

**CERTIFICATE OF COMPLIANCE  
FOR RADIOACTIVE MATERIAL PACKAGES**

1.	a. CERTIFICATE NUMBER	b. REVISION NUMBER	c. DOCKET NUMBER	d. PACKAGE IDENTIFICATION NUMBER	PAGE	PAGES
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2. PREAMBLE

- a. This certificate is issued to certify that the package (packaging and contents) described in Item 5 below meets the applicable safety standards set forth in Title 10, Code of Federal Regulations, Part 71, "Packaging and Transportation of Radioactive Material."
- b. This certificate does not relieve the consignor from compliance with any requirement of the regulations of the U.S. Department of Transportation or other applicable regulatory agencies, including the government of any country through or into which the package will be transported.
3. THIS CERTIFICATE IS ISSUED ON THE BASIS OF A SAFETY ANALYSIS REPORT OF THE PACKAGE DESIGN OR APPLICATION

- |  |   |
|--|---|
| a. ISSUED TO ( <i>Name and Address</i> )<br>Holtec International<br>Holtec Center<br>One Holtec Drive<br>Marlton, NJ 08053 | b. TITLE AND IDENTIFICATION OF REPORT OR APPLICATION<br>Safety Analysis Report on the HI-STAR 100 Cask System, Revision No. <del>15</del> TBD, dated <del>October 11, 2010</del> .TBD |
|--|---|

4. CONDITIONS

This certificate is conditional upon fulfilling the requirements of 10 CFR Part 71, as applicable, and the conditions specified below.

5.

(a) Packaging

- (1) Model No.: HI-STAR 100 System
- (2) Description

The HI-STAR 100 System is a canister system comprising a Multi-Purpose Canister (MPC) or Greater-Than-Class C Waste Canister (GWC) inside of an overpack designed for both storage and transportation (with impact limiters) of irradiated nuclear fuel or reactor-related waste (reactor internals). The HI-STAR 100 System consists of interchangeable MPCs or GWCs that house the spent nuclear fuel and an overpack that provides the containment boundary, helium retention boundary, gamma and neutron radiation shielding, and heat rejection capability. The outer diameter of the overpack of the HI-STAR 100 is approximately 96 inches without impact limiters and approximately 128 inches with impact limiters. Maximum gross weight for transportation (including overpack, MPC, fuel, and impact limiters) is 282,000 pounds. Specific tolerances germane to the safety analyses are called out in the drawings listed below. The HI-STAR 100 System includes ~~the~~ HI-STAR 100 Version HB (also referred to as the HI-STAR HB) and HI-STAR 100 Version HB GTCC (also referred to as HI-STAR HB GTCC).

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5.(a)(2) Description (continued)

**Multi-Purpose Canister**

There are seven Multi-Purpose Canister (MPC) models designated as the MPC-24, MPC-24E, MPC-24EF, MPC-32, MPC-68, MPC-68F, and the MPC-HB. All MPCs are designed to have identical exterior dimensions, except 1) MPC-24E/EFs custom-designed for the Trojan plant, which are approximately nine inches shorter than the generic Holtec MPC design; ~~and 2)~~ MPC-HBs custom-designed for the Humboldt Bay plant, which are approximately 6.3 feet shorter than the generic Holtec MPC designs; ~~and 3) Diablo Canyon MPC-32s custom-designed for Diablo Canyon plant, which are approximately nine inches shorter than the generic Holtec MPC-32.~~ The two digits after the MPC designate the number of reactor fuel assemblies for which the respective MPCs are designed. The MPC-24 series is designed to contain up to 24 Pressurized Water Reactor (PWR) fuel assemblies; the MPC-32 is designed to contain up to 32 intact PWR assemblies; and the MPC-68 and MPC-68F are designed to contain up to 68 Boiling Water Reactor (BWR) fuel assemblies. The MPC-HB is designed to contain up to 80 Humboldt Bay BWR fuel assemblies.

The HI-STAR 100 MPC is a welded cylindrical structure with flat ends. Each MPC is an assembly consisting of a honeycombed fuel basket, baseplate, canister shell, lid, and closure ring. The outer diameter and cylindrical height of each generic MPC is fixed. The outer diameters of the Trojan ~~and Diablo Canyon~~ MPCs ~~is-are~~ the same as the generic MPC, but the heights ~~is approximately nine inches are~~ shorter than the generic MPC design. A steel spacer is used with the Trojan ~~plant and Diablo Canyon~~ MPCs to ensure the MPC-overpack interface is bounded by the generic design. The outer diameter of the Humboldt Bay MPCs is the same as the generic MPC, but the height is approximately 6.3 feet shorter than the generic MPC design. The Humboldt Bay MPCs are transported in a shorter version of the HI-STAR overpack, designated as the HI-STAR HB. The fuel basket designs vary based on the MPC model.

**Multi-Purpose Non-Fuel Waste Canister**

~~There is one GWC model designated as GWC-HB. The HI-STAR 100 GWC is a welded cylindrical structure with flat ends that mimics HI-STAR 100 MPC. Each GWC is an assembly consisting of an internal structure, baseplate, canister shell, lid, and closure ring which may be optional by GWC model. GWC-HB model requires the closure ring. The outer diameter and cylindrical height of each generic GWC is fixed and matches or closely matches the generic MPC. The outer diameter of the Humboldt Bay GWCs is the same as the MPC-HB with a height that matches or closely matches the MPC-HB. Similar to MPC-HBs, GWC-HBs are transported in a shorter version of the HI-STAR overpack, designated as HI-STAR HB GTCC. GWC-HB containment system is made up by the GWC baseplate, canister shell, lid, closure ring and vent and drain port cover plates.~~

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5.(a)(2) Description (continued)

**HI-STAR 100 Overpack**

The HI-STAR 100 overpack is a multi-layer steel cylinder with a welded baseplate and bolted lid (closure plate). The inner shell of the overpack forms an internal cylindrical cavity for housing the MPC. The outer surface of the overpack inner shell is buttressed with intermediate steel shells for radiation shielding. The overpack closure plate incorporates a dual O-ring design to ensure its containment function. The containment system consists of the overpack inner shell, bottom plate, top flange, top closure plate, top closure inner O-ring seal, vent port plug and seal, and drain port plug and seal.

**HI-STAR 100 Version HB GTCC Overpack**

The HI-STAR HB GTCC Overpack is a multi-layer steel cylinder with a welded baseplate and bolted lid (closure plate). The inner shell of the overpack forms an internal cylindrical cavity for housing the GWC. The outer surface of the overpack inner shell is buttressed with intermediate steel shells for radiation shielding. The overpack closure plate does not feature containment seal(s) and corresponding inter-seal leak test port. The primary functions of the HI-STAR HB GTCC Overpack are shielding and structural protection for the GWC.

**Impact Limiters**

There are two impact limiter models designated as HI-STAR 100 Impact Limiter (i.e. standard) and HI-STAR 100 Version HB Impact Limiter (also referred to as HB Impact Limiters). The HI-STAR 100 overpack is fitted with two standard impact limiters fabricated of aluminum ~~honeycomb crush material~~ completely enclosed by an all-welded austenitic stainless steel skin. The two impact limiters are attached to the overpack with 20 and 16 bolts at the top and bottom, respectively. The HI-STAR HB and HI-STAR HB GTCC packages are fitted with custom impact limiters (HB Impact Limiter) that are slightly longer in length with custom specified crush-material crush-strength but essentially the same design as the standard impact limiter.

(3) Drawings

The package shall be constructed and assembled in accordance with the following drawings or figures in Holtec International Report No. HI-951251, *Safety Analysis Report on the HI-STAR 100 Cask System*, Revision No. ~~45~~TBD:

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5.(a)(3) Drawings (continued)

(a)	HI-STAR 100 Overpack	Drawing 3913, Sheets 1-9, Rev. <del>40</del> 11	
(b)	MPC Enclosure Vessel	Drawing 3923, Sheets 1-5, Rev. <del>25</del> 31	
(c)	MPC-24E/EF Fuel Basket	Drawing 3925, Sheets 1-4, Rev. 9	
(d)	MPC-24 Fuel Basket Assembly	Drawing 3926, Sheets 1-4, Rev. <del>44</del> 13	
(e)	MPC-68/68F/68FF Fuel Basket	Drawing 3928, Sheets 1-4, Rev. <del>44</del> 18	
(f)	HI-STAR 100 Impact Limiter	Drawing C1765, Sheet 1, Rev. 6; Sheet 2, Rev. <del>45</del> ; Sheet 3, Rev. 5; Sheet 4, Rev. 5; Sheet 5, Rev. 2; Sheet 6, Rev. <del>56</del> ; and Sheet 7, Rev. 1.	
(g)	HI-STAR 100 Assembly for Transport	Drawing 3930, Sheets 1-3, Rev. 2	
(h)	Trojan MPC-24E/EF Spacer Ring	Drawing 4111, Sheets 1-2, Rev. 0	
(i)	Damaged Fuel Container for Trojan Plant SNF	Drawing 4119, Sheet 1-4, Rev. 1	
(j)	Spacer for Trojan Failed Fuel Can	Drawing 4122, Sheets 1-2, Rev. 0	
(k)	Failed Fuel Can for Trojan	SNC Drawings PFFC-001, Rev. 8 and PFFC-002, Sheets 1 and 2, Rev. 7	
(l)	MPC-32 Fuel Basket Assembly	Drawing 3927, Sheets 1-4, Rev. 16	
(m)	HI-STAR HB Overpack	Drawing 4082, Sheets 1-7, Rev. <del>78</del>	
(n)	MPC-HB Enclosure Vessel	Drawing 4102, Sheets 1-4, Rev. 1	
(o)	MPC-HB Fuel Basket	Drawing 4103, Sheets 1-3, Rev. 6	
(p)	Damaged Fuel Container HB	Drawing 4113, Sheets 1-2, Rev. 2	
(q)	Diablo Canyon Enclosure Vessel	Drawing 4459, Sheets 1-6, Rev. 14	
(r)	Diablo Canyon MPC-32 Fuel Basket	Drawing 4458, Sheets 1-3, Rev. 11	
(s)	MPC Spacer Ring	Drawing 10341, Sheet 1 of 1, Rev. 0	
(t)	HI-STAR HB GTCC Overpack	Drawing 10315, Sheets 1-3, Rev. 0	

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5.(a)(3) Drawings (continued)

(u) GWC-HB Drawing 10316, Sheets 1-4, Rev. 0

(v) HB Impact Limiter Drawing 10447, Sheets 1-7, Rev. 0

5.(b) Contents

(1) Type, Form, and Quantity of Material

(a)(1) **HI-STAR 100 Package:** Fuel assemblies meeting the specifications and quantities provided in Appendix A to this Certificate of Compliance and meeting the requirements provided in Conditions 5.b(1)(b) through 5.b(1)(i) below are authorized for transportation.

(a)(2) **HI-STAR 100 Version HB GTCC Package: Type and Form of Material:**

- **Fissile Exempt Non-Fuel Waste**
  - Segmented and/or non-segmented solid, radiation activated and surface contaminated reactor-related hardware. Exact payload will vary from shipment to shipment. Contents are dewatered according to Chapter 7 of the application.
  - Process waste in the form of spent fuel pool debris including material generated from fuel assembly cladding failures and special nuclear material. The process waste is thermally processed to remove organics and other hydrogen bearing components to produce a dry concentrated residue with a hydrogen concentration of less than 5 percent by volume of the process waste container.
- Maximum decay heat: 0.01 kW
- Post-irradiation minimum cooling time: 1 yr

(a)(3) **HI-STAR 100 Version HB GTCC Package: Quantity of Material:**

- Co-60 activity of 35.3 times Type A quantity.
- Co-60 activity not to exceed 381 curies.
- Co-60 specific activity not to exceed  $6 \times 10^{-4}$  curies/gram.
- Process waste specific activity not to exceed  $1 \times 10^{-3}$  curies/gram
- Mass limits for fissile material, including Special Nuclear Material not to exceed 19 grams
- Maximum weight of contents: 4000 lb including dunnage.

