WTSD-TME-010

Monitored Retrievable Storage Conceptual System Study: METAL STORAGE CASKS

AUGUST 1983

Prepared under Subcontract to
PACIFIC NORTHWEST LABORATORY
for the U.S. Department of Energy
under Contract DE-AC06-76RL01830

waste technology services division

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MONITORED RETRIEVABLE STORAGE CONCEPTUAL SYSTEM STUDY: METAL STORAGE CASKS

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1.0 INTRODUCTION

1.1 PURPOSE

The work presented in this study has been performed for Pacific Northwest Laboratory (PNL) as part of the Monitored Retrievable Storage (MRS) program. The purpose of this study is to assemble descriptions of metal cask storage concepts from available literature and to then modify them as necessary to present an MRS concept for spent fuel or high-level waste storage which satisfies a common set of requirements and assumptions provided by PNL. The MRS concept described herein will be considered by PNL against other similarly "normalized" concepts, will be evaluated for performance against a set of ranking criteria, and will then be considered by DOE for selection as the concept(s) to be developed for the MRS proposal to Congress due in mid-1985.

1.2 CONTENTS

A description of the metal cask storage facility concept is presented with the operations required to handle the spent fuel or high-level wastes and transuranic wastes. A generic Receiving and Handling Facility, provided by PNL, has been used for this study. Modifications to the storage delivery side of the handling facility, necessary to couple the Receiving and Handling Facility with the storage facility, are described. The equipment and support facilities needed for the storage facility are also described.

Two separate storage facilities are presented herein: one for all spent fuel storage, and one for storage of high-level waste (HLW) and transuranic waste (TRU). Each facility is described for the capacities and rates defined by PNL in the Concept Technical Performance Criteria and Base Assumptions (see Table 1.3-1).

Estimates of costs and time-distributions of expenditures have been developed to construct, operate, and decommission the conceptual MRS facilities in mid-1983 dollars, for the base cases given using the cost categories and percentages provided by PNL. Cost estimates and time-distributions of expenditures have also been developed to expand the facility throughput rate from 1800 MTU to 3000 MTU, and to expand the facility storage capacity from 15,000 MTU to 72,000 MTU. The life cycle cost of the facility for the bounding cases of all spent fuel and all HLW and TRU, using the time-distributions of costs developed above and assuming a two percent per year discount rate, are also presented.

1.3 CRITERIA AND ASSUMPTIONS

For purposes of concept evaluation, it is assumed that the MRS facility will receive and store 1800 MTU of spent fuel or equivalent in HLW and TRU per year for the first 5 years of operation, 1200 MTU per year during the next 5 years, storage of the accumulated 15,000 MTU for the next 1.67 years, with retrieval and shipment of the accumulated material for the next 8.33 years at the rate of 1800 MTU/year. The waste materials are assumed to be shipped to and from the MRS facility 50 percent by weight via truck and 50 percent by weight via rail.

Intact Pressurized Water Reactor (PWR) and Boiling Water Reactor (BWR) spent fuel assemblies are received and are disassembled, consolidated, and sealed in canisters having essentially the same outer dimensions as the intact PWR assemblies. Non fuel-bearing components of the assemblies are compacted and placed in canisters having the same outer dimensions as the canisters of compacted fuel rods. One tenth of the PWR fuel assemblies received are assumed to contain a control assembly. The interiors of the canisters are back-filled with an inert atmosphere before sealing.

For purposes of estimating decommissioning costs, it is assumed that 0.1 percent of the stored canisters develop a leak during the storage period, resulting in some contamination of the interior of a number of storage units.

The technical performance criteria and base assumptions applicable to the MRS storage facility are given in Table 1.3-1. The general functional criteria of

TABLE 1.3-1: CONCEPT TECHNICAL PERFORMANCE CRITERIA AND BASE ASSUMPTIONS APPLICABLE TO STORAGE FACILITY

1. Licensed by the NRC (20 year license, renewable)
2. 40-year design lifetime (maintainable or replaceable to double lifetime)
3. Initial operation in 1998
4. Design capacity - 15,000 MTU spent fuel, or equivalent in HLW and TRU (expandable to 72,000 MTU)*
5. Waste acceptance rate - 1800 MTU/year (expandable to 3000 MTU/yr)*
6. Waste discharge rate - 1800 MTU/year (expandable to 3000 MTU/yr)*
7. Capable of safe storage or disposal of all wastes generated at the facility while handling spent fuel, HLW and TRU
8. Capable of storing fuel elements up to 14 feet 9 inches long with 9-inch square cross sections
9. Capable of handling canisters of HLW 10-feet long and 1-foot diameter
10. Capable of maintaining spent fuel temperature below 400°C in an inert gas assuming heat generation rate of 550 watts for a PWR element which contained 462 kg of initial U and 175 watts for a BWR element which contained 186 kg of initial U
11. Capable of maintaining HLW container surface temperature below 375°C assuming a heat generation rate 2200 watts per 12-inch canister

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*See Table 1.3-3 for a description of the spent fuel to be received, processed and stored and Table 1.3-4 for a description of the HLW and TRU to be received and stored.

an MRS facility are given in Table 1.3-2. The types of spent fuel to be stored, their dimensions, and their number per 1000 MTU of spent fuel are given in Table 1.3-3. The same type of information for equivalent quantities of HLW and TRU are listed in Table 1.3-4.

TABLE 1.3-2: FUNCTIONAL CRITERIA

- The MRS system shall have the capability to receive, inspect, repackage where necessary, and store and retrieve for subsequent shipment spent fuel, solidified HLW and TRU waste.
- The MRS system shall be capable of containing radioactive material within the storage package during the entire storage period.
- The MRS system shall have a monitoring system capable of detecting any releases of radioactive material.
- The MRS system shall be capable of protecting the stored material against any likely natural or man-created events, excluding acts of war.
- The MRS system shall be capable of passively removing the heat generated from decay of radioactive materials that have been discharged from a reactor at least 10 years.
- The MRS system shall be capable of adequately protecting operating personnel and the public from the radiation emitted from stored materials.
- The MRS system shall be capable of interfacing with all systems within the total waste management system, including the reprocessing and disposal systems.
- The MRS system shall be capable of accounting for the quantity, type, and history of the material stored in the facility.
- Security, surveillance, and physical protection shall be provided for the facility, with additional safeguards provided to vital areas, in accordance with federal regulations.
- The MRS facility shall be designed to preclude any criticality events.
- The MRS facility shall be of modular design and capable of incrementally increasing or decreasing its processing rate and storage capacity to accommodate different circumstances.

TABLE 1.3-3: PWR and BWR ASSEMBLIES EQUIVALENT TO 1000 MTU SPENT FUEL*

Spent Fuel	Nominal Unit Dimensions	Number of Units
PWR Assembly	14'-9" x (8.6")^2	1400
BWR Assembly	14'-11" x (5.5")^2	2200
PWR Consolidated Fuel Canister	14'-9" x (9")^2	700
BWR Consolidated Fuel Canister	14'-9" x (9")^2	440
PWR Hardware Canister	14'-9" x (9")^2	103
BWR Hardware Canister	14'-9" x (9")^2	76
PWR Control Hardware Canister	14'-9" x (9")^2	8

*Includes 606 MTU of PWR fuel and 394 MTU of BWR fuel.

TABLE 1.3-4: HLW AND TRU WASTES WITH VOLUME REDUCTION AND IMMOBILIZATION EQUIVALENT TO 1000 MTU SPENT FUEL

		Containers at Various Surface Dose Rates (R/hr)				
Waste	Container	<0.2	0.2-5	5-50	50-500	>500
HLW	1'D x 10' can	--	--	--	--	470
Hulls Compacted	2'D x 10' can	--	--	--	--	230
Fuel Hardware	2'D x 10' can	--	--	--	--	93
RHTRU	2'D x 10' can	--	27	5	3	12
RHTRU	55 gal. Drums	--	410	51	5	--
CHTRU	4' x 6' x 6' Steel Boxes	17	--	--	--	--
CHTRU	55 gal. Drums	1150	--	--	--	--
Mox Plant						
CHTRU	55 gal. Drums	1050	--	--	--	--
CHTRU	4' x 6' x 6' Steel Boxes	10	--	--	--	--

2.0 SUMMARY

Conceptual designs of two MRS cask storage facilities have been prepared along with an estimate of life cycle costs for each. The designs are for an all spent fuel storage facility and a high-level waste and transuranic waste facility with capacities of 15,000 equivalent metric tons of uranium (MTU) and 72,000 equivalent MTU. These designs were developed using criteria and assumptions provided by PNL.

For the spent fuel MRS storage facility, intact PWR and BWR spent fuel assemblies are received and consolidated. The spent fuel rods and hardware are sealed in square canisters. For the high-level waste and transuranic waste storage facility, high-level waste, compacted hulls and fuel hardware, and remote-handled transuranic wastes are received in sealed round canisters. Remote-handled and contact-handled transuranic waste is received in 55-gallon drums (some contact-handled transuranic waste is received in steel boxes). The remotely-handled radioactive waste is placed in casks for storage.

Each storage facility consists of a "generic" Receiving and Handling Facility (designed by Kaiser Engineers) with modifications for cask loading and handling, on-site handling and transportation equipment (motorized rail cart, bridge crane, low-bed trailer and tractor, and mobile crane), a storage facility consisting of an array of large seal welded metal storage casks arranged horizontally on concrete storage pads, and the support facilities and equipment (security, utilities, etc.) needed to maintain facility operations. The high-level waste and transuranic waste storage facility includes a prefabricated concrete storage building for the contact-handled transuranic waste received.

Detailed cost estimates have been developed for these facilities which include costs for construction, operation and decommissioning for the 15,000 MTU capacity facility. Total costs and present worth costs in mid 1983 dollars for

these facilities have been estimated. In addition, costs have been developed for the incremental expansion of these facilities to a 72,000 MTU storage capacity.

A summary of the storage facility size, number of storage casks, and costs are presented below:

	Storage Capacity (MTU)		
Spent Fuel Facility	15,000	Expansion 9,000 to 72,000	72,000
Number of Casks	831	3482	3980
Storage Facility Area	16.6 acres	--	67.6 acres
Total Cost	$1,344,949,000	$4,074,965,000*	$4,875,009,600*
Present Worth Cost	$1,129,918,000	--	--
Unit Cost	$89.66/kgU	$64.68/kgU*	$67.71/kgU*
High-Level and Transuranic Waste Facility			
Number of Casks	2266	9513	10,872
Storage Facility Area	40.3 acres	--	184.2 acres
Total Cost	$2,801,742,000	$10,040,161,000*	$11,648,335,000*
Present Worth Cost	$2,339,128,000	--	--
Unit Cost	$186.78/kgU	$159.37/kgU*	$161.78/kgU*

*Does not include removal of waste or facility decommissioning.

3.0 CONCEPTUAL CASK MRS FACILITY

For the purposes of this study, two cask MRS facilities are considered. One is for the storage of consolidated PWR and BWR spent fuel assemblies (and remaining assembly hardware associated with consolidation) and a second is for the storage of High-Level Waste (HLW), Transuranic (TRU) Wastes, and canisters and boxes of remotely-handled or contact-handled wastes from reprocessing spent fuel. Both of these storage facilities are described for storage capacities of 15,000 MTU and 72,000 MTU.

3.1 RECEIVING AND HANDLING

3.1.1 Receiving and Handling Facility

The Receiving and Handling Facility for both cask MRS facilities is the same. This facility is the Kaiser Engineers' designed Receiving and Handling Facility described in Reference 1. This facility is located adjacent to the cask storage area and the combined facility surrounded by a security fence. The Receiving and Handling Facility is designed to accept large multi-element spent fuel shipping casks (as well as single element casks); to unload the spent fuel, HLW, or remote-handled transuranic waste (RHTRU) canisters; and to process them through a set of two or more hot cells. At the end of the hot cells is a Transfer Corridor which is located below the hot cell floor. A hot cell outlet port in the floor of each hot cell allows top loading of canisters into transport shields for transfer to the storage area.

To accommodate cask storage, the Receiving and Handling Facility (as presently designed) must be modified slightly. The proposed method of storage cask loading uses the same arrangement as for shipping cask unloading. Figures 3.1-1 and 3.1-2 show this arrangement. Modifications to the Receiving and Handling Facility include:

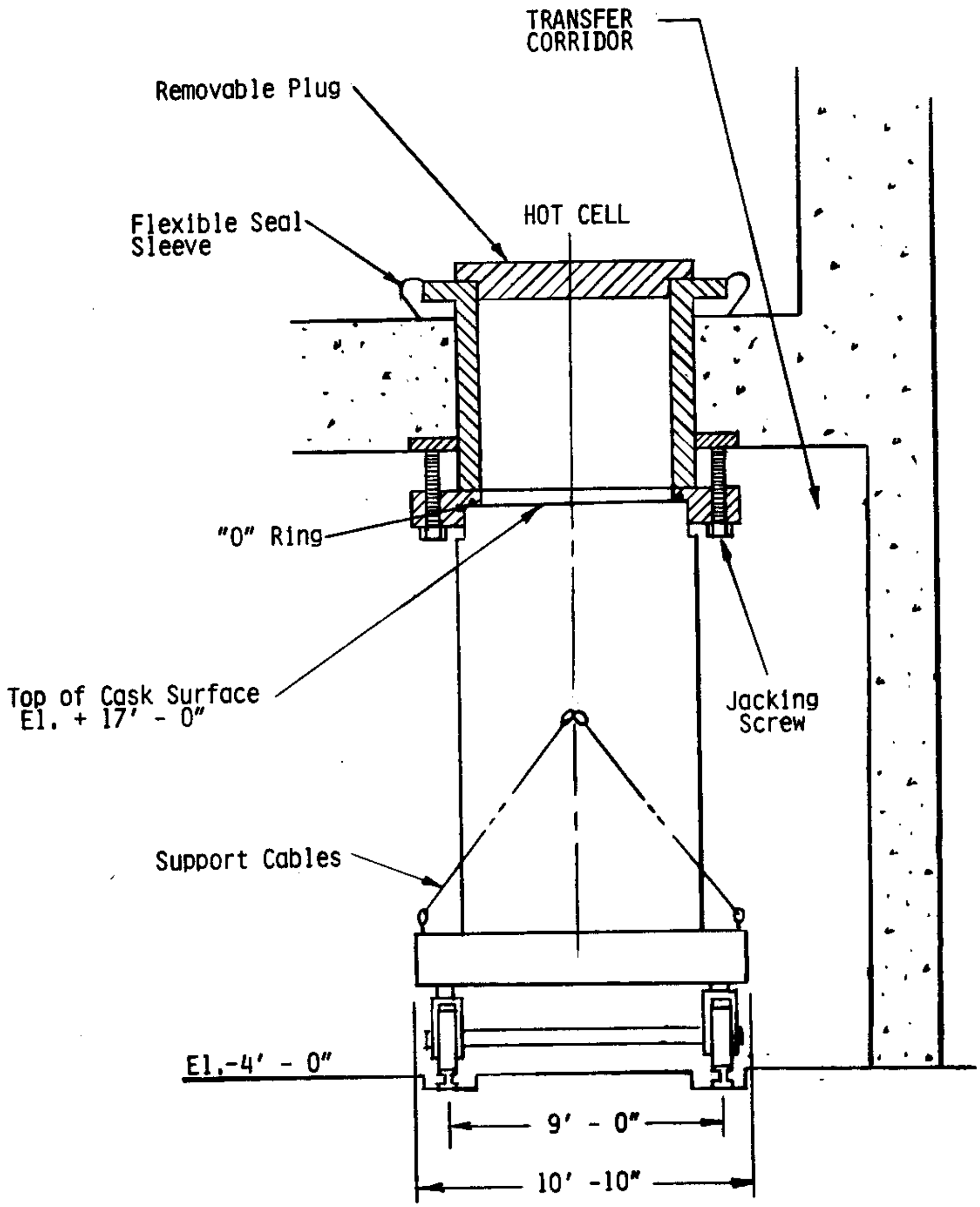


Figure 3.1-1. Receiving and Handling Facility Modifications for Canister Transfer to Storage Casks (Front View)

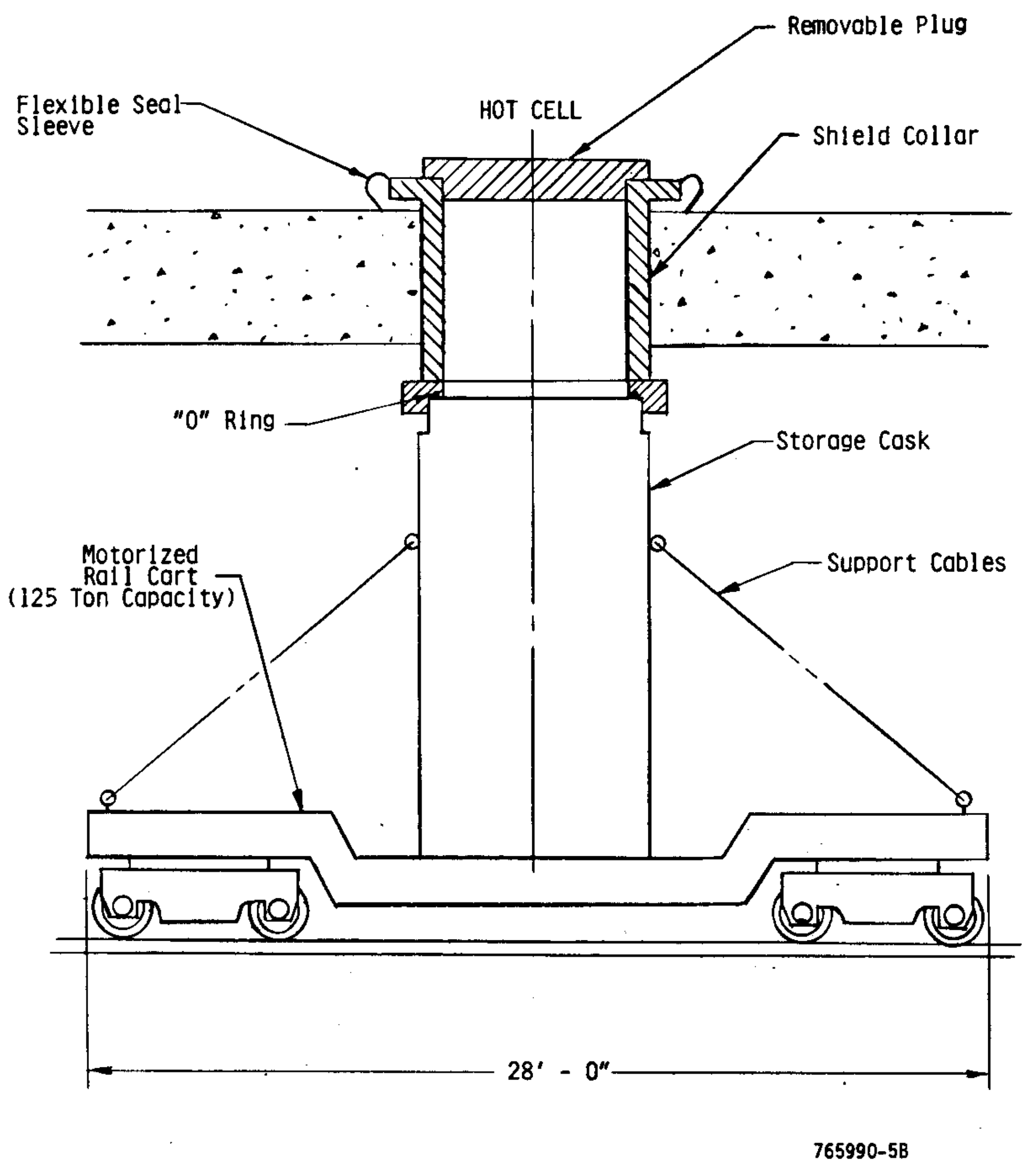


Figure 3.1-2. Receiving and Handling Facility Modifications for Canister Transfer to Storage Casks (Side View)

- Addition of a rail line from the Transfer Corridor to allow a motorized rail cart to move the storage casks into and out of the Transfer Corridor.
- Rail cart positioners at the hot cell outlet port, permitting precise horizontal positioning of the cask for subsequent mating with the hot cell outlet port shield collar.
- A motorized cask rail cart onto which the casks are placed.
- Expansion of the hot cell outlet port.
- A descending hot cell outlet port shield collar for mating with the storage cask.
- Addition of a 125-ton bridge crane for cask handling from rail cart to low-bed trailer.
- Addition of an evacuation and backfill system for the storage casks.

The shield collar has a jacking screw system located in the Transfer Corridor to allow the collar to be lowered onto the cask upper surface. The collar has an inside diameter of sufficient size to allow for cask inner lid removal and replacement from the hot cell. A removable shield plug provides shielding for the Transfer Corridor during cask movement into and out of the corridor. A flexible seal sleeve attached between the top of the shield collar and hot cell floor and a captured O-ring in the bottom of the shield collar prevent contamination from entering the Transfer Corridor. This arrangement of components is comparable to that described by Kaiser in Reference 1.

3.1.2 Spent Fuel Assemblies

For the spent fuel assembly cask storage facility, PWR and BWR fuel assemblies are received and processed in the Receiving and Handling Facility. For this study, three processing rates for fuel assemblies are assumed: 1200 MTU per year, 1800 MTU per year, and 3000 MTU per year. The number of each type of assembly making up these processing rates and the total storage facility are provided in Table 3.1-1.

TABLE 3.1-1: SPENT FUEL ASSEMBLY RECEIVING, PACKAGING AND STORAGE DATA

	RATE PER YEAR			STORAGE CAPACITY	
	1200 MTU	1800 MTU	3000 MTU	15,000 MTU	72,000 MTU
PWR Assemblies	1,680	2,520	4,200	21,000	100,800
BWR Assemblies	2,640	3,960	6,600	33,000	158,400
TOTAL FUEL ASSEMBLIES	4,320	6,480	10,800	54,000	259,200
PWR Consolidated Fuel Canisters*	840	1,260	2,100	10,500	50,400
PWR Hardware Canisters	123.6	185.4	309	1,545	7,416
PWR Control Hardware Canisters	9.6	14.4	24	120	576
BWR Consolidated Fuel Canisters**	528	792	1,320	6,600	31,680
BWR Hardware	90.7	136	226.7	1,134	5,440
TOTAL CANISTERS	1,591.9	2,387.8	3,979.7	19,899	95,512

*Each PWR canister contains fuel rods from two spent fuel assemblies.
**Each BWR canister contains fuel rods from five spent fuel assemblies.

Fuel assembly processing includes the disassembly and consolidation of spent fuel rods and the compaction of the remaining fuel assembly hardware. In addition, ten percent of the PWR spent fuel assemblies contain control assemblies which are also compacted. The fuel rods, fuel assembly hardware, and control assembly hardware are packaged in seal-welded canisters. For this study, all fuel rods and hardware are packaged in a 9-inch square cross-section canister designed by Kaiser Engineers (see Reference 1). This canister is illustrated in Figure 3.1-3. The canister is laser welded to provide a sealed barrier for radioactivity release. The development status of the canister and welding system designs are the responsibility of Kaiser Engineers and should be addressed by them.

