AN OVERVIEW OF HI-STORM: HI-STAR'S METCON CONJUGATE

by

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ABSTRACT

This paper describes the design and operational characteristics of Holtec International's HI-STORM 100 spent fuel storage system. The HI-STORM System provides for the loading, on-site transfer, and long-term storage of spent nuclear fuel assemblies in the HI-STAR Multi-Purpose Canister (MPC). Following the storage period, the HI-STAR 100 MPCs can be transferred to HI-STAR 100 dual-purpose overpacks for off-site transport operations.

1.0 BACKGROUND

The HI-STORM 100 is the storage overpack component of the HI-STAR 100 multi-purpose system developed by Holtec International to meet the growing needs of utilities to provide long-term, on-site storage for spent nuclear fuel in a safe and cost-effective manner. The term HI-STORM is an acronym for Holtec International Storage and Transfer Operation Reinforced Module. The HI-STORM System is designed to be in full compliance with the requirements of 10CFR72 for the storage of spent nuclear fuel and high-level radioactive waste.

2.0 OVERVIEW OF THE HI-STORM 100 SYSTEM

The HI-STORM 100 System is designed to accommodate a wide variety of spent nuclear fuel assemblies and other radioactive materials in a single overpack by utilizing different welded metallic canisters, designated as an MPC. The external dimensions of all MPCs are identical to allow the use of a single overpack design and to allow for ease of transport in the HI-STAR 100 multi-purpose overpack. Each of the MPCs has a different internal basket design to accommodate distinct fuel characteristics.

The HI-STORM 100 overpack is constructed from a combination of steel and concrete, both of which are materials with long, proven histories of usage in nuclear applications. The HI-STORM 100 overpack is an improved design which incorporates the desirable features of previously approved concrete and metal overpack designs. In essence, the HI-STORM overpack is a hybrid of metal and concrete systems which incorporates the best features of both design types and is, therefore, best referred to as a METCON™ (metal/concrete components) system. Figure 1 shows the HI-STORM 100 with two of its major constituents, the MPC and the storage overpacks, in a cutaway view.

3.0 GENERAL DESCRIPTION OF THE HI-STORM SYSTEM

The basic HI-STORM 100 System consists of interchangeable MPCs which provide for the confinement boundary for PWR or BWR spent nuclear fuel or irradiated and contaminated hardware; a METCON™ storage overpack providing structural support and radiation shielding for the long-term storage of the MPC; and a transfer overpack providing the structural and radiological boundary for the loading and transfer of the MPC from the spent fuel pool to the storage overpack. In summary, the system is comprised of three distinct components:

- multi-purpose canister (MPC)
- storage overpack
- HI-TRAC transfer overpack

The auxiliary equipment required to operate the system include the following:

- vacuum drying and helium backfill systems with leakage detector
- lifting and handling system
- remote welding equipment
- transfer vehicle/trailer

3.1 Storage Overpack

The HI-STORM 100 overpack is a rugged, heavy-walled cylindrical vessel. The main structural function of the storage overpack is provided by interior and exterior shells of carbon steel, and the main shielding function is provided by the concrete placed between the steel shell annulus.

The storage overpack has convective ducting at the base and top of the overpack to allow for passive cooling of the contained MPC. The storage overpack is completed with a steel and concrete lid and a thick steel baseplate. The overpack provides an internal cylindrical cavity of sufficient height and diameter for housing an MPC.

Four removable lifting lugs, located on 90° centers, can be attached to the top of the overpack for lifting of the cask body. The overpack may also be lifted from the bottom using a specially-designed lifting transport device, including hydraulic jacks, airpads, and Hillman rollers.

A cross sectional view of the HI-STORM 100 System with an MPC inserted is presented in Figure 2. Key dimensions are provided.

3.2 MPCs

The current HI-STORM 100 licensing application requests approval for four separate MPC designs. These MPC designs are as follows:

- MPC-24 for the storage and transport of 24 standard PWR fuel assemblies;
- MPC-68 for the storage and transport of 68 standard BWR fuel assemblies;
- MPC-32 for the storage of 32 standard PWR fuel assemblies based on boron credit during loading, and ultimately for transport upon approval of DOE's burnup credit methodology by the NRC; and
- MPC-GTCC for the storage and transport of irradiated and contaminated hardware.

