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DOCKET NO. 72-1015

UMS®
UNIVERSAL MPC SYSTEM®

SAFETY ANALYSIS REPORT

for the

UMS® UNIVERSAL STORAGE CASK

Amendment for
MAINE YANKEE ATOMIC POWER COMPANY
Site Specific Spent Fuel

February 2000 UMSS-00A

NAC
INTERNATIONAL

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12A-3	Revision UMSS-00A
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12A1-2	Revision UMSS-00A
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Table 1-1 Terminology

Universal Storage System	The storage component of the Universal MPC System (UMS®) designed by NAC for the storage and transportation of spent nuclear fuel.
Universal Transport Cask	The packaging consisting of a Universal Transport Cask body with a closure lid and energy-absorbing impact limiters. The Universal Transport Cask is used to transport a Transportable Storage Canister containing spent fuel. The cask body provides the primary containment boundary during transport.
Confinement System	The components of the Transportable Storage Canister intended to retain the radioactive material during storage.
Contents	Twenty-four PWR fuel assemblies, or fifty-six BWR fuel assemblies. The fuel assemblies may be configured as Site Specific Fuel. The fuel assemblies are contained in a Transportable Storage Canister.
Standard Fuel	Irradiated fuel assemblies having the same configuration as when originally fabricated consisting generally of the end fittings, fuel rods, guide tubes, and integral hardware. For BWR fuel, the channel is considered to be integral hardware. The design basis fuel characteristics and analysis are based on the standard fuel configuration.
Consolidated Fuel	A nonstandard fuel configuration in which the individual intact fuel rods from one or more fuel assemblies are placed in a single container or a lattice structure that is similar to a fuel assembly.

Table 1-1 Terminology (Continued)

Intact Fuel (Assembly or Rod) (Undamaged Fuel)	A fuel assembly or fuel rod with no fuel rod cladding defects, or with known or suspected fuel rod cladding defects not greater than pinhole leaks or hairline cracks that can be grappled, handled and moved in a normal manner, or A fuel assembly or fuel rod with known or suspected cladding defects greater than pinhole leaks or hairline cracks that can be grappled, handled and moved in a normal manner having an Engineering Evaluation showing that there is reasonable assurance that the defective fuel cladding will retain fuel pellets and fuel particulates in normal and off-normal storage conditions.
Damaged Fuel	A fuel assembly or fuel rod with known or suspected cladding defects greater than pinhole leaks or hairline cracks that cannot, by Engineering Evaluation, demonstrate reasonable assurance that fuel pellets or fuel particulates are retained by the defective fuel cladding in normal and off-normal storage conditions, or A fuel assembly that can not be grappled, handled, and moved in a normal manner, or A previously used fuel assembly lattice into which some damaged fuel rods have been inserted, or Fuel debris, including an intact or a partial fuel rod or an individual intact or partial fuel pellet not contained in a fuel rod. Fuel debris is inserted into a 9 x 9 array of tubes in a lattice that has approximately the same dimensions as a standard fuel assembly. Damaged fuel is placed in the Maine Yankee Fuel Can.

Table 1-1 Terminology (Continued)

Engineering Evaluation	A User determination of the integrity of a spent fuel assembly or a fuel rod with known or suspected cladding defects greater than pinhole leaks or hairline cracks that can be grappled, handled, and moved in a normal manner. The Engineering Evaluation must determine the ability of the fuel cladding to retain fuel pellets and particulates in normal and off-normal conditions of storage. Based on the results of the evaluation, the subject spent fuel shall be classified as Intact Fuel or as Damaged Fuel. Damaged Fuel must be placed in a Maine Yankee Fuel Can.
Site Specific Fuel	Spent fuel configurations that are unique to a site or reactor due to the addition of other components or reconfiguration of the fuel assembly at the site. It includes fuel assemblies which hold nonfuel-bearing components, such as control components or instrument and plug thimbles, or which are modified as required by expediency in reactor operations, research and development or testing. Modification may consist of individual fuel rod removal, fuel rod replacement of similar or dissimilar material or enrichment, the installation, removal or replacement of burnable poison rods, or containerizing damaged fuel. Site specific fuel includes irradiated fuel assemblies designed with variable enrichments and/or axial blankets, fuel that is consolidated and fuel that exceeds design basis fuel parameters.
Maine Yankee Fuel Can	A specially designed stainless steel screened can sized to hold an intact fuel assembly, consolidated fuel, or damaged fuel. The can screening precludes the release of gross particulates into the canister cavity.
Transportable Storage Canister (Canister)	The stainless steel cylindrical shell, bottom end plate, shield lid, and structural lid that contain the fuel basket structure and the contents.

Table 1-1 Terminology (Continued)

Shield Lid	A thick stainless steel disk that is located directly above the fuel basket. The shield lid comprises the first part of a double-welded closure system for the Transportable Storage Canister. The shield lid provides a containment/confinement boundary for storage and shielding for the contents.
- Drain Port	A penetration located in the shield lid to permit draining of the canister cavity.
- Vent Port	A penetration located in the shield lid to aid in draining and in vacuum drying and backfilling the canister with helium.
- Port Cover	The stainless steel covers that close the vent and drain ports, and that are welded in place following draining, drying, and backfilling operations.
- Quick Disconnect	The valved nipple used in the vent and drain ports to facilitate operations.
Structural Lid	A thick stainless steel disk that is positioned on top of the shield lid and welded to the canister. The structural lid is the second part of a double-welded closure system for the Transportable Storage Canister. The structural lid provides a confinement boundary for storage, shielding for the contents, and canister lifting/handling capability.
Fuel Basket (Basket)	The structure located within the Transportable Storage Canister that provides structural support, criticality control, and primary heat transfer paths for the fuel assemblies.
- Support Disk	The primary lateral load-bearing component of the fuel basket. The PWR support disk is a circular stainless steel plate with 24 square holes machined in a symmetrical pattern. The BWR support disk is a circular carbon steel plate with 56 square holes machined in a symmetrical pattern. Each square hole is a location for a fuel tube.

Table 1-1 Terminology (Continued)

- Heat Transfer Disk	A circular aluminum plate with 24 (PWR basket) or 56 (BWR basket) square holes machined in a symmetrical pattern. The heat transfer disk enhances heat transfer in the fuel basket.
- Fuel Tube	A stainless steel tube having a square cross-section with enclosed BORAL neutron poison material on its exterior surfaces. One fuel tube is inserted through each square hole in the support disks and heat transfer disks. Fuel assemblies are loaded into the fuel tube.
- Tie Rod	A stainless steel rod used to align, retain, and support the support disks and the heat transfer disks in the fuel basket structure. The tie rods extend from the top weldment to the bottom weldment.
- Spacer	Installed on the tie rod between the support disks (BWR only) or between the support disks and top and bottom weldments (BWR and PWR) to properly position the disks and provide axial support for the support disks.
- Split Spacer	Spacers installed on the tie rod between the support disks and the heat transfer disks to properly position the disks and provide axial support for the support disks and the heat transfer disks.
Vertical Concrete Cask (Concrete Cask)	A concrete cylinder that contains the Transportable Storage Canister during storage. The Vertical Concrete Cask is formed around a steel inner liner and base and is closed by a shield plug and lid.
- Shield Plug	A thick carbon steel plug installed in the top end of the Vertical Concrete Cask to reduce skyshine radiation. The shield plug contains a 1-inch thick neutron shield.
- Lid	A thick carbon steel plate that serves as the bolted closure for the Vertical Concrete Cask. The lid precludes access to the canister and provides additional radiation shielding.

Table 1-1 Terminology (Continued)

- Liner	A thick carbon steel shell that forms the annulus of the concrete cask. The liner serves as the inner form during concrete pouring and provides radiation shielding of the canister contents.
- Base	A carbon steel weldment that contains the air inlets, the concrete cask jacking points and the pedestal that supports the canister inside of the concrete cask.
Transfer Cask	A shielded lifting device for handling of the Transportable Storage Canister during loading of spent fuel, canister closure operations, and transfer of the canister into or out of the Vertical Concrete Cask during storage, or into or out of the Universal Transport Cask during transportation. The transfer cask incorporates bottom doors that permit the vertical loading of the storage and transport casks.
- Transfer Cask Lifting Trunnions	Four low alloy steel trunnions used to lift and move the transfer cask.
Adapter Plate	A carbon steel plate assembly that attaches to the top of the transport or concrete cask to facilitate installation and alignment of the transfer cask. It also provides the operating mechanism for the transfer cask bottom doors.
NS-4-FR	A solid, borated, hydrogenous, synthetic, polymer material with neutron absorption capabilities, similar to those of borated water. Developed by BISCO Products, Inc., NS-4-FR is now supplied by Japan Atomic Power Company.

Table 1-1 Terminology (Continued)

Air Pad Rig Set (Air Pallet)	A device used to lift the Vertical Concrete Cask by using high volume air.
Heavy Haul Trailer	The trailer used to transport the empty or loaded Vertical Concrete Cask.
Margin of Safety	An analytically determined value defined as the "factor of safety" minus 1. Factor of safety is also analytically determined, and is defined as the allowable stress or displacement of a material divided by its actual (calculated) value.

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1.3.2.1 Maine Yankee Site Specific Spent Fuel

The configurations of Maine Yankee site specific fuel assemblies that have been evaluated and found to be acceptable contents are:

- Fuel assemblies with up to 176 fuel rods removed from the assembly lattice.
- Fuel assemblies with fuel rods replaced with stainless steel rods, solid Zircaloy rods or fuel rods enriched to 1.95 wt %.
- Fuel assemblies with burnable poison rods replaced with hollow Zircaloy tubes.
- Fuel assemblies that are variably enriched with a maximum fuel rod enrichment of 4.21 wt % ^{235}U and that also have a maximum planar average enrichment of 3.99 wt % ^{235}U.
- Fuel assemblies with variable enrichment and/or annular axial blankets.
- Fuel assemblies with a control element inserted.
- Fuel assemblies with an instrument thimble inserted in the center guide tube.
- Fuel assemblies with up to two fuel rods inserted in any or all of the guide tubes.
- Consolidated fuel.
- Fuel assemblies having up to 100% of the rods damaged in each assembly.
- Fuel assemblies having a burnup of greater than 45,000 MWD/MTU but less than 50,000 MWD/MTU.

These site specific fuel configurations are evaluated against the limits established for the UMS® Storage System based on the design basis fuel. The site specific fuel is either shown to be bounded by the evaluation of the design basis fuel or is separately evaluated to establish limits which are maintained by preferential loading administrative controls. Where applicable to specific configurations, the preferential loading controls are described in Section 2.1.3.1.1. The preferential loading controls take advantage of design features of the UMS® Storage System to allow the loading of fuel configurations that may have higher burnup or additional hardware or fuel source material that is not specifically considered in the design basis fuel evaluation.

The Transportable Storage Canister loading procedures will indicate that the loading of a fuel configuration with removed fuel or poison rods, damaged or consolidated fuel in a Maine Yankee fuel can, or fuel with burnup above 45,000 MWD/MTU is administratively controlled in accordance with Section 2.1.3.1 and Table 2.1.3.1-1. As shown in the table, only one consolidated fuel lattice is loaded in any single canister. Preferential loading positions in the canister basket are shown in Figure 2.1.3.1-1.

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1.8 License Drawings

This section presents the list of License Drawings for the Universal Storage System.

1.8.1 License Drawings for the UMS® Universal Storage System

Drawing Number	Title	Revision No.	No. of Sheets
790-501	Canister/ Basket Assembly Table, NAC-UMS®	2	1
790-559	Assembly, Transfer Adapter, NAC-UMS®	1	3
790-560	Assembly, Transfer Cask (TFR) NAC-UMS®	6	5
790-561	Weldment, Structure, Vertical Concrete Cask (VCC), NAC-UMS®	4	2
790-562	Reinforcing Bar And Concrete Placement, Vertical Concrete Cask (VCC), NAC-UMS®	4	4
790-563	Lid, Vertical Concrete Cask (VCC), NAC-UMS®	2	1
790-564	Shield Plug, Vertical Concrete Cask (VCC), NAC-UMS®	2	1
790-565	Nameplate, Vertical Concrete Cask (VCC), NAC-UMS®	1	1
790-570	Fuel Basket Assembly, 56 Element BWR, NAC-UMS®	2	2
790-571	Bottom Weldment, Fuel Basket, 56 Element BWR, NAC-UMS®	2	1
790-572	Top Weldment, Fuel Basket, 56 Element BWR, NAC-UMS®	4	1
790-573	Support Disk and Misc. Basket Details, 56 Element BWR, NAC-UMS®	6	1
790-574	Heat Transfer Disk, Fuel Basket, 56 Element BWR, NAC-UMS®	3	1
790-575	BWR Fuel Tube, NAC-UMS®	3	2
790-581	PWR Fuel Tube, NAC-UMS®	4	2
790-582	Shell Weldment, Canister, NAC-UMS®	5	1
790-583	Assembly, Drain Tube, Canister, NAC-UMS®	3	1
790-584	Details, Canister, NAC-UMS®	7	2
790-585	Transportable Storage Canister (TSC), NAC-UMS®	6	2
790-590	Loaded Vertical Concrete Cask (VCC), NAC-UMS®	1	1
790-591	Bottom Weldment, Fuel Basket, 24 Element PWR, NAC-UMS®	2	1

License Drawings
(Continued)

Drawing Number	Title	Revision No.	No. of Sheets
790-592	Top Weldment, Fuel Basket, 24 Element PWR, NAC-UMS®	4	1
790-593	Support Disk and Misc. Basket Details, 24 Element PWR, NAC-UMS®	4	1
790-594	Heat Transfer Disk, Fuel Basket, 24 Element PWR, NAC-UMS®	2	1
790-595	Fuel Basket Assembly, 24 Element PWR, NAC-UMS®	3	2
790-605	BWR Fuel Tube, Over-Sized Fuel, NAC-UMS®	4	2

1.8.2 Site Specific Spent Fuel License Drawings

Drawing Number	Title	Revision No.	No. of Sheets
412-501	Spent Fuel Can Assembly, Maine Yankee (MY), NAC-UMS®	1	1
412-502	Fuel Can Details, Maine Yankee (MY), NAC-UMS®	1	2

DCR No.	REVISION
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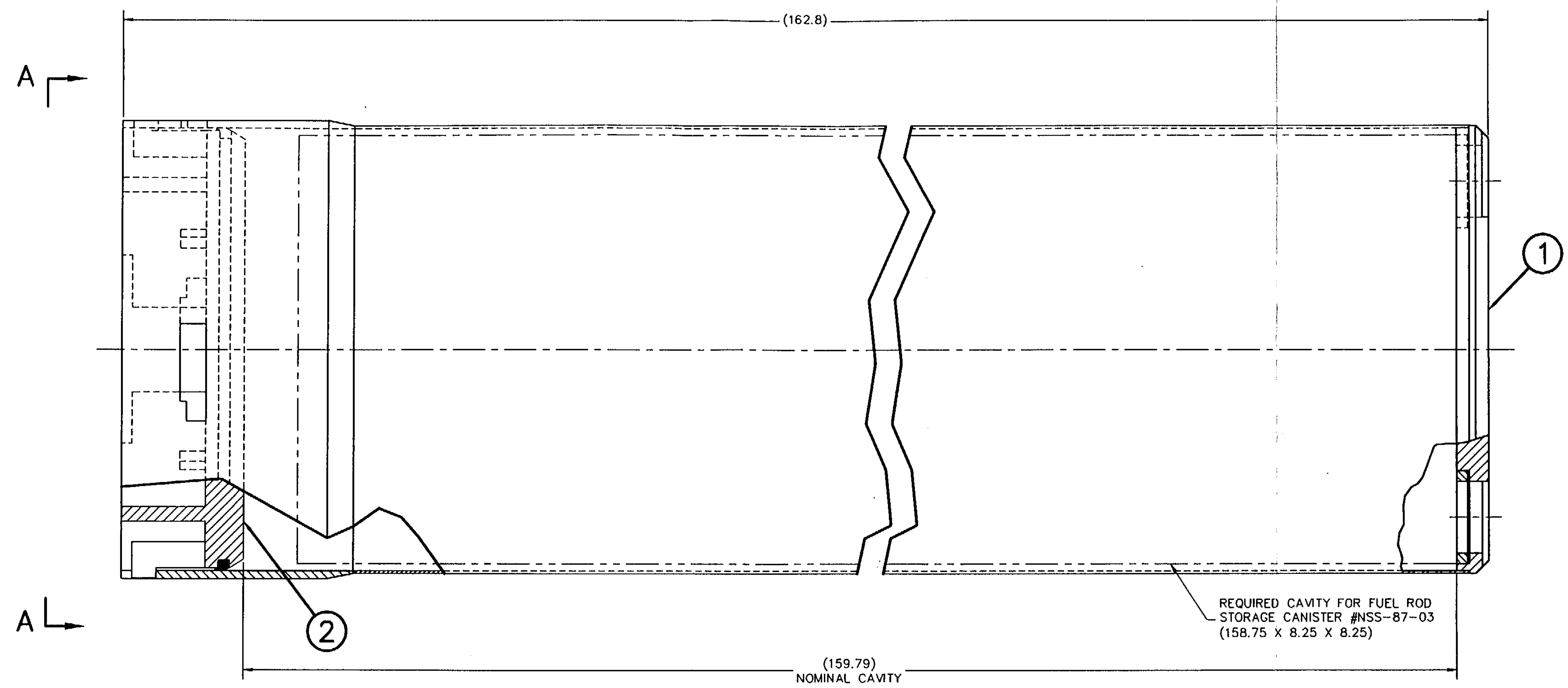
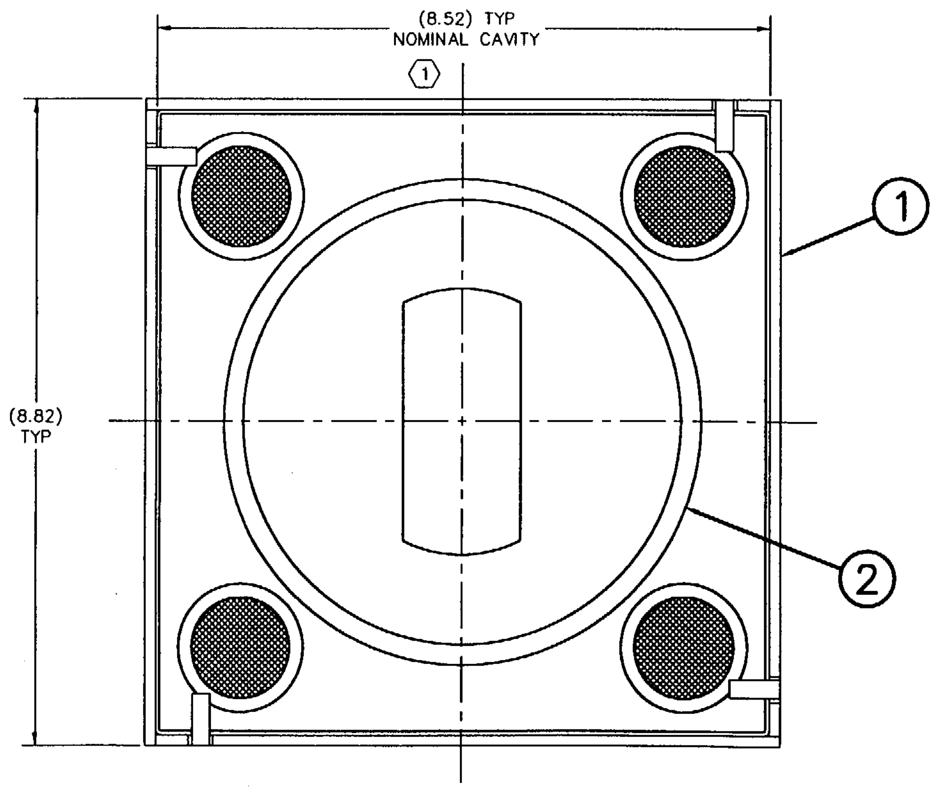
1	INC DCR 0A



⟨1⟩ 99 SPENT FUEL CAN ASSEMBLY



⟨1⟩ VIEW A–A

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				1	1	SPENT FUEL CAN WELDMENT			412-502-99	
ASSY	ASSY	ASSY	ASSY	ASSY						

QUANTITY

NAC INTERNATIONAL

DIMENSIONING AND TOLERANCING SHALL BE PER ANSI Y14.5–82
UNSPECIFIED DIMENSIONS AND TOLERANCES SHOWN BELOW.
DIMENSIONS ARE IN INCHES. FRACTIONAL TOLERANCE: ±1/8

SYM.	GEOMETRY	.XXX	TOL.	.XX	TOL.
⏥	FLATNESS	UNDER 3		UNDER 6	±.04
—	STRAIGHTNESS	3–12		6–18	±.06
∠	ANGULARITY	OVER 12		OVER 18	±.09
⊥	PERPENDICULARITY	.X	±.1	ANGLES ±.5°	
//	PARALLELISM	ALL UNSPECIFIED TOOL RADII: .01 – .03			
◎	CONCENTRICITY	BREAK ALL SHARP CORNERS .01 – .03			
⌖	TRUE POSITION	ALL UNSPECIFIED MACHINED SURFACES SHALL BE ▽ OR BETTER			

NEXT ASSEMBLY:
DRAWING TYPE: LICENSE

GROUP	NAME	DATE
PREPARER	R. Walker	2-3-2000
CHECKER		2/3/00
PROJECT MANAGER		2/3/00
DIRECTOR DESIGN AND ANALYSIS		2/3/00
DIRECTOR LICENSING		2/4/00
VICE PRESIDENT QUALITY		2/4/00

SPENT FUEL CAN ASSEMBLY
MAINE YANKEE (MY)
NAC–UMS®

PROJECT 412	DRAWING 501	REV 1
SCALE FULL	EST.WT. 133#	SH 1 OF 1	11:07AM 2-3-2000

DCR No.	REVISION
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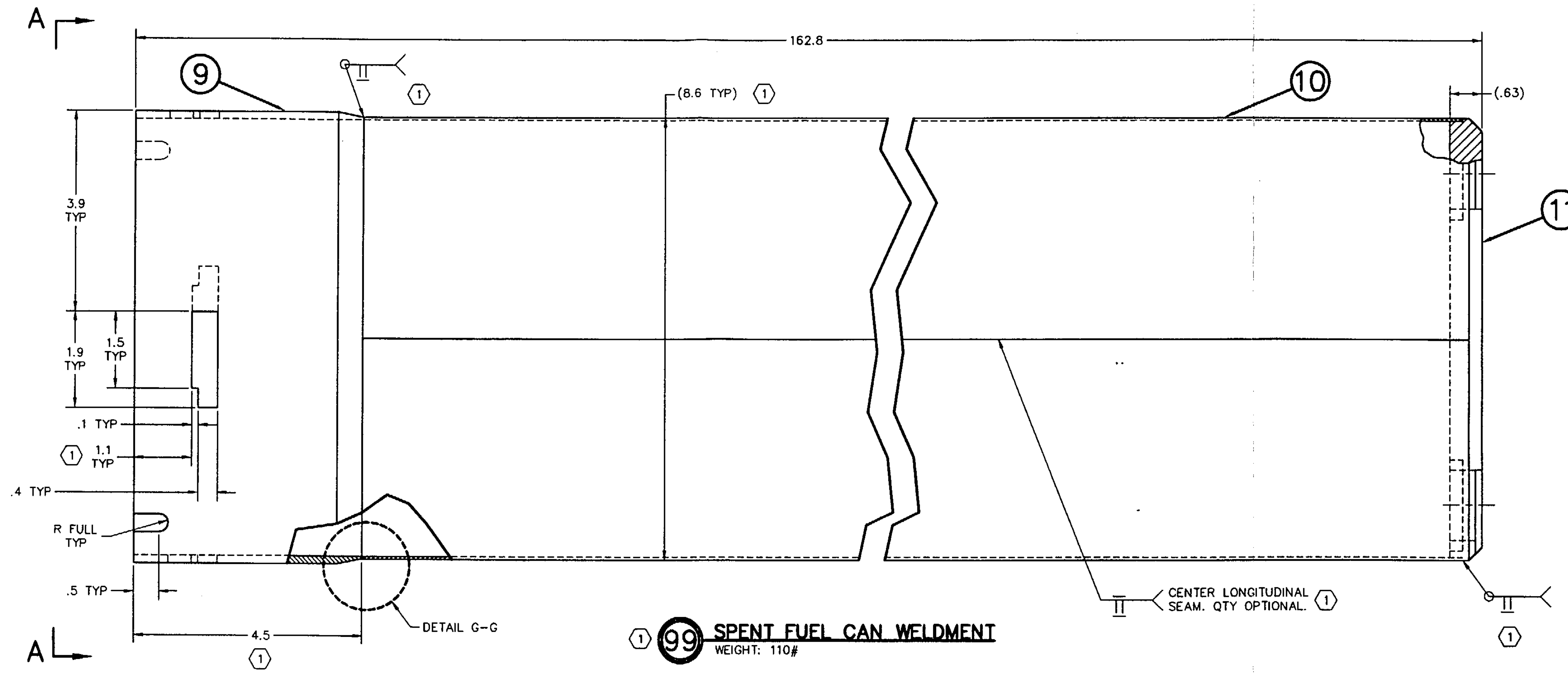
1	INC DCR 0A



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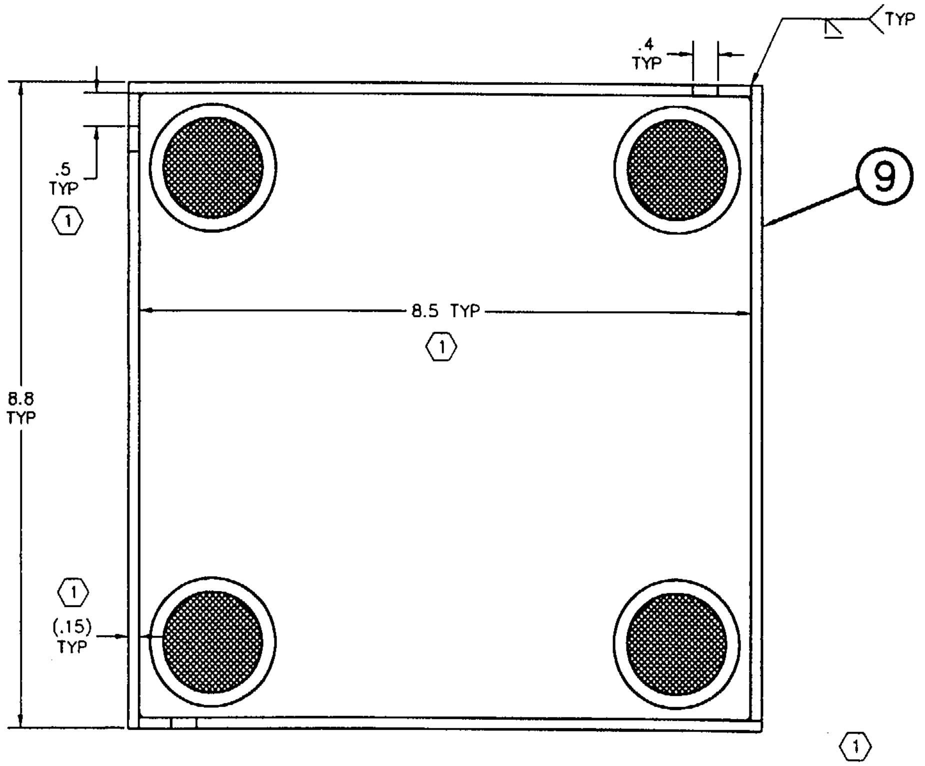

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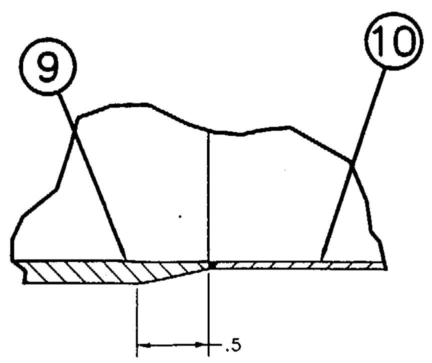

DETAIL G—G
SCALE: 2/1

3. THE FUEL CAN SHALL BE LOAD TESTED TO 3,400 LB AND VISUALLY INSPECTED FOLLOWING COMPLETION OF FABRICATION.

2. VISUALLY INSPECT (VT) ALL WELDS IN ACCORDANCE WITH ASME SECTION V, ARTICLE 9. ACCEPTANCE PER ASME SECTION III, NG-5360.

