Transportation Capabilities Study for DOE-Owned Spent Nuclear Fuel

**G. L. Clark
R. A. Johnson
R. W. Smith
D. G. Abbott^a
M. J. Tyacke^a**

Published October 1994

**Packaging Technology, Inc.
Tacoma, Washington 98424**

**Prepared for Lockheed Idaho Technologies Company
Under Subcontract No. C94-170778
and for the
U.S. Department of Energy
Assistant Secretary for Environmental Management
Under DOE Idaho Operations Office
Contract DE-AC07-94ID13223**

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a. Lockheed Idaho Technologies Company

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ABSTRACT

This study evaluates current capabilities for transporting spent nuclear fuel owned by the U.S. Department of Energy. Currently licensed irradiated fuel shipping packages that have the potential for shipping the spent nuclear fuel are identified and then matched against the various spent nuclear fuel types. Also included are the results of a limited investigation into other certified packages and new packages currently under development. This study is intended to support top-level planning for the disposition of the Department of Energy's spent nuclear fuel inventory.

ACKNOWLEDGMENTS

A good deal of information contained in this report was obtained through direct communication with the various stakeholders (e.g., user sites, U.S. Nuclear Regulatory Commission and U.S. Department of Energy regulatory authorities, packaging developers or owners). Their contributions are too numerous to be listed in detail, but are gratefully acknowledged nonetheless.

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ACRONYMS

AGN	Aerojet-General Nucleonics reactor
ANL-E	Argonne National Laboratory-East
ANL-W	Argonne National Laboratory-West
ARMF	Advanced Reactivity Measurement Facility
ATR	Advanced Test Reactor
ATSR	Argonne Thermal Source Reactor
B&W	Babcock & Wilcox
BNL	Brookhaven National Laboratory
BR	breeder reactor
BRP	Big Rock Point
BSR	Bulk Shielding Reactor
BWR	boiling water reactor
CFRMF	Coupled Fast Reactivity Measurement Facility
CPP	Chemical Processing Plant
DOE	U.S. Department of Energy
DOT	U.S. Department of Transportation
DU	depleted uranium
EBR	Experimental Breeder Reactor
EFPH	effective full-power hours
EH	Transportation and Packaging Safety Division
EPR	Experimental Power Reactor
ERR	Elk River Reactor
FFTF	Fast Flux Test Facility
FSV	Fort St. Vrain
FSVR	Fort St. Vrain Reactor
GCR	gas-cooled reactor
GCRE	Gas-Cooled Reactor Experiment
GE	General Electric
GETR	General Electric Test Reactor
HEU	high enriched uranium
HFBR	High-Flux Beam Reactor
HFEF	Hot Fuel Examination Facility
HFIR	High-Flux Isotope Reactor
HRE	Homogeneous Reactor Experiments
HWCTR	Heavy Water Component Test Reactor
ID	Idaho Operations Office
INEL	Idaho National Engineering Laboratory
JMTR	Japanese Material Test Reactor
LANL	Los Alamos National Laboratory
LEU	low enriched uranium
LM	liquid metal
LOCA	loss-of-coolant accident
LOFT	Loss-of-Fluid Test (reactor)
LW	light water

LWR	light water reactor
LWT	legal weight truck
MIT	Massachusetts Institute of Technology
MITHM	metric initial ton of heavy metal
MNOP	maximum normal operating pressure
MSRE	Molten Salt Reactor Experiment
MTHM	metric tons of heavy metal
MTR	Materials Test Reactor
MURR	Missouri University Research Reactor
NPR	New Production Reactor
NR	Naval Reactors Division
NRAD	Neutron Radiography Facility
NRC	U.S. Nuclear Regulatory Commission
ORNL	Oak Ridge National Laboratory
ORR	Oak Ridge Research Reactor
OSR	Ohio State Reactor
PBF	Power Burst Facility
PNL	Pacific National Laboratory
PUREX	Plutonium-Uranium Extraction (plant)
PWR	pressurized water reactor
RBOF	receiving basin for offsite fuel
REG	R.E. Gina
RINC	Rhode Island Nuclear Center
RSWF	Radioactive Scrap and Waste Facility
SARP	safety analysis report for packaging
SM	Stationary Medium Power Plant
SNAP	System for Nuclear Auxiliary Power
SNF	spent nuclear fuel
SNL	Sandia National Laboratories
SNM	special nuclear material
SPERT	Special Power Excursion Reactor Test
SPR	Sandia Pulsed Reactor
SPSS	Shield Plug Storage Station
SRS	Savannah River Site
TAN	Test Area North
TORY	Experimental Propulsion Test Reactor
TREAT	Transient Reactor Test Facility
TRIGA	training, research, and isotope reactors (built by General Atomic)
TSR	Tower Shielding Reactor
WAG	Waste Area Group
ZPR	Zero Power Reactor

Transportation Capabilities Study for DOE-Owned Spent Nuclear Fuel

1. INTRODUCTION

This study assesses transportation capabilities for U.S. Department of Energy (DOE)-owned noncommercial spent nuclear fuel (SNF). The study was prepared to support top-level planning associated with management of DOE's SNF. The results of this study, when coupled with other recently completed and in-process studies of the various fuels themselves and their respective storage facilities (see References section), will provide guidelines for appropriate actions in dealing with DOE's SNF inventory.

1.1 Scope

Because of the limited time available for this study, the scope carefully focused on identifying currently licensed [U.S. Nuclear Regulatory Commission (NRC) or DOE] irradiated fuel shipping packages with the potential for shipping DOE-owned SNF. Also included are the results of a limited investigation into other International Atomic Energy Agency-certified packages and new packages currently under development.

Five primary goals for the study were established as follows:

1. Identify and discuss the issues potentially affecting transport of DOE-owned SNF.
2. Group and rank DOE-owned fuels in a way meaningful for transportation.
3. Identify currently licensed transport packages potentially suitable for conveying the fuels.
4. Determine, when possible, compatible fuel/package combinations.
5. Develop recommendations for followup actions.

It should be noted that the issues related to transportation of DOE's SNF, as set out in detail in this report, involve a large number of complex and often interrelated technical and political factors that must be resolved with a high degree of certainty before any realistic SNF transportation assessment can be initiated. Foremost among the uncertainties is a notable lack of adequate characterization of much of the SNF inventory. Many questions involving fuel form, radiological characteristics, and physical condition remain to be answered before licensing requirements for suitable transport packages can be determined.

Additionally, any package-related modifications that may be necessary to accommodate these fuels introduce a level of uncertainty that increases with the degree of modification required. Even with comprehensively characterized fuel, there is no guarantee that package analyses or designs can be modified sufficiently to accommodate the fuel. Furthermore, transportation

regulations, and interpretations thereof, have been growing steadily more stringent over the years. Even if the proposed package-related modifications prove to be successful in theory, there is no assurance that they will be acceptable to the appropriate regulators. In the current regulatory and social climate, it should be expected that transporting the noncommercial SNF inventory will demand a very significant amount of time and resources.

1.2 Overview

Details of the DOE-owned SNF are presented in Section 2. This includes a complete listing of DOE-owned SNF. The SNF types are grouped in general categories, along with their most significant transportation-related characteristics. A detailed discussion of fuel characteristics that govern transport is also included in this section.

In many cases, insufficient fuel characteristics data exist at this time to allow a transportation assessment to be made for all DOE-owned SNF. It is estimated that the time frame required to fully characterize all of the SNF inventory will be on the order of five years. This estimate assumes that a relatively high priority in terms of resources will be given to this effort. As the various fuel types are characterized, transport packaging requirements can be developed sequentially, assuming resources are available for such a concurrent activity.

Transportation package characteristics are given in Section 3, and are summarized in Table 3-1. A number of key factors relating to transport packaging design and licensing are included and discussed.

Fuel/package compatibility relationships are discussed in Section 4. Current transport capability is discussed, as well as potential package modifications that might result in extended capability. With this background information in hand, fuel characteristics and cask design details were reviewed to appropriately categorize fuels and to match fuel categories with specific cask types. Considering such fuel-related items as geometry, decay heat and source term, and corresponding packaging characteristics (e.g., cavity size, heat transfer capability, and shielding characteristics), a fuel/package compatibility matrix was developed. This matrix is included as Tables 4-1 through 4-6, and is summarized in Table 6-2.

Additional factors, unrelated to specific fuel/package compatibility issues, are discussed in Section 5. Among these are facility interface modification or development requirements, funding procurement, and accommodation for public involvement.

Finally, the results of the study are summarized in Section 6 in a fuel/package compatibility matrix. Conclusions drawn from the study are included, as well as recommendations for further actions. Section 7 presents the references cited in this study.

1.3 Summary of Results

Early on, the approach being developed indicated that very few direct matchups exist between fuels and currently licensed casks. Of 230 fuel types, only 36 types (16%) qualified for transport in currently licensed casks (see Table 6-1). These matchups involve certain fuel types for which cask designs were specifically developed, and more general, commercial fuel types which can be accommodated by casks designed for such fuel. In all other cases, one or more of the following actions (ordered by increasing level of effort, cost, and risk), coupled with a corresponding NRC or DOE review and certification activity, will be required before shipping DOE-owned SNF:

1. Safety analysis report for packaging (SARP) and Certificate of Compliance amendment to add a new fuel definition (enveloped by the currently authorized payload limits).
2. SARP and Certificate of Compliance revision to accommodate a more demanding payload definition (one that is not enveloped by the currently authorized payload definition, and that extends the package capability or reduces currently documented safety margins).
3. SARP and Certificate of Compliance revision to accommodate a new fuel basket or canister design, and associated fabrication activity for the specific fuel to be transported.
4. SARP and Certificate of Compliance revision, and associated fabrication activity, for a modified packaging design to accommodate a new, more demanding fuel definition.
5. Entirely new package design, license and fabrication activity.

The timeline associated with completing the above changes, including certification, can be as little as three months (in the case of a simple payload amendment) to as much as three or more years (for a new package or major SARP and hardware revision). These time estimates do not include the time that may be required for adequate fuel characterization. The actual overall time frame will be strongly dependent on the priority associated with a particular shipping campaign (within DOE or NRC) and on the demonstration approaches employed, as well as the conservatism embodied in the design or demonstration.

1.4 Summary of Recommendations

Recommendations for further actions are summarized as follows:

- A fairly large amount of DOE-owned SNF can potentially be transported in existing licensed packages. However, these packages will, in most cases, likely require at least some modification before DOE-owned SNF can be transported in them. New transportation systems will have to be developed for the remainder of the SNF inventory.

- A significant fuel characterization effort remains to be accomplished before required package modifications or new package development can be initiated. This characterization effort may result in additional fuel types that can be transported in existing packages.
- An overall materials management and disposition program should be initiated to coordinate fuel characterization and transportation planning among all of the pertinent DOE sites.
- Prioritization of fuel shipments based on fuel or storage facility conditions should be incorporated in any overall transportation plan. Additionally, the transportation plan should consider overall system efficiencies, which will essentially entail a tradeoff between a lower level of transportation optimization with a corresponding greater number of shipments required, or greater initial optimization effort resulting in fewer, more efficient shipments.

2. IDENTIFICATION OF DOE-OWNED SPENT NUCLEAR FUEL

This section identifies all DOE-owned spent nuclear fuel types and the characteristics pertinent to the selection of suitable transport packages in which to ship them. This includes a complete listing of DOE-owned SNF as derived from Reference 1 and Footnote a. Additional fuel information was obtained from References 2, 3, 4, and Footnote b. The SNF types are grouped in general categories in Tables 2-1 through 2-8, along with their most significant transportation-related characteristics. The discussion of fuels is mainly generic in that specific recommendations for package/fuel transport combinations are not developed, but the fuel-related factors involved in making such determinations are set out in detail. Specific package/fuel matchups are discussed in Section 4.

2.1 Fuels List

All noncommercial DOE-owned SNF types are listed in Tables 2-1 through 2-8, along with their current storage locations, total mass in metric tons of heavy metal (MTHM), enrichment (% ^{235}U), decay heat (Kw) and burnup in megawatt days per metric initial ton of heavy metal (MWd/MITHM). The information for this section was derived from References 1 through 4 and Footnotes a and b. Tables 2-7 (test reactor SNF) and 2-8 (miscellaneous SNF) list fuel types for which inadequate information currently exists for purposes of transportation assessments. Additionally, some of the fuels in the other categories (Tables 2-1 through 2-6) are likewise inadequately characterized.

2.2 Discussion of Fuel Characteristics That Govern Transport

A number of factors are involved in matching fuel types with potential transport packages. For a given fuel type, all of these factors must be evaluated to ensure that they fall within the acceptable limits imposed by each candidate package. The parameters defining these limits for transport packages are set out in Section 3.

Additionally, fuel and package characteristics may be interdependent in terms of determining suitability of fuel types as potential payloads (see, for instance, Section 2.2.1). All fuel-related characteristics, as they pertain to transportation packaging, are listed and discussed below.

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a. "Spent Nuclear Fuel Inventory Data (OPE-EIS-94.273)," attached to a letter from Tom Wichmann (DOE Idaho Operations Office) to addressees, May 11, 1994.

b. Private communications between Packaging Technology personnel and knowledgeable spent nuclear fuel authorities.

Table 2-1. Pressurized water reactor (PWR) DOE-owned SNF types.

Source (form)	Type	Location	MTHM	Enrichment (% U-235)	Decay heat (kW)	Burnup (MWd/MITHM)
Shippingport C-2 (assemblies)	UO ₂	Hanford T-Plant	16.2	0.714	0.104/assbly	Unknown
Point Beach-1 (assemblies)	UO ₂	Hanford Bldg 324, 5, 7	1.16	0.88	0.6/assembly	Unknown
Calvert Cliffs (rods)	UO ₂	Hanford Bldg 324, 5, 7	0.664	0.65	Unknown	Unknown
H. B. Robinson (rods)	UO ₂	Hanford Bldg 324, 5, 7	0.03	0.7	Unknown	Unknown
H. B. Robinson (rods)	UO ₂	INEL TAN-607	0.258	1.85	Unknown	Unknown
H. B. Robinson (canister)	UO ₂ +PuO ₂	SRS RBOF	0.0005	Unknown	Unknown	30,000 max
Shippingport C1-S4 (subassembly)	UO ₂	INEL CPP-666	0.08	80.4	<0.33/assbly	38-53%
Shippingport C2-S1 (clusters)	UO ₂	INEL CPP-666	0.219	69.1	<0.33/assbly	38-53%
Shippingport C2-S2 (clusters)	UO ₂	INEL CPP-666	0.3	80.8	<0.33/assbly	38-53%
Shippingport (canister)	UO ₂ +PuO ₂	SRS RBOF	0.0162	0.14	Unknown	18,000
Conn Yankee (assembly)	UO ₂	INEL TAN-607	0.377	1.4 (1.85) ?	Unknown	32,151
LOFT (can, assembly)	UO ₂	INEL TAN-607	2.178	4.3 max	Unknown	1,178 avg
Surrey (assembly, canister)	UO ₂	INEL TAN-790	30.47	1.85	Unknown	32,521
Turkey Point B17	UO ₂	INEL TAN-790	0.412	1.85	Unknown	25,662
Turkey Point EMAD (assembly, can)	UO ₂	INEL TAN-790	7.49	1.85	Unknown	27,525
Battelle Memorial Institute (can)	UO ₂	INEL CPP-603	0.0013	93.2	Unknown	Unknown
R. E. Gina (assembly)	UO ₂	West Valley FRS	15.06	3.473	0.132/assbly	Unknown
TMI-2 (canisters)	UO ₂	INEL TAN-607	81.595	2.98	<0.1/can	3,165
Arkansas ANO-1 (canisters)	UO ₂ ?	B&W Lynchburg	0.0119	0.4	Unknown	Unknown
Oconee (canisters)	UO ₂ ?	B&W Lynchburg	0.001	1.3	Unknown	Unknown

Table 2-2. Boiling water reactor (BWR) DOE-owned SNF types.

Source (form)	Type	Location	MTHM	Enrichment (% U-235)	Decay heat (kW)	Burnup (MWd/MITHM)
EBWR (assembly)	UO ₂ Zr UO ₂ +PuO ₂	SRS RBOF	2.21	LEU/Natural/ Depleted	Unknown	1,600
Dresden (assemblies)	UO ₂	INEL TAN-607	0.166	1.59	Unknown	Unknown
Peach Bottom 1 (elements)	UO ₂	INEL CPP-603	0.046	75.7 (93.15)?	Unknown	Unknown
Peach Bottom 2 (partial assembly)	UO ₂	INEL TAN-607	0.356	1.4 (2.19) ?	Unknown	11,440
Peach Bottom (rods in canisters)	UO ₂	INEL TRA-603	0.010	1.4	Unknown	Unknown
Pathfinder (rod)	UO ₂	INEL CPP-603	0.053	93	Unknown	0.97%
SPSS - SPERT (can)	UO ₂	INEL CPP-603	0.001	93	0.4 W	Unknown
Borax V (assembly)	UO ₂	INEL CPP-603	0.021	93	Unknown	Unknown
Cooper (rods)	UO ₂	Hanford Bldg 324, 5, 7	0.365	4 max ?	Unknown	Unknown
Vallecitos (can)	UO ₂	SRS RBOF	0.001	93	Unknown	8%
Vallecitos (can)	UO ₂	INEL CPP-603	0.012	21.1 (93) ?	Unknown	8%

Table 2-3. Breeder reactor (BR) DOE-owned SNF types.

Source (form) ^a	Type	Location	MTHM	Enrichment (% U-235)	Decay heat (kW)	Burnup (MWd/MITHM)
FFTF - LM (DA)	UO ₂ +PuO ₂	Hanford FFTF	9.0	0.71	<2.0	Unknown
FFTF - LM (TFA)	UO ₂ +PuO ₂ + ThO, UN ₃	Hanford FFTF	2.43	0.71	Very Low	Unknown
Shippingport - LW (pellets)	UO ₂	INEL CPP-749	42.93	0.98 U-233	Unknown	29,048 EFPH
Shippingport - LW (canister)	UO ₂ +ThO ₂	ANL-E Bldg 212	0.045E-3	Unknown	Unknown	53,000 max
Fermi Cores 1 & 2 - LM (can)	UMo	INEL CPP-666	3.913	25.7	<0.021/can	2%
Fermi I Blanket - LM (assembly)	U-238, Mo	INEL CPP-749	34.172	0.36	Unknown	0.35%
EBR-II - LM (casks)	U metal	Hanford Bldg 325	0.08	18	Unknown	Unknown
EBR-II - LM (canister)	U metal	INEL CPP-666	0.8	67	<0.5	25-30,000
EBR-II - LM (scrap)	U metal	INEL CPP-603	1.173	60	Unknown	N/A
EBR-II ANL-6 - LM (can)	U metal	INEL CPP-603	0.002	60	Unknown	N/A
EBR - ? (pieces)	Unknown	Hanford 200W	Unknown	Unknown	Unknown	Unknown
EBR-II - LM (subassembly)	U-10% Zr	ANL-W EBR-II	17.81	69/78	<1.0; 0.004	Unknown
EBR-II - LM (subassembly, element)	U-10% Zr	ANL-W HFEF	11.89	69/78	<1.0; 0.004	Unknown
EBR-II - LM (subassembly)	Metal	ANL-W RSWF	11.33	69/78	<0.001	Unknown
EBR-II - LM (canister)	UO ₂ +PuO ₂	SRS RBOF	0.0006	Unknown	Unknown	62
EBR-II - LM (canister)	UO ₂ +PuO ₂	SRS RBOF	0.0027	Unknown	Unknown	34,000 max
EBR-II - LM targets (canister)	U declad	SRS RBOF	16.9791	Unknown	Unknown	Unknown
Saxton (canister)	UO ₂ +PuO ₂	SRS RBOF	0.2974	Unknown	Unknown	1,000
Saxton (canister)	UO ₂	SRS RBOF	0.0893	Unknown	Unknown	1,600
Dresden - LW (sleeves, canisters)	UO ₂ +ThO ₂	SRS RBOF	2.542	HEU/LEU ?	Unknown	Unknown
ERR (bundle)	UO ₂ +ThO ₂	SRS RBOF	5.043	Unknown/83 ?	Unknown	50,000 max
ML-1 (assemblies)	UO ₂ +PuO ₂ + BeO	SRS RBOF	0.0586	Unknown	Unknown	Unknown

a. LW = Light Water; LM = Liquid Metal.

Table 2-4. Gas-cooled reactor (GCR) DOE-owned SNF types.

Source (form)	Type	Location	MTHM	Enrichment (% U-235)	Decay heat (kW)	Burnup (MWd/MTHM)
Peach Bottom 1 - HT (elements)	UC	INEL CPP-749	1.627	75.7 (93.15)?	Unknown	Unknown
Peach Bottom 2 - HT (elements)	UC	INEL CPP-603 GSF	1.295	53.3 (93.15)?	Unknown	Unknown
FSVR - HT (assembly)	UC	INEL CPP-603 GSF	8.62	93.5	Unknown	6-26,000
FSVR (assembly)	UC	FSVR	16	54	Unknown	Unknown
TORY-IIC (can)	UO ₂	INEL CPP-603 GSF	0.059	93.2	Unknown	1.5%
TORY-IIA (can)	UO ₂	INEL CPP-603	0.049	93	Unknown	0.002%
GCRE Can (can)	UO ₂	INEL CPP-603	0.001	93	Unknown	Unknown
GCRE (canisters)	UO ₂ or UO ₂ +BeO	SRS RBOF	0.061	Unknown	Unknown	Unknown

Table 2-5. Metallic DOE-owned SNF types.

Source (form)	Type	Location	MTHM	Enrichment (% U-235)	Decay heat (kW)	Burnup (MWd/MITHM)
TRIGA AI (rod)	UZrHx	INEL CPP-603	0.104	20	<.001 W/rod	Varies
TRIGA FLIP (rod)	UZrHx	INEL CPP-603	0.001	69.7	N/A	5.7-14.8 %
TRIGA FLIP and Std (element)	UErZrH, UZrH std	ANL-W NRAD	0.010	FLIP 70 std 20	Negligible	Unknown
TRIGA SST (element)	UZrHx	INEL CPP-603	0.050	20	<.001 W/element	Varies
TRIGA SST (assembly)	UZrHx	Hanford Bldg 308	0.019	20	Low	Unknown
TRIGA (assembly)	UZrHx	Hanford 200 W	0.017	20	Unknown	Unknown
TRIGA BER-II (element)	UZrHx	INEL CPP-603 GSF	0.009	44	Unknown	0.13%
TRIGA Areotest (element)	UZrHx ?	San Remon	0.015	19.9	Unknown	Unknown
AFRRI-TRIGA (element)	UZrHx ?	Armed Forces	0.019	19.9	Unknown	Unknown
GA-TRIGA (element)	UZrHx ?	GA San Diego	0.045	19.9	Unknown	Unknown
U.S. Geo-TRIGA (element)	UZrHx ?	Denver	0.02	19.9	Unknown	Unknown
TRIGA (element)	UZrHx ?	McLellam	0.015	19.9	Unknown	Unknown
DOW-TRIGA (element)	UZrHx ?	Midland	0.014	19.9	Unknown	Unknown
TRIGA (assembly?)	UZrHx	University of Arizona	0.081	19.8	Unknown	Unknown
TRIGA (assembly?)	UZrHx	University of Wisconsin	0.039	70/19.8	Unknown	Unknown
TRIGA (assembly?)	UZrHx	U. of Illinois (2 reactors)	0.038	19.8	Unknown	Unknown
TRIGA FLIP (assembly?)	UZrHx	Washington State	0.037	70/20	Unknown	Unknown
TRIGA (assembly?)	UZrHx	Pennsylvania State	0.036	20	Unknown	Unknown
TRIGA (assembly?)	UZrHx	University of Texas	0.029	19.8	Unknown	Unknown

Table 2-5. (continued).

Source (form)	Type	Location	MTHM	Enrichment (% U-235)	Decay heat (kW)	Burnup (MWd/MITHM)
TRIGA FLIP (assembly?)	UZrHx	Texas A&M University	0.027	70/19.8	Unknown	Unknown
TRIGA (assembly?)	UZrHx	University of Utah	0.026	19.8	Unknown	Unknown
TRIGA (assembly?)	UZrHx	Kansas State	0.025	20	Unknown	Unknown
TRIGA (assembly?)	UZrHx	Cornell Univ. (2 reactors)	0.021	20	Unknown	Unknown
TRIGA (assembly?)	UZrHx	U. of California (Irvine)	0.021	19.8	Unknown	Unknown
TRIGA (assembly?)	UZrHx	University of Maryland	0.017	19.8	Unknown	Unknown
TRIGA FLIP (assembly?)	UZrHx	Oregon State	0.017	85	Unknown	Unknown
TRIGA (assembly?)	UZrHx	Reed University	0.013	20	Unknown	Unknown
SNAP (can)	UZrHx	INEL CPP-603	0.02	93	Unknown	<1%
MURR (assembly)	UAlx	INEL CPP-603	0.022	93.4	Unknown	Unknown
MURR (bundle)	UAl	SRS RBOF	0.0486	Unknown	Unknown	120 days
MURR (assembly?)	UAl ?	U. of Missouri (Columbia)	0.047	93.15	Unknown	Unknown
MURR (assembly?)	UAl ?	U. of Missouri (Rolla)	0.018	93.15	Unknown	Unknown
HFBR (element)	UAlx & U ₃ O ₈	INEL CPP-603	0.058	93	Unknown	40.5%
HFBR (fuel handling unit)	U ₃ O ₈	BNL HFBR Canal	0.248	93.17	<4.0/FHU	Unknown
ORR (element)	UAlx	INEL CPP-603	0.003	93	Unknown	Unknown
ATR (assemblies)	UAlx	INEL CPP-603	0.09	93	<634 W/assbly	41%
ATR recycle (element)	UAlx ?	INEL TRA-670	0.586	86	Unknown	Unknown
ATR spent (assembly)	UAlx ?	INEL TRA-670	0.095	82.6	Unknown	Unknown

Table 2-5. (continued).

Source (form)	Type	Location	MTHM	Enrichment (% U-235)	Decay heat (kW)	Burnup (MWd/MITHM)
ATR core (elements)	UAlx ?	INEL ATR Facility	0.046	83	Unknown	Unknown
ATR (assembly)	UAlx	INEL CPP-666	0.649	93	634 W/assbly	41%
HFIR (assembly)	U ₃ O ₈ Al	ORNL HFIR Pool	0.404	93	<0.25	Unknown
RINC (bundles)	UAlx & UAl	SRS RBOF	0.0037	Unknown	Unknown	<4,000
Nereide (bundle)	USiAl	SRS RBOF	0.0354	Unknown	Unknown	600
ANLJ (bundle)	UAl	SRS RBOF	0.0028	Unknown	Unknown	55%
ATSR (bundle)	UAl	SRS RBOF	0.0032	Unknown	Unknown	<20%
JMTR (bundles)	UAl	SRS RBOF	0.0167	Unknown	Unknown	<100,000
RHF (cylinder)	UAl	SRS RBOF	0.0251	Unknown	Unknown	Unknown
S. Forest (bundle)	UAl	SRS RBOF	0.0284	Unknown	Unknown	1,900
Atomics International - LM (pin)	UZrHx	INEL CPP-603	0.008	93	Unknown	Unknown
ARMF (plates)	UAl	INEL CPP-666	0.0002	92.3	Unknown	Negligible
ARMF/CFRMF (element)	UAlx	INEL TRA-660	0.0118	100	Very Low	Very Low
ARMF/CFRMF (unknown)	UAlx	INEL TRA-660	0.0016	100	Very Low	Very Low
ARMF/CFRMF (insert)	UAlx	INEL TRA-660	0.0008	100	Very Low	Very Low
Taiwan RR (canister)	UAl	SRS RBOF	20.4845	Unknown	Unknown	4
SPEC (can)	U metal	SRS RBOF	0.002	Unknown	Unknown	Unknown
Tower Shielding Reactor (assembly)	UAl	ORNL TSR Vessel	0.009	93.15	Unknown	Unknown
BNL MRR (element)	UAl	BNL MRR	0.0058	93 max	Unknown	Unknown

Table 2-5. (continued).

Source (form)	Type	Location	MTHM	Enrichment (% U-235)	Decay heat (kW)	Burnup (MWd/MITHM)
Univ of Wash (bundle)	UAix	INEL CPP-666	0.004	93	Unknown	0.44%
Univ of Virginia (bundle)	UAI	SRS RBOF	0.00193	Unknown	Unknown	63 MWd/assmbly
Univ of Michigan (bundles)	UAI	SRS RBOF	0.0338	Unknown	Unknown	633 days
MTR Type (assembly?)	UAI ?	University of Virginia	0.025	93	Unknown	Unknown
MTR Type (assembly?)	UAI ?	University of Michigan	0.093	20	Unknown	Unknown
MTR Type (assembly?)	Unknown	Georgia Tech	0.029	93	Unknown	Unknown
MTR Type (assembly?)	Unknown	Michigan Inst. of Tech.	0.026	93	Unknown	Unknown
MTR Type (assembly?)	Unknown	U. of Mass. (Lowell)	0.023	93	Unknown	Unknown
MTR Type (assembly?)	Unknown	Iowa State	0.02	93	Unknown	Unknown
MTR Type (assembly?)	Unknown	Worster Polytech. Inst.	0.018	20	Unknown	Unknown
MTR Type (assembly?)	Unknown	Purdue University	0.014	93	Unknown	Unknown
MTR Type (assembly?)	Unknown	Rhode Is Nuclear Sci Cen	0.03	93	Unknown	Unknown
Argonaut (assembly?)	Unknown	University of Florida	0.024	93	Unknown	Unknown
OSR (assembly?)	Unknown	Ohio State	0.02	20	Unknown	Unknown

Table 2-6. Graphite-moderated DOE-owned SNF types.

Source (form)	Type	Location	MTHM	Enrichment (% U-235)	Decay heat (kW)	Burnup (MWd/MITHM)
SPR (element)	U metallic	Hanford 105-KW Basin	2.9 U ?	1.25 max	0.5 W	Unknown
SPR (element)	U metallic	Hanford PUREX	2.9 U ?	1.25 max	0.5 W	Unknown
SPR (element)	U metallic	Hanford 105-KE Basin	0.4 U ?	1.25 max	0.5 W	Unknown
N Reactor (element)	U metallic	Hanford 105-KW/KE	2,106	1.25 max	3.5 W/element	Unknown
N Reactor (element)	U metallic	Hanford PUREX	0.3 U ?	1.25 max	3.5 W/element	Unknown
Big Rock Point (assembly)	UO ₂	West Valley FRS	11.5	5.6 max	0.06/assembly	Unknown
TREAT (assembly)	UO ₂ in graphite	ANL-W TREAT	0.010	93	Negligible	Unknown

Table 2-7. Test reactor DOE-owned SNF types.

Source (form)	Type	Location	MTHM	Enrichment (% U-235)	Decay heat (kW)	Burnup (MWd/MITHM)
Dresden SA-1 (rods in canisters)	UO ₂	INEL TRA-603	0.019	2.1	Unknown	Unknown
Power Burst Facility (canister)	Unknown	INEL TRA-603	0.049	6 avg	Unknown	Unknown
MAPI (canister)	Unknown	INEL TRA-603	0.024	6 avg	Unknown	Unknown
OPTRAN (canister)	Unknown	INEL TRA-603	0.019	6 avg	Unknown	Unknown
LOCA (canister)	Unknown	INEL TRA-603	0.008	6 avg	Unknown	Unknown
Saxton (canister)	Unknown	INEL TRA-603	0.008	6 avg	Unknown	Unknown
RIA (canister)	Unknown	INEL TRA-603	0.007	6 avg	Unknown	Unknown
IE (canister)	Unknown	INEL TRA-603	0.006	6 avg	Unknown	Unknown
PCM (canister)	Unknown	INEL TRA-603	0.006	6 avg	Unknown	Unknown
Halden (canister)	Unknown	INEL TRA-603	0.005	6 avg	Unknown	Unknown
LOFT lead rod (canister)	Unknown	INEL TRA-603	0.004	6 avg	Unknown	Unknown
TC (canister)	Unknown	INEL TRA-603	0.004	6 avg	Unknown	Unknown
CANDU (canister)	Unknown	INEL TRA-603	0.003	6 avg	Unknown	Unknown
Halden IFA (canister)	Unknown	INEL TRA-603	0.003	6 avg	Unknown	Unknown
GAP Conductance (canister)	Unknown	INEL TRA-603	0.001	6 avg	Unknown	Unknown
LP-FP-1 (canister)	Unknown	INEL TRA-603	<0.0001	6 avg	Unknown	Unknown
NPR (canister)	Unknown	INEL TRA-603	<0.0001	6 avg	Unknown	Unknown
H. B. Robinson (rods in canisters)	Unknown	INEL TRA-603	0.020	0.75	Unknown	Unknown
Belgian (canister)	Unknown	INEL TRA-603	0.062	6 avg	Unknown	Unknown
Severe Fuel Damage (inpile test tube)	Unknown	INEL TRA-603	0.062	6	Unknown	Unknown
Power Burst Facility (canister)	Unknown	INEL TRA-603	0.049	18.5	Unknown	Unknown

Table 2-8. Miscellaneous DOE-owned SNF types.

Source (form)	Type	Location	MTHM	Enrichment (% U-235)	Decay heat (kW)	Burnup (MWd/MITHM)
Target (unknown)	Unknown	SRS F-Canyon	22.634	Unknown	Unknown	Unknown
Driver (unknown)	Unknown	SRS H-Canyon	0.068	Unknown	Unknown	Unknown
Driver (unknown)	Unknown	SRS K-Basin	3.256	Unknown	Unknown	Unknown
Non-U target (unknown)	Unknown	SRS KLP-Basin	0.059	Unknown	Unknown	Unknown
Driver/target (unknown)	Unknown	SRS L-Basin	118.11	Unknown	Unknown	Unknown
Driver (unknown)	Unknown	SRS P-Basin	1.408	Unknown	Unknown	Unknown
B&W scrap (canister)	UO ₂ +PuO ₂	SRS RBOF	0.00008	Unknown	Unknown	54
CANDU (canister)	UO ₂	SRS RBOF	0.05	Unknown	Unknown	6,500
Carolina-Virginia TR	UO ₂	SRS RBOF	0.0675	Unknown	Unknown	10,000 max
EPR-1 (canister)	PuO ₂	SRS RBOF	0.00002	Unknown	Unknown	Unknown
HTRE (canister)	UO ₂ +BeO	SRS RBOF	0.004	Unknown	Unknown	Unknown
HWCTR (tubes, canisters)	U or UO ₂	SRS RBOF	1.8267	LEU	Unknown	Unknown
HWCTR (assembly, canisters)	UZr	SRS RBOF	0.0387	HEU	Unknown	Unknown
HWCTR (assembly)	UTh	SRS RBOF	0.0791	Unknown	Unknown	Unknown
MIT (bundle)	UO ₂ +PuO ₂	SRS RBOF	0.0159	Unknown	Unknown	Unknown
ORNL-SIW-1 (canister)	U	SRS RBOF	0.00018	Unknown	Unknown	Low
ORNL Mixed Oxide (canister)	UO ₂ +PuO ₂	SRS RBOF	Unknown	Unknown	Unknown	18,000
ORRa (bundle)	U ₃ Si ₂ Al	SRS RBOF	0.090	16	Unknown	15,600
ORRb (bundle)	U ₃ Si ₂ Al	SRS RBOF	0.0055	11	Unknown	15,600
ORRc (bundle)	U ₃ O ₈ Al	SRS RBOF	0.2051	HEU	Unknown	250 days
Saxton UO (canister)	UO ₂ ?	SRS RBOF	0.089	7.7	Unknown	Unknown
S. Forest (canister)	UO ₂	SRS RBOF	0.09429	HEU	Unknown	<16 days

Table 2-8. (continued).

Source (form)	Type	Location	MTHM	Enrichment (% U-235)	Decay heat (kW)	Burnup (MWd/MITHM)
SPERT-3 (canister)	UO ₂	SRS RBOF	0.0097	Unknown	Unknown	Unknown
SPERT (assembly?)	UO ₂	Rensselaer University	0.388	5	Unknown	Unknown
Sodium Reactor Experiment (unknown)	UO ₂ +ThO ₂	SRS RBOF	2.1274	HEU	Unknown	10,000
Sodium Reactor Experiment (canister)	UC	SRS RBOF	0.0443	Unknown	Unknown	10,000
SRS-P (tubes)	U ₃ O ₈ Al, UAl	SRS RBOF	0.0061	Unknown	Unknown	Unknown
SRS (unknown)	Unknown	SRS RBOF	153.625	Unknown	Unknown	Unknown
SRS target samples (assembly)	U	SRS RBOF	0.369	Unknown	Unknown	Unknown
SRS target material (assembly)	U base	SRS RBOF	Class.	Unknown	Unknown	Unknown
LWR samples (canister)	UO ₂ +PuO ₂	SRS RBOF	0.0127	Unknown	Unknown	Unknown
ZPPR (plates and rods)	PuAl, PuMo, PuO ₂ , U metal, U	ANL-W ZPPR	9.47	93	Unknown	Unknown
ZPTR (assembly?)	UO ₂	Cornell University	1.7	2	Unknown	Unknown
ZPR (assembly?)	UO ₂ ?	Manhattan University	0.019	20	Unknown	Unknown
LFRSB (assembly)	UO ₂	INEL TAN-607	0.312	N/A	Unknown	Unknown
PULSTAR Buffalo (pin)	UO ₂	INEL CPP-603	0.251	6	<7 W/pin	12,000 max
PULSTAR Buffalo ? (pins)	UO ₂	State Univ of NY (Buffalo)	0.493	6	< 7 W/pin ?	12,000 max ?
PULSTAR (unknown)	UO ₂	North Carolina State	0.445	4	Unknown	Unknown
SM-1A Army (assembly)	UO ₂	INEL CPP-603	0.066	93	Unknown	5,124

Table 2-8. (continued).

Source (form)	Type	Location	MTHM	Enrichment (% U-235)	Decay heat (kW)	Burnup (MWd/MITHM)
PBF Driver Core (rod)	UZr/calcia	INEL PBF-620	0.56	18.5	Unknown	1,849
APP [AGE-2] (can)	UO ₂	INEL CPP-603	0.00002	94	Unknown	30%
GETR Filters (basket)	UO ₂ , U ₃ O ₈	INEL CPP-603	0.004	93	Unknown	5%
Core Filter (unknown)	Unknown	INEL TRA-660	0.217	Depleted	Unknown	Unknown
LWR Commercial Fuel (pieces)	UO ₂	Hanford 327 Bldg	0.007	4 max	Unknown, low	Unknown
DOE, Commercial Fuel (pieces)	Various	Hanford 327 Bldg	0.010	4 max	Unknown, low	Unknown
LWR Commercial Fuel (pieces)	UO ₂	Hanford 325 Bldg	0.010	4 max	Unknown, low	Unknown
LWR Commercial Fuel (assembly)	UO ₂	Hanford 324 Bldg	2.24	4 max	0.6/assmbly	Unknown
LWR Commercial Fuel (pieces)	UO ₂	Hanford 200W	0.007	4	0.6/assmbly	Unknown
DOE, Commercial Fuel (pieces)	Various	Hanford 200W	0.223	Varies	Varies	Unknown
Bulk Shielding Reactor (element)	U ₃ O ₈	ORNL BSR Pool	Unknown	93.15	Unknown	Unknown
ORRR Fuel (element)	U ₃ O ₈	ORNL BSR Pool	Unknown	19.8	Unknown	Unknown
MSRE Fuel (storage tank)	UF ₄	ORNL MSRE Vessel	0.037	18.37	0.2	Unknown
JASPER Fuel (pins)	Unknown	ORNL TSR Vessel	0.868	4.81	Unknown	Unknown
Con Edison (can)	U ₃ O ₈	ORNL Bldg 3019 Drywell	1.215 ?	93 (7 ²³³ U)	0.1 W/can	Unknown
Savannah River Oxide (can)	U ₃ O ₈ , UF ₄	ORNL Bldg 3019 Drywell	0.070	100 ²³³ U	0.1 W/can	Unknown
Hanford & Misc. Oxide (can)	U ₃ O ₈	ORNL Bldg 3019 Drywell	0.023	100 ²³³ U	0.1 W/can	Unknown

Table 2-8. (continued).

Source (form)	Type	Location	MTHM	Enrichment (% U-235)	Decay heat (kW)	Burnup (MWd/MITHM)
Misc. Irrad/Unirrad Fuels (misc.)	UO ₂ , UCO, ThO ₂	ORNL Bldg 3525	Unknown	LEU to HEU	Unknown	Unknown
LWR Commercial (rod section)	UO ₂	ORNL Bldg 4501 Drywell	Unknown	7.6 max	Too low to measure	Unknown
Peach Bottom Specimens (elements)	UO ₂ +ThO ₂	ORNL Dry Storage 7929	Unknown	Unknown	Unknown	Unknown
Homogeneous Fuel (aqueous)	U in H ₂ SO ₄	ORNL HRE Wells, WAG7	Unknown	86	Unknown	Unknown
AGN (assembly?)	UO ₂ -poly	Idaho State	0.011	20	Unknown	Unknown
AGN (assembly?)	UO ₂ -poly	University of New Mexico	0.004	20	Unknown	Unknown
HPRR Fuel (plates, rods, etc.)	UMo	ORNL Y-12, 9720-5	Unknown	93.14	Negligible	Unknown
SNAP 10A (core assembly in NaK)	UZr	ORNL Y-12, 9720-5	Unknown	93.29	Negligible	Unknown
DOE Demonstration (core assembly)	Unknown	ORNL Y-12, 9720-5	Unknown	93 max	Unknown	Unknown
MTR Type (element)	U ₃ O ₈	LANL Omega West	0.0064	93.5	4 W/element	Unknown
MTR Type (element)	U ₃ O ₈	LANL CMR	Unknown	93.5	4 W/element	Unknown
EBR-II, FFTF, TREAT (canister)	U+Pu	ANL-E Bldg 212	0.005	Unknown	Unknown	180,000 max
EBR-II, TREAT, MTR (canister)	U metal, alloys	ANL-E Bldg 212	0.004	Unknown	Unknown	100,000 max
EBR-II, TREAT (canister)	UO ₂ +PuO ₂	ANL-E Bldg 212	0.018	Unknown	Unknown	130,000 max
Dresden II, H. B Robinson, BR-3, TMI-2 (canister)	UO ₂	ANL-E Bldg 212	0.020	Unknown	Unknown	40,000 max
ORR Experiments (canister)	U ₃ Si	ANL-E Bldg 212	0.001	Unknown	Unknown	80,000 max
SPR-III (elements)	Unknown	SNL SPR	0.22	93 (est)	Unknown	Unknown

Table 2-8. (continued).

Source (form)	Type	Location	MTHM	Enrichment (% U-235)	Decay heat (kW)	Burnup (MWd/MITHM)
SPR-II (elements)	Unknown	SNL SPR	0.09 (est)	93 (est)	Unknown	Unknown
ACRR (unknown)	Unknown	SNL ACRR	0.03 (est)	35 (est)	Unknown	Unknown
ACRR (experiments)	Unknown	SNL ACRR	0.001	Unknown	Unknown	Unknown
SPR-II & III (unknown)	Unknown	SNL SPR	0.03 (est)	Unknown	Unknown	Unknown
PNL Mixed (unknown)	Unknown	SNL Mansano	0.025	Unknown	Unknown	Unknown
PNL Mixed (unknown)	Unknown	SNL HCF	0.009	Unknown	Unknown	Unknown
CX (elements)	Unknown	SNL	0.02 (est)	93 (est)	Unknown	Unknown
FREC (elements)	Unknown	SNL	0.01 (est)	20 (est)	Unknown	Unknown
SPR-II (unknown)	Unknown	SNL SNM Storage	0.01 (est)	93 (est)	Unknown	Unknown
Experiments (unknown)	Unknown	SNL ACRR	0.001	Unknown	Unknown	Unknown
GENTR (elements)	UO ₂ ?	GE Vallecitos (Pleasanton)	0.008	93	Unknown	Unknown
NIS(T?) (elements)	Unknown	Gaithersburg	0.019	93	Unknown	Unknown
Naval (classified)	Unknown	INEL CPP-603	0.947	classified	classified	classified
Naval (classified)	Unknown	INEL CPP-666	4.816	classified	classified	classified
Naval (classified)	Unknown	NRF	2.5	classified	classified	classified

Note: Question marks (?) indicate that data could not be directly determined from the references, but that reasonable deductions were made based on similar fuel types or other known factors.

2.2.1 Size

Obviously, the size of a particular fuel type must be smaller than the payload cavity of the particular candidate transport package under consideration. In those cases where more than one fuel assembly of a given type will fit within the payload cavity, an optimum loading configuration may have to be determined. Additionally, questions pertaining to package cavity size may also arise from a consideration of the fragility of the fuel. Fuel fragility will determine the robustness (and hence, size) of any support structure that will be necessary to safely transport the fuel while maintaining a noncritical configuration under hypothetical accident condition loading. Robustness of the support structure will in turn be a function of package maximum impact loading (orientation-dependent), which will dictate structural strength requirements. By necessity, the resulting net size (fuel plus support structure) must be smaller than the package payload cavity. Additionally, the support structure may be required to incorporate neutron poisoning, potentially resulting in additional structural size and mass and corresponding reduction in payload capability.

2.2.2 Weight

Maximum payload weight limitations of the package must not be exceeded. Considerations regarding the potential need for payload support structure or poisoning are the same as those described in Section 2.2.1.

Note that package payload weight limitations may not necessarily be restricted to currently licensed values. Package designs could potentially be upgraded for increased carrying capacity, as detailed in Section 4.3 below.

2.2.3 Source Term

This fuel characteristic has implications in two major subcategories: radiation level and radionuclide distribution, and criticality.

2.2.3.1 Radiation Level and Radionuclide Distribution. This factor will determine if the fuel type can be adequately shielded by a particular transport package. That is, maximum dose rates exterior to the package must be maintained according to the regulatory requirements of 10 CFR §71.47, "Normal Conditions of Transport" and 10 CFR §71.51(a)(2), "Hypothetical Accident Conditions," of Reference 5. Obviously, many factors are involved in determining radiation levels. Chief among these are

- Initial fissile material content (kg/assembly)
- Initial enrichment (without U-235 equivalent)
- Burnup (megawatt days per metric ton of uranium—MWD/MTU)
- Cooling time (years)
- Potential presence of activation products.

These factors must be determined for each fuel type in order to develop even a first-level approximation of fuel and package compatibility. A potential complication may arise due to the fact that the Nuclear Regulatory Commission Transportation Committee (the licensing authority) has, in the past, expressed great reluctance in acknowledging anything but the potentially worst-case burnup assumptions for any spent fuel being transported in NRC-licensed packages.

Other factors may also be of importance. For instance, the isotopic distribution of the payload may be a significant factor. Shielding designed for a uniformly distributed source may not be adequate for a source of the same activity level that is concentrated in a relatively small volume within the payload. Even for a nominally "homogeneous" distribution, axial burnup variations may be significant.

2.2.3.2 Criticality. For any given fuel type, fissile content will govern the classification of packaging required, under 10 CFR §71.55, "General Requirements," and 10 CFR §71.59, "Standards for Arrays of Fissile Material Packages." This will also be a key parameter in determining the requirements for payload support in the form of a fuel basket that can withstand regulatory load applications and maintain the fuel in a noncritical configuration. If neutron poisoning is required to be incorporated into the fuel basket, size and weight implications will be involved, as detailed in Sections 2.2.1 and 2.2.2.

This could be a particularly troublesome issue for fuel types that cannot be well characterized because of a lack of sufficient historical data, or for fuels that may be in a deteriorated state. The computer codes used to perform criticality analyses require precise inputs of fuel characteristics. If such data are not available or well defined, conservative bounding analyses would have to be performed. This could potentially result in overly severe limitations on payload capacities and a resulting reduction in transportation efficiency.

2.2.4 Thermal Load

Total heat output of the payload cannot exceed the specified thermal limitations of the package. Again, heat source distribution may be a consideration, with concerns similar to those set out in Section 2.2.3.1. Also, with additional effort (refer to Section 4.3), upward adjustments to a package's thermal limits could potentially be made.

Additionally, even if currently specified packaging thermal limits are maintained, excessive thermal loading may detrimentally affect fuel cladding or basket/support structure integrity.

2.2.5 Fragility

Fragility will be a factor that must be considered in conjunction with size and weight (Sections 2.2.1 and 2.2.2). Robust fuel may need little in the way of support structure, with its accompanying size and weight penalty. Highly fragile fuel may need a fairly massive support structure, at the expense of total fuel payload capacity. Badly deteriorated fuel may require repackaging. The governing consideration will be support of the payload in a noncritical configuration after the hypothetical accident condition loading sequence.

