF canister shall be designed in accordance with the criteria in the ASME B&PV Code, Section III, Division 3 stress limits identified in WB-3224 or Section III, Division 1, Subsection NB-3225 as required. For the repository waste package drop or tip-over event, the canister shall be considered adequate as-developed (per the engineering drawings in Appendix A) since the only requirement is to remove the DOE SNF canister from the damaged waste package and place it into another undamaged waste package.

Another design concern is to maintain permissible deformations for the DOE SNF criticality concerns. However, this design evaluation is considered to be beyond the scope of this current design specification due to the involvement of the not yet defined canister internals (baskets, spacers, sleeves, dividers, cans, etc.). Therefore, the internals shall be required to provide any necessary geometry control regarding criticality evaluations of the DOE SNF.

For situations requiring specific design evaluations where significant compressive stresses occur in the canister, the buckling stress shall be taken into account. Acceptance criteria for buckling evaluations shall be obtained from the ASME Nuclear Code Case N-284 or other appropriate methodology acceptable to ASME Code requirements and the regulatory agency. Buckling situations need to be considered only in terms of being able to remove the canister from the enclosing container (either the storage industry canister or the transportation cask).

3.2.13 Quality Assurance

The designer and fabricator of the DOE SNF canisters shall establish, maintain, and execute a quality assurance program based on the criteria necessary to satisfy ASME B&PV Code, Section III, Division 3 construction criteria, 10 CFR Parts 71 (Subpart H), and 72 (Subpart G) quality assurance requirements.

3.2.14 Physical Protection of SNF

Since the DOE SNF canisters are to be seal-welded for transportation and repository disposal, the DOE SNF canisters do not require the use of an NRC approved tamper-safe seal. Depending on how the DOE SNF canister is being used within an interim storage system, a tamper-safe seal may be required if the DOE SNF canister is not seal-welded.

3.2.15 Labeling

The DOE SNF canisters shall be capable of being properly labeled. The highlights of these requirements include:

- The labels shall be an integral part of the canister [engraved to a depth no greater than 0.8 mm (1/32 of an inch)] that can be reasonably expected to remain legible for 100 years at temperatures of 25°C (77°F) to 400°C (752°F).
- The labels shall have a unique alphanumeric identifier
- The labels shall not impair the integrity of the canister
- The labels shall be chemically compatible with the canister material
- The top label shall be visible from the top of the canister with the lifting fixture engaged, with characters approximately 25.4 mm (1 inch) in height
- The labels shall not cause the canister dimensional limits to be exceeded.

This specification is requiring the DOE SNF canisters to be labeled on the outer most surface of each lifting ring on the top and bottom ends of the canister. The alphanumeric identifier shall be readable as if the remotely operated cameras are on the outside of the canister looking inward toward the axial centerline of the canister. Placement of an alphanumeric label on the lifting ring shall not cause any interference or loading concerns.

3.2.16 Documentation

The designer of the DOE SNF canisters shall provide adequate documentation, reports, and design drawings in the proper form and format to satisfy the proper quality assurance requirements and record storage requirements. In addition, adequate documentation shall also be provided that:

- Supports the acceptable design of the DOE SNF canisters and is to be certified by a qualified professional engineer (the Design Report and Design Drawings)
- Permits an independent review of all design procedures and calculations
- Identifies all software used in the design process
- Indicates appropriate validation and verification documentation of all software used for the design calculations
- Indicates the involved design personnel have the experience, education, training, and proficiency commensurate with the minimum requirements established
- Is legible and in a form suitable for reproduction, filing, and retrieval.

Additional documentation requirements (including the detailed and specific requirements associated with the testing of computer software) can be located in the quality assurance requirements that are applicable. All additional evaluations requested by this design specification shall also be included in the documentation.

4. DOCUMENT REVISION HISTORY

Revision	Description	Effective Date
0	New Document	08/19/98
1	Clarification and detail changes to meet current ASME standards. Removal of references to the OCRWM Quality Assurance Requirements and Description for civilian Radioactive Waste Management Program (DOE/RW-0333P)	11/23/98
2	Changes to reflect that the ASME Code is to be changed rather than a Code Case issued. Clarification that in order to achieve 100-year design life, canister must be protected from adverse environmental conditions that could reduce wall thickness beyond indicated limit. Terminology clarification that final butt weld is the final closure weld. Appendix A drawings also changed. Other minor editorial changes and corrections.	07/15/99
3	To provide better visible clarifications with "ballooned clouds" of past revisions on the drawings in Volume I of this document. This change clarifies the welding symbols and the changes made from Revision 1 to Revision 4 of the drawings. Clarifications will provide easier fabrication and quality inspection of the canisters. No text changes other than revision number, date and Document Revision History section were made to either Volume I or Volume II documents from Revision 2.	08/17/99

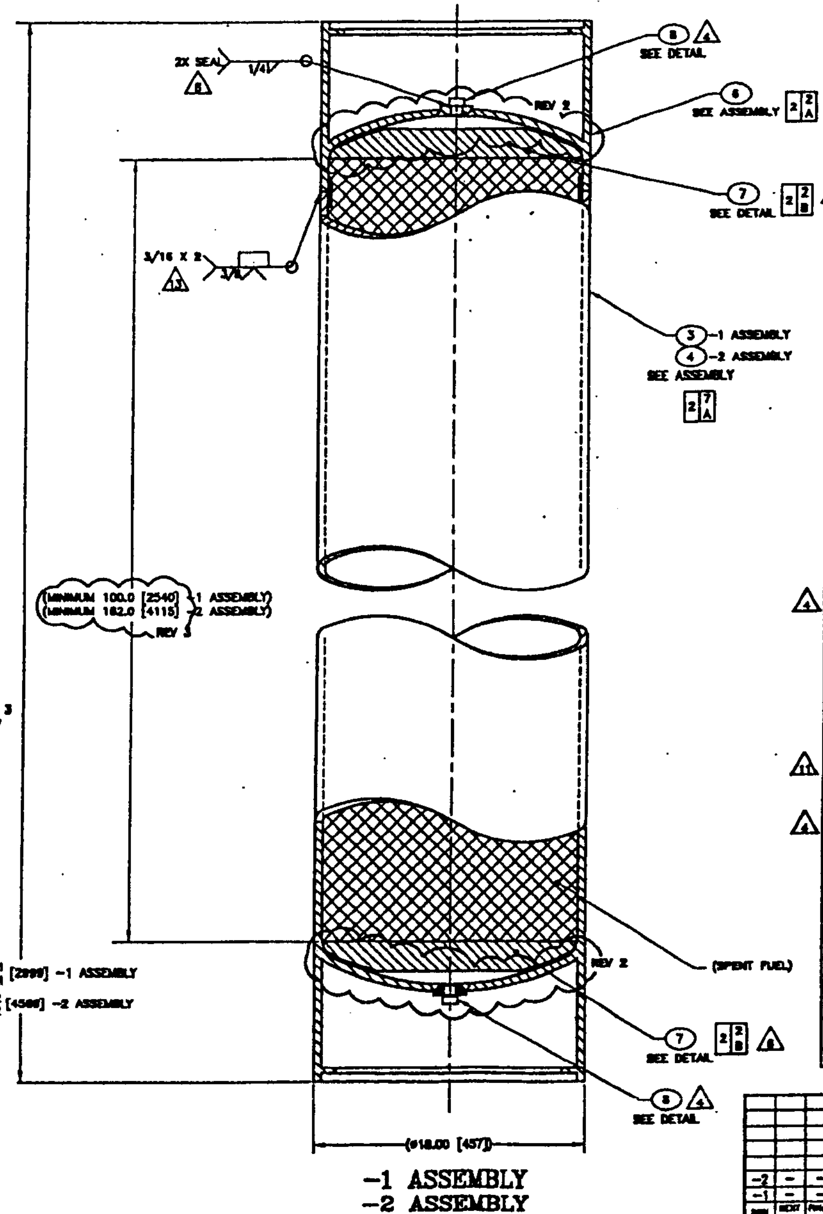
Appendix A

Canister Design Drawings

[Note: The English dimensions are exact. Metric equivalents are approximated.]

NOTES:

1. REMOVE ALL BURRS, SHARP EDGES AND WELD SLAG. EDGES TO BE BROKEN TO R.02 (.5 MM) MAX UNLESS OTHERWISE NOTED.
2. ALL FABRICATION, MATERIALS, TESTING AND EXAMINATIONS SHALL MEET THE REQUIREMENTS OF THE ASME BOILER AND PRESSURE VESSEL CODE, SECTION III, DIVISION 3, SUBSECTIONS WA AND WB. VOLUMETRIC WELD EXAMINATIONS FOR THE FULL PENETRATION WELDS ATTACHING THE PLUG THREAD PLATES TO THE HEADS AND THE HEADS (-5 OR -6 ASSEMBLIES) TO THE MAIN BODY SHALL BE PERFORMED. ALL OTHER WELDS SHALL BE LIQUID PENETRANT EXAMINED. REV 2
3. LABEL CANISTER PER SECTION 3.2.15 OF THE PRELIMINARY DESIGN SPECIFICATION.
4. ACCESS/DRAIN PORTS, PLUGS, PLUG THREAD PLATES, AND SIDE SLOTS ARE OPTIONAL.
5. CANISTERS SHALL NOT BE PRESSURE TESTED.
6. IMPACT PLATES SHOWN IN POSITION WITH SPENT FUEL AND OTHER INTERNALS (BASKETS, SPACERS, SLEEVES, ETC.) LOADED. IMPACT PLATES ARE NOT INTEGRALLY ATTACHED TO THE CANISTER. IMPACT PLATES ARE PART OF THE INTERNALS.
7. CANISTER SHALL BE CODE STAMPED WITH 316L SST NAMEPLATE AFFIXED (TACK WELDED) TO THE OUTER SURFACE OF ITEM 10 OF -6 ASSEMBLY BUT NOT ON THE STRAIGHT FLANGE SECTION.
8. SEAL WELDS SHALL NOT LEAVE ANY THREADS VISIBLE.
9. REMOVED REV 2
10. DIMENSIONS IN BRACKETS ARE APPROXIMATE METRIC (MM) EQUIVALENTS.
11. ORDERING DATA FOR ASME CODE FLANGED AND DISHED HEADS:
    MATERIAL: 316L SA 240 REV 2
    THICKNESS = NOMINAL 3/8" THICK
    KNUCKLE (INSIDE CORNER) RADIUS = 1 1/8" ± 3/16" REV 3
    INSIDE CROWN (DISH) RADIUS = 18" ± 1/4"
    OUTER DIAMETER = 18" ± 1/8"
    STRAIGHT FLANGE = 2"
    OVERALL HEIGHT = 5.25" ± 0.030" (THIS DIMENSION TO TAKE PRIORITY OVER THE STRAIGHT FLANGE DIMENSION)
    EDGE PREPARATION: PREPARE EDGE FOR BUTT WELD TO MATCH NOMINAL 18" PIPE WALL THICKNESS AS REQUIRED TO SATISFY NOTE 2. REV 2
    STRAIGHT FLANGE: THE INSIDE SURFACE OF THE STRAIGHT FLANGE SHALL BE FINISHED SUCH THAT THE FLANGE IS ABLE TO ACCEPT THE BACKING RING (ITEM 12) FLUSH AGAINST THE INSIDE SURFACE OF THE STRAIGHT FLANGE. REV 3
12. THE LIFTING RING SHALL BE INSTALLED AND EXAMINED PRIOR TO PIPE (ITEM 13) ON -5 AND -6 ASSEMBLIES BEING WELDED TO THE HEAD (ITEM 10). REV 2
13. FINAL CANISTER WELD. THIS WELD IS MADE AFTER THE SPENT NUCLEAR FUEL IS LOADED INTO THE CANISTER AND SHALL BE ULTRASONICALLY (UT) AND LIQUID PENETRANT TEST (LPT) EXAMINED. THE AS-WELDED CONDITION (THE CROWN) SHALL NOT EXCEED THE LIMITS OF SECTION III, DIVISION 3, WB-4426.1.
14. WELD PREPARATION DETAILS INDICATED ON THIS DRAWING ARE NOT MANDATORY FOR ASME CODE FABRICATION OF THE N-STAMPED VESSELS. INDICATED WELD PREPARATION DETAILS WERE USED FOR DEVELOPMENTAL TEST CANISTERS ONLY. REV 2
15. DRAWING IS TO 1/4 SCALE WHEN DRAWING SIZE IS 22" X 34".
16. DUE TO CONCERNS OF DISTORTION DURING WELDING, DO NOT THREAD THE PLUG THREAD PLATE HOLE UNTIL AFTER THE PLUG THREAD PLATE IS WELDED TO THE HEAD.
17. WELD REINFORCEMENT TO BE REMOVED (VIA MACHINING, GRINDING, OR OTHER APPROPRIATE METHOD) EXCEPT AT THE LIFTING RING (ITEM 11) AND THE PIPE (ITEM 13) JUNCTION WHERE A 1/16 TO 1/8-INCH RADIUS IS REQUIRED FOR BOTH THE TOP AND BOTTOM SURFACES OF THE LIFTING RING. RESULTING SURFACES SHALL BE FLAT TO MATCH THE ADJACENT SURFACE OF THE LIFTING RING. REV 3
18. A FLAT LIFTING RING BOTTOM SURFACE IS NECESSARY FOR PROPER LIFTING FIXTURE ENGAGEMENT WHILE A FLAT LIFTING RING TOP SURFACE IS NECESSARY FOR CANISTER LABELING, AS PER NOTE 2.



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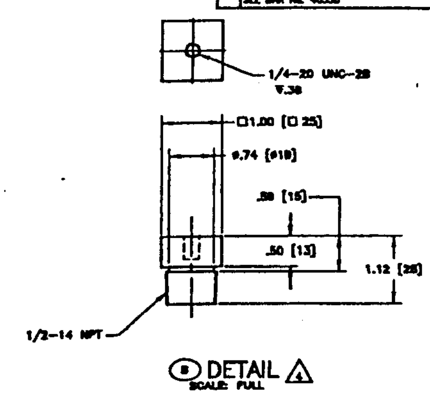

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REV	4	4

REV STATUS OF SHEETS

REVISIONS

REV	DESCRIPTION	EFFECTIVE DATE
1	SEE DAR No. 16310	11-23-98
2	SEE DAR No. 16312	6/8/99
3	SEE DAR No. 19588	6/28/99
4	ADDED BALLOONS FOR REVISIONS 2 AND 3. SEE DAR No. 40530	8/16/99

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AR	AR	AR	AR	AR	AR	2		WELD FILLER METAL	ER 316L ASME SFA A5.9	14
AR	AR	AR	AR			2			PIPE, 18 SCH 5S (.375 WALL) WELDED OR SEAMLESS 316L SST ASME SA312	13
1						2	-12	BACKING RING	3/16" PLATE 316L SST ASME SA240	12
1	1					2	-11	LIFTING RING	1/2" PLATE 316L SST ASME SA240	11
1	1					2	-10	HEAD		10
								REMOVED		9
				2	2	2	-8	PLUG	BAR 316L SST ASME SA479	8
				2	2	2	-7	IMPACT PLATE	2" PLATE, CS ASME SA36	7
				1	1	2	-6	ASSEMBLY		6
		1	1			2	-5	ASSEMBLY		5
				1		2	-4	ASSEMBLY		4
					1	2	-3	ASSEMBLY		3
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						2	-1	ASSEMBLY		1

QTY REQD

PARTS LIST

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-1	-	-	FINAL	
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APPLICATION