1. ALL WELDING PROCEDURES AND QUALIFICATIONS TO BE IN ACCORDANCE WITH ASME SECTION IX.

95 ASSY	96 ASSY	97 ASSY	98 ASSY	99 ASSY	ITEM	NAME	MATERIAL	SPEC	DRAWING No.	DESCRIPTION
			1		13	SUPPORT RING	304 ST. STL.	ASME SA312		6" SCH 40 PIPE
			1		12	LIFT TEE	304 ST. STL.	ASME SA240/SA479		PLATE/BAR
				1	11	BOTTOM ASSEMBLY			412-102-97	
				1	10	TUBE BODY	304 ST. STL.	ASME SA240		18 GAGE SHEET
				4	9	SIDE PLATE	304 ST. STL.	ASME SA240/SA479		PLATE/BAR
		1			8	BOTTOM PLATE	304 ST. STL.	ASME SA240		5/8 PLATE
		AR	AR		7	BACKING SCREEN	ST. STL.	COML		NEWARK ZQ1 16 X 16 .023
		AR	AR		6	FILTER SCREEN	ST. STL.	COML		NEWARK PAC 250 X 250 X .0016
					5	DELETED				
			1		4	WIPER	SILICONE	COML		1/4 THICK, MCMASTER #85925K103
			4		3	LID GUIDE	304 ST. STL.	ASME SA240/SA479		1/4 PLATE/BAR
			1		2	LID PLATE	304 ST. STL.	ASME SA240		3/4 PLATE
		4	4		1	COLLAR	304 ST. STL.	ASME SA240/SA479		PLATE/BAR

QUANTITY

NAC INTERNATIONAL

DIMENSIONING AND TOLERANCING SHALL BE PER ANSI Y14.5-82 UNSPECIFIED DIMENSIONS AND TOLERANCES SHOWN BELOW. DIMENSIONS ARE IN INCHES. FRACTIONAL TOLERANCE: ±1/8

SYM.	GEOMETRY	.XXX	TOL.	.XX	TOL.
▱	FLATNESS	UNDER 3		UNDER 6	±.04
—	STRAIGHTNESS	3-12		6-18	±.06
∠	ANGULARITY	OVER 12		OVER 18	±.09
⊥	PERPENDICULARITY	.X	±.1	ANGLES ±.5°	
//	PARALLELISM	ALL UNSPECIFIED TOOL RADII: .01 - .03			
◎	CONCENTRICITY	BREAK ALL SHARP CORNERS .01 - .03			
⊕	TRUE POSITION	ALL UNSPECIFIED MACHINED SURFACES SHALL BE ∀ OR BETTER			

NEXT ASSEMBLY: 412-501
DRAWING TYPE: LICENSE

GROUP	NAME	DATE
PREPARER	MAR for RAW	2-3-00
CHECKER	[illegible]	2/3/00
PROJECT MANAGER	[illegible]	2/3/00
DIRECTOR DESIGN AND ANALYSIS	[illegible]	2/3/00
DIRECTOR, LICENSING	LC Thompson	2/4/00
VICE PRESIDENT, QUALITY	B Bandtner	2/4/00

FUEL CAN DETAILS
MAINE YANKEE (MY)
NAC-UMS®

PROJECT 412
DRAWING 502
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SH 1 OF 2
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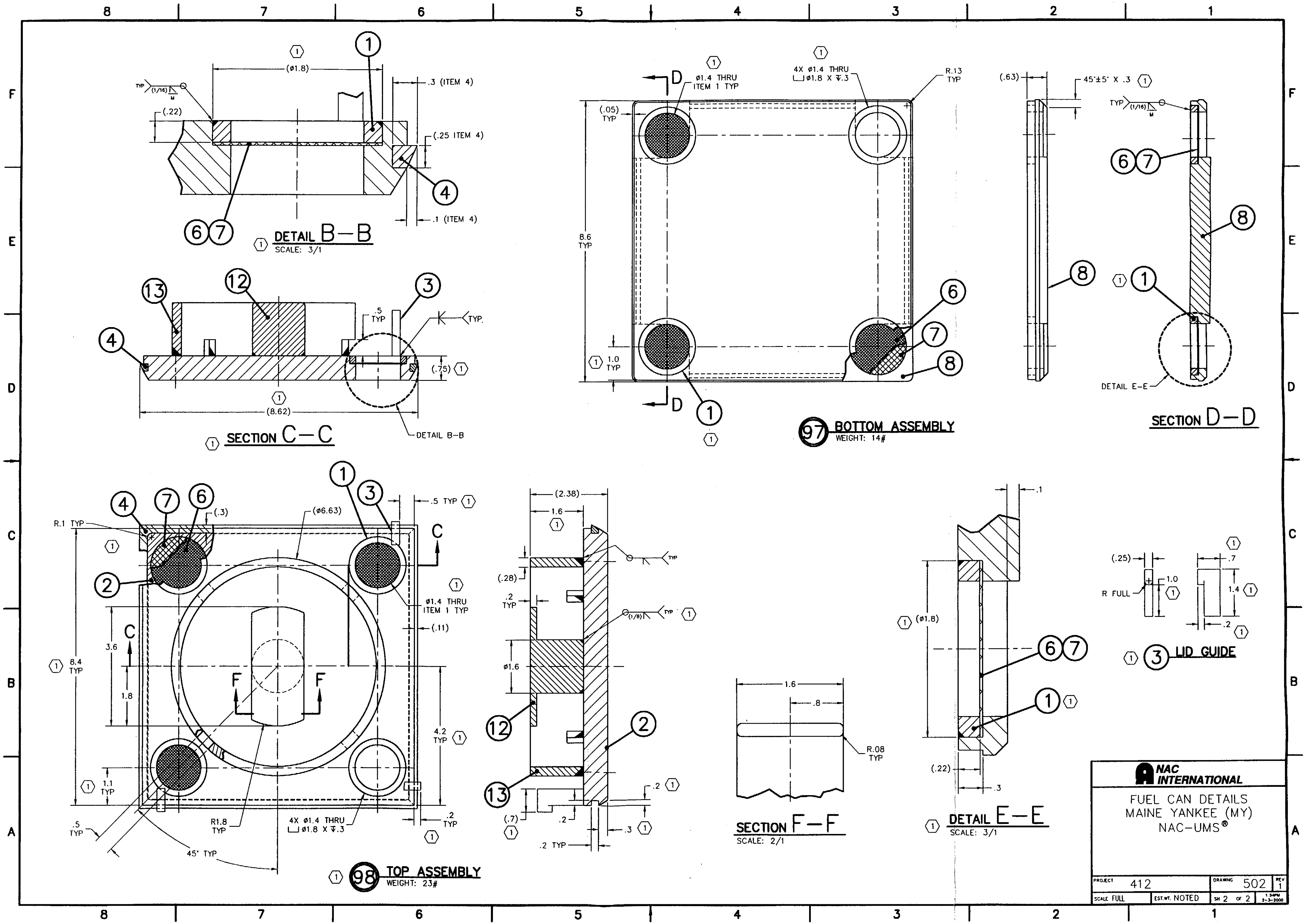

NAC INTERNATIONAL

FUEL CAN DETAILS
MAINE YANKEE (MY)
NAC-UMS®

PROJECT 412
DRAWING 502
REV 1
SCALE FULL
EST.WT. NOTED
SH 2 OF 2
1:34PM 3-3-2000

List of Figures

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2.1.3 Site Specific Spent Fuel

The UMS® Storage System design basis PWR fuel assemblies are described in Section 2.1.1. Four different assembly arrays: 14 x 14, 15 x 15, 16 x 16 and 17 x 17, produced by several different fuel vendors, were evaluated in the determination of the PWR design basis fuel.

The design basis BWR fuel assemblies are described in Section 2.1.2. Three different arrays: 7 x 7, 8 x 8 and 9 x 9, produced by several different fuel vendors were evaluated in the determination of the UMS® BWR design basis fuel.

This section describes site specific spent fuel, i.e., fuel assemblies that are configured differently or that have different fuel parameters, such as enrichment or burnup, than the design basis fuel assemblies. The site specific fuel configurations result from conditions that occurred during reactor operations, participation in research and development programs, testing programs intended to improve reactor operations or from the insertion of control components or other items within the fuel assembly.

A summary description of the site specific spent fuels is presented in Section 1.3.2. The site specific spent fuel configurations are either shown to be bounded by the design basis fuel analysis or are separately evaluated. Unless specifically excepted, site specific spent fuel must also meet the conditions specified for the design basis fuel presented in Section 1.3.1.

2.1.3.1 Maine Yankee Site Specific Spent Fuel

The Maine Yankee site specific spent fuel assemblies are categorized as intact (undamaged) or damaged as defined in Table 1-1. All damaged fuel and certain undamaged fuel configurations are placed in a Maine Yankee fuel can for storage in the Transportable Storage Canister.

The configurations of Maine Yankee site specific spent fuel that have been evaluated and found to be acceptable contents are summarized in Section 1.3.2.1, and include those standard fuel assembly configurations, which were modified by the installation or removal of fuel or non fuel-bearing components.

The three principal types of these modifications are:

- The removal of fuel rods without replacement.
- The replacement of removed fuel rods or burnable poison rods with rods of another material, such as stainless steel, or with fuel rods of a different enrichment.
- The insertion of control elements, or instrument or plug thimbles, in guide tube positions.

Site specific spent fuel also includes fuel assemblies that are uniquely designed to support reactor physics. These fuel assemblies include those that are variably enriched or that are variably enriched with annular axial blankets. Generally, these fuel assemblies (described in Sections 6.6.1.2.2 and 6.6.1.2.3) are bounded by the evaluation of the design basis fuel.

As described in Section 2.1.3.1.6, certain of the site specific spent fuel configurations, including damaged and consolidated fuel, must be preferentially loaded in corner positions of the PWR fuel basket. In addition, certain of the site specific fuel has experienced burnup that exceeds the 45,000 MWD/MTU design basis burnup. The thermal evaluation of these fuel assemblies is presented in Section 4.5.1. The results of that evaluation show that a fuel assembly with a burnup between 45,000 and 50,000 MWD/MTU must be preferentially loaded in peripheral fuel positions in the basket.

2.1.3.1.1 Damaged Fuel Lattices

There are two lattices for damaged fuel rods in the current Maine Yankee fuel inventory, designated CF1 and CA3, that are loaded in Maine Yankee fuel cans. CF1 is a lattice having roughly the same dimensions as a standard fuel assembly. It is a 9 x 9 array of tubes, some of which contain damaged fuel rods. CA3 is a previously used fuel assembly lattice that has had all of the rods removed, and into which, damaged fuel rods have been inserted. The CF1 and CA3 lattices are placed in a Maine Yankee fuel can for storage. No credit is taken for the lattice structures in the criticality, structural, or thermal analysis.

2.1.3.1.2 Maine Yankee Consolidated Fuel

The Maine Yankee fuel inventory includes two consolidated fuel lattices, which house intact fuel rods taken from three fuel assemblies. Each lattice is a 17x17 array formed using stainless steel grids and top and bottom stainless steel end fittings. Four solid stainless steel connector rods connect the end fittings. The top end fitting is designed so that the lattice can be handled by the standard fuel assembly lifting fixture (grapple). These lattices were not used in the reactor and the stainless steel hardware is not activated.

One of these lattices contains 283 fuel rods and 2 rod position vacancies. The other contains 172 fuel rods, with the 76 stainless steel dummy rods in the outer periphery of the lattice.

The consolidated fuel is placed in a Maine Yankee fuel can for storage. No credit is taken for the lattice structures in the criticality, structural, or thermal analysis.

2.1.3.1.3 Maine Yankee Spent Fuel with Inserted Integral Hardware

Certain Maine Yankee fuel assemblies have either a Control Element Assembly or an Instrument Thimble inserted in the fuel assembly. These components add to the gamma radiation source term of the standard fuel assembly.

A Maine Yankee Control Element Assembly (CEA) consists of five control rods mounted on a Type 304 stainless steel spider assembly. The five control rods are inserted in the fuel assembly guide tubes when the CEA is inserted in the fuel assembly. When fully inserted, the control element spider rests on the fuel assembly upper end fitting. The rods are fabricated from Inconel 625 or stainless steel and encapsulate B_4C as the primary neutron poison material. Fuel assemblies with a control element installed must be loaded into a Class 2 canister because of the additional height that the control element spider adds to the fuel assembly overall length.

Some standard fuel assemblies have an in-core instrument thimble inserted in the center guide tube of the fuel assembly. The detector material and lead wire have been removed from the thimble assembly. The thimble top end and tube are primarily Zircaloy. When installed, the instrument thimble does not add to the overall fuel assembly length. Consequently, fuel assemblies with instrument thimbles are loaded in the Class 1 canister.

2.1.3.1.4 Maine Yankee Spent Fuel with Unique Design

Certain Maine Yankee fuel assemblies were uniquely designed to accommodate reactor physics. These assemblies incorporate variable radial enrichment and axial blankets.

Two batches of fuel used at Maine Yankee contain variably enriched fuel rods. The maximum fuel rod enrichment of one batch is 4.21 wt % ^{235}U with the variably enriched rods enriched to 3.5 wt % ^{235}U. The maximum planar average enrichment of this batch is 3.99 wt % ^{235}U. For the other batch, the maximum fuel rod enrichment is 4.0 wt % ^{235}U, with the variably enriched rods enriched to 3.4 wt % ^{235}U. The maximum planar average enrichment of this batch is 3.92 wt % ^{235}U.

One batch of variably enriched fuel also incorporates axial end blankets with fuel pellets that have a center hole, referred to as annular fuel pellets. Annular fuel pellets are used in the top and bottom 5% of the active fuel length of each fuel rod in this batch.

2.1.3.1.5 Maine Yankee Fuel Can

Fuel assemblies classified as damaged and certain undamaged fuel configurations are loaded in a Maine Yankee fuel can, which is shown in Drawings 412-501 and 412-502. The fuel can may be loaded only in a corner position in the basket. The fuel can analysis assume the failure of 100 % of the fuel rods held in the fuel can.

The fuel can is sized to accommodate a fuel assembly and to be inserted in a corner position of the fuel basket. As shown in the drawings, the can is 162.8 inches in length and has an external square dimension of 8.62 inches and an internal square dimension of 8.52 inches. In the top 4.5 inches the external square dimension is 8.82 inches. The fuel can is closed on the bottom end by a 0.63-inch thick plate that is welded to the can shell. The plate has drilled holes in each corner to allow water to drain from the can. A screen covers the holes to preclude the release of gross particulates from the fuel can. A lid having an overall depth dimension of 2.38 inches closes the can. The lid is not secured to the can shell, but is held in place when the shield lid is installed in the canister. The lid also has four drilled and screened holes. The damaged fuel is inserted in the fuel can and the lid is installed. Lifting lugs in the can shell allow the loaded can to be lifted and installed in the basket. Alternately, the fuel can may be inserted in a basket corner position before the damaged fuel assembly is inserted in the fuel can.

A Maine Yankee fuel can containing fuel debris with greater than 20 Curies of plutonium, requires double containment for transport conditions in accordance with 10 CFR 71.63 (b).

The Maine Yankee fuel can design and fabrication specification summary is provided in Table 2.1.3.1-2. The major physical design parameters of the Maine Yankee fuel can are provided in Table 2.1.3.1-3. The structural evaluation of the Maine Yankee site specific fuel configurations is provided in Section 3.6.1. As shown in Section 4.5.1, the maximum allowable heat load for the contents of a Maine Yankee fuel can is 0.958 kW.

2.1.3.1.6 Maine Yankee Site Specific Spent Fuel Preferential Loading

The estimated Maine Yankee site specific spent fuel inventory is shown in Table 2.1.3.1-1. (Note that the population of fuel in a given configuration may change based on future spent fuel inspection or survey.) As shown in this table, certain fuel configurations are preferentially loaded to take advantage of the design features of the Transportable Storage Canister and basket to allow the loading of fuel that does not specifically conform to the design basis spent fuel. The designated preferential loading positions are shown in Figure 2.1.3.1-1. The corner positions are designated by the letter "C." These positions are used primarily for the loading of fuel with missing fuel rods, fuel with fuel rods that have been replaced by rods of other material, for consolidated fuel lattices, and for damaged fuel. The requirements for preferential loading schemes using the corner positions result primarily from shielding or criticality evaluations of the designated fuel configurations.

Maine Yankee consolidated fuel is loaded in a Maine Yankee fuel can and is, therefore, designated for a corner position. Preferential loading is also used for spent fuel having a burnup between 45,000 and 50,000 MWD/MTU. This fuel is assigned to peripheral locations designated by the letter "P" in Figure 2.1.3.1-1. The thermal analysis supporting the use of these locations for higher burnup fuel is presented in Section 4.5.1. As described in that section, the interior locations must be loaded with fuel that has lower burnup and/or longer cool times in order to maintain the design basis heat load and component temperature limits. Loading tables, which provide the limits for decay heat on a per assembly basis, are also provided in Section 4.5.1.

Fuel assemblies with a control element inserted will be loaded in a Class 2 canister and basket for storage and transport due to the increased length of the assembly with the control element installed. However, these assemblies are not restricted as to loading position within the basket.

Figure 2.1.3.1-1 Preferential Loading Diagram for Maine Yankee Site Specific Spent Fuel

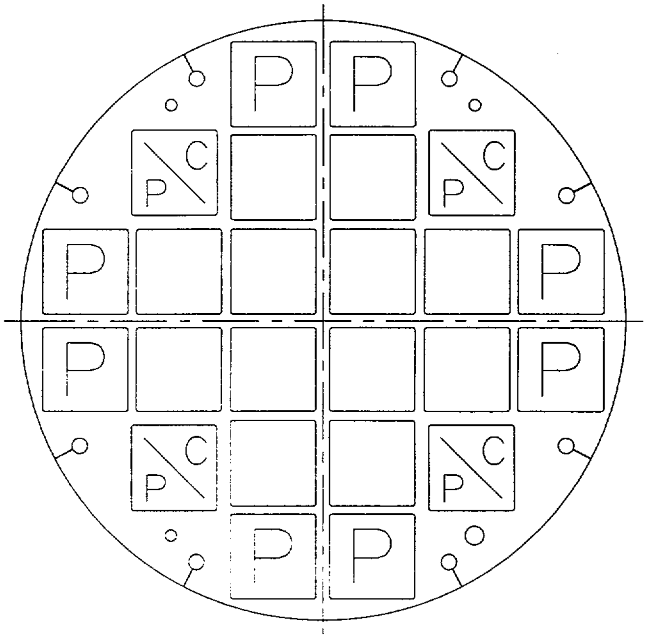

Table 2.1.3.1-1 Maine Yankee Site Specific Fuel Population

Site Specific Spent Fuel Configuration[1]	Number of Assemblies[2]	Canister Loading Position
Inserted Control Element Assembly (CEA)[3,4,5]	168	Any
Inserted In-Core Instrument (ICI) Thimble	138	Any
Consolidated Fuel	2	Corner[6,7,8]
Fuel Rod Replaced by Rod Enriched to 1.95 wt %	3	Any
Fuel Rod Replaced by Stainless Steel Rod or Zircaloy Rod	18	Any
Fuel Rods Removed	10	Corner
Variable Enrichment	72	Any
Variable Enrichment and Axial Blanket	68	Any
Burnable Poison Rod Replaced by Hollow Zircaloy Rod	80	Corner
Damaged Fuel[9,10]	12	Corner
Burnup between 45,000 and 50,000 MWD/MTU	90	Periphery[11]

1. The total number of fuel assemblies in inventory is approximately 1,434.
2. The number of fuel assemblies in some categories may vary depending on future fuel inspections and/or Engineering Evaluations.
3. A fuel assembly with an inserted CEA must be loaded in a Class 2 canister.
4. A fuel assembly without an inserted CEA must not be loaded in a Class 2 canister.
5. CEAs may not be inserted in damaged fuel assemblies, consolidated fuel assemblies or assemblies with irradiated stainless steel replacement rods.
6. Basket corner positions are positions 3, 6, 19, and 22 in Figure 12B2-1. Corner positions are also periphery positions.
7. Only one Consolidated Fuel lattice may be loaded in any Transportable Storage Canister.
8. Consolidated Fuel must be loaded in a Maine Yankee fuel can.
9. All fuel classified as damaged must be placed in a Maine Yankee fuel can, including fuel assemblies with damaged fuel rods or poison rods inserted in guide tubes.
10. All spent fuel, including that held in a Maine Yankee fuel can, must conform to the loading limits presented in Tables 12B2-8 and 12B2-9 for cool time.
11. Basket periphery positions are positions 1, 2, 3, 6, 7, 12, 13, 18, 19, 22, 23, and 24 in Figure 12B2-1. Periphery positions include the corner positions.

Table 2.1.3.1-2 Maine Yankee Fuel Can Design and Fabrication Specification Summary

Design

- The Maine Yankee Fuel Can shall be designed in accordance with ASME Code, Section III, Subsection NG except for: 1) the noted exceptions of table 12B3-1 for fuel basket structures; and 2) the Maine Yankee Fuel Can may deform under accident conditions of storage.
- The Maine Yankee Fuel Can will have screened vents in the lid and base plate. Stainless steel meshed screens (250x250) shall cover all openings.
- The Maine Yankee Fuel Can shall limit the release of material from damaged fuel assemblies and fuel debris to the canister cavity.
- The Maine Yankee Fuel Can lifting structure and lifting tool shall be designed with a minimum factor of safety of 3.0 on material yield strength.

Materials

- All material shall be in accordance with the referenced drawings and meet the applicable ASME Code sections.
- All structural materials are ASME SA 240, Type 304 stainless steel.

Welding

- All welds shall be in accordance with the referenced drawings.
- All welds specified to be visually examined shall be examined as specified in ASME Code Section V, Article 9 with acceptance per ASME Code, Section NG-5360.

Fabrication

- All cutting, welding, and forming shall be in accordance with ASME Code Section III, NG-4000.

Acceptance Testing

- The Maine Yankee Fuel Can (first unit) and handling tool shall be load tested and visually inspected at the completion of fabrication.

Quality Assurance

- The Maine Yankee Fuel Can shall be constructed under a quality assurance program that meets 10 CFR 72 Subpart G. The quality assurance program must be accepted by NAC International and the licensee prior to initiation of the work.
- A Certificate of Conformance (or Compliance) shall be issued by the fabricator stating that the component meets the specifications and drawings.

Table 2.1.3.1-3 Major Physical Design Parameters of the Maine Yankee Fuel Can

Parameter	**Value**
Overall Length (in.)	162.8
Inside Cross Section (in.)	8.52 x 8.52
Outside Cross Section (in.) (1)	8.62 x 8.62
Can Wall Thickness	18 Gauge (0.048 in.)
Internal Cavity Length (in.)	160.0
Empty Weight (nominal) (lbs.)	130

Note (1) Outside cross section of Maine Yankee Fuel Can upper structure is 8.82 x 8.82 in. at top (4.5 in.) for lid engagement and fuel can lifting. This upper structure is located above the top weldment plate of the fuel basket assembly.

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3.4.5 Cold

Severe cold environments are evaluated in Section 11.1.1. Stress intensities corresponding to thermal loads in the canister are evaluated by using a finite element model as described in Section 3.4.4.1. The thermal stresses that occur in the canister as a result of the maximum off-normal temperature gradients in the canister are bounded by the analysis of extreme cold in Section 11.1.1.

The PWR canister and basket are fabricated from stainless steel and aluminum, which are not subject to a ductile-to-brittle transition in the temperature range of interest. The BWR canister and basket are fabricated from stainless steel, aluminum, with carbon steel support disks. The carbon steel support disk thickness, 5/8 in., is selected to preclude brittle fracture at the design basis low temperature (-40°F). However, low temperature handling limits do apply to the transfer cask (See Section 12.2.2.9).

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the can to minimize the potential for dispersal of the fuel material into the canister cavity volume.

The Maine Yankee fuel can is designed to intact, damaged and consolidated fuel currently in the Maine Yankee fuel inventory.

The fuel can is a square cross-section tube made of Type 304 stainless steel with a total length of 162.8 inches. The can walls are 0.048-inch thick sheet (18 gauge). The minimum internal width of the can is 8.52 inches. The bottom of the can is a 0.63-inch thick plate. Four holes in the plates, screened with a Type 304 stainless steel wire screen (250 openings/inch x 250 openings/inch mesh), permit water to be drained from the can during loading operations. Since the bottom surface of the fuel can rests on the canister bottom plate, additional slots are machined in the fuel can (extending from the holes to the side of the bottom assembly) to allow the water to be drained from the can. At the top of the can, the wall thickness is increased to 0.15-inches to permit the can to be handled. Slots in the top assembly side plates allow the use of a handling tool to lift the can and contents. To confine the contents within the can, the top assembly consists of a 0.88-inch thick plate with screened drain holes identical to those in the bottom plate. Once the can is loaded, the can and contents are inserted into the basket, where the can may be supported by the sides of the fuel assembly tube, which are backed by the structural support disks. Alternately, the empty fuel can may be placed in the basket prior to having the designated contents inserted in the fuel can.

In normal operation, the can is in a vertical position. The weight of the fuel can contents is transferred through the bottom plate of the can to the canister bottom plate, which is the identical load path for intact fuel. The only loading in the vertical direction is the weight of the can and the top assembly. The lifting of the can with its contents is also in the vertical direction.

Classical hand calculations are used to qualify the stresses in the Maine Yankee fuel can.

A conservative bounding temperature of 600°F is used for the evaluation of the fuel can for normal conditions of storage. A temperature of 300°F is used for the lifting components at the top of the fuel can and for the lifting tool.

Calculated stresses are compared to allowable stresses in accordance with ASME Code, Section III, Subsection NG.

The ASME Code, Section III, Subsection NG allowable stresses used for stress analysis are:

Property	600°F	300°F
S_u	63.3 ksi	66.0 ksi
S_y	18.6 ksi	22.5 ksi
S_m	16.7 ksi	20.0 ksi
E	25.2×10^3 ksi	27.0×10^3 ksi

The Maine Yankee fuel can is evaluated for dead weight and handling loads for normal conditions of storage. Since the can is not restrained, it is free to expand. Therefore, the thermal stress is considered to be negligible.

The Maine Yankee fuel can lifting components and handling tools are designed with a safety factor of 3.0 on material yield strength.

3.6.1.2.1 Dead Weight and Handling Loading Evaluation

The weight of the Maine Yankee fuel can is 130 lbs. The maximum compressive stress acting in the tube of the fuel can is due to its own weight in addition to that of the top assembly. A 10% dynamic load factor is applied to the fuel can weight for an applied load of 143 pounds to account for loads due to handling. Based on the minimum cross sectional area of $(8.62)^2 - (8.52)^2 = 1.714 \text{ in}^2$, the margin of safety at 300°F is:

$$\text{M.S.} = 20{,}000/(143/1.714) - 1$$

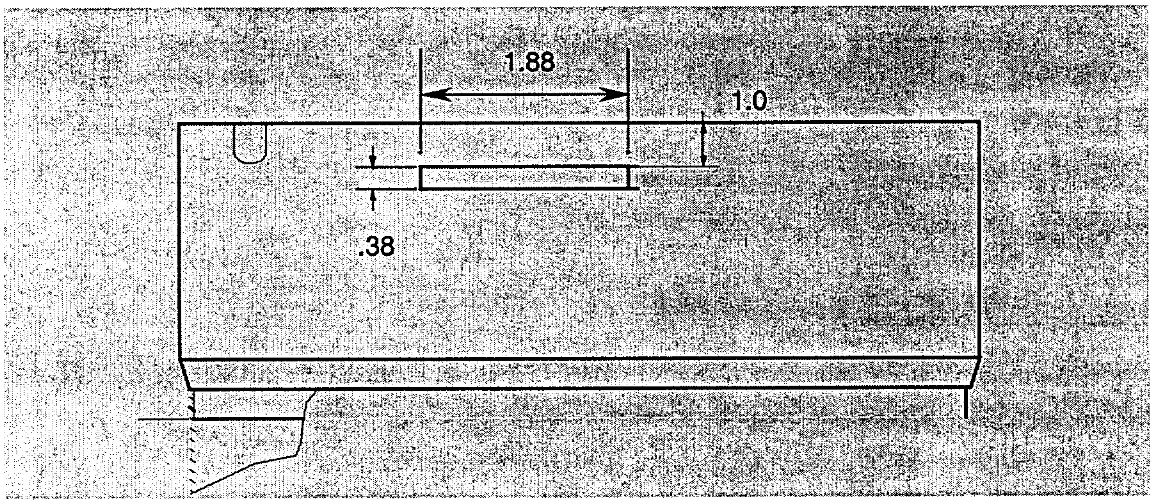
$$\text{M.S.} = +\text{LARGE}$$

3.6.1.2.2 Lifting Evaluation

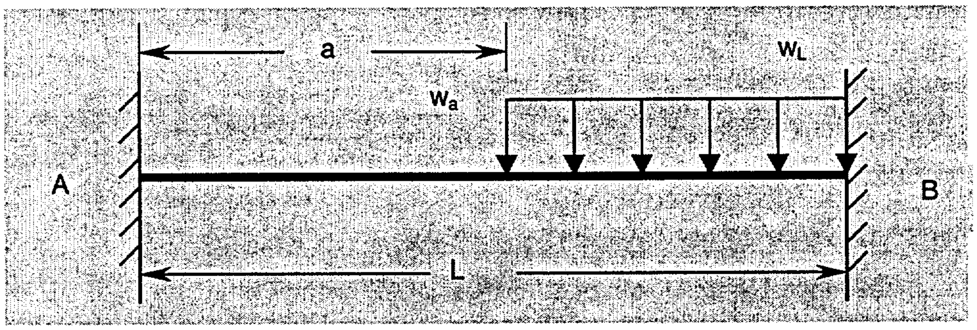
Based on the loaded weight of the fuel can, the lift evaluation does not require the use of the design criteria of ANSI N14.6 or NUREG-0612. However, for purposes of conservatism and good engineering practice, a factor of safety of three on material yield strength is used for the stress evaluations for the lift condition. Since a combined stress state results from the loading and the calculated stresses are compared to material yield strength, the Von Mises stress is computed.