For spent fuel storage in casks, sealed canisters are not necessary since the casks have several sealed lids which provide redundant barriers for radioactive releases. For the purposes of this study, however, the sealed canisters shown in Figure 3.1-3 are being used. Since the consolidated fuel rods and hardware must be placed in a container of some sort for subsequent handling, a comparably priced canister would be required. The basic difference between using this canister and an unsealed one would be in the need for laser welding systems and probably more stringent machining requirements, and the additional time or manpower to complete the welds. Since no detailed breakdown of the cost for this equipment, time or manpower are available in Reference 1, the sealed canisters with laser welding are being used.

The number of canisters needed to encapsulate the PWR and BWR fuel assemblies and hardware are provided in Table 3.1-1. These values are based on placing rods from two PWR assemblies and five BWR assemblies in each spent fuel canister. Consolidated hardware values are based on those provided by PNL for PWR hardware. For BWR hardware, the provided values are adjusted for the cross-sectional area increase from a 6-inch square canister to a 9-inch square canister.

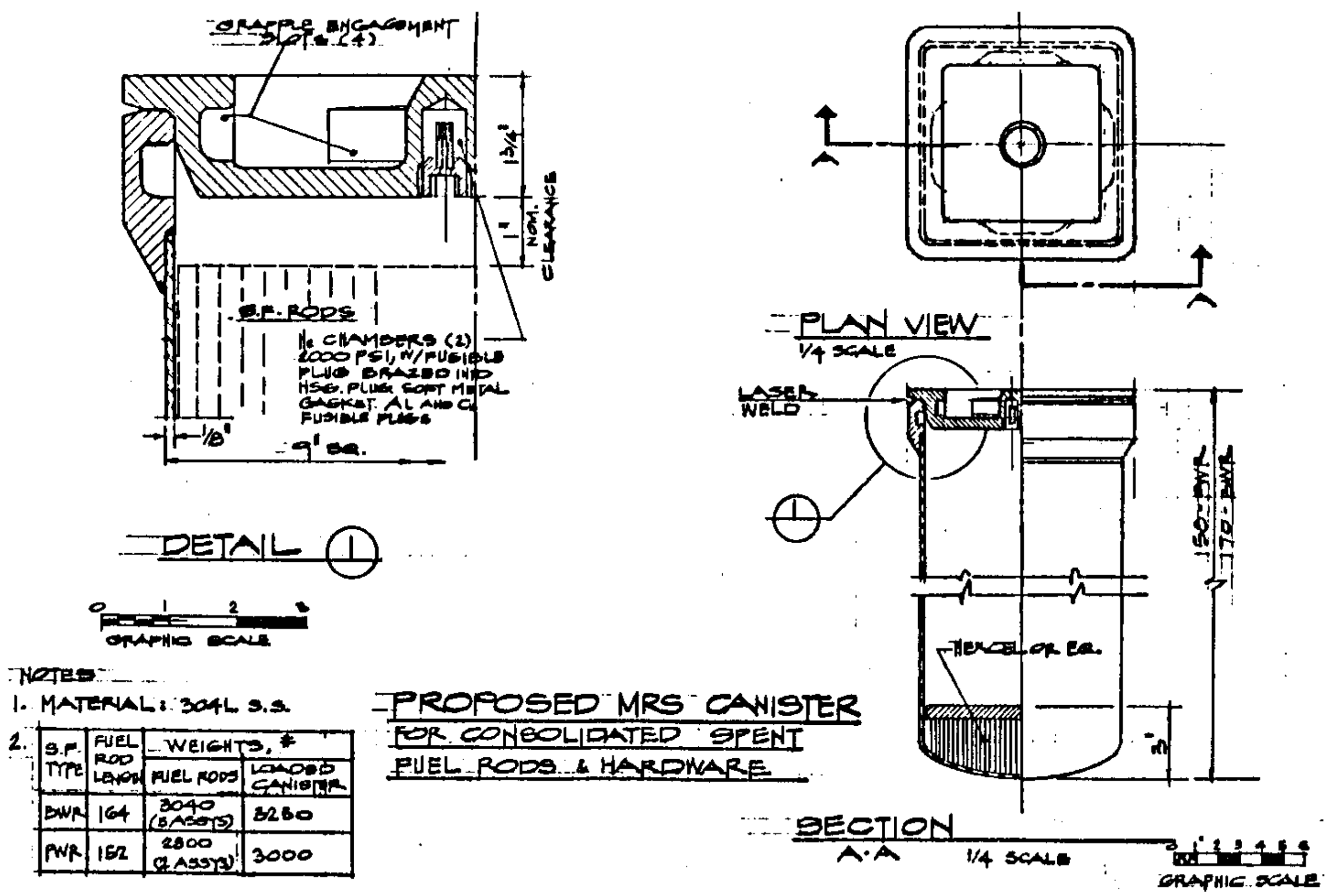


Figure 3.1-3. Spent Fuel Canister

Spent fuel canisters and hardware canisters are placed in the lag storage area prior to being installed into the storage casks.

3.1.3 High-Level Waste and Transuranic Waste

For the High-Level Waste and Transuranic Waste cask storage facility, highlevel waste canisters, compacted hulls and fuel hardware canisters, and remotehandled TRU and contact-handled TRU are received and processed in the Receiving and Handling Facility. High-level waste (HLW) and remote-handled hardware and TRU are received from shipping casks into the hot cells, examined, decontaminated and stored in the lag storage area. These wastes are received in the form of 12.75-inch diameter by 10-foot long canisters (HLW), 24-inch diameter by 10 foot long canisters (compacted hulls, fuel hardware and TRU), and 55-gallon drums (TRU). These containers are illustrated in Figure 3.1-4 and the quantities for each of the processing rates and storage facilities considered in this study are provided in Table 3.1-2.

The contact-handled transuranic (CHTRU) wastes are received at the Receiving and Handling Facility and are inspected, decontaminated and repackaged as necessary. These wastes are received in 55-gallon drums or in steel boxes (4 feet by 6 feet by 6 feet). The drums are palletized and readied for transfer to the CHTRU storage building. The quantities of drums and boxes for each processing rate and storage facility capacity are provided in Table 3.1-2.

3.1.4 Storage Casks

The reference storage cask for this study is the REA-2023 cask. This cask is presently designed for storing PWR and BWR spent fuel and with specially designed baskets is suitable for HLW and remote-handled TRU storage. The cask weighs about 90 tons empty, has a 94-inch outside diameter and a 186-inch length. This cask is further described in Section 3.3.1.

The REA-2023 cask is received at the MRS Receiving and Handling Facility on a rail car in the Cask Receiving and Preparation Area. The empty cask is shipped

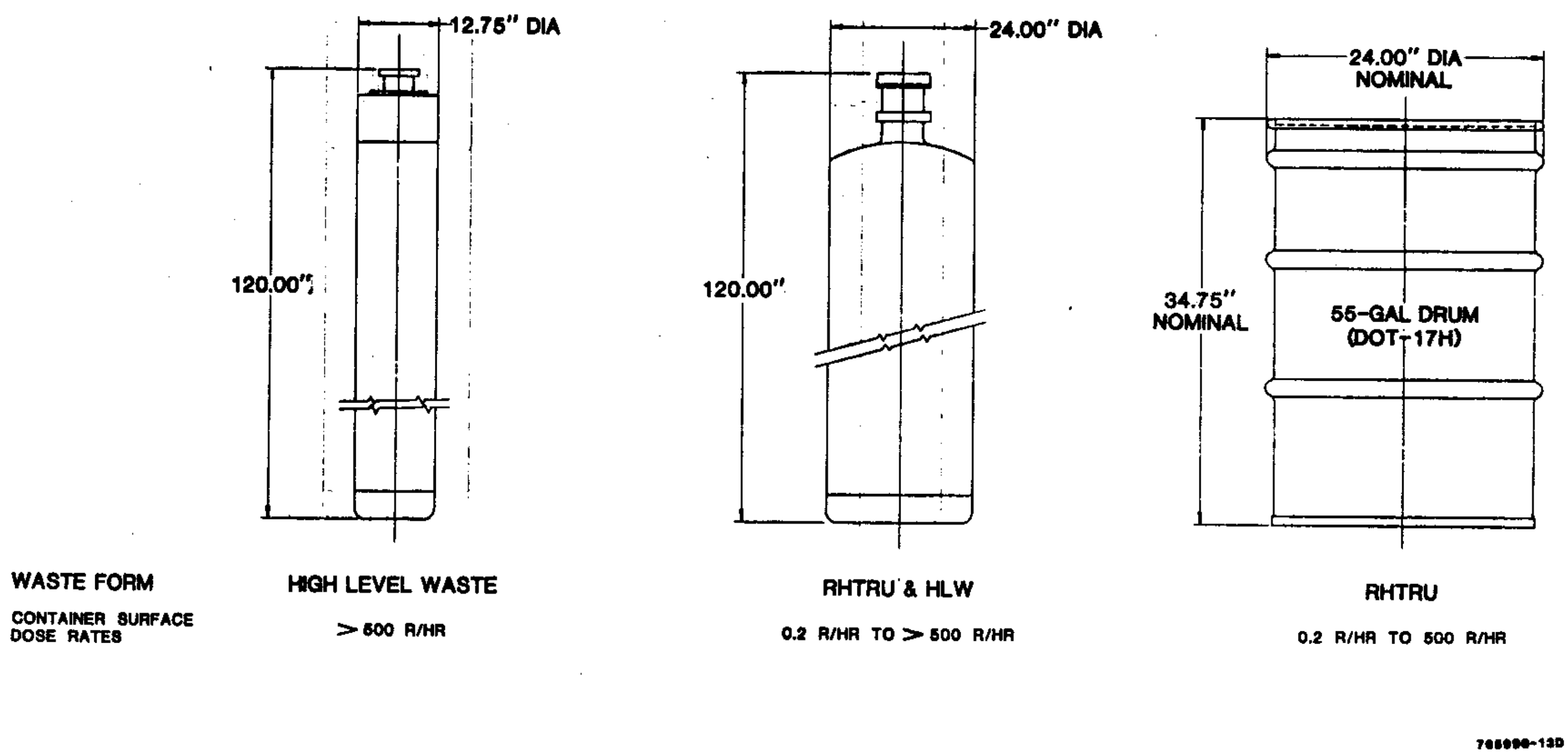


Figure 3.1-4. Storage Containers for High-Level Waste and Remote-Handled Transuranic Waste

TABLE 3.1-2: HIGH-LEVEL WASTE AND TRANSURANIC WASTE RECEIVING AND STORAGE DATA

	RATE PER YEAR			STORAGE CAPACITY	
	1200 MTU	1800 MTU	3000 MTU	15,000 MTU	72,000 MTU
REMOTE-HANDLED:					
HLW Canisters (1' Dia. x 10' long)	564	846	1,410	7,050	33,840
Compacted Hulls, Fuel Hardware and TRU Canisters (2' Dia. x 10' long)	444	666	1,110	5,550	26,640
TRU Drums (55 gallon capacity)	559.2	838.8	1,398	6,990	33,552
CONTACT-HANDLED:					
TRU Boxes (4'x6'x6')	32.4	48.6	81	405	1,944
TRU Drums (55 gallon capacity)	2,640	3,960	6,600	33,000	158,400

horizontally and is assumed to arrive with the storage skid as part of its rail car shipping arrangement. The cask is handled using this skid (see Section 3.3.1 description) and the 125 ton capacity bridge crane in the cask receiving and preparation area. The cask and skid are removed from the rail car, inspected for damage, cleaned of road dirt, and placed on a low-bed trailer (see Section 3.2 for further description) for movement to the Transfer Corridor for spent fuel or waste canister loading. The cask and skid are secured to the trailer and then moved to the Transfer Corridor.

Outside the Transfer Corridor, the 125-ton bridge crane and cask lifting yoke are used to lift, translate from horizontal to vertical, and place the cask on the Transfer Corridor rail cart. The cask is tied down to the rail cart, the outer lid is removed, and the inner lid bolts are loosened. The rail cart then moves the cask into position for spent fuel or waste canister transfer under the hot cell outlet port and the shield collar is lowered into place. Remote hot cell operations include removal of the outlet port shield plug and cask inner lid, canister emplacement in the cask, and lid and shield replacement. The shield collar is raised and the cask moved back under the bridge crane. The inner lid bolts are then tightened to seal the cask cavity, then the cask is evacuated and filled with an inert gas. Following a leak check of the cask inner lid and various fill and drain ports and a contamination check, the cask outer lid is emplaced and welded to the cask, completing cask loading and sealing. The bridge crane and cask lifting yoke are then used to lift the cask, translate it to horizontal, and replace it onto the storage skid (on the low-bed trailer). The cask and skid are secured to the trailer prior to on-site transport to the storage facility.

The equipment used to handle the empty and filled casks and the procedures/processes used to fill, close, and backfill the storage casks are extensions of existing commercially available equipment with licensed and proven experience from commercial nuclear power plants.

3.2 ON-SITE TRANSPORT

3.2.1 Storage Casks

The storage casks are transported on-site using a low-bed trailer and tractor. The trailer capacity must be in excess of 125 tons and it must be long enough for the cask (greater than 188 inches). This type of vehicle is an extension of existing commercially available trailers. The transfer of casks to the storage facility is along paved heavy haul roadways.

3.2.2 Contact-Handled Transuranic Waste

The CHTRU containers are transported on-site using standard flat bed trucks and standard fork lifts. These containers are transferred to the CHTRU storage facility via a paved roadway. These transport vehicles are the same as those used to handle the CHTRU containers in the Receiving and Handling Facility.

3.3 STORAGE

Both of the MRS facilities being considered in the study consist of storage casks containing the highly radioactive spent fuel or wastes and a storage facility. The storage casks and related equipment being considered for use, and the two separate storage facility designs are described in this section.

3.3.1 Storage Casks

Storage casks provide a sealed, self-shielded, dry storage container for intact or consolidated spent fuel assemblies, high-level waste or remote-handled TRU waste. The storage casks examined in this study have been designed for loading in the reactor spent fuel pool (as present shipping casks are) and for transport to a storage area. Design consideration by the cask vendor has also been given to potential use of the storage cask as a shipping container. Storage casks are designed to dissipate spent fuel decay heat to the environment by natural convection from the outer surface. The storage casks under consideration have either single or double containment and can be filled with either air or an inert gas. The storage cask designs use existing shipping cask loading and unloading procedures.

Storage Cask Descriptions

Several cask vendors have developed storage cask designs based on the designs of existing, licensed spent fuel shipping casks. For completeness, storage cask designs from three vendors are described in this section. The relative development status of each and the choice of a reference cask for this study are also presented.

Ridihalgh, Eggers and Associates, Inc. of Columbus, Ohio has designed a storage cask which holds 24 PWR spent fuel assemblies or 52 BWR spent fuel assemblies. This cask, the REA-2023 shown in Figure 3.3-1 for PWR spent fuel, weighs less than 100 tons (loaded), has a 94 inch outside diameter and stands 186 inches high. A slightly different cask design is provided for BWR spent fuel (93-inch outside diameter by 195-inch length). The REA-2023 cask has a 67-inch inside diameter stainless steel liner surrounded by 4.5 inches of lead (as the gamma shield) which is surrounded by a 6-inch thick solution of 48 volume percent water and 52 volume percent ethylene glycol (as the neutron shield). The exterior of the REA-2023 cask is a smooth stainless steel shell. This cask has an internal basket made of either 24 (for PWR) or 52 (for BWR) square stainless steel-clad Boral tubes (as criticality poison) with a grid of copper plates between the tubes to enhance heat transfer from the tubes to the cask body. The REA-2023 cask is designed to operate with an internal helium atmosphere. The primary cover is made of 7.5 inches of stainless steel and contains 2 silicone rubber O-rings which are sealed against the cask body by 36 high strength bolts. The secondary cover (2-inch thick stainless steel) is seal-welded to the cask body to provide a seal as well as a safeguard feature. The cask can be handled using 4 bolt-on lifting trunnions; two additional bolt-on trunnions can be attached near the center of the cask for cask rotation from vertical to horizontal.

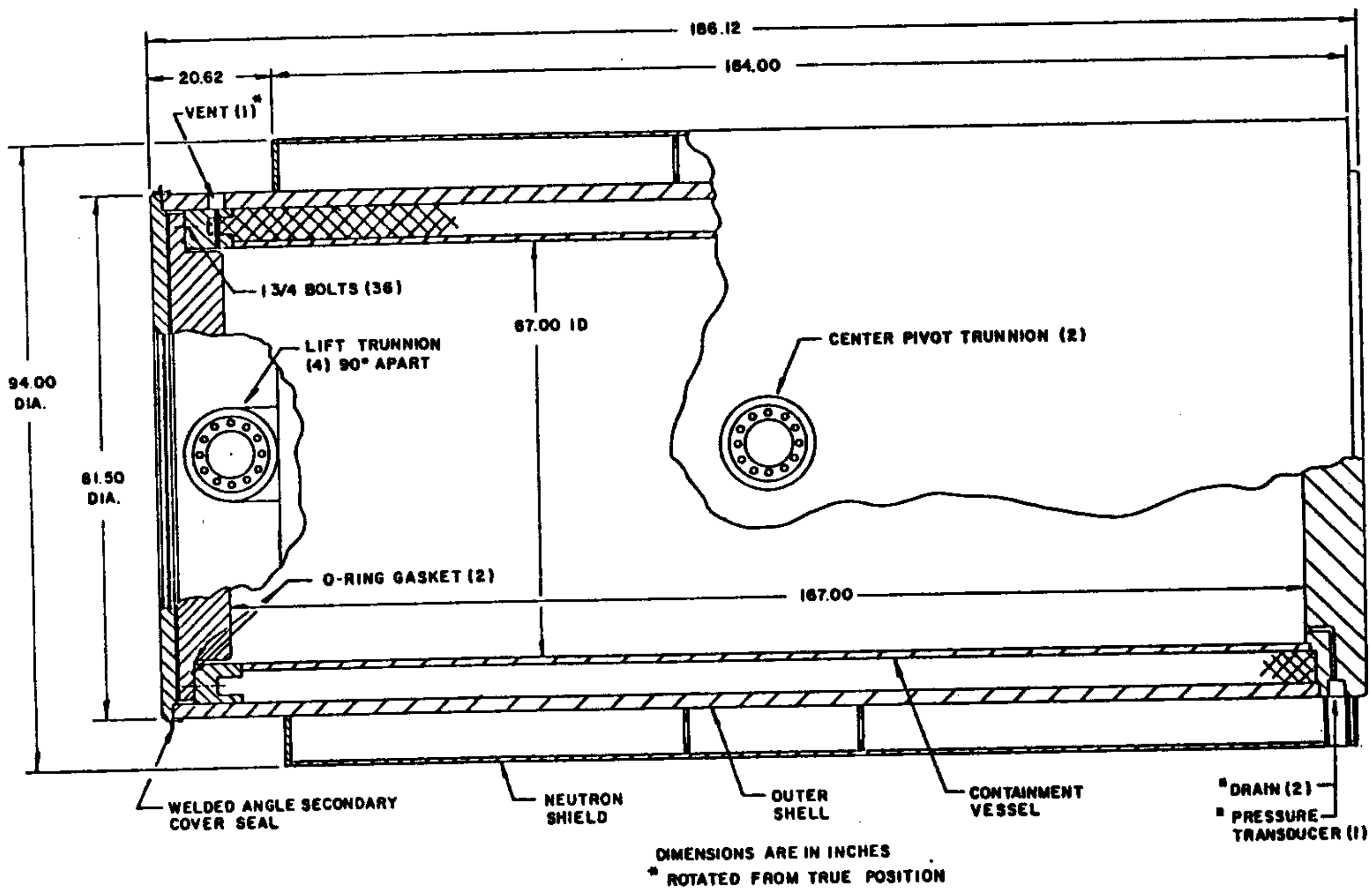


Figure 3.3-1. REA-2023 Dry Storage Cask for PWR Spent Fuel

The REA-2023 cask is claimed to limit fuel clad temperatures to 482°F (250°C) for intact PWR fuel and 572°F (300°C) for consolidated fuel rods. The REA-2023 cask design claims to limit the radiation dose rate to 20 mrem/hr for exterior surface contact for spent fuel 5 years out-of-reactor.

Transnuclear, Inc. (TN) of Germany has designed several storage casks for multiple fuel assemblies. Two of the casks (TN-1200S and TN-1200Z) hold 12 spent PWR fuel assemblies, a third (TN-2100) holds 21 spent PWR fuel assemblies and the fourth (TN-2400) holds 24 spent PWR fuel assemblies or 52 spent BWR fuel assemblies. The two TN-1200 cask designs are adaptions of the TN-12 spent fuel transport cask and use the internal basket design of the TN-12. The TN-2100 and TN-2400 designs are similar to that of the 12 assembly casks. A detailed illustration of the TN-2100 design is provided in Figure 3.3-2. The TN cask designs have either 11 inches of cast ductile iron (TN-1200S and TN-2100) or 9 inches of forged carbon steel (TN-1200Z and TN-2400) as the gamma shield and all have 4 inches of borated solid resin on the outside of the cask as the neutron shield. Each TN-1200 cask weighs about 92 tons (loaded) and is about 93 inches in diameter and 210 inches long. Each has a 48 inch inside diameter stainless steel basket liner. The exterior surface has fins to enhance heat transfer. The TN-2100 cask weighs about 115 tons (loaded) and is 92 inches in diameter by 192 inches long. The TN-2100 cask has a 65.1 inch inside diameter stainless steel basket liner and also has external cooling fins. The TN-2400 cask is shown schematically in Figure 3.3-3 and is the same basic size as the TN-2100 except for a smooth exterior shell surrounding the cooling fins. The basket assembly for any of the TN casks is made of a series of horizontal aluminum spacer plates which form square openings. These plates capture a series of borated plates which surround each square opening for criticality poison. The TN-1200 and 2100 casks use a single cover with two metallic O-rings. The cover is secured by 36 bolts. The TN-2400 uses two covers with double O-rings for interspace gas sampling.

