Idaho
National
Engineering
Laboratory

INEL-95/0300
(Formerly EGG-WM-10877)
Revision 1

June 1995

Waste Management Facilities Cost Information for Transportation of Radioactive and Hazardous Materials

Fred Feizollahi
David Shropshire
David Burton

Lockheed
Idaho Technologies Company

INEL-95/0300
(Formerly EGG-WM-10877)
Revision 1

Waste Management Facilities Cost Information for Transportation of Radioactive and Hazardous Materials

Fred Feizollahi
David Shropshire
David Burton

Published June 1995

Idaho National Engineering Laboratory
Lockheed Martin Idaho Technologies
Radioactive Waste Technical Support Program
Idaho Falls, Idaho 83415

Prepared for the
U.S. Department of Energy
Office of Environmental Management
Under DOE Idaho Operations Office
Contract DE-AC07-94ID13223

DISCLAIMER

Portions of this document may be illegible in electronic image products. Images are produced from the best available original document.

Waste Management Facilities Cost Information for Transportation of Radioactive and Hazardous Materials

Prepared by:

9/15/94
Date

Fred Feizollahi
Morrison Knudsen Corporation
Engineering, Construction & Environmental Group

9-15-94
Date

David Shropshire, Complex Configuration Technical Support,
EG&G Idaho, Inc.

Reviewed by:

9-7-94
Date

Derek Bolton
Morrison Knudsen Corporation
Engineering, Construction & Environmental Group

Reviewed and approved by:

9-15-94
Date

Eric Williams, Manager, Radioactive Waste Technology Initiative,
EG&G Idaho, Inc.

ABSTRACT

This report contains cost information on the U.S. Department of Energy (DOE) Complex waste streams that will be addressed by DOE in the programmatic environmental impact statement (PEIS) project. It describes the results of the task commissioned by DOE to develop cost information for transportation of radioactive and hazardous waste. It contains transportation costs for most types of DOE waste streams: low-level waste (LLW), mixed low-level waste (MLLW), alpha LLW and alpha MLLW, greater-than-Class C (GTCC) LLW and DOE equivalent waste, transuranic (TRU) waste, spent nuclear fuel (SNF), and hazardous waste. Unit rates for transportation of contact-handled (<200 mrem/hr contact dose) and remote-handled (>200 mrem/hr contact dose) radioactive waste are estimated.

Land transportation of radioactive and hazardous waste is subject to regulations promulgated by DOE, the U.S. Department of Transportation (DOT), the U.S. Nuclear Regulatory Commission (NRC), and state and local agencies. The cost estimates in this report assume compliance with applicable regulations.

ACKNOWLEDGMENTS

The authors would like to acknowledge the efforts of those who contributed to this report: Fred Monette and Tony Policastro of Argonne-East, and Steve Maheras of Scientific Applications International Corporation for the extra effort required in reviewing this report.

CONTENTS

ABSTRACT iv

ACKNOWLEDGMENTS v

ACRONYMS ix

1. INTRODUCTION 1
   1.1 Background 1
   1.2 Transportation Cost Estimating Methods 1
   1.3 Limitations 2
   1.4 Mileage Charts 2
   1.5 Report Organization 3

2. LLW, MLLW, ALPHA LLW, ALPHA MLLW, AND GTCC/DOE EQUIVALENT WASTE 8
   2.1 Contact-Handled Waste 8
      2.1.1 Truck Shipment 8
      2.1.2 Rail Shipment 8
   2.2 Remote-Handled Waste 9
   2.3 Guidelines for Liquid Waste Shipments by Truck or Rail 10
   2.4 Guidelines for Lab Pack Shipments 10

3. TRANSURANIC WASTE 11
   3.1 Truck Shipment of Contact-Handled Waste 11
   3.2 Truck Shipment of Remote-Handled TRU Waste 11
   3.3 Rail Shipment of Contact-Handled TRU Waste 12
   3.4 Rail Shipments of Remote-Handled TRU Waste 13

4. SPENT NUCLEAR FUEL 14
   4.1 Truck Shipment of SNF 14
      4.1.1 Method for Estimating Truck Shipment Costs 14
      4.1.2 Guidance for Determining Number of Truck Shipments 14
   4.2 Rail Shipment of SNF 16
      4.2.1 Method for Estimating Rail Shipment Costs 16
      4.2.2 Guidance for Determining Number of Rail Shipments 18

5. HAZARDOUS WASTE 20
   5.1 Truck Shipment 20
   5.2 Rail Shipment 20

6. REFERENCES 22

Appendix A--Methods, Bases, and Assumptions A-1

Appendix B--Backup Data for Low-Level Waste Shipments B-1

Appendix C--Backup Data for TRU Shipments C-1

Appendix C removed because of copyrighted materials AR

Appendix D--Backup Data for SNF Truck Shipments D-1

Appendix E--Backup Data for SNF Rail Shipments E-1

Appendix F--Transportation of HLW Canisters F-1

TABLES

1. Distance (in miles) by truck between DOE sites 4
2. Distance (in miles) by rail between DOE sites 6
3. Capacity of various cask and canister combinations for transport of N-reactor, high-enriched uranium, and low-enriched uranium fuel by truck 15
4. Capacity of various cask and canister combinations for transport of N-reactor, LEU, and HEU fuel by rail 17

ACRONYMS

A	activity (Curies)
BOY	base operating year
BWR	boiling water reactor
CFR	Code of Federal Regulations
CPLM	cost per loaded mile
DOE	U.S. Department of Energy
DOT	U.S. Department of Transportation
FSV	Fort St. Vrain
GTCC LLW	greater-than-class-C low-level waste
HEU	high-enriched uranium
HTGR	high temperature gas-cooled reactor
INEL	Idaho National Engineering Laboratory
LEU	low-enriched uranium
LLW	low-level waste
MLLW	mixed low-level waste
MPC	multi-purpose canister
MRS	monitored retrievable storage
NRC	U.S. Nuclear Regulatory Commission
PEIS	Programmatic Environmental Impact Statement
PLCC	planning life-cycle cost
PWR	pressurized water reactor
RH	remote handled
SNF	spent nuclear fuel
TRU	transuranic waste
TSD	treatment, storage, and disposal
UPRR	Union Pacific Railroad
WIPP	Waste Isolation Pilot Plant
WMFCI	Waste Management Facilities Cost Information

Waste Management Facilities Cost Information for Transportation of Radioactive and Hazardous Materials

1. INTRODUCTION

1.1 Background

The Waste Management Facilities Cost Information (WMFCI) report series contains cost information on the U.S. Department of Energy (DOE) Complex waste streams that will be addressed by DOE in the Programmatic Environmental Impact Statement (PEIS) project. To date, four reports (EGG-WTD-10443, EGG-WM-10670, EGG-WM-10962, and EGG-WM-10701), covering planning life-cycle cost (PLCC) estimates for treatment, storage, and disposal (TSD) facilities, have been issued. This report describes the results of a closely related task commissioned by DOE: development of cost information for transportation of radioactive and hazardous waste.

This report contains transportation costs for most types of DOE waste streams: low-level waste (LLW), mixed low-level waste (MLLW), alpha LLW and alpha MLLW, greater-than-Class C (GTCC) LLW and DOE equivalent waste, transuranic waste (TRU), spent nuclear fuel (SNF), and hazardous waste. Unit rates for transportation of contact-handled (<200 mrem/hr contact dose) and remote-handled (>200 mrem/hr contact dose) radioactive waste have been estimated previously, and a summary has been included in earlier WMFCI reports. In order to have a single source for obtaining transportation cost for all radioactive waste, the transportation costs for the contact- and remote-handled wastes are repeated in this report.

Land transportation of radioactive and hazardous waste is subject to regulations promulgated by DOE, the U.S. Department of Transportation (DOT), the U.S. Nuclear Regulatory Commission (NRC), and state and local agencies. The cost estimates in this report assume compliance with applicable regulations. It should be noted that the trend is toward greater restrictions on transportation of radioactive waste (e.g., truck or rail car speed, shipping route, security escort, and personnel training requirements), which may have a significant impact on future costs.

1.2 Transportation Cost Estimating Methods

This report presents transportation unit rates in a cost-per-loaded-mile (CPLM) format. This allows the reader to determine shipping costs. The primary transportation mode is by truck, although rail has been considered where practical. The transportation cost is divided into two components: variable cost and fixed cost.

- CPLM unit rate is a variable cost dependent on the distance travelled. It has two subcomponents: carrier cost and hardware cost.
    - Carrier cost covers the variable costs associated with the cargo carrier. The carrier is the entity that takes title to the waste from the shipper during transportation, i.e.,

the trucking company or railroad company. The carrier costs include tractor, fuel, labor (drivers), insurance, security escort, taxes, tools, permit fees, and related costs incurred while the waste or SNF is in transport.

- Hardware covers the variable costs associated with procuring and maintaining the special hardware used during the transportation of waste or SNF. Special hardware consists mainly of trailers and railroad cars equipped with special tight-sealing enclosures or shielded casks.

- Fixed costs generally consist of demurrage costs of the carrier and the hardware used in the shipment, which are independent of the distance travelled. Fixed costs are incurred during loading and unloading operations.

The cost of labor during the loading and unloading operation (e.g., crane operators and health physics technicians) is part of the facility operating and maintenance costs rather than transportation costs.

1.3 Limitations

Appendix A must be consulted regarding limitations and qualifications that apply to developing transportation costs. To apply data from this report, the reader must consider the following:

- The CPLM rates given in this report do not include costs of labor or materials needed to load and unload waste and SNF into the casks or onto shipping trailers. These costs are included in the facility operating and maintenance costs.

- Only the estimate for SNF includes the cost of security escorts. This cost is estimated to be 20% of variable carrier cost for truck shipments, and 30% of cask rental rates during loaded portions of the move.

- It is assumed that all shipments will follow routes approved by the NRC.

- Rail costs are based on tariff rates and do not include special dedicated train charges.

- An internal basket has not been designed for the SNF canisters DOE intends to ship by rail.

- No criticality calculations have been performed for the SNF canister and cask recommendations. Conservative assumptions have been made regarding capacities.

- No attempt was made to estimate less than full truckload shipments.

1.4 Mileage Charts

Tables 1 and 2 show distances between DOE sites by truck and by rail. These distances assume bypassing tunnels and major cities (using beltways when available) and travelling on major highways.

1.5 Report Organization

Section 1 presents the background data and scope of this report. Sections 2 through 5 present the cost summaries for LLW, MLLW, alpha LLW, alpha MLLW, GTCC LLW; transuranic waste; SNF; and hazardous waste, respectively. Section 6 contains references. Appendix A lists the methods, bases, and assumptions used during the cost-estimating process. Appendices B–F contain data used in the preparation of LLW, TRU, SNF truck, and SNF rail estimates, respectively.

Table 1. Distance (in miles) by truck between DOE sites.

Origin site	Abbrev	AL	AN	AW	LY	BC	BA	BN	FL	FE	HS	IN	IT	KC	KA	LB	LL	LA	MP
Ames Laboratory	AL	0	351	1,287	0	675	894	1,206	341	611	1,703	1,287	1,129	234	1,163	1,844	1,853	1,136	644
Argonne, East	AN	0	0	1,582	0	348	567	874	36	294	1,998	1,582	1,333	520	831	2,139	2,148	1,431	317
Argonne, West	AW	0	0	0	0	1,906	2,125	2,437	1,572	1,842	599	0	1,177	1,325	2,393	963	972	1,144	1,875
Babcock & Wilcox	LY	0	0	0	0	0	0	0	0	0	2738	2322	0	0	0	0	0	0	0
Batelle Columbus	BC	0	0	0	0	0	223	653	380	113	2,322	1,906	1,463	650	626	2,463	2,472	1,552	72
Bettis Atomic	BA	0	0	0	0	0	0	506	599	312	2,541	2,125	1,682	869	543	2,682	2,691	1,771	291
Brookhaven NL	BN	0	0	0	0	0	0	0	906	760	2,853	2,437	2,113	1,299	241	2,994	3,003	2,201	721
Fermilab (FNAL)	FL	0	0	0	0	0	0	0	0	326	1,975	1,572	1,359	519	863	2,129	2,138	1,421	349
Fernald (FEMP	FE	0	0	0	0	0	0	0	0	0	2,258	1,842	1,399	586	733	2,399	2,408	1,488	49
Hanford Site	HS	0	0	0	0	0	0	0	0	0	0	599	1,593	1,741	2,809	875	894	1,560	2,291
INEL	IN	0	0	0	0	0	0	0	0	0	0	0	1,177	1,325	2,393	963	972	1,144	1,875
ITRI	IT	0	0	0	0	0	0	0	0	0	0	0	0	895	2,085	1,194	1,154	111	1,432
Kansas City Plant	KC	0	0	0	0	0	0	0	0	0	0	0	0	0	1,272	1,881	1,890	984	619
Knolls Atomic	KA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2,950	2,959	2,174	694
Lawrence Berkeley	LB	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	45	1,274	2,432
Lawrence Livermore	LL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1,233	2,441
Los Alamos NL	LA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1,521
Mound Plant	MP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Naval Reactors Facility	NR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nevada Test Site	NT	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ORISE	OI	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Oak Ridge Reserv.	OR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Paducah GDP	PA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pantex Plant	PP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Portsmouth GDP	PO	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Princeton PPL	PR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Reactive Metals	RM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rocky Flats Plant	RF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SNL, Albuquerque	SA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SNL, Livermore	SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Savannah River	SR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SLAC	ST	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
West Valley DP	WV	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
WIPP	WI	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Yucca Mountain, NV	YM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 1. (Cont'd)

Origin site	Abbrev	NR	NT	OI	OR	PA	PP	PO	PR	RM	RF	SA	SL	SR	ST	WV	WI	YM
Ames Laboratory	AL	1,287	1,520	887	900	629	834	755	1,217	751	722	1,120	1,853	1,175	1,885	909	1,301	1,554
Argonne, East	AN	1,582	1,815	571	584	385	1,038	428	822	419	1,017	1,324	2,148	892	2,180	577	1,505	1,849
Argonne, West	AW	0	712	2,077	2,048	1,766	1,468	1,986	2,448	1,982	716	1,168	1,100	2,311	1,004	2,140	1,759	746
Babcock & Wilcox	LY	0	2,491	0	350	0	0	0	0	0	0	0	0	455	0	0	0	2,459
Batelle Columbus	BC	1,906	2,078	399	412	477	1,168	84	546	214	1,283	1,454	2,472	720	2,524	372	1,625	2,112
Bettis Atomic	BA	2,125	2,297	586	563	696	1,387	265	398	175	1,500	1,673	2,691	656	2,723	257	1,813	2,331
Brookhaven NL	BN	2,437	2,670	808	821	1,115	1,817	689	189	531	1,870	2,103	3,003	897	3,035	492	2,192	2,704
Fermilab (FNAL)	FL	1,572	1,805	603	616	417	1,064	460	854	451	1,005	1,350	2,138	924	2,167	609	1,531	1,839
Fernald (FEMP	FE	1,824	2,014	299	312	409	1,104	173	635	321	1,217	1,390	2,408	620	2,440	479	1,526	2,048
Hanford Site	HS	599	1,128	2,493	2,464	2,182	2,884	2,402	2,864	2,398	1,132	1,584	894	2,727	916	2,556	2,175	1,162
INEL	IN	0	712	2,077	2,048	1,766	1,468	1,986	2,448	1,982	716	1,168	1,100	2,311	1,004	2,140	1,759	746
ITRI	IT	1,177	918	1,420	1,391	1,230	313	1,543	2,006	1,673	483	9	1,154	1,653	1,198	1,832	614	952
Kansas City Plant	KC	1,325	1,428	752	723	441	600	730	1,192	860	631	886	1,890	987	1,939	1,018	1,067	1,462
Knolls Atomic	KA	2,393	2,626	872	885	1,099	1,790	688	291	416	1,827	2,076	2,959	961	2,979	314	2,256	2,660
Lawrence Berkeley	LB	963	719	2,592	2,563	2,332	1,485	2,543	3,005	2,538	1,283	1,185	45	2,791	47	2,697	1,509	753
Lawrence Livermore	LL	972	678	2,551	2,523	2,327	1,445	2,552	3,014	2,547	1,292	1,145	0	2,750	64	2,706	1,468	712
Los Alamos NL	LA	1,144	997	1,509	1,480	1,319	402	1,632	2,094	1,762	452	102	1,326	1,742	1,294	1,921	693	1,031
Mound Plant	MP	1,875	2,047	335	348	441	1,137	152	614	282	1,250	1,432	2,441	656	2,473	440	1,561	2,081
Naval Reactors Facility	NR	0	712	2,077	2,048	1,766	1,468	1,986	2,448	1,982	716	1,168	1,100	2,311	1,004	2,140	1,759	746
Nevada Test Site	NT	0	0	2,180	2,151	1,864	1,209	2,158	2,620	2,214	836	909	0	2,414	739	2,373	1,365	46
ORISE	OI	0	0	0	10	333	1,125	358	702	595	1,383	1,411	2,551	369	2,584	753	1,410	2,214
Oak Ridge Reserv.	OR	0	0	0	0	304	1,096	371	715	608	1,354	1,382	2,523	379	2,584	766	1,381	2,185
Paducah GDP	PA	0	0	0	0	0	940	0	1,009	687	1,072	1,226	2,327	568	2,359	845	1,258	1,903
Pantex Plant	PP	0	0	0	0	0	0	1,248	1,710	1,378	774	304	1,445	1,358	1,506	1,537	308	1,243
Portsmouth GDP	PO	0	0	0	0	0	0	0	588	276	1,361	1,543	2,552	540	2,584	434	1,632	0
Princeton PPL	PR	0	0	0	0	0	0	0	0	528	1,823	1,997	3,014	767	3,046	489	2,086	2,654
Reactive Metals	RM	0	0	0	0	0	0	0	0	0	1,415	1,664	2,547	726	2,579	162	1,822	2,248
Rocky Flats Plant	RF	0	0	0	0	0	0	0	0	0	0	474	1,292	1,618	1,324	1,573	1,067	868
SNL, Albuquerque	SA	0	0	0	0	0	0	0	0	0	0	0	1,145	1,644	1,198	1,823	605	943
SNL, Livermore	SL	0	0	0	0	0	0	0	0	0	0	0	0	2,750	64	2,706	1,468	712
Savannah River	SR	0	0	0	0	0	0	0	0	0	0	0	0	0	2,820	1,023	1,524	2,448
SLAC	ST	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2,738	1,529	773
West Valley DP	WV	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1,980	2,407
WIPP	WI	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1,399
Yucca Mountain, NV	YM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 2. Distance (in miles) by rail between DOE sites.

		AL	AN	AW	LY	BC	BA	BN	FL	FE	HS	IN	IT	KC	KA	LB	LL	LA	MP
Ames Laboratory	AL	0	329	1,242	0	700	823	1,365	291	717	1,788	1,242	1,187	275	1,126	1,873	2,018	1,124	715
Argonne, East	AN	0	0	1,655	0	401	518	1,066	49	412	2,201	1,655	1,351	439	827	2,549	2,506	1,288	416
Argonne, West	AW	0	0	0	0	1,942	2,133	2,607	1,533	1,907	658	0	1,247	1,238	2,468	1,102	1,100	1,179	1,926
Babcock & Wilcox	LY	0	0	0	0	0	0	0	0	0	2,879	2,333	0	0	0	0	0	0	0
Batelle Columbus	BC	0	0	0	0	0	280	855	427	135	2,488	1,942	1,759	753	615	2,573	2,718	1,696	65
Bettis Atomic	BA	0	0	0	0	0		772	543	475	2,611	2,133	1,857	943	533	2,696	2,840	1,794	345
Brookhaven NL	BN	0	0	0	0	0	0	0	1,088	984	3,153	2,607	2,414	1,518	239	3,238	3,383	2,351	920
Fermilab (FNAL)	FL	0	0	0	0	0	0	0	0	441	1,971	1,533	1,356	453	853	2,343	2,341	1,405	443
Fernald (FEMP)	FE	0	0	0	0	0	0	0	0	0	2,505	1,907	1,751	717	745	2,590	2,735	1,688	69
Hanford Site	HS	0	0	0	0	0	0	0	0	0	0	658	1,793	1,784	2,914	986	973	1,725	2,472
INEL	IN	0	0	0	0	0	0	0	0	0	0	0	1,247	1,238	2,468	1,102	1,100	1,179	1,926
ITRI	IT	0	0	0	0	0	0	0	0	0	0	0	0	932	2,177	1,266	1,222	104	1,767
Kansas City Plant	KC	0	0	0	0	0	0	0	0	0	0	0	0	0	1,250	2,016	2,013	869	708
Knolls Atomic	KA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2,999	3,144	2,122	680
Lawrence Berkeley	LB	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	46	1,354	2,717
Lawrence Livermore	LL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1,326	2,695
Los Alamos NL	LA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1,704
Mound Plant	MP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Naval Reactors Facility	NR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nevada Test Site	NT	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ORISE	OI	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Oak Ridge Reserv.	OR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Paducah GDP	PA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pantex Plant	PP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Portsmouth GDP	PO	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Princeton PPL	PR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Reactive Metals	RM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rocky Flats Plant	RF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SNL, Albuquerque	SA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SNL, Livermore	SL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Savannah River	SR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SLAC	ST	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
West Valley DP	WV	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
WIPP	WI	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Yucca Mountain, NV	YM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 2. (Cont'd)

		NR	NT	OI	OR	PA	PP	PO	PR	RM	RF	SA	SL	SR	ST	WV	WI	YM
Ames Laboratory	AL	1,242	1,674	956	954	646	809	727	1,197	717	782	1,187	2,018	1,281	1,924	881	1,115	1,674
Argonne, East	AN	1,655	2,348	651	649	390	972	422	898	418	1,194	1,351	2,506	976	2,536	579	1,279	2,348
Argonne, West	AW	0	756	2,099	2,055	1,699	1,141	1,975	2,507	2,060	738	1,247	1,100	2,407	1,160	2,123	1,447	756
Babcock & Wilcox	LY	0	2,765	0	386	0	0	0	0	0	0	0	0	661	0	0	0	0
Batelle Columbus	BC	1,942	2,374	366	393	581	1,381	91	655	207	1,502	1,759	2,718	740	2,947	370	1,688	2,374
Bettis Atomic	BA	2,133	2,496	714	903	816	1,479	429	400	136	1,692	1,857	2,840	947	2,746	244	1,785	2,496
Brookhaven NL	BN	2,607	3,039	1,221	1,152	1,346	2,035	921	410	648	2,266	2,414	3,383	1,239	3,289	549	2,342	3,039
Fermilab (FNAL)	FL	1,533	1,997	679	682	469	977	451	924	445	1,016	1,356	2,341	1,001	2,393	603	1,284	1,997
Fernald (FEMP)	FE	1,907	2,391	331	358	468	1,373	207	938	337	1,466	1,751	2,735	774	2,641	631	1,679	2,391
Hanford Site	HS	658	1,302	2,644	2,601	2,245	1,686	2,515	2,985	2,505	1,284	1,793	973	2,953	1,036	2,669	1,993	1,302
INEL	IN	0	756	2,099	2,055	1,699	1,141	1,975	2,507	2,060	738	1,247	1,100	2,407	1,160	2,123	1,447	756
ITRI	IT	1,247	1,065	1,989	1,749	1,539	379	1,761	2,248	1,769	572	0	1,222	2,315	1,253	1,929	477	1,063
Kansas City Plant	KC	1,238	1,670	881	838	482	554	758	1,289	842	778	932	2,013	1,161	2,073	1,033	861	1,670
Knolls Atomic	KA	2,468	2,800	981	957	1,106	1,807	681	214	408	2,027	2,177	3,144	1,044	3,050	309	2,114	2,800
Lawrence Berkeley	LB	1,102	860	2,890	2,686	2,490	1,561	2,767	3,298	2,851	1,320	1,266	46	3,192	56	2,773	1,660	860
Lawrence Livermore	LL	1100	1,370	2,868	2,831	2,469	1,534	2,745	3,276	2,829	1,394	1,222	0	3,183	60	2,898	1,633	1,370
Los Alamos NL	LA	1,179	1,169	1,926	1,686	1,476	483	1,698	2,186	1,706	504	104	1,326	2,252	1,357	1,866	581	1,169
Mound Plant	MP	1,926	2,386	301	328	564	1,396	156	719	272	1,485	1,767	2,695	744	2,930	562	1,703	2,386
Naval Reactor Fac.	NR	0	756	2,099	2,055	1,699	1,141	1,975	2,507	2,060	738	1,247	1,100	2,407	1,160	2,123	1,447	756
Nevada Test Site	NT	0	0	2,530	2,487	2,131	1,376	2,401	2,871	2,391	987	1,065	1,370	2,839	862	2,554	1,475	0
ORISE	OI	0	0	0	40	632	1,611	392	1,176	575	1,658	1,989	2,868	443	3,103	889	1,918	2,530
Oak Ridge Reserv.	OR	0	0	0	0	527	1,371	442	760	600	1,586	1,749	2,831	417	3,031	889	1,678	2,487
Paducah GDP	PA	0	0	0	0	0	1,103	495	1,145	698	1,220	1,539	2,469	714	2,597	861	1,410	2,131
Pantex Plant	PP	0	0	0	0	0	0	1,382	1,867	1,387	465	379	1,534	1,937	1,564	1,551	307	1,376
Portsmouth GDP	PO	0	0	0	0	0	0	0	838	279	1,535	1,761	2,745	655	2,651	585	1,689	2,401
Princeton PPL	PR	0	0	0	0	0	0	0	0	511	2,066	2,248	3,276	848	3,121	426	2,185	2,871
Reactive Metals	RM	0	0	0	0	0	0	0	0	0	1,619	1,769	2,829	920	2,641	163	1,705	2,391
Rocky Flats Plant	RF	0	0	0	0	0	0	0	0	0	0	572	1,394	1,938	1,377	1,782	769	987
SNL, Albuquerque	SA	0	0	0	0	0	0	0	0	0	0	0	1,222	2,315	1,253	1,929	477	1,065
SNL, Livermore	SL	0	0	0	0	0	0	0	0	0	0	0	0	3,183	60	2,898	1,633	1,370
Savannah River	SR	0	0	0	0	0	0	0	0	0	0	0	0	0	3,194	1,223	2,243	2,839
SLAC	ST	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2,804	1,662	862
West Valley DP	WV	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1,858	2,540
WIPP	WI	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1,475
Yucca Mountain, NV	YM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

2. LLW, MLLW, ALPHA LLW, ALPHA MLLW, AND GTCC/DOE EQUIVALENT WASTE

Transportation of LLW, MLLW, alpha LLW, and alpha MLLW can involve either contact-handled or remote-handled shipments. However, a large portion of the GTCC/DOE equivalent waste will involve only remote-handled shipments. A summary of costs associated with shipment of waste by truck is presented below.

2.1 Contact-Handled Waste

2.1.1 Truck Shipment

Transportation costs for contact-handled LLW, MLLW, and alpha LLW and alpha MLLW are estimated based on the assumption that unshielded 48-ft-long truck trailers containing eighty-eight 500-lb drums are used, yielding a total of 44,000 lb per shipment. The total transportation costs can be calculated using the following steps:

a. If the average weight of the drums is 500 lb or more, divide the total weight of waste (in lb) by 44,000 lb/shipment to obtain the number of shipments. If the average weight of the drums is less than 500 lb, divide the total volume of waste by 640 ft^3 (88 drums at 7.3 ft^3/drum) to obtain the number of shipments.

b. Multiply the CPLM unit rates listed below by the one-way distance (in miles) and the number of shipments (from step a above) to obtain the CPLM cost.

- Less than 30 miles: $5.94/mile
- 30–200 miles: $4.98/mile
- More than 200 miles: $4.00/mile.

c. Multiply the number of shipments (from step a above) by $880 per shipment to obtain the fixed transportation costs.

d. Add the CPLM cost (from step b above) to the fixed cost (from step c above) to obtain the total transportation cost.

2.1.2 Rail Shipment

Transportation costs by rail for contact-handled LLW and MLLW are estimated based on the assumption that waste in drums or steel boxes would be moved in 40-ft-long intermodal (sealand) containers. These containers can be moved by truck or on rail flatcars. Each container would hold seventy-six 500-lb drums, yielding a total weight of 38,000 lb, or would hold eleven 3,945-lb boxes, yielding a total weight of about 44,000 lb. The total transportation costs can be calculated using the following steps:

a. Divide the total weight of waste (in lb) by 38,000 lb (for drums) or 44,000 lb (for boxes) to obtain the number of container loads.

b. Multiply the CPLM unit rates listed below by the one-way distance (in miles) and by the number of container loads (from step a above) to obtain the CPLM.

- 500 to 1,000 miles: $2.32 /mile.
- 1,000 to 2,000 miles: $1.91 /mile
- More than 2,000 miles: $1.60 /mile

c. Multiply the number of container loads (from step a above) by $750 per container load to obtain the fixed transportation costs.

d. Add the CPLM (from step b above) to the fixed cost (from step c above) to obtain the total transportation cost.

The cost estimate was prepared on a per-container basis; the number of containers per flat car will vary by railroad carrier. One can assume three containers per flat car, with an average capacity of 20 tons per container.

2.2 Remote-Handled Waste

Transportation costs by truck[a] for remote-handled LLW, MLLW, alpha LLW, and alpha MLLW, and GTCC/DOE equivalent waste are estimated based on a payload of 13,400 lb per shipment. Typically fourteen 55-gallon drums are loaded per shipment. The total transportation cost for a given scenario can be developed according to the following steps:

a. Divide the total weight of waste by 13,400 lb to obtain the number of shipments.

b. Multiply the CPLM unit rates listed below by the one-way distance (in miles) and the number of shipments (from step a above) to obtain the CPLM cost.

- Less than 30 miles: $11.70/mile
- 30–200 miles: $7.85/mile
- More than 200 miles: $4.90/mile.

c. Multiply the number of shipments (from step b above) by $2,480 per shipment to obtain the fixed transportation costs.

d. Add the CPLM costs (from step b above) to the fixed cost (from step C above) to obtain the total transportation cost.

---

a. The volume of remote-handled waste of this type is very small and does not warrant an estimate of rail costs in addition to truck costs. Also, the standard remote-handled containers are not designed for rail shipment.

2.3 Guidelines for Liquid Waste Shipments by Truck or Rail

Packaging specifications for radioactive waste shipments are found in the newly revised 49 CFR 173.401 (Subpart I). Liquid shipments of contact-handled LLW, MLLW, alpha LLW, alpha MLLW, and GTCC waste normally can be shipped in Type A containers. These shipments have to be evaluated by formulas given in 49 CFR 173.433 to determine whether the source material activity is lower than the limits given in 49 CFR 173.435 (see A_1 and A_2 values). Generally, shipments of liquid LLW and MLLW will qualify as low-specific-activity shipments. Thus, these shipments can be packaged in Type A containers. For shipments with *A* values (Curies) in excess of the limits given in 49 CFR 173.435, the shipper must use Type B containers.

Shippers of liquids in Type A containers can use the CPLM rates given in Section 2.1 for contact-handled waste with the following changes to Section 2.1. Liquid shipments differ from solid shipments because of the need to provide secondary containment of spills that might occur in transit (shippers must provide a 2:1 ratio of containment volume to liquid volume). The level of activity will define the packaging combinations. Some very low-specific-activity shipments may not require secondary containment; however, secondary containment is highly recommended for all shipments. The cost information for liquid shipments assumes eighty-eight drums per truckload, but the liquid component will only be 50% of the shipment volume. The total quantity of liquid per shipment is estimated to be 2,600 gal. The shipper should divide the total quantity of liquid to be shipped by 2,600 gal to determine the number of shipments. A common method used for packaging liquids is to place the liquid waste in a 30-gal closed-top drum and place this drum in a 55-gal open-head drum. Absorbent is placed between the two containers.

Shippers of liquids in Type B containers can use the CPLM rates given in Section 2.2 for remote-handled waste. The number of shipments can be determined by dividing the quantity of liquid to ship by 3,300 lb. Fourteen drums with 30 gal per drum equals 420 gallons, times 8 lb/gal equals approximately 3,300 lb per shipment.

2.4 Guidelines for Lab Pack Shipments

Laboratory chemicals, or sample vials, may be packaged in drums as "lab packs." This type of shipment typically contain small quantities of liquids. To provide secondary containment, the shipper places absorbent in the bottom of the drum and adds the vials in a layer, repeating this procedure until the drum is full. Costs for this type of shipment can be estimated using the procedure given in Section 2.1 with one exception. Assume lab packs weigh 50% less than solid waste drums. Up to ninety-six drums of lab packs can be shipped per truckload, which equals 24,000 lb per shipment.

3. TRANSURANIC WASTE

This section presents cost for shipment of transuranic waste by truck and rail. The TRUPACT-II containers represent the standard packaging for contact-handled waste shipped by truck or rail. The TRUPACT-II is designed for use in DOE's Waste Isolation Pilot Plant (WIPP) in New Mexico. Remote-handled TRU waste can be shipped in a variety of Type B configurations. The specific activity of the waste must be known by the shipper in order to select the appropriate packaging.[b] Costs for contact-handled and remote-handled shipments are presented below.

3.1 Truck Shipment of Contact-Handled Waste

Transportation costs for contact-handled TRU waste are based on using TRUPACT-II overpacks. Each overpack handles fourteen 55-gal drums with a total maximum payload per container of 7,265 lb. Three TRUPACT-II overpacks may be shipped per truckload. The total transportation cost can be calculated by the following steps:

a. Divide the total weight of waste by 7,200 lb to obtain the number of overpacks needed. Divide this number by 3 to obtain the number of truck shipments.

b. Multiply the below listed CPLM unit rates by the one-way distance (in miles) and the number of shipments (from step a above) to obtain the CPLM cost.

   - Less than 200 miles: $19.65/mile
   - 200 to 1,000 miles: $10.87/mile
   - 1,000 to 2,500 miles: $9.31/mile.

c. The fixed costs are obtained by multiplying the number of truck shipments by $4,630.

d. Add the CPLM (from step b above) to the fixed cost (from step c above) to obtain the total transportation cost.

3.2 Truck Shipment of Remote-Handled TRU Waste

Remote-handled TRU waste may come in different forms. The different waste forms will require various combinations of inner and outer packaging. Two cost estimates are provided below. The shipper is advised to use the first estimate for materials suitable for packaging in drums or boxes and then placed in Type B casks. The second estimate is for high-level waste produced from a vitrification process.

---

b. In practice, TRUPACT II loadings may be driven by criticality and thermal considerations at some sites. For instance, some planned TRU shipments from the Rocky Flats Plant are limited to half the container capacity due to these considerations. Shippers should use their knowledge of the waste characteristics to refine the shipping capacity estimate.

Chem-Nuclear and NuPac have an overweight truck cask (Type B) that has been used for truck shipments of remote-handled TRU waste. The overweight truck cask has a net payload capacity of 10,000 lb. Total transportation cost can be calculated by the following steps:

a. Divide the weight of waste by 10,000 lb to obtain the number of truck shipments.

b. Multiply the CPLM unit rates listed below by the one-way distance (in miles) and the number of shipments (from step a above) to obtain the CPLM cost.

   - Less than 200 miles: $19.65/mile
   - 200 to 1,000 miles: $10.87/mile
   - 1,000 to 2,500 miles: $9.31/mile

c. Fixed costs are obtained by multiplying the number of truck shipments by $4,630.

d. Add the CPLM (from step b above) to the fixed cost (from step c above) to obtain the total transportation cost.

A waste stream similar to RH-TRU is high level waste (HLW) generated from defense operations. HLW has risk characteristics similar to RH-TRU. DOE has provided a cost estimate for shipping HLW by truck to Yucca Mountain for disposal. The CPLM is given as $13.70 for HLW, which includes variable and fixed cost components. This information is provided to shippers for comparison purposes. More information about HLW is provided in Appendix F.

3.3 Rail Shipment of Contact-Handled TRU Waste

The user can assume that six TRUPACT-II overpacks, which are designed for the Waste Isolation Pilot Plant (WIPP), can be loaded on a railroad flatcar. If drums are shipped, assume each drum weighs 500 lb and 14 are placed in each TRUPACT-II overpack, for a total weight of 7,000 lb per overpack. Therefore, the total weight per rail car for drums is 42,000 lb. If the waste is packaged in bins rather than drums, assume each bin weighs 4,000 lb and two bins are placed in each overpack, yielding a total weight per rail car of 48,000 lb. The total transportation costs can be calculated using the following steps:

a. Divide the total mass of waste to be shipped by 7,200 lb to obtain the number of TRUPACTs needed. Divide this number by 6 to obtain the number of rail cars needed. The cost presented below assumes one rail car per shipment.

b. Multiply the CPLM unit rates listed below by the one-way distance (in miles) and by the number of container loads (from step a above) to obtain the CPLM.

   - 200 to 500 miles: $42.05/mile
   - 500 to 1,000 miles: $33.95/mile
   - 1,000 to 2,500 miles: $24.04/mile

c. Multiply the number of rail car shipments (from step A above) by $9,260 per shipment to obtain the fixed transportation costs.

d. Add the CPLM (from step b above) to the fixed cost (from step c above) to obtain the total transportation cost.

3.4 Rail Shipments of Remote-Handled TRU Waste

Remote-handled TRU waste can be shipped by rail. Only a few shipping containers exist for this application. The DOE has commissioned designs of equipment, such as the NuPac 72B cask, which is suitable for truck or rail shipment; however, this cask has not yet been constructed. The only known shipment of remote-handled TRU waste by rail was from the damaged reactor at Three Mile Island to the INEL. Details on the cost of this shipping campaign are provided in Appendix A-1.2.

4. SPENT NUCLEAR FUEL

The cost-estimating procedure for SNF is presented below.

4.1 Truck Shipment of SNF

Transportation cost data for truck shipment of SNF casks are based on quotations from private-sector firms. These casks are generally used for shipment of SNF from nuclear power plants.

4.1.1 Method for Estimating Truck Shipment Costs

The total transportation cost for a given scenario can be calculated as follows:

a. Determine the number of canisters needed to package the SNF assemblies or elements (see Table 3). For trucks, the number of canisters is the same as the number of shipments.

b. Multiply the CPLM unit rates listed below by the one-way distance (in miles) and the number of shipments (from step a above) to obtain the CPLM cost.

- Below 200 miles: $47.82/mile
- 200 to 1,000 miles: $16.70/mile
- 1,000 to 2,500 miles: $14.37/mile.

c. Multiply the number of shipments (from step a above) by $8,110 per shipment to obtain transportation fixed costs.

d. Add the CPLM cost (from step b above) to the fixed cost (from step c above) to obtain the total transportation cost.

4.1.2 Guidance for Determining Number of Truck Shipments

The number of assemblies that can be housed in each cask is known for common fuels such as boiling and pressurized water reactor fuel. However, determining the number of assemblies per cask for nonstandard fuel is a relatively complex process and detailed evaluations will be required.[c] To facilitate the planning life-cycle cost (PLCC) estimating process, guidance based on several simplifying assumptions is presented below.

---

c. For odd-shaped fuels (e.g., the special SNF at INEL and the N-reactor fuel at Hanford Site), detailed geometry, physical, and radiological characteristics must be known. Before actual SNF shipments begin, a detailed evaluation will be required to ensure that the shipment of the fuel meets the limitation of the NRC license for the cask. Based on this evaluation, special canisters or baskets may have to be provided to secure the fuel in the cask cavity and to facilitate criticality safety during normal and accident conditions.

Table 3. Capacity of various cask and canister combinations for transport of N-reactor, high-enriched uranium, and low-enriched uranium fuel by truck.

Cask	Net payload (lb)	Fuel category	Canister size (in./lb[a])	Cavity dimension (in.)	Cans per cask	Assem. per canister	Total assem. per cask
FSV-1	3,700	FSV	18 × 187/3,225	18 × 192	1	6	6
		N-reactor	10 × 187/1,750	18 × 192	1	42	42
NAC-LTW	2,000	HEU	Basket	13.4 × 180.9	1	1	1
		LEU	Basket	13.4 × 180.9	1	1-2	1-2
		N-reactor	8 × 120/900	13.4 × 180.9	1	40	40
BMI-1	1,200	Research fuel	14.75 × 51.5/870	15.5 × 54	1	1-2	1-2
GA-4/9	5,000	PWR	Basket	18 × 187 est.	1	4	4
		BWR	Basket	18 × 187 est.	1	9	9

a. Empty weight of canister shell, assuming canisters are 1-in. thick.

4.1.2.1 High-Enriched Uranium (HEU) SNF.

Four factors must be determined to develop the number of truck shipments. Guidelines for developing these factors are discussed below.

Canister size. Table 3 contains a listing of the canisters that are currently in use or proposed for canning SNF. If limited data are available on the fuel geometry and criticality specifications, a canister with a diameter ranging in size from 8 to 12 in. may be assumed for HEU fuel. Long HEU assemblies will not fit into the 120-in.-long canister originally proposed in the EGG-WM-10670 report. It is simpler to use a longer canister than to cut these assemblies for transportation purposes. Longer canisters may readily be used because the maximum available cavity length in a truck cask is 192 in.

Number of canisters per cask. In most cases, the shipment will be limited to one canister per cask. However, several types of HEU fuel already exist in short canisters (i.e., less than 5 ft long). These may be loaded end-to-end within the cask cavity.

Number of fuel elements or assemblies per canister. Three limiting factors determine the number of fuel elements or assemblies that can be placed in a canister: the heat generation rate of the total fuel in the shipment must not exceed the specified heat removal capacity of the cask; the weight must not exceed the cask payload capacity; and the total U_{235} content in each canister must not exceed 40 kg.

Shielding. The cask must provide adequate radiation protection as measured on the outer surface of the cask. Maximum dose rate at the package surface should be below the 200 mrem/hr regulatory limit, and the maximum dose rate at 2 m (6 ft) from the package should not exceed the limit of 10 mrem/hr.

4.1.2.2 Low Enriched Uranium SNF.

The number of truck cask shipments for low enriched uranium (LEU) fuel can be determined in the same manner as the HEU, except that canisters are not restricted to the 40 kg of U_{235} limitation.

4.1.2.3 Other Special Cases.

The recommended shipping methodology for special cases is stated below.

TRIGA SNF. TRIGA can be shipped in a BMI-1 cask, which has a basket specifically designed for TRIGA fuel. DOE currently owns this cask and lends it to universities to ship research fuels. It has a flexible design that includes eight licensed basket and canister combinations. TRIGA fuel is rod shaped; typically 1.5 in. in diameter by 21 in. long. Some of the TRIGA fuel currently in storage may be in long canisters with multiple rods per canister. TRIGA fuel has three basic levels of enrichment: 19.8% (the majority of the fuel), 70%, and 93%.

N-reactor SNF. Rod-shaped N-reactor fuel is about 2.5 in. in diameter by 21 in. long. The average weight of each element is 40 lb. To develop an estimate of truck shipment costs, assume transport by a 10 × 180-in. canister containing 42 elements.

Fort St. Vrain SNF. One-third of this high-temperature graphite reactor fuel has been shipped from Colorado to the INEL. These shipments were made using the FSV-1 truck cask manufactured by General Atomics. There are typically six assemblies per canister, and one canister per cask in each shipment. The canisters used for these shipments are too long to ship by rail.

4.2 Rail Shipment of SNF

Table 4 summarizes the casks that are either currently licensed or being considered for rail shipment of SNF. Two of the rail casks, the Navy's M-140 and Pacific Nuclear's IF-300, have been licensed and are currently in use. Two other rail casks have not yet been licensed: Babcock & Wilcox BR-100 and the multi-purpose canister (MPC) proposed by DOE's Office of Civilian Radioactive Waste Management for use at the monitored retrievable storage facility. General information and 1993 cost data for the M-140 cask is presented in Appendix E. Cost data for rail casks may be obtained from publicly available literature (TRW 1993a and 1993b) or estimated from this study.

4.2.1 Method for Estimating Rail Shipment Costs

To determine the cost of an SNF rail shipment, first determine the type of cask to be employed. The IF-300 is suited for facilities with 70-ton lift capacities, and the M-140 is suited for facilities with 100-ton lift capacities. The total transportation costs for a given scenario then can be calculated as follows:

a. Determine the number of canisters needed to package the SNF assemblies or elements. Determine how many canisters can be loaded in the appropriate cask to arrive at the number of shipments. Refer to Table 4 to determine number of assemblies per shipment.

Table 4. Capacity of various cask and canister combinations for transport of N-reactor, LEU, and HEU fuel by rail.

Rail cask	Net payload (lb)	Fuel category	Canister size (in./lb[a])	Cavity dimension (in.)	Cans per cask	Assem. per canister	Total assem. per cask
IF-300	10,000	N-reactor	8 × 120/900	37.5 × 180	4	40	160
		N-reactor	26 × 126/3,300	37.5 × 180	1	200	200
		PWR	Basket	37.5 × 169	Basket	7	7
		BWR	Basket	37.5 × 180	Basket	18	18
M-140	32,000	N-reactor	26 × 126/3,300	70 × 140	4	195	780
		HEU	8 × 120/900	70 × 140	13	1-2	13
		LEU	8 × 120/900	70 × 140	25	1-2	25
MPC	32,000	N-reactor	21 × 187/3,800	57 × 187 est.	4	195	780
		PWR	Basket	57 × 187 est.	Basket	21	21
		BWR	Basket	57 × 187 est.	Basket	40	40
BR-100	33,000	PWR	Basket	48 × 187 est.	Basket	21	21
		BWR	Basket		Basket	52	52
		N-reactor	21 × 187/3,800		4	150	600

a. Empty weight of canister shell, assuming canisters are 1-in. thick.

b. Multiply the CPLM unit rates for the cask listed below by the one-way distance (in miles) and the number of shipments (from step a above) to obtain the CPLM cost. Choose the nearest rate for the intended destination that exceeds the actual distance required for the shipment.

	IF-300	M-140
• Less than 200 miles:	$182/mile	$205/mile
• 200 to 1,000 miles:	$108/mile	$127/mile
• 1,000 to 2,500 miles:	$ 87/mile	$103/mile

c. Multiply the number of shipments (from step a above) by $18,000 per shipment to obtain transportation fixed costs.

d. Add the CPLM (from step b above) to the fixed cost (from step c above) to obtain the total transportation cost.

4.2.2 Guidance for Determining Number of Rail Shipments

Determining the number of assemblies per cask will require detailed evaluations as discussed in Section 4.1.2. To facilitate developing PLCC estimates, guidance based on several simplifying assumptions is presented below.

4.2.2.1 High Enriched Uranium SNF.

Four factors must be determined to develop the number of rail shipments:

Canister size. If limited data are available on the fuel geometry and criticality specifications, an 8-in.-diameter canister is recommended for HEU fuel (see Table 4).

Number of canisters per cask. If detailed information on the cask basket is not available, the assumed geometry for the basket should be based on maintaining a minimum 8-in. separation distance between the outer surface of any two adjoining canisters. As an example, the basket for the M-140 cask would have twenty-five 13-in.-square cavities with a 1-in. separation between each cavity. In this configuration, 13 of the cavities could be used for HEU and still maintain an 8-in. separation between individual canisters.

Number of fuel elements per canister. Three limiting factors determine the number of fuel elements or assemblies that can be placed in a canister: the heat generation rate of the total fuel in the shipment must not exceed the specified heat removal capacity of the cask, the weight must not exceed the cask payload capacity (shown in Table 4), and the total U_{235} content per canister should not exceed 40 kg.

Shielding. The cask must provide adequate radiation protection as measured at the outer surface of the cask. Maximum dose rate at the package surface should be below the 200 mrem/hr regulatory limit, and the maximum does rate 2 m (6 ft) from the package should not exceed the limit of 10 mrem/hr.

4.2.2.2 Low Enriched Uranium.

The number of rail shipments for LEU fuel can be determined in the same way as for HEU, except that canisters are not restricted to the 40 kg of U_{235} limitation.

Canister size. Because of lower enrichment, the 21-in. MPC (currently being considered by DOE's Office of Civilian Radioactive Management [OCRWM]) may be used. A 26-in.-diameter canister (recommended for the Mined Geological Repository at Yucca Mountain) may also be used.

Number of canisters per shipment. If a 21-in. or a 26-in.-diameter cask is used, the number of canisters per shipment is limited to four. However, if fuel is densely packed inside each canister, weight limitations will dictate a lesser number of canisters per shipment. Up to twenty-five 8- by 120-in. canisters can be shipped in the M-140 cask. The M-140 can accommodate a 25-channel basket with 13-in.-square cavities.

Number of fuel elements or assemblies per canister. The number of elements or assemblies per shipment should be calculated based on the three limitations mentioned above as well as specific criticality and heat generation calculations, if available.

4.2.2.3 Other Special Cases.

Special research fuels. Fuels, such as TRIGA, plate, and Fort St. Vrain's high-temperature graphite reactor (HTGR), have normally been shipped by truck. There are no design, cost, or packaging guidelines for rail shipment of these types of fuel.

N-reactor SNF. The average N-reactor fuel element is 2.5 in. in diameter, 21 in. long, and weighs about 40 lb. A single 21-in.-diameter MPC canister loaded with about 780 fuel elements can be considered for estimating cost of N-reactor rail shipments. This is based on meeting the weight limitation of the cask, but does not consider potential criticality or heat removal problems.

5. HAZARDOUS WASTE

5.1 Truck Shipment

Transportation costs for hazardous waste are estimated based on the assumption that unshielded 48-ft-long truck trailers containing eighty-eight 500-lb drums are used. This configuration yields a total weight of 44,000 lb per shipment. The total transportation costs can be calculated using the following steps:

a. Divide the total weight of waste (in pounds) by 44,000 lb/shipment to obtain the number of shipments.

b. Multiply the CPLM unit rates listed below by the one-way distance (in miles) and the number of shipments (from step a above) to obtain the CPLM cost.