Side Plates

The side plates will be subjected to bending, shear, and bearing stresses because of interaction with the lifting tool during handling operations. The lifting tool engages the 1.875-inch × 0.38-inch lifting slots with lugs that are 1-inch wide and lock into the four lifting slots. For this evaluation, the handling load is the weight of the consolidated fuel assembly (2,100 lbs design weight) plus the Maine Yankee fuel can weight (130 lbs), amplified by a dynamic load factor of 10%. Although the four slots are used to lift the can, the analysis assumes that the entire design load is shared by only two lift slots.



The stress in the side plate above the slot is determined by analyzing the section above the slot as a 0.15-inch wide × 1.875-inch long × 1.125-inch deep beam that is fixed at both ends. The lifting tool lug is 1 inch wide and engages the last 1 inch of the slot. The following figure represents the configuration to be evaluated:



where:

a = 0.875 in.
L = 1.875 in.
$w_a = w_L$ = (2,230 lbs/2)(1.10)/1.0 in. = 613.3 lbs/in, use 620 lbs/in.

Reactions and moments at the fixed ends of the beam are calculated per Roark's Formula, Table 3, Case 2d.

The reaction at the left end of the beam (R_A) is:

$$R_A = \frac{w_a}{2L^3}(L-a)^3(L+a)$$

$$= \frac{620}{2(1.875)^3}(1.875-0.875)^3(1.875+0.875) = 129.3 \text{ lbs}$$

The moment at the left end of the beam (M_A) is:

$$M_A = \frac{-w_a}{12L^2}(L-a)^3(L+3a)$$
$$= \frac{-620}{12(1.875)^2}(1.875-0.875)^3(1.875+3(0.875)) = -66.1 \text{ lbs-in.}$$

The reaction at the right end of the beam (R_B) is:

$$R_B = w_a(L-a) - R_A = 620(1.875-0.875) - 164.2 = 490.7 \text{ lbs}$$

The moment at the right end of the beam (M_B) is:

$$M_B = R_A L + M_A - \frac{w_a}{2}(L-a)^2$$
$$= 129.3(1.875) + (-66.1) - \frac{620}{2}(1.875-0.875)^2 = -133.7 \text{ lbs-in.}$$

The maximum bending stress (σ_b) in the side plate is:

$$\sigma_b = \frac{Mc}{I} = \frac{133.7(0.50)}{0.017} = 4{,}224 \text{ psi}$$

The maximum shear stress (τ) occurs at the right end of the slot:

$$\tau = \frac{R_B}{A} = \frac{490.7}{1.125(0.15)} = 2{,}908 \text{ psi}$$

The Von Mises stress (σ_{max}) is:

$$\sigma_{max} = \sqrt{\sigma_b^2 + 3\tau^2} = \sqrt{4{,}224^2 + 3(2{,}908)^2} = 6{,}573 \text{ psi}$$

The yield strength (S_y) for Type 304 stainless steel is 22,500 psi at 300°F. The factor of safety is calculated as:

$$FS = \frac{22{,}500}{6{,}573} = 3.4 > 3$$

The design condition requiring a safety factor of 3 on material yield strength is satisfied.

Tensile Stress

The tube body will be subjected to tensile loads during lifting operations. The load (P) includes the can contents (2,100 lbs design weight), the tube body weight (78.77 lbs), and the bottom assembly weight (12.98 lbs) for a total of 2,191.8 pounds. A load of 2,200 lbs with a 10% dynamic load factor is used for the analysis.

The tensile stress (σ_t) is then:

$$\sigma_t = \frac{1.1P}{A} = \frac{1.1(2{,}200 \text{ lb})}{1.714 \text{ in.}^2} = 1{,}412 \text{ psi}$$

where:

A = tube cross-section area = $8.62^2 - 8.52^2 = 1.714 \text{ in}^2$

The factor of safety (FS) based on the yield strength at 600°F (18,000 psi) is:

$$FS = \frac{18{,}600 \text{ psi}}{1{,}412} = 13.2 > 3$$

Weld Evaluation

The welds joining the tube body to the bottom weldment and to the side plates are full penetration welds (Type III, paragraph NG-3352.3). In accordance with NG-3352-1, the weld quality factor (n) for a Type III weld with visual surface inspection is 0.5.

The weld stress (σ_w) is:

$$\sigma_w = \frac{1.1(P)}{A} = \frac{1.1(2{,}200)}{1.714} = 1{,}412 \text{ psi}$$

where:

P = the combined weight of the tube body, bottom weldment, and can contents
A = cross sectional area of thinner member joined

The factor of safety (FS) is:

$$FS = \frac{n \cdot S_y}{\sigma_w} = \frac{0.5(18{,}600 \text{ psi})}{1{,}412 \text{ psi}} = +6.6 > 3$$

Table 4.1-2 Summary of Thermal Design Conditions for Transfer

Condition[1,3]	Maximum Duration (Hours)	
	PWR	BWR
Canister Filled with Water[2]	17	17
Vacuum Drying	10	10
Canister Filled with Helium	16	24

(1) The canister is inside the transfer cask, with an ambient temperature of 76°F. The design conditions consider the transient effect for a total of 43 hours (PWR) or 51 hours (BWR) starting from the removal of the transfer cask/canister from the spent fuel pool.

(2) The initial water temperature is considered to be 100°F.

(3) See Chapter 12, Appendix 12A, for Technical Specifications for specific limiting conditions.

Table 4.1-3 Maximum Allowable Material Temperatures

Material	**Temperature Limits (°F)**		**Reference**
	Long Term	**Short Term**	
Concrete	150(B)/200(L)(1)	350	ACI-349 [4]
Fuel Clad PWR Fuel (5-year cooled) BWR Fuel (5-year cooled)	 716(2) 716(2)	 1,058 1,058	 PNL-6189 [5] and PNL-4835 [2]
Aluminum 6061-T651	650	700	MIL-HDBK-5G [7]
NS-4-FR	300	300	GESC [8]
Chemical Copper Lead	600	600	Baumeister [9]
SA693 17-4PH Type 630 Stainless Steel	650	800	ASME Code [13] ARMCO [11]
SA240 Type 304 Stainless Steel	800	800	ASME Code [13]
SA240 Type 304L Stainless Steel	800	800	ASME Code [13]
ASTM A533 Type B Carbon Steel	700	700	ASME Code [13]
ASME SA588 Carbon Steel	700	700	ASME Code Case N-71-17 [12]
ASTM A36 Carbon Steel	700	700	ASME Code Case N-71-17 [12]

(1) B and L refer to bulk temperatures and local temperatures, respectively. The local temperature allowable applies to a restricted region where the bulk temperature allowable may be exceeded.

(2) In accordance with PNL-6189, the temperature limit of 380°C (716°F) is used for the evaluation of fuel considered in the design basis heat load (23 kW). For temperature limits corresponding to different burnup and cooling times, refer to Table 4.4.7-5.

Table 4.2-3 Thermal Properties of Carbon Steel

Material[1] Property (units)	**Value at Temperature**				
	100°F	**200°F**	**400°F**	**500°F**	**700°F**
Conductivity (Btu/hr-in-°F) [13]	1.992	2.033	2.017	1.975	1.867
Density (lb/in^3) [16]	← 0.284 →				
Specific Heat (Btu/lbm-°F) [17]	← 0.113 →				
Emissivity [9]	← 0.80 →				

1. A-36, SA-533, A-588 and SA-350.

Table 4.2-4 Thermal Properties of Chemical Copper Lead

Property (units)	**Value at Temperature**			
	209°F	**400°F**	**581°F**	**630°F**
Conductivity (Btu/hr-in-°F) [18]	1.6308	1.5260	1.2095	1.0079
Density (lb/in^3) [18]	← 0.411 →			
Specific Heat (Btu/lbm-°F) [18]	← 0.03 →			
Emissivity [9]	← 0.28 (75°F) →			

Table 4.2-5 Thermal Properties of Type 6061-T651 Aluminum Alloy

Property (units)	**Value at Temperature**					
	200°F	**300°F**	**400°F**	**500°F**	**600°F**	**700°F**
Conductivity (Btu/hr-in-°F) [7,13]	8.25	8.38	8.49	8.49	8.49	8.49
Specific Heat (Btu/hr-in-°F) [13]	← 0.23 →					
Emissivity [15]	← 0.22 →					

Table 4.2-6 Thermal Properties of Helium

Property (units)	Value at Temperature			
	80°F	**260°F**	**440°F**	**800°F**
Conductivity (Btu/hr-in-°F) [20]	0.00751	0.00915	0.01068	0.01355

Property (units)	Value at Temperature			
	200°F	**400°F**	**600°F**	**800°F**
Density (lb/in^3) [19]	4.83E-06	3.70E-06	3.01E-06	2.52E-06
Specific Heat (Btu/lbm-°F) [19]	← 1.24 →			

Table 4.2-7 Thermal Properties of Dry Air

Property (units)	Value at Temperature			
	100°F	**300°F**	**500°F**	**700°F**
Conductivity (Btu/hr-in-°F) [19]	0.00128	0.00161	0.00193	0.00223
Density (lb/in^3) [19]	4.11E-05	3.01E-05	2.38E-05	1.97E-05
Specific Heat (Btu/lbm-°F) [19]	0.240	0.244	0.247	0.253

4.5.1.1.5 Standard Fuel with In-core Instrument Thimbles

Certain fuel assemblies have in-core instrument thimbles stored within the center guide tube of each fuel assembly. Storing an in-core instrument thimble assembly in the center guide tube of a fuel assembly will slightly increase the axial conductance of the fuel assembly (helium replaced by solid material). Therefore, there is no negative impact on the thermal performance of the fuel assembly with this configuration. The thermal performance of these fuel assemblies is bounded by that of the standard fuel assemblies.

4.5.1.1.6 Standard Fuel Assemblies with Variable Enrichment and Axial Blankets

The thermal conductivities of the fuel assemblies with variable enrichment (radial) and axial blankets are considered to be essentially the same as those of the standard fuel assemblies. Since the heat load per assembly is limited to the design basis heat load, there is no effect on the thermal performance of the system due to this loading configuration.

4.5.1.1.7 Standard Fuel Assemblies with Removed Fuel Rods

Except for assembly number EF0046, the maximum number of missing fuel rods from a standard fuel assembly is 14, or 8% (14/176) of the total number of rods in one fuel assembly. The maximum heat load for any one of these fuel assemblies is conservatively determined to be 0.63 kW. This heat load is 34% less than the design basis heat load of 0.958 kW. Fuel assembly EF0046 was used in the consolidated fuel demonstration program and has only 69 rods remaining in its lattice. This fuel assembly has a heat load of 70 watts, or 7% of the design basis heat load of 0.958 kW. Therefore, the thermal performance of fuel assemblies with removed fuel rods is bounded by that of the standard fuel assemblies.

4.5.1.1.8 Fuel Assemblies with Damaged Fuel Rods

Damaged fuel assemblies are standard fuel assemblies with fuel rods with known or suspected cladding defects greater than hairline cracks or pinhole leaks. Each damaged fuel assembly will be placed in a Maine Yankee fuel can. The primary function of the fuel can is to confine fuel material within the can and to facilitate handling and retrievability. The Maine Yankee fuel can is shown in Drawings 412-501 and 412-502. The placement of the loaded fuel cans is restricted by the operating procedures and/or Technical Specifications to loading into the four fuel tube positions at the periphery of the fuel basket as shown in Figure 12B2-1. The heat load for each damaged fuel assembly is limited to the design basis heat load 0.958 kW (23 kW/24).

A steady-state thermal analysis is performed using the three-dimensional canister model described in Section 4.4.1.2 simulating 100% failure of the fuel rods, fuel cladding, and guide tubes of the damaged fuel held in the Maine Yankee fuel can. The canister is assumed to contain twenty (20) design basis PWR fuel assemblies and damaged fuel assemblies in fuel cans in each of the four corner positions.

Two debris compaction levels are considered for the 100% failure condition: (Case 1) 100% compaction of the fuel rod, fuel cladding, and guide tube debris resulting in a 52-inch debris level in the bottom of each fuel can, and (Case 2) 50% compaction of the fuel rod, fuel cladding, and guide tube debris resulting in a 104-inch debris level in the bottom of each fuel can. The entire heat generation rate for a single fuel assembly (i.e., 0.958 W) is concentrated in the debris region with the remainder of the active fuel region having no heat generation rate applied. To ensure the analysis is bounding, the debris region is located at the lower part of the active fuel region in lieu of the bottom of the fuel can. This location is closer to the center of the basket where the maximum fuel cladding temperature occurs. The effective thermal conductivities for a design basis PWR fuel assembly (Section 4.4.1.5) are used for the debris region while the thermal conductivity of helium is used for the remainder of the active fuel length.

Boundary conditions corresponding to the normal condition of storage are used at the outer surface of the canister model (see Section 4.4.1.2). A steady-state thermal analysis is performed.

The results of the two thermal analyses performed for 100% fuel rod, fuel cladding, and guide tube failure are:

	Maximum Temperature (°F)			
Description	Fuel Cladding	Damaged Fuel	Support Disk	Heat Transfer Disk
Case 1 (100% Compaction)	654	672	598	594
Case 2 (50% Compaction)	674	594	620	616
Design Basis PWR Fuel	670	N/A	615	612
Allowable	716	N/A	650	650

As demonstrated, the extreme case of 100% fuel rod, fuel cladding, and guide tube failure with 50% compaction of the debris results in temperatures that are less than 1% higher than those calculated for the design basis PWR fuel. The maximum temperatures for the fuel cladding, damaged fuel assembly, support disks, and heat transfer disks remain within the allowable temperature range for both 100% failure cases. Additionally, the temperatures used in the structural analyses of the fuel basket envelope those calculated for both 100% failure cases.

4.5.1.1.9 Standard Fuel Assemblies with Damaged Lattice

Certain standard fuel assemblies may have damage or physical alteration to the lattice or cage that holds the fuel rods, but not exhibit damage to the fuel rods.

The effective thermal conductivity for the fuel assembly used in the thermal analyses in Section 4.4 is determined by the two-dimensional fuel model (Section 4.4.1.5). The model conservatively ignores the conductance of the steel cage of the fuel assembly. Therefore, damage or physical alteration to the cage has no effect on the thermal conductivity of the fuel assembly used in the thermal models. The thermal performance of these fuel assemblies is bounded by that of the standard fuel assemblies.

4.5.1.1.10 Failed Fuel Rod Holders

The Maine Yankee site specific fuel inventory includes two (2) damaged fuel lattices designated CF1 and CA3. CF1 is a 9 x 9 array of tubes having roughly the same dimensions as a fuel assembly. Some of the tubes hold damaged fuel rods. CA3 is a previously used fuel assembly cage, into which damaged fuel rods have been inserted.

Similar to the fuel assemblies that have damaged fuel rods, the damaged fuel lattices will be placed in Maine Yankee fuel cans and their location in the basket is restricted to one of the four corner fuel tube positions of the basket. The decay heat generated by the fuel in each of these lattices is less than one-fourth of the design basis heat load of 0.958 kW. Therefore, the thermal performance of the damaged fuel lattices is bounded by that of the standard fuel assemblies.

4.5.1.1.11 Assemblies with Damaged Fuel Rods Inserted in Guide Tubes

Similar to fuel assemblies that have damaged fuel rods, the fuel assemblies that have damaged fuel rods stored in their guide tubes are placed in Maine Yankee fuel cans and their loading positions are restricted to the four corner fuel tubes in the basket. Storing fuel rods in the guide tubes of a fuel assembly slightly increases the axial conductance of the fuel assembly (helium replaced by solid material). Therefore, the thermal performance of these fuel assemblies is bounded by that of the standard fuel assemblies.

Figure 4.5.1.1-3 Evaluated Locations for the Maine Yankee Consolidated Fuel Lattice in the PWR Fuel Basket

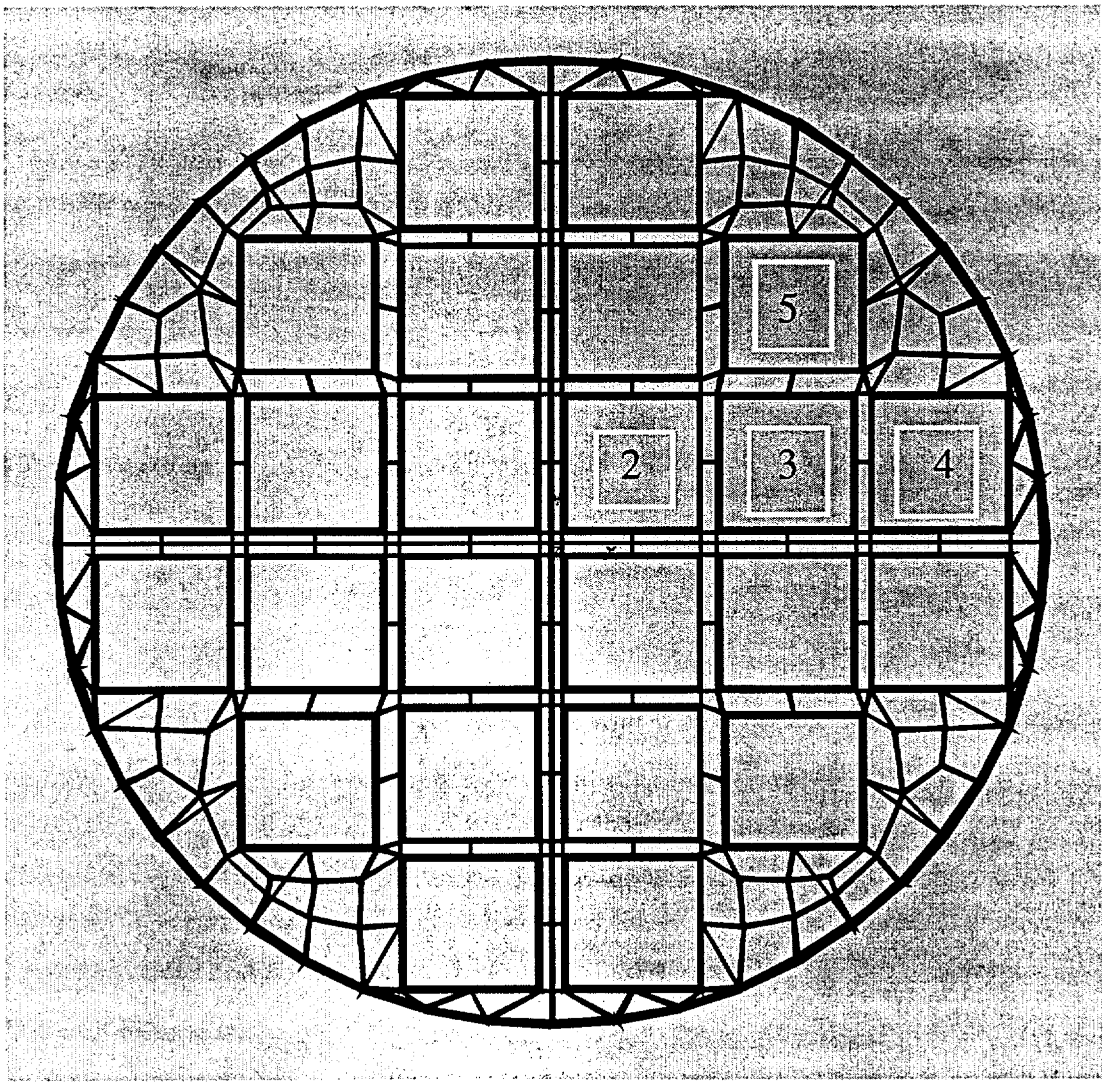
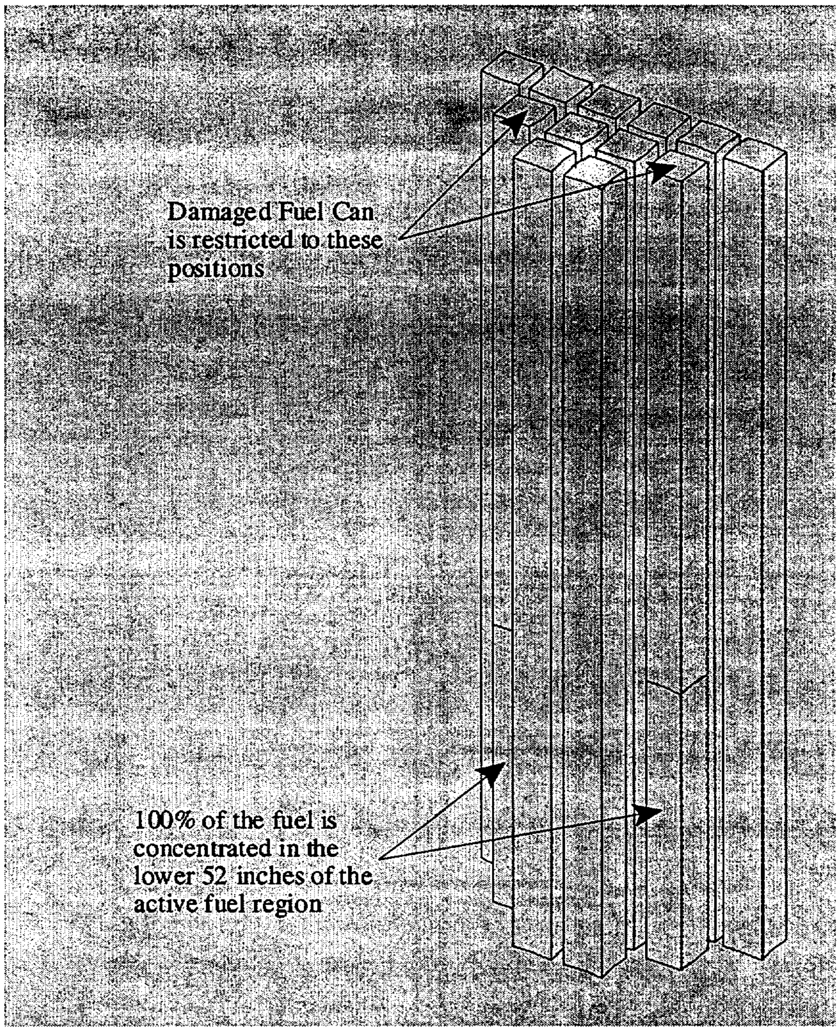


Figure 4.5.1.1-4 Active Fuel Region in the Three-Dimensional Canister Model



Note: Finite element mesh not shown for clarity.

4.5.1.2 Maximum Allowable Heat Loads for Maine Yankee Site Specific Spent Fuel

This section includes evaluations for the Maine Yankee fuel inventory that is not bounded by the evaluation performed in Section 4.4.7. This fuel may have higher burnup than the design basis fuel, have a higher decay heat on a per assembly basis, have a burnup/cool time condition that is outside of the cladding temperature evaluation presented in Section 4.4.7, or be subject to all of these differences.

Maximum allowable clad temperatures and decay heats are evaluated for:

1. Fuel with burnup in excess of 45,000 MWD/MTU (maximum 50,000 MWD/MTU),
2. Preferential loading patterns with hotter fuel on the periphery of the basket, and
3. Preferential loading with fuel exceeding design basis heat load (0.958 kW) per assembly on the basket periphery.

As shown in Section 4.4.7, the standard CE 14 x 14 fuel assembly has a significantly lower cladding stress level than the equivalent burnup Westinghouse 14 x 14 assembly. It is, therefore, conservative to apply the characteristics of the design basis assembly to the CE 14 x 14 Maine Yankee fuel assemblies. (Note that the Westinghouse 14 x 14 assembly evaluated in Section 4.4.7 is the fuel assembly used in Westinghouse reactors, but it is not the Westinghouse 14 x 14 assembly built for use in the CE reactors, such as the Maine Yankee reactor.)

The maximum allowable decay heat, listed either on a per canister or per assembly basis, is combined with dose rate limits in Chapter 5 to establish cool time limits as a function of burnup and initial enrichment. Cool time limits are shown in Tables 5.6.1-10 for Maine Yankee fuel assemblies without installed control components, and in Table 5.6.1-12 for fuel assemblies with installed control components.

4.5.1.2.1 Maximum Allowable Temperature and Decay Heat for 50,000 MWD/MTU Fuel

To evaluate higher burnup fuel, oxidation layer thickness and fission gas release fractions are established. For higher burnup fuels (i.e., rod peak burnup up to 50,000 MWD/MTU), Maine Yankee experience is that the maximum oxide layer thickness on the fuel cladding is 120 microns, and that the maximum gas release rate (fuel pellet to rod plenum in intact fuel rods) is less than 3% [36]. Therefore, the allowable cladding temperature calculations employ an oxide layer thickness of 0.012 cm. A 12% release fraction, established for BWR fuel, is conservatively applied for the higher burnup PWR fuel.

Using the evaluation method presented in Section 4.4.7 and a cladding oxidation thickness of 0.012 cm, the cladding stress levels for the 50,000 MWD/MTU burnup PWR assembly (maximum stress) are determined and listed in Table 4.5.1.2-1. The data is plotted against the generic allowable temperature curves in Figure 4.5.1.2-2. Included in Figure 4.5.1.2-2 are the 35,000 MWD/MTU to 45,000 MWD/MTU limit lines developed in Section 4.4.7. The intercept of the 50,000 MWD/MTU results in the limiting cladding temperatures shown in Table 4.5.1.2-2. The resulting maximum allowable heat load per canister for fuel assemblies with burnup of 50,000 MWD/MTU is listed in Table 4.5.1.2-3.

4.5.1.2.2 Preferential Loading with Hotter Fuel on the Periphery of the Basket

The design basis heat load for the UMS thermal analysis is 23 kW uniformly distributed throughout the basket (0.958 kW per assembly). This heat load applies to the basket structural components at any initial fuel loading time. Further reduction in heat load is required for the Maine Yankee fuel assemblies that fall outside the bounds of the requirement of maximum heat load as shown in Tables 4.4.7-8 and 4.5.1.2-3. These assemblies include:

1. Fuel assemblies (with specific burnup and cool time) that may exceed the maximum allowable decay heat dictated by their cladding temperature allowable (exceeding the limits as shown in Tables 4.4.7-8 and 4.5.1.2-3), if loaded uniformly (all 24 fuel assemblies with the same burnup and cool time, i.e., the same decay heat).
2. Fuel assemblies that are expected to exceed the design basis heat load of 0.958 kW per assembly (maximum heat per assembly less than 1.05 kW).

To ensure that these fuel assemblies do not exceed their allowable cladding temperatures, a loading pattern is considered that places higher heat load assemblies at the periphery of the basket (Positions "A" in Figure 4.5.1.2-1) and compensates by placing lower heat load assemblies in the basket interior positions (Positions "B" in Figure 4.5.1.2-1). There are 12 interior basket locations and 12 peripheral basket locations in the UMS PWR basket design. The maximum total basket heat loads indicated in Tables 4.4.7-8 and 4.5.1.2-3 are maintained for these peripheral loading scenarios.

Two preferential loading scenarios are evaluated. The first approach limits any assembly to the 0.958 kW design basis heat load limit (23 kW divided by 24 assemblies), while the second approach increases the per assembly heat load limit to 1.05 kW for assemblies in the basket peripheral locations. The split approach allows maximum flexibility at fuel loading.

In order to load the preferential pattern, the fuel cladding maximum temperature must be maintained below the allowable temperatures for peripheral and interior assemblies. The requirement of maximum total heat load per basket, as shown in Tables 4.4.7-8 and 4.5.1.2-3, must also be met.