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5.(b)(1) Type, Form, and Quantity of Material (continued)

(b) The following definitions apply:

**Damaged Fuel Assemblies** are fuel assemblies with known or suspected cladding defects, as determined by review of records, greater than pinhole leaks or hairline cracks, empty fuel rod locations that are not filled with dummy fuel rods, missing structural components such as grid spacers, whose structural integrity has been impaired such that geometric rearrangement of fuel or gross failure of the cladding is expected based on engineering evaluations, or that cannot be handled by normal means. Fuel assemblies that cannot be handled by normal means due to fuel cladding damage are considered FUEL DEBRIS.

**Damaged Fuel Containers (or Canisters) (DFCs)** are specially designed fuel containers for damaged fuel assemblies or fuel debris that permit gaseous and liquid media to escape while minimizing dispersal of gross particulates.

The DFC designs authorized for use in the HI-STAR 100 are shown in Figures 1.2.10, 1.2.11, and 1.1.1 of the HI-STAR 100 System Safety Analysis Report, Rev. 15.

**Fuel Debris** is ruptured fuel rods, severed rods, loose fuel pellets, and fuel assemblies with known or suspected defects which cannot be handled by normal means due to fuel cladding damage, including containers and structures supporting these parts. Fuel debris also includes certain Trojan plant-specific fuel material contained in Trojan Failed Fuel Cans.

**Incore Grid Spacers** are fuel assembly grid spacers located within the active fuel region (i.e., not including top and bottom spacers).

**Intact Fuel Assemblies** are fuel assemblies without known or suspected cladding defects greater than pinhole leaks or hairline cracks and which can be handled by normal means. Fuel assemblies without fuel rods in fuel rod locations shall not be classified as intact fuel assemblies unless dummy fuel rods are used to displace an amount of water greater than or equal to that displaced by the original fuel rod(s). Trojan fuel assemblies not loaded into DFCs or FFCs are classified as intact assemblies.

**Minimum Enrichment** is the minimum assembly average enrichment. Natural uranium blankets are not considered in determining minimum enrichment.

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5.(b)(1)(b) Definitions (continued)

**Non-Fuel Hardware** is defined as Burnable Poison Rod Assemblies (BPRA), Thimble Plug Devices (TPDs), **Control Rod Assemblies (CRAs), Axial Power Shaping Rods (APSRs), Wet Annular Burnable Absorbers (WABAs), and Rod Cluster Control Assemblies (RCCAs), Control Element Assemblies (CEAs), water displacement guide tube plugs, orifice rod assemblies, vibration suppressor inserts and Neutron Sources (NSA).**

**Planar-Average Initial Enrichment** is the average of the distributed fuel rod initial enrichments within a given axial plane of the assembly lattice.

**Trojan Damaged Fuel Containers (or Canisters)** are Holtec damaged fuel containers custom-designed for Trojan plant damaged fuel and fuel debris as depicted in Drawing 4119, Rev. 1.

**Trojan Failed Fuel Cans** are non-Holtec designed Trojan plant-specific damaged fuel containers that may be loaded with Trojan plant damaged fuel assemblies, Trojan fuel assembly metal fragments (e.g., portions of fuel rods and grid assemblies, bottom nozzles, etc.), a Trojan fuel rod storage container, a Trojan Fuel Debris Process Can Capsule, or a Trojan Fuel Debris Process Can. The Trojan Failed Fuel Can is depicted in Drawings PFFC-001, Rev. 8 and PFFC-002, Rev. 7.

**Trojan Fuel Debris Process Cans** are Trojan plant-specific canisters containing fuel debris (metal fragments) and were used to process organic media removed from the Trojan plant spent fuel pool during cleanup operations in preparation for spent fuel pool decommissioning. Trojan Fuel Debris Process Cans are loaded into Trojan Fuel Debris Process Can Capsules or directly into Trojan Failed Fuel Cans. The Trojan Fuel Debris Process Can is depicted in Figure 1.2.10B of the HI-STAR100 System Safety Analysis Report, Rev. 15.

**Trojan Fuel Debris Process Can Capsules** are Trojan plant-specific canisters that contain up to five Trojan Fuel Debris Process Cans and are vacuumed, purged, backfilled with helium and then seal-welded closed. The Trojan Fuel Debris Process Can Capsule is depicted in Figure 1.2.10C of the HI-STAR 100 System Safety Analysis Report, Rev. 15.

**Undamaged Fuel Assemblies** are fuel assemblies where all the exterior rods in the assembly are visually inspected and shown to be intact. The interior rods of the assembly are in place; however, the cladding of these rods is of unknown condition. This definition only applies to Humboldt Bay fuel assembly array/class 6x6D and 7x7C.

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5.(b)(1)(b) Definitions (continued)

**ZR** means any zirconium-based fuel cladding materials authorized for use in a commercial nuclear power plant reactor.

- (c) For MPCs partially loaded with stainless steel clad fuel assemblies, all remaining fuel assemblies in the MPC shall meet the more restrictive of the decay heat limits for the stainless steel clad fuel assemblies or the applicable ZR clad fuel assemblies.
- (d) For MPCs partially loaded with damaged fuel assemblies or fuel debris, all remaining ZR clad intact fuel assemblies in the MPC shall meet the more

5.(b)(1) Type, Form, and Quantity of Material (continued)

restrictive of the decay heat limits for the damaged fuel assemblies or the intact fuel assemblies.

- (e) For MPC-68s partially loaded with array/class 6x6A, 6x6B, 6x6C, or 8x8A fuel assemblies, all remaining ZR clad intact fuel assemblies in the MPC shall meet the more restrictive of the decay heat limits for the 6x6A, 6x6B, 6x6C, and 8x8A fuel assemblies or the applicable Zircaloy clad fuel assemblies.
- (f) PWR non-fuel hardware and neutron sources are not authorized for transportation except as specifically provided for in Appendix A to this CoC.
- (g) BWR stainless-steel channels and control blades are not authorized for transportation.
- (h) For spent fuel assemblies to be loaded into MPC-32s and Diablo Canyon MPC-32s, core average soluble boron, assembly average specific power, and assembly average moderator temperature in which the fuel assemblies were irradiated, shall be determined according to ~~Section-Subparagraph~~ 1.2.3.7.1 and Subsection 6.III.2.3 of the SAR, respectively, and the values shall be compared against the limits specified in Part VI and Part VII, respectively of Table A.1 in Appendix A of this Certificate of Compliance.
- (i) For spent fuel assemblies to be loaded into MPC-32s and Diablo Canyon MPC-32s, ~~one of the burnup verification methods the reactor records on spent fuel assemblies average burnup shall be confirmed through physical burnup measurements as de,~~ described in Section 1.2.3.7.2 of the application, shall be applied.

5.(c) Criticality Safety Index (CSI): 0.0



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6. In addition to the requirements of Subpart G of 10 CFR Part 71:
- (a) Each package shall be both prepared for shipment and operated in accordance with detailed written operating procedures. Procedures for both preparation and operation shall be developed. At a minimum, those procedures shall include the provisions provided in Chapter 7 of the application.
  - (b) All acceptance tests and maintenance shall be performed in accordance with detailed written procedures. Procedures for acceptance testing and maintenance shall be developed and shall include the provisions provided in Chapter 8 of the application.
7. The maximum gross weight of the package as presented for shipment shall not exceed 282,000 pounds, except for the HI-STAR HB, where the gross weight shall not exceed ~~187,200~~189,300 pounds and for the HI-STAR HB GTCC, where the gross weight shall not exceed 145,100 pounds.
8. The package shall be located on the transport vehicle such that the bottom surface of the bottom impact limiter is at least 9 feet (along the axis of the overpack) from the edge of the vehicle.
9. The personnel barrier shall be installed at all times while transporting a loaded overpack, ~~except HI-STAR HB GTCC overpack.~~
10. The package authorized by this certificate is hereby approved for use under the general license provisions of 10 CFR 71.17.
11. Transport by air of fissile material is not authorized.
12. Expiration Date: April 30, 2019

Attachment: Appendix A

REFERENCES

Holtec International Report No. HI-951251, *Safety Analysis Report on the HI-STAR 100 Cask System*, Revision ~~15~~TBD, dated ~~October 11, 2010; and February 11, 2014~~ and TBD.

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FOR THE U.S. NUCLEAR REGULATORY COMMISSION

/RA/

~~Michele Sampson~~TBD, Chief  
Licensing Branch  
Division of Spent Fuel Storage and Transportation  
Office of Nuclear Material Safety  
and Safeguards

Date: April 9, 2014TBD



**APPENDIX A**

**CERTIFICATE OF COMPLIANCE NO. 9261, REVISION 9TBD**

**MODEL NO. HI-STAR 100 SYSTEM**



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Page A-1		MPC-24: Uranium oxide, PWR intact fuel assemblies listed in Table A.2.
A-2		MPC-68: Uranium oxide, BWR intact fuel assemblies listed in Table A.3 with or without Zircaloy channels.
A-3		MPC-68: Uranium oxide, BWR damaged fuel assemblies, with or without Zircaloy channels, placed in damaged fuel containers. Uranium oxide BWR damaged fuel assemblies shall meet the criteria specified in Table A.3 for fuel assembly array/class 6x6A, 6X6C, 7x7A, or 8x8A.
A-4		MPC-68: Mixed oxide (MOX), BWR intact fuel assemblies, with or without Zircaloy channels. MOX BWR intact fuel assemblies shall meet the criteria specified in Table A.3 for fuel assembly array/class 6x6B.
A-5		MPC-68: Mixed oxide (MOX), BWR damaged fuel assemblies, with or without Zircaloy channels, placed in damaged fuel containers. MOX BWR damaged fuel assemblies shall meet the criteria specified in Table A.3 for fuel assembly array/class 6x6B.
A-6		MPC-68: Thoria rods (ThO <sub>2</sub> and UO <sub>2</sub> ) placed in Dresden Unit 1 Thoria Rod Canisters
A-7		MPC-68F: Uranium oxide, BWR intact fuel assemblies, with or without Zircaloy channels. Uranium oxide BWR intact fuel assemblies shall meet the criteria specified in Table A.3 for fuel assembly array/class 6x6A, 6x6C, 7x7A, or 8x8A.
A-8		MPC-68F: Uranium oxide, BWR damaged fuel assemblies, with or without Zircaloy channels, placed in damaged fuel containers. Uranium oxide BWR damaged fuel assemblies shall meet the criteria specified in Table A.3 for fuel assembly array/class 6x6A, 6x6C, 7x7A, or 8x8A.
A-9		MPC-68F: Uranium oxide, BWR fuel debris, with or without Zircaloy channels, placed in damaged fuel containers. The original fuel assemblies for the uranium oxide BWR fuel debris shall meet the criteria specified in Table A.3 for fuel assembly array/class 6x6A, 6x6C, 7x7A, or 8x8A.