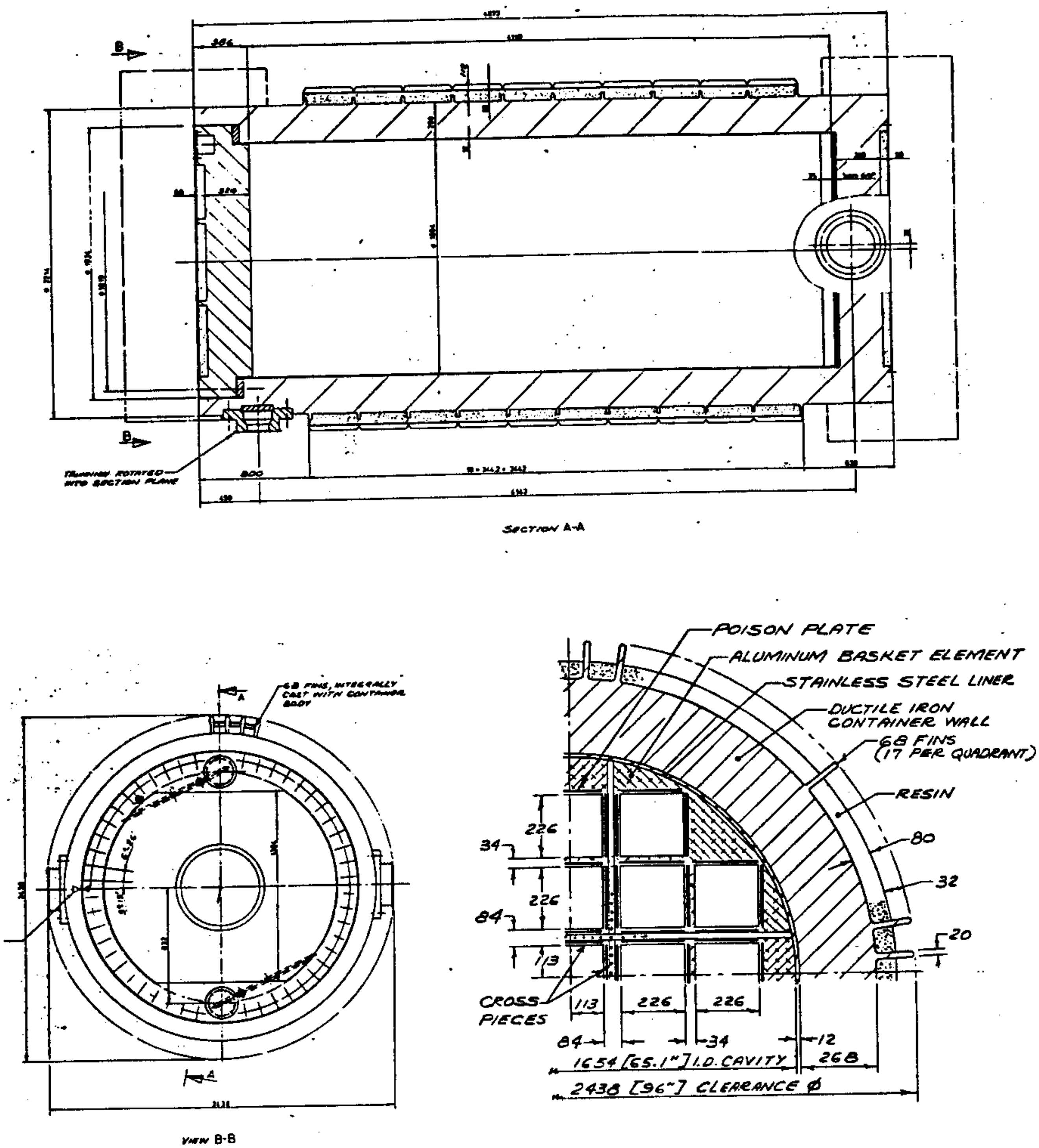
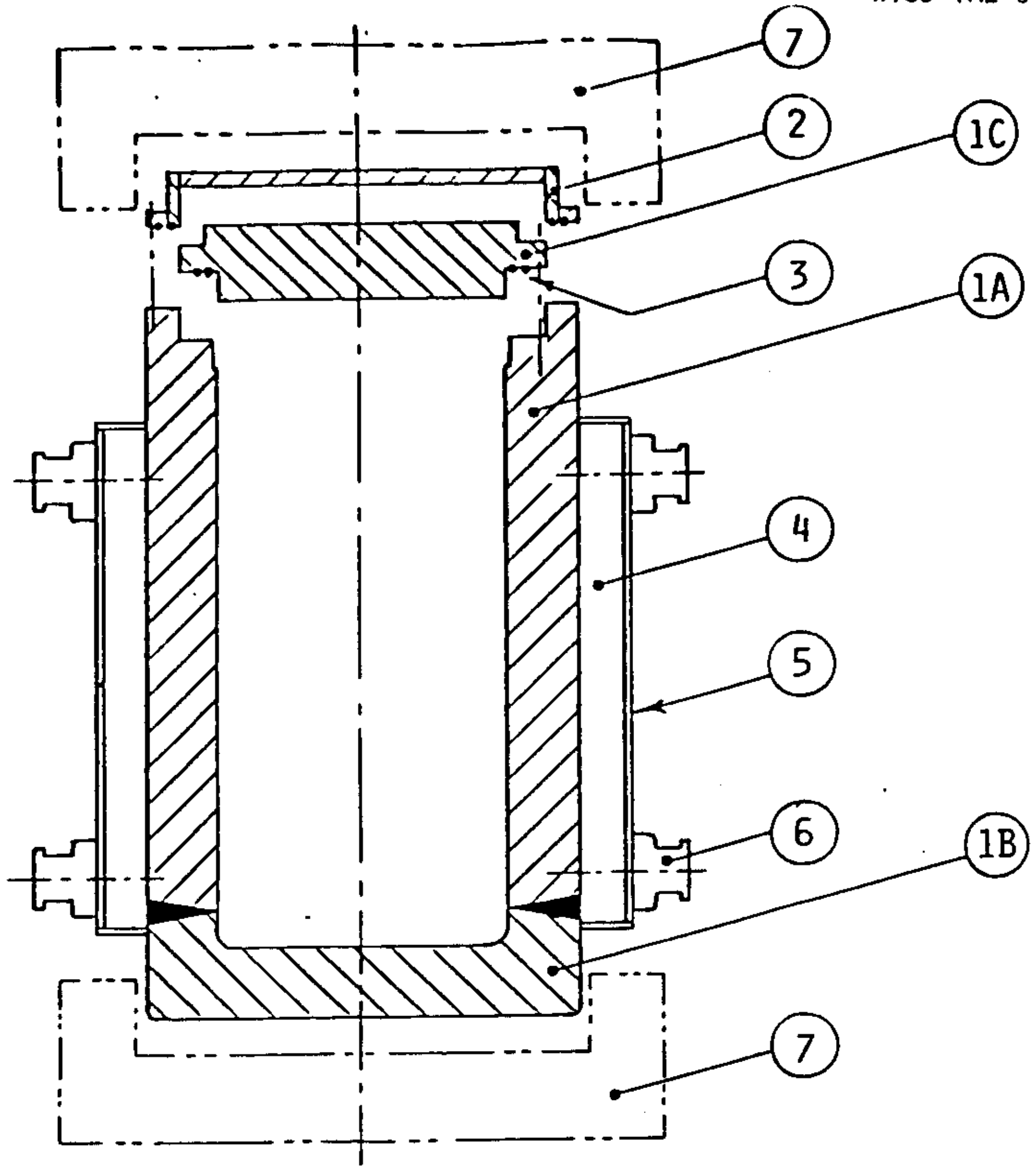


Figure 3.3-2. Transnuclear, Inc. TN-2100 Storage Cask



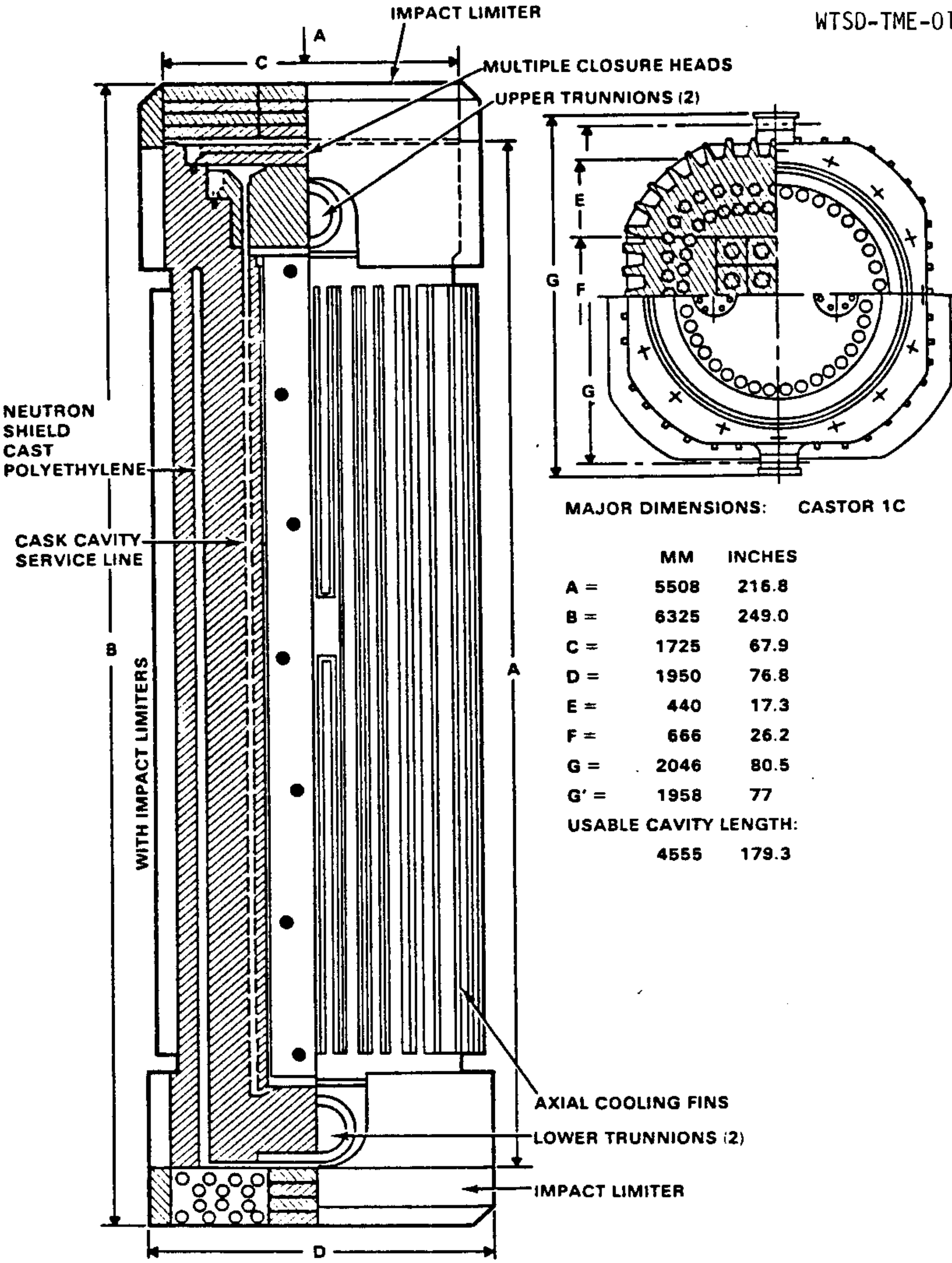
1. Forged Steel Vessel
   A. Shell
   B. Bottom
   C. Lid Closure
2. Lid Cover (Double Closure)
3. Double O-Ring Seals with Interspace Sniffing
4. Solid Neutron Shield
5. Smooth Heat Rejection Surface
6. Removable Trunnions for Handling and Transport Tiedown
7. Impact Limiters

Figure 3.3-3. Transnuclear, Inc. TN-2400 Storage Cask

Technical information provided for the TN storage casks stated a maximum predicted fuel clad temperature of about 425°F (220°C) for a design heat load of 1 kW per assembly for the TN-1200's, a maximum fuel clad temperature of about 400°F (205°C) for a design heat load of 0.7 kW per assembly for the TN-2100, and a maximum fuel clad temperature of 707°F (375°C) for a design heat load of 0.5 kW per assembly for the TN-2400. External dose rates were quoted to be less than 20 mrem/hr on the cask surface for spent fuel 5 to 8 years out-of-reactor.

Another German company, Gesellschaft für Nuklear Service (GNS), has designed several CASTOR V storage casks which are comparable to the presently designed and licensed (in the Federal Republic of Germany) CASTOR over-the-road transportation casks. Two CASTOR V casks were identified with storage capacities of 16 or 21 intact PWR assemblies or consolidated fuel rod assemblies from 32 or 42 spent fuel assemblies. These two casks have loaded weights of 100 and 105 tons for intact fuel assemblies and loaded weights of 115 and 120 tons for consolidated fuel rods. A comparable shipping cask (CASTOR 1C - a nominal 80-ton cask with a 28 inch square cross section cavity) is shown in Figure 3.3-4. The material of the CASTOR cask is nodular graphite cast iron. The cask body thickness is approximately 11 inches to provide gamma shielding. Neutron shielding is provided by a double row of long cylindrical, borated polyethylene channels or a single layer cast into the body of the cask. The exterior surface of the CASTOR storage casks are likely to be smooth; however, fins may be required for the storage of consolidated fuel rods depending on the internal heat load. The exterior surface is epoxy coated to provide corrosion protection and to ease surface decontamination operations. The internal cavity has a basket of boron steel which provides support and criticality poison for the fuel.

The CASTOR V casks use a double or triple cover containment system. The primary and secondary covers are stainless steel and have multiple seals of metal and radiation resistant elastomer O-rings. These two covers are each held in



MAJOR DIMENSIONS: CASTOR 1C

	MM	INCHES
A =	5508	216.8
B =	6325	249.0
C =	1725	67.9
D =	1950	76.8
E =	440	17.3
F =	666	26.2
G =	2046	80.5
G' =	1958	77
USABLE CAVITY LENGTH:	4555	179.3

Figure 3.3-4. GNS Castor IC Shipping Cask

0548I-33

place by 36 bolts. The third cover is carbon steel, has a single elastomer O-ring and is held in place by 18 bolts. This optional cover serves to protect the other two covers from impact and from the environment. The CASTOR cask cover system is designed to allow either periodic checks of the three cover seals or continuous monitoring of pressure between the covers. The CASTOR casks are handled using 4 bolt-on trunnions and may also use two additional bolt-on trunnions for rotating the cask from vertical to horizontal.

The two CASTOR V casks were quoted to limit the fuel clad temperature to 715°F (380°C) and to limit the radiation dose rate to 10 mrem/hr at 6 feet from the cask surface (detailed information in spent fuel parameters which correspond to these values was not available).

Development Status

Each of the casks described are extensions of proven construction concepts for licensed spent fuel shipping casks. The REA-2023 cask body is very similar to that of the NL 10/24 cask which is licensed for spent fuel shipment in the U. S. The neutron poison in the REA-2023 cask basket is Boral (a borated aluminum composite), which has been used extensively for high-density spent fuel racks. Boral has been extensively evaluated for corrosion, irradiation stability, heat transfer, and nuclear criticality prevention over a 20-year period and has been approved by the NRC for a number of applications. As noted for the CASTOR and TN storage casks, these are extensions of shipping casks (body and poisoned baskets) licensed in Europe.

Both the REA-2023 and the GNS Castor casks are presently in active design/construction phases. Full-scale testing of both casks is planned for 1983 at the Barnwell Nuclear Fuel Plant for uncontaminated checkout purposes, and at the TVA-Browns Ferry Plant for "warm" checkout. Tests performed in Europe on the Castor 1C cask have demonstrated the strength of this cask under simulated drop- and fire-accident conditions. Both REA and GNS have already submitted topical reports to the NRC for their casks and Transnuclear is preparing a topical report for its cask for submittal to the NRC in the fall of 1983. These topical reports present the feature descriptions and analyses results to allow each cask to be evaluated against the criteria of 10CFR Part 72, "Licensing Requirements for Storage of Spent Fuel In An Independent Spent Fuel Storage Installation".

Reference Storage Cask

The REA-2023 storage cask was selected as the reference storage cask for this study based on the response of REA to an inquiry specific to the needs of this study. This information included cask cost data, production rate data, and storage capability information for the HLW and RHTRU canisters. For this study, the number of storage casks needed for each processing rate and total facility capacity were based on: 1) storing 24 spent fuel assembly canisters or 24 spent fuel consolidated hardware canisters in each cask assuming that each cask would hold spent fuel rod canisters or hardware canisters from only one type of spent fuel (PWR or BWR); and 2) storing 16 HLW canisters, 4 RHTRU canisters or 16 55-gallon drums in each cask. Storage of the HLW and RHTRU canisters would require specially designed baskets for each type of storage canisters. The cask storage arrangements are shown in Figures 3.3-5 and 3.3-6.

The REA-2023 cask is designed to safely store spent fuel above grade without need of a building or other enclosure in compliance with the requirements of 10CFR Part 72. The cask may be stored in either a horizontal or a vertical orientation. For this study, the casks are stored horizontally. In the horizontal orientation, the cask is supported by a transport/storage skid, as illustrated in Figure 3.3-7. The horizontal orientation provides a number of advantages relative to vertical storage orientation which include:

1. Simplifies storage site handling operations and on-site transfer equipment requirements.

2. Allows easy access to monitoring ports.

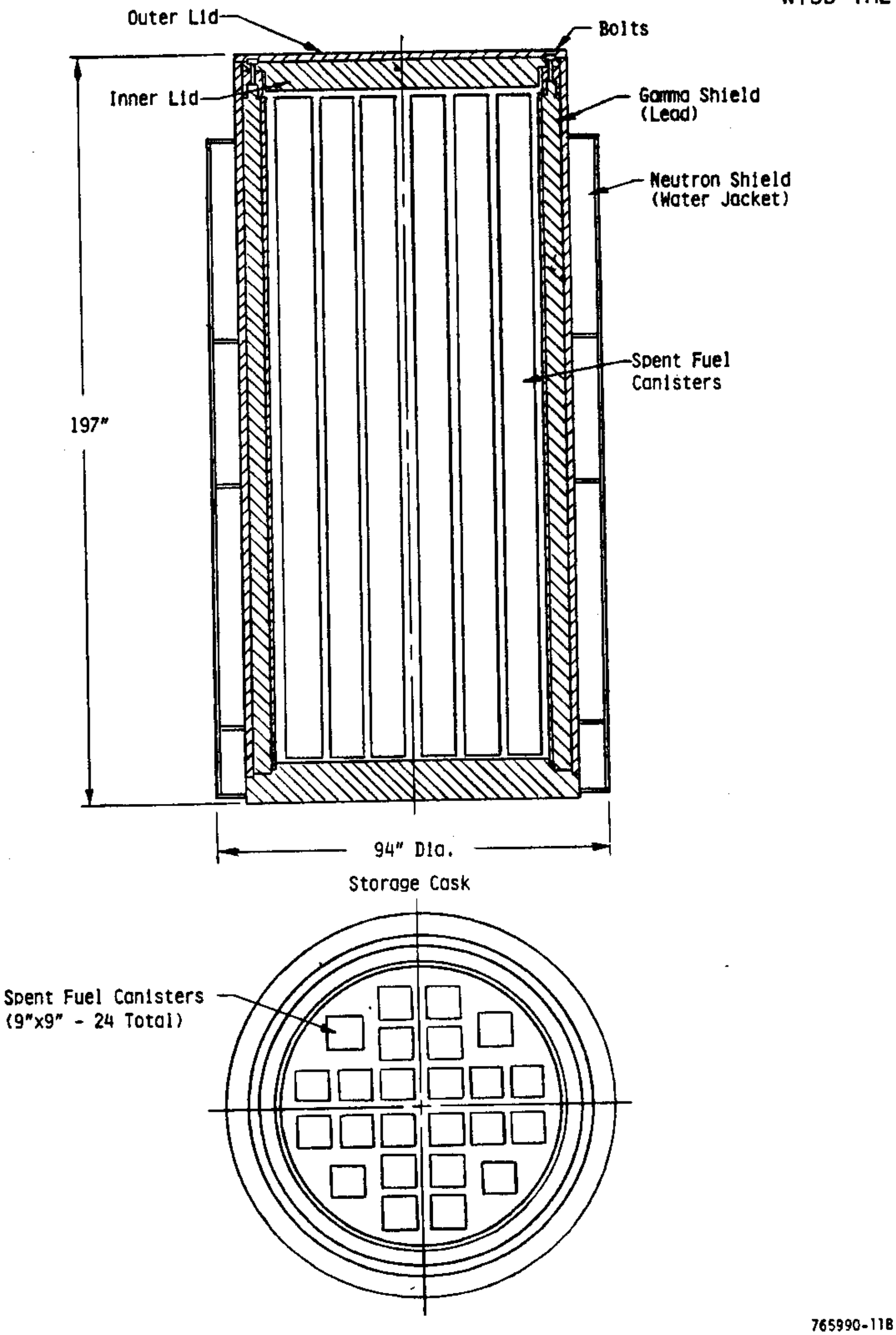


Figure 3.3-5. Spent Fuel Storage Cask Arrangement

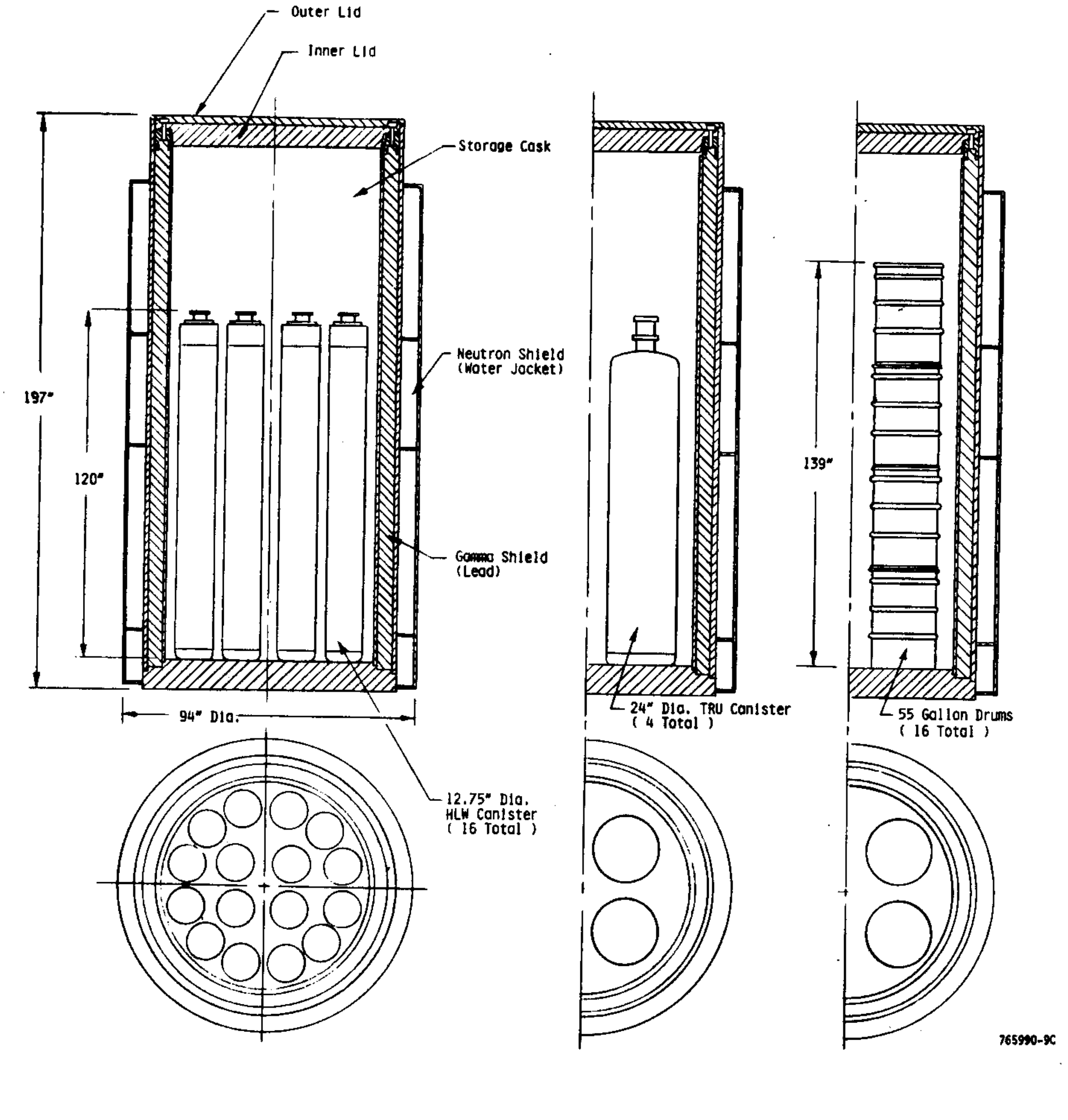


Figure 3.3-6. High-Level Waste and Remote-Handled Transuranic Waste Storage Cask Arrangement