4.5.1.2.2.1 Peripheral Assemblies Limited to a Decay Heat Load of 0.958 kW per Assembly

With a basket heat load of 23 kW, uniformly loaded, the maximum cladding temperature of a peripheral assembly location was determined to be 566°F (297°C) based on the thermal analysis using the three-dimensional canister model as presented in Section 4.4.1.2. While any basket location is restricted to a heat load of 0.958 kW, any non-uniform loading with a total basket heat load less than 23 kW will result in a peripheral assembly cladding temperature less than 297°C. This temperature is well below the lowest maximum allowable clad temperature of 313°C indicated in Table 4.5.1.2-2 (which was already reduced to 95% of the actual allowable of 329°C). Fuel assemblies at a maximum heat load of 0.958 kW may, therefore, be loaded into the peripheral basket location at any cool time, provided interior assemblies meet the restrictions outlined below.

Decay Heat Limit on Fuel Assemblies Loaded into Basket Interior Positions

Interior fuel assembly decay heat loads must be reduced from those in a uniform loading configuration, see Table 4.4.7-8 and Table 4.5.1.2-3, to allow loading of the higher heat load assemblies in the peripheral locations. A parametric study is performed using the three-dimensional periodic model as described in Section 4.5.1.1 (Figure 4.5.1.1-2) to demonstrate that placing a higher heat load in the peripheral locations does not result in heating of the fuel assemblies in the interior locations beyond that found in the uniform heat loading case. The side surface of the model is assumed to have a uniform temperature of 350°F.

Two cases are considered (total heat load per cask = 20 kW for both cases):

1. Uniform loading: Heat load = 0.833 (20/24) kW per assembly for all 24 assemblies
2. Non-uniform loading:
   Heat load = 0.958 (23/24) kW per assembly for 12 Peripheral assemblies
   Heat load = 0.708 (17/24) kW per assembly for 12 Interior assemblies

The analysis results (maximum temperatures) are:

	Case 1 Uniform Loading (°F)	Case 2 Non-Uniform Loading (°F)
Fuel (Location 1)	675	648
Fuel (Locations 2 & 4)	632	611
Fuel (Location 5)	577	588
Fuel (Locations 3 & 6)	563	576
Basket	611	592

Locations are shown in Figure 4.5.1.2-1.

The maximum fuel cladding temperature for Case 2 (non-uniform loading pattern) is well below that for Case 1 (uniform loading pattern). The comparison shows that placing hotter fuel in the peripheral locations of the basket and cooler fuel in the interior locations (while maintaining the same total heat load per basket) reduces the maximum fuel cladding temperature (which occurs in the interior assembly), as well as the maximum basket temperature.

Because the basket interior temperatures decrease for non-uniform loading, it is conservative to determine the maximum allowable heat load for the interior assemblies based on the values (total allowed heat load) shown in Tables 4.4.7-8 and 4.5.1.2-3, and the heat load for the fuel assemblies in 12 peripheral locations (12 x 0.958 kW). For example, the 10-year cooled, 45,000 MWD/MTU fuel in a uniform loading pattern, is restricted to a basket average heat load of 19.5 kW per Table 4.4.7-8. Placing 12 fuel assemblies at 23/24 (0.958) kW into the basket periphery requires the interior assemblies to be reduced to 0.667 kW per assembly to retain the 19.5 kW basket total heat load. Table 4.5.1.2-4 contains the matrix of maximum allowable heat loads per assembly as a function of burnup and cool time for interior assemblies for the configuration with the peripheral assemblies having a maximum heat load of 0.958 kW per assembly.

Figure 4.5.1.2-2 Maximum Allowable Cladding Temperature at Initial Storage versus Cladding Stress (50,000 MWD/MTU)

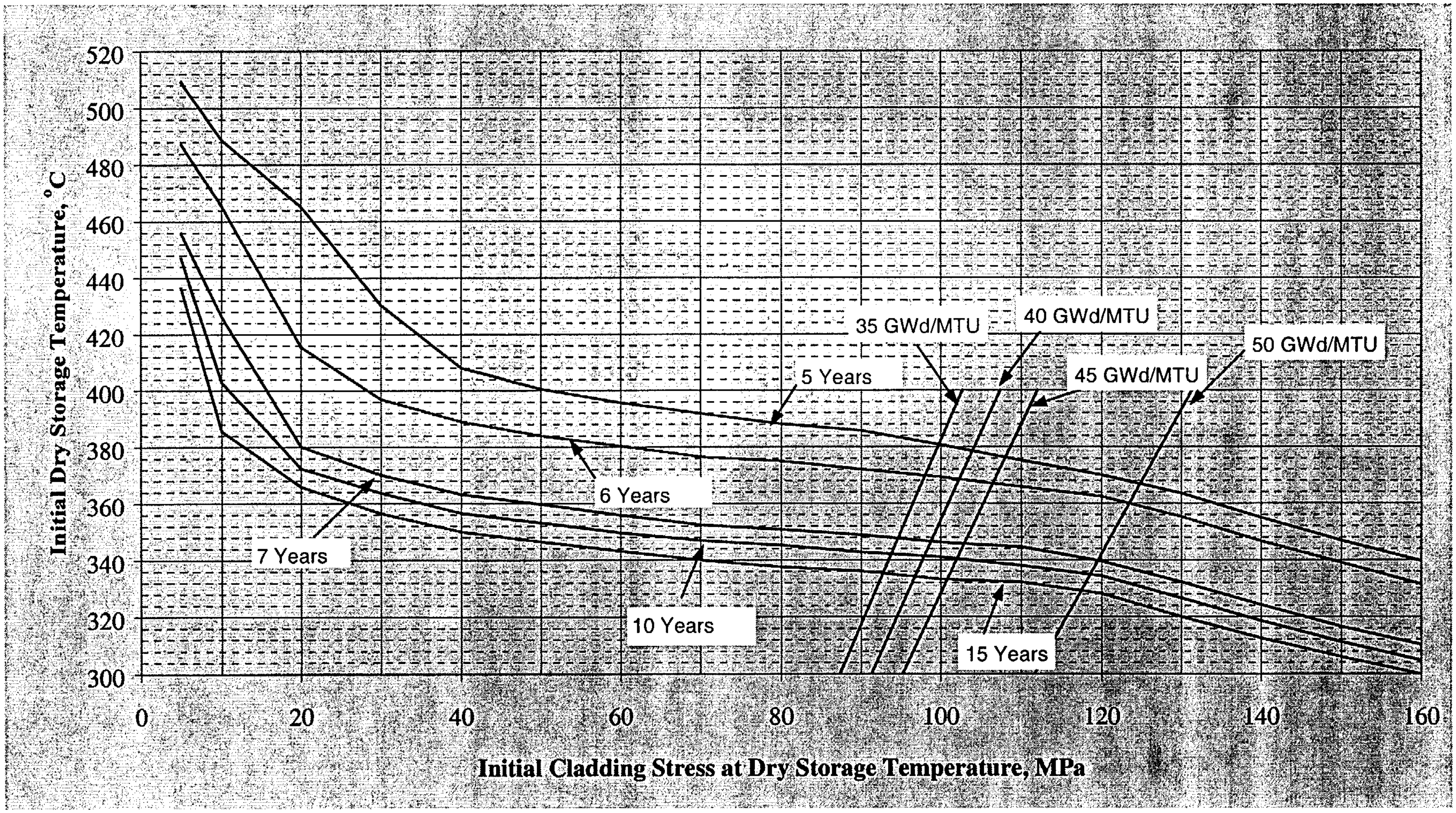


Table 4.5.1.2-1 Cladding Stress for 50,000 MWD/MTU Burnup Fuel

Clad Maximum Temperature	**300°C**	**400°C**
Stress (MPa)	111.7	131.4

Table 4.5.1.2-2 Maximum Allowable Cladding Temperature for 50,000 MWD/MTU Burnup Fuel

Cool Time	**Maximum Allowable Cladding Temperature**	**Cladding Temperature Adjusted to 95% of Maximum**
5 yr	368°C	350°C
6 yr	360°C	342°C
7 yr	340°C	323°C
10 yr	335°C	318°C
15 yr	329°C	313°C

Table 4.5.1.2-3 Maximum Allowable Canister Heat Load for 50,000 MWD/MTU Burnup Fuel

Cool Time	**Maximum Allowable Heat Load**
5 yr	22.1 kW
6 yr	21.2 kW
7 yr	19.5 kW
10 yr	19.1 kW
15 yr	18.7 kW

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5.6.1 Shielding Evaluation for Maine Yankee Site Specific Spent Fuel

This analysis considers both assembly fuel sources and sources from activated non-fuel material such as control element assemblies (CEA), in-core instrument (ICI) thimbles, and fuel assemblies containing activated stainless steel replacement (SSR) rods. It considers the consolidated fuel, damaged fuel, and fuel debris present in the Maine Yankee spent fuel inventory, in addition to those fuel assemblies having a burnup between 45,000 and 50,000 MWD/MTU.

The Maine Yankee spent fuel inventory also contains fuel assemblies with hollow zirconium rods, removed fuel rods, axial blankets, poison rods, variable radial enrichment, and low enriched substitute rods. These components do not result in additional sources to be considered in shielding evaluations and are, therefore, enveloped by the standard fuel assembly evaluation. For shielding considerations of the variable radial enrichment assemblies, the planar-average enrichment is employed in determining minimum cool times. As described in Section 6.6.1.2.2, fuel assemblies with variable radial enrichment incorporate fuel rods that are enriched to one of two levels of enrichment. Fuel assemblies that also incorporate axial blankets are described in Section 6.6.1.2.3. Axial blankets consist of annular fuel pellets enriched to 2.6 wt % ^{235}U, used in the top and bottom 5% (≈ 7 inches) of the active fuel length. The remaining active fuel length of the fuel rod is enriched to one of two levels of enrichment incorporated in the fuel design.

5.6.1.1 Fuel Source Term Description

Maine Yankee utilized 14 x 14 array size fuel based on designs provided by Combustion Engineering, Westinghouse, and Exxon Nuclear. The previously analyzed Combustion Engineering CE 14 x 14 standard fuel design is selected as the design basis for this analysis because its potential uranium loading is the highest of the three vendor fuel types, based on a 0.3765-inch nominal fuel pellet diameter, a 137-inch active fuel length, and a 95% theoretical fuel density. This results in a fuel mass of 0.4037 MTU. This exceeds the maximum reported Maine Yankee fuel mass of 0.397 MTU and, therefore, produces bounding source terms. The SAS2H model of the CE 14 x 14 assembly (shown in Figure 5.6.1-1) at a nominal burnup of 40,000 MWD/MTU and initial enrichment of 3.7 wt %, is based on data provided in Table 2.1.1-1.

Source terms for various combinations of burnup and initial enrichment are computed by adjusting the SAS2H BURN parameter to model the desired burnup and specifying the initial enrichment in the Material Information Processor input for UO_2.

5.6.1.1.1 Control Element Assemblies (CEA)

For the CEA evaluation, the assumptions are:

1. The irradiated portion of the CEA assembly is limited to the CEA tips since during normal operation the elements are retracted from the core and only the tips are subject to significant neutron flux.
2. The CEA tips are defined as that portion present in the "Gas Plenum" neutron source region in the Characteristics Database (CDB) [10].
3. Material subject to activation in the CEA tips is limited to stainless steel, Inconel and Ag-In-Cd in the tip of the CEA absorber rods. Stainless steel and Inconel is assumed to have a concentration of 1.2 g/kg ^{59}Co. The CDB indicates that a total of 2.495 kg/CEA of this material is present in the Gas Plenum region of the core during operation. The Ag-In-Cd alloy present in the gas plenum region during core operation is approximately 80% silver and weighs 2.767 kg/CEA.
4. The irradiated CEA material is assumed to be present in the lower 8 inches of the active fuel region when inserted in the assembly. The location of the CEA source is based on the relative length of the fuel assembly and CEA rods and the insertion depth of the CEA spider into the top end-fitting.
5. The decay heat generated in the most limiting CEA at 5 years cool time is 2.16 W/kg of activated steel and inconel, and 3.11 W/kg of activated Ag-In-Cd. Although longer cool times are considered in this analysis for the fuel source term, this decay heat generation rate is conservatively used for all longer CEA cool times. For a cask fully loaded with fuel assemblies containing design basis CEAs, the additional heat generation due to the CEAs amounts to (2.16 W/kg x 2.495 kg/CEA + 3.11 x 2.767 kg/CEA)(24 CEA/cask) = 336 W/cask, which is conservatively rounded to 350 W/cask.

Since the activated portion of the CEA is present only in the lower 8 inches of the active fuel, an adjustment to the one-dimensional dose rate limit is derived based on detailed three-dimensional results obtained for the CE 14 x 14 fuel with and without a CEA present.

Table 5.6.1-1 shows the activation history for CEAs employed at Maine Yankee. Based on this data, individual source term calculations are performed for each CEA group, and a single

5.6.1.3 Shielding Evaluation

The shielding evaluation consists of a loading table analysis of the CE 14 x 14 fuel following the methodology developed in Section 5.5 (Minimum Allowable Cooling Time Evaluation for PWR and BWR fuel). Fuel assemblies which include non-fuel hardware are addressed explicitly. The results of the analysis are loading tables which give the required cool time for a particular fuel configuration.

No restrictions are placed on the loading locations for any of the non-fuel assembly hardware components. This implies that a canister may contain up to 24 CEAs, 24 ICI thimbles, or 24 steel substitute rod assemblies or any combination thereof as long as the most limiting cool time is selected for any of the components in the canister. Neither CEA's or ICI thimbles may be placed into an assembly containing steel substitute rods that have received core exposure. ICI thimbles and CEA's may be inserted in fuel assemblies that also have hollow Zircaloy rods replacing burnable poison rods, solid steel rods replacing fuel rods provided there has been no reactor core exposure of the steel rods, fuel assemblies with fuel rods removed from the lattice, fuel assemblies with variable enrichment or low enrichment replacement fuel rods, or axial blanket fuel assemblies. Due to physical constraints, ICI thimbles and CEAs cannot be located in the same assembly.

5.6.1.4 Standard Fuel Source Term

Results are obtained, for CE 14 x 14 fuel with no additional non-fuel material included, by following the minimum allowable cooling time evaluation (loading table analysis) methodology developed in Section 5.5. CE 14 x 14 source terms at various combinations of initial enrichment and burnup are computed using the CE 14 x 14 SAS2H model described in Section 5.6.1.1.

Following the methodology developed in Section 5.5, one-dimensional shielding calculations are performed for CE 14 x 14 fuel region sources at various combinations of initial enrichment, burnup, and cool time. The resulting dose rate and source term data is interpolated to determine the cool time required for each combination of enrichment and burnup to decay below the design basis limiting values of dose and heat generation rate.

The resulting loading table for CE 14 x 14 fuel with no additional non-fuel material is shown in Table 5.6.1-10.

In addition to the standard fuel evaluation two preferential loading strategies are analyzed. Both preferential loading configuration rely on placing higher heat load fuel assemblies on the periphery of the basket than would be allowed with a uniform loading strategy. Peripheral loadings are evaluated with decay heats of 0.958 kW and 1.05 kW per peripheral assembly. To maintain the maximum allowable heat load per basket indicated in Section 4.5 the maximum allowable per assembly heat load in the interior location of the basket is reduced to compensate for the higher heat load peripheral elements. Burnup and cool time combinations for peripheral and interior assemblies are listed in Table 5.6.1-10 as a function of initial enrichment. The cool time column for peripheral element and interior assembly loading is indicated by the "p" and "i" indicators in the column headings.

5.6.1.4.1 Control Element Assemblies (CEA)

The result of the analysis is a set of loading tables for Maine Yankee fuel giving the cool time required for a fuel assembly with a specified burnup and enrichment combination to contain a design basis CEA with a cool time of 5, 10, 15, or 20 years. Fuel assemblies containing CEAs will be loaded into Class 2 canisters, which are slightly longer than the Class 1 canisters used for bare fuel assemblies. The additional length is required to accommodate the CEA, which is inserted in the top of the fuel assembly.

The approach taken is to compute downward adjustments to the design basis one-dimensional dose rate limiting value for the storage cask (as specified in Table 5.5-3) which ensures that the fuel sources have decayed adequately to cover the effect of the additional source added as a result of CEA containment. The adjustment is determined on the basis of a conservative comparison of three-dimensional shielding analysis results for the original Class 1 canister containing CE 14 x 14 fuel assemblies and the Class 2 canister containing either no CEA or CEAs cooled to 5, 10, 15, or 20 years. Results for CEA cool times longer than 20 years are bounded by the 20 year results.

Assuming design basis CE 14 x 14 fuel with a burnup of 40,000 MWD/MTU, 3.7 wt. % enrichment and 5 years cool time, the additional CEA source results in a localized peak near the bottom of the transfer cask that results in a surface dose rate that is less than 500 mrem/hr. Since this is comparable to the no-CEA case, it is not necessary to extend cool time of fuel assemblies with CEAs inserted to account for an increased transfer cask surface dose.

Table 5.6.1-11 Three-Dimensional Shielding Analysis Results for Various Maine Yankee CEA Configurations Establishing One-Dimensional Dose Rate Limits for Loading Table Analysis

CEA Cool Time [years]	Dose Rate [mrem/hr]	FSD	Delta [mrem/hr]	Limit [mrem/hr]
Class 1 Result	32.0	0.85%	-	34.2
NoCea	32.0	0.85%	-0.0	34.2
05y	43.8	0.59%	-11.8	22.4
10y	33.1	0.69%	-1.1	33.1
15y	32.0	0.85%	-0.0	34.2
20y	32.0	0.85%	-0.0	34.2

Table 5.6.1-12 Loading Table for Maine Yankee CE 14 x 14 Fuel Containing CEA Cooled to Indicated Time

Loading Table for ce14x14 Fuel - Minimum Required Cool Time in Years						
Burnup	**30 GWD/MTU**	**Minimum Cool Time [y] for**				
Enrichment	**NoCEA (Class 1)**	**NoCEA (Class 2)**	**5 Yr CEA**	**10 Yr CEA**	**15 Yr CEA**	**20 Yr CEA**
1.9	5	5	5	5	5	5
2.1	5	5	5	5	5	5
2.3	5	5	5	5	5	5
2.5	5	5	5	5	5	5
2.7	5	5	5	5	5	5
2.9	5	5	5	5	5	5
3.1	5	5	5	5	5	5
3.3	5	5	5	5	5	5
3.5	5	5	5	5	5	5
3.7	5	5	5	5	5	5
Burnup	**35 GWD/MTU**	**Minimum Cool Time [y] for**				
Enrichment	**NoCEA (Class 1)**	**NoCEA (Class 2)**	**5 Yr CEA**	**10 Yr CEA**	**15 Yr CEA**	**20 Yr CEA**
1.9	5	5	5	5	5	5
2.1	5	5	5	5	5	5
2.3	5	5	5	5	5	5
2.5	5	5	5	5	5	5
2.7	5	5	5	5	5	5
2.9	5	5	5	5	5	5
3.1	5	5	5	5	5	5
3.3	5	5	5	5	5	5
3.5	5	5	5	5	5	5
3.7	5	5	5	5	5	5
Burnup	**40 GWD/MTU**	**Minimum Cool Time [y] for**				
Enrichment	**NoCEA (Class 1)**	**NoCEA (Class 2)**	**5 Yr CEA**	**10 Yr CEA**	**15 Yr CEA**	**20 Yr CEA**
1.9	7	7	7	7	7	7
2.1	6	6	6	6	6	6
2.3	6	6	6	6	6	6
2.5	5	5	6	5	5	5
2.7	5	5	6	5	5	5
2.9	5	5	6	5	5	5
3.1	5	5	5	5	5	5
3.3	5	5	5	5	5	5
3.5	5	5	5	5	5	5
3.7	5	5	5	5	5	5
Burnup	**45 GWD/MTU**	**Minimum Cool Time [y] for**				
Enrichment	**NoCEA (Class 1)**	**NoCEA (Class 2)**	**5 Yr CEA**	**10 Yr CEA**	**15 Yr CEA**	**20 Yr CEA**
1.9	11	11	11	11	11	11
2.1	9	9	9	9	9	9
2.3	8	8	8	8	8	8
2.5	8	8	8	8	8	8
2.7	8	8	8	8	8	8
2.9	8	8	8	8	8	8
3.1	7	7	8	8	8	8
3.3	6	6	7	7	7	7
3.5	6	6	6	6	6	6
3.7	6	6	6	6	6	6
Burnup	**50 GWD/MTU**	**Minimum Cool Time [y] for**				
Enrichment	**NoCEA (Class 1)**	**NoCEA (Class 2)**	**5 Yr CEA**	**10 Yr CEA**	**15 Yr CEA**	**20 Yr CEA**
1.9	18	18	18	18	18	18
2.1	16	16	16	16	16	16
2.3	14	14	14	14	14	14
2.5	12	12	12	12	12	12
2.7	12	12	12	12	12	12
2.9	11	11	12	12	12	12
3.1	10	10	12	12	12	12
3.3	10	10	11	11	11	11
3.5	10	10	10	10	10	10
3.7	10	10	10	10	10	10

Note: The NoCEA (Class 2) column is provided for comparison. Fuel assemblies without a CEA insert may not be loaded in a Class 2 canister.

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that contains more fuel. The most reactive removed fuel rod case occurs when 24 fuel rods are removed in the diamond shaped geometry shown in Figure 6.6.1-1, from the model containing the largest allowed pellet diameter. This case represents the bounding number and geometry of removed fuel rods for the Maine Yankee fuel assemblies. It results in a more reactive system than either the Maine Yankee hybrid 14 x 14 fuel accident case or the Westinghouse 17 x 17 OFA accident case assuming unrestricted loading. However, as shown in Table 6.6.1-6, when the loading of any assembly with less than 176 fuel rods or filler rods is restricted to the four corner fuel tube the reactivity of the worse case drops well below that of the Westinghouse 17 x 17 OFA fuel assemblies. Therefore, loading of Maine Yankee fuel assemblies with removed fuel rods, or with hollow Zircaloy rods, is restricted to the four corner fuel tube positions of the basket. With this loading restriction, the Westinghouse 17 x 17 OFA criticality evaluation remains bounding.

6.6.1.2.5 Assemblies with Fuel Rods in the Guide Tubes

A few of the Maine Yankee assemblies contain up to two fuel rods in some of the guide tubes. To evaluate loading of these assemblies into the canister, an analysis adding 1 and then 2 intact fuel rods into 1, 2, 3 and then 5 guide tubes is made. The results of the evaluation of these configurations are shown in Table 6.6.1-7.

While higher in reactivity than the Maine Yankee hybrid base case, any fuel configuration with up to 2 fuel rods per guide tube is less reactive than the accident case for the Westinghouse 17 x 17 OFA fuel assemblies. Therefore, the Westinghouse 17 x 17 OFA fuel criticality evaluation is bounding.

In addition to the fuel rods, some Maine Yankee assemblies may contain poison shim rods in guide tubes. These solid fill rods will serve as parasitic absorber and displace moderator and are therefore not included in the criticality model but are bounded by the evaluation performed.

6.6.1.2.6 Consolidated Fuel

The consolidated fuel is a 17 x 17 array of intact fuel rods with a pitch of 0.492 inches. Some of the locations in the array contain solid fill rods and some are empty. To determine the reactivity of the consolidated fuel lattice with empty fuel rod positions, an analysis changing the location and the number of empty positions is performed. This consolidated fuel analysis considers 24 consolidated fuel lattices in the basket. All 24 consolidated fuel lattices are centered in the fuel tubes and have the same number and location of empty fuel rod positions.

As shown in Section 6.6.1.2.4, the removed fuel rod configuration with a 0.380-inch pellet diameter provides a more reactive system than a system using the optimum pellet diameter from Section 6.6.1.2.1. The larger pellet cases are more reactive, since moderator is added at the empty fuel rod positions to an assembly that contains more fuel. Therefore, the consolidated assembly empty rod position evaluation is performed with the 0.380-inch pellet diameter.

The results of this evaluation are shown in Table 6.6.1-8. Configurations having more than 73 empty positions result in a more reactive system than the Westinghouse 17 x 17 OFA model. The most reactive consolidated assembly case occurs with 113 empty rod positions in the geometry shown in Figure 6.6.1-2. However, when the loading of the consolidated fuel is restricted to the four corner fuel tubes, the reactivity of the system is lower than the accident condition of the basket loaded with Westinghouse 17 x 17 OFA assemblies. Therefore, loading of the consolidated fuel is restricted to the four corner fuel tube positions of the basket. With this loading restriction, the Westinghouse 17 x 17 OFA fuel criticality evaluation is bounding.

6.6.1.2.7 Conclusions

The criticality analyses for the Maine Yankee site specific fuel demonstrates that the UMS® basket loaded with these fuel assemblies results in a system that is less reactive than loading the basket with the Westinghouse 17 x 17 OFA fuel assemblies, provided that loading is restricted to the four corner fuel tube positions in the basket for:

- All 14 x 14 fuel assemblies with less than 176 fuel rods or solid filler rods
- All 14 x 14 fuel assemblies with hollow rods
- All 17 x 17 consolidated fuel lattices

The following Maine Yankee fuels are not restricted as to loading position within the basket:

- All 14x14 fuel assemblies with 176 fuel rods or solid filler rods at a maximum enrichment of 4.2 wt % ^{235}U.
- Variably enriched fuel with a maximum fuel rod enrichment of 4.21 wt % ^{235}U with a maximum planar average enrichment of 3.99 wt % ^{235}U.
- Fuel with solid stainless steel filler rods, solid Zircaloy filler rods or solid poison shim rods in any location.
- Fuel with annular axial end blankets of up to 4.2 wt % ^{235}U.
- Fuel with a maximum of 2 fuel rods in any guide tube.

Assemblies defined as unrestricted may be loaded into the basket in any basket location and may be mixed in the same basket. While not analyzed in detail, CEAs and ICI thimble assemblies may be loaded into any intact assemblies. These components displace a significant amount of water in the fuel lattice while adding parasitic absorber, thereby reducing system reactivity.

Since the storage cask and the transfer cask loaded with the Westinghouse 17 x 17 OFA fuel assemblies is criticality safe, it is inherent that the same cask loaded with the less reactive fuel assemblies employed at Maine Yankee, using the fuel assembly loading restrictions presented above, is also criticality safe.

6.6.1.3 Maine Yankee Damaged Spent Fuel and Fuel Debris

Damaged fuel assemblies are placed in a Maine Yankee fuel can prior to loading in the basket (See Drawings 412-501 and 412-502). The Maine Yankee fuel can has screened openings in the baseplate and the lid to permit drainage, vacuum drying, and inerting of the can. This evaluation conservatively considers 100 percent of the fuel rods in the fuel can as damaged. Loading of any fuel debris is restricted to a mass equivalent of one fuel rod of an intact fuel assembly in each rod or tube used to hold fuel debris.

The Maine Yankee spent fuel inventory includes fuel assemblies with fuel rods inserted in the guide tubes of the assembly. The integrity of the cladding of the fuel rods in the guide tubes cannot be ascertained, then those fuel rods are assumed to be damaged.

6.6.1.3.1 Damaged Fuel Rods

All of the spent fuel classified as damaged, and all of the spent fuel not in its original lattice, are stored in a Maine Yankee fuel can. This fuel is analyzed using a 100% fuel rod failure assumption. The screened fuel can is designed to preclude the release of pellets and gross particulate to the canister cavity. Evaluation of the canister with four (4) Maine Yankee fuel cans containing CE 14 x 14 fuel assemblies that have up to 176 damaged fuel rods, or consolidated fuel consisting of up to 289 fuel rods, considers 100% dispersal of the fuel from these rods within the fuel can. The Maine Yankee fuel can is restricted to loading in the four corner positions of the basket.

All loose fuel in each analysis is modeled as a homogeneous mixture of fuel and water of which the volume fractions of the fuel versus the water are varied from 0-100. By varying the fuel fraction up to 100%, this evaluation addresses fuel masses significantly larger than those available in a standard or consolidated fuel assembly. First, loose fuel from damaged fuel rods within a fuel assembly is evaluated between the remaining rods of the most reactive missing rod array. The results of this analysis, provided in Table 6.6.1-9, show a slight decrease in the reactivity of the system. This results from adding fuel to the already optimized H/U ratio of the bounding missing rod array reduces the reactivity of the system as this effectively returns the system to an undermoderated state. Second, loose fuel is considered above and below the active fuel region of this most reactive missing rod array. This analysis is performed within a finite cask model. The results of this study, provided in Table 6.6.1-10, show that any possible mixture combination of fuel and water above and below the active fuel region, and hence, above and below the BORAL sheet coverage, will not significantly increase the reactivity of the system beyond that of the missing rod array. Loose fuel is also considered to replace all contents of the Maine Yankee fuel can in each four corner fuel tube location. The results of this study, provided in Table 6.6.1-11, show that any mixture of fuel and water within this cavity will not significantly increase the reactivity of the system beyond that of the missing rod array.