2.2.6 Form

Damaged fuel (i.e., breached or deteriorated cladding) that falls under the restrictions imposed by 10 CFR §71.63 (i.e., quantities of plutonium greater than 20 Ci per shipment) will probably be required to be transported in double-containment, leaktight packages. The significance of this requirement should be strongly emphasized. Currently, only one of the candidate SNF transport packages (the 125-B) features a double containment design. Even this package, with its highly specialized inner containment vessel configuration, is not expected to be generally useful for payload types other than that for which it was specifically designed. Accordingly, it is anticipated that, if double containment is necessary, *all* of the candidate packages will have to be requalified for custom-designed, separate inner containment vessels. The implications of this requirement are quite profound. From a licensing aspect, qualifying an existing package with a newly designed level of containment could be tantamount to licensing an entirely new packaging design.

2.2.7 Special Concerns

- Chemical compatibility (payload reactions with package cavity materials, seal materials, etc.)
- Chemical stability (pyrophoric form, etc.)
- Radiolytic gas generation [effect on package maximum normal operating pressure (MNOP), etc.]
- Water content (dry transport is mandatory in currently NRC or DOE-licensed packages).

2.2.8 Location

The fuel storage facility must be accessible by the transport package under consideration, unless multiple transfers are undertaken. This factor is discussed in greater detail in Section 5.3.

2.3 Discussion of Unknowns and Uncertainties Related to Fuels

Note that some fuel types may involve multiple variations of the above parameters. For instance, a single fuel type may exhibit various degrees of integrity, from very robust to very fragile, as well as demonstrate a wide range of radiological and thermal activity. In addition, the fuel may be stored at several facilities.

If the worst-case fuel condition is used for purposes of selecting a transport package for a particular fuel type, it is possible that a highly inefficient transportation campaign would result. That is, the worst-case fuel of the selected fuel type may compose only a small portion of the total inventory of that particular fuel type. The bulk of the fuel type might possibly be transported more efficiently (more fuel per trip) in a different type of package, or several types of packages.

Consequently, it is conceivable that, in some instances, more than one type of package may be required to efficiently transport a single type of fuel.

Additionally, priority may be an important concern in the process of determining the suitability of transport packages. Some fuels are badly deteriorated or stored in poorly controlled conditions (Reference 4). These fuels would likely require the most immediate attention in assessing their transportability.

Finally, while detailed checks were not undertaken to confirm the fuels data in the listed references, a number of inconsistencies between data sets were discovered in the course of the study. In those cases, the worst-case quantity or other physical characteristic was used to estimate total transportation requirements.

3. IDENTIFICATION OF CANDIDATE PACKAGINGS CURRENTLY IN EXISTENCE

This section identifies all current NRC or DOE-licensed irradiated fuel transport packages and the characteristics pertinent to the selection of suitable spent fuel types to ship in them. The discussion of transport packages is mainly generic, in that specific recommendations for package/fuel transport combinations are not developed, but the package-related factors involved in making such determinations are set out in detail. Packaging information was derived from References 6, 7, 8, 9, and Footnote d. Section 4 discusses specific package/fuel matchups.

For this transportation assessment, it is assumed that no "out-of-commerce" shipments will be allowed. That is, all shipments will be in accordance with current federal regulations [for NRC or U.S. Department of Transportation (DOT) rules] or DOE Order 5480.3 (Reference 10, for DOE rules) governing transportation of radioactive material in the public domain. The applicable DOT rules are set out in 49 CFR 173 (Reference 11), Sections 416, "Authorized Type B Packages," and 417, "Authorized Packaging—Fissile Materials." These regulations cover shipments of radioactive materials, but (except in the case of overseas shipments) they generally either defer to the control of the NRC regulations (10 CFR 71, Reference 5) or involve packages that either are too small, are obsolete and no longer available, or are designed for very limited, specific payload types (e.g., UF₆ containers).

3.1 Packaging List

All current NRC or DOE-licensed irradiated fuel packages are listed in Table 3-1, along with the design characteristics that could limit and otherwise determine which types of spent fuels can potentially be transported in them. The information shown in Table 3-1 was derived from a variety of sources, listed as References 6 through 9.

Design details, including top-level engineering drawings and current Certificates of Compliance, can be found in Appendix B of this report.

3.2 Discussion of Packaging-Imposed Payload Restrictions

Because of the stringency of the governing regulations for the transportation of radioactive materials, as set out in 10 CFR 71, specific limits are delineated for all significant design and operational factors for each licensed package. These limits are summarized in the specific Certificates of Compliance, and are listed and discussed in detail below.

In many cases, there may be little compatibility between certified package parameters and the corresponding SNF parameters set out in Section 2.2. Since use of the packagings outside of their specific operating parameters is not legally permitted, it is anticipated that, at a minimum, amendments or revisions to the relevant SARPs and Certificates of Compliance will be required for most of the DOE's SNF.

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d. Private communications between Packaging Technology and owners and users of the listed packagings.

Table 3-1. Transport package information.^a

Package name	Certificate of compliance	Certificate expiration	Gross weight (pounds)	External dimensions (inches) ^b	Transport mode	Payload weight (pounds)	Internal dimensions (inches) ^b	Shielding config. ^c	Content(s) ^d	Maximum heat load	Maximum impact load (g's) / orientation ^e	Owner ^f	Availability	Number
GE T-2	USA/5607/ B( )F (DOE)	5/31/98	18,400	36.0 ϕ x 133 long	Legal weight truck	160	6.06 ϕ x 99.69 long	Double stl wall w/ 4.2" 8" Pb (s)	3 w/o ²³⁵ U fuel pins 57 Kci 18 Mwd/kg	290 w (+other)	N/A	DOE-EH	N/A	2
GE-100	USA/5926/ B( )F	2/28/98	4,800	20.25 ϕ x 26.88 long	Legal weight truck	N/A	7.625 ϕ x 10.00 long	Double stl wall w/ 5.88" Pb (s)	500 g ²³⁵ U (TI=5.6)	400 w	N/A	General Electric	Approx. 50%	3
BMI-1	USA/5957/ B( )F	5/31/95	23,660	33.37 ϕ x 73.37 high	Legal weight truck	1,800	15.50 ϕ x 54.00 high	Double stl wall (0.75" total) w/ 8.0" Pb (s) 7.75" Pb (t)	93.5 w/o / 510 g ²³⁵ U 25.6 w/o ²³⁵ U for Fermi	N/A	375/end 500/side 128/corner	DOE-EH	Limited availability	1
FSV-1	USA/6346/ B( )F	4/30/96	47,600	31.0 ϕ x 208.0 long	Legal weight truck	4,430	17.7 ϕ x 187.6 long	Double stl wall w/ 6.4" DU (max) (s) 3.75" stl + 2.25" DU (t)	93.5 w/o max ²³⁵ U (+other)	4.1 Kw	SARP?	Public Service of Colorado	Readily avail.	2
NLI-1/2	USA/9010/ B( )F	3/31/96	49,250	75.0 ϕ x 178.0 long	Legal weight truck	3,000	12.63 ϕ x 237.00 long	2.75" DU 5.0" H ₂ O/ glycol 2.13" Pb (s) 5.0" H ₂ O (t?)	3.7 w/o max ²³⁵ U + Pu/ 40000Mwd for PWR 2.65 w/o / 34000 Mwd for BWR	750 w	39.4/end 38.6/side 37.5/corner	Nuclear Assurance Corp.	Possibly full time	5
NLI-6502	USA/9103/ B( )F	10/31/93	45,300	33.5 ϕ x 130.0 long	Legal weight truck	N/A	11.5 ϕ x 120.0 long	Triple stl wall (2" total) w/ 3" Pb & 5.72" (max) DU + Pb (s) ?" stl w/ 6.63" Pb (t&b)	550 g max ²³⁵ U 45% burnup	4.1 Kw	N/A	Nuclear Assurance Corp.	N/A	N/A
T-3	USA/9132/ B(M)F	3/31/96	38,200	52.00 ϕ x 213.20 long	Legal weight truck	700	7.98 ϕ x 147.0 long	Double stl wall (1.3" total) w/ 8.0" Pb (s) 11.83" stl (b) 11.625" stl (t)	31 w/o PuO ₂ 69 w/o U ₂	1.4 Kw	87.8/end 94.5/side 50.2/corner	DOE -EH	Immed. (1 custom trailer only)	3
NAC-1	USA/9183/ B( )F	9/30/94	49,000	50.0 ϕ x 214.0 long	Legal weight truck	3,700	13.5 ϕ x 178.0 long	Double stl wall (1.56" total) w/ 5" (min) Pb (s) 2" stl (b) 7.5" stl (t)	1600 Mwd/MTU metallic U	750 w	76.6/end 96/side 45.5/corner	Nuclear Assurance Corp.	Possibly full time	6

Table 3-1. (continued).

Package name	Certificate of compliance	Certificate expiration	Gross weight (pounds)	External dimensions (inches) ^b	Transport mode	Payload weight (pounds)	Internal dimensions (inches) ^b	Shielding config. ^c	Content(s) ^d	Maximum heat load	Maximum impact load (g's) / orientation ^e	Owner ^f	Availability	Number
CNS 1-13G	USA/9216/ B( )F	12/31/97	25,500	68.00 ϕ x 81.80 high 38.5 ϕ x 67.19 high (w/o I/L)	Legal weight truck	"Not restricted"	26.5 ϕ x 54.00 high	Dbl stl wall (1.0" total) w/ 5.0" Pb (s)	PuO ₂ and UO ₂ in Zr or SST	600 w (+other)	SARP?	Chem-Nuclear Systems	Available after Barnwell closes	1
NRBK-41	USA/9221/ B( )F	1/31/96	9,000	27.16 ϕ x 40.00 long (high?)	Legal weight truck	N/A	5.00 ϕ x 16.00 long (high?)	Double stl shell (0.5" total) w/ 10.00" Pb (s)	350 g equiv. ²³⁵ U	264 w (exclusive use)	N/A	DOE-NR	N/A	N/A
NAC-LWT	USA/9225/ B(U)F	12/31/94	51,200	65.0 ϕ x 232.0 long 44.0 ϕ x 200.0 long (w/o I/L)	Legal weight truck	4,000	13.4 ϕ x 178.0 long	1.95" stl + 5.75" Pb + 5" H ₂ O/glycol(s) 3.5" stl + 3" Pb (b) 11.3" stl (t)	1 PWR or 2 BWR or 15 rods 3.7 w/o / 4.0 w/o 35000/ 30000 Mwd/MTU	2.5 kW (+other)	SARP?	Nuclear Assurance Corp.	Possibly full time	4
GE Model 2000	USA/9228/ B(U)F	10/31/94	33,550	72.0 ϕ x 131.5 high 38.5 ϕ x 71.0 high (w/o I/L)	Legal weight truck	5,450	26.5 ϕ x 54.0 high	Double stl wall (2" total) w/ 4" Pb (s) 6" stl (b) ?" stl + ?" Pb (t)	1.75 kg ⁵ w/o or 500 g ²³⁵ U equiv. mass 45000 Mwd/MTU	600 w	SARP?	General Electric	Approx. 50%	2 (plus 1 currently in fab)
TN-FSV	USA/9253/ B(U)F	5/31/99	47,000	78.0 ϕ x 247.0 long 31.0 ϕ x ? long (w/o I/L)	Legal weight truck	5,000	18.0 ϕ x 199.0 long	Double stl wall (2.62" total) w/ 3.44" Pb (s) 5.5" stl (b) 2.5" stl w/ ?" DU (t)	6 irradiated HTGR fuel elements (8.4 kg total ²³⁵ U - 93.5 w/o + 66 kg Th)	360 w (total)	SARP?	Public Service Co. of Colorado	Depends on availability of storage for FSV fuel at INEL	2
TN-8 TN-8L	USA/9015/ B( )	5/31/96	79,380	67.64 ϕ x 217.2 long	Over-weight truck	4,850	3 x 9.06 $\square$ x 168.5 long	1.023" stl + 5.315" Pb + 5.905" resin	4 w/o ²³⁵ U, 38500 Mwd/MTU	35.5 Kw (+other)	155/end 155/side 80/corner	Transnuclear	1 immed. 1 soon (after Barnwell campaign)	2
TN-9	USA/9016/ B( )F	5/31/96	79,380	67.64 ϕ x 226.61 high	Over-weight truck	4,652.6	7 x 5.91 $\square$ x 177.95 long	1.023" stl + 5.039" Pb + 5.905" resin (s)	2.65 w/o ²³⁵ U, 36500 Mwd/MTU	24.4 Kw total 3.54 Kw/ass'y	155/end 155/side 80/corner	Transnuclear	Immed. (trailers need refurbish)	2

Table 3-1. (continued).

Package name	Certificate of compliance	Certificate expiration	Gross weight (pounds)	External dimensions (inches) ^b	Transport mode	Payload weight (pounds)	Internal dimensions (inches) ^b	Shielding config. ^c	Content(s) ^d	Maximum heat load	Maximum impact load (g's) / orientation ^e	Owner ^f	Availability	Number
M-130	USA/6003/B( )F	12/31/97	228,000	84.00 ϕ x 158.0 high	Rail	N/A	55.0 od x 29.0 id x 130.0 high	Double stl wall (2" total) w/ 10.0" Pb (s)	fuel elements	9815.5 w	N/A	DOE-NR	Not available	27
IF-300	USA/9001/B( )F	5/31/95	185,000 w/ skid 140,000 cask only	64.0 ϕ x 210.0 long	Rail	21,000	37.5 ϕ x 180.25 long	Double stl wall (2.13" total) w/ 4" DU + 4.5" H ₂ O (s) ?" stl + 3" DU (t&b)	4 w/o ²³⁵ U, 35000 Mwd/MTU	11.72 Kw	234/end 109/side 69/corner	CP&L -- Vectra Technologies	2 not available -- 2 readily available	2 CP&L -- 2 Vectra
NLI-10/24	USA/9023/B( )F	3/31/97	194,000	96.00 ϕ x 204.5 long	Rail	34,100	45.00 ϕ x 179.50 long	Triple stl wall (3.5" stl) w/ 6.0" Pb + 9.0" H ₂ O (s) ?" DU + ?" stl + polymer (t&b)	3.5 w/o ²³⁵ U, 35500 Mwd/MTU for PWR 2.8 w/o ²³⁵ U, 29700 Mwd/MTU for BWR	70 Kw	29.4/end 80.8/side 31/corner	Nuclear Assurance Corp.	Possibly full time	2
125-B	USA/9200/B(M)F	5/31/96	181,500	120.0 ϕ x 279.5 long 65.5 ϕ x 207.5 long (w/o I/L)	Rail	57,580 w/ Outer vessel only 20,580 w/ Inner vessel also (for double containment)	51.25 ϕ x 192.5 long (outer vessel) 7 x 14.5 ϕ x 183.25 long (inner vessel, for double containment)	Double stl wall (3" total) w/ 3.88" Pb (s) (Outer Vessel) + 1" stl (s) (Inner Vessel) 7.5" stl (t) 7.5" stl (b) (Outer Vessel) + 5" stl (t) 4" stl (b) (Inner Vessel)	2.98 w/o ²³⁵ U, 3165 Mwd/MTU, 6 year cooling	100 w per canister (700 w total)	51.6/end 67.8/side 34.7/corner	DOE-ID -- Vectra Technologies	Immediate	2 DOE -- 1 Vectra
TN-BRP	USA/9202/B(U)F	6/30/94	215,000	131.0 ϕ x 244.5 long 83.25 ϕ x 196.5 long (w/o I/L)	Rail	41,250	64.0 ϕ x 171.0 long	9.62" stl (s) 9.75" stl (b&t)	44 BWR ass'ys 5.6 w/o ²³⁵ U, 25000 Mwd/MTU, 14 year cooling	3.1 Kw total 103 w/ass'y	SARP?	DOE-ID	None if W. Valley campaign begins (low probability) also limited on time of year & payload	1

Table 3-1. (continued).

Package name	Certificate of compliance	Certificate expiration	Gross weight (pounds)	External dimensions (inches) ^b	Transport mode	Payload weight (pounds)	Internal dimensions (inches) ^b	Shielding config. ^c	Content(s) ^d	Maximum heat load	Maximum impact load (g's) / orientation ^e	Owner ^f	Availability	Number
TN-REG	USA/9206/B(U)F	5/31/95	225,000	131.0 ϕ x 234.0 long	Rail	50,500	71.75 ϕ x 163.25 long	9.25" stl (s) 8.5" stl (t)	20 PWR ass'ys 3.5 w/o ²³⁵ U, 15000 Mwd/MTU	2.7 Kw (+other)	SARP?	DOE-ID	Same as TN-BRP above	1
M-160	USA/9781/B(U)F	7/31/97	237,000	79.00 ϕ x 199.0 high	Rail	N/A	55.0 od x 21.0 id x 160.0 high	Double (?) stl wall (2.5" total) w/ 9.44" Pb (s) 15" stl (t) 7" stl (b)	Fuel elements	6240.9 w	N/A	DOE-NR	Not available	1
M-140	USA/9793/B(U)F	10/31/96	375,000	126.0 ϕ x 194.0 high	Rail	N/A	70.0 ϕ x 146.0 high	14" stl (s) 12" stl (b) 13" stl (t)	Fuel elements	18.25 Kw (+other)	N/A	DOE-NR	Not available	24 currently

a. Information for this table was taken from the references listed in Section 3.1; N/A indicates information is not available from referenced sources; (+other) indicates additional parameters specified in referenced sources; ? indicates information could not be obtained from the references in Section 7.

b. ϕ = diameter for circular geometry, $\square$ = length of side for square geometry, I/L = Impact Limiters (given when information is available), "long" implies horizontal transport, "high" implies vertical transport.

c. stl = steel, Pb = lead, DU = depleted uranium, H₂O = water, (s) = sides, (t) = top, (b) = bottom.

d. TI = Transportation Index.

e. SARP? indicates missing information may be available from the safety analysis report for packaging (SARP).

f. EH = Transportation and Packaging Safety Division, ID = Idaho Operations Office, NR = Naval Reactors Division.

3.2.1 Payload Cavity Size

The packaging payload cavity size will be a primary factor in determining what fuel types and how many of each may be transported. Size considerations relating to fuel-specific internal structures (baskets or canisters) must be accounted for, in addition to the spent fuel itself.

3.2.2 Overall Size

Facility interface considerations will govern maximum package size that can be accommodated without facility modifications. This factor is discussed in greater detail in Section 5.3.

3.2.3 Payload Weight Limits

Payload weight cannot exceed specified package limits. Weight capacity can potentially be increased by detailed analysis and Certificate of Compliance revision, as discussed in Section 5.3.

3.2.4 Gross Weight

Facility interface considerations (e.g., crane capacity, may limit package access for particular fuel types). Refer to Section 5.3 for details.

3.2.5 Thermal Limits

Maximum permissible payload thermal loading is usually specified as an operational limit on a transport package. The implications of these limits are discussed in Sections 3.2.6 through 3.2.9.

3.2.6 Shielding Capabilities

Radiological activity will be governed by regulatory dose rate limits of 10 CFR §71.47, "Normal Conditions of Transport," and 10 CFR §71.51(a)(2), "Hypothetical Accident Conditions." In addition, thermal limits must be maintained to preclude biological shielding deterioration (e.g., lead melt, neutron shielding degeneration).

3.2.7 Containment Capabilities

Fuels with breached cladding and plutonium content in excess of 20 Ci per shipment will probably have to be transported in double-containment, leak-tight packages, in accordance with 10 CFR §71.63 (note that intact fuel meets the double containment exemption). As discussed in Section 2.2.6, the implications of these restrictions are very serious. Qualifying an existing package for a new inner containment vessel could be an undertaking similar in magnitude to qualifying an entirely new package. Furthermore, the leaktight restriction could introduce even more complications. Most of the candidate transport packages do not currently feature qualified leaktight closure configurations on even the single level of containment they incorporate. Accordingly, these packages would either have to be requalified for maximum leakage rates well below currently licensed levels, or would have to be retrofitted with leaktight closure designs. Of special importance is the requirement to demonstrate that the leaktight closure remains leaktight

after the hypothetical accident condition impact and fire tests. In addition, excessive thermal loading, particularly that which may develop from the accident fire test, may adversely affect intact fuel cladding, seal material integrity, or package maximum normal operating pressure, all potentially leading to additional containment concerns.

3.2.8 Maximum Impact Loading

Impact loading at various orientations arising from the hypothetical accident condition 30-ft free drop requirement will drive requirements for payload protection (i.e., baskets or other structural support). Typically, a nonyielding support structure is desired. Thermal loading must not result in excessive loss of strength of these structures. In addition, elevated temperatures of impact limiting materials may affect their mechanical properties and, hence, associated impact loadings. Structurally fragile SNF assemblies will require special consideration, and criticality evaluations hinge directly on post-impact payload configurations.

Variations in package weight also directly affect impact acceleration magnitudes; reduced weight typically increases g-loading, increased weight typically reduces g-loads. Shielding deformation in the hypothetical accident condition 30-ft free drop may be increased under greater impact loading, leading to compromise of package shielding capabilities. Finally, the load path from the packaging to the payload may be an important factor. For instance, the inner containment vessel of the 125-B package spans the inner surface of the outer vessel, resulting in reaction loads being applied at either end of both vessels. Any new basket developed for this package would have to either span the loads to the ends of the basket or employ a suitably reduced payload weight.

3.2.9 Materials of Construction

Package materials, particularly payload cavity and seal materials, must be chemically compatible with proposed payloads, as well as with associated thermal loadings.

3.2.10 Transportation Index

10 CFR §71.59, "Standards for Arrays of Fissile Material Packages," governs the shipping configuration for irradiated fuel transport packages. Such packages are normally shipped via an exclusive use vehicle, though multiple package shipments might be feasible with certain payload restrictions (reduced fissile content or other form of inherent criticality control) that would reduce the transportation index to the required level.

Fissile-rated packages (i.e., packages rated for transportation of fissile contents greater than 15 g total) must undergo strenuous criticality evaluations to ensure that nuclear criticality safety is maintained during transportation. These criticality analyses require detailed information concerning the payload characteristics. In many instances, adequate SNF characteristics are not currently available to make such determinations. Additionally, maintenance of criticality safe payload configurations following the hypothetical accident condition tests will almost surely require positive geometrical configuration control (i.e., internal support structures). Design and qualification of such structures for the often unusual, nonstandard SNF geometries is expected to

be a significant undertaking. The level of effort involved in qualifying an existing package for a new basket structure and payload type could be on par with that required to qualify an entirely new package.

3.2.11 Operational Requirements

Special tools, specially trained personnel, remote handling equipment, etc., may be required at the facility or facilities where the fuel is stored. Refer to Section 5.2 for details.

3.2.12 Transport Mode

Facilities containing proposed fuel types must be accessible by the particular transport package. A rail-mounted package will be of little use at a facility with road access only. Additionally, augmentation of a package's payload weight capacity, according to Section 3.2.3, may affect the transport limitations of the package (e.g., 80,000-lb maximum gross weight for legal weight truck transport). Refer to Section 5.3 for details.

3.3 Discussion of Unknowns and Uncertainties Related to Packagings

There are a number of uncertainties relating to packaging capabilities for any given fuel type. Fuel parameters set out in Section 2.2 are all interrelated insofar as all factors for a given fuel type must be fully bounded by the documented and certified capabilities of any package under consideration for purposes of transporting the fuel type. The final determination and categorization of such a wide range of parameters for the large number of fuel types in the DOE inventory with the degree of accuracy required to satisfy regulatory requirements will be a daunting task.

Economics will be a significant factor in grouping fuel types for transportation. At one extreme, an attempt could be made to reduce the overall number of package modifications required by qualifying a relatively small number of packages. This would result in the necessity of qualifying each candidate package for a relatively large group of fuel types. Such an effort would, in general, tend to result in limitations on capacity for each of the fuel types in any transport group. The final outcome could be an unacceptably large number of shipments required for each fuel type and, hence, a level of transportation inefficiency that would offset the initial developmental savings. Conversely, small groups of fuel types will lead to a need for a greater number of individual package amendments or revisions. This opposite extreme could also potentially impose unnecessarily severe cost and schedule hardships.

Additionally, while some currently licensed packages in their present form may not be suitable for shipment of any significant quantities of DOE-owned SNF, it is possible that modifications could be made to increase their payload capacity. However, a new level of uncertainty is thereby introduced. Categorizing SNF based on the postulated performance of a modified package would be an even greater undertaking than attempts to do so for well-defined,

known package capabilities. This is particularly true since several levels of performance enhancement, each increasingly more demanding (and expensive), are potentially possible. Refer to Sections 4.2 through 4.5 for details of possible modifications of existing packages for purposes of upgrading their payload capabilities.

4. DISCUSSION OF COMPATIBILITY BETWEEN FUELS AND PACKAGINGS

The regulations governing the transportation of radioactive material are very restrictive. The packaging Certificates of Compliance are normally quite explicit as to the definition of the material that is qualified for transportation in a particular package. Because of these factors, it is likely that, apart from the fuel types referred to in Section 4.1 below, transport of DOE-owned SNF will not be able to proceed without at least some additional effort. This effort could include adjustments to existing packages (either design or SARP related), or development of entirely new packages. These adjustments or replacements are categorized in Sections 4.2 through 4.6 below by the level of effort, as well as risk and cost, expected to be required. Fuels/packaging compatibilities were developed with the aid of Footnote d and Reference 12.

DOE-owned spent nuclear fuel will have to be comprehensively characterized by the parameters set out in Section 2 before transportation can take place. Once this is accomplished, candidate packages whose design characteristics (as detailed in Section 3) indicate a potential matchup can be further investigated. Depending on the desired carrying capability, packaging adjustments will be made, as detailed below. If transportation economics indicate that a large quantity or variety of fuels is to be transported in a single package, extensive package modifications or package development will probably have to be considered. More modest transportation goals will likely require less extensive packaging changes.

Using some the most important considerations set out in Sections 2 and 3, a fuels/packages compatibility matrix has been developed, and is included as Tables 4-1 through 4-6. The listed matchups have been based on size, thermal and shielding compatibility between each package, and the various types of SNF. For many of the SNF types, insufficient data exist to make a realistic determination of transportation requirements. These fuel types include all those listed in Tables 2-7 and 2-8, as well as some of the fuels listed in the other tables of Section 2. For the remainder of the fuels, the estimated fuel/package matchups generally fall into two categories:

1. Those fuels whose characteristics are sufficiently well defined so as to provide reasonable confidence in the selection of transportation packages for their conveyance. This category includes fuels for which transportation packages have been specifically designed (e.g., the Fort St. Vrain fuel, which both the FSV-1 and TN-FSV packages are licensed to transport).
2. Those fuels whose characteristics definitions were insufficient as listed in the reference documents, but which could be reasonably deduced by comparison to similar fuels with known transportation capabilities.

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d. "Department of Energy-Owned Spent Nuclear Fuel/Certified Transportation Cask Compatibility Matrix; Forwarding of Preliminary Results," attached to a letter from R. A. Roesener (EG&G Idaho) to D. G. Abbott, RAR-07-94, April 29, 1994.

Table 4-1. Packaging compatibility with pressurized water reactor type SNF.

PWR fuels	Legal weight truck packages													Overweight truck packages		Rail packages									
	GE T-2	GE- 100	BMI-1	FSV-1	NLI- 1/2	NLI- 6502	T-3	NAC-1	CNS 1-13G	NRBK-41	NAC- LWT	GE Model 2000	TN-FSV	TN-8 TN-8L	TN-9	M-130	IF- 300	NLI- 10/24	125-B	TN- BRP	TN- REG	M-160	M-140		
Ship'port (Hanford)	No a	No a	No a	N/A b	N/A b	No a	No a	N/A b	No a	No a	N/A b	No a	N/A b	N/A b	No a	No a	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b		
Point Beach	No a	No a	No a	Yes C	Yes? C	No a	No a	Yes? C	No a	No a	Yes C	No a	No c	Yes? B	No a	No a	Yes B	Yes B	Yes? C	Yes? C	Yes? B	N/A b	No a		
Calvert Cliffs	N/A a	No a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	No a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a		
H. B. Robinson (Hanford)	No a	No a	No a	N/A b/c	N/A b/c	No a	No a	N/A b/c	No a	No a	N/A b/c	No a	N/A b/c	N/A b/c	No a	No a	N/A b/c	N/A b/c	N/A b/c	N/A b/c	N/A b/c	N/A b/c	No a		
H. B. Robinson (INEL)	No a	No a	No a	N/A b/c	N/A b/c	No a	No a	N/A b/c	No a	No a	N/A b/c	No a	N/A b/c	N/A b/c	No a	No a	N/A b/c	N/A b/c	N/A b/c	N/A b/c	N/A b/c	N/A b/c	No a		
H. B. Robinson (SRS)	No a	No a	No a	N/A b/c	N/A b/c	No a	No a	N/A b/c	No a	No a	N/A b/c	No a	N/A b/c	N/A b/c	No a	No a	N/A b/c	N/A b/c	N/A b/c	N/A b/c	N/A b/c	N/A b/c	No a		
Ship'port S4 (INEL)	No a	No a	No a	Yes C	Yes C	Yes C	No a	Yes? c	No a	No a	Yes C	No a	Yes C	Yes? C	No a	N/A b	Yes ? C	Yes? C	Yes? C	Yes? C	Yes? C	N/A b	N/A b		
Ship'port S1 (INEL)	No a	No a	No a	Yes C	Yes C	Yes C	No a	Yes? c	No a	No a	Yes C	No a	Yes C	Yes? C	No a	N/A b	Yes ? C	Yes? C	Yes? C	Yes? C	Yes? C	N/A b	N/A b		
Ship'port S2 (INEL)	No a	No a	No a	Yes C	Yes C	Yes C	No a	Yes? c	No a	No a	Yes C	No a	Yes C	Yes? C	No a	N/A b	Yes ? C	Yes? C	Yes? C	Yes? C	Yes? C	N/A b	N/A b		
Ship'port (SRS)	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes? C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	N/A b	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C		
Conn Yankee	No a	No a	No a	Yes C	Yes A	No a	No a	Yes? c	No a	No a	Yes A	No a	Yes C	Yes C	No a	No a	Yes C	Yes C	Yes C	Yes C	Yes C	N/A b	No a		

Table 4-1. (continued).

PWR fuels	Legal weight truck packages													Overweight truck packages		Rail packages									
	GE T-2	GE- 100	BMI-1	FSV-1	NLI- 1/2	NLI- 6502	T-3	NAC-1	CNS 1-13G	NRBK-41	NAC- LWT	GE Model 2000	TN-FSV	TN-8 TN-8L	TN-9	M-130	IF- 300	NLI- 10/24	125-B	TN- BRP	TN- REG	M-160	M-140		
LOFT	Yes C	No a	No a	Yes C	Yes C	Yes C	No a	Yes C	No a	No a	Yes C	No a	Yes C	Yes C	No a	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	N/A b	N/A b		
Surrey	No a	No a	No a	Yes C	Yes B	No a	No a	Yes C	No a	No a	Yes A	No a	Yes C	Yes A	No a	No a	Yes A	Yes A	Yes? C	Yes C	Yes C	N/A b	No a		
Turkey Point B17	No a	No a	No a	Yes C	Yes A	No a	No a	Yes C	No a	No a	Yes A	No a	Yes C	Yes A	No a	No a	Yes A	Yes A	Yes? C	Yes C	Yes C	N/A b	No a		
Turkey Point EMAD	No a	No a	No a	Yes C	Yes A	No a	No a	Yes C	No a	No a	Yes A	No a	Yes C	Yes A	No a	No a	Yes A	Yes A	Yes? C	Yes C	Yes C	N/A b	No a		
BMI	N/A b/c	No a	Yes A	N/A b/c	N/A b/c	N/A b/c	N/A b/c	N/A b/c	N/A b/c	No a	N/A b/c	N/A b/c	N/A b/c	N/A b/c	No a	N/A b/c	N/A b/c	N/A b/c	N/A b/c	N/A b/c	N/A b/c	N/A b/c	N/A b/c		
R. E. Gina	No a	No a	N/A c	Yes C	Yes A	N/A b/c	Yes C	Yes C	Yes C	No a	Yes C	Yes C	Yes C	Yes C	No a	N/A b	Yes A	Yes A	Yes C	Yes C	Yes A	N/A b/c	N/A b/c		
TMI-2	No a	No a	No a	No a	No a	No a	No a	No a	No a	No a	No a	No a	No a	No a	No a	N/A b	Yes B	Yes B	Yes A	Yes C	Yes B	N/A b	No a		
Arkansas ANO-1	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a		
Oconee	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a		

Table 4-2. Packaging compatibility with boiling water reactor type SNF.

BWR Fuels	Legal weight truck packages												Overweight truck packages		Rail packages									
	GE T-2	GE-100	BMI-1	FSV-1	NLI-1/2	NLI-6502	T-3	NAC-1	CNS 1-13G	NRBK-41	NAC-LWT	GE Model 2000	TN-FSV	TN-8 TN-8L	TN-9	M-130	IF-300	NLI-10/24	125-B	TN-BRP	TN-REG	M-160	M-140	
EBWR	Yes C	No a	No a	Yes C	Yes C	Yes? C	Yes C	Yes B	No a	No a	Yes C	Yes C	Yes C	Yes C	Yes C	N/A b	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	N/A b	N/A b
Dresden (Ass'ys)	No	No a	No a	N/A b	N/A b	No a	No a	N/A b	No a	No a	N/A b	No a	N/A b	No a	N/A b	No a	N/A b	N/A b	N/A b	N/A b	No a	No a	No a	No a
Peach Bottom 1 (elements)	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a
Peach Bottom 2 (partial ass'ys)	No a	No a	No a	Yes C	Yes A	No a	No a	Yes C	No a	No a	Yes B	No a	Yes C	No a	Yes B	No a	Yes B	Yes B	Yes C	No a	No a	No a	No a	
Peach Bottom (rods in canisters)	No a	No a	No a	No a	No a	No a	No a	No a	No a	No a	No a	No a	No a	No a	No a	No a	No a	No a	No a	No a	No a	No a	No a	
Pathfinder	N/A b	No a	No a	Yes C	Yes C	Yes C	Yes C	Yes C	No a	No a	Yes C	No a	Yes C	Yes C	Yes C	N/A b	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	N/A b	N/A b
SPSS-SPERT	Yes C	No a	Yes A	Yes B	Yes C	Yes C	Yes C	Yes C	Yes C	No a	Yes C	Yes C	Yes B	Yes C	Yes C	N/A b	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	N/A b	N/A b
BORAX V	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b
Cooper	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b
Vallecitos (SRS)	No a	No a	Yes B	Yes C	Yes C	Yes C	Yes C	Yes C	N/A b	No a	Yes C	Yes C	Yes C	Yes C	No a	N/A b	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	N/A b	N/A b
Vallecitos (INEL)	No a	No a	Yes B	Yes C	Yes C	Yes C	Yes C	Yes C	N/A b	No a	Yes C	Yes C	Yes C	Yes C	No a	N/A b	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	N/A b	N/A b

Table 4-3. Packaging compatibility with breeder reactor type SNF.

Breeder reactor fuels ^a	Legal weight truck packages												Overweight truck packages		Rail packages								
	GE T-2	GE- 100	BMI-1	FSV-1	NLI- 1/2	NLI- 6502	T-3	NAC-1	CNS 1-13G	NRBK-41	NAC- LWT	GE Model 2000	TN- FSV	TN-8 TN-8L	TN-9	M-130	IF- 300	NLI- 10/24	125-B	TN- BRP	TN- REG	M-160	M-140
FFTF-LM (DA)	No a	No a	No a	Yes C	No b	No a	Yes B	No b	No a	No a	No b	No a	No b	No b	No b	No a	Yes C	No b	No b	No b	No b	N/A b	N/A b
FFTF-LM (TFA)	No a	No a	No a	Yes C	No b	No a	Yes A	No b	No a	No a	No b	No a	No b	No b	No b	No a	Yes C	No b	No b	No b	No b	N/A b	N/A b
Ship'port- LW (INEL)	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a
Ship'port- LW (ANL-E)	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a
Fermi Core 1 & 2 - LM	Yes C	No a	Yes A	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	No a	Yes C	Yes C	Yes C	Yes C	Yes C	N/A b	Yes C	Yes C	Yes C	Yes C	Yes C	N/A b	N/A b
Fermi 1 Blanket-LM	Yes B	No a	Yes B	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	No a	Yes C	Yes C	Yes C	Yes C	Yes C	N/A b	Yes C	Yes C	Yes C	Yes C	Yes C	N/A b	N/A b
EBR II-LM (Hanford - casks)	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a
EBR II-LM (INEL canister)	No c	No a	Yes B	Yes B	Yes C	Yes C	Yes C	Yes C	Yes C	No a	Yes C	Yes C	Yes C	Yes C	Yes C	N/A b	Yes C	Yes C	Yes C	Yes C	Yes C	N/A b	N/A b
EBR II-LM (INEL pin)	Yes C	No a	Yes B	Yes B	Yes C	Yes C	Yes C	Yes C	Yes C	No a	Yes C	Yes C	Yes B	Yes C	Yes C	N/A b	Yes C	Yes C	Yes C	Yes C	Yes C	N/A b	N/A b
EBR-II (ANL-6)	Yes C	No a	Yes B	Yes B	Yes C	Yes C	Yes C	Yes B	Yes C	No a	Yes C	Yes C	Yes B	Yes C	Yes C	N/A b	Yes C	Yes C	Yes C	Yes C	Yes C	N/A b	N/A b
EBR (Hanford - pieces)	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	No a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/a a	N/A a	N/A a	N/A a	N/A a	N/A a	N/a a
EBR II-LM (ANL-W - EBR-II)	N/A a	No a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/a a	N/A a	N/A a	N/A a	N/A a	N/A a	N/a a

Table 4-3. (continued).

Breeder reactor fuels ^a	Legal weight truck packages												Overweight truck packages		Rail packages								
	GE T-2	GE- 100	BMI-1	FSV-1	NLI- 1/2	NLI- 6502	T-3	NAC-1	CNS 1-13G	NRBK-41	NAC- LWT	GE Model 2000	TN- FSV	TN-8 TN-8L	TN-9	M-130	IF- 300	NLI- 10/24	125-B	TN- BRP	TN- REG	M-160	M-140
EBR II-LM (ANL-W - HFEF)	No a	No a	No a	Yes B	Yes C	Yes C	No a	Yes C	No a	No a	Yes C	No a	No c	Yes C	Yes C	N/A b	Yes C	Yes C	No c	Yes C	Yes C	N/A b	N/A b
EBR II-LM (ANL-W - RSWF)	No a	No a	No a	No a	No a	No a	No a	No a	No a	No a	No a	No a	No a	No a	No a	No a	Yes C	Yes C	Yes C	Yes C	Yes C	N/A b	N/A b
EBR-II (SRS)	N/A b	No a	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	No a	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b
EBR-II (SRS)	N/A b	No a	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	No a	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b
EBR-II Targets	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/a a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/a a	N/A a	N/A a	N/A a	N/A a	N/A a	N/a a
Saxton (Mixed oxide)	N/A b	No a	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	No a	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b
Saxton (UO ₂)	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/a a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/a a
Dresden	N/A b/c	N/A b/c	N/A b/c	N/A b/c	N/A b/c	N/A b/c	N/A b/c	N/A b/c	N/A b/c	N/A b/c	N/A b/c	N/A b/c	N/A b/c	N/A b/c	N/A b/c	N/A b/c	N/A b/c	N/A b/c	N/A b/c	N/A b/c	N/A b/c	N/A b/c	N/A b/c
ERR	N/A b	No a	No a	N/A b	N/A b	N/A b	N/A b	N/A b	No a	No a	N/A b	No a	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b
ML-1	N/A a	No a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/a a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/a a	N/A a	N/A a	N/A a	N/A a	N/A a	N/a a

a. LM = Liquid Metal, LW = Light Water

Table 4-4. Packaging compatibility with gas-cooled reactor type SNF.

Gas-cooled reactor fuels	Legal weight truck packages												Overweight truck packages		Rail packages									
	GE T-2	GE- 100	BMI-1	FSV-1	NLI- 1/2	NLI- 6502	T-3	NAC-1	CNS 1-13G	NRBK-41	NAC- LWT	GE Model 2000	TN- FSV	TN-8 TN-8L	TN-9	M-130	IF-300	NLI- 10/24	125-B	TN- BRP	TN- REG	M-160	M-140	
Peach Bottom 1	No a	No a	No a	N/A b	N/A b	No a	N/A b	N/A b	No a	No a	N/A b	No a	N/A b	N/A b	N/A b	No a	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	
Peach Bottom 2	No a	No a	No a	N/A b	N/A b	No a	N/A b	N/A b	No a	No a	N/A b	No a	N/A b	N/A b	N/A b	No a	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	
FSVR-HT	No a	No a	No a	Yes A	Yes A	No a	No a	No a	N/A b	No a	No a	N/A b	Yes A	No a	No a	No a	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	
FSVR	No a	No a	No a	Yes A	Yes A	No a	No a	No a	N/A b	No a	No a	N/A b	Yes A	No a	No a	No a	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	
TORY-IIC	Yes C	No a	No a	Yes C	Yes C	Yes C	Yes C	Yes C	No a	No a	Yes C	No a	Yes C	Yes C	Yes C	N/A b	Yes C	Yes C	Yes C	Yes C	Yes C	N/A b	N/A b	
TORY-IIA	Yes C	No a	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	No a	Yes C	Yes C	Yes C	Yes C	Yes C	N/A b	Yes C	Yes C	Yes C	Yes C	Yes C	N/A b	N/A b	
GCRE (INEL)	N/A b	No a	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	No a	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	
GCRE (SRS)	N/A b	No a	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	No a	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	

Table 4-5. Packaging compatibility with metallic type SNF.

Metallic fuels	Legal weight truck packages												Overweight truck packages		Rail packages								
	GE T-2	GE- 100	BMI-1	FSV-1	NLI- 1/2	NLI- 6502	T-3	NAC-1	CNS 1-13G	NRBK-41	NAC- LWT	GE Model 2000	TN- FSV	TN-8 TN-8L	TN-9	M-130	IF- 300	NLI- 10/24	125-B	TN- BRP	TN- REG	M-160	M-140
TRIGA AL (INEL)	Yes C	No a	Yes A	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	No a	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C
TRIGA FLIP (INEL)	Yes C	No a	Yes A	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	No a	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C
TRIGA FLIP (ANL-W)	Yes C	No a	Yes A	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	No a	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C
TRIGA SST (INEL)	Yes C	No a	Yes A	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	No a	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C
TRIGA SST (Hanford)	Yes C	No a	Yes A	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	No a	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C
TRIGA Ass'y (Hanford)	Yes C	No a	Yes A	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	No a	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C
TRIGA BER-II	Yes C	No a	Yes B	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	No a	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C
Areotest TRIGA (San Ramon)	Yes C	No a	Yes B	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	No a	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C
AFRRI- TRIGA	Yes C	No a	Yes B	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	No a	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C
GA-TRIGA	Yes C	No a	Yes B	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	No a	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C
USGS- TRIGA	Yes C	No a	Yes B	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	No a	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C
TRIGA (McLellam)	Yes C	No a	Yes B	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	No a	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C

Table 4-5. (continued).

	Legal weight truck packages											Overweight truck packages		Rail packages									
	GE T-2	GE-100	BMI-1	FSV-1	NLI-1/2	NLI-6502	T-3	NAC-1	CNS 1-13G	NRBK-41	NAC-LWT	GE Model 2000	TN-FSV	TN-8L TN-8	TN-9	M-130	IF-300	NLI-10/24	125-B	TN-BRP	TN-REG	M-160	M-140
Metallic fuels	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
DOW TRIGA (Midland)	C	a	B	C	C	C	C	C	C	a	C	C	C	C	C	C	C	C	C	C	C	C	C
TRIGA (U. Arizona)	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
TRIGA (U. Wisconsin)	C	a	A	C	C	C	C	C	C	a	C	C	C	C	C	C	C	C	C	C	C	C	C
TRIGA (U. Illinois)	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
TRIGA FLIP (Wash. St.)	C	a	B	C	C	C	C	C	C	a	C	C	C	C	C	C	C	C	C	C	C	C	C
TRIGA (Penn. St.)	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
TRIGA (U. Texas)	C	a	A	C	C	C	C	C	C	a	C	C	C	C	C	C	C	C	C	C	C	C	C
TRIGA FLIP (Tex. A&M)	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
TRIGA (U. Utah)	C	a	A	C	C	C	C	C	C	a	C	C	C	C	C	C	C	C	C	C	C	C	C
TRIGA (Kan. St.)	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
TRIGA (Cornell U.)	C	a	B	C	C	C	C	C	C	a	C	C	C	C	C	C	C	C	C	C	C	C	C
TRIGA (UC Irvine)	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Table 4-5. (continued).

Metallic fuels	Legal weight truck packages													Overweight truck packages		Rail packages							
	GE T-2	GE- 100	BMI-1	FSV-1	NLI- 1/2	NLI- 6502	T-3	NAC-1	CNS 1-13G	NRBK-41	NAC- LWT	GE Model 2000	TN- FSV	TN-8 TN-8L	TN-9	M-130	IF- 300	NLI- 10/24	125-B	TN- BRP	TN- REG	M-160	M-140
TRIGA (U. Maryland)	Yes C	No a	Yes A	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	No a	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C
TRIGA FLIP (Oregon St)	Yes C	No a	Yes A	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	No a	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C
TRIGA (Reed U.)	Yes C	No a	Yes A	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	No a	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C
SNAP	Yes C	No a	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	No a	Yes C	Yes C	Yes C	Yes C	Yes C	N/A b	Yes C	Yes C	Yes C	Yes C	Yes C	N/A b	N/A b
MURR (INEL)	No a	No a	N/A b	N/A b	N/A b	No a	No a	N/A b	N/A b	No a	N/A b	N/A b	No a	N/A b	N/A b	N/A b	N/ A b	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b
MURR (SRS)	No a	No a	No a	N/A b	N/A b	No a	No a	N/A b	No a	No a	N/A b	No a	N/A b	N/A b	N/A b	No a	N/ A b	N/A b	N/A b	N/A b	No a	No a	No a
MURR (U. Missouri Columbia)	N/A b	No a	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	No a	N/A b	N/A b	N/A b	N/A a	N/A a	N/A b	N/ A b	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b
MURR (U. Missouri Rolla)	N/A b	No a	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	No a	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	N/ A b	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b
HFBR (INEL)	N/A b/c	No a	N/A b/c	N/A b/c	N/A b/c	N/A b/c	N/A b/c	N/A b/c	N/A b/c	No a	N/A b/c	N/A b/c	N/A b/c	N/A b/c	N/A b/c	N/A b/c	N/ A b/c	N/A b/c	N/A b/c	N/A b/c	N/A b/c	N/A b/c	N/A b/c
HFBR (BNL)	No a	No a	N/A b	N/A b	No c	N/A b	No c	No c	No c	No a	No c	No c	No c	N/A b	N/A b	N/A b	N/ A b	N/A b	No c	N/A b	No c	N/A b	N/A b

Table 4-5. (continued).

Metallic fuels	Legal weight truck packages													Overweight truck packages		Rail packages							
	GE T-2	GE- 100	BMI-1	FSV-1	NLI- 1/2	NLI- 6502	T-3	NAC-1	CNS 1-13G	NRBK-41	NAC- LWT	GE Model 2000	TN- FSV	TN-8 TN-8L	TN-9	M-130	IF- 300	NLI- 10/24	125-B	TN- BRP	TN- REG	M-160	M-140
ORR	N/A b	No a	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	No a	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	N/ A b	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b
ATR Ass'ys (INEL CPP-603)	No c	No a	N/A c	Yes C	N/A b	Yes C	Yes C	Yes? C	No c	No a	Yes C	No c	Yes C	Yes C	Yes C	N/A b	Yes C	Yes C	Yes C	Yes C	Yes C	N/A b	N/A b
ATR Recycle	N/A b	No a	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	No a	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	N/ A b	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b
ATR Spent	N/A b	No a	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	No a	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	N/ A b	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b
ATR Core	N/A b	No a	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	No a	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	N/ A b	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b
ATR Ass'ys (INEL CPP-666)	No c	No a	N/A c	Yes C	N/A b	Yes C	Yes C	Yes? C	No c	No a	Yes C	No c	Yes C	Yes C	Yes C	N/A b	Yes C	Yes C	Yes C	Yes C	Yes C	N/a b	N/A b
HFIR	No a	No a	No a	No a	No a	No a	No a	No a	Yes C	No a	No a	Yes A	No a	No a	No a	No a	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C
RINC	N/A a	No a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	No a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/ A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a
Nereide	N/A b	No a	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	No a	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	N/ A b	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b
ANLJ	No a	No a	No a	N/A b	N/A b	No a	No a	N/A b	No a	No a	N/A b	No a	N/A b	N/A b	N/A b	No a	N/ A b	N/A b	N/A b	N/A b	No a	No a	No a

Table 4-5. (continued).