In addition to the standard MPCs described above, the system design provides sufficient capability to accommodate plant-specific MPC designs to accommodate unique fuel designs and plant handling characteristics.

Each MPC is an all-stainless steel, fully-welded cylindrical pressure vessel designed, fabricated, and inspected to meet ASME Section III Class 1 requirements to the maximum practical extent. Except for the field welds of the MPC lid, all welds of the MPC enclosure vessel are fully inspected by radiographic examination methods. Within each MPC, a honeycombed stainless steel fuel basket is provided. Each fuel basket is designed, fabricated, and inspected in accordance with ASME Code, Section III, Subsection NG-criteria.

Key design parameters for the HI-STORM 100 System are summarized in Table 1.

3.3 HI-TRAC Transfer Overpack

The HI-TRAC transfer overpack is a rugged, heavy-walled cylindrical vessel. The main structural function of the transfer overpack is provided by carbon steel shells and forgings with the main gamma and neutron shielding provided by lead and water. The transfer overpack is a steel, lead, steel layered cylinder with an exterior water jacket. Figure 3 provides various views of the HI-TRAC transfer cask.

The HI-TRAC is utilized to load the MPC with fuel assemblies and/or waste; prepare the MPC for storage and transport; and to transfer the loaded MPC to the storage overpack at the reactor facility or on the storage pad.

To facilitate handling of the HI-TRAC, the transfer overpack is provided with lifting trunnions located at the top of the cask for vertical handling, and two rear pocket trunnions for overpack rotation and horizontal on-site transport of the loaded MPC to the storage overpack located on the pad.

The standard HI-TRAC transfer overpack is designed to impose less than 125 tons loading on the plant crane system when being removed fully loaded from the spent fuel pool, including water and handling equipment. The selection of a heavier standard transfer overpack was based on minimizing doses to the operators to the maximum extent. The standard HI-TRAC design can be modified to meet lower crane loading limits. A unique design feature of the HI-TRAC transfer cask is the use of an in-pool lid. The in-pool lid is a simple multi-layered plate structure designed to be bolted to the base of the transfer overpack. The in-pool lid is fitted with an elastomer gasket to seal against the intrusion of contaminated pool water.

Following removal of the HI-TRAC with the loaded MPC from the spent fuel pool, and completion of the welding, drying, and backfilling operations to prepare the MPC for storage and transport, the in-pool lid is removed and replaced with the transfer lid which consists of two heavily shielded doors to allow the lowering of the MPC from the HI-TRAC to the HI-STORM storage overpack.

The use of the in-pool lid provides significant operational benefits, including the following:

- decreased risk of external contamination of MPC surfaces as the in-pool lid is easier to seal;
- a reduction in decontamination time as the transfer lid with its complex operating mechanisms is never exposed to the contaminated spent fuel pool water; and
- a smaller footprint for the transfer cask in the spent fuel pool, as the protruding components of the transfer lid are only installed after the overpack is removed from the pool.

3.4 Applicable Codes and Standards

A listing of the applicable ASME Codes for the design and fabrication of the HI-STORM System are provided in Table 2.

3.5 HI-STORM System Operational Characteristics

The HI-STORM 100 System is operationally straightforward, requiring a minimum number of operational steps and personnel to perform the loading operations. Long-term maintenance and surveillance activities are similarly limited to inspection and touch-up painting of the external steel components as required.

To perform fuel loading operations, the HI-TRAC with an empty MPC is lowered into the spent fuel pool cask-loading area; fuel meeting the canister specifications are placed in the fuel storage locations, and the MPC lid is lowered into place; the HI-TRAC is moved to the cask preparation area where the HI-TRAC and MPC are dewatered, the MPC lid is welded into place and inspected; the MPC is vacuum dryed and backfilled with helium; and the decontaminated HI-TRAC is moved to the location of the HI-STORM overpack. Table 3 provides the basic sequence of operations necessary to prepare the HI-STORM System for long-term storage operations.

At the completion of the storage period, the HI-TRAC transfer cask is utilized to transfer the MPCs to HI-STAR 100 dual-purpose overpacks for off-site shipment.