- Less than 200 miles: $3.00/mile
- 200 to 1,000 miles: $2.50/mile
- More than 1,000 miles: $1.95/mile.

There are no significant fixed costs for transporting hazardous waste by truck to add to the variable cost given in step b (see Appendix A, Section A-4.4). However, for very short truck hauls, e.g., less than 80 miles, trucking costs will be independent of mileage and will not fall below a minimum charge set by the trucking company (e.g., $250).

5.2 Rail Shipment

Costs for transporting hazardous waste by rail are estimated based on the assumption that waste in drums or steel boxes would be moved in 40-ft-long intermodal (sealand) containers. The containers can be moved by truck or on rail flatcars. Each container would hold seventy-six 500-lb drums, yielding a total weight of 38,000 lb, or would hold eleven 3,945-lb boxes, yielding a total weight of about 44,000 lb. The total transportation costs can be calculated using the following steps:

a. Divide the total weight of waste (in lb) by 38,000 lb (for drums) or 44,000 lb (for boxes) to obtain the number of container loads.

b. Multiply the CPLM unit rates listed below by the one-way distance (in miles) and by the number of container loads (from step a above) to obtain the CPLM.

- 500 to 1,000 miles: $1.96/mile.
- 1,000 to 2,000 miles: $1.74/mile.
- More than 2,000 miles: $1.46/mile

c. Multiply the number of container loads (from step a above) by $750 per container load to obtain the fixed transportation costs.

d. Add the CPLM (from step b above) to the fixed cost (from step c above) to obtain the total transportation cost.

6. REFERENCES

Feizollahi, F. and D. Shropshire, 1993, *Waste Management Facilities Cost Information Report for Spent Nuclear Fuel*, EGG-WM-10670, March 1993.

Schmid, S. P., F. L. Danese, and M. W. Wankerl, 1993, "Site & Facility Waste Transportation Planning Documents (SPD's) Status and Findings," in *Proceedings of the Fourth Annual International Conference on High Level Radioactive Waste Management*, Las Vegas, NV.

TRW, Inc., 1993a, *A Preliminary Evaluation of Using Multi-Purpose Canisters within the Civilian Radioactive Waste Management System*, Doc. No. A00000000-AA-07-00002, March 1993.

TRW, Inc., 1993b, *Reference Transportation Data and Assumptions*, May 1993.

Telephone contacts: A variety of cask vendors, transportation carriers, and DOE contractors supplied information for use in preparing this report. These include the following firms:

- Argonne National Laboratory, Argonne, Illinois: mileage tables.
- Babcock & Wilcox, Lynchburg, Virginia: BR-100 SNF rail cask design information.
- Chem Nuclear, Columbia, SC: cask data.
- CSX Railroad, Jacksonville, Florida: rail rates.
- EG&G, Idaho Falls, Idaho: SNF rates and operational details.
- Envirolease/GATX, Morristown, NJ; Intermodal equipment data.
- General Atomics, San Diego, California: FSV-1 truck cask rates for HTGR fuel and TRIGA Information.
- Nuclear Assurance Corporation, Norcross, Georgia: truck cask rates.
- Pacific Nuclear, various offices: SNF rail cask rates, TRUPACT-II design information, container information, and operational details.
- Santa Fe Railway, Schaumburg, Illinois: rail rates.
- SEG, Oak Ridge, Tennessee: LLW shipping cost and container data.
- Southern Pacific Transportation Company, San Francisco, California: rail rates.
- Tri-State Motor Transit Company, Joplin, Missouri: truck transportation rates.
- Union Pacific Railroad, Omaha, Nebraska: rail rates.
- Westinghouse, Carlsbad, New Mexico: TRUPACT-II shipping costs for TRU waste.

- Vectra Technologies, Inc., Federal Way, Washington: NuPac Data.
- Cho Yang Shipping Lines, San Francisco, California: intermodal container, chassis costs.
- DSR-Senator, San Francisco, California: intermodal container cost.
- Mi-Jack, Portland, Oregon: intermodal container lift equipment cost.

Appendix A

Methods, Bases, and Assumptions

Appendix A
Methods, Bases, and Assumptions

This appendix contains cost estimating methods, assumptions, and technical bases that were used to develop the planning life-cycle cost (PLCC) estimates. Specific additional assumptions and bases for waste stream transportation cost estimates are given in the main body of the report. First, technical assumptions as they apply to the four main waste types in this report are discussed in the following sections. Second, cost bases and assumptions as they apply to transport in intermodal containers and without are presented. Third, additional waste type-specific assumptions are presented. The backup data for the cost estimates are included in separate appendices.

A-1 TECHNICAL ASSUMPTIONS

The approach is based on developing well-documented transportation cost estimates for various waste streams. Initially, waste is grouped into the following four categories: (1) LLW, MLLW, alpha LLW and MLLW, and GTCC LLW/DOE equivalent; (2) TRU waste; (3) SNF; and (4) hazardous waste.

A-1.1 Shipment Assumptions for LLW, MLLW, Alpha LLW, Alpha MLLW, and GTCC LLW/DOE Equivalent

Transportation of LLW, MLLW, alpha LLW and LLMW, and GTCC LLW/DOE equivalent is accomplished either as contact-handled or remote-handled shipments. Contact-handled shipments are accomplished by placing the waste in DOE, DOT, and NRC approved packages (drums or boxes) and placing them in open-top truck trailers, rag-top trailers, enclosed trailers, or intermodal (sealand) containers. Remote-handled shipments are accomplished by placing the waste in packages and loading the packages into trailer or railcar-mounted casks (overpacks) that are licensed by DOE, DOT, and NRC. It is assumed that remote-handled waste will use Type B casks as defined by the NRC regulations.

The physical forms of the waste include heterogeneous solid waste (consisting of soils, debris, trash, surface contaminated metals, stabilized liquids, etc.), activated metals, and organic liquids.

Before shipment, all waste is assumed to be characterized, treated, and packaged in accordance with all applicable regulations. All LLW is assumed to be transported in DOT/NRC certified Type A packages, such as 55-gal drums or standard waste boxes. 55-gal drums have a maximum capacity of 500 lb (227 kg) according to DOT regulations. Boxes are B25s, made of 12- or 14-gauge steel, similar to those manufactured by Container Products Corp., of Wilmington, North Carolina. B25s have a volume capacity of 90 ft^3 and a maximum rated load capacity of 3,945 lb gross. To convert between volume and mass, assume a density of 70 lb/ft^3. It is further assumed that if radiological characterization shows that the total activity in a package exceeds A_2 values, then the package contents would be divided between one or more additional containers until the A_2 limits are met. Shipments of liquid organic waste would meet additional regulatory requirements specified for liquids (i.e., packages would contain adequate absorbent for twice the liquid volume, and a leak-tight overpack would be used).

Shipment requirements are determined by weight [total waste mass (kg) at each site divided by the appropriate vehicle capacity (kg)]. For truck transportation, the DOT gross weight limit is 80,000 lb. Tractor-trailer combinations are assumed to weigh from 30,000 to 35,000 lb. The maximum payload weight has been taken to be 44,000 lb (20,000 kg). This would require a 48-ft trailer to accommodate the shipment. For rail shipment of LLW, MLLW, and hazardous waste, it is assumed two 40-ft intermodal containers would be placed on a rail flatcar. Payload weight of these containers would be 38,000 lb in the case of drums and 44,000 lb for boxes.

A-1.2 Transuranic Waste Shipment Assumptions

Transportation of TRU waste is accomplished either as contact-handled or remote-handled shipments. It is assumed that all contact-handled TRU waste shipments will be shipped in TRUPACT-II containers. Remote-handled TRU waste will be shipped in Type B casks or SNF casks, depending on the specific characteristics of the waste shipment.

The physical forms of TRU waste are highly variable. They include heterogeneous solid debris, soils, laboratory trash, surface contaminated metals, stabilized liquids, vitrified high level waste, and debris reactor cores and fuel rods assemblies, all of which may be contaminated with transuranic elements. It is assumed that the shipper will package waste in accordance with all applicable regulations.

For contact-handled TRU waste, the payload capacity of each TRUPACT-II is limited to 7,265 lb; 7,200 was used for calculations. Three TRUPACT-IIs are assumed to be transported per truck and six per rail car. Total shipment capacities are 21,600 lb for truck and 43,200 lb for rail. Each TRUPACT-II can accommodate fourteen 55-gal drums. The safety analysis report for the TRUPACT-II did not address rail shipment of these containers. We assume that TRUPACTs can be transported by rail. Rates were calculated using costs provided for SNF shipments, and include two buffer cars for the loaded portion of the shipment.

For remote-handled TRU waste, truck transport has been the normal method of shipment. Rates for overweight truck casks were supplied by Chem-Nuclear and NuPac. A legal-weight cask has been design by NuPac, but the cask has not been built. This cask, known as the NuPac 72-B, is suitable for shipment of vitrified high level waste and has a payload of 8,000 lb. NuPac stated that the container could be shipped by truck or rail.

DOE has provided a cost estimate for shipping high level waste by truck to Yucca Mountain for disposal. The CPLM is given as $13.70 for high level waste, which includes variable and fixed cost components. This estimate assumes a waste form similar to the vitrified material produced at Savannah River. No details are given for the type of container used in this shipment. Yucca Mountain's design basis for a repository cask suitable for vitrified high-level waste is 26-in. in diameter by 10-ft long. More information about this cost estimate is provided in Appendix F.

Otherwise, the cost of shipping remote-handled TRU waste with a high specific activity by rail is roughly equal to the cost of shipping SNF by rail (refer to Section 4.2). The assumption is based on the fact that remote-handled TRU waste containers require Type B casks with all the associated special handling and equipment related to SNF. This assumption has been validated by the DOE in their campaign to ship remote-handled TRU waste from the damaged reactor at Three Mile Island.

SNF cask vendors have provided their casks for remote-handled TRU waste shipments. For example, DOE has purchased three 125-B casks from NuPac to ship remote-handled TRU-related debris from Three Mile Island. Several shipments were made between 1986-1990. An article describing these shipments is included in Appendix C. The distance traveled was 2,350 miles each way. Each shipment included three casks, four buffer cars, and a caboose. Two railroads, UPRR and Conrail, provided the locomotives for these dedicated shipments. The Three Mile Island cost data represents a limited estimate of remote-handled TRU rail shipping costs. A cost estimate based on DOE's Three Mile Island shipments is presented below:

Average railroad cost per TMI shipment, including security	$200,000
Cask lease rate $ 7,150 per day X three casks X 10 days per shipment (based on method presented in A-3.2.3)	$214,500
Total variable cost =	$414,500

Variable cost of $414,500/2,350 miles = cost per loaded mile of $176.30
CPLM $176.30/3 casks per shipment = CPLM per cask of $58.77

Fixed cost of 2 days demurrage per cask = $14,300

A-1.3 SNF Waste Shipment Assumptions

Transportation of SNF is accomplished by using licensed SNF casks. Hardware (casks) used for shipping SNF generally has features for cooling the SNF during shipment, provides shielding, and has impact absorbing features. Several different SNF casks are available (Schmid et al. 1993), and each one is licensed for a special type of SNF. Grouping of the various SNF casks, described in report EGG-WM-10670, is as follows: HEU fuel, which is assumed to have >20% enriched uranium content, can be shipped in Type A canisters; LEU fuel, which is assumed to have <20% enriched uranium content, can be shipped in Type B canisters; and Fort St. Vrain Facility fuel (high-temperature graphite fuel) can be shipped in Type C canisters.

Using the above waste groupings, the CPLM unit rates and fixed costs were estimated by soliciting bids from carriers (trucking and railroad) and commercial cask-rental firms. Their prices (which were specific to specified routes or lease periods and timetables) per shipment were calculated. Additional conversations with DOE contractors helped to clarify some of the data and assumptions. The information obtained from the vendors has been summarized and presented in variable CPLM and fixed cost per shipment format.

Additional assumptions are as follows:

- Casks are available 168 days per year, based on a 240-day year and a 70% utilization rate.
- Average truck cask weight is 40,000 lb for legal weight truck shipments of SNF.
- Cask loading and unloading is performed by facility operations staff.
- Two days are required to load and unload an SNF cask.

A-1.4 Hazardous Waste Shipment Assumptions

Transportation of hazardous waste is accomplished by truck in bulk in appropriate truck trailers, or in packages (drums or boxes) placed in open-top truck trailers, rag-top trailers, enclosed trailers, or intermodal (sealand) containers. Transportation of hazardous waste is accomplished by rail in drums or boxes placed in intermodal containers. The physical forms of the waste include heterogeneous solid waste (consisting of soils, debris, trash, surface-contaminated metals, stabilized liquids, etc.), activated metals, and organic liquids. Before shipment, all waste is assumed to be characterized, treated, and packaged in accordance with all applicable regulations. The packages are assumed to be DOT-certified, such as 55-gal drums or standard waste boxes. 55-gal drums have a maximum capacity of 500 lb (227 kg) according to DOT regulations. Boxes are B25s, made of 12- or 14-gauge steel, similar to those manufactured by Container Products Corp., of Wilmington, North Carolina. B25s have a volume capacity of 90 ft^3 and a maximum rated load capacity of 3,945 lb gross. To convert between volume and mass, assume a density of 70 lb/ft^3.

Shipment requirements are determined by weight [total waste mass (kg) at each site divided by the appropriate vehicle capacity (kg)]. For truck transportation, the DOT gross weight limit is 80,000 lb. Tractor-trailer combinations are assumed to weigh from 30,000 to 35,000 lb. The maximum payload weight has been taken to be 44,000 lb (20,000 kg). This would require a 48-foot trailer to accommodate the shipment. For rail shipment of hazardous waste, it is assumed two 40-ft intermodal containers would be placed on a rail flatcar. Payload weight of these containers would be 38,000 lb in the case of drums and 44,000 lb for boxes.

A-3 COST BASIS AND ASSUMPTIONS

A-3.1 Shipment Primarily by Rail In Intermodal Containers

Cost estimates for transporting contact-handled LLW, contact-handled MLLW, and hazardous waste by rail were based on movement in intermodal (sealand) containers. It is assumed DOE owns or leases (from a third party) a number of intermodal containers and chassis, which would be dedicated to the task of transporting these types of DOE waste. Four hypothetical destinations for the waste were chosen: (1) Hanford Site, (2) Idaho National Engineering Laboratory (INEL), (3) Nevada Test Site, and (4) Oak Ridge National Laboratory (ORNL). These are hypothetical disposal sites and are also the assumed locations where containers and lift equipment are stored.

A facility needing to ship waste would call for empty intermodal containers from the nearest storage location. The shipping facility (waste-generating facility) would call a trucking company to meet the empty intermodal container at the nearest public rail loading ramp. The trucking company would bring the empty container to the shipping facility, where it would be loaded by the shipping facility. The shipper is assumed to have a standard forklift (not included in the transportation cost) for loading the waste onto the truck. The truck will bring the loaded container to the public ramp, where the container is placed on a rail flatcar. The disposal installation will purchase a special lift device to transfer loaded intermodal containers between the rail flatcar and truck chassis; this lift device will be part of fixed transportation costs. The containers, after reaching one of the destination installations and being unloaded, are returned to the pool of containers at the destination installation.

It is assumed that rail lines directly service the destination facility. The containers will still need to be trucked between the rail spur and treatment, storage, and disposal facilities within the destination installation. A lift device will be needed for this transfer, and a small number of chassis will be needed for the in-plant moves within the installation.

A-3.1.1 Costs of Trucking Segments

Trucking costs make up part of the rail transportation costs presented in Sections 2.1.2 and 5.2 (trucking costs are already included in the rail costs presented). The basis for these trucking costs are as follows.

It is assumed that rail lines do not directly service the shipping facility nor go directly to the TSD facilities at the destination facility. Therefore, truck shipment will augment rail transportation at both ends of the rail movement. A total truck shipment distance of 150 miles was added to the rail shipment.

Assumptions regarding the trucking segments of rail transportation costs are substantially the same as trucking assumptions used elsewhere in this report (see Section A-3.2.1). The main exception is an absence of a demurrage charge associated with the pickup, loading, or dropoff of the intermodal container. It is assumed that drums or boxes can be loaded into and unloaded from the container in less than 2 hours and that lifton and liftoff of the container at the rail ramps can also be accomplished within that time.

A-3.1.2 Costs of Rail Segment

Rail movement comprises the main, central segment of the trip described in Sections 2.1.2 and 5.2. Rail rates are based on quotations from railroads for specific routes. Actual rates are typically defined by a contract between the shipper and railroad. Shipments of contact-handled LLW, contact-handled MLLW, and hazardous waste are assumed to involve the movement of two 40-foot intermodal containers on an 89-foot flatcar. The railroad provides the flatcar. A short-haul rate quote was provided by Union Pacific Railroad (UPRR) for the route from Seattle, Washington, to Nampa, Idaho (655 miles). Two medium-length rate quotes were provided by CSX for the route from Bettis Atomic Power Plant, Pennsylvania, to Savannah River Site, South Carolina (947 miles), and for the route from Rocky Flats Plant, Colorado, to the Y-12 Plant, Tennessee (1,586 miles). A long-haul rate quote was provided by UPRR for East St. Louis, Illinois, to Hanford, Washington (2,040 miles) (see Table A-1).

Table A-1. Rail rate quotes for containerized contact-handled LLW, contact-handled MLLW and hazardous waste.

Origin	Destination	Rail mileage	Roundtrip rail rate per container	Railroad
Seattle, WA	Nampa, ID	655	$1,125	UPRR
Bettis Atomic Power Plant, PA	Savannah River Site, SC	947	$1,250	CSX
Rocky Flats Plant, CO	Y-12 Plant, TN	1,586	$2,575	CSX
E. St. Louis, IL	Hanford, WA	2,040	$2,750	UPRR

A-3.1.3 Transportation Hardware Costs

Transportation hardware costs consist of intermodal containers and chassis, and one lift device at the disposal facility. These costs work out to a charge of $750 per container shipped that DOE will assess the shipping facility for the use of the equipment.

The costs of a container, chassis, and lift device are amortized over 5 years using a straight-line depreciation. The total cost of equipment is divided by 5 years to yield an annualized cost. The annual maintenance cost is assumed to be 25% of the annualized capital cost, and the cost of money, overhead, and fee are assumed to be 50% of annualized cost. The sum of these annualized costs are divided by 168 days to obtain the daily container cost. (It is assumed the equipment will be used 70% of the time 240 days per year, or 168 days per year.) An average purchase cost of $3,500 for a 40-ft sealand container and $3,000 for a chassis were obtained from Cho Yang Lines and DSR-Senator Agency. The daily cost for containers and chassis is multiplied by 7 days, assuming the equipment will be used this long during the average round trip movement. Two cost quotes for a lift device were obtained: $350,000 was quoted by Mi-Jack Corporation, Portland, Oregon, and $280,000 was quoted by Tenco, Union City, California. These two amounts were averaged to arrive at a cost of $315,000 per lift device.

A-3.2 Shipment in Other Than Intermodal Containers

A-3.2.1 Truck Carrier Costs

Shipment of waste by truck is based on the following assumptions:

- Carrier costs include the following:
  - Dispatching crews from their base of operations to pick up an empty cask,
  - One day of demurrage at the shipper's facility while the cask is loaded.
  - Transporting the loaded cask from the shipper to the receiving facility.
  - One day of demurrage at the shipper's facility while the cask is unloaded.
  - Return of the empty cask from the receiving to the shipping facility.
  - Carrier surcharges for special equipment used to ship radioactive material.
  - Carrier insurance costs.
  - Security escort as a direct quote where available, or at 20% of the carrier's variable costs.
- Carrier cost is converted into dollars per mile by assuming a crew (two drivers) covers 900 round-trip miles per day (or 450 loaded miles per day).
- Carrier freight rates are based on specific rate quotes from Tri-State Motor Transit for three specific routes.

- Carrier detention (demurrage) costs are calculated based on a daily rate of $840, which includes stand-by costs for the special spent fuel crew during cask loading/unloading operations.

A-3.2.2 Rail Carrier Costs

Cost estimates for rail shipment in other than intermodal containers are based on tariff quotations from different railroads. The estimates assume that normal service can accommodate the 35 miles-per-hour-in-transit requirement. Actual rail rates are typically defined by a contract between the shipper and the railroad. It is also assumed that rail lines directly serve the shipping facility and the destination facility and that both facilities have the necessary lift devices (cranes, forklifts) to move waste onto and off the rail cars.

SNF shipments are assumed to require the movement of a loaded cask, its dedicated flatcar, two buffer cars, and a caboose for escort personnel. This assumption is similar to the requirements of Carolina Power and Light, which has maintained a dedicated fleet of its own equipment for multiple shipments over several years. They contract out only the traction (power) equipment from CSX. They own two IF-300 casks, two buffer cars, and a caboose. Four IF-300s have been in service for nearly 20 years. Pacific Nuclear Fuel Services (formerly GE Morris, Illinois) owns the other two IF-300 casks. Most of the fixed cost portion of SNF rates are based on lease rates for the IF-300 cask supplied by Pacific Nuclear. This cask has a basket design suitable for most types of DOE fuel; however, a new basket must be designed for the canisters listed in Table 4. A cost estimate cost for a new basket design is beyond the scope of this report.

Tariff rates were provided on a cost-per-hundredweight basis. The total weight of TRU waste and SNF shipments were estimated for both the loaded (heavy) and unloaded (light) segments of the trip. These costs were combined and divided by the total mileage for the estimated range to arrive at the CPLM.

Two short-haul rate quotes were received for trips in the 200-mile range. These were provided by Southern Pacific (Mare Island, California, to Sacramento, California, about 80 miles), and CSX railroad (Newport News, Virginia, to Portsmith, Virginia, about 238 miles). The rate quote in the 1,000-mile range was provided by UPRR for a trip between Sacramento, California, and Scoville, Idaho. UPRR provided other rates for shipments from Idaho Falls, Idaho, to both Hanford, Washington, and Las Vegas, Nevada. It is interesting that the rates from Idaho Falls were lower than the rates from Sacramento. UPRR explained that distance is not the main factor in rail rates. The amount of rail traffic along a given corridor is the main factor in determining the shipping cost. For the 1,000- to 2,500-mile range, a combined move of nearly 2,200 miles was priced out for a shipment between Idaho Falls and Barnwell, South Carolina. This rate is divided between UPRR and CSX. A 1,300-mile quote for a shipment between Morris, Illinois, and Albuquerque, New Mexico, has also been received from Santa Fe Railway. A comparison of only the loaded tariff rates for various distances has been prepared (see Table A-2).

Table A-2. Rail rate quotes for SNF and TRU waste.

Origin	Destination	Mileage	Loaded SNF rate	Tariff #
Mare Island, CA	Sacramento, CA	80	$ 2.96/cwt.	SPTC
Newport News, VA	Portsmith, VA	238	$ 2.92/cwt	CSXT 4600g
Sacramento, CA	Scoville, ID	1,020	$12.15/cwt	UPRR 4605d
Idaho Falls, ID	Hanford, WA	641	$ 9.07/cwt	UPRR 4605d
Idaho Falls, ID	Las Vegas, NV	671	$ 8.84/cwt	UPRR 4605d
Idaho Falls, ID	E. St. Louis, MO	1,510	$13.73/cwt	UPRR portion
E. St. Louis, MO	Barnwell, SC	665	$ 6.44/cwt	CSX portion
Idaho Falls, ID	Barnwell, SC	2,175	$20.17/cwt	Combined Rate
Argonne	Albuquerque, NM	1,315	$ 7.15/cwt	Santa Fe 4043-A

cwt = cost per hundredweight

Security related costs were assumed to be 30% of the cask rental charges during the loaded portion of the move. Train crew and security personnel may have to be relieved while a shipment is in progress to maintain the designated rate of travel. This often involves special arrangement to deliver a crew to a remote location when an existing crew has run out of hours as prescribed by the DOT.

A-3.2.3 Transportation Hardware Costs

Transportation hardware costs include equipment capital and maintenance costs. Capital costs associated with hardware needed for shipment of contact-handled LLW, MLLW, and alpha LLW and LLMW are assumed to be negligible.

Capital costs for casks, trailers, and rail cars used during shipment of remote-handled waste and SNF are estimated using either a commercial lease rate or a purchase cost, as described below.

The annual commercial lease rate submitted by the commercial cask leasing firms are averaged to obtain a basic daily leasing cost. The basic annual leasing cost is divided by 168 days to obtain the daily lease rate. The daily lease rate for a given trip is calculated by dividing the one-way distance by 450 miles to obtain the number of days the hardware will be in use. If the number of days is a fraction, it is rounded up to the next whole number and multiplied by 2 to determine the cask rental period for the round trip. Next, the number of days is multiplied by the daily lease rate to arrive at the variable cost component of the cask rental. For example, a 1,000-mile trip requires 3 days each way at 450 miles/day, multiplied by 2, resulting in 6 days total cask rental.

The cost of purchased casks is depreciated straight-line over 5 years. The annualized capital cost is obtained by dividing the capital cost into 5 years. The annual maintenance cost is assumed to be 25% of the annualized capital cost. The cost of money, and the cask vendor overhead and fee are assumed to be 50% of the total annualized capital costs. The sum of the annualized capital, maintenance, and vendor overhead profit and fee is divided by 168 days to obtain the cask daily capital payment cost.

The calculation of rates for daily cask rental are presented in Table A-3.

Table A-3. Rates for daily cask rental.

Vendor	Cask	1-year lease rate	Daily rate based on 168 days per year
General Atomics	FSV-1	$432,000	$2,571
Dept. of Defense	M-140	$1,400,000	$8,333
DOE	BMI-1	NA	$1,200
Pacific Nuclear	IF-300	$1,620,000	$9,643
NAC	NLI-1/2 LWT	$648,000	$3,214

The cask lease rates for the IF-300 were provided by Pacific Nuclear, of San Jose, California. The lease terms are $4,500 per day based on a 1-year commitment (360 days). The total for the year is $1,620,000. In previous reports, capital costs were divided by 168 days (70% of 240 operating days) to determine the daily rate. Using this formula, the daily lease rate is $9,643. In addition to the capital cost of the lease, a charge for annual operation and maintenance (O&M) related costs will be added to the capital rate. Pacific Nuclear estimated $50,000 for annual O&M-related expenses. This number is divided by 168 and equals approximately $300 day. The total variable cost rate of the cask rental is $9,943 per day.

The Department of Defense has provided cost information on the M-140 cask used by Naval Reactors. The basic hardware cost is $4,000,000, which equates to $800,000 per year, assuming use for 5 years. The annual maintenance cost is $200,000, and the overhead cost is $400,000 per year. The total yearly cost for the M-140 cask is $1,400,000. The daily lease rate is $8,333.

The fixed cost portion of the rate is assumed to be two times the daily rate. The average of the 2-day lease rate was used as the basis for the fixed cost portion, which equals $18,000 (rounded). There is no train demurrage since the cask and its flatcar can be spotted at the shipper's or receiver's facility.

TRUPACT-II casks are assumed to weigh 12,000 lb empty and 19,200 lb full. Rail rates are based on cost-per-hundred-weight quotes. The loaded segment of the move includes two buffer cars at 24,000 lb each. The return assumed six empty TRUPACTs and no buffer cars. No security escorts are provided for TRU shipments. The total cost per loaded mile is the sum of loaded and empty return cost divided by the distance between the shipper and the destination facility. No rail car exists to ship TRUPACTs by rail. A safety analysis report, design, and fabrication of hardware by others are in progress.

A-4 BASIS FOR WASTE STREAM SPECIFIC COST ESTIMATES

A-4.1 LLW, MLLW, Alpha LLW, and Alpha MLLW

The backup data used to prepare the cost information present in Section 2 is located in Appendix B. The main source of information was provided by Scientific Ecology Group (SEG). This data was presented in an earlier WMFCI report, and has been repeated here to give the user a single source of cost information. Information on intermodal equipment and transport rates has been added to Appendix B.

A-4.2 TRU Waste

The backup data used to prepare Section 3 is located in Appendix C. Pacific Nuclear provided the TRUPACT-II specifications. Phil Gregory, Westinghouse-WIPP, provided cost information based on life-cycle cost studies prepared by his office. Bill Dean, EG&G INEL, provided cost information on the TMI shipments. A journal article on the TMI shipping campaign is also included.

A-4.3 Spent Nuclear Fuel

The backup data for SNF transportation cost estimates is broken down into two parts. Appendix D contains the information on SNF truck shipments, and Appendix E contains the information on SNF rail shipments. Union Pacific Railroad has extensive experience with SNF shipments to INEL. CSX is the contract carrier for Carolina Power and Light, who has an ongoing program to ship SNF by rail. Tri-State Motor Transit has an excellent reputation as a highway carrier. It should be noted that the greatest expense, in the short distance shipments, is dispatching the crew from their base of operation. For example, the 30-mile quote represents an internal move at Hanford. However, the crew must travel 1,800 miles each way to pick up the shipment and deliver it. Another hidden cost is incurred if shipping containers are not stored at the shipper's or receiver's facility.

A-4.4 Hazardous Waste

Transportation costs for hazardous waste are similar to those presented for contact-handled low-level radioactive waste. Relevant backup data are presented in Appendix B. Costs for shipment of hazardous waste are sightly lower than radioactive waste, because these shipments differ in the following ways:

- There are many more carriers for hazardous waste than radioactive waste
- No significant fixed costs are related to container rental and demurrage
- Hazardous waste does not require complex packaging and secondary containment
- Bulk containers, such as dump trucks, roll-off boxes, and vacuum trucks are readily available

- No requirement exists for health physics technicians to inspect loaded trucks before release
- Insurance and training related costs are lower.

The cost difference between radioactive low-level shipments and hazardous waste is reflected in lower CPLM rates for hazardous waste. The limited number of radioactive waste shippers increases the cost of mobilization of transportation equipment to the shipper's facility. In addition, shipment of radioactive waste requires monitoring by health physics technicians (per NRC regulations CFR 10) and compliance with DOT regulations (Subpart I of CFR 49.173), which lead to additional fixed costs for radioactive waste shipments.

Appendix B

Backup Data for Low-Level Waste Shipments

Appendix B-1: SEG Quotation/Cask Data
Appendix B-2: Chem Nuclear Cask Data
Appendix B-3: NuPac Cask Data

Appendix B-1

SEG Quotation/Cask Data

SCIENTIFIC ECOLOGY GROUP, INC.

February 18, 1993

Lisa Penaska
M.K. Environmental
180 Howard Street
12th Floor
San Francisco, CA 94105

Dear Lisa,

Scientific Ecology Group is pleased to provide the attached data sheets for your reference. SEG has a full line of process containers and radwaste shipping casks to meet a variety of needs.

Feel free to contact me at (615) 376-8115 if you have any further questions. We are looking forward to hearing from you.

Sincerely,

William J. Horsey

William J. Horsey
Manager Field Services

Ltr-93-05

P.O. Box 2530
1560 Bear Creek Rd.
Oak Ridge, Tennessee 37831-2530
(615) 481-0222

P.O. Box 2308
Carlsbad, New Mexico 88220
(505) 887-1673

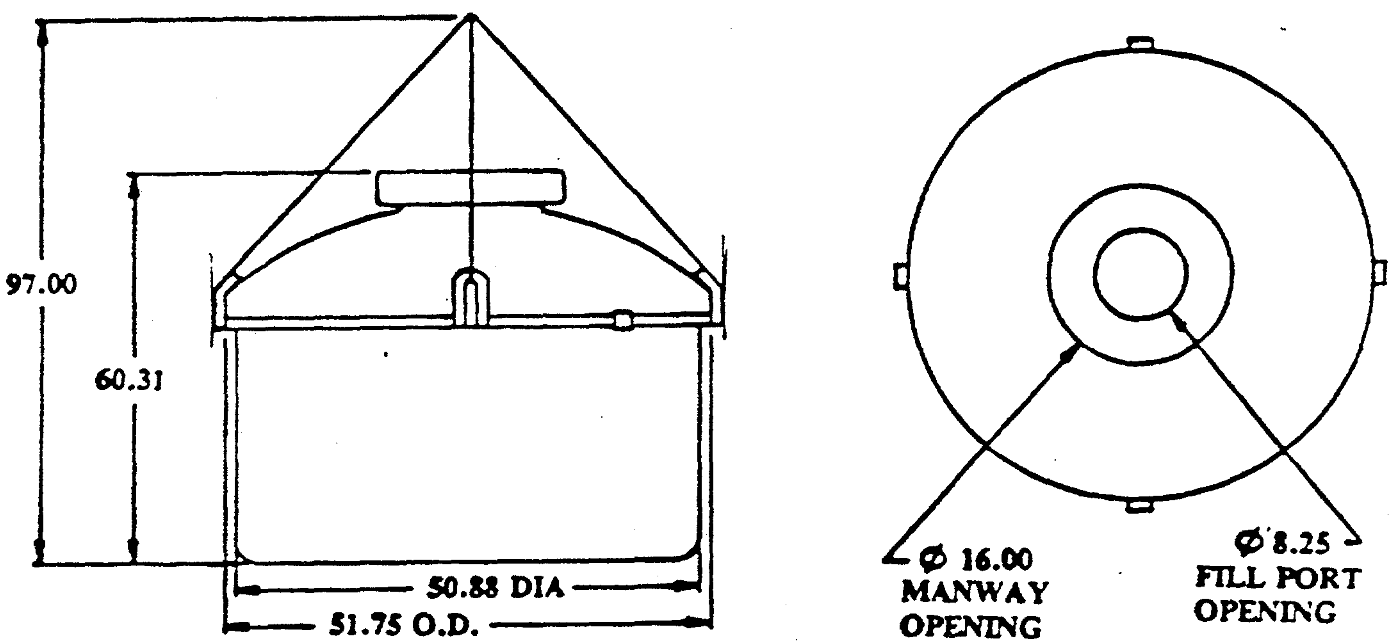
1234 Columbia Dr. S.E.
Richland, Washington 99352
(509) 736-0626

SCIENTIFIC ECOLOGY GROUP, INC.
A Westinghouse Subsidiary

DISPOSABLE CONTAINER DATA SHEET

Data Sheet No. RT-14
Rev. No. 6
Date 8-26-91
Reference DCN 91-054
Approved [signature]

Model Designation: RADLOK®-200 (RADLOK-73) High Integrity Container
South Carolina Certification No.: DHEC-HIC-PL-007
Cask Application: 3-82B Cask & HN-142 Cask



ALL DIMENSIONS NOMINAL

DESIGN DATA

Configuration	Total Nom. Cap.	Approx. (empty) Wt.	
Plain	57.5 cu ft	400 lb	Material: Polyethylene
Underdrain			
			Max Gross Wt:
a. For Powdered Resin	56.9 cu ft	450 lb	5,500 lb
b. For Bead Resin	57.3 cu ft	440 lb	

REFERENCE DRAWINGS/DOCUMENTS

User Drawing: STD-03-104
User Manual: STD-D-03-009

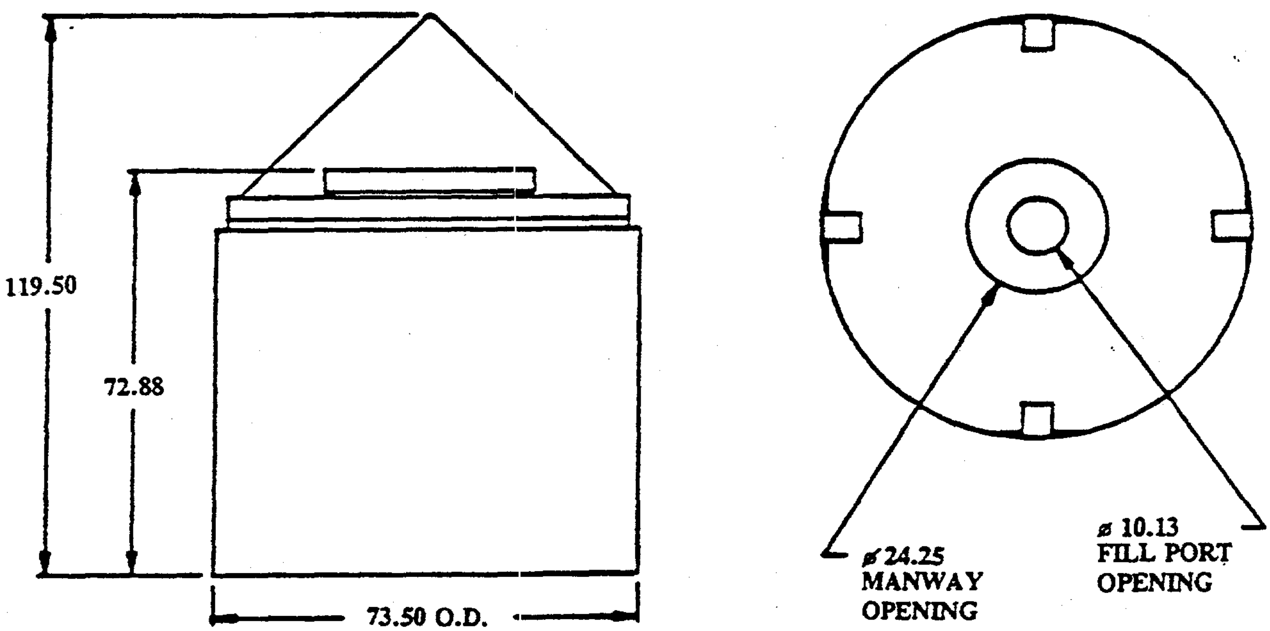
HANDLING AND SHIPMENT

Lifting: Double wire rope sling

Closure: Two (2) concentric threaded closures

SCIENTIFIC ECOLOGY GROUP, INC. A Westinghouse Subsidiary	Data Sheet No RT-24-1
	Rev. No. 4
	Date 3/30/92
DISPOSABLE CONTAINER DATA SHEET	Reference DCN 92-100
	Approved - 1 ABR 1SB

SEG Model Designation: RADLOK - 179 High Integrity Container
South Carolina Certification No.: DHEC-HIC-PL-005
Cask Application: All HN-100 Casks except the HN-100 Series 3 w/shield insert



ALL DIMENSIONS NOMINAL

DESIGN DATA

Configuration	Total Nom. Cap.	Approx. (empty) Wt.
Plain	156.8 cu ft	1090 lb
w/Underdrain		
a. For Powdered Resin	155.9 cu ft	1150 lb
b. For Bead Resin	156.4 cu ft	1150 lb

Material: Polyethylene

Max. Gross Wt.: 14,000 lb

REFERENCE DRAWINGS/DOCUMENTS

User Drawing: STD-03-147

User Manual: STD-D-03-009

HANDLING AND SHIPMENT

:ing: Double wire rope sling

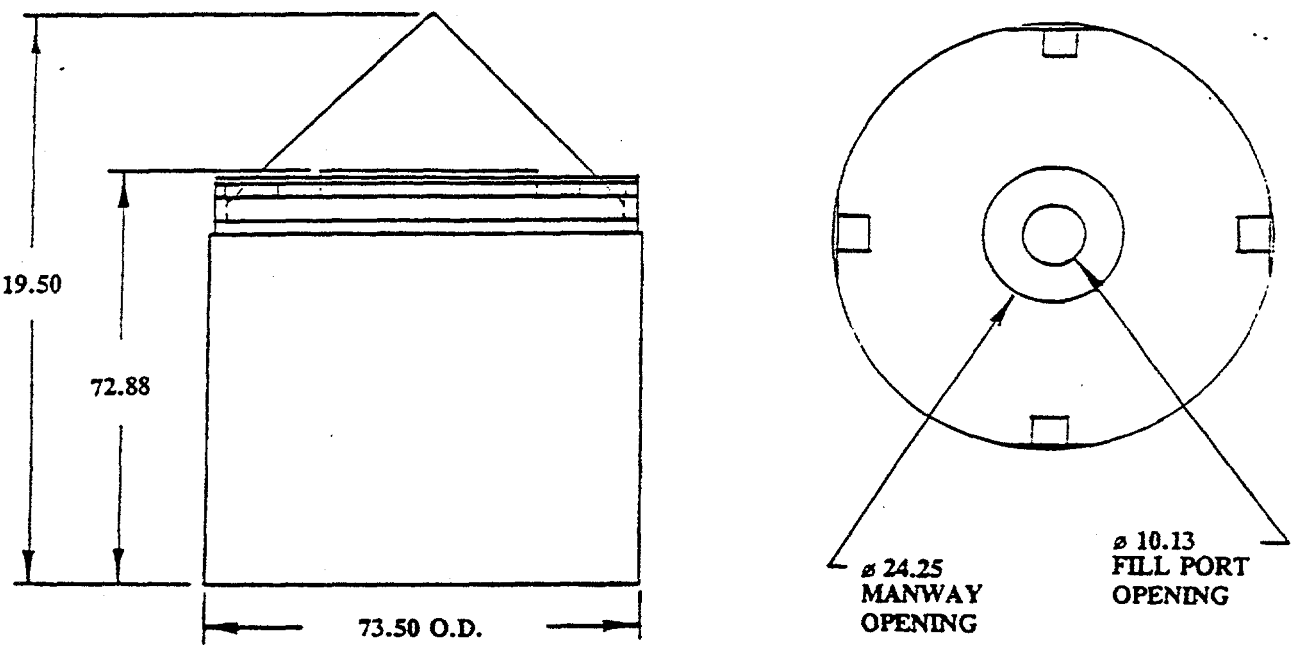
Closure: Two (2) concentric threaded closures

SCIENTIFIC ECOLOGY GROUP, INC.
A Westinghouse Subsidiary

DISPOSABLE CONTAINER DATA SHEET

Data Sheet No RT-24-2
Rev. No. 0
Date 3/31/92
Reference —
Approved - HBR 1508

SEG Model Designation: RADLOK - 179 High Integrity Container (Grappable)
South Carolina Certification No.: DHEC-HIC-PL-005
Cask Application: All HN-100 Casks except the HN-100 Series 3 w/shield insert



ALL DIMENSIONS NOMINAL

DESIGN DATA

Configuration	Total Nom. Cap.	Approx. (empty) Wt.
Plain	156.8 cu ft	1290 lb
w/Underdrain		
a. For Powdered Resin	155.9 cu ft	1350 lb
b. For Bead Resin	156.4 cu ft	1350 lb

Material: Polyethylene

Max. Gross Wt.: 14,000 lb

REFERENCE DRAWINGS/DOCUMENTS

User Drawing: STD-03-147

User Manual: STD-D-03-009

HANDLING AND SHIPMENT

Lifting: Grapple or Double wire rope sling

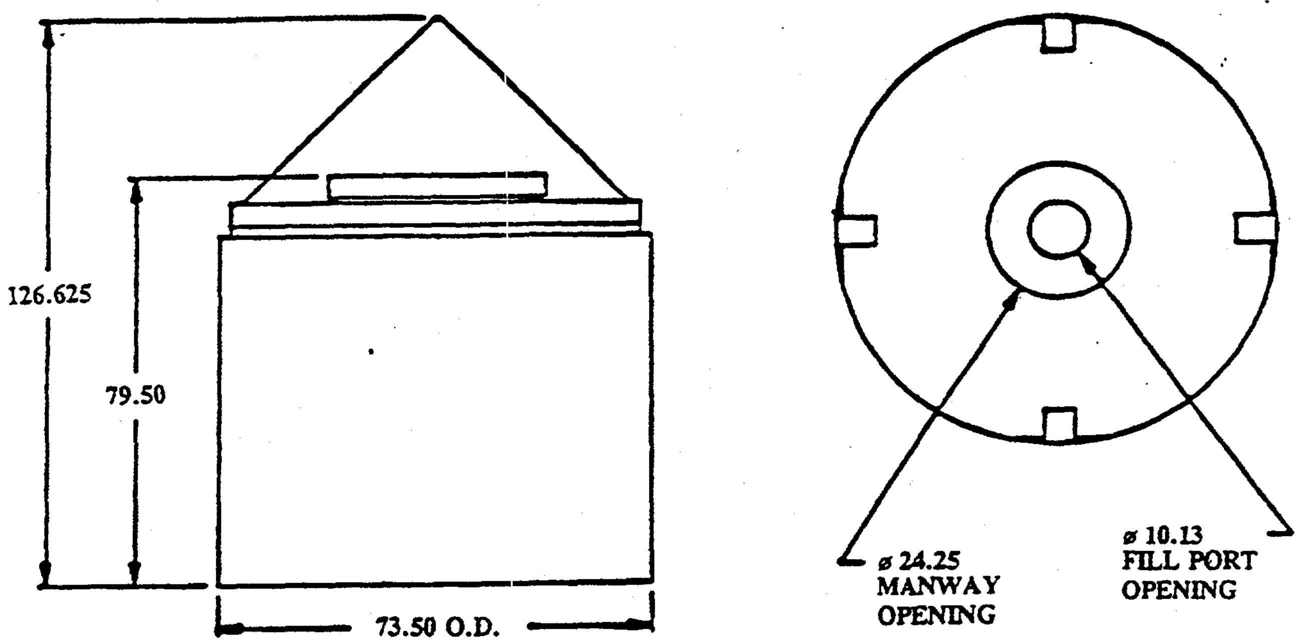
Closure: Two (2) concentric threaded closures

SCIENTIFIC ECOLOGY GROUP, INC.
A Westinghouse Subsidiary

DISPOSABLE CONTAINER DATA SHEET

Data Sheet No. RT-25-1
Rev. No. 4
Date 3/30/92
Reference DCN 92-102
Approved - WBR/SDB

Model Designation: RADLOK® -195 High Integrity Container
South Carolina Certification No.: DHEC-HIC-PL-005
Cask Application: 14-215H Cask



ALL DIMENSIONS NOMINAL

DESIGN DATA

Configuration	Total Nom. Cap.	Approx. (empty) Wt.	
Plain	172.8 cu ft	1150 lb	Material: Polyethylene
Underdrain			
a. For Powdered Resin	171.9 cu ft	1210 lb	Max Gross Wt: 15,500 lb
b. For Bead Resin	172.4 cu ft	1210 lb	

REFERENCE DRAWINGS/DOCUMENTS

User Drawing: STD-03-147
User Manual: STD-D-03-009

HANDLING AND SHIPMENT

Lifting: Double wire rope sling

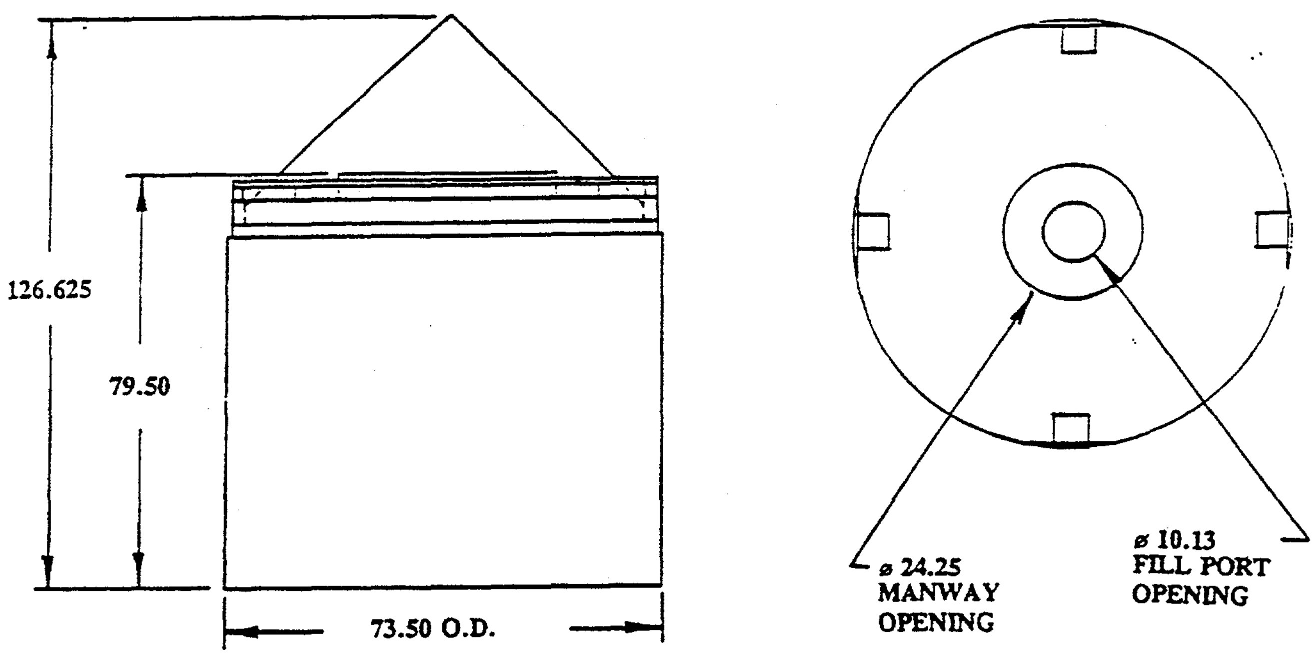
Closure: Two (2) concentric threaded closures

SCIENTIFIC ECOLOGY GROUP, INC.
A Westinghouse Subsidiary

DISPOSABLE CONTAINER DATA SHEET

Data Sheet No. RT-25-2
Rev. No. 0
Date 3/30/92
Reference —
Approved — [illegible]

Model Designation: RADLOK®-195 High Integrity Container (Grappable)
South Carolina Certification No.: DHEC-HIC-PL-005
Cask Application: 14-215H Cask



ALL DIMENSIONS NOMINAL

DESIGN DATA

Configuration	Total Nom. Cap.	Approx. (empty) Wt.	
Plain	172.8 cu ft	1350 lb	Material: Polyethylene
Underdrain			
			Max Gross Wt:
a. For Powdered Resin	171.9 cu ft	1410 lb	15,500 lb
b. For Bead Resin	172.4 cu ft	1410 lb	