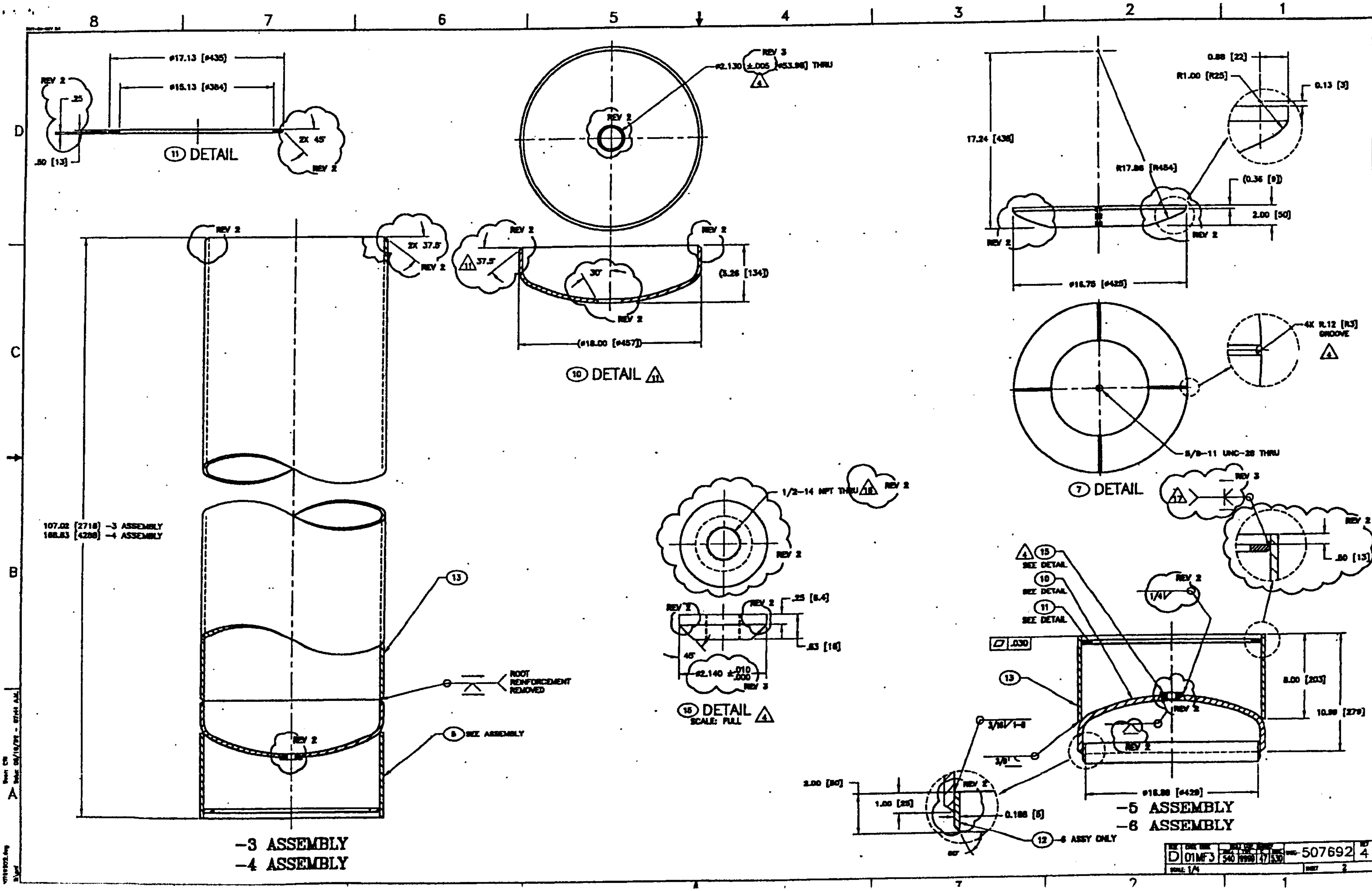
DRAWN: R. L. SMITH
CHECK: D. E. NORTON
DATE: 8/12/98

LOCKHEED MARTIN

18 INCH O.D. DOE STANDARDIZED SPENT NUCLEAR FUEL CANISTERS

SIZE D | 01MF3 | DWG NO. 507692 | REV 4

SCALE 1/4 & NOTED | SHEET 1 OF 2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-6 ASSEMBLY
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4
SCALE: 1/4
SHEET 2

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    INSIDE CROWN (DISH) RADIUS = 24" ± 1/4" REV 3
    OUTER DIAMETER = 24" ± 1/8"
    STRAIGHT FLANGE = 2"
    OVERALL HEIGHT = 6.340" ± 0.030" (THIS DIMENSION TO TAKE PRIORITY OVER THE STRAIGHT FLANGE DIMENSION)
    EDGE PREPARATION: PREPARE EDGE FOR BUTT WELD TO MATCH NOMINAL 24" PIPE WALL THICKNESS AS REQUIRED TO SATISFY NOTE 2. REV 2
    STRAIGHT FLANGE: THE INSIDE SURFACE OF THE STRAIGHT FLANGE SHALL BE FINISHED SUCH THAT THE FLANGE IS ABLE TO ACCEPT THE BACKING RING (ITEM 12) FLUSH AGAINST THE INSIDE SURFACE OF THE STRAIGHT FLANGE. REV 3
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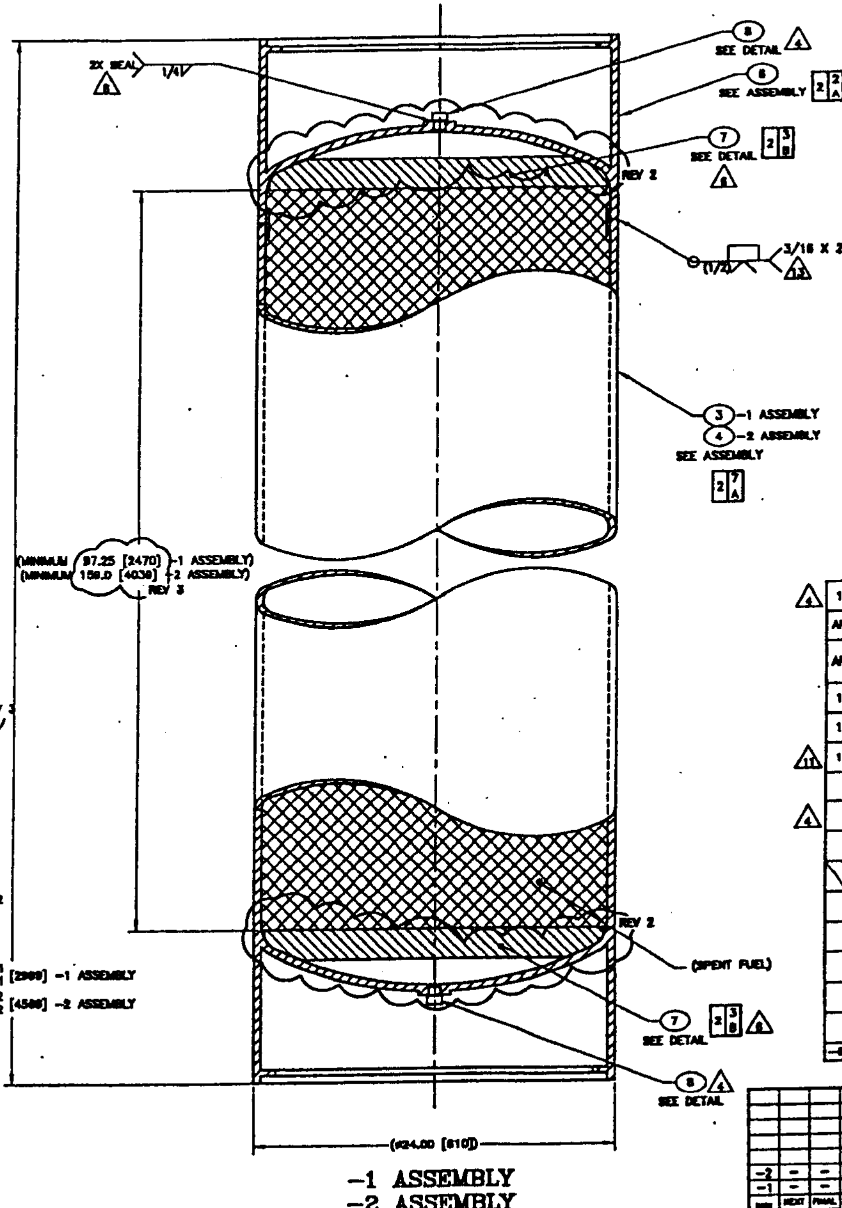

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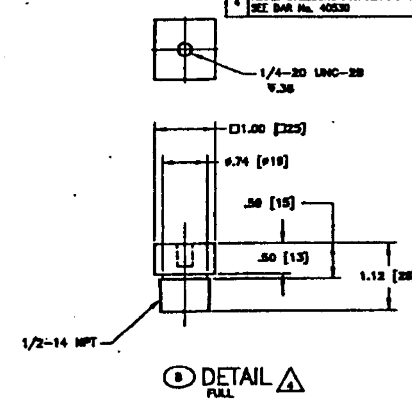

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AR	AR	AR	AR	AR	AR	2		WELD FILLER METAL	ER 316L ASME SFA A5.9	14
AR	AR	AR	AR			2			PIPE, 24 SCH X STRONG (.50 WALL) WELDED OR SEAMLESS 316L SST ASME SA312	13
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1	1					2	-11	LIFTING RING	1/2" PLATE 316L SST ASME SA240	11
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				2	2	2	-8	PLUG	BAR 316L SST ASME SA479	8
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				1		2	-4	ASSEMBLY		4
					1	2	-3	ASSEMBLY		3
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						2	-1	ASSEMBLY		1
-6	-5	-4	-3	-2	-1	QUAL. LEVEL	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	MATERIAL/SPECIFICATION OR VENDOR NAME	ITEM NO.

PARTS LIST

REVISIONS

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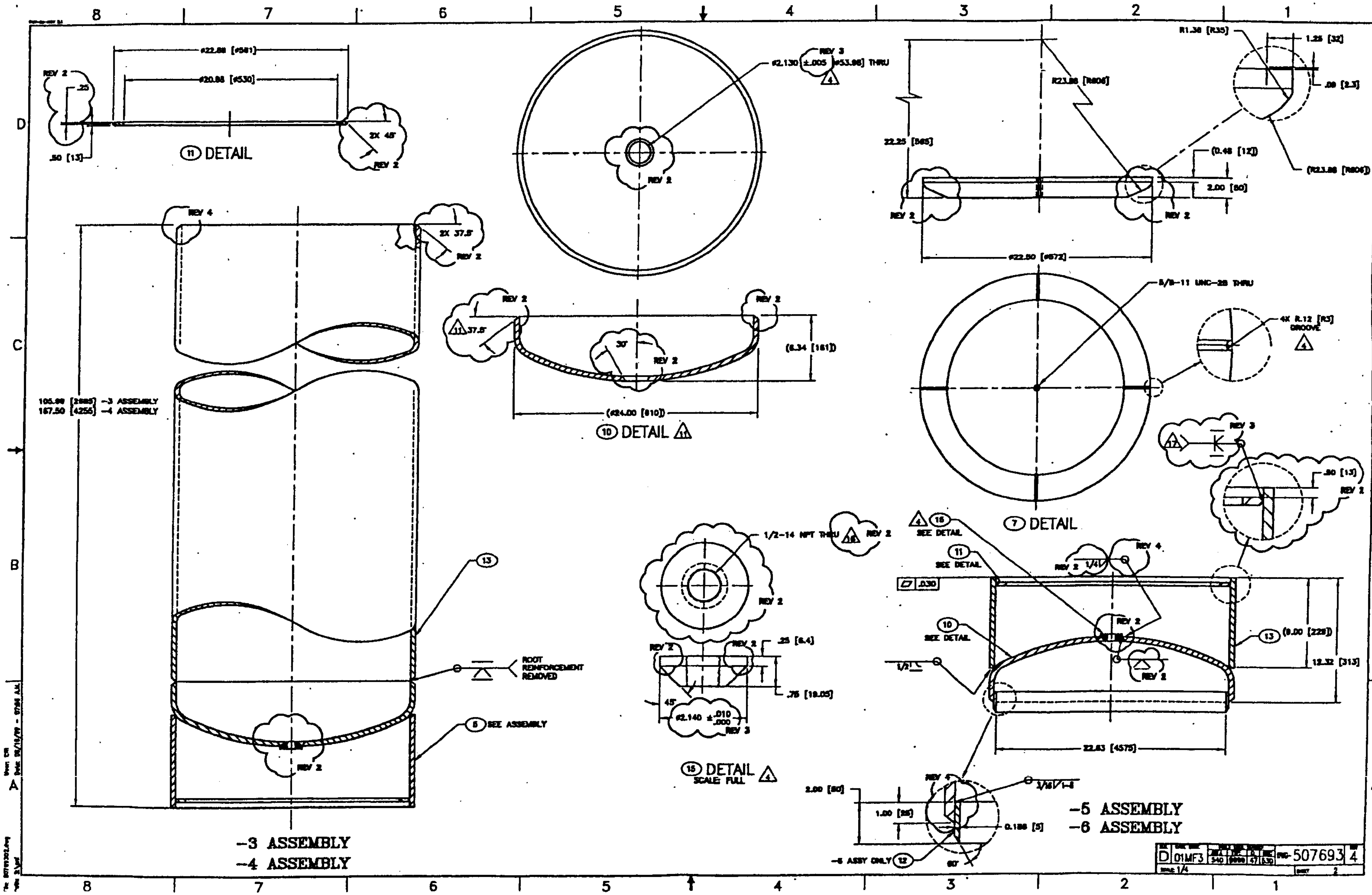
2	SEE DAR No. 10312	6/9/99
3	SEE DAR No. 10380	6/28/99
4	ADDED BALLOONS FOR REVISIONS 2 AND 3. SEE DAR No. 40530	8/16/99

LOCKHEED MARTIN

24 INCH O.D. DOE STANDARDIZED SPENT NUCLEAR FUEL CANISTERS

D 01MF3 DWG 507693 REV 4 SCALE 1/4 & NOTED SHEET 1 OF 2

ORIGINATOR R L SMITH
DRAWN D K MORTON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ROOT REINFORCEMENT REMOVED
5/8-11 UNC-2B THRU
1/2-14 NPT THRU
4X R.12 [R3] GROOVE
SEE DETAIL
SEE ASSEMBLY
-6 ASSY ONLY
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SCALE 1/4

DOE/SNF/REP-011
Revision 3

United States Department of Energy

National Spent Nuclear Fuel Program

Preliminary Design Specification for Department of Energy Standardized Spent Nuclear Fuel Canisters

Volume II – Rationale Document

August 17, 1999

U.S. Department of Energy
Assistant Secretary for Environmental Management
Office of Spent Fuel Management and Special Project

DOE/SNF/REP-011
REVISION 3

Preliminary Design Specification for Department of Energy Standardized Spent Nuclear Fuel Canisters

Volume II – Rationale Document

Idaho National Engineering and Environmental Laboratory
Lockheed Martin Idaho Technologies Company
Idaho Falls, Idaho 83415

Revision 3
August 17, 1999

Document Preparer: D. K. Morton	Date: 8/17/99
Manager, NSNF Program Support: [signature]	Date: 8-17-99
NSNF QAPM: [signature]	Date: 8/17/99
NSNF Program Manager: Mark R. Arenaz	Date: 17 Aug 99

Prepared for the
U.S. Department of Energy
Assistant Secretary for Environmental Management
Under DOE Idaho Operations Office
Contract No. DE-AC07-94ID13223

ABSTRACT

This document (Volume II) is a companion document to a preliminary design specification for the design of canisters to be used during the handling, storage, transportation, and repository disposal of Department of Energy (DOE) spent nuclear fuel (SNF). This document contains no procurement information, such as the number of canisters to be fabricated, explicit timeframes for deliverables, etc. However, this rationale document does provide background information and design philosophy in order to help engineers better understand the established design criteria (contained in Volume I respectively) necessary to correctly design and fabricate these DOE SNF canisters.

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ACKNOWLEDGMENTS

The author of this document would especially like to acknowledge the following personnel who provided information and support during the development of this design specification: R. K. Blandford, J. A. Dearien Jr., W. L. Hurt, H. H. Loo, T. E. Rahl, N. L. Smith, S. D. Snow, P. D. Wheatley, and A. G. Ware.

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CONTENTS

FIGURES

TABLES

ACRONYMS, ABBREVIATIONS, AND DEFINITIONS

ANS	American Nuclear Society
ANSI	American National Standards Institute
ASME	American Society of Mechanical Engineers
B&PV	Boiler and Pressure Vessel
can	a smaller structure surrounding SNF or other highly radioactive components that can be placed into a canister
canister	a large structure (approximately 18 to 24-inch diameter) surrounding SNF or other highly radioactive components (bare or in cans) that facilitates handling, storage, transportation, and/or disposal and can be placed into a disposal container or cask
cask	a structure used for the transportation or storage of SNF and/or HLW comprised of components intended to provide radiation shielding and retention of spent nuclear fuel and radioactive material contents during storage or transportation that meets all applicable regulatory requirements
CFR	Code of Federal Regulations
confinement	retention of a material within an area from which releases or leakage are permitted but controlled, and leakage of other substances into the area may also occur
containment	the complete and absolute retention of any substance within a closed area and no other substance may gain access inside the closed area
CRWMS	Civilian Radioactive Waste Management System
damaged SNF	SNF with cladding defects greater than hairline cracks or pinhole leaks (per Draft NUREG-1617)
DIS	Disposability Interface Specification (CRWMS Document B00000000-01717-4600-00108, Rev 00) (Draft)
disposal container	the container in which the DOE SNF canisters are to be placed at the geologic repository for disposal, prior to acceptance of the final barrier weld, at which time the disposal container becomes a waste package
DOE	Department of Energy
DOT	Department of Transportation
EM	Office of Environmental Management (DOE)
failed SNF	SNF with hairline cracks or pinhole leaks in the cladding (as defined for this document only)

FRR	foreign research reactors
HEPA	high efficiency particulate air
HEU	highly enriched uranium
HLW	high-level radioactive waste means (1) the highly radioactive material resulting from the reprocessing of spent nuclear fuel and (2) other highly radioactive material that the NRC determines by rule requires permanent isolation
ICD	Interface Control Document (OCRWMS Document DOE/RW-0511, Rev 0,)
intact SNF	SNF with no hairline cracks or pinhole leaks in the cladding (as defined for this document only)
INEEL	Idaho National Engineering and Environmental Laboratory
internals	items (baskets, spacers, sleeves, dividers, cans, etc.) placed inside the DOE SNF canister along with the SNF for supporting and positioning the SNF and to also prevent criticality if necessary
ISFSI	independent spent fuel storage installation
LMITCO	Lockheed Martin Idaho Technologies Company
MGDS	Mined Geologic Disposal System
MNIP	Maximum Normal In-plant Handling Pressure (Section III, Division 3 definition)
MNOP	Maximum Normal Operating Pressure (Section III, Division 3 definition)
MRS	monitored retrieval storage
NRC	Nuclear Regulatory Commission
NSNFP	National Spent Nuclear Fuel Program
NWPA	Nuclear Waste Policy Act of 1982
NWPAA	Nuclear Waste Policy Amendments Act of 1987
OCRWM	Office of Civilian Radioactive Waste Management (DOE)
OD	outer diameter
package	the packaging together with its radioactive contents as presented for transport
packaging	assembly of components necessary to ensure compliance with the requirements of 10 CFR Part 71
psig	pounds per square inch gage pressure

QA	quality assurance
QAPM	quality assurance program manager
repository	synonymous with geologic repository, a system that is intended to be used for the disposal of radioactive wastes in excavated geologic media
RT	radiographic test
SNF	spent nuclear fuel is fuel that has been withdrawn from a nuclear reactor following irradiation, the constituent elements of which have not been separated by reprocessing
SRS	Savannah River Site
SST	stainless steel
SHIC	standard high integrity can
storage industry canister	large outer container (approximately 5 or 6 feet in diameter) used in storage of SNF
U.S.	United States
USNRC	United States Nuclear Regulatory Commission
UT	ultrasonic testing
waste package	the name of the disposal container after the final barrier weld is accepted (formal definition in 10 CFR Part 60.2)

Preliminary Design Specification for Department of Energy Standardized Spent Nuclear Fuel Canisters

Volume II – Rationale Document

1. INTRODUCTION

The Department of Energy's National Spent Nuclear Fuel Program (NSNFP) is working with the Department's Office of Civilian Radioactive Waste Management (OCRWM), the Idaho National Engineering and Environmental Laboratory (INEEL), Hanford, Oak Ridge National Laboratory, Argonne National Laboratory, and the Savannah River Site (SRS) to develop a set of standard canisters for handling, interim storage, transportation, and disposal in the national repository of Department of Energy (DOE) spent nuclear fuel (SNF). This resulting preliminary specification is written in two volumes. Volume I contains design parameters for the standardized SNF canisters. Volume II provides background information and associated reasons for specifying certain design parameters for these standard canisters.