4.0 LICENSING AND DEPLOYMENT STATUS

The HI-STORM 100 Topical Safety Analyses Report (TSAR) was initially submitted to the NRC for review and approval under Subpart L of 10CFR72 in October 1995. Following receipt of the initial questions and comments on the HI-STAR applications in March 1996, Holtec requested the NRC to suspend review of the HI-STORM TSAR awaiting resolution of the NRC's comments.

The revised TSAR and transport SAR for the HI-STAR 100 System was submitted to the NRC in September and October 1996, and the HI-STORM TSAR, revised to be in full accord with the HI-STAR applications, will be submitted in the first week of February 1997.

Approval of the HI-STORM 100 System is expected in the middle of 1998. Facilitating the NRC review process will be the separate licensing process for the private storage facility planned by the Private Storage Facility, LLC. The HI-STORM System is one of the two selected cask designs now being incorporated into the facility design and licensing documentation.

Table 1

KEY PARAMETERS FOR HI-STORM/HI-STAR 100 MULTI-PURPOSE CANISTERS IN STORAGE

	PWR	**BWR**
Pre-disposal service life (years)	100	100
Design temperature, max./min. (°F)	650°/-40°	650°/-40°
Design internal pressure (psig) Normal conditions Off-normal conditions Accident conditions	 100 100 125	 100 100 125
Minimum cooling time (yrs)	5	5
Total head load, max. (kW)	30	30
Initial enrichment, (% U^{235})	4.1-4.6	4.2
Maximum burnup (MWD/MTU)	45,000 at 5 years 50,000 at 8 years	45,000 at 5 years 50,000 at 8 years
Maximum permissible peak fuel cladding temperature: Normal (°F) Short-Term & Accident (°F)	 <716 <1058	 <716 <1058
Maximum permissible reactivity including all uncertainties and biases	<0.95	<0.95
End closure(s)	Welded	Welded
Fuel handling	Opening compatible with standard grapples	Opening compatible with standard grapples
Heat dissipation	Passive	Passive
Max. midplane dose rate (mrem/hr)	30	30

Table 2

HI-STORM 100 ASME BOILER AND PRESSURE VESSEL CODE APPLICABILITY

HI-STORM 100 Component	Material Procurement	Design	Fabrication	Inspection
Overpack steel structure	Section II, Section III, Subsection NF, NF-2000	Section III, Subsection NF, NF-3300	Section III, Subsection NF, NF-4000	Section III, Subsection NF, NF-5360 and Section V
Overpack concrete structure	ACI-349	ACI-349	ACI-318	ACI-349
MPC confinement boundary	Section II, Section III, Subsection NB, NB-2000	Section III, Subsection NB, NB-3200	Section III, Subsection NB, NB-4000	Section III, Subsection NB, NB-5000 and Section V
MPC fuel basket	Section II, Section III, Subsection NG, NG-2000	Section III, Subsection NG, NG-3300 and NG-3200	Section III, Subsection NG, NG-4000	Section III, Subsection NG, NG-5000 and Section V
Trunnions	Section II, Section III, Subsection NF, NF-2000	ANSI 14.6	Section III, Subsection NF, NF-4000	See Chapter 9
MPC basket supports	Section II, Section III, Subsection NG, NG-2000	Section III, Subsection NG, NG-3300 and NG-3200	Section III, Subsection NG, NG-4000	Section III, Subsection NG, NG-5000 and Section V
HI-TRAC steel structure	Section II, Section III, Subsection NF, NF-2000	Section III, Subsection NF, NF-3300 for normal conditions only	Section III, Subsection NF, NF-4000	Section III, Subsection NF, NF-5360 and Section V

Table 3

HI-STORM 100 OPERATIONS DESCRIPTION

Site-specific handling and operations procedures will be prepared, reviewed, and approved by each owner/user.	
1	HI-TRAC and MPC lowered into the fuel pool without lids
2	Fuel assemblies transferred into the MPC fuel basket
3	MPC lid lowered onto the MPC
4	HI-TRAC/MPC assembly moved to the decon pit and MPC lid welded in place
5	MPC dewatered, vacuum dried, backfilled with helium, leak tested, and the closure ring welded
6	HI-TRAC drained and external surfaces decontaminated
7	MPC lifting device installed and MPC weight assumed by rigging
8	HI-TRAC pool lid removed and transfer lid attached
9	MPC lowered and seated on HI-TRAC transfer lid
10	HI-TRAC/MPC assembly transferred to HI-STORM overpack
11	HI-TRAC/MPC assembly lifted and seated atop HI-STORM overpack with lifting system
12	MPC weight assumed by rigging and transfer lid doors opened
13	MPC lowered into HI-STORM overpack, HI-TRAC transfer lid doors closed, and HI-TRAC removed from atop HI-STORM overpack
14	HI-STORM overpack lid installed