REFERENCE DRAWINGS/DOCUMENTS

User Drawing: STD-03-147
User Manual: STD-D-03-009

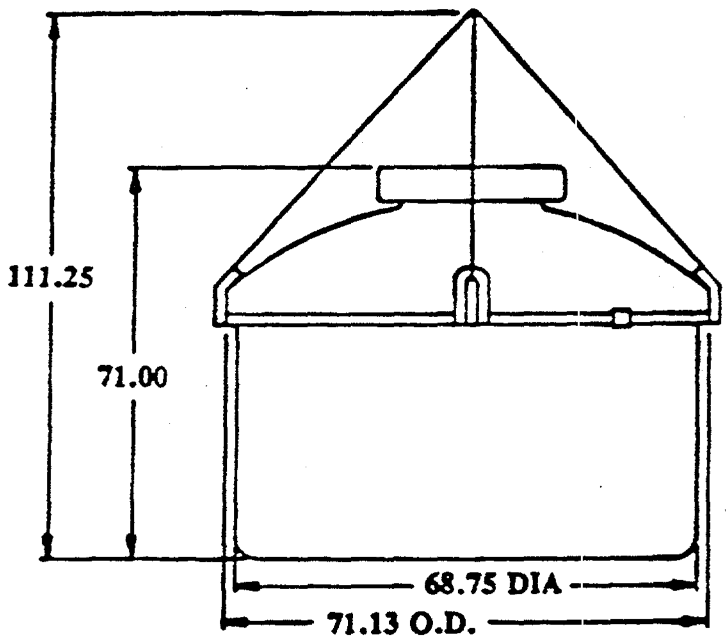
HANDLING AND SHIPMENT

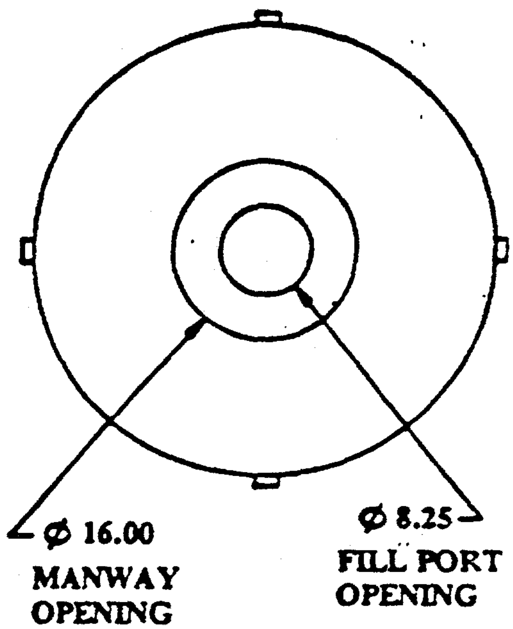
Lifting: Grapple or Double wire rope sling

Closure: Two (2) concentric threaded closures

SCIENTIFIC ECOLOGY GROUP, INC.	Data Sheet No. RT-12
A Westinghouse Subsidiary	Rev. No. 7
	Date 8-26-91
DISPOSABLE CONTAINER DATA SHEET	Reference DCN 91-052
	Approved ABRKD [illegible]

Model Designation: RADLOK®-100 (RADLOK-163) High Integrity Container
South Carolina Certification No.: DHEC-HIC-PL-005
Cask Application: HN-190-1, HN-190-2, HN-194S, 14-215H and HN-100 Series 3 Casks





ALL DIMENSIONS NOMINAL

DESIGN DATA

Configuration	Total Nom. Cap.	Approx. (empty) Wt.	
Plain	125.7 cu ft	695 lb	Material: Polyethylene
Underdrain			
a. For Powdered Resin	123.9 cu ft	745 lb	Max Gross Wt: 10,500 lb.
b. For Bead Resin	125.4 cu ft	760 lb	

REFERENCE DRAWINGS/DOCUMENTS

User Drawing: STD-03-007
User Manual: STD-D-03-009

HANDLING AND SHIPMENT

Lifting: Double wire rope sling

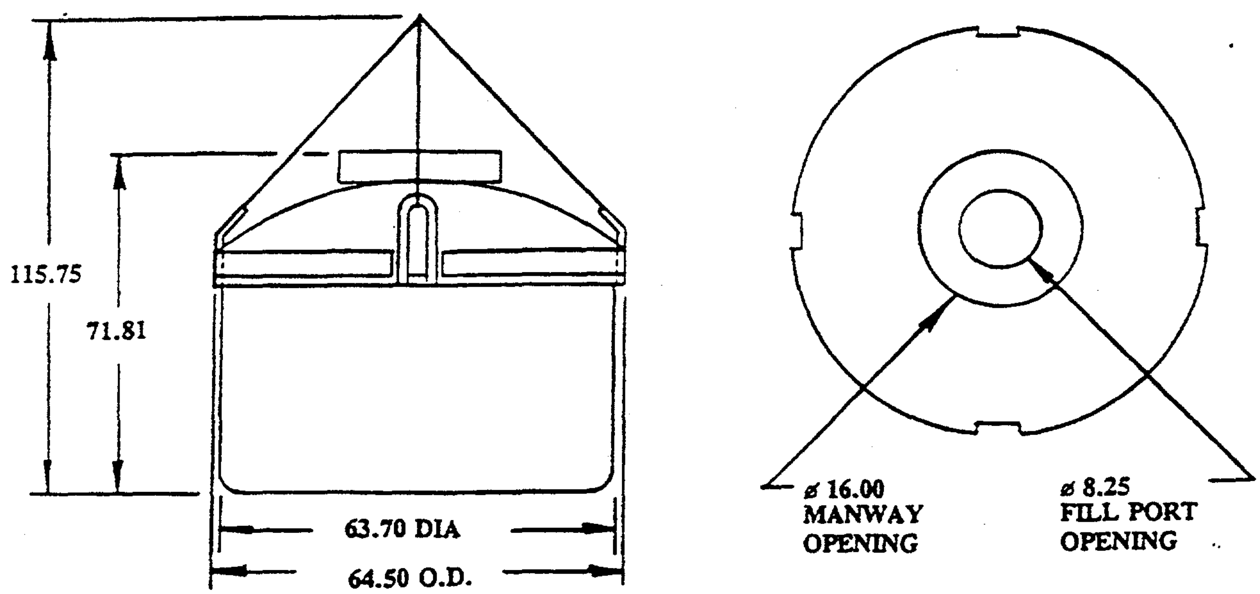
losure: Two (2) concentric threaded closures

SCIENTIFIC ECOLOGY GROUP, INC.
A Westinghouse Subsidiary

DISPOSABLE CONTAINER DATA SHEET

Data Sheet No. RT-17-1
Rev. No. 5
Date 3/30/92
Reference DCN 92-098
Approved - [illegible]

Model Designation: RADLOK®-500 (RADLOK-136) High Integrity Container
South Carolina Certification No.: DHEC-HIC-PL-014
Cask Application: HN-142 Cask & HN-100 Cask



ALL DIMENSIONS NOMINAL

DESIGN DATA

Configuration	Total Nom. Cap.	Approx. (empty) Wt.	
Plain	111.0 cu ft	680 lb	Material: Polyethylene
Underdrain			
a. For Powdered Resin	110.2 cu ft	740 lb	Max Gross Wt: 9,500
b. For Bead Resin	110.7 cu ft	745 lb	

REFERENCE DRAWINGS/DOCUMENTS

User Drawing: STD-03-110
User Manual: STD-D-03-009

HANDLING AND SHIPMENT

Lifting: Double wire rope sling

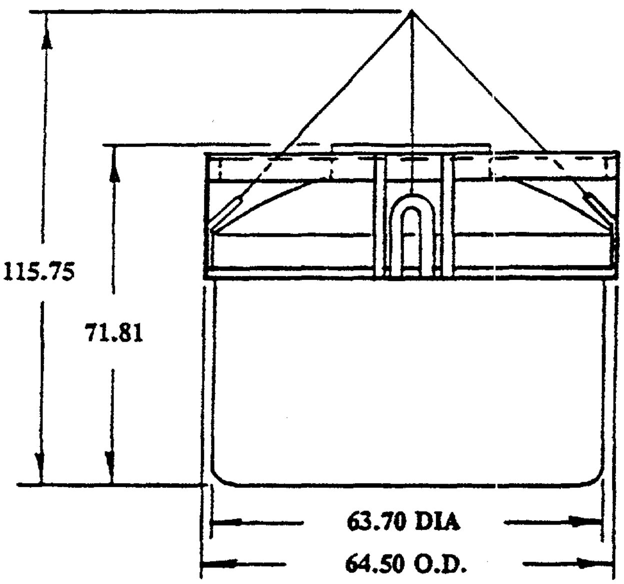
Closure: Two (2) concentric threaded closures

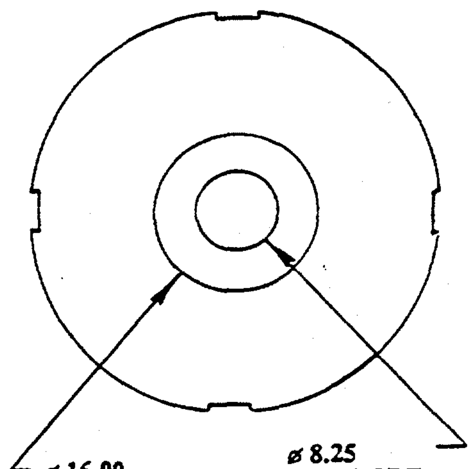
SCIENTIFIC ECOLOGY GROUP, INC.	Data Sheet No. RT-17-2
A Westinghouse Subsidiary	Rev. No. 0
	Date 3/30/92
DISPOSABLE CONTAINER DATA SHEET	Reference –
	Approved – [illegible]

Model Designation: RADLOK®-500 (RADLOK-136) High Integrity Container (Grappable)

South Carolina Certification No.: DHEC-HIC-PL-014

Cask Application: HN-142 Cask & HN-100 Cask





ALL DIMENSIONS NOMINAL

DESIGN DATA

Configuration	Total Nom. Cap.	Approx. (empty) Wt.	
Plain	111.0 cu ft	980 lb	Material: Polyethylene
Underdrain			
a. For Powdered Resin	110.2 cu ft	1040 lb	Max Gross Wt: 9,500
b. For Bead Resin	110.7 cu ft	1045 lb	

REFERENCE DRAWINGS/DOCUMENTS

User Drawing: STD-03-110
User Manual: STD-D-03-009

HANDLING AND SHIPMENT

Lifting: Grapple or Double wire rope sling

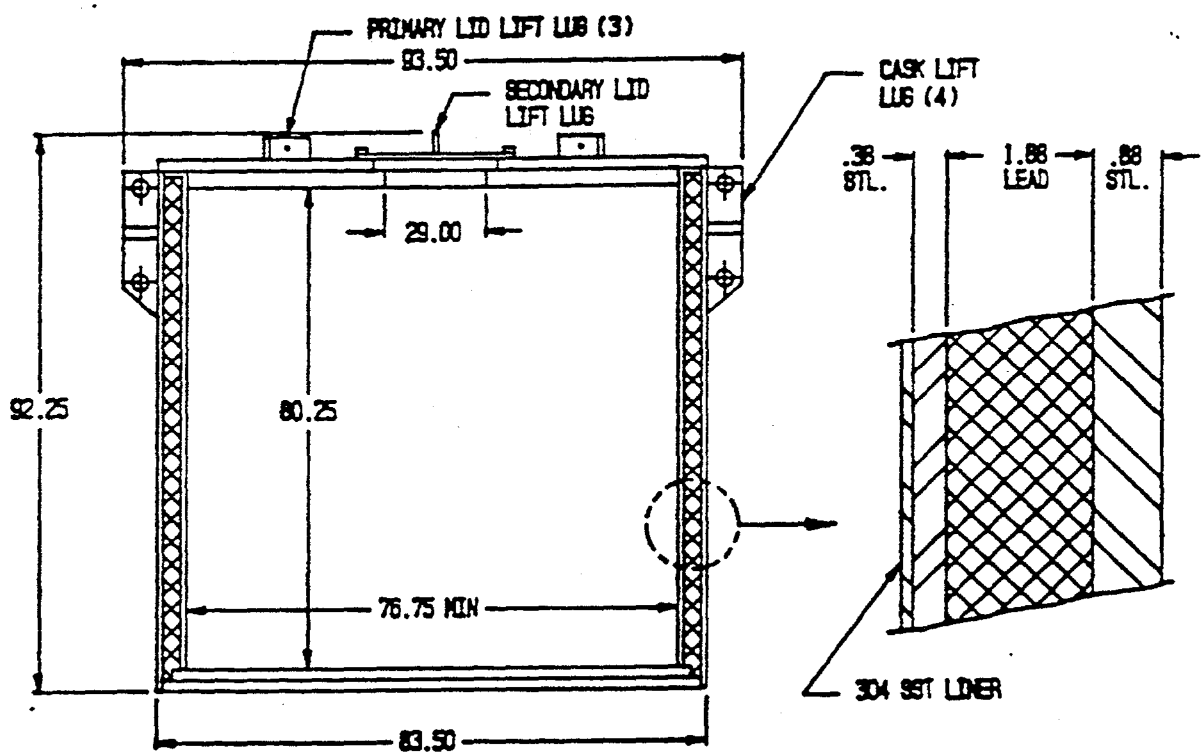
Closure: Two (2) concentric threaded closures

SCIENTIFIC ECOLOGY GROUP, INC.

RADWASTE SHIPPING CASK DATA SHEET

Data Sheet No. RE-13
Rev. No. 2
Date 6-14-90
Refer(EWR/ECN) —
Approved GAR / GAR / —

Model Designation: 14-215 USNRC Certificate. No. USA/9222/A
Empty Wgt: 38,400 lbs Max Payload: 20,000 lbs Shipping Wgt: 58,400 lbs
Shielding: 2.75 (Lead Equivalent)



SHIPPING CONFIGURATIONS

Shipping Configuration	No.	Capacity	Max Rad Level
55-gallon Drum	14	55 Gal.	20 rem per hr
215 Liner	1	Data Sheet RT-27	20 rem per hr
RADLOK -55 High Integrity Container	14	Data Sheet RT-13	20 rem per hr
RADLOK -195 High Integrity Container	1	Data Sheet RT-25	20 rem per hr

REFERENCE DRAWINGS/DOCUMENTS

Drawings: STD-02-077
Cask Operating Procedures: STD-P-02-020

Auxiliary Equipment Data Sheets: Standard Pallets, DP-1

E-A

SCIENTIFIC ECOLOGY GROUP, INC.
A Westinghouse Subsidiary

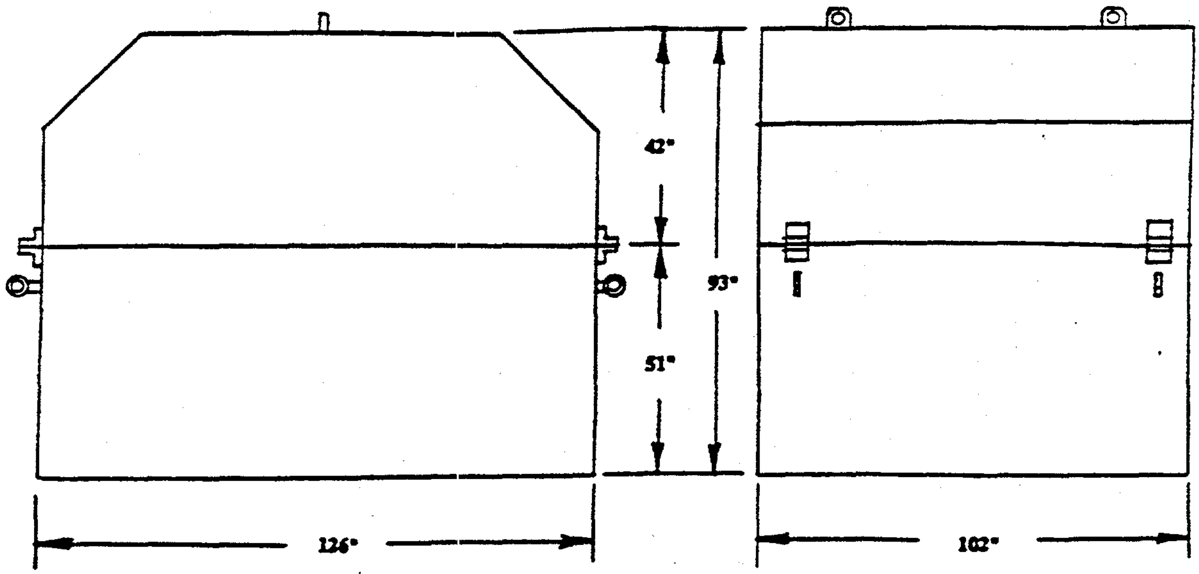
RADWASTE SHIPPING CASK DATA SHEET

Data Sheet No.	RE-22
Rev. No.	1
Date	7/10/92
Reference	DCN 92-110
Approved	- [illegible]

Model Designation: 14-215 CASK IN CLOSED TRANSPORT VEHICLE (CTV-2)
USNRC Certificate No. USA/9222/A
Empty Wgt: 44,000 lbs Max Payload: 20,000 lbs* Shipping Wgt: 64,000 lbs
Shielding: 3.25" (Lead Equivalent)

*Indivisible Payload Only- Contact SEG for Additional Information

Side Wall Thickness 1" Maximum
CTV Weight 5600 lbs Maximum



Side View   Front View

Reference Data Sheet No. RE-13 for 14-215 Cask

SHIPPING CONFIGURATIONS

Container Options	Capacity	Max Rad Level
See 14-215 CASK DATA SHEETS		45 rem/hr

REFERENCE DRAWINGS/DOCUMENTS

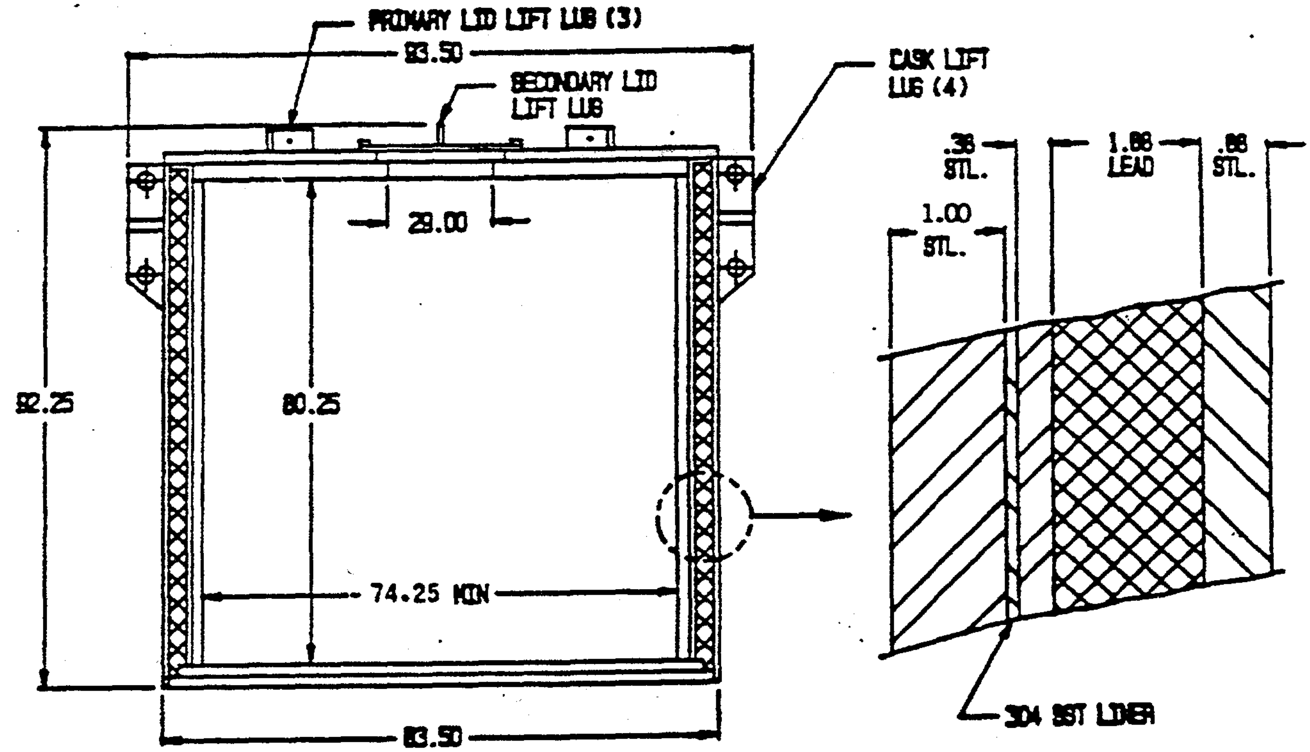
Drawings: STD-02-077, 9414-M-3205 SHEETS 1 AND 2

Cask Operating Procedures: STD-P-02-020

`uxiliary Equipment Data Sheets: Standard Pallets, DP-1

SCIENTIFIC ECOLOGY GROUP, INC.	Data Sheet No.	RE-18
	Rev. No.	1
	Date	12-19-90
RADWASTE SHIPPING CASK DATA SHEET	Refer(EWR/ECN)	
	Approved	[signature] / [signature] / -

Model Designation: 14-215 with 1" Shield Insert
USNRC Certificate. No. USA/9222/A
Empty Wgt: 43,600 lbs Max Payload: 14,800 lbs Shipping Wgt: 58,400 lbs
Shielding: 3.35 (Lead Equivalent)



SHIPPING CONFIGURATIONS

	Shipping Configuration	No.	Capacity	Max Rad Level
	55-gallon Drum	14	55 Gal.	30 rem per hr
*	190 Liner	1		30 rem per hr
	RADLOK -55 High Integrity Container	14	Data Sheet RT-13	30 rem per hr
	RADLOK -195 High Integrity Container	1	Data Sheet RT-25	30 rem per hr

REFERENCE DRAWINGS/DOCUMENTS

Drawings: STD-02-077, STD-02-086
Cask Operating Procedures: STD-P-02-020
Auxiliary Equipment Data Sheets: Standard Pallets, DP-1

* **SPECIAL ORDER, CONTACT SEG**

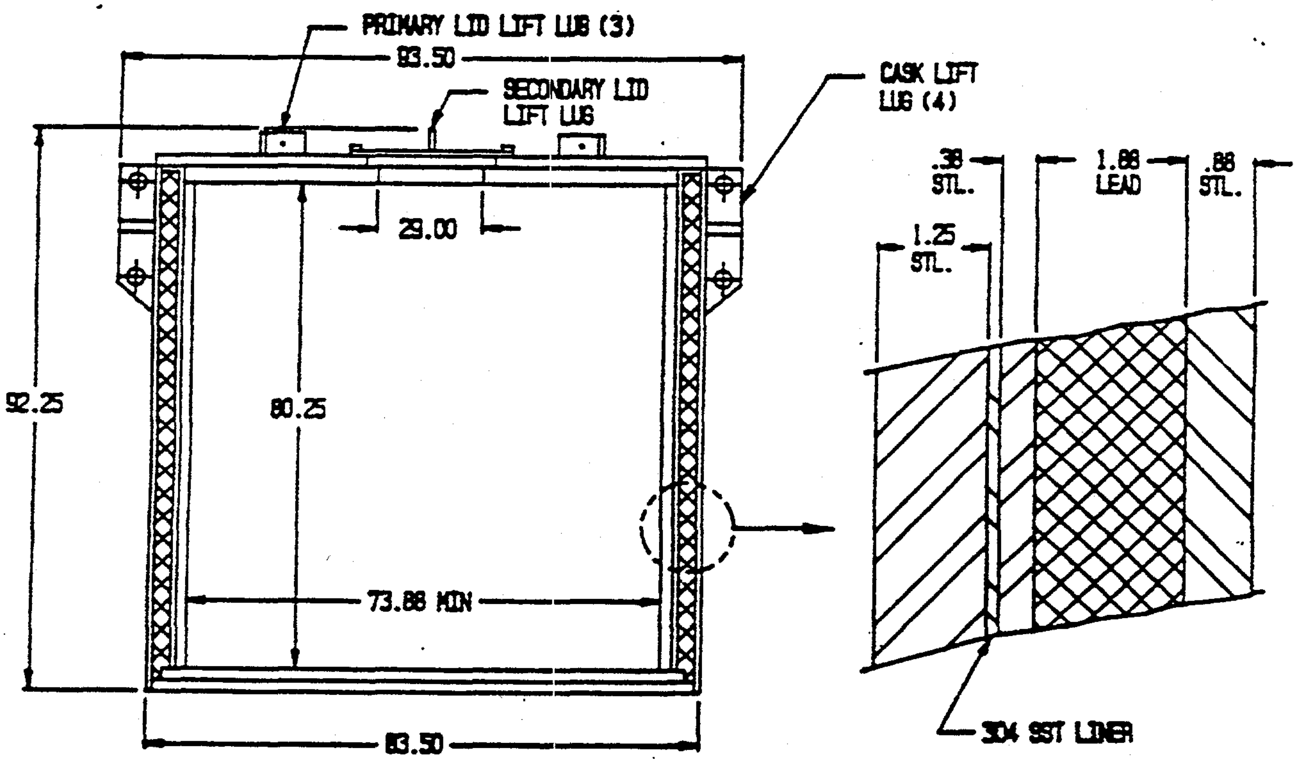
RE-A

SCIENTIFIC ECOLOGY GROUP, INC.

RADWASTE SHIPPING CASK DATA SHEET

Data Sheet No. RE-14
Rev. No. 2
Date 12-19-90
Refer(EWR/ECN)
Approved [handwritten initials] / [handwritten initials] / –

Model Designation: 14-215 with 1-1/4" Shield Insert
USNRC Certificate. No. USA/9222/A
Empty Wgt: 45,000 lbs Max Payload: 13,400 lbs Shipping Wgt: 58,400 lbs
Shielding: 3.50 (Lead Equivalent)



SHIPPING CONFIGURATIONS

Shipping Configuration	No.	Capacity	Max Rad Level
55-gallon Drum	14	55 Gal.	35 rem per hr
* 190 Liner	1		35 rem per hr
RADLOK -55 High Integrity Container	14	Data Sheet RT-13	35 rem per hr
RADLOK -195 High Integrity Container	1	Data Sheet RT-25	35 rem per hr

REFERENCE DRAWINGS/DOCUMENTS

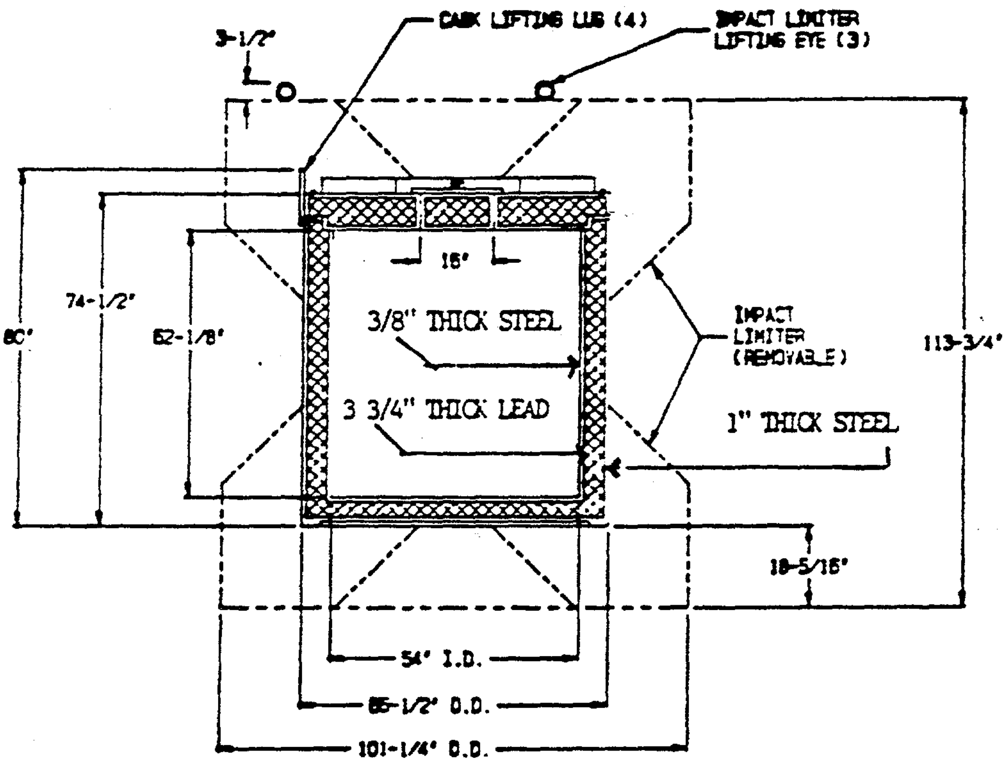
Drawings: STD-02-077, STD-02-086
Cask Operating Procedures: STD-P-02-020
Auxiliary Equipment Data Sheets: Standard Pallets, DP-1

* **SPECIAL ORDER, CONTACT SEG**

RE-A

SCIENTIFIC ECOLOGY GROUP, INC.	Data Sheet No. RE-4
	Rev. No. 8
	Date
RADWASTE SHIPPING CASK DATA SHEET	Refer(EWR/DCN) DCN-91-069
	Approved [signature] 16FEB 1992

SEG Model Designation: 3-82B USNRC Certificate. No. USA/6574/B()
Empty Wgt: 41,805 lbs Max Payload: 8,195 lbs Shipping Wgt: 50,000 lbs
Shielding: 4.58 inches (Lead Equivalent)



SHIPPING CONFIGURATIONS

Shipping Configuration	No.	Capacity	Max Rad Level
55-gallon Drum	3	55 Gal.	1000 rem per hr
L76 Standard Steel Liner	1	Data Sheet	800 rem per hr
RADLOK® -55 High Integrity Container	3	Data Sheet RT-13	1000 rem per hr
RADLOK® -200 High Integrity Container	1	Data Sheet RT-14	800 rem per hr

REFERENCE DRAWINGS/DOCUMENTS

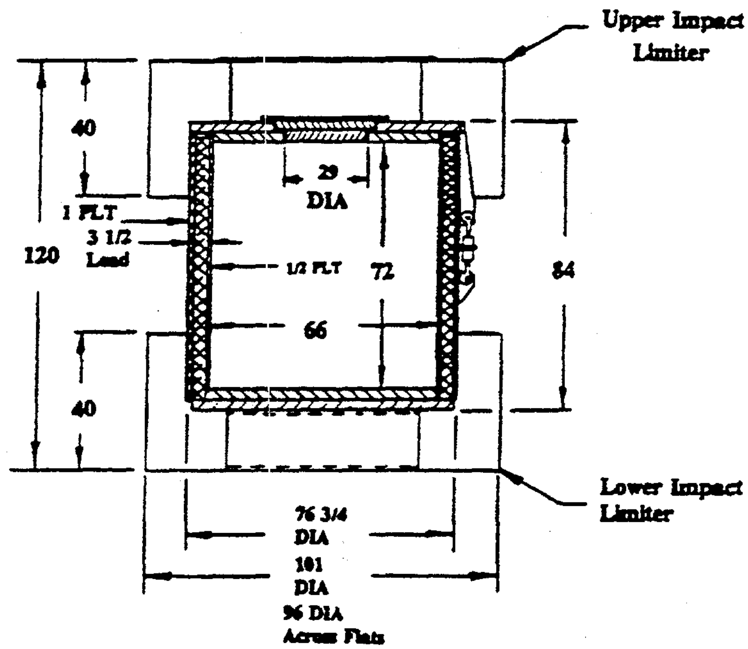
Drawings: STD-02-076, Sheets 1-3
Cask Operating Procedures: STD-P-02-017 and STD-P-02-024
Auxiliary Equipment Data Sheets: Drum Pallet, DP-2

SCIENTIFIC ECOLOGY GROUP, INC.
A Westinghouse Subsidiary

RADWASTE SHIPPING CASK DATA SHEET

Data Sheet No. RE-21
Rev.. No. 0
Date
Reference
Approved [signature]

Model Designation: LN-142	USNRC Certificate. No. USA/9073/A
Empty Wgt: 54,000 lbs	Max Payload: 10,000 lbs
Shielding: 4.4" (Lead Equivalent)	Shipping Wgt: 64,000 lbs



SHIPPING CONFIGURATIONS

Shipping Configuration	No.	Capacity	Max Rad Level
55-Gallon Drum	10	55 Gal.	350 rem per hr
*142 liner	1	Contact SEG	350 rem per hr
Barrier Plus 131C High Integrity Container	1	114.3CF	350 rem per hr
RADLOK®-500 High Integrity Container	1	Data Sheet RT-17	350 rem per hr

REFERENCE DRAWINGS/DOCUMENTS

Drawings: 9414-M-3204
Cask Operating Procedures: WM-011, WM-013, WM-021 WM-022
Auxiliary Equipment Data Sheets: Standard Pallets, DP-4

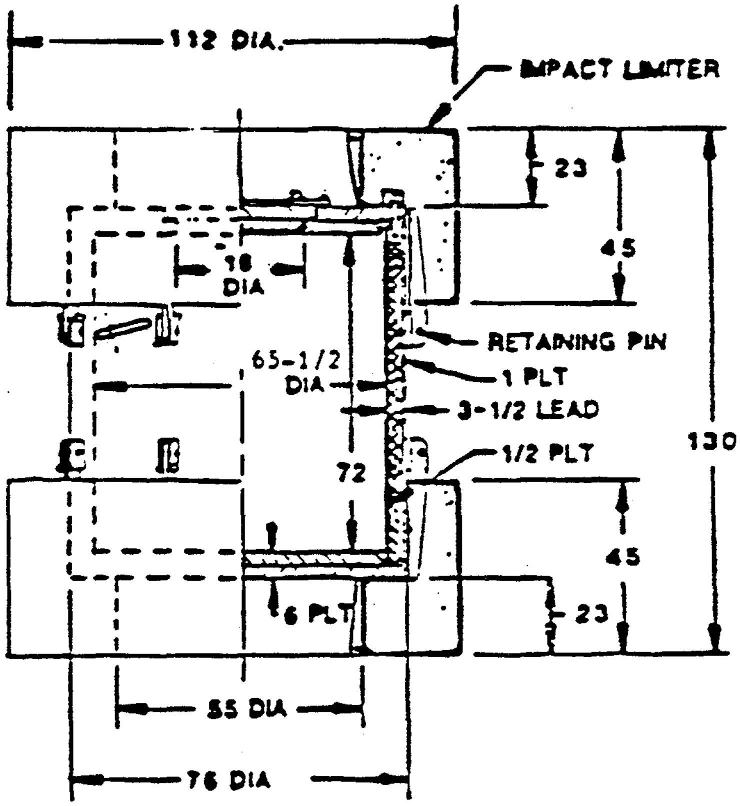
* Special Order, Contact SEG

SCIENTIFIC ECOLOGY GROUP, INC.

RADWASTE SHIPPING CASK DATA SHEET

Data Sheet No. RE-12
Rev. No. 7
Date 02-11-91
Refer(EWR/DCN) 91-023
Approved [signature] /6FEB 1991

Model Designation: HN-142 USNRC Certificate. No. USA/9208/B ( )
Empty Wgt: 58,100 lbs Max Payload: 10,000 lbs Shipping Wgt: 68,100 lbs
Shielding: 4.4" (Lead Equivalent)



SHIPPING CONFIGURATIONS

Shipping Configuration	No.	Capacity	Max Rad Level
55-gallon Drum	10	55 Gal.	350 rem per hr
*142 Liner	1	Contact SEG	350 rem per hr
Barrier Plus 131C High Integrity Container	1	114.3CF	350 rem per hr
RADLOK® -500 High Integrity Container	1	Data Sheet RT-17	350 rem per hr

REFERENCE DRAWINGS/DOCUMENTS

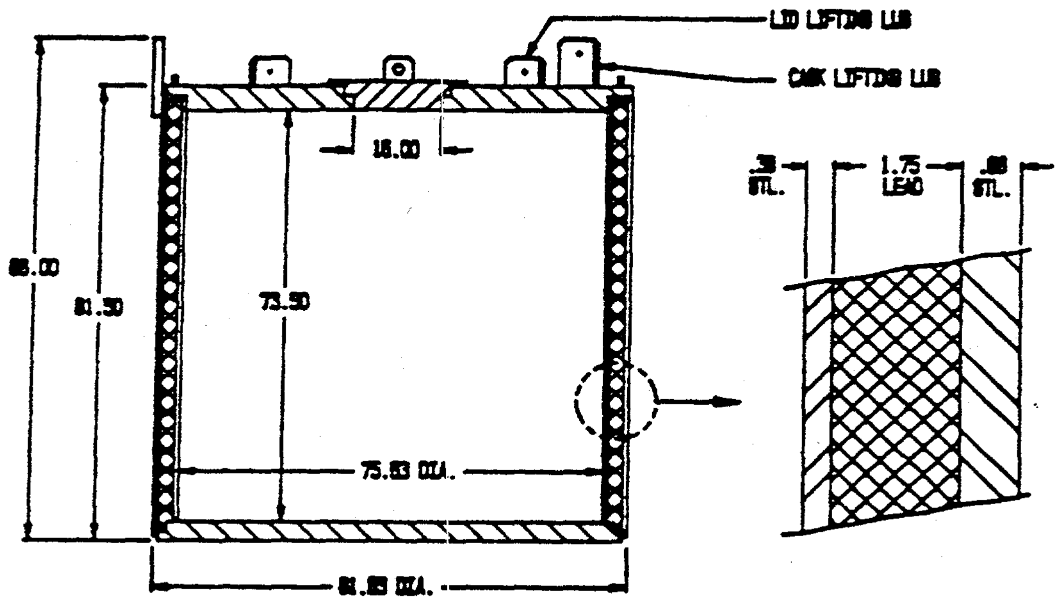
Drawings: STD-SD-02-316
Cask Operating Procedures: STD-P-02-012; STD-P-02-013
Auxiliary Equipment Data Sheets: Standard Pallets, DP-04
*SPECIAL ORDER, CONTACT SEG

WESTINGHOUSE HITTMAN NUCLEAR INCORPORATED
A Westinghouse Subsidiary

RADWASTE SHIPPING CASK DATA SHEET

Data Sheet No. RF-1
Rev. No. 7
Date 8-4-88
Refer(EWR/ECN) EWR 88-017
Approved DAN 1GPB 1 BAB

Hittman Model Designation: HN-190-1 USNRC Certificate No. USA/9086/A
Empty Wgt: 35,500 lbs Max Payload: 14,500 lbs Shipping Wgt: 50,000 lbs
Shielding: 2.5" (Lead Equivalent)



SHIPPING CONFIGURATIONS

Shipping Configuration	Capacity	Reference	Max/Avg Rad Level
55-gallon Drum	14	---	15/8 rem per hr
RADLOK® -55 High Integrity Container	14	Data Sheet RT-13	15/8 rem per hr
HN-100 Liner or HN-100 Large Vol.(LV)Liner	1	Data Sheet RT-1 or RT-2	12/-- rem per hr
RADLOK-100 High Integrity Container	1	Data Sheet RT-12	12/-- rem per hr
HN-600 Large Vol.(LV)Liner Stackable/Grappable	2	Data Sheet RT-18	12/-- rem per hr
RADLOK-179 High Integrity Container	1	Data Sheet RT-24	12/-- rem per hr

REFERENCE DRAWINGS/DOCUMENTS

Drawings: STD-02-028, STD-02-029, and STD-02-030
Cask Operating Procedure: STD-P-02-022
Auxiliary Equipment Data Sheets: Standard Pallets, DP-1

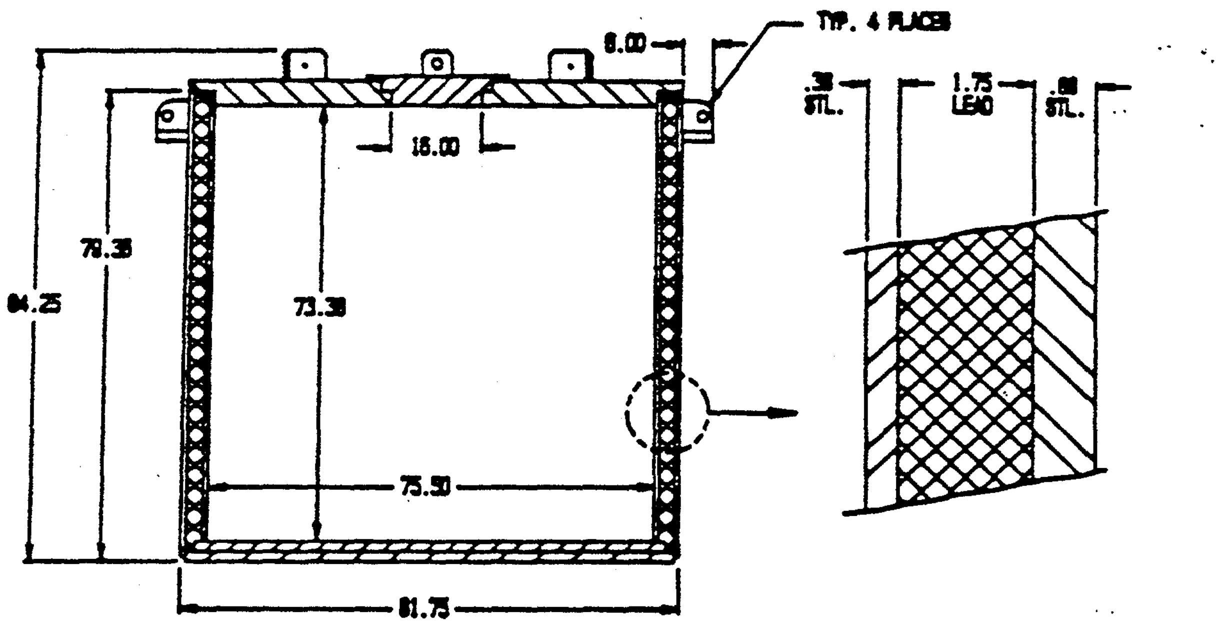
WESTINGHOUSE RADIOLOGICAL SERVICES, INC.
A Westinghouse Subsidiary

RADWASTE SHIPPING CASK DATA SHEET

Data Sheet No. RE-2
Rev. No. 9
Date 3-21-89
Refer (EWR/ECN) EWR-88-055

Approved [signature] / BAR / BAR

Hittman Model Designation: HN-190-2 USNRC Certificate. No. USA/9224/A
Empty Wgt: 33,800 lbs Max Payload: 14,200 lbs Shipping Wgt: 48,000 lbs
Shielding: 2.5" (Lead Equivalent)



SHIPPING CONFIGURATIONS

Shipping Configuration	No.	Capacity	Max/Avg Rad Level
55-gallon Drum	14	---	15/8 rem per hr
RADLOK®-55 High Integrity Container	14	Data Sheet RT-13	15/8 rem per hr
HN-100 Liner or HN-100 Large Vol. (LV) Liner	1	Data Sheet RT-1 or RT-2	12/-- rem per hr
RADLOK-100 High Integrity Container	1	Data Sheet RT-12	12/-- rem per hr
HN-600 Large Vol. (LV) Liner Stackable/Grappable	2	Data Sheet RT-18	12/-- rem per hr
RADLOK-179 High Integrity Container	1	Data Sheet RT-24	12/-- rem per hr

REFERENCE DRAWINGS/DOCUMENTS

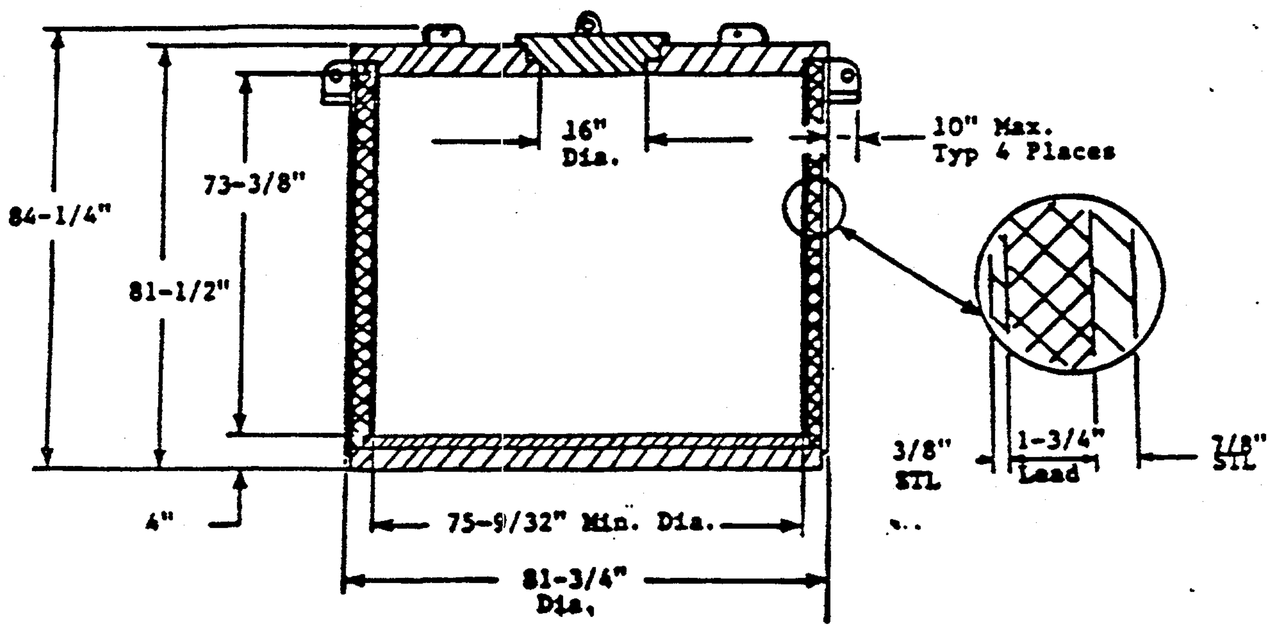
Drawings: C001-5-9122, C001-5-9123, and C001-5-9124 or
STD-02-080, STD-02-081, STD-02-082
Cask Operating Procedure: STD-P-02-019
Auxiliary Equipment Data Sheets: Standard Pallets, DP-1

WESTINGHOUSE RADIOLOGICAL SERVICES, INC.
A Westinghouse Subsidiary

RADWASTE SHIPPING CASK DATA SHEET

Data Sheet No. RE-9
Rev. No. 6
Date 6-29-89
Refer(EWR/ECN) EWR 89-016
Approved [signature]

Model Designation: HN-100 Series 3 USNRC Certificate No. USA/9151/A
Empty Wgt: 35,200 lbs Max Payload: 17,800 lbs Shipping Wgt: 53,000 lbs
Shielding: 2.5" (Lead Equivalent)



SHIPPING CONFIGURATIONS			
Shipping Configuration	Reference	Capacity	Max/Avg Rad Level
55-gallon Drum	----	14	15/8 rem per hr
HN-100 Liner or HN-100 Large Vol. (LV) Liner	Data Sheet RT-1 or RT-2	1	12/- rem per hr
HN-600 Large Vol. (LV) Liner Stackable/Grappable	Data Sheet RT-18	2	12/- rem per hr
HN-190 Liner	Data Sheet RT-26	1	12/- rem per hr
RADLOK®-55 High Integrity Container	Data Sheet RT-13	14	15/8 rem per hr
RADLOK®-100 High Integrity Container	Data Sheet RT-12	1	12/- rem per hr
RADLOK®-179 High Integrity Container	Data Sheet RT-24	1	12/- rem per hr

REFERENCE DRAWINGS/DOCUMENTS

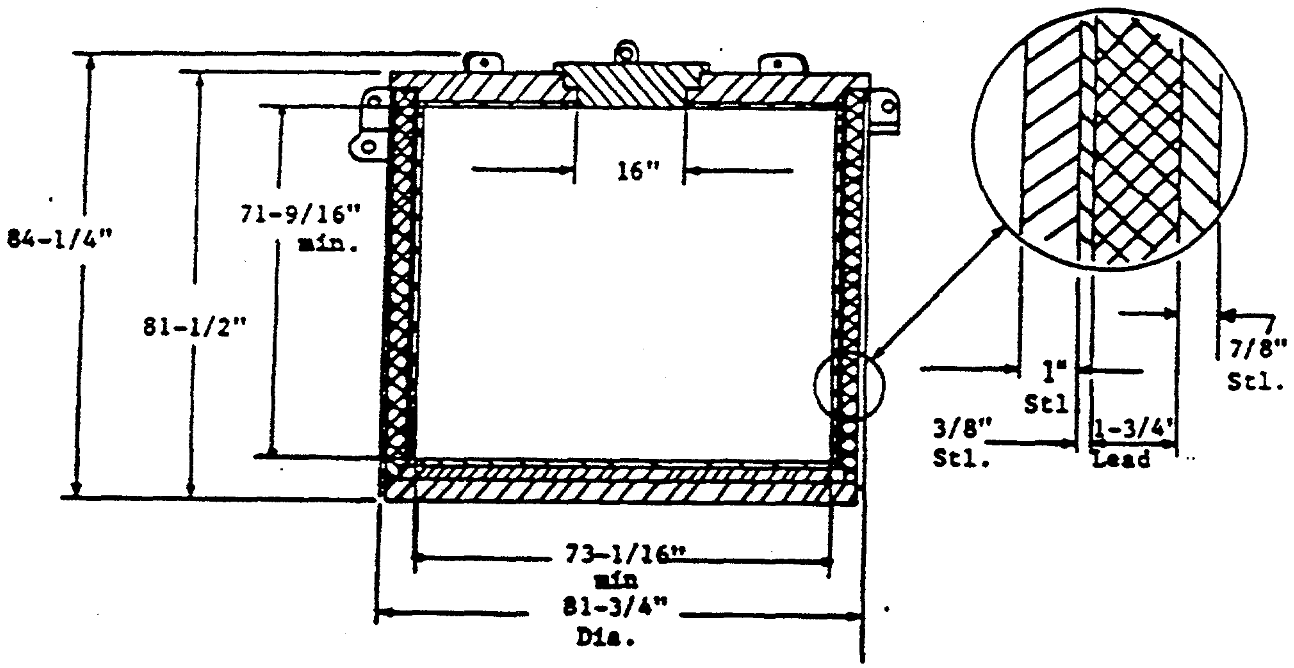
Drawings: C001-5-9138; C001-5-9139; C001-5-9140; C001-5-9141; C001-5-9142; C001-5-9143; and C001-5-9144