A-10	Table A. 1 (Cont'd)	MPC-68F: Mixed oxide (MOX), BWR intact fuel assemblies, with or without Zircaloy channels. MOX BWR intact fuel assemblies shall meet the criteria specified in Table A.3 for fuel assembly array/class 6x6B.
A-11		MPC-68F: Mixed oxide (MOX), BWR damaged fuel assemblies, with or without Zircaloy channels, placed in damaged fuel containers. MOX BWR damaged fuel assemblies shall meet the criteria specified in Table A.3 for fuel assembly array/class 6x6B.
A-12		MPC-68F: Mixed Oxide (MOX), BWR fuel debris, with or without Zircaloy channels, placed in damaged fuel containers. The original fuel assemblies for the MOX BWR fuel debris shall meet the criteria specified in Table A.3 for fuel assembly array/class 6x6B.
A-13		MPC-68F: Thoria rods (ThO <sub>2</sub> and UO <sub>2</sub> ) placed in Dresden Unit 1 Thoria Rod Canisters.
A-15		MPC-24E: Uranium oxide, PWR intact fuel assemblies listed in Table A.2.
A-16		MPC-24E: Trojan plant damaged fuel assemblies.
A-17		MPC-24EF: Uranium oxide, PWR intact fuel assemblies listed in Table A.2.
A-18		MPC-24EF: Trojan plant damaged fuel assemblies.
A-19		MPC-24EF: Trojan plant Fuel Debris Process Can Capsules and/or Trojan plant fuel assemblies classified as fuel debris.
A-20 to A-21		MPC-32: Uranium oxide, PWR intact fuel assemblies in array classes 15X15D, E, F, and H and 17X17A, B, and C as listed in Table A.2.
A-22 to A-23		Diablo Canyon MPC-32: Uranium oxide, PWR intact fuel assemblies in array classes 17X17A as listed in Table A.2 and 17x17B (subclasses 17x17B01 and 17X17B06) as listed in Table A.2 and as modified by SAR Table 6.III.1.
A-22-24 to A-2325		MPC-HB: Uranium oxide, intact and/or undamaged fuel assemblies and damaged fuel assemblies, with or without channels, meeting the criteria specified in Table A.3 for fuel assembly array/class 6x6D or 7x7C.
A-24-26 to A-2729	Table A.2	PWR Fuel Assembly Characteristics
A-28-30 to A-3335	Table A.3	BWR Fuel Assembly Characteristics

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A-3436	Table A.5	Fuel Assembly Cooling, Average Burnup, and Initial Enrichment MPC-24/24E/24EF PWR Fuel with Zircaloy clad and with Zircaloy In-Core Grid Spacers.
A-3537	Table A.6	Fuel Assembly Cooling, Average Burnup, and Initial Enrichment MPC-24/24E/24EF PWR Fuel with Stainless Steel Clad.
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A-3638	Table A.8	Trojan Plant Fuel Assembly Cooling, Average Burnup, and Initial Enrichment Limits.
A-3638	Table A.9	Trojan Plant Non-Fuel Hardware and Neutron Source Cooling and Burnup Limits.
A-3739	Table A.10	Fuel Assembly Cooling, Average Burnup, and Minimum Enrichment MPC-32 PWR Fuel with Zircaloy Clad and with Non-Zircaloy In-Core Grid Spacers.
A-3740	Table A.11	Fuel Assembly Cooling, Average Burnup, and Minimum Enrichment MPC-32 PWR Fuel with Zircaloy Clad and with Zircaloy In-Core Grid Spacers.
A-3841	Table A.12	Fuel Assembly Maximum Enrichment and Minimum Burnup Requirement for Transportation in MPC-32.
A-3942	Table A.13	Loading Configurations for the MPC-32.
A-43	Table A.14	Non-Fuel Hardware and Neutron Sources Burnup and Cooling Time Limits
A-4440		References.

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Fuel Assembly Limits

I. MPC MODEL: MPC-24

A. Allowable Contents

1. Uranium oxide, PWR intact fuel assemblies listed in Table A.2 and meeting the following specifications:

- a. Cladding type: ZR or stainless steel (SS) as specified in Table A.2 for the applicable fuel assembly array/class
- b. Maximum initial enrichment: As specified in Table A.2 for the applicable fuel assembly array/class.
- c. Post-irradiation cooling time, average burnup, and minimum initial enrichment per assembly
  - i. ZR clad: An assembly post-irradiation cooling time, average burnup, and minimum initial enrichment as specified in Table A.4 or A.5, as applicable.
  - ii. SS clad: An assembly post-irradiation cooling time, average burnup, and minimum initial enrichment as specified in Table A.6, as applicable.
- d. Decay heat per assembly:
  - i. ZR Clad: ≤833 Watts
  - ii. SS Clad: ≤488 Watts
- e. Fuel assembly length: ≤ 176.8 inches (nominal design)
- f. Fuel assembly width: ≤ 8.54 inches (nominal design)
- g. Fuel assembly weight: ≤ 1,680 lbs

B. Quantity per MPC: Up to 24 PWR fuel assemblies.

C. Fuel assemblies shall not contain non-fuel hardware or neutron sources.

D. Damaged fuel assemblies and fuel debris are not authorized for transport in the MPC-24.

E. Trojan plant fuel is not permitted to be transported in the MPC-24.

Table A.1 (Page 2 of ~~2523~~)  
Fuel Assembly Limits

## II. MPC MODEL: MPC-68

## A. Allowable Contents

1. Uranium oxide, BWR intact fuel assemblies listed in Table A.3, except assembly classes 6x6D and 7x7C, with or without Zircaloy channels, and meeting the following specifications:

- |  |  |
|--|--|
| a. Cladding type:  | ZR or stainless steel (SS) as specified in Table A.3 for the applicable fuel assembly array/class.   |
| b. Maximum planar-average initial enrichment:  | As specified in Table A.3 for the applicable fuel assembly array/class.  |
| c. Initial maximum rod enrichment:   | As specified in Table A.3 for the applicable fuel assembly array/class.  |
| d. Post-irradiation cooling time, average burnup, and minimum initial enrichment per assembly: |  |
| i. ZR clad:  | An assembly post-irradiation cooling time, average burnup, and minimum initial enrichment as specified in Table A.7, except for (1) array/class 6x6A, 6x6C, 7x7A, and 8x8A fuel assemblies, which shall have a cooling time $\geq 18$ years, an average burnup $\leq 30,000$ MWD/MTU, and a minimum initial enrichment $\geq 1.45$ wt% $^{235}\text{U}$ , and (2) array/class 8x8F fuel assemblies, which shall have a cooling time $\geq 10$ years, an average burnup $\leq 27,500$ MWD/MTU, and a minimum initial enrichment $\geq 2.4$ wt% $^{235}\text{U}$ . |
| ii. SS clad:   | An assembly cooling time after discharge $\geq 16$ years, an average burnup $\leq 22,500$ MWD/MTU, and a minimum initial enrichment $\geq 3.5$ wt% $^{235}\text{U}$ .  |
| e. Decay heat per assembly:  |  |
| i. ZR Clad:  | $\leq 272$ Watts, except for array/class 8X8F fuel assemblies, which shall have a decay heat $\leq 183.5$ Watts.   |
| a. SS Clad:  | $\leq 83$ Watts  |
| f. Fuel assembly length:   | $\leq 176.2$ inches (nominal design)   |
| g. Fuel assembly width:  | $\leq 5.85$ inches (nominal design)  |
| h. Fuel assembly weight:   | $\leq 700$ lbs, including channels   |



Table A.1 (Page 3 of **2523**)  
Fuel Assembly Limits

## II. MPC MODEL: MPC-68 (continued)

## A. Allowable Contents (continued)

2. Uranium oxide, BWR damaged fuel assemblies, with or without Zircaloy channels, placed in damaged fuel containers. Uranium oxide BWR damaged fuel assemblies shall meet the criteria specified in Table A.3 for fuel assembly array/class 6x6A, 6x6C, 7x7A, or 8x8A, and meet the following specifications:

a. Cladding type:	ZR
b. Maximum planar-average initial enrichment:	As specified in Table A.3 for the applicable fuel assembly array/class.
c. Initial maximum rod enrichment:	As specified in Table A.3 for the applicable fuel assembly array/class.
d. Post-irradiation cooling time, average burnup, and minimum initial enrichment per assembly:	An assembly post-irradiation cooling time $\geq 18$ years, an average burnup $\leq 30,000$ MWD/MTU, and a minimum initial enrichment $\geq 1.45$ wt% $^{235}\text{U}$ .
e. Fuel assembly length:	$\leq 135.0$ inches (nominal design)
f. Fuel assembly width:	$\leq 4.70$ inches (nominal design)
g. Fuel assembly weight:	$\leq 550$ lbs, including channels and damaged fuel containers

Table A.1 (Page 4 of **2523**)  
 Fuel Assembly Limits

II. MPC MODEL: MPC-68 (continued)

A. Allowable Contents (continued)

3. Mixed oxide (MOX), BWR intact fuel assemblies, with or without Zircaloy channels. MOX BWR intact fuel assemblies shall meet the criteria specified in Table A.3 for fuel assembly array/class 6x6B and meet the following specifications:

- |  |  |
|--|--|
| a. Cladding type:  | ZR   |
| b. Maximum planar-average initial enrichment:  | As specified in Table A.3 for fuel assembly array/class 6x6B.  |
| c. Initial maximum rod enrichment:   | As specified in Table A.3 for fuel assembly array/class 6x6B.  |
| d. Post-irradiation cooling time, average burnup, and minimum initial enrichment per assembly: | An assembly post-irradiation cooling time $\geq 18$ years, an average burnup $\leq 30,000$ MWD/MTIHM, and a minimum initial enrichment $\geq 1.8$ wt% $^{235}\text{U}$ for the $\text{UO}_2$ rods. |
| e. Fuel assembly length:   | $\leq 135.0$ inches (nominal design)   |
| f. Fuel assembly width:  | $\leq 4.70$ inches (nominal design)  |
| g. Fuel assembly weight:   | $\leq 400$ lbs, including channels   |

Table A.1 (Page 5 of **2523**)  
 Fuel Assembly Limits

II. MPC MODEL: MPC-68 (continued)

A. Allowable Contents (continued)

4. Mixed oxide (MOX), BWR damaged fuel assemblies, with or without Zircaloy channels, placed in damaged fuel containers. MOX BWR damaged fuel assemblies shall meet the criteria specified in Table A.3 for fuel assembly array/class 6x6B and meet the following specifications:

a. Cladding type:	ZR
b. Maximum planar-average initial enrichment:	As specified in Table A.3 for array/class 6x6B.
c. Initial maximum rod enrichment:	As specified in Table A.3 for array/class 6x6B.
d. Post-irradiation cooling time, average burnup, and minimum initial enrichment per assembly:	An assembly post-irradiation cooling time $\geq 18$ years, an average burnup $\leq 30,000$ MWD/MTIHM, and a minimum initial enrichment $\geq 1.8$ wt% $^{235}\text{U}$ for the $\text{UO}_2$ rods.
e. Fuel assembly length:	$\leq 135.0$ inches (nominal design)
f. Fuel assembly width:	$\leq 4.70$ inches (nominal design)
g. Fuel assembly weight:	$\leq 550$ lbs, including channels and damaged fuel containers.

Table A.1 (Page 6 of **2523**)  
Fuel Assembly Limits

II. MPC MODEL: MPC-68 (continued)

A. Allowable Contents (continued)

5. Thoria rods (ThO<sub>2</sub> and UO<sub>2</sub>) placed in Dresden Unit 1 Thoria Rod Canisters (as shown in Figure 1.2.11A of the HI-STAR 100 System application, Revision 15) and meeting the following specifications:

- |   |  |
|---|--|
| a. Cladding type:   | ZR   |
| b. Composition:   | <del>98.298.5</del> wt.% ThO <sub>2</sub> , <del>1.81.5</del> wt. % UO <sub>2</sub> with an enrichment of 93.5 wt. % <sup>235</sup> U. |
| c. Number of rods per Thoria Rod Canister:  | ≤ 18   |
| d. Decay heat per Thoria Rod Canister:  | ≤ 115 Watts  |
| e. Post-irradiation fuel cooling time and average burnup per Thoria Rod Canister: | A fuel post-irradiation cooling time ≥ 18 years and an average burnup ≤ 16,000 MWD/MTIHM.  |
| f. Initial heavy metal weight:  | ≤ 27 kg/canister   |
| g. Fuel cladding O.D.:  | ≥ 0.412 inches   |
| h. Fuel cladding I.D.:  | ≤ 0.362 inches   |
| i. Fuel pellet O.D.:  | ≤ 0.358 inches   |
| j. Active fuel length:  | ≤ 111 inches   |
| k. Canister weight:   | ≤ 550 lbs, including fuel  |

B. Quantity per MPC: Up to one (1) Dresden Unit 1 Thoria Rod Canister plus any combination of damaged fuel assemblies in damaged fuel containers and intact fuel assemblies, up to a total of 68.

C. Fuel assemblies with stainless steel channels are not authorized for loading in the MPC-68.

D. Dresden Unit 1 fuel assemblies (fuel assembly array/class 6x6A, 6x6B, 6x6C, or 8x8A) with one Antimony-Beryllium neutron source are authorized for loading in the MPC-68. The Antimony-Beryllium source material shall be in a water rod location.