1.1 Background

The *Nuclear Waste Policy Act of 1982* (NWPA) assigned DOE the responsibility for managing the disposal of SNF and high-level waste (HLW) of domestic origin. The OCRWM is responsible for SNF and HLW disposal, including the development and licensing of a geologic repository. The process and the schedule for this program were specified initially in the NWPA. Additionally, a Presidential Memorandum dated April 30, 1985, stated that there was no compelling reason to build a separate repository for defense HLW; therefore, that waste will also be emplaced in the civilian geologic repository mandated by the NWPA. In the *Nuclear Waste Policy Amendments Act* (1987) (NWPAA), Yucca Mountain, Nevada, was designated for characterization as the candidate site for a geologic repository.

The NWPA defines SNF as the fuel that has been withdrawn from a nuclear reactor following irradiation, the constituent elements of which have not been separated by reprocessing. As used in the design specification, SNF is also defined to include nonfuel components as identified in 10 CFR Part 961, Appendix E. In the NWPA, HLW is defined as the highly radioactive material resulting from reprocessing SNF, including liquid waste produced directly in reprocessing, any solid material derived from such liquid waste that contains fission products in sufficient concentrations, and other highly radioactive material that has been determined by the U.S. Nuclear Regulatory Commission (USNRC or NRC), consistent with law, to require permanent isolation. As used in the design specification, HLW is defined to include solidified HLW resulting from commercial and defense operations. Note that the 10 CFR Part 60 definition of HLW includes SNF. The repository will accept SNF and solidified HLW.

In the NWPA, Congress identified that storage of SNF in monitored retrievable storage (MRS) facilities is a safe and reliable option for managing SNF. In the NWPAA, Congress authorized the Secretary of Energy to site, construct, and operate one MRS facility. As stated in 10 CFR Part 72, the MRS will have an initial 40-year license term with the option for renewal by the NRC. The MRS, if it is built, will provide temporary storage of SNF until the SNF is shipped to the Mined Geologic Disposal System (MGDS) geologic repository for permanent disposal. Additionally, SNF can pass through or flow through the MRS to the MGDS. HLW will be shipped from the producer sites directly to the MGDS.

The Office of Environmental Management (EM) at DOE is responsible for the interim management and preparation for disposal of the DOE SNF. The latter primarily includes SNF generated within DOE's nuclear materials (including nuclear weapons materials) and research programs. EM's Office of Spent Fuel Management (EM-67) establishes the methods to be employed in the treatment, handling, storage, and preparation for disposal of the DOE SNF, including both current inventory and expected receipts. The NSNFP, operating from the INEEL, assists EM-67 in implementing these methods. The mission of the DOE Spent Fuel Program is to safely, reliably, and efficiently manage the DOE-owned SNF and SNF returned to the U.S. from foreign research reactors (FRR) and to prepare it for disposal.

1.2 Objective

The objective of this specification is to provide the requirements and necessary information to design the standardized canisters to be used for handling, interim storage, transportation, and disposal in the national repository of DOE SNF. This design specification addresses two different outer diameter (OD) sizes of DOE SNF standardized canisters, including two different lengths for each canister OD, resulting in a total of four unique canister geometries. This design specification does not consider using these DOE SNF canisters for either U.S. Navy or commercial SNF or HLW (either commercial or defense) materials. This design specification does not provide any procurement-specific information.

Although using the same terminology, the standardized DOE SNF canister must not be confused with the containers used in current interim SNF storage systems for commercial spent nuclear fuels. Many independent spent fuel storage installation (ISFSI) or dry storage system vendors also call their SNF container a canister. However, the commercial nuclear industry storage canister (hereafter referred to as the storage industry canister) is typically 5 to 6 feet in diameter. The DOE SNF canisters are approximately 1.5 to 2 feet in diameter.

1.3 Standardized Canister Design Approach

According to the Foreword in ANSI/ANS-57.9-1992, "...the safe storage of spent fuel assemblies is achieved by maintaining a minimum of two independent barriers between the fuel and the environs. The fuel cladding is considered the primary barrier for undamaged fuel. ...In addition, the complete confinement system for the stored fuel is conservatively designed to withstand damaging events... so that there is an effective secondary barrier(s) to the release of radioactive materials under all credible conditions." The storage industry canister is intended to provide the secondary barrier for the commercial SNF. The DOE SNF canisters are intended to provide the primary barrier (cladding replacement) for damaged DOE SNF during interim storage and transportation to the repository. Intact, failed, and damaged DOE SNF can be placed directly into the standardized DOE SNF canisters.

Although details regarding SNF loading, interim storage, and transportation are not yet finalized, the NSNFP is establishing a design for the DOE SNF canisters. The approach taken by the NSNFP is to specify a design[a] for the DOE SNF canister. This design must be robust. Robust is defined herein to mean a design that has significant safety margins for the known loads and safety margins for the loads that have been estimated.

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a. The mention of any specific products and/or manufacturers in this document implies neither endorsement or preference, nor disapproval by the U. S. Government, any of its agencies, or LMITCO, of the use of a specific product for any purpose.

Table 1.1. Design requirements matrix for DOE SNF canisters.

Requirement	Subject	Rationale Document Section
Code of Federal Regulations		
10 CFR Part 60.131 (h)	Criticality control	4.11
10 CFR Part 60.135 (a) (1)	In situ chemical, physical, and nuclear properties do not compromise function of waste package	4.7.2
10 CFR Part 60.135 (a) (2)	Design considerations for waste package and content interactions	4.7.2
10 CFR Part 60.135 (b) (1)	Waste package and its components shall not contain explosive, pyrophoric, or chemically reactive materials	4.8
10 CFR Part 60.135 (c) (1)	DOE SNF shall be in solid form and placed in sealed containers	4.9
10 CFR Part 71.63 (b)	Double containment of certain SNF	4.2 & 4.5
10 CFR Part 72.122 (h) (1) & (5)	Confinement of SNF	4.2.& 4.5
10 CFR Part 72.122 (1)	Retrievability from storage	4.1.2
10 CFR Part 72.124	Criticality control	4.11
10 CFR Part 72.128 (a) (3)	Confinement during storage	4.2 & 4.5
DOE OCRWM Documents		
Disposability Interface Specification – July 1998 (Draft)		
Disposability Standard 2.1.20	Canister shell and lid materials shall be low-carbon austenitic stainless steel or stabilized austenitic stainless steel or other equally corrosion-resistant alloys	4.7.2
Disposability Standard 2.1.21	Canisters shall be vacuum dried, backfilled with an inert gas (e.g., helium) and sealed	4.9
Disposability Standard 2.1.26	Canisters shall have a unique alphanumeric identifier	4.15.2
Disposability Standard 2.1.27	Canisters not seal-welded shall have a tamper-indicating device	4.15.1
Disposability Standard 2.1.28	Damage or deformation to canisters shall be limited such that the canisters can (1) still be lifted and moved, (2) continue to meet the dimensional envelope required for disposal (loading into the disposal container), and (3) maintain a seal	4.3
Disposability Standard 2.2.20.3	Canisters shall have the capability to stand upright without support on a flat surface and be capable of being placed, without forcing, into a right-circular cylindrical cavity of the proper dimension	4.7.1

Table 1.1. Design requirements matrix for DOE SNF canisters. (Continued).

Disposability Standard 2.2.21.3	Canisters shall not exceed the total weight limits as specified (DIS conflicts with ICD values but ICD values are used)	4.8
Disposability Standard 2.2.22.2	Canisters shall be capable of being lifted vertically with remote handling fixtures	4.12.1
Disposability Standard 2.3.22	Canistered SNF shall be shown to have a calculated k_{eff} of 0.95 or less	4.11
Disposability Standard 2.4.21	Canisters shall comply with thermal output limits [currently vague on DOE SNF canisters]	4.12.3
Disposability Standard 2.4.22	Canisters shall comply with surface contamination limits	4.7.2
Disposability Standard 2.4.23	Canisters shall not exceed pressure limits	4.12.2
Disposability Standard 2.4.24	Canisters shall have no detectable leak rate at the time of receipt at the repository. At a minimum, the canister shall be leak tested using OCRWM-approved method or shown via an OCRWM-approved method of fabrication controls and volumetric inspections to be properly sealed. The canister shall be reevaluated prior to shipment, as required, if suspected of leaking.	4.9
Interface Control Document – March 1999		
ICD Section 10.1.1	Canisters are right-circular cylinders and after being filled with SNF can stand vertically on a flat surface	4.7.1
ICD Section 10.1.2	Canisters shall not exceed weight limits	4.8
NUREG-1617 (Draft) – March 1998		
Section 4.5.1.3	Packages designed for the transport of damaged SNF include packaging of the damaged fuel in a separate inner container (second containment system) that meets the requirements of 10 CFR 71.63 (b)	4.5

Table Notes:

Quality assurance (QA) requirements were not specifically addressed in the above table.

2. FUNCTIONAL REQUIREMENTS

2.1 Project Requester and End User

The development of the standardized DOE SNF canisters is guided under the direction of the National Spent Nuclear Fuel Program, as an implementor of the DOE Spent Nuclear Fuel Program. The DOE Spent Fuel Program is the project requestor. The National Program personnel are located at the INEEL administered by the Lockheed Martin Idaho Technologies Company (LMITCO) contract. The end user of the finished canisters will ultimately be the geologic repository program where SNF will be permanently disposed. However, where applicable, the fuel custodians at the DOE sites (Hanford, INEEL, and SRS) will be responsible for loading, handling, and storing DOE SNF in these standardized canisters.

2.2 Purpose of the Standardized Canisters

A standardized canister for DOE-owned SNF has the purpose of (1) providing an easy and standard handleable unit to confine DOE SNF materials, (2) providing durable units for storing SNF, (3) providing easily transportable units, and (4) ultimately, providing a unit for final disposal at the national repository, without the necessity of the DOE SNF being removed from the canister or reopening a sealed canister.

The standardized DOE SNF canisters will provide long term advantages in four basic areas:

Handling and safety:

- Ensure that the DOE SNF is directly handled (bare) only once during its interim storage, transportation, and final disposal handling stages
- Promote standardized handling of materials at all facilities, interim storage sites, and the repository
- Improve human factors and performance efficiency of handling procedures
- Provide contamination control to reduce safety risks
- Reduce radiation exposure and risk to the workers and to the public, by not having to open the canisters for inspection and provide better automated, remote handling possibilities

Storage and disposal:

- Provide standardized storage configurations at the interim storage sites and the repository
- Minimize the number of canisters which must be qualified for interim storage and receipt by the repository

Transportation:

- Promote standard sizing configurations to fit into transportation casks or packagings for better efficiency in packaging design and, consequently, more efficient loading and unloading procedures
- Promote standardized sizes and compatibility for maximum utilization of transportation facilities and equipment

Economics:

- Reduce overall handling, transportation, and repository emplacement costs in a simpler, more integrated operation since fewer modifications will be required for OCRWM to accept DOE SNF, and

- Minimize system costs by reducing the design costs of multiple canister designs.

2.3 General Functional Criteria

Figure 2.1 shows a schematic for the various paths that the current DOE SNF may follow from the point it begins its initial disposal handling until placement into the repository. This basic schematic showing the route SNF can take from initial handling, through interim storage to repository disposal is to be used as a guide in the demonstration of the technical adequacy of the canister design as well as demonstrating the compliance with regulatory requirements. Note that it is possible that some DOE SNF might not utilize the canisters but that is not a certainty at this time. The indicated process guides the general functional criteria of the standardized canisters. These functional criteria are listed below.

- The canisters shall be right circular cylinders.

- Two different diameter-sized canisters shall be designed, with nominal outer diameters of 610 mm (24.00 inches) and 457 mm (18.00 inches), to accept a significant portion of the various DOE SNF currently in existence.

- Two overall lengths for each canister size, 3,000 mm (118.11 inches) and 4,570 mm (179.92 inches), will be considered maximum lengths from end to end inclusive of the cap ends, labeling, and any handling fixtures.

- The 610 mm (24.00 inches) OD canister can be accommodated into a repository waste package as a replacement for one of the HLW canisters, providing a canister for large sized DOE SNF where needed and to also provide a potential overpack option for the 457 mm (18.00 inches) OD canister.

- The 457 mm (18.00 inches) OD canister can be accommodated in the center hole of a five pack waste package at the repository as well as being able to be stored in various facilities at the INEEL, Hanford, or SRS.

- The canisters must perform as required while subjected to the most severely anticipated environmental conditions and natural phenomenon postulated to occur for the entire service life of the canister.

- The design of the standardized canisters shall be robust enough to accommodate the grappling and handling equipment configurations at the interfacing facilities when loaded to the weight limits of the canister.

- Sealing of the canisters shall be accomplished by welding.

- The canisters shall be designed to provide safe storage (in coordination with the storage facility design) of SNF at any location in the continental United States for a minimum of 40 years. The canisters, in coordination with the handling systems, interim storage systems, and transportation systems of many different facilities, as well as the repository disposal system must provide confinement for the SNF under all anticipated normal, off-normal, and accident conditions.

- A safety analysis will need to be performed commensurate with the potential consequences of any activity being performed in conjunction with these canisters.

2.4 Assumptions for Standardized Canister Design

The basic assumptions used for the functional performance of the standardized canister designs for DOE-owned SNF are:

- The standardized canisters shall have an inherently robust design such that they can be readily incorporated into storage and transportation systems meeting 10 CFR Part 72 and 10 CFR Part 71 requirements respectively

- The standardized canisters shall be compatible with the currently known repository requirements

- The design of any internal components such as baskets, spacers, sleeves, dividers, cans, etc., necessary for the loading of the SNF and for the control of criticality must be constrained by the existing design and interior dimensions of the DOE SNF canisters

- Handling facilities will have to accommodate modification to their facilities if these canisters do not fit within the safety envelope of the design criteria for accidental drops and confinement for expected accidental release scenarios

- The SNF custodian shall select those canisters, or combinations of canisters, that provide an optimum packing configuration for the custodian's SNF

- The DOE SNF canisters shall be capable of accepting intact, failed, or damaged SNF, directly or canned

- The loading of DOE SNF into a canister is done in a hot cell or shielded facility so that the fuel can be properly dried and adequate radiation and temperature measurements can be taken to assure compliance with applicable canister design limits. If necessary, the DOE SNF can be initially placed into a canister underwater (drain holes are provided in the canister design) but the fuel and canister must then be properly dried. Final loading and testing would still occur in a hot cell or shielded facility

- The loading of the SNF into a canister will not cause significant localized thermal gradients in the pressure boundary nor will it result in significant bowing concerns for the canister

- After SNF loading and radiation and temperature acceptance, the canisters shall be backfilled with an inert gas (e.g., helium). Canister sealing during storage is optional (depending on the storage system used) but seal-welded canisters (backfilled with an inert gas) are required for transportation and repository disposal

- The amount of added pressurization from the SNF during interim storage and transportation is assumed to be small such that the actual maximum pressure experienced by the canisters during their containment lifetime is less than the repository acceptance pressure of 151.7 kPa (22 psig)

- After loading the canisters with SNF, all canisters will require either remote handling due to a lack of canister shielding or placement into another container or overpack which provides adequate shielding

- Inspections of the SNF after interim storage and prior to transportation to the repository are not anticipated at this time.

The SNF being considered for movement to interim storage, transportation, and final disposal are those listed in the Spent Fuel Database, currently maintained by the NSNFP. The two standardized sized canisters, 457 mm (18.00 inches) and 610 mm (24.00 inches) nominal outer diameter (OD), each with two suggested lengths as listed in the specification, shall provide confinement for the listed DOE SNF, with minimal exceptions for larger sized SNF that may or may not have the ability to be transported as bare SNF in transportation casks. Some SNF or other radioactive materials, such as the particulate waste described in 10 CFR 60.135(c)(2), may require an interior sealed container such as the 5-inch OD (approximately) standard high-integrity can (SHIC) for ease of packaging due to their smaller size, to maintain structural integrity of the SNF or radioactive material, or to reduce the possibility of criticality configurations or other dangerous scenarios and gas generation concerns. The SNF that is placed in the canister will be assumed to be adequately characterized for storage, transportation, and final disposal when sealed into the canister. This information includes radiation shielding, decay heat removal, corrosion, gas generation, criticality control, and other parameters necessary for adequate safety.