Cask Operating Procedures: STD-P-02-018

Auxiliary Equipment Data Sheets: Standard Pallets, DP-1

WESTINGHOUSE RADIOLOGICAL SERVICES, INC. A Westinghouse Subsidiary RADWASTE SHIPPING CASK DATA SHEET	Data Sheet No. RE-10 Rev. No. 5 Date 6-24-89 Refer(EWR/ECN) EWR 89-016 Approved [illegible]

Model Designation: HN-100 Series 3 Cask with Shield Insert
USNRC Certificate No. USA/9151/A
Empty Wgt: 42,445 lbs Max Payload: 10,555 lbs Shipping Wgt: 53,000 lbs
Shielding: 3.2" (Lead Equivalent)



SHIPPING CONFIGURATIONS

Shipping Configuration	Reference	Capacity	Max/Avg Rad Level
55-gallon Drum	----	14	50 rem per hr
RADLOK® -55 High Integrity Container	Data Sheet RT-13	7	50 rem per hr
RADLOK® -100 High Integrity Container	Data Sheet RT-12	1	50 rem per hr

REFERENCE DRAWINGS/DOCUMENTS

Drawings: C001-5-9138; C001-5-9139; C001-5-9140; C001-5-9141; C001-5-9142; C001-5-9143; C001-5-9144; STD-02-035; STD-02-036; and STD-02-037

Cask Operating Procedures: STD-P-02-018

Auxiliary Equipment Data Sheets: Modified Pallets, DP-3

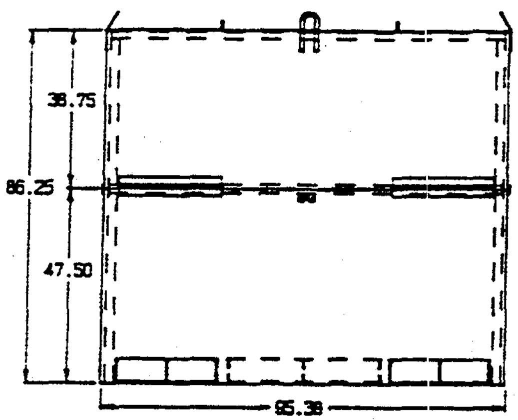
Scientific Ecology Group, Inc.
A Westinghouse Subsidiary

RADWASTE SHIPPING CASK DATA SHEET

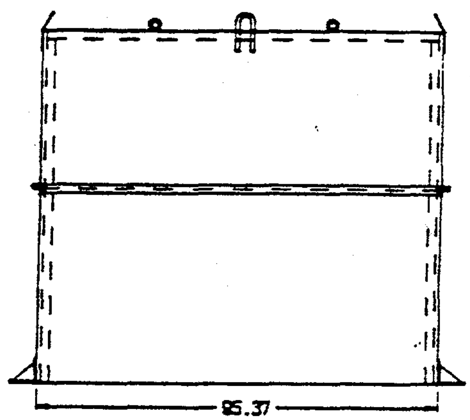
Data Sheet No. RE-15
Rev. No. 1
Date 7/10/92
Reference DCN 92-132
Approved - / dBR /

Model Designation: HN-100 Series 3 Cask with Shield Insert in Closed Transport Vehicle (CTV-1)
USNRC Certificate No. USA/9151/A
Empty Wgt: 51,045 lbs Max Payload: 10,555 lbs* Shipping Wgt: 61,600 lbs
Shielding: 4.0" (Lead Equivalent)

*Indivisible Payload Only- Contact SEG for Additional Information
Side Wall Thickness 1" Maximum
CTV Weight 8600 lbs



FRONT VIEW CTV



SIDE VIEW CTV

Reference Data Sheet No. RE-10 for HN-100 Series 3 Cask with Shield Insert Data

SHIPPING CONFIGURATIONS

Shipping Configuration	Reference	Capacity	Max Rad Level
RADLOK -100 High Integrity Container	Data Sheet RT-12	1	75 rem per hr

REFERENCE DRAWINGS/DOCUMENTS

Drawings: C001-5-9138; C001-5-9139; C001-5-9140; C001-5-9141; C001-5-9142; C001-5-9143; C001-5-9144; STD-02-035; STD-02-036; and STD-02-037

Cask Operating Procedures: STD-P-02-018 & CTV Operating Procedure

Auxiliary Equipment Data Sheets: Modified Pallets, DP-3

Appendix B-2

Chem Nuclear Cask Data

TELECOPY TRANSMITTAL

TELECOPY SENT TO: Lisa Peraska, 415/442-7673

Morrison Knudsen

SENT BY: Jack Harrison

CHEM-NUCLEAR SYSTEMS, INC. - MIDWEST OFFICES

TELEPHONE: (815) 467-3000 (TO VERIFY)

(815) 467-4646 (TELECOPIER)

****

NUMBER OF PAGES SENT (INCLUDING THIS TRANSMITTAL COVER SHEET: 5

DATE: 2-16-93 OPERATOR: DH

****

CHEM-NUCLEAR DISPOSAL LINERS
DIMENSION AND VOLUME

Liner Composition	Liner Size/Type*	Empty Weight (lbs.)	Height (inches)	Diameter (inches)	Max. Internal Vol. (Cu.Ft.)	Usable Vol. (Cu.Ft.) Dewater/Solid	Disposal Volume
Carbon Steel	L1-13	500	51.375	25	12.5	12/NA	14.6
	L3-55	945	109.25	34	52.9	52/NA	57.4
	L6-80 HT	1000	57	58	82.9	NA	87.2
	L6-80 CHT	1150	57	58	82.9	NA/80	87.2
	L6-80 In-Situ	3500	57	58	49.8	NA	87.2
	L6-80 FR	1050	57	58	82.9	77/NA	87.2
	L6-80 FP/FEDX	1225	57	58	82.9	75/NA	87.2
	L7-100 HT	1300	40	74.5	94.1	NA	100.9
	L7-100 CHT	1450	40	74.5	94.1	NA/89	100.9
	L8-120 HT	1200	74	61	120.2	NA	125.2
	L8-120 CHT	1350	74	61	120.2	NA/117	125.2
	L8-120 In-Situ	4200	74.5	61	80.3	NA	126
	L8-120 FR	1250	74	61	120.2	114/NA	125.2
	L8-120 FP/FEDX	1325	74	61	120.2	112/NA	125.2
	L14-170 TVA Custom	1450	73.25	69	151.3	NA/147	158.5
	L14-170 HT	1550	71.375	74.5	172.7	NA	180.1
	L14-170 CHT	1750	71.375	74.5	172.7	NA/168	180.1
	L14-170 In-Situ [redacted]	T B D	74	74.5	66.1	NA	186.7
	L14-170 FR	1600	71.375	74.5	172.7	163/NA	180.1
	L14-170 FP/FEDX	1750	71.375	74.5	172.7	160/NA	180.1
	L14-195 HT	1650	79	76	199.6	NA	207.4
	L14-195 CHT	1850	79	76	199.6	NA/195	207.4
	L14-195 In-Situ	6300	78.5	76	138.5	NA	206.1
	L14-195 FR	1700	79	76	199.6	190/NA	207.4
	L14-195 FP/FEDX	1850	79	76	199.6	187/NA	207.4
	L21-300 HT	2200	108	82	320.6	NA	330.1
	L21-300 FP/FEDX	2450	108	82	320.6	303/NA	330.1
	24" x 72" PV	530	72	24	16.6	14/NA	18.8

NOTE: Steel Liners

A. Cement liners are for 0 filters. For 3 filters add 15 lbs. For 6 filters add 25 lbs.

B. For remote grapple rings add:

14-195 - 93 lbs.
14-170 - 91 lbs.
8-120 - 74 lbs.
7-100 - 91 lbs.
6- 80 - 71 lbs.

*See attached standard codes

CHEM-NUCLEAR DISPOSAL LINERS
DIMENSION AND VOLUME

Liner Position	Liner Size/Type*	Empty Weight (lbs.)	Height (inches)	Diameter (inches)	Max. Internal Vol. (Cu.Ft.)	Usable Vol. (Cu.Ft.) Dewater/Solid	Disposal Volume
HIC	PL6-80 HT	500	56.5	57	73.3	NA/NA	83.4
	PL6-80 HTIF	525	56.5	57	64.1	NA/NA	83.4
	PL6-80 FR	550	56.5	57	73.3	64/NA	83.4
	PL6-80 FP/FEDX	625	56.5	57	73.3	62/NA	83.4
	PL8-120 HT	600	73.5	60	107.6	NA/NA	120.3
	PL8-120 HTIF	625	73.5	60	95.8	NA/NA	120.3
	PL8-120 FR	650	73.5	60	107.6	101/NA	120.3
	PL8-120 FP/FEDX	725	73.5	60	107.6	99/NA	120.3
	PL14-170 HT	800	71.5	72.5	150.3	NA/NA	170.8
	PL14-170 HTIF	850	71.5	72.5	134.9	NA/NA	170.8
	PL14-170 FR	850	71.5	72.5	150.3	141/NA	170.8
	PL14-170 FP/FEDX	1000	71.5	72.5	150.3	138/NA	170.8
	PL14-195 HT	850	78	74	171.4	NA/NA	194.1
	PL14-195 HTIF	900	78	74	154.6	NA/NA	194.1
	PL14-195 FR	900	78	74	171.4	162/NA	194.1
	PL14-195 FP/FEDX	1050	78	74	171.4	159/NA	194.1
	PL14-215 HT	1200	78.375	76	189.2	NA/NA	205.8
	PL14-215 HTIF	1250	78.375	76	171.7	NA/NA	205.8
	PL14-215 FR	1250	78.375	76	189.2	177/NA	205.8
	PL14-215 FP/FEDX	1400	78.375	76	189.2	174/NA	205.8
	°PL21-300 HT	1100	108	80	285.1	NA/NA	314.2
	°PL21-300 HTIF	1175	108	80	262.1	NA/NA	314.2
	°PL21-300 FR	1150	108	80	285.1	269/NA	314.2
	°PL21-300 FP/FEDX	1350	108	80	285.1	264/NA	314.2
	Overpacks						
	Small	250	56.5	33	23.8	NA/NA	28.0
	246-gallon**	285	73.75	33	32.7	NA/NA	36.5
	Medium***	300	77.375	33	33.5	NA/NA	38.3
	60-gallon	100	34.5	25.5	8.4	NA/NA	10.2

NOTE: HICs

A. For remote grapple basket add:

14-215 - 218 lbs.
14-195 - 218 lbs.
14-170 - 210 lbs.
8-120 - 148 lbs.
6- 80 - 135 lbs.

°Lead time is a minimum of six weeks.

*See attached standard codes
**For Drums
***For Pressure Vessels

CHEM-NUCLEAR TRANSPORT CASK INVENTORY

SI ANSPORT NTAINER	CLASSIFICATION C OF C	INTERNAL DIMENSIONS DIA. X HEIGHT	PB SHIELDING EQUIVALENCE (INCHES)	APPROXIMATE MAXIMUM RADLEVELS (R/HR) *BASED ON Co-60	LINER CAPACITY (FT^3)	DRUM (55 GAL) CAPACITY	APPROXIMATE MAXIMUM EMP.WT.(LBS)	MAXIMUM PAYLOAD (LBS)
S 1-8	Type B USA/9070/B	24" x 34.50"	Nil	0.200	8	1	200	560
S 1-13G	Type B USA/9044/B	26.50" x 54"	6.20	6,000	13	1	23,050	5,000
1-13C	Type B USA/9081/B	26.50" x 54"	5.70	4,600	13	1	20,950	5,000
3-55 -57-65)	Type B USA/6805/B	36" x 116.75"	7.00	15,000	60	3	64,980	9,220
4-85	Type B USA/6244/B	46" x 100"	3.38	80	88	4	40,300	5,700
6-75 -33-90)	SPEC 7A USA/9108/A	53" x 74.50"	4.00	160	85	6	31,000	10,300
6-80-1	Strong, Tight Container, Type A Quantities Only	59" x 58"	5.00	No more than 1 R/hr on Contact	85	6	47,500 Est.	No Limit
6-80-2	SPEC 7A USA/9111/A	59" x 58"	5.00	1,000	85	4	44,000	7,500
6-107	SPEC 7A USA/9105/A	34" x 156"	3.28	60	N/A	6	54,200 Inc. Trailer	6,000
7-100	[redacted]	75.50" x 40.75"	3.60	100	85-100	7	35,500	13,000
8-120 0-100)	Type B USA/6601/B	62" x 75"	4.50	660	120-130	8	58,000	20,000
12-180 1-12D)	Strong, tight Container, Type A Quantities Only	54" x 40" x 147"	2.00	No more than 1 R/hr @ Contact	N/A	12	31,000	No Limit
14-170	USA/9079/A	75.50" x 73.25"	2.13	9	170-185	14	33,800	14,000
14-170 ES III	USA/9151/A	75.50" x 73.25"	2.13	9	170-185	14	33,800	19,205

)

Drum
55 - 24" x 30"

CHEM-NUCLEAR TRANSPORT CASK INVENTORY

NSI TRANSPORT CONTAINER	CLASSIFICATION C OF C	INTERNAL DIMENSIONS DIA. X HEIGHT	PB SHIELDING EQUIVALENCE (INCHES)	APPROXIMATE MAXIMUM RADLEVELS (R/HR) *BASED ON Co-60	LINER CAPACITY (FT^3)	DRUM (55 GAL) CAPACITY	APPROXIMATE MAXIMUM EMP.WT.(LBS)	MAXIMUM PAYLOAD (LBS)
NS14-195L	Strong, tight Container, Type A Quantities Only	77" x 80"	2.00	No more than 1 R/hr on Contact	200	14	31,660	17,700
NS14-195H	SPEC 7A USA/9094/A	77" x 80"	2.16	18	195	14	39,660	17,700
4-215H	Type A USA/9176/A	77.25" x 80.25"	2.13	25	195	14	39,000	20,000
NS14-220L (AL27-240)	Strong, tight Container, LSA Type A Quantities Only	77.5" x 89"	1.76	No more than 1 R/hr on Contact	200	14	33,200	No Limit
NS16-160S	Strong, tight Container, LSA Type A Quantities Only	124" x 35" x 72"	1.75	No more than 1 R/hr on Contact	2 @ 80	15	42,000	No Limit
NS15-160B	Type B USA/6144/B	126" x 36" x 75"	1.50	3	2 @ 80	15	37,000	5,000
NS21-300	SPEC 7A USA/9096/A	83" x 109"	1.50	3	315	21	30,200	27,250
1-300 / SHIELD INSERT	Type A USA/9096/A	76" x 106-1/2"	2.0	21	170	8	39,310	27,250
LAT BED	N/A	8'W x 40'L 8'W x 45'L	N/A	61	N/A	N/A	14,000	48,000
EGULAR AN	N/A	13'6"H x 40'L 13'6"H x 45'L	N/A	56	N/A	N/A	17,500	45,000
HIELDED AN	CLOSED, TRANSPORT VEHICLE	7'5" x 40" x 9'	0.50	75	N/A	0.750	33,000	*26,000
NS BTC-C	BULK SHIPMENT ONLY	Dump type vehicles for the transport of bulk LSA, radioactive wastes - 620 ft^3 capacity, 36,000+ lb payload capacity (depending on various state limits). Dimensions 18' x 52" x 84")						
NS BTC-S	STC	Closed box-type containers for the shipment of bulk, LSA, radioactive wastes - 360 ft^3 capacity, 40,000+ lb payload capacity (depending on various state limits). Dimensions: without inserts - 78" x 180" x 52"						

ased on Cobalt 60 gamma energy, these Rad levels are generally found to be conservative, however, equivalent shielding should e carefully evaluated in relation to the specific isotopes involved.

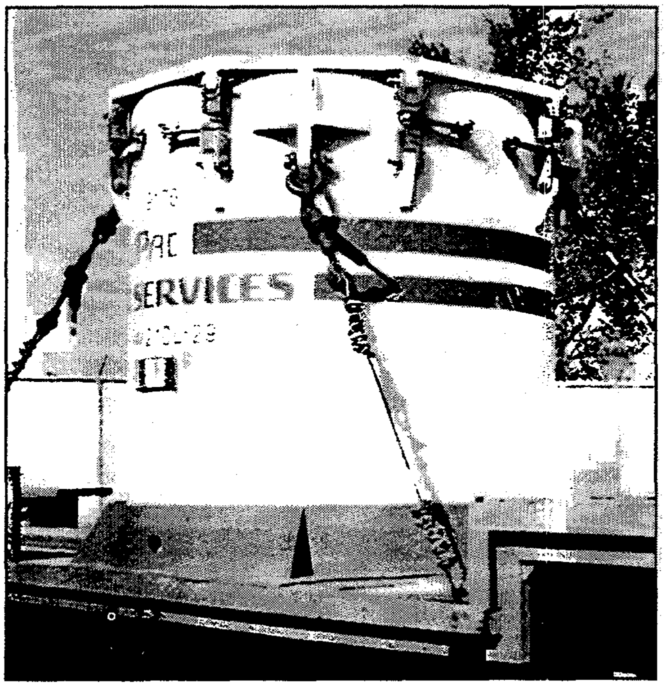
591S)

Appendix B-3

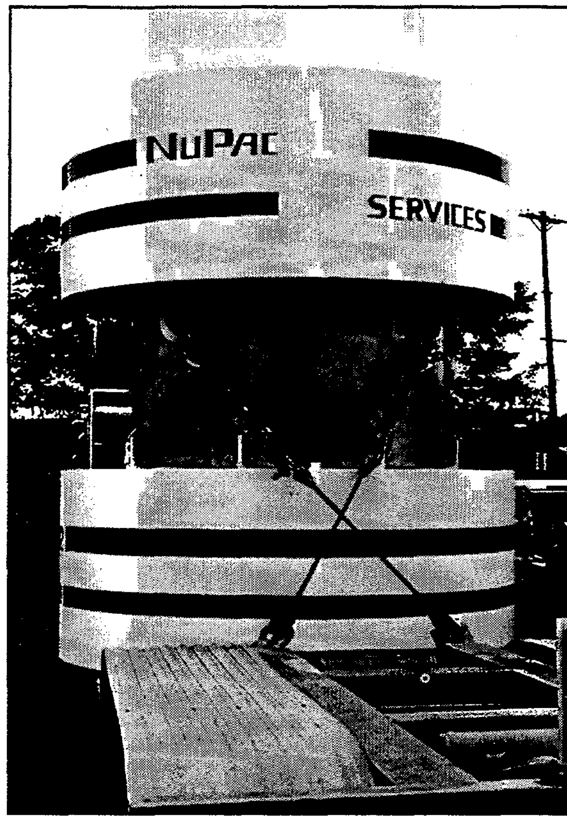
NuPac Cask Data

SHIELDED TRANSPORTATION CASKS

NRC-Licensed Type A and Type B Casks



MODEL NuPac 14-210L Type "A" C of C 9176.



MODEL NuPac 10-142 NRC Type "B" C of C 9208

- NRC-licensed Type A or Type B
- Full range of sizes for drums or bulk liners
- Shielding thickness from 1.5 to 4.4" lead
- Rapid lid removal lowers operator exposure
- Designed and fabricated to NRC approved Q.A. program

NUCLEAR® PACKAGING
A Pacific Nuclear Company

1010 South 336th Street Federal Way, Washington 98003 (206) 874-2235

Nuclear Packaging, Inc. is America's largest supplier of nuclear transportation and handling equipment. NuPac casks are used to transport a variety of radioactive materials, from low-level waste to spent fuel. We can design, license and fabricate shielded transportation casks to fit your particular application. Or, you may choose from our list of standard designs as shown on the table below. Typical design features include:

- High-strength, quick-acting binders secure the primary lid. This reduces operator exposure and turn-around time by 50% over conventional bolting systems.
- High-quality epoxy phenolic paint and internal stainless steel liner facilitates decontamination.
- Drain with external plug.

Choose the cask that best fits your needs. Custom-designed casks can also be provided.

		BASIC DATA							
		Characteristics			Weights (lbs.)			Cavity (in.)	
Model	USNRC C of C	Drum Cap.	P/L Vol. (Ft.^{3})	Lead Equiv. (in.)	Empty	Auth. P/L	Loaded	Inner Dia. A	Inner Height B
TYPE A CASKS									
NuPac 14/210L	9176	14	217	2.00	31,600	20,000	51,600	77.25	80.25
NuPac 14/210H	9176	14	217	2.73	38,400	20,000	58,400	77.25	80.25
NuPac 14/190L	9159	14	190	2.00	29,200	20,000	49,200	75.50	73.38
NuPac 14D-2.0	9079	14	190	2.25	34,000	14,000	48,000	75.50	73.38
NuPac 14/190M	9159	14	190	2.25	33,500	20,000	53,500	75.50	73.38
NuPac 14/190H	9159	14	190	3.50	45,200	20,000	65,200	75.50	73.38
NuPac 10/140	9177	10	144	3.60	41,500	15,000	56,500	66.00	73.00
NuPac 7/100	9178	7	105	3.50	35,900	13,000	48,900	75.50	40.75
NuPac 6/100L	9179	6	105	3.25	30,900	12,000	42,900	61.00	62.00
NuPac 6/100H	9179	6	105	4.40	41,900	12,000	53,900	61.00	62.00
NuPac 50-1.5L	9145	—	56	1.50	9,000	4,200	13,200	48.50	52.50
NuPac 50-2.5L	9145	—	56	2.50	15,000	4,200	19,200	48.50	52.50
NuPac 50-3.0L	9145	—	56	3.00	18,000	4,200	22,000	48.50	52.50
NuPac 50-4.0L	9145	—	56	4.00	24,700	4,200	28,900	48.50	52.50
TYPE B CASKS									
NuPac-B 10/140 MB	—	10	150	3.25	53,000	15,000	68,000	66.00	73.00
NuPac-B 10/142	9208	10	142	4.25	58,100	10,000	68,100	66.00	72.00

NUCLEAR PACKAGING®
A Pacific Nuclear Company

1010 South 336th Street Federal Way, Washington 98003 (206) 874-2235

B-25 LSA WASTE CONTAINER

FOR THE STORAGE AND SHIPPING OF LSA MATERIALS

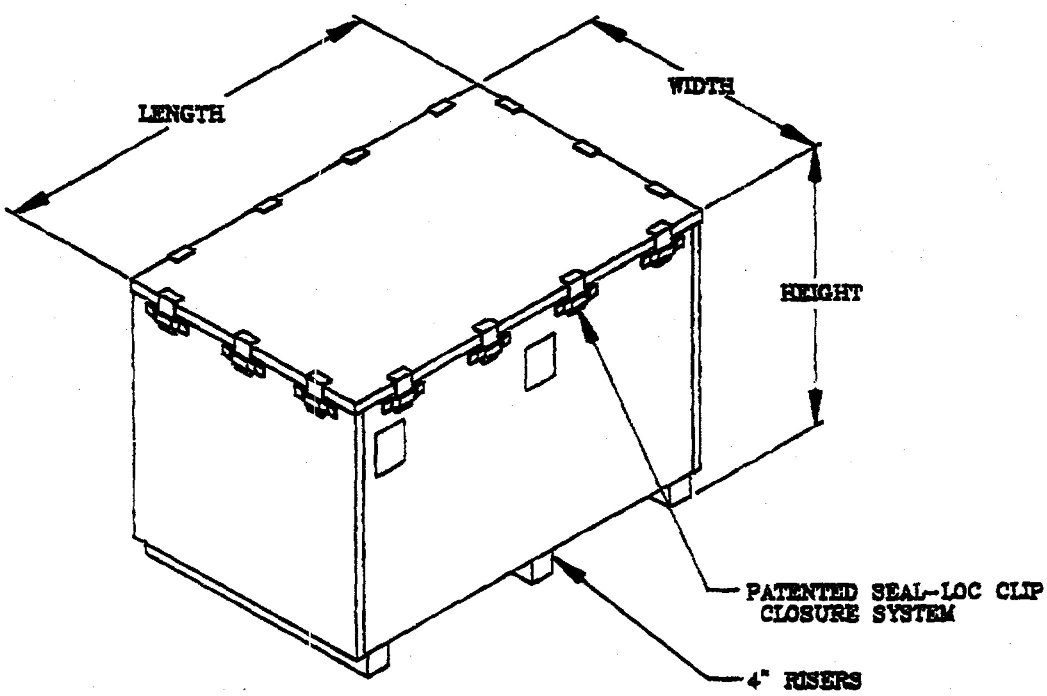
DIMENSIONS (INCHES)	INTERIOR	EXTERIOR
HEIGHT	47	52
WIDTH	46	47
LENGTH	72	73

DESCRIPTION

CLASSIFICATION	LSA WASTE CONTAINER
PACKAGE TYPE	CFR SPECIFICATION "STRONG-TIGHT"
CAPACITY	90 CUBIC FEET
MATERIAL	ASTM A-569 LOW CARBON HOT ROLLED STEEL
GROSS WEIGHT (EMPTY)	445 POUNDS TO 895 POUNDS
PAYLOAD	4,000 POUNDS TO 10,000 POUNDS
MAX LOADED WEIGHT	4,445 POUNDS TO 10,895 POUNDS

ADDITIONAL INFORMATION

- MEETS GENERAL CONTAINER REQUIREMENTS (49 CFR 173.24) FOR ASBESTOS, ORM AND HAZARDOUS WASTE MATERIALS.
- PATENTED, EXCLUSIVE "SEAL-LOC" POSITIVE CLOSURE SYSTEM TO PRECLUDE INADVERTENT OPENING.
- OPTIONAL REMOVABLE RISERS
- OPTIONAL ANTI-SPRINGBACK RETENTION SYSTEM FOR COMPACTOR APPLICATION
- FINAL PROTECTIVE FINISH TO MEET CUSTOMER REQUIREMENTS
- OPTIONAL SHIELDING AVAILABLE



U.S. PATENT NUMBERS 4371092 AND 4426927

ONTAINER
RODUCTS
ORPORATION

CONTAINER PRODUCTS CORPORATION
P.O. BOX 3767 112 NORTH COLLEGE ROAD
WILMINGTON, NORTH CAROLINA 28405
(919)392-6100 FAX (919)392-6778

B-88 LSA WASTE CONTAINER

FOR THE STORAGE AND SHIPPING OF LSA MATERIALS

DIMENSIONS (INCHES)	INTERIOR	EXTERIOR
HEIGHT	44	48
WIDTH	43	44
LENGTH	88	89

DESCRIPTION

CLASSIFICATION	LSA WASTE CONTAINER
PACKAGE TYPE	CFR SPECIFICATION "STRONG-TIGHT"
CAPACITY	98 CUBIC FEET
MATERIAL	ASTM A-569 LOW CARBON HOT ROLLED STEEL
GROSS WEIGHT (EMPTY)	530 POUNDS TO 695 POUNDS
PAYLOAD	4,000 POUNDS TO 6,000 POUNDS
MAX LOADED WEIGHT	4,530 POUNDS TO 6,695 POUNDS

ADDITIONAL INFORMATION

MEETS GENERAL CONTAINER REQUIREMENTS (49 CFR 173.24) FOR ASBESTOS, ORM AND HAZARDOUS WASTE MATERIALS.

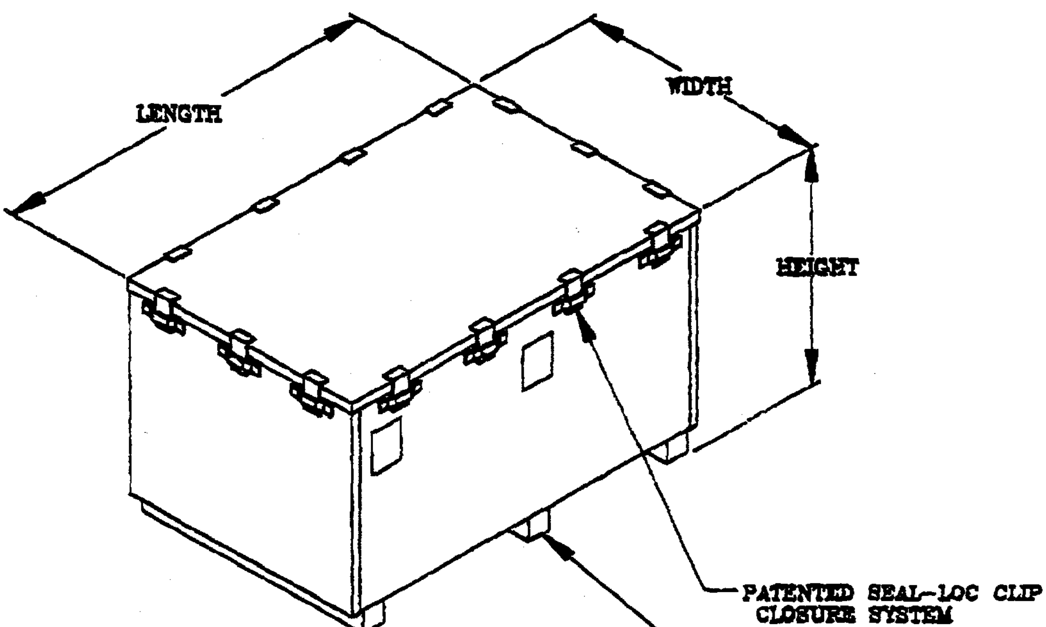
PATENTED, EXCLUSIVE "SEAL-LOC" POSITIVE CLOSURE SYSTEM TO PRECLUDE INADVERTENT OPENING.

OPTIONAL REMOVABLE RISERS

OPTIONAL ANTI-SPRINGBACK RETENTION SYSTEM FOR COMPACTOR APPLICATION

FINAL PROTECTIVE FINISH TO MEET CUSTOMER REQUIREMENTS

OPTIONAL SHIELDING AVAILABLE



U.S. PATENT NUMBERS 4371092 AND 4426927

CONTAINER
PRODUCTS
CORPORATION

CONTAINER PRODUCTS CORPORATION
P.O. BOX 3767 112 NORTH COLLEGE ROAD
WILMINGTON, NORTH CAROLINA 28405
(919)392-6100 FAX (919)392-6778

PSB88 2/14/89

GATX

NEWS RELEASE

FOR FURTHER INFORMATION CONTACT:

Holly Rea, GATX
(312) 621-6493

Stephen Fraser, Envirolease
(201) 292-2456

FOR RELEASE: IMMEDIATELY

GATX CAPITAL WASTE BY RAIL JOINT VENTURE

SAN FRANCISCO, April 11--GATX Capital Corporation has entered into a joint venture with Envirolease, Inc. to provide capital equipment for the intermodal movement of selected wastes and recyclables. GATX EnviroLease Corporation combines the equipment and financial expertise of GATX Capital with the knowledge and specialization of the waste by rail market of Envirolease, Inc., and Fraser Group, Inc.

GATX EnviroLease will provide lease financing for a full range of intermodal equipment including special purpose containers, chassis, railcars, and other material and container handling systems such as tippers, sidehandlers and rotary dumping technologies. The equipment will be dedicated to the intermodal transportation of non-hazardous and selected hazardous waste such as municipal solid waste, incinerator and coal ash, sanitary and industrial sludges, contaminated soil, construction and demolition debris, and recyclables.

Potential customers include a wide range of waste companies, railroads, waste transportation companies, and other generators of waste which are considering in-house remediation of captive sites which would require intermodal containers to transport and dispose of the waste.

--more--

"We embraced the expertise and reputation of Envirolease and Fraser Group as an entrance into providing financial services for the intermodal movement of waste by rail," said Brooks Laudin, vice president, corporate development, GATX Capital Corporation. "The movement of waste and recyclables is making a shift toward rail due in part to the industry's consolidation of waste streams. Intermodal containers are interchangeable between truck, barge and rail offering waste managers greater flexibility with shipments and cost effective modes of transporting wastes." Intermodal containers eliminate the need for onsite rail loading facilities and the intermediate transfer of waste from one mode to another, he added.

"The strength of transporting waste by rail is enhanced by the economies of scale coupled with a more environmentally secure mode of transportation," commented Stephen Fraser, president, GATX EnviroLease. "As the number of available disposal sites continues to diminish, the average length of haul rises, making special-purpose intermodal equipment more suitable and cost effective."

Based in Convent Station, New Jersey, Envirolease, Inc. has marketed intermodal equipment on short and long term leases to the waste industry. Fraser Group, Inc., has provided consulting expertise and market development services to some of the nation's leading public waste companies on waste by rail issues. GATX EnviroLease is headquartered in Morristown, New Jersey.

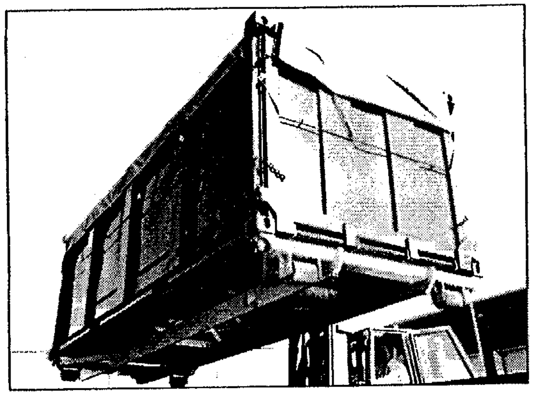
GATX Capital Corporation is a diversified, asset-oriented, financial services company which invests for its own account and manages assets for other institutional investors. GATX Capital owns or manages portfolio assets with an original cost of approximately $8 billion, the largest concentration of which includes air, rail and manufacturing equipment.

--more--

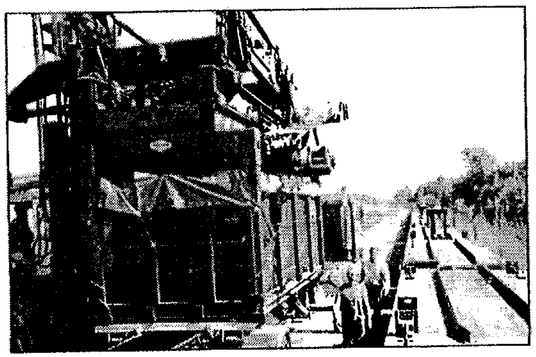
GATX Capital is a subsidiary of GATX Corporation, which provides more than $4 billion of service-based assets including transportation equipment, primarily railroad tank cars, bulk liquid terminals, ships, warehouses, commercial aircraft, and other capital assets worldwide. GATX also offers a variety of financial services focusing on owning or managing transportation and distribution assets.

--30--

(4-11-94)



Under side view of container and optional removable adapter allowing container to be handled as conventional roll-off box.



Transferring container from truck to rail car at intermodal rail terminal. An Envirolease Hammarlift can do this task at any rail siding.

Emptying container is quick and easy after sturdy and reliable safety latches on the rear door are released.

More Than Just Containers

Envirolease offers a range of products and services to support your use of Envirolease containers...

Products

- **Chassis**
  Envirolease offers special chassis for use with its containers designed to allow payloads weights exceeding those permissible using ordinary chassis.
- **Tip Chassis**
  Special chassis equipped with hydraulic cylinders allowing containers to be emptied like a dump truck.
- **Hammarlift**
  Mobile container lifting device which turns any rail siding into an intermodal terminal.
- **Roll-Off Sleds**
  Sled like adapter which allows Envirolease containers to be handled as a roll-off box.

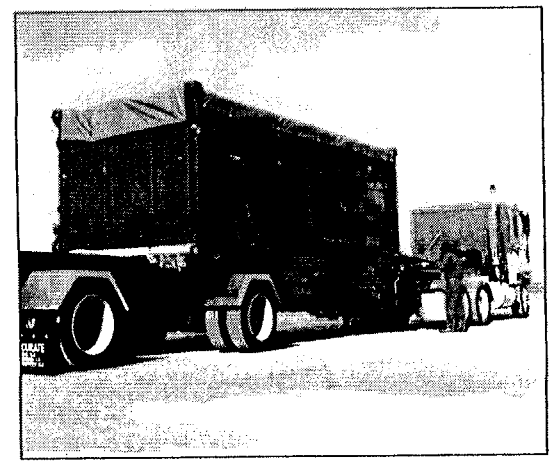
Services

- **Fleet Management**
  Envirolease will manage your container equipment insuring optimal utilization and maintenance.
- **Project Planning**
  Envirolease can help you determine if containers make sense for you or to assist in the use of containers on specific projects.

GATX EnviroLease Corporation
High Street Court
Morristown, NJ 07960
Fax: 201/292-9160
800/405-2555

Reduce Your Waste Transportation Costs Now By Leasing Intermodal Shipping Containers From

Envirolease



With containers from Envirolease, convert your waste shipments to intermodal movement and take advantage of lower costs and flexibility of containerized transportation. Here is how...

Why Lease Containers?

More and more waste companies are reducing transportation costs by shipping their waste by rail using specially designed containers. Until now, these containers have not been available for lease and could only be obtained through purchase.

Envirolease now offers a complete line of shipping containers, support equipment and services to enable your company to enjoy the following benefits of containerizing waste shipments:

- Waste shipped in Envirolease containers is sealed from the environment in a weather tight container which is hydrostatically tested prior to leaving the factory.
- Envirolease containers can be used regardless of the availability of rail track at waste handling or disposal sites.
- Shipments of waste in Envirolease containers move unobtrusively through established channels of commerce.
- Transferring containerized shipments for waste from one mode of transportation to another can be performed at hundreds of intermodal facilities in North America.
- Shipping waste by rail is recognized as being the safest way to ship your waste and offers a means to reduce or eliminate traffic congestion problems at some facilities.

Physical Description

Envirolease containers are the product of a four year development and testing process. The containers are based on designs currently used by several thousand existing containers which have been handling hazardous and non-hazardous waste throughout North America by rail, truck and barge since 1985.

Envirolease containers represent a refinement of these earlier designs and users of Envirolease containers will enjoy the generational improvements and added flexibility incorporated into Envirolease containers.

Fabricated of heavy gauge steel, the containers have been designed and tested to meet impact and durability requirements of rail and truck carriers. The containers are built to nominal International Standard Organization (ISO) specifications insuring universal compatibility with container handling equipment throughout the world.

The containers incorporate an open top to facilitate loading. This opening is sealed prior to transit by means of a tarpaulin top and elastic cords. An optional light-weight, durable hard top is also available.

Emptying the container is identical to that of a dump truck by means of a single piece top-hinged door at the rear of the container. This door is equipped with compression gaskets, reliable locking mechanisms and ratchets which are designed to achieve a water tight seal allowing the container to handle moist cargo.

Technical Specifications

Units are capable of two high stacking when loaded and fit within 20 foot ISO envelope.

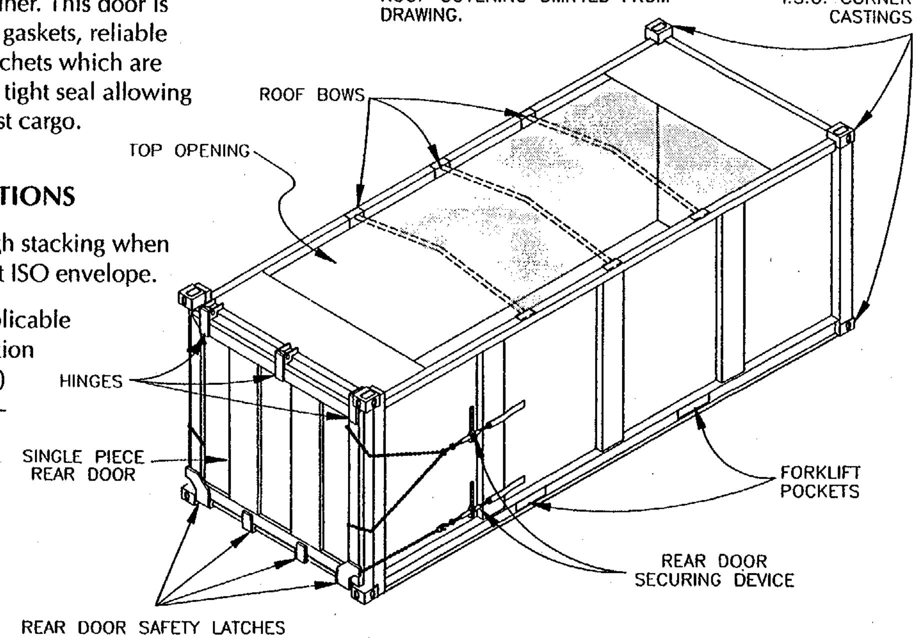
Containers comply with applicable requirements of the Association of American Railroads (AAR) M-930-90 performance standards and will be tested and certified as required.

Containers are tested and certified by American Bureau of Shipping (ABS).

External Dimensions	Ft	In	MM
Container Length	19	10.5	6,058
Container Width	8		2,438
Container Height	6	4.5	1,943
Apertures			
Door Width	7	1.25	2,165
Door Height	5	.75	1,543
Top Opening Length	15	1.13	4,600
Top Opening Width	7	5.25	2,267

Volumes	Cu Yds	Cu M
	29.5	27.42

Weights	Lbs	KG
Maximum Gross Weight	52,910	23,996
Tare Weight	5,500	12,128
Payload Weight	47,410	21,501



Since 1931
TENCO CAT

May 10, 1994 Quote 730-194

Mr. Frank Groffie
Morrison Knudsen Corp.
180 Howard St.
San Francisco, CA 94102

Tenco Material Handling Division is pleased to submit the following proposal for your consideration:

1 Model: V800D Cat New Lift Truck
Caterpillar 3208T Diesel Engine
Planetary Drive Axle with Oil Disc Brakes
Oscillating Steer Axle
3-Section Valve
Five degree forward, 10 degree back High Mount Tilt Cylinders
Counterweight
Cab consisting of:
- Full suspension seat
- Tilt steering column
- Front, rear and top windshield wipers
- Front and rear windshield washers
- 80dB(a) sound level at operator's ear
- pressurized filtered ventilation system
- heater
- rear view mirror
- Tail and stop lights
- two side view lights
- audible back up alarm
- power steering

Tires: 18.00 x 33 dual drive tires (E-4)
18.00 x 25 steer tires (E-4)
Mast: Maximum fork height: 301"
Overall lowered height: 259.0"
Twist lock height: 385" (3 high stack)
Gooseneck mounted container handler
Includes container handler carriage with 20' - 40' expansion
Capacity for 3 high: 61,000 lbs.
Working light package: 4 flood lights front & rear
Air conditioned cab
Site assembly

Price: F.O.B. delivered $275,547.00
plus tax

TENCO

Options:

4 high stacking, twist lock height 483", Capacity: 53,400 lbs.	$283,421.00 plus tax
V900CH with container handler Good neck mounted, 3 high Capacity: 75,700 lbs. On site assembly included Price: F.O.B. factory	$282,258.00 plus tax
4 high stacking Capacity: 67,400 lbs. On site assembly included Price: F.O.B. factory	$289,553.00 plus tax

Delivery: August, 1994

Warranty: Cat 12 month parts and labor, unlimited hour usage, Cat "Parts Fast, Parts Free" policy

Accepted by:

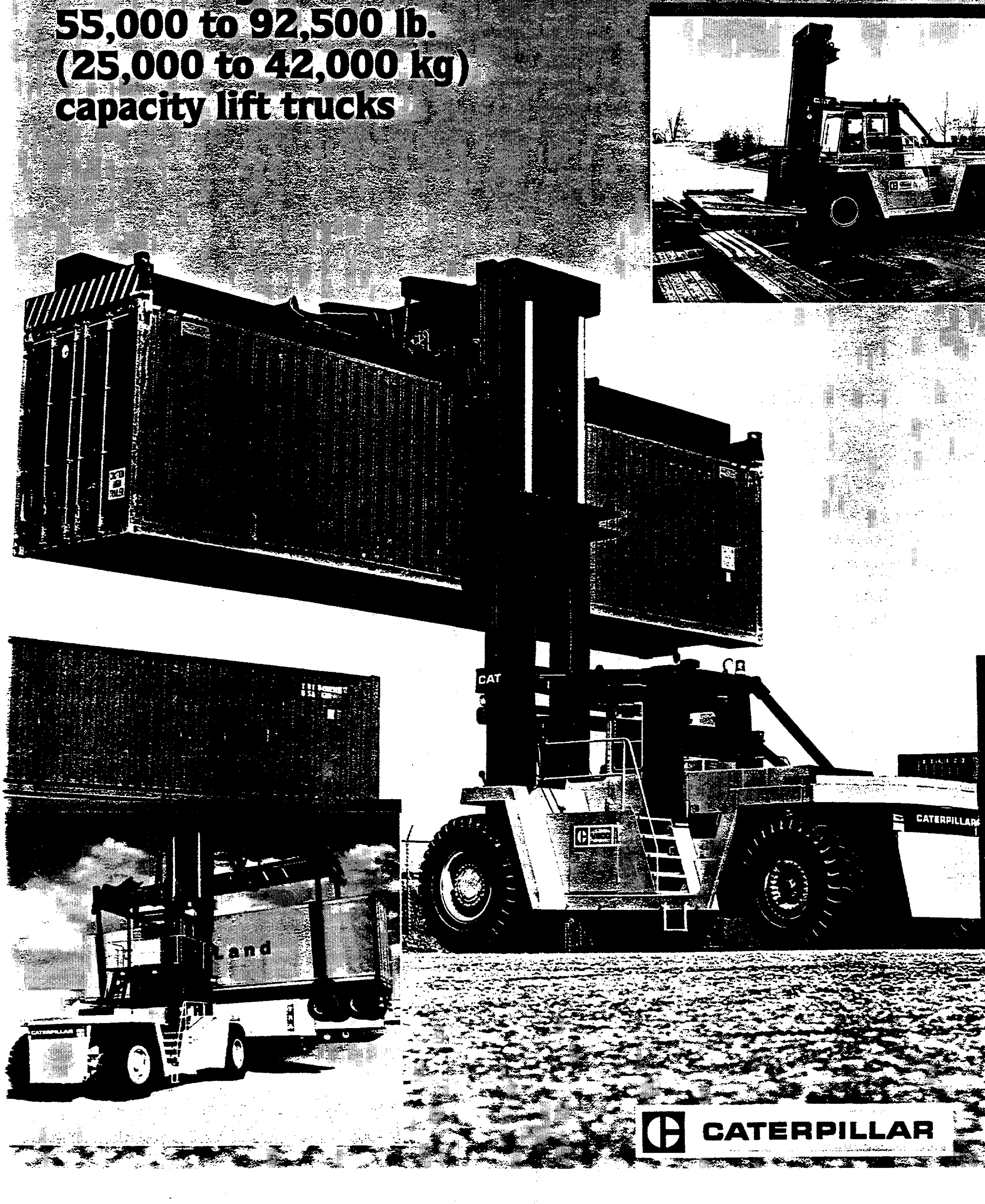
Morrison Knudsen Date

Proposed by:

Jay Taylor

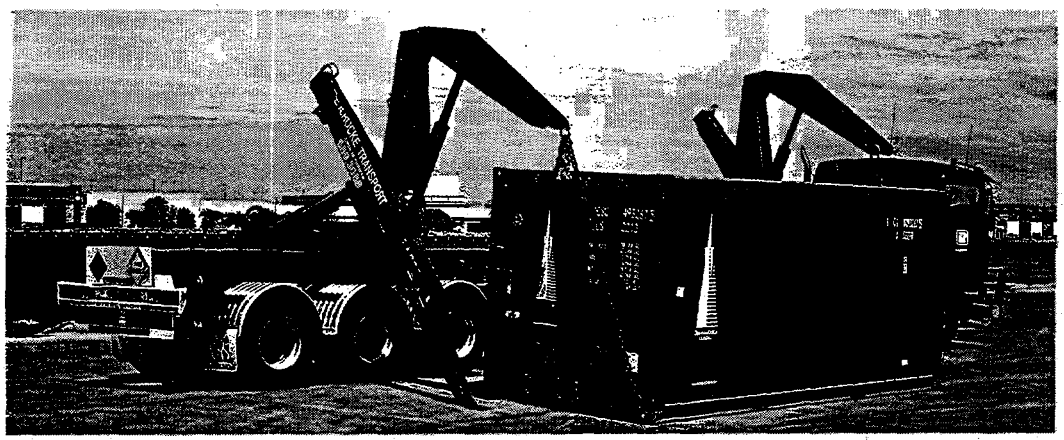
Jay Taylor Account Manager

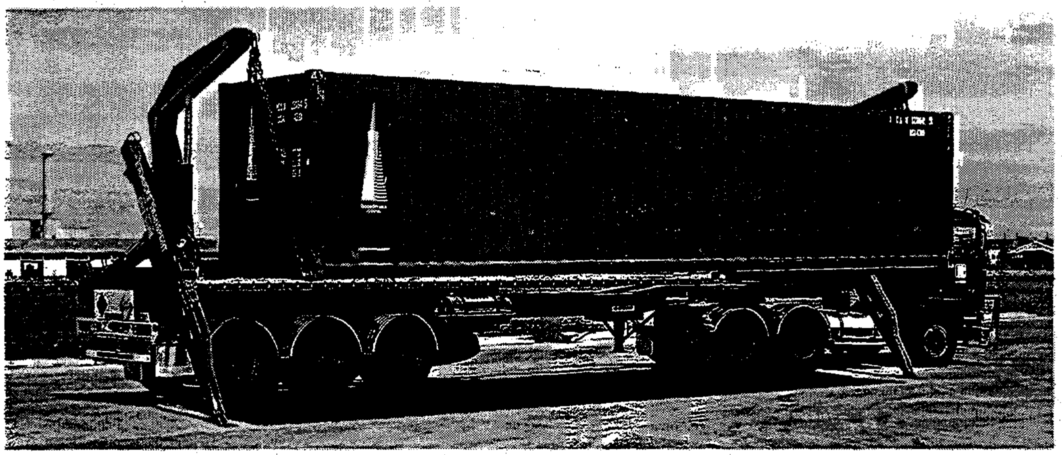
For the Big Jobs: 55,000 to 92,500 lb. (25,000 to 42,000 kg) capacity lift trucks



STEELBRO

MK6 STEELBRO SIDELIFTER





SHORTER, LIGHTER, FASTER, STRONGER AND MORE VERSATILE

Steelbro Sidelifters are highly efficient all-in-one container handling and delivery systems.