Damaged fuel within the fuel can may also result from a loss of integrity of a consolidated fuel assembly. As described in Section 6.6.1.2.6, the consolidated assembly missing rod study shows that a potentially higher reactivity heterogeneous configuration does not increase the overall reactivity of the system beyond that of loading 24 Westinghouse 17x17 OFA assemblies when this configuration is restricted to the four corner locations. The homogeneous mixture study of loose fuel and water replacing the contents of the Maine Yankee fuel can (in each of the four corner fuel tube locations) considers more fuel than is present in the 289 fuel rod consolidated assembly. This study shows that a homogeneous mixture at an optimal H/U ratio within the fuel can also does not affect the reactivity of the system.

Since the transfer and the storage casks loaded with the Westinghouse 17 x 17 OFA fuel assemblies is criticality safe, it is inherent that a statistically equivalent, or less reactive, canister loading of 4 Maine Yankee fuel cans containing assemblies with up to 176 damaged rods or consolidated assemblies with up to 289 rods and 20 of the most reactive Maine Yankee fuel assemblies is also criticality safe. Therefore, assemblies with up to 176 damaged rods and consolidated assemblies with up to 289 rods are allowed contents as long as they are loaded into Maine Yankee fuel cans.

6.6.1.3.2 Fuel Debris

Prior to loading fuel debris into the screened Maine Yankee fuel can, fuel debris must be placed into a rod type structure. Placing the debris into rods confines the spent nuclear material to a known volume and allows the fuel debris to be treated identically to the damaged fuel for criticality analysis.

Based on the arguments presented in Section 6.6.1.3.1, the maximum k_s of the UMS® canister with fuel debris will be less than 0.95, including associated uncertainty and bias.

Figure 6.6.1-1 24 Removed Fuel Rods - Diamond Shaped Geometry, Maine Yankee Site Specific Fuel

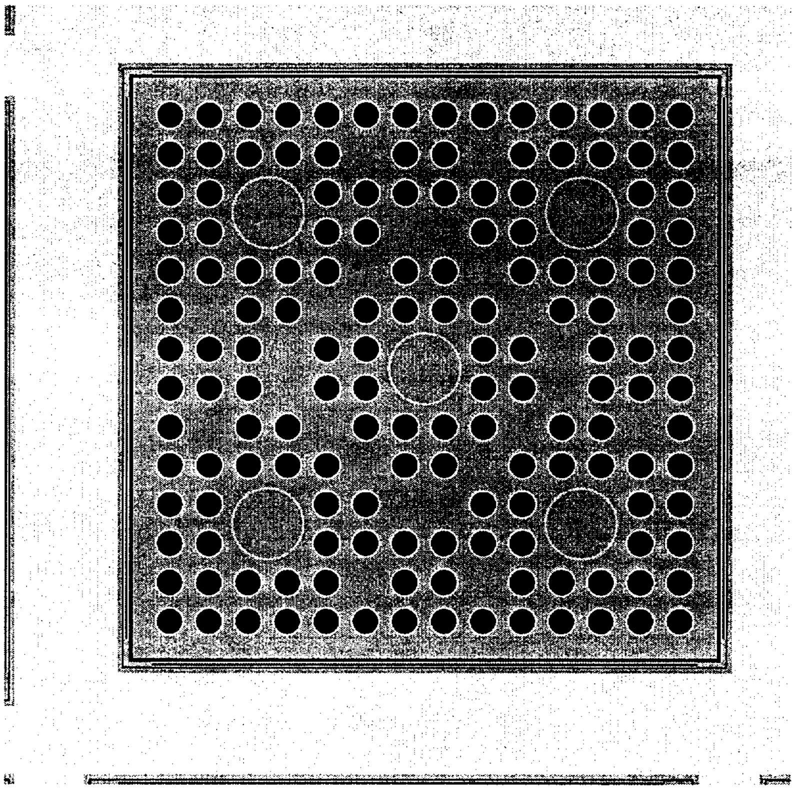

Figure 6.6.1-2 Consolidated Fuel Geometry, 113 Empty Fuel Rod Positions, Maine Yankee Site Specific Fuel

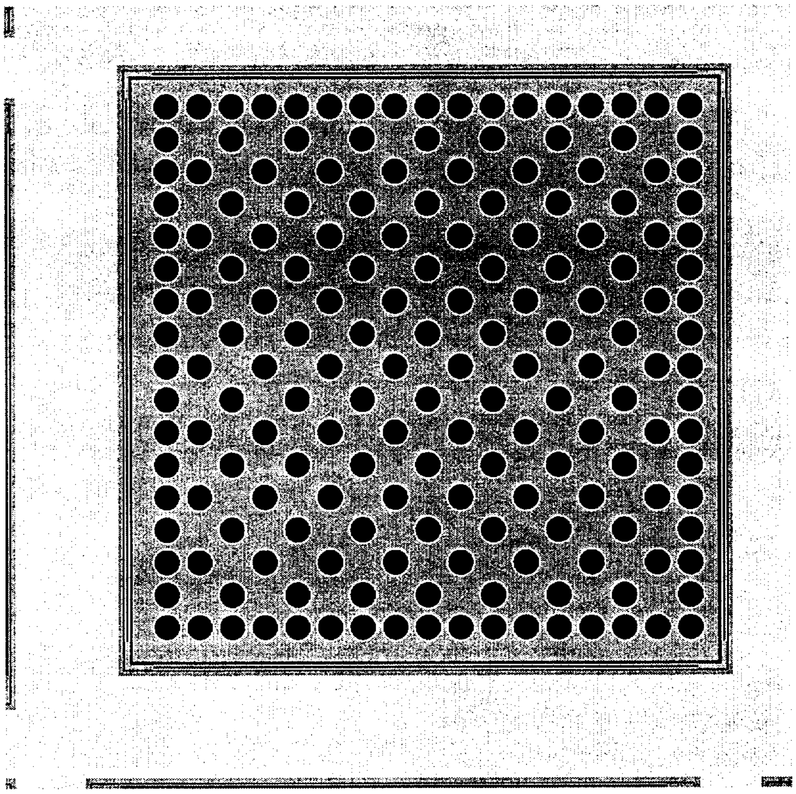

Table 6.6.1-1 Maine Yankee Standard Fuel Characteristics

Fuel Class[1]	**Vendor**	**Array**	**Version**	**Number of Fuel Rods**	**Pitch (in.)**	**Rod Diameter (in.)**	**Clad ID (in.)**	**Clad Thickness (in.)**	**Pellet Diameter (in.)**	**GT**[2] **Thickness (in.)**
1	CE	14x14	Std.	160-176	0.570-0.590	0.438-0.442	0.3825-0.3895	0.024-0.028	0.376-0.380	0.036-0.040
1	Ex/ANF	14x14	CE	164-176	0.580	0.438-0.442	0.3715-0.3795	0.0294-0.031	0.3695-0.3705	0.036-0.040
1	WE	14x14	CE	176	0.575-0.585	0.438-0.442	0.3825-0.3855	0.0262-0.028	0.376-0.377	0.034-0.038

1. All fuel rods are Zircaloy clad.
2. Guide Tube thickness.

Table 6.6.1-2 Maine Yankee Most Reactive Fuel Dimensions

Parameter	**Bounding Dimensional Value**
Maximum Rod Enrichment[1]	4.2 wt % ^{235}U
Maximum Number of Fuel Rods[2]	176
Maximum Pitch (in.)	0.590
Maximum Active Length (in.)	N/A – Infinite Model
Minimum Clad OD (in.)	0.4375
Maximum Clad ID (in.)	0.3895
Minimum Clad Thickness (in.)	0.024
Maximum Pellet Diameter (in.)	0.3800 - Study
Minimum Guide Tube OD (in.)	1.108
Maximum Guide Tube ID (in.)	1.040
Minimum Guide Tube Thickness (in.)	0.034

1. Variably enriched fuel assemblies may have a maximum fuel rod enrichment of 4.21 wt % ^{235}U with a maximum planar average enrichment of 3.99 wt % ^{235}U.
2. Assemblies with less than 176 fuel rods or solid dummy rods are addressed after the determination of the most reactive dimensions.

Table 6.6.1-3 Maine Yankee Pellet Diameter Study

Diameter (inches)	**k_{eff}**	**σ**	**$k_{eff}+2\sigma$**
0.3800	0.95585	0.00085	0.95755
0.3779	0.95784	0.00080	0.95944
0.3758	0.95714	0.00085	0.95884
0.3737	0.95863	0.00082	0.96027
0.3716	0.95862	0.00084	0.96030
0.3695	0.95855	0.00083	0.96021
0.3674	0.95863	0.00085	0.96033
0.3653	0.95982	0.00084	0.96150
0.3632	0.95854	0.00088	0.96030
0.3611	0.95966	0.00083	0.96132
0.3590	0.95990	0.00084	0.96158
0.3569	0.96082	0.00082	0.96246
0.3548	0.96053	0.00083	0.96219
0.3527	0.96104	0.00082	0.96268
0.3506	0.95964	0.00087	0.96138
0.3485	0.95993	0.00086	0.96165
0.3464	0.95916	0.00084	0.96084
0.3443	0.95847	0.00083	0.96013
0.3422	0.95876	0.00083	0.96042
0.3401	0.95865	0.00081	0.96027
0.3380	0.95734	0.00084	0.95902

Table 6.6.1-4 Maine Yankee Annular Fuel Results

Case Description	**k_{eff}**	**σ**	**$k_{eff}+2\sigma$**
All pellets with a diameter of 0.3527 inches	0.90896	0.00083	0.91061
Annular pellet diameter changed to 0.3800 inches	0.91013	0.00087	0.91187

Table 6.6.1-5 Maine Yankee Removed Rod Results with Small Pellet Diameter

Number of Removed Rods	Number of Fuel Rods	k_{eff}	σ	$k_{eff}+2\sigma$
4	172	0.91171	0.00088	0.91347
4	172	0.91292	0.00086	0.91464
4	172	0.91479	0.00081	0.91640
4	172	0.91125	0.00087	0.91299
6	170	0.91418	0.00087	0.91592
6	170	0.91264	0.00085	0.91435
6	170	0.91314	0.00086	0.91487
6	170	0.90322	0.00086	0.90493
8	168	0.91555	0.00087	0.91729
8	168	0.91490	0.00093	0.91676
8	168	0.91457	0.00088	0.91633
8	168	0.91590	0.00087	0.91764
8	168	0.89729	0.00088	0.89905
12	164	0.91654	0.00086	0.91827
12	164	0.91469	0.00085	0.91639
12	164	0.91149	0.00083	0.91315
16	160	0.91725	0.00084	0.91893
16	160	0.91567	0.00084	0.91735
16	160	0.90986	0.00088	0.91162
16	160	0.90849	0.00083	0.91015
16	160	0.90704	0.00086	0.90876
24	152	0.91572	0.00083	0.91739
32	144	0.91037	0.00088	0.91213
48	128	0.89385	0.00085	0.89554
48	128	0.84727	0.00079	0.84886
64	112	0.79602	0.00083	0.79768
96	80	0.69249	0.00077	0.69402
Westinghouse 17 x 17 OFA		0.9192	0.0009	0.9210

Table 6.6.1-6 Maine Yankee Removed Fuel Rod Results with Maximum Pellet Diameter

Number of Removed Rods	Number of Fuel Rods	k_{eff}	σ	$k_{eff} + 2\sigma$
4	172	0.91078	0.00086	0.91250
4	172	0.90916	0.00085	0.91085
4	172	0.91164	0.00087	0.91338
4	172	0.90809	0.00085	0.90979
6	170	0.91223	0.00085	0.91393
6	170	0.91223	0.00080	0.91384
6	170	0.91270	0.00086	0.91442
6	170	0.90245	0.00086	0.90416
6	170	0.89801	0.00086	0.89972
8	168	0.91567	0.00085	0.91736
8	168	0.91448	0.00085	0.91618
8	168	0.91355	0.00086	0.91526
8	168	0.91293	0.00085	0.91463
12	164	0.91639	0.00090	0.91818
12	164	0.91803	0.00086	0.91974
12	164	0.91235	0.00083	0.91401
16	160	0.91665	0.00091	0.91847
16	160	0.92136	0.00087	0.92310
16	160	0.91231	0.00084	0.91400
16	160	0.90883	0.00087	0.91057
24	152	0.92227	0.00087	0.92400
32	144	0.92164	0.00088	0.92340
48	128	0.91212	0.00081	0.91373
48	128	0.86308	0.00082	0.86472
64	112	0.81978	0.00080	0.82138
88	88	0.72087	0.00083	0.72247
24 (Four Corners)	152	0.91153	0.00085	0.91323
Westinghouse 17 x 17 OFA		0.9192	0.0009	0.9210

Table 6.6.1-7 Maine Yankee Fuel Rods in Guide Tube Results

Number of Guide Tubes with Rods	Number of Rods in Each	k_{eff}	σ	$k_{eff} + 2\sigma$
1	1	0.91102	0.00089	0.91280
2	1	0.91059	0.00088	0.91234
3	1	0.91172	0.00087	0.91346
5	1	0.91411	0.00086	0.91583
1	2	0.91169	0.00090	0.91349
2	2	0.91201	0.00087	0.91375
3	2	0.91173	0.00086	0.91344
5	2	0.91357	0.00086	0.91529
Design Basis Westinghouse 17 x 17 OFA		0.9192	0.0009	0.9210

Table 6.6.1-8 Maine Yankee Consolidated Fuel Empty Fuel Rod Position Results

Number of Empty Positions	Number of Fuel Rods	k_{eff}	σ	$k_{eff} + 2\sigma$
4	285	0.79684	0.00082	0.79848
9	280	0.80455	0.00081	0.80616
9	280	0.80812	0.00079	0.80970
13	276	0.81573	0.00083	0.81739
24	265	0.84187	0.00080	0.84347
25	264	0.84017	0.00083	0.84182
25	264	0.84634	0.00081	0.84795
25	264	0.84583	0.00083	0.84750
25	264	0.85524	0.00083	0.85690
25	264	0.83396	0.00081	0.83558
25	264	0.84625	0.00083	0.84790
27	262	0.85438	0.00083	0.85604
29	260	0.85179	0.00081	0.85340
31	258	0.85930	0.00084	0.86098
33	256	0.86407	0.00082	0.86571
35	254	0.86740	0.00082	0.86904
37	252	0.87372	0.00084	0.87541
45	244	0.88630	0.00081	0.88793
45	244	0.87687	0.00079	0.87844
52	237	0.90062	0.00083	0.90228
57	232	0.87975	0.00087	0.88149
61	258	0.89055	0.00083	0.89221
73	216	0.90967	0.00082	0.91131
84	205	0.93261	0.00091	0.93443
85	204	0.94326	0.00086	0.94499
113	176	0.95626	0.00084	0.95794
117	172	0.95373	0.00088	0.95549
119	170	0.95315	0.00085	0.95485
125	164	0.95020	0.00086	0.95192
141	148	0.94348	0.00086	0.94521
145	144	0.93868	0.00089	0.94047
113 (Four Corners)	176	0.91292	0.00087	0.91466
Design Basis Westinghouse 17 x 17 OFA		0.9192	0.0009	0.9210

Table 6.6.1-9 Fuel Can Infinite Height Model Results of Fuel - Water Mixture Between Rods

Volume Fraction of UO_2 in Water	k_{eff}	Δk_{eff} to 24 (Four Corners)[1]
0.000	0.91090	-0.00063
0.001	0.91138	-0.00015
0.002	0.91120	-0.00033
0.003	0.91177	0.00024
0.004	0.91285	0.00132
0.005	0.90908	-0.00245
0.006	0.91001	-0.00152
0.007	0.90895	-0.00258
0.008	0.91005	-0.00148
0.009	0.90986	-0.00167
0.010	0.90864	-0.00289
0.020	0.91003	-0.00150
0.030	0.90963	-0.00190
0.040	0.91063	-0.00090
0.050	0.90931	-0.00222
0.060	0.90765	-0.00388
0.070	0.90753	-0.00400
0.080	0.91088	-0.00065
0.090	0.91122	-0.00031
0.100	0.90879	-0.00274
0.150	0.90968	-0.00185
0.200	0.90952	-0.00201
0.250	0.90815	-0.00338
0.300	0.90748	-0.00405
0.350	0.90581	-0.00572
0.400	0.90963	-0.00190
0.450	0.90547	-0.00606
0.500	0.90603	-0.00550
0.550	0.90753	-0.00400
0.600	0.90674	-0.00479
0.650	0.90589	-0.00564
0.700	0.90594	-0.00559
0.750	0.90568	-0.00585
0.800	0.90532	-0.00621
0.850	0.90693	-0.00460
0.900	0.90639	-0.00514
0.950	0.90684	-0.00469
1.000	0.90677	-0.00476

[1] See Table 6.6.1-6.

Table 6.6.1-10 Fuel Can Finite Model Results of Fuel-Water Mixture Outside BORAL Coverage

Volume Fraction of UO_2 in Water	**k_{eff}**	**Δk_{eff} to 0.00 UO_2 in Water**	**Δk_{eff} to 24 (Four Corners)[1]**
0.00	0.91045[2]	NA	-0.00108
0.05	0.90781	-0.00264	-0.00372
0.10	0.90978	-0.00067	-0.00175
0.15	0.91048	0.00003	-0.00105
0.20	0.90916	-0.00129	-0.00237
0.25	0.90834	-0.00211	-0.00319
0.30	0.90935	-0.00110	-0.00218
0.35	0.90786	-0.00259	-0.00367
0.40	0.90892	-0.00153	-0.00261
0.45	0.91015	-0.00030	-0.00138
0.50	0.91011	-0.00034	-0.00142
0.55	0.91003	-0.00042	-0.00150
0.60	0.90874	-0.00171	-0.00279
0.65	0.91165	0.00120	0.00012
0.70	0.90977	-0.00068	-0.00176
0.75	0.90813	-0.00232	-0.00340
0.80	0.90909	-0.00136	-0.00244
0.85	0.91028	-0.00017	-0.00125
0.90	0.91061	0.00016	-0.00092
0.95	0.91129	0.00084	-0.00024
1.00	0.91076	0.00031	-0.00077

1. See Table 6.6.1-6.
2. $\sigma = 0.00084$.

Table 6.6.1-11 Fuel Can Finite Model Results of Replacing All Rods with Fuel-Water Mixture

Volume Fraction of UO_2 in Water	k_{eff}	**Δk_{eff} to 24 (Four Corners) Finite Height Model**	**Δk_{eff} to 24 (Four Corners) Infinite Height Model**
0	0.90071	-0.00974	-0.01082
5	0.90194	-0.00851	-0.00959
10	0.90584	-0.00461	-0.00569
15	0.90837	-0.00208	-0.00316
20	0.91008	-0.00037	-0.00145
25	0.91086	0.00041	-0.00067
30	0.90964	-0.00081	-0.00189
35	0.90828	-0.00217	-0.00325
40	0.90805	-0.00240	-0.00348
45	0.90730	-0.00315	-0.00423
50	0.90637	-0.00408	-0.00516
55	0.90672	-0.00373	-0.00481
60	0.90649	-0.00396	-0.00504
65	0.90632	-0.00413	-0.00521
70	0.90435	-0.00610	-0.00718
75	0.90792	-0.00253	-0.00361
80	0.90376	-0.00669	-0.00777
85	0.90528	-0.00517	-0.00625
90	0.90454	-0.00591	-0.00699
95	0.90360	-0.00685	-0.00793
100	0.90416	-0.00629	-0.00737

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8.1 Procedures For Loading the Universal Storage System

The Universal Storage System consists of three principal components: the transportable storage canister (canister), the transfer cask, and the vertical concrete cask. The transfer cask is used to hold the canister during loading and while the canister is being closed and sealed. The transfer cask is also used to transfer the canister to the concrete cask and to load the canister into the transport cask. The principal handling operations involve closing and sealing the canister by welding, and placing the loaded canister in the vertical concrete cask. The vent and drain port locations are shown in Figure 8.1.1-1.

This procedure assumes that the canister with an empty basket is installed in the transfer cask, that the transfer cask is positioned in the decontamination area or other suitable work station, and that the vertical concrete cask is positioned in the plant cask receiving area or other suitable staging area. The transfer cask extension must be installed on the transfer cask if its use is required. To facilitate movement of the transfer cask to the concrete cask, the staging area should be within the operational "footprint" of the cask handling crane. The concrete cask may be positioned on a heavy-haul transporter, or on the floor of the work area.

The User must ensure that the fuel assemblies selected for loading conform to the Approved Contents provisions of Section B2.0 of Appendix 12B and to the Certificate of Compliance. Fuel assembly loading may also be administratively controlled to ensure that fuel assemblies with specific characteristics are preferentially loaded in specified positions in the canister. Preferential loading requirements are described in Appendix 12B, Sections B2.1.2 and B2.1.3.

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8.1.1 Loading and Closing the Transportable Storage Canister

1. Visually inspect the basket fuel tubes to ensure that they are unobstructed and free of debris. Ensure that the welding zones on the canister, shield, and structural lids, and the port covers are prepared for welding. Ensure transfer cask door lock bolts are installed and secure.
2. Fill the canister with clean or filtered pool water until the water is about 4 inches from the top of the canister.

   Note: Do not fill the canister completely in order to avoid spilling water during the transfer to the spent fuel pool.
3. Attach clean or filtered pool water lines to the transfer cask.
4. If it is not already attached, attach the transfer cask lifting yoke to the cask handling crane, and engage the transfer cask lifting trunnions.

   Note: The minimum temperature of the transfer cask (i.e., surrounding air temperature) must be verified to be higher than 0°F prior to lifting, in accordance with Appendix 12B, Section B3.4 (8).
5. Raise the transfer cask and move it over the pool, following the prescribed travel path.
6. Lower the transfer cask to the pool surface and turn on the clean or filtered pool water line to fill the canister and the annulus between the transfer cask and canister.
7. Lower the transfer cask as the annulus fills with clean or filtered pool water until the trunnions are at the surface, and hold that position until the clean or filtered pool water fills the remainder of the canister and overflows the sides of the transfer cask. Then lower the transfer cask to the bottom of the pool cask loading area.

   Note: If an intermediate shelf is used to avoid wetting the cask handling crane hook, follow the plant procedure for use of the crane lift extension piece.
8. Disengage the transfer cask lifting yoke to provide clear access to the canister.
9. Load the previously designated fuel assemblies into the canister.

   Note: Contents must be in accordance with the Approved Contents provisions of Appendix 12B, Section B2.0.

   Note: Contents may be administratively controlled to ensure that fuel assemblies with certain characteristics are preferentially loaded in specified positions in the basket. Preferential loading requirements are presented in Appendix 12B, Sections B2.1.2 and B2.1.3.

Note: Ensure that the shield lid key slot aligns with the key welded to the canister shell.

11. Using the cask handling crane, or auxiliary hook, lower the shield lid until it rests in the top of the canister.
12. Raise the transfer cask until its top just clears the pool surface. Hold at that position, and using a suction pump, drain the pool water from above the shield lid. After the water is removed, continue to raise the cask. Note the time that the transfer cask is removed from the pool. Operations through Step 28 must be completed within 17 hours.

    Note: Alternately, the temperature of the water in the canister may be used to establish the time for completion through Step 28. Those operations must be completed within 2 hours of the time that the canister water temperature is 200°F. For this alternative, the water temperature must be determined every 2 hours beginning 17 hours after the time the transfer cask is removed from the pool.
13. As the cask is raised, spray the transfer cask outer surface with clean or filtered pool water to wash off any gross contamination.
14. When the transfer cask is clear of the pool surface, but still over the pool, turn off the clean or filtered pool water flow to the annulus, remove hoses and allow the annulus water to drain to the pool. Move the transfer cask to the decontamination area or other suitable work station.

    Note: Access to the top of the transfer cask is required. A suitable work platform may need to be erected.
15. Verify that the shield lid is level and centered.
16. Attach the suction pump to the suction pump fitting on the vent port. Operate the suction pump to remove free water from the shield lid surface. Disconnect the suction pump and suction pump fitting. Remove any free standing water from the shield lid surface and from the vent and drain ports.
17. Decontaminate the top of the transfer cask and shield lid as required to allow welding and inspection activities.

    Note: Supplemental shielding may be used for activities around the shield lid.
18. Insert the drain tube assembly through the drain port of the shield lid into the basket drain tube sleeve. Torque the drain tube assembly to 125 ± 5 ft-lbs. Install a mating quick-disconnect fitting in the vent line to open the vent.
19. Connect the suction pump to the drain port. Verify that the vent port is open. Remove approximately 50 gallons of water from the canister. Disconnect and remove the pump.

    Caution: Radiation level may increase as water is removed from the canister.
20. Install the automatic welding equipment.

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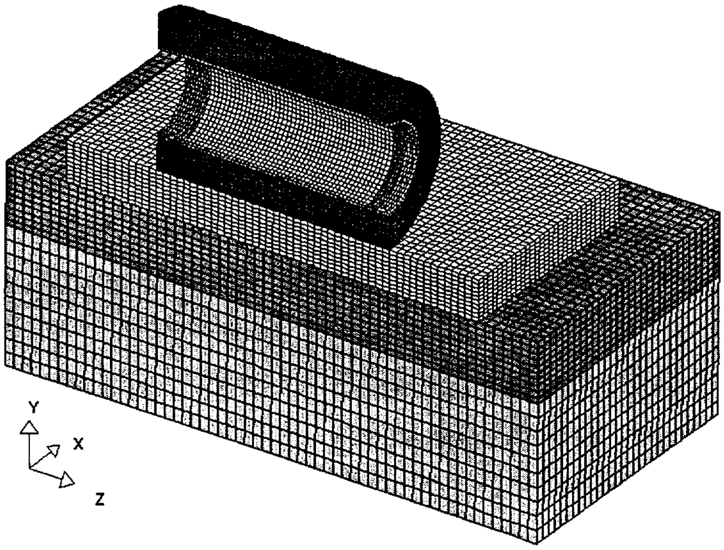
The model includes a half section of the concrete cask, the concrete ISFSI pad and soil subgrade, as shown:



Concrete Pad Properties

Vertical concrete cask tip-over analyses are performed for ISFSI pad concrete compressive strengths of 3,000 and 4,000 psi. The Poisson's Ratio (ν_c) is 0.22. The concrete dry density is considered to be between 135 pcf and 145 pcf. To account for the weight of reinforcing bar in the pad, three values of Density (ρ) are used in the model:

ρ (lbs/ft^3)	E_c (psi)	K_c (psi)
140	2.994×10^6	1.782×10^6
145	3.156×10^6	1.879×10^6
152	3.387×10^6	2.016×10^6

The corresponding values of Modulus of Elasticity (E_c) and Bulk Modulus (K_c) are also provided, where:

Modulus of Elasticity (E_c) $= 33\rho_c^{1.5}\sqrt{f_c'}$ (ACI 318-95)

Bulk Modulus (K_c) $= \dfrac{E_c}{3(1-2\nu_c)}$ (Blevins [19])

Soil Properties

The soil properties used in the model are based on two soil layers. The vertical concrete cask tip-over analyses are performed for two different combinations of soil densities: (1) 4.5-foot thick upper layer density of 135 pcf (Modulus of Elasticity, E = 162,070 psi), with a 10-foot thick lower layer density of 127 pcf (E = 31,900 psi); and (2) 4.5-foot thick upper layer density of 130 pcf, with a 10-foot thick lower layer density of 127 pcf. The Poisson's Ratio (v_s) of the soil is 0.45.

Vertical Concrete Cask Properties

The material properties used in the model for the Vertical Concrete Cask are the same as the properties used in the PWR models in Section 11.2.12.3. The tip-over impact is simulated by applying an initial angular velocity of 1.485 rad/sec (PWR Class 1) and 1.483 rad/sec (PWR Class 2), respectively to the entire cask. The angular velocity values are determined by the method used in Section 11.2.12 based on the weight of the loaded concrete cask with Maine Yankee fuel (285,513 pounds and 297,509 pounds for PWR Class 1 and PWR Class 2 respectively).

A cut-off frequency of 210 Hz (PWR Class 1) and 190 Hz (PWR Class 2) is applied to filter the analysis results from the LS-DYNA models and determine the peak accelerations. The resulting calculated accelerations on the canister at the location of the top support disk and of the top of the structural lid are tabulated for all of the analysis cases that were run. The maximum accelerations at the two key locations on the canister for the PWR Class 1 and Class 2 configurations are:

	Position Measured from the Bottom of the Concrete Cask (inches)		Acceleration (g)	
Component Location	Class 1	Class 2	Class 1	Class 2
Top Support Disk	176.7	185.2	32.3	34.2
Top of the Canister Structural Lid	197.9	207.0	35.3	37.6

The maximum acceleration values correspond to the analysis run for an ISFSI concrete pad density of 140 pcf and a compressive strength of 3,000 psi, with an upper soil layer density of 135 pcf and a lower soil layer density of 127 pcf.