Table A.1 (Page 7 of **2523**)  
 Fuel Assembly Limits

III. MPC MODEL: MPC-68F

A. Allowable Contents

1. Uranium oxide, BWR intact fuel assemblies, with or without Zircaloy channels. Uranium oxide BWR intact fuel assemblies shall meet the criteria specified in Table A.3 for fuel assembly array/class 6x6A, 6x6C, 7x7A, or 8x8A and meet the following specifications:

a. Cladding type:	ZR
b. Maximum planar-average initial enrichment:	As specified in Table A.3 for the applicable fuel assembly array/class.
c. Initial maximum rod enrichment:	As specified in Table A.3 for the applicable fuel assembly array/class.
d. Post-irradiation cooling time, average burnup, and minimum initial enrichment per assembly:	An assembly post-irradiation cooling time $\geq 18$ years, an average burnup $\leq 30,000$ MWD/MTU, and a minimum initial enrichment $\geq 1.45$ wt% $^{235}\text{U}$ .
e. Fuel assembly length:	$\leq 176.2$ inches (nominal design)
f. Fuel assembly width:	$\leq 5.85$ inches (nominal design)
g. Fuel assembly weight:	$\leq 400$ lbs, including channels

Table A.1 (Page 8 of **2523**)  
 Fuel Assembly Limits

III. MPC MODEL: MPC-68F (continued)

A. Allowable Contents (continued)

2. Uranium oxide, BWR damaged fuel assemblies, with or without Zircaloy channels, placed in damaged fuel containers. Uranium oxide BWR damaged fuel assemblies shall meet the criteria specified in Table A.3 for fuel assembly array/class 6x6A, 6x6C, 7x7A, or 8x8A, and meet the following specifications:

a. Cladding type:	ZR
b. Maximum planar-average initial enrichment:	As specified in Table A.3 for the applicable fuel assembly array/class.
c. Initial maximum rod enrichment:	As specified in Table A.3 for the applicable fuel assembly array/class.
d. Post-irradiation cooling time, average burnup, and minimum initial enrichment per assembly:	An assembly post-irradiation cooling time $\geq 18$ years, an average burnup $\leq 30,000$ MWD/MTU, and a minimum initial enrichment $\geq 1.45$ wt% <sup>235</sup> U.
e. Fuel assembly length:	$\leq 135.0$ inches (nominal design)
f. Fuel assembly width:	$\leq 4.70$ inches (nominal design)
g. Fuel assembly weight:	$\leq 550$ lbs, including channels and damaged fuel containers

Table A.1 (Page 9 of **2523**)  
 Fuel Assembly Limits

III. MPC MODEL: MPC-68F (continued)

A. Allowable Contents (continued)

3. Uranium oxide, BWR fuel debris, with or without Zircaloy channels, placed in damaged fuel containers. The original fuel assemblies for the uranium oxide BWR fuel debris shall meet the criteria specified in Table A.3 for fuel assembly array/class 6x6A, 6x6C, 7x7A, or 8x8A, and meet the following specifications:

- |  |   |
|--|---|
| a. Cladding type:  | ZR  |
| b. Maximum planar-average initial enrichment:  | As specified in Table A.3 for the applicable original fuel assembly array/class.  |
| c. Initial maximum rod enrichment:   | As specified in Table A.3 for the applicable original fuel assembly array/class.  |
| d. Post-irradiation cooling time, average burnup, and minimum initial enrichment per assembly: | An assembly post-irradiation cooling time $\geq 18$ years, an average burnup $\leq 30,000$ MWD/MTU, and a minimum initial enrichment $\geq 1.45$ wt% $^{235}\text{U}$ for the original fuel assembly. |
| e. Fuel assembly length:   | $\leq 135.0$ inches (nominal design)  |
| f. Fuel assembly width:  | $\leq 4.70$ inches (nominal design)   |
| g. Fuel assembly weight:   | $\leq 550$ lbs, including channels and damaged fuel containers  |

Table A.1 (Page 10 of **2523**)  
 Fuel Assembly Limits

III. MPC MODEL: MPC-68F (continued)

A. Allowable Contents (continued)

4. Mixed oxide (MOX), BWR intact fuel assemblies, with or without Zircaloy channels. MOX BWR intact fuel assemblies shall meet the criteria specified in Table A.3 for fuel assembly array/class 6x6B and meet the following specifications:

- |  |  |
|--|--|
| a. Cladding type:  | ZR   |
| b. Maximum planar-average initial enrichment:  | As specified in Table A.3 for fuel assembly array/class 6x6B.  |
| c. Initial maximum rod enrichment:   | As specified in Table A.3 for fuel assembly array/class 6x6B.  |
| d. Post-irradiation cooling time, average burnup, and minimum initial enrichment per assembly: | An assembly post-irradiation cooling time $\geq 18$ years, an average burnup $\leq 30,000$ MWD/MTIHM, and a minimum initial enrichment $\geq 1.8$ wt% $^{235}\text{U}$ for the $\text{UO}_2$ rods. |
| e. Fuel assembly length:   | $\leq 135.0$ inches (nominal design)   |
| f. Fuel assembly width:  | $\leq 4.70$ inches (nominal design)  |
| g. Fuel assembly weight:   | $\leq 400$ lbs, including channels   |



Table A.1 (Page 11 of **2523**)  
 Fuel Assembly Limits

III. MPC MODEL: MPC-68F (continued)

A. Allowable Contents (continued)

5. Mixed oxide (MOX), BWR damaged fuel assemblies, with or without Zircaloy channels, placed in damaged fuel containers. MOX BWR intact fuel assemblies shall meet the criteria specified in Table A.3 for fuel assembly array/class 6x6B and meet the following specifications:

- |  |  |
|--|--|
| a. Cladding type:  | ZR   |
| b. Maximum planar-average initial enrichment:  | As specified in Table A.3 for array/class 6x6B.  |
| c. Initial maximum rod enrichment:   | As specified in Table A.3 for array/class 6x6B.  |
| d. Post-irradiation cooling time, average burnup, and minimum initial enrichment per assembly: | An assembly post-irradiation cooling time $\geq 18$ years, an average burnup $\leq 30,000$ MWD/MTIHM, and a minimum initial enrichment $\geq 1.8$ wt% $^{235}\text{U}$ for the $\text{UO}_2$ rods. |
| e. Fuel assembly length:   | $\leq 135.0$ inches (nominal design)   |
| f. Fuel assembly width:  | $\leq 4.70$ inches (nominal design)  |
| g. Fuel assembly weight:   | $\leq 550$ lbs, including channels and damaged fuel containers   |

Table A.1 (Page 12 of **2523**)  
 Fuel Assembly Limits

III. MPC MODEL: MPC-68F (continued)

A. Allowable Contents (continued)

6. Mixed oxide (MOX), BWR fuel debris, with or without Zircaloy channels, placed in damaged fuel containers. The original fuel assemblies for the MOX BWR fuel debris shall meet the criteria specified in Table A.3 for fuel assembly array/class 6x6B and meet the following specifications:

- |  |  |
|--|--|
| a. Cladding type:  | ZR   |
| b. Maximum planar-average initial enrichment:  | As specified in Table A.3 for original fuel assembly array/class 6x6B.   |
| c. Initial maximum rod enrichment:   | As specified in Table A.3 for original fuel assembly array/class 6x6B.   |
| d. Post-irradiation cooling time, average burnup, and minimum initial enrichment per assembly: | An assembly post-irradiation cooling time $\geq 18$ years, an average burnup $\leq 30,000$ MWD/MTIHM, and a minimum initial enrichment $\geq 1.8$ wt% $^{235}\text{U}$ for the $\text{UO}_2$ rods in the original fuel assembly. |
| e. Fuel assembly length:   | $\leq 135.0$ inches (nominal design)   |
| f. Fuel assembly width:  | $\leq 4.70$ inches (nominal design)  |
| g. Fuel assembly weight:   | $\leq 550$ lbs, including channels and damaged fuel containers   |

Table A.1 (Page 13 of **2523**)  
Fuel Assembly Limits

III. MPC MODEL: MPC-68F (continued)

A. Allowable Contents (continued)

7. Thoria rods ( $\text{ThO}_2$  and  $\text{UO}_2$ ) placed in Dresden Unit 1 Thoria Rod Canisters (as shown in Figure 1.2.11A of the HI-STAR 100 System application, Revision 15) and meeting the following specifications:

- |   |   |
|---|---|
| a. Cladding Type:   | ZR  |
| b. Composition:   | <del>98.298.5</del> wt.% $\text{ThO}_2$ , <del>1.81.5</del> wt. % $\text{UO}_2$ with an enrichment of 93.5 wt. % $^{235}\text{U}$ . |
| c. Number of rods per Thoria Rod Canister:  | $\leq 18$   |
| d. Decay heat per Thoria Rod Canister:  | $\leq 115$ Watts  |
| e. Post-irradiation fuel cooling time and average burnup per Thoria Rod Canister: | A fuel post-irradiation cooling time $\geq 18$ years and an average burnup $\leq 16,000$ MWD/MTIHM.                                 |
| f. Initial heavy metal weight:  | $\leq 27$ kg/canister   |
| g. Fuel cladding O.D.:  | $\geq 0.412$ inches   |
| h. Fuel cladding I.D.:  | $\leq 0.362$ inches   |
| i. Fuel pellet O.D.:  | $\leq 0.358$ inches   |
| j. Active fuel length:  | $\leq 111$ inches   |
| k. Canister weight:   | $\leq 550$ lbs, including fuel  |

Table A.1 (Page 14 of **2523**)  
Fuel Assembly Limits

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III. MPC MODEL: MPC-68F (continued)

B. Quantity per MPC:

Up to four (4) damaged fuel containers containing uranium oxide or MOX BWR fuel debris. The remaining MPC-68F fuel storage locations may be filled with array/class 6x6A, 6x6B, 6x6C, 7x7A, and 8x8A fuel assemblies of the following type, as applicable:

1. Uranium oxide BWR intact fuel assemblies;
2. MOX BWR intact fuel assemblies;
3. Uranium oxide BWR damaged fuel assemblies placed in damaged fuel containers;
4. MOX BWR damaged fuel assemblies placed in damaged fuel containers; or
5. Up to one (1) Dresden Unit 1 Thoria Rod Canister.

C. Fuel assemblies with stainless steel channels are not authorized for loading in the MPC-68F.

D. Dresden Unit 1 fuel assemblies (fuel assembly array/class 6x6A, 6x6B, 6x6C or 8x8A) with one Antimony-Beryllium neutron source are authorized for loading in the MPC-68F. The Antimony-Beryllium neutron source material shall be in a water rod location.

Table A.1 (Page 15 of **2523**)  
Fuel Assembly Limits

IV. MPC MODEL: MPC-24E

A. Allowable Contents

1. Uranium oxide, PWR intact fuel assemblies listed in Table A.2 and meeting the following specifications:

- |   |  |
|---|--|
| a. Cladding type:   | ZR or stainless steel (SS) as specified in Table A.2 for the applicable fuel assembly array/class  |
| b. Maximum initial enrichment:  | As specified in Table A.2 for the applicable fuel assembly array/class.  |
| c. Post-irradiation cooling time, average burnup, and minimum initial enrichment per assembly |  |
| i. ZR clad:   | Except for Trojan plant fuel, an assembly post-irradiation cooling time, average burnup, and minimum initial enrichment as specified in Table A.4 or A.5, as applicable. |
| ii. SS clad:  | An assembly post-irradiation cooling time, average burnup, and minimum initial enrichment as specified in Table A.6, as applicable.                                      |
| iii. Trojan plant fuel  | An assembly post-irradiation cooling time, average burnup, and minimum initial enrichment as specified in Table A.8.   |
| iv. Trojan plant non-fuel hardware and neutron sources  | Post-irradiation cooling time, and average burnup as specified in Table A.9  |
| d. Decay heat per assembly  |  |
| i. ZR Clad:   | Except for Trojan plant fuel, decay heat $\leq$ 833 Watts.<br>Trojan plant fuel decay heat: $\leq$ 725 Watts   |
| ii. SS Clad:  | $\leq$ 488 Watts   |
| e. Fuel assembly length:  | $\leq$ 176.8 inches (nominal design)   |
| f. Fuel assembly width:   | $\leq$ 8.54 inches (nominal design)  |
| g. Fuel assembly weight:  | $\leq$ 1,680 lbs, including non-fuel hardware and neutron sources  |