They permit rapid loading and unloading on virtually any flat, reasonably hard surface, allow double stacking of fully loaded containers, permit stuffing and de-stuffing at ground level and make the transfer of containers to another semi-trailer a simple and safe operation.

The new MK6 Steelbro Sidelifter has an overall length of 13.6m (including the front arc) and easily complies with 13.72 m (45 ft) trailer length regulations. This means that 40 ft and 20ft containers can not only be loaded and unloaded with safety and ease, but can be carried in many countries without travel restrictions being imposed due to the overall length of the trailer.

There are a number of other features of the new MK6 Sidelifter that bring considerable benefits to the transport industry.

With a tare weight from 11 tonnes, the new design is considerably lighter. Also, operation has been made faster through dual speed and variable speed controls. It is safer as there is greater control over the movement of the container and it is stronger as the lift capacity is rated to 30 tonnes and tested to 37.5 tonnes. Finally the MK6 is more versatile as its extended working radius enables companion vehicles to drive past during container transfers.

MAJOR NEW FEATURES

- Greater emphasis on safety
- Rapid deployment of stabilizer legs for faster turnarounds
- Easy to use controls
- Variable speed remote controls for superior handling flexibility of the container
- Greater lift capacity, particularly at full outreach
- High speed operation, with dual speed and variable speed controls
- Significantly reduced tare weight, now from 11 tonnes
- Greater stability
- New style of twistlocks and lifting lugs for reduced maintenance
- Length reduced to 13.6 m, including front arc, to suit regulations.
- Superior manoeuvrability (now a conventional turning circle) and greater control over movement of the container.
- Rated capacity of SWL 30 tonnes (tested to 37.5 tonnes)
- Reduced shock loadings in the hydraulic system resulting in lower stresses and strains
- Higher capacity motor.

Companion vehicles can drive past the MK6 Sidelifter due to its extended reach

Cranes fold low to improve loading by other means at terminals, protect lifting equipment and reduce pivot pin wear

Distributed by

Steel Bros (NZ) Ltd
P.O. Box 11077,
Sockburn, Christchurch,
New Zealand
Telephone:
INT + 64 + 3 + 348 8499
Facsimile:
INT + 64 + 3 + 348 5786

STEELBRO

Appendix D-1

TSMT Quotes (3)

PRINTED 05/04/93 TRI-STATE MOTOR TRANSIT, CO. QUII006
14:38:28 QUOTING SYSTEM - QUOTE INQUIRY PAGE 1

QUOTE NUMBER: 145026 ENTERED BY: SLH ENTERED: 05/04/93 COMPLETED: 00/00/00

CUST: NAME: MORRISON-KNUDSEN ADD: FAX 415-442-7673
CITY: SAN FRANCISCO, CA ZIP: 94100 PHONE: 415-442-7575 EXT:
CONTACT: PHIL KELLEHER ORIGINATED:

1 OF 3 ORIGIN: JOPLIN STATE: MO ZIP: SHIP: 00/00/00
DEST : CHARLESTON STATE: SC ZIP: MILES: 1003

WEIGHT: 15000 LENGTH: - WIDTH: - HEIGHT: - TRAILER:
LOADED DIMS - LENGTH: - WIDTH: - HEIGHT: - TARIFF: 4007C

1 OF 1	COMMODITY DESCRIPTION	M/H	EXT	WEIGHT	RATE	CHARGE
DEADHEAD SPENT FUEL TRUCK/TEAM	XXRX				.000	.00

CODE	ACCESSORIAL DESCRIPTION	EXT	RATE	M/H/W	ACC CHARGE
970	DEADHEAD SPEC EQUIPT	M	2.45	1003	2457.35
0			.00		.00
5001	DETENTION-TRAC/TRLR $35/HR		.00		.00
0	FOR ALL HOURS		.00		.00

COMMODITY CHARGE 2457.35

TOTAL CHARGES 2457.35

2 OF 3 ORIGIN: CHARLESTON STATE: SC ZIP: SHIP: 00/00/00
DEST : DUNBARTON STATE: SC ZIP: MILES: 134

WEIGHT: 47000 LENGTH: - WIDTH: - HEIGHT: - TRAILER:
LOADED DIMS - LENGTH: - WIDTH: - HEIGHT: - TARIFF: 4007C

1 OF 1	COMMODITY DESCRIPTION	M/H	EXT	WEIGHT	RATE	CHARGE
SPENT FUEL IN CASK	XXRX	134	F	47000	3.139	1976.94

CODE	ACCESSORIAL DESCRIPTION	EXT	RATE	M/H/W	ACC CHARGE
340	PIER ARBITRARY	X	.00		50.00
1200	TRAILER SET-OUT	X	.00		95.00
5001	DETENTION-TRAC/TRLR $35/HR		.00		.00
0	FOR ALL HOURS		.00		.00
0			.00		.00
0			.00		.00
0	APPROXIMATE TRANSIT TIME 4 HRS		.00		.00

COMMODITY CHARGE 2121.94

TOTAL CHARGES 2121.94

3 OF 3 ORIGIN: DUNBARTON STATE: SC ZIP: SHIP: 00/00/00

PRINTED 05/04/93 TRI-STATE MOTOR TRANSIT, CO. QUII006
14:38:29 QUOTING SYSTEM - QUOTE INQUIRY PAGE 2

QUOTE NUMBER: 145026 ENTERED BY: SLH ENTERED: 05/04/93 COMPLETED: 00/00/00

DEST : CHARLESTON STATE: SC ZIP: MILES: 115

WEIGHT: 43000 LENGTH: - WIDTH: - HEIGHT: - TRAILER:
LOADED DIMS - LENGTH: - WIDTH: - HEIGHT: - TARIFF: 4007C

1 OF 1	COMMODITY DESCRIPTION	M/H	EXT	WEIGHT	RATE	CHARGE
EMPTY CASK						
MIN CHG		XXRX	X		.000	600.00

CODE	ACCESSORIAL DESCRIPTION	EXT	RATE	M/H/W	ACC CHARGE
340	PIER ARBITRARY	X	.00		50.00
0			.00		.00
5001	DETENTION-TRAC/TRLR $35/HR		.00		.00

COMMODITY CHARGE 650.00

TOTAL CHARGES 650.00

*** END OF QUOTE ***

PRINTED 05/04/93 TRI-STATE MOTOR TRANSIT, CO. QUII006
14:38:39 QUOTING SYSTEM - QUOTE INQUIRY PAGE 1

QUOTE NUMBER: 145032 ENTERED BY: SLH ENTERED: 05/04/93 COMPLETED: 00/00/00

CUST: NAME: MORRISON-KNUDSEN ADD: FAX 415-442-7673
CITY: SAN FRANCISCO, CA ZIP: 94100 PHONE: 415-442-7575 EXT:
CONTACT: PHIL KELLEHER ORIGINATED:

1 OF 3 ORIGIN: JOPLIN STATE: MO ZIP: SHIP: 00/00/00
DEST : OAK RIDGE STATE: TN ZIP: MILES: 667

WEIGHT: 15000 LENGTH: - WIDTH: - HEIGHT: - TRAILER:
LOADED DIMS - LENGTH: - WIDTH: - HEIGHT: - TARIFF: 4007C

1 OF 1	COMMODITY DESCRIPTION	M/H	EXT	WEIGHT	RATE	CHARGE
DEADHEAD SPENT FUEL TRUCK/TEAM	XXRX				.000	.00

CODE	ACCESSORIAL DESCRIPTION	EXT	RATE	M/H/W	ACC CHARGE
970	DEADHEAD SPEC EQUIPT	M	2.45	667	1634.15
0			.00		.00
5001	DETENTION-TRAC/TRLR $35/HR		.00		.00
0	FOR ALL HOURS		.00		.00

COMMODITY CHARGE 1634.15

TOTAL CHARGES 1634.15

2 OF 3 ORIGIN: OAK RIDGE STATE: TN ZIP: SHIP: 00/00/00
DEST : DUNBARTON STATE: SC ZIP: MILES: 359

WEIGHT: 47000 LENGTH: - WIDTH: - HEIGHT: - TRAILER:
LOADED DIMS - LENGTH: - WIDTH: - HEIGHT: - TARIFF: 4007C

1 OF 1	COMMODITY DESCRIPTION	M/H	EXT	WEIGHT	RATE	CHARGE
SPENT FUEL IN CASK	XXRX	359	F	47000	1.540	2598.44

CODE	ACCESSORIAL DESCRIPTION	EXT	RATE	M/H/W	ACC CHARGE
0			.00		.00
1200	TRAILER SET-OUT	X	.00		95.00
5001	DETENTION-TRAC/TRLR $35/HR		.00		.00
0	FOR ALL HOURS		.00		.00
0			.00		.00
0			.00		.00
0	APPROX. TRANSIT TIME 10 HRS		.00		.00

COMMODITY CHARGE 2693.44

TOTAL CHARGES 2693.44

3 OF 3 ORIGIN: DUNBARTON STATE: SC ZIP: SHIP: 00/00/00

PRINTED 05/04/93 14:38:40

TRI-STATE MOTOR TRANSIT, CO.
QUOTING SYSTEM - QUOTE INQUIRY

QUII006
PAGE 2

QUOTE NUMBER: 145032 ENTERED BY: SLH ENTERED: 05/04/93 COMPLETED: 00/00/00

DEST : OAK RIDGE STATE: TN ZIP: MILES: 330

WEIGHT: 43000 LENGTH: - WIDTH: - HEIGHT: - TRAILER:
LOADED DIMS - LENGTH: - WIDTH: - HEIGHT: - TARIFF: 4007C

1 OF 1 COMMODITY DESCRIPTION	M/H	EXT	WEIGHT	RATE	CHARGE
EMPTY CASK					
XXRX		W	43000	1.830	786.90

CODE	ACCESSORIAL DESCRIPTION	EXT	RATE	M/H/W	ACC CHARGE
0			.00		.00
0			.00		.00
5001	DETENTION-TRAC/TRLR $35/HR		.00		.00

COMMODITY CHARGE 786.90

TOTAL CHARGES 786.90

*** END OF QUOTE ***

PRINTED 05/04/93 TRI-STATE MOTOR TRANSIT, CO. QUII006
14:38:44 QUOTING SYSTEM - QUOTE INQUIRY PAGE 1

QUOTE NUMBER: 145038 ENTERED BY: SLH ENTERED: 05/04/93 COMPLETED: 00/00/00

CUST: NAME: MORRISON-KNUDSEN ADD: FAX 415-442-7673
CITY: SAN FRANCISCO, CA ZIP: 94100 PHONE: 415-442-7575 EXT:
CONTACT: PHIL KELLEHER ORIGINATED:

1 OF 2 ORIGIN: JOPLIN STATE: MO ZIP: SHIP: 00/00/00
DEST : FORT WORTH STATE: TX ZIP: MILES: 371

WEIGHT: 15000 LENGTH: - WIDTH: - HEIGHT: - TRAILER:
LOADED DIMS - LENGTH: - WIDTH: - HEIGHT: - TARIFF: 4007C

1 OF 1	COMMODITY DESCRIPTION	M/H EXT	WEIGHT	RATE	CHARGE
DEADHEAD SPENT FUEL TRUCK/TEAM					
	XXRX			.000	.00

CODE	ACCESSORIAL DESCRIPTION	EXT	RATE	M/H/W	ACC CHARGE
970	DEADHEAD SPEC EQUIPT	M	2.45	371	908.95
0			.00		.00
5001	DETENTION-TRAC/TRLR $35/HR		.00		.00
0	FOR ALL HOURS		.00		.00

COMMODITY CHARGE 908.95

TOTAL CHARGES 908.95

2 OF 2 ORIGIN: FORT WORTH STATE: TX ZIP: SHIP: 00/00/00
DEST : OAK RIDGE STATE: TN ZIP: MILES: 1000

WEIGHT: 47000 LENGTH: - WIDTH: - HEIGHT: - TRAILER:
LOADED DIMS - LENGTH: - WIDTH: - HEIGHT: - TARIFF: 4007C

1 OF 1	COMMODITY DESCRIPTION	M/H EXT	WEIGHT	RATE	CHARGE
SPENT FUEL IN CASK					
	XXRX 1001	F	47000	.902	4243.64

CODE	ACCESSORIAL DESCRIPTION	EXT	RATE	M/H/W	ACC CHARGE
0			.00		.00
0			.00		.00
5001	DETENTION-TRAC/TRLR $35/HR		.00		.00
0	FOR ALL HOURS		.00		.00
0			.00		.00
0	APPROX. TRANSIT TIME 30 HRS		.00		.00

COMMODITY CHARGE 4243.64

TOTAL CHARGES 4243.64

*** END OF QUOTE ***

PRINTED 05/04/93 TRI-STATE MOTOR TRANSIT, CO. QUII006
16:19:37 QUOTING SYSTEM - QUOTE INQUIRY PAGE 1

QUOTE NUMBER: 145038 ENTERED BY: SLH ENTERED: 05/04/93 COMPLETED: 00/00/00

CUST: NAME: MORRISON-KNUDSEN ADD: FAX 415-442-7673
CITY: SAN FRANCISCO, CA ZIP: 94100 PHONE: 415-442-7575 EXT:
CONTACT: PHIL KELLEHER ORIGINATED:

1 OF 3 ORIGIN: JOPLIN STATE: MO ZIP: SHIP: 00/00/00
DEST : FORT WORTH STATE: TX ZIP: MILES: 371

WEIGHT: 15000 LENGTH: - WIDTH: - HEIGHT: - TRAILER:
LOADED DIMS - LENGTH: - WIDTH: - HEIGHT: - TARIFF: 4007C

1 OF 1 COMMODITY DESCRIPTION	M/H EXT	WEIGHT	RATE	CHARGE
DEADHEAD SPENT FUEL TRUCK/TEAM				
	XXRX		.000	.00

CODE	ACCESSORIAL DESCRIPTION	EXT	RATE	M/H/W	ACC CHARGE
970	DEADHEAD SPEC EQUIPT	M	2.45	371	908.95
0			.00		.00
5001	DETENTION-TRAC/TRLR $35/HR		.00		.00
0	FOR ALL HOURS		.00		.00

COMMODITY CHARGE 908.95

TOTAL CHARGES 908.95

2 OF 3 ORIGIN: FORT WORTH STATE: TX ZIP: SHIP: 00/00/00
DEST : OAK RIDGE STATE: TN ZIP: MILES: 1000

WEIGHT: 47000 LENGTH: - WIDTH: - HEIGHT: - TRAILER:
LOADED DIMS - LENGTH: - WIDTH: - HEIGHT: - TARIFF: 4007C

1 OF 1 COMMODITY DESCRIPTION	M/H EXT	WEIGHT	RATE	CHARGE
SPENT FUEL IN CASK				
	XXRX 1001 F	47000	.902	4243.64

CODE	ACCESSORIAL DESCRIPTION	EXT	RATE	M/H/W	ACC CHARGE
1200	TRAILER SET-OUT	M	1.98	144	285.12
0			.00		.00
5001	DETENTION-TRAC/TRLR $35/HR		.00		.00
0	FOR ALL HOURS		.00		.00
0			.00		.00
0	APPROX. TRANSIT TIME 30 HRS		.00		.00

COMMODITY CHARGE 4528.76

TOTAL CHARGES 4528.76

3 OF 3 ORIGIN: OAK RIDGE STATE: TN ZIP: SHIP: 00/00/00
DEST : FT WORTH STATE: TX ZIP: MILES: 847

PRINTED 05/04/93 TRI-STATE MOTOR TRANSIT, CO. QUII006
16:19:38 QUOTING SYSTEM - QUOTE INQUIRY PAGE 2

QUOTE NUMBER: 145038 ENTERED BY: SLH ENTERED: 05/04/93 COMPLETED: 00/00/00

WEIGHT: 43000 LENGTH: - WIDTH: - HEIGHT: - TRAILER:
LOADED DIMS - LENGTH: - WIDTH: - HEIGHT: - TARIFF: 4007C

1 OF 1	COMMODITY DESCRIPTION	M/H	EXT	WEIGHT	RATE	CHARGE
EMPTY CASK						
	XXRX		W	43000	3.770	1621.10

CODE	ACCESSORIAL DESCRIPTION	EXT	RATE	M/H/W	ACC CHARGE
0			.00		.00
0			.00		.00
5001	DETENTION-TRAC/TRLR $35/HR		.00		.00

COMMODITY CHARGE 1621.10

TOTAL CHARGES 1621.10

*** END OF QUOTE ***

COMMAND: Q C: _1 Q: ___ TRI-STATE MOTOR TRANSIT QUII001

QUOTE NUMBER: 143839 QUOTING SYSTEM - QUOTE INQUIRY ENTERED BY: SLH

CUST: NAME: MORRISON-KNUDSEN ADD: FAX 415-442-7673

CITY: SAN FRANCISCO STATE: CA ZIP: PHONE: 4154427390 EXT:

CONTACT: DAVID BURTON ORIGINATED BY: SHIP DATE:

3 OF 6 ORIGIN: DUNBARTON STATE: SC ZIP:

DEST : NV TS STATE: NV ZIP: MILES: 2495

STOPS: 1) 2) MORE? N N

WEIGHT: 40000 LENGTH: - WIDTH: - HEIGHT: - TRAILER:

LOADED DIMS - LENGTH: - WIDTH: - HEIGHT: - TARIFF: 4007C 24000

1 OF 1 COMMODITY DESCRIPTION	M/H	EXT	WEIGHT	RATE	CHARGE
SPENT FUEL IN CASK					
	XXRX 2495	F	40000	0.902	9001.96

CODE	ACCESSORIAL DESCRIPTION	EXT	RATE	M/H/W	ACC CHARGE
970	DEADHEAD SPEC EQUIPT	M	2.450	895	2192.75
	SPENT FUEL TEAM FROM JOPLIN,MO				
8102	SPENT FUEL SECUR PRV	M	0.450	2495	1122.75
1200	TRAILER SET-OUT	M	1.980	411	813.78
905	PERMIT/TAX/FEE/NOTIF	X			50.00
5001	DETENTION-TRAC/TRLR $35/HR				
5002	DETENTION-TRL ONLY $50/DAY				

TOTAL CHARGES: 13181.24 COMMODITY CHARGE: 13181.24

4

COMMAND: Q C: _1 Q: __ TRI-STATE MOTOR TRANSIT QUII001

QUOTE NUMBER: 143839 QUOTING SYSTEM - QUOTE INQUIRY ENTERED BY: SLH

CUST: NAME: MORRISON-KNUDSEN ADD: FAX 415-442-7673

CITY: SAN FRANCISCO STATE: CA ZIP: PHONE: 4154427390 EXT:

CONTACT: DAVID BURTON ORIGINATED BY: SHIP DATE:

4 OF 6 ORIGIN: NV TS STATE: NV ZIP:

DEST : DUNBARTON STATE: SC ZIP: MILES: 2376

STOPS: 1) 2) MORE? N N

WEIGHT: 32000 LENGTH: - WIDTH: - HEIGHT: - TRAILER:

LOADED DIMS - LENGTH: - WIDTH: - HEIGHT: - TARIFF: 4007C 21000

1 OF 1 COMMODITY DESCRIPTION	M/H	EXT	WEIGHT	RATE	CHARGE
EMPTY SPENT FUEL CASK					
	XXRX	W	32000	10.780	3449.60

CODE	ACCESSORIAL DESCRIPTION	EXT	RATE	M/H/W	ACC CHARGE

TOTAL CHARGES: 3449.60 COMMODITY CHARGE: 3449.60

Appendix D-2

Nuclear Assurance Corporation—Cask Rates and Specifications

Nuclear Assurance Corporation
655 Engineering Drive
Suite 200
Norcross. Georgia 30092
(404) 447-1144
FAX # (404) 447-1797

March 15, 1993
IFS/93/043/EDS

Mr. David Burton
Morrison Knudsen
180 Howard Street
San Francisco, CA 94105

Dear Mr. Burton:

In response to our teleconference today, I an enclosing a specification sheet and photograph of each of Nuclear Assurance Corporation's (NAC) transport cask types. Also enclosed is a standard lease rate sheet applicable for the casks. Please note that the lease rate varies significantly with the period of the lease. In addition, labor for any required lease is separate above the base lease period and cost.

As I cautioned you in our discussion, assessing the relative value of leasing versus purchasing a cask requires defining several details of the planned use. Thus the enclosed information needs to be used carefully for such evaluations. NAC would be pleased to perform such an evaluation if needed. Please call if you need further information.

Sincerely,

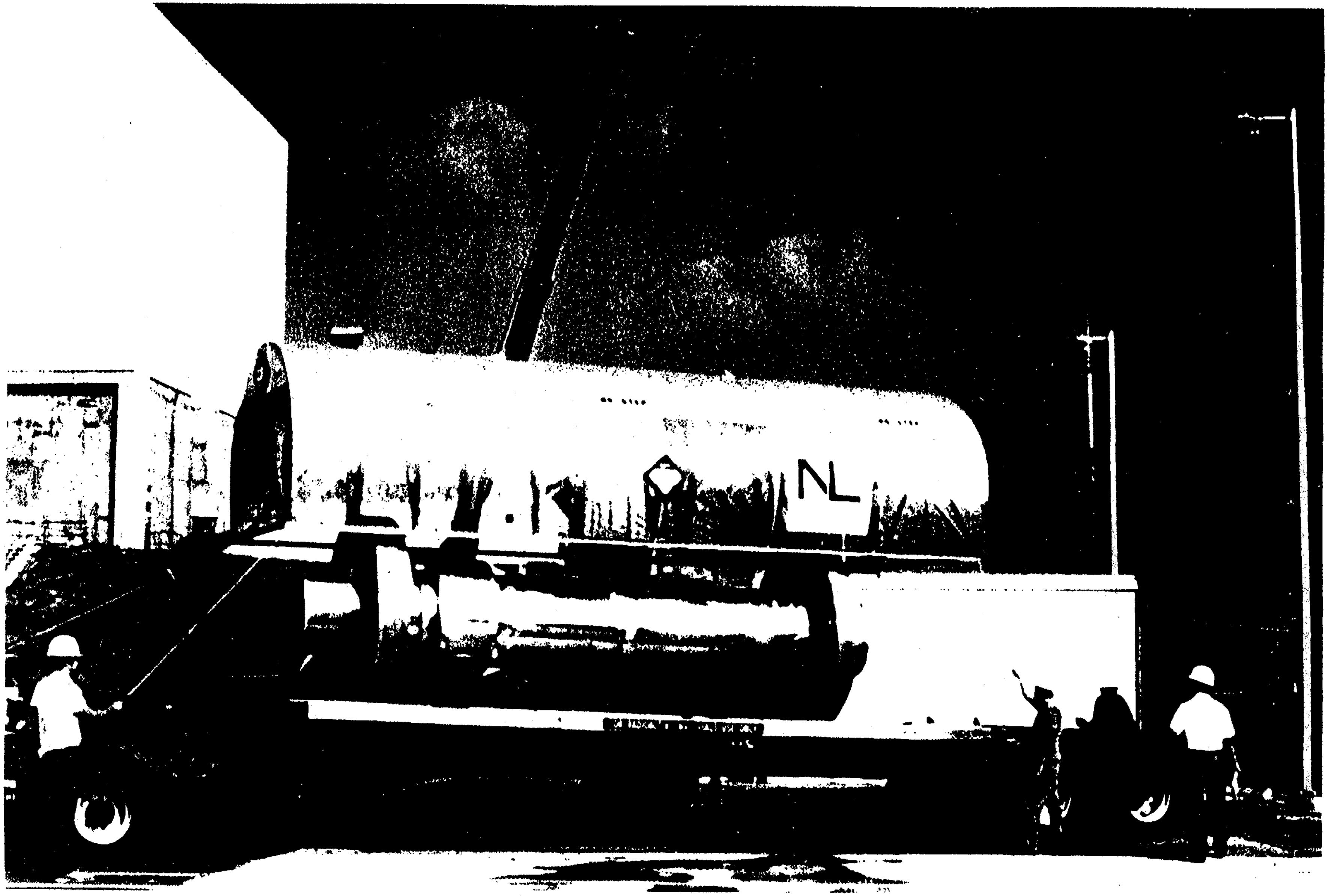
Ivan F. Stuart

Ivan F. Stuart
Vice President
Engineering Design Services

IFS:sb

enclosure:

Gary T; ...



NLI 1/2 TWI
Transport Cask

1993

NUCLEAR ASSURANCE CORPORATION

Standard Commercial Policy for Legal Weight Truck Cask Leasing

Base Price $60,000

The base price is for a single, continuous cask lease period of not more than 10 days. Additional days of cask lease will be at the following rates:

Days 11 through 30	$3,500/day
Days 31 through 90	$3,000/day
Days 91 through 180	$2,500/day
Days 181 through 360	$1,800/day

Included in the base price are four days of labor for site assistance: two days at the shipment origination facility and two at the shipment destination facility.

Additional Equipment and Services

NAC will provide additional equipment and services to support the cask lease. In general, expenses will be invoiced at cost plus 15 percent and labor will be invoiced at the following rates:

Officer	$220/hour
Senior Manager/Engineer	$150/hour
Manager/Engineer	$130/hour
Associate Engineer/Designer	$ 85/hour
Secretary/Clerk	$ 50/hour

Additional equipment and services include the following:

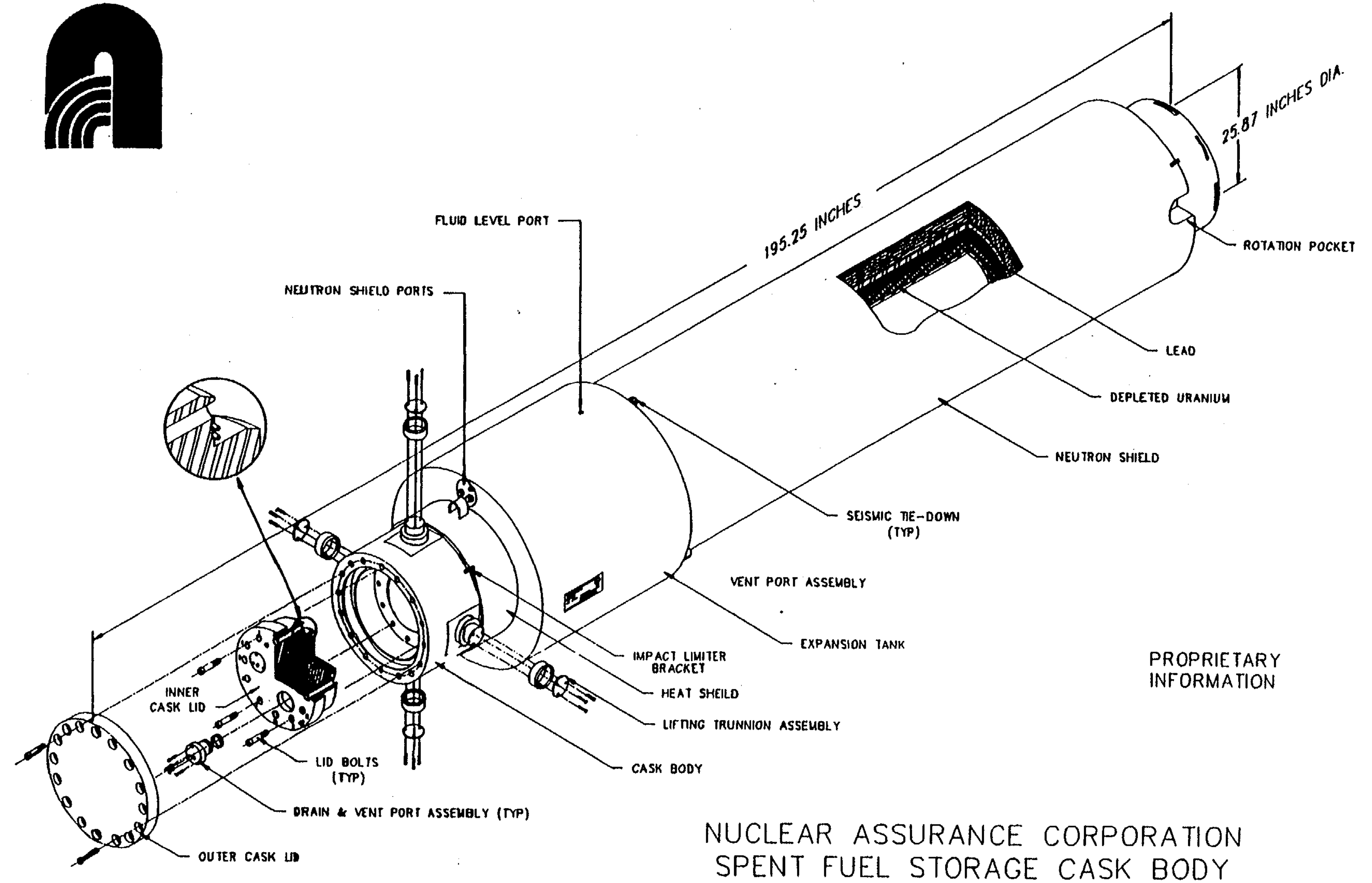
- Special equipment design and fabrication
- Cask and related equipment transportation
- NAC reviews and licensing
- Cask internals (basket) change-out
- Neutron shield tank filling and draining
- Preliminary site visits and interface assessments
- Additional site assistance, site visits and meetings
- Travel and subsistence costs
- Schedule changes
- Shipment notifications and escort arrangements
- Route approvals and special permits
- Shipper and consignee support and coordination
- IAEA endorsements
- Other services as requested

NLI-1/2

Owner	Nuclear Assurance Corporation
Type	Legal Weight Truck Shipping Cask
Manufacturer/Vendor	NL Industries Inc.
Capacity	
Intact Spent Fuel Assemblies	1 PWR; 2 BWR
Cans Consolidated Fuel Rods	2 PWR; 4 BWR
Other Configuration	Metallic Fuel
Weight (tons)	
Loaded	23.1
Empty	22.3
Design Heat Rejection (kW)	10.6
Shape	Cylindrical
Dimensions	
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
Materials of Construction	
Cask Body	SS/Depleted U/Lead/SS
Neutron Shield	
Sides	Water & Ethylene Glycol
End	None
Basket	SS and Aluminum
Cavity Atmosphere	He, Air if heat is less than 2.5 kW
Operating Temperature (°F)	1010 (maximum fuel cladding temperature)
Operating Pressure (psig)	117 (maximum)
Outside Surface Dose (mrem/hr)	53 (maximum)

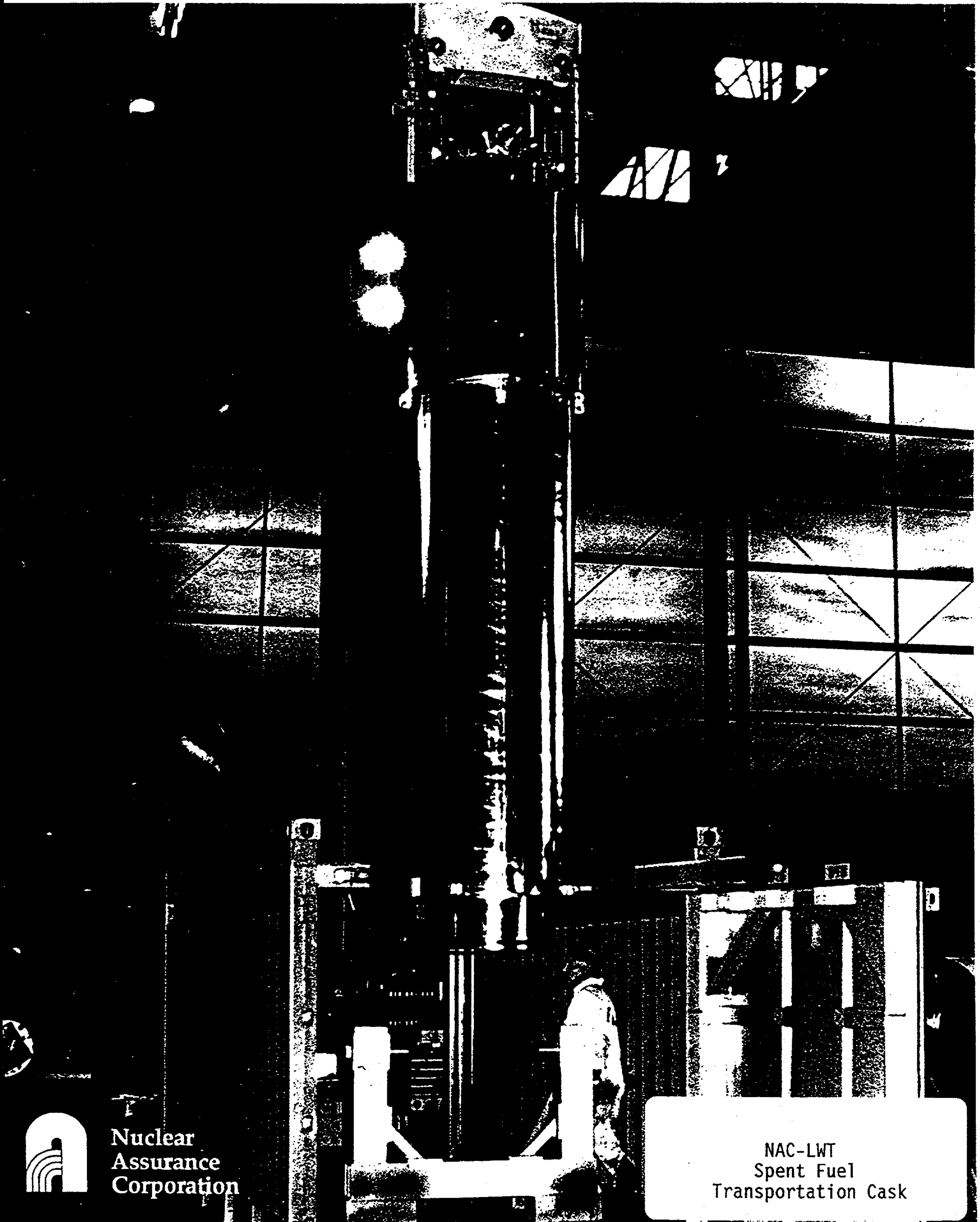
Licensing Status - Initially licensed by the USNRC in 1974; can be used to ship either intact or consolidated LWR fuel.

Comments - Casks have separate baskets for PWR and BWR fuel. There are five casks currently in existence.



PROPRIETARY
INFORMATION

NUCLEAR ASSURANCE CORPORATION
SPENT FUEL STORAGE CASK BODY
NLI-1/2



NAC-LWT
Spent Fuel
Transportation Cask

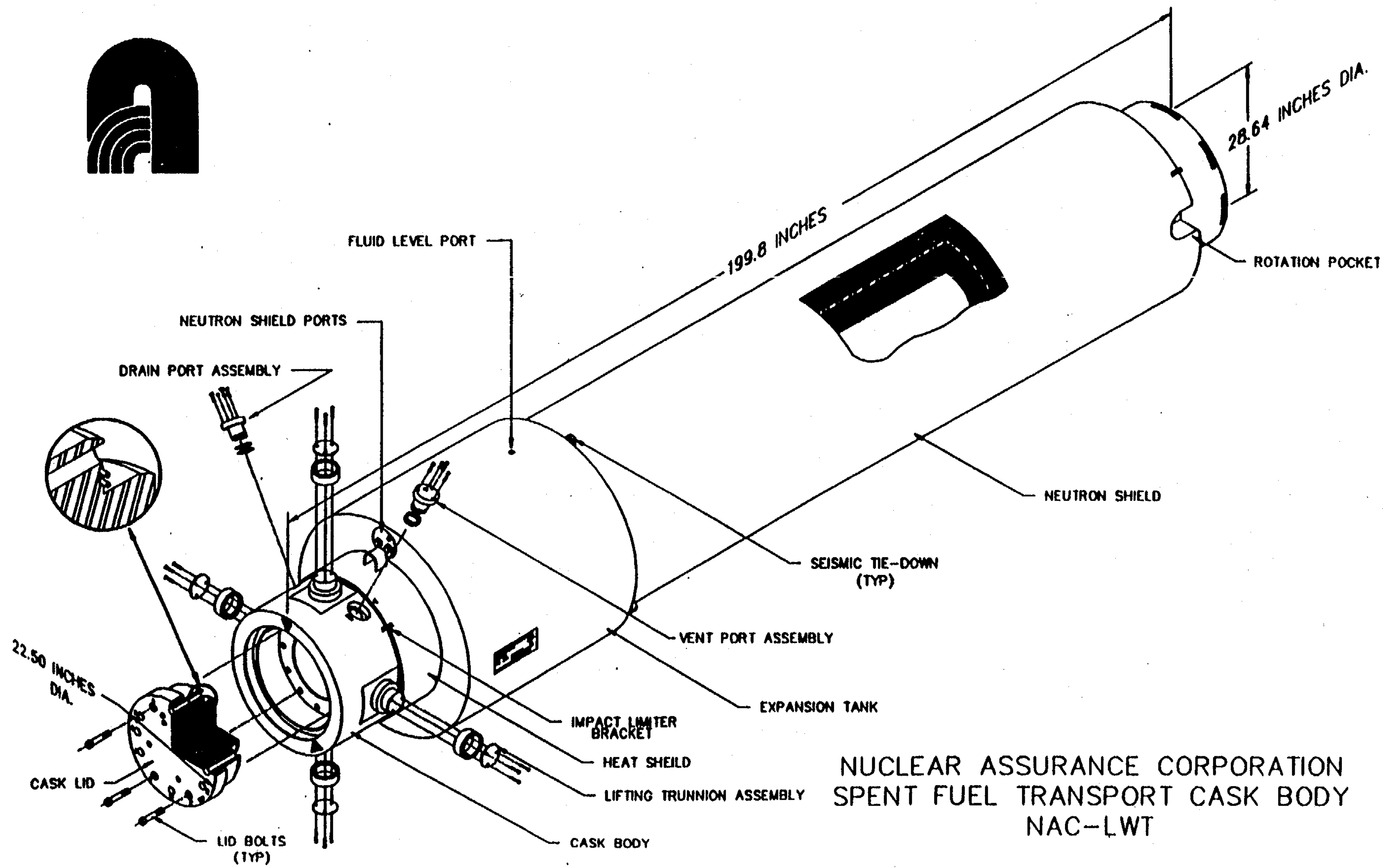
Nuclear
Assurance
Corporation

NAC-LWT

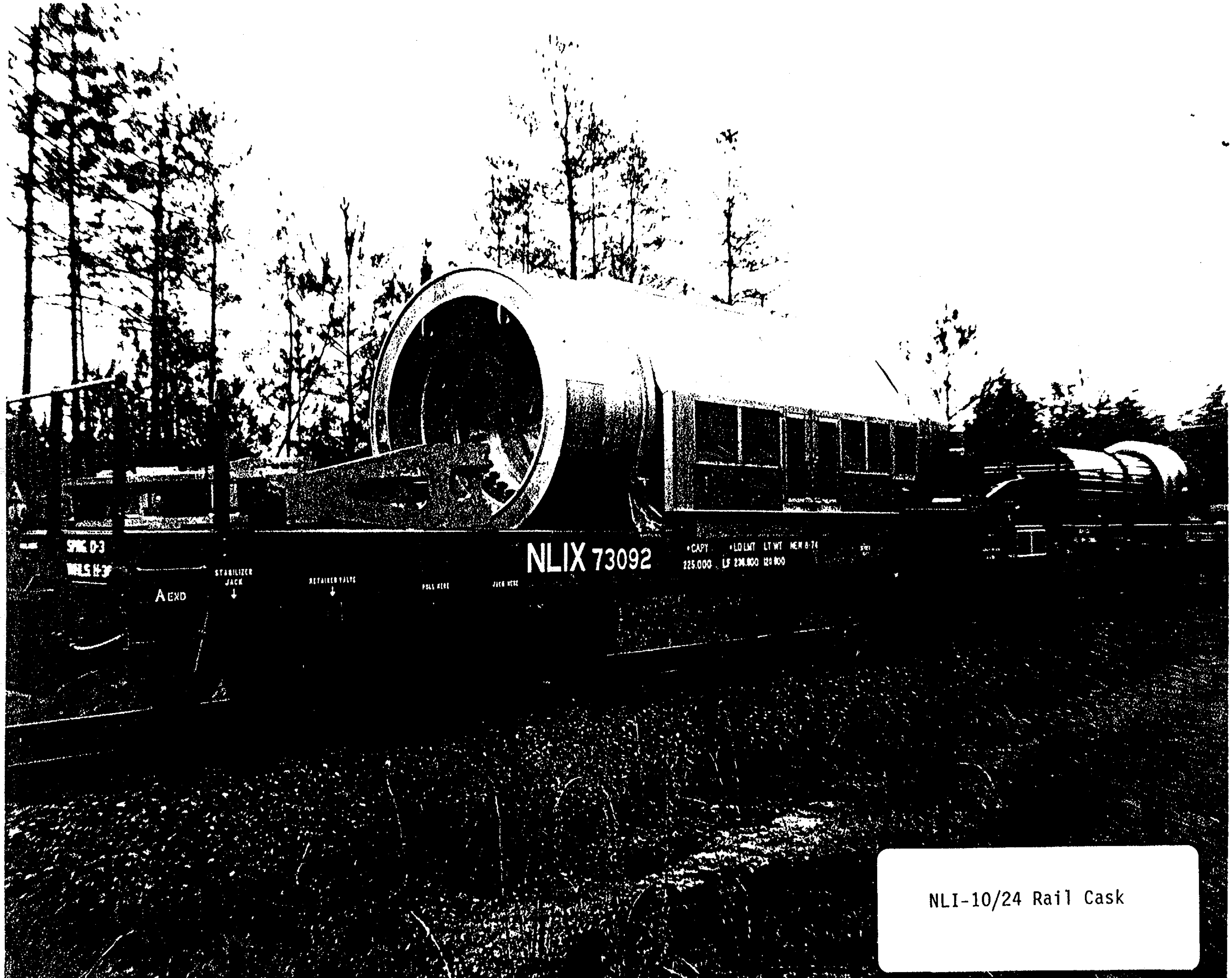
Designer	Nuclear Assurance Corporation
Type	Legal Weight Truck Shipping Cask
Capacity	
Intact Spent Fuel Assemblies	1 PWR; 2 BWR (3.7 w/o; 4.0 w/o enrichment)
Other Configurations	15 Metallic Fuel Rods
Weight (tons)	
Loaded	25.6
Empty	24.0
Design Heat Rejection (kW)	2.5
Shape	Cylindrical
Dimensions	
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
Materials of Construction	
Cask Body	SS/Lead/SS
Neutron Shield	
Sides	Water & Ethylene Glycol (1.0 w/o Boron)
End	None
Basket	Aluminum
Cooling Fins	None
Cavity Atmosphere	Air or Inert Gas
Operating Temperature (°F)	229 (cask radial surface; maximum)
Operating Pressure (psig)	0
Outside Surface Dose (mrem/hr)	100 (maximum)

Licensing Status - Safety Analysis Report submitted in March 1988 and licensed by the USNRC December 6, 1989.

Comments - Casks have separate baskets for one PWR, two BWR or metallic fuel. Legal truck weight 80,000 pounds (maximum).



NUCLEAR ASSURANCE CORPORATION
SPENT FUEL TRANSPORT CASK BODY
NAC-LWT



NLI-10/24 Rail Cask

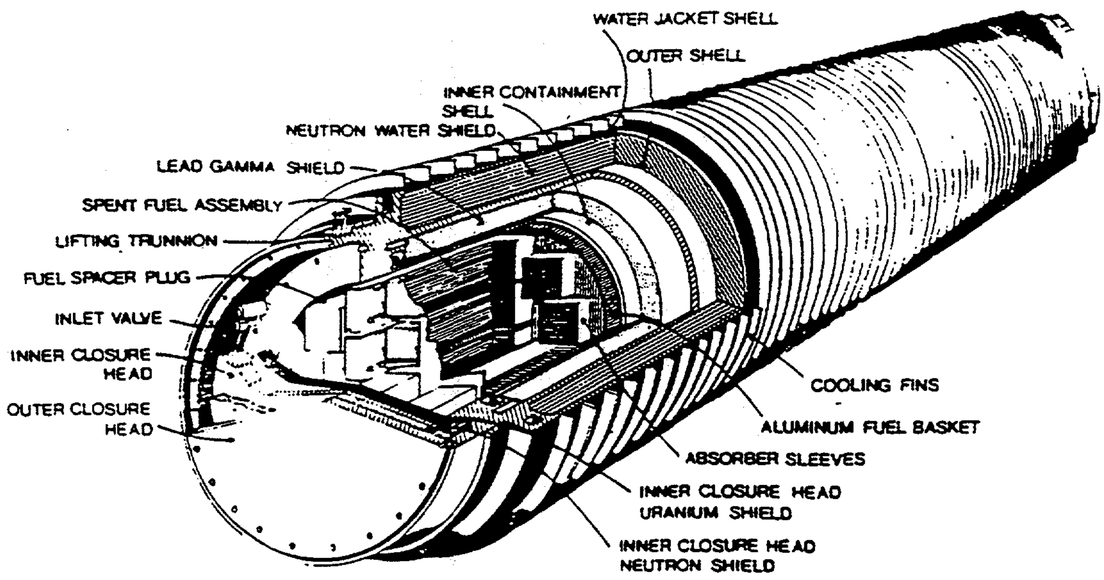
NLI-10/24

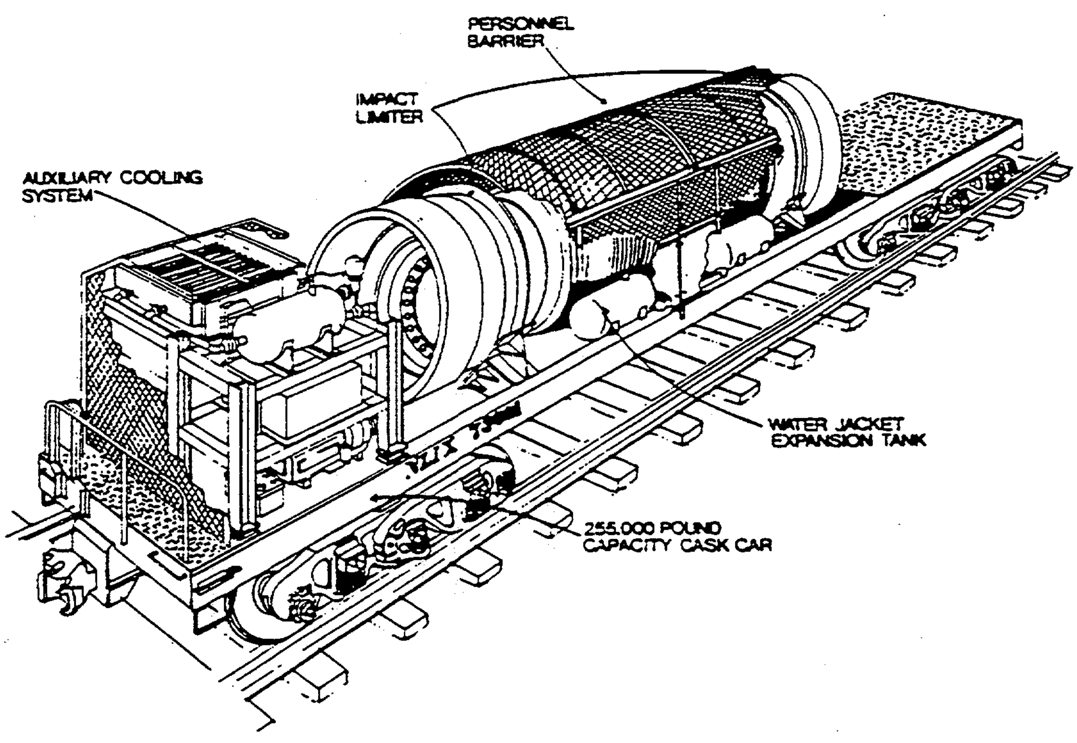
Owner	Nuclear Assurance Corporation
Type	Rail Shipping Cask
Manufacturer/Vendor	NL Industries Inc.
Capacity	
Intact Spent Fuel Assemblies	10 PWR; 24 BWR
Weight (tons)	
Loaded	96.5
Empty	89
Design Heat Rejection (kW)	70
Shape	Cylindrical
Dimensions	
Overall Length (in)	204.5
Overall Diameter (in)	88
Cavity 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
Materials of Construction	
Cask Body	SS/Lead/SS
Neutron Shield	
Sides	Water
Ends & Strategic Wall Locations	Ricorad
Basket	Aluminum-lined with Ag-In-Cd plates in SS
Cooling Fins	Concentric (forced water circulation cooling from separate cooling circuit)
Dry Shipment	
Atmosphere	He
Cavity Pressure (psig)	23.1 (normal); 500 (maximum.)
Normal Operating Temperatures (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)
Outside Surface Dose (mrem/hr)	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.

NL 10/24 RAIL CASK





Appendix D-3

General Atomics--Cask Rates and Specifications

GENERAL ATOMICS

NWM:RMG:198:93
File 6.25.3
April 27, 1993

Mr. David Burton
Morrison-Knudsen Corp.
180 Howard
San Francisco, CA 94105

Dear Mr. Burton:

Please find enclosed the information you requested concerning the use of GA's FSV-1 Cask.

If you have any questions or if I can be of any assistance, please don't hesitate to call me at 619-455-2583 (FAX 619-455-2596).