The impact accelerations for the vertical concrete cask tip-over on the Maine Yankee ISFSI pad site are observed to be slightly higher than those reported in Section 11.2.12.3.1 for the design-basis

ISFSI pad. Therefore, peak accelerations are calculated for the top support disk and are evaluated with respect to the analysis presented in Section 11.2.12.4.1.

To determine the effect of the rapid application of the inertia loading for the support disk, a dynamic load factor (DLF) is computed using the method presented in Section 11.2.12.4. The DLF is computed to be 1.07 and 1.02 for PWR Class 1 and Class 2, respectively. Applying the DLFs to the 32.3g and 34.2g results in peak accelerations of 34.6g and 34.9g for the top support disk PWR Class 1 and Class 2, respectively. The DLFs for the canister lids are considered to be unity since the lids have significant in-plane stiffness and are considered to be rigid. Therefore, the maximum acceleration for the canister and basket for the cask tip-over accident on the Maine Yankee site ISFSI pad is bounded by the 40g used in Section 11.2.12.4.1 (Analysis of canister and basket for PWR configurations for tip-over event).

11.2.15.1.2 Parametric Study of Support Disk Evaluation for Maine Yankee Consolidated Fuel

A parametric study is performed to show that the PWR basket loaded with a Maine Yankee consolidated fuel lattice is bounded by the PWR basket design basis loading for a side impact condition. Only one consolidated fuel lattice, in a Maine Yankee Fuel Can, will be loaded in any single Transportable Storage Canister. However, Maine Yankee Fuel Cans holding other intact or damaged fuel can be loaded in the other three corner positions of the basket. (Maine Yankee Fuel Cans may be loaded only in the four corner positions of the basket. See Figure 11.2.15.1.2-2 for corner positions.) Therefore, the bounding case for Maine Yankee is the basket configuration with twenty (20) Maine Yankee fuel assemblies, three (3) fuel cans containing spent fuel, and one (1) fuel can containing consolidated fuel.

A two-dimensional ANSYS model is employed for the parametric study as shown in Figure 11.2.15.1.2-1. The load from a PWR fuel assembly is modeled as a pressure load at the inner surface of each support disk slot opening. The design basis fuel pressure loading (1g) is 12.26 psi. Based on the same design parameters (slot size = 9.272 in., disk thickness = 0.5 inch, and the number of disks = 30), the pressure load corresponding to a Maine Yankee standard CE 14 x 14 fuel assembly is 10.3 psi. The pressure load is 11.3 psi for a Maine Yankee fuel can holding an intact or damaged fuel assembly. For a Maine Yankee fuel can holding consolidated fuel the pressure load is 17.0 psi.

This study considers a 60g side impact condition for four different basket orientations: 0°, 18.22°, 26.28° and 45°, as shown in Figure 11.2.15.1.2-2. Note that 60g bounds the maximum g-load for the PWR support disks (40g) due to the Vertical Concrete Cask tip-over accident as shown in Section 11.2.12.

A total of five cases are considered in the study. Inertial loads are applied to the support disk in all cases. The base case considers that all 24 fuel positions hold design basis PWR fuel assemblies. The other four cases (Cases 1 through 4) represent four possible load combinations for the placement of four Maine Yankee fuel cans in the corner positions, one of which holds consolidated fuel. The remaining twenty basket positions hold Maine Yankee standard 14 × 14 fuel assemblies. The basket loading positions are shown in Figure 11.2.15.1.2-2. The load combinations evaluated in the four Maine Yankee fuel can loading cases are:

Case	Basket Position 1	Basket Position 2	Basket Position 3	Basket Position 4
1	Consolidated	Damaged	Damaged	Damaged
2	Damaged	Consolidated	Damaged	Damaged
3	Damaged	Damaged	Damaged	Consolidated
4	Damaged	Damaged	Consolidated	Damaged

Table 11.2.15.1.2-1 provides a parametric comparison between the Base Case and the four cases evaluated, based on the maximum sectional stress in the support disk. As shown in the table, the maximum stress in the PWR basket support disk loaded with 20 standard fuel assemblies and four Maine Yankee fuel cans, including one holding consolidated fuel, is bounded by that for the support disk loaded with the design basis PWR fuel.

Additionally, a three-dimensional analysis was performed for Case 4 with a 26.28° drop orientation using the three-dimensional canister/basket model presented in Section 11.2.12.4.1. Results of the analysis for the top support disk, where maximum stress occurs, are presented in Tables 11.2.15.1.2-2 and 11.2.15.1.2-3. The minimum margin of safety is +1.12 and +0.11 for P_m stresses and $P_m + P_b$ stresses, respectively. The minimum margin of safety for the corresponding analysis for the design basis PWR configuration is +0.97 and +0.05 for P_m and $P_m + P_b$ stresses, respectively (See Table 11.2.12.4.1-4). Therefore, it is further demonstrated that the maximum stress in the PWR support disk loaded with Maine Yankee fuel with consolidated fuel is bounded by the stress for the PWR support disk loaded with the design basis PWR fuel.

Since no credit is taken for the structural integrity of the consolidated fuel or damaged fuel inside the fuel can, it is assumed that 100% of the fuel rods fail during an accident. For a Maine Yankee standard 14×14 fuel assembly, the volume of 176 fuel rods (100%) and 5 guide tubes will fill up the lower 103.6 inches (about at the elevation of the 21st support disk) assuming a 50% volume compaction factor. For the consolidated fuel, the volume of 283 rods (100%) and 4 connector rods will fill up the lower 109.6 inches (about at the elevation of the 22nd support disk) assuming a 75% compaction factor. The compaction factor of 75% for the consolidated fuel considers that the number of rods in the consolidated fuel is approximately 1.5 times of the number of rods in the standard Maine Yankee fuel and these rods are initially more closely spaced.

During a tip-over accident of the vertical concrete cask, the maximum total load on the support disk (top/30th disk) for the design basis PWR basket is 54.6 kips (12.26 psi × 9.272-inch × 0.5-inch × 24 × 40g), considering the design deceleration of 40g (Section 11.2.12.4). With the assumption of 100% rod failure for the damaged fuel and consolidated fuel in the Maine Yankee fuel can, the 21st disk is subjected to the maximum total load (including weight from 20 standard fuel assemblies, 3 damaged fuel assemblies and the consolidated fuel). The pressure load (1g) on the support disk corner slot corresponding to 100% failed damaged fuel is 15.3 psi (load distributed to 21 support disks) and the pressure load corresponding to the 100% failed consolidated fuel is 22.6 psi (load distributed on 22 support disks). For the tip-over accident, the g-load at the 21st disk is 30g, based on the design deceleration of 40g at the top (30th) disk. The total load (W_{21}) on the 21st support disk is:

$$W_{21} = (10.3\times20+15.3\times3+22.6\times1)\times9.272\times0.5\times30 = 38{,}200 \text{ pounds} = 38.2 \text{ kips}$$

The support disk load is only 70% (38.2/54.6=0.7) of the maximum total load on the support disk due to the design basis PWR fuel load. Consequently, the maximum stress in the support disk for the Maine Yankee configuration assuming 100% rod failure of the damaged and consolidated fuel in Maine Yankee fuel cans is bounded by the maximum stress in the support disk calculated for the design basis fuel.

Figure 11.2.15.1.2-1 Two-Dimensional Support Disk Model

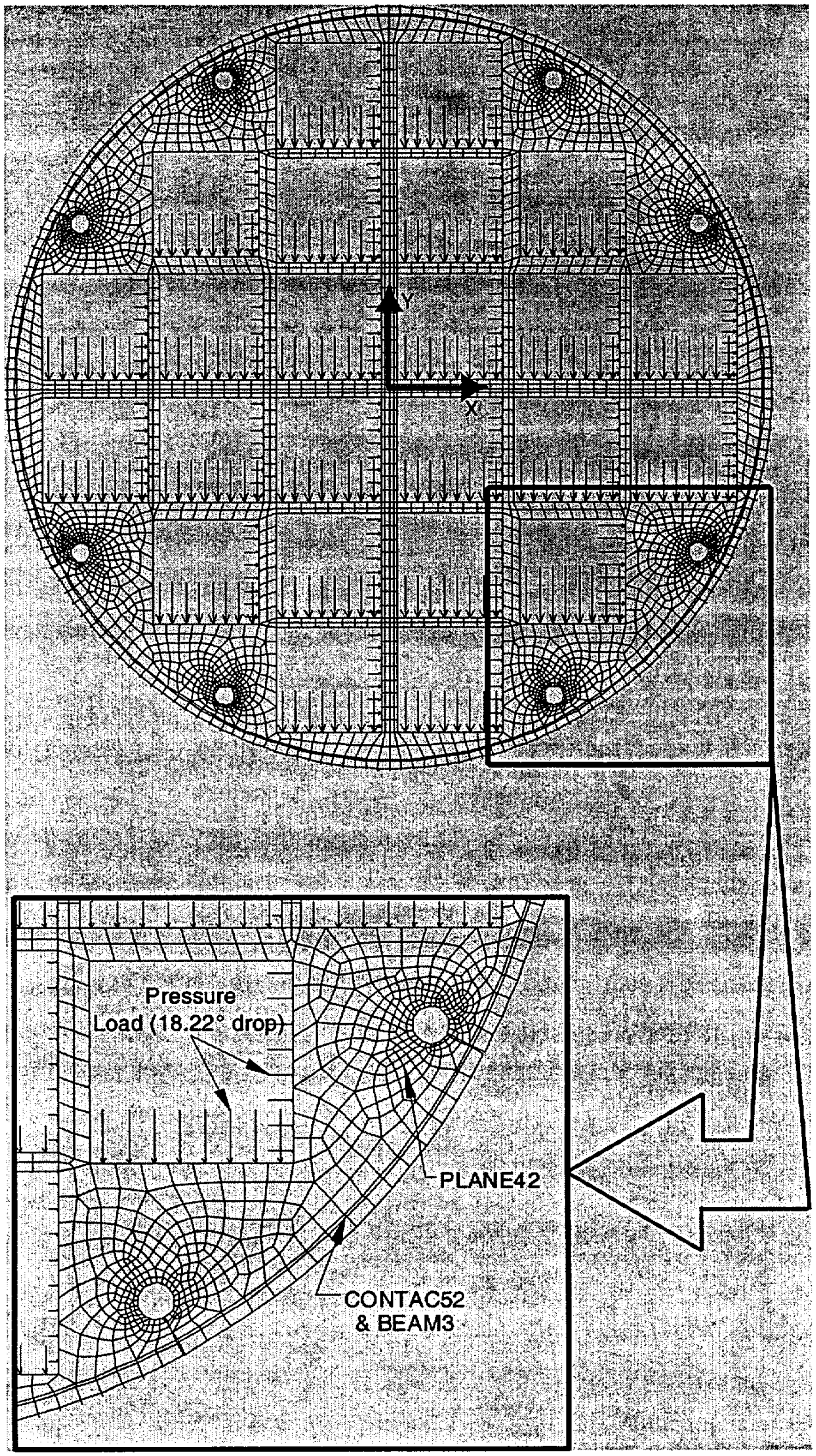


Figure 11.2.15.1.2-2 PWR Basket Impact Orientations and Case Study Loading Positions for Maine Yankee Consolidated Fuel

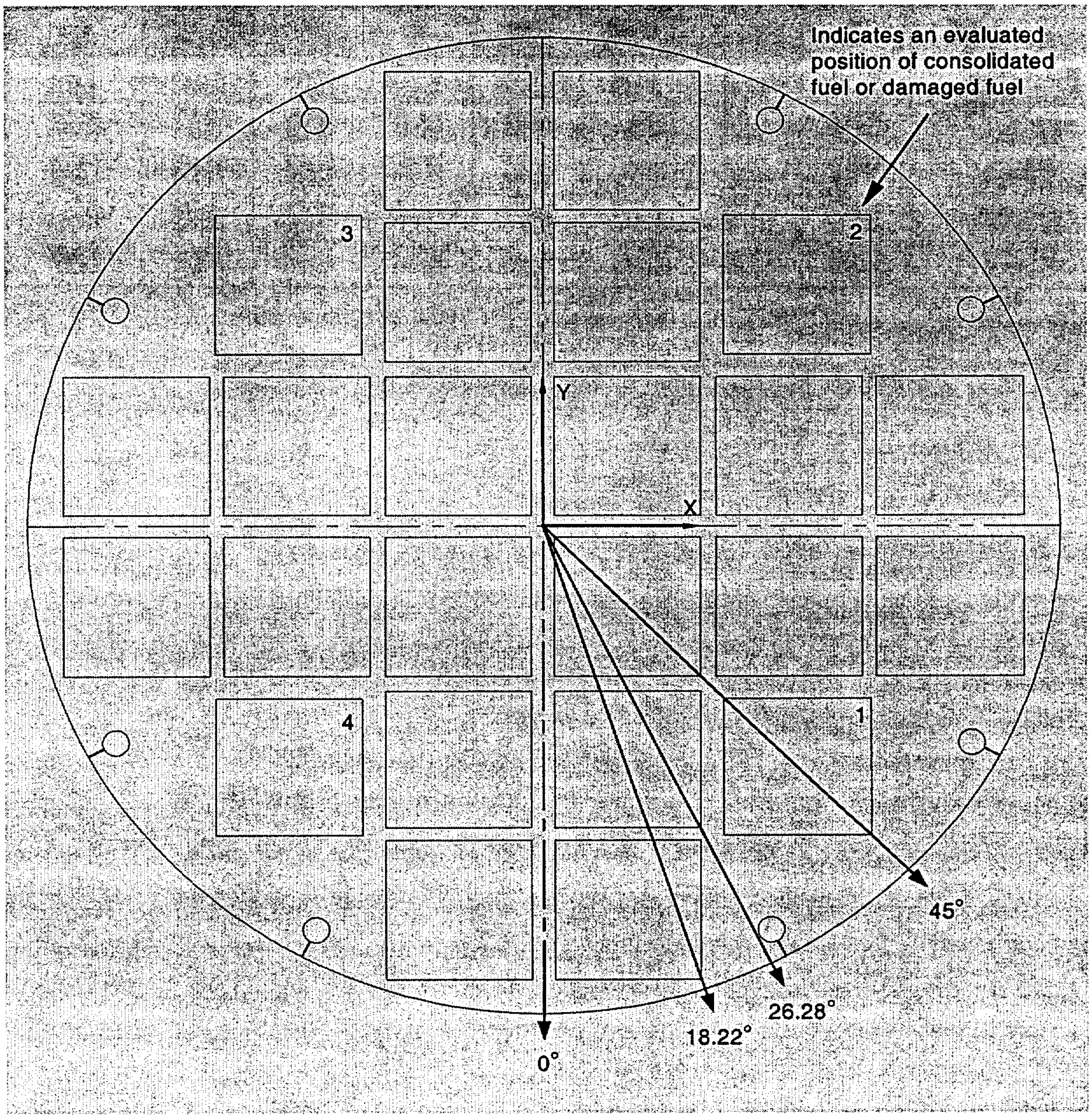


Table 11.2.15.1.2-1 Normalized Stress Ratios – PWR Basket Support Disk Maximum Stresses

Orientation[1]	**Membrane Stress Ratio**[2]				**Membrane + Bending Stress Ratio**[2]			
	0°	**18.22°**	**26.28°**	**45°**	**0°**	**18.22°**	**26.28°**	**45°**
Base Case	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Case 1	0.91	0.94	0.94	0.94	0.96	0.94	0.94	0.94
Case 2	0.91	0.94	0.94	0.95	0.95	0.95	0.95	0.95
Case 3	0.91	0.95	0.95	0.95	0.96	0.95	0.95	0.95
Case 4	0.91	0.95	0.95	0.96	0.96	0.98	0.98	0.97

1. Orientations correspond to those shown in Figure 11.2.15.1.2-2.
2. Stress ratios are based on the maximum sectional stresses of the support disk.

Table 11.2.15.1.2-2 Support Disk Primary Membrane (P_m) Stresses for Case 4, 26.28° Drop Orientation (ksi)

Section Number	Sx	Sy	Sxy	Stress Intensity	Allowable Stress	Margin of Safety
18	19.3	-22.9	2.8	42.6	90.4	1.12
3	27.1	-12.2	2.4	39.6	89.3	1.26
16	37.1	-22.8	1	37.2	89.3	1.4
1	32.3	-12.1	0.6	32.3	90.4	1.8
94	26.8	-19	2.7	27.6	90.5	2.28
17	-0.1	-22.8	1.9	23.1	89.8	2.9
88	18.3	-5.6	-7.3	21.6	91.5	3.23
96	6.7	-13.8	-3.2	21.4	91.5	3.27
95	-0.1	-19.9	1.5	20	91.1	3.55
90	15.3	-3.5	0.8	18.9	90.5	3.8
84	15.6	-18.5	-0.4	18.6	91.5	3.93
61	15.7	-10.5	4.7	18.5	91.5	3.96
60	10.2	-17.5	1.3	17.7	89.3	4.03
82	15.7	-7.8	3.8	17.2	90.8	4.27
37	11.9	-4.3	0.6	16.3	89.3	4.49
58	10.3	-12.1	5	16.3	90.4	4.54
62	15.7	-0.2	2.6	16.3	91.2	4.59
83	15.7	-0.2	1.7	15.8	91.2	4.75
91	-7.4	-15.4	-1.5	15.7	90.5	4.78
63	15.6	-9.9	0.5	15.7	90.8	4.8
30	14.1	-9.3	3.1	15.6	91.9	4.89
33	14.6	-4.7	2.3	15.1	89.3	4.93
108	13.5	-5.6	-3.9	15.1	91.5	5.07
24	-2	-14.3	1.7	14.5	91.5	5.31
79	-5.3	6.3	4.1	14.2	89.3	5.31
23	-0.1	-14.2	0.7	14.2	91.2	5.41
22	-7.3	-14.1	-0.4	14.2	90.8	5.42
28	13.2	-9.1	1.8	13.9	90.9	5.56
7	13.6	-11.9	-0.7	13.8	91.5	5.62
46	-2.4	-10.8	5.1	13.2	89.3	5.74

Note: See Figure 11.2.12.4.1-7 for Section locations.

Table 11.2.15.1.2-3 Support Disk Primary Membrane + Primary Bending ($P_m + P_b$) Stresses for Case 4, 26.28° Drop Orientation (ksi)

Section Number	Sx	Sy	Sxy	Stress Intensity	Allowable Stress	Margin of Safety
61	-116.4	-39.3	10.1	117.7	130.8	0.11
58	-109.5	-43.9	8.7	110.6	129.1	0.17
43	-92.6	-32.4	6.2	93.2	129.1	0.39
82	-87.8	-27.9	7	88.6	129.8	0.46
60	-81.6	-39.9	7.7	83	127.6	0.54
79	-82	-18.9	2	82	127.6	0.56
55	-83.5	-29.3	4.6	83.9	130.8	0.56
16	-52.5	-71.9	15	80.1	127.6	0.59
46	-77.1	-49.3	9.5	80	127.6	0.59
64	-76.2	-31.8	7	77.2	127.6	0.65
30	-34.4	-75.2	13.1	79.1	131.3	0.66
18	-2.8	-77.6	-2.9	77.8	129.1	0.66
3	10.1	-65.4	-6	76.5	127.6	0.67
63	-75.4	-26	4.3	75.8	129.8	0.71
76	69	21	4.7	69.5	129.8	0.87
48	-66	-42.7	4	66.7	125.7	0.89
19	-38.2	-65.3	2.6	65.5	125.7	0.92
6	-43.2	-62	5.4	63.4	125.7	0.98
45	-63.2	-15.3	-0.2	63.2	127.6	1.02
94	-56.3	-40.8	10.4	61.5	129.3	1.1
21	-47.1	-57.5	5.3	59.7	127.6	1.14
67	-54.5	-42.3	5.3	56.5	125.7	1.22
1	-47.7	-40.7	12.7	57.3	129.1	1.25
33	-29.7	-52.9	7.4	55	127.6	1.32
51	26.7	-27.3	3.9	54.5	127.7	1.34
39	-29	-49.8	6.3	51.6	129.1	1.5
81	-49.9	-29.5	5.3	51.2	129.1	1.52
84	-48	-26.1	6.2	49.7	130.8	1.63
4	-41.7	-43.6	5.3	48	127.6	1.66
28	-44.6	-29.6	8.3	48.2	129.9	1.69

Note: See Figure 11.2.12.4.1-7 for Section locations.

11.2.15.1.3 Structural Evaluation for the Maine Yankee Fuel Can

Twenty-Four Inch Drop of the Vertical Concrete Cask

The 24-inch drop of the Vertical Concrete Cask onto an unyielding surface (Section 11.2.4) results in accelerations that are bounded by the 60g acceleration used in this structural evaluation for the Maine Yankee fuel can. The compressive load (P) on the tube is the combined weight of the lid, side plates and tube body.

The compressive load (P) is:

$$P = (17.89 + 6.57 + 78.77) \times 60 = 6{,}193.8 \text{ lbs, use } 8{,}500 \text{ lbs.}$$

The compressive stress (S_c) in the tube body is:

$$S_c = \frac{P}{A} = \frac{8{,}500}{1.714} = 4{,}959 \text{ psi}$$

The margin of safety (MS) is determined based on the accident condition allowable primary membrane stress (0.7 S_u) at a bounding temperature of 600°F for Type 304 stainless steel:

$$MS = \frac{0.7S_u}{S_c} - 1 = \frac{0.7(63{,}300)}{4{,}959} - 1 = +7.9$$

The potential buckling of the tube is evaluated, using the Euler formula, to determine the critical buckling load (P_{cr}):

$$P_{cr} = \frac{\pi^2 EI}{L_e^2} = \frac{\pi^2 (25.2\times10^6)(20.98)}{2(157.8)} = 16.5 \text{ x } 10^6 \text{ lbs}$$

where:

$$E = 25.2\times10^6 \text{ psi}$$

$$I = \frac{8.62^4 - 8.52^4}{12} = 20.98 \text{ in.}^4$$

$L_e = 2L$ (worst case condition)

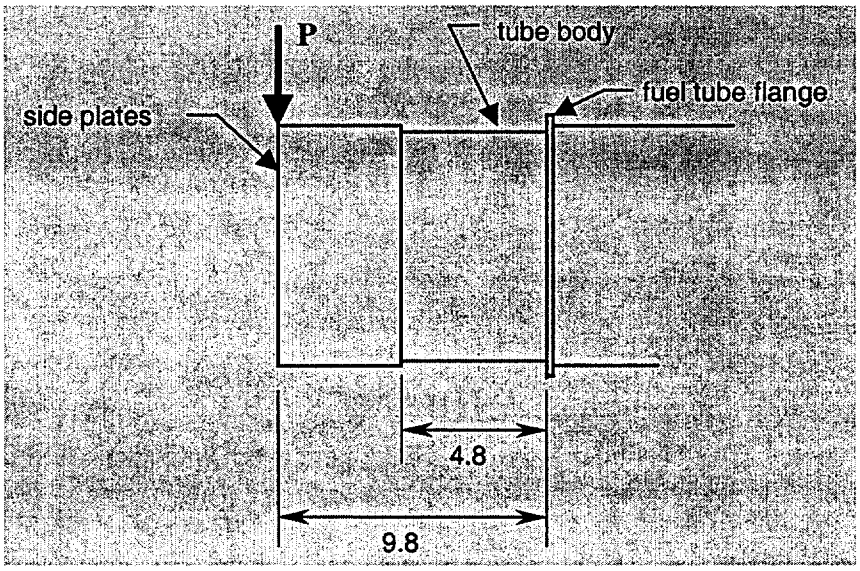
L = tube body length (157.8 in.)

Because the maximum compressive load (8,500 lbs under the accident condition) is much less than the critical buckling load (16.5×10^6 psi) the tube has adequate resistance to buckling.

Tip–Over of the Vertical Concrete Cask

The majority of the fuel can tube body is contained within the fuel tube in the basket assembly. Because both the tube body of the fuel can and the fuel tube have square cross sections, they are effectively in full contact (for 153.0 in. longitudinally) during a side impact and no significant bending stress is introduced into the tube body. The last 4.8 inches of the tube body and the 5.0 inches length of the side plates are unsupported past the fuel tube flange in the side impact orientation.

The tube body is evaluated as a cantilevered beam with the combined weight (P) of the overhanging tube body and side plates and conservatively, concentrated at the top end of the side plates multiplied by a deceleration factor of 60g. Note that the maximum g-load for the PWR basket is 40g for the tip-over accident (Section 11.2.12).



The maximum bending moment (M) is:

$$M = Pg \times L = 25(60)(9.8) = 14{,}700 \text{ lbs}\cdot\text{in.}$$

where:

P = 25 lbs (weight of the overhung tube and side plates)

g = 60 (conservative g-load that bounds the tip over condition)

L = 9.8 in. (the total overhung length of the tube body and side plates)

The maximum bending stress, f_b, is:

$$f_b = \frac{Mc}{I} = \frac{14{,}700(4.31)}{20.98} = 3{,}020 \text{ psi}$$

where:

c = half of the outer dimension of the tube

I = the moment of inertia

The shear stress (τ) is:

$$\tau = \frac{Pg}{A} = \frac{25(60)}{1.714} = 875 \text{ psi}$$

where:

A = the cross-sectional area of the tube = 1.714 in^2

The principle stresses are calculated to be 3,255 psi and - 470 psi, and the corresponding stress intensity is determined to be 3,725 psi.

The margin of safety (MS) is calculated based on the allowable primary membrane plus bending stress (1.0 S_u) at a bounding temperature of 600°F for Type 304 stainless steel:

$$MS = \frac{1.0S_u}{\sigma_{max}} - 1 = \frac{63{,}300 \text{ psi}}{3{,}725 \text{ psi}} - 1 = +16$$

As discussed in Section 11.2.15.1.2, the Maine Yankee fuel can may hold a 100% failed damaged fuel lattice or consolidated fuel lattice. An evaluation is performed to demonstrate that the fuel can maintains its integrity during a tip-over accident for this condition. The fuel can is evaluated using the methodology presented in Section 11.2.12.4.1 for the PWR Fuel Tube Analysis for a 60-g side impact condition. This g-load bounds the maximum g-load (40g) for the PWR basket in the concrete cask tip-over event. Similar to the finite element model used for the PWR fuel tube analysis for the uniform pressure case (see Section 11.2.12.4.1), an ANSYS finite element model is generated to represent a section of the damage fuel can with a length of three spans, i.e. the model is supported at four locations by the support disks. The fuel tube, the BORAL plate, and its stainless steel cover plate are conservatively ignored in the model. A bounding uniform pressure is applied to the lower inside surface of the fuel can wall. The pressure is determined based on the weight of the 100% failed consolidated fuel (2,100 lbs × 60g) occupying a length of 109.6 inches (see Section 11.2.15.1.2) as shown below. The inside dimension of the fuel can is 8.52-inches.

$$P = \frac{2{,}100}{109.6(8.52)} \times 60 = 135 \text{ psi}$$

The finite element analysis results show that the maximum stress in the fuel can is 25.4 ksi, which is local to the sections of the tube resting on the support disks. At 750°F the ultimate strength for Type 304 stainless steel is 63.1 ksi. The Margin of Safety is:

$$MS = \frac{63.1}{25.4} - 1 = +1.48$$

The analysis shows that the maximum total strain is 0.05 inch/inch. Defining the acceptable elastic-plastic response of the stainless steel as one half of the material failure strain of 0.40 in./in. at 750°F, the resulting Margin of Safety is:

$$MS = \frac{0.40/2}{0.05} - 1 = +3.0$$

Similarly, the Margin of Safety for elastic-plastic stress is:

$$MS = \frac{63.1 - 17.3}{25.4 - 17.3} - 1 = +4.65$$

where the yield strength of Type 304 stainless steel is 17.3 ksi at 750°F.

Therefore the Maine Yankee fuel can maintains its integrity for the accident conditions.

11.2.15.1.4 Maine Yankee Site Specific Earthquake Evaluation of the Vertical Concrete Cask

This section provides an evaluation of the response of the vertical concrete cask to an earthquake imparting a horizontal acceleration of 0.38g at the top surface of the concrete pad. The evaluation shows that the loaded or empty vertical concrete cask does not tip over or slide in the earthquake event. The methodology used in this evaluation is identical to that presented in Section 11.2.8.

Tip-Over Evaluation of the Vertical Concrete Cask

To maintain the concrete cask in equilibrium, the restoring moment, M_R must be greater than, or equal to, the overturning moment, M_o (i.e. $M_R \geq M_o$). Based on this premise, the following derivation shows that a 0.38g acceleration of the design basis earthquake at the surface of the concrete pad is well below the acceleration required to tip-over the cask.