Metallic fuels	Legal weight truck packages													Overweight truck packages		Rail packages									
	GE T-2	GE- 100	BMI-1	FSV-1	NLI- 1/2	NLI- 6502	T-3	NAC-1	CNS 1-13G	NRBK-41	NAC- LWT	GE Model 2000	TN- FSV	TN-8 TN-8L	TN-9	M-130	IF- 300	NLI- 10/24	125-B	TN- BRP	TN- REG	M-160	M-140		
ATSR	No a	No a	No a	N/A b	N/A b	No a	No a	N/A b	No a	No a	N/A b	No a	N/A b	N/A b	N/A b	No a	N/ A b	N/A b	N/A b	N/A b	No a	No a	No a		
JMTR	No a	No a	No a	N/A b	N/A b	No a	No a	N/A b	No a	No a	N/A b	No a	N/A b	N/A b	N/A b	No a	N/ A b	N/A b	N/A b	N/A b	No a	No a	No a		
RHF	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/ A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a		
S Forest	N/A a	No a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/ A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a		
AI-LM	N/A b	No a	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	No a	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	N/ A b	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b		
ARMF (plates)	Yes ? C	No a	Yes? C	Yes? C	Yes? C	Yes? C	Yes? C	Yes? C	Yes? C	No a	Yes? C	Yes? C	Yes? C	Yes? C	No a	Yes? C	Yes ? C	Yes? C	Yes? C	Yes? C	Yes? C	Yes? C	Yes? C		
ARMF/ CFRMF (Element)	Yes ? C	No a	Yes? C	Yes? C	Yes? C	Yes? C	Yes? C	Yes? C	Yes? C	No a	Yes? C	Yes? C	Yes? C	Yes? C	Yes? C	Yes? C	Yes ? C	Yes? C	Yes? C	Yes? C	Yes? C	Yes? C	Yes? C		
ARMF/ CFRMF (Unknown)	Yes ? C	No a	Yes? C	Yes? C	Yes? C	Yes? C	Yes? C	Yes? C	Yes? C	No a	Yes? C	Yes? C	Yes? C	Yes? C	Yes? C	Yes? C	Yes ? C	Yes? C	Yes? C	Yes? C	Yes? C	Yes? C	Yes? C		
ARMF/ CFRMF (Insert)	Yes ? C	No a	Yes? C	Yes? C	Yes? C	Yes? C	Yes? C	Yes? C	Yes? C	No a	Yes? C	Yes? C	Yes? C	Yes? C	Yes? C	Yes? C	Yes ? C	Yes? C	Yes? C	Yes? C	Yes? C	Yes? C	Yes? C		
Taiwan RR	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/ A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a		

Table 4-5. (continued).

Metallic fuels	Legal weight truck packages												Overweight truck packages		Rail packages									
	GE T-2	GE- 100	BMI-1	FSV-1	NLI- 1/2	NLI- 6502	T-3	NAC-1	CNS 1-13G	NRBK-41	NAC- LWT	GE Model 2000	TN- FSV	TN-8 TN-8L	TN-9	M-130	IF- 300	NLI- 10/24	125-B	TN- BRP	TN- REG	M-160	M-140	
SPEC	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/ A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a
TSR	N/A a	No a	No a	No a	No a	No a	No a	No a	No a	No a	No a	No a	No a	No a	No a	No a	N/ A b	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b
BNL MRR	N/A b	No a	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	No a	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	N/ A b	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b
U. Wash.	Yes C	No a	Yes B	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	No a	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C
U. Virginia	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/ A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a
U. Michigan	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/ A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a
MTR Type (U. Virginia)	N/A b	No a	Yes A	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	No a	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	N/ A b	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b
MTR Type (U. Mich.)	N/A b	No a	Yes A	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	No a	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	N/ A b	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b
MTR Type (Georgia Tech)	N/A b	No a	Yes A	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	No a	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	N/ A b	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b
MTR-Type (MIT)	N/A b	No a	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	No a	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	N/ A b	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b

Table 4-5. (continued).

Metallic fuels	Legal weight truck packages												Overweight truck packages		Rail packages								
	GE T-2	GE- 100	BMI-1	FSV-1	NLI- 1/2	NLI- 6502	T-3	NAC-1	CNS 1-13G	NRBK-41	NAC- LWT	GE Model 2000	TN- FSV	TN-8 TN-8L	TN-9	M-130	IF- 300	NLI- 10/24	125-B	TN- BRP	TN- REG	M-160	M-140
MTR Type (U. Lowell)	N/A b	No a	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	No a	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	N/ A b	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b
MTR Type (Iowa St.)	No a	No a	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	No a	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	N/ A b	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b
MTR Type (Worster Tech. Inst.)	N/A b	No a	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	No a	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	N/ A b	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b
MTR Type (Purdue U.)	N/A b	No a	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	No a	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	N/ A b	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b
MTR Type (RINSC)	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	No a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/ A a	N/A a	N/A a	N/A a	N/A a	N/A a	N/A a
Argonaut (U. Florida)	N/A b	No a	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	No a	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	N/ A b	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b
OSR (Ohio St.)	N/A b	No a	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	No a	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	N/ A b	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b

Table 4-6. Packaging compatibility with graphite-moderated reactor type SNF.

Graphite moderated reactor fuels	Legal weight truck packages										Overweight truck packages		Rail packages										
	GE T-2	GE-100	BMI-1	FSV-1	NLI-1/2	NLI-6502	T-3	NAC-1	CNS 1-13G	NRBK-41	NAC-LWT	GE Model 2000	TN-FSV	TN-8L	TN-9	M-130	IF-300	NLI-10/24	125-B	TN-BRP	TN-REG	M-160	M-140
SPR (Hanford 105-KW)	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes B	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	N/A b	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C
SPR (Hanford PUREX)	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes B	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	N/A b	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C
SPR (Hanford 105-KE)	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes B	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	N/A b	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C
N Reactor (Hanford 105-KW/E)	Yes C	No a	Yes C	Yes C	Yes C	Yes C	Yes C	Yes B	Yes C	No a	Yes C	Yes C	Yes C	Yes C	Yes C	N/A b	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C
N-Reactor (Hanford PUREX)	Yes C	No a	Yes C	Yes C	Yes C	Yes C	Yes C	Yes B	Yes C	No a	Yes C	Yes C	Yes C	Yes C	Yes C	N/A b	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C
Big Rock Point	No a	No a	No a	Yes C	Yes C	Yes C	No a	Yes C	No a	No a	Yes C	No a	Yes C	Yes C	No a	N/A b	Yes C	Yes C	Yes C	Yes A	Yes C	Yes C	Yes C
TREAT	No a	No a	No a	Yes C	Yes C	Yes C	Yes C	Yes C	No a	No a	Yes C	No a	Yes C	Yes C	Yes C	N/A b	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C

Legend:

Yes: Fuel/Package matchup is anticipated with a relatively high degree of confidence.
 Yes?: Fuel/Package matchup is anticipated with a lower degree of confidence.
 No: Fuel/Package matchup is not anticipated to be feasible with any reasonable package modifications.
 N/A: Insufficient data exist to predict matchup with any degree of confidence.

Table 4-6. (continued).

Legend (continued):

- a. Matchup is not feasible due to dimensional discrepancies (No), or matchup cannot be evaluated because available fuel dimensional data is insufficient to make a determination with any degree of confidence (N/A).
  - b. Matchup is not feasible due to shielding requirements (No), or matchup cannot be evaluated because available fuel radiological data is insufficient to make a determination with any degree of confidence (N/A).
  - c. Matchup is not feasible due to thermal limitations (No), or matchup cannot be evaluated because available fuel thermal data is insufficient to make a determination with any degree of confidence (N/A).
  - d. Matchup is not feasible due to payload weight restrictions (No), or matchup cannot be evaluated because available fuel weight data is insufficient to make a determination with any degree of confidence (N/A).
-
- A: No package modifications expected to be required (see Section 4.1)
  - B: Package Certificate of Compliance amendment probably required (see Section 4.2)
  - C: Package SARP and Certificate of Compliance revisions probably required (see Section 4.3)

4.1 Capability That Currently Exists

The specific cask/fuel matchups which currently permit transport are as follows:

- FFTF fuel and certain other irradiated materials are authorized for shipment in the T-3 package
- Three-Mile Island damaged fuel is authorized for shipment in the 125-B package
- Naval reactor fuel is authorized for shipment in the M-130, M-140, and M-160 packages
- Fort St. Vrain spent fuel is authorized for shipment in the FSV-1 and TN-FSV packages
- R.E. Gina (REG) spent fuel is authorized for shipment in the TN-REG package
- Big Rock Point (BRP) spent fuel is authorized for shipment in the TN-BRP package
- GE Model 2000 has been specifically modified to transport HFIR fuel
- BMI-1 has been authorized to carry several research reactor fuel types
- Commercial-type fuels that are adequately characterized can be shipped in casks specifically developed for commercial fuel.

4.2 Capability via Amended SARP and Certificate of Compliance (No Hardware Changes)

This action will be the least effort expected in order to qualify a package for a payload for which it is not specifically licensed. If a fuel type or types can be determined which are fully bounded by a package's current payload definition, as determined by all the parameters listed in Section 2.2, then an amendment to the certificate of compliance should be obtainable. Based on recent experience of licensing the T-3 package for alternative payloads, this effort could be completed in anywhere from 3 to 12 months.

4.3 Capability via Revised SARP and Certificate of Compliance (No Hardware Changes)

For fuel types whose governing parameters fall outside of the payload capabilities of a currently licensed package, it is possible that the safety analysis report for that package could be revisited with an eye to revising calculations based on extended payload demands (heavier payload, greater heat load, higher operating pressure, etc.). If the resulting margins of safety remain positive, it is conceivable that a revised Certificate of Compliance might be obtained for the package, qualifying it for the desired fuel type(s). However, smaller margins almost automatically dictate a significantly greater level of analysis refinement and regulatory interaction.

It is also possible that some currently licensed packages not specifically designed to transport irradiated fuel could be requalified for that purpose. It is unlikely that any revisions such as detailed above could be accomplished in less than a year's time.

4.4 Capability via Revised SARP and Certificate of Compliance (Hardware Development Anticipated)

This type of modification is not directly indicated in Tables 4-1 through 4-6, because it is expected be the minimum level of effort required for nearly *all* of the fuel types. With the exception of those listed in Section 4.1, very few of the SNF types have geometries compatible with existing transport packages. Almost all will likely require some type of support before they can be transported in packages that were generally designed for different payload geometries. This support could take the form of either custom-designed baskets (possibly incorporating neutron poisoning material for criticality control), or possibly repackaging (canistering). The required design development and fabrication of the associated hardware, along with the related licensing activities, would probably not be accomplished in less than 18 months.

4.5 Capability via Packaging Design Change (New Certificate of Compliance)

It is possible that, with fairly modest design changes (new impact limiters, different types of seals, additional closure bolts, etc.), an existing package could be qualified for a new certificate of compliance for increased payload capability. It is anticipated that such an approach could not be successfully accomplished in less than two years' time.

4.6 No Apparent Capability (New Package Design Required)

For fuel types (or possibly, certain subsets of fuel types) that cannot be accommodated by the above approaches, a new package design or designs would have to be undertaken. Based on recent experience, development of an entirely new package through the design, licensing, and fabrication phases is unlikely to be accomplished in a time frame of less than three years. If packages currently undergoing development could be used, this time frame could be shortened, depending on the stage of development of the particular package.

4.7 Additional Study Needed to Establish Capability

The many types of fuels, and wide variety of conditions within some fuel types, will require that careful and detailed evaluations be performed in order to characterize the fuel adequately for determination of a suitable packaging matchup (or development) for transportation of that fuel. This study can only provide a rough order of magnitude of the effort that will be required for transportation of a portion of the noncommercial spent nuclear fuel inventory.

As a final note, it should be emphasized that the above estimates on time required for package licensing are based largely on experience with the Nuclear Regulatory Commission's Transportation Branch. The built-in assumption is that the licensing contractor will be well

qualified and experienced, with a good, long-term working relationship with the NRC regulators, who themselves have had many years of experience in transportation system design review. These factors will assure a timely and efficient review process. Since the relative youth of the current DOE regulatory system generally precludes these conditions, it can be expected that, on the whole, obtaining a DOE Certificate of Compliance will probably require a longer time frame.

5. OTHER FACTORS

In addition to all of the fuels and packaging parameters listed in the above sections, numerous other factors will affect the transport feasibility of the SNF inventory.

5.1 Packaging Availability

Some of the currently licensed packages may be involved in shipping campaigns in the near or intermediate future, which will reduce or eliminate their availability for purposes of transporting DOE-owned SNF. Approximate anticipated availability for the irradiated fuel packages is summarized in Table 3-1. Exact figures are difficult to determine in many cases, since the shipping campaigns depend on a variety of other factors, not the least of which is availability of storage sites to which the designated payloads are to be shipped. An example would be the TN-REG and TN-BRP packages, which are earmarked for transport of West Valley fuels to intermediate storage facilities yet to be developed. In some cases, the planned shipping campaigns involve the study fuels, such as the TN-FSV package is scheduled to transport Fort St. Vrain fuel, and the M-series packages (M-130, M-140 and M-160) will be utilized to ship naval reactor fuels. Unless program priorities change, these packages would not be available for other duty. Other packages are readily available, and their owners are eager to have them utilized as soon as possible. Whether the immediately available packages are those which would be of greatest utility for transporting DOE-owned SNF remains to be determined.

Another factor to be considered is that existing packages are limited in number, sometimes one of a kind. Due to recent regulatory revisions, additional fabrication of most of these packages (those fabricated prior to August 31, 1986) cannot be undertaken. By December 31, 1995, additional fabrication of the remainder of the currently licensed package designs will also likely be prohibited unless they are demonstrated to be in compliance with revised (more stringent) transportation rules.

5.2 Transport Vehicles and Auxiliary Equipment

Some of the currently licensed packages require specially designed, dedicated transport vehicles (e.g., the 125-B requires an articulated railcar). Some have specialty transporters, but are capable of being transported on other vehicles, suitably modified (e.g., the T-3, which has three packages but only one dedicated specialty trailer). The trailers for the TN-9 packages will require refurbishment before being put back into service. Unless periodic maintenance is performed on these specialty transporters, it is likely that, over time, they will deteriorate and eventually become unusable without some amount of rework.

Additionally, specialty auxiliary equipment will almost certainly be required for each package for loading and unloading operations. The 125-B was originally furnished with remote handling equipment suitable for its design payload. This equipment may or may not still exist in a serviceable condition. Handling equipment for this and other packages will likely have to be developed specifically for the off-design fuels they may be required to transport. While the development of such equipment does not require the extensive effort required for licensed

transport packages, it will still require a not-insignificant expenditure of time and resources, and must be included in any SNF transportation management plan.

In the case of leak-tight sealing requirements, which is likely to be necessary, at least for damaged and deteriorated fuels, specialty leak-detection equipment will be required. For the very small leak rate defined as "leaktight" by Reference 13 (1×10^{-7} scc/sec, air maximum), a rather complex leak-check procedure utilizing precision equipment, such as a helium mass spectrometer, will be necessary. Training of the personnel who will undertake this activity will be required. Other loading activities will also require special training (dewatering or drying, inert gas backfill, etc.). Allowance must be made for developing procedures and training personnel for these activities for all affected facilities.

5.3 Site and Facility Interfaces

As mentioned earlier, an important consideration is facility accessibility by the particular transport package required to service that facility. A summary of facility interface parameters is given in Table 5-1. The main interface considerations are as follows:

- Transport mode (road, rail, ship)
- Loading mode (wet or dry)
- Gross package weight (should not exceed facility crane capacity)
- Dimensional restrictions (access door dimensions, ceiling height, etc., as applicable)
- Operation restrictions (electrical equipment important to safety).

These restrictions could potentially limit access by the package (or packages) that might be required to remove spent fuel from the particular facility where it is located. In that event, multiple transfers or facility modifications might be required. Further complication is introduced by the fact that some of the fuel types are stored in more than one location. See Table 5-1 for a partial listing of these fuels.

5.4 System Efficiencies

As previously set out in Section 2.3, it is conceivable that the most efficient shipping campaign for even a single fuel type might require more than one transport package, or multiple authorized payload definitions for a given package. This is because any single fuel type might involve a large variety of significant transport-related factors.

As an example, the N-Reactor fuel at the Hanford site spans a wide range of key parameters. As shown in Figure 5-1, this fuel type has two major configurations, Mark IV and Mark IA. Between these two configurations, there are a total of seven different sizes, each size with two primary burnup levels, and each of these with a potentially large span of time out of

Table 5-1. Examples of single fuel types currently stored in multiple locations.

Fuel Type	Location (Facility)	MTHM	Total MTHM
N Reactor	Hanford (KE-Basin)	1145	—
	Hanford (KW-Basin)	961	—
	Hanford (PUREX)	0.3	—
N Reactor Total			2,106.30
Target	SRS (L-Basin)	115.498	—
	SRS (F-Canyon)	22.634	—
	SRS (RBOF)	0.37	—
Target Total			138.50
EBR-II	ANL-W (EBR-II)	25	—
	ANL-W (HFEF)	11.89	—
	INEL (CPP-603)	1.2	—
	INEL (CPP-666)	0.799	—
	Hanford (Bldg-325)	0.08	—
EBR-II Total			38.97
FSVR	PSC (FSVR)	16	—
	INEL (CPP-IFSF)	8.6	—
FSVR Total			24.60
Shippingport PWR	Hanford (T-Plant)	16.2	—
	NRF (ECF)	1.6	—
	INEL (CPP-666)	0.599	—
Ship'pt PWR Total			18.40

Table 5-1. (continued).

Fuel Type	Location (Facility)	MTHM	Total MTHM
Naval	INEL (CPP-666)	4.816	—
	NRF (ECF)	2.5	—
	INEL (CPP-603)	0.952	—
Naval Total			8.27
SPR	Hanford (PUREX)	2.9	—
	Hanford (KE-Basin)	0.4	—
	Hanford (KW-Basin)	0.1	—
SPR Total			3.40
Peachbottom	INEL (CPP-749)	1.654	—
	INEL (CPP-603)	1.346	—
	INEL (TAN-607)	0.356	—
	INEL (TRA-603)	0.010	—
	ORNL (Bldg-7829)	unknown (probably < .005)	—
Peachbottom Total			3.37
HFBR	BNL (HFBR)	0.25	—
	INEL (CPP-666)	0.0584	—
	INEL (CPP-603)	0.005	—
HFBR Total			0.31

5-1. N-Reactor fuel variables.

reactor. Additionally, some of this fuel is deteriorated, involving every condition from breached cladding down to disintegration into sludge. It is highly unlikely that a single transport package could be efficiently utilized to transport all of this fuel.

If the worst-condition fuel were used as the baseline for package selection, the selected transport package would probably be greatly oversized for the remainder of the fuel. The resulting limited transport capability would necessarily involve more shipments than would be required for a package more optimally matched with the non-worst-case fuel.

Even in those instances where all of a given fuel type can be transported in a single package, transportation efficiency might be unacceptably low. An example would be the T-3 package, which is capable of carrying only one Fast Flux Test Facility (FFTF) fuel assembly per shipment.

As discussed in Section 3.3, if several fuel types can be categorized and administratively controlled to the satisfaction of the regulatory authority, multiple payload definitions or amendments for a given package could be developed, significantly improving overall system efficiency. However, it must be emphasized that this goal will not be easily obtainable. In general, the greater the variety of payload types, the larger will be the envelope of characteristics (thermal, radiological, etc.) imposed on a candidate packaging. It should be realized that the process of obtaining a Certificate of Compliance for a package design that includes only a single payload type, or a small, very well-defined subset of payload types, is itself a very laborious undertaking. Attempting to broaden the payload definition will likely only compound the effort required to license the candidate package.

5.5 Schedule Requirements

There are a great number of factors affecting schedule. The single biggest schedule driver will likely be privatization of shipping campaigns within the DOE system. Priorities will depend strongly on fuel or storage facility conditions, as well as politics, and certain shipping campaigns may be found to require immediate action.

Once governing schedule constraints are identified and priorities established, detailed implementation strategies and schedules can then be developed. If schedule constraints are minimal, more efficient shipping campaigns can be achieved. Tight schedules will tend to minimize implementation options (due to funding availability problems, time frames which dictate simple licensing amendments, etc.), and inherently lead to less efficient shipments.

It must be kept in mind that, although preparations for an efficient shipping campaign may require more up-front time and cost, the savings realized once shipments begin may be found to easily offset these impacts. The extent of necessary package modifications, or possibly development efforts, would determine when a shipping campaign for a particular fuel could commence. Multiple transfers, or facility modifications, where there is an incompatible package/facility interface might be another consideration affecting a shipping campaign. Package availability would be a concern, as well as time required for transfer equipment and procedure development, and personnel training.

In any case, except for those few cases where fuel/package compatibility already exists, a minimum of six months should be allowed for preparation of a shipping campaign. The subsequent length of the campaign will depend on quantity of fuel and efficiency of shipments. If program priorities are low or design/SARP revisions are significant, a three or more year preparation time may be required.

5.6 Costs

All of the factors mentioned in the above section will have a direct impact on total transport costs, as well. It is expected that the following factors will play the largest role in overall transportation costs:

- Lease or purchase costs for transport existing packages
(The IF-300 lease fees are currently on the order of \$3000 - \$4000 per day)
- SARP revision costs
(Recent T-3 amendments have cost from \$20,000 to \$50,000, exclusive of any necessary design and review costs; NRC fees are currently \$134 per hour for SARP review)
- New package development and fabrication costs (including SARP preparation)
(A current package development project is just entering its licensing stage (i.e., drop testing and Rev 0 SARP submittal) after more than three and a half years since contract award; projected total development costs are anticipated to be in excess of \$15 million)
- Facility upgrade or development is expected to be a major cost driver.

5.7 Public Involvement

A major factor in the development of SNF Transportation Plans is the very large degree of public involvement which can be expected. The single shipping campaign involving the Three-Mile Island damaged fuel transport attracted an enormous amount of attention and sparked an unprecedented public relations campaign on the part of the DOE (see References 14 and 15 for details). An undertaking involving up to 230 different types of SNF from a large number of different locations over an extensive variety of routes will provoke a proportionally greater response. Preparing and coordinating transportation plans with the numerous state and local officials, congressional delegations, local emergency planning groups, interest groups, etc., will require a significant expenditure of resources on the part of DOE before the first SNF shipment is even initiated.

6. SUMMARY AND CONCLUSIONS

This section includes a summary of the fuel/package compatibility results, draws conclusions based on the results, and then suggests recommended actions.

6.1 Summary

The overall results are condensed and summarized in Table 6-1; see Table 6-2 for a more detailed summary. Table 6-1 shows that, of the approximately 230 different fuel types in the DOE-owned SNF inventory, 66% either do not have a packaging matchup, or insufficient fuel characteristics data were available to make a transportation assessment. Of the remaining 34% of the fuel types, 16% appear to have at least one compatible package as is. Another 12% could potentially have at least one compatible package if minor Certificate of Compliance changes are made and a new basket assembly is designed and qualified, as necessary. The final 6% could potentially have at least one compatible package if extensive changes are made to the safety analysis report for packaging and the Certificate of Compliance, and a new basket assembly is designed and qualified, as necessary.

A great deal of engineering judgment has been used in formulating Table 6-1 and 6-2, and it is accordingly provided as a top-level approximation of SNF transportation capabilities only. For much of the SNF inventory, fuel characterization is currently inadequate to make even a first-order approximation of transportation capabilities, and these fuels are not included in Table 6-2. The matchups have been estimated using primarily the data from Reference 1, which is incomplete and, in some cases, has been found to be erroneous. Consequently, some of the postulated matchups may not agree with the opinions of those with a more detailed or accurate knowledge of specific fuel types.

Table 6-1. Summary of potential transportation package and fuel type matchups.

Transportation package acceptability category	Number of fuel types	Percentage of total fuel types
Package/fuel matchup acceptable as is (no Certificate of Compliance or SARP changes required)	36	16%
Package/fuel matchup requires Certificate of Compliance changes and probably design and qualification of new basket	28	12%
Package/fuel matchup requires extensive SARP and Certificate of Compliance changes and probably design and qualification of new basket	13	6%
No package/fuel matchup, either no matchup found or insufficient fuel type data available for determination	153	66%
Totals	230	100%

Table 6-2 summarizes the results of the study in a fuel/package compatibility matrix. **The reader is strongly urged to carefully review both this section as well as the legend and notes included at the end of the table before attempting to use Table 6-2.** The table provides estimated matchups between various DOE-owned SNF types and currently licensed transportation packages that are, or that might be, capable of conveying them. **The table includes only those fuel types for which sufficient data exist to estimate transportation requirements.** It is condensed from Tables 4-1 through 4-6, which are in turn derived from Tables 2-1 through 2-8. It is these latter tables that contain the full set of DOE-owned SNF. It must be emphasized that this study involves a **top-level** assessment of **potential** transportation capabilities. No attempt has been made to optimize transportation. Hence, many of the postulated fuel and package matchups, while theoretically feasible, are highly impractical (e.g., extensive modifications required to allow a 125-B rail cask to transport one or two light-water reactor fuel assemblies).

The postulated matchups of Table 6-2 are divided into two categories: Those for which sufficient fuel information exists to afford a fairly high level of confidence in transportation requirements (marked simply "yes"), and those for which insufficient direct data exist, but which can be reasonably deduced from similar fuels of known characteristics or transport requirements (marked "yes?"). Where lack of compatibility between a specific package and fuel is determined, the corresponding cell in the matrix is marked "no." When insufficient fuel data exist to make a determination, the corresponding matrix cell is marked with "N/A" (not available). For the latter two categories, the reason for the incompatibility (or lack of ability to make a determination) is indicated with a lower case letter: "a" indicates dimensional incompatibility (or lack of fuel dimensional data), "b" indicates shielding incompatibility (or lack of fuel radiological data), "c" indicates thermal incompatibility (or lack of fuel thermal data), and "d" indicates weight incompatibility (or lack of fuel weight data). Refer to the legend for details.

In addition to estimated compatibility, Table 6-2 also provides an appraisal of the additional packaging-related work, if any, that may be required in order to transport a particular fuel in the package. These modifications range from "none" through two progressively greater degrees of effort, as discussed in detail in Sections 4.1 through 4.3. These classifications are indicated by uppercase letters, with "A" signifying no additional effort needed, through "C", where the most extensive effort is expected to be required. Refer to the legend for details. **It should be strongly emphasized that the highest level of effort must generally be viewed as a major undertaking, and entails a significant amount of risk. Furthermore, it is anticipated that most projected matchups, other than level "A" matchups, will require the design and qualification (licensing) of some sort of internal payload support structure (basket). This essentially implies a complete relicensing effort for most "B" as well as "C" matchups (refer to Note 1 for details).**

Finally, the table also provides an estimate of the amount of a particular fuel type that each qualified cask can transport, as well as an approximate total number of shipments that the cask will be required to make in order to transport all of that particular fuel. These two estimates are given in the last line of each appropriate cell, separated by a slash mark. For instance, 5/15 would indicate that a total of 5 fuel units can be transported at one time, with a total of 15 shipments expected to be required to transport all of that particular fuel. Specific fuel units are listed for each fuel type in Tables 2-1 through 2-6. **It should be realized that these quantities are estimates at best, and do not make detailed allowances for additional structure that may be required to support or poison a given fuel during transport. As such, they should be considered at least**

somewhat optimistic. If fuel data are not sufficient to estimate package capacity, the lower part of the matrix cell will contain "N/A" (not available), along with the appropriate lowercase letter signifying the specific data required but not available. If payload capacity can be estimated, but no data on total fuel quantities exist, the estimated number of shipments is signified by an "e." Refer to the legend for details.

Table 6-2. Fuel/package matchup summary matrix.

DOE SNF	Legal weight truck packages											Overweight truck packages		Rail packages				
	GE T-2	BMI-1	FSV-1	NLI-1/2	NLI-6502	T-3	NAC-1	CNS 1-13G	NAC-LWT	GE Model 2000	TN-FSV	TN-8 TN-8L	TN-9	IF-300	NLI-10/24	125-B	TN-BRP	TN-REG
PWR																		
Point Beach (N/A)	No a	No a	Yes C 1/?(e)	Yes? C 1/?(e)	No a	No a	Yes? C 1/?(e)	No a	Yes C 1/?(e)	No a	No c	Yes? B 3/?(e)	No a	Yes B 7/?(e)	Yes B 10/?(e)	Yes? C 1/?(e)	Yes? C 6/?(e)	Yes? B 5/?(e)
Shippingport (INEL) (43)	No a	No a	Yes C 1/43	Yes C 1/43	Yes C 1?(d)/43	No a	Yes? C 1/43	No a	Yes C 1/43	No a	Yes C 1/43	Yes? C 3/15	No a	Yes? C 7/7	Yes? C 10/5	Yes? C 2/22	Yes? C 11/4	Yes? C 10/5
Shippingport (SRS) (1)	Yes C N/A c/d	Yes C N/A c/d	Yes C N/A c/d	Yes C N/A c/d	Yes C N/A c/d	Yes C N/A c/d	Yes? C N/A c/d	Yes C N/A c/d	Yes C N/A c/d	Yes C N/A c/d	Yes C N/A c/d	Yes C N/A c/d	Yes C N/A c/d	Yes C N/A c/d	Yes C N/A c/d	Yes C N/A c/d	Yes C N/A c/d	Yes C N/A c/d
Conn Yankee (1)	No a	No a	Yes C 1?(c)/1	Yes A 1?(c)/1	No a	No a	Yes? C 1?(c)/1	No a	Yes A 1?(c)/1	No a	Yes C 1?(c)/1	Yes C 1?(c)/1	No a	Yes C 1?(c)/1	Yes C 1?(c)/1	Yes C 1?(c)/1	Yes C 1?(c)/1	Yes C 1?(c)/1
LOFT (19)	Yes C N/A c	No a	Yes C N/A c	Yes C N/A c	Yes C N/A c	No a	Yes C N/A c	No a	Yes C N/A c	No a	Yes C N/A c	Yes C N/A c	No a	Yes C N/A c	Yes C N/A c	Yes C N/A c	Yes C N/A c	Yes C N/A c
Surrey (69)	No a	No a	Yes C 1?(c)/69	Yes B 1?(c)/69	No a	No a	Yes C 1?(c)/69	No a	Yes A 1?(c)/69	No a	Yes C 1?(c)/69	Yes A 3?(c)/32	No a	Yes A 7?(c)/10	Yes A 10?(c)/7	Yes? C N/A c	Yes C N/A c	Yes C N/A c
Turkey Point B17 (17)	No a	No a	Yes C 1?(c)/17	Yes A 1?(c)/17	No a	No a	Yes C 1?(c)/17	No a	Yes A 1?(c)/17	No a	Yes C 1?(c)/17	Yes A 3?(c)/6	No a	Yes A 7?(c)/3	Yes A 10?(c)/2	Yes? C N/A c	Yes C N/A c	Yes C N/A c
Turkey Point EMAD (1)	No a	No a	Yes C 1?(c)/1	Yes A 1?(c)/1	No a	No a	Yes C 1?(c)/1	No a	Yes A 1?(c)/1	No a	Yes C 1?(c)/1	Yes A 3?(c)/1	No a	Yes A 7?(c)/1	Yes A 10?(c)/1	Yes? C N/A c	Yes C N/A c	Yes C N/A c

Table 6-2. (continued).

	Legal weight truck packages										Overweight truck packages				Rail packages			
	GE T-2	BMI-1	FSV-1	NLI-1/2	NLI-6502	T-3	NAC-1	CNS 1-13G	NAC-LWT	GE Model 2000	TN-FSV	TN-8 TN-8L	TN-9	IF-300	NLI-10/24	125-B	TN-BRP	TN-REG
DOE SNF	N/A	Yes? A 37(c)/1	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	No	N/A	N/A	N/A	N/A	N/A
BMI (3)	N/A	N/A	Yes C 10/2	Yes A 9/3	N/A	Yes C 3/14	Yes C 6/7	Yes C 10/4	Yes C 12/4	Yes C 10/24	Yes C 10/2	Yes C 18/3	No	Yes A 42/1	Yes A 60/1	Yes C 6/7	Yes C 28/2	Yes A 25/2
R. E. Gina (40)	No	No	No	No	No	No	No	No	No	No	No	No	No	Yes B 1/large	Yes B 1/large	Yes A 7/49	Yes C 2/large	Yes B 4/86
TMI-2 (342)	No	No	No	No	No	No	No	No	No	No	No	No	No	Yes B 1/large	Yes B 1/large	Yes A 7/49	Yes C 2/large	Yes B 4/86
BWR																		
EBWR (227)	Yes C	No	No	Yes C	Yes C	Yes? C	Yes C	Yes B	No	Yes C	Yes C	Yes C	Yes C	N/A	Yes C	Yes C	Yes C	Yes C
Peach Bottom 2 (partial ass'ys) (2)	No	No	Yes C 27(c)/1	Yes A 27(c)/1	No	No	Yes C 17(c)/2	No	Yes B 27(c)/1	No	Yes C 27(c)/1	No	Yes B 77(c)/1	Yes B 177(c)/1	Yes B 247(c)/1	Yes C N/A	No	No
Pathfinder (417)	N/A	No	Yes C	Yes C	Yes C	Yes C	Yes C	No	Yes C	No	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C
SSPS-SPERT (1)	Yes C	Yes A 17(c)/1	Yes B 17(d)/1	Yes C 17(d)/1	Yes C 17(d)/1	Yes C 17(d)/1	Yes C 17(d)/1	Yes C 17(d)/1	Yes C 17(d)/1	Yes C 17(d)/1	Yes B 17(d)/1	Yes C 17(d)/1	Yes C 17(d)/1	Yes C 17(d)/1	Yes C 17(d)/1	Yes C 17(d)/1	Yes C 17(d)/1	Yes C 17(d)/1
Vallecitos (SRS) (4)	No	Yes B	Yes B/C	Yes C	Yes C	Yes C	Yes C	N/A	Yes C	Yes C	Yes B/C	Yes C	No	Yes C	Yes C	Yes C	Yes C	Yes C

Table 6-2. (continued).

DOE SNF	Legal weight truck packages											Overweight truck packages		Rail packages				
	GE T-2	BMI-1	FSV-1	NLI-1/2	NLI-6502	T-3	NAC-1	CNS 1-13G	NAC-LWT	GE Model 2000	TN-FSV	TN-8 TN-8L	TN-9	IF-300	NLI-10/24	125-B	TN-BRP	TN-REG
Vallecitos (INEL) (4)	No a	Yes B N/A c	Yes B/C N/A c	Yes C N/A c	Yes C N/A c	Yes C N/A c	Yes C N/A c	N/A b	Yes C N/A c	Yes C N/A c	Yes C N/A c	Yes C N/A c	No a	Yes C N/A c	Yes C N/A c	Yes C N/A c	Yes C N/A c	Yes C N/A c
BR																		
FFTF-DA (310)	No a	No a	Yes C 2/large	No b	No a	Yes B 1/large	No b	No a	No b	No a	No b	No b	No b	Yes C 6/52	No b	No b	No b	No b
FFTF-TFA (8)	No a	No a	Yes C 5/2	No b	No a	Yes A 1/8	No b	No a	No b	No a	No b	No b	No b	Yes C 13/1	No b	No b	No b	No b
Fermi Core 1&2 (214)	Yes C 16/2	Yes A 1/large	Yes C 60/4	Yes C 35/7	Yes C 9?(d)/24	Yes C 6/36	Yes C 24/9	Yes C 24/9	Yes C 24/9	Yes C 24/9	Yes C 20/11	Yes C 27/8	Yes C 28/8	Yes C 208/2	Yes C 304/1	Yes C 40/6	Yes C 177/2	Yes C 100/3
Fermi 1 Blanket (510)	Yes B N/A c	Yes B N/A c	Yes C N/A c	Yes C N/A c	Yes C N/A c	Yes C N/A c	Yes C N/A c	Yes C N/A c	Yes C N/A c	Yes C N/A c	Yes C N/A c	Yes C N/A c	Yes C N/A c	Yes C N/A c	Yes C N/A c	Yes C N/A c	Yes C N/A c	Yes C N/A c
EBR-II (INEL canister) (1472)	No c	Yes B N/A c	Yes B 4/large	Yes C 2/large	Yes C 4?(d)/large	Yes C 2/large	Yes C 1/large	Yes C 1/large	Yes C 5/large	Yes C 1/large	Yes C 1/large	Yes C 75/20	Yes C 50/30	Yes C 25/62	Yes C 168/9	Yes C 1/large	Yes C 7/large	Yes C 6/large
EBR-II (INEL pin) (2165)	No c	Yes B N/A c	Yes B 8/large	Yes C 2/large	Yes C 8?(c)/large	Yes C 3/large	Yes C 2/large	Yes C 2/large	Yes C 5/large	Yes C 2/large	Yes B 1/large	Yes C 66/33	Yes C 50/44	Yes C 28/78	Yes C 168/13	Yes C 1/large	Yes C 7/large	Yes C 6/large
EBR-II (ANL-6) (4)	Yes C N/A c	Yes B N/A c	Yes B N/A c	Yes C N/A c	Yes C N/A c	Yes C N/A c	Yes B N/A c	Yes C N/A c	Yes C N/A c	Yes C N/A c	Yes B N/A c	Yes C N/A c	Yes C N/A c	Yes C N/A c	Yes C N/A c	Yes C N/A c	Yes C N/A c	Yes C N/A c

Table 6-2. (continued).

DOE SNF	Legal weight truck packages											Overweight truck packages		Rail packages				
	GE T-2	BMI-1	FSV-1	NLI-1/2	NLI-6502	T-3	NAC-1	CNS 1-13G	NAC-LWT	GE Model 2000	TN-FSV	TN-8 TN-8L	TN-9	IF-300	NLI-10/24	125-B	TN-BRP	TN-REG
EBR-II (ANL-W/HFEF) (1790)	No a	No a	Yes B 4/large	Yes C 1/large	Yes C 1?(d)/ large	No a	Yes C 2/large	No a	Yes C	No a	No c	Yes C 3/large	Yes C 7/large	Yes C 14/large	Yes C 26/35	No c	Yes C 3/large	Yes C 3/large
EBR-II (ANL-W/RSWF) (15000)	Yes C N/A c	No a	No a	No a	No a	No a	No a	No a	No a	No a	No a	No a	No a	Yes C 42/large	Yes C 60/large	Yes C 40/large	Yes C 116/ large	Yes C 135/ large
GCR																		
FSVR-HT (744)	No a	No a	Yes A 6?(c)/ large	No a	No a	No a	No a	N/A b	No a	N/A b	Yes A 6?(c)/ large	No a	No a	N/A b	N/A b	N/A b	N/A b	N/A b
FSVR (1500)	No a	No a	Yes A 6?(c)/ large	No a	No a	No a	No a	N/A b	No a	N/A b	Yes A 6?(c)/ large	No a	No a	N/A b	N/A b	N/A b	N/A b	N/A b
TORY-IIC (655)	Yes C N/A c	No a	Yes C N/A c	Yes C N/A c	Yes C N/A c	Yes C N/A c	Yes C N/A c	No a	Yes C N/A c	No a	Yes C N/A c	Yes C N/A c	Yes C N/A c	Yes C N/A c	Yes C N/A c	Yes C N/A c	Yes C N/A c	Yes C N/A c
TORY-IIA (146)	Yes C N/A c	Yes C N/A c	Yes C N/A c	Yes C N/A c	Yes C N/A c	Yes C N/A c	Yes C N/A c	Yes C N/A c	Yes C N/A c	Yes C N/A c	Yes C N/A c	Yes C N/A c	Yes C N/A c	Yes C N/A c	Yes C N/A c	Yes C N/A c	Yes C N/A c	Yes C N/A c
Metallic																		
TRIGA-AL (INEL) (578)	Yes C 30/20	Yes A 38?(c)/ 16	Yes C 240/3	Yes C 170/4	Yes C 98?(d)/6	Yes C 50/12	Yes C 150/4	Yes C 120/5	Yes C 150/4	Yes C 120/5	Yes C 240/3	Yes C 225/3	Yes C 280/3	Yes C 900/1	Yes C 1600/1	Yes C 1428/1	Yes C 3700/1	Yes C 3800/1

Table 6-2. (continued).

DOE SNF	Legal weight truck packages											Overweight truck packages		Rail packages				
	GE T-2	BMI-1	FSV-1	NLI-1/2	NLI-6502	T-3	NAC-1	CNS 1-13G	NAC-LWT	GE Model 2000	TN-FSV	TN-8 TN-8L	TN-9	IF-300	NLI-10/24	125-B	TN-BRP	TN-REG
TRIGA FLIP (INEL) (7)	Yes C 77(c)/1	Yes A 197(c)/1	Yes C 1207(c)/1	Yes C 857(c)/1	Yes C 497(c/d)/1	Yes C 257(c)/1	Yes C 757(c)/1	Yes C 607(c)/1	Yes C 757(c)/1	Yes C 607(c)/1	Yes C 1207(c)/1	Yes C 1057(c)/1	Yes C 1407(c)/1	Yes C 4507(c)/1	Yes C 8007(c)/1	Yes C 7147(c)/1	Yes C 18507(c)/1	Yes C 19007(c)/1
TRIGA FLIP (ANL-W) (116)	Yes C 307(d)/9	Yes A 197(c/d)/7	Yes C 1207(d)/1	Yes C 497(d)/3	Yes C N/A d	Yes C 257(d)/5	Yes C 757(d)/2	Yes C 607(d)/2	Yes C 757(d)/2	Yes C 607(d)/2	Yes C 1207(d)/1	Yes C 1057(d)/2	Yes C 1407(d)/1	Yes C 4507(d)/1	Yes C 8007(d)/1	Yes C 7147(d)/1	Yes C 18507(d)/1	Yes C 19007(d)/1
TRIGA SST (INEL) (263)	Yes C 307(d)/4	Yes A 387(c/d)/7	Yes C 2407(d)/2	Yes C 987(d)/3	Yes C N/A d	Yes C 507(d)/6	Yes C 1507(d)/2	Yes C 1207(d)/3	Yes C 1507(d)/2	Yes C 1207(d)/3	Yes C 2407(d)/2	Yes C 2257(d)/2	Yes C 2807(d)/1	Yes C 9007(d)/1	Yes C 16007(d)/1	Yes C 14287(d)/1	Yes C 37007(d)/1	Yes C 38007(d)/1
TRIGA SST (Hanford) (101)	Yes C 307(d)/4	Yes A 387(c/d)/3	Yes C 2407(d)/1	Yes C 1707(d)/1	Yes C N/A d	Yes C 507(d)/3	Yes C 1507(d)/1	Yes C 1207(d)/1	Yes C 1507(d)/1	Yes C 1207(d)/1	Yes C 2407(d)/1	Yes C 2257(d)/1	Yes C 2807(d)/1	Yes C 9007(d)/1	Yes C 16007(d)/1	Yes C 14287(d)/1	Yes C 37007(d)/1	Yes C 38007(d)/1
TRIGA Ass'y (Hanford) (N/A)	Yes C N/A c	Yes A 387(c/d)/7 (e)	Yes C 2407(c/d)/7(e)	Yes C 1707(c/d)/7(e)	Yes C N/A d	Yes C 507(c/d)/7(e)	Yes C 1507(c/d)/7(e)	Yes C 1207(c/d)/7(e)	Yes C 1507(c/d)/7(e)	Yes C 1207(c/d)/7(e)	Yes C 2407(c/d)/7(e)	Yes C 2257(c/d)/7(e)	Yes C 2807(c/d)/7(e)	Yes C 9007(c/d)/7(e)	Yes C 16007(c/d)/7(e)	Yes C 14287(c/d)/7(e)	Yes C 37007(c/d)/7(e)	Yes C 38007(c/d)/7(e)
TRIGA BER-II (21)	Yes C N/A c/d	Yes B N/A c/d	Yes C N/A c/d	Yes C N/A c/d	Yes C N/A c/d	Yes C N/A c/d	Yes C N/A c/d	Yes C N/A c/d	Yes C N/A c/d	Yes C N/A c/d	Yes C N/A c/d	Yes C N/A c/d	Yes C N/A c/d	Yes C N/A c/d	Yes C N/A c/d	Yes C N/A c/d	Yes C N/A c/d	Yes C N/A c/d
Acrotect TRIGA (San Ramon) (93)	Yes C N/A c/d	Yes B N/A c/d	Yes C N/A c/d	Yes C N/A c/d	Yes C N/A c/d	Yes C N/A c/d	Yes C N/A c/d	Yes C N/A c/d	Yes C N/A c/d	Yes C N/A c/d	Yes C N/A c/d	Yes C N/A c/d	Yes C N/A c/d	Yes C N/A c/d	Yes C N/A c/d	Yes C N/A c/d	Yes C N/A c/d	Yes C N/A c/d

Table 6-2. (continued).

	Legal weight truck packages										Overweight truck packages				Rail packages			
	GE T-2	BMI-1	FSV-1	NLI-1/2	NLI-6502	T-3	NAC-1	CNS 1- 13G	NAC- LWT	GE Model 2000	TN- FSV	TN-8 TN-8L	TN-9	IF-300	NLI- 10/24	125-B	TN- BRP	TN- REG
DOE SNF	Yes C	Yes B	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C
AFRR-TRIGA (110)	N/A c/d	N/A c/d	N/A c/d	N/A c/d	N/A c/d	N/A c/d	N/A c/d	N/A c/d	N/A c/d	N/A c/d	N/A c/d	N/A c/d	N/A c/d	N/A c/d	N/A c/d	N/A c/d	N/A c/d	N/A c/d
GA-TRIGA (263)	Yes C	Yes B	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C
USGS-TRIGA (162)	N/A c/d	N/A c/d	N/A c/d	N/A c/d	N/A c/d	N/A c/d	N/A c/d	N/A c/d	N/A c/d	N/A c/d	N/A c/d	N/A c/d	N/A c/d	N/A c/d	N/A c/d	N/A c/d	N/A c/d	N/A c/d
TRIGA (McLellan) (90)	Yes C	Yes B	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C
DOW TRIGA (Midland) (78)	Yes C	Yes B	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C
TRIGA (U. Ariz) (97)	Yes C	Yes A	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C
TRIGA (U. Wisconsin) (92)	Yes C	Yes A	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C	Yes C

Table 6-2. (continued).

DOE SNF	Legal weight truck packages											Overweight truck packages		Rail packages				
	GE T-2	BMI-1	FSV-1	NLI-1/2	NLI-6502	T-3	NAC-1	CNS 1-13G	NAC-LWT	GE Model 2000	TN-FSV	TN-8 TN-8L	TN-9	IF-300	NLI-10/24	125-B	TN-BRP	TN-REG
TRIGA (U. Illinois) (193)	Yes C 30?(c)/7	Yes B 38?(c/d)/6	Yes C 240?(c/d)/1	Yes C 170?(c/d)/2	Yes C N/A d	Yes C 50?(c/d)/4	Yes C 150?(c/d)/2	Yes C 120?(c/d)/2	Yes C 150?(c/d)/2	Yes C 120?(c/d)/2	Yes C 240?(c/d)/2	Yes C 225?(c/d)/1	Yes C 280?(c/d)/1	Yes C 900?(c/d)/1	Yes C 1600?(c/d)/1	Yes C 1428?(c/d)/1	Yes C 3700?(c/d)/1	Yes C 3800?(c/d)/1
TRIGA FLIP (Wash St) (25)	Yes C N/A d	Yes B N/A d	Yes C N/A d	Yes C N/A d	Yes C N/A d	Yes C N/A d	Yes C N/A d	Yes C N/A d	Yes C N/A d	Yes C N/A d	Yes C N/A d	Yes C N/A d	Yes C N/A d	Yes C N/A d	Yes C N/A d	Yes C N/A d	Yes C N/A d	Yes C N/A d
TRIGA (Penn St) (175)	Yes C 30?(c/d)/6	Yes A 38?(c/d)/5	Yes C 240?(c/d)/1	Yes C 170?(c/d)/2	Yes C N/A d	Yes C 50?(c/d)/4	Yes C 150?(c/d)/2	Yes C 120?(c/d)/2	Yes C 150?(c/d)/2	Yes C 120?(c/d)/2	Yes C 240?(c/d)/2	Yes C 225?(c/d)/1	Yes C 280?(c/d)/1	Yes C 900?(c/d)/1	Yes C 1600?(c/d)/1	Yes C 1428?(c/d)/1	Yes C 3700?(c/d)/1	Yes C 3800?(c/d)/1
TRIGA (U. Texas) (126)	Yes C 30?(c/d)/5	Yes A 38?(c/d)/4	Yes C 240?(c/d)/1	Yes C 170?(c/d)/1	Yes C N/A d	Yes C 50?(c/d)/3	Yes C 150?(c/d)/1	Yes C 120?(c/d)/2	Yes C 150?(c/d)/1	Yes C 120?(c/d)/2	Yes C 240?(c/d)/2	Yes C 225?(c/d)/1	Yes C 280?(c/d)/1	Yes C 900?(c/d)/1	Yes C 1600?(c/d)/1	Yes C 1428?(c/d)/1	Yes C 3700?(c/d)/1	Yes C 3800?(c/d)/1
TRIGA FLIP (Tex. A&M) (186)	Yes C 30?(c/d)/7	Yes A 19?(c/d)/10	Yes C 120? (c/d)/2	Yes C 85?(c/d)/3	Yes C N/A d	Yes C 25?(c/d)/8	Yes C 75?(c/d)/3	Yes C 60?(c/d)/4	Yes C 75?(c/d)/3	Yes C 60?(c/d)/4	Yes C 120?(c/d)/2	Yes C 105?(c/d)/2	Yes C 140?(c/d)/2	Yes C 450?(c/d)/1	Yes C 800?(c/d)/1	Yes C 714?(c/d)/1	Yes C 1850?(c/d)/1	Yes C 1900?(c/d)/1
TRIGA (U. Utah) (100)	Yes C 30?(c/d)/4	Yes A 38?(c/d)/3	Yes C 240?(c/d)/1	Yes C 170?(c/d)/1	Yes C N/A d	Yes C 50?(c/d)/2	Yes C 150?(c/d)/1	Yes C 120?(c/d)/1	Yes C 150?(c/d)/1	Yes C 120?(c/d)/1	Yes C 240?(c/d)/1	Yes C 225?(c/d)/1	Yes C 280?(c/d)/1	Yes C 900?(c/d)/1	Yes C 1600?(c/d)/1	Yes C 1428?(c/d)/1	Yes C 3700?(c/d)/1	Yes C 3800?(c/d)/1

Table 6-2. (continued).