Sincerely,

Robert M. Grenier

Robert M. Grenier
Director
Nuclear Waste Management Division

RMG/j

Enclosure

cc: D. Rickard

GENERAL ATOMICS

INFORMATION REQUEST
TO
MORRISON KNUDSEN CORP.
April 27, 1993

FSV-1 CASK

Daily Rent *	$1,200 / Day
Transportation	Actual Costs Plus 15%
Burial Liners	$8,000 / Each

LABOR RATES

Staff Engineer	$ 110 / Hour
Senior Engineer	$ 90 / Hour
Engineer	$ 78 / Hour
Technician	$ 68 / Hour

PER DIEM

DOE Allowables

* Minimum rent duration is 30 days; includes all calendar days including shipping time; includes lifting yoke.

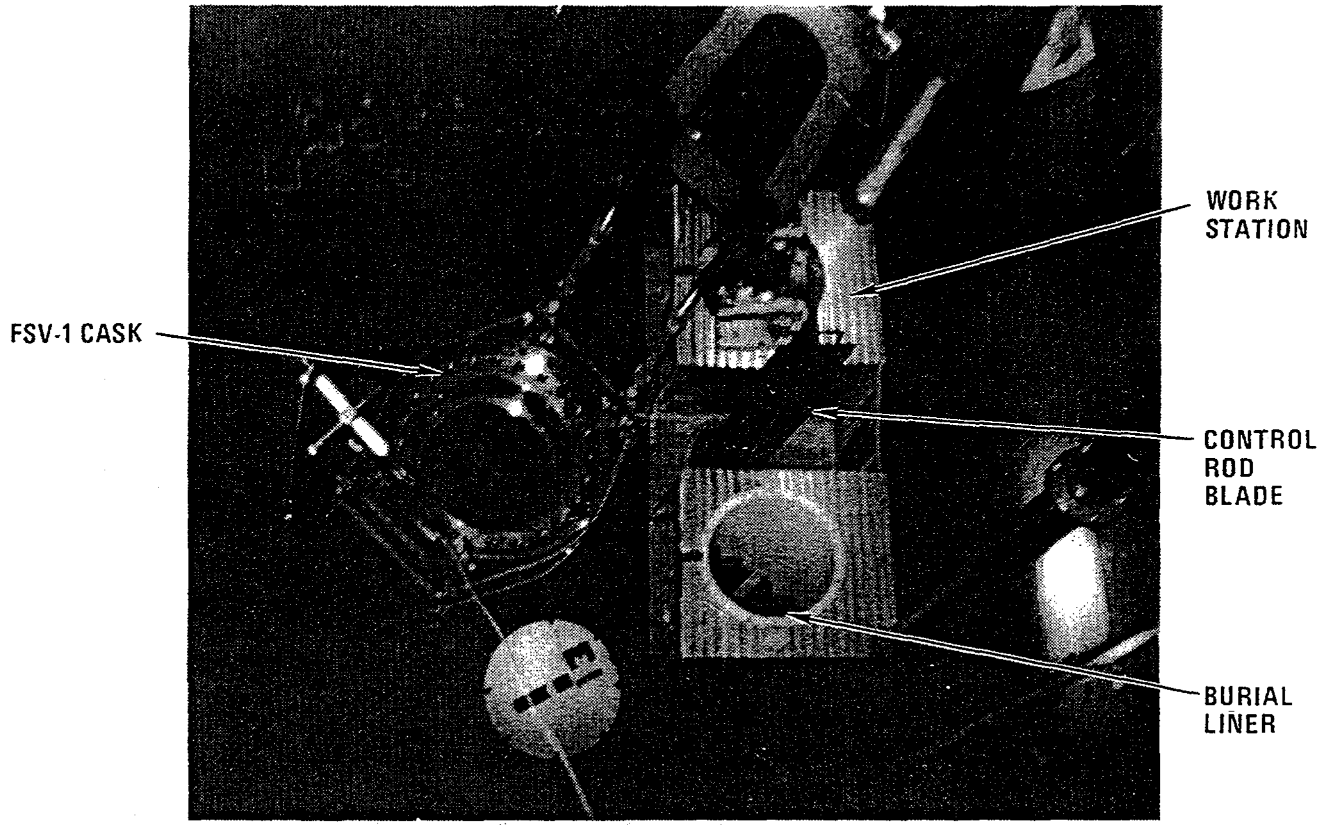
BURIAL LINER VOLUME

$26\ Ft^3$

MAX ALLOWABLE CONTENTS WEIGHT (Includes 750 lbs weight of burial liner)	3720 Lbs

3550 GENERAL ATOMICS COURT, SAN DIEGO, CA 92121-1194 PO BOX 85608, SAN DIEGO, CA 92186-9784 (619) 455-3000

BWR CONTROL ROD AND IRRADIATED HARDWARE DISPOSAL



In 1983, GA became the first to successfully dispose of irradiated BWR control rod blades when the first nine shipments were made from the Monticello nuclear plant in Minnesota. Since then, GA has shipped about 400 control rod blades from seven different BWR plants.

GA's Model FSV-1 cask can carry 4 intact BWR control rod blades. Additionally, in response to the high cost of burial, GA has developed a compaction system that increases the cask capacity to up to 12 control rod blades. GA's volume reduction equipment uses shears and a compactor, and unlike systems that use saws, GA's equipment does not generate chips and debris.

GENERAL ATOMICS

EXPERIENCED AND RELIABLE

GA provides a full range of BWR control rod and irradiated hardware disposal services, from simple cask and equipment leasing to managing and staffing operations from start to finish. Our personnel will:

- provide utility liaison to ensure proper matchup with utility handling equipment and procedures
- train utility personnel on site
- provide fuel pool operations manpower
- perform radwaste survey and analysis
- optimize packaging to minimize burial costs.

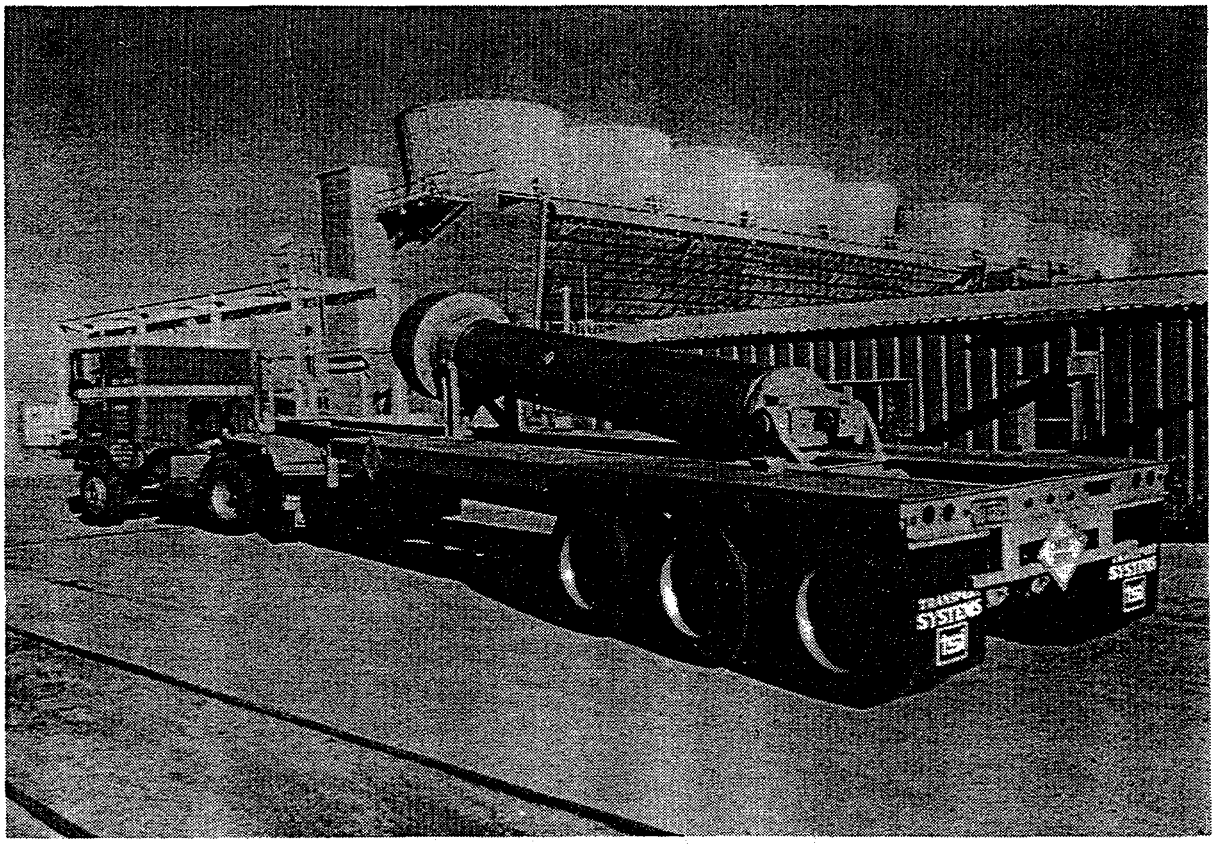
GA's EQUIPMENT IS TAILORED TO UTILITIES' NEEDS

In-Pool Work Station	When suspended from the curb of the fuel pool, holds the control rod blade, FSV-1 burial liner, and receiving container for stellite balls and axles.
Control Rod Corner Shear	Removes stellite balls and axles.
Control Rod Inverter, Reach Tool, and Grapple Tool	Provides efficient means for handling control rod blades.
Mobile and Stationary LPRM Cutters and LPRM Grapples	Simplifies preparation and handling of LPRMs.
Control Rod Velocity Limiter Shear	Removes velocity limiters prior to blade compaction.
Control Rod Compactor	Flattens the cruciform cross-section of the control rod blade to 1 in. thickness. Triples the capacity of the FSV-1 burial liner.

GA augments its BWR control rod and irradiated hardware disposal equipment with miscellaneous handling tools, fixtures, and underwater vacuuming systems.

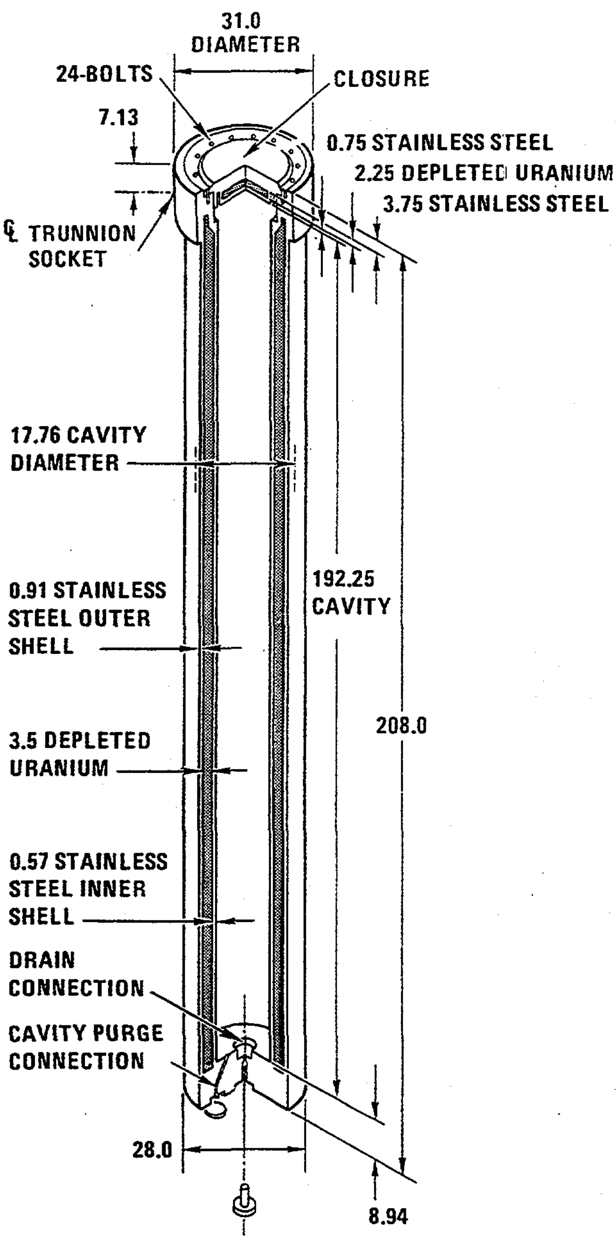
MODEL FSV-1 CASK

GA designed, procured, and now operates the FSV-1 casks. GA has used the FSV-1 casks to ship control rod blades and contaminated hardware from utilities around the country to a burial site in South Carolina. Utilities prefer the FSV-1 because of its simple design and ease of handling. Repeated use in fuel pools has demonstrated that the smooth, stainless steel walls and uncluttered exterior of the cask minimize contamination and simplify cask clean-up. In addition, the ample length of the internal cavity allows shipments of BWR control rod blades with minimal preparation. Shipments in the FSV-1 are legal weight, thus, avoiding the restrictions and limitations associated with overweight radioactive shipments.



GENERAL ATOMICS

MODEL FSV-1 TRANSPORTATION SYSTEM



DIMENSIONS ARE IN INCHES

FSV-1 SPECIFICATIONS

Cask	Type B, NRC Certificate of Compliance No. 6346, Revision 16
Authorized Contents	Irradiated HTGR fuel and irradiated and contaminated hardware
Primary Shielding	Depleted uranium encased in stainless steel
Cask Weight	42,300 lbs, empty
Maximum Contents Weight	3700 lbs
Thermal Rating	4.1 kW

TRAILERS

The FSV-1 casks are shipped on dedicated legal weight trailers fitted with tiedown and handling equipment. The rear tiedown pivots for vertical loading and off-loading of the cask from the trailer. The front tiedown clamps the cask against a cradle. The trailers are available with and without personnel barriers. Each trailer weighs 9,100 lbs.

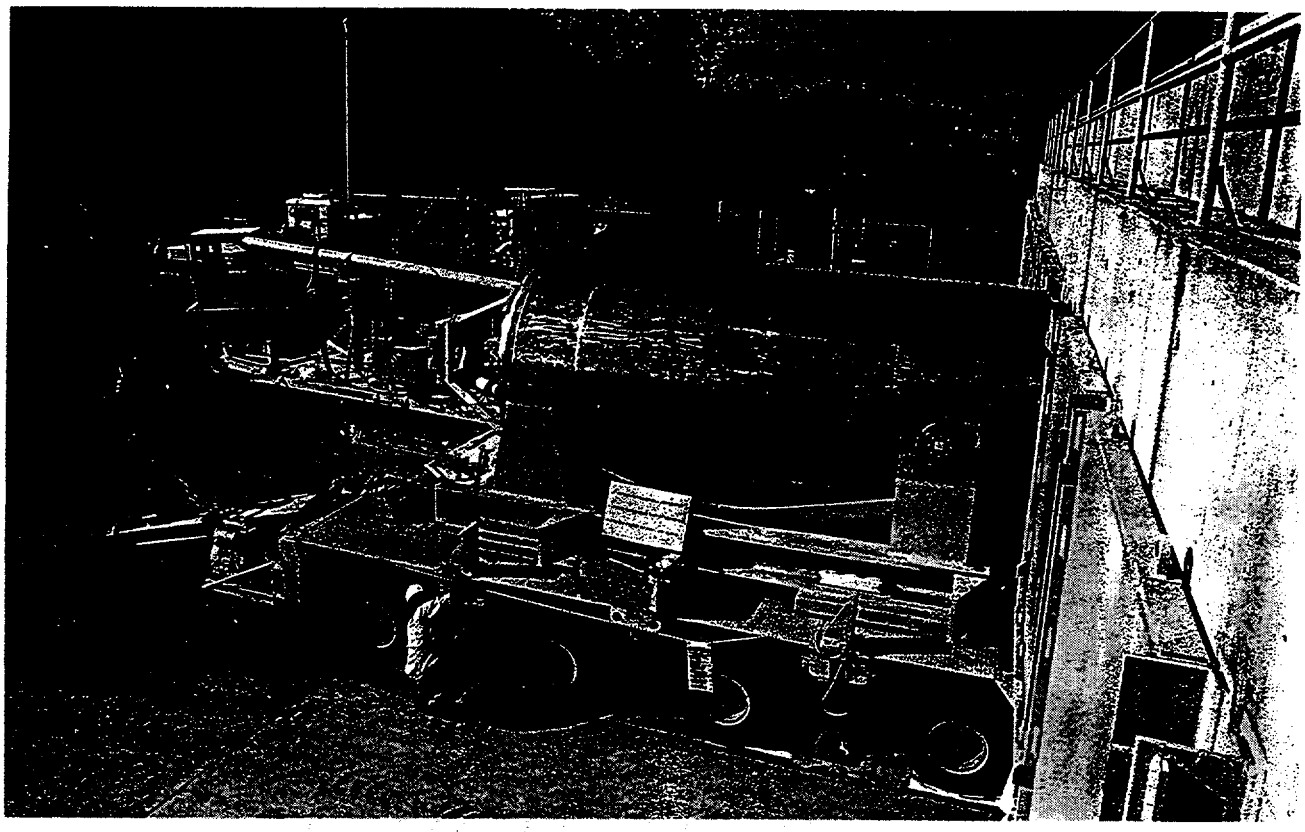
CASK HANDLING

The FSV-1 cask lifting system consists of a (1) lifting yoke which engages two trunnion sockets in the upper cask body and (2) a redundant lifting system mounted to the cask at the upper collar.

The lifting yoke is remotely operated using a water actuated hydraulic cylinder. The design is inherently fail-safe since the yoke arms are forced together by the weight of the cask, independent of the action of the operating cylinder.

DOE/RW-0355P
OCRWM Fact Sheet

Storage of Spent Nuclear Fuel

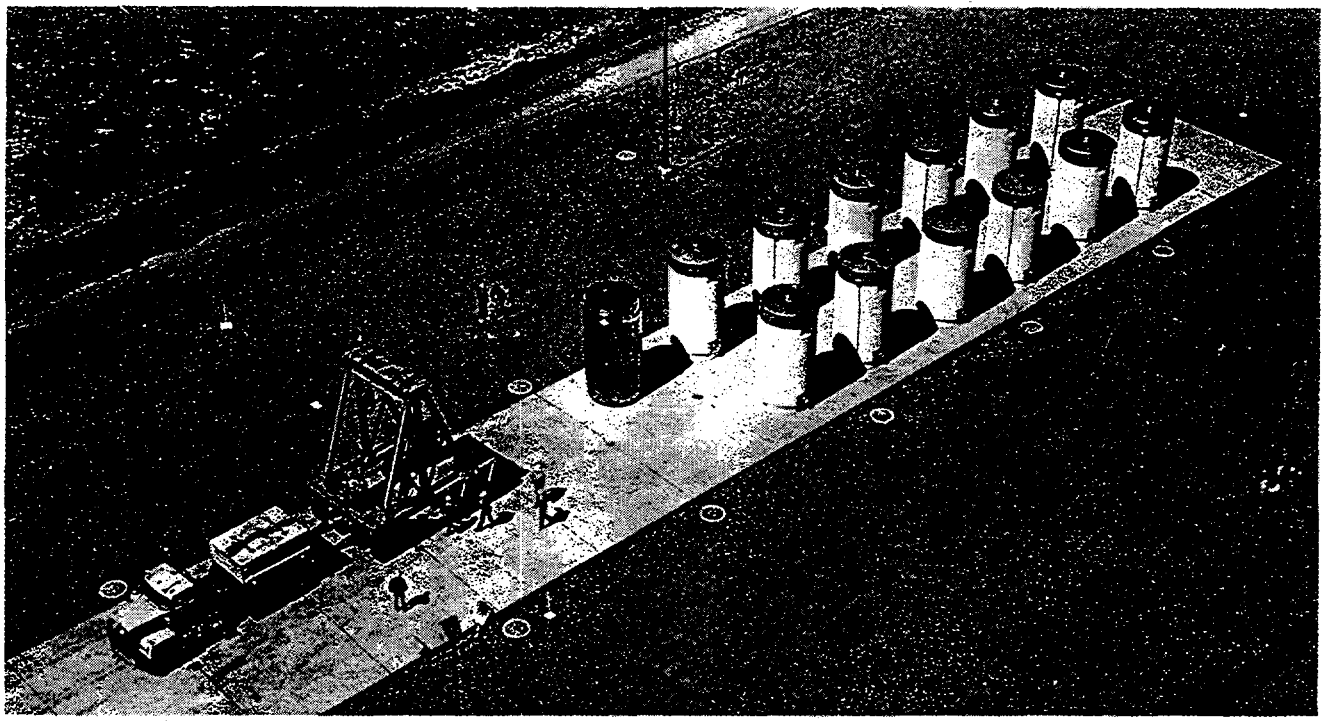


Loading of spent nuclear fuel into a concrete storage module from shielded transfer cask at Duke Power's dry storage facility.

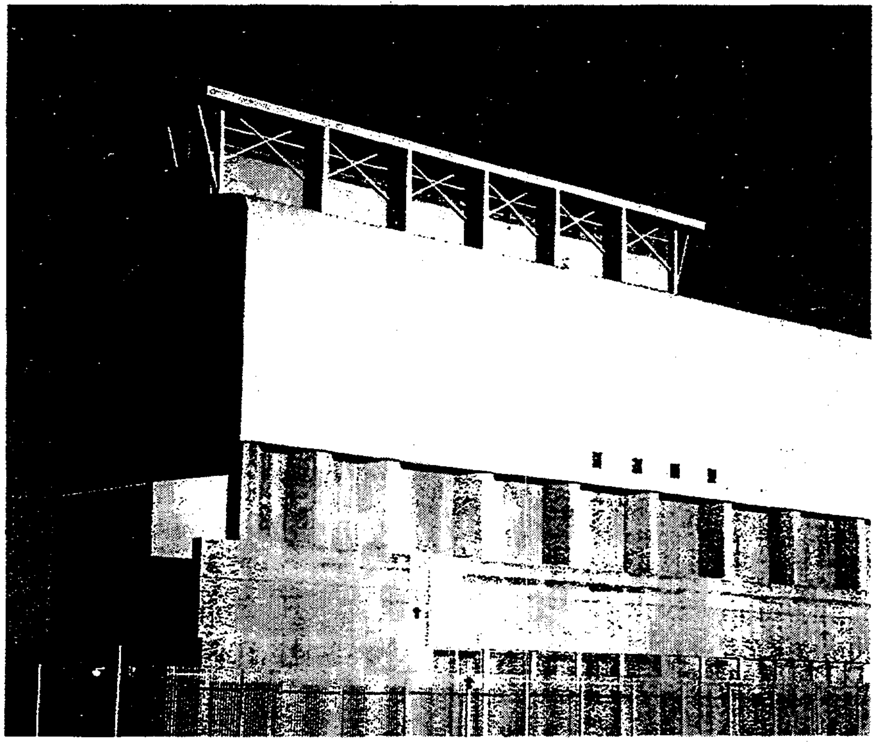
Nuclear waste is material that either contains a radioactive substance or has been contaminated by radioactive elements and is no longer useful. It includes waste products from nuclear processes, such as mining uranium ore, fissioning of uranium in commercial nuclear power plants, processing defense materials, and preparing nuclear isotopes for use in medical applications. It also includes used protective clothing and containers that once held nuclear material.

In 1983 Congress enacted the Nuclear Waste Policy Act (NWPA), which outlines a comprehensive plan for the safe disposal of spent nuclear fuel and other forms of high-level nuclear waste. It also includes development of a mined, geologic repository for long-term disposal of all forms of high-level radioactive wastes. An amendment enacted in 1987 authorizes the development of a temporary, above-ground storage facility called a Monitored Retrievable Storage (MRS) facility. The MRS will store a limited amount of "spent" or "used" nuclear fuel from commercial nuclear power plants, a solid form of radioactive waste.

To produce electricity, nuclear power plants use solid, ceramic fuel pellets made of uranium. Tremendous amounts of energy are stored in the centers of uranium atoms. When these atoms split, highly radioactive fission products are generated along with the large amounts of heat that make steam to turn turbine generators. The rock-hard fuel pellets are encased in strong metal rods. After three or four years in an operating nuclear reactor, the energy remaining inside the pellets is no longer efficient enough to produce usable heat and the pellets have become highly radioactive. These pellets and the surrounding rods must be isolated from the human environment for long periods of time, on the order of thousands of years. Until a permanent repository is in operation, spent fuel will continue to be stored in above-ground facilities such as the ones shown. The MRS will build upon



Storage of spent nuclear fuel in metal storage containers at Virginia Power's dry storage facility.



A modular vault dry storage facility operated by the Public Service Company of Colorado built to hold spent nuclear fuel.

storage technologies already in operation and demonstrated to be safe.

The U.S. Department of Energy (DOE) is responsible for the Nation's Civilian Radioactive Waste Management System. Within DOE, the Office of Civilian Radioactive Waste Management (OCRWM) is charged with executing policy and managing the program to safely dispose of used nuclear fuel and other forms of high-level radioactive waste.

For more information, please write:
OCRWM Information Center
Post Office Box 44375
Washington, D.C. 20026
or call: 1-800-225-NWPA
(or call 488-5513 in Washington, D.C.)

Published by the U.S. Department of Energy
Office of Civilian Radioactive Waste Management
(OCRWM)

Please recycle.

August 1992

Cask Systems Development:

GA-4 & GA-9 Truck Cask

INTRODUCTION

The Nuclear Waste Policy Act of 1982, as amended, made the Office of Civilian Radioactive Waste Management (OCRWM) of the U.S. Department of Energy (DOE) responsible for managing the program for the permanent disposal of spent nuclear fuel from commercial power plants and high-level radioactive waste from national defense activities.

Transportation casks will contribute toward the safety of the nuclear waste transportation system. They will protect the public and transportation workers from potential exposure to radiation during normal transportation activities and if an accident occurs. This protection is provided through the use of rugged materials designed and constructed according to regulations established by the U.S. Nuclear Regulatory Commission (NRC).

The OCRWM Cask Systems Development Program is designing a variety of casks to safely transport radioactive waste from the generator sites to a geologic repository or a monitored retrievable storage facility. Five contracts have been awarded; three to develop rail/barge casks and two for legal-weight truck casks.

As of December 1989, all five cask contractors had submitted preliminary designs to the OCRWM. The designs have been reviewed by a Technical Review Group composed of national experts in cask development areas. This backgrounder describes the General Atomics GA-4 and GA-9 spent fuel shipping casks for legal-weight truck shipments.

Contractor

General Atomics Corporation
San Diego, California

Features

Square cask cavity
Two specialized designs: one exclusively for pressurized-water reactor (PWR) and another exclusively for boiling-water reactor (BWR) fuel.

Payload
4 PWR (GA-4) or 9 BWR (GA-9) intact fuel assemblies

Structural material
Stainless steel

Basket
Stainless steel

Gamma shielding
Depleted uranium

Neutron shielding
Borated polyethylene

Closure type
Bolted

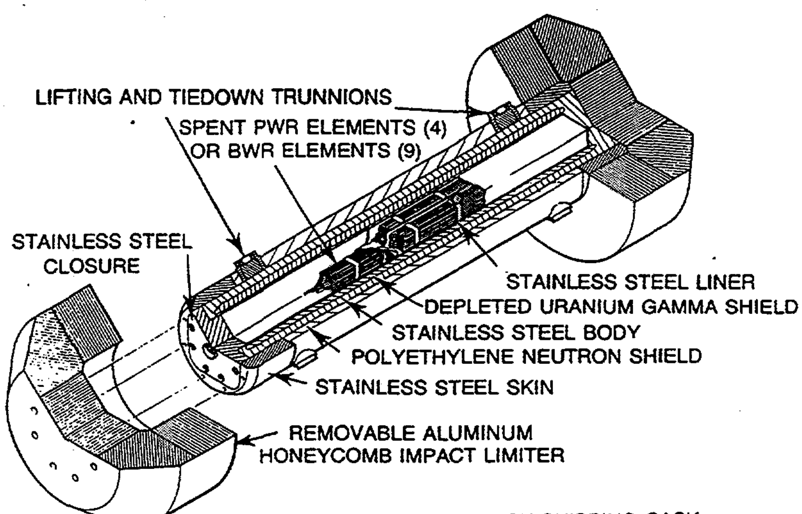
Impact limiters
Aluminum honeycomb with stainless steel shell

Type of Cask

27-ton legal-weight truck shipping casks

Size

Length—19.5′ (GA-4) and 20.3′ (GA-9)
Diameter—7.5′ and 7.5′ (with impact limiters)
Weight—26.3 and 26.45 tons



GA-4/GA-9 LEGAL-WEIGHT TRUCK SHIPPING CASK

General Atomics Corporation GA-4 and GA-9 27-Ton Legal-Weight Truck Shipping Casks

General Atomics Corporation's GA-4 and GA-9 are two specialized shipping cask designs: one for pressurized-water reactor fuel assemblies and the other for boiling-water reactor fuel assemblies. The casks' stainless steel structural material has distinctive shaped cross-sections that minimize weight and maximize payload. Neutron shielding is provided by borated polyethylene and the gamma shielding is constructed of depleted uranium. The removable impact limiters are made from aluminum honeycomb with a stainless steel shell.

Casks must meet design performance standards, testing conditions, and certification requirements established by the NRC. Cask design certification applications must demonstrate to the NRC, through analysis and/or testing, that casks can withstand both normal transportation and accident conditions, as specified in Federal regulations.

Published by the Office of External Relations and Policy
To provide current background information on program facts, issues and initiatives. For further information write to: Information Services Division, Office of Civilian Radioactive Waste Management, U.S. Department of Energy, Mail Stop RW-43, Washington, DC 20585.

Interface Guidelines, Cask Size/Weight Limits

Diameter—6′

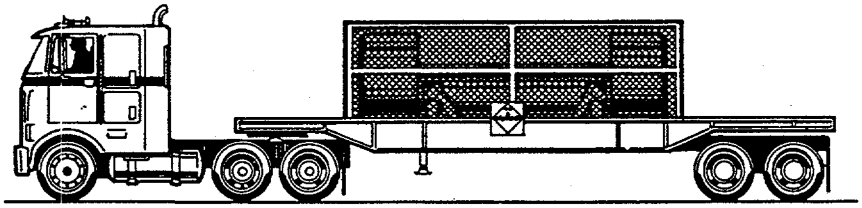
Height (Length)—Limited by headroom

Headroom—22′

Cask loading height—18′

Gross vehicle weight—40 tons (max.) including tractor, trailer, and loaded cask

Shipping Cask with Personnel Barrier on Truck Trailer



Appendix E

Backup Data for SNF Rail Shipments

Appendix E-1: IF-300 Product Literature
Appendix E-2: BR 100 Design Information
Appendix E-3: M-140 Cost Information
Appendix E-4: Railroad Rate Quotations

Appendix E-1

IF-300 Product Literature

NEDO-10864C
79NED47R
Class I
July 1983

General Description

IF-300 Irradiated Fuel Transportation System

NUCLEAR ENERGY BUSINESS OPERATIONS • GENERAL ELECTRIC COMPANY
SAN JOSE, CALIFORNIA 95125

GENERAL ELECTRIC

DISCLAIMER OF RESPONSIBILITY

This general description was prepared by General Electric Company and is being made available without consideration. General Electric Company does not:

A. *Make any warranty or representation, expressed or implied, with respect to the accuracy, completeness, or usefulness of the information contained in this report, or that the use of any information disclosed in this report may not infringe privately owned rights; or*

B. *Assume any responsibility for liability or damage which may result from the use of any information disclosed or contained in this general description document.*

CONTENTS

	Page
FEATURES OF THE IF-300 IRRADIATED FUEL TRANSPORTATION SYSTEM	1
EQUIPMENT DESCRIPTION	2
Design Summary	2
Cask	7
Skid and Supports	9
Cooling System	11
Enclosure	12
Cask Lifting Yokes	12
SAFETY ANALYSIS AND LICENSING REQUIREMENTS	12
IF-300 Licensing Status	12
Licensing Procedures	15
Design Conditions	15
EXPERIENCE	16
Cask Fabrication	16
Fuel Shipments	16
TRANSPORTATION SUPPORT SERVICES	17
Site Facilities	17
Pre-Shipment Preparations	17
Personnel Training	17
SUMMARY	17

ILLUSTRATIONS

Figure	Title	Page
1	IF-300 Irradiated Fuel Transportation System in Normal Rail Configuration	3
2	IF-300 Irradiated Fuel Shipping Cask	4
3	IF-300 General Arrangement — Side View	5
4	IF-300 General Arrangement — Front View	6
5	Intermodal Transportation Transfer	7
6	Typical Fuel Basket Spacer Discs — BWR/PWR	10
7	Whiting Arrangement of Redundant Yoke Assembly	13
8	Isometric of the Redundant Yoke	14

FEATURES OF THE IF-300 IRRADIATED FUEL TRANSPORTATION SYSTEM

The IF-300 Irradiated Fuel Transportation System is designed to transport irradiated (spent) nuclear fuel in accordance with the requirements of the Nuclear Regulatory Commission (NRC), and the Department of Transportation.* The system is operational under Certificate of Compliance 9001, which was originally issued by the NRC (then Atomic Energy Commission) in 1973. At the present time, this Certificate permits shipment of all currently used Boiling (BWR) and Pressurized (PWR) Water Reactor fuel in a dry mode. Fuels of nominal burn-up can be shipped after approximately 2-1/2 years of cooling time. The cask is presently utilized in a "zero-release" configuration and uses a rupture disk device for overpressure protection rather than the original controlled-release valve.

The IF-300, which has a capacity of 7 PWR or 18 BWR bundles, was the first multi-bundle cask with the neutron shielding required for high exposure fuel. It is the only multi-bundle cask with actual operating experience and is noted for its relative compactness and ease of handling in currently operating nuclear stations.

Capacity, weight, and dimensional specifications of the IF-300 are as follows:

Capacity	**BWR**	**PWR**
Bundles	18	7
Approximate Maximum Loaded Weight (wet)**		
Cask only, pounds	140,000	136,000
Skid, enclosure, and cooling system, pounds	45,000	45,000
Rail Car	75,000	75,000
Total System, pounds	260,000	256,000
Cavity		
Length, inches	180	169
Diameter, inches	37.5	37.5
Cask Body		
Length, inches	208	198
Nominal Diameter, inches	64	64
Redundant Yoke		
Weight, pounds	15,000	15,000
Standard Yoke		
Weight, pounds	5,000	5,000
Skid		
Length, feet	37.5	37.5
Width, feet	8	8
Heat Dissipation		
Btu/hr	40,000	40,000

*U.S. Code of Federal Regulations, 10CFR71 and 49CFR17

**Weight of water in cask when removed from pool is approximately 4,000 pounds.

EQUIPMENT DESCRIPTION

DESIGN SUMMARY (Figures 1, 2, 3, 4, and 5)

The General Electric IF-300 Irradiated Fuel Transportation System is designed to ship 18 BWR bundles or 7 PWR fuel bundles. The various loads are individually accommodated through the use of removable fuel baskets and two different length closure heads.

Transportation is primarily by rail, although the skid is designed to accept wheel assemblies for short-haul, special permit trucking. This dual-mode shipping configuration permits the use of the IF-300 cask at those reactor sites which have no direct rail access. The short-haul capability is used to move the cask and equipment skid to the nearest convenient railhead, where it can be transferred to its railroad car using roll-on/roll-off techniques.

The cask is mounted on the skid in a horizontal position during transport. It is supported on the skid by a saddle at the head end and a cradle at the bottom end. The cradle forms the pivot about which the cask is rotated for vertical removal from the skid. There is one pickup position on the cask body just below the closure flange. At this same location, the support saddle engages the cask.

The cask is lifted by a special yoke, designed to be used with either length head. This yoke accepts the normal reactor building crane hook in its upper end and engages the cask lifting trunnions with two hooks on its lower end. The cask head is removed using four steel cables which are part of the yoke. A single yoke is used for both cask rotation and cask lifting. Also available, where needed, is a redundant lifting yoke designed to interface with single failure-proof reactor building cranes. The redundant yoke is a necessary component of the critical load lifting system installed in certain reactor plants to provide protection against the occurrence of a cask drop accident.

All external and internal surfaces of the cask are stainless steel. Both gamma and neutron shielding are provided by the depleted uranium metal within the cask shell and by the exterior water-filled annular enclosure. This enclosure is fabricated from thin-walled stainless steel and is corrugated to maximize the heat transfer area. These corrugations also significantly increase the strength of the outer jacket and its resistance to damage. The annular neutron shielding enclosure is attached to the cask body and masks the active fuel zone.

The cask cavity is sealed with a metallic gasket at the cask closure head. The maximum normal operating pressure of the cask cavity in the dry mode is less than 25 psig. However, the design working pressure is 400 psig at a cask body temperature of 815°F. Overpressure protection is provided by a rupture disk, with a burst pressure range of 350 to 400 psig at 443°F. The cask cavity is equipped with two nuclear service valves, one in each of two valve boxes, for filling, draining, venting, and sampling. These valves have quick disconnect fittings for ease in servicing. Both valve handles are secured during transit to prevent tampering. The neutron shielding water enclosure is protected from overpressure by a 200-psig relief valve. It is serviced by fill and drain valves located in the two valve boxes.

Fuel bundles are contained within a removable, slotted, stainless steel basket. Two alternate baskets are available, one designed to accommodate BWR bundles and one for the PWR bundles. Fuel bundles are restrained axially by spacers mounted on the inside of the closure head. The basket is centered within the cask cavity by nine spacer discs, mounted along the fuel basket length. Fuel bundles are inserted and removed from the basket using standard grapples. Criticality control is achieved by using B_4C-filled stainless steel tubes within the basket.

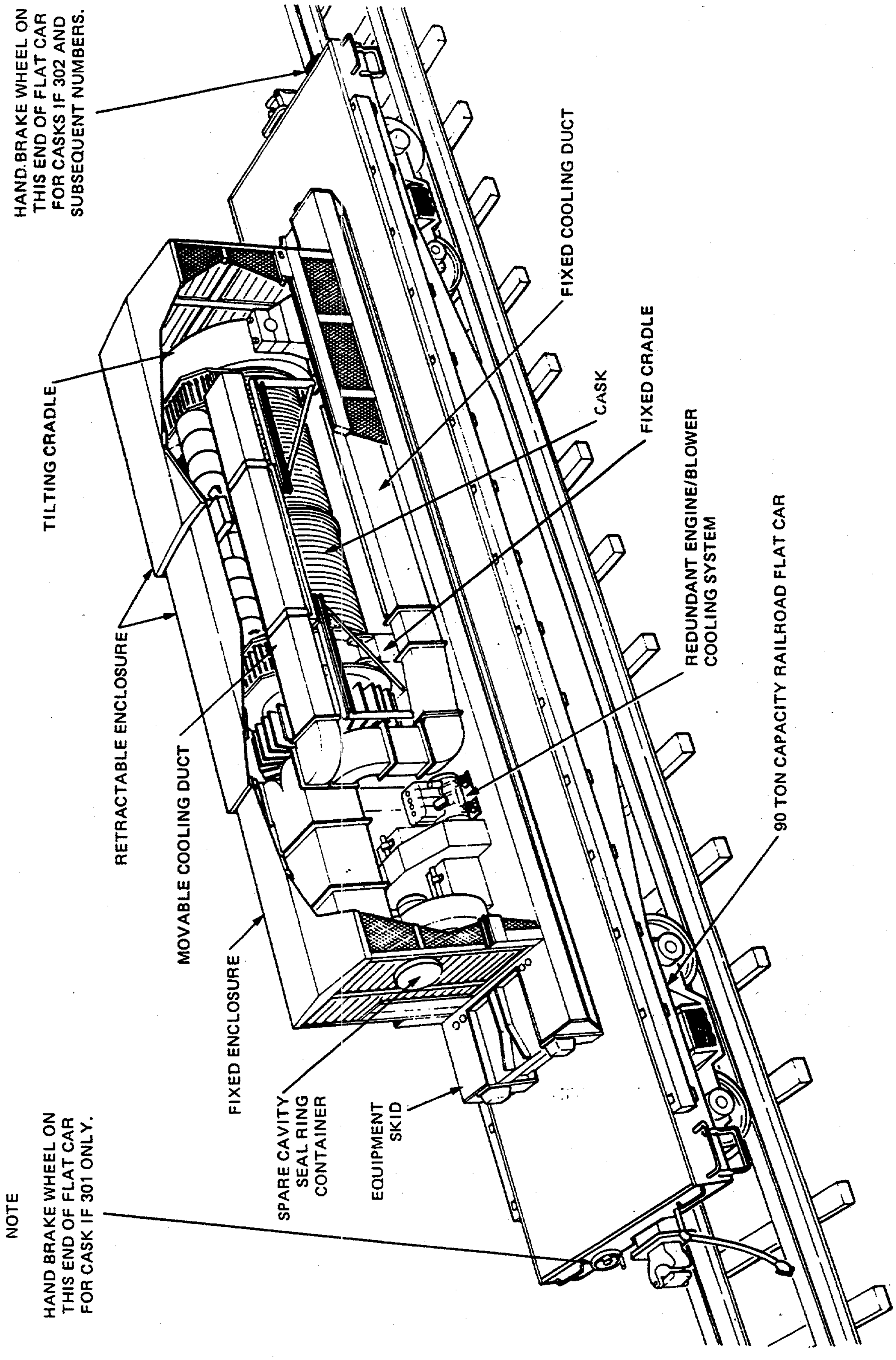


Figure 1. IF-300 Irradiated Fuel Transportation System in Normal Rail Configuration

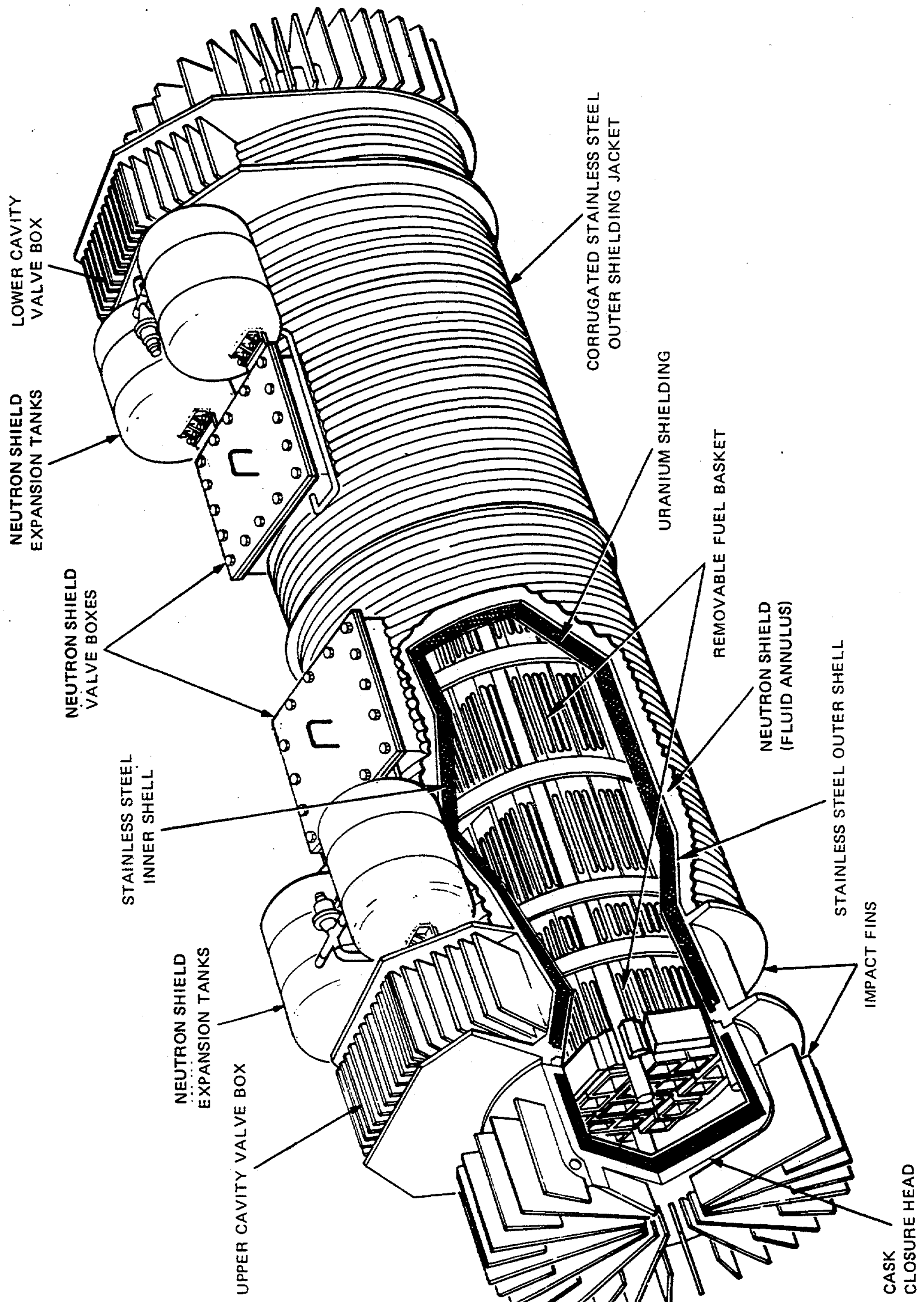


Figure 2. IF-300 Irradiated Fuel Shipping Cask

DIM	CAR SER NUMBERS GEX-50000, GEX-50001	CAR SER NUMBERS CPRX-10000, GEX-50003
A	12 ft	9 ft
B	4 ft	2 ft
C	53 ft 6 in.	48 ft 6 in.
D	38 ft	35 ft 10 in.
E	58 ft 6 in.	53 ft 8 in.