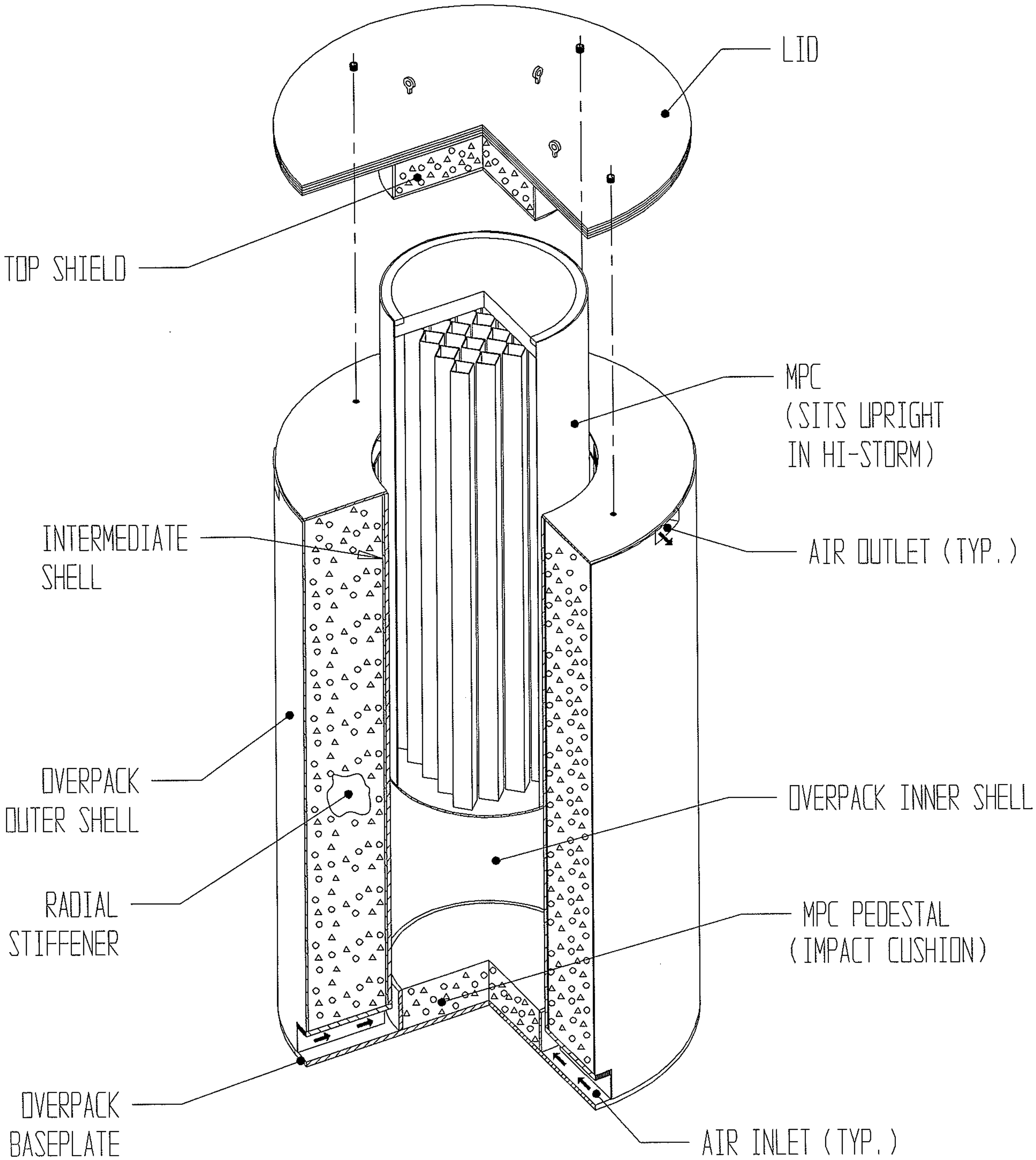

FIGURE 1; PICTORIAL VIEW OF THE HI-STORM 100 SYSTEM