The combination of horizontal and vertical acceleration components is based on the 100-40-40 approach of ASCE 4-86 [36], which considers that when the maximum response from one component occurs, the response from the other two components are 40% of the maximum. The vertical component of acceleration is obtained by scaling the corresponding ordinates of the horizontal components by two-thirds.

Using this method, two cases are evaluated where:

$a_x = a_z = a$ = horizontal acceleration components
$a_y = (2/3)\ a$ = vertical acceleration component
G_h = Vector sum of two horizontal acceleration components
G_v = Vertical acceleration component

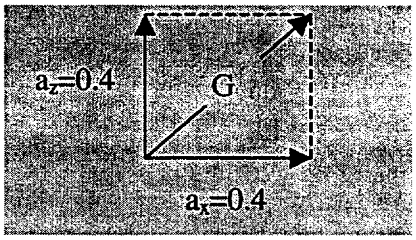
In the first case, the horizontal acceleration is at its maximum. In the second, one horizontal acceleration is at its maximum.

Case 1) The vertical acceleration, a_y, is at its peak: ($a_y = 2/3a$, $a_x = 0.4a$, $a_z = 0.4a$)

$$G_h = \sqrt{a_x^2 + a_z^2}$$

$$G_h = \sqrt{(0.4 \times a)^2 + (0.4 \times a)^2} = 0.566 \times a$$

$$G_v = 1.0 \times a_y = 1.0 \times \left(a \times \frac{2}{3} \right) = 0.667 \times a$$

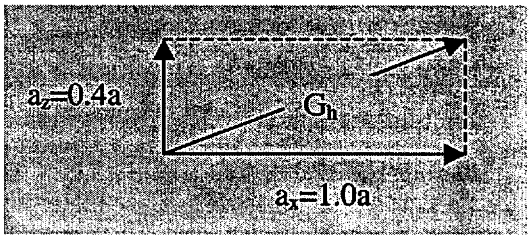


Case 2) One horizonal acceleration, a_x, is at its peak: (a_y= 0.4 x 2/3a, a_x = a, a_z = 0.4a)

$$G_h = \sqrt{a_x^2 + a_z^2}$$

$$G_h = \sqrt{(1.0 \times a)^2 + (0.4 \times a)^2} = 1.077 \times a$$

$$G_v = 0.4 \times a_y = 0.4 \times \left(a \times \frac{2}{3} \right) = 0.267 \times a$$



In order for the cask to resist overturning, the restoring moment, M_R, about the point of rotation, must be greater than the overturning moment, M_o, that:

$$M_R \geq M_o \text{, or}$$

$$F_r \times b \geq F_o \times d \Rightarrow (W \times 1 - W \times G_v) \times b \geq (W \times G_h) \times d$$

where:

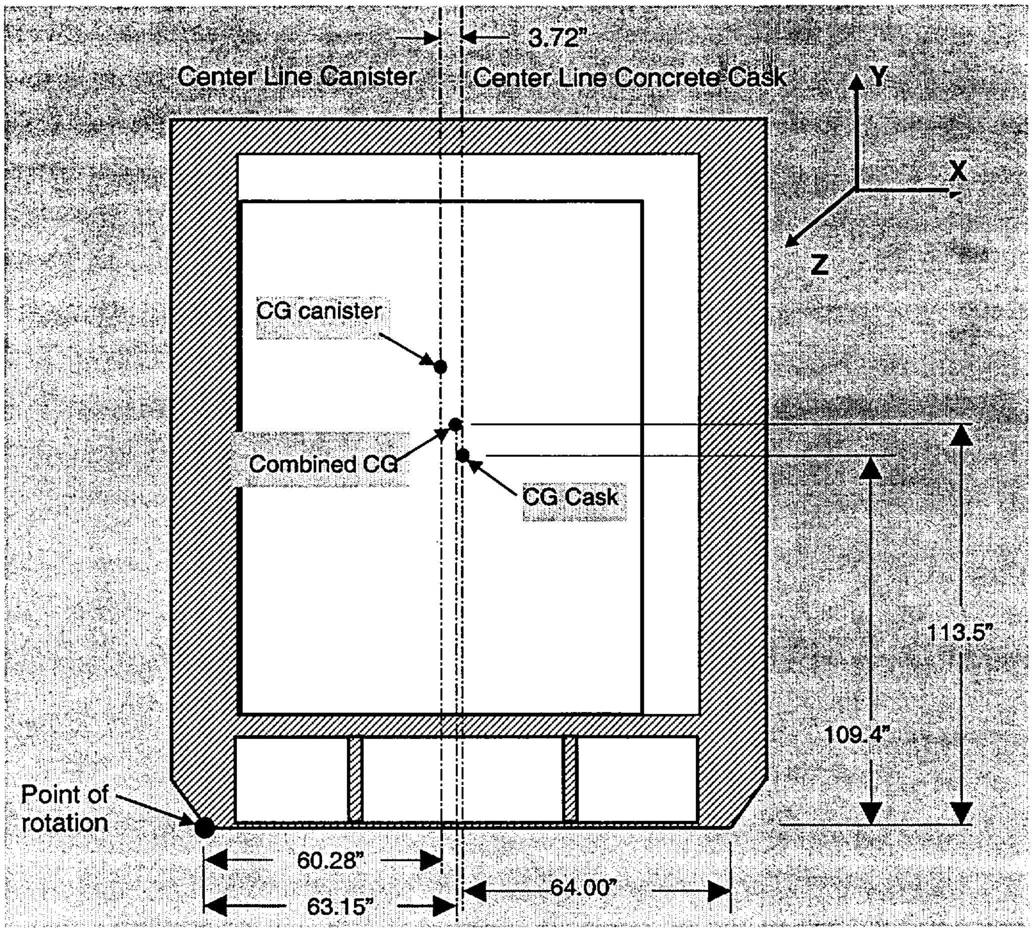
d = vertical distance measured from the base of the Vertical Concrete Cask to the center of gravity

b = horizontal distance measured from the point of rotation to the C.G.

W = the weight of the Vertical Concrete Cask

F_o = overturning force

F_r = restoring force



Substituting for G_h and G_v gives:

Case 1

$$(1 - 0.667a)\ \frac{b}{d} \geq 0.566 \times a$$

$$a \leq \frac{b/d}{0.566 + 0.667\left(b/d\right)}$$

Case 2

$$(1 - 0.267a)\frac{b}{d} \geq 1.077a$$

$$a \leq \frac{b/d}{1.077 + 0.267\left(b/d\right)}$$

Because the canister is not attached to the concrete cask, the combined center of gravity for the concrete cask, with the canister in its maximum off-center position, must be calculated. The point of rotation is established at the outside lower edge of the concrete cask.

The inside diameter of the concrete cask is 74.5 inches and the outside diameter of the canister is 67.06 inches; therefore, the maximum eccentricity between the two is:

$$e = \frac{74.50\text{ in} - 67.06\text{ in}}{2} = 3.72\text{ in.}$$

The horizontal displacement, x, of the combined C.G. due to eccentric placement of the canister is

$$x = \frac{70{,}783(3.72)}{308{,}432} = 0.85\text{ in}$$

Therefore,

$$b = 64 - 0.85 = 63.15\text{ in.}$$

and

$$d = 113.5\text{ in.}$$

The C.G. of the loaded Maine Yankee Vertical Concrete Cask is conservatively assumed to be 113.5 inches, which bounds all of the Maine Yankee UMS® Storage System configurations.

$$1)\ a \le \frac{63.15/113.5}{0.566 + 0.667 \times \left(63.15/113.5\right)} \qquad 2)\ a \le \frac{63.15/113.5}{1.077 + 0.267 \times \left(63.15/113.5\right)}$$

$$a \le 0.59g \qquad\qquad a \le 0.45g$$

Therefore, the minimum ground acceleration that may cause a tip-over of a loaded concrete cask is 0.45g. Since the 0.38g design basis earthquake ground acceleration for the UMS® System at the Maine Yankee site is less than 0.45g, the storage cask will not tip-over.

The factor of safety is 0.45 / 0.38 = 1.18, which is greater than the required factor of safety of 1.1 in accordance with ANSI/ANS-57.9.

Since an empty vertical concrete cask has a lower C.G. as compared to a loaded concrete cask, the tip-over evaluation for the empty concrete cask is bounded by that for the loaded concrete cask.

Sliding Evaluation of the Vertical Concrete Cask

To keep the cask from sliding on the concrete pad, the force holding the cask (F_s) has to be greater than or equal to the force trying to move the cask.

Based on the equation for static friction:

$$F_s = \mu N \geq G_h W$$
$$\mu \left(1 - G_v\right) W \geq G_h W$$

Where:

μ = coefficient of friction
N = the normal force
W = the weight of the concrete cask
G_v = vertical acceleration component
G_h = resultant of horizontal acceleration component

Substituting G_h and G_v for the two cases:

Case 1) $\mu(1 - 0.667a) \geq 0.566\,a$ $\quad \mu \geq \dfrac{0.566a}{1 - 0.667a}$

Case 2) $\mu(1 - 0.267a) \geq 1.077\,a$ $\quad \mu \geq \dfrac{1.077a}{1 - 0.267a}$

For a = 0.38g

Case 1) $\mu \geq 0.29$

Case 2) $\mu \geq 0.45$

The analysis shows that the minimum coefficient of friction, μ, required to prevent sliding of the concrete cask is 0.45. The coefficient of friction between the steel bottom plate of the concrete cask and the concrete surface (broom finish) of the storage pad, 0.50, is greater than the coefficient of friction required to prevent sliding of the concrete cask. Therefore, the concrete cask will not slide under design-basis earthquake conditions. The factor of safety is 0.50 / 0.45 =1.11 which is greater than the required factor of safety of 1.1 in accordance with ANSI/ANS-57.9 [1].

12.0 OPERATING CONTROLS AND LIMITS

This chapter identifies operating controls and limits, technical parameters and surveillance requirements imposed to ensure the safe operation of the NAC-UMS® System.

Controls used by NAC International (NAC) as part of the NAC-UMS® design and fabrication are provided in the NAC Quality Assurance Manual and Quality Procedure. The NAC Quality Assurance Program is discussed in Chapter 13.0. If procurement and fabrication of the NAC-UMS® System is performed by others, a Quality Assurance Program prepared in accordance with 10 CFR 72 Subpart G shall be implemented. Site specific controls for the organization, administrative system, procedures, record keeping, review, audit and reporting necessary to ensure that the NAC-UMS® storage system installation is operated in a safe manner, are the responsibility of the user of the system.

12.1 Administrative and Operating Controls and Limits for the NAC-UMS® System

The NAC-UMS® Storage System operating controls and limits are summarized in Table 12-1. Appendix 12A provides the proposed Limiting Conditions for Operations (LCO). The Approved Contents and Design Features for the NAC-UMS® System are presented in Technical Specification format. The bases for the specified controls and limits are presented in Appendix 12C.

Section 3.0 Appendix 12B presents Design Features that are important to the safe operation of the NAC-UMS® System, but that are not included as Technical Specifications. These include items which are singular events, those that cannot be readily determined or re-verified at the time of use of the system, or that are easily implemented, verified and corrected, if necessary, at the time the action is undertaken.

12.2 Administrative and Operating Controls and Limits for SITE SPECIFIC FUEL

This section describes the administrative and operating controls and limits placed on the loading of fuel assemblies that are unique to specific reactor sites. SITE SPECIFIC FUEL configurations result from conditions that occurred during reactor operations, participation in research and development programs, testing programs intended to improve reactor operations, from the placement of control components or other items within the fuel assembly and from the disposition of damaged fuel assemblies or fuel rods.

SITE SPECIFIC FUEL assembly configurations are either shown to be bounded by the analysis of the standard design basis fuel assembly configuration of the same type (PWR or BWR), or are shown to be acceptable contents by specific evaluation of the configuration. Separate evaluation may establish different limits, which are maintained by administrative controls for preferential loading. The preferential loading controls take advantage of design features of the UMS® Storage System to allow the loading of fuel configurations that may have higher burnup or additional hardware material that is not specifically considered in the design basis fuel evaluation.

Unless specifically excepted, SITE SPECIFIC FUEL must meet all of the conditions specified for the design basis fuel presented in Table 12-1.

12.2.1 Operating Controls and Limits for Maine Yankee SITE SPECIFIC FUEL

The fuel design used at Maine Yankee is the Combustion Engineering (CE) 14 x 14 fuel assembly. The CE 14 x 14 fuel assembly is one of those included in the design basis evaluation of the UMS® Storage System as shown in Table 12B2-2. The estimated Maine Yankee SITE SPECIFIC FUEL inventory is shown in Table 12B2-6. Except as noted in this section, the spent fuel in this inventory meets the Fuel Assembly Limits provided in Table 12B2-1.

As shown in Table 12B2-6, certain of the Maine Yankee fuel has characteristics, such as fuel assembly lattice configurations, different from STANDARD FUEL, from PWR INTACT FUEL ASSEMBLIES - including CONSOLIDATED FUEL, DAMAGED FUEL and fuel with higher burnup or enrichment, that differs from the characteristics of the fuel considered in the design basis. As shown in Table 12B2-6, certain fuel configurations must be preferentially loaded in corner or peripheral fuel tube positions in the fuel basket based on the shielding, criticality or thermal evaluation of the fuel configuration.

The corner positions are used for the loading of fuel configurations with missing fuel rods, and for DAMAGED FUEL and CONSOLIDATED FUEL in the MAINE YANKEE FUEL CAN. Specification for placement in the corner fuel tube positions results primarily from shielding or criticality evaluations of the designated fuel configurations.

Spent fuel having a burnup from 45,000 to 50,000 MWD/MTU is assigned to peripheral locations. The interior locations must be loaded with fuel that has lower burnup and/or longer cool times in order to maintain the design basis heat load and component temperature limits for the basket and canister.

The Fuel Assembly Limits for the Maine Yankee SITE SPECIFIC FUEL are shown in Table 12B2-7. Part A of the table lists the STANDARD, INTACT FUEL ASSEMBLY and SITE SPECIFIC FUEL that does not require preferential loading except as required by Section B 2.1.2 to assure that short-term fuel cladding temperature limits are not exceeded.

Part B of the table lists the SITE SPECIFIC FUEL configurations that require preferential loading due to the criticality, shielding or thermal evaluation. The loading pattern for Maine Yankee SITE SPECIFIC FUEL that must be preferentially loaded is presented in Section B 2.1.3. The preferential loading controls take advantage of design features of the UMS® Storage System to allow the loading of fuel configurations that may have higher burnup or additional hardware or fuel source material that is not specifically considered in the design basis fuel evaluation. The preferential loading required by Part B must also consider the preferential loading requirements of Section B 2.1.2 for short-term cladding temperature limits.

Fuel assemblies with a control element inserted are loaded in a Class 2 canister and basket due to the increased length of the assembly with the control element installed. However, these assemblies are not restricted as to loading position within the basket.

The Transportable Storage Canister loading procedures for Maine Yankee SITE SPECIFIC FUEL will indicate that the loading of a fuel configuration with removed fuel or poison rods, or a MAINE YANKEE FUEL CAN, or fuel with burnup between 45,000 MWD/MTU and 50,000 MWD/MTU, is administratively controlled in accordance with the requirements of Section B 2.1.3.

Table 12-1 NAC-UMS® System Controls and Limits

Control or Limit	**Applicable Technical Specification**	**Condition or Item Controlled**
1. Fuel Characteristics	Table 12B2-1	Type and Condition
	Table 12B2-2	Class, Dimensions and Weight for PWR
	Table 12B2-3	Class, Dimensions and Weight for BWR
	Table 12B2-4	Minimum Cooling Time for PWR Fuel
	Table 12B2-5	Minimum Cooling Time for BWR Fuel
	Table 12B2-7	Maine Yankee SITE SPECIFIC FUEL Loading
	Table 12B2-8	Minimum Cooling Time for Maine Yankee Fuel – No CEA
	Table 12B2-9	Minimum Cooling Time for Maine Yankee Fuel – With CEA
2. Canister	LCO 3.1.4	Time in Transfer Cask (fuel loading)
Fuel Loading	Table 12B2-1	Weight and Number of Assemblies
	Table 12B2-7	Maine Yankee SITE SPECIFIC FUEL Loading
	Table 12B2-4	Minimum Cooling Time for PWR Fuel
	Table 12B2-5	Minimum Cooling Time for BWR Fuel
Drying	LCO 3.1.2	Vacuum Drying Pressure
Backfilling	LCO 3.1.3	Helium Backfill Pressure
Sealing	LCO 3.1.5	Helium Leak Rate
Vacuum	LCO 3.1.1	Time in Vacuum Drying
External Surface	LCO 3.2.1	Level of Contamination
Unloading	LCO 3.1.7	Fuel Cooldown Requirements
3. Concrete Cask	LCO 3.2.2	Surface Dose Rates
	Note 1	Cask Spacing
	Note 2	Cask Handling Height
4. Surveillance	LCO 3.1.6	Heat Removal System
5. Transfer Cask	12B 3.4(8)	Minimum Temperature
	LCO 3.1.8	Canister Removal from the CONCRETE Cask
6. ISFSI Concrete Pad	Note 3	Pad Concrete Thickness
	Note 3	Pad Subsoil Thickness
	Note 3	Pad Concrete Compressive Strength

1. Limits are presented in the Operating Procedures of Chapter 8.
2. Lifting height and handling restrictions are provided in Section A5.1.1 of Appendix 12A.
3. Limits are verified at the time of construction of the ISFSI per Section B3.4(6) of Appendix 12B.

APPENDIX 12A

TECHNICAL SPECIFICATIONS FOR THE NAC-UMS® SYSTEM

Appendix 12A
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Appendix 12A
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A 1.0 USE AND APPLICATION

A 1.1 Definitions

---NOTE---
The defined terms of this section appear in capitalized type and are applicable throughout Chapter 12.

Term	Definition
ACTIONS	ACTIONS shall be that part of a Specification that prescribes Required Actions to be taken under designated Conditions within specified Completion Times.
CANISTER	See TRANSPORTABLE STORAGE CANISTER
CANISTER HANDLING FACILITY	The CANISTER HANDLING FACILITY includes the following components and equipment: (1) a canister transfer station that allows the staging of the TRANSFER CASK with the CONCRETE CASK or transport cask to facilitate CANISTER lifts involving spent fuel handling not covered by 10 CFR 50; and (2) either a stationary lift device or mobile lifting device used to lift the TRANSFER CASK and CANISTER.
CONCRETE CASK	See VERTICAL CONCRETE CASK
INDEPENDENT SPENT FUEL STORAGE INSTALLATION (ISFSI)	The facility within the perimeter fence licensed for storage of spent fuel within NAC-UMS® SYSTEMs (see also 10 CFR 72.3).
INTACT FUEL (ASSEMBLY OR ROD) (Undamaged Fuel)	A fuel assembly or fuel rod with no fuel rod cladding defects, or with known or suspected fuel rod cladding defects not greater than pinhole leaks or hairline cracks that can be grappled, handled and moved in a normal manner, or

(continued)

INTACT FUEL (ASSEMBLY OR ROD) (Undamaged Fuel) (Continued)	A fuel assembly or fuel rod with known or suspected cladding defects greater than pinhole leaks or hairline cracks that can be grappled, handled and moved in a normal manner having an ENGINEERING EVALUATION showing that there is reasonable assurance that the defective fuel cladding will retain fuel pellets and fuel particulates in normal and off-normal storage conditions.
LOADING OPERATIONS	LOADING OPERATIONS include all licensed activities on an NAC-UMS® SYSTEM while it is being loaded with fuel assemblies. LOADING OPERATIONS begin when the first fuel assembly is placed in the CANISTER and end when the NAC-UMS® SYSTEM is secured on the transporter. LOADING OPERATIONS does not include CANISTER transfer operations between the TRANSFER CASK and the CONCRETE CASK or transport cask.
INITIAL PEAK PLANAR-AVERAGE ENRICHMENT	THE INITIAL PEAK PLANAR-AVERAGE ENRICHMENT is the maximum planar-average enrichment at any height along the axis of the fuel assembly. The 4.0 wt % ^{235}U enrichment limit for BWR fuel applies along the full axial extent of the assembly. The INITIAL PEAK PLANAR-AVERAGE ENRICHMENT may be higher than the bundle (assembly) average enrichment.
NAC-UMS® SYSTEM	NAC-UMS® SYSTEM includes the components approved for loading and storage of spent fuel assemblies at the ISFSI. The NAC-UMS® SYSTEM consists of a CONCRETE CASK, a TRANSFER CASK, and a CANISTER.
OPERABLE	The CONCRETE CASK heat removal system is OPERABLE if the difference between the ISFSI ambient temperature and the average outlet air temperature is ≤ 102°F for the PWR CANISTER or ≤ 92°F for the BWR CANISTER.

(continued)

STORAGE OPERATIONS	STORAGE OPERATIONS include all licensed activities that are performed at the ISFSI, while an NAC-UMS® SYSTEM containing spent fuel is located on the storage pad within the ISFSI perimeter.
TRANSFER CASK	TRANSFER CASK is a shielded lifting device that holds the CANISTER during LOADING and UNLOADING OPERATIONS and during closure welding, vacuum drying, leak testing, and non-destructive examination of the CANISTER closure welds. The TRANSFER CASK is also used to transfer the CANISTER into and from the CONCRETE CASK and into the transport cask.
TRANSPORT OPERATIONS	TRANSPORT OPERATIONS include all licensed activities involved in moving a loaded NAC-UMS® CONCRETE CASK and CANISTER to and from the ISFSI. TRANSPORT OPERATIONS begin when the NAC-UMS® SYSTEM is first secured on the transporter and end when the NAC-UMS® SYSTEM is at its destination and no longer secured on the transporter.
TRANSPORTABLE STORAGE CANISTER (CANISTER)	TRANSPORTABLE STORAGE CANISTER is the sealed container that consists of a tube and disk fuel basket in a cylindrical canister shell that is welded to a baseplate, shield lid with welded port covers, and structural lid. The CANISTER provides the confinement boundary for the confined spent fuel.
TRANSFER OPERATIONS	TRANSFER OPERATIONS include all licensed activities involved in transferring a loaded CANISTER from a CONCRETE CASK to another CONCRETE CASK or to a TRANSPORT CASK.

(continued)

UNLOADING OPERATIONS	UNLOADING OPERATIONS include all licensed activities on a NAC-UMS® SYSTEM to be unloaded of the contained fuel assemblies. UNLOADING OPERATIONS begin when the NAC-UMS® SYSTEM is no longer secured on the transporter and end when the last fuel assembly is removed from the NAC-UMS® SYSTEM.
VERTICAL CONCRETE CASK (CONCRETE CASK)	VERTICAL CONCRETE CASK is the cask that receives and holds the sealed CANISTER. It provides the gamma and neutron shielding and convective cooling of the spent fuel confined in the CANISTER.
STANDARD FUEL	Irradiated fuel assemblies having the same configuration as when originally fabricated consisting generally of the end fittings, fuel rods, guide tubes, and integral hardware. For BWR fuel, the channel is considered to be integral hardware. The design basis fuel characteristics and analysis are based on the STANDARD FUEL configuration.
ENGINEERING EVALUATION	A User determination of the integrity of a spent fuel assembly or a fuel rod with known or suspected cladding defects greater than pinhole leaks or hairline cracks that can be grappled, handled, and moved in a normal manner. The ENGINEERING EVALUATION must determine the ability of the fuel cladding to retain fuel pellets and particulates in normal and off-normal conditions of storage. Based on the results of the evaluation, the subject spent fuel shall be classified as INTACT FUEL or as DAMAGED FUEL. DAMAGED FUEL must be placed in a MAINE YANKEE FUEL CAN.

(continued)

DAMAGED FUEL	A fuel assembly or fuel rod with known or suspected cladding defects greater than pinhole leaks or hairline cracks that cannot, by ENGINEERING EVALUATION, demonstrate reasonable assurance that fuel pellets or fuel particulates are retained by the defective fuel cladding in normal and off-normal storage conditions, or A fuel assembly that can not be grappled, handled, and moved in a normal manner, or A previously used fuel assembly lattice into which, damaged fuel rods have been inserted, or Fuel debris, including an intact or a partial fuel rod or an individual intact or partial fuel pellet not contained in a fuel rod. Fuel debris is inserted into a 9 x 9 array of tubes in a lattice that has approximately the same dimensions as a standard fuel assembly. DAMAGED FUEL is placed in the MAINE YANKEE FUEL CAN.
CONSOLIDATED FUEL	A nonstandard fuel configuration in which the individual fuel rods from one or more fuel assemblies are placed in a single container or a lattice structure that is similar to a fuel assembly. CONSOLIDATED FUEL is stored in a MAINE YANKEE FUEL CAN.

SITE SPECIFIC FUEL	Spent fuel configurations that are unique to a site or reactor due to the addition of other components or reconfiguration of the fuel assembly at the site. It includes fuel assemblies, which hold nonfuel-bearing components, such as control components or instrument and plug thimbles, or which are modified as required by expediency in reactor operations, research and development or testing. Modification may consist of individual fuel rod removal, fuel rod replacement of similar or dissimilar material or enrichment, the installation, removal or replacement of burnable poison rods, or containerizing damaged fuel. Site specific fuel includes irradiated fuel assemblies designed with variable enrichments and/or axial blankets, fuel that is consolidated and fuel that exceeds design basis fuel parameters.
MAINE YANKEE FUEL CAN	A specially designed stainless steel screened can sized to hold INTACT FUEL, CONSOLIDATED FUEL or DAMAGED FUEL, and to preclude the release of gross particulate from the can into the canister.

A 3.1 NAC-UMS® SYSTEM

A 3.1.6 CONCRETE CASK Heat Removal System

LCO 3.1.6 The CONCRETE CASK Heat Removal System shall be OPERABLE.

APPLICABILITY: During STORAGE OPERATIONS

ACTIONS

---NOTE---

Separate Condition entry is allowed for each NAC-UMS® SYSTEM.

CONDITION	REQUIRED ACTION	COMPLETION TIME
A. CONCRETE CASK Heat Removal System inoperable	A.1 Restore CONCRETE CASK Heat Removal System to OPERABLE status	8 hours
B. Required Action A.1 and associated Completion Time not met	B.1 Perform SR 3.1.6.1	Immediately and every 6 hours thereafter
	AND	
	B.2.1 Restore CONCRETE CASK Heat Removal System to OPERABLE status	12 hours

(continued)

CONDITION	REQUIRED ACTION	COMPLETION TIME

SURVEILLANCE REQUIREMENTS

SURVEILLANCE		FREQUENCY
SR 3.1.6.1	Verify the difference between the average CONCRETE CASK air outlet temperature and ISFSI ambient temperature is ≤ 102°F (for the PWR CANISTER) and ≤ 92°F (for the BWR CANISTER)	24 hours
SR 3.1.6.2	Verify the difference between the average CONCRETE CASK air outlet temperature and ISFSI ambient temperature is ≤ 102°F (for the PWR CANISTER) and ≤ 92°F (for the BWR CANISTER)	4 hours after an off-normal, accident, or natural phenomena

A 5.0 ADMINISTRATIVE CONTROLS AND PROGRAMS

A 5.1 Training Program

A training program for the NAC-UMS® Universal Storage System shall be developed under the general licensee's systematic approach to training (SAT). Training modules shall include comprehensive instructions for the operation and maintenance of the NAC-UMS® Universal Storage System and the independent spent fuel storage installation (ISFSI).

A 5.2 Pre-Operational Testing and Training Exercises

A dry run training exercise on loading, closure, handling, unloading, and transfer of the NAC-UMS® Storage System shall be conducted by the licensee prior to the first use of the system to load spent fuel assemblies. The training exercise shall not be conducted with spent fuel in the CANISTER. The dry run may be performed in an alternate step sequence from the actual procedures, but all steps must be performed. The dry run shall include, but is not limited to the following:

a. Moving the CONCRETE CASK into its designated loading area
b. Moving the TRANSFER CASK containing the empty CANISTER into the spent fuel pool
c. Loading one or more dummy fuel assemblies into the CANISTER, including independent verification
d. Selection and verification of fuel assemblies requiring preferential loading
e. Installing the shield lid
f. Removal of the TRANSFER CASK from the spent fuel pool
g. Closing and sealing of the CANISTER to demonstrate pressure testing, vacuum drying, helium backfilling, welding, weld inspection and documentation, and leak testing
h. TRANSFER CASK movement through the designated load path
i. TRANSFER CASK installation on the CONCRETE CASK
j. Transfer of the CANISTER to the CONCRETE CASK

(continued)

A 5.2 Pre-Operational Testing and Training Exercises (continued)

k. CONCRETE CASK shield plug and lid installation
l. Transport of the CONCRETE CASK to the ISFSI
m. CANISTER unloading, including reflooding and weld removal or cutting
n. CANISTER removal from the CONCRETE CASK

A 5.3 Surveillance After an Off-Normal, Accident, or Natural Phenomena Event

A Response Surveillance is required following off-normal, accident or natural phenomena events. The NAC-UMS® SYSTEMs in use at an ISFSI shall be inspected within 4 hours after the occurrence of an off-normal, accident or natural phenomena event in the area of the ISFSI. This inspection must specifically verify that all the CONCRETE CASK inlets and outlets are not blocked or obstructed. At least one-half of the inlets and outlets on each CONCRETE CASK must be cleared of blockage or debris within 24 hours to restore air circulation.