2.5 Requirements Documentation

The basic design must conform to the applicable sections of these higher-level documents and organization specific criteria (as indicated in the preliminary design specification, Volume I of this document):

- Requirements from the Code of Federal Regulations (CFR) Title 10, Parts 60, 71, and 72
- Nuclear Regulatory Commission (NRC) requirements for interim storage and transportation to the repository
- Department of Transportation (DOT) requirements for transportation to the repository
- Department of Energy-OCRWM requirements for transportation, handling, and disposal at the repository.

2.6 Necessary Analyses

2.6.1 Design

A design analysis shall be required to clearly demonstrate compliance with the specified design criteria. The Design Report, certified by a competent and qualified professional engineer associated with an N-stamp holder, must be submitted by the designer of the DOE SNF canisters.

2.6.2 Safety

A safety analysis shall be required commensurate with the potential consequences of any activity being performed in conjunction with the use of the DOE SNF canisters. This safety analysis must be performed by those SNF custodians using the DOE SNF canisters.

2.6.3 Performance

SNF dimensions and composition must be characterized for interim storage, transportation, and disposal requirements, including radiation shielding, decay heat removal and criticality control. The DOE SNF must be characterized for repository disposal performance assessment in support of licensing requirements which have not yet been finalized.

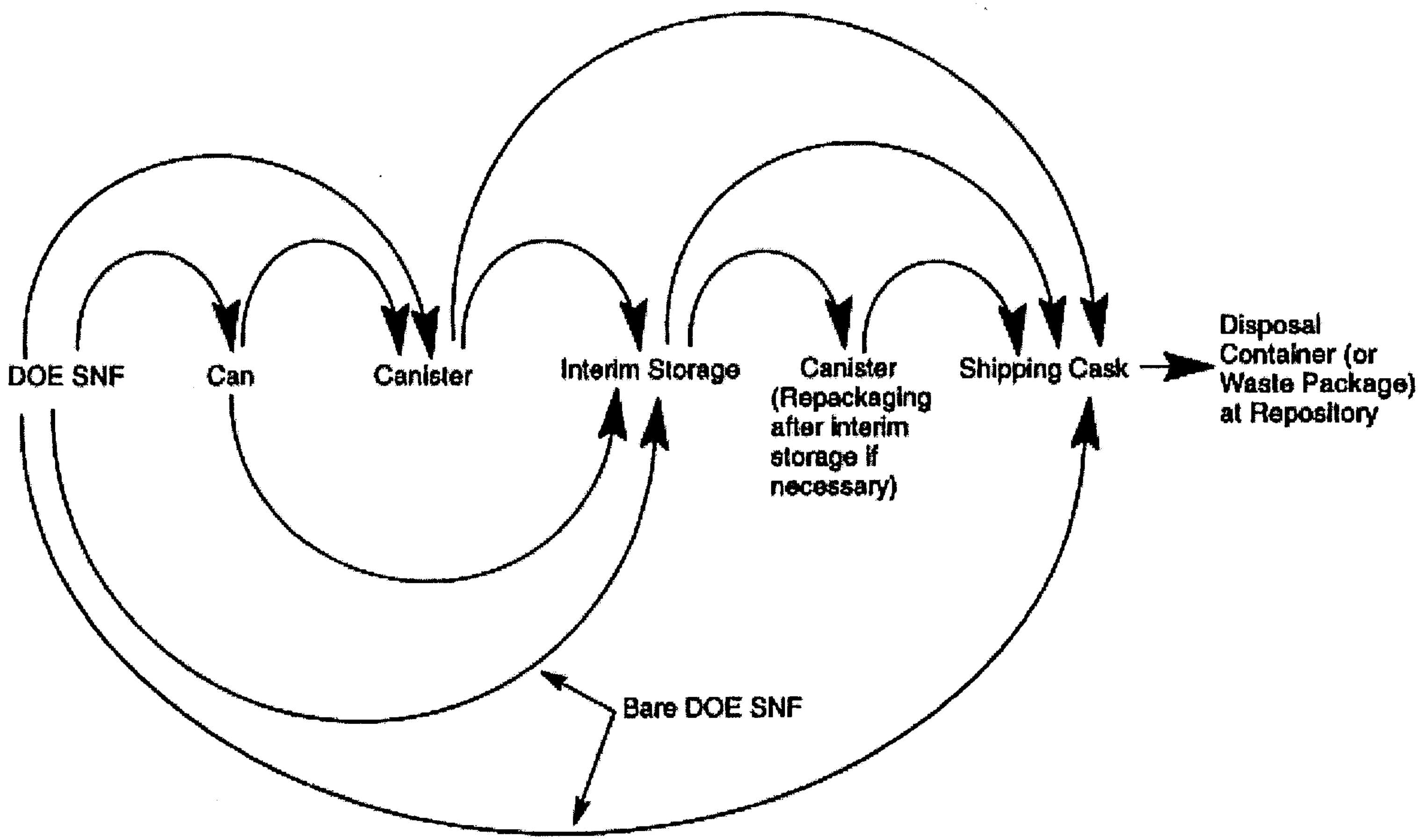


Figure 2.1. Possible DOE SNF paths to repository disposal.

3. REFERENCES

Federal Laws:

A. 42 USC 10101 et seq — Nuclear Waste Policy Act

Federal Regulations:

A. 10 CFR Part 60, January 1, 1998 Edition — Disposal of High-Level Radioactive Waste in Geologic Repositories

B. 10 CFR Part 71, January 1, 1998 Edition — Packaging and Transportation of Radioactive Material

C. 10 CFR Part 72, January 1, 1998 Edition — Licensing Requirements for the Independent Storage of Spent Nuclear Fuel and High-Level Radioactive Waste

DOE RW Documents:

A. B00000000-01717-4600-00108, Rev 01, Draft B, July 1998 — CRWMS Mined Geologic Disposal System Draft Disposability Interface Specification (DIS)

B. DOE/RW-0511, Rev 0, March 1999 — OCRWM Integrated Interface Control Document Volume 1 U.S. Departmentof Energy Spent Nuclear Fuel To The Monitored Geologic Repository For Mechanical and Envelope Interfaces (ICD)

NRC Documents:

A. NUREG-1536, January 1997 — Standard Review Plan for Dry Cask Storage Systems

B. NUREG-1567, October 1996 — Standard Review Plan for Spent Fuel Dry Storage Facilities (Draft Report for Comment)

C. NUREG-1617, March 1998 — Standard Review Plan for Transportation Packages for Spent Nuclear Fuel (Draft Report for Comment)

D. NRC Bulletin 96-04, July 5, 1996 — Chemical, Galvanic, or Other Reactions in Spent Fuel Storage and Transportation Casks

National Standards:

A.	ANSI/ANS-57.9 1992	Design Criteria for an Independent Spent Fuel Storage Installation (Dry Type)
B.	ANSI N14.5 1987	American National Standard for Radioactive Materials - Leakage Tests on Packages for Shipment
C.	ANSI N14.6 1993	American National Standard for Special Lifting Devices for Shipping Containers Weighing 10,000 Pounds (4500 kg) or More for Nuclear Materials
D.	ASME B&PV Code, Section II, 1995 Edition, 1997 Addenda*	Materials
E.	ASME B&PV Code, Section III, Division 1, Subsection NB, 1989 Edition*	Rules for Construction of Nuclear Power Plant Components Class 1 Components
F.	ASME B&PV Code, Section III, Division 3, 1997 Edition*	Containment Systems and Transport Packagings for Spent Nuclear Fuel and High Level Radioactive Waste
G.	ASME B&PV Code, Section V, 1995 Edition, 1997 Addenda*	Nondestructive Examination
H.	ASME B&PV Code, Section IX, 1995 Edition, 1997 Addenda*	Welding and Brazing Qualifications

* The most current edition of the ASME B&PV Code (approved by the NRC) may be used for design purposes provided the proposed changes described in Section 4.5 have been incorporated.

Other Documents:

A.	Presidential Memo April 30, 1985	Disposal of Defense Waste in a Commercial Repository
B.	INEEL Letter NLS-02-98 March 24, 1998	Meeting Minutes for March 4-5, 1998, Meeting Regarding Possible System Engineering Studies Toward Baselining the Interface Control Document
C.	INEEL EDF AMG-06-98 September 30, 1998	Analytical Evaluation of Preliminary Drop Tests Performed to Develop a Robust and Drop Resistant Design Concept for the Standardized DOE Spent Nuclear Fuel Canister
D.	INEEL letter HUJS-06-98 June 23, 1998	Summary of Materials Selection for the DOE Standardized SNF Canisters
E.	INEEL Letter GLH-02-98 June 18, 1998	Letter Report on DOE-SNF Canister Thermal Analysis
F.	INEEL Letter ELS-09-98 May 26, 1998	Radiation Damage of Canister Materials,

4. COMMENTARY ON THE DESIGN SPECIFICATION FOR THE DOE SNF CANISTERS

This preliminary design specification establishes a common basis for all standardized DOE SNF canisters so that they can be accepted for disposal at the repository. It is recognized that the DOE SNF canister final design must be integrated with the total system design, including storage and transportation requirements. Different groups of DOE SNF canisters may be stored in a variety of facilities and these same groups of DOE SNF canisters may even be transported in a variety of transportation casks.

Each unique group of DOE SNF canisters will require Design Specifications and Design Reports [per the ASME Boiler & Pressure Vessel (B&PV) Code]. The Design Report must establish the design bases and establish the specified uses of the DOE SNF canister. The Design Reports may also have to be updated as necessary when design information changes.

4.1 Canister Use

How the DOE SNF canisters are to be used can obviously affect their design. Many different DOE facilities at locations throughout the U.S. are expected to use these standardized canisters. The preliminary design specification assumes that after the DOE SNF is placed in the canister, their use shall be limited to that indicated in four areas: (1) initial loading and subsequent handling of the canister by itself, (2) interim storage, (3) transportation to the repository, and (4) disposal at the repository. These four use categories are discussed below. Figure 4.1 illustrates the various anticipated uses of the DOE SNF canister.

4.1.1 Initial Loading and Canister Handling

Prior to loading, all canister materials shall be suitably examined and all canister welds necessary for structural integrity of the pressure boundary shall be volumetrically examined, using either radiography (RT) or ultrasonic (UT) methods, to assure weld integrity. During SNF loading, due to the potential high levels of radiation, all final loading operations, sealing, and testing must be performed remotely. Therefore, it is assumed that these activities will be performed while the canisters are inside of a hot cell or shielded facility. After loading the SNF and any necessary internals, the canister top head will be attached. A clamping device (e.g., a dearman clamp) may be necessary to minimize ovalization of the canister shell for proper head fit-up. The top head closure weld (a simple butt weld) will be made using a vessel head that has a backing ring. The backing ring will help with weld fit up and also protect the canister contents during welding. Inspection of the top head weld can be achieved using UT techniques.

Sealing of the DOE SNF canisters may be required for interim storage, depending on the type of storage system utilized. However, if the storage system permits it, the DOE SNF canisters may be sealed after interim storage. Incorporated into the DOE SNF canister design is the option of a threaded plug in the top and bottom head. However, prior to transportation and repository disposal, the DOE SNF canister must be seal-welded closed. The DOE SNF canisters shall be backfilled with an inert cover gas (e.g., helium) inside of the canister at a pressure of 13.8 to 27.6 kPa (2 to 4 psig). The final closure weld shall implement a welding procedure that can be qualified to yield leaktight welds. A leaktight weld shall be considered equal to or better than the required leak rate necessary to satisfy the applicable 10 CFR Parts 71 and 72 requirements. At a minimum, in order to demonstrate compliance with the ASME Code, the DOE SNF canister shall be helium leak tested per the requirements identified in Section V, Article 10, Appendix IV to verify that no leakage is detected that exceeds the rate of 1×10^{-4} std cm^3/sec.

Once loaded with SNF, the DOE SNF canisters will have to be handled (by themselves) a number of times. These operations include, but are not necessarily limited to, preparing the canister for interim storage, preparing the canister for transportation, and preparing for disposal at the repository. All of these handling situations are assumed to be performed within the confines of a facility that has high efficiency particulate air (HEPA) filter capabilities. With this assumption, design requirements associated with accident events are significantly reduced. The consequences of a potential drop accident of a DOE SNF canister (by itself) are that the facility's offsite dose limits must not be exceeded.

With this approach, the DOE SNF canister is not required to satisfy any specific ASME B&PV Code design stress limits for an accidental drop inside of a HEPA-filtered facility. Anytime the canister is outside of a HEPA-filtered facility, it will be inside of another containment vessel (a storage industry canister for interim storage or a transportation cask for transportation to the repository). This no-drop design philosophy for handling scenarios inside of a HEPA-filtered facility is similar to that followed by many SNF storage system vendors for their storage industry canisters at commercial nuclear power plants.

4.1.2 Interim Storage

The DOE SNF canisters are expected to be used for interim storage (in conjunction with an acceptable storage system) at different locations and facilities throughout the U.S. before disposal at the repository. It is assumed that a SNF storage facility, properly designed and licensed per the criteria established in 10 CFR Part 72 will be utilized. It is also assumed that the DOE SNF canisters will be incorporated into those SNF storage systems. However, the specifics of any storage system are not currently known and may actually vary among the various DOE sites. Therefore, the precise details of how the DOE SNF canister is supported within the interim storage system and the associated storage industry canister details are simply not known at this time.

Therefore, for the purposes of this design specification, the SNF storage system must be designed to incorporate the DOE SNF canister into its system. Since the canister is assumed to provide a robust design, it is anticipated that incorporation of the DOE SNF canister into any storage system will not be difficult. Many design considerations, including retrievability, seismic loads, accidental drop loads, and environmental conditions must be adequately addressed by the storage system vendor in order to ensure the proper care and use of these DOE SNF canisters.

A major assumption made regarding the use of the DOE SNF canister in any SNF storage system is that the DOE SNF canister will either stay in the hot cell facility for interim storage purposes or be placed inside of another storage container (either a storage industry canister, storage cask, or combination storage and transportation cask). Typically, this other container will be a containment vessel designed to withstand the anticipated operational and accidental loads identified for the SNF storage system.

4.1.3 Transportation

Since transportation casks have not yet been identified or designed for the DOE SNF canisters, a similar situation exists as it does with the interim storage system. Although the DOE SNF canister is to be placed inside of a licensed transportation cask, the precise details of how the canister is supported within the cask and associated cask details are not known at this time.

Therefore, for the purposes of this design specification, the transportation cask must be designed to incorporate the DOE SNF canister into its system. Since the canister is assumed to provide a robust design, it is anticipated that incorporation of the DOE SNF canister into a transportation cask system is achievable. Many design considerations, including the hypothetical accident conditions of 10 CFR

Part 71.73 must be adequately addressed by the entire transportation system (canister and cask) in order to ensure the proper care and use of these DOE SNF canisters.

4.1.4 Disposal at the Repository

The loaded DOE SNF canisters will be handled (by themselves) at the repository (see Section 4.1.1 above) during the unloading phase from the transportation cask and during the placement of the canister into the repository disposal container (or "waste package" once the final barrier weld is accepted). As mentioned above, all of those activities are assumed to occur within the confines of a HEPA-filtered building. Placing the canisters into the waste package means that the DOE SNF canisters must be able to conform to the material compatibility and criticality issues indicated in 10 CFR Part 60. There are additional canister design requirements for the DOE SNF canister but they are contained in various repository documents and cover allowable materials, pressures, weights, and other miscellaneous criteria including labeling.

However, the DOE SNF canisters are not currently listed on the Q-list for repository equipment. This is an indication that the repository is not currently requiring the canisters to provide any safety function and therefore there are no quality assurance (QA) requirements that need to be imposed on the canister from the position of the repository.

Besides the design requirements for safely lifting and handling the DOE SNF canisters, the repository has indicated that the only remaining requirements imposed on the DOE SNF canisters are those associated with accidental drops or tip-overs of the waste package. Since the canister is assumed to provide a robust design, it is anticipated that incorporation of the DOE SNF canister into the waste package design accidental drop scenarios (2-meter drop and tip-over) should not be a difficult task. Repository personnel have indicated (Reference INEEL letter NLS-02-98) a requirement to remove the DOE SNF canister (not the individual fuel pieces) from a damaged (due to tip-over or drop accident) waste package so that it can be reloaded into another undamaged waste package. Once the waste package has been placed into a drift, repository personnel have indicated that there are no additional design requirements imposed on the DOE SNF canister. This includes any requirements associated with the retrieval of a waste package per 10 CFR Part 60.111(b). The repository is only anticipating the ability to retrieve a waste package, and is not concerned with removing any contents from a waste package during any retrieval efforts.

4.1.5 Other Uses

By definition, intact SNF is fuel with cladding that has no hairline cracks or pinholes. Failed SNF is fuel with cladding that has hairline cracks or pinhole leak defects. Damaged fuel, by definition, is fuel with cladding that has defects greater than hairline cracks or pinhole leaks. The DOE SNF canisters are to be designed to directly accommodate the placement of intact, failed, or damaged SNF inside of the canister. Using this approach, if the DOE SNF degrades during storage or transportation, the canister still satisfies necessary requirements.