DOE SNF	Legal weight truck packages											Overweight truck packages		Rail packages				
	GE T-2	BMI-1	FSV-1	NLI-1/2	NLI-6502	T-3	NAC-1	CNS 1-13G	NAC-LWT	GE Model 2000	TN-FSV	TN-8 TN-8L	TN-9	IF-300	NLI-10/24	125-B	TN-BRP	TN-REG
TRIGA (Kan. St) (105)	Yes C 30?(c/d)/4	Yes A 38?(c/d)/3	Yes C 240?(c/d)/1	Yes C 170?(c/d)/1	Yes C N/A d	Yes C 50?(c/d)/3	Yes C 150?(c/d)/1	Yes C 120?(c/d)/1	Yes C 150?(c/d)/1	Yes C 120?(c/d)/1	Yes C 240?(c/d)/1	Yes C 225?(c/d)/1	Yes C 280?(c/d)/1	Yes C 900?(c/d)/1	Yes C 1600?(c/d)/1	Yes C 1428?(c/d)/1	Yes C 3700?(c/d)/1	Yes C 3800?(c/d)/1
TRIGA (Cornell) (100)	Yes C N/A c/d	Yes B N/A c/d	Yes C N/A c/d	Yes C N/A c/d	Yes C N/A c/d	Yes C N/A c/d	Yes C N/A c/d	Yes C N/A c/d	Yes C N/A c/d	Yes C N/A c/d	Yes C N/A c/d	Yes C N/A c/d	Yes C N/A c/d	Yes C N/A c/d	Yes C N/A c/d	Yes C N/A c/d	Yes C N/A c/d	Yes C N/A c/d
TRIGA (UC Irvine) (113)	Yes C 30?(c/d)/4	Yes A 38?(c/d)/3	Yes C 240?(c/d)/1	Yes C 170?(c/d)/1	Yes C N/A d	Yes C 50?(c/d)/3	Yes C 150?(c/d)/1	Yes C 120?(c/d)/1	Yes C 150?(c/d)/1	Yes C 120?(c/d)/1	Yes C 240?(c/d)/1	Yes C 225?(c/d)/1	Yes C 280?(c/d)/1	Yes C 900?(c/d)/1	Yes C 1600?(c/d)/1	Yes C 1428?(c/d)/1	Yes C 3700?(c/d)/1	Yes C 3800?(c/d)/1
TRIGA (U. Maryland) (93)	Yes C 30?(c/d)/4	Yes A 38?(c/d)/3	Yes C 240?(c/d)/1	Yes C 170?(c/d)/1	Yes C N/A d	Yes C 50?(c/d)/2	Yes C 150?(c/d)/1	Yes C 120?(c/d)/1	Yes C 150?(c/d)/1	Yes C 120?(c/d)/1	Yes C 240?(c/d)/1	Yes C 225?(c/d)/1	Yes C 280?(c/d)/1	Yes C 900?(c/d)/1	Yes C 1600?(c/d)/1	Yes C 1428?(c/d)/1	Yes C 3700?(c/d)/1	Yes C 3800?(c/d)/1
TRIGA FLIP (Ore. St.) (85)	Yes C 30?(c/d)/3	Yes A 19?(c/d)/5	Yes C 120?(c/d)/1	Yes C 85?(c/d)/1	Yes C N/A d	Yes C 25?(c/d)/4	Yes C 75?(c/d)/2	Yes C 60?(c/d)/2	Yes C 75?(c/d)/2	Yes C 60?(c/d)/2	Yes C 120?(c/d)/1	Yes C 105?(c/d)/1	Yes C 140?(c/d)/1	Yes C 450?(c/d)/1	Yes C 800?(c/d)/1	Yes C 714?(c/d)/1	Yes C 1850?(c/d)/1	Yes C 1900?(c/d)/1
TRIGA (Reed U.) (60)	Yes C 30?(c/d)/2	Yes A 38?(c/d)/2	Yes C 240?(c/d)/1	Yes C 170?(c/d)/1	Yes C N/A d	Yes C 50?(c/d)/2	Yes C 150?(c/d)/1	Yes C 120?(c/d)/1	Yes C 150?(c/d)/1	Yes C 120?(c/d)/2	Yes C 240?(c/d)/1	Yes C 225?(c/d)/1	Yes C 280?(c/d)/1	Yes C 900?(c/d)/1	Yes C 1600?(c/d)/1	Yes C 1428?(c/d)/1	Yes C 3700?(c/d)/1	Yes C 3800?(c/d)/1

Table 6-2. (continued).

DOE SNF	Legal weight truck packages											Overweight truck packages		Rail packages				
	GE T-2	BMI-1	FSV-1	NLI-1/2	NLI-6502	T-3	NAC-1	CNS 1-13G	NAC-LWT	GE Model 2000	TN-FSV	TN-8 TN-8L	TN-9	IF-300	NLI-10/24	125-B	TN-BRP	TN-REG
SNAP (19)	Yes C N/A c	Yes C N/A c	Yes C N/A c	Yes C N/A c	Yes C N/A c/d	Yes C N/A c	Yes C N/A c	Yes C N/A c	Yes C N/A c	Yes C N/A c	Yes C N/A c	Yes C N/A c	Yes C N/A c	Yes C N/A c	Yes C N/A c	Yes C N/A c	Yes C N/A c	Yes C N/A c
ATR Ass'y (INEL/ CPP-603) (109)	No c	N/A c	Yes C 6/19	N/A b	Yes C 4?(d)/28	Yes C 2/55	Yes C 1/large	No c	Yes C 4/28	No c	No c	Yes C 18/7	Yes C 21/6	Yes C 22/5	Yes C 88/2	Yes C 1/large	Yes C 5/22	Yes C 5/22
ATR Ass'y (INEL/ CPP-666) (785)	No c	N/A c	Yes C 6/13	Yes C 1/large	Yes C 4?(d)/large	Yes C 2/large	Yes? C 1/large	No c	Yes C 4/large	No c	Yes C 6/large	Yes C 18/44	Yes C 21/38	Yes C 22/36	Yes C 88/9	Yes C 1/large	Yes C 5/22	Yes C 5/22
HFIR (43)	No a	No a	No a	No a	No a	No a	No a	Yes C 1/43	No a	Yes A 1/43	No a	No a	No a	Yes C 10/5	Yes C 10/5	Yes C 3/15	Yes C 14/4	Yes C 13/4
ARMF (Plates) (15)	Yes? C >15?(c)/1	Yes? C >15?(c)/1	Yes? C >15?(c)/1	Yes? C >15?(c)/1	Yes? C >15? (c/d)/1	Yes? C >15? (c)/1	Yes? C >15? (c)/1	Yes? C >15? (c)/1	Yes? C >15? (c)/1	Yes? C >15?(c)/1	Yes? C >15? (c)/1	Yes? C >15? (c)/1	No a	Yes? C >15?(c)/1	Yes? C >15?(c)/1	Yes? C >15?(c)/1	Yes? C >15?(c)/1	Yes? C >15?(c)/1
ARMF/ CRFMF (Element) (58)	Yes? C N/A d	Yes? C N/A c/d	Yes? C N/A d	Yes? C N/A d	Yes? C N/A d	Yes? C N/A d	Yes? C N/A d	Yes? C N/A d	Yes? C N/A d	Yes? C N/A d	Yes? C N/A d	Yes? C N/A d	Yes? C N/A d	Yes? C N/A d	Yes? C N/A d	Yes? C N/A d	Yes? C N/A d	Yes? C N/A d
ARMF/CRFMF (Unknown) (8)	Yes? C N/A d	Yes? C N/A c/d	Yes? C N/A d	Yes? C N/A d	Yes? C N/A d	Yes? C N/A d	Yes? C N/A d	Yes? C N/A d	Yes? C N/A d	Yes? C N/A d	Yes? C N/A d	Yes? C N/A d	Yes? C N/A d	Yes? C N/A d	Yes? C N/A d	Yes? C N/A d	Yes? C N/A d	Yes? C N/A d
ARMF/CRFMF (Insert) (4)	Yes? C N/A d	Yes? C N/A c/d	Yes? C N/A d	Yes? C N/A d	Yes? C N/A d	Yes? C N/A d	Yes? C N/A d	Yes? C N/A d	Yes? C N/A d	Yes? C N/A d	Yes? C N/A d	Yes? C N/A d	Yes? C N/A d	Yes? C N/A d	Yes? C N/A d	Yes? C N/A d	Yes? C N/A d	Yes? C N/A d

Table 6-2. (continued).

	Legal weight truck packages										Overweight truck packages		Rail packages					
	GE T-2	BMI-1	FSV-1	NLI-1/2	NLI-6502	T-3	NAC-1	CNS 1-13G	NAC-LWT	GE Model 2000	TN-FSV	TN-8L TN-8	TN-9	IF-300	NLI-10/24	125-B	TN-BRP	TN-REG
DOE SNF	Yes C 3/9	Yes B 57(c)/6	Yes C 36/1	Yes C 22/2	Yes C 127(d)/3	Yes C 6/5	Yes C 20/2	Yes C 15/2	Yes C 20/2	Yes C 17/2	Yes C 36/1	Yes C 36/1	Yes C 42/1	Yes C 180/1	Yes C 264/1	Yes C 189/1	Yes C 500/1	Yes C 700/1
U. Wash. (26)	N/A b	Yes A N/A c/d	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b
MTR Type (U. Vir.) (56)	N/A b	Yes A N/A c/d	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b
MTR Type (U. Mich.) (69)	N/A b	Yes A N/A c/d	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b
MTR Type (Georgia Tech.) (60)	N/A b	Yes A N/A c/d	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b	N/A b
Graphite Moderated																		
SPR (Hanford 105-KW) (47)	Yes C 10/5	Yes C N/A c	Yes C 320/1	Yes C 416/1	Yes C 2007(d)/1	Yes C 80/1	Yes B 170/1	Yes C 320/1	Yes C 170/1	Yes C 320/1	Yes C 320/1	Yes C 460/1	Yes C 532/1	Yes C 2204/1	Yes C 3420/1	Yes C 1400/1	Yes C 6260/1	Yes C 7290/1
SPR (Hanford PUREX) (779)	Yes C 10/78	Yes C N/A c	Yes C 320/3	Yes C 416/2	Yes C 2007(d)/4	Yes C 80/10	Yes B 170/5	Yes C 320/3	Yes C 170/5	Yes C 320/1	Yes C 320/3	Yes C 460/1	Yes C 532/1	Yes C 2204/1	Yes C 3420/1	Yes C 1400/1	Yes C 6260/1	Yes C 7290/1
SPR (Hanford 105-KE) (138)	Yes C 10/14	Yes C N/A c	Yes C 320/1	Yes C 416/1	Yes C 2007(d)/1	Yes C 80/2	Yes B 170/1	Yes C 320/1	Yes C 170/1	Yes C 320/1	Yes C 320/1	Yes C 460/1	Yes C 532/1	Yes C 2204/1	Yes C 3420/1	Yes C 1400/1	Yes C 6260/1	Yes C 7290/1

Table 6-2. (continued).

DOE SNF	Legal weight truck packages											Overweight truck packages		Rail packages				
	GE T-2	BMI-1	FSV-1	NLI-1/2	NLI-6502	T-3	NAC-1	CNS 1-13G	NAC-LWT	GE Model 2000	TN-FSV	TN-8 TN-8L	TN-9	IF-300	NLI-10/24	125-B	TN-BRP	TN-REG
N-Reactor (Hanford 105-KW) (52959)	Yes C 9/large	Yes C N/A c	Yes C 70/large	Yes C 32/large	Yes C 22?(d)/ large	Yes C 18/large	Yes B 60/large	Yes C 85/large	Yes C 60/large	Yes C 85/large	Yes C 70/large	Yes C 108/ large	Yes C 84/ large	Yes C 528/101	Yes C 708/75	Yes C 147/ large	Yes C 1620/33	Yes C 2140/25
N-Reactor (Hanford 105-KE) (50683)	Yes C 9/large	Yes C N/A c	Yes C 70/large	Yes C 32/large	Yes C 22?(d)/ large	Yes C 18/large	Yes B 60/large	Yes C 85/large	Yes C 60/large	Yes C 85/large	Yes C 70/large	Yes C 108/ large	Yes C 84/ large	Yes C 528/96	Yes C 708/72	Yes C 147/ large	Yes C 1620/32	Yes C 2140/24
N Reactor (Hanford PUREX) (19)	Yes C 9/3	Yes C N/A c	Yes C 70/1	Yes C 32/1	Yes C 22?(d)/1	Yes C 18/2	Yes B 60/1	Yes C 85/1	Yes C 60/1	Yes C 85/1	Yes C 70/1	Yes C 108/1	Yes C 84/1	Yes C 528/1	Yes C 708/1	Yes C 147/1	Yes C 1620/1	Yes C 2140/1
Big Rock Point (85)	No a	No a	Yes C 2/43	Yes C 2/43	Yes C 1?(d)/85	No a	Yes C 2/43	No a	Yes C 2/43	No a	Yes C 2/43	Yes C 6/15	No a	Yes C 21/5	Yes C 28/4	Yes C 14/6	Yes A 62/2	Yes C 54/2
TREAT (390)	No a	No a	Yes C N/A d	Yes C N/A d	Yes C N/A d	Yes C N/A d	Yes C N/A d	No a	Yes C N/A d	No a	Yes C N/A d	Yes C N/A d	Yes C N/A d	Yes C N/A d	Yes C N/A d	Yes C N/A d	Yes C N/A d	Yes C N/A d

Legend:

Yes: Fuel/package matchup is anticipated with a relatively high degree of confidence.

Yes?: Fuel/package matchup is anticipated with a lower degree of confidence.

No: Fuel/package matchup is not anticipated to be feasible with any reasonable package modifications.

N/A: Insufficient data exist to predict matchup with any degree of confidence.

- a: Matchup is not feasible because of dimensional discrepancies (No), or matchup cannot be evaluated because available fuel dimensional data are insufficient to make a determination with any degree of confidence (N/A).
- b: Matchup is not feasible because of shielding requirements (No), or matchup cannot be evaluated because available fuel radiological data are insufficient to make a determination with any degree of confidence (N/A).
- c: Matchup is not feasible because of thermal limitations (No), or matchup cannot be evaluated because available fuel thermal data are insufficient to make a determination with any degree of confidence (N/A).
- d: Matchup is not feasible because of payload weight restrictions (No), or matchup cannot be evaluated because available fuel weight data are insufficient to make a determination with any degree of confidence (N/A).
- e: Payload quantities cannot be estimated because total fuel quantity data are not available.
- A: No package modifications are expected to be required (see Section 4.1)
- B: Package Certificate of Compliance amendment probably required (see Section 4.2)
- C: Package SARP and Certificate of Compliance revisions probably required (see Section 4.3)

Number of fuel units per payload and total number of shipments for the particular fuel inventory are given for each potential package/fuel matchup below the "Yes" or "Yes?" as x/y, where "x" represents units per payload and "y" represents total number of shipments. When the total number of shipments exceeds 100, "y" is simply given as "large." Where sufficient information exists to postulate a package/fuel matchup, but not enough to estimate specific payload capacities, an "N/A" is given instead. If sufficient information is not directly available to determine payload capacities, but adequate indirect means exist (comparison to other, similar fuels, etc.), the payload estimate is followed by a question mark (?) and a lowercase letter indicating the area of uncertainty (see letters "a" through "e" above). Total fuel units for each fuel type are given in parentheses below the fuel type name (column 1), where specific units are stated in Tables 2-1 through 3-6. If total number of units of a particular fuel is not known, "N/A" is given in parentheses below the fuel type name.

Notes:

1. Only coarse allowance has been made in payload capacity estimates for payload support structure, such as baskets (see Section 4.4). **In general, except for direct (level "A") fuel/package matchups, it can be expected that new internal support structures of some kind will have to be designed and qualified for almost all payloads. The significance of this assumption cannot be overemphasized. It essentially entails a complete relicensing effort for the affected packages.** For packages that might be capable of transporting more than one fuel type, this will involve either a more complicated qualification effort (licensing for multiple payloads), or relicensing the cask for each individual payload type.
2. Only coarse allowance has been made for criticality control in payload capacity estimates. Consequently, reductions in payload capacity, either through the introduction of neutron poisoning material, or reduction in the quantity of fuel transported per shipment, may occur after final criticality analyses for the SNF have been performed.
3. No estimates have been made for payload capacities using revised package designs (see Section 4.5). Too many uncertainties exist to allow such estimates to be made with any degree of confidence.
4. Except for the 125-B, all packages listed provide a single level of containment only. **No allowance has been made for fuels with cladding whose integrity may have been compromised. Such fuels will probably require double containment transportation systems.** In this case, either the 125-B must be used, if possible, or another level of containment (canister) must be incorporated in some other package. No allowance for such additional containment structure has been made in estimates of payload capacity.
5. Packages with limited capacity (GE-100 and NRBK-41) have not been included in the summary. Likewise, naval fuels and packages (M-130, M-140 and M-160) have not been included because sufficient information is not available to make payload capacity estimates for them with any degree of confidence.

6.2 Conclusions

Key conclusions resulting from the study are summarized below.

- Much of DOE's spent nuclear fuel (approximately one-third of all SNF types) appears to be transportable in existing shipping packages. However, most of this fuel will require that extensive additional effort be made before shipments can commence. Significant amounts of time and resources will be required for most SNF shipping campaigns due to the following:
  - Most campaigns utilizing existing packages will require changes to licensing documents, hardware, or facilities. In general, these changes are expected to be extensive in terms of time and resources.
  - The majority of fuels require significantly enhanced or improved fuel characterization before compatibility with existing packages can be properly and completely assessed.
  - Compatibility with existing packages does not appear to exist for many DOE-owned fuels. Thus, completely new transportation systems will likely be required if all DOE fuel is to eventually be shipped in licensed packages.
  - Although the total quantity of DOE-owned SNF is far less than the quantity of commercial SNF, total cost on a per-MTHM basis is expected to be significantly greater for transport of DOE fuels than commercial fuels (due to the wide variety of fuel types within the DOE system and the small quantities that exist at many individual storage facilities).
  - Extensive public involvement during the entire process will be an absolute necessity in a successful completion of the transportation objectives.
- Coordination of the SNF characterization and transportation efforts should be accomplished by a centralized materials management and disposition program office with oversight authority in all pertinent DOE facilities.
- Planning should be founded on a global assessment of transportation economics. Greater initial effort and expenditure will likely result in long-term savings (fewer required total fuel shipments). Less initial effort will like result in a greater long-term expenditures. The balance between these two extremes must be carefully determined in order to produce the greatest programmatic efficiency. For example, completely new transportation system designs should be considered when fuel quantities are relatively large and use of existing packages is found to require a large number of inefficient shipments. While the initial outlay will be greater, resulting shipping efficiencies may provide an overall long-term economic advantage.
- DOE prioritization of SNF shipments and identification of desired and required schedules is needed early on to ensure optimized planning for all shipping campaigns as

a whole. In those cases where current storage facilities are adequate, continued storage in such facilities or use of administratively controlled onsite transfers to such facilities (using nonlicensed packages) should be considered as potential alternatives to immediate shipment in licensed packages. Fuels in less-than-adequate storage facilities should be given the highest priority for transportation planning.

More detailed discussions of these conclusions follow.

The primary conclusion from this study is that a relatively large quantity, but not all, of DOE-owned spent nuclear fuel can likely be transported in existing, currently licensed, irradiated fuel shipping packages. It is estimated that 77 of the approximately 230 fuels listed in Reference 2-1 might potentially be accommodated by existing packages. These fuels represent approximately 34% of all the various fuel types, and about 87.5% of the total heavy metal in the DOE-owned SNF inventory. Therefore, of all the different fuel types in the DOE-owned SNF inventory, approximately two-thirds either do not have a packaging matchup, or there were not sufficient fuel characteristics data available to make a transportation assessment. Of the remaining one-third of the fuel types, 16% appear to have at least one compatible package as-is. Another 12% could potentially have at least one compatible package if minor Certificate of Compliance changes are made and a new basket assembly is designed and qualified, as necessary. The final 6% could potentially have at least one compatible package if extensive changes are made to the safety analysis report for packaging and the Certificate of Compliance, and a new basket assembly is designed and qualified, as necessary. In addition, it is possible that additional design changes to existing packages, other than new basket designs, could be undertaken to allow additional fuel types to be transported. However, due to the complexity and interrelated nature of the many factors involved in packaging design, no estimates have been made in this study for such a level of packaging-related modification. Additionally, such an undertaking would almost inevitably entail resource and schedule requirements similar to those which would be required to qualify and entirely new package design.

The above estimates are based on data engineering judgments that indicate, for many categories of fuels, geometries, weights, decay heat loads and shielding needs appear to fall within the capability of one or more of the various existing shipping packages (see Tables 4-1 through 4-6). Potential criticality concerns have not been specifically addressed by this study, since criticality assessments involve complex and detailed analyses, which themselves call for detailed fuel-related characteristics data that are largely not currently available. Instead, it has been assumed that criticality concerns for any specific fuel type can eventually be addressed by appropriately limiting the quantity of fuel per shipment, maintaining positive post-accident payload configuration control, or incorporating neutron poisoning materials. Ultimately, more detailed criticality assessments for such fuels will probably result in a need for a greater number of shipments than has been estimated in this report. In most cases, however, it is unlikely that complete elimination of an otherwise compatible fuel/package combination would result.

Although shipment in existing packages is considered possible for many spent fuel categories, timelines and costs associated with implementation of most shipments will be significant. With only a few exceptions (i.e., the specific fuel/package matchups that currently exist), changes to current licensing documents (SARPs and Certificates of Compliance) will be required at a minimum, prior to the start of actual shipping campaigns. For the existing fuel/package matchups,

it is reasonable to expect that at least three months of planning, coordinating, and system acquisition activities will be required prior to initial shipments taking place.

For those fuels for which there is no specific transportation package matchup, a significant amount of resource expenditure is likely to be required in order to sufficiently characterize the SNF for purposes of adequately determining transportation package needs. In some cases, this effort may consist only of compiling existing records into an appropriately formatted, centralized data base. An example would be the Savannah River RBOF, for which comprehensive inventory data currently exist. At the other end of the spectrum, the Hanford K-Basin fuels will require a greater amount of detailed classification in terms of fuel age and condition before an efficient transportation campaign can be planned. It has been estimated that, given a reasonable amount of priority, a minimum of five years will be required to sufficiently characterize the entire inventory of noncommercial DOE-owned SNF. Obviously, transportation planning need not wait for the completion of the entire characterization effort. As characteristics for individual fuel types are determined, detailed transportation for those fuel types can commence.

Presently there appears to be little communication between the various fuel storage facilities regarding the definitions and eventual dispositions of their SNF inventories. For a reasonable transportation plan to be developed, greater facility coordination should be implemented. To this end, a materials management and disposition program should be initiated for purposes of detailed fuel characterization and transportation planning.

Once the SNF is adequately characterized and transportation planning is completed, detailed transport package modifications can commence, as required. If relatively simple and straightforward SARP and Certificate of Compliance modifications are required, initiation of shipments for a given fuel will realistically take a minimum of six months, even if the particular shipping campaign has high priority within the DOE system and with the DOE or NRC regulatory body having jurisdiction. In addition, depending on the actual characteristics of any specific fuel to be transported and the operational constraints imposed at the fuel's current storage location or ultimate receiving facility, much more extensive activities may be required prior to implementation of shipments. Potential activities range from development of new fuel baskets or repackaging of fuels to packaging or facility modifications to satisfaction of political and public concerns. Shipments requiring such hardware-related activities or those that are politically sensitive and publicly visible can be expected to require two or more years prior to initial shipment.

For certain fuel types or categories, it is expected that entirely new transportation package systems will actually be required if shipment is to occur in a licensed shipping package. It is also noted that even though use of existing packages is viable in many cases, such an approach may not always be the most cost-effective solution. If large quantities of fuel requiring multiple shipments are to be transported (e.g., N-Reactor fuel), and priorities and needs are such that up-front schedule delays are acceptable, it will likely be more cost effective to develop an entirely new, reasonably optimized transportation system. For these reasons, any detailed planning activities associated with management of DOE-owned SNF should include provisions for the development of at least one new transportation package system designed specifically for DOE-owned SNF. Development of such a system should, however, be deferred until after all DOE-owned SNF has been properly characterized, shipping priorities initially set, and detailed facility constraints appropriately factored in. At that time, a detailed specification identifying required and

desired package system attributes can be developed, which will ensure a cost-effective approach to dealing with DOE-owned fuels. With a design specification in hand, a new transport system development effort will likely require three or more years prior to initial shipments of SNF.

In order to ensure an optimally designed new package transportation system (or optimal use of an existing system), fuel groups or fuel characteristics to be accommodated must be carefully selected. Attempting to accommodate too large of a group of fuels in a specific package will either lead to an over-constrained set of design requirements and hence, no transport capability, or result in an inefficient system for many shipping campaigns. Conversely, too few fuels in a category, although possibly being more efficient for a given shipping campaign, will likely require multiple packages to be developed. Consequently, once fuel characteristics are clearly understood and shipping priorities set, a proper balance will need to be made between a "one package does all" approach with its potential inefficiencies for a given fuel type and a "one package per fuel type" approach, which will require far more development and licensing effort. The HFIR cask development effort, which would have accommodated a subset of DOE fuels, serves as a good "lessons learned" example. The request for proposal for that development effort was issued in May of 1986. To date, the subsequent development effort has been unsuccessful and has apparently been abandoned. The problems associated with that program must be avoided if successful transportation of DOE-owned SNF in licensed packages is to become a reality.

Additionally, although the total quantity of DOE-owned SNF is small compared to the quantity of commercial SNF, it must be realized that costs per MTHM for shipping DOE-owned SNF can be expected to greatly exceed corresponding costs for shipping commercial fuel. This is due to the wide variety of fuel types within the DOE system and the small quantities that exist at many different facilities. The wide variety of fuels will lead to a need for numerous different shipping campaigns and the small quantities per facility will lead to a need for many shipments per campaign. This rather large mix of fuels and facilities again points to the need for thorough and complete fuel characterization efforts and carefully established shipping priorities as early on steps in preparation for transport of DOE-owned SNF.

Last, though by no means least, the importance of public involvement throughout the entire planning and operation of the SNF transportation program cannot be overemphasized. Public resistance to large-scale movements of highly radioactive material will be enormous. Accordingly, the resources expended to overcome this resistance must be equally great.

Based on the above discussions, it is apparent that transport of DOE-owned SNF will not be a simple or rapidly completed activity. A tremendous amount of time and resources will be required. Consequently, continued storage in current facilities or use of administratively controlled onsite transfers to alternate facilities using nonlicensed packages should be considered as potential near-term alternatives to shipment in licensed packages.

6.3 Recommended Actions

Based on the study results documented and discussed herein, the following recommendations are made. Ideally, these actions would be carried out in the order presented. However, if shipping priorities so dictate, many of the actions could be carried out in parallel, with an increased risk that certain shipping campaigns could become less efficient or delayed due to conflicts with the

needs of the higher priority campaigns. At a minimum, an initial effort to address items 1 through 3 should be performed prior to completion of the remaining items.

1. In parallel with Items 2 and 3 below, DOE should prioritize shipping campaigns based on considerations such as the following. Note that significant funding and supporting studies may be required to adequately address these items.
  - a. Fuel condition
  - b. Fuel quantity at a given storage location
  - c. Storage facility condition
  - d. Political considerations.
2. Continue with the various fuels characterization efforts currently under way at many of the DOE sites, and complete the characterization of all DOE-owned spent nuclear fuel that must eventually be transported. This is a vital step, since packaging requirements directly relate to payload characteristics, and proper packagings can only be selected or developed once payloads are fully understood. In addition, past experiences indicate that successful licensing activities have always required well-understood and well-characterized payload definitions. Specific sub-steps include the following.
  - a. Correct inconsistencies between various reference documents, fill in the many unknowns currently identified in the data bases, identify special problems or restrictions associated with each fuel, etc. Note that prior characterization efforts were often based on voluntary, unfunded inputs. Significant funding may be required to adequately obtain all necessary data.
  - b. DOE should provide sufficient guidance to each site to ensure that all efforts are properly prioritized, coordinated, and consistently carried out. It appears that in many cases, fuels characterization activities being performed at one site are not visible to other sites.
3. The initial matrix of compatible fuels and packagings presented in this report should be revisited and corrected or expanded following, or in parallel with, completion of item 2. The potential use of new packages now under development, such as the multipurpose container (MPC) for commercial fuels (Request for Proposal issued June 1994, award expected in early 1995), the Office of Civilian Radioactive Waste Management-developed (but not yet licensed) GA 4/9 package, etc., should also be more closely investigated for potential application to DOE-owned SNF.
4. Based on the first three items and available funding, a detailed implementation strategy and desired and required shipping schedule should be developed. As part of the strategy, consideration should be given to continued storage at current facilities or possible onsite transfers to appropriate facilities in other than licensed packages. Keeping in mind that an optimized solution for one fuel type may be rather inefficient

for another type, this is also an appropriate time to revisit fuel categories or groups, the intent being to optimize transportation solutions for all fuels as a whole. A detailed assessment of the benefits of one or more entirely new package design development efforts geared specifically at DOE-owned SNF should also be included once governing characteristics for all fuels are fully understood. If a new system appears beneficial, it would be "speced out" at this time.

5. Select two or three specific fuels or fuel groups for detailed studies based on shipping priorities and the item 4 implementation strategy. Include the highest priority, the largest quantity, or one of the more difficult to address fuel groups. Include fuel at two or more sites, and shipping campaigns that involve both NRC and DOE certification activities, if possible.
6. Perform detailed paper studies for dealing with the selected fuel types, discuss details of intended design and licensing approaches in face-to-face meetings with the regulators, and document results for DOE consideration. These more detailed studies would include more rigorous structural, thermal, shielding or criticality analyses as appropriate to establish allowed fuel quantities per shipment, etc.
7. Fully implement study results for highest priority shipment including SARP and hardware modifications, certification activities, and actual transport.
8. Again considering shipping priorities, and applying lessons learned from the detailed studies of previously selected fuel types, refine or develop appropriate action plans for all remaining fuel groups.
9. Implement action plans for all remaining fuels.

As a final note, throughout this entire process, the need for public involvement must not be overlooked or underestimated. An overall public outreach strategy must be devised early on in the program. Large-scale efforts to inform and educate the public will be required continuously throughout the duration of the SNF shipping campaign. These educational programs should incorporate not only discussion but also demonstrations of actual program-related hardware, with an emphasis on the large degree of safety incorporated into its development and operation. Without such a public relations effort, no degree of technical effort will be sufficient to ensure a successful transportation program.

7. REFERENCES

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3. K. H. Bergsman, *Hanford Irradiated Fuel Inventory Baseline*, WHC-SD-CP-TI-175, Rev. 1, January 1993.
4. U.S. Department of Energy, *Spent Fuel Working Group Report*, Volume I, November 1993.
5. Code of Federal Regulations, 10 CFR 71, "Packaging and Transportation of Radioactive Material," Office of the Federal Register, proposed rule, June 8, 1988.
6. U.S. Department of Energy, Radioactive Materials Packages Database (RAMPAC), maintained by Analysas Corporation for the DOE's Transportation and Packaging Safety Division.
7. U.S. Nuclear Regulatory Commission, *Directory of Certificates of Compliance for Radioactive Materials Packages*, NUREG-0383, Volume 2, Revision 16, NRC Office of Nuclear Material Safety and Safeguards, October 1993.
8. U.S. Department of Energy, *Directory of Certificates of Compliance for Radioactive Materials Packaging*, DOE Transportation and Packaging Safety Division, April 26, 1994.
9. M. J. Monthey, *Engineering Study of the Transfer of Irradiated Fuels on the Hanford Site*, WHC-SD-TP-ES-001, Rev 0, April 20, 1993.
10. U.S. Department of Energy, DOE Order 5480.3, "Safety Requirements for the Packaging and Transportation of Hazardous Materials, Hazardous Substances, and Hazardous Wastes."
11. Code of Federal Regulations, 49 CFR 173, "Shippers—General Requirements for Shipments and Packagings," Office of the Federal Register, October 1993.
12. T. L. Sanders et al., *A Method for Determining the Spent-Fuel Contribution to Transport Cask Containment Requirements*, SAND90-2406/TTC-1019/UC-820, November 1992.
13. American National Standards Institute for Radioactive Materials, ANSI N14.5-1987, "Leakage Tests on Packages for Shipment," 1987.
14. H. W. Reno et al., "Transporting Spent and Damaged Fuel in the United States: Recent Experience and Lessons Learned Related to the Evolving Transportation Policy of the U.S. Department of Energy," *Proceedings of the 9th International Symposium on the Packaging and Transportation of Radioactive Materials (PATRAM)*, CONF-890631 (Vol 2), pp. 648-653, June 11-16, 1989.

15. U.S. Department of Energy, *History Summary of the Three-Mile Island Unit 2 Core Debris Transportation Campaign*, DOE/ID-10400, March 1993.

Appendix A

Fuel Data Sheets and Design Drawings/Sketches

This appendix provides available drawings of U.S. Department of Energy spent nuclear fuel. The data are drawn from References 1 through 4.

Dimensional Illustration of the Assembled HFIR Fuel Element.

(NIST?)
 SCHEMATIC OF NBSR FUEL SECTION

17 inner fuel plates 23.75 x 0.050 thick
 Fuel alloy core 22.75 long x 0.021 thick
 Cladding 0.012 thick, both sides

2 outer fuel plates 25 long x 0.140 thk.
 Fuel alloy core 22.75 long, 0.009 thick
 Cladding 0.015 thick, minimum

Notes:

1. Fuel cut to 24.50 to load in cask.
2. Dimensions are in inches.

SCHEMATIC OF SHORT HFBR TYPE KL SPENT FUEL ASSEMBLY

January, 1985

Dimensions are in inches.

SCHEMATIC OF MURR SPENT FUEL ASSEMBLY

MURR FUEL ELEMENT

TYPICAL X-SECTION
WITHOUT COMB

24 FUEL PLATES

TYPICAL X-SECTION
WITH COMB

Lifetime Record

8/11/88

APP

ELEVATION

Source: DOE, 1992e

N Reactor fuel assembly (this is a production reactor fuel).

Source: DOE, 1992f.
Figure 3. ATR fuel assembly.

Figure 3.1

MFC-80-C-11-175 REV 1

ZIRCONIUM ROD

GRAPHITE

GRAPHITE

U-Er-Zr 1.6

15.0-in.

30.0-in.

4234

1.411
in.

A-15

TRIGA FLIP FUEL ROD

(MI-9B)

Fuel-moderator element for Mark I reactor

PWR-2 Seed 1 and Seed 2 Fuel Cluster

21-1A Fuel Assembly Schematic

ACC-8-1456

FIG 2-19. 1-02

Pulsar Fuel Element

ACC-A-2906

LOWER

17"
BLANKET

Fermi I Axial Blanket Subassembly

Fermi I Radial Blanket Subassembly

REGULATING ROD	2
SAFETY ROD	8
CORE ELEMENT	105
INNER RADIAL BLANKET ELEMENT	22
OUTER RADIAL BLANKET ELEMENT	500
POSSIBLE ELEMENT STORAGE	24
STAINLESS STEEL THERMAL SHIELD ROD	193
STAINLESS STEEL THERMAL SHIELD ROD USED AS SURVEILLANCE TUBE	3
SURVEILLANCE TUBE	1
NEUTRON SOURCE	1
TOTAL	871

CORE ELEMENT

HORIZONTAL SECTION
REACTOR ENRICO FERMI

DATA SHEET I - ATTACHMENT 1

MTR FUEL ELEMENT

Fort St. Vrain graphite fuel.

Z93 0298

EBR-II FUEL SUBASSEMBLY AND FUEL ELEMENT

Appendix B

Packaging Data Sheets and Design Drawings/Sketches

This appendix provides copies of packaging Certificates of Compliance and basic dimension data in the form of drawings and, in some cases, individual data summaries.

GE T-2

**CERTIFICATE OF COMPLIANCE
FOR RADIOACTIVE MATERIALS PACKAGES**

U.S. NUCLEAR REGULATORY COMMISSION

1. a. CERTIFICATE NUMBER	b. REVISION NUMBER	c. PACKAGE IDENTIFICATION NUMBER	d. PAGE NUMBER	e. TOTAL NUMBER PAGES
5607	--8	USA/5607/B( )F	1	3

2. PREAMBLE

- This certificate is issued to certify that the 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."
- 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 (Name and Address)

U.S. Department of Energy
EH-33.2
Washington, DC 20585

b. TITLE AND IDENTIFICATION OF REPORT OR APPLICATION:

T-2 Shipping Package, Safety Analysis
Report, Draft: April 1980,
as supplemented.

c. DOCKET NUMBER

71-5607

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.: T-2
- (2) Description

Packaging for irradiated reactor fuel and components consisting of a lead encased in steel cask, removable containment vessel insert and shipping case.

The cask is a double-walled steel circular cylinder with thickened shielding in the center portion. The central cavity is 6.065 inches in diameter by 100 inches long. The lead shielding is 8.0 inches thick along a 45-inch center section reduced to 4.2 inches at each 36-inch end section. The containment vessel is positioned within the cask. Cask closure is accomplished by a gasketed and bolted steel plug. The cask is enclosed in the shipping case which is 36 inches in diameter by 133 inches long welded to a 4-foot by 6-foot steel pallet. The maximum weight of the packaging is 18,400 pounds.

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5.(a) (3) Drawings

- (i) The shipping case is constructed in accordance with DuPont Drawing Nos.: W716539, Rev. 0; 180191, Rev. 1; 180192, Rev. 0; 180193, Rev. 1; 180194, Rev. 0; 180197, Rev. 0; W716538, Rev. 0; 180195, Rev. 0; 180196, Rev. 0; and 180089, Rev. 0.
- (ii) The cask is constructed in accordance with General Electric Drawing Nos.: 919D755, Rev. 0; 135C5202, Rev. 0; 153F966, Rev. 0; and 106D3721, Rev. 0; or it is constructed in accordance with DuPont Drawing Nos.: W239534, Rev. 2*; 147214, Rev. 15; 147215, Rev. 2*; and 147216, Rev. 1.
- (iii) The ANL insert is constructed in accordance with Argonne National Laboratory Drawing Nos.: W0147-0227-DD, Rev. 7; W0147-0228-DD, Rev. 6; W0147-0229-DC, Rev. 6; W0147-0231-DD, Rev. 3; W0147-0234-DC, Rev. 4; and W0147-0312-DE, Rev. 2.
- (iv) The TREAT Vessel insert is constructed in accordance with Westinghouse Hanford Company Drawing Nos.: H-3-39082, Sheets 1 through 4 and 6, Rev. 0, and Sheet 5, Rev. 1; H-3-36134, Sheet 1, Rev. 3 and Sheet 2, Rev. 2; and H-3-36823, Sheet 1, Rev. 1 and Sheets 2 through 4, Rev. 0.

(b) Contents

(1) Type and form of material

- (i) Irradiated clad fuel in the form of solid metal, oxides, nitrides, and carbides of uranium, plutonium, or mixed uranium-plutonium contained within the ANL insert or TREAT vessel insert. The clad fuel may contain small quantities of Na or NaK. The minimum cooling time must be no less than 150 days.
- (ii) Irradiated clad fuel pins of uranium dioxide enriched to up to 3.0 w/o in U-235 contained within the ANL insert or TREAT vessel insert. Average exposure of fuel not to exceed 18 megawatt days per kilogram. The clad fuel may contain small quantities of Na or NaK. The minimum cooling time must be no less than 90 days.
- (iii) Irradiated reactor components held within the container shown in Drawing No. W0147-0234-DC, Rev. 4.

*As provided in the April 12, 1983, supplement.

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5.(b) (2) Maximum quantity of material per package.

Internal decay heat not to exceed 208 watts, and:

(i) For the material described in 5(b)(1)(i), fissile material not to exceed 1.71 kg.

(ii) For the material described in 5(b)(1)(ii), fissile material (U-235) not to exceed 300 grams.

(c) Fissile Class for the material described in 5(b)(1)(i) and 5(b)(1)(ii), and limited in 5(b)(2)(i) and 5(b)(2)(ii) I

6. The contents must be shipped dry. When loaded underwater, the package must be dried using Consumer Power Company's procedure, "T-2 Cask Liner Assembly Drying Procedure," Proc. No. EE&T-C12, Rev. 1, 11/12/81.
7. The ANL Insert and TREAT Vessel insert must be leak tested prior to first use and annually thereafter in accordance with the procedures specified in Argonne National Laboratories Document No. W0195-0054-ES-00.
8. Prior to each shipment, the package must be leak tested in accordance with procedures specified in Appendix A to HEEF/N.OMM 5202, Rev. 2, March 17, 1981.
9. In addition to the requirements of Subpart G of 10 CFR Part 71 and the other conditions of this certificate:
  - (a) The package shall be operated and prepared for shipment in accordance with the Operating Procedures in Chapter 7 of the application, as supplemented; and
  - (b) The package must be maintained in accordance with the Maintenance Program of Chapter 8 of the application, as supplemented.
10. The package authorized by this certificate is hereby approved for use under the general license provisions of 10 CFR §71.12.
11. Expiration date: May 31, 1995

REFERENCES

DuPont Safety Analysis Report, Draft April 1980.

Department of Energy supplements dated: February 11, April 8 and 20, 1982; April 12, 1983; February 26, 1992; and February 3, 1993.

FOR THE U.S. NUCLEAR REGULATORY COMMISSION

Charles E. MacDonald
Charles E. MacDonald, Chief
Transportation Branch
Division of Industrial and
Medical Nuclear Safety, NMSS

MAY 20 1993

Date: _____

GE-100

MODEL 100

REF. DWG. 7-1

ISOMETRIC VIEW
OF COMPLETE PACKAGE

THE TOP LID IS
13 1/2 DIA. 5/16
IN. THICK (1.000)

LOSS WIRE 4
REF. 129D4729

ENERGY ABSORBING ANGLES

PROTECTIVE JACKET
REF. 129D4729 01

PALLET
REF. 129D4729 02

JACKET REF. BOLT 2
200 CALIB. 1/4
IN. DIA. 1/2
IN. LONG 1/2
IN. THICK 1/2
IN. DIA. 1/2
IN. THICK

5 TYPICAL SHIELDING LINER
REF. 129D4731

SHIPPING CASK B.20V
REF. 129D4730

4 CASK LID
REF. 129D4730

ENERGY ABSORBING ANGLES

SECTION A-A

NOT FOR FABRICATION

CHECK PRINT	
NOT FOR PRODUCTION	
129D4727	10

PACKAGE WT. 4,570 LBS.
2,070 KG.

MODEL 100
NET ASSEMBLY

3 LID ATTACHMENT BOLTS
1.0-8UNF-2A-187A
GRADE 8 CAP OR TINE PLATE
(6 REQ.)

8 CASK PLATE
70.38 DIA. 1.125 THK.

14 DIAL
1.5 DIA. 1.25 THK.

28.75 REF
12 LID
1.25 DIA.

CASK LID 2
LEAD SWEETING

SEAL
TOP SEAL
2.07 x .13 THK.
SEAL ALUM.
BOTTOM SEAL
2.07 x .13 THK.
ALUM. w/ 8 WELDS
EUGENIE

CASK BODY SECTION A-A
WELDED JOINTS SHOWN
SHELL CASK MAY BE WELDED
STEEL AT 300 PSI MIN. ST.

TOP VIEW

NOT FOR FABRICATION

CHECK PRINT
NOT FOR PRODUCTION

10
1290 J73

CASK WT. 3200 LBS.
1450 KG.

**CERTIFICATE OF COMPLIANCE
FOR RADIOACTIVE MATERIALS PACKAGES**

U.S. NUCLEAR REGULATORY COMMISSION

1. a. CERTIFICATE NUMBER 5926	b. REVISION NUMBER 15	c. PACKAGE IDENTIFICATION NUMBER USA/5926/B( )F	d. PAGE NUMBER 1	e. TOTAL NUMBER PAGES 3

PREAMBLE

- a. This certificate is issued to certify that the 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 (Name and Address)

b. TITLE AND IDENTIFICATION OF REPORT OR APPLICATION:

General Electric Company
P.O. Box 460, Vallecitos Road
Pleasanton, CA 94566

General Electric Company application
dated November 19, 1987, as supplemented.

c. DOCKET NUMBER

71-5926

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.: GE-100

(2) Description

A steel encased lead shielded shipping cask. The cask is double-walled steel circular cylinder, 20-1/4-inch diameter by 26-7/8 inch high with a central cavity approximately 7-5/8-inch diameter, by 10 inches high. Approximately 5-7/8 inches of lead surround the central cavity. The cask is equipped with a cavity drain line and lifting device. Closure is accomplished by a gasketed and bolted steel lead filled plug. For additional shielding lead, tungsten or uranium liners may be inserted in the cask cavity. The maximum weight of the packaging is 4,800 pounds.

(3) Drawings

The packaging is constructed in accordance with General Electric Company Drawing Nos. 129D4727, Rev. 5; 129D4729, Rev. 5; 129D4730, Rev. 4; and 129D4731, Rev. 1.

CONDITIONS (continued)

Page 2 - Certificate No. 5926 - Revision No. 15 - Docket No. 71-5926

5. (b) Contents

(1) Type and form of material

(i) Byproduct and irradiated special nuclear material in the form of fuel rods, or plates, fuel assemblies, or meeting the requirements of special form radioactive material; or

(ii) Solid nonfissile irradiated metal hardware and reactor control rods (blades).

(2) Maximum quantity of material per package

Radioactive decay heat not to exceed 400 watts and 500 grams U-235 equivalent mass fissile material. (U-235 equivalent mass equals U-235 mass plus 1.66 times U-233 mass plus 1.66 times Pu mass).

Plutonium in excess of twenty (20) curies per package must be in the form of metal, metal alloy or reactor elements,

(c) Fissile Class

Minimum transport index to be shown on label:

II

Contents 5.(b)(1)(i):

5.6

6. Shoring shall be provided to minimize movement of contents during accident conditions of transport.
7. At the time of delivery of the loaded package to a carrier for transport, the package contents shall be dry and the fissile material unmoderated (H to X atomic ratio less than 2).
8. In addition to the requirements of Subpart G of 10 CFR Part 71:
  - (a) The package must be maintained in accordance with the maintenance procedures submitted with GE application dated January 18, 1993.
  - (b) The package must be prepared for shipment and operated in accordance with the operating procedures submitted with GE application dated January 18, 1993.
9. The package authorized by this certificate is hereby approved for use under the general license provisions of 10 CFR §71.12.
10. Expiration date: February 28, 1998.

CONDITIONS (continued)

Page 3 - Certificate No. 5926 - Revision No. 15 - Docket No. 71-5926

REFERENCES

General Electric Company application dated January 18, 1993.

Supplements dated: March 3, 1993.

FOR THE U.S. NUCLEAR REGULATORY COMMISSION

Charles E. MacDonald
Charles E. MacDonald, Chief
Transportation Branch
Division of Industrial and
and Medical Nuclear Safety, NMSS

Date: MAR 10 1993

BMI-1

**CERTIFICATE OF COMPLIANCE
FOR RADIOACTIVE MATERIALS PACKAGES**

U.S. NUCLEAR REGULATORY COMMISSION

1. a. CERTIFICATE NUMBER 5957	b. REVISION NUMBER 19	c. PACKAGE IDENTIFICATION NUMBER USA/5957/B( )F	d. PAGE NUMBER 1	e. TOTAL NUMBER PAGES 7

2. PREAMBLE

- a. This certificate is issued to certify that the 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 (Name and Address)

Department of Energy
Transportation & Packaging
Safety Div., EH-33.2
Washington, DC 20585

b. TITLE AND IDENTIFICATION OF REPORT OR APPLICATION:

Battelle Columbus Laboratories application
dated June 20, 1985, as supplemented.

c. DOCKET NUMBER 71-5957

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.: BMI-1

(2) Description

A steel-encased lead shielded shipping cask. The basic cask body is a cylinder 33.37 inches in diameter by 73.37 inches high formed by two concentric stainless steel shells whose annular region is filled with lead. The outer 1/2-inch thick shell has a 0.12-inch thick plate spot welded to it, providing a 0.06-inch thick air gap insulator. The inner shell is 15.5 inches inside diameter by 54 inches inside length. The cask lid is a stainless steel weldment having 7.75 inches of lead shielding. The cask lid is secured to the cask by twelve steel studs which are welded to the cask body. The cask is provided with a drain line with needle valve and plug, pressure gauge, and a pressure relief valve. The total cask weight, including maximum contents of 1,800 lbs, is 23,660 lbs.