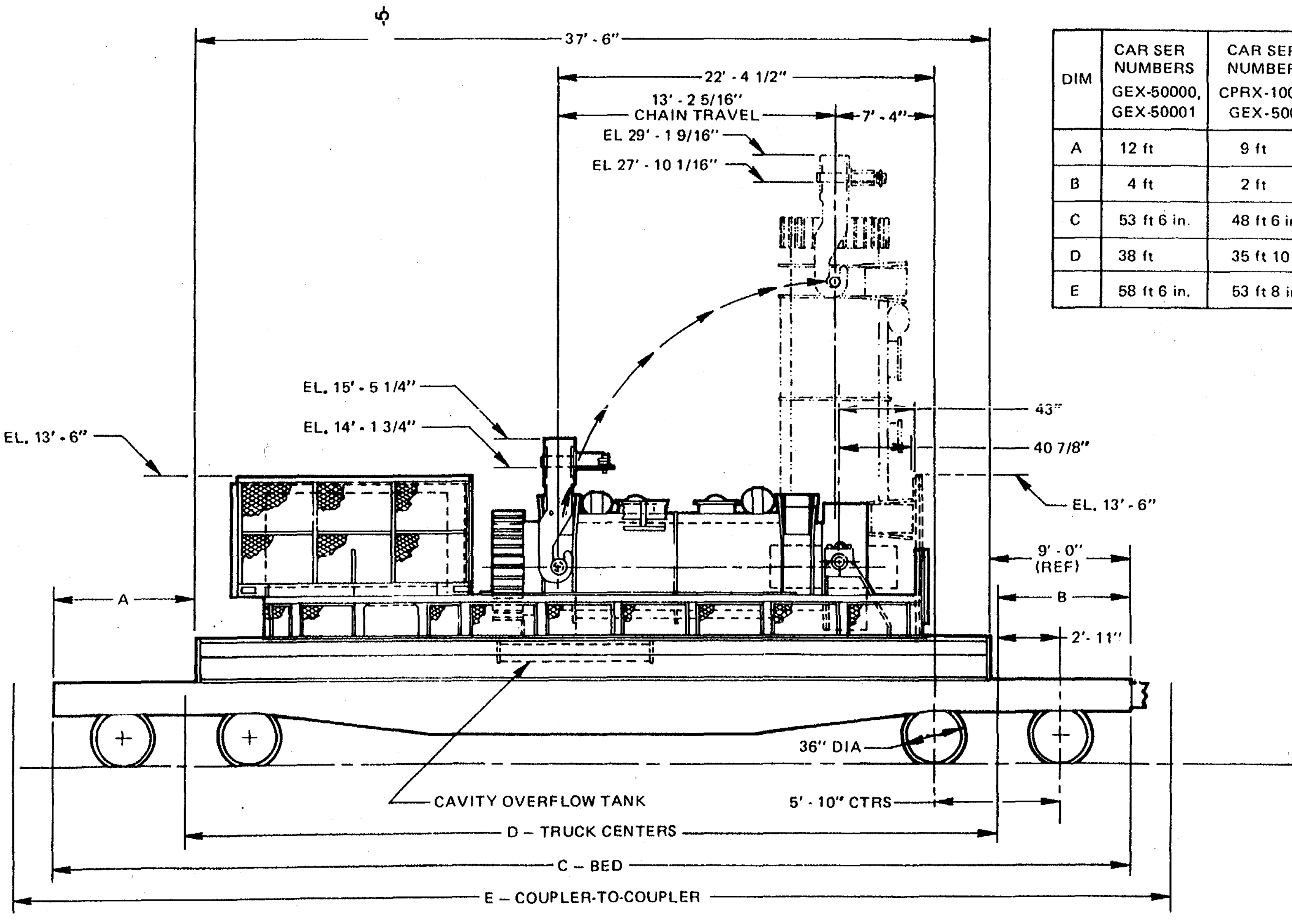


Figure 3. IF-300 General Arrangement — Side View

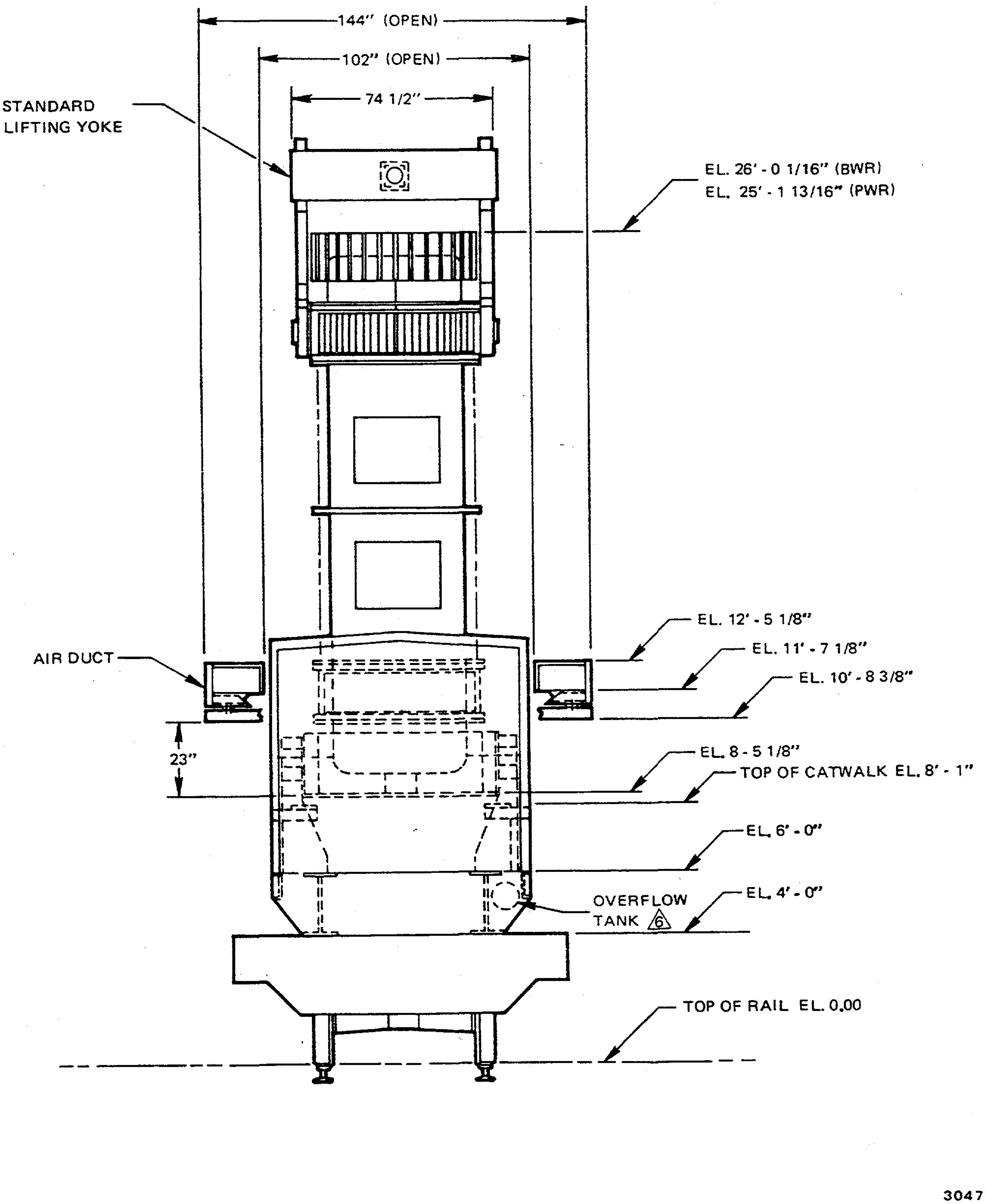


Figure 4. IF-300 General Arrangement — Front View

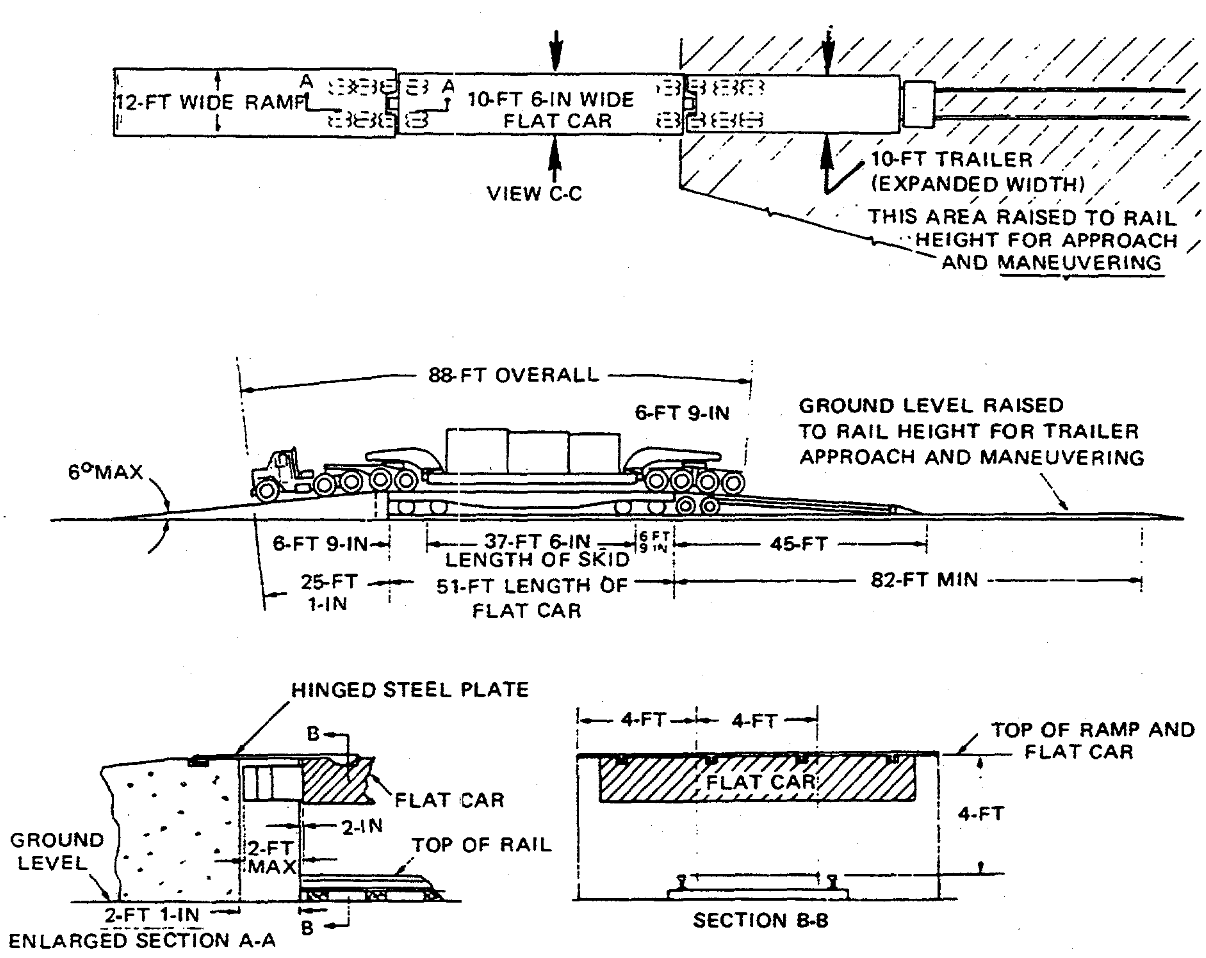


Figure 5. Intermodal Transportation Transfer

CASK

1. Cask Body

The IF-300 cask inner cavity is a stainless steel cylinder, 37-1/2-inch inside diameter and 1/2-inch-thick walls, having its bottom end sealed with a 1-7/16-inch-thick stainless steel plate. The upper end is welded to the closure flange. Processes and procedures described in Section III of the ASME Code were used for guidance in the fabrication of the cask.

Surrounding the inner cavity is the depleted uranium metal shielding material. This heavy metal assembly consists of annular castings, each with a 38-1/2-inch i.d. and a 4-inch-thick wall. Sections are interlocked, end-to-end, using an overlapping joint which holds the stack together and prevents radiation streaming. This assembly is shrink-fitted to the inner cavity to ensure good thermal contact for heat transfer purposes. The bottom end shield is a 3-3/4-inch-thick uranium metal casting.

To prevent the formation of a low melting point alloy of steel and uranium, a 5-mil-thick copper diffusion barrier is provided at every uranium-steel interface. This barrier is plated or flame-sprayed on the larger pieces such as the inner and outer shells. Copper foil is used in some of the smaller areas.

The outer body shell is also a stainless steel cylinder with a 46-1/2-inch i.d. and a 1-1/2-inch-thick wall. The outer shell is also shrink-fitted to the uranium to ensure good heat transfer characteristics.

The outer body shell of the cask is encircled by a thin-walled, corrugated stainless steel water enclosure jacket, extending axially from the upper valve box to a point slightly above the cask bottom, thus masking the active fuel zone. Water contained in this annular enclosure functions as a neutron shield. An antifreeze and water mixture is used when the cask is subject to cold ambient temperature conditions. The jacket surface is corrugated for heat transfer purposes. Additionally, the use of continuous corrugation provides a surface which is easily decontaminated. The jacket has a pressure rating of 200 psig and is equipped with fill, flush, and pressure relief valves.

Welded to the outer shell are four 1-1/4-inch-thick circumferential fins. These members serve as lifting rings and impact fins. They are also used to support the water jacket sections. The IF-300 cask is lifted by a set of trunnions located just below the closure head flange. These lifting trunnions are pinned to the upper pair of heavy rings and are designed to be removed for transit. The upper pair of lifting rings also acts as the forward support/axial restraint when the cask is in the horizontal transport position.

Radially mounted at the lower end of the cask are 32 stainless steel impact fins, 1-1/4 inches thick. Sixteen protrude 8-1/8 inches from the surface and the remaining protrude 6 inches. They are welded in place and prepared for ease of decontamination.

There are two large valve boxes on the exterior of the cask body nested between the pairs of impact fins. These fixtures have finned lids which are removed during loading and unloading. The head end valve box contains both a nuclear service vent and flush valve and a rupture disc device. The lower box contains a fill and flush valve only. Stainless steel Schedule 40 pipe connects the upper valve and the rupture disk device to the cask cavity side wall near the flange. The lower valve is connected to the inner cavity bottom, 180 degrees from the upper valve location. Both the stainless steel vent and flush valves are equipped with quick disconnect fittings.

Temperature monitoring is performed with a thermocouple mounted between the uranium and the inner cavity. This thermocouple is located equidistant from the ends of the cask body at what is expected to be the hottest axial point. The thermocouple is contained within a well which enters the bottom of the cask, thus permitting easy replacement.

The overall length of the cask body from fins to flange face is 184-3/16 inches. The cask cavity depth from the flange face is 169-1/2 inches. The flange is a stainless steel machined forging whose face contains 32 equally spaced studs, each of which is 1-3/4 inches in diameter. The studs protrude 6-3/4 inches from the face and are made of 17-4 PH stainless steel.

2. Cask Closure Heads

The IF-300 cask can be equipped with either of two different cask closure heads. These cask closure heads provide two alternate cask cavity lengths to match the particular dimensions of the fuel being shipped. With the short cask closure head in place, the overall cavity length is 169-1/2 inches. The long cask closure head increases the cavity to 180 inches. Most PWR fuel will be shipped using the short cask closure (PWR) head. BWR fuel (and some longer designs of PWR fuel) will necessitate using the extended cask closure (BWR) head.

Shielding in the cask closure heads consists of 3 inches of uranium. The outer shell and flange is a single stainless steel machined casting. A circular stainless steel plate is welded in place to form the cask closure head cover. As in the case of the cask body assembly, each steel-uranium interface is isolated with a 5-mil copper layer.

Each cask closure head has 32 radially mounted fins on the end, 16 of which protrude 9-1/2 inches from the surface. The remaining fins protrude 6 inches from the surface. These fins are designed to provide impact protection to the cask and contents. These fins are stainless steel and are welded in place.

Because of variations in fuel lengths, it is necessary to provide some spacing scheme. There are five spacer assemblies for the two cask closure heads. These spacers are mounted on circular plates which bolt to the top of the cask closure head cavity. Spacing is accomplished with struts and pads which protrude from the circular plate. Several sizes of basket bottom spacers are provided to elevate short bundles. Each plate is numbered and indexed to ensure proper installation.

3. Closure

The cask body is joined to either head, using the 32 studs in the body flange and an equal number of special sleeve nuts. Short, 3-1/2-inch-length nuts are used to secure the PWR cask closure head assembly. Because of its greater length, the BWR cask closure head must utilize 13-3/4-inch-long sleeve nuts. Using the sleeve nut approach makes it possible to change cask closure heads without changing the studs. Two guide pins provide alignment and orientation.

Cask sealing is accomplished using a metallic gasket. The cask closure head and body flanges interlock to provide shear steps to protect the gasket in case of impact.

4. Fuel Baskets (Figure 6)

Two different fuel baskets may be used in the IF-300 cask — a 7-cell PWR unit and an 18-cell BWR unit.

Each basket "cell" has walls which are slotted to provide coolant flow to the contained fuel. Cells are held in place by nine circular spacers equally placed along the basket length. These same spacers center the basket in the cask cavity. The basket cells run the full length of the fuel and function as guides for ease in fuel loading. When the cask is horizontal, the weight of the fuel bundles is carried by the spacer discs.

Criticality control in each fuel basket is provided by boron-carbide-filled stainless steel tubes located adjacent to the basket cells. Design and fabrication of these tubes follow GE/BWR practice for control rod blade absorber rods.

Both baskets are of welded, stainless steel construction. Each is keyed into the cask to prevent rotation during shipment. Basket removal is accomplished using a special basket removal yoke which engages two lifting bars at the upper end of the assembly.

SKID AND SUPPORTS

1. Equipment Skid (Figure 2)

The equipment skid functions as both a unitized pallet for the cask and cooling equipment and a trailer deck for special permit short haul trucking.

The skid frame uses 24-inch fabricated I-beams. Fuel tanks for the cooling system diesel engines are incorporated into the framing. The cooling system and cask support members are attached directly to the frame. The skid is 37-1/2 feet long, 8 feet wide, and is of all-steel construction. Both ends of the skid are designed to accept a type of hydraulic gooseneck assemblies used in the heavy hauling industry. When transporting the package by truck, wheeled assemblies will be attached to both ends of the skid. The gooseneck will be used to lift the unit to a minimum road clearance of 12 inches. Deck plate is provided for all accessible areas.

During rail shipment, the skid sits directly on the bed of a slightly modified standard 90-ton-capacity flat car. During transport, the skid is restrained by a securing system designed to resist the peak loads anticipated under normal railroad conditions for the hydraulically cushioned draft gear.

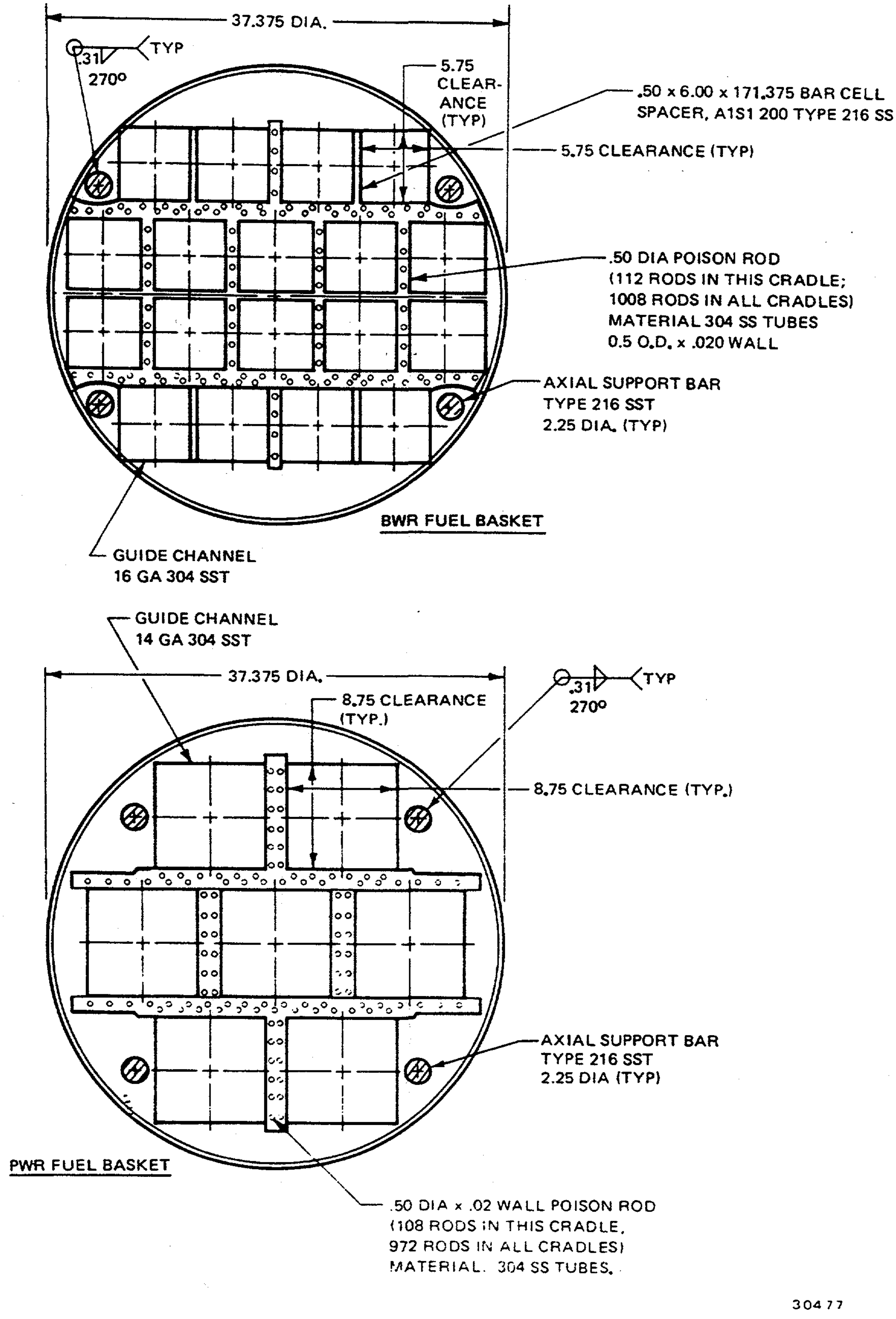


Figure 6. Typical Fuel Basket Spacer Discs — BWR/PWR

2. Cask Supports

The horizontally transported cask is supported in two locations: just below the closure flange by a saddle and at the cask base by a pivot cradle.

Constructed of ASTM A516 Gr70 steel, the support saddle for the head end is welded directly to the skid frame. This U-shaped structure engages the cask at its upper lifting rings. Hardened pins are inserted through the lifting rings to provide restraint of the head end of the cask in the vertical and lateral directions, and through the saddle ears to furnish axial restraint for the total cask weight. During the lowering operation, contact between the saddle and one lifting ring moves the cask forward, slightly away from the bottom of the rear support. This movement provides end clearance for the differential thermal expansion of the cask and skid components.

The pivot cradle, consisting of two pedestals which are welded directly to the skid frame and a counterbalanced cradle or "cup," supports the base of the cask. The cradle pivots between the pedestals on two trunnions. When the cask is removed, the "cup" remains in a horizontal position with its open end upward. During the replacement operation, the cask base is lowered into the "cup." Two hardened guides provide alignment.

Once the cask is seated in the cradle, the pivot cradle and "cup" are rotated downward to the normal transport position. A shoe on the cask base becomes the bearing surface between the cradle and cask when in the transport position. All contact surfaces are coated with a lubricant to reduce the friction when the cask is moved forward for expansion clearance.

The two cradle-mounted tipping trunnions are held in the pedestals by pillow-blocks, each having a lubricated phosphor bronze bushing, to prevent galling. The cradle is counterweighted with lead to hold it in an upright position when the cask is removed. The trunnions are mounted on the cradle slightly off-center so that there is a natural tipping direction toward the cooling system end of the skid when the cask is rotated. Both the cradle and pedestals are constructed from ASTM A516 Gr 70 steel.

COOLING SYSTEM

External cask cooling is not needed for nuclear safety and therefore is not required by the cask Certificate of Compliance. An external cooling system is provided to maintain reasonable cask surface temperatures for cask handling with high heat load fuel.

Cask surface cooling is accomplished using a unique air jet impingement technique. Air, at a velocity of 47 feet per second, is directed perpendicular to the cask surface from four ducts, running the length of the cask and 90 degrees apart, bisecting the four quadrants. The two lower ducts are fixed to the skid while the two upper ducts lock in place during transit, but move outward to facilitate cask removal.

Each engine/blower unit is independent of the others and capable of producing a minimum flow of 10,000 cubic feet of air per minute. During normal operation, both units will be run simultaneously, delivering ≈18,000 cfm to the cask surface. Fuel tanks which are located in the skid, have a total capacity of 570 gallons. This quantity will permit the continuous running of both units for at least 10 days. Either one of the units is capable of supplying sufficient air to cool the cask surface.

Both blowers discharge into a common air plenum, which feeds the four axial ducts that cool the cask. If one blower fails, a gravity damper prevents a back-flow of air from the plenum. Intakes are well isolated and are located within a screened enclosure to prevent debris ingestion.

ENCLOSURE

The cask and cooling system is enclosed by an aluminum frame and expanded metal cage. This enclosure is in three sections: two are over the cask and the third covers the cooling system. The two cask enclosures move along a rail and telescope over the third one, which is semi-permanent, to facilitate cask removal. The enclosure ends are also semi-permanently attached to the skid. The cage extends out to the edge of the 8-foot wide skid. When the movable sections are retracted, the rails form a sill, which protects the bottom ducting and provides a work platform along the cask. When the sections are in place over the cask, a locking device lifts them off of their tracks and secures their movement. This device is locked during transit.

The cooling equipment end wall has a lockable access door for inspection. In addition, there is one small removable panel on each side of the equipment enclosure which permits access to each of the engine/blower instrument consoles. The equipment enclosure and the end walls may be removed by unbolting.

All three sections have solid roofs for sun shading. The enclosure ends are also solid. This entire enclosure makes the nearest accessible shipping package surface approximately 4 feet from the cask centerline.

CASK LIFTING YOKES (Figures 7 and 8)

The standard cask lifting yoke is a steel structure which engages a building crane at the top and the IF-300 cask lifting trunnions at the bottom. This yoke is used for all cask handling operations including removal and replacement on the equipment skid, insertion in the fuel pool, and cask closure head removal and installation. The upper engagement with the building crane hook is accomplished using a retractable 6-inch-diameter AISI 4340 heat-treated pin. The cask trunnions are engaged by the yoke J-hooks. The yoke cross-members hold four cables which are used to remove the cask closure head.

The entire structure, except for the lifting points, is painted for corrosion protection. All lifting pins and hooks are periodically nondestructively tested for internal and surface flaws. All components of the standard lifting yoke have a minimum safety factor of 3 on static and dynamic loads in compliance with Federal requirements.

At some reactor sites, the NRC will require a redundant lifting yoke (Figures 7 and 8) to be employed with a redundant crane as additional protection against cask-drop accidents. General Electric can furnish a redundant yoke which meets the requirements of NUREG-0612 and which accommodates most redundant crane concepts. As shown in Figure 7, the primary yoke (Item 1) engages the cask trunnions (Item 2) in the same manner as the standard lifting yoke. Once the cask is vertical, the secondary yoke arms (Item 3) are extended from their retracted position and coupled to the fixed arms (Item 5) of a supporting cradle (Item 6) which is bolted onto the cask's lower impacting ring assembly at the reactor site. Movement of the secondary yoke arms is accomplished by a traveling block on an air motor driven power screw. As with the standard lifting yoke, both portions of the redundant lifting yoke have a safety factor of 3 on static and dynamic loads.

SAFETY ANALYSIS AND LICENSING REQUIREMENTS

IF-300 LICENSING STATUS

The IF-300 cask design has received full Nuclear Regulatory Commission (NRC) and Department of Transportation approvals. NRC Certificate of Compliance No. 9001 was issued for the IF-300 in 1973. This Certificate of Compliance applies to all casks of the IF-300 design and currently permits irradiated fuel shipments, by specifically registered cask users, in the dry mode.

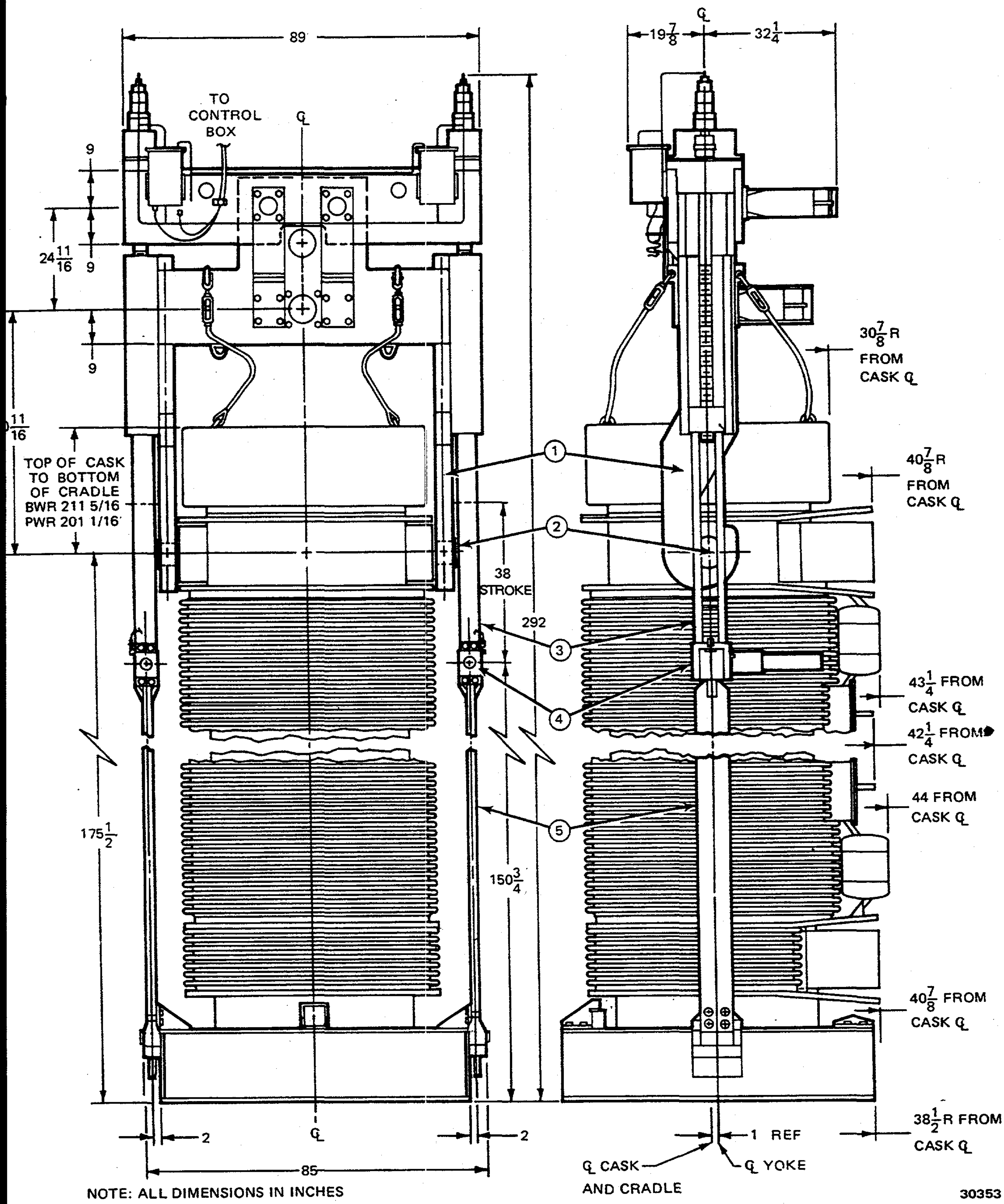


Figure 7. Whiting Arrangement of Redundant Yoke Assembly

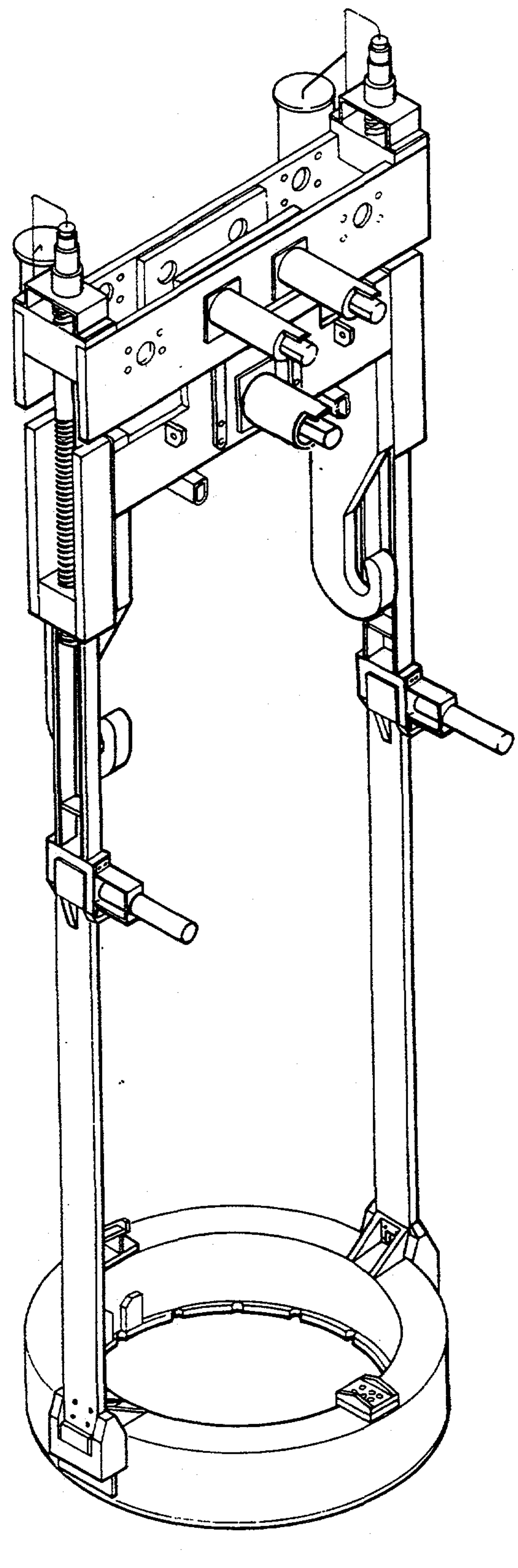


Figure 8. Isometric of the Redundant Yoke

LICENSING PROCEDURES

Containers used for shipping radioactive material currently undergo a license appraisal in the same context as that associated with nuclear reactors. The cask design is evaluated against the criteria specified by regulatory requirements and conditions governing transportation of irradiated material, as promulgated by the Nuclear Regulatory Commission and the U.S. Department of Transportation (DOT).

After a thorough study encompassing cask design and postulated usage, the cask supplier submits a Safety Analysis Report. This document contains: (1) a comprehensive design description of the cask equipment; (2) reports of associated structural, thermal, and criticality analyses; and (3) discussions of proposed cask contents, compliance with safety regulations, and operation, maintenance, and quality assurance plans. Using this document, the NRC performs an evaluation of the cask design as to its adequacy for use in making shipments of irradiated material; the NRC performs this evaluation for the DOT as well as for itself. After completion of the evaluation and a determination of cask acceptability in meeting regulatory requirements, the NRC issues a Certificate of Compliance authorizing the proposed cask contents and permitting the licensee to deliver the loaded cask to a carrier for transport.

DESIGN CONDITIONS

The regulations specify both normal and accident conditions against which the radioactive material packaging design must be evaluated. These conditions are intended to assure that the package has the requisite integrity to meet all conditions which may conceivably be encountered during the course of transportation. The normal shipping conditions require that the package be able to withstand temperatures ranging from −40°F to +130°F and vibrations, shocks, and wetting incident to normal transport. In addition, the packages are required to withstand specified accident conditions with a minimum release of radioactivity. The accident conditions for which the package must be designed include the following sequence; a 30-foot free fall onto a completely unyielding surface, a 40-inch drop onto a 6-inch diameter pin, 30 minutes in a 1475°F fire, and 8 hours immersion in 3 feet of water.

It is unlikely that the casks will experience conditions in transport as severe as those imposed by the 10 CFR Part 71 requirements and, in any event, conditions far more severe than those would be required to result in a substantial breach of a cask. Further, since the cask design is evaluated by applying these conditions to the casks in sequence, the margin of conservatism is increased. It is highly improbable that a cask would be subjected to an event as severe as even one of these conditions, let alone all four. The conditions specified by 10 CFR Part 71 and the calculated results for the IF-300 cask are described below.

1. Thirty-Foot Free Fall

The shipping cask is required to withstand a 30-foot free fall onto a completely unyielding surface. In this analysis, the 30-foot drop of the cask involved consideration of ten different orientations — four vertical and six horizontal. The accident analysis also includes several parts: (1) the cask cavity as a pressure vessel; (2) the cask as a structure; and (3) the cask contents.

The cask body undergoes severe loading in all of the 30-foot drop orientations. There is a slight flange yielding in the corner drop and slight outer shell yielding in the side drop orientations. However, the cask remains sealed with no reduction in heavy metal shielding. The fuel and fuel baskets also undergo severe loading in the postulated drop accident and some yielding will occur. However, the extent of yielding is limited by the short duration of the impact and the confinement of the cavity walls. Based on ultimate strength, no fuel or basket failures occur in the accident analysis.

The components which mitigate the vertically oriented drop effects are the impact fins which protrude from the cask ends and side. The structures deform on impact in a predictable manner and limit the forces transmitted to the cask body and contents. Protection from horizontally oriented drops is provided by side impact rings, and in the case of the valve boxes, rectangular fins. The cask body is encircled by four thick steel rings which form the primary impact protection. These rings function in a manner similar to the end fins in that they deform under impact and limit the loads imposed on the cask body.

2. Forty-Inch Puncture

The 40-inch puncture analysis requires that the cask be dropped from a height of 40 inches, with the center of gravity directly above the point of impact, onto a 6-inch diameter pin of sufficient length to puncture the container. The formula for analysis of this condition was developed at Oak Ridge National Laboratories and other places based on extensive testing of steel and lead shipping casks. In regard to the relationship of this analysis to the transportation environment, it was originally intended that the 6-inch diameter pin would approximate that of the end of a rail for rail transportation accidents.

It should be noted that the casks are required to pass the puncture without rupture of even the outer shell. Generally, there is a heavy outer shell backed up by several inches of shielding material followed by an inner steel shell; thus, a wide margin exists between the damage that the cask would sustain as a result of the required puncture test and that which would be required to rupture the inner vessel such that there could be dispersal of the radioactive contents.

3. Thirty-Minute Fire

The cask must be designed to withstand a 30-minute exposure to a uniform heat flux environment corresponding to a thermal emissivity of 0.9 at a temperature of 1475°F. This requirement is similar to the cask being completely surrounded by a fire resulting from the open burning of petroleum such as diesel or jet fuel. In actuality, the cask would most likely be lying on the ground nearer the cooler part of the flames such that it would not be entirely surrounded by the fire. Furthermore, while there may be individual flame temperatures higher than the proposed 1475°F, average flame temperatures would not exceed this value.

The analysis shows that the neutron shielding containment structure remains in place and acts as a thermal radiation barrier, thus limiting the heat transmission into the inner cavity. Throughout and subsequent to the fire, there is no fuel failure or radiation release.

EXPERIENCE

CASK FABRICATION

As of 1983, four IF-300 casks and associated peripheral equipment have been fabricated under General Electric direction and placed in service. The casks form an important experience base for assessing design adequacy, fabrication lead times, component costs, and vendor capabilities.

FUEL SHIPMENTS

General Electric Company, Morris Operation, has received hundreds of irradiated fuel shipments by both truck and rail. Morris personnel have also worked closely with electric utilities engaged in irradiated fuel movements, using the IF-300 cask and others. The result of this is a significant experience base in irradiated fuel transportation system operations. The capabilities for logistical studies, licensing, carrier interfacing, training, maintenance, and field services have been developed by General Electric and can be made available in support of the IF-300 cask.

TRANSPORTATION SUPPORT SERVICES

SITE FACILITIES

Prior to the initiation of any irradiated fuel shipping campaign, it is essential that a thorough review of plant facilities be conducted to assure compatibility with the intended shipping cask. Many existing reactor buildings were designed prior to the time that the final weights, dimensions, and operational requirements of large, modern shipping casks were determined. As a result, interferences, lifting limitations, or needs for additional plant facilities have often been identified. Since the time required to accomplish significant plant modifications can be long, it is important that a thorough review to identify such needs be conducted at an early date. General Electric personnel experienced in cask handling can assist utility personnel in site surveys and assessment of specific reactor plant facilities where appropriate.

PRE-SHIPMENT PREPARATIONS

Once a cask is selected and a shipment date is established, it is important to make a determination of the specific tools, procedures, and equipment required for each cask handling operation. IF-300 Transportation System operating manuals furnished by GE can assist plant personnel in this determination. Adequate advanced preparation can prevent costly delays and operating errors.

PERSONNEL TRAINING

General Electric will provide training of plant personnel involved in cask handling operations during first use of an IF-300 cask and as needed for later shipments. In General Electric's view, such training is an important part of a cask supplier's role. This training will help to assure that casks are handled expeditiously and in conformance with governmental regulations and industry safety practices. Detailed operating and maintenance manuals for the IF-300 Irradiated Fuel Transportation System are available to supplement the training program.

SUMMARY

The IF-300 Transportation System combines the proven economy of a high payload, multi-bundle cask with great flexibility. The capability of shipping both high exposure BWR and PWR fuel via either rail or overweight truck permits the IF-300 to serve the needs of most modern reactors.

The IF-300 is a product of an experienced nuclear materials transportation organization, responsible for the cask's optimum design and operability characteristics and capable of providing the technical suport to efficiently meet the utility industry's needs.

NUCLEAR ENERGY BUSINESS OPERATIONS • GENERAL ELECTRIC COMPANY
SAN JOSE, CALIFORNIA 95125

GENERAL ELECTRIC

TECHNICAL INFORMATION EXCHANGE

TITLE PAGE

AUTHOR	SUBJECT	TIE NUMBER 79NED47R
K. K. Fujikawa A. W. Fanning	730	DATE July 1983
TITLE IF-300 Irradiated Fuel Shipping Cask		GE CLASS I GOVERNMENT CLASS
REPRODUCIBLE COPY FILED AT REPROGRAPHIC SERVICES, SAN JOSE, CALIFORNIA 95125 (Mail Code 305)		NUMBER OF PAGES 18

SUMMARY

This document is a general description of the IF-300 Irradiated Fuel Transportation System. The IF-300 Cask is the first of the modern generation of irradiated fuel shipping casks which can accommodate either 18 BWR or 7 PWR fuel bundles for rail transportation. The IF-300 Cask transports fuel in a dry mode.

By cutting out this rectangle and folding in half, the above information can be fitted into a standard card file.

DOCUMENT NUMBER NEDO-10864C

INFORMATION PREPARED FOR General Electric Co.

SECTION GEUMCO

BUILDING AND ROOM NUMBER 995, 1806 MAIL CODE S56

NEO 914 (REV 1/83)

Appendix E-2

BR 100 Design Information

DOE/ID/12701-1 Ex.sum.

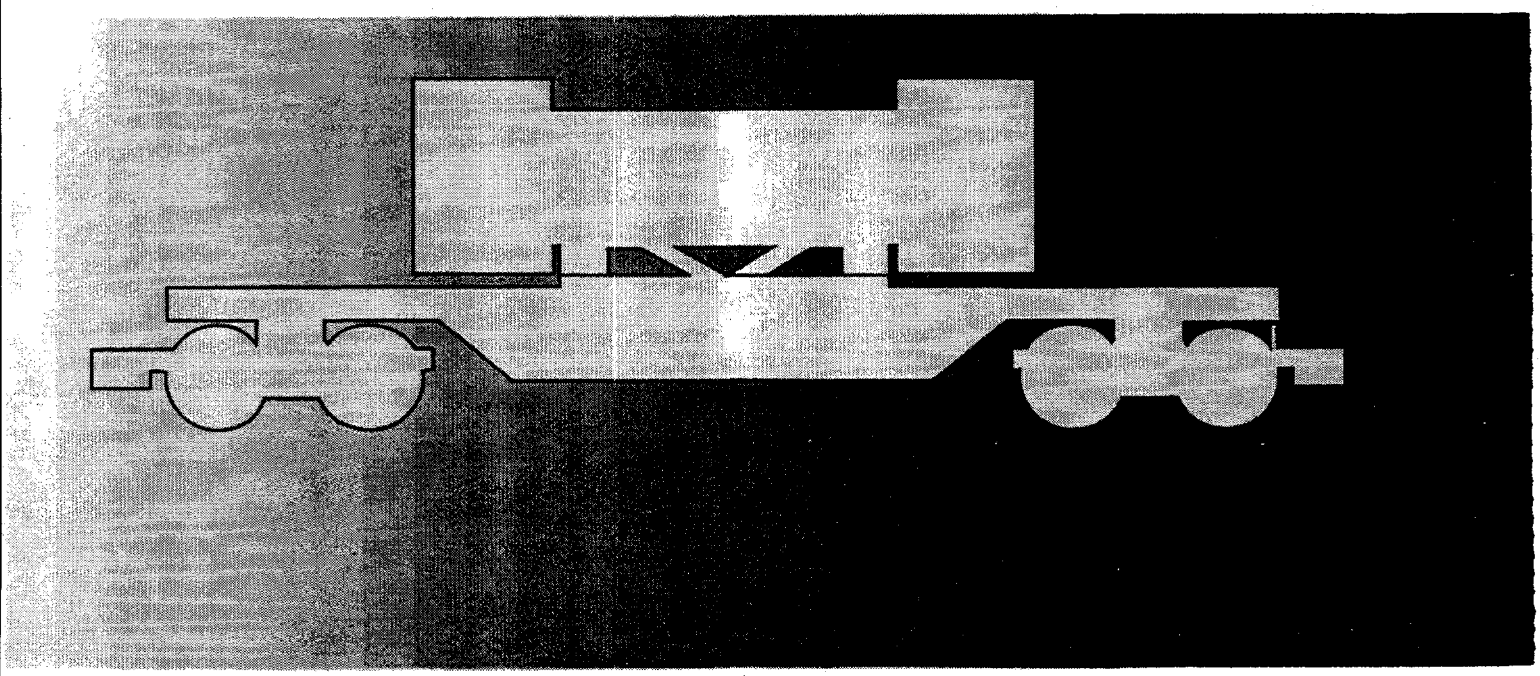
Preliminary Design Report Executive Summary

Babcock and Wilcox BR-100 Cask

May 1990

Prepared For
U.S. Department of Energy

Office of Civilian Radioactive Waste Management
Contract # DE-AC07-88ID12701



This report has been reproduced directly from the
best available copy.

Available to DOE and DOE contractors from the
Office of Scientific and Technical Information
P.O. Box 62
Oak Ridge, TN 37831
Prices available from
(615) 576-8401, FTS 626-8401

Available to the public from the
National Technical Information Service
U.S. Department of Commerce
5285 Port Royal Rd.
Springfield, VA 22161

Price: Printed Copy A02
Microfiche A01

DOE/ID/12701-1 Ex. Sum.
Distribution Category: UC-820

PRELIMINARY DESIGN REPORT EXECUTIVE SUMMARY

Babcock and Wilcox
BR-100 Cask

Published May 1990

B&W Fuel Company
P. O. Box 10935
Lynchburg, VA 24506

Prepared for the
U.S. Department of Energy
Idaho Operations Office
Under DOE Contract No. DE-AC07-88ID12701

CONTENTS

INTRODUCTION 1

CONTAINER DESCRIPTION 1

STRUCTURAL EVALUATION 3

THERMAL EVALUATION 5

CONTAINMENT EVALUATION 6

SHIELDING EVALUATION 7

CRITICALITY EVALUATION 7

QUALITY ASSURANCE 8

CERTIFICATION ISSUES 9

TRANSPORTER SYSTEM 10

ALARA/SAFETY CONSIDERATIONS 10

RELIABILITY AND MAINTAINABILITY 11

FIGURES

1. B&W BR-100 rail/barge cask 2

2. BR-100 cask schematic of shielding materials 2

3. BR-100 cask on railcar 2

TABLES

1. BR-100 component weights 2

2. BR-100 safety margins during normal conditions of transport 4

3. BR-100 safety margins during hypothetical accident conditions 4

4. Baseline thermal performance summary 5

5. PWR dose rates for normal operating conditions 8

6. Design features required to meet criticality criterion 8

7. Assumed fuel characteristics 9

PRELIMINARY DESIGN REPORT EXECUTIVE SUMMARY

BABCOCK AND WILCOX BR-100 CASK

INTRODUCTION

The Nuclear Waste Policy Act of 1982, as amended, made the Office of Civilian Radioactive Waste Management (OCRWM) of the U.S. Department of Energy (DOE) responsible for managing the program for the permanent disposal of spent nuclear fuel from commercial power plants and high-level radioactive waste from national defense activities.

Transportation casks will contribute to the safety of the nuclear waste transportation system. They will protect the public and transportation workers from potential exposure to radiation during normal transportation activities and if an accident occurs. This protection is provided through the use of a new generation of casks designed and constructed according to regulations established by the U.S. Nuclear Regulatory Commission (NRC).

The OCRWM Cask Systems Development Program is designing a variety of casks to safely transport radioactive waste from the generator sites to a geologic repository or a monitored retrievable storage facility. Five contracts have been awarded: three to develop rail/barge casks and two for legal-weight truck casks.

By December 1989, all five cask contractors had submitted preliminary designs to the OCRWM. The designs have been reviewed by a Technical Review Group composed of national experts in cask development areas. This Executive Summary describes the major features of the B&W BR-100 rail/barge spent fuel cask design.

CONTAINER DESCRIPTION

The Babcock & Wilcox BR-100 shipping container system is shown in Figure 1. The system consists of the container, impact limiters, skid, railcar and ancillary equipment. The cavity within the cylindrical container holds a removable fuel basket that accommodates either 21 fuel assemblies from a pressurized water reactor (PWR) or 52 fuel assemblies from a boiling water reactor (BWR). Fuel is shipped dry in a helium atmosphere to enhance safety during transport.

The container, with impact limiters, has an overall length of 21 ft, a diameter of 10.5 ft, and weighs 102 tons. Calculated or estimated weights for the BR-100 container system (both PWR and BWR configurations) are given in Table 1.

The BR-100 shipping container is transported horizontally in a shipping skid compatible with rail or barge shipment. Container loading and unloading operations are performed with the BR-100 container in a vertical orientation. The closure lid end is defined as the top with the container vertical, and is the forward end when horizontal. Trunnions bolted to the container body are provided for lifting and handling operations, including rotation between vertical and horizontal positions.

A specially designed railcar will be used to transport the BR-100 container. A personnel barrier is used to protect workers and the public from heat or radiological exposure. Placards and shipping information are displayed in accordance with relevant state and federal regulations.

The basic structure of the BR-100 container consists of a multi-wall body and a bolted closure lid. The container body consists of two concentric stainless steel cylinders welded at the top to the forged stainless steel bolting flange and to separate forged plates on the bottom. Layers of borated cement and lead separate the steel cylinders providing neutron and gamma shields. The high-strength stainless steel closure lid uses two elastomer O-ring seals to accomplish containment. The bolts used to attach the lid to the container body are made of a high-strength nickel alloy.

Impact limiters, consisting of balsa and redwood encased in a Kevlar®/epoxy composite, are attached to each end of the container. These materials have been

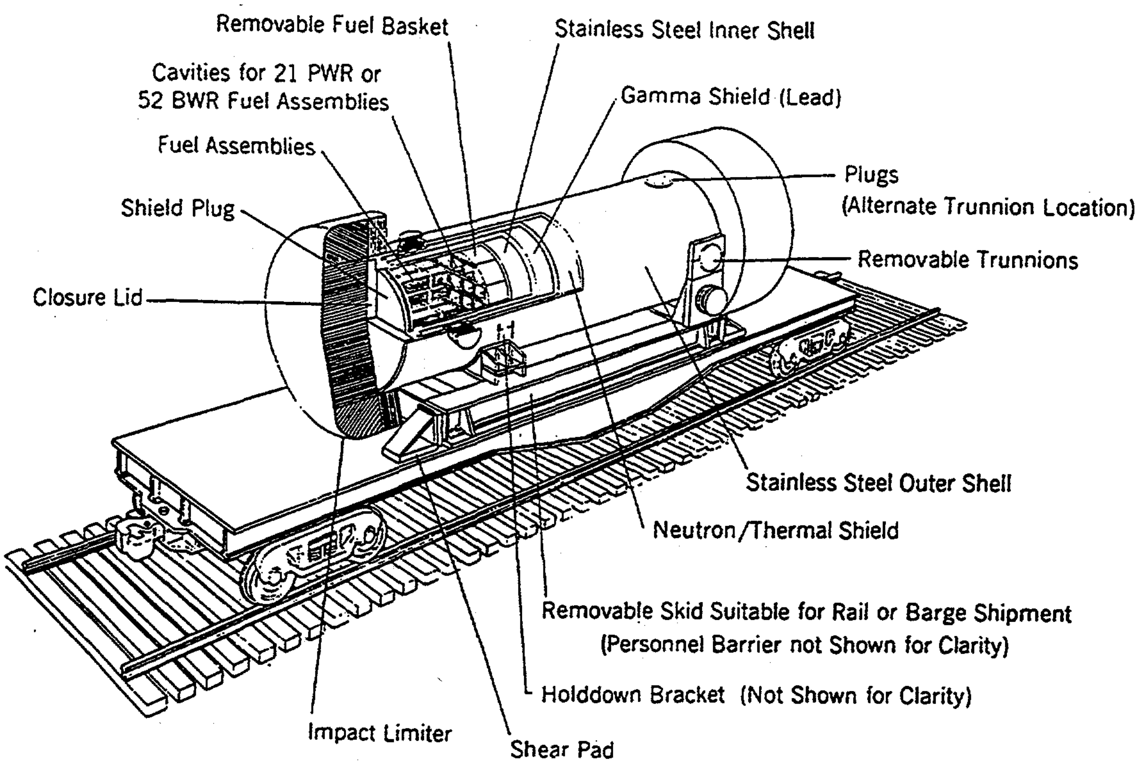


Figure 1. B&W BR-100 rail barge cask.

selected for their energy-absorbing abilities, ultimately reducing impact loads on the container during an accident. The fuel baskets are assemblies of individual fuel storage cells made primarily of anodized aluminum for structural and thermal reasons and a boron-aluminum sheet material for criticality control. A separate shield plug of lead encased in stainless steel is located between the fuel and the closure lid.