The CONCRETE CASK and CANISTER shall be inspected if they experience a drop or a tipover.

A 5.4 Radioactive Effluent Control Program

The program implements the requirements of 10 CFR 72.44(d):

a. The NAC-UMS® SYSTEM does not create any radioactive materials or have any radioactive waste treatment systems. Therefore, specific operating procedures for the control of radioactive effluents are not required. LCO 3.1.5, CANISTER Helium Leak Rate, provides assurance that there are no radioactive effluents from the NAC-UMS® SYSTEM.

b. This program includes an environmental monitoring program. Each general license user may incorporate NAC-UMS® SYSTEM operations into their environmental monitoring program for 10 CFR Part 50 operations.

c. An annual report shall be submitted pursuant to 10 CFR 72.44(d)(3).

(continued)

A 5.5 NAC-UMS® SYSTEM Transport Evaluation Program

This program provides a means for evaluating various transport configurations and transport route conditions to ensure that the design basis drop limits are met. For lifting of the loaded TRANSFER CASK or CONCRETE CASK using devices, which are integral to a structure governed by 10 CFR Part 50 regulations, 10 CFR 50 requirements apply. This program is not applicable when the TRANSFER CASK or CONCRETE CASK is in the fuel building or is being handled by a device providing support from underneath (i.e., on a rail car, heavy haul trailer, air pads, etc.).

Pursuant to 10 CFR 72.212, this program shall evaluate the site specific transport route conditions.

a. The lift height above the transport surface prescribed in Section B3.4.6 of Appendix B to Certificate of Compliance (CoC) No. 1015 shall not exceed the limits in Table A5-1. Also, the program shall ensure that the transport route conditions (i.e., surface hardness and pad thickness) are equivalent to or less limiting than those prescribed for the reference pad surface which forms the basis for the values cited in Section B3.4.6 of Appendix B to CoC No. 1015.

b. For site specific transport conditions which are not bounded by the surface characteristics in Section B3.4.6 of Appendix B to CoC No. 1015, the program may evaluate the site specific conditions to ensure that the impact loading due to design basis drop events does not exceed 60g. This alternative analysis shall be commensurate with the drop analyses described in the Safety Analysis Report for the NAC-UMS® SYSTEM. The program shall ensure that these alternative analyses are documented and controlled.

c. The TRANSFER CASK and CONCRETE CASK may be lifted to those heights necessary to perform cask handling operations, including CANISTER transfer, provided the lifts are made with structures and components designed in accordance with the criteria specified in Section B3.5 of Appendix B to CoC No. 1015, as applicable.

(continued)

Table 12A5-1 TRANSFER CASK and CONCRETE CASK Lifting Requirements

Item	**Orientation**	**Lifting Height Limit**
TRANSFER CASK	Horizontal	None Established
TRANSFER CASK	Vertical	None Established[1]
CONCRETE CASK	Horizontal	Not Permitted
CONCRETE CASK	Vertical	20 inches

Note:

1. See Technical Specification A5.5 (c).

APPENDIX 12B

APPROVED CONTENTS AND DESIGN FEATURES FOR THE NAC-UMS® SYSTEM

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Appendix 12B
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Using a similar argument, fuel assemblies with cooling times between the highest and lowest cooling times of the designated fuel, are placed in intermediate fuel positions.

For the PWR fuel basket configuration, shown in Figure 12B2-1, fuel positions are numbered using the drain line as the reference point. Fuel positions 9, 10, 15 and 16 are considered to be basket center positions for the purpose of meeting the preferential loading requirement. The fuel with the shortest cooling times from among the fuel designated for loading in the CANISTER will be placed in the center positions. A single fuel assembly having the shortest cooling time may be loaded in any of these four positions. Fuel positions 1, 2, 3, 6, 7, 12, 13, 18, 19, 22, 23 and 24 are periphery positions, where fuel with the longest cooling times will be placed. Fuel with the longest cooling times may be loaded in any of these 12 positions. Similarly, designated fuel assemblies with cooling times in the midrange of the shortest and longest cooling times will be loaded in the intermediate fuel positions – 4, 5, 8, 11, 14, 17, 20 and 21.

For the BWR fuel basket configuration, shown in Figure 12B2-2, fuel positions are also numbered using the drain line as the reference point. Fuel positions 23, 24, 25, 32, 33 and 34 are considered to be basket center positions for the purpose of meeting the preferential loading requirement. The fuel with the shortest cooling times from among the fuel designated for loading in the CANISTER will be placed in the center positions. However, the single fuel assembly having the shortest cooling time will be loaded in either position 24 or position 33. Fuel positions 1, 2, 3, 4, 5, 6, 12, 13, 19, 20, 28, 29, 37, 38, 44, 45, 51, 52, 53, 54, 55 and 56 are periphery positions, where fuel with the longest cooling times will be placed. Fuel with the longest cooling times may be loaded in any of these 23 positions. Designated fuel assemblies with cooling times in the midrange of the shortest and longest cooling times will be divided into two tiers. The fuel assemblies with the shorter cooling times in the midrange will be loaded in the inner intermediate fuel positions - 15, 16, 17, 22, 26, 31, 35, 40, 41, and 42. Fuel assemblies with the longer cooling times in the midrange will be loaded in the outer intermediate fuel positions - 7, 8, 9, 10, 11, 14, 18, 21, 27, 30, 36, 39, 43, 46, 47, 48, 49 and 50.

(continued)

These loading patterns result in the placement of fuel such that the shortest-cooled fuel is in the center of the basket and the longest-cooled fuel is on the periphery. Based on engineering evaluations, this loading pattern ensures that fuel assembly allowable cladding temperatures are satisfied.

B 2.1.3 Maine Yankee SITE SPECIFIC FUEL Preferential Loading

The estimated Maine Yankee SITE SPECIFIC FUEL inventory is shown in Table 12B2-6. As shown in this table, certain of the site Maine Yankee fuel configurations must be preferentially loaded in specific basket fuel tube positions.

Corner positions are used for CONSOLIDATED FUEL, DAMAGED FUEL and FUEL DEBRIS loaded in the MAINE YANKEE FUEL CAN, and for fuel assemblies with missing fuel rods or fuel with fuel rods that have been replaced by rods of other material. Designation for placement in corner positions results primarily from shielding or criticality evaluations of these fuel configurations. CONSOLIDATED FUEL is conservatively designated for a corner position, even though analysis shows that these lattices could be loaded in any basket position. Corner positions are positions 3, 6, 19, and 22 in Figure 12B2-1.

Preferential loading is also used for spent fuel having a burnup between 45,000 and 50,000 MWD/MTU. This fuel is assigned to peripheral locations, positions 1, 2, 3, 6, 7, 12, 13, 18, 19, 22, 23, and 24 in Figure 12B2-1. The interior locations must be loaded with fuel that has lower burnup and/or longer cool times in order to maintain the design basis heat load and component temperature limits for the basket and canister, and the spent fuel short-term temperature limits, as described in Section B 2.1.1.

Fuel assemblies with a control element inserted will be loaded in a Class 2 canister and basket due to the increased length of the assembly with the control element installed. However, these assemblies are not restricted as to loading position within the basket.

The Transportable Storage Canister loading procedures will indicate that loading of a fuel configuration with removed fuel or poison rods, CONSOLIDATED FUEL, or a MAINE YANKEE FUEL CAN with DAMAGED FUEL or FUEL DEBRIS, or fuel with burnup between 45,000 MWD/MTU and 50,000 MWD/MTU, is administratively controlled in accordance with Section B 2.1.

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Table 12B2-6 Maine Yankee Site Specific Fuel Population

Site Specific Spent Fuel Configuration[1]	Number of Assemblies[2]	Canister Loading Position
Inserted Control Element Assembly (CEA)[3,4,5]	168	Any
Inserted In-Core Instrument (ICI)Thimble	138	Any
Consolidated Fuel	2	Corner[6,7,8]
Fuel Rod Replaced by Rod Enriched to 1.95 wt %	3	Any
Fuel Rod Replaced by Stainless Steel Rod or Zircaloy Rod	18	Any
Fuel Rods Removed	10	Corner
Variable Enrichment	72	Any
Variable Enrichment and Axial Blanket	68	Any
Burnable Poison Rod Replaced by Hollow Zircaloy Rod	80	Corner
Damaged Fuel[9,10]	12	Corner
Burnup between 45,000 and 50,000 MWD/MTU	90	Periphery[11]

1. The total number of fuel assemblies in inventory is approximately 1,434.
2. The number of fuel assemblies in some categories may vary depending on future fuel inspections and/or Engineering Evaluation.
3. A fuel assembly with an inserted CEA must be loaded in a Class 2 canister.
4. A fuel assembly without an inserted CEA must not be loaded in a Class 2 canister.
5. CEAs may not be inserted in damaged fuel assemblies, consolidated fuel assemblies or assemblies with irradiated stainless steel replacement rods.
6. Basket corner positions are positions 3, 6, 19, and 22 in Figure 12B2-1. Corner positions are also periphery positions.
7. Only one Consolidated Fuel lattice may be loaded in any Transportable Storage Canister.
8. Consolidated Fuel must be loaded in a Maine Yankee fuel can.
9. All fuel classified as damaged must be placed in a Maine Yankee fuel can, including fuel assemblies with damaged fuel rods or poison rods inserted in guide tubes.
10. All spent fuel, including that held in a Maine Yankee fuel can, must conform to the loading limits presented in Tables 12B2-8 and 12B2-9 for cool time.
11. Basket periphery positions are positions 1, 2, 3, 6, 7, 12, 13, 18, 19, 22, 23, and 24 in Figure 12B2-1. Periphery positions include the corner positions.

Table 12B2-7 Maine Yankee Site Specific Fuel Limits

A. Allowable Contents

1. Combustion Engineering 14 x 14 PWR INTACT FUEL ASSEMBLIES meeting the specifications presented in Tables 12B2-1, 12B2-2 and 12B2-4.
2. PWR INTACT FUEL ASSEMBLIES may contain inserted Control Component Assemblies (CEA) or inserted In-Core Instrument (ICI) Thimbles.
3. PWR INTACT FUEL ASSEMBLIES with fuel rods replaced with stainless steel or Zircaloy rods or with Uranium oxide rods nominally enriched to 1.95 wt %.
4. PWR INTACT FUEL ASSEMBLIES with fuel rods having variable enrichments with a maximum fuel rod enrichment of 4.21 wt % ^{235}U and that also have a maximum planar average enrichment of 3.99 wt % ^{235}U.
5. PWR INTACT FUEL ASSEMBLIES with annular axial end blankets. The axial end blanket enrichment is nominally 2.6 wt % ^{235}U.
6. PWR INTACT FUEL ASSEMBLIES with up to two fuel rods inserted in each fuel assembly guide tube or with poison rods inserted in guide tubes.

B. Allowable Contents requiring preferential loading based on shielding, criticality or thermal constraints. The preferential loading requirement for these fuel configurations is described in Table 12B2-6.

1. PWR INTACT FUEL ASSEMBLIES with up to 176 fuel rods missing from the fuel assembly lattice.
2. PWR INTACT FUEL ASSEMBLIES with a burnup between 45,000 and 50,000 MWD/MTU.
3. PWR INTACT FUEL ASSEMBLIES with a burnable poison rod replaced by a hollow Zircaloy rod.

Table 12B2-7 Maine Yankee Site Specific Fuel Limits (continued)

B. Allowable Contents requiring preferential loading based on shielding, criticality or thermal constraints. The preferential loading requirement for these fuel configurations is described in Table 12B2-6. (continued)

5. FUEL enclosed in a Maine Yankee fuel can. The allowable contents of the MAINE YANKEE FUEL CAN are:

   a) A PWR Intact Fuel Assembly.
   b) A PWR INTACT FUEL ASSEMBLY with damaged fuel rods within the guide tube positions.
   c) A Damaged Fuel Assembly with up to 100% of the fuel rods classified as damaged and/or damaged or missing assembly hardware components.
   d) Individual intact or damaged fuel rods in a rod type structure, which may be a guide tube, to maintain configuration control.
   e) Fuel debris consisting of fuel rods with exposed fuel pellets or individual intact or partial fuel pellets not contained in fuel rods.
   f) Consolidated fuel lattice structure with a 17 x 17 array formed by grids and top and bottom end fittings connected by four solid stainless steel rods. Maximum contents:
      - Up to 289 fuel rods
      - Lattice weight ≤ 2,100 pounds

C. Unenriched fuel assemblies are not authorized for loading.

Table 12B2-8 Loading Table for Maine Yankee CE 14 x 14 Fuel with No Non-Fuel Material – Required Cool Time in Years Before Assembly is Acceptable

30 GWD/MTU Burnup		**Minimum Cool Time [years] for[1]**			
Enrichment	**Standard**	**Pref(0.958i)**	**Pref(0.958p)**	**Pref(1.05i)**	**Pref(1.05p)**
1.9	5	5	5	5	5
2.1	5	5	5	5	5
2.3	5	5	5	5	5
2.5	5	5	5	5	5
2.7	5	5	5	5	5
2.9	5	5	5	5	5
3.1	5	5	5	5	5
3.3	5	5	5	5	5
3.5	5	5	5	5	5
3.7	5	5	5	5	5
35 GWD/MTU Burnup		**Minimum Cool Time [years] for**			
Enrichment	**Standard**	**Pref(0.958i)**	**Pref(0.958p)**	**Pref(1.05i)**	**Pref(1.05p)**
1.9	5	5	5	5	5
2.1	5	5	5	5	5
2.3	5	5	5	5	5
2.5	5	5	5	5	5
2.7	5	5	5	5	5
2.9	5	5	5	5	5
3.1	5	5	5	5	5
3.3	5	5	5	5	5
3.5	5	5	5	5	5
3.7	5	5	5	5	5
40 GWD/MTU Burnup		**Minimum Cool Time [years] for**			
Enrichment	**Standard**	**Pref(0.958i)**	**Pref(0.958p)**	**Pref(1.05i)**	**Pref(1.05p)**
1.9	7	7	6	15	5
2.1	6	6	6	15	5
2.3	6	6	5	14	5
2.5	5	5	5	14	5
2.7	5	5	5	14	5
2.9	5	5	5	6	5
3.1	5	5	5	6	5
3.3	5	5	5	6	5
3.5	5	5	5	6	5
3.7	5	5	5	6	5

[1] Cool times for preferential loading of fuel assemblies with a decay heat of either 0.958 or 1.05 kw per assembly, loaded in either interior (i) or periphery (p) basket positions.

Table 12B2-8 Loading Table for Maine Yankee CE 14 x 14 Fuel with No Non-Fuel Material – Required Cool Time in Years Before Assembly is Acceptable (continued)

45 GWD/MTU Burnup		**Minimum Cool Time [years] for**[1]			
Enrichment	**Standard**	**Pref(0.958i)**	**Pref(0.958p)**	**Pref(1.05i)**	**Pref(1.05p)**
1.9	11	20	7	Not Allowed	6
2.1	9	15	7	Not Allowed	6
2.3	8	15	6	Not Allowed	6
2.5	8	15	6	Not Allowed	6
2.7	8	14	6	Not Allowed	6
2.9	8	14	6	Not Allowed	6
3.1	7	14	6	Not Allowed	5
3.3	6	14	6	Not Allowed	5
3.5	6	13	6	Not Allowed	5
3.7	6	13	6	Not Allowed	5
50 GWD/MTU Burnup		**Minimum Cool Time [years] for**			
Enrichment	**Standard**	**Pref(0.958i)**	**Pref(0.958p)**	**Pref(1.05i)**	**Pref(1.05p)**
1.9	18	Not Allowed	8	Not Allowed	7
2.1	16	Not Allowed	8	Not Allowed	7
2.3	14	Not Allowed	8	Not Allowed	7
2.5	12	Not Allowed	8	Not Allowed	7
2.7	12	Not Allowed	8	Not Allowed	7
2.9	11	Not Allowed	8	Not Allowed	7
3.1	10	Not Allowed	7	Not Allowed	7
3.3	10	Not Allowed	7	Not Allowed	6
3.5	10	Not Allowed	7	Not Allowed	6
3.7	10	Not Allowed	7	Not Allowed	6

1. Cool times for preferential loading of fuel assemblies with a decay heat of either 0.958 or 1.05 kw per assembly, loaded in either interior (i) or periphery (p) basket positions.

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Table 12B2-9 Loading Table for Maine Yankee CE 14 x 14 Fuel Containing CEA Cooled to Indicated Time

30,000 MWD/MTU Burnup – Minimum Cool Time in Years for						
Enrichment	**No CEA (Class 1)**		**5 Year CEA**	**10 Year CEA**	**15 Year CEA**	**20 Year CEA**
1.9	5		5	5	5	5
2.1	5		5	5	5	5
2.3	5		5	5	5	5
2.5	5		5	5	5	5
2.7	5		5	5	5	5
2.9	5		5	5	5	5
3.1	5		5	5	5	5
3.3	5		5	5	5	5
3.5	5		5	5	5	5
3.7	5		5	5	5	5
35,000 MWD/MTU Burnup – Minimum Cool Time in Years for						
Enrichment	**No CEA (Class 1)**		**5 Year CEA**	**10 Year CEA**	**15 Year CEA**	**20 Year CEA**
1.9	5		5	5	5	5
2.1	5		5	5	5	5
2.3	5		5	5	5	5
2.5	5		5	5	5	5
2.7	5		5	5	5	5
2.9	5		5	5	5	5
3.1	5		5	5	5	5
3.3	5		5	5	5	5
3.5	5		5	5	5	5
3.7	5		5	5	5	5
40,000 MWD/MTU Burnup – Minimum Cool Time in Years for						
Enrichment	**No CEA (Class 1)**		**5 Year CEA**	**10 Year CEA**	**15 Year CEA**	**20 Year CEA**
1.9	7		7	7	7	7
2.1	6		6	6	6	6
2.3	6		6	6	6	6
2.5	5		5	5	5	5
2.7	5		5	5	5	5
2.9	5		5	5	5	5
3.1	5		5	5	5	5
3.3	5		5	5	5	5
3.5	5		5	5	5	5
3.7	5		5	5	5	5
45,000 MWD/MTU Burnup – Minimum Cool Time in Years for						
Enrichment	**No CEA (Class 1)**		**5 Year CEA**	**10 Year CEA**	**15 Year CEA**	**20 Year CEA**
1.9	11		11	11	11	11
2.1	9		9	9	9	9
2.3	8		8	8	8	8
2.5	8		8	8	8	8
2.7	8		8	8	8	8
2.9	8		8	8	8	8
3.1	7		7	8	8	8
3.3	6		6	7	7	7
3.5	6		6	6	6	6
3.7	6		6	6	6	6
50,000 MWD/MTU Burnup – Minimum Cool Time in Years for						
Enrichment	**No CEA (Class 1)**		**5 Year CEA**	**10 Year CEA**	**15 Year CEA**	**20 Year CEA**
1.9	18		18	18	18	18
2.1	16		16	16	16	16
2.3	14		14	14	14	14
2.5	12		12	12	12	12
2.7	12		12	12	12	12
2.9	11		11	12	12	12
3.1	10		10	12	12	12
3.3	10		10	11	11	11
3.5	10		10	10	10	10
3.7	10		10	10	10	10

B 3.4.2 Maine Yankee Site Specific Parameters and Analyses

The design basis site-specific parameters and analyses that require verification by Maine Yankee are:

1. The temperature of 76°F is the maximum average yearly temperature. The 3-day average ambient temperature shall be 106°F or less.
2. The allowed temperature extremes, averaged over a 3-day period, shall be greater than –40°F and less than 133°F.
3. The design basis earthquake horizontal and vertical seismic acceleration levels at the top surface of the ISFSI pad are bounded by the values shown:

Horizontal g-level in each of Two Orthogonal Directions	**Corresponding Vertical g-level (upward)**
0.38g	0.38 x 0.667 = 0.253g

4. The analyzed flood condition of 15 fps water velocity and a height of 50 feet of water (full submergence of the loaded cask) are not exceeded.
5. The potential for fire and explosion shall be addressed, based on site-specific considerations. This includes the condition that the fuel tank of the cask handling equipment used to move the loaded CONCRETE CASK onto or from the ISFSI site contains no more than 50 gallons of fuel.

(continued)

B 3.4.2 Maine Yankee Site Specific Parameters and Analyses (continued)

6. In addition to the requirements of 10 CFR 72.212(b)(2)(ii), the ISFSI pads and foundation shall include the following characteristics as applicable to the end drop, earthquake or tip-over analyses:

a.	Concrete thickness	36 inches maximum
b.	Pad subsoil thickness	4.5 feet maximum (upper layer) 10 foot minimum (lower layer)
c.	Specified concrete compressive strength	$\le 4{,}000$ psi at 28 days
d.	Concrete dry density (ρ)	$135 \le \rho \le 145$ lbs/ft^3
e.	Soil in place density (ρ)	$\rho \le 135$ lbs/ft^3 (upper layer) $\rho \le 127$ lbs/ft^3 (lower layer)
f.	Soil Modulus of Elasticity	$\le 150{,}000$ psi (upper layer) $\le 30{,}000$ psi (lower layer)
g.	Surface	Broom Finish / Brushed Surface

The concrete pad maximum thickness excludes the ISFSI pad footer. The compressive strength of the concrete should be determined according to the test method given in Section 5.6 of ACI-318. Steel reinforcement is used in the pad and footer. The basis for acceptance of concrete shall be as described in Section 5.6 of ACI-318. The soil modulus of elasticity should be determined according to the test method described in ASTM D4719.

The surface of the ISFSI pad shall have a broom finish or brushed surface as defined in ACI 116R-90 and described in Sections 7.12 and 7.13.4 of ACI 302.1R.

7. In cases where engineered features (i.e., berms, shield walls) are used to ensure that requirements of 10 CFR 72.104(a) are met, such features are to be considered important to safety and must be evaluated to determine the applicable Quality Assurance Category on a site specific basis.

B 3.4.2 Maine Yankee Site Specific Parameters and Analyses (continued)

8. TRANSFER CASK OPERATIONS shall only be conducted with surrounding air temperatures ≥ 0°F.

B 3.5 CANISTER HANDLING FACILITY (CHF)

B 3.5.1 TRANSFER CASK and CANISTER Lifting Devices

Movements of the TRANSFER CASK and CANISTER outside of the 10 CFR 50 licensed facilities, when loaded with spent fuel are not permitted unless the movements are made with a CANISTER HANDLING FACILITY designed, operated, fabricated, tested, inspected and maintained in accordance with the guidelines of NUREG-0612, "Control of Heavy Loads at Nuclear Power Plants" and the below clarifications. This Technical Specification does not apply to handling heavy loads under a 10 CFR 50 license.

B 3.5.2 CANISTER HANDLING FACILITY Structure Requirements

B 3.5.2.1 CANISTER Station and Stationary Lifting Devices

1. The weldment structure of the CANISTER HANDLING FACILITY shall be designed to comply with the stress limits of ASME Code, Section III, Subsection NF, Class 3 for linear structures. The applicable loads, load combinations, and associated service condition definitions are provided in Table 12B3-2. All compression loaded members shall satisfy the buckling criteria of ASME Code, Section III, Subsection NF.

2. If a portion of the CANISTER HANDLING FACILITY structure is constructed of reinforced concrete, then the factored load combinations set forth in ACI-318 (1995) for the loads defined in Table 12B3-2 shall apply.

3. The TRANSFER CASK and CANISTER lifting device used with the CANISTER HANDLING FACILITY shall be designed, fabricated, operated, tested, inspected and maintained in accordance with NUREG-0612, Section 5.1.

(continued)

B 3.5.2.1 CANISTER HANDLING Station and Stationary Lifting Devices (continued)

4. The CHF design shall incorporate an impact limiter. The impact limiter must be designed and fabricated to ensure that, if a CANISTER is dropped, the confinement boundary of the CANISTER would not be breached.

B 3.5.2.2 Mobile Lifting Devices

If a mobile lifting device is used as the lifting device, in lieu of a stationary lifting device, it shall meet the guidelines of NUREG-0612, Section 5.1, with the following clarifications:

1. Mobile lifting devices shall have a minimum safety factor of two over the allowable load table for the lifting device in accordance with the guidance of NUREG-0612, Section 5.1.6(1)(a) and shall be capable of stopping and holding the load during a Design Basis Earthquake (DBE) event.
2. Mobile lifting devices shall conform to the requirements of ANSI B30.5, "Mobile and Locomotive Cranes," in lieu of the requirements of ANSI B30.2, "Overhead and Gantry Cranes."
3. Mobile cranes are not required to meet the requirements of NUREG-0612, Section 5.1.6(2) for new cranes.

Table 12B3-2 Load Combinations and Service Condition Definitions for the CANISTER HANDLING FACILITY (CHF) Structure

Load Combination	**ASME Section III Service Condition for Definition of Allowable Stress**	**Comment**
D* D + S	Level A	All primary load bearing members must satisfy Level A stress limits
D + M + W'[1] D + F D + E D + Y	Level D	Factor of safety against overturning shall be ≥ 1.1

D = Dead load
D* = Apparent dead load
S = Snow and ice load for the CHF site
M = Tornado missile load of the CHF site[1]
W' = Tornado wind load for the CHF site[1]
F = Flood load for the CHF site
E = Seismic load for the CHF site
Y = Tsunami load for the CHF site

Note:

1. Tornado missile load may be reduced or eliminated based on a PRA for the CHF site.

LCO (continued)

Operability of the heat removal system ensures that the decay heat generated by the stored fuel assemblies is transferred to the environment at a sufficient rate to maintain fuel cladding and CANISTER component temperatures within design limits.

APPLICABILITY

The LCO is applicable during STORAGE OPERATIONS. Once a CONCRETE CASK containing a CANISTER loaded with spent fuel has been placed in storage, the heat removal system must be OPERABLE to ensure adequate heat transfer of the decay heat away from the fuel assemblies.

ACTIONS

A note has been added to ACTIONS which states that, for this LCO, separate Condition entry is allowed for each CONCRETE CASK. This is acceptable since the Required Actions for each Condition provide appropriate compensatory measures for each CONCRETE CASK not meeting the LCO. Subsequent CONCRETE CASKs that do not meet the LCO are governed by subsequent Condition entry and application of associated Required Actions.

A.1

If the heat removal system has been determined to be inoperable, it must be restored to OPERABLE status within 8 hours. Eight hours is reasonable based on the accident analysis which shows that the limiting CONCRETE CASK component temperatures will not reach their temperature limits for 24 hours after a complete blockage of all inlet air ducts. This time frame allows for the 4 hour Response Surveillance required following an off-normal, accident, or natural phenomena event established in Section 12.4, plus eight hours (typically, one operating shift) to take action to remove the obstructions in the air flow path.

B.1

SR 3.1.6.1 or SR 3.1.6.2 are performed to document the continuing status of the operability of the CONCRETE CASK Heat Removal System.

B.2.1

Efforts must continue to restore the heat removal system to OPERABLE status by removing the air flow obstruction(s).

(continued)

ACTIONS
(continued)

B.2.1 (continued)

This Required Action must be completed in 12 hours. The Completion Time reflects a conservative total time period without any cooling of 24 hours, assuming all of the air inlets and outlets become blocked 4 hours prior to the Response Surveillance. The results of the thermal analysis of this accident show that the fuel cladding temperature does not reach its short-term temperature limit for more than 24 hours. It is also unlikely that an unforeseen event could cause complete blockage of all four air inlets and outlets immediately after the last successful Surveillance.

SURVEILLANCE
REQUIREMENTS

SR 3.1.6.1

The long-term integrity of the stored fuel is dependent on the ability of the CONCRETE CASK to reject heat from the CANISTER to the environment. The temperature rise between ambient and the CONCRETE CASK air outlets shall be monitored to verify operability of the heat removal system. Blocked air inlets or outlets will reduce air flow and increase the temperature rise experienced by the air as it removes heat from the CANISTER. Based on the analyses, provided the air temperature rise is less than the limits stated in the SR, adequate air flow and, therefore, adequate heat transfer is occurring to provide assurance of long-term fuel cladding integrity. The reference ambient temperature used to perform this Surveillance shall be measured at the ISFSI facility.

The Frequency of 24 hours is reasonable based on the time necessary for CONCRETE CASK components to heat up to unacceptable temperatures assuming design basis heat loads, and allowing for corrective actions to take place upon discovery of the blockage of the air inlets and outlets.

(continued)