Table A.1 (Page 16 of **2523**)  
 Fuel Assembly Limits

IV. MPC MODEL: MPC-24E

A. Allowable Contents (continued)

2. Trojan plant damaged fuel assemblies meeting the applicable criteria listed in Table A.2 and meeting the following specifications:

- |   |  |
|---|--|
| a. Cladding type:   | ZR   |
| b. Maximum initial enrichment:  | 3.7% <sup>235</sup> U  |
| c. Fuel assembly post-irradiation cooling time, average burnup, decay heat, and minimum initial enrichment per assembly | An assembly post-irradiation cooling time, average burnup, and initial enrichment as specified in Table A.8<br><br>Decay Heat: ≤ 725 Watts |
| d. Fuel assembly length:  | ≤ 169.3 inches (nominal design)  |
| e. Fuel assembly width:   | ≤ 8.43 inches (nominal design)   |
| f. Fuel assembly weight:  | ≤ 1,680 lbs, including DFC or Failed Fuel Can  |

- B. Quantity per MPC: Up to 24 PWR intact fuel assemblies. For Trojan plant fuel only, up to four (4) damaged fuel assemblies may be stored in fuel storage locations 3, 6, 19, and/or 22. The remaining MPC-24E fuel storage locations may be filled with Trojan plant intact fuel assemblies.
- C. Trojan plant fuel must be transported in the custom-designed Trojan MPCs with the MPC spacer installed. Fuel from other plants is not permitted to be transported in the Trojan MPCs.
- D. Except for Trojan plant fuel, the fuel assemblies shall not contain non-fuel hardware or neutron sources. Trojan intact fuel assemblies containing non-fuel hardware may be transported in any fuel storage location.
- E. Trojan plant damaged fuel assemblies must be transported in a Trojan Failed Fuel Can or a Holtec damaged fuel container designed for Trojan Plant fuel.
- F. One (1) Trojan plant Sb-Be and /or up to two (2) Cf neutron sources in a Trojan plant intact fuel assembly (one source per fuel assembly) may be transported in any one MPC. Each fuel assembly neutron source may be transported in any fuel storage location.
- G. Fuel debris is not authorized for transport in the MPC-24E.
- H. Trojan plant non-fuel hardware and neutron sources may not be transported in the same fuel storage location as a damaged fuel assembly.

Table A.1 (Page 17 of **2523**)  
 Fuel Assembly Limits

V. MPC MODEL: MPC-24EF

A. Allowable Contents

1. Uranium oxide, PWR intact fuel assemblies listed in Table A.2 and meeting the following specifications:

- |   |  |
|---|--|
| a. Cladding type:   | ZR or stainless steel (SS) as specified in Table A.2 for the applicable fuel assembly array/class.   |
| b. Maximum initial enrichment:  | As specified in Table A.2 for the applicable fuel assembly array/class.  |
| c. Post-irradiation cooling time, average burnup, and minimum initial enrichment per assembly |  |
| i. ZR clad:   | Except for Trojan plant fuel, an assembly post-irradiation cooling time, average burnup, and minimum initial enrichment as specified in Table A.4 or A.5, as applicable. |
| ii. SS clad:  | An assembly post-irradiation cooling time, average burnup, and minimum initial enrichment as specified in Table A.6, as applicable.                                      |
| iii Trojan plant fuel:  | An assembly post-irradiation cooling time, average burnup, and minimum initial enrichment as specified in Table A.8.   |
| iv Trojan plant non-fuel hardware and neutron sources:  | Post-irradiation cooling time, and average burnup as specified in Table A.9.   |
| d. Decay heat per assembly:   |  |
| a. ZR Clad:   | Except for Trojan plant fuel, decay heat $\leq$ 833 Watts.<br>Trojan plant fuel decay heat: $\leq$ 725 Watts.  |
| b. SS Clad:   | $\leq$ 488 Watts   |
| e. Fuel assembly length:  | $\leq$ 176.8 inches (nominal design)   |
| f. Fuel assembly width:   | $\leq$ 8.54 inches (nominal design)  |
| g. Fuel assembly weight:  | $\leq$ 1,680 lbs, including non-fuel hardware and neutron sources.   |

Table A.1 (Page 18 of **2523**)  
Fuel Assembly Limits

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V. MPC MODEL: MPC-24EF

A. Allowable Contents (continued)

2. Trojan plant damaged fuel assemblies meeting the applicable criteria listed in Table A.2 and meeting the following specifications:

- |  |   |
|--|---|
| a. Cladding type:  | ZR  |
| b. Maximum initial enrichment:   | 3.7% <sup>235</sup> U   |
| c. Fuel assembly post-irradiation cooling time, average burnup, decay heat, and minimum initial enrichment per assembly: | An assembly post-irradiation cooling time, average burnup, and initial enrichment as specified in Table A.8.<br><br>Decay Heat: ≤ 725 Watts |
| d. Fuel assembly length:   | ≤ 169.3 inches (nominal design)   |
| e. Fuel assembly width:  | ≤ 8.43 inches (nominal design)  |
| f. Fuel assembly weight:   | ≤ 1,680 lbs, including DFC or Failed Fuel Can.  |



Table A.1 (Page 19 of **2523**)  
Fuel Assembly Limits

V. MPC MODEL: MPC-24EF

A. Allowable Contents (continued)

3. Trojan Fuel Debris Process Can Capsules and/or Trojan plant fuel assemblies classified as fuel debris, for which the original fuel assemblies meet the applicable criteria listed in Table A.2 and meet the following specifications:

- |  |   |
|--|---|
| a. Cladding type:  | ZR  |
| b. Maximum initial enrichment:   | 3.7% <sup>235</sup> U   |
| c. Fuel debris post-irradiation cooling time, average burnup, decay heat, and minimum initial enrichment per assembly: | Post-irradiation cooling time, average burnup, and initial enrichment as specified in Table A.8.<br><br>Decay Heat: ≤ 725 Watts |
| d. Fuel assembly length:   | ≤ 169.3 inches (nominal design)   |
| e. Fuel assembly width:  | ≤ 8.43 inches (nominal design)  |
| f. Fuel assembly weight:   | ≤ 1,680 lbs, including DFC or Failed Fuel Can.  |

- B. Quantity per MPC: Up to 24 PWR intact fuel assemblies. For Trojan plant fuel only, up to four (4) damaged fuel assemblies, fuel assemblies classified as fuel debris, and/or Trojan Fuel Debris Process Can Capsules may be stored in fuel storage locations 3, 6, 19, and/or 22. The remaining MPC-24EF fuel storage locations may be filled with Trojan plant intact fuel assemblies.
- C. Trojan plant fuel must be transported in the custom-designed Trojan MPCs with the MPC spacer installed. Fuel from other plants is not permitted to be transported in the Trojan MPCs.
- D. Except for Trojan plant fuel, the fuel assemblies shall not contain non-fuel hardware or neutron sources. Trojan intact fuel assemblies containing non-fuel hardware may be transported in any fuel storage location.
- E. Trojan plant damaged fuel assemblies, fuel assemblies classified as fuel debris, and Fuel Debris Process Can Capsules must be transported in a Trojan Failed Fuel Can or a Holtec damaged fuel container designed for Trojan Plant fuel.
- F. One (1) Trojan plant Sb-Be and /or up to two (2) Cf neutron sources in a Trojan plant intact fuel assembly (one source per fuel assembly) may be transported in any one MPC. Each fuel assembly neutron source may be transported in any fuel storage location.
- G. Trojan plant non-fuel hardware and neutron sources may not be transported in the same fuel storage location as a damaged fuel assembly.

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Table A.1 (Page 20 of **2523**)  
Fuel Assembly Limits

VI. MPC MODEL: MPC-32

A. Allowable Contents

1. Uranium oxide, PWR intact fuel assemblies in array/classes 15x15D, E, F, and H and 17x17A, B, and C listed in Table A.2 and meeting the following specifications (Note: Allowable Contents of Table A.1, Part VII, are also allowed in the MPC-32):

- a. Cladding type: ZR
- b. Maximum initial enrichment: As specified in Table A.2 for the applicable fuel assembly array/class. 5.0 wt% <sup>235</sup>U
- c. Post-irradiation cooling time, maximum average burnup, and minimum initial enrichment per assembly: An assembly post-irradiation cooling time, average burnup, and minimum initial enrichment as specified in Table A.10 or A.11, as applicable.
- d. Minimum average burnup per assembly (Assembly Burnup shall be confirmed per Subsection 1.2.3.7.2 of the SAR, which is hereby included by reference): Calculated value as a function of initial enrichment. See Table A.12.
- e. Decay heat per assembly: ≤ 625 Watts
- f. Fuel assembly length: ≤ 176.8 inches (nominal design)
- g. Fuel assembly width: ≤ 8.54 inches (nominal design)
- h. Fuel assembly weight: ≤ 1,680 lbs including non-fuel hardware and neutron sources
- i. Operating parameters during irradiation of the assembly (Assembly operating parameters shall be determined per Subsection 1.2.3.7.1 of the SAR, which is hereby included by reference)
- Core ave. soluble boron concentration: ≤ 1,000 ppmb
- Assembly ave. moderator temperature: ≤ 601 K for array/classes 15x15D, E, F, and H  
≤ 610 K for array/classes 17x17A, B, and C
- Assembly ave. specific power: ≤ 47.36 kW/kg-U for array/classes 15x15D, E, F, and H  
≤ 61.61 kW/kg-U for array/classes 17x17A, B, and C

Table A.1 (Page 21 of **2325**)  
Fuel Assembly Limits

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VI. MP C MODEL: MPC-32 (continued)

A.1 Allowable Contents (continued)

- j. In-Pool Soluble Boron Required  $\geq 800$  ppmb  
by Burnup Verification Method B During  
Loading and Unloading (See SAR  
Subparagraph 1.2.3.7.2)

B. Quantity per MPC: Up to 32 PWR intact fuel assemblies.

~~Fuel assemblies shall not contain non-fuel hardware~~

C. Damaged fuel assemblies and fuel debris are not authorized for transport in MPC-32.

D. Trojan plant fuel is not permitted to be transported in the MPC-32.

E. One NSA is permitted for loading with a fuel assembly in fuel storage locations 13, 14, 19, or 20 (the fuel storage location numbers are provided in the licensing drawing package). The allowable combinations of burnup and post-irradiation cooling time are provided in Table A.14.

F. BPRAs, TPDs, WABAs, water displacement guide tube plugs, orifice rod assemblies, and/or vibration suppressor inserts may be stored with fuel assemblies in any fuel cell location. The allowable combinations of burnup and post-irradiation cooling time are provided in Table A.14.

G. RCCAs, CRAs, and CEAs may be stored with fuel in fuel cell locations 7, 8, 12-15, 18-21, 25 and/or 26 (the fuel storage location numbers are provided in the licensing drawing package). The allowable combinations of burnup and post-irradiation cooling time are provided in Table A.14.