The DOE SNF canisters shall not be arbitrarily used for any other purposes beyond those indicated in the design specification without additional detailed analysis, evaluation, and testing in order to assure that other uses do not violate any of the limitations imposed by the design specification. Examples of use not considered herein include placing molten glass or molten HLW in these canisters, dropping the canister onto sharp projectiles, and dropping the canister from heights greater than that considered.

4.2 Canister Barrier Requirements

The foreword of ANSI/ANS-57.9-1992 indicates that "... the safe storage of spent fuel assemblies is achieved by maintaining a minimum of two independent barriers between the fuel and the environs. The fuel cladding is considered the primary barrier for undamaged fuel. ... In addition, the complete confinement system for the stored fuel is conservatively designed to withstand damaging events ... so that there is an effective secondary barrier(s) to the release of radioactive materials under all credible conditions."

This barrier philosophy is also followed with the design of the DOE SNF canister. Since it has been assumed that damaged SNF will be loaded directly into the DOE SNF canister, the DOE SNF canister must perform the function of the cladding as the primary barrier. In this fashion, the storage system outer container (typically the storage industry canister) or the transportation cask will continue to provide the function of the secondary barrier. Redundant sealing is achieved with this design approach. The design specification assumes that the storage or transportation systems do not provide the double barriers themselves.

4.3 Development of a Robust Design for the Canister

Although details regarding SNF loading, interim storage, and transportation are not yet finalized, the NSNFP is establishing a design for the DOE SNF canisters. The approach taken by the NSNFP is to specify a design for the DOE SNF canister. This design must be robust. Robust is defined herein to mean a design that has significant safety margins for the known loads and safety margins for the loads that have been estimated. With this robust design, the NSNFP can proceed with the design and fabrication of the DOE SNF canisters. The specified standardized DOE SNF canister designs for the four unique geometries are shown on the engineering drawings (see Appendix A in Volume I). The storage system vendor and the transportation cask designer must incorporate the specified DOE SNF canister design into their respective system designs.

A canister developed to physically maintain containment (proven by actual testing) after a potential 9-meter (30-foot) drop accident (similar to that required for transportation casks as described in 10 CFR Part 71.73) enhances the robust design concept. It is the capability to maintain containment after a 9-meter (30-foot) drop that truly makes the DOE SNF canister robust. A robust design also minimizes canister deformations and damage that could potentially occur during normal, everyday handling scenarios, as described in the repository requirement Disposability Standard 2.1.28.

A major design concern, accidental drop scenarios should not be a major design problem for the interim storage vendor or the transportation designer. The assumption has been made that the smaller DOE SNF canister will be placed inside of another container (the larger storage industry canister or the transportation cask). The storage industry canisters have already been successfully designed to accommodate their applicable site-specific and system-specific accidental drop or tip-over loads for commercial fuel. Transportation casks must be designed to accommodate 9-meter (30-foot) drops onto an unyielding surface and still be able to remove the SNF contents. Therefore, the DOE SNF canister, being inside of the storage industry canister or transportation cask (and being robust), should present an easier design situation than deforming baskets. At most, impact limiters inside of the storage or transportation systems may be required for certain fuels with special criticality concerns.

The only remaining accidental drop concerns are when the canister is being handled by itself or when it is inside of the waste package at the repository. These anticipated drop scenarios defined to date are a 7.3-meter (24-foot) accidental drop of a DOE SNF canister at the repository while being placed into a disposal container, a 2-meter (6.56-foot) drop of the waste package with the DOE SNF canister inside, and a tip-over of the waste package with the DOE SNF canister inside. These accident events are not listed in the design criteria because the canisters are not to be specifically designed to ASME B&PV Code stress limits for these accident event loads. These accident events are listed in order to provide a clear understanding of the intended use of the canister with regards to potential accidental drop events that have been identified.

There are significant advantages to constructing a DOE SNF canister that has a robust design and is drop resistant. By definition, drop resistant means that the DOE SNF canister can maintain containment during most, if not all, accidental drops from heights less than or equal to 9 meters (30 feet). Since a vast amount of design information is still unknown (e.g., drop surfaces, possible puncture targets, canister internals, etc.), absolute assurances of maintaining containment for all possible drop accidents cannot be provided at this time. By constructing a drop resistant canister, more assurances are provided that the canister can be readily incorporated into storage and transportation systems. These systems must be designed for certain postulated drop accidents in addition to other dynamic events. Also, if a drop accident occurs even in a HEPA-filtered facility, recovery would be much simpler and quicker for a canister that maintains containment of the SNF than if contamination of the facility resulted. It is believed that a severe drop accident resulting in contamination of the repository could shutdown the receiving operations for a significant period of time and the ripple effect from such a shutdown would impose nationwide schedule delays that could cost millions of dollars.

It is virtually impossible to design a usable DOE SNF canister that satisfies ASME B&PV Code, Section III, Subsection NB, Level D or Section III, Division 3, Subsection WB, hypothetical accident condition stress limits for an accidental drop scenario of significant height [greater than 6 meters (20 feet)] without having some form of energy absorption. Due to the high radiation levels involved, putting on and removing external impact limiters is not practical for the DOE SNF canisters. Having integral energy absorption capability is very desirable. Given other constraints of size and useable volume, keeping the elastically calculated stresses below the acceptable stress limits for the DOE SNF canister is still nearly impossible even with self-contained energy absorption capabilities. Therefore, the NSNFP has designed the DOE SNF canister using a plastic strain approach (Reference INEEL EDF AMG-06-98). The canister is designed with symmetrical, skirted ends and a cylindrical shell sized to absorb a sufficient amount of energy during the impact event so as to limit pressure boundary material strains to acceptable levels. Permanent local deformation is expected as a result of accidental drops. However, low strain limits have been established (using a relatively severe SNF and basket load geometry) to reasonably assure that breech of the canister pressure boundary will not occur during impact for a variety of other SNF and internals. Actual drop testing from heights of 9 meters (30 feet) with the canister and various internals in multiple essential orientations will be used to validate the containment capability of the DOE SNF canister design.

At this time, details of the SNF that will affect the canister performance during a drop event are not precisely known, i.e., how much SNF weight is in the canister, geometry of the SNF, placement of the SNF in the canister, load footprint of the SNF during a potential accidental drop, etc. Knowledge of the canister internals design (e.g. baskets, spacers, sleeves, cans, and dividers) and impact surface are also unknown. These currently unknown details make it impossible to accurately predict the resulting stress and strain levels in the DOE SNF canister material during impact. Therefore, the design of the specified DOE SNF canister was made robust in order to have margin between expected strain levels and those strains that could cause a loss of containment in the canister shell.

To support the specified DOE SNF canister design, the following recommendations should be considered when details and procedures affecting movement of the canister, design of the canister internals, and loading of the canister are finalized. Movements should be planned to minimize the amount of handling of the canister and the number of lifts. Unnecessary lifting should be avoided. Movements should be made at minimum heights, as close to the floor as practical. Movement paths should be defined and restricted to minimize lifts over walls, transport carts, machinery and other obstructions that would require increased lift heights and impose sharp edges and other puncture threats to the canister. To minimize high lifts over walls, facilities should be designed using a labyrinth arrangement for divider walls when shielding or other reasons for wall separation are required. Facilities and support equipment should be designed to eliminate sharp edges, corners, and protrusions. Tops of walls over which lifts may occur should be rounded and covered with replaceable energy absorbing impact structures. All features of the related facility and support equipment design should give priority to protection of the canister and the SNF.

During accidental drop events, high stress and strain values are expected in local regions of the DOE SNF canister where internal structures contact the canister shell pressure boundary. Internal structures (baskets, spacers, sleeves, dividers, cans, etc.) and fuel elements may contain sharp, stiff elements that pose a puncture threat to the canister containment. Results of the canister drop test evaluations will be contingent on the internal structure designs. Canister internal structure designs must consider fuel safety, condition, stability and criticality concerns for numerous unique fuel types. A generous volume has been allotted in the DOE SNF canister design to allow flexibility in meeting these demands. Canister protection shall also be considered in the internal structure design requirements. The DOE SNF specified canister design includes two-inch-thick internal end impact plates (part of the internals design) to protect the dished heads from internal impacts and punctures. Internal baskets, sleeves, dividers, cans, and spacers shall also be designed to avoid sharp corners and protrusions and provide large bearing surfaces and energy absorption features that minimize point loads on the containment shell pressure boundary and resulting high localized regions of stress and strain.

Based on discussions with repository personnel, once the DOE SNF canister is placed inside the waste package, there are no long-term performance characteristics expected of the DOE SNF canister itself. However, the waste package must satisfy certain design requirements for drop and tip-over accidents. A dropped or damaged waste package may no longer have the required long-term performance capability and may need to be replaced. In order to utilize a new waste package, the SNF must be removed from the damaged waste package. For commercial fuels, this means that the baskets inside of a damaged waste package must limit deformations to such an extent that the commercial fuel can still be removed.

The consequences of a waste package drop or tip-over, however, are not expected to be as severe to the DOE SNF canister as they may be to commercial fuels. If a waste package is dropped 2 meters (6.56 feet) or if it tips over, there is still the repository requirement to unload that waste package. Unloading the DOE SNF out of a damaged waste package does not require maintaining such a precise geometry as demanded for commercial fuels. All that is needed is to remove the DOE SNF canister (as well as the HLW canisters) so they can be loaded into a new waste package. That means that the ease of removing the DOE SNF canister depends only on the removal of at least one of the HLW canisters. That one HLW canister could be the canister that was located on top of all the other canisters during the drop or tip-over accident. Being on top, it should be relatively undamaged. Once one HLW canister has been removed, there should be adequate room for removal of the remaining HLW canisters and the DOE SNF canister.

Additionally, the thick, internal end impact plates incorporated into all of the DOE SNF canisters will provide support and resistance to crushing forces generated during the waste package 2-meter (6.56-foot) drop or tip-over events. Other canister internal components (e.g., baskets, spacers, sleeves, cans, and dividers) can also be designed to protect the integrity of the canister as well as the fuel. This will help mitigate the consequences of these accident events. Therefore, the waste package 2-meter (6.56-foot) drop or tip-over accident is not considered to be a design-controlling event for the DOE SNF canister itself.

All design concerns resulting from the materials (SNF and internals) placed inside the DOE SNF canisters must be addressed, during normal and off-normal conditions of handling, interim storage, transportation, and disposal. The materials to be placed inside of these sealed canisters must be controlled to the extent that adverse or excessive heat, internal pressures, corrosive conditions, and excessive radiation fields are not generated. Since a significant amount of the DOE SNF is highly enriched uranium (HEU) with U^{235} enrichment levels greater than 20%, criticality concerns must also be carefully addressed when determining what SNF, how much SNF, and where the SNF is to be placed inside of these canisters. Maintaining SNF placement may be very crucial at times for certain fuels, requiring internal devices such as baskets and spacers to not deform under any specified canister loadings.

Clearly, the design of the SNF and any internals and the canister itself must be evaluated together. However, the design of the canisters is preceding the design of the canister internals. Internals required for the proper placement of SNF will have to be designed to conform to the design constraints imposed by the existing DOE SNF canisters. This includes the consideration of geometry as bounded by the inner diameter of the canisters, basket, spacer, or other internals deformations, canister deformations, and canister stresses from SNF or internals loads.

Using the above approach, a lightweight, spacious and robust canister can be designed for DOE SNF that can meet accident condition demands and satisfy performance requirements for handling, storage, transportation and disposal at the repository.

4.4 Regulation Guidance

At the present time, Title 10 of the Code of Federal Regulations provide very little explicit design criteria for the standardized DOE SNF canisters. 10 CFR Part 72 regulations describe the design criteria necessary for an interim storage facility to be approved and licensed by the NRC. The DOE SNF canisters will be part of the components comprising an interim storage facility but it is not intended for the DOE SNF canisters to be an interim storage facility by themselves outside of a hot cell facility. 10 CFR Part 71 regulations describe the criteria necessary for transportation casks. The DOE SNF canisters by themselves are not transportation casks but will be placed into NRC licensed transportation casks. 10 CFR Part 71.63(b) does mention double containment under certain SNF circumstances. The DOE SNF canisters will not be placed directly into the repository but will be placed into a disposal container (or waste package after the final barrier weld is accepted) before being officially disposed. Generic requirements such as confinement or containment barriers for the SNF, material interactions and compatibilities, and the need for criticality control are mentioned in the regulations but complete and explicit design parameters for the DOE SNF canisters are not provided in the Code of Federal Regulations.

4.5 Design Basis

With the assumption that the transportation cask does not provide double containment, the direct placement of damaged SNF into the DOE SNF canister imposes the requirement of using ASME B&PV Code, Section III design criteria. As indicated in NUREG-1617 (Draft), "Verify that packages designed for the transport of damaged SNF include packaging of the damaged fuel in a separate inner container (second containment system) that meets the requirements of 10 CFR 71.63(b)."

Since the term "packaging" was used, the DOE SNF canisters shall be designed, fabricated, and examined to the requirements of the ASME B&PV Code, Section III, Division 3, Subsections WA and WB, 1997 Edition (or most recent edition approved by the NRC provided the specific code changes explained below have been incorporated) for the loads and environments identified in the design specification (Volume I). Section III, Division 3 provides the design, fabrication, and examination criteria specified in NUREG-1617 (Draft) for assuring containment in transportation casks or packagings.

Certain changes to Section III, Division 3 need to be made in order for the DOE SNF canisters to be fabricated as N-stamped vessels. First, Division 3 must be changed to allow field operations in order to complete construction (e.g., perform the final closure weld) at locations other than the Code shop. Division 3 must also be changed to allow the actual N-stamping prior to the SNF being loaded into the DOE SNF canisters. In addition, clarifications that allow the use of ultrasonic examination for the final closure weld must be made. Due to the presence of the SNF after loading, the DOE SNF canisters shall not be required to satisfy pressure test requirements of Section III, Division 3, Subsection WB after loading the SNF and final closure welding. Changes permitting helium leak testing (per ASME Code, Section V requirements) in lieu of pressure testing for low design pressure vessels must be made to Division 3 rules. The DOE SNF canisters shall not contain any pressure relief devices. The DOE SNF canisters shall be considered N-stamped (with the Data Report signed) after the authorized nuclear inspector has accepted the final closure weld.

The DOE SNF canisters shall be designed to the loads and environment specified in the preliminary design specification (Volume I) and evaluated to the acceptance criteria of Section III, Division 3, Subsections WA and WB. Once storage and transportation details become available, the DOE SNF canisters shall also have the Design Reports incorporate storage and transportation system specifics so that the canisters can be utilized in those systems. The Design Report justifies how the DOE SNF canister can be used. As such, the design loads defined in 10 CFR Parts 71.71 and 71.73 shall be applied to the DOE SNF canister and the outer transportation cask as a combined system (canister and cask), not individually. The same combined system design philosophy applies to the DOE SNF canister and the applicable storage system.

Depending on how the DOE SNF canister is used for interim storage, there could exist the possible requirement to demonstrate DOE SNF canister structural adequacy. If this occurs, it may be necessary to demonstrate compliance with the requirements of the ASME B&PV Code, Section III, Division 1, Subsection NB. However, this is achievable because the DOE SNF canisters are already Section III vessels.

4.6 Canister Design Limitations

Reasonable design criteria must be established to adequately address anticipated loadings and events. However, all potential site-specific or facility-specific circumstances may not be incorporated into the design bases of these DOE SNF canisters. Hence, it becomes incumbent on all users of these canisters to understand their design limitations and be able to adjust their operations where necessary. One obvious example may be the potential internal pressure. If a specific user intends to load DOE SNF in such a manner that the internal pressure exceeds the maximum considered design pressure, then adjustments should be made to limit the amount of SNF, the amount of included water, or whatever variable that can be adjusted such that the design pressure is not exceeded.

Another more subtle example of user awareness may be the potential for canister puncture during a possible drop event. From a design perspective, it is nearly impossible to identify geometries of an unlimited number of potential targets that might puncture the canisters. Therefore, the DOE SNF canisters have not been explicitly designed for any specific puncture resistance, although the drop-resistant robust design instills a significant puncture resistance capability by itself. Hence, it will be up to the user to determine if any potential exists for canister puncture during any canister (by itself) handling operations. If the potential for puncture exists, the user can either perform an analytical evaluation to determine if puncture is possible or the user can pad the identified target to prevent puncture.

Establishing the acceptability of future use of canisters that may have been subjected to significant loadings imposed while empty or while filled with SNF but before the top head is attached becomes the responsibility of the user. Any significant loadings imposed on empty canisters (such as accidental drops) shall be evaluated per the final acceptance criteria specified in Section III, Division 3, Subsections WA and WB, (or possibly Section III, Division 1, Subsection NB if appropriate) of the ASME B&PV Code. Significant loadings inadvertently imposed on filled canisters (before the top head is attached) should be evaluated in the same fashion. If a filled canister (before the top head is attached) is adversely loaded or dropped, the facility must address the potential cleanup situation under its own operating requirements. Once the canister can be emptied and decontaminated (if necessary), then the user can perform the evaluations and inspections necessary to demonstrate the acceptability of future use or properly dispose of the nonconforming canister. Under many circumstances, attempting to use a canister that has been adversely stressed or strained (e.g., dropped from a significant height) may be more difficult to justify from a political than a technical standpoint.

