Design and Licensing of the TranStor™ Multi-Purpose System

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INTRODUCTION

This paper describes the design features and licensing criteria of the TranStor™ Multi-Purpose System. The TranStor™ System design (Figure 1) is based upon the licensed and proven Ventilated Storage Cask (VSC) System. The TranStor™ System is a fully integrated, irradiated fuel-handling, storage, shipping, and disposal system. The system was designed by a team comprised of Sierra Nuclear and BNFL plc. The system is designed to effectively interface with at-reactor storage, but also away-from-reactor central storage facilities and geological disposal facilities.

TranStor™ SYSTEM COMPONENTS

The primary components of the TranStor™ System are the irradiated fuel basket which confines the fuel assemblies; the concrete storage cask which provides physical protection and radiation shielding during storage; the transfer cask which is used to safely transfer the loaded basket from the fuel pool to the concrete storage or shipping cask; and the shipping cask which is used to ship the basket directly offsite without the need to reopen it or rehandle individual fuel assemblies.

The TranStor™ System utilizes two basket designs – one for PWR fuel and a second for BWR fuel. These basket configurations are shown in Figure 2. The physical characteristics of the basket designs are provided in Table 1.

Table 1. Physical Characteristics of TranStor™ Basket

Parameter	Value
Capacity	24 PWR / 61 BWR fuel assemblies
Diameter	66.0 in. O.D.
Shell Thickness	0.75 in.
Length	Variable (Fuel Assembly length + 12 in.)
Basket Shell Material	304L Stainless Steel
Basket Structure Material	Ferritic / Stainless
Weight (Loaded in transfer cask)	<100 Ton

The basket is equipped with a shield lid and a structural lid. The shield lid is a thick steel disk which is placed in the basket while the basket is still in the pool after the fuel assemblies have been loaded. The shield lid is welded in place after the basket and transfer cask have been removed from the pool. Next, the basket is drained, dried, and the structural lid is then welded in place prior to transfer to the concrete storage or shipping cask. The basket is then backfilled with helium to provide an inert atmosphere for long-term storage.

The basket structure incorporates flux traps and boron/aluminum matrix neutron absorbers to maintain criticality control under all normal, off-normal, and accident conditions.

The thermal and nuclear design criteria for the TranStor™ System are shown in Table 2.

Table 2. TranStor™ Thermal and Nuclear Design Parameters

Parameter	PWR Value	BWR Value
Heat Load	26 kW/24 kW for transport	26 kW/24 kW for transport
Max Fuel Burnup (Depends on Cooling Time)	40 GWd/MT (5 years) 45 GWd/MT (6 years)	35 GWd/MT (5 years) 40 GWd/MT (7 years)
Initial Enrichment	4.2% ^{235}U	3.7%, 4.1% ^{235}U
Internal Atmosphere	Helium	Helium
Maximum Cladding Temperature (Storage)	PNL-6189 Criteria (330 - 400 °C)	PNL-6189 Criteria (380 - 460 °C)
Maximum Cladding Temperature (Transportation)	PNL-6364 < 570 °C	PNL-6364 < 570 °C
Maximum K_{eff}	< 0.95	< 0.95

The structural design criteria for the basket are shown in Table 3 for both transportation (10CFR71) and storage (10CFR72).

Table 3. TranStor™ Basket Structural Design Criteria

Design Parameter	Storage Design Criteria	Shipping Design Criteria
Applicable Regulation	10CFR72	10CFR71
Allowable Stress Non-containment Structures	ASME Section III, NC-3000, Appendix F, Subsection NG	ASME Section III, NB-3000, Appendix F, Subsection NG
Structural Design	ASME Section III, Subsection NC	ASME Section III, Subsection NB, Subsection NG, 10CFR71, Regulatory Guide 7.8
Buckling Evaluation	ASME Section III, Subsection NF	NUREG/CR-6322
Fracture Toughness	15 ft-lb at -50 °F ASTM A370	Regulatory Guides 7.11, 7.12

The concrete cask (Figure 1) provides structural support, shielding, and natural convection cooling for the basket. The steel and concrete walls of the cask are sufficiently thick to limit the calculated design basis side contact dose rates to <20 mrem/hr. the internal cavity of the concrete cask is formed by a thick cylindrical steel liner. Air flow paths (See Figure 1) are formed by channels at the bottom air inlets, the annular gap between the internal cavity and the basket, and the air outlet ducts. The cask also includes a metal lid to further reduce dose contributions from skyshine and to provide missile protection for the basket.