H. ITTRs may be present in the fuel assembly along with other types of non-fuel hardware or neutron sources.

I. APSRs not permitted.

Table A.1 (Page 22 of 25)  
Fuel Assembly Limits

VII. MPC MODEL: Diablo Canyon MPC-32

A. Allowable Contents

1. Uranium oxide, PWR intact fuel assemblies in array/classes 17x17A in Table A.2, 17x17B (subclasses 17x17B01 and 17x17B06) in Table A.2 (as modified by SAR Table 6.III.1) and meeting the following specifications:

- a. Cladding type: ZR
- b. Maximum initial enrichment: 5.0 wt% <sup>235</sup>U
- c. Post-irradiation cooling time, maximum average burnup, and minimum initial enrichment per assembly: An assembly post-irradiation cooling time, average burnup, and minimum initial enrichment as specified in Table A.10 or A.11, as applicable.
- d. Minimum average burnup per assembly (Assembly Burnup shall be confirmed per Subsection 1.2.3.7.2 of the SAR, which is hereby included by reference) Calculated value as a function of initial enrichment. See Table A.12.
- e. Decay heat per assembly: ≤ 562.5 Watts
- f. Fuel assembly length: ≤ 166.9 inches (nominal design)
- g. Fuel assembly width: ≤ 8.54 inches (nominal design)
- h. Fuel assembly weight: ≤ 1,621 lbs including non-fuel hardware and neutron sources
- i. Operating parameters during irradiation of the assembly (Assembly operating parameters shall be determined per Subsection 6.III.2.3 of the SAR, which is hereby included by reference)
  - Core ave. soluble boron concentration: ≤ 900 ppmb
  - Assembly ave. moderator temperature: ≤ 594 K
  - Assembly ave. specific power: ≤ 59.24 kW/kg-U

Table A.1 (Page 23 of 25)

Table A.1 (Page 23 of 25)  
Fuel Assembly Limits

VII. MPC MODEL: Diablo Canyon MPC-32 (continued)

A.1. Allowable Contents (continued)

- j. In-Pool Soluble Boron Required  $\geq 800$  ppmb  
by Burnup Verification Method B During  
Loading and Unloading (See SAR  
Subparagraph 1.2.3.7.2)
- B. Quantity per MPC: Up to 32 PWR intact fuel assemblies.
- C. Damaged fuel assemblies and fuel debris are not authorized for transport.
- D. One NSA is permitted for loading with a fuel assembly in fuel storage locations 13, 14, 19, or 20 (the fuel storage location numbers are provided in the licensing drawing package). The allowable combinations of burnup and post-irradiation cooling time are provided in Table A.14.
- E. BPRAs, TPDs, WABAs, water displacement guide tube plugs, orifice rod assemblies, and/or vibration suppressor inserts may be stored with fuel assemblies in any fuel cell location. The allowable combinations of burnup and post-irradiation cooling time are provided in Table A.14.
- F. RCCAs, CRAs, and CEAs may be stored with fuel in fuel cell locations 13, 14, 19, or 20 (the fuel storage location numbers are provided in the licensing drawing package). The allowable combinations of burnup and post-irradiation cooling time are provided in Table A.14.
- G. ITTRs may be present in the fuel assembly along with other types of non-fuel hardware or neutron sources.
- H. APSRs not permitted.
- I. Total number of BPRA's, TPDs and RCCAs is limited to 25.

Table A.1 (Page **22-24** of **2325**)  
Fuel Assembly Limits

VIII. MPC MODEL: MPC-HB

A. Allowable Contents

1. Uranium oxide, INTACT and/or UNDAMAGED FUEL ASSEMBLIES, DAMAGED FUEL ASSEMBLIES, and FUEL DEBRIS, with or without channels, meeting the criteria specified in Table A.3 for fuel assembly array/class 6x6D or 7x7C and the following specifications:

- |  |  |
|--|--|
| a. Cladding type:  | ZR   |
| b. Maximum planar-average enrichment:  | As specified in Table A.3 for the applicable fuel assembly array/class.  |
| c. Initial maximum rod enrichment:   | As specified in Table A.3 for the applicable fuel assembly array/class.  |
| d. Post-irradiation cooling time, average burnup, and minimum initial enrichment per assembly: | An assembly post-irradiation cooling time $\geq$ 29 years, an average burnup $\leq$ 23,000 MWD/MTU, and a minimum initial enrichment $\geq$ <del>2.092.08</del> wt% $^{235}\text{U}$ . |
| e. Fuel assembly length:   | $\leq$ 96.91 inches (nominal design)   |
| f. Fuel assembly width:  | $\leq$ 4.70 inches (nominal design)  |
| g. Fuel assembly weight:   | $\leq$ 400 lbs, including channels and DFC   |
| h. Decay heat per assembly:  | $\leq$ 50 W  |
| h. Decay heat per MPC:   | $\leq$ 2000 W  |

Table A.1 (Page 23-25 of 2325)  
Fuel Assembly Limits

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VIII. MPC MODEL: MPC-HB (continued)

B. Quantity per MPC-HB: Up to 80 fuel assemblies

C. Damaged fuel assemblies and fuel debris must be stored in a damaged fuel container. Allowable Loading Configurations: Up to 28 damaged fuel assemblies/fuel debris, in damaged fuel containers, may be placed into the peripheral fuel storage locations as shown in SAR Figure 6.1.3, or up to 40 damaged fuel assemblies/fuel debris, in damaged fuel containers, can be placed in a checkerboard pattern as shown in SAR Figure 6.1.4. The remaining fuel locations may be filled with intact and/or undamaged fuel assemblies meeting the above applicable specifications, or with intact and/or undamaged fuel assemblies placed in damaged fuel containers.

NOTE 1: The total quantity of damaged fuel or fuel debris permitted in a single damaged fuel container is limited to the equivalent weight and special nuclear material quantity of one intact assembly.

NOTE 2: Fuel debris includes material in the form of loose debris consisting of zirconium clad pellets, stainless steel clad pellets, unclad pellets, or rod segments up to a maximum of one equivalent fuel assembly. A maximum of 1.5 kg of stainless steel clad is allowed per cask.

Table A.2 (Page 1 of 4)  
PWR FUEL ASSEMBLY CHARACTERISTICS (Note 1)

Fuel Assembly Array/Class	14x14A	14x14B	14x14C	14x14D	14x14E
Clad Material (Note 2)	ZR	ZR	ZR	SS	Zr
Design Initial U (kg/assy.) (Note 3)	≤ 407	≤ 407	≤ 425	≤ 400	≤ 206
Initial Enrichment (MPC-24, 24E, and 24EF) (wt % <sup>235</sup> U)	≤ 4.6 (24) ≤ 5.0 (24E/EF)	≤ 4.6 (24) ≤ 5.0 (24E/EF)	≤ 4.6 (24) ≤ 5.0 (24E/EF)	≤ 4.0 (24) ≤ 5.0 (24E/EF)	≤ 5.0
No. of Fuel Rod Locations	179	179	176	180	173
Fuel Clad O.D. (in.)	≥ 0.400	≥ 0.417	≥ 0.440	≥ 0.422	≥ 0.3415
Fuel Clad I.D. (in.)	≤ 0.3514	≤ 0.3734	≤ 0.3880	≤ 0.3890	≤ 0.3175
Fuel Pellet Dia. (in.)	≤ 0.3444	≤ 0.3659	≤ 0.3805	≤ 0.3835	≤ 0.3130
Fuel Rod Pitch (in.)	≤ 0.556	≤ 0.556	≤ 0.580	≤ 0.556	Note 6
Active Fuel Length (in.)	≤ 150	≤ 150	≤ 150	≤ 144	≤ 102
No. of Guide Tubes	17	17	5 (Note 4)	16	0
Guide Tube Thickness (in.)	≥ 0.017	≥ 0.017	≥ 0.038	≥ 0.0145	N/A



Table A.2 (Page 2 of 4)  
PWR FUEL ASSEMBLY CHARACTERISTICS (Note 1)

Fuel Assembly Array/Class	15x15A	15x15B	15x15C	15x15D	15x15E	15x15F
Clad Material (Note 2)	ZR	ZR	ZR	ZR	ZR	ZR
Design Initial U (kg/assy.) (Note 3)	≤ 464	≤ 464	≤ 464	≤ 475	≤ 475	≤ 475
Initial Enrichment (MPC-24, 24E, and 24EF) (wt. % <sup>235</sup> U)	≤ 4.1 (24) ≤ 4.5 (24E/EF)	≤ 4.1 (24) ≤ 4.5 (24E/EF)	≤ 4.1 (24) ≤ 4.5 (24E/EF)	≤ 4.1 (24) ≤ 4.5 (24E/EF)	≤ 4.1 (24) ≤ 4.5 (24E/EF)	≤ 4.1 (24) ≤ 4.5 (24E/EF)
Initial Enrichment (MPC-32) (wt. % <sup>235</sup> U) (Note 5)	N/A	N/A	N/A	(Note 5)	(Note 5)	(Note 5)
No. of Fuel Rod Locations	204	204	204	208	208	208
Fuel Clad O.D. (in.)	≥ 0.418	≥ 0.420	≥ 0.417	≥ 0.430	≥ 0.428	≥ 0.428
Fuel Clad I.D. (in.)	≤ 0.3660	≤ 0.3736	≤ 0.3640	≤ 0.3800	≤ 0.3790	≤ 0.3820
Fuel Pellet Dia. (in.)	≤ 0.3580	≤ 0.3671	≤ 0.3570	≤ 0.3735	≤ 0.3707	≤ 0.3742
Fuel Rod Pitch (in.)	≤ 0.550	≤ 0.563	≤ 0.563	≤ 0.568	≤ 0.568	≤ 0.568
Active Fuel Length (in.)	≤ 150	≤ 150	≤ 150	≤ 150	≤ 150	≤ 150
No. of Guide and/or Instrument Tubes	21	21	21	17	17	17
Guide/Instrument Tube Thickness (in.)	≥ 0.015	≥ 0.015	≥ 0.0165	≥ 0.0150	≥ 0.0140	≥ 0.0140

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Table A.2 (Page 3 of 4)  
PWR FUEL ASSEMBLY CHARACTERISTICS (Note 1)

Fuel Assembly Array/ Class	15x15G	15x15H	16x16A	17x17A	17x17B	17x17C
Clad Material (Note 2)	SS	ZR	ZR	ZR	ZR	ZR
Design Initial U (kg/assy.) (Note 3)	≤ 420	≤ 475	≤ 443	≤ 467	≤ 467	≤ 474
Initial Enrichment (MPC-24, 24E, and 24EF) (wt % <sup>235</sup> U)	≤ 4.0 (24) ≤ 4.5 (24E/EF)	≤ 3.8 (24) ≤ 4.2 (24E/EF)	≤ 4.6 (24) ≤ 5.0 (24E/EF)	≤ 4.0 (24) ≤ 4.4 (24E/EF)	≤ 4.0 (24) ≤ 4.4 (24E/EF) (Note 7)	≤ 4.0 (24) ≤ 4.4 (24E/EF)
Initial Enrichment (MPC-32) (wt. % <sup>235</sup> U) (Note 5)	N/A	(Note 5)	N/A	(Note 5)	(Note 5)	(Note 5)
No. of Fuel Rod Locations	204	208	236	264	264	264
Fuel Clad O.D. (in.)	≥ 0.422	≥ 0.414	≥ 0.382	≥ 0.360	≥ 0.372	≥ 0.377
Fuel Clad I.D. (in.)	≤ 0.3890	≤ 0.3700	≤ 0.3320	≤ 0.3150	≤ 0.3310	≤ 0.3330
Fuel Pellet Dia. (in.)	≤ 0.3825	≤ 0.3622	≤ 0.3255	≤ 0.3088	≤ 0.3232	≤ 0.3252
Fuel Rod Pitch (in.)	≤ 0.563	≤ 0.568	≤ 0.506	≤ 0.496	≤ 0.496	≤ 0.502
Active Fuel Length (in.)	≤ 144	≤ 150	≤ 150	≤ 150	≤ 150	≤ 150
No. of Guide and/or Instrument Tubes	21	17	5 (Note 4)	25	25	25
Guide/Instrument Tube Thickness (in.)	≥ 0.0145	≥ 0.0140	≥ 0.0400	≥ 0.016	≥ 0.014	≥ 0.020

Table A.2 (Page 4 of 4)  
PWR FUEL ASSEMBLY CHARACTERISTICS (Note 1)

Notes:

1. All dimensions are design nominal values. Maximum and minimum dimensions are specified to bound variations in design nominal values among fuel assemblies within a given array/class.
2. ZR Designates cladding material made of Zirconium or Zirconium alloys.
3. Design initial uranium weight is the nominal uranium weight specified for each assembly by the fuel manufacturer or reactor user. For each PWR fuel assembly, the total uranium weight limit specified in this table may be increased up to 2.0 percent for comparison with users' fuel records to account for manufacturer tolerances.
4. Each guide tube replaces four fuel rods.
5. ~~Minimum burnup and m~~Maximum initial enrichment as specified in Table A.421 (Part VI and Part VII).
6. This fuel assembly array/class includes only the Indian Point Unit 1 fuel assembly. This fuel assembly has two pitches in different sectors of the assembly. These pitches are 0.441 inches and 0.453 inches
7. Trojan plant-specific fuel is governed by the limits specified for array/class 17x17B and will be transported in the custom-designed Trojan MPC-24E/EF canisters. The Trojan MPC-24E/EF design is authorized to transport only Trojan plant fuel with a maximum initial enrichment of 3.7 wt.% <sup>235</sup>U.