Although the criteria identified in the preliminary design specification (Volume I) will incorporate reasonable and appropriate design bases, the user must once again recognize that local conditions and situations must be addressed if they exceed the specified design criteria. Hence, as indicated before, it becomes incumbent on all users of these canisters to understand the design limitations of the canisters and be able to adjust their operations where necessary in order to achieve the functionality expected of these DOE SNF canisters. This includes the proper storage (e.g., dry storage without contamination by damaging environments) of empty DOE SNF canisters prior to loading.

4.7 Geometry and Materials

Appendix A of the preliminary design specification (Volume I) contains engineering drawings which provide canister design details, including geometry and material information.

4.7.1 Geometry

Since the intent was for the DOE SNF canisters to be used during interim storage, transportation, and disposal at the repository, all of these uses have to be considered before a final canister size is specified.

All of the DOE SNF canisters shall be right circular cylinders that are able to stand vertically when placed on a flat surface after being loaded with SNF [Disposability Standard 2.2.20.3]. The large canister shall have a nominal OD of 610 mm (24.00 inches) and a nominal wall thickness of 12.7 mm (0.500 inches). The small canister shall have a nominal OD of 457 mm (18.00 inches) and a nominal wall thickness of 9.53 mm (0.375 inches). Both of these canisters shall be designed for a maximum overall length of either 3,000 mm (118.11 inches) or 4,570 mm (179.92 inches). Appendix A of the preliminary design specification contains the engineering drawings showing the specified NSNFP canister design. Dimensional tolerances and fabrication processes (including weld grinding where necessary) shall be controlled so that the maximum dimensions are not exceeded.

Typical fabrication tolerances are indicated on the engineering drawings. Since the material specification is SA-312 (for seamless and welded austenitic stainless steel pipes), certain dimensional tolerances (from material specification SA-530 in Section II of the ASME B&PV Code) associated with the exterior canister shell are already specified. Outer diameter variations shall not be over by more than 3.2 mm (0.125 inches) for the 610 mm (24.00 inches) canister and 2.4 mm (0.093 inches) for the 457 mm (18.00 inches) canister. For ovality, the difference in extreme outside diameter readings in any one cross-section shall not exceed 1.5% of the specified nominal outside diameter. Straightness tolerances for each canister shall not exceed 3.2 mm (0.125 inches) maximum deviation for every 3.0 m (10 feet) of pipe length (both ends of a 3.0-m (10-foot) straightedge used for the measurement are in contact with the surface). In addition to the above mentioned mill tolerances, provisions must be made for the as-welded condition of the final canister weld (attaching the top head to the canister shell). Therefore, an additional diameter increase of 4.76 mm (0.1875 inches) shall be considered acceptable for the crown of the final canister weld.

In order to ensure that certain contents can be placed inside these canisters and that the canister can be placed in the repository waste package, the following dimensions shall be incorporated into the canister design:

Table 4.1. DOE SNF canister dimensions.

Canister Size	Nominal Outer Diameter	Long Canister Max. External Length	Short Canister Max. External Length	Min. Internal Diameter	Long Canister Min. Internal Length	Short Canister Min. Internal Length
Large	610 mm (24.00 in.)	4,570 mm (179.92 in.)	3,000 mm (118.11 in.)	579 mm (22.80 in.)	4,038.6 mm (159 in.)	2,470.2 mm (97.25 in.)
Small	457 mm (18.00 in.)	4,570 mm (179.92 in.)	3,000 mm (118.11 in.)	430 mm (16.93 in.)	4,114.8 mm (162 in.)	2,540.0 mm (100 in.)

4.7.2 Materials

Since the intent was for the DOE SNF canisters to be used during interim storage, transportation, and disposal at the repository, all of these uses have to be considered before a canister material selection could be made. Current repository criteria (Disposability Standard 2.1.20) indicates that low-carbon austenitic stainless steel or stabilized austenitic stainless steel materials are acceptable. The NSNFP is proceeding on the assumption that low-carbon austenitic stainless steel will be acceptable to the repository.

In order to make some effective progress, stainless steel is currently the identified material in this design specification due to its performance in scoping drop tests and its ease of availability and relatively low cost. Although canister specific drop tests have been performed that clearly demonstrate the acceptability of 304L, stainless steel 316L has better resistance to pitting corrosion and hydrogen embrittlement (Reference INEEL letter HUJS-06-98). It is believed that the use of 316L (considering the variations in actual material properties of stainless steel) would be an acceptable canister material, even considering accidental drop events.

Therefore, the DOE SNF canisters shall be made of SA-312, type 316L stainless steel for the shell and SA-240, type 316L for all other parts, including the heads, nameplates, and lifting rings. The optional plugs and plug thread plates shall be SA-479, type 316L stainless steel. All stainless steel materials shall be annealed and pickled. Per the DIS, the DOE SNF and canister internals shall preclude chemical, electrochemical, or other reactions (such as internal corrosion) of the canister or waste package such that there will be no adverse effects on normal handling, transportation, storage, emplacement, containment, or isolation or on abnormal occurrences such as a canister drop accident and premature failure in the repository [Disposability Standard 2.1.25].

As part of the material selection process, important parameters to consider are the anticipated erosion and corrosion values expected during interim storage and transportation use. A total value of 1.27 mm (0.050 inches) of pressure boundary wall thickness reduction has been established as the erosion and corrosion value to be used for canister design purposes. This corrosion/erosion value reflects the full design lifetime of 100 years. Therefore, prior to acceptance at the repository, the DOE SNF canisters shall be protected from adverse environmental conditions in such a manner as to prevent the total wall thickness corrosion/erosion limit from being exceeded. A 50-year interim storage and transportation interval shall be assumed for this specific wall thickness reduction evaluation. The assumption is made that once the DOE SNF canister is placed inside the waste package, insignificant corrosion or erosion will occur for the next 50-year interval.

The canisters will be subjected to a radiation environment. Since criticality is to be eliminated, the canisters should not be exposed to large neutron fluences. Long-term cumulative exposures to high neutron fluence (on the order of 10^{17} n/cm^2 and greater) has caused degradation in reactor vessels but this is not applicable to the DOE SNF canisters. Radiation fields (10^7 rad/hr or less) are expected but no significant material damage or degradation is anticipated for the stainless steel material (Reference INEEL letter ELS-09-98).

Both the inner and outer surfaces of the canisters shall have a finished condition such that acceptable nondestructive examinations can be performed in order to satisfy ASME B&PV Code, Section III, Division 3, Subsection WB requirements. However, no specific surface finish is specified for the DOE SNF canisters. The repository has limits on outside surface contamination for the canister but has not imposed an associated surface finish in conjunction with the surface contamination requirement [Disposability Standard 2.4.22]. The repository does require that any burrs, sharp edges, and weld edges shall not exceed 0.5 mm (0.0197 inches). The interior surfaces shall be smooth enough to allow easy loading of any DOE SNF or internals (baskets, spacers, sleeves, dividers, cans, etc.) so as to not damage the SNF.

4.8 Contents

As indicated previously, the contents (SNF and any applicable internals necessary for the safe placement and orientation of the DOE SNF) have not been specifically defined to date. Therefore, minimal criteria which is believed to provide reasonable design parameters have been specified. However, it is assumed that all contents will not compromise the structural integrity of the DOE SNF canister. It is also assumed that the contents will satisfy any and all applicable regulations and requirements, especially those set forth by the repository. For example, per the DIS, the contents of the disposal canister shall contain no pyrophoric, combustible, explosive, or chemically reactive materials in an amount that could compromise surface-facility or repository preclosure safety or repository long-term performance [Disposability Standard 2.1.24 and 2.1.25].

The DOE SNF canisters shall be designed for the total maximum allowable weights (canister plus contents) listed in the table below. These weight limits are equal to or less than the weight limits established in the repository's ICD.

Table 4.2. DOE SNF canister maximum total allowable weights.

Canister Size	Nominal Outer Diameter	Long Canister Maximum Total Weight	Short Canister Maximum Total Weight
Large	610 mm (24.00 in.)	4,535 kg (10,000 lb_f)	4,080 kg (8996 lb_f)
Small	457 mm (18.00 in.)	2,721 kg (6,000 lb_f)	2,270 kg (5,005 lb_f)

When loading the DOE SNF, the center-of-gravity of the entire contents (SNF, baskets, spacers, sleeves, dividers, etc.) shall be within 127.0 mm (5 inches) of the canister centerline for the 457 mm (18.00 inches) nominal OD canister and within 203.2 mm (8 inches) of the canister centerline for the 610 mm (24.00 inches) nominal OD canister. These loading restrictions are to avoid excessive lop-sided loading situations and to limit resulting stresses in the lifting ring and adjacent skirt portion of the canister to stress limits that satisfy the requirements of ANSI N14.6. When possible, the center-of-gravity of the loaded DOE SNF will be as close to the canister centerline as reasonably achievable. The axial location of the center-of-gravity of a loaded DOE SNF canister shall be within 609.6 mm (24.0 inches) of the canister centroid. Sites performing SNF loading may make separate evaluations of center-of-gravity locations if the indicated center-of-gravity limitations are exceeded. However, all acceptance criteria shall still be satisfied.

4.9 Canister Sealing

Storage, transportation, and repository disposal criteria all indicate specific requirements associated with the safe and proper sealing of SNF containers. The NRC issued Bulletin 96-04 which discussed how an inert cover gas introduced into the storage industry canisters or transportation casks could reduce the generation of hydrogen gas which could combust during final seal welding. After loading the SNF, the DOE SNF canisters shall be inerted with a cover gas (e.g., helium) inside of the canister [Disposability Standard 2.1.21]. Such a gas is intended to eliminate or significantly reduce SNF corrosion, provide more appropriate heat transfer conditions internally, and to reduce combustion concerns.

Sealing of the DOE SNF canisters may be required for interim storage, depending on the type of storage system utilized. However, if the storage system permits it, the DOE SNF canisters may be sealed after interim storage. Incorporated into the DOE SNF canister design is the option of a threaded plug in the top and bottom head. However, prior to transportation and repository disposal, the DOE SNF canister must be seal-welded closed. The DOE SNF canisters shall be backfilled with an inert cover gas (e.g., helium) inside of the canister at a pressure of 13.8 to 27.6 kPa (2 to 4 psig). The final canister weld (attaching the top head to the canister shell) shall implement a welding procedure that can be qualified to yield leaktight welds. A leaktight weld shall be considered equal to or better than the required leak rate necessary to satisfy the applicable 10 CFR Parts 71 and 72 requirements. At a minimum, in order to demonstrate compliance with the ASME Code and obtain the Code stamp per the proposed Code changes, the DOE SNF canister shall be helium leak tested per the requirements identified in Section V, Article 10, Appendix IV to verify that no leakage is detected that exceeds the rate of 1×10^{-4} std cm^3/sec. After closure of the canister, the DOE SNF canister shall not contain or generate free gases other than air, inert cover gas, and radiogenic gases with an immediate internal gas pressure not to exceed 151.7kPa (22 psig) [Disposability Standard 2.4.23]. Therefore, the DOE SNF canister shall have a maximum allowable (design) pressure of 344.8 kPa (50 psig).

Incorporated into the DOE SNF canister design is the option of a threaded plug in the top and bottom head. These threaded plugs can be used, where necessary, for a number of functions including canister draining, degassing, and remote inspection among others. Installation or removal of the threaded plug(s) would be expected to be performed while the DOE SNF canister is inside of a hot cell since the containment feature of the canister depends upon the proper installation of the threaded plug. When using these threaded plugs, it is necessary to seal-weld the threaded plugs in order to establish an acceptable containment boundary per ASME B&PV Code, Section III requirements. The seal weld shall cover any exposed threads on the plug.

4.10 Shielding

For the purposes of the design specification, it is assumed that the DOE SNF canisters do not require additional shielding beyond that provided by the canisters themselves or in conjunction with shielding provided by the facilities handling the DOE SNF canisters or the storage or transportation systems. It is assumed that any of the facilities handling the DOE SNF canisters or the repository will have adequate equipment necessary to handle the DOE SNF canisters by themselves. If additional shielding is required by local sites or facilities, it is up to the user to provide adequate shielding measures without adversely affecting the DOE SNF canisters.

4.11 Criticality

For the purposes of the design specification, it is assumed that adequate attention to the types and amounts (proper fissile limits) of SNF to be loaded into the canisters or proper configuration using properly designed internals (baskets, spacers, sleeves, dividers, cans, etc.) will preclude any criticality concerns [Disposability Standard 2.3.22]. Therefore, this design specification assumes no criticality events during the canister's design life. For criticality concerns, the DOE SNF canisters must be capable of maintaining reasonable geometric integrity only. The personnel responsible for any designs of internals necessary for criticality prevention must address any associated concerns should the DOE SNF canisters be loaded, dropped or handled in such a fashion as to adversely load the SNF or internals.

4.12 Normal Operating Loads and Environmental Conditions for the DOE SNF Canister

The assumption has been made that the physical condition of the DOE SNF canister during interim storage, transportation, and initial disposal at the repository will govern the design of the DOE SNF canisters. Corrosion effects identified in Section 4.7.2 of this companion document shall be included where required. The DOE SNF canisters are assumed to have adequate room (diameter and length) for stress-free thermal expansion during all uses. Preliminary thermal evaluations (Reference INEEL letter GLH-02-98) provided insights into heat generation limits each specific SNF could introduce into the canisters assuming the temperature limitations indicated in the design specification.

Since all of the canister design parameters are not known at this time, it is not currently possible to identify the limiting design parameters for the DOE SNF canisters. Therefore, the currently known environmental and loading conditions that could occur during each use (loaded canister handling by itself, interim storage, transportation, and repository disposal) are identified in the design specification. Once additional design parameters become known (for either interim storage, transportation, or even repository disposal, if necessary), the DOE SNF canister Design Report must incorporate the information in order to qualify the DOE SNF canister for that use.

4.12.1 Weight

The weight considerations listed in Table 4.1 are for all of the DOE SNF canister geometries. The DOE canisters shall not be horizontally or vertically stacked at any time with any other canisters without a proper evaluation of all possible consequences. Interim storage, transportation, and disposal scenarios are situations where the canisters are within other enclosures or facilities and these canister placements shall be properly evaluated. The limitation of no vertical or horizontal stacking is imposed not from a strength concern but rather from a safety viewpoint. Vertically stacking these long, slender canisters (either empty or filled) would prove to be a major safety concern for personnel due to a lack of stability. Horizontally stacking these canisters (like a cord of firewood) could be permissible in an empty condition but that could also be unstable due to rolling concerns unless specific actions are taken to prevent it from happening. Horizontally stacking these canisters when filled with SNF appears to be undesirable from a rolling stability concern. Potential criticality implications and excessive heat generation concerns may exist if the canisters were to be stacked in close proximity to each other. Therefore, due to a number of unknown implications and concerns, the preliminary design specification assumes that the canisters will not be vertically or horizontally stacked. If the canister user needs to stack the DOE SNF canisters, then the user must provide the justification, addressing all potential implications.

The lifting fixture is not part of the canister design specification. However, the design of the lifting fixture does have an affect on the resulting design of the canister. Therefore, some insights regarding design requirements of the lifting fixture should be mentioned. The lifting fixture shall provide at least three locations to engage the canister lifting ring, with the capability to engage and disengage remotely. The lifting fixture shall be capable of engaging and disengaging while remaining within the projected perimeter of the DOE SNF canisters. The amount of engagement provided by the lifting fixture shall be determined so that ANSI N14.6 stress criteria for the canister are satisfied. With a proper lifting fixture available, the DOE SNF canister shall be designed so that the canisters can be lifted and moved safely.

1. The DOE SNF canisters shall be designed to be vertically lifted with a lifting fixture that engages underneath the 12.7-mm (1/2-inch) thick lifting ring [Disposability Standard 2.2.22.2]. The amount of engagement provided by the lifting fixture shall be determined so that ANSI N14.6 stress criteria for the canister are satisfied. Material temperature limits for lifting the canisters shall be 148.9°C (300°F). Due to the symmetry of the specified DOE SNF canister design (see the engineering drawings in the preliminary design specification, Appendix A), either end shall be capable of being used to lift the canister. The Maximum Normal In-Plant Handling Pressure (MNIP) shall be considered to be acting coincidentally.

2. With respect to recovering from an accidental canister drop or tip-over (regardless of severity), the canisters shall be designed to be picked up from both extreme ends or tilted back upright from a horizontal position. Stresses resulting from this action shall satisfy normal operating condition stress limits defined in the ASME B&PV Code, Section III, Division 3, Subsection WB. Worst case temperatures and pressures shall be considered to be acting coincidentally. The weight of the contents shall be assumed to be lumped at the centroid of the canister.

4.12.2 Pressure

The following specified pressure loadings are listed for all of the DOE SNF canister geometries.

1. The Maximum Normal In-Plant Handling Pressure (MNIP) is the maximum pressure that would develop in a DOE SNF canister during initial handling, interim storage, transportation, or initial repository handling or disposal container loading prior to actual emplacement in a repository drift under the most severe conditions of normal in-plant handling operations. The DOE SNF canister shall be designed for a MNIP not to exceed 344.8 kPa (50 psig) per the criteria of the ASME B&PV Code, Section III, Division 3, Subsection WB. (For ASME B&PV Code, Section III, Division 1, Subsection NB evaluations, the MNIP shall be considered to be the design pressure.)

2. The Maximum Normal Operating Pressure (MNOP) is the maximum pressure that would develop in a DOE SNF canister during initial handling, interim storage, transportation, or initial repository handling or disposal container loading prior to actual emplacement in a repository drift without venting. The DOE SNF canister shall be designed for a MNOP not

to exceed 151.7 kPa (22 psig) per the criteria of the ASME B&PV Code, Section III, Division 3, Subsection WB. (For ASME B&PV Code, Section III, Division 1, Subsection NB evaluations, the MNOP shall be considered to be the operating pressure.)