(3) Drawings

The cask is constructed in accordance with the following Battelle Memorial Institute (BMI) Drawing Nos.: 43-6704-0001, Rev. B; and 41-4409-0003, Rev. B.

Page 2 - Certificate No. 5957 - Revision No. 19 - Docket No. 71-5957

5. (a) Packaging (continued)

(4) Product Containers

The various authorized product containers are constructed in accordance with the following Drawing Nos.:

- (i) Inner can assembly as shown in BMI Drawing No. 00-000-421, Rev. C.
- (ii) Basket Assembly as shown in BMI Drawing Nos. BCL-000-500, Rev. A; BCL-000-501, Rev. A; and 0048, Rev. A.
- (iii) Fermi Fuel Element copper casting assembly as shown in BMI Drawing No. K5928-5 0049D, Rev. to May 12, 1966.
- (iv) Basket Assembly as shown in BMI Drawing No. 1020, Rev. B (or with alternate spacer shown in CI Drawing No. 334D2193) or GA Drawing No. 9590001, Rev. A. Failed fuel assemblies must be seal welded in aluminum or stainless steel tubes with wall and end cap thicknesses of at least 0.015 inch.
- (v) Basket Assembly defined by BMI Drawing No. BCL-000-500, Rev. A, as modified by BMI Drawing Nos. 00-000-236, Rev. C, and BCL-000-502, Rev. B.
- (vi) Basket Assembly and storage can defined by BMI Drawing No. 00-000-391, Rev. C, and Atomic International Drawing No. AIHL, S8DR 0019-01, Rev. A, respectively.
- (vii) Inner can assembly as shown in Union Carbide Corporation Drawing No. 101501, Rev. A.
- (viii) Basket Assembly as shown in University of Missouri Research Reactor (MURR) Drawing No. 2234, Sheets 1 through 5, Revision 0.

(b) Contents

(1) Type and form of material

- (i) Intact irradiated MTR- or BRR-type fuel assemblies containing not more than 200 grams U-235 per assembly prior to irradiation. Uranium may be enriched to a maximum 93.5 w/o in the U-235 isotope. Active fuel length shall be approximately 25 inches.
- (ii) Intact irradiated Enrico Fermi Core. A fuel assembly containing not more than 4.77 kgs U-235 prior to irradiation. Uranium may be enriched to 25.6 w/o in the U-235 isotope.

CONDITIONS (continued)

Page 3 - Certificate No. 5957 - Revision No. 19 - Docket No. 71-5957

- (iii) Greater than Type A quantity of radioactive material which may include uranium enriched in the U-235 isotope, U-233, plutonium, as metal, oxides, or compounds which are thermally stable up to 600°F. Plutonium in excess of twenty (20) curies per package must be in the form of metal, metal alloy, or reactor elements.
- (iv) Greater than Type A quantity of byproduct material meeting the requirements of special form radioactive material.
- (v) Greater than Type A quantity of byproduct material in normal form as metal, oxides, or compounds which are thermally stable up to 600°F.
- (vi) Irradiated Triga Type fuel assemblies described in Section 6.6 of the application (pp. 6-23 through 6-27).
- (vii) Irradiated S8DR fuel elements 0.56-inch OD by 18.7 inches long by 0.010-inch wall thickness of Hastelloy-N. The fuel material is U-235 fully enriched in U-235.
- (viii) Intact irradiate CP-5 fuel assemblies containing not more than 176 grams U-235 per assembly prior to irradiation. Uranium may be enriched to a maximum 93 w/o in the U-235 isotope. Active fuel length shall be 28.5 inches.
- (ix) Solid nonfissile irradiated hardware which may contain encapsulated fission monitors.
- (x) Irradiated uranium oxide waste enriched in the U-235 isotope up to a nominal 93 w/o which is thermally stable up to 800°F.
- (xi) Irradiated uranium enriched in the U-235 isotope meeting the requirements of special form radioactive material.
- (xii) Intact irradiated MURR fuel assemblies containing not more than 775 grams of U-235 per assembly prior to irradiation. Uranium may be enriched to a maximum 93.5 w/o in the U-235 isotope. Active fuel length shall be 24 inches.
- (xiii) Intact irradiated MTR-II fuel assemblies containing not more than a nominal 510 grams of U-235 per assembly prior to irradiation. Uranium may be enriched to a maximum 93.5 w/o in the U-235 isotope. Active fuel length shall be approximately 24 inches.

(2) Maximum quantity of material per package

The minimum cooling time of each fuel assembly and rod is 90 days, maximum decay heat generation per package not to exceed 1.5 kw, and the external dose rate not to exceed 10 mrem/hr 3 feet from the external surface of the cask and:

(i) For the contents described in 5(b)(1)(i):

Twenty-four (24) fuel assemblies as contained in product containers specified in 5(a)(4)(ii) or 12 fuel assemblies as contained in product containers specified in 5(a)(4)(v).

(ii) For the contents described in 5(b)(1)(ii):

One (1) fuel assembly as contained in product container specified in 5(a)(4)(iii).

(iii) For the contents described in 5(b)(1)(iii):

480 grams U-233 or 480 grams Pu-239 or 800 grams U-235 as contained in product container specified in 5(a)(4)(i).

(iv) For the contents described in 5(b)(1)(iv):

Gamma sources securely confined in the cask cavity to preclude secondary impacts during accident conditions of transport. Thermal heat generation rate is limited to 200 watts.

For the contents described in 5(b)(1)(v):

Contained in product containers specified in 5(a)(4)(i) and limited to 200 thermal watts.

(vi) For the contents described in 5(b)(1)(vi):

Thirty-eight (38) fuel assemblies as contained in product containers specified in 5(a)(4)(iv). Fuel assemblies with an initial enrichment (U-235 in U) of greater than 70 w/o U-235 are limited to 19 assemblies per product container. Shipments of less than 19 assemblies with a U-235 enrichment greater than 70 w/o may be combined with assemblies of 70 w/o U-235 or less provided: $x/38 + y/19 \leq 1$; x = no. assy's ≤ 70 w/o U-235, y = no. assy's 70 w/o U-235.

CONDITIONS (continued)

Page 5 - Certificate No. 5957 - Revision No. 19 - Docket No. 71-5957

(vii) For the contents described in 5(b)(1)(vii):

Twenty-four (24) fuel elements per can and six sealed cans per basket as described in 5(a)(4)(vi). Each of the six cans may contain up to 818 g U-235 and 158 g hydrogen. The cask is limited to 4.908 kg U-235.

(viii) For the contents described in 5(b)(1)(viii):

Twelve (12) fuel assemblies.

(ix) For the contents described in 5(b)(1)(ix):

Thermal heat generation rate is limited to 200 watts.

(x) For the contents described in 5(b)(1)(x):

Twenty-four (24) containers each limited to 352 grams U-235 as contained in product containers specified in 5(a)(4)(vii). The decay heat per container is limited to 20 watts. The containers must be leak tested in accordance with Union Carbide Corporation letter dated November 17, 1980.

(xi) For the contents described in 5(b)(1)(xi):

Twenty-four (24) capsules each limited to 100 grams U-235.

(xii) For the contents described in 5(b)(1)(xii):

Eight (8) fuel assemblies as contained in the product container specified in 5(a)(4)(viii). The maximum burnup is 150 MWD/Assembly and the minimum cooling time of each fuel assembly is 150 days. The maximum radiation source term is 400,000 curies.

(xiii) For the contents described in 5(b)(1)(xiii):

Eight (8) fuel assemblies, contained in the product container specified in 5(a)(4)(viii). The maximum decay heat per package is 200 watts.

(c) Fissile Class

I and III

(1) Class I

For the contents specified in 5(b)(1)(iii) and limited in 5(b)(2)(iii).

CONDITIONS (continued)

Page 6 - Certificate No. 5957 - Revision No. 19 - Docket No. 71-5957

(2) Maximum number of
packages per shipment
as Fissile Class III

For the contents specified in
5(b)(1)(i), 5(b)(1)(ii),
5(b)(1)(vi), 5(b)(1)(vii),
5(b)(1)(viii), 5(b)(1)(x),
5(b)(1)(xi), 5(b)(1)(xii),
and 5(b)(1)(xiii), and
limited in 5(b)(2)(i),
5(b)(2)(ii), 5(b)(2)(vi),
5(b)(2)(vii), 5(b)(2)(viii),
5(b)(2)(x), 5(b)(2)(xi),
5(b)(2)(xii), and
5(b)(2)(xiii):

One (1) package.

6. For Item 5(b)(1)(iii), mixtures of fissile material are authorized, provided the following equation is satisfied:

$$\frac{X}{480} + \frac{Y}{480} + \frac{Z}{800} \leq 1, \text{ where}$$

X = Grams U-233 to be shipped

Y = Grams Pu-239 to be shipped

Z = Grams U-235 to be shipped

7. Except for the contents described in 5(b)(1)(i), 5(b)(1)(iv) and 5(b)(1)(xv); and limited in 5(b)(2)(i), 5(b)(2)(iv) and 5(b)(2)(xii), the cask must be shipped dry.
8. If the cask contents of 5(b)(1)(i), 5(b)(1)(iv) or 5(b)(1)(xii) are shipped wet, the licensee must confirm that the pressure relief valve is operable (set pressure - 75 psig). When needed, sufficient antifreeze in the cask must be used to prevent damage of any component of the package by freezing.
9. Loading and unloading operations of the contents described in 5(b)(1)(iii) and limited in 5(b)(2)(iii) must preclude contact of water with the contents.
10. When the contents of 5(b)(1)(vi) are loaded wet, the optional 0.5-inch diameter drain hole must be present in the primary basket lower plate to assure proper draining of the basket.
11. The presence and effectiveness of the Boral poison plate in the Basket Assemblies as shown in BMI Drawing Nos. BCL-000-500, Rev. A; 0048, Rev. A; and 00-000-236, Rev. C, must be verified by neutron measurements prior to first use and records maintained of such verification. Verification of the presence of the Boral must be made in each subsequent use.

CONDITIONS (continued)

Page 7 - Certificate No. 5957 - Revision No. 19 - Docket No. 71-5957

12. Contents 5(b)(1)(i) and 5(b)(1)(x) may be mixed provided the sum of the product containers and fuel assemblies does not exceed 24.
13. For contents described in 5(b)(1)(xiii), removable spacers may be used in each section of the basket to limit axial movement of the assemblies.
14. Contents must be securely confined in the cask cavity to preclude secondary impacts during accident conditions of transport.
15. Prior to each use, adequacy of containment vessel must be demonstrated by performance of the leak test described in Section 7.1.1.1 of the application.
16. Gaskets and seals (cask and fuel canister) must be replaced at least every 12 months or earlier if visible degradation occurs.
17. In addition to the requirements of Subpart G of 10 CFR Part 71:
  - (a) The package shall be prepared for shipment and operated in accordance with the Operating Procedures of Chapter 7 of the application.
  - (b) The packaging must meet the Acceptance Tests and Maintenance Program of Chapter 8 of the application.
18. The package authorized by this certificate is hereby approved for use under the general license provisions of 10 CFR 17.12.
19. Expiration date: May 31, 1995.

Battelle Columbus Laboratories consolidated application dated June 20, 1985.

Cintichem Inc. supplements dated December 14, 1987; May 30, July 15 and September 28, 1988; and April 17, 1990.

University of Missouri Research Reactor letters dated April 18, June 7, June 11, June 13, and August 8, 1990.

Massachusetts Institute of Technology Nuclear Reactor Laboratory letters dated October 19, 1992, and January 11, 1993.

FOR THE U.S. NUCLEAR REGULATORY COMMISSION

for *Ross Chappele*
Charles E. MacDonald, Chief
Transportation Branch
Division of Safeguards
and Transportation, NMSS

JAN 15 1993

Date: _____

FSV-1

SECTION II - PHYSICAL AND FUNCTIONAL DESCRIPTION

SECTION II - PHYSICAL AND FUNCTIONAL DESCRIPTION

GADR-55
SUPPLEMENT C

**CERTIFICATE OF COMPLIANCE
FOR RADIOACTIVE MATERIALS PACKAGES**

1. a. CERTIFICATE NUMBER 6346	b. REVISION NUMBER 23	c. PACKAGE IDENTIFICATION NUMBER USA/6346/B( )F	d. PAGE NUMBER 1	e. TOTAL NUMBER PAGES 5

2. PREAMBLE

- a. This certificate is issued to certify that the 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 (Name and Address)
- b. TITLE AND IDENTIFICATION OF REPORT OR APPLICATION:

Public Service Company of Colorado
2420 W. 26th Avenue, Suite 100D
Denver, CO 80211

Public Service Company of Colorado
application dated April 11, 1990,
as supplemented.

c. DOCKET NUMBER 71-6346

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.: FSV-1

(2) Description

A stainless steel encased, depleted uranium shielded cask. The cask body is a cylinder 208 inches long and 28 inches in diameter, except for the top flange area, which is 31 inches in diameter. The cavity is approximately 17.7 inches in diameter and 187.6 inches long.

The cask may be used in one of seven configurations (A through G) depending on contents. Configurations A, B, C and D are used to ship solid, non-fissile irradiated hardware. These configurations use an outer lid consisting of a 3.75-inch thick stainless steel plate and a 2.25-inch thick depleted uranium shield. The lid is bolted to the cask body by twenty-four 1.25-inch diameter fasteners. The primary seal is a silicone elastomeric seal ring between the outer lid and cask body. Configuration B does not require an inner container. Configuration C uses a supplemental stainless steel shield ring and cover plate. Configuration D uses a supplemental carbon steel shield ring and cover plate.

Configuration E is used to ship Fort St. Vrain (FSV) high temperature gas reactor (HTGR) fuel elements. This configuration uses the stainless steel inner container (as shown in General Atomic Drawing Nos. GADR 55-2-1, Rev. C, and GADR 55-2-2, Rev. A) as the containment vessel. The inner container lid is a stainless steel shell containing depleted uranium 4.15 inches thick. The inner lid is secured to the inner container body by twelve 0.5-inch diameter fasteners. The primary seal is a silicone elastomeric seal ring between the inner lid and inner container body. Configuration E is equipped with an impact limiter on the upper end.

CONDITIONS (continued)

Page 2 - Certificate No. 6346 - Revision No. 23 - Docket No. 71-6346

Configurations F and G are used to ship solid non-fissile irradiated and contaminated hardware from the FSV HGTR. These configurations use a 4.75-inch thick steel outer lid. The lid is secured to the cask body by twenty-four 1.25-inch diameter fasteners. The primary seal is a molded silicone elastomeric seal ring between the outer lid and cask body. Configurations F and G both use an impact limiter on the upper end. Configurations F and G also use a burial canister with a 12-inch thick carbon steel plug. The shielded spacer in the burial canister is used only in Configuration G.

The overall weight for the FSV-1 package is 46,025 pounds for Configurations A, B, C and D and 47,600 pounds for Configurations E, F and G.

(3) Drawings

The FSV-1 package is constructed in accordance with the following drawings:

Configuration A

National Lead Company Drawing Nos.: 70086F, Rev. 7; 70296F, Rev. 2; and General Atomics Drawing No. 1501-003, Rev. C.

Configuration B

Same as for Configuration A except that an inner container is not required.

Configuration C and D

In addition to the drawings for Configuration A, General Atomics Drawing Nos. GADR 55-2-10, Issue D and GADR 55-2-14, Issue N/C (optional). Configuration C uses a supplemental stainless steel shield ring and cover plate constructed in accordance with Drawing No. GADR 55-2-11, Issue B. Configuration D uses a supplemental carbon steel shield ring and cover plate constructed in accordance with Drawing No. GADR 55-2-11, Issue A.

Configuration E

In addition to the drawings for Configuration A, General Atomic Drawings Nos. GADR 55-2-1, Issue C; GADR 55-2-2, Issue A; and GADR 55-2-3, Issue B.

Configurations F and G

In addition to the drawings for Configuration A, General Atomic Drawings Nos. GADR 55-2-1, Issue C; GADR 55-2-2, Issue A; GADR 55-2-12, Issue C; and GADR 55-2-13, Issue A.

5. (b) Contents

(1) Type and form of material

- (i) Irradiated fuel elements consisting of graphite body, hexagonal in horizontal cross section, approximately 31.2 inches high and 14.2 inches across the flats. Prior to irradiation, each fuel element contains thorium and uranium enriched to a maximum of 93.5 w/o in the U-235 isotope, or
- (ii) Solid, irradiated and contaminated hardware, which may include fissile material, provided the quantity of fissile material does not exceed a Type A quantity and does not exceed the mass limits of 10 CFR §71.53, and neutron source components, or
- (iii) Solid, nonfissile, irradiated and contaminated hardware which has been removed from the Fort St. Vrain High-Temperature Gas Cooled Reactor and the surface contamination does not exceed 51 millicuries per package.

(2) Maximum quantity of material per package

Decay heat not to exceed 4.1 kw and:

(i) Item 5(b)(1)(i) above:

Six fuel elements each containing a maximum of 1.4 kg of enriched uranium, having a thorium/uranium ratio greater than 8.1:1 and weighing approximately 300 lbs. The gross weight of the cask cavity contents, including the component spacers, inner container and irradiated fuel elements shall not exceed 4,430 pounds. Contents must be shipped in Configuration E.

(ii) Item 5(b)(1)(ii) above:

The gross weight of the cask cavity contents, including appropriate component spacers, liners, inner containers, shield rings and solid, nonfissile irradiated and contaminated hardware shall not exceed 3,720 lbs. Contents must be shipped in Configuration A,B,C or D.

(iii) Item 5(b)(1)(iii) above:

The gross weight of all of the cask cavity contents, including burial canister and spacers, with or without supplemental shielding shall not exceed 4,430 pounds. Contents must be shipped in Configuration F or G.

CONDITIONS (continued)

Page 4 - Certificate No. 6346 - Revision No. 23 - Docket No. 71-6346

5. (b) (2) Continued

(c) Fissile Class

III

Maximum number of packages per shipment

One (1)

6. As needed, appropriate component spacers must be used in the cask cavity when shipping the contents described in paragraph 5(b) to limit movement of contents during shipment.
7. For transport of the contents of Item (b)(1)(ii) in Configuration D, the dose rate measured on the surface of the package must not exceed 200 mr/hr. For the purpose of this requirement, the surface of any personnel barrier may not be considered the surface of the package.
8. The Model No. FSV-1 cask may be wrapped with reinforced plastic when shipping the contents described in Item 5(b)(1)(ii) or (iii) provided the heat generation rate does not exceed 500 watts. The applicable requirements of 10 CFR §71.87 must be satisfied prior to wrapping the cask.
9. Use of packaging fabricated after August 31, 1986 is not authorized.
10. In addition to the requirements of Subpart G of 10 CFR Part 71:
  - (a) Configurations A, B, C, and D of the Model FSV-1 shipping cask shall be prepared for shipment and operated in accordance with the Operating Procedures of Section 7.0, Volume I, of the application, as supplemented. The package shall be maintained in accordance with the Maintenance Program in Section 8.0, Volume I, of the application, as supplemented.
  - (b) Configurations E, F, and G of the Model FSV-1 shipping cask shall be prepared for shipment and operated in accordance with the Operating Procedures of Section 7.0, Volume II, of the application, as supplemented. The package shall be maintained in accordance with the Maintenance Program in Section 8.0, Volume II, of the application, as supplemented.
  - (c) The main flange seals must be replaced within (12) months prior to any use of the packaging and must be replaced if inspection shows any defect.
  - (d) The silicone O-ring on the inner container primary plug in Configuration E must be replaced within the twelve (12) months prior to any use of the packaging and must be replaced if inspection shows any defect.

CONDITIONS (continued)

Page 5 - Certificate No. 6346 - Revision No. 23 - Docket No. 71-6346

11. The package authorized by this certificate is hereby approved for use under the general license provisions of 10 CFR §71.12.
12. Expiration date: April 30, 1996.

REFERENCES

Public Service Company of Colorado application dated April 11, 1990.

Supplements dated: June 28, and November 2, 1990; March 27, 1991; and March 30, 1992.

FOR THE U.S. NUCLEAR REGULATORY COMMISSION

Charles E. MacDonald
Charles E. MacDonald, Chief
Transportation Branch
Division of Safeguards
and Transportation, NMSS

Date: JUN 23 1992

NLI-1/2

PROPRIETARY
INFORMATION

NUCLEAR ASSURANCE CORPORATION SPENT FUEL STORAGE CASK BODY

NLI-1/2

NLI-1/2

<u>Owner</u>	Nuclear Assurance Corporation
<u>Type</u>	Legal Weight Truck Shipping Cask
<u>Manufacturer/Vendor</u>	NL Industries Inc.
<u>Capacity</u>	
Intact Spent Fuel Assemblies	1 PWR; 2 BWR
Cans Consolidated Fuel Rods	2 PWR; 4 BWR
Other Configuration	Metallic Fuel
<u>Weight (tons)</u>	
Loaded	23.1
Empty	22.3
<u>Design Heat Rejection (kW)</u>	10.6
<u>Shape</u>	Cylindrical
<u>Dimensions</u>	
Overall Length (in)	195.25
Overall Diameter (in)	47.125
Cavity Length (in)	178
Cavity Diameter (in)	13.375
Inner Shell Wall Thickness (in)	0.5
Depleted U Wall Thickness (in)	2.75
Lead Shield Wall Thickness (in)	2.125
Outer Shell Wall Thickness (in)	0.875
Neutron Shield Tank Thickness (in)	5.25
Inner Container Wall Thickness (in)	0.25
<u>Materials of Construction</u>	
Cask Body	SS/Depleted U/Lead/SS
Neutron Shield	
Sides	Water & Ethylene Glycol
End	None
Basket	SS and Aluminum
<u>Cavity Atmosphere</u>	He, Air if heat is less than 2.5 kW
<u>Operating Temperature (°F)</u>	1010 (maximum fuel cladding temperature)
<u>Operating Pressure (psig)</u>	117 (maximum)
<u>Outside Surface Dose (mrem/hr)</u>	53 (maximum)
<u>Licensing Status</u> - Initially licensed by the USNRC in 1974; can be used to ship either intact or consolidated LWR fuel.	
<u>Comments</u> - Casks have separate baskets for PWR and BWR fuel. There are five casks currently in existence.	

**CERTIFICATE OF COMPLIANCE
FOR RADIOACTIVE MATERIALS PACKAGES**

U.S. NUCLEAR REGULATORY COMMISSION

1. a. CERTIFICATE NUMBER	b. REVISION NUMBER	c. PACKAGE IDENTIFICATION NUMBER	d. PAGE NUMBER	e. TOTAL NUMBER PAGES
9010	35	USA/9010/B( )F	1	12

2. PREAMBLE

- This certificate is issued to certify that the 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."
- 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 (Name and Address)

b. TITLE AND IDENTIFICATION OF REPORT OR APPLICATION

Nuclear Assurance Corporation.
6251 Crooked Creek Road
Norcross, GA 30092

Nuclear Assurance Corporation application
dated November 1, 1990, as supplemented.

555 Engineering Drive, Suite 200

c. DOCKET NUMBER

71-9010

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.: NLI-1/2

(2) Description

A depleted uranium, water, and lead shielded shipping cask, encased in stainless steel, and equipped with balsa impact limiters. The cylindrical cask body is 195-1/4 inches long by 47-1/8 inches OD. The principal shielding consists of 2-3/4 inches of depleted uranium, 2-1/8 inches of lead, and 5 inches of (borated) water-ethylene glycol mixture.

A 7/8-inch thick stainless steel outer shell is welded to a solid stainless steel forging at each end of the cask. The outer shell of the cask is surrounded by a 1/4-inch thick steel water jacket that is also attached to the end forgings. A water expansion tank is welded to the water jacket shell. The inner cask cavity is formed by a 1/2-inch thick, stainless steel cylindrical shell; welded at its top end to the upper cask forging and its bottom end to a circular plate.

There are four separate configurations of the cask.

Configuration (A): The containment vessel is a right circular stainless steel shell, 12-5/8 inches ID by 178 inches inside length by 1/4-inch thick, located within the inner cask cavity. The containment vessel is closed and sealed by a 5-inch thick, composite steel and uranium closure head, twelve, 1-inch diameter bolts, and silver plated, metallic O-ring. Eight of the twelve closure bolts are used to secure the containment vessel to the upper cask forging. Closure of the cask cavity is by a 1-1/2-inch thick steel closure head, eight, 1-inch diameter bolts, and elastomer O-ring. The radioactive contents are positioned and supported within the containment vessel (inner container) by an aluminum basket and internal support structure.

5. (a) Packaging (continued)

(2) Description (continued)

Configuration (B): The containment vessel is the 1/2-inch thick inner cavity shell. The 1/4-inch thick inner container is not used. The cask cavity is closed by two closure heads. The inner head is a 6-inch thick, composite steel and uranium plate secured to the upper cask forging by twelve, 1-inch diameter bolts and sealed with a silver plated, metallic O-ring. The outer head is 1-1/2-inch thick steel plate secured to the top of the upper cask forging by eight, 1-inch diameter bolts and sealed with an elastomer O-ring. The radioactive contents are positioned and supported within the containment vessel (inner cask cavity) by a modified aluminum basket and internal support structure.

Configuration (C): Same as Configuration (B), above, except the radioactive contents are positioned and supported within the containment vessel (inner cask cavity) in a stainless steel structure containing Boral sheets positioned so as to provide necessary neutron absorption.

Configuration (D): Same as Configuration (B) above, except that the radioactive contents are positioned and supported within the containment vessel (inner cask cavity) in a 3-element stainless steel structure as shown in NAC Drawing No. 347-291-F12, Rev. 2, and the cask must be enclosed in a closed shipping container.

The package, including impact limiters, has an overall length of 237 inches and an outside diameter of 75 inches. The maximum weight of the contents is 3,000 pounds. The weight of the package is approximately 49,250 pounds.

(3) Drawings

The Model No. NLI-1/2 shipping cask is constructed in accordance with the following National Lead Company Drawing Nos.:

General

70514F, Sheet 1, Rev. 8, Cask and Trailer General Arrangement
 70514F, Sheet 2, Rev. 8, Cask and Trailer General Arrangement
 70885F, Sheet 1, Rev. 3, Spent Fuel Cask Details
 70885F, Sheet 2, Rev. 2, Spent Fuel Cask Details
 70885F, Sheet 3, Rev. 2, Spent Fuel Cask Details
 70885F, Sheet 4, Rev. 1, Spent Fuel Cask Details
 70887F, Sheet 1, Rev. 1, Outer Closure Head

CONDITIONS (continued)

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5. (a) Packaging (continued)

(3) Drawings (Continued)

Configuration (A)

70516F, Sheet 1, Rev. 8; Spent Fuel Cask General Assembly
70562F, Sheet 1, Rev. 10, Inner Container
70562F, Sheet 2, Rev. 6, Inner Container
70562F, Sheet 3, Rev. 0, Inner Container*
70562F, Sheet 4, Rev. 0, Inner Container*

Configuration (B)

70888F, Sheet 1, Rev. 3, Spent Fuel Cask General Assembly
70886F, Sheet 1, Rev. 2, Basket Concept
70884F, Sheet 1, Rev. 2, Inner Closure Head

Configuration (C)

70888F, Sheet 1, Rev. 3, Spent Fuel Cask General Assembly
460-052-F8, Sheet 1, Rev. 4, Rockwell Fuel Basket-NLI-1/2 Cask*
460-052-F9, Sheet 1, Rev. 3, Container - Fermi Fuel, Rockwell
Basket, NLI-1/2 Cask, Assy of*

Configuration (D)

70888F, Sheet 1, Rev. 3, Spent Fuel Cask General Assembly
347-291-F12, Rev. 2, Eimer - 3 Element, NLI-1/2 Cask, Fuel
Movement Project*

*Nuclear Assurance Corporation drawings.

5. (b) Contents

(1) Type and form of material

(i) Irradiated PWR or BWR uranium oxide fuel assemblies of the following specifications:

	<u>PWR</u>	<u>BWR</u>	<u>Consolidated Fuel Rods</u>
Fuel form	Clad UO ₂ pellet	Clad UO ₂ pellet	Clad UO ₂ pellets
Cladding material	Zr or SS	Zr or SS	Zr or SS
Maximum initial fuel pin pressure at 100°F psig	550	200	550
Maximum initial U content/assembly, kg	475	197	950
Maximum average initial U-235 enrichment, w/o	3.70	3.65	3.70
Maximum bundle cross section, inches	8.75	8.75	8.75
Fuel pin array size	14x14/15x15 16x16/17x17	7x7 8x8	Pins from 7x7, 8x8, 14x14, 15x15, 16x16, 17x17 in triangular pitch

CONDITIONS (continued)

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(b) (1) (i) (continued)

	<u>PWR</u>	<u>BWR</u>	<u>Consolidated Fuel Rods</u>
Maximum active fuel length, inches	144	145.25	144
Maximum specific power, kw/kgU	40	27	40
Maximum average burnup, MWD/MTU	40,000**	34,000	40,000
Maximum decay heat, kw	10.6	10.6	0.6
Minimum cooling time, days	150*	120	4,380

The PWR type assembly may be shipped either with or without burnable poison rods or control rods.

*Four (4) fuel rods may have a minimum cooling time of 120 days.

**PWR fuel assembly may have a maximum average burnup of 56,000 MWD/MTU provided the minimum cooling time prior to shipment is 450 days and the neutron shield fluid contains 1.0 weight percent boron. (The borated fluid may be left in the shielding tanks during the shipment of other contents.)

(ii) Irradiated metallic fuels of the following specifications:

	<u>Fermi-1</u>	<u>FBR-II Blanket</u>
Fuel form	Uranium-Molybdenum alloy pins	Uranium metal cylindrical slugs
Cladding Material	Zr ★ ★ ★ ★ ★	Aluminum containers
Max. initial U content/assembly, kg	18.7/assy. 300/16 assy. cask load	292/container
Max. avg. initial U-235 enrichment, w/o	26.0	0.21 (3.88 kg Pu/canister)

CONDITIONS (continued)

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5. (b) (1) (ii) (continued)

	<u>Fermi-1</u>	<u>EBR-II Blanket</u>
Max. bundle cross section, inches	2.93 sq	4.875 dia
Fuel rods per canister	140	41
Max. active fuel length, inches	30.5 / assy 122 / cask	157
Max. Average Burnup, MWD/MTU	2,840	2,400
Max. Decay Heat, watts	20	300
Min. Cooling Time, days	5,000	365
(iii)		<u>Research Reactor</u>
Fuel Form		Uranium metal rods
Cladding Material		Aluminum
Maximum initial U Content/Assembly - kg		54.5
Maximum average initial U-235 enrichment		Natural
Maximum bundle cross-section, inches		1.36
Intact Fuel Rods per canister, maximum		7
Canisters per cask		3 intact fuel
Max. Active fuel length, inches		120.5
Maximum average burnup MWD/MTU		1,600
Maximum decay heat, watts		750
Minimum Cooling Time, days		365

CONDITIONS (continued)

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j. (b) (1) (Continued)

(iv) Irradiated PWR* or BWR uranium oxide fuel rods of the following specifications:

	<u>PWR Rods</u>	<u>BWR Rods</u>
Fuel form	Clad UO_2 pellets	Clad UO_2 pellets
Cladding material	Zr or SS	Zr or SS
Maximum initial fuel pin pressure at 100°F, psig	550	200
Maximum initial U content, kg	58.2	75
Maximum average initial U-235 enrichment, w/o	4.9	5.0
Maximum bundle cross section, inches	8.75	5.75
Maximum active fuel length, inches	150	150
Maximum specific power, kw/kgU	44	60
Maximum average burnup, MWD/MTU	60,000	75,000
Maximum decay heat, kw	1.65	4.0
Minimum cooling time, days	150	150

* For the shipments of irradiated PWR fuel rods, the neutron shield fluid must contain 1.0 weight percent boron (the borated fluid may be left in the shielding tanks during the shipment of other contents)..

5. (b) (1) (v) Solid, non-fissile, irradiated hardware and neutron source components.
  - (vi) Byproduct and special nuclear material in the form of irradiated uranium and plutonium oxide fuel rods. Prior to irradiation, the maximum average enrichment in U-235 plus plutonium not to exceed 3.70 w/o and the maximum enrichment not to exceed 4.0 w/o.
  - (vii) Irradiated PWR uranium oxide fuel assemblies including additional irradiated fuel rods inserted and secured in the guide thimbles. The fuel assemblies must conform to the maximum active dimensions as described in Item 5 (b) (i) except that maximum initial U content must be 495 kg and the maximum average initial U-235 enrichment shall be 3.35 w/o.
  - (viii) Irradiated Connecticut Yankee fuel assembly with a maximum average initial U-235 enrichment of 4.0 w/o and each of the 15 x 15 fuel rods clad by stainless steel. 204 rods/assembly; active length of 121.4 inches.
  - (ix) Irradiated MARK 42 fuel assemblies consisting of three concentric fuel tubes with PuO₂-Al powder metallurgy cores clad with type 6063 aluminum, containing a total of 3.35 kg of plutonium. The plutonium was initially enriched to contain 78.28 w/o Pu-239, 2.27 w/o Pu-241 and 0.15 w/o Pu-238.
  - (x) Irradiated MARK 22 fuel assemblies consisting of two concentric fuel tubes with uranium-aluminum cores clad with type 8001 aluminum, containing a total of 3.2 kg of uranium-235. The uranium was initially enriched to contain 66 w/o to 80 w/o uranium-235. The irradiated MARK 22 fuel assembly has an active length of 150 inches, a maximum burn-up of 1226 MWD and a minimum cooling time of 150 days.
- (2) Maximum Quantity of material per package
  - (i) Items 5(b)(1)(i) or 5(b)(1)(vii) above: one PWR fuel assembly; two BWR fuel assemblies; or one consolidated fuel canister. Fuel assemblies to be contained in their respective fuel baskets as shown on National Lead Company Drawing No. 70562F, Sheet 1, Rev. 10 or 70886F, Sheet 1, Rev. 2. The consolidated fuel canister to be contained in Configuration (A) fuel basket as shown on National Lead Company Drawing No. 70562F, Sheet 1, Rev. 10.
  - (ii) Item 5(b)(1)(ii) above: four canisters per cask. The fuel canisters and fuel basket must be in accordance with Configuration (C) above.

CONDITIONS (continued)

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5. (b) (2) (continued)

(iii) Item 5(b)(1)(iii) above:

- (a) three canisters of unfailed fuel containing up to seven fuel rods per canister. The fuel canisters and fuel basket must be in accordance with Configuration (D) above; or
- (b) up to six canisters containing one defective fuel rod per canister. The canisters are 2.75-inch I.D. failed fuel rod canisters as shown on Nuclear Assurance Corporation Drawing No. 340-108-D2, Rev. 10, and are placed in the six-rod capacity liner as shown on Nuclear Assurance Corporation Drawing No. 347-029-20, Rev. 1. The maximum decay heat load for a defective fuel rod is limited to 5 watts; or
- (c) up to three canisters containing either one defective fuel rod per canister or up to 10 failed fuel filters per canister. The canisters are 4.00-inch I.D. failed fuel rod canisters as shown on Nuclear Assurance Corporation Drawing No. 340-108-D1, Rev. 10. The fuel basket is in accordance with Configuration (D) above. The weight of the filters is limited to 125 pounds per canister. The maximum decay heat load for the defective fuel rods and the failed fuel filters is limited to 5 watts per canister. Plutonium content of the filters not to exceed 20 curies plutonium per package.

(iv) Item 5(b)(1)(iv) above: up to 25 PWR fuel rods or up to 25 BWR fuel rods per cask, in Configuration (A) or (B). Up to 2 of the 25 PWR rods may have a maximum burnup of 65,000 MWD/MTU. PWR fuel rods with burnup in excess of 45,000 MWD/MTU and BWR fuel rods with burnup in excess of 50,000 MWD/MTU will be shipped in Configuration (A) only. The maximum initial uranium content is limited to 58.2 kg per package for PWR rods and 75 kg per package for BWR rods.

(v) Item 5(b)(1)(v) above, weight not to exceed 1,600 pounds.

(vi) Item 5(b)(1)(vi) above, the maximum mass of U-235 plus plutonium must not exceed 4.0 kg. Fuel rods must be contained in fuel baskets as shown on National Lead Company Drawing No. 70562F, Sheet 1, Rev. 10 or 70886F, Sheet 1, Rev. 2.

(vii) Item 5(b)(1)(vii) above: One Connecticut Yankee intact irradiated fuel assembly.

(viii) Item 5(b)(1)(ix) above: One irradiated MARK 42 fuel assembly in either intact or sectioned form, using Configuration (C) above. If sectioned, each section must be seal welded in a shipping can as shown on Martin Marietta Energy Systems Drawing Nos. M-12821-CP-105E, Rev. 0 and M-12821-CP-106E, Rev. 1. Four shipping cans will

be loaded into a MARK 42 Segment Dry Shipping Canister as shown on Martin Marietta Energy Systems Drawing No. M-12821-CP-102, Rev. 1, along with a shipping canister spacer, as shown on Martin Marietta Energy Systems Drawing No. M-12821-CP-103, Rev. 1. The shipping canister will be loaded on top of a carrier spacer as shown on Martin Marietta Energy Systems Drawing No. M-12821-CP-112, Rev. 0. A maximum of 2 shipping canisters may be loaded into a cask. Intact fuel assemblies will be shipped in a MARK 42 Element Wet Shipping Canister as shown on Martin Marietta Energy Systems Drawing No. M-12821-CP-114, Rev. 0. A maximum of one intact assembly may be loaded into a cask.

- (ix) Item 5(b)(1)(x) above: Two MARK 22 fuel assemblies or one MARK 22 fuel assembly with the two cores separated, using Configuration (C) above. Each assembly or core will be shipped in a shipping canister as shown on Sandia National Laboratory Drawing No. R21563, Sheet 1, Iss. B.

(c) Fissile Class

III

Maximum number of packages per shipment

One

6. Irradiated fuels described in items 5(b)(1)(i), 5(b)(1)(ii), 5(b)(1)(iii) and 5(b)(1)(iv) above may not have a maximum burnup which exceeds 1.25 times the specified maximum average burnup.
7. The cask cavity and containment vessel (inner container) must be dry (no free water) when delivered to a carrier for transport. Residual moisture must be promptly removed from the cask cavity and containment vessel by the methods described in Section XV of the Application. Removal of the residual moisture from cask cavity when package is used in Configurations (B), (C), or (D) is not required providing the decay heat load does not exceed 2.0 kw.
8. For the shipment of irradiated fuel assemblies or a canister of consolidated irradiated fuel, the cask cavity canister of consolidated irradiated fuel (if present), and containment vessel must be promptly inerted following removal of the water from the cavity. For contents not vacuum dried, the cask cavity and containment vessel must be purged at least three times with argon, nitrogen, or helium. Each purge volume must be equivalent to or greater than the cask cavity and containment vessel volume. After the final purge, or following vacuum drying, the cavity and containment vessel must be promptly filled with argon, nitrogen, or helium at 1.0 atm pressure.
9. Known or suspected failed fuel assemblies (rods) and fuel with cladding defects greater than pin holes and hairline cracks must be shipped in Configuration (A).
10. The consolidated fuel canister must be provided with vent and drain lines (openings) to permit free draining of the canister. No valves can be installed on the vent and drain lines.

CONDITIONS (continued)

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11. The cask may be shipped in a closed shipping container (Configuration D) provided that the closed shipping container, and the transport vehicle (trailer) meet the applicable requirements of the Department of Transportation. Tie-down devices which are a structural part of the cask and the cask support structures must comply with 10 CFR 71.45.
12. When the cask is shipped in a closed shipping container the center of gravity of the combined cask, closed shipping container and trailer must not exceed 75.0 inches.
13. When the cask is shipped in a closed shipping container, the internal heat load must not exceed 750 watts.
14. The neutron shielding tank must be filled with a mixture of water and ethylene glycol (52% by volume). This mixture must not freeze or precipitate in a temperature range from 40°F to 330°F. The neutron shield tank may be empty when the cask is in Configuration D.
15. The structures used to support the package on the transport vehicle must be as described in the Application.
16. Any system used for cooling down the package must be provided with a pressure relief device set so that during the cool-down process, the maximum pressure in the containment vessel cannot exceed 310 psig when the package is used in Configuration (A) or 365 psig when the package is used in Configuration (B).
17. As needed, appropriate component spacers must be used in the cask cavity to limit movement of contents during shipment.
18. Shipping cans used for sectioned MARK-42 irradiated fuel assemblies must be seal welded and must be leak tested to 1×10^{-5} std cm³/sec.
19. In addition to the requirements of Subpart G of 10 CFR Part 71:
  - (a) The package shall be prepared for shipment and operated in accordance with the operating procedures in Section XV of the application, as supplemented.
  - (b) The package shall be maintained and tested in accordance with the maintenance program in Section XVI of the application, as supplemented.

CONDITIONS (continued)

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20. The package authorized by this certificate is hereby approved for use under the general license provisions of 10 CFR §71.12.
21. Expiration date: March 31, 1996.

REFERENCES

Nuclear Assurance Corporation application dated November 1, 1990.

Supplements dated: March 7 and 18, August 21, October 2 and 23, 1991; and April 14, 1992.

FOR THE U.S. NUCLEAR REGULATORY COMMISSION

Charles E. MacDonald, Chief
Transportation Branch
Division of Safeguards
and Transportation, NMSS

Date: JUN 16 1992

NLI 6502

Drawing Not Available

**CERTIFICATE OF COMPLIANCE
FOR RADIOACTIVE MATERIALS PACKAGES**

U.S. NUCLEAR REGULATORY COMMISSION

1. CERTIFICATE NUMBER 9103	2. REVISION NUMBER 6	3. PACKAGE IDENTIFICATION NUMBER USA/9103/B( )F	4. PAGE NUMBER 1	5. TOTAL NUMBER PAGES 4

PREAMBLE

- This certificate is issued to certify that the 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."
- 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.

2. THIS CERTIFICATE IS ISSUED ON THE BASIS OF A SAFETY ANALYSIS REPORT OF THE PACKAGE DESIGN OR APPLICATION
a. ISSUED TO (Name and Address) b. TITLE AND IDENTIFICATION OF REPORT OR APPLICATION:

Nuclear Assurance Corporation
6251 Crooked Creek Road
Norcross, GA 30092

NL Industries, Inc. application dated
September 7, 1977, as supplemented.

71-9103

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.: NLI-6502

(2) Description

A steel, lead, and depleted uranium shielded shipping cask. Its overall dimensions are 24.5 inches in diameter by 130 inches long. The loaded cask weighs about 46,300 pounds. The wall thickness of the cavity and outer shell is 1 1/2 inch. The wall thickness of the inner shell is 1 inch. The main body of the cask is divided into two regions. The upper region, which is a maximum of 5 3/4 inches thick, contains uranium shielding angles at the four corners; the remainder of the shielding region is filled with chemical grade lead. The outer (sacrificial) 3-inch thick region is filled with lower melting point 6% antimonial lead. The cask contains six fusible "weep holes" around the cask at each end. This sacrificial region also contains 10 layers of 0.018-in terne plate. The main body of the cask is equipped with two lids, one at each end. The two lids are similar in construction, each being 24.5 inches in diameter and extending 5 inches into the cask recess. The lids, like the main cask body, contain an outer sacrificial region (2" thick containing ten 0.018-in terne discs with the remaining volume filled with 6% antimonial lead) and an inner region (4-5/8" thick) containing chemical grade lead. The sacrificial region in each lid is fitted with exterior weep holes.

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5. (a) (2) Description (Cont'd)

One lid contains a 1/2-inch drain line and valve. The other lid contains two, 1/2-inch lines for a pressure relief valve and the other line is capped.

The fuel rods are contained within an approximate 11-1/2-inch square by 128-1/2-inch long openwork basket constructed of stainless steel angle and strap. The basket has a full-length lid along one side, for horizontal loading and a lid on one end for vertical unloading. A vertical, stainless steel-clad Boron poison plate divides the basket into two full-length halves, and two partial poison plates are incorporated into the sides of the basket.

A metal screen enclosure surrounds the package in transport to serve as a sun shade and prevent inadvertent use of structural parts of the package, other than the tie-down devices for securing the package to the vehicle during transport.

The cask rests horizontally on its integral supporting structure at each end, and the supporting structure is bolted to a separate structure attached to the deck of the special trailer provided for its use.

(3) Drawings

The Model No. NLI-6502 shipping package is constructed in accordance with the National Fuel Company Drawing Nos.:

5797-B, Rev. 1	Details Safety Shield
5798-0, Rev. 1	Cask Tie-Down
6502-01, Rev. 5	Basket Details
6502-03, Rev. 4	Latch and Basket Details
6502-04, Rev. 3	Basket and Lid Assembly
6502-07, Rev. 5	Cask
6502-08, Rev. 4	Lid Assembly and Details

5. (b) Contents

(1) Type and form of material

Irradiated aluminum-uranium alloy fuel rods enriched in the U-235 isotope with the following specifications:

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5. (b) (1) (Cont'd)

	<u>NRU</u>	<u>NRX and Miscellaneous*</u>
Maximum U-235 content per rod prior to irradiation, g	495 (1.8 per cm)	550 (4.0 per cm)
Minimum average burnup, %	45	45
Minimum decay time, days	120	120

*May be a mixture of NRX fuel rods, NRX fuel rod element sections in a can, bundles of SLOWPOKE fuel elements in a can and sections of fast neutron fuel tubes and plugs in a can.

(2) Maximum quantity of material per package

The maximum decay heat load per package not to exceed 14,000 Btu/hr; and 9.9 kg U-235 in the form of NRU fuel rods or 15.4 kg U-235 in the form of NRX fuel rods or miscellaneous SLOWPOKE elements, fast neutron tubes and plugs.

(c) Fissile Class

Maximum number of packages
per shipment

IIIF

One (1)

6. Poison inspection and loading of fuel rods must be subject to the following conditions:

- Poison inspection and loading of fuel rods in accordance with Section VII-B.2.(B).(3.) (pp. VII-10 thru VII-11) of the application, and
- The package must not be loaded with a mass which exceeds 75% of critical, determined by extrapolation to zero reciprocal count rate.

7. Dummy fuel rods consisting of empty aluminum pipes must be installed in every fuel rod position not occupied with fuel.

8. The cask cavity must be dry (no free water) when delivered to a carrier for transport.

Page 4 - Certificate No. 9103 - Revision No. 6 - Docket No. 71-9103

9. The cavity pressure relief valve must be tested at set pressure every twelve (12) months.
10. Additional contents in accordance with Nuclear Assurance Corporation application dated February 17, 1982. Fuel rods must be contained within a fuel basket to minimize damage to the rods during normal conditions of transport.
11. In addition to the requirements of Subpart G of 10 CFR Part 71:
  - (a) Prior to each shipment, the Buna-N rubber lid gasket(s) (if opened) must be inspected. These gaskets must be replaced if inspection shows any defects or replace both gaskets every twelve (12) months, whichever occurs first. Cavity lines must be sealed with appropriate sealant applied to threads of pipe caps or plugs.
  - (b) The package must be maintained in accordance with Section VIII of the application.
  - (c) The package must be prepared for shipment and operated in accordance with UNIT-NLI-040, supplement dated September 20, 1988.
12. The cask contents must be so limited under normal conditions of transport that the dose rate will not exceed 10 mrem/hr at one meter from the external surface of the cask.
13. The package authorized by this certificate is hereby approved for use under the general license provisions of 10 CFR § 21.12.
14. Expiration date: October 31, 1993.

REFERENCES

NL Industries, Inc. application dated September 7, 1977.

Supplements dated: May 1, 1978; December 16, 1985; and May 11, July 5, and September 20, 1988.

FOR THE U.S. NUCLEAR REGULATORY COMMISSION

Charles E. MacDonald, Chief
Transportation Branch
Division of Safeguards and
Transportation, NMSS

Date: OCT 13 1988

T-3

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1. The defendant
 The defendant is the
 person who is being
 charged with a crime.
 2. The victim
 The victim is the
 person who has been
 harmed by the crime.
 3. The witness
 The witness is the
 person who has seen
 the crime being
 committed.
 4. The police
 The police are the
 law enforcement
 officers who are
 responsible for
 investigating and
 prosecuting crimes.
 5. The judge
 The judge is the
 official who presides
 over the trial and
 makes the final
 decision on the
 guilt of the
 defendant.
 6. The jury
 The jury is a group
 of people who are
 responsible for
 deciding the guilt
 of the defendant.
 7. The prosecutor
 The prosecutor is the
 lawyer who represents
 the state and
 brings the charges
 against the
 defendant.
 8. The defense attorney
 The defense attorney
 is the lawyer who
 represents the
 defendant and
 tries to prove
 their innocence.
 9. The court
 The court is the
 place where the
 trial takes place.
 10. The trial
 The trial is the
 process of
 presenting evidence
 and arguments to
 the judge and jury
 to determine the
 guilt of the
 defendant.