Table A.3 (Page 1 of 6)  
BWR FUEL ASSEMBLY CHARACTERISTICS (Note 1)

Fuel Assembly Array/Class	6x6A	6x6B	6x6C	7x7A	7x7B	8x8A
Clad Material (Note 2)	ZR	ZR	ZR	ZR	ZR	ZR
Design Initial U (kg/assy.) (Note 3)	≤ 110	≤ 110	≤ 110	≤ 100	≤ 195	≤ 120
Maximum planar-average initial enrichment (wt.% <sup>235</sup> U)	≤ 2.7	≤ 2.7 for the UO <sub>2</sub> rods. See Note 4 for MOX rods	≤ 2.7	≤ 2.7	≤ 4.2	≤ 2.7
Initial Maximum Rod Enrichment (wt.% <sup>235</sup> U)	≤ 4.0	≤ 4.0	≤ 4.0	≤ 5.5	≤ 5.0	≤ 4.0
No. of Fuel Rod Locations	35 or 36	35 or 36 (up to 9 MOX rods)	36	49	49	63 or 64
Fuel Clad O.D. (in.)	≥ 0.5550	≥ 0.5625	≥ 0.5630	≥ 0.4860	≥ 0.5630	≥ 0.4120
Fuel Clad I.D. (in.)	≤ 0.5105	≤ 0.4945	≤ 0.4990	≤ 0.4204	≤ 0.4990	≤ 0.3620
Fuel Pellet Dia. (in.)	≤ 0.4980	≤ 0.4820	≤ 0.4880	≤ 0.4110	≤ 0.4910	≤ 0.3580
Fuel Rod Pitch (in.)	≤ 0.710	≤ 0.710	≤ 0.740	≤ 0.631	≤ 0.738	≤ 0.523
Active Fuel Length (in.)	≤ 120	≤ 120	≤ 77.5	≤ 80	≤ 150	≤ 120
No. of Water Rods (Note 11)	1 or 0	1 or 0	0	0	0	1 or 0
Water Rod Thickness (in.)	≥ 0	≥ 0	N/A	N/A	N/A	≥ 0
Channel Thickness (in.)	≤ 0.060	≤ 0.060	≤ 0.060	≤ 0.060	≤ 0.120	≤ 0.100

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Table A.3 (Page 2 of 6)  
BWR FUEL ASSEMBLY CHARACTERISTICS (Note 1)

Fuel Assembly Array/Class	8x8B	8x8C	8x8D	8x8E	8x8F	9x9A
Clad Material (Note 2)	ZR	ZR	ZR	ZR	ZR	ZR
Design Initial U (kg/assy.) (Note 3)	≤ 185	≤ 185	≤ 185	≤ 185	≤ 185	≤ 177
Maximum planar-average initial enrichment (wt.% <sup>235</sup> U)	≤ 4.2	≤ 4.2	≤ 4.2	≤ 4.2	< 4.0	≤ 4.2
Initial Maximum Rod Enrichment (wt.% <sup>235</sup> U)	≤ 5.0	≤ 5.0	≤ 5.0	≤ 5.0	≤ 5.0	≤ 5.0
No. of Fuel Rod Locations	63 or 64	62	60 or 61	59	64	74/66 (Note 5)
Fuel Clad O.D. (in.)	≥ 0.4840	≥ 0.4830	≥ 0.4830	≥ 0.4930	≥ 0.4576	≥ 0.4400
Fuel Clad I.D. (in.)	≤ 0.4295	≤ 0.4250	0.4230	≤ 0.4250	≤ 0.3996	≤ 0.3840
Fuel Pellet Dia. (in.)	≤ 0.4195	≤ 0.4160	≤ 0.4140	≤ 0.4160	≤ 0.3913	≤ 0.3760
Fuel Rod Pitch (in.)	≤ 0.642	≤ 0.641	≤ 0.640	≤ 0.640	≤ 0.609	≤ 0.566
Design Active Fuel Length (in.)	≤ 150	≤ 150	≤ 150	≤ 150	≤ 150	≤ 150
No. of Water Rods (Note 11)	1 or 0	2	1 - 4 (Note 7)	5	N/A (Note 12)	2
Water Rod Thickness (in.)	≥ 0.034	> 0.00	> 0.00	≥ 0.034	≥ 0.0315	> 0.00
Channel Thickness (in.)	≤ 0.120	≤ 0.120	≤ 0.120	≤ 0.100	≤ 0.055	≤ 0.120

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Table A.3 (Page 3 of 6)  
BWR FUEL ASSEMBLY CHARACTERISTICS (Note 1)

Fuel Assembly Array/Class	9x9B	9x9C	9x9D	9x9E (Note 13)	9x9F (Note 13)	9x9G
Clad Material (Note 2)	ZR	ZR	ZR	ZR	ZR	ZR
Design Initial U (kg/assy.) (Note 3)	≤ 177	≤ 177	≤ 177	≤ 177	≤ 177	≤ 177
Maximum planar-average initial enrichment (wt.% <sup>235</sup> U)	≤ 4.2	≤ 4.2	≤ 4.2	≤ 4.0	≤ 4.0	≤ 4.2
Initial Maximum Rod Enrichment (wt.% <sup>235</sup> U)	≤ 5.0	≤ 5.0	≤ 5.0	≤ 5.0	≤ 5.0	≤ 5.0
No. of Fuel Rods	72	80	79	76	76	72
Fuel Clad O.D. (in.)	≥ 0.4330	≥ 0.4230	≥ 0.4240	≥ 0.4170	≥ 0.4430	≥ 0.4240
Fuel Clad I.D. (in.)	≤ 0.3810	≤ 0.3640	≤ 0.3640	≤ 0.3640	≤ 0.3860	≤ 0.3640
Fuel Pellet Dia. (in.)	≤ 0.3740	≤ 0.3565	≤ 0.3565	≤ 0.3530	≤ 0.3745	≤ 0.3565
Fuel Rod Pitch (in.)	≤ 0.572	≤ 0.572	≤ 0.572	≤ 0.572	≤ 0.572	≤ 0.572
Design Active Fuel Length (in.)	≤ 150	≤ 150	≤ 150	≤ 150	≤ 150	≤ 150
No. of Water Rods (Note 11)	1 (Note 6)	1	2	5	5	1 (Note 6)
Water Rod Thickness (in.)	> 0.00	≥ 0.020	≥ 0.0300	≥ 0.0120	≥ 0.0120	≥ 0.0320
Channel Thickness (in.)	≤ 0.120	≤ 0.100	≤ 0.100	≤ 0.120	≤ 0.120	≤ 0.120

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Table A.3 (Page 4 of 6)  
BWR FUEL ASSEMBLY CHARACTERISTICS (Note 1)

Fuel Assembly Array/Class	10x10A	10x10B	10x10C	10x10D	10x10E
Clad Material (Note 2)	ZR	ZR	ZR	SS	SS
Design Initial U (kg/assy.) (Note 3)	≤ 186	≤ 186	≤ 186	≤ 125	≤ 125
Maximum planar-average initial enrichment (wt.% <sup>235</sup> U)	≤ 4.2	≤ 4.2	≤ 4.2	≤ 4.0	≤ 4.0
Initial Maximum Rod Enrichment (wt.% <sup>235</sup> U)	≤ 5.0	≤ 5.0	≤ 5.0	≤ 5.0	≤ 5.0
No. of Fuel Rod Locations	92/78 (Note 8)	91/83 (Note 9)	96	100	96
Fuel Clad O.D. (in.)	≥ 0.4040	≥ 0.3957	≥ 0.3780	≥ 0.3960	≥ 0.3940
Fuel Clad I.D. (in.)	≤ 0.3520	≤ 0.3480	≤ 0.3294	≤ 0.3560	≤ 0.3500
Fuel Pellet Dia. (in.)	≤ 0.3455	≤ 0.3420	≤ 0.3224	≤ 0.3500	≤ 0.3430
Fuel Rod Pitch (in.)	≤ 0.510	≤ 0.510	≤ 0.488	≤ 0.565	≤ 0.557
Design Active Fuel Length (in.)	≤ 150	≤ 150	≤ 150	≤ 83	≤ 83
No. of Water Rods (Note 11)	2	1 (Note 6)	5 (Note 10)	0	4
Water Rod Thickness (in.)	≥ 0.0300	> 0.00	≥ 0.031	N/A	≥ 0.022
Channel Thickness (in.)	≤ 0.120	≤ 0.120	≤ 0.055	≤ 0.080	≤ 0.080

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Table A.3 (Page 5 of 6)  
BWR FUEL ASSEMBLY CHARACTERISTICS (Note 1)

Fuel Assembly Array/Class	6x6D	7x7C
Clad Material (Note 2)	Zr	Zr
Design Initial U (kg/assy.)(Note 3)	≤ 78	≤ 78
Maximum planar-average initial enrichment (wt.% <sup>235</sup> U)	≤ 2.6	≤ 2.6
Initial Maximum Rod Enrichment (wt.% <sup>235</sup> U) (Note 14)	≤ 4.0	≤ 4.0
No. of Fuel Rod Locations	36	49
Fuel Clad O.D. (in.)	≥ 0.5585	≥ 0.486
Fuel Clad I.D. (in.)	≤ 0.505	≤ 0.426
Fuel Pellet Dia. (in.)	≤ 0.488	≤ 0.411
Fuel Rod Pitch (in.)	≤ 0.740	≤ 0.631
Active Fuel Length (in.)	≤ 80	≤ 80
No. of Water Rods (Note 11)	0	0
Water Rod Thickness (in.)	N/A	N/A
Channel Thickness (in.)	≤ 0.060	≤ 0.060



Table A.3 (Page 6 of 6)  
BWR FUEL ASSEMBLY CHARACTERISTICS (Note 1)

Notes:

1. All dimensions are design nominal values. Maximum and minimum dimensions are specified to bound variations in design nominal values among fuel assemblies within a given array/class.
2. ZR designates cladding material made from Zirconium or Zirconium alloys.
3. Design initial uranium weight is the uranium weight specified for each assembly by the fuel manufacturer or reactor user. For each BWR fuel assembly, the total uranium weight limit specified in this table may be increased up to 1.5% for comparison with users' fuel records to account for manufacturer's tolerances.
4.  $\leq 0.635$  wt. %  $^{235}\text{U}$  and  $\leq 1.578$  wt. % total fissile plutonium ( $^{239}\text{Pu}$  and  $^{241}\text{Pu}$ ), (wt. % of total fuel weight, i.e.,  $\text{UO}_2$  plus  $\text{PuO}_2$ ).
5. This assembly class contains 74 total fuel rods; 66 full length rods and 8 partial length rods.
6. Square, replacing nine fuel rods.
7. Variable
8. This assembly class contains 92 total fuel rods; 78 full length rods and 14 partial length rods.
9. This assembly class contains 91 total fuel rods, 83 full length rods and 8 partial length rods.
10. One diamond-shaped water rod replacing the four center fuel rods and four rectangular water rods dividing the assembly into four quadrants.
11. These rods may be sealed at both ends and contain Zr material in lieu of water.
12. This assembly is known as "QUAD+" and has four rectangular water cross segments dividing the assembly into four quadrants.
13. For the SPC 9x9-5 fuel assembly, each fuel rod must meet either the 9x9E or 9x9F set of limits for clad O.D., clad I.D., and pellet diameter.
14. Only two assemblies may contain one rod each with an initial maximum enrichment up to 5.5 wt%.