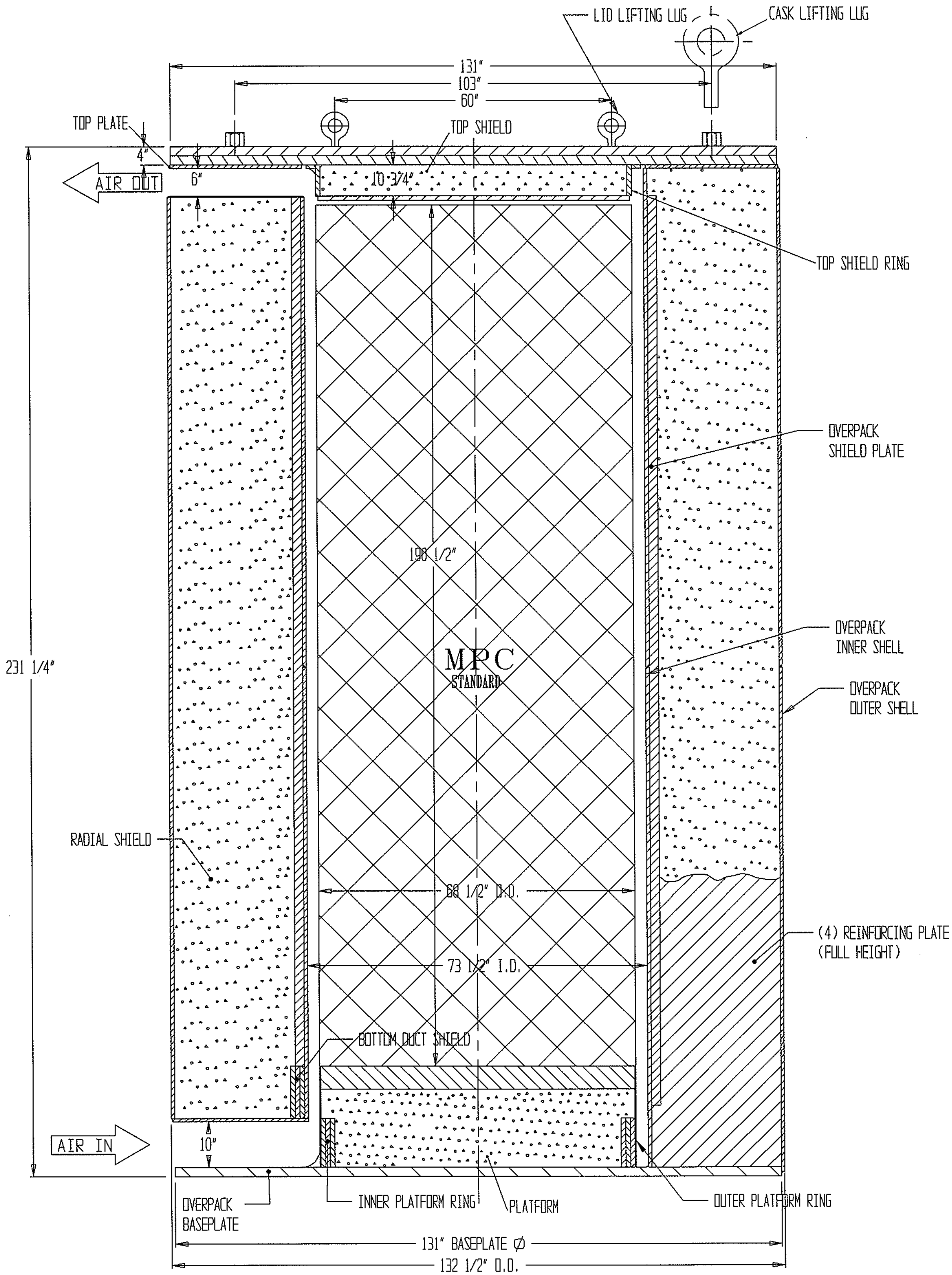

FIGURE 2; HI-STORM: HOLTEC INTERNATIONAL STORAGE AND TRANSFER