Rev 2.

2-297

**CERTIFICATE OF COMPLIANCE
FOR RADIOACTIVE MATERIALS PACKAGES**

U.S. NUCLEAR REGULATORY COMMISSION

1. a. CERTIFICATE NUMBER	b. REVISION NUMBER	c. PACKAGE IDENTIFICATION NUMBER	d. PAGE NUMBER	e. TOTAL NUMBER PAGES
9132	12	USA/9132/B(M)R	1	5

2. PREAMBLE

- a. This certificate is issued to certify that the packaging and contents described in Item 5 below, meet 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 (Name and Address)   b. TITLE AND IDENTIFICATION OF REPORT OR APPLICATION:

U.S. Department of Energy
EH-32
Washington, DC 20585

Nuclear Packaging, Inc. application
April 22, 1985, as supplemented.

c. DOCKET NUMBER   71-9132

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.: T-3
- (2) Description

A stainless steel and lead shielded irradiated fuel shipping package (cask). The cask is a right circular cylinder with upper and lower steel encased rigid polyurethane foam (20 lb/ft³) impact limiters. The overall dimensions are 213.2 inches in length and 52 inches in diameter. The cask without the impact limiters measures 177.2 inches in length and 26.44 inches in diameter.

The outer cask shell is comprised of a one-inch thick stainless steel shell overlaid with a 10 gauge stainless steel cover. Between these two materials is a 0.08-inch diameter wire wrap, providing an air gap for additional thermal protection.

The inner shell (containment vessel) is a standard seamless stainless steel Schedule 40 pipe having an outside diameter of 8.625 inches with a nominal wall thickness of 0.322 inch. The annular space between the inner and outer shells is filled with lead having a thickness of approximately 8 inches.

Both the inner and outer shells are welded at each end to heavy steel closure plates with conical surfaces to assist in positioning and sealing. The containment vessel measures 147 inches in length by 7.981 inches in diameter.

The containment vessel is sealed at the bottom end with a 11.83-inch thick stainless steel plug with 2 Viton O-ring seals. The top end of the containment vessel is sealed with a 11.625-inch thick stainless steel plug with 2 Viton O-ring seals. The bottom plug is retained by a closure plate secured by 8, 1/2"-13UNC x 2-1/4-inch ASTM A320, Grade L7 socket head cap screws. The top plug is secured in place utilizing 16, 1/2"-13UNC x 1-3/4-inch ASTM A320, Grade L7 hex flange screws.

CONDITIONS (continued)

Page 2 - Certificate No. 9132 - Revision No. 12 - Docket No. 71-9132

5. (a) Packaging (continued)

No drain or vents penetrate directly into the containment vessel. A drain/vent line opens directly into the area between the 2 O-ring seals at each end of the cask (end plugs). During shipment, the lines are sealed with Viton O-ring sealed threaded fasteners.

The cask is provided with 6 trunions, 4 spaced 90 degrees apart at the top end and two spaced at 180 degrees apart at the bottom end of the cask. The cask is tied down at the forward and aft ends by means of a cradle and yoke assembly. The gross weight of the cask and contents is 38,200 pounds.

(3) Drawing

The packaging is constructed in accordance with Energy Research and Development Administration (ERDA) Drawing No. H-4-66230, Sheets 1,3,5, and 6, Revision No. 0, and Sheets 2 and 4, Revision No. 1. For payloads in spent fuel containers the applicable drawings are DOE Drawing Nos. H-3-4747, Sheets 1 and 2, Revision No. 0 and H-4-66535, Revision No. 0, and Los Alamos Drawing No. 54Y-110854, Sheets 1 and 2, Revision No. B.

(b) Contents

Type, form, and maximum quantity of material per package

Irradiated, spent mixed oxide (MOX) fuel pins and assemblies, (b) reactor fuel comprised of U-235 and/or U-238 oxides, carbides, nitrides or metallic alloys and (c) structural components. The minimum cooling time of each assembly and rod must be 90 days and the cask may contain 1,400 thermal watts. Prior to irradiation the fuel and structural components must have the following specifications:

Type	Fuel Description	Array Description	Maximum Fissile Package Loading	Pin Dimensions
(1) 217 Pin DFA Assembly	31% PuO ₂ -69% UO ₂ (natural U)	Hexagonal Array w/pins at 0.26" center-to-center	11.2 kg	0.23"Dia 36" Active Fuel Length
(2) 217-Pin MOX Fuel Pins	50% max PuO ₂ + 235 UO ₂ - remainder natural UO ₂	Circular array groups of pins in seven compartments in 5" Schedule 5 Pipe	27.5 kg	0.23"-0.29" Dia. 36" Active Fuel Length
(3) 109-Pin MOX Fuel Pins	35% PuO ₂ -65% UO ₂ (86% U-235)	Circular Array Individual Pins contained in 0.44" Dia. Tubes	26.2 kg	0.23"-0.29" Dia. 36" Active Fuel Length

CONDITIONS (continued)

Page 3 - Certificate No. 9132 - Revision No. 12 - Docket No. 71-9132

5. (b) Contents (continued)

Type	Fuel Description*	Array Description	Maximum Fissile Package Loading	Pin Dimensions
(4) 55-Pin MOX Fuel Pins	35% PuO ₂ -65% UO ₂ (86% U-235)	Circular Array Individual Pins contained in 0.625" Dia. Tubes	13.2 kg	0.23"-0.29" Dia. 36" Active Fuel Length
(5) 37-Pin MOX Fuel Pins	35% PuO ₂ -65% UO ₂ (86% U-235)	Circular Array Individual Pins contained in 0.75" Dia. Tubes	8.9 kg	0.23"-0.29" Dia. 36" Active Fuel Length
(6) 42-Pin MOX Fuel Pins	35% PuO ₂ -65% UO ₂ (86% U-235)	Circular Array Individual Pins contained in 0.625" Dia. Tubes	10.1 kg	0.23"-0.29" Dia. 36" Active Fuel Length
(7) 40-Pin MOX Fuel Pins	35% PuO ₂ -65% UO ₂ (86% U-235)	Circular Array Individual Pins contained in 0.625" Dia. Tubes	9.6 kg	0.23"-0.29" Dia. 36" Active Fuel Length
(8) 19-Pin MOX Fuel Pins	35% PuO ₂ -65% UO ₂ (86% U-235)	Circular Array Individual Pins contained in 0.88" Dia. Tubes	6 kg	0.23"-0.29" Dia. 36" Active Fuel Length
(9) PU Compounds Fuel Pins (spent fuel containers)	50% PUX max-UX X=C, W, or O (94% U-235)	Unrestricted array Individual Pins contained in SS 5-inch Schedule 40 pipe	8.0 kg	Container Cavity 5.047" Dia. by 38.9" length
(10) LAMPRE Fuel Pins (spent fuel container)	97.5% Pu max-X alloy X=Fe, Co or Cs	Circular Array Individual Pins contained in 0.625" or 0.75" Dia. steel tubes	8.0 kg	0.425" Dia. 38" Active Fuel length
(11) Structural Components (incl. Control assemblies)	Dosimetry Foils	—	1.0 kg	—

CONDITIONS (continued)

Page 4 - Certificate No. 9132 - Revision No. 12 - Docket No. 71-9132

(12)	24 Max. Pins. U-Pu Carbide Fuel Pins	85-94%(Pu-U)C -6 to 15% (Pu-U) ₂ C ₃ . Max 23% Pb, Uranium is not enriched	Circular array; individual pins contained in 0.625-in. dia. tubes within 5-in. Schedule 40 pipe	3.0 kg	0.37" outer Dia. 36" Active Fuel Length
(13)	18 max. pins. Sodium bonded (fuel- to-clad)	10% Zr-20% Pu max. Remainder U (U enriched to 40% max. U-235).	Circular array; individual pins contained in 0.625- in. diam. tubes within 5-in. Schedule 40 pipe.	1.9 kg	0.30" Outer Dia. 36" Active Fuel Length

*All plutonium in the fuel Types (1) thru (8) contains at least 10% Pu-240; fuel type (9) has no limit for PU-240; Type (10) contains at least 6% PU-240.

5. (c) Fissile Class III
- Maximum number of packages per shipment One
6. Content 5.(b)(1) shown in AEC Drawing No. H-4-21500, Rev. 9; and ERDA Drawing No. H-4-66230, Sheet 5, Rev. 0
- Contents 5.(b)(2), (3), (4), and (5) must be contained within inner container Ident 69 described by ERDA Drawing Nos. H-4-66160, Sheet 1, Rev. 0; and H-4-66230, Sheets 5 and 6, Rev. 0
- Contents 5.(b)(6), (7), (8), (12) and (13) must be contained within inner container Ident 1578 described by ERDA Drawing Nos. H-4-66160, Sheet 2, Rev. 0; and H-4-66230, Sheets 5 and 6, Rev. 0.
- Contents 5.(b)(9) and (10) shown in DOE Drawing No. H-3-47474, Sheets 1 and 2, Revision No. 0 and Los Alamos Drawing No. 541-110854, Sheets 1 and 2, Revision No. B must be contained within the Ident 69 Liner shown in ERDA Drawing No. H-4-66230, Sheets 5 and 6, Revision No. 0 and DOE Drawing No. H-4-66535, Revision No. 0.
7. The cask must be shipped dry (no water coolant in cask cavity). Shipment of sodium wetted fuel rods (external) is authorized for up to 200 g of sodium provided the additional requirements of Section 7.4 of the application are adhered to.

CONDITIONS (continued)

Page 5 - Certificate No. 9132 - Revision No. 12 - Docket No. 71-9132

8. In addition to the requirements of Subpart G of 10 CFR Part 71:

- (a) Each package must meet the Acceptance Tests and Maintenance Program of Chapter 8 of the application, as supplemented. The leak test to satisfy ANSI N 14.5 and Regulatory Guide 7.4 in Section 8.1.3 of the application must be a test having sufficient sensitivity to detect a leak rate (air at standard temperature and pressure leaking to 10^{-2} atm) of 10^{-7} atm cc/sec. The results of these tests must be documented and retained for the life of the cask.
- (b) Each package shall be operated and prepared for shipment in accordance with the Operating Procedures of Chapter 7 of the application, as supplemented.

9. Any repair to the trunnions because of out-of-roundness or weld failure must be authorized by NRC prior to returning the package to service.
10. The containment closure bolts (as specified by Note 9, Drawing No. H-4-66230, Sheet 1, Revision No. 0) must be torqued to 70 ± 10 ft-lb.
11. The cask authorized by this certificate is hereby approved for use under the general license provisions of 10 CFR 57.12.
12. Expiration Date: March 31, 1996

REFERENCES

Nuclear Packaging, Inc. application dated April 22, 1985.

Supplements dated: October 8 and 31, 1985; February 4, 1986; March 21, 1986; May 24, 1988; September 11, 1990; and March 22, 1991.

FOR THE U.S. NUCLEAR REGULATORY COMMISSION

Charles E. MacDonald
Charles E. MacDonald, Chief
Transportation Branch
Division of Safeguards
and Transportation, NMSS

APR 3 1991

Date: _____

NAC-1

NAC-1 (NFS-4)

<u>Designer</u>	Nuclear Assurance Corporation
<u>Type</u>	Legal Weight Truck Shipping Cask
<u>Capacity</u>	
Intact Spent Fuel Assemblies	1 PWR; 2 BWR (on-site only)
Other Configurations	Metallic Fuel
<u>Weight (tons)</u>	
Loaded	23
Empty	22
<u>Design Heat Rejection (kW)</u>	11.5
<u>Shape</u>	Cylindrical
<u>Dimensions</u>	
Overall Length (in)	214
Overall Diameter (in)	38
Cavity Length (in)	178
Cavity Width (in)	13.5
Inner Shell Wall Thickness (in)	0.3125
Lead Shield Wall Thickness (in)	6.625
Outer Shell Wall Thickness (in)	1.25
Neutron Shield Tank Thickness (in)	4.5
<u>Materials of Construction</u>	
Cask Body	SS/Lead/SS
Neutron Shield	
Sides	Borated Water & Ethylene Glycol
Ends	None
Basket	SS
<u>Cooling Fins</u>	None - Smooth Surface
<u>Operating Temperature (°F)</u>	345 (maximum)
<u>Operating Pressure (psig)</u>	5 (984 maximum)
<u>Outside Surface Dose (mrem/hr)</u>	200 (maximum)
<u>Cavity Atmosphere</u>	Air

Licensing Status - Originally licensed by AEC and USNRC. USNRC did not recertify the cask for off-site movement of LWR fuel due to some concerns about distortion in the inner cavity.

Comments - NAC obtained a license for the NFS-4 cask design for use by NAC. NAC later took possession of two NFS-4 casks and has rights to lease them. A total of seven casks are in existence, one of which is owned by Duke Power Company and the others are available for lease from NAC. Casks have interchangeable baskets for PWR and BWR fuel.

**CERTIFICATE OF COMPLIANCE
FOR RADIOACTIVE MATERIALS PACKAGES**

U.S. NUCLEAR REGULATORY COMMISSION

1. a. CERTIFICATE NUMBER	b. REVISION NUMBER	c. PACKAGE IDENTIFICATION NUMBER	d. PAGE NUMBER	e. TOTAL NUMBER PAGES
9183	10	USA/9183/B(1)F	1	4

PREAMBLE

- This certificate is issued to certify that the 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."
- 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
- ISSUED TO (Name and Address)
  - TITLE AND IDENTIFICATION OF REPORT OR APPLICATION

Nuclear Assurance Corporation
6251 Crooked Creek Road
Norcross, GA 30092

Nuclear Assurance Corporation application dated
May 26, 1989, as supplemented.

c. DOCKET NUMBER

9183

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

- Model No.: NAC-1
- Description

A steel and lead shielded shipping cask. The cask is a right circular cylinder with upper and lower steel encased balsa impact limiters. The overall dimensions are 27 inches in length and 50 inches in diameter. The gross weight of the cask is approximately 49,000 pounds. The inner cavity is 178 inches long and 43.5 inches in diameter. The thickness of the inner shell is 5/16 inch and 1-1/4 inches for the outer shell. The two stainless steel shells are welded to a 2-inch thick stainless steel shield disc at the bottom. The annulus between the inner and outer shells is filled with lead (max. lead thickness 6-5/8 inches, minimum 5 inches).

The stainless steel lid is a frustum of a cone 7.5 inches thick. The lid is secured to the cavity flange by six, ASTM-A320, Grade L43, 1-1/4-inch diameter bolts. The seal is provided by two polytetrafluoroethylene O-rings. Four trunnions, two located on either side of the upper or lower impact limiter, are provided. Other cask features include two drain valves located in the bottom shield disc, vent valve, head closure gasket leak check valve, and rupture disc - pressure relief valve system located in the cavity flange. For transport, the cask may be enclosed in an expanded metal cage or closed shipping container.

(3) Drawings

The Model No. NAC-1 shipping cask is constructed in accordance with Nuclear Fuel Services, Inc., Drawing No. E 10080, Sheets 1 through 4, Rev. 22.

Page 2 - Certificate No. 9183 - Revision No. 10 - Docket No. 71-9183

(b) Contents

(1) Type and form of material

- (i) Clad, irradiated metallic natural uranium fuel rods.
- (ii) Solid nonfissile irradiated hardware.

(2) Maximum quantity of material per package

The cavity content must not exceed a thermal decay heat load of 750 watts and a weight of 3,700 lbs including weight of component spacers (or fuel basket) used in the cask cavity to limit movement of contents during shipment. Fuel rods are additionally limited as follows:

- (i) 21 intact rods or 6 encapsulated (defective) rods. Each defective rod will be encapsulated in either a 2.75-inch I.D. failed fuel rod can, as shown on Nuclear Assurance Corporation Drawing No. 340-108-D2, Rev. 9, or a 4.00-inch I.D. failed fuel rod can, as shown on Nuclear Assurance Corporation Drawing No. 340-108-D1, Rev. 9. Defective rods encapsulated in the 2.75-inch I.D. failed fuel rod cans will be shipped in a six rod capacity liner, as shown on Nuclear Assurance Corporation Drawing No. 491-001, Rev. 0, and defective rods encapsulated in the 4.00-inch I.D. failed fuel rod cans will be shipped in a three rod capacity liner, as shown on Nuclear Assurance Corporation Drawing No. 347-211-F10, Rev. 5.
- (ii) 600 MW/MGR average burnup.
- (iii) Minimum 365-day cooling time after irradiation.

(c) Fissile Class

- 6. The cask cavity must be dry (no free water) when delivered to a carrier for transport.
- 7. As needed, appropriate component spacers (fuel basket and axial spacers for shipment of fuel rods) must be used in the cask cavity to limit movement of contents during accident conditions of transport.
- 8. The cask may be shipped in a closed shipping container provided that the closed container, the cask tie-down and support system and the transport vehicle (trailer) meet the applicable requirements of the Department of Transportation. Tie-down devices which are a structural part of the package must comply with 10 CFR §71.45.
- 9. When the cask is shipped in a closed shipping container, the center of gravity of the combined cask, closed shipping container and trailer must not exceed 75 inches.
- 10. When the cask is shipped in a closed shipping container, the internal heat load must not exceed 750 watts.

Page 3 - Certificate No. 9183 - Revision No. 10 - Docket No. 71-9183

- .. In lieu of the requirements of 10 CFR §71.87(e), the licensee must perform periodic maintenance and testing of O-rings, drain and vent ball valves, relief valves, and rupture discs of the cask as indicated in the table given below. During inactive periods, the maintenance and testing frequency may be disregarded provided that the package is brought into full compliance prior to the next use of the package.

<u>Cask Component</u>	<u>Period</u>	<u>Test/Action</u>
Ball Valve	Each shipment	Hydro test to 30 psig*
Ball Valve	Annually	Replace seats and seals
O-rings	Each shipment	Test to 30 psig*
O-rings	Annually	Test to 100 psig*
Inner Containment Vessel	Annually	Test to 100 psig
Cavity Relief Valve	Annually	Test at set point
Cavity Rupture Disc	Annually	Replace
Neutron Shield Tank Rupture Disc	Annually	Replace
Impact Limiters	Annually	Test to 5 psig*

*There must be no visual (pressure gauge) indications of pressure drop for the component under test during a 10-minute test period. Otherwise, corrective action must be taken and the test repeated until such time as the component meets the specified tests. (Test to pressures equal to or greater than those indicated.)

12. The package shall be prepared for shipment and operated in accordance with the operating procedures in Chapter 7 of the application.
13. Each package must be maintained in accordance with the maintenance program in Chapter 8 of the application.
14. The package authorized by this certificate is hereby approved for use under the general license provisions of 10 CFR §71.12.
15. Expiration date: September 30, 1994.

Page 4 - Certificate No. 9183 - Revision No. 10 - Docket No. 71-9183

REFERENCES

Nuclear Assurance Corporation application dated May 26, 1989.

Supplements dated January 29 and March 20, 1990.

FOR THE U.S. NUCLEAR REGULATORY COMMISSION

Charles E. MacDonald
Charles E. MacDonald, Chief
Transportation Branch
Division of Safeguards and
Transportation, NMSS

Date: MAY 04 1990

CNS 1-13G

The curves shown at left may be used to determine the maximum activity concentration (Figure 1) and the maximum liner dose rate (Figure 2) which can be shipped in this cask. For a well mixed, uniform concentration of waste, use of these figures will result in compliance with legal dose rates on the cask surface and at a distance of 2 meters from the surface (See Cautionary Note).

These curves are related to the relative concentration of Co-60 in the waste. The Co-60 concentration is obtained from a representative sample of the waste prior to filling a drum or liner. Practical experience shows that Co-60 is the dominant isotope in most mixtures and is the most significant from a shielding standpoint. The conservative assumption is made that the remaining isotopes (other than Co-60) emit one gamma per disintegration with an energy of 1.0 MEV.

Two general types of waste forms are normally shipped, concreted or dewatered resins and liner media. A normal average density of 2.0 g/cc for concreted wastes and 0.8 g/cc for resins was used in developing the curves.

CAUTIONARY NOTE
The curves include a safety factor (peak-to-average factor) of 2.0 which relates field measurements to shielding calculations assuming uniform waste mixtures. The calculations were made using a comprehensive computer analysis. The field measurements are based on a statistical analysis of a large number of cask shipments. However, due to variations in waste materials, tolerances in measurement instruments, and other real world factors, there is still a large scatter in the peak-to-average factor. Statistically, these curves yield compliance in about 60% of the shipments. To obtain compliance in about 95% of the shipments, multiply the maximum allowable activity concentration and the maximum allowable liner dose rate by 0.6.

CHEM-NUCLEAR SYSTEMS, INC.

CNS 1-13G

CNS 1-13G

NRC Certificate No. USA/9216/B ( ) F

Capacity: (1) 55-gallon drum
(1) 8-17 ft³ liner
Shielding: 6.20" lead equivalent
Dose Rate: 6000 R/hr (approx.)
(Maximum based on Cobalt 60)

Total Empty Package Weight: 25,500#
Empty Cask Weight
(with lid): 19,100#
Cask Lid Weight: 2,000#
Overpack with Baseplate: 5,400#
Payload weight not restricted

The CNS 1-13G cask is specially designed for transporting activated reactor components and nuclear therapy sources.

The CNS 1-13G cask is a lead and steel shipping cask for fissile, solid metal, or metal oxides by-product material. The decay heat of the contents must not exceed 600 watts (38,800 curies of Cobalt-60).

Loading: (A) One drum with appropriate lifting sling may be lowered into the cask. (B) A disposable liner may be lowered into the cask while mounted on the transport trailer. (C) Activated reactor components contained in a disposable liner may be loaded into the cask underwater.

Rev 2

**CERTIFICATE OF COMPLIANCE
FOR RADIOACTIVE MATERIALS PACKAGES**

U.S. NUCLEAR REGULATORY COMMISSION

1. a. CERTIFICATE NUMBER 9216	b. REVISION NUMBER 3	c. PACKAGE IDENTIFICATION NUMBER USA/9216/B( )F	d. PAGE NUMBER 1	e. TOTAL NUMBER PAGES 4

2. PREAMBLE

- a. This certificate is issued to certify that the 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 (Name and Address)

b. TITLE AND IDENTIFICATION OF REPORT OR APPLICATION:

Chem-Nuclear Systems, Inc.
140 Stoneridge Drive
Columbia, SC 29210

Chem-Nuclear Systems, Inc. application
dated November 24, 1987, as supplemented.

c. DOCKET NUMBER 71-9216

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.: CNS 1-13G
- (2) Description

Steel encased lead shielded shipping cask. A double-walled steel cylinder protective jacket encloses the cask during transport. It is bolted to a steel pallet. The cask is closed by a lead-filled flanged plug fitted with a silicone rubber gasket and bolted closure. The cavity is equipped with a drain line and the physical description is as follows:

Cask height, in	67.19
Cask diameter, in	38.5
Cavity height, in	54.0
Cavity diameter, in	26.5
Lead shielding, in	5.0
Protective jacket height, in	81.8
Protective jacket width, in	68.0
Packaging weight, lb	25,500

(3) Drawings

The packaging is constructed in accordance with Chem-Nuclear Systems, Inc. Drawing Nos.: C-110-B-06402-001, Rev. A; C-110-B-06402-002, Rev. A; C-110-B-06402-003, Rev. C; and C-110-B-06402-004, Rev. A.

5. (b) Contents

(1) Type, form and maximum quantity of material per package

Plutonium in excess of 20 curies per package must be in the form of metal, metal alloy or reactor fuel elements; and

- (i) Byproduct material and special nuclear material as solid metal or oxides. Decay heat not to exceed 600 watts. The radioactive material shall be in the form of fuel rods, or plates, fuel assemblies, or meeting the requirements of special form radioactive material.

500 gm U-235 equivalent mass;

- (ii) Neutron sources meeting the requirements of special form radioactive material.

500 gm U-235 equivalent mass. Decay heat not to exceed 50 watts; or

- (iii) Irradiated PuO_2 and UO_2 fuel rods clad in Zircalloy or stainless steel. Decay heat not to exceed 600 watts. All fuel rods shall be contained within a closed 5-inch Schedule 40 pipe with a maximum useable length of 39-5/8 inches.

1,200 gm fissile material with no more than 300 gm fissile material per 5-inch Schedule 40 pipe.

- (iv) Process solids, either dewatered, solid, or solidified in a secondary sealed container meeting the requirements for low specific activity radioactive material.

- (v) Solid nonfissile irradiated metal hardware, reactor control rods (blades), reactor start-up sources, and segmented boron carbide tubes (tube contents not to exceed a Type A quantity).

- (vi) Radioactive (Hot Cell) waste materials immobilized with cement grout and contained in a 55-gallon (or extended 55-gallon drum) DOT Specification 17H or 17C steel drum, lid and closure. The Waste material must be packaged in accordance with the Procedural Outline of the Immobilization of Cell Waste Using Cement Grout, Attachment D of the application. The cement grout must be at least 50 volume percent (estimated) of the drum contents and relatively uniformly distributed throughout the drum. At least 3/4" thick layer of grout must cover all radioactive waste contents. Decay heat not to exceed 100 watts, and fissile material not to exceed 500 grams U-235 equivalent mass.

5. (c) Fissile Class

III

CONDITIONS (continued)

Page 3 - Certificate No. 9216 - Revision No. 3 - Docket No. 71-9216

Maximum number of packages
per shipment

(i) Contents 5.(b)(1)(i),
5.(b)(1)(ii), 5.(b)(1)(iii),
or 5.(b)(1)(vi):

Two (2)

6. The U-235 equivalent mass is determined by U-235 mass plus 1.66 times U-233 mass plus 1.66 times Pu mass.
7. (a) For any package containing water and/or organic substances which could radiolytically generate combustible gases, determination must be made by tests and measurements or by analysis of a representative package such that the following criteria are met over a period of time that is twice the expected shipment time:
  - (i) The hydrogen generated must be limited to a molar quantity that would be no more than 5% by volume (or equivalent limits for other inflammable gases) of the secondary container gas void if present at STP (i.e., no more than 0.063 g-moles/ft³ at 14.7 psia and 70°F) or
  - (ii) The secondary container and cask cavity must be inerted with a diluent to assure that oxygen must be limited to 5% by volume in those portions of the package which could have hydrogen greater than 5%.

For any package delivered to a carrier for transport, the secondary container must be prepared for shipment in the same manner in which determination for gas generation is made. Shipment period begins when the package is prepared (sealed) and must be completed within twice the expected shipment time.
- (b) For any package containing materials with radioactivity concentration not exceeding that for low specific activity material, and shipped within 10 days of preparation or within 10 days after venting of drums or other secondary containers, the determination in (a) above need not be made, and the time restriction in (a) above does not apply.
8. For packaging of neutron sources, the cavity drain line must be closed with a plug with a melting temperature of 200°F and the cask cavity must be dry before delivery of the package to a carrier.
9. For packaging of other than neutron sources, the cask must be delivered to a carrier dry and the cavity drain line must be closed with a plug which will maintain its seal at temperatures up to at least 620°F.
10. For the shipment of irradiated metal hardware, the use of the auxiliary shielded inner container and shoring plug shown in Chem-Nuclear Systems, Inc. Drawing Nos. 8651-E-02, Rev. A and 8651-C-01, Rev. B is authorized. The inner container must be provided with vent and drain lines.

CONDITIONS (continued)

Page 4 - Certificate No. 9216 - Revision No. 3 - Docket No. 71-9216

11. Shoring must be provided to minimize movement of contents during accident conditions of transport.
12. In addition to the requirements of Subpart G of 10 CFR Part 71:
  - (a) The package shall be prepared for shipment and operated accordance with Chem-Nuclear Systems, Inc. Operating Procedures, Section 7.0.
  - (b) Prior to each shipment the silicone rubber lid gasket(s) must be inspected. This gasket(s) must be replaced if inspection shows any defects or every twelve (12) months, whichever occurs first. Cavity drain line must be sealed with appropriate sealant applied to threads of pipe plug.
  - (c) Prior to each shipment the baseplate to cask shell weld must be visually inspected in accordance with Chem-Nuclear Systems, Inc. Operating Procedures, Section 7.0.
  - (d) The packaging must meet Chem-Nuclear Systems, Inc. Acceptance tests and Maintenance Program, Section 8.0.
13. For packaging of neutron sources, 50 times measured neutron dose rate at one meter from the surface of a cask must be less than 1,000 mrem/hr.
14. The contents described in 5(b)(1)(iv) must be transported on a motor vehicle, railroad car, aircraft, inland watercrafts, or hold or deck of a seagoing vessel assigned for sole use of the licensee.
15. The package authorized by this certificate is hereby approved for use under the general license provision of 10 CFR 57.12.
16. Expiration date: December 31, 1997.

REFERENCES

Chem-Nuclear Systems, Inc. application dated November 24, 1987.

Supplement dated: November 24, 1992.

FOR THE U.S. NUCLEAR REGULATORY COMMISSION

Charles E. MacDonald

Charles E. MacDonald, Chief
Transportation Branch
Division of Safeguards and
Transportation, NMSS

DEC 16 1992

Date: _____

NRBK-41

Drawing Not Available

**CERTIFICATE OF COMPLIANCE
FOR RADIOACTIVE MATERIALS PACKAGES**

1. a. CERTIFICATE NUMBER 9221	b. REVISION NUMBER 1	c. PACKAGE IDENTIFICATION NUMBER USA/9221/B(-)F	d. PAGE NUMBER 1	e. TOTAL NUMBER OF PAGES 3

2. PREAMBLE

- This certificate is issued to certify that the 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."
- 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

- ISSUED TO (Name and Address)
- TITLE AND IDENTIFICATION OF REPORT OR APPLICATION:

U.S. Department of Energy
Division of Naval Reactors
Washington, DC 20585

Safety Analysis for Radioactive Material
Shipping Cask NRBK-41, 42 and 43 dated
March 11, 1968 as supplemented.

c. DOCKET NUMBER **71-9221**

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.: **NRBK-41**
- (2) Description

Top loading cylindrical, lead shielded 304L stainless steel clad casks for the shipment of irradiated test specimens. The cask has an outside diameter of 27.16 inches and is 40 inches high. The outer shell is 1.72-inch thick stainless steel. The cask cavity is 5 inches in diameter by 16 inches deep and is provided with a bottom drain. The cavity shell is 1/4-inch thick stainless steel and is shielded by 10 inches of lead. The cask is closed by a lead-filled flanged plug fitted with an elastomer O-ring gasket and bolted closure. The cask has a seal-welded, 1/4-inch thick, stainless steel outer thermal shield which provides a 1/16-inch air gap between the outer surface of the cask outer shell and the inside surface of the thermal shield. A one-inch thick stainless steel plate is welded to the bottom of cask. A second one-inch thick stainless steel plate with a 1/8-inch deep, 25.5-inch diameter recess is welded to the first plate to provide a thermal shield for the bottom surface of the cask. The cask is bolted to a 48-inch square, all welded, "I" beam skid. Gross weight of the package is approximately 9,000 pounds.

(3) Drawings

The packaging is constructed in accordance with Battelle Memorial Institute Drawing No. 41-0001, Sheet 1, Rev. A and Sheet 2 of 2, Rev. B and Westinghouse Electric Corporation Drawing No. 1755E01, Rev. A.

CONDITIONS (continued)

Page 2 - Certificate No. 9221 - Revision No. 1 - Docket No. 71-9221

5. (b) Contents

(1) Type and form of material

Byproduct and special nuclear material in solid form, contained within the MIN-41 product container. The MIN-41 container is constructed in accordance with Westinghouse Electric Corporation, Drawing No. 2D77456.

(2) Maximum quantity of material per package

The fissile contents of the package must be limited to a maximum of 350 equivalent grams of U-235. The number of equivalent grams of U-235 is determined by the equation: $1.0 \times \text{grams U-235} + 1.4 \times \text{grams U-233} + 1.6 \times \text{grams plutonium}$. The maximum decay heat load per package must not exceed 900 Btu/hr for an exclusive use shipment or 250 Btu/hr for a non-exclusive use shipment.

(c) Fissile Class

6. In addition to the requirements of Subpart G of 10 CFR Part 71:

(a) The MIN-41 container must be tested for leak tightness within one year prior to use to a minimum sensitivity of 10^{-3} atm-cm/sec.

(b) Prior to each shipment, the MIN-41 container must be leak tested after assembly to a minimum sensitivity of 10^{-3} atm-cm/sec.

7. The NRBK-41 shipping container may be covered with a wrapping of polyvinyl chloride (PVC) during shipment provided the shipment is made in a closed vehicle. The applicable requirements of 10 CFR §71.87 must be satisfied prior to wrapping the shipping container.

8. Expiration date: January 31, 1996.

CONDITIONS (continued)

Page 3 - Certificate No. 9221 - Revision No. 1 - Docket No. 71-9221

REFERENCES*

Safety Analysis for Radioactive Material Shipping Cask No. NRBK-41, 42 and 43 dated March 11, 1968.

Supplements: Division of Naval Reactors letters S# 1458 dated June 19, 1968; S# 1570 dated September 19, 1968; S# 1597 dated September 19, 1968; S# 1658 dated October 22, 1968; S# 1681 dated November 7, 1968; S# 1690 dated November 22, 1968; S# 1903 dated March 19, 1969; S# 2000 dated June 2, 1969; S# 2509 dated June 10, 1970, and Bettis Atomic Power Laboratory letter WAPD-CL(IH)-733, dated October 10, 1968, and Division of Naval Reactors letters Z# 85-1605 dated April 1, 1985; S# 86-3305 dated February 3, 1986; and S# 86-3332 dated June 16, 1986, and Bettis Atomic Power Laboratory letter WAPD-D(PAS)-526 dated June 20, 1986; and Division of Naval Reactors letter S# 87-2738 dated September 18, 1987; and Naval Reactors letter S# 90-12,039 dated December 24, 1990.

* See Docket No. 71-5814

FOR THE U.S. NUCLEAR REGULATORY COMMISSION

Charles E. McDonald, Chief
Transportation Branch
Division of Safeguards and
Transportation, NMSS

Date: FEB 12 1991

NAC-LWT

NAC-LWT

<u>Designer</u>	Nuclear Assurance Corporation
<u>Type</u>	Legal Weight Truck Shipping Cask
<u>Capacity</u>	
Intact Spent Fuel Assemblies	1 PWR; 2 BWR (3.7 w/o; 4.0 w/o enrichment)
Other Configurations	15 Metallic Fuel Rods
<u>Weight (tons)</u>	
Loaded	25.6
Empty	24.0
<u>Design Heat Rejection (kW)</u>	2.5
<u>Shape</u>	Cylindrical
<u>Dimensions</u>	
Overall Length (in)	199.80
Overall Diameter (in)	44.2
Cavity Length (in)	180.90
Cavity Diameter (in)	13.375
Inner Shell Wall Thickness (in)	0.75
Lead Shield Wall Thickness (in)	5.75
Outer Shell Wall Thickness (in)	1.20
Neutron Shield Tank Thickness (in)	5.00
Neutron Shield Wall Thickness (in)	0.25
<u>Materials of Construction</u>	
Cask Body	SS/Lead/SS
Neutron Shield	
Sides	Water & Ethylene Glycol (1.0 w/o Boron)
End	None
Basket	Aluminum
<u>Cooling Fins</u>	None
<u>Cavity Atmosphere</u>	Air or Inert Gas
<u>Operating Temperature (°F)</u>	229 (cask radial surface; maximum)
<u>Operating Pressure (psig)</u>	0
<u>Outside Surface Dose (mrem/hr)</u>	100 (maximum)
<u>Licensing Status</u> - Safety Analysis Report submitted in March 1988 and licensed by the USNRC December 6, 1989.	
<u>Comments</u> - Casks have separate baskets for one PWR, two BWR or metallic fuel. Legal truck weight 80,000 pounds (maximum).	

**CERTIFICATE OF COMPLIANCE
FOR RADIOACTIVE MATERIALS PACKAGES**

U.S. NUCLEAR REGULATORY COMMISSION

1. a. CERTIFICATE NUMBER	b. REVISION NUMBER	c. PACKAGE IDENTIFICATION NUMBER	d. PAGE NUMBER	e. TOTAL NUMBER OF PAGES
9225	5	USA/9225/B(U)F	1	5

2. PREAMBLE

- This certificate is issued to certify that the 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."
- 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 (Name and Address)

b. TITLE AND IDENTIFICATION OF REPORT OR APPLICATION:

Nuclear Assurance Corporation
6251 Crooked Creek Road
Norcross, GA 30092

Nuclear Assurance Corporation application
dated June 10, 1988, as supplemented.

c. DOCKET NUMBER 71-9225

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.: NAC-LWT
- (2) Description

A steel encased lead shielded shipping cask. The cask is designed to transport one PWR assembly, two BWR assemblies or up to 15 metallic fuel rods. The total weight of the package is approximately 51,200 pounds. The contents including the fuel basket weigh about 4,000 pounds. The overall dimensions of the package, with impact limiters, are 232 inches long by 65 inches in diameter. The cask body is approximately 200 inches in length and 44 inches in diameter. The cask cavity is 178 inches long and 13.4 inches in diameter. The volume of the cavity is approximately 14.5 cubic feet.

The cask body consists of a 3/4-inch thick stainless steel inner shell, a 5-3/4 inch thick lead gamma shield, a 1-1/5 inch thick stainless steel outer shell, and a neutron shield tank. The inner and outer shells are welded to a 4-inch thick stainless steel bottom end forging. The cask bottom consists of a 3-inch thick, 20-3/4 inch diameter lead disk enclosed by a 3-1/2 inch thick stainless steel plate and bottom end forging. The cask lid is 11.3-inch thick stainless steel stepped design, secured to a 14-1/4 inch thick ring forging with twelve 1-inch diameter bolts. The cask seal is a metallic O-ring. A second teflon O-ring and a test port are provided to leak test the seal. Other penetrations in the cask cavity include the fill and drain ports, which are sealed with port covers and teflon O-rings.

The neutron shield tank consists of a 0.24-inch thick stainless steel shell with 0.50-inch thick end plates. The neutron shield region is 164 inches long and 5 inches thick. The neutron shield tank contains an ethylene glycol/water solution that is 1% boron by weight.

CONDITIONS (continued)

Page 2 - Certificate No. 9225 - Revision No. 5 - Docket No. 71-9225

(2) Description (cont'd)

The cask is equipped with aluminum honeycomb impact limiters. The top impact limiter has an outside diameter of 65.25 inches and a maximum thickness of 27.8 inches. The bottom impact limiter has an outside diameter of 60.25 inches and maximum thickness of 28.3 inches. Both impact limiters extend 12 inches along the side of the cask body.

(3) Drawings

- (i) The packaging is constructed in accordance with the following Nuclear Assurance Corporation Drawings:

LWT 315-40-01, Rev. 2	Cask Assembly
LWT 315-40-02, Rev. 4	Body Assembly
LWT 315-40-03, Rev. 6	Transport Cask Body
(Sheets 1 through 6)	
LWT 315-40-04, Rev. 5	Cask Lid Assembly
LWT 315-40-05, Rev. 4	Upper Impact Limiter
LWT 315-40-06, Rev. 4	Lower Impact Limiter
LWT 315-40-08, Rev. 4	Cask Parts Detail
(Sheets 1 and 2)	

- (ii) The fuel assembly baskets are constructed in accordance with the following Nuclear Assurance Corporation Drawings:

LWT 315-40-09, Rev. 2	PWR Basket Spacer
LWT 315-40-10, Rev. 2	PWR Basket
LWT 315-40-11, Rev. 1	BWR Basket Assembly
LWT 315-40-12, Rev. 3	Metal Fuel Basket Assembly

5. (b) Contents

(1) Type and form of material

Irradiated PWR or BWR uranium oxide fuel assemblies or metallic fuel rods of the following specifications.

	<u>PWR</u>	<u>BWR</u>	<u>Metallic Rods</u>
Fuel Form	Clad UO_2 pellets	Clad UO_2 pellets	Nat. Uranium pellets
Nominal Pellet Diameter, in.	0.3659	0.487	1.36
Cladding material	Zircalloy-4	Zircalloy-4	Aluminum

CONDITIONS (continued)

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.. (b) (1) Continued

	<u>PWR</u>	<u>BWR</u>	<u>Metallic Rods</u>
Nominal cladding thickness, in.	0.0243	0.032	0.080
Maximum fuel rod length, in.	162	172	120.5
Assembly array	15 x 15	7 x 7	n/a
Maximum Assembly weight, lbs	1,650	650	1,805 (15 rods)
Maximum initial fuel pin pressure at 70°F, psig	565	565	n/a
Maximum initial ^{U235} enrichment, w/o	3.7	4.0	Natural
Maximum initial U content/assembly, kg	475	186	54.5
Maximum Average Burnup, MWD/MTU	35,000	30,000	1,600
Maximum decay heat, kw	2.5	1.1	0.036
Minimum cooling time, yr	2	2	1

(2) Maximum quantity of material per package

Not to exceed 4,000 pounds, including contents and fuel assembly basket.

(i) For contents described in Item 5.(b)(1): one PWR assembly, two BWR, or up to 15 intact metallic fuel rods positioned within the respective fuel assembly basket. Maximum decay heat not to exceed 2.5 Kilowatts.

(ii) For failed metallic fuel of the type described in Item 5.(b)(1):

(a) up to six canisters containing one defective metallic fuel rod per canister. The canisters are 2.75-inch I.D. failed fuel rod canisters as shown on Nuclear Assurance Corporation Drawing No. 340-108-02, Rev. 10, and are placed in a six-hole liner as shown on Nuclear Assurance Corporation Drawing No. 315-040-43, Rev. 1. The maximum decay heat load for a defective metallic fuel rod is limited to 5 watts; or

CONDITIONS (continued)

Page 4 - Certificate No. 9225 - Revision No. 5 - Docket No. 71-9225

J. (b) (2) Continued

- (b) Up to three canisters containing either up to three defective metallic fuel rods per canister or up to 10 failed fuel filters per canister. The canisters are 4.00-inch I.D. failed fuel rod canisters as shown on Nuclear Assurance Corporation Drawing No. 340-108-D1, Rev. 10, and are placed in a three-hole basket as shown on Nuclear Assurance Corporation Drawing No. 315-40-12, Rev. 3. The weight of the filters is limited to 125 pounds per canister. For canisters containing fuel rods, the maximum decay heat load is 15 watts per canister; and for canisters containing filters, the maximum decay heat load is 5 watts per canister. Plutonium content of the filters not to exceed 20 curies plutonium per package.

(c) Fissile Class

- (i) For Metallic Fuel Rods: I
(ii) For BWR and PWR assemblies: III

Maximum number of packages in Fissile Class III shipment: One

6. Known or suspected failed fuel assemblies (rods) and fuel with cladding defects greater than pin holes and hair line cracks are not authorized, except as described in 5(b)(2)(ii).
7. The cask must be dry (no free water) when delivered to a carrier for transport.
8. Bolt torque:
The cask lids bolts must be torqued to 260 ft-lbs.
The bolts used to secure the vent and drain port covers must be torqued to 100 inch-lbs.
9. Prior to each shipment, the package must be leak tested to 1×10^{-3} std cm³/sec. Prior to first use, after third use, and at least once within the 12-month period prior to each subsequent use, the package must be leak tested to 5.5×10^{-7} std cm³/sec.
10. In addition to the requirements of Subpart G of 10 CFR Part 71:
- (a) The metallic O-ring seal must be replaced prior to each shipment; and
- (b) Each package must meet the Acceptance Tests and Maintenance Program of Chapter 8 of the application; and
- (c) The package shall be prepared for shipment and operated in accordance with the Operating Procedures of Chapter 7 of the application. If the cask is loaded under water or water is introduced into the cask cavity, the cask must be vacuum dried as described in Chapter 7 of the application. The cask cavity must be backfilled with 1.0 atm of helium when shipping PWR or BWR assemblies.

CONDITIONS (continued)

Page 5 - Certificate No. 9225 - Revision No. 5 - Docket No. 71-9225

11. When shipping PWR or BWR assemblies, the neutron shield tank must be filled with a mixture of water and ethylene glycol which will not freeze or precipitate in a temperature range from -40°F to 250°F. The water and ethylene glycol mixture must contain at least 1% boron by weight.
12. A personnel barrier must be used when shipping PWR and BWR assemblies.
13. Packages used to ship metallic fuel rods may be shipped in a closed shipping container provided that the closed container, the cask tie-down and support system and transport vehicle (trailer) meet the applicable requirements of the Department of Transportation. When the cask is shipped in a closed shipping container, the center of gravity of the combined cask, closed shipping container and trailer must not exceed 75 inches.
14. Units 1,2,3,4 and 5 of the Model No. MAC-LWT package are authorized for use. Fabrication of additional packages is not authorized.
15. The package authorized by this certificate is hereby approved for use under the general license provisions of 10 CFR §71.12.
16. Expiration Date: December 31, 1994.

REFERENCES

Nuclear Assurance Corporation application dated June 10, 1988.

Supplements dated: August 8, August 17, and December 8, 1988; March 23, June 21, August 16, September 11, September 29, October 19, and November 8, 1989; July 19, September 24, and December 17, 1990; February 12, April 4, April 5, May 16, August 22, and October 24, 1991.

FOR THE U.S. NUCLEAR REGULATORY COMMISSION

Charles E. MacDonald, Chief
Transportation Branch
Division of Safeguards
and Transportation, NMSS

Date: OCT 30 1991

GE Model 2000

NEDO-32229

Model 2000 Transport Packaging

**CERTIFICATE OF COMPLIANCE
FOR RADIOACTIVE MATERIALS PACKAGES**

1. a. CERTIFICATE NUMBER	b. REVISION NUMBER	c. PACKAGE IDENTIFICATION NUMBER	d. PAGE NUMBER	e. TOTAL NUMBER PAGES
9228	4	USA/9228/B(U)F	1	4

2. PREAMBLE

- a. This certificate is issued to certify that the 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 (Name and Address)

b. TITLE AND IDENTIFICATION OF REPORT OR APPLICATION:

General Electric Company
Vallecitos Nuclear Center
P.O. Box 460, Vallecitos Road
Pleasanton, CA 94566

General Electric Company application
dated May 19, 1988, as supplemented.

c. DOCKET NUMBER 71-9228

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.: 2000
- (2) Description

A steel encased lead shielded shipping cask. The cask is within a double-walled overpack with toroidal shell impact limiters at each end. The overall dimensions are approximately 131.5 inches in height and 72.0 inches in diameter. The cask is transported in the upright position. The gross weight of the package is approximately 33,550 lbs.

The cask is constructed of two concentric 1-inch thick 304 stainless steel cylindrical shells (ASTM A 240) joined at the bottom end to a 6-inch thick 304 stainless steel forging (ASTM A 182). The annulus between the two shells is filled with lead approximately 4 inches thick. The cask is approximately 71.0 inches in height and has an outer diameter of 38.5 inches. The cask cavity is approximately 26.5 inches in diameter and 54.0 inches deep.

The cask lid is 304 stainless steel and lead, has a stepped design, and is fully recessed into the cask top flange. The lid is secured to the cask body by 15 1.25-inch diameter socket head screws. The cask is sealed by elastomeric O-rings bonded to a thin aluminum disc-shaped ring. The cask is equipped with a seal test port on the side of the cask body, a vent port in the cask lid, and a drain port near the bottom of the cask.

The cask is positioned within an overpack constructed from two 0.5-inch thick concentric 304 stainless steel cylindrical shells (ASTM A 240). The shells are separated radially by eight equally spaced tubes and horizontally by two tube sections. A 304 stainless steel toroidal shell impact limiter is attached to each end of the overpack. The overpack opens just above the lower impact limiter for access to the cask. The top of the overpack is joined to the base by 15 1-3/8-inch diameter shoulder screws.

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Gussets on the top and bottom impact limiters provide tie-down points for the package. The cask body is equipped with attachment plates for lifting devices. The cask lifting devices are detached during transport.

(3) Drawings

The packaging is constructed and assembled in accordance with General Electric Company Drawing Nos. 129D4946, Rev. 8; 105E9520, Rev. 0; and 105E9521, Rev. 0.

Packaging Serial No. 2001 is constructed and assembled in accordance with General Electric Company Drawing Nos. 129D4946, Rev. 8; 101E8718, Rev. 11; and 101E8719, Rev. 9.

(b) Contents

(1) Type and form of material

- (i) Irradiated fuel rods, which may be cut or segmented.
- (ii) Byproduct, source, or special nuclear material in solid form.