4.12.3 Thermal

1. The Primary Service Temperature for a DOE SNF canister when it is not inside any other container (by itself, in a 25°C (77°F) calm air environment) is 176.7°C (350°F), and 343.3°C (650°F) after placement within another enclosed container (e.g., a storage industry canister for interim storage or a transportation cask), possibly with other heat generating DOE SNF canisters or HLW canisters. (For ASME B&PV Code, Section III, Division 1, Subsection NB evaluations, the Primary Service Temperature shall be considered to be the design temperature.)

2. The maximum operating temperature for a DOE SNF canister when it is not inside any other container (by itself, in a 25°C (77°F) calm air environment) is 148.9°C (300°F), and 315.5°C (600°F) after placement within another enclosed container (e.g., a storage industry canister for interim storage or a transportation cask), possibly with other heat generating DOE SNF canisters or HLW canisters.

3. The DOE SNF canisters shall be designed for 20 full MNIP and temperature cycles of a canister achieving its maximum steady state operating temperature of 315.5°C (600°F) inside of another container and then suddenly being exposed to an external calm air temperature environment of 10°C (50°F) while the canister simultaneously loses its internal pressure. The maximum thermal gradient associated with this event shall be evaluated per the criteria of the ASME B&PV Code, Section III, Division 3, Subsection WB. If the canisters are subjected to any other significant fatigue loads due to initial SNF loading, interim storage, transportation, or loading into a disposal container at the repository, a detailed fatigue analysis shall be performed per WB-3221.9(e). If necessary, cumulative usage factors from all uses (SNF loading, canister handling, storage, or transportation) shall be evaluated once these values are known.

4. The DOE SNF canisters shall be capable of maintaining containment in temperature environments that range from -40°C to 343.3°C (-40°F to 650°F), excluding accidental drop scenarios or other accidental events when being handled by itself or inside of the waste package at the repository.

4.12.4 Other Normal Operating Condition Loads

1. For situations requiring specific design evaluations where significant compressive stresses occur in the canister, the buckling stress shall be taken into account. Acceptance criteria for buckling evaluations shall be obtained from the ASME Nuclear Code Case N-284 or other appropriate methodology acceptable to ASME Code requirements and the regulatory agency. Buckling situations need to be considered in terms of being able to remove the canister from the enclosing container (either the storage industry canister or the transportation cask).

2. The DOE SNF canisters shall be designed for any other normal operating condition loads resulting from initial handling, interim storage, transportation, or handling and loading into a disposal container at the repository once the loads and environments have been defined.

4.13 Hypothetical Accident Loads and Environmental Conditions for the DOE SNF Canister

As discussed previously, anytime a loaded DOE SNF canister is being handled by itself, the canister shall be within a HEPA-filtered building or facility. This eliminates the requirement of specifically designing the DOE SNF canisters to any specific ASME B&PV Code stress limits for accidental drop events. However, when the DOE SNF canister is enclosed within a storage industry canister for interim storage purposes or within a transportation cask, the DOE SNF canister shall be designed in accordance with the criteria in the ASME B&PV Code, Section III, Division 3 stress limits identified in WB-3224 or Section III, Division 1, Subsection NB-3225 as required. For the repository waste package drop or tip-over event, the canister shall be considered adequate as-developed since the only requirement is to remove the DOE SNF canister from the damaged waste package and place it into another undamaged waste package. The DOE SNF canister has a robust design since it was developed to maintain containment when subjected to a 9-meter (30-foot) drop onto an essentially unyielding surface. It is this robust design that makes the DOE SNF canister adequate to survive the waste package drop or tip-over event.

Another design concern is to maintain permissible deformations for the DOE SNF criticality concerns. However, this design evaluation is considered to be beyond the scope of this current design specification due to the involvement of the not yet defined canister internals (baskets, spacers, sleeves, dividers, cans, etc.). Therefore, the internals shall be required to provide any necessary geometry control regarding criticality evaluations of the DOE SNF.

For situations requiring specific design evaluations where significant compressive stresses occur in the canister, the buckling stress shall be taken into account. Acceptance criteria for buckling evaluations shall be obtained from the ASME Nuclear Code Case N-284 or other appropriate methodology acceptable to ASME Code requirements and the regulatory agency. Buckling situations need to be considered only in terms of being able to remove the canister from the enclosing container (either the storage industry canister or the transportation cask).

4.14 Quality Assurance

The designer and fabricator of the DOE SNF canisters shall establish, maintain, and execute a quality assurance program based on the criteria necessary to satisfy ASME B&PV Code, Section III, Division 3 construction criteria, 10 CFR Parts 71 (Subpart H), and 72 (Subpart G) quality assurance requirements.

4.15 Miscellaneous Requirements

4.15.1 Physical Protection of SNF

Since the DOE SNF canisters are to be seal-welded for transportation and repository disposal, the DOE SNF canisters do not require the use of an NRC approved tamper-safe seal. Per the DIS, tamper indicating devices are only required on canisters containing strategic special nuclear material that are not seal-welded [Disposability Standard 2.1.27]. Depending on how the DOE SNF canister is being used within an interim storage system, a tamper-safe seal may be required if the DOE SNF canister is not seal-welded.

4.15.2 Labeling

The DOE SNF canisters shall be capable of being properly labeled per the requirements of the DIS [Disposability Standard 2.1.26]. The highlights of these requirements include:

- The labels shall be an integral part of the canister [engraved to a depth no greater than 0.8 mm (1/32 of an inch)] that can be reasonably expected to remain legible for 100 years at temperatures of 25°C (77°F) to 400°C (752°F).
- The labels shall have a unique alphanumeric identifier
- The labels shall not impair the integrity of the canister
- The labels shall be chemically compatible with the canister material
- The top label shall be visible from the top of the canister with the lifting fixture engaged, with characters approximately 25.4 mm (1 inch) in height
- The labels shall not cause the canister dimensional limits to be exceeded.

This specification is requiring the DOE SNF canisters to be labeled on the outer most surface of each lifting ring on the top and bottom ends of the canister (two places). The alphanumeric identifier shall be readable as if the remotely operated cameras are on the outside of the canister looking inward toward the axial centerline of the canister. Placement of an alphanumeric label on the lifting ring shall not cause any interference or loading concerns.

4.15.3 Documentation

The designer of the DOE SNF canisters shall provide adequate documentation, reports, and design drawings in the proper form and format to satisfy the proper quality assurance requirements and record storage requirements. In addition, adequate documentation shall also be provided that:

- Supports the acceptable design of the DOE SNF canisters and is to be certified by a qualified professional engineer (the Design Report and Design Drawings)
- Permits an independent review of all design procedures and calculations
- Identifies all software used in the design process
- Indicates appropriate validation and verification documentation of all software used for the design calculations
- Indicates the involved design personnel have the experience, education, training, and proficiency commensurate with the minimum requirements established
- Is legible and in a form suitable for reproduction, filing, and retrieval.

Additional documentation requirements (including the detailed and specific requirements associated with the testing of computer software) can be located in the quality assurance requirements that are applicable. All additional evaluations requested by this design specification shall also be included in the documentation.

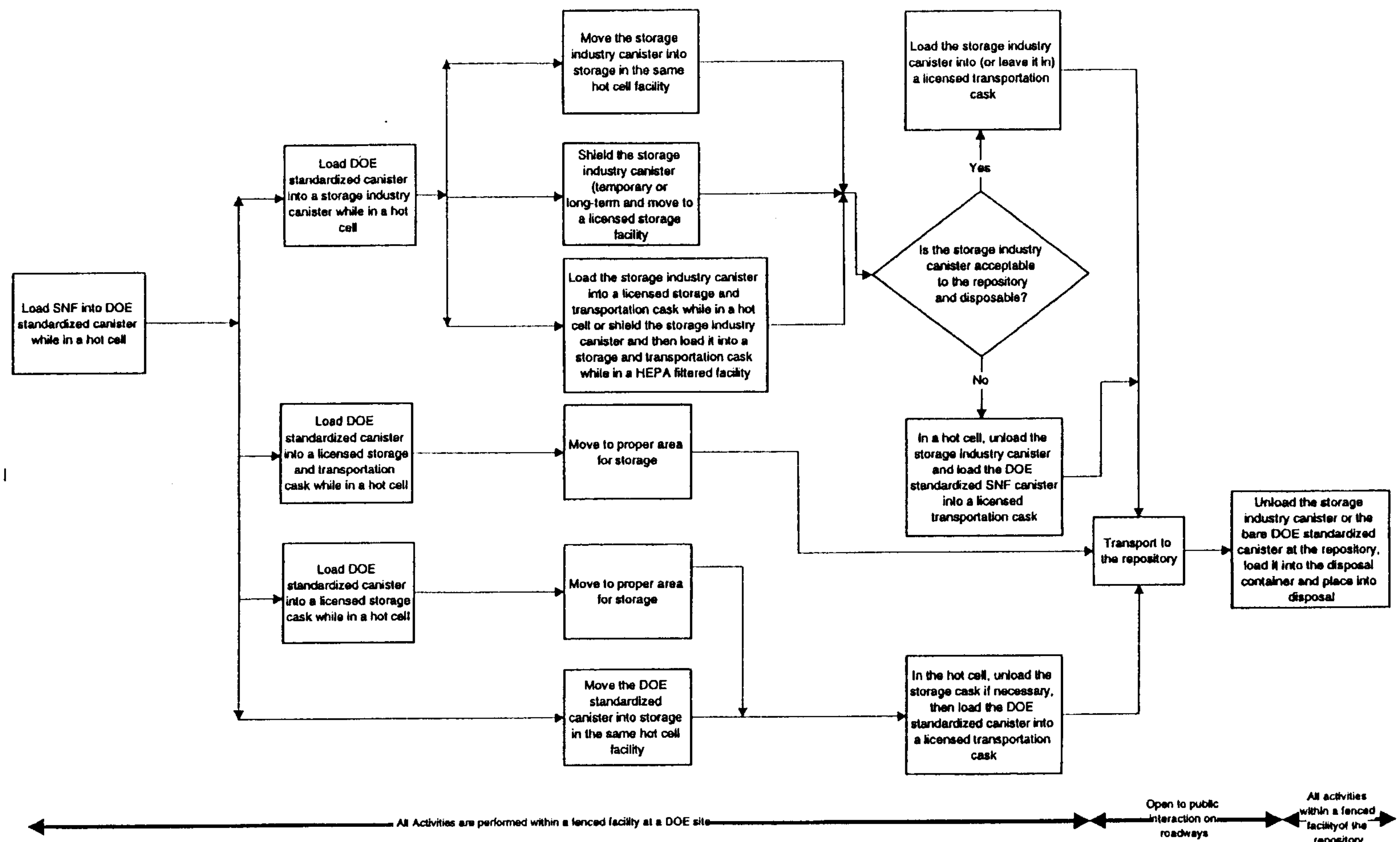


Figure 4.1. Standardized DOE SNF Canister Usage

5. DOCUMENT REVISION HISTORY

Revision	Description	Effective Date
0	New Document	08/19/98
1	Clarification and detail changes to meet current ASME standards. Removal of references to the OCRWM Quality Assurance Requirements and Description for Civilian Radiological Waste Management Program (DOE/RW-0333P).	11/23/98
2	Changes to reflect that the ASME Code is to be changed rather than a Code Case issued. Clarification that in order to achieve 100-year design life, canister must be protected from adverse environmental conditions that could reduce wall thickness beyond indicated limit. Terminology clarification that final butt weld is the final closure weld. Clarification that structural integrity of pressure boundary welds shall be volumetrically examined. Other minor editorial changes and corrections	07/15/99
3	To provide better visible clarifications with "ballooned clouds" of past revisions on the drawings in Volume I of this document. This change clarifies the welding symbols and the changes made from Revision 1 to Revision 4 of the drawings. Clarifications will provide easier fabrication and quality inspection of the canisters. No text changes other than revision number, date and Document Revision History section were made to either Volume I or Volume II documents from Revision 2.	8/17/99

Standardized DOE SNF Canister

Lifting/Handling System Concepts

3-1

Standardized DOE SNF Canister Lifting/Handling System Concepts

The Standardized DOE SNF Canister Lifting/Handling System (grapple) concept is similar to the TMI canister grapple currently used at the INEEL TAN-607 Hot Shop. The TMI grapple has features that assure it will remain engaged with the canister in all identified single-failure modes during lifting operations. The TMI grapple cannot be disengaged from the canister until the canister weight is off the grapple and supported by an external support structure. Once the load is removed from the grapple, electrical power can be supplied to a solenoid valve which controls the air supply to an air cylinder to provide the motive force to overcome gravity and the compression spring to disengage the grapple lifting lugs from the canister. Without electrical power and an air supply the grapple remains in the locked position by spring force and weight of the operator mechanism. In this way the grapple has a passive power-off failsafe feature to prevent accidental disengagement. The SNF grapple described herein has similar safety features described later in this document.

The following discussions present a viable grapple concept that is compatible with the proposed Standardized DOE SNF canister design. Details of final design features of the grapple will depend on the facility specific lifting and handling criteria. Details of the design presented herein are purposefully omitted to the extent possible to accentuate that this is a conceptual design. It is intended that any further development of this design be carefully reviewed, and analyzed by competent design engineers based on the then current and well developed design requirements.

GRAPPLE CONCEPT

Sheet one of the drawing shows the salient features of the Standardized DOE SNF Canister Grapple concept. Specific items of the design are indicated hereinafter by italicized names. Canister engagement is achieved by supplying air to the rod side of an *air cylinder* mounted along the centerline of the grapple. Air pressure on the rod side of the *air cylinder* retracts the cylinder rod into the cylinder and lifts the *actuating rod* causing the upper surface of the *lower actuating ring* to engage the cross bar of each of the three *lug links* and retracts the *lifting lugs*. The grapple is then lowered onto the canister and engaged by supplying air to the head side of the *air cylinder* to drive the *lug links* and *lifting lugs* outward to engage the grapple to the canister. The design offers the following advantages:

- Proven and acceptable concept for handling radioactive waste canisters
- Allows for remote operation
- Fail safe design

- Flexible actuation system motive forces adaptable to pneumatic, electrical or mechanical

- Flexible grapple length; can add flanged sections to a basic unit

- Optional electrical safety lockout when the grapple is loaded with a canister

- Optional remote operation and maintenance capabilities

- Optional mechanical override capabilities to release a canister from the grapple.

Two separate grapple designs would be required; one for the 18-inch OD canister and another for the 24-inch OD canister.

LIFTING CONSIDERATIONS ON CANISTER DESIGN

Using stresses in the canister from model evaluations performed by LMITCO personnel and insights obtained from a review of applicable standards and reports, the following parameters are recommended for the canister to satisfy normal operation handling needs.

<u>18-inch OD by 15-ft long Canister, 6000 lb Maximum Weight</u>

- Design the lifting device to the requirements of ANSI N14.6-1993 provided the load is not considered a critical load per ANSI N14.6.

- Design the canister lip and skirt to the 1/3 yield and 1/5 ultimate criteria for handling conditions. A ½ inch thick by 1 inch long lip will work assuming the lift load is applied at the halfway point on the canister lifting ring lip. The canister shell can be nominally 3/8-inch thick.

- Use 1.15g for dynamic lifting load factor. A 2g load can be considered for impact when sitting the canister down.

- Use 300°F for the maximum handling temperature.

- Design the lifting fixture with a minimum of 3 pickup points (bearing pads) each having a bearing on a minimum of 10 inches length of canister lifting ring lip circumference.

- Limit the center-of-gravity (CG) of the canister contents so that it lies within 5 inches of the canister centerline in order to limit the maximum load on a single bearing pad (assumes three pads).

<u>18-inch OD by 10-ft long Canister, 5000 lb Maximum Weight</u>

The recommended design parameters for this canister are the same as for the 18-inch OD by 15-ft long canister.

24-inch OD by 15-ft long Canister, 10000 lb Maximum Weight

- Design the lifting device to the requirements of ANSI N14.6-1993 provided the load is not considered a critical load per ANSI N14.6.
- Design the canister lip and skirt to the 1/3 yield and 1/5 ultimate criteria for handling conditions. A ½-inch thick by 1-inch long lip will work assuming the lift load is applied at the halfway point on the lip. The canister shell can be nominally ½-inch thick.
- Use 1.15g for dynamic lifting load factor. A 2g load can be considered for impact when sitting the canister down.
- Use 300°F for the maximum handling temperature.
- Design the lifting fixture with a minimum of 3 pickup points (bearing pads) each having a bearing on a minimum of 12 inches length of canister lifting ring lip circumference.
- Limit the CG of the canister contents so that it lies within 8 inches of the canister centerline in order to limit the maximum load on a single bearing pad (assumes three pads).

24-inch OD by 10-ft long Canister, 9000 lb Maximum Weight

The recommended design parameters for this canister are the same as for the 24-inch OD by 15-ft long canister.

CANISTER TILT

It is likely that the CG of the full canister will **not** lie on the longitudinal centerline of the cylinder. Evaluations were made regarding the range of displacement of the bottom of the canister that might be expected during lifting and lowering for storage, transportation or disposal. The CG always lies directly under the lift point and when the CG moves horizontally off the geometric centerline of the canister, the elevation of the CG becomes important in the horizontal displacement of the bottom of the canister. The shorter the distance from the pivot point at the grapple lifting eye to the CG location of the canister, the more the bottom of the canister will be displaced.