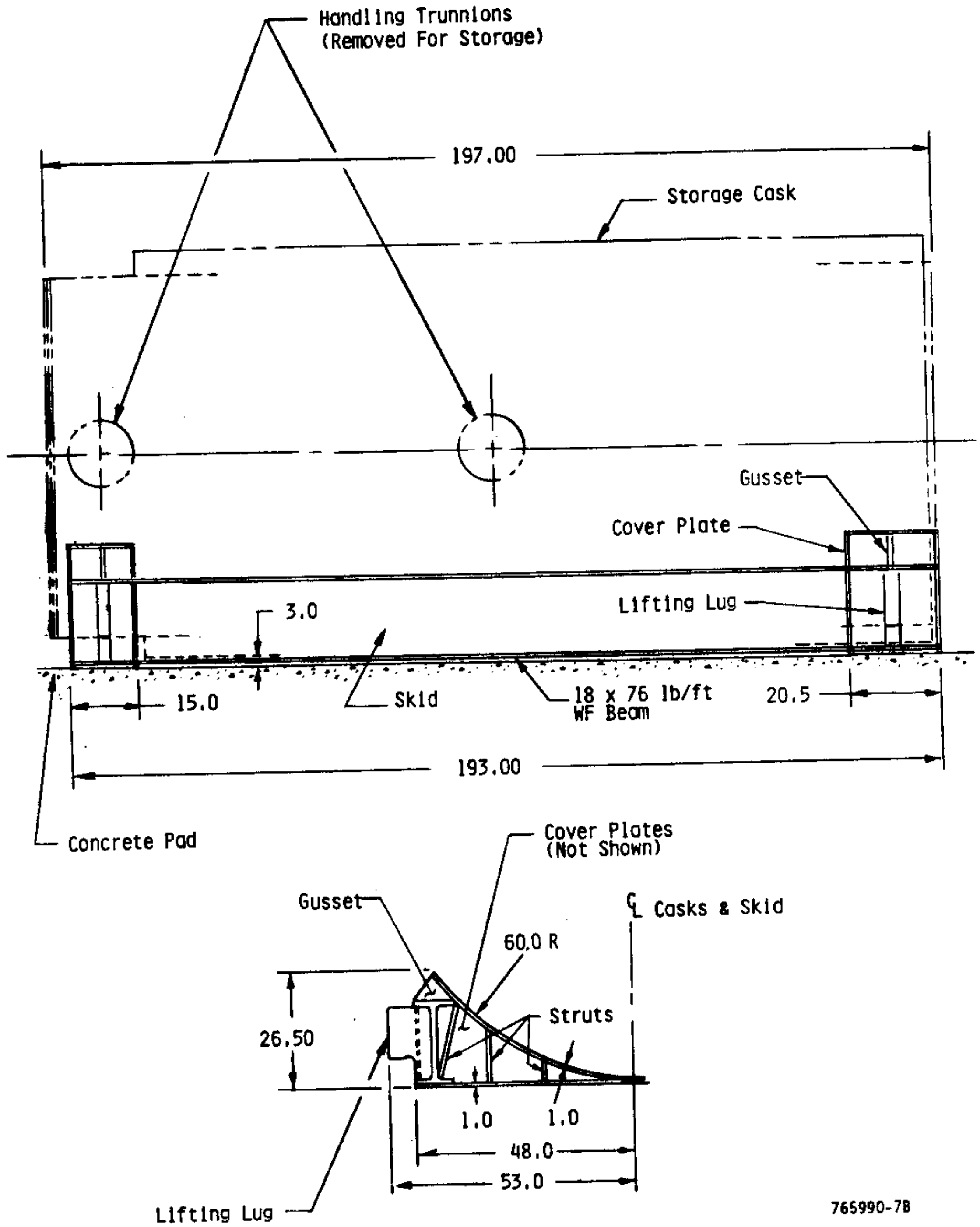


Figure 3.3-7. Cask Horizontal Storage Configuration

3. Reduces site boundary dose with convenient localized shielding, if required, and more self-shielding by each cask.

4. Eliminates possibility of cask tip-over during on-site transfer or storage, or any accident situation (earthquake, tornado).

5. Reduces load per unit area on storage pad by a factor of up to two.

When the cask is horizontal, it rests on cradles which are part of the skid designed by REA for storage or transport, or on special cradles integrated into the storage pad design. These cradles support the horizontal cask above the storage pad surface a minimum of 3 inches which is sufficient for air circulation around the cask for cooling. The cradles prevent the cylindrical cask from rolling while protecting the integrity of the neutron shield shell by concentrating the load at each end of the cask where plates and rings are located for support.

For this study, the casks are stored on the skid shown in Figure 3.3-7. This skid is made of welded carbon steel beams and plates and includes four lifting lugs at the corners. This skid also allows cask and skid handling with a simplified lifting fixture of spreader bars and wire cables.

Control methods used to prevent criticality with the REA-2023 cask consist of geometric separation of fuel assemblies within storage tubes that are composed of fixed neutron absorbing material (poison). The REA-2023 cask for dry storage of PWR unconsolidated design basis fuel was analyzed by REA for nuclear criticality safety. Spent fuel was modelled conservatively as active fuel enriched to 3.5 percent during worst case (wet) loading conditions. Loading and handling conditions were also analyzed with borated water moderation and at lower enrichment. Dry storage conditions were analyzed with both 3.5 and 1.5 percent enriched fuel. Finally, an infinite array of casks was modelled with optimum moderated, fully enriched (3.5 percent), active PWR fuel in each cask.

The REA analysis results (see Reference 2) indicate that the REA-2023 cask is designed to be maintained subcritical and to prevent a nuclear criticality accident in compliance with 10 CFR, Part 72, Section 72.73, criteria for nuclear criticality safety. The design is considered criticality safe not only during dry storage under various conditions (fuel assembly spacing, with or without poison) but also during loading conditions with active fuel enriched to 3.5 percent U-235 in a pool of unborated water. The latter, worst case condition, was calculated to be subcritical even when modelled as an infinite array of closely spaced casks. The REA-2023 design for storage and handling includes margins of safety for the nuclear criticality parameters that are commensurate with the uncertainties in the handling and storage conditions, in the data and methods used in calculations, and in the nature of the immediate environment under accident conditions.

A pressure transducer is provided with the REA-2023 cask to allow continuous monitoring of internal cavity pressure while the cask is in operation at the storage facility. Once connected to a control station, performance of the REA-2023 can be monitored remotely.

No radioactive releases during normal operation or accidents resulting in radioactive releases are considered credible. In addition, the gaseous releases postulated as the result of the hypothetical accidents are of a very small magnitude.

The peak fuel clad temperatures for the 10 year old consolidated PWR and BWR spent fuel are estimated by REA to be less than 260°C. The maximum HLW canister temperature for 16 in a cask is estimated to be less than 350°C for the 2200 watt decay heat generation rate per canister. The average surface dose rate for casks with either consolidated spent fuel or HLW canisters is estimated to be less than 20 mrem/hour.

The thermal analysis methodology used to evaluate the REA-2023 cask is described in Reference 2. The thermal calculations were performed by REA using the TRUMP computer code (Reference 3). Additional information relative to the predicted temperatures is available from REA.

3.3.2 Spent Fuel Cask Storage Facility

The cask storage facility for consolidated spent fuel consists of concrete slabs constructed on a prepared site of compacted and rolled gravel. Access to the storage facility from the Receiving and Handling Facility is via a paved heavy haul roadway. The 15,000 MTU facility is shown in Figure 3.3-8. A double security fence, with lights, intrusion alarms, and/or TV surveillance systems continuously manned by security guards provides access control. A small concrete block building located at the entrance to the storage facility provides required amenities for security and operating personnel, as well as equipment for status monitoring of the storage casks.

Cask storage facility site preparation includes removal of surface material to firm soil, compacting selected fill material to a firm level surface, addition of two 6-inch layers of large and smaller size gravel, and compacting and rolling the gravel to serve as pad foundation and vehicle roadway. Wire mesh reinforced concrete storage pads (each 40 feet wide, 140 feet long and 12 inches deep) are formed (using reusable steel forms) on top of the gravel, the concrete poured and finished, and the forms removed. Each storage pad is sized to hold 18 storage casks arranged as shown in Figure 3.3-8. The pads are constructed as needed to allow for the incremental expansion for the three processing and storage rates.

An evaluation of storage array packing density was performed by REA including such factors as radiation dose rates, handling requirements, heat dissipation and static loads on the storage pad. Based on these factors, the distance between adjacent cask sides is set at eight feet. The cask ends are placed two feet apart to minimize pad width.

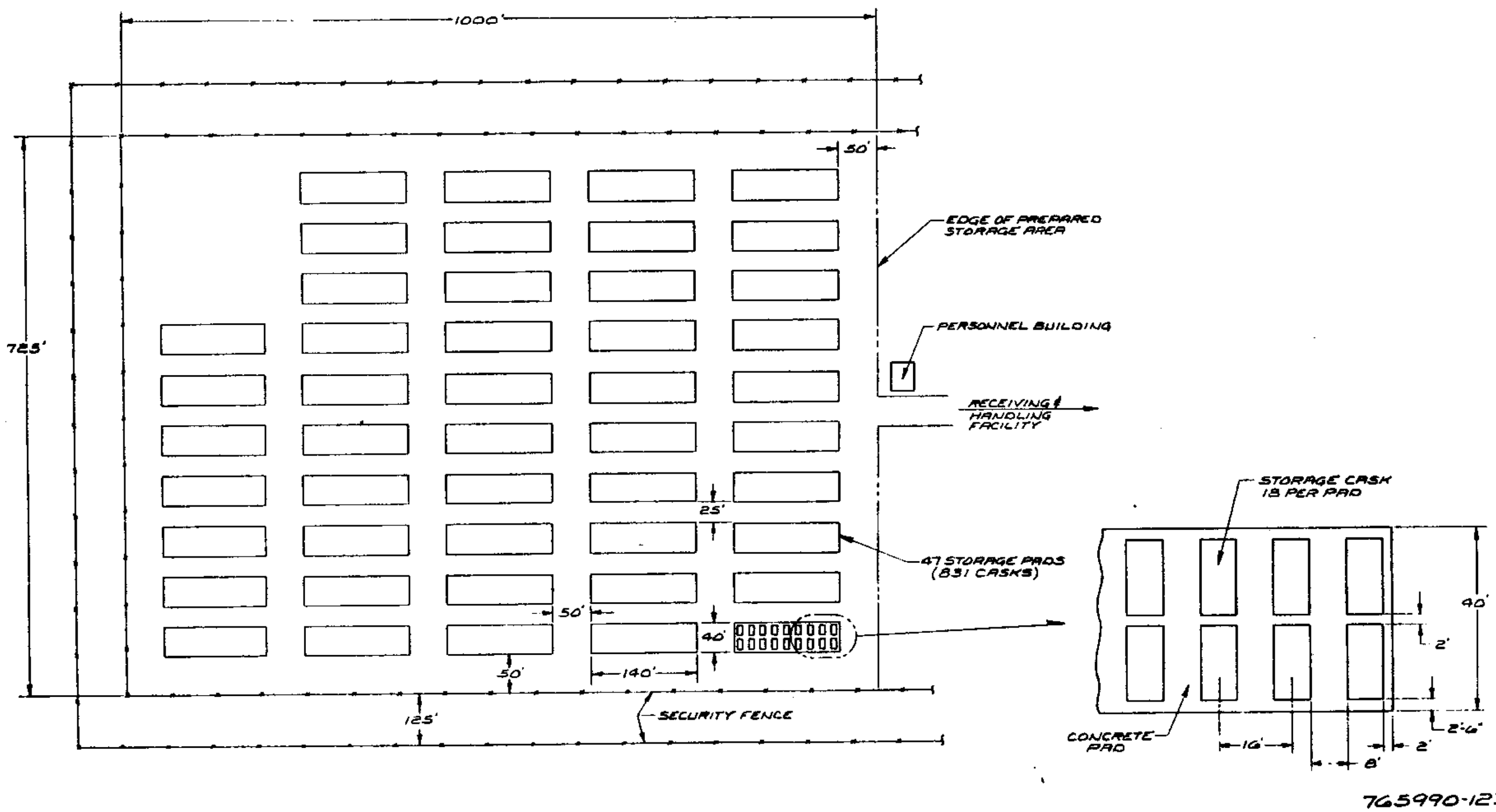


Figure 3.3-8. Spent Fuel Cask Storage Facility - 15,000 MTU Capacity

The number of storage casks and pads required for each processing rate and each facility capacity are provided in Table 3.3-1. The total facility size for the 15,000 MTU capacity is 16.6 acres. Expansion of this facility to a 72,000 MTU capacity involves expanding the storage pad array to 11 rows of 20 pads each which increases the area to 67.6 acres. The dimensions of these facilities are shown in Figure 3.3-9.

Operations at the storage facility include:

- Position the low-bed trailer for cask removal.
- Remove the cask-to-vehicle tie-down devices.
- Lift the cask and skid from the vehicle using a 125 ton capacity mobile crane, and set it on the concrete pad.
- Remove lifting trunnions from cask and store for future use (if not previously removed before transport to the storage facility).
- Install pressure transducer and bolt cover plate on cask.
- Take cask surface temperature and radiation level measurements.
- Return low-bed trailer to the Receiving and Handling Facility.

The cask storage facility can be constructed at most any site without geologic or hydrologic constraints other than the site's ability to support cask and handling equipment loads. The design of the storage facility foundation to accommodate the loads is well within present technology. The choice of various storage sites may require a thicker foundation layer to raise the casks above the maximum flood level which can be accomplished by construction of special berm. Construction methods for the most complicated cask storage facility are presently utilized in commercial power plant construction.

TABLE 3.3-1: SPENT FUEL STORAGE CASKS AND PADS REQUIRED

	RATE PER YEAR			STORAGE CAPACITY	
	1200 MTU	1800 MTU	3000 MTU	15,000 MTU	72,000 MTU
PWR Consolidated Fuel Casks	35	52.5	87.5	438	2,100
PWR Fuel and Control Hardware Casks	5.6	8.4	13.9	70	333
BWR Consolidated Fuel Casks	22	33	55	275	1,320
BWR Hardware Casks	3.8	5.7	9.5	48	227
TOTAL CASKS	66.4	99.6	165.9	831	3,980
Concrete Pads	3.7	5.5	9.2	47	222

TABLE 3.3-2: HIGH-LEVEL WASTE AND TRANSURANIC WASTE STORAGE CASKS AND PADS REQUIRED

	RATE PER YEAR			STORAGE CAPACITY	
	1200 MTU	1800 MTU	3000 MTU	15,000 MTU	72,000 MTU
HLW Canister Casks*	35.3	52.9	88.1	441	2,115
Hulls, Hardware and TRU Canister Casks**	111	166.5	227.5	1,388	6,660
TRU Drum Casks***	34.9	52.4	87.4	437	2,097
TOTAL CASKS	181.2	271.8	453	2,266	10,872
Concrete Pads	10.1	15.1	25.2	126	604

*Each cask contains 16 HLW canisters.

**Each cask contains 4 hulls, hardware or TRU 2-foot diameter canisters.

***Each cask contains 16-55 gallon TRU drums.

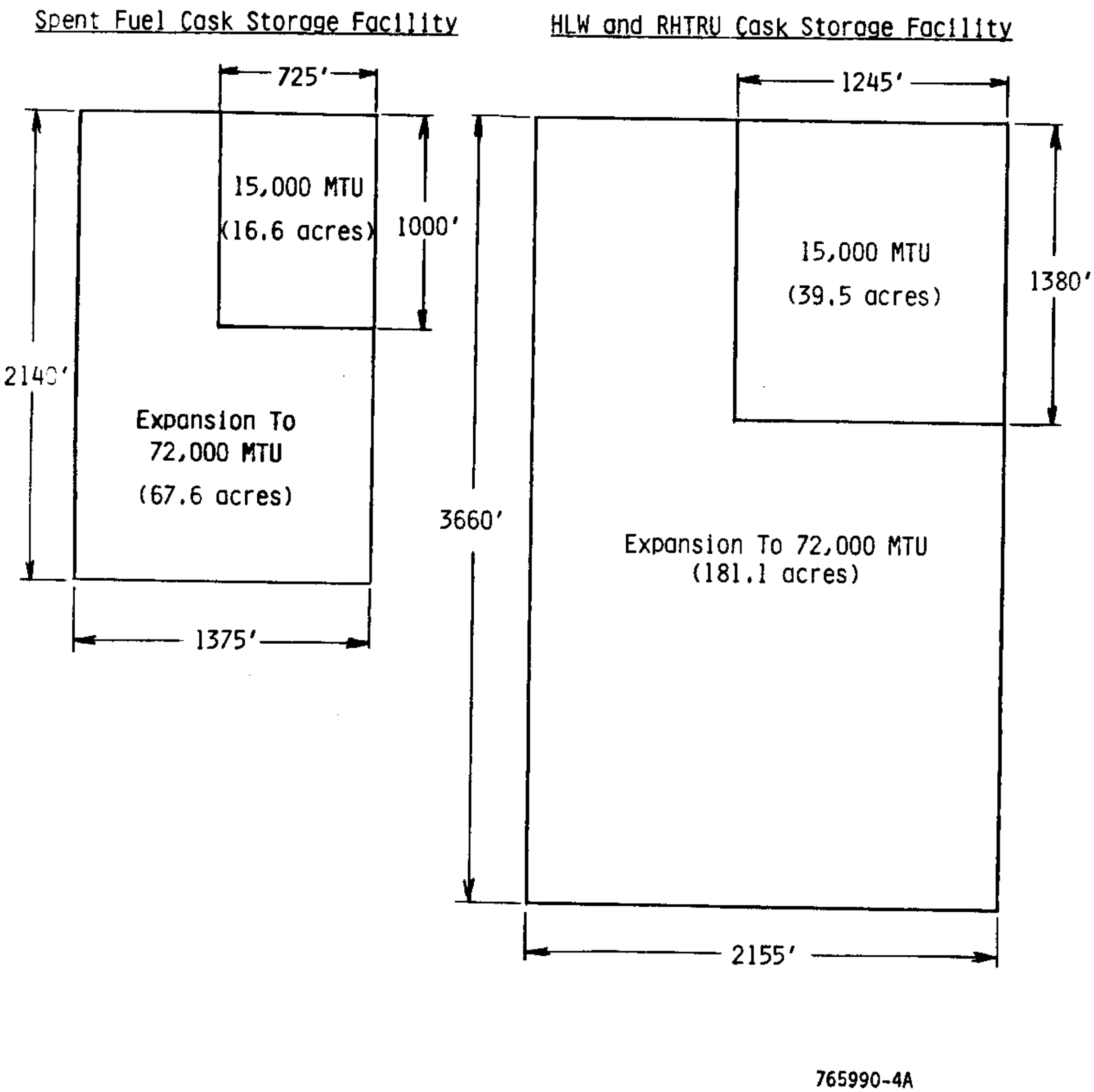


Figure 3.3-9. Cask Storage Facility Arrangements and Expansions

3.3.3 High-Level Waste and Transuranic Waste Storage Facility

The HLW and TRU storage facility is divided into two separate sections. The HLW and RHTRU wastes are stored in storage casks in a facility similar to that described for spent fuel. The contact-handled TRU waste drums and boxes are stored in a prefabricated concrete and steel building since the radiation and decay heat levels are low.

HLW and RHTRU Cask Facility

The HLW and RHTRU canisters and RHTRU drums are contained in casks stored on concrete pads in the same configuration and arrangement as spent fuel (shown in Figure 3.3-8). The number of storage casks and pads required for each processing rate and the totals required for each facility capacity are provided in Table 3.3-2. The total facility size for the 15,000 MTU capacity is 39.5 acres and expansion to a 72,000 MTU capacity increases this area to 181.1 acres. The 15,000 MTU facility consists of an array of 7 rows of 18 storage pads each which is enlarged to an array of 19 rows of 32 storage pads each for the 72,000 MTU facility. The dimensions of these facilities are shown in Figure 3.3-9.

CHTRU Storage Building

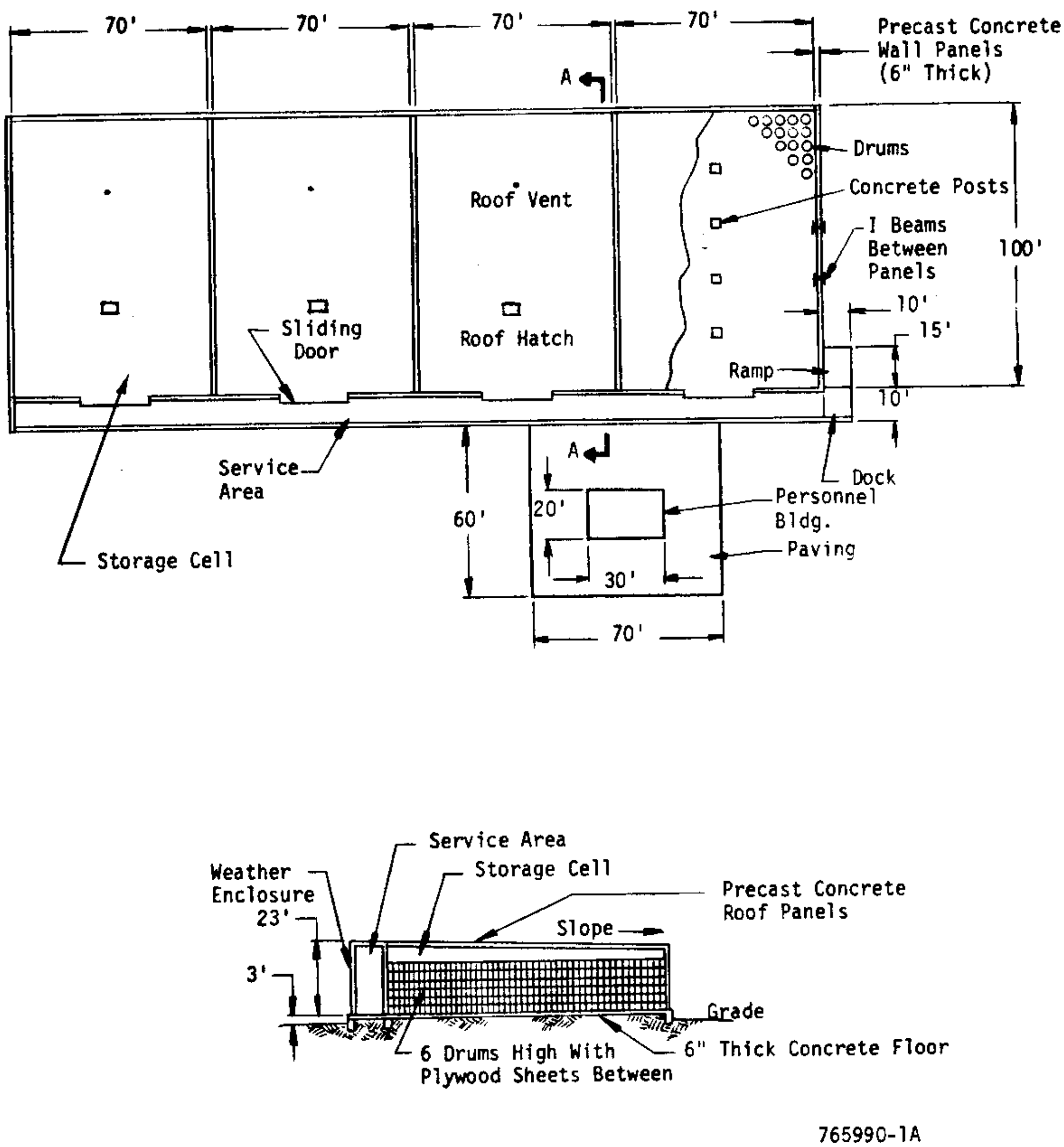
The retrievable storage of CHTRU for extended periods is a recent development. However, the use of an interim storage step for CHTRU for short periods at the point of its generation is a routine operation. Nuclear facilities, both commercial and government, have stored CHTRU for a short time prior to its shipment as a matter of practicality, ensuring that a full shipment is in inventory to gain maximum utilization of transportation equipment. At present, Oak Ridge National Laboratory is using indoor interim storage of CHTRU on a long-term basis, while Idaho National Engineering Laboratory is developing that capability. The concept is quite simple, requiring no special handling equipment for CHTRU. The construction of a traditional warehouse is sufficient to meet storage needs. Variations in the concept are mostly in the choice of structural materials.