(2) Maximum quantity of material per package

- Not to exceed 5,450 lbs., including carrier racks, shoring, secondary containers and shielding liner; 600 watts decay heat; and

(i) For the contents described in 5(b)(1)(i):

Fissile contents not to exceed 1175 grams U-235 equivalent mass with initial enrichment not to exceed 5 weight percent in the fissile isotope; minimum pellet diameter of 0.3 inch, maximum burnup of 45 GWd/MTU, and minimum cooling time of 120 days; or

Fissile contents not to exceed 1750 grams U-235 equivalent mass with initial enrichment not to exceed 5 weight percent in the fissile isotope; minimum pellet diameter of 0.35 inch, maximum burnup of 38 GWd/MTU, and minimum cooling time of 120 days. Fuel rods must be contained in closed, 5-inch schedule 40 pipe, with a maximum of 437.5 grams U-235 equivalent per pipe.

(ii) For the contents described in 5(b)(1)(ii):

Fissile contents not to exceed 500 grams U-235 equivalent mass.

(c) Fissile Class

III

Maximum number of packages per shipment

One

Page 3 - Certificate No. 9228 - Revision No. 4 - Docket No. 71-9228

Plutonium in excess of twenty curies per package must be in the form of metal, metal alloy or reactor fuel elements.

7. The U-235 equivalent mass is determined by U-235 mass plus 1.66 times U-233 mass plus 1.66 times Pu mass.

8. Bolt torque:

The cask lid bolts must be torqued to 690 ft-lbs (lubricated).

The bolts used to secure the top of the overpack to the overpack base must be torqued to 100 ft-lbs (dry).

9. For any package containing organic or inorganic substances which could radiolytically generate combustible gases, determination must be made by tests and measurements or by analysis of a representative package such that the following criteria are met over a period of time that is twice the expected shipment time:

- (i) The hydrogen generated must be limited to a molar quantity that would be no more than 5% by volume (or equivalent limits for other inflammable gases) of the secondary container gas void if present at STP (i.e., no more than 0.063 g-moles/ft³ at 14.7 psia and 70°F); or

- (ii) The secondary container and cask cavity must be inerted with a diluent to assure that oxygen must be limited to 5% by volume in those portions of the package which could have hydrogen greater than 5%.

For any package delivered to a carrier for transport, the secondary container must be prepared for shipment in the same manner in which determination for gas generation is made. Shipment period begins when the package is prepared (sealed) and must be completed within twice the expected shipment time.

10. Prior to each shipment (except for contents meeting the requirements of special form radioactive material), the package must be leak tested to 1×10^{-3} std cm³/sec. Prior to first use, after the third use, and at least once within the 12-month period prior to each subsequent use, the package must be leak tested to 1×10^{-7} std cm³/sec.
11. The cask must be vacuum dried prior to shipment if contents are loaded under water, or if water is introduced into the cask cavity.
12. In addition to the requirements of Subpart G of 10 CFR Part 71:
  - (a) Prior to each shipment the cask seal must be inspected. The seal must be replaced with a new seal if inspection shows any defects or every 12 months, whichever occurs first; and

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- (b) Each package must meet the Acceptance Tests and Maintenance Program of Chapter 8 of the application, except that inspections in Section 8.2 of the application must be performed at least once within the 12-month period prior to each use; and
  - (c) The package shall be prepared for shipment and operated in accordance with the Operating Procedures of Chapter 7 of the application.
- 13. Appropriate carrier racks or shoring must be provided to minimize movement of contents during accident conditions of transport. A lead liner, as shown in General Electric Company Drawing No. 12904922, Rev. -, which was included in the March 29, 1989 supplement, may be used inside the cask.
  - 14. Each batch of ethylene propylene seals must be tested in accordance with Section 8.1.4.2 of the application.
  - 15. The package authorized by this certificate is hereby approved for use under the general license provisions of 10 CFR §71.12.
  - 16. Expiration date: October 31, 1994.

REFERENCES

General Electric Company application dated May 19, 1988.

Supplements dated: March 29 and August 24, 1989; May 30, October 11, and December 12, 1990; May 22, 1991; and June 8, and July 27, 1993.

FOR THE U.S. NUCLEAR REGULATORY COMMISSION

Cass R. Chappell
Cass R. Chappell, Section Leader
Cask Certification Section
Storage and Transport Systems Branch
Division of Industrial and
Medical Nuclear Safety, NMSS

AUG 24 1993

Date: _____

TN-FSV

CERTIFICATE OF COMPLIANCE
FOR RADIOACTIVE MATERIALS PACKAGES

U.S. NUCLEAR REGULATORY COMMISSION

1. a. CERTIFICATE NUMBER 9253	b. REVISION NUMBER 0	c. PACKAGE IDENTIFICATION NUMBER USA/9253/B(U)F	d. PAGE NUMBER 1	e. TOTAL NUMBER PAGES 3

2. PREAMBLE

- a. This certificate is issued to certify that the 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 (Name and Address)

Public Service Company
of Colorado
Platteville, Colorado 80651

b. TITLE AND IDENTIFICATION OF REPORT OR APPLICATION:

Public Service Company of Colorado
application dated March 31, 1993,
as supplemented

c. DOCKET NUMBER **71-9253**

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.: TN-FSV

(2) Description

A steel and lead shielded shipping cask for irradiated high temperature gas cooled reactor (HTGR) fuel elements. The cask is a right circular cylinder, with a balsa and redwood impact limiter at each end. The package has approximate dimensions and weights as follows:

Cavity diameter	18 inches
Cavity length	199 inches
Cask body outer diameter	31 inches
Lead shield thickness	3.44 inches
Package overall outer diameter, including impact limiters	78 inches
Package overall length, including impact limiters	247 inches
Packaging weight	42,000 pounds
Gross package weight, including contents	47,000 pounds

The cask body is made of two concentric shells of Type 304 stainless steel, welded to a bottom plate and a top closure flange. The inner shell has an ID of 18 inches and is 1.12 inches thick. The outer shell has an OD of approximately 30 inches and is 1.5 inches thick. The annular space between the inner and outer shells is filled with lead. The bottom plate is 5.5-inch thick Type 304 stainless steel. The closure lid is 2.5-inch thick Type 304 stainless steel, and is fully recessed into the cask top flange. The lid is fastened to the cask body by 12, 1-inch diameter closure bolts. The lid is sealed with double silicone O-rings, equipped with a leak test port. A vent port and drain port are sealed with single silicone O-rings and cover plates. The cask body is covered with a stainless steel thermal shield composed of 0.25-inch thick stainless steel plate over a wire wrap. The impact limiters are constructed of balsa and redwood encased in stainless steel shells.

5.(a)(2) Description (Continued)

The cask has two lifting sockets bolted to the cask top flange. Two rear trunnions are provided for cask tie-down.

The fuel elements are stacked in a carbon steel fuel storage container, which has an OD of approximately 17.6 inches and an overall length of 195 inches. The fuel storage container has a 0.5-inch thick shell, a 2.0-inch thick bottom plate, and a 1.5-inch thick lid. The lid accommodates a removable depleted uranium plug.

(3) Drawings

The packaging is constructed and assembled in accordance with the following Transnuclear, Inc. Drawing Nos.:

1090-SAR-1, Rev. 1	1090-SAR-6, Rev. 1
1090-SAR-2, Rev. 1	1090-SAR-7, Rev. 1
1090-SAR-3, Rev. 1	1090-SAR-8, Rev. 1
1090-SAR-4, Rev. 1	1090-SAR-9, Rev. 1
1090-SAR-5, Rev. 1	1090-SAR-10, Rev. 1

(b) Contents

(1) Type and form of material

Irradiated HTGR fuel elements. Each fuel element consists of a graphite block containing fuel rods. The fuel is composed of thorium/uranium carbide and thorium carbide fuel particles within the fuel rods. The graphite block is hexagonal in cross section and is approximately 14.2 inches across the flats and 31.2 inches long. Each fuel element contains a maximum of 1.4 kg of uranium enriched to a maximum of 93.5 weight percent U-235 and approximately 11.3 kg of thorium. The maximum burnup is approximately 70,000 MWD/MTIHM, and the minimum cool time is 1600 days.

(2) Maximum quantity of material per package

Six fuel elements, with decay heat not to exceed 60 watts per fuel element. The fuel elements are contained within a fuel storage container. Total weight of contents not to exceed 5,000 pounds, including fuel elements, fuel storage container, and depleted uranium shield plug.

(c) Fissile Class

III

Maximum number of
packages per shipment

One

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6. The package must be leak tested as follows:

- (a) Within the 12-month period prior to shipment, and after seal replacement, the package must be tested to show a leak rate no greater than 1×10^{-3} std-cm³/sec. The leak test must have a sensitivity of at least 5×10^{-4} std-cm³/sec.
- (b) Prior to each shipment, the package seals (main seal and vent seal) must be leak tested in accordance with Section 7.1.2 of the application. The acceptance criterion is a leak rate no greater than 1×10^{-3} std-cm³/sec. The test must have a sensitivity of at least 1×10^{-3} std-cm³/sec. The drain seal must also be tested if the drain port cover has been removed since the seal was last leak tested.

7. In addition to the requirements of Subpart G of 10 CFR Part 71:

- (a) The package must be prepared for shipment and operated in accordance with the Operating Procedures of Chapter 7 of the application.
- (b) Each packaging must meet the acceptance tests and must be maintained in accordance with the Acceptance Tests and Maintenance Program of Chapter 8 of the application.
- (c) Prior to each shipment, the cask main closure seal and vent seal must be inspected. The drain seal must be inspected if the drain port cover has been removed during preparation for shipment. All seals must be replaced within the 12-month period prior to shipment, or earlier if inspection shows any defect.

8. The package authorized by this certificate is hereby approved for use under the general license provisions of 10 CFR §71.12.

9. Expiration date: May 31, 1999.

REFERENCES

Public Service Company of Colorado application dated March 31, 1993.

Supplements dated: February 24, June 2, and June 14, 1994.

FOR THE U.S. NUCLEAR REGULATORY COMMISSION

Cass R. Chappell

Cass R. Chappell, Section Leader
Cask Certification Section
Storage and Transport Systems Branch
Division of Industrial and
Medical Nuclear Safety, NMSS

JUN 15 1994.

Date _____

TN-88L

**CERTIFICATE OF COMPLIANCE
FOR RADIOACTIVE MATERIALS PACKAGES**

1. a. CERTIFICATE NUMBER	b. REVISION NUMBER	c. PACKAGE IDENTIFICATION NUMBER	d. PAGE NUMBER	e. TOTAL NUMBER PAGES
9015	17	USA/9015/B( )	1	5

2. PREAMBLE

- a. This certificate is issued to certify that the 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 (Name and Address)

b. TITLE AND IDENTIFICATION OF REPORT OR APPLICATION:

Transnuclear, Inc.
Two Skyline Drive
Hawthorne, NY 10532-2120

Transnuclear, Inc. application dated
March 25, 1991, as supplemented.

c. DOCKET NUMBER 71-9015

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 Nos.: TN-8 and TN-8L

(2) Description

Lead, steel and resin shielded irradiated fuel shipping casks. The cask approximates a right circular cylinder 1,718 mm in diameter and 5,516 mm long. The cavity consists of three stainless steel square pressure vessels welded to an end plate and a circular stepped top flange, separated by a T-shaped copper plate and surrounded with B4C + Cu plates. Each cavity is 230 x 230 mm and 4,280 mm long. The main shielding consists of 135 mm of lead, 26 mm of steel and 150 mm of resin. A wet cement layer is located between the lead and the outer shell. Radial copper fins are welded to the outer shell and cover the surface of the cask between each end drum. The Model No. TN-8 has 150 rows of fins and the Model No. TN-8L has 104 rows of fins.

The lid is a welded stainless steel shell containing lead and resin shields. The pressure vessels are closed and sealed by sixteen, 1-1/4-inch diameter bolts and two silicone rubber or Viton O-rings located within recessed grooves on the top flange. Each extremity of the cask is surrounded by circular stainless steel drums reinforced by radial gusset plates and filled with balsa wood. A disk shaped impact limiter, constructed of carbon steel and balsa wood is fastened to each drum with four, 1-1/4-inch bolts. The vent and drain lines which penetrate the inner cavity are equipped with positive closures. In addition, all access ports are protected by the impact limiters.

The lid of the cask may be replaced with a modified lid which increases the cavity length to 4,362 mm or to 4,394 mm with the lid plate removed. This arrangement will be referred to as "Configuration X."

Trunnions are used for lifting and tie-down of the package. The package weighs approximately 36,000 kg.

(3) Drawings

The Model No. TN-8 packaging is constructed in accordance with Transnuclear Drawing No. 9317.01, Rev. J. The Model No. TN-8L is constructed in accordance with Transnuclear Drawing No. 9317.138, Rev. A. The materials of construction and welds shall be in accordance with Annex A, B, and C to Chapter II of the Application.

The lid for Configuration X is constructed in accordance with Transnuclear Drawings Nos. 9040-500-1, Rev. 1, 9040-500-2, Rev. 1 and 9040-500-3, Rev. 0.

(b) Contents

(1) Type and form of material

(i) Irradiated PWR uranium oxide fuel assemblies of the following specifications:

Fuel form	Clad UO ₂ Pellets
Cladding material	Zr or SS
Maximum initial U content/assembly, kg	469
Maximum average initial U-235 enrichment with Zr cladding, w/o	3.2
Maximum average initial U-235 enrichment with SS cladding, w/o	4.0
Maximum bundle cross section, in	8.5
Maximum active fuel length, in	146
Minimum cooling time, day	150
Maximum weight/fuel assembly kg	733; and

Group I fuel assemblies

Initial fuel pin pressure at 100°F, psig	250
Maximum average burnup, MWD/MTU	38,500; or

Group II fuel assemblies

Maximum average burnup, MWD/MTU	36,000

For the casks in Configuration X, the minimum cooling time of the fuel assemblies shall be 1,460 days with the lid plate installed and 2,190 days with the lid plate removed.

(ii) Solid non-fissile irradiated hardware. As needed, appropriate component spacers must be used when loading irradiated hardware into the cask cavity to limit movement of the contents during accident conditions of transport.

- (iii) Intact BWR and PWR fuel rods. The rods shall be constrained by a basket or grid structure; initial U-235 content shall be less than 15.0 kg per rod bundle; cross sectional area of the rods, tubes, and full length structural material shall not be less than 29.6 square inches; and the bundle cross section shall not be greater than 8.5 inches. Maximum weight per bundle shall not exceed 733 kg. The Group I and Group II burnup limits of paragraph 5.(b)(1)(i) apply.

(2) Maximum quantity of material per package

- (i) For the contents described in Item 5.(b)(1)(i), Group I fuel assemblies:

Three PWR assemblies. The maximum decay heat load is not to exceed 35.5 kilowatts per package and 12 kilowatts per assembly for the Model No. TN-8 packaging and 23.7 kilowatts per package and 7.9 kilowatts per assembly for the Model No. TN-8L packaging.

- (ii) For the contents described in Item 5.(b)(1)(i), Group II fuel assemblies:

Three PWR assemblies. The maximum decay heat load and the maximum free gas volume are not to exceed the limits listed in the table below:

Decay Heat per Shipment, kw ^(a)	Maximum Free Gas for 3 Assemblies ^(b) m ³ (NTP)	Configuration X Maximum Free Gas for 3 Assemblies ^(b) m ³ (NTP)
1.5	0.558	0.601
3.0	0.543	0.585
9.0	0.483	0.520
15.0	0.441	0.475
21.0	0.408	0.439
27.0	0.384	0.413

Notes: (a) Decay heat load per assembly must not exceed 7.9 kilowatts for Model No. TN-8L packaging.

(b) NTP conditions are 25°C and one (1) bar.

5. (b)(2) (Continued)

- (iii) For the contents described in Item 5.(b)(1)(iii):
Three rod bundles. The maximum decay heat load and maximum free gas volume are not to exceed the limits listed in Paragraph 5.(b)(2)(ii).

(c) Fissile Class

III

Maximum number of packages per shipment

One (1)

6. Group I and Group II fuel assemblies, either Zr or SS clad, and bundles of PWR and/or BWR fuel rods that individually meet all the appropriate specifications of 5.(b)(1)(i), 5.(b)(2)(i), 5.(b)(1)(iii), and 5.(b)(2)(iii) above may be packaged in any combination.
7. PWR assemblies may be shipped either with or without burnable poison rod, thimble plug, or control rod assemblies.
8. As needed, appropriate component spacers may be used in the cask cavity to properly position the fuel assemblies.
9. The maximum weight of the contents (fuel assemblies, component spacers, inserts, irradiated hardware, etc.) must not exceed 2,200 kg.
10. The cask cavity must be dry (no free water) when delivered to a carrier for transport. Residual moisture must be promptly removed from the cask cavity by the methods described in Annex I to Chapter VIII of the Application. For contents 5.(b)(1)(i) and 5.(b)(1)(iii), the cavity must be promptly backfilled with 1.0 atm of helium, nitrogen, or argon gas.
11. Known or suspected failed fuel assemblies (rods) and fuel cladding defects greater than pin holes and hairline cracks are not authorized.
12. For contents 5.(b)(1)(ii), the dryness verification test is required but leakage tests for containment assembly verification are not required.
13. The package contents must be so limited that under normal conditions of transport, the total dose rates must not exceed 17 mrem/hr at one meter from the surface of the package.
14. Any system used for cooling down the package must be provided with a pressure relief device set so that the maximum pressure in the containment vessel cannot exceed 7 atmospheres during the cool-down process.
15. The systems and components of each packaging must meet the periodic tests and criteria specified in Chapter VIII of the Application. The K_{eff} verification and shielding efficiency verification tests in Chapter VIII of the Application must be performed on each packaging within the two year period preceding any shipment of contents listed in 5(b)(1)(i) and 5(b)(1)(iii). The K_{eff} verification and shielding efficiency verification tests need not be performed on packaging during periods (which may exceed two years) when only irradiated hardware as specified in 5(b)(1)(ii) is shipped.

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16. In addition to the requirements of 10 CFR Part 71:

- (a) The package must be prepared for shipment and operated in accordance with the Operating Procedures in the application dated March 25, 1991.
- (b) Each package must be tested, repaired and maintained in accordance with the Acceptance Tests and Maintenance Procedures in the application dated March 25, 1991.

17. All valves, fittings, seals and relief devices must be of the type, size, model and manufacture as indicated on the design drawings. The resin material must be of the specifications stated in Annex A to Chapter II of the Application.

18. In accordance with Annex L to Chapter VIII, at periodic intervals not to exceed two years, the thermal performance of the cask must be analyzed to verify that the cask operation has not degraded below that which is licensed*. Following the initial acceptance tests, the heat source may be that provided by the decay heat from the loading of the package, provided that the heat source is equal to at least 25% of the design heat load for the package. Each cask that fails to meet the thermal acceptance criteria given in Annex L of the Application must be withdrawn from service until corrective action can be completed or the license amended to limit the package to a lower heat load.

* The thermal performance test is not required at periodic intervals when the maximum decay heat load per package does not exceed 25% of the design heat load.

19. The Configuration X lid shall be operated and maintained in accordance with Annex N to Chapter VIII, in the application dated March 25, 1991.

20. The package authorized by this certificate is hereby approved for use under the general license provisions of 10 CFR 471.12.

21. Expiration date: May 31, 1996.

REFERENCES

Transnuclear, Inc. application dated March 25, 1991

Supplements dated: April 22, 1991.

FOR THE U.S. NUCLEAR REGULATORY COMMISSION

Charles E. MacDonald
Charles E. MacDonald, Chief
Transportation Branch
Division of Safeguards
and Transportation, NMSS

Date: MAY 17 1991

TN-9

B-103

**CERTIFICATE OF COMPLIANCE
FOR RADIOACTIVE MATERIALS PACKAGES**

1. a. CERTIFICATE NUMBER 9016	b. REVISION NUMBER 9	c. PACKAGE IDENTIFICATION NUMBER USA/9016/B( )F	d. PAGE NUMBER 1	e. TOTAL NUMBER PAGES 4

2. PREAMBLE

- a. This certificate is issued to certify that the 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 (Name and Address)

b. TITLE AND IDENTIFICATION OF REPORT OR APPLICATION:

Transnuclear, Inc.
Two Skyline Drive
Hawthorne, NY 10532-2120

Transnuclear, Inc. application dated
March 25, 1991, as supplemented.

c. DOCKET NUMBER **71-9016**

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.: TN-9

(2) Description

A lead, steel and resin shielded irradiated fuel shipping casks. The cask approximates a right circular cylinder 1,718 mm in diameter and 5,756 mm long. The cavity consists of three rectangular, stainless steel pressure vessels welded to end plates and a circular stepped top flange, separated by thin copper plates. The bays are divided into a total of seven square compartments, 150 x 150 mm and 4,520 mm long. The main shielding consists of 128 mm of lead, 26 mm of steel and 150 mm of resin. A wet cement layer is located between the lead and the outer shell. Radial copper fins are welded to the outer shell and cover the surface of the cask between each end drum.

The lid is a welded stainless steel shell containing lead and resin shields. The pressure vessels are closed and sealed by sixteen, 1-1/4-inch diameter bolts and two silicone rubber or Viton O-rings located within recessed grooves on the top flange. Each extremity of the cask is surrounded by circular stainless steel drums reinforced by radial gusset plates and filled with balsa wood. A disk shaped impact limiter, constructed of carbon steel and balsa wood is fastened to each drum with four, 1-1/4-inch bolts. The vent and drain lines which penetrate the inner cavity are equipped with positive closures. In addition, all access ports are protected by the impact limiters. Trunnions are used for lifting and tie-down of the package. The weight of the package is approximately 36,000 kg.

(3) Drawings

The package is constructed in accordance with Transnuclear Drawing No. 9317.03, Rev. J. The materials of construction and welds must be in accordance with Annex A, B, and C to Chapter II of the Application.

5. (b) Contents

(1) Type and form of material

- (i) Irradiated BWR uranium oxide fuel assemblies of the following specifications:

Fuel form	Clad UO ₂ Pellets
Cladding material	Zr or SS
Initial fuel pin pressure at 100°F, psig	200
Maximum initial U content/ assembly, kg	201
Maximum average initial U-235 enrichment, w/o	2.65
Maximum bundle cross section, in	5.52
Maximum active fuel length, in	144
Average burnup, MWD/MTD	36,500
Minimum cooling time, day	150
Maximum weight/fuel assembly, kg	300

- (ii) Solid non-fissile irradiated hardware. As needed, appropriate component spacers must be used when loading irradiated hardware into the cask cavity to limit movement of the contents during accident conditions of transport.

(2) Maximum quantity of material per package

- (i) Seven BWR assemblies. The maximum decay heat load per package is not to exceed 24.4 kilowatts and 3.5 kilowatts per assembly. As needed, appropriate component spacers may be used in the cask cavity to properly position the fuel assemblies.
- (ii) The maximum weight of the contents (fuel assemblies, component spacers, inserts, irradiated hardware, etc.) must not exceed 2,110 kg.

(c) Fissile Class

III

Maximum number of packages per shipment

One (1)

6. The cask cavity must be dry (no free water) when delivered to a carrier for transport. Residual moisture must be promptly removed from the cask cavity by the methods described in Annex I to Chapter VIII of the application. For contents 5.(b)(1)(i), the cavity must be promptly backfilled with 1.0 atm of helium, nitrogen, or argon gas.

7. In addition to the requirements of Subpart 6 of 10 CFR Part 71:
  - (a) The package must be prepared for shipment and operated in accordance with the Operating Procedures in Chapter VIII of the Application.
  - (b) Each package must be tested and maintained in accordance with the Acceptance Test and Maintenance Procedures in Chapter VIII of the Application.
8. Known or suspected failed fuel assemblies (rods) and fuel with cladding defects greater than pin holes and hairline cracks are not authorized.
9. For contents 5.(b)(1)(ii), the dryness verification test is required but leakage tests for assembly verification are not required.
10. The package contents must be so limited that under normal conditions of transport, the total dose rates must not exceed 14 mrem/hr at one meter from the surface of the package.
11. Any system used for cooling down the package must be provided with a pressure relief device set so that the maximum pressure in the containment vessel cannot exceed 7 atmospheres during the cool-down process.
12. The systems and components of each packaging must meet the periodic tests and criteria specified in Chapter VIII of the Application. Each packaging that fails to meet these criteria must be withdrawn from service until corrective action has been completed.
13. All valves, fittings, seals and relief devices must be of the type, size, model and manufacture as indicated on the design drawings. The resin material must be of the specifications stated in Annex A to Chapter II of the Application.
14. In accordance with Annex L to Chapter VIII, at periodic intervals not to exceed two years, the thermal performance of the cask must be analyzed to verify that the cask operation has not degraded below that which is licensed*. Following the initial acceptance tests, the heat source may be that provided by the decay heat from the loading of the package, provided that the heat source is equal to at least 25% of the design heat load for the package. Each cask that fails to meet the thermal acceptance criteria given in Annex L of the Application must be withdrawn from service until corrective action can be completed or the license amended to limit the package to lower heat load.

* The thermal performance test is not required at periodic intervals when the maximum decay heat load per package does not exceed 25% of the design heat load.

CONDITIONS (continued)

Page 4 - Certificate No. 9016 - Revision No. 9 - Docket No. 71-9016

15. The package authorized by this certificate is hereby approved for use under the general license provisions of 10 CFR §71.12.
16. Expiration date: May 31, 1996.

REFERENCES

Transnuclear, Inc. application dated March 25, 1991

Supplements dated: April 22, 1991.

FOR THE U.S. NUCLEAR REGULATORY COMMISSION

Charles E. MacDonald

Charles E. MacDonald, Chief
Transportation Branch
Division of Safeguards
and Transportation, NMSS

Date: MAY 9 1991

M-130

B-109

Drawing Not Available

CERTIFICATE OF COMPLIANCE
FOR RADIOACTIVE MATERIALS PACKAGES

U.S. NUCLEAR REGULATORY COMMISSION

1. a. CERTIFICATE NUMBER	b. REVISION NUMBER	c. PACKAGE IDENTIFICATION NUMBER	d. PAGE NUMBER	e. TOTAL NUMBER PAGES
6003	15	USA/6003/B( )F	1	7

2. PREAMBLE

- This certificate is issued to certify that the 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."
- 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 (Name and Address)

U.S. Department of Energy
Division of Naval Reactors
Washington, DC 20585

b. TITLE AND IDENTIFICATION OF REPORT OR APPLICATION:

Safety Analysis Report for M-130 shipping
container dated December 30, 1968, as
supplemented.

c. DOCKET NUMBER 71-6003

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.: M-130
- (2) Description

The Model No. M-130 shipping container is an upright cylinder 84 inches in diameter by 158 inches overall height. The container walls consist of a finned 1-inch thick outer shell fabricated from either carbon steel, carbon steel with stainless steel clad, or solid stainless steel, 10 inches of lead shielding, and a 1-inch thick inner pressure vessel fabricated from carbon steel clad with stainless steel. The top of the container is covered with a shielded closure head which is bolted to the container and seals the pressure vessel. An access opening with a bolted shield plug is provided in the closure head for loading and unloading spent fuel.

The pressure vessel has an inside diameter of 55 inches. The central region contains a secondary heat exchanger (not used during shipment) surrounded by 1/2 inch thick carbon steel backup cylinder 29 inches in diameter. The annulus which remains between the backup cylinder and the pressure vessel provides a space 13 inches wide and 130 inches high for spent fuel. The spent fuel is contained in the annulus by module holders designed for the particular core to be shipped.

The container has external penetrations to the pressure vessel for steam and water relief lines and a fill and drain line (which are capped during shipment) and a pressure sensing line which remains open to a pressure gage during shipment. The container also has penetrations which do not open to the pressure vessel for secondary heat exchanger lines (which are capped during shipment) and a temperature sensing line.

CONDITIONS (continued)

Page 2 - Certificate No. 6003 - Revision No. 15 - Docket No. 71-6003

i.(a) Packaging (cont'd)

(2) Description (cont'd)

For LWBR spent fuel shipments, the heat exchanger and associated structures have been removed, external penetrations plugged and seal welded, and an external shield and energy absorber added during modifications.

The container is supported on its transport vehicle by an "A" frame structure. Gross weight of the loaded container without its support structure is approximately 228,000 pounds.

(3) Drawings

The packaging is constructed in accordance with General Electric Drawing Nos. 247E209, Sheet 1, Rev. R; Sheet 2, Rev. K; Sheet 3, Rev. T; Sheet 4, Rev. U; Sheet 5 of 5, Rev. F and 247E228, Rev. F.

For LWBR spent fuel shipments, the container has been modified in accordance with Westinghouse Electric Drawing 1176J48, Sheet 1 Rev. G, Sheet 2 Rev. E and an external energy absorber added in accordance with Westinghouse Electric Drawing 1525E32, Rev. A.

(b) Contents

(1) Type and form of material

Irradiated fuel assemblies, activated corrosion products and structural parts containing up to 40 gallons of residual contaminated water. The fuel assemblies and structural parts are of the following types:

- (i) S3N/S4W fuel subassemblies of core type 2.
- (ii) S5W fuel modules of core types 2 or 3.
- (iii) S5W corner fuel modules of core types 2 or 3.
- (iv) D1G fuel modules of core types 1 or 2.
- (v) D1G removable fuel assemblies of core types 1 or 2.
- (vi) S1C/S2C fuel modules with control rods.
- (vii) S1C/S2C peripheral fuel modules.
- (viii) S3G-3/3A fuel module with or without control rods.
- (ix) SAD cell.

CONDITIONS (continued)

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i. (b) Contents (cont'd)

(1) Type and form of material (cont'd)

- (x) S3G-3/3A irradiated thermocouples and thermocouple cases.
- (xi) S8G full size fuel cell with or without control rod.
- (xii) S8G partial size fuel cell with or without control rod.
- (xiii) S5W-4A recoverable irradiated fuel modules with control rod.
- (xiv) S7G recoverable irradiated fuel cells.
- (xv) D2W fuel cells with control rods.
- (xvi) NR-1 fuel modules with or without control rods.
- (xvii) ATC fuel modules with or without control rods.
- (xviii) A1W-3 recoverable irradiated fuel modules. Fuel modules that use control rods shall have control rods inserted.

(2) Maximum quantity of material per package:

- (i) 52 fuel assemblies as described in 5(b)(1)(i).
- (ii) 12 fuel assemblies as described in 5(b)(1)(ii) or 9 fuel assemblies as described in 5(b)(1)(ii) and 4 fuel assemblies as described in 5(b)(1)(iii).
- (iii) 6 fuel assemblies as described in 5(b)(1)(iv) and 4 fuel assemblies as described in 5(b)(1)(v).
- (iv) 9 fuel assemblies as described in 5(b)(1)(vi) and 8 fuel assemblies as described in 5(b)(1)(vii).
- (v) 10 fuel assemblies as described in 5(b)(1)(viii).
- (vi) 9 fuel assemblies as described in 5(b)(1)(viii) and one fuel assembly as described in 5(b)(1)(ix).
- (vii) 9 fuel assemblies as described in 5(b)(1)(viii) and one structure as described in 5(b)(1)(x).

CONDITIONS (continued)

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5. (b) (2) Contents (cont'd)

- (viii) 4 fuel cells as described in 5(b)(1)(xi); or
2 fuel cells as described in 5(b)(1)(xi) and
2 fuel cells as described in 5(b)(1)(xii).
- (ix) 6 fuel assemblies as described in 5(b)(1)(xiii).
- (x) 8 fuel cells as described in 5(b)(1)(xiv).
- (xi) 4 fuel cells as described in 5(b)(1)(xv) plus
2 corner fuel cells or 1 RFA fuel cell.
- (xii) 4 fuel modules as described in 5(b)(1)(xvi).
- (xiii) 10 fuel modules as described in 5(b)(1)(xvii).
- (xiv) For contents described in 5(b)(1)(xviii), 6 fuel modules, or
8 fuel modules, as described in supplement dated March 30, 1992.

(3) Shipments shall be further limited by thermal requirements as follows:

- (i) Shipment of contents specified in 5(b)(1)(iv) and 5(b)(1)(v) and limited in 5(b)(2)(iii) shall be made no earlier than 75 days after shutdown and shall have a decay heat load not to exceed 33,500 Btu/hr per shipment.
- (ii) Shipment of contents specified in 5(b)(1)(vi) and 5(b)(1)(vii) and limited in 5(b)(2)(iv) shall be made in a stainless steel M-130 container and shall have a decay heat load not to exceed 18,960 Btu/hr per shipment.
- (iii) Shipment of contents specified in 5(b)(1)(viii), 5(b)(1)(ix) and 5(b)(1)(x) and limited in 5(b)(2)(v), 5(b)(2)(vi) and 5(b)(2)(vii) shall be made at a time after shutdown as determined from Bettis Atomic Power Laboratory report WAPD-OP(PP)S-4401 dated June 29, 1979 and shall have a decay heat load not to exceed 28,620 Btu/hr for the shipboard core and 30,000 Btu/hr for the prototype core.
- (iv) Shipment of contents specified in 5(b)(1)(i), 5(b)(1)(ii) shall be made no earlier than 72 days after shutdown and shall have a decay heat load not to exceed 33,500 Btu/hr per shipment.
- (v) Shipment of contents specified in 5(b)(1)(xi) or 5(b)(1)(xii) as limited by 5(b)(2)(vii) shall have a fully loaded container heat load not to exceed 15,400 Btu/hr per shipment.
- (vi) Shipment of contents specified in 5(b)(1)(xiii) and limited in 5(b)(2)(ix) shall have a heat load not to exceed 23,800 Btu/hr and shall be made no earlier than 92 days after shutdown.

CONDITIONS (continued)

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5. (b) (3) Contents (cont'd)

- (vii) Shipment of contents specified in 5(b)(1)(xiv) and limited in 5(b)(2)(x) shall have a heat load not to exceed 22,400 Btu/hr and shall be made no earlier than 122 days after shutdown.
- (viii) Shipment of contents specified in 5(b)(1)(xv) and limited in 5(b)(2)(xi) shall have a heat load not to exceed 19,100 Btu/hr and shall be made no earlier than 420 days after shutdown.
- (ix) Shipment of contents specified in 5(b)(1)(xvi) and limited in 5(b)(2)(xii) shall have a heat load not to exceed 6,000 Btu/hr and shall be made no earlier than 50 days after shutdown.
- (x) Shipment of contents specified in 5(b)(1)(xvii) and limited in 5(b)(2)(xiii) shall have a heat load not to exceed 27,400 Btu/hr and shall be made no earlier than 195 days after shutdown.
- (xi) Shipment of contents specified in 5(b)(1)(xviii) and limited in 5(b)(2)(xiv) shall have a heat load not to exceed 43,800 BTU/hr and shall be made no earlier than 400 days after shutdown.

(c) Fissile Class

Maximum number of packages per shipment:

Except for the contents described in 5(b)(1)(viii) and limited in 5(b)(2)(v)

One (1)

For the contents described in 5(b)(1)(viii) and limited in 5(b)(2)(v)

Two (2)

- 6. For shipments involving the contents specified in 5(b)(1)(ii) or 5(b)(1)(iii) the Model No. M-130 package shall be inspected to verify that boron poison plates are in the module holders.
- 7. For shipments involving the contents specified in 5(b)(1)(viii), 5(b)(1)(ix) or 5(b)(1)(x) the thermocouples and thermocouple cases if included or the vacant module holder shall be located in the mid-position of either cage and module holder assembly.

CONDITIONS (continued)

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8. Shipments shall be made in the dry condition, except for residual water as limited in 5(b)(1), 5(b)(3)(v), and 5(b)(3)(vii).
9. Container number three (M-130-3) has been modified by adding two 4-inch thick by 8-inch wide steel plates welded between fins 25 and 50 and between fins 110 and 135 at approximately 14.75 inches from the bottom of the container. The cooling fins in this localized area are removed to permit attachment of the plate directly to the outer shell of the container.
10. Container number four (M-130-4) has been modified by adding a 2-inch thick by 4-inch wide steel plate welded between fins 32 and 49 at approximately 18.4 inches from the bottom of the container. The cooling fins in this localized area removed to permit attachment of the plate directly to the outer shell of the container.
11. Containers M-130-3, M-130-4, M-130-6, and M-130-7 may be used for the contents specified in 5(b)(1)(viii) and 5(b)(1)(x) only. Containers M-130-10 and M-130-15 may be used for the contents specified in 5(b)(1)(viii), 5(b)(1)(x) and 5(b)(1)(xviii) only.
12. Container M-130-11 may be used for NR-1 shipments only.
13. For shipments involving the contents specified in 5(b)(1)(xvii) which do not contain a full complement of fuel modules (i.e. one position is occupied by either two flux thimbles or a vacant fuel module holder with pocket shield plug), that position shall be located in the middle module holder of either half of the cage assembly.
14. Expiration date: December 31, 1997.

CONDITIONS (continued)

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REFERENCES

Safety analysis report for M-130 shipping container, MAO-E8-703 dated December 30, 1968.

Supplements: Naval Reactors letters A#2256 dated February 24, 1969 and G#1931 dated March 3, 1969; General Electric Company letter ONP-74520-526 dated April 3, 1972; Naval Reactors letter G#3207 dated April 27, 1972; General Electric Company letter ONP-74520-528 dated April 28, 1972; Naval Reactors letter G#3250 dated June 6, 1972; General Electric Company letters ONP-74570-635 dated October 25, 1972; ONP-74570-654 dated December 4, 1972; ONP-14570-666 dated December 12, 1972; ONP-74570-682 dated January 12, 1973; ONP-74570-698 dated January 31, 1973; ONP-74570-687 dated February 6, 1973; ONP-74390-65 dated March 26, 1973; DLGN-85570-854 dated September 24, 1973; DLGN-85570-901 dated January 10, 1974; Naval Reactors letter G#4061 dated January 29, 1974; General Electric Company letters DLGN-85570-924 dated February 15, 1974; DLGN-85570-923 dated March 6, 1974; DLGN-85570-969 dated May 24, 1974; Naval Reactors letter G#4991 dated November 25, 1975; General Electric Company letters ONP-74340-JTT-73 dated December 17, 1975; CGN-85570-1145 dated September 9, 1976; CGN-85570-1146 dated September 10, 1976; CGN-85570-1148 dated September 14, 1976; Bettis Atomic Power Laboratory letter WAPD-R(K)-1378 dated August 30, 1976; WAPD-OP(PP)S-4401 dated June 29, 1979; Naval Reactors letters G#6197 dated July 13, 1979; G#7136 dated March 17, 1982; Naval Reactors letter G#7022 dated July 14, 1981 and WAPD-LD-(CES)SE-181 dated September, 1981; WAPD-LP(CES)SE-96 dated February, 1982; WAPD-LP-(CES)SE-170 dated July 1981; Naval Reactors letter G#7160 dated May 18, 1982; Naval Reactors letter G#7582 dated September 7, 1983; Naval Reactors letter G#C87-5682 dated September 2, 1987; Naval Reactors letter G#C87-5689 dated September 23, 1987, and Naval Reactors letters G#C87-8008 dated January 19, G#C88-5931 dated May 12, and G#C88-5961 dated July 25, 1988. Naval Reactors letter G#C89-2853 dated August 11, 1989; Naval Reactor letter G#C89-2825 dated March 29, 1989; Naval Reactors letter G#C92-63392 dated March 30, 1992; and Naval Reactors letter G#92-03729 dated October 20, 1992.

FOR THE U.S. NUCLEAR REGULATORY COMMISSION

Charles E. MacDonald
Charles E. MacDonald, Chief
Transportation Branch
Division of Industrial and
Medical Nuclear Safety, NMSS

Date: MAR 2 1993

IF-300

B-118

B-120

**CERTIFICATE OF COMPLIANCE
FOR RADIOACTIVE MATERIALS PACKAGES**

U.S. NUCLEAR REGULATORY COMMISSION

1. a. CERTIFICATE NUMBER	b. REVISION NUMBER	c. PACKAGE IDENTIFICATION NUMBER	d. PAGE NUMBER	e. TOTAL NUMBER PAGES
9001	28	USA/9001/B( )F	1	7

2. PREAMBLE

- This certificate is issued to certify that the 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."
- 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 (Name and Address)

Pacific Nuclear Systems, Inc.
1010 South 336th Street
Federal Way, WA 98003

b. TITLE AND IDENTIFICATION OF REPORT OR APPLICATION:

General Electric Uranium Management Corporation
application dated September 24, 1984, as
supplemented.

71-9001

c. DOCKET NUMBER

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.: IF-300

(2) Description

A stainless steel encased, depleted uranium shielded cask. The cask is cylindrical in shape, 64 inches in diameter and a maximum of 210 inches long with maximum cavity dimensions of 37-1/2 inches in diameter by 180-1/4 inches long. Shielding is provided by 4 inches of depleted uranium, 2-1/8 inches of stainless steel and a minimum of 4-1/2 inches (550 gallons) of a water-ethylene glycol mixture.

Two closure heads are provided for the shipment of BWR and PWR fuel assemblies. The heads are 304 stainless steel forgings and end plates which encase the 3-inch thick depleted uranium shielding. Either closure head may be used for packaging solid irradiated hardware.

The closure heads are secured to the cask body by means of 32, 1-3/4 inch studs and nuts. The cask is sealed with a metallic ring gasket.

The cavity is penetrated by a vent line at the top and a drain line at the bottom. These lines are sealed by bellows stainless steel globe valves and valved quick-disconnect couplings. Stainless steel pipe caps may be used in lieu of the quick-disconnect couplings. The vent line is also equipped with a 350-400 psig rated rupture disk. All valves are housed in protected boxes on the cask exterior.

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5.(a) Packaging (continued)

(2) Description (continued)

Neutron shielding is provided by a liquid-filled, thin-walled, corrugated containment on the cask exterior. This cylindrical structure is separated into two longitudinal compartments, each equipped with two expansion tanks, fill relief valves. The fill line from each compartment is terminated by a stainless steel globe valve in a protected box (separate from cavity boxes) on the cask exterior. The stainless steel globe valves may be replaced by stainless steel blind flanges. The vent line from each compartment goes to an expansion tank which is provided with a pressure-relief valve set at 200 psig.

The cask has four types of fuel baskets which can be interchanged to accommodate various fuels. The PWR basket holds seven assemblies, the unchannelled BWR basket holds eighteen assemblies, the channelled BWR basket holds seven assemblies, and the Shoreham BWR fuel basket holds seventeen Shoreham BWR fuel assemblies. The channelled and unchannelled BWR fuel baskets may be provided with supplementary shielding (depleted uranium) near the cask closure.

The cask is shipped horizontally with the bottom supported in a tipping cradle between two pedestals and the upper end resting in a semi-circular saddle; the upper end is pinned to the saddle. The cask supports are welded to the frame of a 37-1/2-foot long by 8-foot wide structural steel skid. The skid may also have installed on it an auxiliary cooling system, consisting of two diesel engines driving two blowers which discharge cooling air to the corrugated surface of the cask via common ducting. Neither installation nor operation of all or part of this auxiliary cooling system is a requirement of this package approval.

The entire cask and cooling system is covered by a retractable aluminum enclosure. Access to the enclosure is via locked panels in the side and a locked door in one end. Although the Model No. IF-300 cask can be transported for short distances on the highway, its principal mode of transportation is by railroad.

The gross weight of the cask is approximately 140,000 pounds. The skid and other external components weigh approximately 45,000 pounds.

(3) Drawings.

The Model No. IF-300 shipping cask is described by the following General Electric Company Drawing Nos.: 159C5238 - Sheet 1, Rev. 9; Sheet 2, Rev. 3; Sheet 3, Rev. 9; Sheet 4, Rev. 8; Sheet 5, Rev. 5; Sheet 6, Rev. 8; Sheet 7, Rev. 4; Sheet 8, Rev. 5; Sheet 9, Rev. 8; Sheet 10, Rev. 5; and Sheet 11, Rev. 2, and Pacific Nuclear Systems, Inc. Drawing Nos.: 420-11-3000, Sheets 1, through 9, Rev. 0; 420-11-3001, Sheet 1, Rev. 0; 420-11-3002, Sheets 1 and 2, Rev. 0; 420-11-3003, Sheets 1 and 2, Rev. 0; 420-11-3004, Sheets 1 and 2, Rev. 0; 420-11-3005, Sheets 1 and 2, Rev. 0; 420-11-3006, Sheet 1, Rev. 0; 2045.300 Sheets 1 to 4, Rev. 1; 2045.3001, Sheets 1 and 2, Rev. 1; 2045.3002, Sheet 1, Rev. 1; and 2045.3003, Sheet 1, Rev. 0.

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5.(a)(4) Basic Components

The basic components of the Model No. IF-300 shipping cask that are important to nuclear safety are listed in Section IX, Table IX-1.

(b) Contents

(1) Type and form of material

- (1) Irradiated PWR and BWR uranium oxide fuel assemblies. PWR assemblies may be shipped with or without control rods. Partial fuel assemblies, that is, assemblies from which fuel pins are missing, must not be shipped unless dummy fuel pins are used to displace an amount of water equal to that displaced by the original pins. The specific power of each fuel assembly must not exceed 40 kw/kgU and the burnup of each fuel assembly must not exceed 35,000 MWD/MTU. The minimum cooling time of each assembly must be no less than 120 days. Prior to irradiation, the BWR and PWR fuel assemblies must have the following dimensions and specifications:

Group I fuel assemblies

	PWR	BWR
Fuel form	Clad UO ₂ pellets	Clad UO ₂ pellets
Cladding material	Zr or SS	Zr or SS
Maximum initial U content/assembly, kg	465	198
Maximum initial U-235 enrichment, w/o	4.0	4.0
Maximum bundle cross section, in	8.75	5.75
Fuel pin array	14x14/15x15	7x7
Fuel diameter, in	0.380-0.460	0.500-0.600
Fuel pin pitch range, in	0.502-0.582	0.647-0.809
Maximum active fuel length, in	145	146

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5. (b) Contents (continued)

Group II fuel assemblies

	<u>PWR</u>	<u>BWR</u>
Fuel form	Clad UO_2 pellets	Clad UO_2 pellets
Cladding material	Zr or SS	Zr or SS
Maximum initial U content/assembly, kg	475	198
Maximum initial U-235 enrichment, w/o	4.0	4.0
Maximum bundle cross section, in	8.75	5.75
Fuel pin array	16x16/17x17	8x8
Fuel diameter, in	0.376-0.400	0.475-0.505
Fuel pin pitch range, in	0.496-0.507	0.630-0.645
Maximum active fuel length, in	150	150

- (ii) Irradiated Shoreham BWR fuel assemblies composed of UO_2 fuel rods in an 8 x 8 square array. Each fuel assembly has a maximum average enrichment of 2.19 w/o U-235. The fuel rods have the following nominal dimensions: 0.410-inch fuel pellet diameter, 0.032-inch thick zircalloy cladding, 0.64-inch rod pitch, and 150-inch active fuel length. The maximum assembly burnup is 87.0 MWD/MTU, and the minimum cool time is three years. Fuel assemblies may be shipped with protective packaging as described in Section 1.2.3.1 of application dated February 25, 1993. Fuel assemblies must be positioned within stainless steel channels which have a nominal thickness of 0.0595 inch and a nominal length of 167 inches. For natural uranium fuel assemblies, zircalloy channels, having a nominal thickness of 0.1 inch and a length of approximately 167 inches, may be used in lieu of stainless steel channels.

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5.(b) Contents (continued)

(iii) Solid irradiated hardware, which may include fissile material, provided the quantity of fissile material does not exceed a Type A quantity and does not exceed the mass limits of 10 CFR §71.53. As needed, appropriate component spacers must be used when loading irradiated hardware into the cask cavity to limit movement of the contents during accident conditions of transport. Use of a steel liner is authorized provided: (1) its outside dimensions are approximately those of the cask cavity inside dimensions, (2) constructed of single thickness of steel plate with full penetration welds, (3) thickness of steel plate does not exceed one inch, and (4) the liner is provided with a drain and vent to insure water removal.

(2) Maximum quantity of material per package

(i) Maximum decay heat per package not to exceed 40,000 Btu/hr. Maximum 5,725 Btu/hr/PWR assembly. Maximum 2,225 Btu/hr/BWR assembly.

(ii) Seven PWR fuel assemblies, seventeen channelled BWR assemblies, eighteen unchannelled BWR fuel assemblies, or seventeen Shoreham BWR fuel assemblies.

(iii) Above fuel assemblies to be contained in their respective fuel baskets as shown in GE Drawing No. 159C5238 -- Sheet 6, Rev. 8, PNSI Drawing No. 420-111-3000, Sheet 1 through 9, Rev. 0, or PNSI Drawing No. 2045.3002, Sheet 1, Rev. 1.

(c) Unloaded package - contents and maximum quantity of material

Greater than a Type A quantity of residual radioactive material consisting of mixed-fission and activation products adhering to interior cavity and fuel basket surfaces.

(d) Fissile Class I

6. The end of life total calculated residual gas that could become available from the fuel pins must not exceed 0.50 lb moles for content 5.(b).
7. The maximum gross weight of the cavity contents must not exceed 21,000 pounds.
8. For the shipment of irradiated fuel assemblies, the cask cavity (containment vessel) must be promptly inerted following removal of the water from the cavity. The cask cavity must be purged at least three times with argon, nitrogen, or helium. Each purge volume must be equivalent to or greater than the cask cavity volume. After the final purge, the cavity must be promptly filled with argon, nitrogen, or helium at 1.0 atm pressure.
9. Known or suspected failed fuel assemblies (rods) and fuel with cladding defects greater than pin holes and hairline cracks are not authorized.