A calculation was performed based on a 3-foot grapple (assumed distance from grapple lifting eye to canister lip) which was rigidly attached to the top of the canister. A maximum content weight was assumed for all canister configurations. In a worst case assumption the CG of the canister contents was assumed to be at or below the canister mid-height point and at the cylinder shell face horizontally (a full radius off center). Resulting displacements of the bottom of the canister were 7 to 15 inches from plumb relative to a vertical line taken downward from the lifting eye. The range of distances was dependent upon the specific canister diameter and length.

For the 18-inch OD by 15 ft long canister, assuming the CG to be at mid-height of the canister vertically and limiting it horizontally to the 5-inch off-center dimension determined to limit loads at the bearing pad and shell wall, the displacement off-center of the bottom of the canister was determined to be about 4-3/4 inches. If the CG is horizontally off-center 1 inch at mid-height, the canister displacement off-center at the bottom is about 1-3/4 inches.

Even if limits are set on the location of the canister contents CG, it seems unreasonable that they could be controlled to within 1 inch. Determining the CG this close would be difficult and time consuming and keeping it in one location during shipping and handling doesn't seem feasible. Since a displacement of the CG off-center of 1 inch can result in a displacement off-center at the bottom of the canister of 2 inches or greater, it seems that a centering device should be used to place the canisters. It is recommend that the facilities handling the canister, design and plan for using a centering device which would allow for the canisters to be out of alignment from vertical by as much as 24 inches when suspended from the lifting crane. It appears that some type of centering device will be required anyway to locate the canisters tightly together even if they are hung straight.

GRAPPLE DESIGN FEATURES

The grapple concept, shown in Sheet 1 of the drawing, has six main sections. Starting at the bottom:

- the first section is the *Grappling Mechanism*
- the second section is an optional *Extension Section* which allows the grapple to be stretched to various lengths for different facility requirements
- the third section is the *Operator Section*
- the forth section is the lifting or *Crane Attachment Section*
- the fifth section is the optional *Safety Interlock Section* and
- the last section is the optional remote readout load cell.

The functions and salient design features of each section are described below.

GRAPPLING MECHANISM

The grappling mechanism has the following features:

- tapered bottom to provide easy insertion and self centering of the grapple onto the canister top

- three large (10" minimum) *lifting lugs* provides the required engagement stated above
- interlocked twin acting *lug links* that prevent binding of the *lifting lugs* within the housings during extension and retraction
- flange mounted *pivot points* that change the vertical movement in the Operator Section into the necessary horizontal motion needed to extend and retract the *lifting lugs*
- a *quick release pin* for each *pivot point*
- lower actuation ring that has three radial extension points to keep the *actuation rings* centered in the grapple housing
- the *upper actuation ring* that forces the *lifting lugs* outward and holds them under the canister lifting ring.

EXTENSION SECTION

The extension section allows the grapple to be stretched for use in situations where the operation mechanism needs to be separated from the grapple mechanism. This section is used on the TMI grapple to allow the canisters to be lowered into underwater storage racks without wetting the electrical components.

OPERATOR SECTION

The operator for the TMI grapple is an air cylinder which has two integral limit position switches to indicate the position of the piston within the air cylinder. One switch is activated when the cylinder rod is retracted into the cylinder to indicate that the grapple lifting lugs are retracted. The second switch is activated when the rod is fully extended and the grapple lifting lugs are fully extended. The air cylinder can be operated by plant air from an attached airline or from compressed gas bottles mounted on the grapple. The TMI grapple uses two E size cylinders to provide enough air volume at a preset regulated operating pressure for numerous grapple-operating cycles.

CRANE ATTACHMENT SECTION

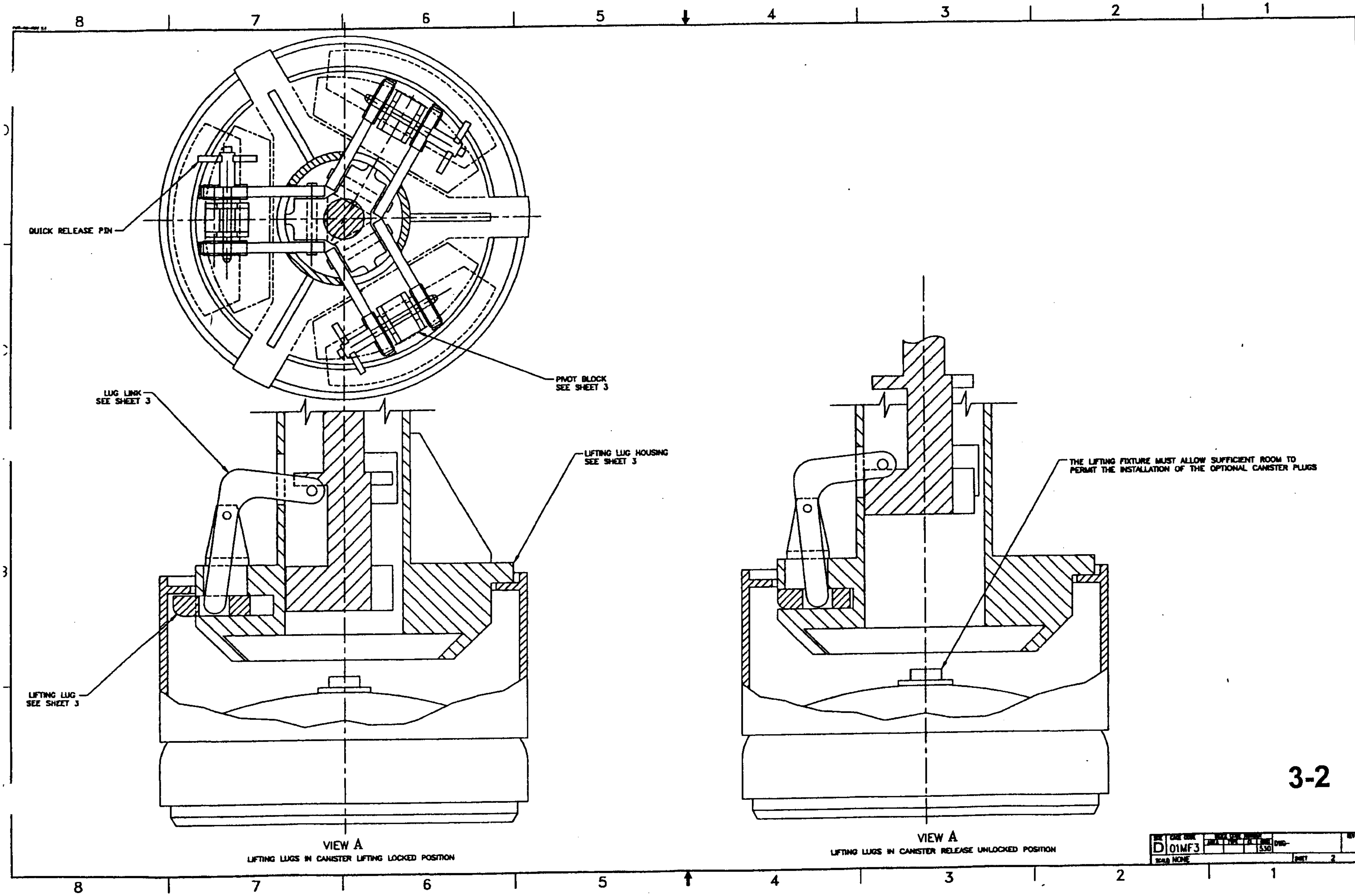
In the TMI grapple the crane actually attaches to the optional *load cell* and the load cell attaches to the *attachment section*. The *standoff arms* at the *attachment section* provide a convenient place to attach electrical and air lines to the grapple to minimize the side force on the grapple from cable tension. This side force can cause the grapple to hang off vertical which makes interfacing with the canister difficult. Maintaining the attachment at the top of the grapple minimizes this problem. This attachment also protects the electrical or air connections to the *safety switch, air cylinder limit switch*, *solenoid valve* and *air cylinder ports*.

SAFETY INTERLOCK SECTION

An optional safety switch can be incorporated into the grapple design to prevent electrical signals from going to the solenoid valve when the grapple is loaded. It prevents power from being supplied to the solenoid by using a *limit or reed switch* to open the power supply circuit. This feature is shown on sheet 1 of the drawing.

LOAD CELL

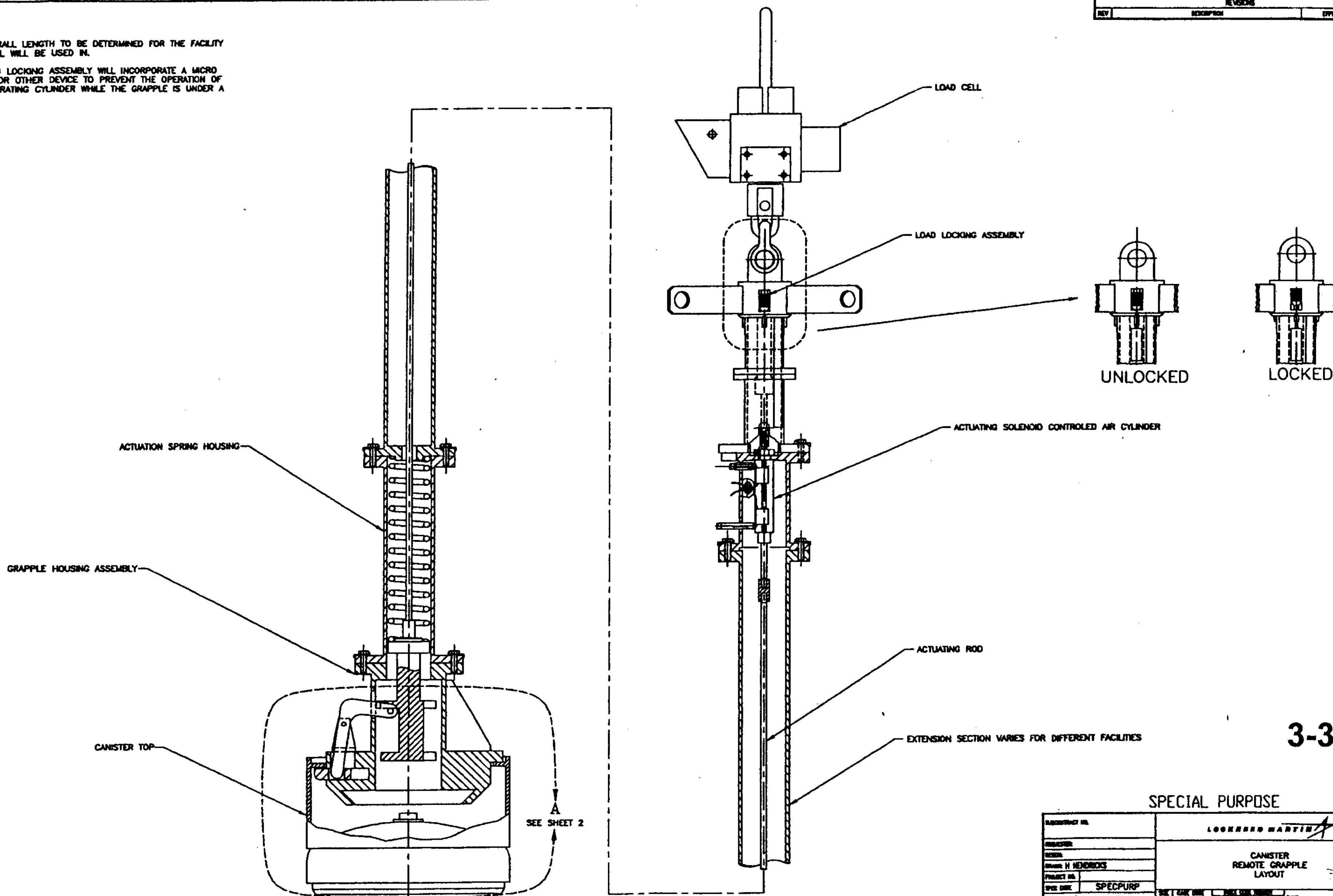
The TMI grapple has an optional *load cell* with remote readout capabilities. This feature provides a double check for the operators that the proper canister has been selected and that there has not been a weight change in the canister inventory.


QUICK RELEASE PIN
PIVOT BLOCK
SEE SHEET 3
LUG LINK
SEE SHEET 3
LIFTING LUG HOUSING
SEE SHEET 3
LIFTING LUG
SEE SHEET 3
VIEW A
LIFTING LUGS IN CANISTER LIFTING LOCKED POSITION
THE LIFTING FIXTURE MUST ALLOW SUFFICIENT ROOM TO
PERMIT THE INSTALLATION OF THE OPTIONAL CANISTER PLUGS
VIEW A
LIFTING LUGS IN CANISTER RELEASE UNLOCKED POSITION
D 01MF3
SCALE NONE
SHEET 2

3-2

NOTES:

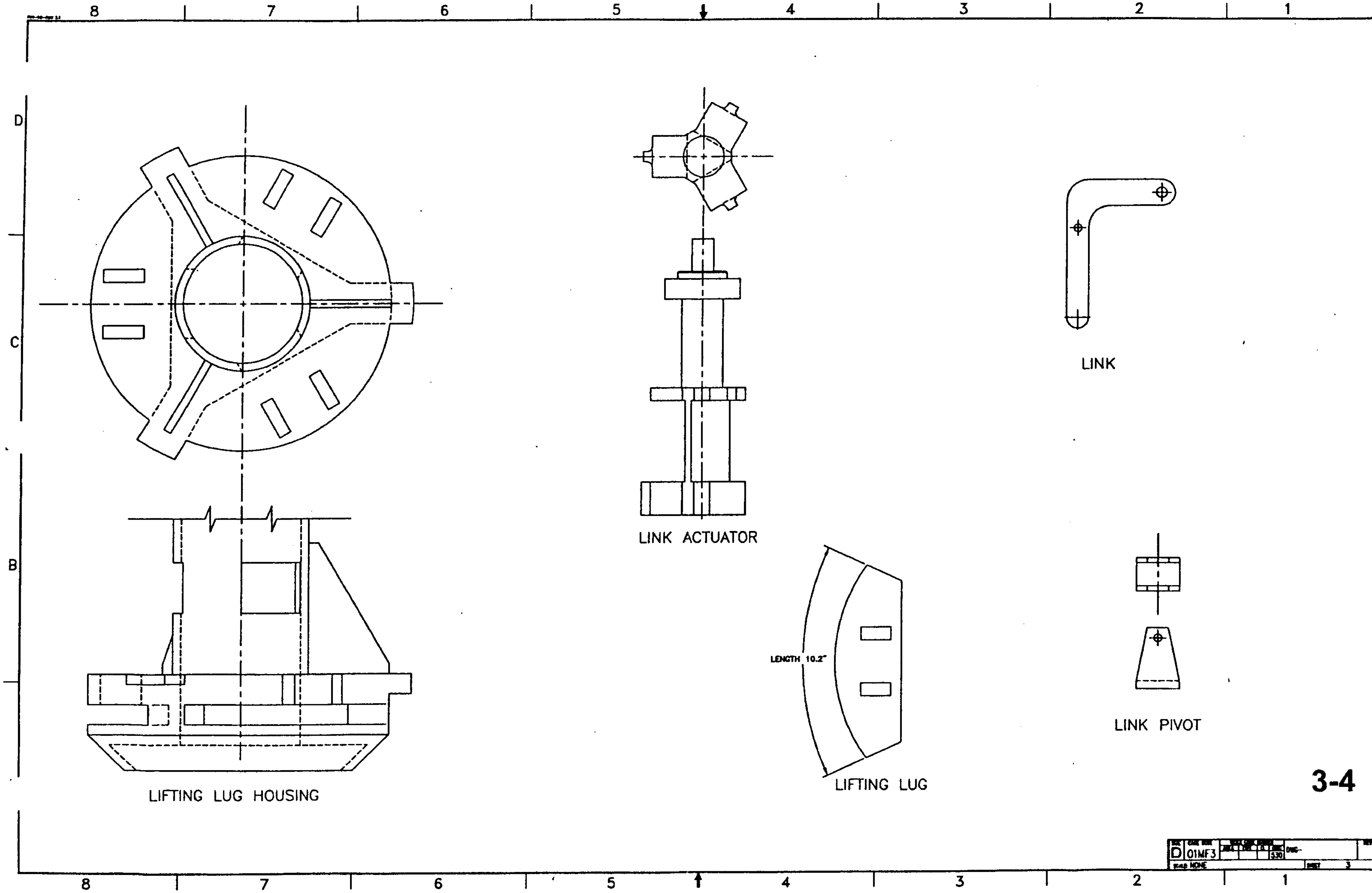
1. THE OVERALL LENGTH TO BE DETERMINED FOR THE FACILITY THE TOOL WILL BE USED IN.
2. THE LOAD LOCKING ASSEMBLY WILL INCORPORATE A MICRO SWITCH OR OTHER DEVICE TO PREVENT THE OPERATION OF THE OPERATING CYLINDER WHILE THE GRAPPLE IS UNDER A LOAD.



3-3

SPECIAL PURPOSE

DRAWN H HENDRICKS	LOCKHEED MARTIN
SPEC CODE SPECPURP	CANISTER REMOTE GRAPPLE LAYOUT
SIZE D	CAGE CODE 01MF3
SCALE NONE	SHEET 1 OF 1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LINK ACTUATOR
LENGTH 10.2"
LIFTING LUG
LINK
LINK PIVOT
3-4
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