Table A.4

FUEL ASSEMBLY COOLING, AVERAGE BURNUP, AND INITIAL ENRICHMENT  
MPC-24/24E/24/EF PWR FUEL WITH ZIRCALOY CLAD AND  
WITH NON-ZIRCALOY IN-CORE GRID SPACERS

Post-irradiation Cooling Time (years)	Assembly Burnup (MWD/MTU)	Assembly Initial Enrichment (wt. % U-235)
≥ 9	≤ 24,500	≥ 2.3
≥ 11	≤ 29,500	≥ 2.6
≥ 13	≤ 34,500	≥ 2.9
≥ 15	≤ 39,500	≥ 3.2
≥ 18	≤ 44,500	≥ 3.4

Table A.5

FUEL ASSEMBLY COOLING, AVERAGE BURNUP, AND INITIAL ENRICHMENT  
MPC-24/24E/24EF PWR FUEL WITH ZIRCALOY CLAD AND  
WITH ZIRCALOY IN-CORE GRID SPACERS

Post-irradiation Cooling Time (years)	Assembly Burnup (MWD/MTU)	Assembly Initial Enrichment (wt. % U-235)
≥ 6	≤ 24,500	≥ 2.3
≥ 7	≤ 29,500	≥ 2.6
≥ 9	≤ 34,500	≥ 2.9
≥ 11	≤ 39,500	≥ 3.2
≥ 14	≤ 44,500	≥ 3.4

Table A.6

FUEL ASSEMBLY COOLING, AVERAGE BURNUP, AND INITIAL ENRICHMENT  
MPC-24/24E/24EF PWR FUEL WITH STAINLESS STEEL CLAD

Post-irradiation Cooling Time (years)	Assembly Burnup (MWD/MTU)	Assembly Initial Enrichment (wt. % U-235)
$\geq 19$	$\leq 30,000$	$\geq 3.1$
$\geq 24$	$\leq 40,000$	$\geq 3.1$

Table A.7

FUEL ASSEMBLY COOLING, AVERAGE BURNUP, AND INITIAL ENRICHMENT  
MPC-68

Post-irradiation Cooling Time (years)	Assembly Burnup (MWD/MTU)	Assembly Initial Enrichment (wt. % U-235)
$\geq 5$	$\leq 10,000$	$\geq 0.7$
$\geq 7$	$\leq 20,000$	$\geq 1.35$
$\geq 8$	$\leq 24,500$	$\geq 2.1$
$\geq 9$	$\leq 29,500$	$\geq 2.4$
$\geq 11$	$\leq 34,500$	$\geq 2.6$
$\geq 14$	$\leq 39,500$	$\geq 2.9$
$\geq 19$	$\leq 44,500$	$\geq 3.0$

Table A.8

TROJAN PLANT FUEL ASSEMBLY COOLING, AVERAGE BURNUP, AND INITIAL ENRICHMENT LIMITS (Note 1)

Post-irradiation Cooling Time (years)	Assembly Burnup (MWD/MTU)	Assembly Initial Enrichment (wt.% <sup>235</sup> U)
≥16	≤42,000	≥3.09
≥16	≤37,500	≥2.6
≥16	≤30,000	≥2.1

NOTES:

1. Each fuel assembly must only meet one set of limits (i.e., one row)

Table A.9

TROJAN PLANT NON-FUEL HARDWARE AND NEUTRON SOURCES COOLING AND BURNUP LIMITS

Type of Hardware or Neutron Source	Burnup (MWD/MTU)	Post-irradiation Cooling Time (Years)
BPRAs	≤15,998	≥24
TPDs	≤118,674	≥11
RCCAs	≤125,515	≥9
Cf neutron source	≤15,998	≥24
Sb-Be neutron source with 4 source rods, 16 burnable poison rods, and 4 thimble plug rods	≤45,361	≥19
Sb-Be neutron source with 4 source rods, 20 thimble plug rods	≤88,547	≥9

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Table A.10

FUEL ASSEMBLY COOLING, AVERAGE BURNUP, AND MINIMUM ENRICHMENT MPC-32 PWR FUEL WITH ZIRCALOY CLAD AND WITH NON-ZIRCALOY IN-CORE GRID SPACERS

Post-irradiation cooling time (years)	Assembly burnup (MWD/MTU)	Assembly Initial Enrichment (wt. % U-235)
<b>WITHOUT NON-FUEL HARDWARE</b>		
≥12	≤24,500	≥2.3
≥14	≤29,500	≥2.6
≥16	≤34,500	≥2.9
≥19	≤39,500	≥3.2
≥20	≤42,500	≥3.4
≥24	≤45,000	≥3.6
<b>WITH NON-FUEL HARDWARE</b>		
≥ 13	≤ 24,500	≥ 2.3
≥ 16	≤ 29,500	≥ 2.6
≥ 18	≤ 34,500	≥ 2.9
≥ 21	≤ 39,500	≥ 3.2
≥ 23	≤ 42,500	≥ 3.4
≥ 25	≤ 45,000	≥ 3.6

Table A.11

FUEL ASSEMBLY COOLING, AVERAGE BURNUP, AND MINIMUM ENRICHMENT MPC-32 PWR FUEL WITH ZIRCALOY CLAD AND WITH ZIRCALOY IN-CORE GRID SPACERS

Post-irradiation cooling time (years)	Assembly burnup (MWD/MTU)	Assembly Initial Enrichment (wt.% U-235)
<b>WITHOUT NON-FUEL HARDWARE</b>		
≥8	≤24,500	≥2.3
≥9	≤29,500	≥2.6
≥12	≤34,500	≥2.9
≥14	≤39,500	≥3.2
≥19	≤44,500	≥3.4
≥20	≤45,000	≥3.6
<b>WITH NON-FUEL HARDWARE</b>		
≥ 13	≤ 24,500	≥ 2.3
≥ 16	≤ 29,500	≥ 2.6
≥ 18	≤ 34,500	≥ 2.9
≥ 21	≤ 39,500	≥ 3.2
≥ 23	≤ 42,500	≥ 3.4
≥ 25	≤ 45,000	≥ 3.6

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Table A.12

FUEL ASSEMBLY MAXIMUM ENRICHMENT AND MINIMUM BURNUP REQUIREMENTS FOR TRANSPORTATION IN MPC-32

Fuel Assembly Array/Class	Configuration (Note 2)	Maximum Enrichment (wt.% U-235)	Minimum Burnup (B) as a Function of Initial Enrichment (E) (Note 1) (GWD/MTU)
15x15D, E, F, H	A	4.65	$B = (1.6733) * E^3 - (18.72) * E^2 + (80.5967) * E - 88.3$
	B	4.38	$B = (2.175) * E^3 - (23.355) * E^2 + (94.77) * E - 99.95$
	C	4.48	$B = (1.9517) * E^3 - (21.45) * E^2 + (89.1783) * E - 94.6$
	D	4.45	$B = (1.93) * E^3 - (21.095) * E^2 + (87.785) * E - 93.06$
17x17A, B, C	A	4.49	$B = (1.08) * E^3 - (12.25) * E^2 + (60.13) * E - 70.86$
	B	4.04	$B = (1.1) * E^3 - (11.56) * E^2 + (56.6) * E - 62.59$
	C	4.28	$B = (1.36) * E^3 - (14.83) * E^2 + (67.27) * E - 72.93$
	D	4.16	$B = (1.4917) * E^3 - (16.26) * E^2 + (72.9883) * E - 79.7$

Fuel Assembly Array/Class	Configuration (Note 2)	Minimum Burnup (B) as a Function of Initial Enrichment (E) (Note 1) (GWD/MTU)
Standard MPC-32		
15x15D, E, F, H	A	$B = +(1.2222) * E^3 - (14.9530) * E^2 + (70.1230) * E - 81.1400$
	B	$B = +(1.6446) * E^3 - (19.1690) * E^2 + (84.1940) * E - 94.3490$
17x17A, B, C	A	$B = +(0.6704) * E^3 - (8.7858) * E^2 + (49.6000) * E - 62.7720$
	B	$B = +(1.2284) * E^3 - (14.5450) * E^2 + (69.7780) * E - 82.1460$
Diablo Canyon MPC-32		
17X17A (Note 3)	A	See SAR Table 6.III.4
17x17B (subclasses 17X17B01 and 17X17B06) (Note 4)	A	See SAR Table 6.III.4.

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### NOTES:

1. E = Initial enrichment (e.g., for 4.05 wt.% , E = 4.05). **Maximum initial enrichment as specified in Table A.1 (Part VI and Part VII).**
2. See Table A.13.
3. ~~Fuel Assemblies must be cooled 5 years or more.~~ Array/classes 17x17A characteristics per CoC Table A.2.
4. Array/Subclasses 17x17B01 and 17x17B06 characteristics are defined by Array/classes 17x17B characteristics per Table A.2 with certain parameters modified per SAR Table 6.III.1.





Table A.13

LOADING CONFIGURATIONS FOR THE MPC-32

CONFIGURATION	ASSEMBLY SPECIFICATIONS
A	<ul style="list-style-type: none"> <li>Assemblies that have not been located in any cycle under a control rod bank that was permitted to be inserted during full power operation (per plant operating procedures); or</li> <li>Assemblies that have been located under a control rod bank that was permitted to be inserted during full power operation (per plant operating procedures), but where it can be demonstrated, based on operating records, that the insertion never exceeded 8 inches from the top of the active length during full power operation.</li> </ul>
B	<ul style="list-style-type: none"> <li>Of the 32 assemblies in a basket, up to 8 assemblies can be from core locations where they were located under a control rod bank, that was permitted to be inserted more than 8 inches during full power operation. There is no limit on the duration (in terms of burnup) under this bank.</li> <li>The remaining assemblies in the basket must satisfy the same conditions as specified for configuration A.</li> </ul>
<del>C</del>	<ul style="list-style-type: none"> <li><del>Of the 32 assemblies in a basket, up to 8 assemblies can be from core locations where they were located under a control rod bank, that was permitted to be inserted more than 8 inches during full power operation. Location under such a control rod bank is limited to 20 GWD/MTU of the assembly.</del></li> <li><del>The remaining assemblies in the basket must satisfy the same conditions as specified for configuration A.</del></li> </ul>
<del>D</del>	<ul style="list-style-type: none"> <li><del>Of the 32 assemblies in a basket, up to 8 assemblies can be from core locations where they were located under a control rod bank, that was permitted to be inserted more than 8 inches during full power operation. Location under such a control rod bank is limited to 30 GWD/MTU of the assembly.</del></li> <li><del>The remaining assemblies in the basket must satisfy the same conditions as specified for configuration A.</del></li> </ul>

Table A.14

NON-FUEL HARDWARE AND NEUTRON SOURCES BURNUP AND COOLING TIME LIMITS

Post-irradiation Cooling Time (yrs)	Inserts (Note 4) Maximum Burnup (MWD/MTU)	NSA or Guide Tube Hardware (Notes 5 and 9) Maximum Burnup (MWD/MTU)	Control Component (Note 6) Maximum Burnup (MWD/MTU)
≥ 15	≤ 24,635	N/A (Note 7)	N/A
≥ 16	≤ 30,000	≤ 20,000	N/A
≥ 17	≤ 36,748	≤ 25,000	≤ 630,000
≥ 18	≤ 44,102	≤ 30,000	-
≥ 19	≤ 52,900	≤ 40,000	-
≥ 20	≤ 60,000	≤ 45,000	-
≥ 21	-	≤ 50,000	-
≥ 22	-	≤ 60,000	-
≥ 23	-	≤ 75,000	-
≥ 24	-	≤ 90,000	-
≥ 25	-	≤ 180,000	-
≥ 26	-	≤ 630,000	-

NOTES:

1. Burnups for non-fuel hardware are to be determined based on the burnup and uranium mass of the fuel assemblies in which the component was inserted during reactor operation.
2. Linear interpolation between points is permitted, except that NSA or Guide Tube Hardware burnups > 180,000 MWD/MTU and ≤ 630,000 MWD/MTU must be cooled ≥ 26 years.
3. Not used.
4. Includes Burnable Poison Rod Assemblies (BPRAs), Wet Annular Burnable Absorbers (WABAs), and vibration suppressor inserts. For TPDs with absorber rodlets refer to Note 9.
5. Includes Thimble Plug Devices (TPDs), water displacement guide tube plugs, and orifice rod assemblies.
6. Includes Control Rod Assemblies (CRAs), Control Element Assemblies (CEAs), and Rod Cluster Control Assemblies (RCCAs).
7. N/A means not authorized for loading at this cooling time.
8. Non-fuel hardware burnup and cooling time limits are not applicable to Instrument Tube Tie Rods (ITTRs), since they are installed post-irradiation.
9. Maximum burnup for TPDs with absorber rodlets is limited to 60,000 MWD/MTU.

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**REFERENCES:**

Holtec International Report No. HI-951251, *Safety Analysis Report on the HI-STAR 100 Cask System*, Revision ~~15~~TBD, dated ~~October 11, 2010~~TBD.