Alternatives for indoor storage of CHTRU primarily involve materials and methods for constructing the storage facility. Possible construction materials include: 1) reinforced concrete, 2) wood, 3) metal and 4) coated fabric. Corresponding construction methods include: 1) precast concrete, cast-in-place concrete or concrete block; 2) wood frame; 3) metal frame; and 4) air-supported or structurally-supported coated-fabric buildings. A precast concrete indoor storage facility has been selected as the reference concept for this study. Among the parameters considered in making this choice were relative cost, maintenance, ease of decontamination, ease of dismantling, service life, salvage value, and resistance to fire, wind and rain.

The storage building for the CHTRU waste is modular in construction and consists of precast reinforced concrete slabs. The modular design is suggested because it allows for future expansion at a cost effective price. When additional capacity is required, another modular unit is added on. The adjoining wall of the first building along with the receiving and docking facilities can be shared thus reducing cost. The storage facility can then be expanded to include a large number of modular units.

Figure 3.3-10 illustrates the CHTRU modular facility design. Two modular units have capacity to store up to 8,300 MTU. This is equivalent to approximately 18,300 (55 gal.) drums and over 225 (4'x6'x6') steel boxes. The third and fourth modules are added to expand the facility to a total capacity of 15,000 MTU. Figure 3.3-11 illustrates the dimensions and arrangements for the 15,000 MTU facility and expansion to a 72,000 MTU capacity. The facility size for the 15,000 MTU capacity is 0.8 acres and increases to 3.2 acres for expansion to 72,000 MTU.

The four module design concept has a common service area leading to the dock and ramp. The service area is a raised walk-way/road 10 feet wide and 3 feet above ground level with a steel weather enclosure. This permits direct access to each modular unit on the same level. Each modular unit's floor is 3 feet



SECTION A-A

Figure 3.3-10. Contact-Handled TRU Storage Facility - 15,000 MTU Capacity

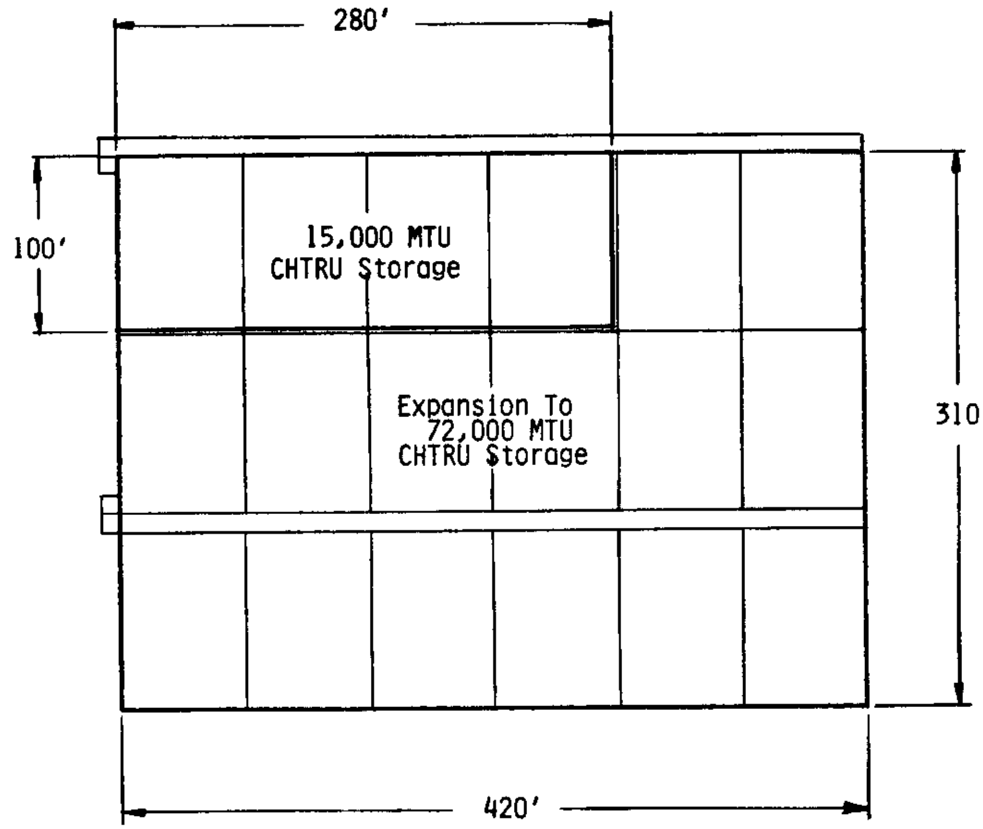


Figure 3.3-11. Contact-Handled TRU Storage Facility Expansion

above the surrounding grade to eliminate flooding concerns. The raised service area also allows for easy access to facilitate drum and box unloading at the dock. The dock and ramp sections are portable concrete structures and can be detached from the modular storage facility when new modular units are added. Each unit is equipped with natural circulation ventilation roof vents and wall openings. Roof hatches provide access to the facility to monitor and check storage containers. For normal operation of the facility, a mobile crane, fork lift truck with a drum grabber, and portable lighting are required. Individual handling of drums or boxes does not require shielding outside the storage facility. However, a shielded fork lift truck may be needed to limit operator exposure inside the facility. This is due to the "wall effect" of a stack of drums six high and 100 feet long assuming the containers are at maximum surface dose rates of 0.2 Rem. Radiation levels associated with a reference CHTRU storage facility have been estimated to be about 20 mrem/hour.

The CHTRU waste is assumed to arrive from the Receiving and Handling Facility by truck. Most of the waste is in single 55 gallon drums and arrives palletized with several drums per pallet. A small portion of the CHTRU waste is in steel boxes (4'x6'x6'). At the storage building, a mobile crane is used to unload the drums or boxes. A fork-lift truck then moves the waste packages into the storage building for stacking. Drums are stacked six high in horizontal layers with plywood sheets between layers. The forklift truck is equipped with a drum grabber and is used to stack the waste containers. When the storage building is full, a sliding door is closed and sealed. The waste containers are then inspected and monitored through roof hatches in the building.

Removing the drums and boxes from the storage building for final repository storage is a similar operation. The drums and boxes are removed to the storage building loading dock by a fork-lift truck. They are then returned to the Receiving and Handling Facility and either loaded onto rail cars or trucks for transfer to a terminal storage site.

3.4 SUPPORT

The support required for either MRS cask storage facility include the facilities, utilities and equipment needed to maintain facility operation. The facilities include the cask storage facility security building, the asphalt paved roads leading from the Receiving and Handling Facility, the new rail line from the Transfer Corridor to the cask handling bridge crane, and the personnel building and paved parking lot for the CHTRU storage building. These were previously described in Section 3.3. The utilities for the storage facility are provided from the Receiving and Handling Facility and are extensions from the existing water, sewage, electric power and communication systems. The water, electric power and sewage are needed for the storage facility personnel building. The communications systems include the in-plant telephone system, a VHF radio system, and an intercom/paging system connecting the storage facility with the rest of the MRS.

The support equipment for the MRS cask storage facility are needed to handle and transfer the storage casks or CHTRU containers to their respective storage locations. Equipment for the storage casks include a 125-ton capacity motorized rail cart and a 125-ton capacity mobile crane while fork lift trucks and flat bed trucks are needed for CHTRU. This equipment was previously noted and represents an increase in total MRS support equipment. Additional fuel oil and gasoline are needed for the motorized vehicles.

The increased size of the MRS facility to include the storage facility results in an increased security and monitoring system. The security system increase includes more double chain link fence and sensors and lighting for the interfence zone. Radiation monitors for the perimeter of the storage facility are also needed to assure that radiation levels do not exceed preset limits and to detect any airborne radiative particulates. The pressure transducers for each storage cask and their hookup to monitoring areas in the personnel/security buildings and the main control room in the Receiving and Handling Facility also represent additions to the MRS.

4.0 COST ANALYSIS

Cost estimates and time distributions of expenditures have been developed for construction, operation, and decommissioning of the spent fuel and HLW and TRU MRS facilities described in Section 3. All cost estimates are presented in mid-1983 dollars. Wage rates for construction labor estimates represent those prevailing in the Oak Ridge, Tennessee area in mid-1983.

The life cycle costs for the 15,000 MTU capacity storage facilities and the estimated costs for expansion of the storage capacities to 72,000 MTU exclude the effects of general inflation and escalation resulting from local shortages of labor or material. Other costs specifically excluded from the estimates are listed in Table 4.0-1.

4.1 CONSTRUCTION

Construction cost estimates have been developed for the 15,000 MTU spent fuel cask storage facility and the 15,000 MTU HLW and TRU cask storage facility. These costs include the initial construction phase costs and the total costs to complete each facility.

Construction costs for the generic Receiving and Handling Facility and support facilities were taken from Reference 1. The schedule presented in the Kaiser Engineers study was used to develop the construction schedule shown in Figure 4.1-1. The construction schedules for both storage facilities are compatible with the initial 5-year construction phase identified in the Kaiser Engineers schedule. It may be noted that no time has been scheduled for Nuclear Regulatory Commission licensing of the facility prior to initiation of site construction. This activity would increase the duration of the initial construction phase by at least 15 months.

The elements of the construction costs common to both storage facilities are:

TABLE 4.0-1: COST EXCLUSIONS

1. Land and right-of-way acquisition
2. Extension of railroad spurs, access roads, and utilities to the facility site boundary
3. PNL and DOE engineering and administrative costs
4. Permits and licenses including NRC licensing
5. Sales or use tax
6. Transportation of spent fuel, HLW and TRU to or from facility
7. Process and patent royalties
8. Costs incurred beyond those that reflect the current degree of involvement in securing approvals from regulatory agencies monitoring environmental and safety considerations
9. Costs generated directly by any governing or regulatory agency for administration, engineering, procurement, or construction
10. Local property taxes or payments in lieu thereof
11. Impact payments to local governments
12. Insurance or prorate cost of self-insurance
13. Nuclear hazards insurance that may be required if such hazards exist on site before completion of project
14. Housing for construction

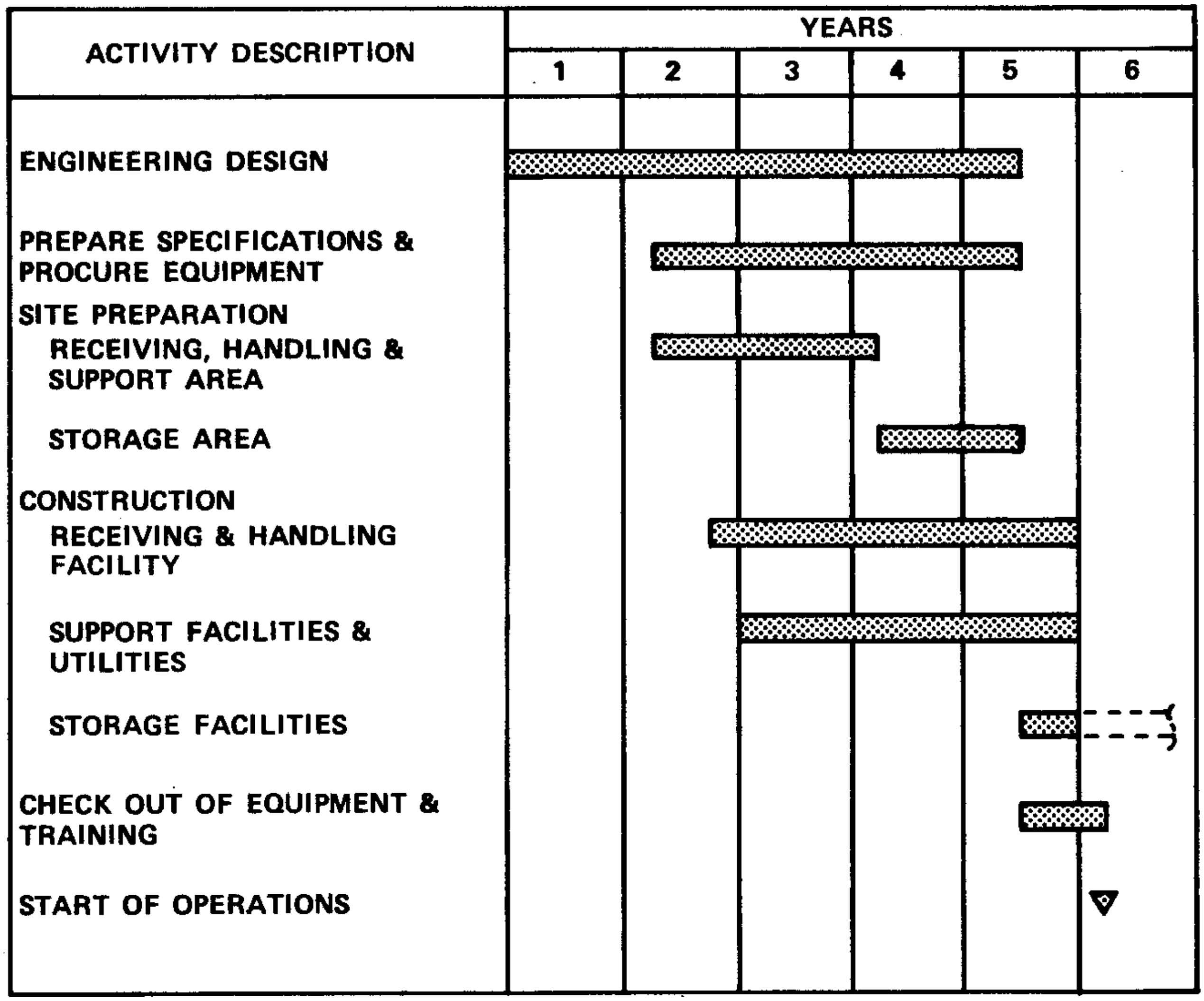


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Figure 4.1-1. MRS Storage Facility Engineering and Construction Schedule

- Generic Receiving and Handling Facility with support facilities
- Modifications to the Receiving and Handling Facility
- Storage casks and cask storage skids
- Site preparation and improvements
- Concrete storage pads
- Cask transportation equipment

A description of the bases for developing these common cost elements follows.

Modifications to the Receiving and Handling Facility

Modifications to adapt the generic Receiving and Handling Facility for the cask storage systems described in Section 3.1 include:

- Increase the diameter of the outlet ports in the hot cell floors
- Addition of movable shield collars at the outlet ports
- Installation of tracks for a rail-mounted cask cart
- Procurement and installation of a 125-ton bridge crane to handle loaded casks
- Procurement and installation of an evacuation and backfill system for the storage casks

These modifications are typical for the spent fuel cask storage facility and the HLW and TRU cask storage facility. The total cost for these modifications is estimated to be $1,480,000 which includes the cost of approximately 5547 manhours of installation labor.

Casks and Cask Storage Skids

The costs used for storage casks are based on recent estimates received from the reference cask vendor.

Delivered Storage Cask Cost	$750,000
Delivered Storage Skid Cost	5,000
Delivered Cost Per Storage Cask	$755,000

These costs represent a noncompetitive bidder environment and might be substantially reduced under more competitive conditions.

The repetitive costs presented for both storage cask facilities consider the cask cost as a direct construction cost and as such have a 25 percent contingency and a 4 percent owner's cost added to the delivered cost. Based on the present finalized design status of the reference storage cask, this additional 30 percent may be excessive. In addition, for the storage of HLW and TRU in casks, the cost for these casks was quoted as the same as that for the spent fuel casks even though the HLW- and TRU-containing casks can be shortened (approximately 5 feet) and the internal support cages simplified. These two potential cost reduction factors have not been considered in the costs presented in this study.

Site Preparation and Improvements

The cask storage facility is assumed to be located in a semi-arid region where the in situ soil consists primarily of clean sand with some silt, gravel, and larger stones. The undisturbed terrain is assumed to be reasonably level with an average grade of approximately 1 percent. Site preparation includes clearing and grubbing, excavation of approximately two feet of loose soil from the surface, and backfilling with selected material compacted in three 8-inch lifts to 95 percent of theoretical density. Twelve inches of crushed gravel are spread and rolled on top of the backfill to provide a suitable base for the concrete storage pads and access roadways for the cask transport vehicle. Drainage is promoted by site grading and ditches to direct run-off away from the storage area. Site improvements include security fencing, lighting, a personnel/security building and a security alarm system.

The site preparation and improvement costs given in Tables 4.1-1 and 4.1-3 for the storage facilities are nonrepetitive. They include a markup of 40 percent on direct labor and 10 percent on equipment use and materials to cover subcontractor overhead and profit. The estimated labor for site preparation and improvements is 18,924 manhours for the spent fuel storage facility and 41,484 manhours for the HLW and TRU cask storage area.

Concrete Storage Pads

The casks are stored horizontally on concrete pads as described in Section 3.3.2. Because of the repetitive construction methods used and the variable installation schedule, the costs for the concrete pads are separated from the site preparation and improvement costs. The costs given below are billing costs for a single concrete pad. They include a markup of 40 percent on direct labor and 10 percent on equipment and materials to cover subcontractor overhead and profit. The estimated construction labor for each pad is 328 manhours.

COST FOR INDIVIDUAL CONCRETE STORAGE PAD CONSTRUCTION

Equipment Use	Labor	Materials	Total
$726	$6080	$14,706	$21,512

Cask Transportation Equipment

The equipment and procurement costs for cask transportation equipment common to both storage facilities include:

Equipment	Quantity	Cost
Rail Mounted Motorized Cask Handling Cart	1	$ 100,000
Mobile Crane (125-ton capacity at 18' radius)	1	800,000

TABLE 4.1-1: INITIAL CONSTRUCTION COST SUMMARY SPENT FUEL CASK STORAGE FACILITY (15,000 MTU)

COSTS ($1000 - Mid 1983)

	EQUIPMENT USE	LABOR	MATERIAL	MAJOR EQUIP AND COMPONENT PROCUREMENT	TOTAL
DIRECT CONSTRUCTION COSTS					
Site Preparation (storage area only)	312	203	486	--	1,001
Site Improvements (storage area only)	6	121	195	--	322
Concrete Storage Pads (10 only)	7	61	147	--	215
Receiving and Handling Facility & Support Facilities					117,968
Facility Modification Allowance					1,480
Cask Transportation Equipment				1,055	1,055
Spent Fuel Storage Canisters (250)				398	398
Storage Casks & Skids (10 only)				7,550	7,550
Subtotal Direct Construction Costs	325	385	828	9,003	129,989
INDIRECT CONSTRUCTION COSTS					
Construction Services and Field Office Engineering (12.5%)					16,249
Home Office Engineering (12%)					17,549
Subtotal of Indirect Construction Costs					33,798
Total of Direct and Indirect Construction Costs					163,787
Contingency (25%)					40,947
Owner's Cost (7%)					14,331
Total Construction Cost Including Contingency and Owner's Cost					219,065

TABLE 4.1-2: TOTAL CONSTRUCTION COST SUMMARY SPENT FUEL CASK STORAGE FACILITY (15,000 MTU)

COSTS ($1000 - Mid 1983)

	INITIAL CONSTRUCTION	COST TO COMPLETE	TOTAL
DIRECT CONSTRUCTION COSTS			
Site Preparation (storage area only)	1,001	--	1,001
Site Improvements (storage area only)	322	--	322
Concrete Storage Pads	215	796	1,011
Receiving and Handling Facility & Support Facilities	117,968	--	117,968
Facility Modification	1,480	--	1,480
Cask Transportation Equipment	1,055	--	1,055
Spent Fuel Storage Canisters	398	24,957	25,355
Storage Casks & Skids	7,550	619,855	627,405
Subtotal Direct Construction Costs	129,989	645,608	775,597
INDIRECT CONSTRUCTION COSTS			
Construction Services and Field Office Engineering (12.5% for Construction, 0% for Repetitive Purchased Items)	16,249	100	16,349
Home Office Engineering (12% for Initial Construction, 6% for Repetitive Construction, 0% for Repetitive Purchased Items)	17,548	54	17,603
Subtotal of Indirect Construction Costs	33,797	154	33,952
Total of Direct and Indirect Construction Costs	163,786	645,762	809,549
Contingency (25%)	40,947	161,441	202,388
Owner's Cost (7% for Initial Construction, 4% for Completion)	14,331	32,288	46,619
Total Construction Cost Including Contingency and Owner's Cost	219,064	839,491	1,058,556

Equipment	Quantity	Cost
Low-Bed Trailer With Tractor	1	125,000
Cask Lifting Fixtures	2	30,000
		$1,055,000

4.1.1 Spent Fuel Cask Storage Facility Construction

The costs for the initial 5-year construction phase of the spent fuel cask storage facility are summarized in Table 4.1-1. The costs include:

- Site preparation of approximately 17 acres for the storage area
- Site improvements for the storage area
- Ten concrete storage pads
- Receiving and Handling Facility with support facilities and modifications
- On-site transportation equipment
- An initial complement of 250 storage canisters
- An initial complement of ten storage casks with skids

The costs for the initial complement of storage canisters were derived from the following information supplied by PNL:

PWR Canister	$1250 each
BWR Canister	$1300 each

An additional one-time set up charge of $80,000 was amortized over the initial 250 canisters.