TranStor™ SHIPPING CASK DESIGN

The TranStor™ shipping cask (Figure 3) consists of an inner and outer shell assembly, lead gamma shielding between the inner and outer shells, neutron shielding outside the structural shell, and a jacket shell around the neutron shielding material. The inner and outer shells are welded to top and bottom forgings. The top forging is designed to mate with the cask lid. Solid neutron shielding material is contained outside the structural shell. The inner shell, top forging, bottom forging, and the closure lid establish the cavity to contain the loaded basket. Key physical characteristics are shown in Table 4. The design conditions and criteria are summarized in Table 5.

Table 4. TranStor™ Shipping Cask Characteristics

Parameter	Value
Cavity Diameter	67.0 in.
Cavity Length	193.0 in.
Cask Body Length	208.0 in.
Cask O.D. w/ Impact Limiters	124.0 in.
Cask Length w/ Impact Limiters	277.0 in.
Cask Weight (Loaded)	<125 tons

The shipping cask has a fully recessed closure lid for protection from side impact loadings. The closure lid contains a vent port, a test port, and captured primary and secondary face seals. The closure lid is held in place with 60 bolts outside the seals in a conventional bolted flange design.

Redundant lifting capability for the packages is provided by four lifting trunnions. The trunnions extend radially from the cask body at 90-degree intervals. Removable positioning (rotating) trunnions are located on the bottom forging near the bottom of the cask to permit the TranStor™ cask to be rotated to/from the horizontal position.

The TranStor™ shipping cask is fitted with energy-absorbing impact limiters, installed over each end of the cask, to provide protection during normal conditions and in the event of a postulated accident during transportation. The impact limiters are fabricated of selectively oriented redwood encased in a 0.25 in. Type 304 stainless steel jacket. The impact limiters dissipate any impact forces that may be applied to the cask by controlled crushing of the wood. The impact limiters are removable and are bolted over the upper and lower ends of the cask by equally spaced attachment bolts.

The transportation design conditions and criteria for the shipping cask and basket package are shown in Table 5.

Table 5. TranStor™ Transportation Design Conditions and Criteria

Design Load Type	Design Parameters	Applicable Codes
Nuclear Design		
Normal Conditions	200 mrem/hr (accessible surface); 10 mrem/hr at 2m; 2 mrem/hr (occupied vehicle)	10CFR71.47
Hypothetical Accident Condition	1 rem/hr at 1 m (with neutron shield and shell removed)	10CFR71.51
Normal Conditions		
Hot Environment	38°C (100°F)	10CFR71
Cold Environment	-40°C (-40°F)	10CFR71
Min. or Max. external pressure	24.5 kPa(3.5 psia) or 140 kPa (20 psi)	10CFR71
Vibration and Shock	10g long; 5g lateral; 2g vert.	10CFR71
1-ft. Free Drop	Any orientation onto unyielding surface.	10CFR71
Water Spray	One hour rainfall	10CFR71
Penetration	13-lb steel bar	10CFR71

Hypothetical Accident Conditions		
9m (30-ft) Free Drop	Any orientation onto unyielding surface.	10CFR71 R.G. 7.6, 7.8
Puncture	1-m (40-in.) drop onto 15-cm (6-in.) mild steel bar	10CFR71 R.G. 7.6, 7.8
Fire Accident	30-min. fire	10CFR71 R.G. 7.6, 7.8
Immersion	15-m (50-ft) head of water	10CFR71 R.G. 7.6, 7.8
Submergence	200-m head of water	10CFR71 (1996)

LICENSING

The TranStor™ System will be submitted for certification by the NRC for both storage (10CFR72) and transportation (10CFR71). Presubmittal meetings were held with the NRC during 1995 to discuss design features and parameters and applicable regulatory criteria. The 10CFR71 Certification Safety Analysis Report was submitted in December 1995. The 10CFR72 Certification Safety Analysis Report will be submitted in January 1996.