OPERATION REINFORCED MODULE

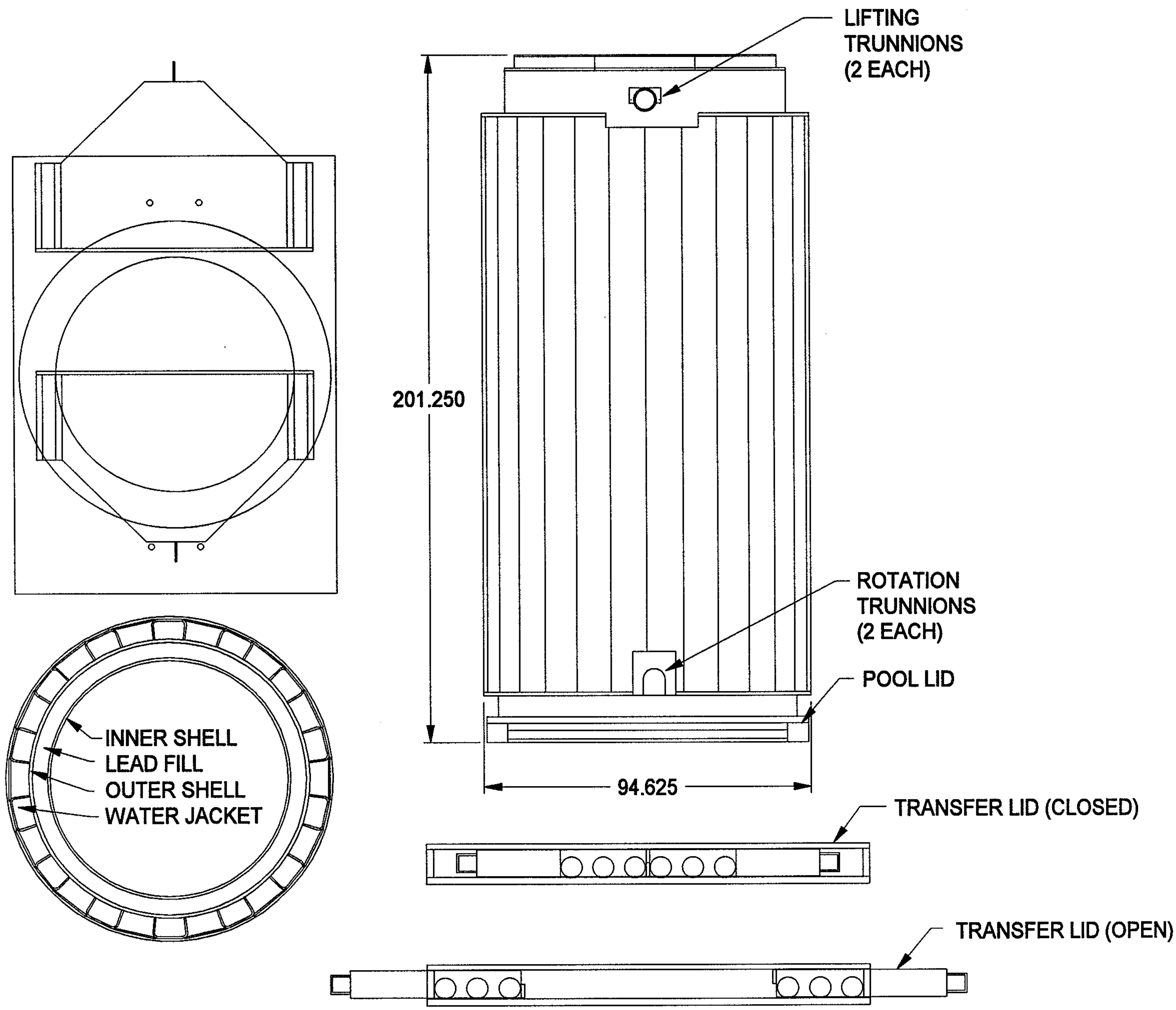

FIGURE 3 - HI-TRAC TRANSFER CASK