The total construction costs for the 15,000 MTU spent fuel cask storage facility are summarized in Table 4.1-2. The total construction labor and material costs are presented in Table B-1 in Appendix B. The total facility construction costs consist of adding 821 casks and skids, 19,704 spent fuel canisters and 37 concrete storage pads to the initial construction costs. For the life cycle costs presented in Section 4.5, these repetitive cost items were applied based on the storage data presented in Tables 3.1-1 and 3.3-1 for the defined storage rates per year. During operating years 1 to 5, 1800 MTU of spent fuel is stored and during operating years 6 to 10, 1200 MTU of spent fuel is stored. Specific quantities are as follows:

- Concrete storage pads are constructed at a rate of 10 per year for years 1, 2, and 3 of operation with the final 7 being constructed in operating year 4.
- Casks, skids and canisters are purchased as follows: 90 casks and skids and 2160 canisters during operating year 1, 100 casks and skids and 2400 canisters during operating years 2 through 5, 67 casks and skids and 1608 canisters during operating year 6, and 66 casks and skids and 1584 canisters during operating years 7 through 10.

4.1.2 HLW and TRU Cask Storage Facility Construction

The costs for the initial 5-year construction phase of the HLW and TRU cask storage facility are summarized in Table 4.1-3. The direct costs include:

- Site preparation of approximately 40 acres for the storage area
- Site improvements for the storage area
- 10 concrete storage pads
- Receiving and Handling Facility with support facilities and modifications
- Cask transportation equipment
- An initial complement of 18 storage casks with skids
- Contact-handled TRU storage building (2 modules) and handling equipment

The total construction costs for the 15,000 MTU HLW and TRU cask storage facility are provided in Table 4.1-4. The total construction labor and material costs are presented in Table B-1 in Appendix B. The total facility construction costs consist of adding 2248 casks and skids and 116 concrete storage pads to the initial construction costs. For the life cycle costs presented in Section 4.5, these repetitive cost items were applied, based on the storage data presented in Table 3.3-2 for the defined storage rates per year. Specific quantities are as follows:

- Concrete storage pads are constructed at a rate of 15 per year for operating years 1 through 5, at a rate of 10 per year for operating years 6, 7 and 8, with the final 11 being constructed during operating year 9.
- Storage casks and skids are purchased as follows: 264 during operation year 1, 272 during operating years 2 through 5, 181 during operating years 6 through 9, and 172 during operating year 10.

Contact-Handled TRU Storage

The CHTRU storage building is described in Section 3.3.3. It consists of four adjacent modular units to contain the CHTRU fraction of the 15,000 equivalent MTU of HLW and TRU received at the MRS facility. The installed costs for each storage module are:

Labor	Material	Total
$469,000	$417,000	$886,000

These costs include a markup of 40 percent on direct labor and 10 percent on material to cover subcontractor overhead and profit. Approximately 23,330 man-hours are included for construction of each storage module.

The costs of two storage modules are included as nonrepetitive initial construction costs in Table 4.1-3. The third storage module is constructed during the third year of facility operation, and the fourth storage module is constructed during the sixth year of facility operation.

TABLE 4.1-3: INITIAL CONSTRUCTION COST SUMMARY HLW AND TRU CASK STORAGE FACILITY (15,000 MTU)
COSTS ($1000 - Mid 1983)

	EQUIPMENT USE	LABOR	MATERIAL	MAJOR EQUIP AND COMPONENT PROCUREMENT	TOTAL
DIRECT CONSTRUCTION COSTS					
Site Preparation (storage area only)	742	484	1,157	--	2,383
Site Improvements (storage area only)	15	222	391	--	628
Concrete Storage Pads (10 only)	7	61	147	--	215
Receiving and Handling Facility & Support Facilities					98,577
Facility Modification					1,480
Cask Transportation Equipment				1,055	1,055
CHTRU Storage Modules (2 only)		938	834		1,772
CHTRU Handling Equip.				201	201
Storage Casks & Skids (18 only)				13,590	13,590
Subtotal Direct Construction Costs	764	1,705	2,529	14,846	119,901
INDIRECT CONSTRUCTION COSTS					
Construction Services and Field Office Engineering (12.5%)					14,988
Home Office Engineering (12%)					16,187
Subtotal of Indirect Construction Costs					31,175
Total of Direct and Indirect Construction Costs					151,076
Contingency (25%)					37,769
Owner's Cost (7%)					13,219
Total Construction Cost Including Contingency and Owner's Cost					202,064

TABLE 4.1-4: TOTAL CONSTRUCTION COST SUMMARY HLW AND TRU CASK STORAGE FACILITY (15,000 MTU)

COSTS ($1000 - Mid 1983)

	INITIAL CONSTRUCTION	COST TO COMPLETE	TOTAL
DIRECT CONSTRUCTION COSTS			
Site Preparation (storage area only)	2,383	--	2,383
Site Improvements (storage area only)	628	--	628
Concrete Storage Pads	215	2,495	2,710
Receiving and Handling Facility & Support Facilities	98,577	--	98,577
Facility Modification	1,480	--	1,480
Cask Transportation Equipment	1,055	--	1,055
CHTRU Storage Modules	1,772	1,772	3,544
CHTRU Handling Equip.	201	--	201
Storage Casks & Skids	13,590	1,697,240	1,710,830
Subtotal Direct Construction Costs	119,901	1,701,507	1,821,408
INDIRECT CONSTRUCTION COSTS			
Construction Services and Field Office Engineering (12.5% for Construction, 0% for Repetitive Purchased Items)	14,988	533	15,521
Home Office Engineering (12% for Initial Construction, 6% for Repetitive Construction, 0% for Repetitive Purchased Items)	16,187	288	16,475
Subtotal of Indirect Construction Costs	31,175	821	31,996
Total of Direct and Indirect Construction Costs	151,076	1,702,328	1,853,404
Contingency (25%)	37,769	425,582	463,351
Owner's Cost (7% for Initial Construction, 4% for Completion)	13,219	85,116	98,335
Total Construction Cost Including Contingency and Owner's Cost	202,064	2,213,026	2,415,090

Additional handling equipment required to move the CHTRU from the Receiving and Handling Facility to the storage building includes:

• 2 Heavy duty Fork Lift Trucks with 20' lift capacity at $60,000 ea.	$120,000
• 1 Mobile Crane (5-ton capacity)	60,000
• 1 Flat-bed Truck (3-ton)	21,000
	$201,000

The cost of the handling equipment is included as a nonrepetitive cost in Table 4.1-3.

4.2 FACILITY OPERATIONS

Labor costs for operating the cask storage facilities were derived from information supplied by PNL. The information provided basic staffing levels by job category, annual salaries, and applicable overhead rates. These basic staffing levels were adjusted as necessary to represent the manpower required for the cask storage concepts described in Section 3. Table 4.2-1 shows the facility staffing requirements for spent fuel and HLW and TRU receiving rates of 1800 MTU per year and 3000 MTU per year. Supplemental operational information relative to the detailed operational steps and the times, staff, and support equipment for each step is presented in Appendix A.

4.2.1 Spent Fuel Cask Storage Operations

Approximately 100 storage casks per year or two per week must be processed for a spent fuel receiving rate of 1800 MTU per year. This cask storage rate can be achieved with a crew consisting of a crew chief, five operators and a QA/Accountability technician working one shift a day, five days a week.

For the life cycle cost analyses (see Section 4.5), it was assumed that the 1800 MTU per year staffing levels would be maintained during the 10-year receiving phase of operations. Staffing levels were reduced for the subsequent storage and shipping phases. The staff reductions from the 1800 MTU per year level were as follows:

TABLE 4.2-1: STAFFING FOR STORAGE CASK MRS FACILITY

POSITION CATEGORY	ANNUAL SALARY ($1000)	OVERHEAD PERCENT	SPENT FUEL STORAGE 1800 MTU/YR MANYEARS PER YEAR	SPENT FUEL STORAGE 1800 MTU/YR COST PER YEAR ($1000)	SPENT FUEL STORAGE 3000 MTU/YR MANYEARS PER YEAR	SPENT FUEL STORAGE 3000 MTU/YR COST PER YEAR ($1000)	HLW AND TRU STORAGE 1800 MTU/YR MANYEARS PER YEAR	HLW AND TRU STORAGE 1800 MTU/YR COST PER YEAR ($1000)	HLW AND TRU STORAGE 3000 MTU/YR MANYEARS PER YEAR	HLW AND TRU STORAGE 3000 MTU/YR COST PER YEAR ($1000)
ADMINISTRATION										
Site Manager	60	70	1	102.0	1	102.0	1	102.0	1	102.0
Manager Finances	32	70	1	54.4	1	54.4	1	54.4	1	54.4
Secretary	22	50	1	33.0	1	33.0	1	33.0	1	33.0
Clerks	21	50	4	126.0	4	126.0	4	126.0	4	126.0
Subtotals	--	--	7	315.4	7	315.4	7	315.4	7	315.4
QA/ACCOUNTABILITY										
Manager	40	70	1	68.0	1	68.0	1	68.0	1	68.0
Secretary	22	50	1	33.0	1	33.0	1	33.0	1	33.0
Shift Leader	31	70	4	210.8	4	210.8	4	210.8	4	210.8
Technicians	30	50	17	765.0	22	990.0	15	675.0	20	900.0
Subtotals	--	--	23	1076.8	28	1301.8	21	986.8	26	1211.8
OPERATIONS										
Manager	50	70	1	85.0	1	85.0	1	85.0	1	85.0
Secretary	22	50	1	33.0	1	33.0	1	33.0	1	33.0
Shift Supervisors	40	70	4	272.0	4	272.0	4	272.0	4	272.0
"A" Shift Crew Chiefs	37	70	3	188.7	4	251.6	3	188.7	4	251.6
"A" Shift Technicians	35	50	22	1155.0	31	1627.5	22	1155.0	31	1627.5
"B" Shift Crew Chiefs	37	70	2	125.8	4	251.6	3	188.7	4	251.6
"B" Shift Technicians	35	50	17	892.5	31	1627.5	22	1155.0	31	1627.5
"C" Shift Crew Chiefs	37	70	2	125.8	3	188.7	3	188.7	4	251.6
"C" Shift Technicians	35	50	17	892.5	21	1102.5	22	1155.0	31	1627.5
"D" Shift Crew Chiefs	37	70	2	125.8	3	188.7	2	125.8	4	251.6
"D" Shift Technicians	35	50	17	892.5	21	1102.5	17	892.5	31	1627.5
CHTRU Technicians	35	50	--	--	--	--	4	210.0	8	420.0
Monitor Crew Chief	37	70	1	62.9	1	62.9	1	62.9	1	62.9
Monitor Technicians	35	50	2	105.0	3	157.5	2	105.0	3	157.5
On-Site Waste Treatment										
Crew Chief	37	70	1	62.9	1	62.9	1	62.9	1	62.9
Technicians	35	50	2	105.0	2	105.0	2	105.0	2	105.0
Radioactive Shipment Specialist	31	70	1	52.7	1	52.7	1	52.7	1	52.7
Maintenance Supervisor	39	70	1	66.3	1	66.3	1	66.3	1	66.3
Maintenance Craftsmen	35	50	21	1102.5	21	1102.5	21	1102.5	21	1102.5
Equipment Attendant	22	50	1	33.0	1	33.0	1	33.0	1	33.0
Clerks	21	50	6	189.0	6	189.0	6	189.0	6	189.0
Subtotals	--	--	124	5567.9	161	8562.4	140	7428.7	191	10,158.2
SERVICES										
Manager	50	70	1	85.0	1	85.0	1	85.0	1	85.0
Secretary	22	50	1	33.0	1	33.0	1	33.0	1	33.0
Security Supervisor	35	70	1	59.5	1	59.5	1	59.5	1	59.5
Security Shift Leader	30	70	4	204.0	4	204.0	4	204.0	4	204.0
Security Patrolmen	25	50	20	750.0	20	750.0	20	750.0	20	750.0
Facility Support Supervisor	34	70	1	57.8	1	57.8	1	57.8	1	57.8
Support Technicians	30	50	16	720.0	16	720.0	16	720.0	16	720.0
Janitorial Services	20	50	6	180.0	6	180.0	6	180.0	6	180.0
Health & Safety Supervisor	42	70	1	71.4	1	71.4	1	71.4	1	71.4
Safety Engineer	32	70	1	54.4	1	54.4	1	54.4	1	54.4
Firemen	28	50	8	336.0	8	336.0	8	336.0	8	336.0
Paramedics	30	50	4	180.0	4	180.0	4	180.0	4	180.0
Health Physicist	39	70	1	66.3	1	66.3	1	66.3	1	66.3
H.P. Shift Leader	35	70	4	238.0	4	238.0	4	238.0	4	238.0
H.P. Technicians	34	50	24	1224.0	24	1224.0	24	1224.0	27	1377.0
Clerks	21	50	3	94.5	3	94.5	3	94.5	3	94.5
Subtotals	--	--	96	4353.9	96	4353.9	96	4353.9	99	4506.9
TOTAL PER YEAR (Receiving & Shipping Phases)			250	11,314.0	292	14,533.5	264	13,084.8	323	16,192.3

- QA/Accountability
  - 1 Shift Leader
  - 4 Technicians

- Operations
  - 1 "D" Shift Supervisor
  - 2 "D" Shift Crew Chiefs
  - 17 "D" Shift Technicians
  - 4 "D" Shift Maintenance Craftsmen

- Services
  - 4 Support Technicians
  - 2 Janitors
  - 1 Paramedic
  - 1 H.P. Shift Leader
  - 4 H.P. Technicians

Hot cell operations were reduced from three shifts a day, seven days a week to three shifts a day, five days a week. This reduction in hot cell operations is possible because fuel rod consolidation and canister processing operations, required during the receiving phase, are unnecessary during the shipping phase.

4.2.2 HLW and TRU Cask Storage Operations

Approximately 272 storage casks per year must be processed for a receiving rate of 1800 equivalent MTU of HLW and TRU per year. In addition, 3960 drums (55-gallon) and 49 boxes (4 feet x 6 feet x 6 feet) of contact-handled TRU must be stored. The cask storage rate can be achieved with a crew consisting of a crew chief, five operators, and a QA/Accountability technician working three shifts a day, five days a week. The contact-handled TRU storage rate can be achieved by four operators working one shift a day, five days a week.

For the life cycle cost analyses (see Section 4.5), it was assumed that staffing would be maintained at the 1800 MTU per year level during the 20-year operating lifetime of the facility.

4.3 DECOMMISSIONING

The plans adopted for decommissioning of the cask storage facilities must provide reasonable assurance that the health and safety of the public will be protected following termination of facility operations. For this study, it was assumed that complete removal of all structures, particularly the heavy concrete shielding walls in the Receiving and Handling Building and the concrete cask storage pads, was unwarranted. A thorough decontamination of the waste handling areas of the building will be completed. All contaminated wastes and equipment will be packaged in containers approved for off-site shipment of low-level waste or TRU waste, as appropriate. Final decommissioning will be accomplished by disposition of major uncontaminated equipment and effectively abandoning any remaining structures.

Storage casks will be decommissioned as they are taken out of service during the shipping phase of operations. It is expected that less than 1 percent of the casks will contain any evidence of internal contamination. Decontamination of these casks can be accomplished by the normal facility operating staff. It is assumed that the costs for cask disposal, such as extra handling and shipping, will be balanced by their value, either as scrap or as a reusable storage cask.

The decommissioning costs developed for the life cycle cost analyses presented in Section 4.5 cover the labor force and materials necessary to perform the final facility decontamination, packaging and shipping of contaminated equipment, and abandonment of the remaining structures. It was assumed that the potential salvage value of 20-year old major capital equipment will not have a significant impact on the life cycle cost analyses.

4.4 INCREMENTAL EXPANSION TO 72,000 MTU

The Engineering and Construction Schedule presented in Reference 1 indicates that receiving and handling capabilities can be expanded from 1800 MTU per year to 3000 MTU per year approximately five years after initiation of facility operations. This schedule assumes that a decision to expand the facility will be made within approximately two years of initial operation.

4.4.1 Incremental Expansion of the Spent Fuel Drywell Storage Facility

Approximately 166 storage casks a year must be processed for a spent fuel receiving rate of 3000 MTU per year. This cask processing rate can be achieved with a crew consisting of a crew chief, five operators and a QA/Accountability technician working two shifts a day, five days a week. The increased staffing levels to receive, process, and store 3000 MTU of spent fuel per year are shown in Table 4.2-1.

There are no new major storage equipment requirements for the increased receiving rate except for the addition of the third hot cell and adapting the hot cell outlet port to the cask transport system. The direct construction cost for the third hot cell (taken from Reference 1) is $31,080,000 and the modification is estimated to be $65,000.

The cask storage area is expanded in three steps from the original 16.6-acre plot which has the capacity to store 900 casks on 50 concrete storage pads. The first expansion is completed during the seventh year of operation. This expansion adds storage capacity for 990 casks. The second expansion is completed during the thirteenth year of operation and adds storage capacity for 1080 casks increasing the total storage capacity to 2970 casks. The third and final expansion is completed during the nineteenth year of operation. This final expansion provides storage capacity for an additional 1188 casks which provides a margin of 4 percent over the 3980 casks required to accommodate the 72,000 MTU of spent fuel.

To increase the storage capacity from the 9000 MTU stored at the end of 5 years of operation to 72,000 MTU requires that the 3000 MTU storage rate be maintained for 21 years. The repetitive construction of an additional 194 storage pads and the repetitive purchase of additional casks and skids (3482) and spent fuel canisters (83,572) can be applied evenly over the 21 years of storage. The resulting yearly costs for 9.2 storage pads, 165.8 casks and skids, and 3979.6 canisters are included in total construction costs. Table 4.4-1 provides the construction costs for spent fuel cask storage facility expansion from 9000 to 72,000 MTU. The years defined for major construction activities are relative to the start of facility engineering and construction as noted on Figure 4.1-1.

The construction and operating costs for the storage facility expansion from 9000 to 72,000 MTU total $4,074,965,000. The incremental cost increase is $1,170,294 per storage cask or $64.68 per kilogram of uranium. The minimum increment of storage facility increase is one storage pad with 18 casks. The cost for this minimum increment is $21,065,292 which represents 325.7 MTU of spent fuel per storage pad. The total construction and operating costs for the 72,000 MTU facility are $4,875,009,600 which does not include removal of the spent fuel or decommissioning of the facility.

4.4.2 Incremental Expansion of the HLW and TRU Cask Storage Facility

For a receiving rate of 3000 equivalent MTU of HLW and TRU per year, 453 storage casks must be processed per year. The increased staffing levels to receive, process, and store HLW and TRU at this rate are shown in Table 4.2-1.

There are no new major storage equipment requirements for the increased receiving rate except for adding the third hot cell and adapting it to the cask transport system. The direct construction cost for the third hot cell (taken from Reference 1) is $16,898,000 and the modification is estimated to be $245,500.

The cask storage area is expanded in three steps from the original storage capacity of 2268 casks. The first expansion increment, completed in the seventh year of operation, adds storage capacity for 2268 casks. The second expansion increment, completed in the twelfth year of operation, adds storage

TABLE 4.4-1: CONSTRUCTION COSTS ($1000's) FOR EXPANSION OF SPENT FUEL CASK STORAGE FACILITY FROM 9000 TO 72,000 MTU

	ADDITIONS TO R&H FACILITY (YEAR 10)	FIRST STORAGE AREA EXPANSION (YEAR 12)	SECOND STORAGE AREA EXPANSION (YEAR 18)	THIRD STORAGE AREA EXPANSION (YEAR 24)	YEARLY (YRS 11-31)	TOTAL
DIRECT CONSTRUCTION COSTS						
Site Preparation	--	968	1,123	1,086	--	3,177
Site Improvements	--	257	305	259	--	821
Concrete Storage Pads	--	--	--	--	199	4,173
Additions to R&H Facility	31,080	--	--	--	--	31,080
Facility Modifications	240	--	--	--	--	240
Casks, Skids and Canisters	--	--	--	--	130,240	2,735,040
Subtotal Direct Construction Costs	31,320	1,225	1,428	1,345	130,439	2,774,531
INDIRECT CONSTRUCTION COSTS						
Construction Services and Field Office Engineering (12.5%)	3,915	153	179	168	25	4,940
Home Office Engineering (12% for Initial Additions, 6% for Repetitives)	4,228	83	96	91	13	4,771
Subtotal Indirect Construction Costs	8,143	236	275	259	38	9,711
TOTAL CONSTRUCTION COSTS	39,463	1,461	1,703	1,604	130,477	2,784,242
Contingency (25%)	9,866	365	426	401	32,691	696,057
Owner's Costs (7% for Initial Additions, 4% for Repetitives)	3,453	73	85	80	6,524	140,695
TOTAL CONSTRUCTION COSTS INCLUDING CONTINGENCY AND OWNER'S COST	52,782	1,899	2,214	2,085	169,620	3,620,994

TABLE 4.4-2: CONSTRUCTION COSTS ($1000's) FOR EXPANSION OF HLW AND TRU CASK STORAGE FACILITY FROM 9000 TO 72,000 MTU

	ADDITIONS TO R&H FACILITY (YEAR 10)	FIRST STORAGE AREA EXPANSION (YEAR 12)	SECOND STORAGE AREA EXPANSION (YEAR 17)	THIRD STORAGE AREA EXPANSION (YEAR 24)	YEARLY (YRS 11-31)	TOTAL
DIRECT CONSTRUCTION COSTS						
Site Preparation	--	2,152	3,144	2,922	--	8,218
Site Improvements	--	520	749	641	--	1,910
Concrete Storage Pads	--	--	--	--	541	11,359
CHTRU Storage Modules	--	--	--	--	591	12,405
Additions to R&H Facility	16,898	--	--	--	--	16,898
Facility Modifications	240	--	--	--	--	240
Casks and Skids	--	--	--	--	342,015	7,182,315
Subtotal Direct Construction Costs	17,138	2,672	3,893	3,563	343,147	7,233,345
INDIRECT CONSTRUCTION COSTS						
Construction Services and Field Office Engineering (12.5%)	2,142	334	487	445	141	6,369
Home Office Engineering (12% for Initial Additions, 6% for Repetitives)	2,314	180	263	240	76	4,593
Subtotal Indirect Construction Costs	4,456	514	750	685	217	10,692
TOTAL CONSTRUCTION COSTS	21,594	3,186	4,643	4,248	343,364	7,244,307
Contingency (25%)	5,399	797	1,161	1,062	85,841	1,811,080
Owner's Costs (7% for Initial Additions, 4% for Repetitives)	1,890	159	232	212	17,168	361,131
TOTAL CONSTRUCTION COSTS INCLUDING CONTINGENCY AND OWNER'S COST	28,883	4,142	6,036	5,522	446,373	9,418,408

capacity for 3240 casks. The third expansion, completed in the nineteenth year of operation, adds storage capacity for 3096 casks, bringing the cumulative storage capacity to 10,872 casks.