Table 1. BR-100 component weights (lb)

	Pool Lifting Configuration		Transportation Configuration	
Component	PWR	BWR	PWR	BWR
Cask body	139,000	139,000	139,000	139,000
Shield plug	5,200	5,200	5,200	5,200
Main closure lid	--	--	7,700	7,700
Basket assembly	9,000	10,000	9,000	10,000
Payload	32,800	33,800	32,800	33,800
Dewatering tool	1,000	1,000	--	--
Handling equipment	2,500	2,500	--	--
Water (before drain)	10,000	8,500	--	--
Impact limiters	--	--	8,000	8,000
Package and Contents	199,500	200,000	201,700	203,700
Railcar	--	--	45,000	45,000
Skid	--	--	11,500	11,500
Personnel Barrier	--	--	500	500
Gross Vehicle Weight	--	--	258,700	260,700

The total empty weight of the BR-100 container is 168,900 lb with the PWR basket or 169,900 lb with the BWR basket. Its corresponding loaded weight can range up to 201,700 lb for the heaviest PWR payload or 203,700 lb for the heaviest BWR payload.

The BR-100 design functions over a full range of expected environments without the use of forced cooling or any supplemental equipment or power source. Both for normal conditions of operation and hypothetical accident conditions, per 10 CFR 71, it will satisfy its goals of containment, shielding, and prevention of fuel criticality.

The BR-100 design has several features common to other containers that have been certified and used for many years. The uses of stainless steel as a containment material, lead as a gamma shield, and balsa/redwood for impact absorption, for example, have been proven to be reliable and economical. The BR-100 design has combined these efficient features with several innovative ideas to optimize container performance in safety, operations, and cost. The most significant of these innovations are: (1) the use of a borated cement/copper fin array as a combination neutron shield and "thermal switch," (2) the use of Kevlar® to contain the wood of the impact limiter, (3) the fuel cell basket construction technique, and (4) the use of a two-piece lid/shield plug closure.

The borated cement/copper fin feature is a patented system previously certified and used in France for similar containers. The boron and water in the cement act as an excellent neutron absorber, with no significant decrease in effectiveness even after hypothetical accident conditions. The copper fins allow heat generated by the fuel payload to be conducted to the outer skin of the container and then to the environment, but a layer of cement between the fins and the outer skin dehydrates if the heat coming from the environment is too intense, as in the case of a thermal transient. The partial dehydration insulates the lead gamma shield and the fuel from any detrimental effects of external heat, but allows the heat flow from the fuel to resume after the thermal transient is over.

The use of Kevlar® to contain the balsa and redwood of the impact limiter allows the weight of the impact limiter to be significantly reduced without sacrificing structural integrity. Kevlar® is six times stronger than steel per unit weight. Scoping compression tests have demonstrated the energy-absorbing superiority of the wood/Kevlar® combination. Specific wood and Kevlar® selected for use in final design will be characterized to establish mechanical property variability.

The two-piece closure system consists of a shield plug placed in the container after fuel loading and a closure lid bolted on after the container is removed from the reactor storage pool. The separate shield plug allows quick draining of the container before it is lifted from the storage pool by pressurizing the container to 3 atm. of nitrogen or dry air. The two-piece system then allows the container to be lifted to a work station where the closure lid can be quickly installed and remaining operations performed, thereby reducing worker exposure.

STRUCTURAL EVALUATION

The BR-100 shipping container is designed to meet all applicable regulatory criteria for normal transport and hypothetical accident conditions. These conditions are described in 10 CFR 71 (1986 Revision), "Packaging and Transportation of Radioactive Material." Design criteria and loading combinations are taken from NRC Regulatory Guides 7.6[a] and 7.8[b], respectively, to assess structural integrity based on allowable stress limits provided in Section III of the ASME Boiler & Pressure Vessel Code. The methods and material properties required for use by these codes are conservative. During the preliminary design phase, only major components of the container were analyzed; all were shown to provide margins of safety that exceed the requirements.

Major container components were analyzed during preliminary design to identify margins of safety for both normal operation and hypothetical accident conditions. Results are shown in Tables 2 and 3, respectively. The loadings analyzed were the maximum for each condition and, in most cases, cannot

a. Reg Guide 7.6 - Design Criteria for the Structural Analysis of Shipping Cask Containment Vessels

b. Reg Guide 7.8 - Load Combinations for the Structural Analysis of Shipping Casks for Irradiated Fuel occur simultaneously. The stresses obtained by these methods are the highest to be expected over the life of the container.

Normal conditions of transport, per 10 CFR 71, are:

- Heat - ambient temperature up to 100°F
- Cold - ambient temperature down to -40°F
- Reduced external pressure to 3.5 psia
- Increased external pressure to 20 psia
- Vibration incidental to transportation
- Water spray simulating 2 in./h of rain for 1 h
- Free drop - 1 ft onto unyielding horizontal surface
- Penetration - impact of the hemispherical end of a vertical steel cylinder 1.25-in. diameter and weighing 13 lb dropped from a height of 40 in.

Table 2. BR-100 safety margins during normal conditions of transport

	Margin of Safety, %[a]	
Component	Primary Membrane Tensile	Primary Membrane Plus Bending
Cask outer shell	>500	73
Cask inner shell	262	45
Cask bottom outer forging	>500	15
Closure lid	>500	32
Closure lid bolts	115	N/A
PWR cell	N/A	70
BWR cell	N/A	82
Trunnion	N/A	13

a. Margins, reported in %, are derived by $\frac{\text{Allowable Stress - Maximum Stress}}{\text{Maximum Stress}} \times 100$.

Table 3. BR-100 safety margins during hypothetical accident conditions

	Margin of Safety, %[a]			
	Primary Membrane			
	Tensile	Compressive Buckling	Primary Plus Bending	Puncture
Cask outer shell	487	13	7	224
Cask inner shell	>500	393	1	31
Cask bottom outer forging	491	N/A	6	96
Closure lid	367	N/A	1	306
Closure lid bolts	106	N/A	N/A	
PWR Cell	N/A	61	2	N/A
BWR Cell	N/A	638	9	N/A

a. Margins, reported in %, are derived by $\frac{\text{Allowable Stress - Maximum Stress}}{\text{Maximum Stress}} \times 100$.

Hypothetical accident conditions, per 10 CFR 71, are:

- Free drop - a 30-ft drop in the most damaging orientation onto an unyielding, horizontal surface
- Puncture - a 40 in.-drop of the container onto a 6-in. diameter mild steel cylinder at least 8-in. long
- Thermal - exposure of the container for 30 min or longer to an enveloping environment of 1475°F
- Immersion - a water head of 656 ft.

During preliminary design, the structural integrity was evaluated using conservative analytical or empirical methods. Detailed analytical methods will be employed for the final design. Also during final design, testing of a quarter-scale model and certain full-scale components will supplement these analyses. All structural materials are ASME Class 1 or equivalent. For conservatism, the structural strengths of the lead and cement layers of the shell are not used, but their weights are considered in structural analyses. The impact limiters are designed to limit the forces imposed on the container to 80 "g" during side impact, and 60 "g" for an end drop.

Finite-element analysis techniques are used extensively to analyze stress distributions and deformations in container components. These techniques use computer codes that have been developed for specific applications. All codes will be certified and benchmarked to known solutions before use. The codes used are:

- ANSYS - a general-purpose program employing the state-of-the-art, finite-element technology applicable to component static and dynamic analysis
- PATRAN - A pre- and post-processing code used to develop analytical models for finite-element codes
- ABAQUS - A finite-element code for general use in both nonlinear and linear structural analysis. It is particularly useful for puncture and impact analysis
- ILAN - A B&W-code used in the design of the impact limiters. It also predicts impact angles for maximum energy absorption.

THERMAL EVALUATION

The BR-100 design meets the thermal requirements of 10 CFR 71. It additionally offers substantial margins to established material temperature limits set by analysis, testing, and sound engineering practice. This ability to remove heat during normal transport or insulate the spent fuel during a hypothetical thermal event is significant in preserving the integrity of the container and its contents.

Thermal limits established for the various components and materials must be met for the 10 CFR 71 requirement of a 100°F (38°C) day with solar insulation of 388 W/m^2 and a fuel payload generating the maximum heat credible within the bounds of expected transport conditions. Calculations are made at the point of maximum heat input to the BR-100 container. Limits for the fuel basket, lead gamma shield, and fuel cladding must also be met for the hypothetical thermal event conditions.

The margins that exist for the BR-100 design are evident in the thermal performance summary for baseline fuel shown in Table 4.

The thermal output of the fuel used to determine the normal condition temperatures is 12 kW. The thermal capacity of the BR-100 container approaches 18 kW before any of the temperature limits are reached.

Table 4. Baseline thermal performance summary

Location	Maximum Temperature Limits (°F/°C)	Normal[b] Conditions (°F/°C)	
		PWR	BWR
Personnel barrier	180/82[a]	<180/82	<180/82
Peak cement	250/121[a]	210/99	198/92
Peak gamma shield	620/327	215/102	201/94
Peak fuel basket	350/177	274/135	239/115
Peak fuel cladding	680/360	364/185	285/141

Notes:
a. Normal transport conditions only, can be higher for accident conditions.
b. Accident conditions are to be calculated during final design. Extrapolation from French experimental data indicates that the peak temperatures for the gamma shield, basket, and fuel cladding will be substantially below their limits.

The inner and outer shells of the BR-100 container body are subjected to different thermally induced pressure environments during normal or accident events. For normal conditions, the outer shell is exposed to a pressure based on a combination of noncondensible gas and vapor pressure. The major contribution results from the moisture in the cement being driven off as vapor at saturation pressure. At the cement temperature limit, 250°F/121°C, this value corresponds to a saturation pressure of 30 psig (0.21 MPa), substantially below the level that would cause any structural concerns. The inner shell under normal conditions will function with an internal pressure less than atmospheric. The Maximum Normal Operating Pressure (MNOP, as defined in 10 CFR 71) assumes all fuel rods are ruptured and would result in an internal pressure less than 100 psig (0.69 MPa). Such an event is highly unlikely but has been used to establish extremely conservative requirements. In addition, a 50% margin is used for pressure testing the containment.

For hypothetical accident conditions, the outer shell experiences pressures developed in the same fashion as for the normal conditions with the following exception; the outer shell has strategically placed fusible plugs that melt at about 300°F (144°C), thus limiting the saturation pressure to less than 60 psig (0.40 MPa). The inner shell internal pressures are estimated to be only slightly above the 100 psig (0.69 MPa) predicted for MNOP conditions because of the small increase in internal temperatures. Those pressures are well within design limits for the shells.

The heat transfer relationships used during preliminary design are:

- A one-dimensional model to calculate heat transfer through the container body
- The Wooten-Epstein relationship to generate peak spent fuel clad temperatures
- Finite-element codes to calculate the two-dimensional heat flow in the fuel basket.

Two computer codes were used to support thermal analysis during preliminary design: PATRAN (briefly described under STRUCTURAL EVALUATION) and PTHERMAL, which is a general-purpose thermal analysis program capable of 1-, 2-, or 3-dimensional analysis. This code calculates conduction, convection, multiple-surface radiation networks, and limited convection.

CONTAINMENT EVALUATION

The BR-100 containment boundary is designed to meet regulatory release requirements for normal transportation and hypothetical accident conditions. During preliminary design, a structural evaluation of the main closure was considered sufficient for containment evaluation. Criteria used were:

- No plastic deformation of the closure lid
- No yield of closure bolts
- Conservation of compression characteristics of the elastomer seals.

The objective of a containment analysis is to demonstrate the design of the shipping container for a leak-tight capacity as defined in ANSI N14.5. However, as results of DOE's ongoing source term evaluation program become available, leakage testing requirements will be set to satisfy containment requirements of 10 CFR 71.51(a). The containment vessel is an ASME Code Class 1 component with highest Quality Assurance standards for materials and construction. The materials are compatible with both wet and dry environments and were selected to prevent chemical or galvanic effects leading to corrosion.

There are only two penetrations into the primary containment: one 3/8-in. and one 1/2-in. quick-disconnect valve, both located in the closure lid. They are used for final draining of the container, vacuum drying, pressurization with inert gas, pressure measurements, cavity gas analysis, and cavity cooling. Closure is ensured by 32 high-strength bolts on the closure lid and 6 high-strength bolts on the penetration cover plate.

The containment evaluation during preliminary design considered the cold environment and the free drop for normal conditions of transport, and immersion, free drop, puncture, and thermal conditions for the hypothetical accident.

In both cases, the free drop provides the maximum loading on the bolted closure. No adverse effects from either normal or accident conditions are expected to impact performance of the containment.

SHIELDING EVALUATION

Concentric layers of lead and borated cement encapsulated between inner and outer steel shells ensure acceptable external dose rates for the BR-100. Lead provides the primary gamma-radiation shielding and is arranged to minimize overall weight of the container without sacrificing the shielding effectiveness. A borated cement was chosen to moderate and absorb neutrons. Figure 2 shows materials, locations, and thicknesses of these elements.

Fuel characteristics used in the shielding analyses were chosen to yield the maximum credible radiation generation. Material properties were chosen to minimize their shielding effectiveness, thus providing further conservatism.

Gamma and neutron dose rates calculated during preliminary design are shown in Table 5 and include neutrons and primary gammas originating from the fuel, and secondary gammas resulting from neutron capture in shielding materials. Maximum dose rate at the package surface is well below the 200 mrem/hr regulatory limit, and the maximum dose rate at 2 m (6 ft) from the package does not exceed the limit of 10 mrem/hr.

Dose rates for BWR fuel loading are about 50% of those calculated for PWR fuel. The use of more discrete methods during final design should reduce the predicted dose rates significantly and measured dose rates are usually significantly lower than predicted.

The dose rates for post-accident conditions are estimated to be only slightly higher than for normal operating conditions, and they will be verified by testing and analysis during final design.

The following computer codes were used to estimate dose rates:

- ORIGEN2 - calculates the source from the fuel region consisting of neutron and gamma components from activation products, actinides, and fission products. Sources from structural components of the fuel assembly (primarily gamma radiation from decay of Co-60) were hand calculated
- ANISN BW - a one-dimensional discrete-ordinates transport code that solves the Boltzmann transport equation for neutrons and/or gammas. This code was used to calculate radial centerline dose rates and neutron dose rates at the ends of the container
- QAD-CGGP - a three-dimensional point-kernel code originally developed by Oak Ridge National Laboratory (as QAD-GP). This code was used to estimate gamma dose rates from the fuel and Co-60 in end fittings and spacer grids of the fuel.

CRITICALITY EVALUATION

Criticality control for the BR-100 shipping container is maintained below the regulatory limit, $k_{max} = 0.95$, by a combination of geometry, fixed poison, and burnup credit. Two separate basket configurations allow the container to hold either 21 PWR or 52 BWR intact fuel assemblies. Each configuration requires a different combination of design features to meet the $k_{max} < 0.95$ criterion as shown in Table 6.

Analysis indicates that burnup credit is required for the PWR configuration only. (This is discussed in more detail under CERTIFICATION ISSUES).

The fuel characteristics assumed for the preliminary design analyses for PWR and BWR fuels are shown in Table 7.

The computer code, KENO-IV, was used to evaluate criticality safety for both PWR and BWR configurations with an assumption that the container internals are flooded, thus adding conservatism to the analysis. During final design, more realistic assumptions will be used in accordance with NRC regulations. Other codes supporting the analysis included:

- ORIGEN 2 - to develop PWR burnup isotopics
- NULIF - to identify the most reactive PWR fuel
- NITAWL 8 - to generate cross-section data XSDRNPM.

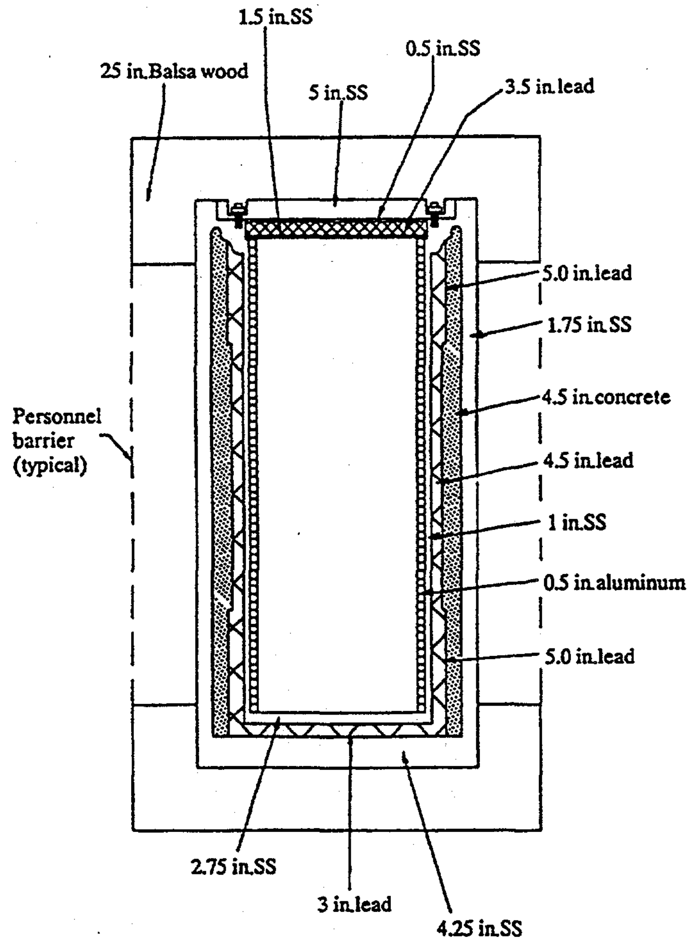


Figure 2. BR-100 cask schematic of shielding materials.

Table 5. PWR dose rates for normal operating conditions

Location	Dose Rate (mrem/h)		
	Neutron	Gamma	Total
Top surface, axial centerline	4.7	49.5	54.2
Axial centerline, 2m from package	0.1	8.8	8.9
Radial surface, upper end	7.1	112.9	120.0
Radial at 2m, upper end	1.9	6.9	8.8
Radial surface, midplane	15.2	20.9	36.1
Radial at 2m, midplane	3.8	5.8	9.6

Table 6. Design features required to meet criticality criterion

	PWR	BWR
Water gap between fuel cells (flux traps)	0.75 in.	Not req'd
Fixed poison (B_4C Cermet)	Yes	Yes
Fuel Avg. burnup credit	18 GWD/MTU	Not req'd

QUALITY ASSURANCE

The design, testing, fabrication, and operation of the BR-100 shipping container will be performed to requirements specified by a Quality Assurance Program (QAP) generated by B&W, and approved and audited by the NRC, DOE, and DOE's subcontractor, EG&G Idaho. B&W's QAP is in accordance with nationally recognized standards for quality assurance, including American National Standards Institute (ANSI) NQA-1 and American Society of Mechanical Engineers (ASME) Boiler & Pressure Vessel Code, Section III.

Documentation of NRC's QA approval is provided in NRC Docket No. 71-0506-Rev. 2.

Highlights of B&W's QAP implementation for the BR-100 preliminary design phase include:

a. Baseline drawings, calculations, and specifications were produced in accordance with design and control procedures. They were independently reviewed by qualified individuals to ensure their technical accuracy.

b. Computer software was controlled in accordance with the QAP requirements for preliminary design.

c. Testing was performed in accordance with requirements commensurate with the scope of approved test plans and procedures.

d. A design review by independent experts was conducted to ensure that all DOE and NRC requirements and industry objectives for safety and reliability were properly addressed in the BR-100 design.

e. The peer review requirements imposed by DOE document RW/0032 are implemented in the BR-100 project through the technical and design reviews mentioned above, as well as by conducting quarterly reviews by an Advisory Review Board (ARB). The ARB is comprised of senior engineers and managers from Babcock & Wilcox, Robatel, and utility and railroad industry consultants. In addition, specific independent reviews are held on an as-needed basis.

Table 7. Assumed fuel characteristics

Parameter	PWR	BWR
Assembly rod array	W 17 X 17	GE 8 X 8
Active fuel length, in.	144	138
Fuel rods/assembly	264	62
Fuel rod diameter, in.	0.36	0.483
Cladding material	Zirc-4	Zirc-2
Cladding thickness, in.	0.0225	0.032
Pellet diameter, in.	0.3088	0.41
Fuel cell pitch, in.	0.496	0.641
Pellet material	UO_2	UO_2
Maximum initial enrichment, wt % U-235	4.5	4.5
Design basis burnup, GWD/MTU	35	30
Initial uranium weight, kg/assembly	423.2	176.8

CERTIFICATION ISSUES

B&W met with the NRC three times during the BR-100 preliminary design phase. Representatives from DOE and their subcontractors were also present at these meetings, which are recorded in the NRC Public Document Room under Docket Number 71-9230. The purpose of these meetings was to describe the BR-100 design to the appropriate regulatory experts and to identify areas where additional analysis or testing would be required for certification. Areas that require special attention have been classified as certification issues. For the BR-100 design they are:

a. Thermal Switch/Neutron Shield -- The borated cement/copper fin feature has not previously been certified by the NRC; therefore, its performance must be verified through testing.

b. Closure Seals -- Both material properties and configuration performance must be verified by testing over the range of regulatory temperature conditions.

c. Impact Limiters -- The specifications to be used for fabrication of the production impact limiters are to be duplicated for test specimens. The performance of the test specimens will be documented over a range of predicted worst-case conditions and benchmarked to a computer code that will then extrapolate the forces applied to the container in any postulated drop accident.

d. Burnup Credit -- The BR-100 uses burnup credit only for PWR fuel with initial U-235 enrichments over 3.2%. Burnup is a term that describes the amount of U-235 in a fuel assembly that has been used, or "burned." As the U-235 in a fuel assembly is "burned," less is available for further heat generation. The criticality analyses performed on the BR-100 assume a "burnup credit." This is a means of accounting for reduced reactivity as a result of the fissile material (U-235) depletion and build-up of fission product poisons.

Sufficient analytical data to cover all fuel-related parameters and a verification technique to ensure the required burnup level will be necessary for inclusion of burnup credit in the certification process.

TRANSPORTER SYSTEM

The transport system for the BR-100 shipping container consists of a railcar, skid, and personnel barrier. The system is shown in Figure 3.

The railcar meets AAR requirements to allow free interchange on all major U.S. railroads. The railcar is 47 ft 6 in. long and 10 ft 6 in. wide and rides on two 2-axle trucks. The Gross Vehicle Weight limit on the loaded railcar is 263,000 lb, or 65,600 lb per axle. The railcar weighs 45,000 lb and is a flatbed with provisions for attaching the shipping skid and trollies on each end for removing and storing the impact limiters.

The railcar is designed for easy inspection and maintenance and has high-performance running gear and brakes per AAR guidelines. The two-truck configuration was chosen because of its stability and reliability. The center of gravity of the container is 92 in. above the rails, less than the 98-in. maximum recommended by AAR. A ride index will be specified in the final design that is consistent with structural analysis and testing. The railcar design will be approved by the AAR before operation.

The shipping skid holds the BR-100 container secure during all conditions of transport and is compatible with either rail or barge shipment. The skid is secured to the BR-100 container and allows rotation of the container between vertical and horizontal via two trunnions near the rear (bottom) end of the container. The trunnions are offset so that the container can only rotate in the correct direction. The skid has a saddle that supports, and holddown brackets that retain, the front end of the BR-100 container. The skid can be picked up while holding the BR-100 container via two rear trunnions on the skid and two front trunnions.

The personnel barrier for the BR-100 container extends between the two impact limiters to prevent any inadvertent contact with the container body. It is made of metal fabric with an aluminum frame. The open fabric allows air circulation around the container, while the white color and partial solar protection help reduce the outer temperature of the container. The personnel barrier attaches to the railcar and can be lifted off via lifting eyes on top of the frame.

ALARA/SAFETY CONSIDERATIONS

Design considerations for the BR-100 shipping container incorporate ALARA (As Low As Reasonably Achievable) and safety as integral parts of the design process. ALARA has as its goal the systemic reduction of worker and public exposure to workplace radiation. The BR-100 design team includes several members

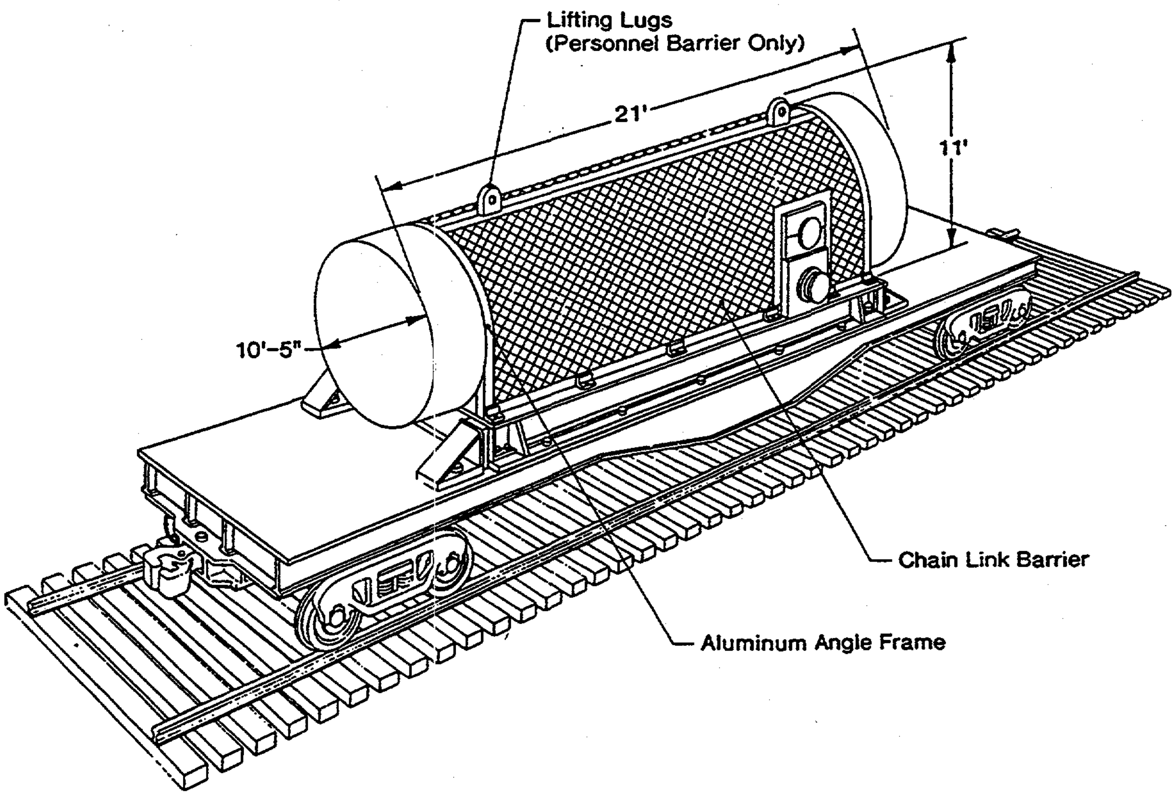


Figure 3. BR-100 cask on railcar.

experienced in ALARA principles, and the BR-100 design undergoes periodic review by ALARA/Safety experts.

Design features that contribute to ALARA and Safety goals include:

- Borated cement/copper fins -- This feature ensures that both the container neutron shield and gamma shield will remain effective after hypothetical accident conditions.
- Two-piece closure -- The lid/shield plug system allows quicker operations in preparing the container for shipment, thus reducing total worker exposure. The closure lid is never inserted into the pool water, further minimizing contamination.
- Smooth exterior -- The BR-100 design has no cooling fins and has minimal protrusions and crevices. This keeps cleaning and decontamination efforts simple and effective, and helps to keep worker exposure to a minimum.
- Quick attachments -- The closure and impact limiter attachment bolts are designed for easy installation and disassembly by being compatible with remote and remotely automated equipment.
- Preparation for shipment -- All draining, drying, inerting, and leak testing operations are performed at the top of the container. This ensures better shielding, lower exposures, and safer operations.

RELIABILITY AND MAINTAINABILITY

The BR-100 container system, including the railcar, handling equipment, operational equipment, and all other ancillary equipment, was reviewed in the preliminary design phase using a Failure Modes and Effects Analysis (FMEA) technique. This technique is useful in identifying the probability and consequences of any potential failure mechanism and thus helps establish reliability and maintenance standards. Potential areas that are adverse to reliability and maintainability are identified and corrected as a result of the FMEA.

Before operations and maintenance manuals are prepared during the final design phase, and before the ancillary equipment and container design has been finalized, another FMEA will be performed.

In addition, the BR-100 system design is reviewed on a quarterly basis by an independent panel that includes container users, fabricators, and inspectors. Their input on the efficiency and safety of the design is then used for revisions and updates.

☆U.S. GOVERNMENT PRINTING OFFICE: 1990-0-750-635

Appendix E-3

M-140 Cost Information

File WMF

MEMORANDUM

RECEIVED
SEP 1 1993
IDAHO BRANCH OFFIC

From : I. M. Pratt

Date : August 31, 1993

Subject: RIF Container Costs

To : A. N. Richardson

cc :

Pursuant to our conversation yesterday, here is the remaining information on the container processing costs and design parameters.

As earlier stated, the M-140 cask, internals, and rail car cost approximately $ 4,000,000. The internals contributed around $ 300,000 and the rail car contributed around $ 250,000.

The rail cars which transport the M-130's, M-140's, and the M-160 are owned by the Army. PNR tracks the rail cars and controls the general maintenance of the rail cars. All of the M-140 rail cars were purchased within the Naval Reactors program and not by the Army.

The core independent SARP indicates a heat removal capacity of 75,770 Btu/hr. Per a conversation with Bettis (Crawford), this capacity is dependant on the fuel modules and module holders inside, but for a general design number this number can be used.

The transportation costs of an M-130 and M-140 are dependant on weight of the total package, and if the casks are going West or East. The breakdown is as follows:

M-130 West - $46 per mile
East - $25 per mile

M-140 West - $ 64 per mile
East - $ 36 per mile

Sincerely,

Ian M. Pratt

Post-it™ brand fax transmittal memo 7671 | # of pages ▸ 1

To D. Burton	From D. Shropshire
Co. MK	Co. EG&G
Dept.	Phone #
Fax # (415) 442-7673	Fax #

The Atchison, Topeka and Santa Fe Railway Company

1700 East Golf Road
Schaumburg, Illinois 60173-5860

June 4, 1993

Mr. David Burton
Transportation Specialist
Morrison Knudsen Corporation
Environmental Services Division
180 Howard Street
San Francisco, CA 94105

Dear Mr. Burton:

This has reference to your fax request of May 27, requesting a rail quotation on shipment of spent nuclear fuel originating from Morris, Illinois (rail head Argonne, Illinois), terminating Los Alamos, New Mexico, (rail head Albuquerque, New Mexico).

Please find attached copy of Santa Fe Tariff 4043-A covering shipments of nuclear wastes on both loaded and empty movements.

This tariff is set in mileage format, with rates and charges assessed for the distance Santa Fe actually handles each car.

Our tariff does not include rates applicable to cabooses or guard cards. We are investigating these rates which will be supplied in the near future.

Mileage - 1,315
Routing - Santa Fe direct

Column (1) = $7,100.00
wt. not to exceed 224,999 lbs. per car

Column (2) = $9,541.00
wt. of 225,000 lbs. or more per car

Column (3) = $4,928.00
each buffer car

Morrison Knudsen will need to select and provide for a loading site at origin and an unloading site at destination, as well as, provide for transportation from Morris, Illinois to Argonne, Illinois and from Albuquerque to Los Alamos, New Mexico since Santa Fe does not serve these locations, nor do we provide for over the road transportation.

Please let us know if you require any assistance in locating rail served property at either origin or destination, as well as let us know how we can further assist your efforts in moving this product.

Sincerely,

J.D. Keuck
Director - Waste Products

JK/df

ILCC 916	NMSCC 4043-A	SUPPLEMENT TO ICC ATSF 4043-A

THE ATCHISON, TOPEKA AND SANTA FE RAILWAY COMPANY

SUPPLEMENT 33
TO

FREIGHT TARIFF ATSF 4043-A

(Cancels Supplements 19, 24 and 32)

Supplement 33 and Special Supplements shown below contain all changes.
Supplement 4 - Substitution of Interchange Points.
Supplements 7 and 12 - Special Notice.

LOCAL DISTANCE RATES
ON
NUCLEAR FUEL AND NUCLEAR WASTE

FROM		TO	
ARIZONA	LOUISIANA	ARIZONA	LOUISIANA
CALIFORNIA	MISSOURI	CALIFORNIA	MISSOURI
COLORADO	NEBRASKA	COLORADO	NEBRASKA
IOWA	NEW MEXICO	IOWA	NEW MEXICO
ILLINOIS	OKLAHOMA	ILLINOIS	OKLAHOMA
INDIANA	TEXAS	INDIANA	TEXAS
KANSAS		KANSAS	

This tariff is also applicable on intrastate traffic, except where expressly provided to the contrary in connection with particular items, rates or charges.

NUCLEAR TARIFF

Governed, except as otherwise provided herein, by Uniform Classification, see Item 5.

ISSUED JULY 8, 1992 EFFECTIVE JULY 29, 1992

ISSUED BY
P. J. URSO
TARIFF PUBLISHING OFFICER
900 SOUTH FRONTAGE ROAD
WOODRIDGE, IL 60517-4905

SUPPLEMENT 33 TO TARIFF ATSF 4043-A

APPLICATION OF RATES

▲ ITEM 350-A

Rates apply as local or proportional rates between stations for which mileages are provided in Tariff ICC ATSF 6000-series when routed via ATSF direct. Revenues from the application of these rates will accrue solely to ATSF.
Rates in dollars per car.

ATSF DISTANCE IN MILES	FOR EXPLANATION OF COLUMNS SEE ITEM 300		
	COLUMN 1	COLUMN 2	COLUMN 3
300 and under	3,258.00	4,439.00	1,826.00
400 and over 300	3,606.00	4,948.00	2,107.00
500 and over 400	3,955.00	5,305.00	2,388.00
600 and over 500	4,305.00	5,775.00	2,672.00
700 and over 600	4,655.00	6,245.00	2,954.00
800 and over 700	5,003.00	6,717.00	3,235.00
900 and over 800	5,353.00	7,186.00	3,517.00
1000 and over 900	5,703.00	7,659.00	3,799.00
1100 and over 1000	6,051.00	8,129.00	4,083.00
1200 and over 1100	6,401.00	8,599.00	4,364.00
1300 and over 1200	6,750.00	8,844.00	4,647.00
1400 and over 1300	7,100.00	9,541.00	4,928.00
1500 and over 1400	7,447.00	10,014.00	5,211.00
1600 and over 1500	7,798.00	10,482.00	5,492.00
1700 and over 1600	8,145.00	10,953.00	5,775.00
1800 and over 1700	8,496.00	11,425.00	6,055.00
1900 and over 1800	8,845.00	11,895.00	6,339.00
2000 and over 1900	9,194.00	12,366.00	6,620.00
2100 and over 2000	9,544.00	12,837.00	6,903.00
2200 and over 2100	9,892.00	13,309.00	7,184.00
2300 and over 2200	10,244.00	13,779.00	7,465.00
2400 and over 2300	10,590.00	14,250.00	7,748.00
2500 and over 2400	10,952.00	14,723.00	8,028.00
2600 and over 2500	11,290.00	15,190.00	8,312.00

EXPLANATION OF REFERENCE MARKS

▲ Denotes changes in wording which results in neither increases nor reductions in charges.

\- THE END -

ILCC 916 (Cancels ILCC 909)	NMSCC 4043-A (Cancels NMSCC 4043)	ICC ATSF 4043-A (Cancels ICC ATSF 4043)

THE ATCHISON, TOPEKA AND SANTA FE RAILWAY COMPANY

FREIGHT TARIFF ATSF 4043-A

(Cancels Freight Tariff ATSF 4043)

440 9-19-90

LOCAL DISTANCE RATES

ON

NUCLEAR FUEL AND NUCLEAR WASTE

FROM		TO	
ARIZONA	LOUISIANA	ARIZONA	LOUISIANA
CALIFORNIA	MISSOURI	CALIFORNIA	MISSOURI
COLORADO	NEBRASKA	COLORADO	NEBRASKA
IOWA	NEW MEXICO	IOWA	NEW MEXICO
ILLINOIS	OKLAHOMA	ILLINOIS	OKLAHOMA
INDIANA	TEXAS	INDIANA	TEXAS
KANSAS		KANSAS	

This tariff is also applicable on intrastate traffic, except where expressly provided to the contrary in connection with particular items, rates or charges.

NUCLEAR TARIFF

Governed, except as otherwise provided herein, by Uniform Classification, see Item 5.

ISSUED AUGUST 1, 1990 **EFFECTIVE AUGUST 22, 1990**

ISSUED BY
P. J. URSO
TARIFF PUBLISHING OFFICER
80 EAST JACKSON BLVD.
CHICAGO, IL 60604-2505

RULES AND OTHER GOVERNING PROVISIONS
GENERAL RULES AND REGULATIONS

ITEM 5

DESCRIPTION OF GOVERNING CLASSIFICATION

The Term "Uniform Classification" when used herein means Tariff ICC UFC 6000-series Uniform Classification Committee, Agent.

ITEM 10

STATION LISTS AND CONDITIONS

This tariff is governed by Tariff ICC OPSL 6000-series. Station List Publishing Company, Agent, to the extent shown below:

PREPAY REQUIREMENTS AND STATIONS CONDITIONS

(a) For additions and abandonments of stations, and, except as otherwise shown herein, for prepay requirements, changes in names of stations, restrictions as to acceptance or delivery of freight, and changes in station facilities.

When a station is abandoned as of a date specified in the above-named tariff, the rates from and to such station as published in this tariff are inapplicable on and after that date.

GEOGRAPHICAL LIST OF STATIONS

(b) For geographical locations of stations referred to in this tariff by station numbers.

STATION NUMBERS

(c) For the identification of stations when stations are shown or referred to by numbers in this tariff.

ITEM 15

EXPLOSIVES, DANGEROUS ARTICLES

For rules and regulations governing the transportation of explosives and other dangerous articles by freight, also specifications for shipping containers and restrictions governing the acceptance and transportation of explosives and other dangerous articles, see Tariff ICC BOE 6000-series, R. M. Graziano, Agent.

ITEM 20

REFERENCE TO TARIFFS, ITEMS, NOTES, RULES, ETC.

Where reference is made in this tariff to tariffs, items, notes, rules, etc., such reference are continuous and include supplements to and successive issues of such tariffs and reissues of such items, notes, rules, etc.

ITEM 40

CONSECUTIVE NUMBERS

Where consecutive numbers are represented in this tariff by the first and last number connected by the word "to" or a hyphen, they will be understood to include both of the numbers shown.

If the first number only bears a reference mark, such reference mark also applies to the last number shown and to all numbers between the first and last numbers.

ITEM 60

NATIONAL SERVICE ORDER TARIFF

This tariff is subject to provisions of various Interstate Commerce Commission Service Orders and General Permits shown in Tariff ICC NSO 6100-series.

ITEM 75

METHOD OF CANCELLING ITEMS

As this tariff is supplemented, numbered items with letter suffixes cancel correspondingly numbered items in the original tariff or in a prior supplement. Letter suffixes will be used in alphabetical sequence starting with A. EXAMPLE: Item 100-A cancels Item 100, and Item 200-B cancels Item 200-A in a prior supplement, which in turn, cancelled Item 200.

ITEM 100

METHOD OF DENOTING REISSUED MATTER IN SUPPLEMENTS

Matter brought forward without change from one supplement to another will be designated as "Reissued" by a reference mark in the form of a square enclosing a number, the number being that of the supplement in which the reissued matter first appeared in its currently effective form. To determine its original effective date, consult the supplement in which the reissued matter first became effective.

RULES AND OTHER GOVERNING PROVISIONS
SPECIAL RULES AND REGULATIONS - UNLIMITED

ITEM 200

RULES, REGULATIONS AND PACKING REQUIREMENTS

The commodities for which rates are provided for in this tariff will be subject to all rules, regulations and packing requirements of the governing classification and the Exceptions thereto, as named in Item 5, unless otherwise specifically provided for herein.

ITEM 210

RULE 24 UNIFORM FREIGHT CLASSIFICATION

Rates will not be subject to Rule 24 of Uniform Freight Classification or exceptions thereto (See Item 5).

ITEM 220

NON-APPLICATION OF TRANSIT PRIVILEGES

Rates will not apply on shipments accorded transit privileges at origin, at intermediate points, or at destination.

APPLICATION OF RATES

ITEM 300

Radioactive Materials: Per car rates on Radioactive Waste and fuel elements, nuclear reactor, irradiated and requiring protective shielding in containers on flatcars, as described in Items 80762, 80769 and 81295, respectively, of Tariff ICC UFC 6000-series released value of lading and container framework not to exceed 40 cents per pound (See notes 1, 2, 3, 4 and 5)

Rates applicable on flatcars which have container/framework weight of up to 224,999 lbs:

Each car, loaded or empty .... Column 1, Item 350

Rates applicable on flatcars which have container/framework weight of 225,000 lbs or more:

Each car, loaded or empty .... Column 2, Item 350

Rates applicable on each buffer car in a shipment .... Column 3, Item 350

NOTE 1. Shipments of irradiated fuel elements and radioactive waste material will not be received for transportation unless the shipper executes a certificate, endorsed upon or attached to the bill of lading, reading as follows:

"This is to certify that the above-named materials are properly classified, described, packaged, marked and labeled, and are in proper condition for transportation according to the applicable regulations of the Department of Transportation and any other requirement prescribed by the Nuclear Regulatory Commission and the Department of Transportation for said shipment.

The shipper is making the shipment described in such bill of lading (1) as contractor of licensee of the United States Nuclear Regulatory Commission under the provisions of the Atomic Energy Act of 1954, as amended by the 'Price-Anderson Act', Public Law 85-256, as amended or (2) to such contractor or licensee; that there is now in full force and effect a contract between such contractor or licensee and such Commission under such Act indemnifying such contractor or licensee and the carrier or carriers handling this shipment against public liability as defined in such Act, and (1) that there are no monetary exclusions or limitations in such contract of indemnity, except as stated in such Act, or (2) that, if there be any such exclusions or limitations in such contract, such contractor or licensee maintains in full force and effect a policy or policies of insurance issued by an insurance company or companies licensed to do business in the State of New York or other adequate financial protection as provided by regulations of such Commission in an amount equal to that provided under such Act and regulations thereunder holding the carrier or carriers handling such shipment free and harmless of and from such public liability."

If shipper fails or is unable to execute and furnish the above certificate the participating carriers do not hold themselves out as common carriers to transport the above materials. Upon request, transportation may be provided by individual railroads as private carriers under a seperate contract negotiated with respect to each shipment of such materials, such contract to be executed by the shipper and by the originating carrier, for itself and on behalf of each carrier involved in such movement which may authorize such action in writing.

NOTE 2. The released value must be entered on the shipping order and bill of lading in the following form:

"The agreed or declared value of the property is hereby specifically stated by the shipper to be not exceeding 40 cents per pound."

If the shipper fails or declines to execute the above statement or designates a value exceeding 40 cents per pound, shipment will not be accepted.

NOTE 3. Rates apply only on cars which ATSF is not required to furnish. No mileage allowance will be paid by ATSF for the use of such cars.

NOTE 4. Each shipment must be accompanied by an appropriate number of buffer cars supplied by shipper as required by Federal, State or local laws or regulations. Each buffer car must contain lading adequate to equal a minimum of 250,000 pounds gross weight on rail.

NOTE 5. Caboose(s) or guard car(s) may also be included for escort personnel but charges for escort personnel and rail equipment are not included in the rates herein.

Appendix F

Transportation of HLW Canisters

Appendix F

Transportation of HLW Canisters

Very limited cost information exists for shipment of HLW canisters. However, on the basis of numerous reports, there is general agreement that transportation costs for HLW would be similar to SNF, for which cost data are available. The total cost of transport is defined to be the sum of capital costs, maintenance costs, and shipping costs. Detailed cost algorithms exist to estimate the cost of shipping SNF in repository casks from a reactor site to another site, including the national geologic repository (U. S. DOE 1986, 1991; Tang and Saling 1990). In general, to calculate the total required number of transportation casks, information on average speeds, cask turnaround times, and availability of casks must be known or estimated. This determines the required number of shipping casks to support the scheduled shipment of HLW canisters from one site to another and from a given site to the geologic repository. Because of the lack of information on the shipping rate and the number of HLW shipping casks to be assumed for the various alternatives, a more generic approach was used based on a unit transportation cost. (The HLW shipping cask design to be assumed was determined to be very important, as shown by use of the cost algorithm in Tang and Saling 1990; order-of-magnitude differences in the total transportation cost resulted from using two different shipping cask designs.)

A unit transportation cost (by truck) of $10,000 per canister has been quoted in the literature (Tang and Saling 1990; DOE 1990). The above unit transportation cost was developed on the basis of 17,750 HLW canisters generated from defense operations; these canisters would be shipped from the three major HLW sites (Hanford, INEL, SRS) to Yucca mountain. The above unit cost does not account for the distance traveled. This deficiency is now addressed.

The total transportation cost for shipping 17,750 HLW canisters has been estimated to be $297 million in 1988 dollars (DOE 1990). This cost covers the capital costs of purchasing the transportation casks and conveyances and the operating costs of accepting the waste and providing all required transportation services (e.g., cask maintenance cost, demurrage cost). The total number of canister miles was estimated (Table F-1) on the basis of the distribution of canisters among the three defense HLW sites and the distance of these sites to Yucca Mountain.

The unit transportation cost is estimated based on total canister miles and transportation cost:

Unit transportation cost \$/HLW canister mile = $\$297 \times 10^6 / 2.564 \times 10^7$ canister miles x 1.184 = \$13.7/HLW canister mile

where the factor of 1.184 converts 1988 dollars to base operating year (BOY) 1994 dollars.

Given the number of HLW canisters to be shipped between the various sites and the shipping distance, the above unit cost is used to determine the effect of shipping the various number of HLW canisters for the different HLW alternatives. The total undiscounted transportation costs for the various alternatives are given in Table F-2 in BOY 1994 dollars. The estimates of the total transportation cost in Table F-2 agree with those projected by DOE (329 million 1991 dollars). The lowest-cost alternative (as expected) is the no-action case.

Table F-1. Determination of the total number of canister miles.

HLW site	Number of HLW canisters	Distance to Yucca Mountains (miles)	Canister (miles)
Hanford	1,500	1,302	1.95E+6
INEL	10,650	756	8.05E+6
SRS	5,600	2,792	15.64E+6
Total	17,750		2.564E+7

Table F-2. Transportation cost for the four HLW alternatives.

Case and origin	Destination	No. of shipments	Distance (miles)	Total distance (miles)	Total transportation cost ($)
No-action					
WVDP	Yucca Mtn	300	2,540	7.620E+05	1.05E+07
SRS	Yucca Mtn	5,282	2,839	1.500E+07	2.06E+08
INEL	Yucca Mtn	8,500	756	6.426E+06	8.81E+07
Hanford	Yucca Mtn	1,960	1,302	2.552E+06	3.50E+07
Total		16,042		2.474E+07	3.39E+08
Case 1					
WVDP	SRS	300	1,217	3.651E+05	5.01E+06
SRS	Yucca Mtn	5,282	2,839	1.585E+07	2.17E+08
INEL	Yucca Mtn	8,500	756	6.426E+06	8.81E+07
Hanford	Yucca Mtn	1,960	1,302	2.552E+06	3.50E+07
Total		16,342		2.519E+07	3.45E+08
Case 2					
WVDP	Hanford	300	2,654	7.962E+05	1.09E+07
SRS	Yucca Mtn	5,282	2,839	1.500E+07	2.06E+08
INEL	Yucca Mtn	8,500	756	6.426E+06	8.81E+07
Hanford	Yucca Mtn	2,260	1,302	2.943E+06	4.04E+07
Total		16,342		2.516E+07	3.45E+08

Table F-2. (Cont'd)

Case 3					
WVDP	Hanford	300	1,654	7.962E+05	1.09E+07
SRS	Hanford	5,282	2,953	1.560E+07	2.14E+08
INEL	Yucca Mtn	8,500	756	6.426E+06	8.81E+07
Hanford	Yucca Mtn	7,542	1,302	9.820E+06	1.35E+08
Total		21,624		3.264E+07	4.48E+08

Appendix F References

Tang, Y.S., and J.H. Saling, 1990, *Radioactive Waste Management,* Hemisphere Publishing Corporation, New York, N.Y.

U.S. Department of Energy, 1986, *Perspective on methods to calculate a fee for disposal of defense high-level waste in combined (Civilian Defense) repositories,* DOE/RL-86-10, Washington, D.C.

U.S. Department of Energy, 1990, *Estimates of the total-system cost for the restructured program: an addendum to the May 1989 analysis of the total-system life cycle cost for the Civilian Radioactive Waste Management Program,* DOE/RW-0295P, Office of Civilian Radioactive Waste Management, Washington, D.C.

U.S. Department of Energy, 1991, *Reference transportation data for the Civilian Radioactive Waste Management Program, Revision 1,* Office of Civilian Radioactive Waste Management, Washington, D.C.