SUMMARY

Utilization of the TranStor™ System will allow utilities and DOE facilities to safely store, transport, and eventually effect final disposal of irradiated fuel in a safe and proven manner. Utilization of a multi-purpose basket licensed for both transportation (10CFR71) and storage (10CFR72) will eliminate the need to reopen the baskets at a future date, thus minimizing fuel handling risk, costs, and occupational exposure. Since the future of the DOE Multi-Purpose Canister may be impacted by budgetary constraints, the TranStor™ System will provide a "privatized" system for general use that was developed by the industry and for the industry.

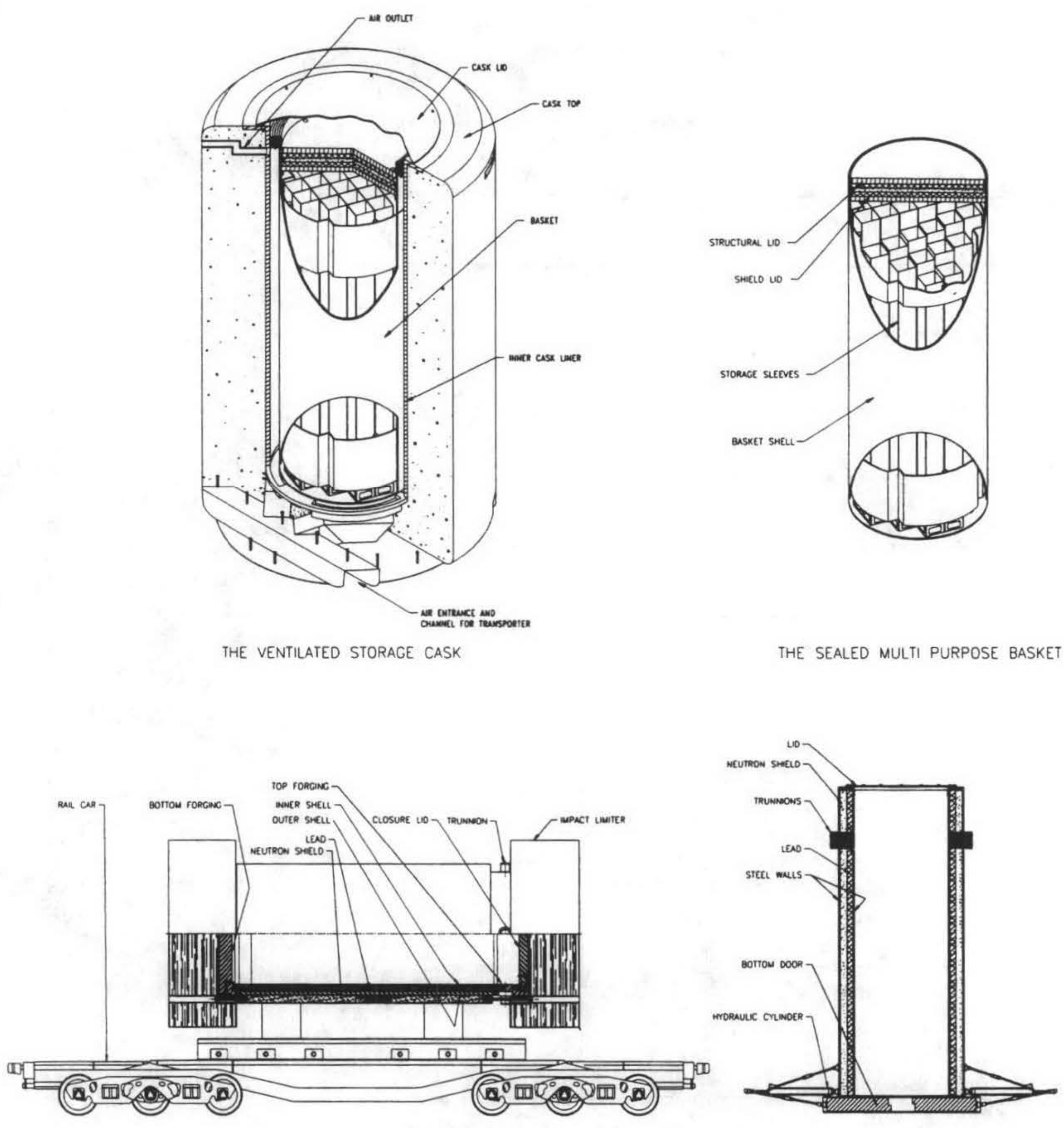
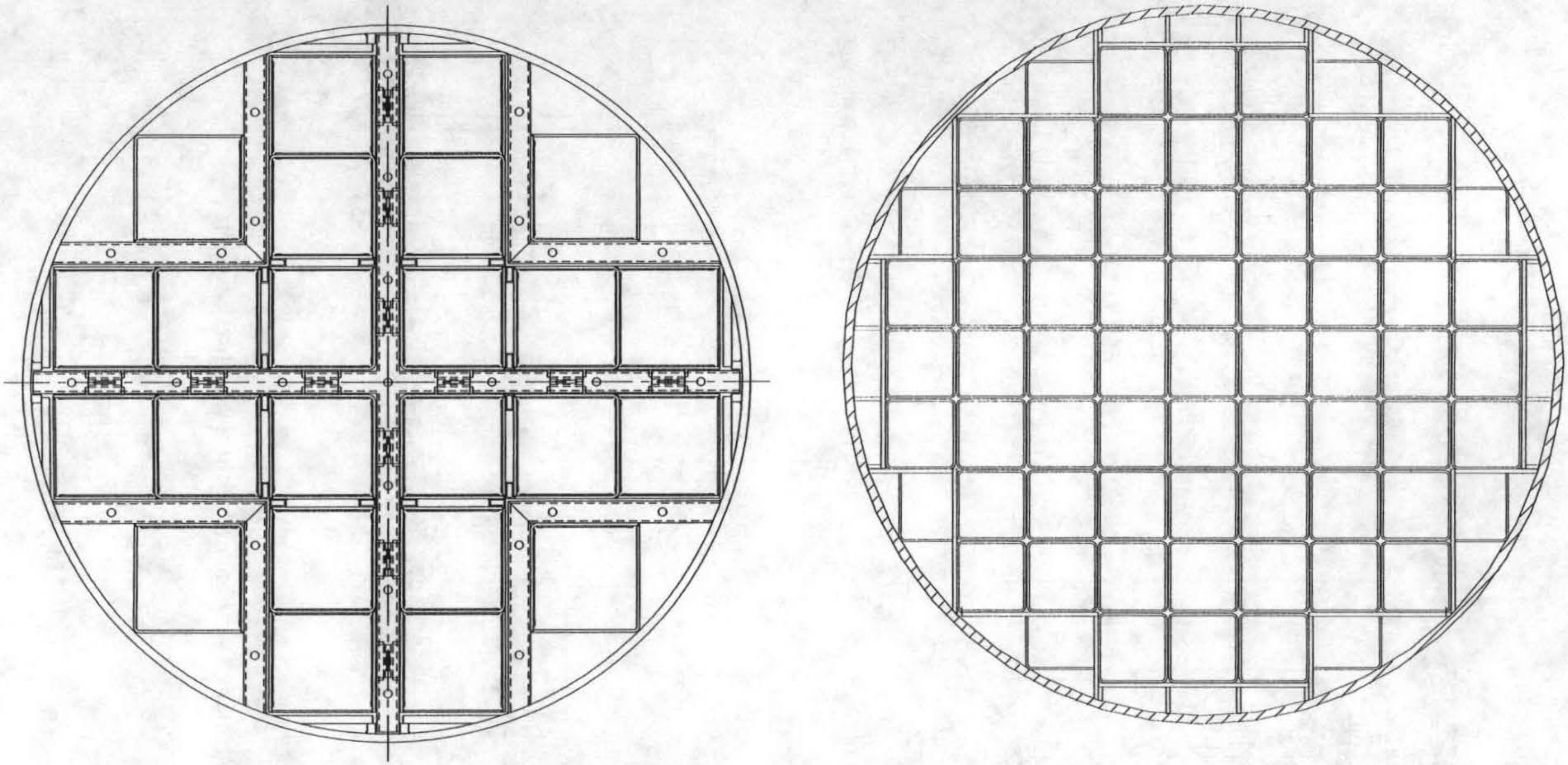