To increase the storage capacity from 9000 MTU (after 5 years of operation) to 72,000 MTU requires 21 years of receiving, processing and storing HLW and RHTRU at 3000 MTU per year. The repetitive construction of an additional 528 storage pads and the repetitive purchase of 9513 additional casks and skids can be applied evenly over the 21 years. The resulting yearly costs for 25.1 storage pads and for 453 casks are included in the total construction costs. Table 4.4-2 provides the construction cost for expansion from 9000 to 72,000 MTU. The years defined for major construction activities are relative to the start of facility engineering and construction as noted on Figure 4.1-1. Storage of the CHTRU portion of the 72,000 equivalent MTU of HLW and TRU requires a total of 18 storage modules as described in Section 3.3.3. The additional 14 storage modules to expand the facility can be erected during the 21-year receiving phase on an as-needed basis and are applied as a yearly cost in Table 4.4-2.

The construction and operating costs for the storage facility expansion from 9000 to 72,000 MTU total $10,040,161,000. The incremental cost increase is $1,055,415 per storage cask or $159.37 per equivalent kilogram of uranium. The minimum increment of storage facility increase is one storage pad with 18 casks. The cost for this minimum increment is $18,997,470 which represents 119.2 MTU of equivalent HLW and TRU per storage pad. The total construction and operating costs for the 72,000 MTU facility are $11,648,335,000 which does not include removal of the high-level or transuranic waste or decommissioning of the facility.

4.5 LIFE CYCLE COSTS

Life cycle costs for the 15,000 MTU spent fuel and HLW and TRU cask storage facilities are summarized in Table 4.5-1 and Table 4.5-2, respectively. These tables were developed by distributing the estimated costs for construction, operation, and decommissioning over the project life. The project life consists of a 5-year initial construction phase, a 20-year operating phase and a 1-year decommissioning phase. All costs are given in mid-1983 dollars.

The operating costs presented in Tables 4.5-1 and 4.5-2 were determined using the PNL-provided cost estimating methods. Consumables were determined using 10 percent of the annual labor costs, maintenance costs were determined based on 2 percent of the total construction costs less the owner's cost, and the G&A costs were determined based on 12 percent of the sum of the annual labor, consumables and maintenance costs. The maintenance costs were distributed over time based on the capital assets in service each year.

The total present worth is calculated by discounting each annual cash flow to the end of the first year of cash flow using a 2 percent discount rate and then summing the annual discounted cash flows.

The time distribution of construction costs for the generic Receiving and Handling Facility and support facilities was supplied by PNL.

TABLE 4.5-1: LIFE CYCLE COSTS FOR 15,000 MTU SPENT FUEL CASK STORAGE FACILITY

VALUES SHOWN IN DOLLARS X 1000

	CAPITAL COSTS					OPERATING COSTS							
YEAR	DIRECT	IN-DIRECT	CONTIN-GENCY	OWNER COST	SUB-TOTAL	LABOR	CONSUM-ABLES	MAINT	G & A	SUB-TOTAL	DECOM-MISSION COSTS	TOTAL	PRESENT WORTH OF CASH FLOW
1	5065	1317	1596	558	8536	0	0	0	0	0		8536	8536
2	13716	3746	4366	1528	23356	0	0	0	0	0		23356	22898
3	37102	10188	11822	4138	63250	0	0	0	0	0		63250	60794
4	45886	12146	14508	5078	77618	0	0	0	0	0		77618	73141
5	27835	6300	8534	2987	45656	5657	566	0	747	6970		52626	48618
6	71265	141	17851	3588	92845	11314	1131	335	1534	14314		107159	97057
7	78748	41	19697	3940	102426	11314	1131	479	1551	14475		116901	103805
8	78748	41	19697	3940	102426	11314	1131	622	1568	14635		117061	101909
9	78684	29	19678	3936	102327	11314	1131	765	1585	14795		117122	99962
10	78533	0	19633	3927	102093	11314	1131	909	1602	14956		117049	97941
11	52607	0	13152	2630	68389	11314	1131	1052	1620	15117		83506	68504
12	51852	0	12963	2593	67408	11314	1131	1195	1637	15277		82685	66500
13	51852	0	12963	2593	67408	11314	1131	1339	1654	15438		82846	65324
14	51852	0	12963	2593	67408	11314	1131	1482	1671	15598		83006	64166
15	51852	0	12963	2593	67408	11314	1131	1625	1688	15758		83166	63029
16	0	0	0	0	0	9237	924	1625	1414	13200		13200	9808
17	0	0	0	0	0	9237	924	1482	1397	13040		13040	9499
18	0	0	0	0	0	9237	924	1339	1380	12880		12880	9198
19	0	0	0	0	0	9237	924	1195	1363	12719		12719	8905
20	0	0	0	0	0	9237	924	1052	1346	12559		12559	8621
21	0	0	0	0	0	9237	924	909	1328	12398		12398	8343
22	0	0	0	0	0	9237	924	765	1311	12237		12237	8074
23	0	0	0	0	0	9237	924	622	1294	12077		12077	7812
24	0	0	0	0	0	9237	924	479	1277	11917		11917	7557
25	0	0	0	0	0	9237	924	335	1260	11756		11756	7309
26											4279	4279	2608
TOTAL	775597	33949	202386	46622	1058554	211167	21116	19606	30227	282116	4279	1344949	1129918

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TABLE 4.5-2: LIFE CYCLE COSTS FOR 15,000 MTU HLW AND TRU CASK STORAGE FACILITY

VALUES SHOWN IN DOLLARS X 1000

	CAPITAL COSTS					OPERATING COSTS							
YEAR	DIRECT	IN-DIRECT	CONTIN-GENCY	OWNER COST	SUB-TOTAL	LABOR	CONSUM-ABLES	MAINT	G & A	SUB-TOTAL	DECOM-MISSION COSTS	TOTAL	PRESENT WORTH OF CASH FLOW
1	4233	1100	1333	467	7133	0	0	0	0	0		7133	7133
2	10880	3149	3507	1228	18764	0	0	0	0	0		18764	18396
3	29906	8736	9661	3381	51684	0	0	0	0	0		51684	49677
4	41519	11179	13175	4611	70484	0	0	0	0	0		70484	66419
5	33041	6927	9992	3497	53457	6542	654	0	864	8060		61517	56832
6	199965	146	50027	10020	260158	13085	1309	556	1794	16744		276902	250799
7	205683	62	51436	10287	267468	13085	1308	947	1841	17181		284649	252760
8	206569	233	51700	10340	268842	13085	1309	1338	1888	17620		286462	249382
9	205683	62	51436	10287	267468	13085	1308	1730	1935	18058		285526	243694
10	205683	62	51436	10287	267468	13085	1309	2121	1982	18497		285965	239283
11	137756	212	34492	6899	179359	13085	1308	2512	2029	18934		198293	162669
12	136870	41	34228	6846	177985	13085	1309	2904	2076	19374		197359	158729
13	136870	41	34228	6846	177985	13085	1308	3295	2123	19811		197796	155961
14	136890	46	34234	6847	178017	13085	1309	3686	2170	20250		198267	153267
15	129860	0	32465	6493	168818	13085	1308	4078	2217	20688		189506	143622
16	0	0	0	0	0	13085	1309	4078	2217	20689		20689	15372
17	0	0	0	0	0	13085	1308	3686	2169	20248		20248	14750
18	0	0	0	0	0	13085	1309	3295	2123	19812		19812	14149
19	0	0	0	0	0	13085	1308	2904	2076	19373		19373	13564
20	0	0	0	0	0	13085	1309	2512	2029	18935		18935	12998
21	0	0	0	0	0	13085	1308	2121	1982	18496		18496	12447
22	0	0	0	0	0	13085	1309	1730	1935	18059		18059	11915
23	0	0	0	0	0	13085	1308	1338	1888	17619		17619	11397
24	0	0	0	0	0	13085	1309	947	1841	17182		17182	10896
25	0	0	0	0	0	13085	1308	556	1794	16743		16743	10409
26											4279	4279	2608
TOTAL	1821408	31996	463350	98336	2415090	268242	26824	46334	40973	382373	4279	2801742	2339128

8/8/83

5.0 REFERENCES

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2. "Topical Report: REA-2023, Dry Storage Cask for PWR Spent Fuel", Ridihalgh, Eggers and Associates, Inc., Columbus, Ohio, REA-2023/PI (submitted to U. S. Nuclear Regulatory Commission).

3. Edwards, A. L., "TRUMP: A Computer Program for Transient and Steady State Temperature Distributions in Multidimensional Systems", UCRL-14754, Rev. 3, Lawrence Radiation Laboratory, Livermore, California, 1972.

APPENDIX A
SUPPLEMENTAL OPERATIONAL INFORMATION FOR METAL STORAGE CASKS

A.1 INTRODUCTION

This appendix presents additional detailed information on the operational steps required to store spent fuel canisters, high level waste (HLW) canisters, and remote-handled transuranic waste (RHTRU) canisters and drums in metal storage casks, and to retrieve the casks for waste package unloading; the operational times required for the steps; the staff required to perform the steps; and the required support equipment. The same information is provided for the storage of contact-handled transuranic waste (CHTRU) drums in a separate building.

A.2 STORAGE OPERATIONS

The basic operational steps for metal cask storage of the waste packages defined in Section 3.1 are illustrated in Figure A-1 and are detailed in Table A-1. Comparable operations for retrieval of the casks are illustrated in Figure A-2 and are detailed in Table A-2. The operations described include the steps from empty cask receipt through retrieved empty cask shipping off-site as part of decommissioning. Operations within the Receiving and Handling Facility begin with transferring the waste packages from the lag storage pit into the empty cask and conclude with waste package return to the lag storage pit. An estimate of the time required to complete each operational step and the personnel required to perform the step are included in Tables A-1 and A-2. The same information is defined in Table A-3 for the storage of the CHTRU drums.

The crew required to perform the metal cask storage and retrieval operations consists of eight people which includes a crew chief; a truck driver; two crane operators (one for bridge crane operation, one for mobile crane operation); two technicians for material handling, welding, cutting, etc.; a technician responsible for quality assure and material accountability; and a Health Physics technician. Of these eight, the Health Physics technician and the

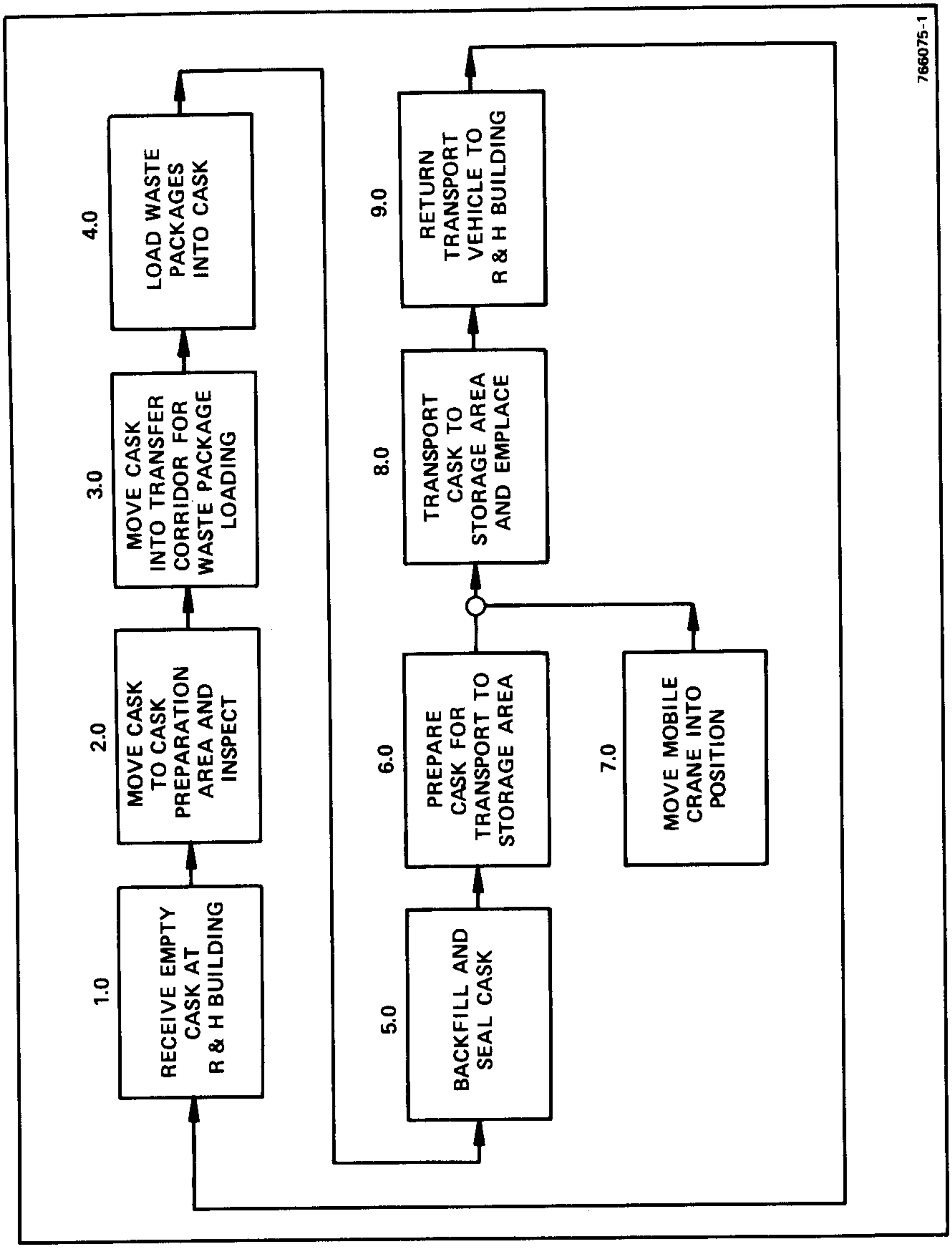

Figure A-1. Storage Cask Emplacement Operations Flow Chart

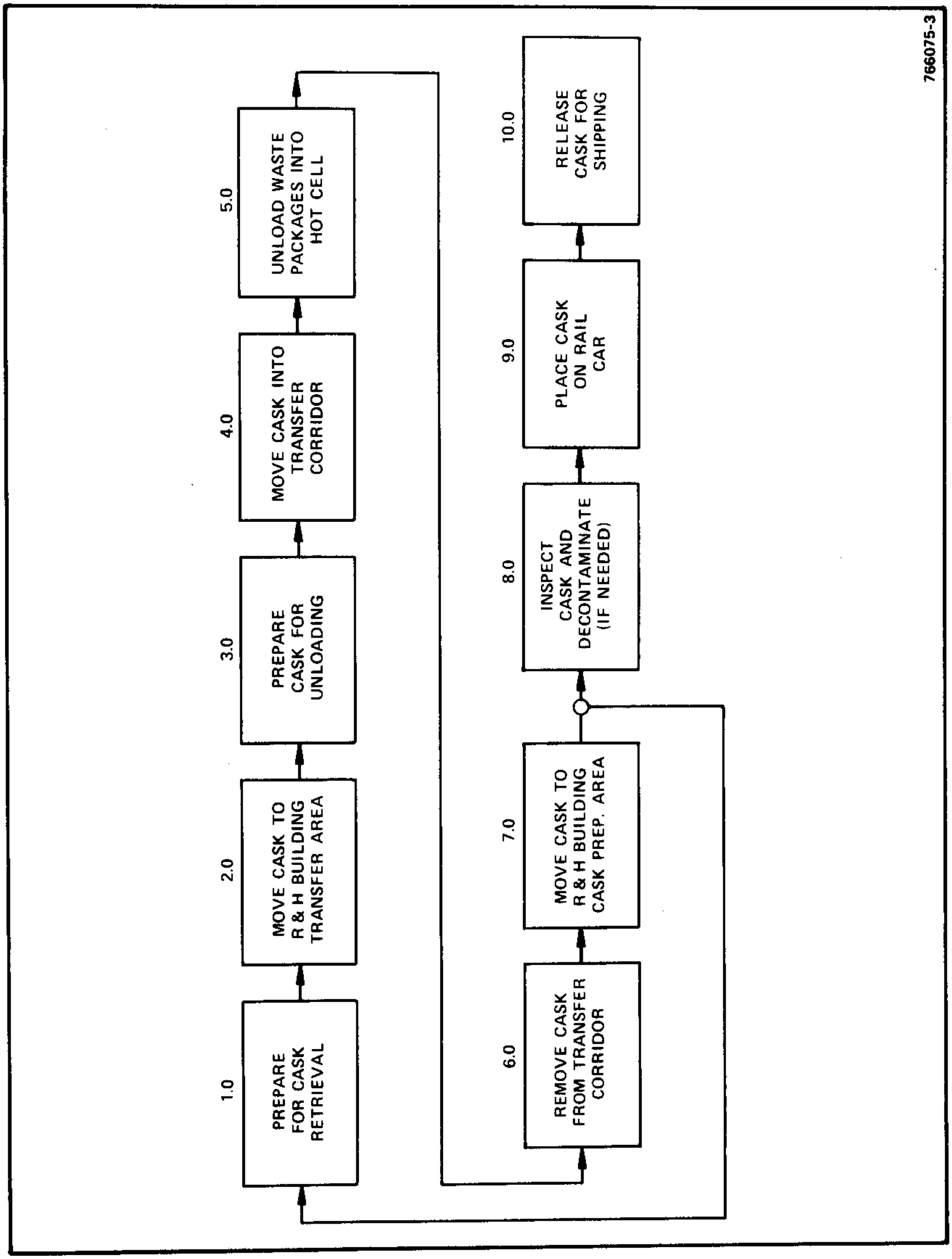

Figure A-2. Storage Cask Retrieval Operations Flow Chart

QA/accountability technician are required during waste package handling and loaded cask handling operations on a part time basis.

The crew and times required for cask handling, loading, and storing can be summarized as follows (from Table A-1):

- Receive cask and prepare for loading. (Steps 1.0 through 3.0) - Performed by storage crew in four hours and 10 minutes.
- Load cask (Step 4.0) - Performed by hot cell crew in 10 hours for spent fuel, in three hours and 40 minutes for HLW and RHTRU drums, and in one hour and 40 minutes for RHTRU canisters.
- Seal cask, backfill and emplace (Steps 5.0 through 9.0) Performed by storage crew in seven hours and 10 minutes.

The number of shifts needed to store the varying number of casks for each of the waste forms and storage rates was determined assuming that the cask preparation operations or cask sealing and emplacement operations for one cask can be done in parallel with the loading of a second cask, if needed. The number of storage crews included as staffing in Table 4.2-1 represents one storage crew per shift with a varying number of shifts depending on the number of casks to be stored.

The crew and times required for cask handling and unloading can be summarized as follows (from Table A-2):

- Retrieve cask and prepare for unloading (Steps 1.0 through 4.0) - Performed by storage crew in four hours and 50 minutes.
- Unload Cask (Step 5.0) - Performed by hot cell crew (same as loading times)
- Move cask to R&H Building Cask Receiving and Preparation Area (Steps 6.0 and 7.0) - Performed by storage crew in three hours and 10 minutes.
- Inspect, decontaminate and prepare for shipping (Steps 8.0 through 10.0) - Performed by decommissioning crew in three hours. (The final three major steps are part of the cask facility decommissioning.)

The crew and time required for CHTRU drum handling can be summarized from Table A-3 as requiring two technicians plus a part-time Health Physics technician and one hour and 16 minutes to emplace (or retrieve) eight drums.

A.3 SUPPORT EQUIPMENT

A list of the support equipment required for metal cask operations is provided in Table A-4. The use of these items in specific operations is defined in Tables A-1, A-2, and A-3. The identified equipment consists of either commercially available non-nuclear related equipment with proven reliability or equipment normally used for commercial spent fuel shipping. Cask operations with comparable equipment have been performed reliably for many years in the nuclear industry. A brief discussion of the reliability aspects of the support equipment and the availability of the equipment follow:

- Cask Handling Fixtures - The cask lifting and handling fixtures have no moving parts (except possibly a pivoting support arm on the upending fixture) and have a record of reliable performance. The only period of unavailability would be that time required to perform load testing and NDE testing to assure structural adequacy. This is expected to be about one shift per quarter which would not interfere with cask handling operations.

- Standard Equipment - The pressure testing equipment, portable welding and cutting equipment, standard hand tools, drum grabber, and cask tiedowns (cables) are very reliable. Availability of pressure testing and welding equipment would be impacted by periodic checkout and recalibration done during shifts when not needed for operations. Other tools availability can be affected by tool failure which can be compensated by having spares available.

- Motorized equipment - The motorized equipment (cranes, trucks, fork lift, rail cart) has a relatively high reliability when considering the limited operating time for each. The equipment will be available except during periods of maintenance (oil change, filter change, lubrication, etc.) or periods of load testing (cranes, trailer, etc.). The availability can be enhanced by preventive maintenance performed during shifts when the equipment is not needed for operation.

- Other Cask Related Equipment - The personnel support stand will be available 100 percent of the time barring major accidents. (such as cask drop on the stand). The cask evacuation and

> backfill system consists of reliable hand operated valves with a vacuum pump and exhaust filter plumbed together with an inert gas cylinder. The vacuum pump is the major component where a single failure affecting system availability is possible. A second vacuum pump can be installed as a redundant pump to enhance system availability.

Based on the limited number of operations for the casks (a maximum of 453 per year), the support equipment defined in Table A-4 is expected to be available for all operations.