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10. Prior to each shipment, the licensee must confirm that the cask contains no more than 1 cubic foot of water in the cavity and the licensee must prepare the cask for shipment, in accordance with Subsection 10.1 of the application.
11. The cask contents shall be so limited that under normal conditions prior to transport, 62 times the neutron dose rate plus 6.3 times the gamma dose rate will not exceed 560 mrem/hr at a distance of six feet from the side of the cask (ten feet from the cask center-line).
12. The neutron shielding tanks must be filled with approximately a 50/50 volume percent mixture of ethylene glycol and water during the months of October through May.
13. Replacement globe valves other than the valve specified on Drawing No. 159C5238-Sheet 4, Rev. 8. must be tested as stated in Subsection 6.6.3.2 of the application.
14. The packaging must be maintained in accordance with the requirements of Subsection 10.2 of the application. During inactive periods, the maintenance and testing frequency may be disregarded provided that the package is brought into full compliance with these requirements prior to the next use of the package.
15. The cask cavity must be equipped with a rupture disk device with a burst pressure within the range of 350-400 psig (243°F), including all tolerances.
16. The uranium shielding material must be separated from all steel surfaces with a minimum copper thickness of 4 mils, except that the stud bolts attaching the shield assemblies to top of the unchannelled BWR basket must be coated with a minimum of 1/2-mil of copper.
17. A shutoff valve must not be installed between each neutron shield tank and its respective thermal expansion tank.
18. The cask may be wrapped with reinforced plastic during shipment, provided that the decay heat of the contents does not exceed 1.5 Kw. The reinforced plastic used to wrap the cask must not be greater than 0.015 inches thick or have a thermal conductivity less than 0.0242 Btu/hr-ft-°F. The reinforced plastic wrapping cannot be used as the cask surface for purposes of complying with 10 CFR §71.87.
19. For transport of Shoreham BWR fuel assemblies, the package may be covered with a tarpaulin. The tarpaulin may not be used as the package surface for purposes of complying with 10 CFR §71.87.
20. The package authorized by the certificate is hereby approved for use under the general license provisions of 10 CFR §71.12.
21. Expiration date: May 31, 1995.

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REFERENCES

General Electric Uranium Management Corporation consolidated application dated September 24, 1984.

General Electric supplements dated: February 8, April 4, and May 10, 1985, and March 12, 1990.

Pacific Nuclear Systems, Inc. supplements dated: July 26, 1990; March 28, April 12, July 19, and August 30, 1991; January 3, 1992; and February 25, April 9, July 29, and August 10, 1993.

FOR THE U.S. NUCLEAR REGULATORY COMMISSION

Cass R. Chappell

Cass R. Chappell, Section Leader
Cask Certification Section
Storage and Transport Systems Branch
Division of Industrial and Medical
Nuclear Safety, NMSS

AUG 19 1993

Date: _____

NLI-10/24

NL 10/24 RAIL CASK

NLI-10/24

<u>Owner</u>	Nuclear Assurance Corporation
<u>Type</u>	Rail Shipping Cask
<u>Manufacturer/Vendor</u>	NL Industries Inc.
<u>Capacity</u>	
Intact Spent Fuel Assemblies	10 PWR; 24 BWR
<u>Weight (tons)</u>	
Loaded	96.5
Empty	89
<u>Design Heat Rejection (kW)</u>	70
<u>Shape</u>	Cylindrical
<u>Dimensions</u>	
Overall Length (in)	204.5
Overall Diameter (in)	88
Cavity Length (in)	179.5
Cavity Diameter (in)	45
Inner Shell Thickness (in)	0.75
Outer Shell Thickness (in)	2
Lead Shield Wall Thickness (in)	6
Neutron Shield Tank Thickness (in)	9.75
Outer Closure Head Thickness (in)	2.5
<u>Materials of Construction</u>	
Cask Body	SS/Lead/SS
Neutron Shield	
Sides	Water
Ends & Strategic Wall Locations	Ricorad
Basket	Aluminum-lined with Ag-In-Cd plates in SS
<u>Cooling Fins</u>	Concentric (forced water circulation cooling from separate cooling circuit)
<u>Dry Shipment</u>	
Atmosphere	He
Cavity Pressure (psig)	23.1 (normal); 500 (maximum.)
<u>Normal Operating Temperatures</u>	
(with only one of two cooling systems operative)	
Outer Surface (°F)	227
Inner Seal (°F)	268
Basket (°F)	451 (maximum)
Fuel Assembly (°F)	690 (average)
<u>Outside Surface Dose (mrem/hr)</u>	200 (maximum)

Licensing Status - Licensed by the USNRC for shipment using Ag-In-Cd basket.

Comments - Cask has two separate baskets—one for PWR and one for BWR. Due to no demand for the use of this cask, previous owner recovered silver from the baskets in the late 1970s; thus, no baskets exist for the cask at present. There are two casks currently in existence.

CERTIFICATE OF COMPLIANCE
FOR RADIOACTIVE MATERIALS PACKAGES

U.S. NUCLEAR REGULATORY COMMISSION

1. a. CERTIFICATE NUMBER 9023	b. REVISION NUMBER 6	c. PACKAGE IDENTIFICATION NUMBER USA/9023/B( )F	d. PAGE NUMBER 1	e. TOTAL NUMBER 1

2. PREAMBLE

- a. This certificate is issued to certify that the 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 (Name and Address)

b. TITLE AND IDENTIFICATION OF REPORT OR APPLICATION:

Nuclear Assurance Corporation
6251 Crooked Creek Road
Suite 200
Norcross, GA 30092

Nuclear Assurance Corporation, application
dated November 18, 1991, as supplemented.

c. DOCKET NUMBER 71-9023

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.: NLI-10/24

(2) Description

A lead, water, depleted uranium and high temperature polymer shielded shipping cask, encased in stainless steel, equipped with Jalsa impact limiters, and mounted to a railcar which is considered to be an integral part of the packaging for normal conditions of transport. The cask body is 204.5 inches long by 96 inches in OD. The principal shielding consists of 6 inches of lead and 9 inches of water. Depleted uranium plates are encased in the bottom end forging and cask inner closure head. High temperature polymer sheet is encased in the bottom end and positioned between the inner and outer closure heads at the top end.

The lead shield is bonded between 0.75-inch stainless steel inner shell and a 2-inch stainless steel outer shell. The outer shell is surrounded by a 0.75-inch stainless steel water jacket shell. The three shells are welded to stainless steel forgings at both ends. Four water expansion tanks are mounted to the railcar, and are connected to the water jacket by a flexible metal hose.

5. (a) Packaging (continued)

(2) Description (continued)

The primary containment vessel is comprised of the 0.75-inch inner shell and the inner closure head. It is 179.5 inches long and has a 45-inch inside diameter. The inner closure head is held in place by sixteen bolts, and is sealed with a metallic O-ring. Secondary containment is provided by the outer closure head which is bolted, and has a Viton or silicone O-ring seal. There is no direct penetration between the containment cavity and the ambient. The two penetrations into the containment cavity are from the space between the inner and outer closure heads, which has a single penetration through the cask body connecting it with the ambient. The two lid penetrations are sealed with 1.5-inch quick-disconnect valves and metal O-ring seals each in a valve box arrangement.

The radioactive contents are positioned within the containment cavity using neutron poisoned aluminum baskets and internal support structures. The PWR and BWR fuel basket cavities are lined with neutron absorber sleeves composed of a silver-indium-cadmium (80-15-5 w/o) alloy.

An auxiliary cooling system, mounted to the railcar, is used to maintain the cask and fuel temperatures so as to facilitate handling and cooldown.

The fully loaded cask, excluding the railcar, is approximately 194,000 pounds, which includes a maximum gross weight of the cavity contents of 34,100 pounds (fuel, spacers, fuel basket, etc.).

(3) Drawings

The Model No. NL-I-10/24 shipping cask is constructed in accordance with the NL Industries, Inc. and National Lead Company Drawing Nos. as specified on page XVIII-1, Rev. 9 and page XVIII-2, Rev. 8, in Section XVIII of the application.

5. (b) Contents

(1) Type and form of material

Irradiated PWR and BWR uranium oxide fuel assemblies of the following specifications:

CONDITIONS (continued)

Page 3 - Certificate No. 9023 - Revision No. 6 - Docket No. 71-9023

5. (b) Contents (1) (continued)

Fuel form	PWR Clad UO_2 pellets	BWR Clad UO_2 pellets
Cladding material	Zr or SS	Zr or SS
Maximum initial U content/assembly, kg	475	200
Maximum average initial U-235 enrichment, w/o	3.5	2.8
Maximum initial U-235 content/assembly, kg	16.6	5.6
Maximum bundle cross section, inches	9.00	5.75
Fuel pin array size, number of pins	14x14/15x15 16x16/17x17	7x7/8x8
Maximum active fuel length, inches	144	144
Maximum specific power, kw/kgU	40	27
Maximum average burnup, MWD/MTU	33,500	29,700
Minimum cooling time, days	150	150

The PWR type assemblies may be shipped either with or without control rods.

(2) Maximum quantity of material per package

The maximum decay heat load per package not to exceed 70 kilowatts, and:

Ten PWR fuel assemblies or twenty-four BWR fuel assemblies.

Above assemblies must be contained in their respective fuel baskets as shown on NL Industries, Inc. and National Lead Company Drawing Nos.:

70652F, Sheet 1, Rev. 7 PWR Fuel Basket,
Sheet 2, Rev. 5 10/24 Rail Cask
70653F, Sheet 1, Rev. 7 BWR Fuel Basket,
Sheet 2, Rev. 5 10/24 Rail Cask

CONDITIONS (continued)

Page 4 - Certificate No. 9023 - Revision No. 6 - Docket No. 71-9023

5. (c) Fissile Class III
- Maximum number of packages per shipment for Class III One(1)
6. The maximum gross weight of the cavity contents must not exceed 34,100 pounds (fuel, spacers, basket, etc.).
7. The containment vessel must be dry (no free water) when delivered to a carrier for transport. Residual moisture must be promptly removed from the containment vessel by the methods described in Section XVI of the Application. The containment vessel must be promptly filled with helium to 1.0 atm pressure.
8. Known or suspected failed fuel assemblies (rods) and fuel with cladding defects greater than pin holes and hairline cracks are not authorized.
9. The cask contents must be so limited under normal conditions of transport that the following measured dose rates be satisfied:
- a) at one meter from the external radial midplane surface of the package: 625 times the neutron dose rate plus 2.5 times the gamma dose rate will not exceed 1,000 millirems per hour; and
  - b) at one meter from the external surface of the bottom of the package; 115 times the neutron dose rate plus 2.0 times the gamma dose rate will not exceed 1,000 millirems per hour.
10. The neutron shielding system and any cooling system must be filled with a mixture of water and ethylene glycol (53% to 58% by weight ethylene glycol).
11. The neutron shielding system must be equipped with two pressure relief valves (one on the cask and one on an expansion tank) set at 220 psig.
12. Any system used for cooling down the package must be provided with a pressure relief device set so that the maximum pressure in the containment vessel cannot exceed 233 psig during the cooldown process.
13. The systems and components of each packaging must meet the criteria for the periodic tests specified in Section XVII of the Application.
14. In addition to the requirements of Subpart G of 10 CFR Part 71:
- (i) Each packaging must meet the acceptance tests and be maintained in accordance with Section XVII of the Application, and
  - (ii) The package must be prepared for shipment and operated in accordance with the Operating Procedures of Section XVI of the Application.

CONDITIONS (continued)

Page 5 - Certificate No. 9023 - Revision No. 6.- Docket No. 71-9023

15. Prior to first use, each packaging shall meet the criteria for the acceptance tests specified in Sections XIV and XV of the Application, except that the prototype railcar test, meeting the stated design criteria, need be performed only once.
16. Packaging is authorized for rail mode of transport only.
17. Expiration date: March 31, 1997.

REFERENCES

Nuclear Assurance Corporation application dated November 18, 1991.

Supplement dated: February 7, 1992.

FOR THE U.S NUCLEAR REGULATORY COMMISSION

Charles E. MacDonald, Chief
Transportation Branch
Division of Safeguards
and Transportation, NMSS

Date: _____

MAK 11 1992

125-B

B-136

**CERTIFICATE OF COMPLIANCE
FOR RADIOACTIVE MATERIALS PACKAGES**

U.S. NUCLEAR REGULATORY COMMISSION

1. a. CERTIFICATE NUMBER 9200	b. REVISION NUMBER 8	c. PACKAGE IDENTIFICATION NUMBER USA/9200/B(M)F	d. PAGE NUMBER 1	e. TOTAL NUMBER PAGES 5

2. PREAMBLE

- a. This certificate is issued to certify that the 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 (Name and Address)

b. TITLE AND IDENTIFICATION OF REPORT OR APPLICATION:

Department of Energy
Idaho Operations Office
550 Second Street
Idaho Falls, ID 83401

Nuclear Packaging, Inc. application dated
April 6, 1991, as supplemented.

c. DOCKET NUMBER 71-9200

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.: 125-B

(2) Description

A stainless steel and lead shielded shipping cask. The contents are shipped dewatered. The cask is a right circular cylinder, 65.5-inch outer diameter by 207.5-inch length. The cavity dimensions are 51.25-inch diameter by 192.5-inch length. A 1.0-inch thick stainless steel inner shell, 3.88-inch thick lead annulus and 2.0-inch thick stainless steel outer shell and 7.50-inch thick welded stainless steel bottom plate make up the cask body. A ten gauge stainless steel thermal shield surrounds the cask outer shell with standoff provided by a wire wrap on a 3.3-inch pitch spacing. The outer lid is 7.50-inch thick stainless steel equipped with a 300 psig rupture disc. The seal is provided by 2 Neoprene O-rings secured by 32, 1-1/2-6 UNC closure bolts. A test port is provided between the O-rings. The lid is also provided with a vent port. Protrusions from the outer cask external cylindrical surface include 2 lifting and 4 tie-down trunnions, 1 shear block for fitting to the shipping skid, and 16 impact limiter attachment lugs (8 at each end of the cask). The impact limiters are 120 inches in diameter by 75 inches long fabricated from 1/4-inch thick stainless steel and filled with closed-cell polyurethane foam. Each impact limiter is secured to the cask by 8, 1-1/4-7 UNC bolts necked down to 1 inch. Plastic pipe plugs are provided in each impact limiter. The overall dimensions of the cask with upper and lower impact limiters are 120-inch outer diameter by 279.5-inch length.

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

A separate inner vessel (fuel/canister basket) is positioned within the cask cavity. The inner vessel consists of 7, 14.5-inch ID by 0.38-inch wall pipes with a welded bottom plate and top end fixture plate which provides a 151-inch long cavity for the canisters. The pipe assembly is positioned within a 50.25-inch OD by 1.0-inch thick steel shell with a 2.0-inch thick welded bottom plate. The space between the pipes and steel shell contain stainless steel structural members and solid neutron moderator and absorber. The top of each tube is shielded by a 10-inch thick stainless steel plug. The inner lid is 5.0-inch thick stainless steel equipped with 2, 300 psig rupture discs in series. The lid has 2 Neoprene O-rings and is secured to the inner vessel by 24, 3/4-10 UNC closure bolts. A test port is provided between the O-rings. The lid is also provided with a vent port.

A fuel, filter, or knockout canister is positioned within the inner vessel with canister impact limiters and a top 10.0-inch thick stainless steel shield plug. Each canister is 14.0-inch OD by 150.0-inch long by 0.25-inch wall and contains Boral sheets or B₄C rods. Canister containment is not required with closure provided by welded or bolted plate with 2 or 4 fittings.

The weight of the cask (100,500 pounds), impact limiters (11,700 pounds each), inner vessel (17,000 pounds), canisters (1,040 to 1,440 pounds each), and canister contents (1,500 to 1,894 pounds each) is approximately 181,500 pounds.

(3) Drawings

- (i) The packaging is constructed in accordance with Nuclear Packaging Inc. Drawing No. X-101-100, Sheets 1 through 7, Rev. T.
- (ii) The canisters are constructed in accordance with Babcock and Wilcox Company Drawing Nos.: 1161299D, Rev. T; 1161300D, Rev. B1; and 1161301D, Rev. T.

(b) Contents

(1) Type and form of material

- (i) Byproduct and special nuclear material in the form of irradiated fuel particles, partial fuel rods, partial assemblies, and core debris. The maximum pre-irradiation U-235 enrichment must not exceed 2.98 weight percent. The average burnup of the fuel material must not exceed 3,165 MWD/MTU and be cooled for at least 6.0 years.

CONDITIONS (continued)

Page 3 - Certificate No. 9200 - Revision No. 8 - Docket No. 71-9200

5. (b) (1) (Continued)

- (ii) Irradiated core structural components, contaminated defueling equipment, and filter-aid materials.

Except for close fitting contents, dunnage must be provided in the shipping cask cavity sufficient to prevent significant movement of the contents and secondary containers relative to the outer packaging under accident conditions.

- (iii) Byproduct and special nuclear material in the form of internal contamination inside the inner vessel. Internal contamination shall not exceed the limits for low specific activity material as defined in 10 CFR 81.4.

(2) Maximum quantity of material per package

Seven fuel knockout, or filter canisters or any combination thereof within the inner vessel. The radioactive decay heat load must not exceed 100 watts in each canister. The gross weight of each canister must not exceed 2,940 pounds.

(c) Fissile Class

Maximum number of packages
per shipment (vehicle)

III

One

6. The cask cavity and inner vessel must be dry when delivered to a carrier for transport, except for free water which may be present following drip drying of the canisters for a minimum of 2 minutes after removal from the storage pool. The canisters must be loaded and dewatered in accordance with Section 7.1.1 of the application which includes approximately 2 atm of argon, nitrogen, or helium cover gas. The cask cavity and inner vessel must be filled with argon, nitrogen, or helium at 1.0 atm pressure.

7. In addition to the requirements of Subpart G of CFR Part 71:

- (a) Prior to each shipment, the inner and outer lid seals must be inspected. The seals must be replaced with new seals if inspection shows any defects or every 12 months, whichever occurs first; and

- (b) Each package must meet the Acceptance Tests and Maintenance Program of Section 8.0 of the application.

- (c) The package must be prepared for shipment and operated in accordance with Section 7.0 of the application.

8. For any canister containing water and/or organic substances which could radiolytically generate combustible gases, a determination must be made by tests and measurements or by analysis of a representative canister that the following criteria are met over a period of time that is twice the expected shipment time:

8. (Continued)

The hydrogen generated must be limited to a molar quantity that would be no more than 5% by volume (or equivalent limits for other inflammable gases) of the canister gas void if present at STP (i.e., no more than 0.063 g-moles/ft³ at 14.7 psia and 70°F); or that oxygen is limited to 5% by volume in those portions of the canister which could have hydrogen greater than 5%.

For any package delivered to a carrier for transport, the canister must be prepared for shipment in the same manner in which determination for gas generation is made. Shipment period begins when the canister is closed and must be completed within twice the expected shipment time.

9. Bolt torque:

The outer cask lid must be secured by 32, ASTM A320, Grade L43 (Cadmium plated), 1-1/2-6 UNC-2A x 5.5 long bolts torqued to 780-945 ft-lbs (lubricated).

The inner vessel lid must be secured by 24, ASTM A320, Grade L43 (Cadmium plated), 3/4-10 UNC-2A x 2.25 long bolts torqued to 130-158 ft-lbs (lubricated).

The upper and lower overpack limiters must each be secured by 8, ASTM A320, Grade L43 (Cadmium plated), 1-1/4-7 UNC-2A x 4.25 long bolts torqued to 225-270 ft-lbs (lubricated).

10. Except for the contents specified in 5.(b)(1)(iii), prior to each shipment, the licensee must confirm that the cask and inner vessel are properly sealed by tests as specified in Appendix 2.4 or Section 8.2.2 of the application. The test is satisfied if no leakage is detected using a test with a minimum sensitivity of 1×10^{-5} atm-cm/s.
11. The neoprene O-ring seals used in the containment vessel closure must be fabricated from neoprene material specified as Cascade Gaskets compound number CG 100-111-60.
12. The licensee may use a tarpaulin to cover the cask during time of transport.
13. The package authorized by the certificate is hereby approved for use under the general provisions of 10 CFR §71.12.
14. Expiration date: May 31, 1996.

CONDITIONS (continued)

Page 5 - Certificate No. 9200 -- Revision No. 8 - Docket No. 71-9200

REFERENCES

Nuclear Packaging, Inc. application dated April 6, 1991.

Supplement dated: April 9 and 15, 1991.

FOR THE U.S. NUCLEAR REGULATORY COMMISSION

Charles E. MacDonald
Charles E. MacDonald, Chief
Transportation Branch
Division of Safeguards and
Transportation, NMSS

Date: _____

MAY 6 1991

TN-BRP

NOTES:
 1. SEE SECTION 504-150-2.
 2. FOR PARTS LIST
 3. SEE DIMS 504-150-13.

TRANSNUCLEAR, INC.		DATE		REV	
TN-BEP PACKAGING		DATE		REV	
LONGITUDINAL SECTION		DATE		REV	
504-150-1		DATE		REV	

Rev 1 Drawing and
 2. Modifying Assembly

**CERTIFICATE OF COMPLIANCE
FOR RADIOACTIVE MATERIALS PACKAGES**

U.S. NUCLEAR REGULATORY COMMISSION

1. a. CERTIFICATE NUMBER 9202	b. REVISION NUMBER 2	c. PACKAGE IDENTIFICATION NUMBER USA/9202/B(U)F	d. PAGE NUMBER 1	e. TOTAL NUMBER PAGES 4

2. PREAMBLE

- a. This certificate is issued to certify that the 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 (Name and Address)

b. TITLE AND IDENTIFICATION OF REPORT OR APPLICATION:

Department of Energy
Idaho Operations Office
50 Second Street
Idaho Falls, ID 83401

Transnuclear, Inc. application
dated January 19, 1989, as supplemented.

c. DOCKET NUMBER

71-9202

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.: TN-BRP

(2) Description

The TN-BRP is a right circular cylindrical cask designed for shipment of up to 44 BWR spent fuel assemblies by rail. The total weight of the package is approximately 215,000 pounds. This includes the payload capacity of 41,250 pounds. The overall dimensions of the package, with impact limiters, are 244.5 inches long by 131 inches diameter. The cask body is 190.5 inches long by 83.25 inches in diameter. The cask has a cylindrical payload cavity which is 171 inches long and 64 inches in diameter. The volume of the cavity is approximately 185 cubic feet.

The containment vessel consists of a 9.62-inch thick forged steel (ASME SA-350; Grade LF3) cylindrical shell, with bottom plate and lid. The bottom plate and lid are made from 9.75-inch thick steel (ASME SA-350, Grade LF3). The 74.75-inch diameter lid is bolted to the cask with forty-eight, 1-5/8-inch diameter steel (ASME SA 540 Grade B24, Class 1) bolts. The cask is sealed with a viton O-ring mounted in a groove machined in the underside of the lid. The containment vessel is provided with access and vent ports in the lid, and two gas sampling ports and a research instrumentation port in the cask body.

The spent fuel assemblies are housed in a specially designed 44 compartment fuel basket. Each compartment can accommodate two BRP fuel assemblies stacked end-to-end. During transport, one-half the compartments are loaded with spent fuel and the remaining with stainless steel inserts. Peripheral inserts fabricated from an aluminum alloy are positioned between the fuel basket and cask cavity wall.

5. (a) Packaging (continued)

(2) Description (continued)

The cask is provided with steel encased balsa-red wood impact limiters. The limiters have an outer diameter of 131 inches, an inner diameter of 91 inches, and a thickness of 20 to 26 inches. Each impact limiter is attached to the cask by four equally spaced 2.25-inch diameter bolts. The impact limiters are also connected to each other with fourteen 1.50-inch diameter tie rods.

The cask has four lifting lugs welded to the lid, and four lifting/tiedown trunnions bolted to the cask body.

(3) Drawings

- (i) The packaging is constructed in accordance with the following Transnuclear, Inc. Drawings:

3024-150-1, Rev. 1	Longitudinal Section
3024-150-2, Rev. 4	Transverse Section
3024-150-3, Rev. 2	Shell and Bottom
3024-150-4, Rev. 2	Lid
3024-150-5, Rev. 3	Trunnion
3024-150-6, Rev. 2	Front Impact Limiter
3024-150-7, Rev. 2	Rear Impact Limiter
3024-150-11, Rev. 1	Packaging Penetrations
3024-150-12, Rev. 2	Lid Bolt
3024-150-13, Rev. 2	Parts List
3024-150-14, Rev. 2	Trunnion Shoulder Bolt
3024-150-16, Rev. 0	Impact Limiter Spacers

- (ii) The fuel assembly basket is constructed in accordance with the following Transnuclear, Inc. Drawings:

3024-150-8, Rev. 1	Basket General Arrangement
3024-150-9, Rev. 0	Basket Cross Section
3024-150-10, Rev. 1	Basket Plane View
3024-150-15, Rev. 0	Type A and B Spacers
3024-150-17, Rev. 1	Basket Peripheral Inserts
3042-150-18, Rev. 1	Fuel Replacement Inserts

5. (b) Contents

(1) Type and form of material

(i) Irradiated BWR uranium oxide fuel assemblies as described in the application and including the following specifications:

Assembly Type	Array	Pellet dia. (in.)	Clad Thickness	Rod OD (in.)	Pitch (in)	Mass (U) Kg
B	11x11	0.275/0.373	0.034	0.344/0.449	0.577	132
C	11x11	0.275/0.373	0.034	0.344/0.449	0.577	121
D	7x7	0.620	0.040	0.700	0.921	133
D	8x8	0.500	0.035	0.570	0.807	113
E	9x9	0.471	0.040	0.562	0.707	141
F	9x9	0.471	0.040	0.562	0.707	137
D(EG)	9x9	0.471	0.040	0.562	0.707	136
EP	9x9	0.471	0.040	0.562	0.707	118

The BWR fuel assemblies have a maximum burnup of 25,000 MWD/MTU. The minimum cooling time for any assembly is fourteen years.

(2) Maximum quantity of material per package

(i) Forty-four BWR assemblies.

(ii) Maximum decay heat per package not to exceed 3.1 kilowatts. Maximum 103 watts per BWR assembly.

(iii) Above fuel assemblies to be positioned in the fuel baskets as shown in the drawings referenced in 5(a)(3)(ii).

(c) Fissile Class

III

Maximum number of packages per shipment (vehicle)

One

6. Shipments must be completed between April 1 and October 31.

7. In addition to the requirements of Subpart 6 of 10 CFR Part 71:

- The packaging must be prepared for shipment and operated in accordance with the Operating Procedures of Chapter 7 of the application, except that the required assembly verification leak test is 1×10^{-3} atm-cm/sec.
- The packaging must meet the Acceptance Tests and Maintenance Program of Chapter 8 of the application.
- The packaging must be loaded in accordance with Section 7.1.2.19 and Chapter 1 of the application.

CONDITIONS (continued)

Page 4 - Certificate No. 9202 - Revision No. 2 - Docket No. 71-9202

8. The package authorized by this certificate is hereby approved for use under the general license provisions of 10 CFR §71.12.
9. Expiration Date: June 30, 1994.

REFERENCES

Transnuclear Inc. application dated January 19, 1989.

Supplement dated March 22, 1989, December 19, 1990, March 4, and October 3, 1991.

FOR THE U.S. NUCLEAR REGULATORY COMMISSION

Charles E. MacDonald
Charles E. MacDonald, Chief
Transportation Branch
Division of Safeguards
and Transportation, NMSS

NOV 27 1991

Date: _____

TN-REG

NOTES:
1. FOR SECTION
2. SEE DRAWING 3024-150-28.
3. FOR PARTS LIST
SEE DWG 3024-150-28.

TRANSNUCLEAR, INC.	
7N-229 PACKAGING	
LONGITUDINAL SECTION	
DATE	10/24/50
BY	10/24/50
CHKD	10/24/50
APP'D	10/24/50
REV	10/24/50

NOT CURRENT REV

**CERTIFICATE OF COMPLIANCE
FOR RADIOACTIVE MATERIALS PACKAGES**

1. a. CERTIFICATE NUMBER 9206	b. REVISION NUMBER 0	c. PACKAGE IDENTIFICATION NUMBER USA/9206/R(U)F	d. PAGE NUMBER 1	e. TOTAL NUMBER PAGES 4

2. PREAMBLE

- a. This certificate is issued to certify that the 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 (Name and Address)

b. TITLE AND IDENTIFICATION OF REPORT OR APPLICATION:

Department of Energy
Idaho Operations Office
550 Second Street
Idaho Falls, ID 83401

Transnuclear, Inc. application dated
September 1, 1989, as supplemented.

c. DOCKET NUMBER **71-9206**

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.: TN-REG

(2) Description:

The TN-REG package is a cylindrical steel cask designed for rail shipment of up to 20 PWR spent fuel assemblies. The package, with impact limiters attached, is approximately 234 inches long and 131 inches in diameter. The total weight of the package is about 275,000 pounds. The maximum weight of the contents, including the fuel basket assembly, is approximately 50,500 pounds. The cask is transported in a horizontal orientation on a specially designed shipping frame.

The containment vessel consists of a 9.25-inch thick forged steel (ASME SA-350) cylindrical shell and lid. The lid is approximately 82.25 inches in diameter and has a maximum thickness of 8.5 inches. The lid is bolted to the cask with forty-eight 1-5/8 inch steel (ASME SA-540, Grade B24, Class 1) bolts. The cask is sealed with a Viton O-ring mounted in a groove machined in the underside of the lid. A second metallic O-ring is provided to leak test the Viton O-ring. The cask is provided with access and vent ports in the lid, and two gas sampling ports and a research instrumentation port in the cask body. All five of these penetrations are sealed using Viton O-rings.

The spent fuel assemblies are positioned within a 40 compartment fuel basket. Each compartment can accommodate a single PWR assembly. During transport, one-half of the compartments are loaded with spent fuel and the remaining with stainless steel inserts. Peripheral inserts fabricated from an aluminum alloy are positioned between the fuel basket and cask cavity wall.

Page 2 - Certificate No. 9206 - Revision No. 0 - Docket No. 71-9206

5. (a) (2) Continued

The cask is equipped with impact limiters made of balsa and redwood encased in carbon steel shells. The impact limiters have an outer diameter of 131 inches, an inner diameter of 91 inches, and a thickness ranging from 20 to 26 inches. Each impact limiter is attached to the cask by four 2.25-inch diameter bolts. The impact limiters are also connected to each other with fourteen 1.5-inch diameter tie rods.

The cask has four lifting lugs welded to the lid, and four lifting/tiedown trunnions bolted to the cask body.

(3) Drawings

(i) The packaging is constructed in accordance with the following Transnuclear, Inc. Drawings:

3024-150-6, Rev. 3	Front Impact Limiter
3024-150-7, Rev. 3	Rear Impact Limiter
3024-150-11, Rev. 2	Packaging Penetrations
3024-150-12, Rev. 2	Lid Bolt
3024-150-19, Rev. 0	Tie Rods and Tie Rod Brackets
3024-150-21, Rev. 1	Longitudinal Section
3024-150-22, Rev. 2	Transverse Sections
3024-150-23, Rev. 1	Shell and Bottom
3024-150-24, Rev. 1	Lid
3024-150-25, Rev. 1	Trunnion
3024-150-26, Rev. 0	Front Impact Limiter and Tie Rod Bracket Assembly
3024-150-27, Rev. 0	Rear Impact Limiter and Tie Rod Bracket Assembly
3024-150-31, Rev. 0	Impact Limiter Attachment Bolt
3024-150-32, Rev. 0	Disc Spring at Impact Limiter
3024-150-33, Rev. 1	Parts List
3024-150-34, Rev. 0	B,C Poison Rod
3024-150-36, Rev. 0	Impact Limiter Front Spacer

(ii) The fuel basket assembly is constructed in accordance with the following Transnuclear Drawings:

3024-150-28, Rev. 0	Basket-General Arrangement
3024-150-29, Rev. 0	Basket-Cross Section
3024-150-30, Rev. 0	Basket-Plan View
3024-150-37, Rev. 0	Peripheral Insert
3024-150-38, Rev. 0	Fuel Replacement Insert

Page 3 - Certificate No. 9206 - Revision No. 0 - Docket No. 71-9206

5. (b) Contents

(1) Type and form of material

- (i) Irradiated PWR uranium oxide fuel assemblies as described in the application and including the following specifications:

Fuel form	UO ₂ pellets
Nominal pellet diameter	0.367 inch
Cladding material	Zircalloy
Cladding thickness	0.024 inch
Maximum fuel rod length	162 inches
Maximum active fuel rod length	144 inches
Assembly array	14 x 14
Maximum initial fuel pin pressure at 70°F	1 atm
Maximum initial U ²³⁵ enrichment	3.5% w/o
Initial uranium loading	383 kg

The PWR fuel assemblies have a maximum burnup of 15,000 MWD/MTU. The minimum cooling time for any assembly is 17 years.

(2) Maximum quantity of material per package

- (i) Maximum of twenty PWR fuel assemblies.
- (ii) Maximum decay heat per package not to exceed 2.7 kilowatts. Maximum 135 watts per PWR assembly.
- (iii) Above fuel assemblies to be positioned in the fuel baskets as shown in the drawings referenced in 5(a)(2)(ii).

(3) Fissile Class

Maximum number of packages per shipment One

6. Shipments must be completed between April 1 and October 31.

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7. Bolt torques:

- (a) The cask lid bolts must be torqued to 1120 ft-lbs.
- (b) The bolts used to secure the vent and drain port covers must be torqued to 50 ft-lbs.
- (c) The bolts used to secure the upper gas sampling port transport plug must be torqued to 30 ft-lbs.
- (d) The bolts used to secure the lower gas sampling port cover and port transport plug must be torqued to 15 ft-lbs.

8. Known or suspected failed fuel assemblies (rods) and fuel with cladding defects greater than hairline cracks are not authorized.

9. In addition to the requirements of Subpart G of 10 CFR Part 71:

- (a) Each packaging must be prepared for shipment and operated in accordance with the operating procedures in Chapter 7 of the application. After loading, the cask must be vacuum dried and backfilled with nitrogen at one atmosphere as described in Chapter 7 of the application.
- (b) Each packaging must meet the Acceptance Tests and Maintenance Program of Chapter 8 of the application.
- (c) The packaging must be loaded in accordance with Section 7.1.2.19 of the application.

10. The package authorized by this certificate is hereby approved for use under the general license provisions of 10 CFR 71.12.

11. Expiration Date: May 31, 1995.

REFERENCES

Transnuclear, Inc. application dated September 1, 1989.

Supplement dated March 7, 1990.

FOR THE U.S. NUCLEAR REGULATORY COMMISSION

Charles E. MacDonald, Chief
Transportation Branch
Division of Safeguards
and Transportation, NMSS

MAY 15 1990

Date: _____

M-160

B-155

Drawing Not Available

**CERTIFICATE OF COMPLIANCE
FOR RADIOACTIVE MATERIALS PACKAGES**

1. a. CERTIFICATE NUMBER 9781	b. REVISION NUMBER 5	c. PACKAGE IDENTIFICATION NUMBER USA/9781/B( )F	d. PAGE NUMBER 1	e. TOTAL NUMBER PAGES 3

2. PREAMBLE

- a. This certificate is issued to certify that the 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 (Name and Address)

b. TITLE AND IDENTIFICATION OF REPORT OR APPLICATION

U.S. Department of Energy
Division of Naval Reactors
Washington, DC 20585

Safety Analysis Report for M-160 Shipping
Container dated October 18, 1968, as
supplemented.

c. DOCKET NUMBER **71-9781**

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.: **M-160**
- (2) Description

The packaging is a right circular cylinder, 79 inches in diameter by 199 inches overall height. The packaging outer shell consists of 84 evenly spaced vertical fins 15 1/2 inches long, attached to a 1 1/2-inch thick wall (fabricated from carbon steel and clad with stainless steel on the outer surface). The inner shell, the containment vessel, is 1-inch thick (having a 1/8-inch thick rollbonded stainless steel cladding) whose base is 7 inches thick. The 9-7/16-inch annulus between the outer and inner shells is filled with lead. The top of the container is covered with a rotatable closure head fabricated of stainless steel 15 inches thick which is bolted to the container and seals the containment vessel. An oblong access plug in the cover allows for individual spent fuel cell loading or unloading.

The containment vessel has an inside diameter of 55 inches. The central region contains a secondary heat exchanger which is supported by the closure head. (This heat exchanger is not used during shipment.) An inner backup cylinder, 21 inches in diameter, occupies the central region of the containment vessel. The annulus between the backup cylinder and of the containment vessel shell provides a space 17 inches wide by 160 inches high for spent fuel. The spent fuel is contained in the annulus by aluminum module holders designed for the particular spent fuel to be shipped.

The packaging has external penetrations to the containment vessel for a steam and water vent line, which is capped during shipment. Shipments are by rail. The packaging is cradled in a support which permits the packaging to be nearly horizontal during shipment. The maximum loaded shipping weight is 237,000 pounds.

CONDITIONS (continued)

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5. (a) Packaging (continued)

(3) Drawings

The packaging is constructed in accordance with the description and Drawing Nos. contained in the Bettis Atomic Power Laboratory Safety Analysis Reports (WAPD-OP(R)C-243, WAPD-OP(R)C-558 and WAPD-OP(R)C-621 dated May 1973, October 1, 1976 and March 1977.

(b) Contents

(1) Type and form of material

Irradiated fuel assemblies and blanket modules of the following type:

- (i) PWR Core 2 Seed 1 Fuel Assembly.
- (ii) PWR Core 2 Seed 2 Fuel Assembly.
- (iii) PWR Core 2 Blanket Fuel Assembly.
- (iv) S5G Fuel Module, rodded or unrodded.
- (v) S5G Center Cell.

All shipments shall be made dry and shall use one holdown device per PWR module. Each PWR Core 2 Seed 1 or Seed 2 Fuel assembly shall contain a poison rod or a control rod.

(2) Maximum quantity of material per package

- (i) 12 fuel assemblies as described in 5(b)(1)(i) or 11 fuel assemblies and one specific blanket fuel assembly, Serial No. 62A-W01-67. Shipment shall not be made prior to 1,614 days after last power operation of the fuel and shall not exceed 12,846 Btu/hr of decay heat per shipment.
- (ii) 12 fuel assemblies as described in 5(b)(1)(ii) which shall not exceed 1,100 Btu/hr per fuel assembly of decay heat or 13,200 Btu/hr per shipment.
- (iii) 12 blanket fuel assemblies as described in 5(b)(1)(iii) which shall not exceed 21,300 Btu/hr of decay heat per shipment. Shipment shall not be made prior to 1,123 days after last power operation of the fuel.

(b) Contents (continued)

(2) Maximum quantity of material per package (continued)

- (iv) 8 fuel assemblies as described in 5(b)(1)(ii) and 4 specific blanket fuel assemblies, Serial Numbers G2A-F01-26B, G2A-F01-02, G2A-F01-10 and G2A-W01-73, which shall not exceed 12,016 Btu/hr of decay heat per shipment. Shipment shall not be made prior to 1,487 days after last power operation of the fuel, with the four blanket fuel assemblies located adjacent to each other in a clockwise or counter-clockwise direction as specified by the serial numbers previously stated.
- (v) 4 fuel assemblies as described in 5(b)(1)(iv) or 3 fuel assemblies and one center cell as described in 5(b)(1)(v). Shipment shall not be made prior to 168 days after last power operation of the fuel rod and shall not exceed 12,800 Btu/hr of decay heat per shipment.

(c) Fissile Class

Maximum number of packages per shipment

One (1)

6. Expiration date: July 31, 1992

Safety Analysis Report for M-160 Shipping Container: Core Independent Analyses, SRSD-106, dated October 18, 1968, as transmitted by Naval Reactors Letter G#2097, dated June 3, 1969.

Supplements: Knolls Atomic Power Laboratory letter G#74520-414, dated November 26, 1969; Naval Reactors letter G#3742, dated May 15, 1973; Bettis Atomic Power Laboratory letters WAPD-OP(R)C-284, dated August 23, 1973 and WAPD-OR(R)C-297, dated October 8, 1973; Naval Reactor letters G#5582, dated December 17, 1976; G#5671, dated April 15, 1977; G#5702, dated May 23, 1977; G#5792, dated September 22, 1977; G#5793, dated September 29, 1977; G#5872, dated December 20, 1977; G#5897, dated January 11, 1978; G#6658, dated April 14, 1980, and G#92-03424, Dated March 20, 1992.

FOR THE U.S. NUCLEAR REGULATORY COMMISSION

Charles E. MacDonald
 Charles E. MacDonald, Chief
 Transportation Branch
 Division of Safeguards and
 Transportation, NMSS

Date: APR 20 1992

M-140

B-160

Drawing Not Available

CERTIFICATE OF COMPLIANCE
FOR RADIOACTIVE MATERIALS PACKAGES

1. a. CERTIFICATE NUMBER	b. REVISION NUMBER	c. PACKAGE IDENTIFICATION NUMBER	d. PAGE NUMBER	e. TOTAL NUMBER PAGES
9793	3	USA/9793/B(II)F	1	5

2. PREAMBLE

- a. This certificate is issued to certify that the 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 (Name and Address)

U.S. Department of Energy
Division of Naval Reactors
Washington, DC 20585

b. TITLE AND IDENTIFICATION OF REPORT OR APPLICATION:

"Core Independent M-140 Safety Analysis Report for Packaging" and "S3G-3 Recoverable Irradiated Fuel in the M-140 Safety Analysis Report for Packaging" transmitted February 27, 1991, as supplemented.

c. DOCKET NUMBER

71-9793

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.: M-140

(2) Description

A stainless steel cask for transporting recoverable irradiated fuel modules. The cask is a right circular cylinder and is transported in the upright position. The package has approximate dimensions and weights as follows:

Cavity diameter	70 inches
Cavity height	146 inches
Body outer diameter	98 inches
Body steel wall thickness	14 inches
Package overall outer diameter	126 inches
Package overall height	194 inches
Packaging weight, including standard internals	315,000 pounds
Maximum package weight, including contents	375,000 pounds

The cask body is made from 304 stainless steel forgings. The cask walls are 14 inches thick and the bottom plate is 12 inches thick. The cask body flange provides a seating surface for the closure head and its protective dome. The flange contains 36 wedge assemblies located radially around the inside diameter. Retention of the closure head is achieved by engaging the wedges in a tapered groove in the circumferential edge of the closure head. The cask body has 180 external cooling fins welded to the exterior wall. A support ring is welded to the external cooling fins at a point above the center of gravity. The support ring seats on and is bolted to the rail car mounting ring during transport. The cask bottom is equipped with an energy absorber which is composed of five concentric stainless steel rings varying in thickness and height.

(2) Description (con't)

The closure head is made from forged 304 stainless steel, and is approximately 13 inches thick and 81.7 inches in diameter. The closure head is equipped with an access port, which is approximately 24 inches in diameter, and is offset from the center of the closure head. The access port plug is a stepped design with a maximum diameter of approximately 31 inches and is attached to the closure head by 24 bolts. The closure head and access port are sealed with double ethylene propylene O-ring seals. Seal test ports are provided for the closure head and access port seals. A stainless steel protective dome is positioned over the closure head and is secured to the cask body flange by 12, 1.38-inch diameter, 38.5-inch long studs installed in a vertical direction and 6, 2.5-inch diameter, 9-inch long shear bolts installed in the radial direction.

The containment system is composed of the cask body, the closure head and the closure head access port plug. There are five penetrations in the containment system: a drain port and vent port in the closure head, and a thermocouple penetration, a water inlet penetration, and a water outlet penetration in the cask body. Each penetration is sealed with a plug and a double ethylene propylene O-ring seal, and is equipped with a leak test port.

The fuel modules are positioned in an internals assembly. The internals assembly is composed of stacked internal spacer plates which have openings for the fuel modules. The internals assembly has a top plate or top plate subassembly which is preloaded by springs against a retaining ring fitted in a groove in the cask cavity wall. The internals assembly may be a standard internals assembly or an S3G-3 internals assembly.

(3) Drawings

The packaging is constructed and assembled in accordance with the Westinghouse Electric Corporation Drawings in Appendix 1.3.2 of the application.

(b) Contents

(1) Type and form of material

Recoverable irradiated fuel modules, limited to the following types, including associated activated corrosion products:

- (i) S3G-3 recoverable irradiated fuel modules.
- (ii) S8G recoverable irradiated fuel modules.
- (iii) D1G Core 2 recoverable irradiated fuel modules.

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(2) Maximum quantity of material per package

Total package weight, including fuel modules and internals assembly, not to exceed 375,000 pounds; and

(i) For contents described in 5(b)(1)(i):

S3G-3 recoverable irradiated fuel modules, not to exceed 62,300 Btu/hr decay heat per package.

(ii) For contents described in 5(b)(1)(ii):

S8G recoverable irradiated fuel modules, not to exceed 51,609 Btu/hr decay heat per package (prototype modules), or 45,713 Btu/hr decay heat per package (shipboard modules).

(iii) For contents described in 5(b)(1)(iii):

D1G Core 2 recoverable irradiated fuel modules, not to exceed 37,750 Btu/hr decay heat per package.

(c) Fissile Class

Maximum number of
packages per shipment

6. For S3G-3 recoverable irradiated fuel shipments:

- (a) Only a full load is authorized. A minimum of twelve fuel modules must have either control rods or poison shipping rods. All rodded and unrodded modules must be positioned as specified on page 6-11 (Rev. 1) of "S3G-3 Recoverable Irradiated Fuel in the M-140 Safety Analysis Report for Packaging;"
- (b) Minimum fuel cooling time is 130 days after shutdown;
- (c) Core age must be at least 4,000 logging corrected full power hours;
- (d) Control rod hold-down devices must be installed on cells which have control rods;
- (e) All cells must have top and bottom energy absorbers;
- (f) The weight of the fuel modules must be limited as specified on page 1-23 (Rev. 2) of "S3G-3 Recoverable Irradiated Fuel in the M-140 Safety Analysis Report for Packaging;" and
- (g) S3G-3 internals assembly must be used for shipment of S3G-3 fuel modules.

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7. For S8G recoverable irradiated fuel shipments:
- (a) Only a full load is authorized. Full and partial fuel modules may be shipped in any combination. All full and partial fuel modules must have control rods;
  - (b) Minimum fuel cooling time is 248 days after shutdown for prototype modules, and 157 days after shutdown for shipboard modules;
  - (c) All fuel modules must have lower supports and grapple adapters;
  - (d) Standard internals assembly must be used for shipment of S8G fuel modules. Full fuel modules must have two full (side) spacers, partial fuel modules must have two full (side) spacers and one partial (inside) spacer; and
  - (e) The weight of the fuel modules must be limited as specified on page 1.23 (Rev. 4) of "S8G Recoverable Irradiated Fuel in the M-140 Safety Analysis Report For Packaging."
8. For DIG Core 2 recoverable irradiated fuel shipments:
- (a) Up to eight fuel modules may be shipped per package. Fuel modules of different types may be shipped in any combination.
  - (b) Minimum fuel cooling time is 181 days after shutdown.
  - (c) All normally rodded fuel modules must have control rods. Control rod hold-down devices must be installed on rodded modules.
  - (d) Rodded modules must have top and bottom energy absorbers. Unrodded modules must have top energy absorbers.
  - (e) Standard internals assembly must be used for shipment of DIG Core 2 fuel modules. Fuel module cavity spacers must be used for all fuel modules.
9. The package must contain no more than 6 gallons of residual water.
10. Failed fuel, or fuel with defective cladding is not authorized for shipment.
11. Each packaging must meet the Acceptance Tests and Maintenance Program of Chapter 8 of the application, except:
- All containment seals, including the main closure head seal, must be replaced with new seals within the 12-month period prior to each shipment, or earlier if inspection shows any defect.
12. The package must be prepared for transport and operated in accordance with Chapter 7 of the application, except:
- The containment seals, excluding the main closure head seal, must pass a leak test after final closure prior to each shipment. The leak test must have a sensitivity of at least 1×10^{-3} std-cm/sec.

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13. Prior to first use, and within the 12-month period prior to each shipment, all containment seals, including the main closure head seal, must be leak tested to show a leak rate no greater than 1×10^{-4} std-cm/sec. The leak test must have a sensitivity of at least 5×10^{-5} std-cm/sec.
14. Expiration date: October 31, 1996.

REFERENCES

"Core Independent M-140 Safety Analysis Report For Packaging," and "S3G-3 Recoverable Irradiated Fuel in the M-140 Safety Analysis Report For Packaging," transmitted February 27, 1991.

Supplements dated: May 23, June 21, and July 17, 1991, and February 4 and 7, August 17, and December 2, 1992.

FOR THE U.S. NUCLEAR REGULATORY COMMISSION

Cass R. Chappell
Cass R. Chappell, Section Leader
Cask Certification Section
Transportation Branch
Division of Industrial and
Medical Nuclear Safety, NMS

JUN 08 1993

Date: _____