Figure 1. Primary Components of the TranStor™ System



PWR Basket **BWR Basket**

Figure 2. TranStor™ Basket Configurations

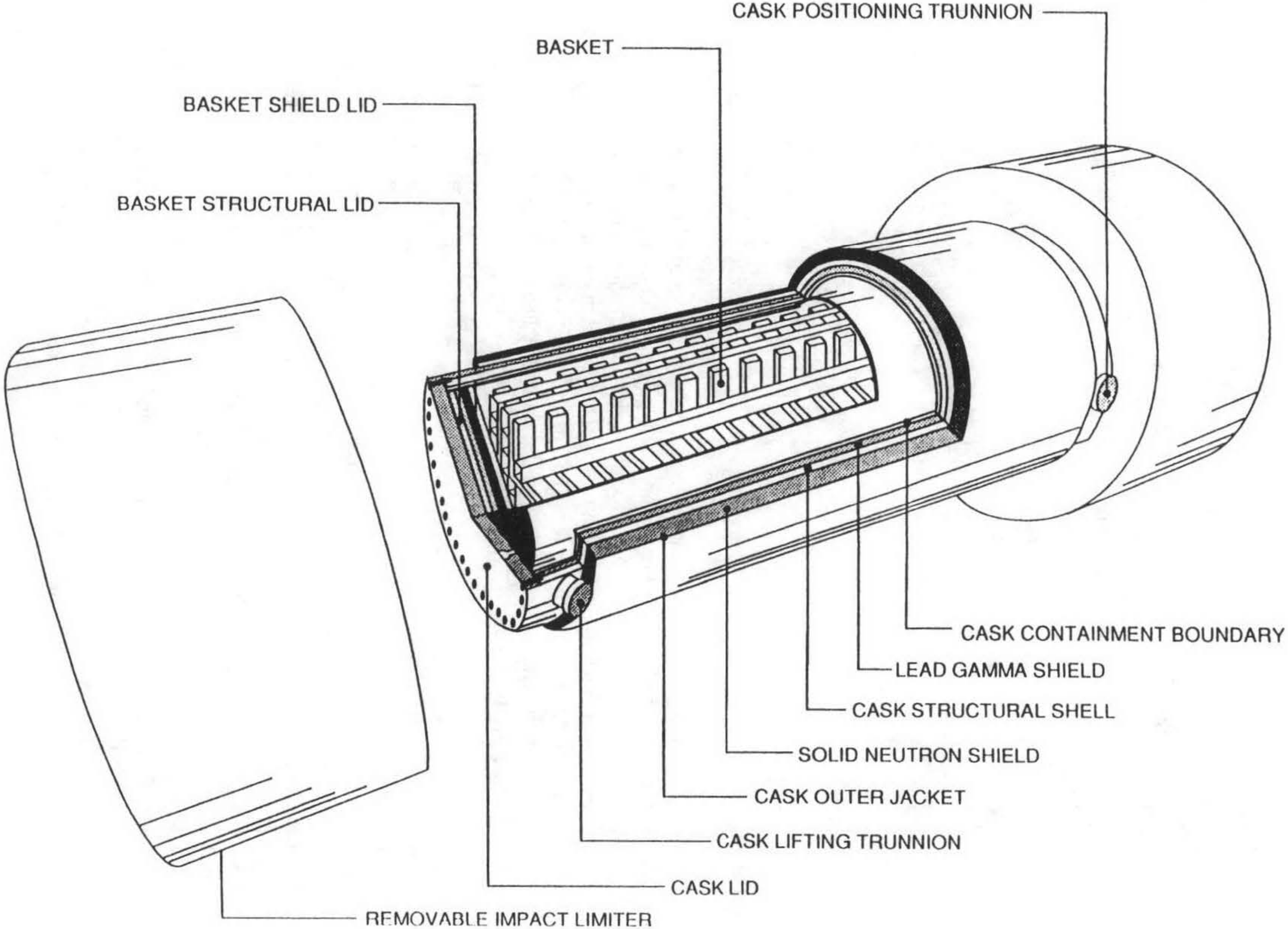


Figure 3. TranStor™ Shipping Cask with PWR Basket