TABLE A-1. STORAGE CASK EMPLACEMENT OPERATIONS

OPERATIONS	EQUIPMENT REQUIREMENTS	STAFFING	OPERATION TIMES (MINUTES)
1.0 Receive Empty Cask at R&H Building			
1.1 Receive empty cask, move into cask washdown area, clean and inspect cask exterior	Locomotive, rail car water hose	Locomotive Engineer, Brakeman Tech 1 QA Tech	60
1.2 Move cask into cask receiving and preparation area	Locomotive, rail car	Locomotive Engineer, Brakeman	10
1.3 Move low-bed trailer into cask receiving and preparation area	Low-bed trailer, tractor	Truck Driver	10 (noncontrolling)
1.4 Remove cask shipping hold downs and engage cask and skid lifting fixture	Wrenches, cask and skid lifting fixtures	Crane Operator, 2 Handling Techs Truck Driver	20
1.5 Lift cask and skid, place on low-bed trailer, and secure	Wrenches, cask and skid lifting fixtures	Crane Operator, 2 Handling Techs Truck Driver	20
1.6 Return rail car to storage location	Locomotive rail car	Locomotive Engineer, Brakeman	10 (noncontrolling)
			Subtotal Step 1.0 110
2.0 Move Cask to Cask Preparation Area and Inspect			
2.1 Move cask around R&H Building to cask preparation area outside transfer corridor, position for unloading	Low-bed trailer, Tractor	Truck Driver, 2 Handling Techs	20
2.2 Release cask tie downs, attach cash upending fixture	Bridge crane, cask upending fixture	Crane Operator 2 Handling Techs Truck Driver	20

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TABLE A-1. STORAGE CASK EMPLACEMENT OPERATIONS (Continued)

OPERATIONS	EQUIPMENT REQUIREMENTS	STAFFING	OPERATION TIMES (MINUTES)
2.3 Raise and translate cask to vertical, move to work stand and remove upending fixture	Bridge crane, cask upending fixture	Crane Operator 2 Handling Techs Truck Driver	20
2.4 Remove outer lid clamp and outer lid, loosen inner lid bolts, attach inner lid lifting fixture, remove inner lid	Bridge crane, wrenches, slings, inner lid lifting fixture	Crane Operator 2 Handling techs Truck Driver	25
2.5 Inspect cask interior and cask seals, and replace inner lid	Bridge crane, inner lid lifting fixture	Crane Operator 2 Handling Techs Truck Driver	15 Subtotal Step 2.0 100
3.0 <u>Move Cask into Transfer Corridor for Waste Package Loading</u>			
3.1 Reattach cask upending fixture, raise cask, place on rail cart and secure	Cask upending fixture, rail cart bridge crane	Crane Operator 2 Handling Techs	20
3.2 Move rail cart and cask into transfer corridor and position for loading	Rail cart	2 Handling Techs 1 HP Tech	15
3.3 Lower shield collar into position on cask	Wrenches	2 Handling Techs 1 HP Tech	5 Subtotal Step 3.0 40
4.0 <u>Load Waste Packages into Cask</u>			
4.1 Remove shield collar shield plug and place on hot cell floor	Overhead crane	2 Process Cell Techs 1 HP Tech	20
4.2 Remove cask inner lid and place on hot cell floor	Overhead crane	2 Process Cell Techs	20

TABLE A-1. STORAGE CASK EMPLACEMENT OPERATIONS (Continued)

OPERATIONS	EQUIPMENT REQUIREMENTS	STAFFING	OPERATION TIMES (MINUTES)
4.3 Move waste packages from lag storage pit and install in cask o Spent fuel canisters (24) o HLW Canisters, RHTRU Drums (16) o RHTRU canisters (4)	Overhead crane, grapples	2 Process Cell Techs 1 HP Tech 1 QA/Accountability Tech	600 For spent fuel 400 For HLW and drums 100 For RHTRU cans
4.4 Replace cask inner lid and shield collar plug	Overhead crane	2 Process Cell Techs 1 HP Tech	40 Subtotals Step 4.0 680 For spent fuel 480 For HLW and drums 180 for RHTRU cans
5.0 Backfill and Seal Cask			
5.1 Raise shield collar, tighten cask inner lid bolts, loosen lid lifting fixture bolts	Wrenches	2 Handling Techs 1 QA/Account Tech 1 HP Tech	30
5.2 Check cask seals, perform radiation survey of cask	Pressure test equipment, radiation monitor	2 Handling Techs 1 QA/Account. Tech 1 HP Tech	40
5.3 Attach evaucation/backfill system to cask, evacuate and backfill with inert gas	Evacuation/backfill system, inert gas bottle, wrenches	2 Handling Techs 1 QA/Account Tech 1 HP Tech	40
5.4 Move cask out of transfer corridor, remove lid lifting fixture, attach cask upending fixture to cask	Rail cart, bridge crane, cask upending fixture	Crane Operator 2 Handling Techs 1 QA/Account Tech 1 HP Tech	20
5.5 Lift cask and place in work stand, release impending fixture	Bridge crane cask upending fixture	Crane Operator 2 Handling Techs 1 QA/Account Tech 1 HP Tech	20

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TABLE A-1. STORAGE CASK EMPLACEMENT OPERATIONS (Continued)

OPERATIONS	EQUIPMENT REQUIREMENTS	STAFFING	OPERATION TIMES (MINUTES)
5.6 Install outer lid on cask, and weld cask and lid	Bridge crane, portable welding equipment	Crane Operator 2 Handling Techs 1 QA/Account Tech 1 HP Tech	60
5.7 Inspect lid/cask weld		1 QA/Account Tech	30
			Subtotal Step 5.0 240
6.0 <u>Prepare Cask for Transport to Storage Area</u>			
6.1 Engage cask upending fixture, lift cask and move to low-bed trailer	Bridge crane, cask upending fixture Low-bed trailer	Crane Operator 2 Handling Techs 1 QA/Account. Tech 1 HP Tech	15
6.2 Lower cask to horizontal, remove upending fixture and secure cask and skid to trailer	Bridge crane, Cask upending fixture Low bed trailer	Crane Operator 2 Handling Techs 1 QA/Account. Tech 1 HP Tech	25
			Subtotal Step 6.0 40
7.0 <u>Move Mobile Crane into Position</u>			
7.1 Release crane from parked position	Mobile crane, cask lifting fixture	Crane Operator	10
7.2 Move crane to proper storage location	Mobile crane, cask lifting fixture	Crane Operator	15
7.3 Position crane and lower stabilizers	Mobile crane, cask lifting fixture	Crane Operator	5
			Subtotal Step 7.0 30 (noncontrolling)
8.0 <u>Transport Cask to Storage Area and Emplace</u>			

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TABLE A-1. STORAGE CASK EMPLACEMENT OPERATIONS (Continued)

OPERATIONS	EQUIPMENT REQUIREMENTS	STAFFING	OPERATION TIMES (MINUTES)
8.1 Move cask from preparation area to storage location	Low-bed trailer, tractor	Truck Driver	30
8.2 Position cask for transfer, release cask hold downs, attach cask lifting fixture	Low-bed trailer, mobile crane cask lifting fixture	2 Handling Techs Truck Driver Crane Operator 1 QA/Account Tech 1 HP Tech	20
8.3 Raise cask and skid, move to storage pad location and emplace, release lifting fixture	Low-bed trailer mobile crane cask lifting fixture	2 Handling Techs Truck Driver Crane Operator 1 QA/Account Tech 1 HP Tech	20
8.4 Remove lifting tunnions from cask, check cask internal pressure and external temperature, hookup pressure transducer, install transducer coverplate	Wrenches	2 Handling Techs Truck Driver Crane Operator 1 QA/Account Tech 1 HP Tech	30 Subtotal Step 8.0 100
9.0 <u>Return Transport Vehicle to R&H Building</u>			
9.1 Return low-bed trailer to cask preparation area	Low-bed trailer, tractor	Truck Driver	20
9.2 Return mobile crane to parked position and secure	Mobile crane	Crane Operator	30 (noncontrolling) Subtotal Step 9.0 20
			Total steps 1.0 to 9.0 1250 For spent fuel 1050 For HLW and drums 750 For RHTRU cans

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TABLE A-2. STORAGE CASK RETRIEVAL OPERATIONS

OPERATIONS	EQUIPMENT REQUIREMENTS	STAFFING	OPERATION TIMES (MINUTES)
1.0 Prepare for Cask Retrieval			
1.1 Perform radiation survey of cask	Radiation monitor	1 HP Tech	20
1.2 Remove pressure transducer coverplate, disconnect transducer leads, replace cover, attach cask lifting trunnions	Wrenches	2 Handling Techs 1 QA/Accountability Tech 1 HP Tech	30
1.3 Move low-bed trailer and tractor to storage area, position for transfer	Low-bed trailer, tractor	Truck Driver	20 (noncontrolling)
1.4 Release mobile crane and lifting fixture from parked position and move to storage location	Mobile crane, Cask lifting fixture	Crane Operator	20 (noncontrolling)
1.5 Position crane and lower stabilizers	Mobile crane, Cask lifting fixture	Crane Operator	10 (noncontrolling) Subtotal Step 1.0 50
2.0 Move Cask to R&H Building Transfer Area			
2.1 Attach cask lifting fixture raise cask and skid, place on low-bed trailer, release lifting fixture, secure cask	Low-bed trailer, Mobile crane, Cask lifting fixture, Cask tie downs	2 Handling Techs Truck Driver Crane Operator 1 QA/Account. Tech 1 HP Tech	40
2.2 Move cask from storage area to cask preparation area, position for unloading	Low-bed trailer, tractor	Truck Driver	30

TABLE A-2. STORAGE CASK RETRIEVAL OPERATIONS (Continued)

OPERATIONS	EQUIPMENT REQUIREMENTS	STAFFING	OPERATION TIMES (MINUTES)
2.3 Return mobile crane and cask lifting fixture to parked position and secure	Mobile crane	Crane Operator	30 (noncontrolling) Subtotal Step 2.0 70
3.0 Prepare Cask for Unloading			
3.1 Release cask tie downs, attach cask upending fixture	Cask upending fixture Bridge crane	2 Handling Techs Crane Operator Truck Driver 1 QA/Account. Tech 1 HP Tech	20
3.2 Raise and translate cask to vertical, move to work stand and release cask upending fixture	Cask upending fixture Bridge crane	2 Handling Techs Crane Operator Truck Driver 1 QA/Account. Tech 1 HP Tech	20
3.3 Draw gas between cask lids into vacuum bottle and replace with air, send sample for analysis	Vacuum bottle and fittings	2 Handling Techs 1 HP Tech	20
3.4 Cut weld between cask and lid	Cutting torch	2 Handling Techs 1 HP Tech	30
3.5 Remove outer lid, attach inner lid lifting fixture Sling	Bridge crane, Inner lid lifting fixture	Crane Operator 2 Handling Techs 1 HP Tech	20
3.6 Engage cask upending fixture, raise cask, place on rail cart and secure, remove cask fixture	Bridge crane, Rail cart, Cask upending fixture	Crane Operator 2 Handling Techs 1 HP Tech	20 Subtotal Step 3.0 130

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TABLE A-2. STORAGE CASK RETRIEVAL OPERATIONS (Continued)

OPERATIONS	EQUIPMENT REQUIREMENTS	STAFFING	OPERATION TIMES (MINUTES)
4.0 Move Cask into Transfer Corridor			
4.1 Move cask and rail cart into transfer corridor and position for unloading	Rail cart	2 Handling Techs 1 HP Tech	15
4.2 Loosen inner lid bolts, lower shield collar into position on cask	Wrenches	2 Handling Techs 1 HP Tech	25
			Subtotal Step 4.0 40
5.0 Unload Waste Packages into Hot Cell			
5.1 Remove shield collar shield plug and place on hot cell floor	Overhead crane	2 Process Cell Techs 1 HP Tech	20
5.2 Remove cask inner lid and place on hot cell floor	Overhead crane	2 Process Cell Techs 1 HP Tech	20
5.3 Remove waste packages from cask and install in lag storage pit o Spent fuel canisters (24) o HLW canisters, RHTRU drums (16) o RHTRU canisters (4)	Overhead crane Grapples	2 Process Cell Techs 1 HP Tech 1 QA/Account. Tech	600 For spent fuel 400 For HLW and drums 100 For RHTRU Cans
5.4 Replace cask inner lid and shield collar plug	Overhead crane	2 Process Cell Techs 1 HP Tech	40
			Subtotals Step 5.0 680 For spent fuel 480 For HLW and drums 180 For RHTRU cans
6.0 Remove Cask from Transfer Corridor			
6.1 Raise shield collar, tighten cask inner lid bolts	Wrenches	2 Handling Techs 1 HP Tech	25

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TABLE A-2. STORAGE CASK RETRIEVAL OPERATIONS (Continued)

OPERATIONS	EQUIPMENT REQUIREMENTS	STAFFING	OPERATION TIMES (MINUTES)
6.2 Move cask out of transfer corridor, attach cask upending fixture; remove inner lid lifting fixture	Rail cart Cask upending fixture	2 Handling Techs Crane Operator	15
6.3 Lift cask, move to low-bed trailer, translate to horizontal and secure, remove cask fixture	Bridge crane, Cask upending fixture, Low-bed trailer, Cask tie downs	Crane Operator 2 Handling Techs	40 Subtotal Step 6.0 80
7.0 Move Cask to R&H Building Cask Preparation Area			
7.1 Move cask around R&H building and into cask washdown area	Low-bed trailer, tractor	Truck Driver	20
7.2 Washdown cask exterior	Water supply	Cask Handling Tech	20
7.3 Move cask into cask preparation area	Low-bed trailer, tractor	Truck Driver	10
7.4 Install cask upending fixture, release cask tie downs, raise and translate to vertical and move to cask work stand	Cask upending fixture Overhead crane Work stand	2 Handling Techs Crane Operator	40
7.5 Release low-bed trailer for return for next operation	Low-bed trailer, tractor	Truck Driver	-- Subtotal Step 7.0 90 Totals Steps 1.0 to 7.0 1140 For spent fuel 940 For HLW and drums 640 For RHTRU cans

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TABLE A-2. STORAGE CASK RETRIEVAL OPERATIONS (Continued)

OPERATIONS	EQUIPMENT REQUIREMENTS	STAFFING	OPERATION TIMES (MINUTES)
8.0 Inspect Cask and Decontaminate (If Needed)			
8.1 Loosen inner lid bolts, attach inner lid lifting fixture, remove inner lid	Wrenches Overhead crane Inner lid lifting fixture	Crane Operator 2 Handling Techs 1 HP Tech	20
8.2 Perform radition survey of cask interior	Swipes	1 HP Tech	30
8.3 Flush cask interior and resurvey (if needed)	Cleaning solution Radwaste drain hose Swipes	2 Handling Techs 1 HP Tech	60
8.4 Replace cask inner lid tighter bolts, remove lifting fixture	Overhead crane Wrenches Lifting fixture	2 Handling Techs Crane Operator	20 Subtotal Step 8.0 130
9.0 Place Cask on Rail Car			
9.1 Move rail car into cask preparation area	Rail car, Locomotive	Locomotive Engineer Brakeman	10 (noncontrolling)
9.2 Attach cask upending fixture to cask	Overhead crane, Cask upending fixture	Crane Operator 2 Handling Techs	10
9.3 Lift cask, place on rail car, translate to horizontal release upending fixture, and secure cask to rail car	Overhead crane Cask upending fixture, Rail car	Crane Operator 2 Handling Techs	20 Subtotal Step 9.0 30
10.0 Release Cask for Shipping			
10.1 Move cask and rail car to rail yard and store until released	Locomotive Rail car	Locomotive Engineer Brakeman	20

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TABLE A-2. STORAGE CASK RETRIEVAL OPERATIONS (Continued)

OPERATIONS	EQUIPMENT REQUIREMENTS	STAFFING	OPERATION TIMES (MINUTES)
10.2 Complete paperwork and release			
			Subtotal Step 10.0 20
			Total Steps 8.0 to 10.0 180

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TABLE A-3. CHTRU STORAGE OPERATIONS

OPERATIONS	EQUIPMENT REQUIREMENTS	STAFFING	OPERATION TIMES (MINUTES)
1.0 Prepare CHTRU Drums for Transport			
1.1 Place 8 drums on 2 transport pallets	Transport pallets, Jib crane or forklift with drum grabber	1 CHTRU Tech 1/2 HP Tech	16
1.2 Move pallets to loading dock and load on truck	Fork lift, Flat bed truck, Transport pallets	2 CHTRU Techs	12
2.0 Transport to CHTRU Storage Building	Flat bed truck, transport pallets	2 CHTRU Techs	6
3.0 Unload Drums and Store			
3.1 Unload pallets from truck and move into CHTRU storage building	Flat bed truck, Fork lift, Transport pallets	2 CHTRU Techs 1 HP Tech	6
3.2 Remove drums (8) from pallets and stack in CHTRU storage building	Fork lift,	2 CHTRU Techs 1/2 HP Tech	24
3.3 Load empty pallets on truck	Fork lift, Flat bed truck	2 CHTRU Techs	6
3.4 Return truck to R&H Building	Flat bed truck	2 CHTRU Techs	6 Total 76

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TABLE A-4. SUPPORT EQUIPMENT

Cask Upending Fixture (for translating and material handling)
Cask Lifting Fixture (for horizontal handling)
Cask Inner Lid Lifting Fixture
Cask Tie Downs
Low-bed Trailer and Tractor
Mobile Crane
Personnel Support Stand
Motorized Rail Cart (with Personnel Support Stand)
Cask Evacuation and Backfill System
Pressure Test Equipment
Portable Welding/Cutting Equipment
Standard Hand Tools (Wrenches, etc.)
Bridge Crane
Flat Bed Truck*
Fork Lift*
Drum Grabber*

*For CHTRU Drums

APPENDIX B
ADDITIONAL INFORMATION REQUESTED BY PNL

This appendix presents the PNL requested information which supplemented or amplified that presented in the final draft of this report.

Table B-1 presents a summary of the total construction costs broken down into labor cost (and manhours) and material cost using the information presented in Section 4.1.

The following are questions received from PNL and the answers provided in response to each question.

QUESTION 1: The report says heat and radiation doses were considered in setting the amount of spacing between casks on the pads, but doesn't say which was the driving constraint. Can higher heat rate casks be stored on the same spacing grid?

RESPONSE: The major constraint on cask spacing is maintaining the peak fuel clad temperatures below acceptable limits. Of secondary consideration is providing adequate space for cask handling, maintenance and monitoring and radiation levels between casks. Thermal analysis indicate that with the decay heat rate used for the MRS study, the spacing between casks can be reduced from 8 feet to approximately 6 feet without a significant effect on the peak fuel clad temperatures. Higher decay rates can probably be accommodated with the 8-foot cask spacing but further thermal analyses would be required to confirm the resulting peak fuel clad temperatures.

QUESTION 2: Expansion cost estimates don't seem to include casks. If they're there, what category are they listed under?

RESPONSE: Section 4.4 has been amended to include all costs for expansion to the 72,000 MTU capacity facility. These costs include construction,

TABLE B-1: TOTAL CONSTRUCTION LABOR AND MATERIAL COSTS* FOR 15,000 MTU FACILITIES

	TOTAL CONSTRUCTION LABOR (MANHOURS)	TOTAL CONSTRUCTION LABOR COST** ($1,000's)	TOTAL CONSTRUCTION MATERIAL COSTS*** ($1,000's)
METAL CASK - SPENT FUEL			
Site Preparation (Storage Area Only)	12,463	203	486
Site Improvements (Storage Area Only)	6,461	121	195
Concrete Storage Pads	15,416	286	691
R&H Facility Modifications	5,547	117	4
TOTAL	39,887	727	1,376
METAL CASK - HLW & TRU			
Site Preparation (Storage Area Only)	29,650	484	1,157
Site Improvements (Storage Area Only)	11,834	222	391
Concrete Storage Pads	41,328	766	1,853
R&H Facility Modifications	5,547	117	4
CHTRU Storage Modules	93,316	1,876	1,668
TOTAL	181,675	3,465	5,073

*Costs on this table are direct costs only and do not include indirect costs, contingencies, or owner's costs.
**Includes 40% subcontractor mark-up to cover overhead and profit.
***Includes 10% subcontractor mark-up.

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operation, and casks but do not include the costs for the dormant storage period, or unloading and decommissioning of the expanded facility.

QUESTION 3: What is the estimated volume of radwaste generated during the 1) operation, and 2) decommissioning and decontamination of the facility.

RESPONSE: The only radwaste for the casks would be generated in decontaminating casks with failed fuel canisters. This would involve filling and draining the casks with a decon solution (approximately 2750 gallons per cask). This would apply to about one percent of the casks per the PNL assumptions. No radwaste would be generated during operations beyond that involved in handling, consolidating, and canisterizing the spent fuel which is not part of our responsibilities.

QUESTION 4: Only the area for the cask storage is listed. Need to know the total exclusion area size including receiving and handling and CHTRU storage facility.

RESPONSE: It is assumed that the MRS Facility will be designed in accordance with 10CFR Part 72 which does not use the term "exclusion area." Instead, 10CFR Part 72 defines "real property" and "controlled area." For the cask MRS study, real property would be the area within the site boundary fences. The controlled area is established by limitations on radiation dose rates to an individual outside the controlled area. Furthermore, the distance from spent fuel handling and storage facilities to the nearest boundary of the controlled area is required to be greater than 100 meters (328 feet).

The storage areas for the MRS study are surrounded by double fences. The inner fence is set 50 feet from the edge of the concrete storage pads and the outer fence is arbitrarily set 125 feet outside the inner fence. The actual distance between the fences will be established by the security plan developed for each specific site.

For the generic Receiving and Handling Facility, developed by Kaiser Engineers for the MRS study, it appears that the real property and controlled area is approximately 64 acres.

The total acreage for the cask storage concepts are given below.

<u>Cask Storage for 15,000 MTU of Consolidated Spent Fuel</u>

Storage area (within inner fence)	16.6 acres	
Real property for storage (within outer fence)	29.3 acres	
Controlled area for storage		36.5 acres
Receiving & Handling Facility Area		64 acres
Total MRS Facility Area		100.5 acres

<u>Cask Storage for 15,000 MTU of HLW and TRU</u>

Storage area (within inner fence including CHTRU Buildings)	41.3 acres	
Real Property for Storage (within outer fence)	58.9 acres	
Controlled area for storage		77.2 acres
Receiving & Handling Facility Area		64 acres
Total MRS Facility Area		141.1 acres

QUESTION 5: What access routes are available for intrusion?

RESPONSE: The cask storage facilities are located in open areas accessible by land surface or air and, with some stretch of imagination, by tunnelling under the security perimeter. Land surface intrusion is restricted by double fences surrounding the facility. The fences and the area between the two fences can be equipped with intrusion alarms and closed circuit television monitored by security personnel. No special provisions for intrusion by air have been considered. In the final analysis, the site security forces must be equipped to detect and resist intrusion attempts until outside help can be summoned.

QUESTION 6: What is the total land area required for the largest fully expanded facility now envisioned? This estimate needs to include the exclusion area, the parking lot, the visitor facilities (if any) and all other site facilities.

RESPONSE: It is assumed that the "largest fully expanded facility" refers to the 72,000 MTU capacity facilities. Based on the responses given above, which related to the total MRS facility areas for 15,000 MTU capacity the total areas for the 72,000 MTU capacity facilities are given below.

<u>Metal Cask Storage for 72,000 MTU of Spent Fuel</u>

Storage Area (within inner fence)	67.6 acres	
Real property for storage (within outer fence)	89.2 acres	
Controlled area for storage		114 acres
Receiving and Handling Facility Area		64 acres
Total MRS Facility Area		178 acres

Metal Cask Storage for 72,000 MTU of HLW and TRU

Storage area (within inner fence including CHTRU Buildings)	186 acres	
Real Property for storage (within outer fence)	225.4 acres	
Controlled area for storage		267 acres
Receiving and Handling Facility Area		64 acres
Total MRS Facility Area		331 acres

QUESTION 7: Are there any plans or scenarios for dispersal of the waste containers in the event of a severe natural disaster or military attack?

RESPONSE: There are no plans or scenarios for dispersal of the waste containers in the event of a severe natural disaster or military attack. The REA cask, as well as other storage casks, has been analyzed for response to natural disasters such as earthquake, tornado (missiles in particular), floods, etc. and has been found to not release any radioactive material contained therein. The response to this question becomes part of the licensing process for the cask vendor to have a "salable" item for dry storage use.

QUESTION 8: Is the use of liquid materials (water and ethylene glycol) for the neutron shield likely to pose a licensing problem?

RESPONSE: No. The REA cask selected as a reference design for the MRS study uses a mixture of water and ethylene glycol for neutron shielding. In this respect, the REA cask design is similar to existing casks that have been licensed by the Nuclear Regulatory Commission for rail and truck transportation of spent fuel. Temporary loss of the neutron shield would result in an increase in the local radiation dose rate but would not present a significant nuclear safety problem. Other available storage casks without a liquid neutron shield were also described in Section 3.3.1.

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