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HLDW TRANSPORTATION SYSTEM DESIGN BASIS AND CONCEPTS

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INTRODUCTION

A system is being developed to transport solidified High Level Defense Waste (HLDW) from the Defense Waste Processing Facility (DWPF) at Savannah River to a federal repository. This work is being performed under DOE contract and under the technical direction of the Transportation Technology Center at Sandia National Laboratory. A design goal of the project is to develop a High Level Defense Waste Transportation System (HLDWTS) which is compatible with the solidified HLDW forms generated at Hanford and Idaho sites as well as the solidified waste which may be generated at a waste solidification facility to be built at West Valley, New York.

WASTE GENERATING SITES

DOE operates High Level Waste (HLW) management operations at the Savannah River Plant, the Hanford site and the Idaho site. In addition there is commercial and defense HLW stored at the NFS plant near West Valley, New York. The locations of these sites are shown in figure 1. Alternatives for long term HLW management at the SRP, Hanford, and the Idaho site are described in references 1, 2 and 3. The options being studied for disposal of currently stored HLLW and decommissioning of the West Valley site are described in reference 4.

High-Level radioactive wastes generated at Hanford, SRP and West Valley are similar in chemical and radionuclide composition. Hanford, SRP and West valley wastes are processed to excess alkalinity and transferred to large underground storage tanks where they are stored as high level liquid waste (HLLW). In addition, the NFS wastes also include a small quantity of acid Thorex waste. At the Hanford site radiocesium and radiostrontium are being removed from the waste and stored in double-wall canisters as cesium chloride and strontium fluoride. Idaho Chemical Processing Plant (ICPP) high-level waste composition varies greatly depending on the type of fuel being processed, the irradiation history of the fuel, and the length of time the fuel is stored before processing (Ref. 3). Unlike the alkaline wastes at Savannah River, Hanford and West Valley, ICPP high-level liquid waste is initially stored as an acid solution and contains high fluoride concentrations. After a suitable decay period, the acidic waste is converted to, and stored as, a granular calcined solid.

DESCRIPTION OF THE HLDW FORM

The objective of the current Defense Waste management program is the development of a waste form which can be reliably and safely isolated from the biosphere for extremely long periods of time. The form which is in the most advanced state of development and, to date, has been of the most interest is borosilicate glass. One of the advantages of borosilicate glass is that it can accommodate a large variety of glass formers and waste compositions. The waste glass can thus be tailored to the particular waste composition and to the particular processing equipment and conditions. Work on adapting the borosilicate glass to the site specific waste forms is underway at each of the defense waste sites.

In addition to borosilicate glass many alternate waste forms are under study. These alternate waste forms are not nearly as well developed as the borosilicate glass. The HLDW transportation system is, therefore, being developed using borosilicate glass waste as a reference, however, it is expected that the resulting design will be compatible with most of the alternate waste forms currently under development.

Waste Canister Design

The borosilicate glass waste is poured into stainless steel canisters and allowed to cool slowly to minimize cracking of the glass. Although each of the sites has somewhat different canister design concepts, for the purpose of the transportation system development the dimensions of the SRP canister have been adopted since it represents the most advanced design. A working group has been formed to standardize the canister size for HLDW. A summary of the SRP canister design is given in Figure 2 and Table 1.

TABLE 1

REFERENCE (SRP) HLDW CANISTER DESIGN

Diameter	610 mm (24 inches)
OAL	3000 mm (9 feet - 10 inches)
Wall thickness	915 mm (0.375 inches)
Material	Type 304L stainless steel
Head	Welded dished head with combination fill neck and lifting pintle
Bottom	Welded reverse dished head
Working Volume	640 liters (22.5 cu. feet) at 80% fill
Empty Weight	500 Kg (1100 Lb.)
Glass Weight	1480 Kg (3260 Lb.)
Filled Weight	1980 Kg (4360 Lb.)

Following cooldown, the canisters are remote seal welded and leak checked, and the exterior surface is decontaminated. The waste canister may then be transferred to interim storage or to the loading facility for offsite shipment.

Shielding Requirements

The HLDW glass composition and activity varies from site to site as a result of process and fuel variations. An evaluation of the isotopic composition of the HLDW glass for each site concludes that the neutron dose rate is low compared to the gamma and that no neutron shielding will be required, however, the neutron dose rate is large enough that it must be included in the total dose rate calculation.

For conceptual evaluation dose rate criteria have been established consistent with U.S. NRC and DOT requirements except that the allowable cask surface dose rate was reduced from 200 mr/hr to 50 mr/hr to facilitate implementation of ALARA requirements for cask handling activities at the DWPF or repository. During the more detailed design phase it is planned to do a time and motion evaluation of the cask handling process in order to establish expected crew exposure times. In conjunction with dose criteria established for plant technicians the need for supplementary shielding, or remote handling operations can then be determined.

Table 2 lists the thickness of steel shielding required for each of the waste forms to maintain the dose rate at 50 mr/hr or less on the cask surface or 10 mr/hr or less at 2 meters from transport vehicle. In all cases the cask surface dose rate controls.

TABLE 2

HLDW CASK SHIELDING REQUIREMENTS

Waste Type (Ref. decay time)	Steel Thickness* mm (in.)	Important Contributors**
SRP (5 yrs out of reactor)	229 (9.0)	Pr144, Cs134, Eu154, Co60
Idaho (5 yrs out of reactor)	180 (7.1)	Cs134, Ba137m, Pr144,Eu154
Hanford Existing (decayed to 1995)	158 (6.2)	Ba137m, Eu154, Co60
Hanford Future (decayed to 2010)	173 (6.8)	Eu154, Ba137m, Co60, Cm244
West Valley 8D2 (decayed to 1990)	196 (7.7)	Ba137m, Eu154, Cm244
West Valley 8D4 (decayed to 1990)	183 (7.2)	Ba137m, Eu154, Co60

* 6.4 mm (¼ in.) canister wall assumed

** in the order of importance

Decay Heat

The site specific decay heat generation is shown in Table 3. The maximum thermal activity of 700 watts/canister occurs for the West Valley HLW glass.

TABLE 3

HLDW DECAY HEAT

Waste Type (Ref. Time)	Watts/Canister
SRP (5 yrs. out of reactor)	540
Hanford Exist. (decayed to 1995)	125
Hanford future (decayed to 2010)	54
Idaho (5 yr. out of reactor)	200
West Valley (decayed to 1990)	700

Since these heat generation values are much lower than either spent fuel assemblies or anticipated processed waste from commercial power reactors the dissipation of heat from a HLDW cask is expected to be non-critical.

TRANSPORTATION SCHEDULES

The DWPF at Savannah River is scheduled to be the first solidification facility on line and will begin operation in 1989. Transportation of West Valley solidified waste can begin in 1990. The Hanford and Idaho facilities will become operational in 1995 and 2000 respectively. The canister shipping requirements are given in Table 4.

TABLE 4

HLDW TRANSPORTATION SCHEDULE

Site	Period	Canisters/Yr	Total Canisters
Savannah River (DWPF)	1989-2003	511	7,665
	2004-2006	170	510
West Valley	1990-1995	60	300
Hanford	1995-2010	1282*	19,230
Idaho	2000-2014	2164	32,460
	2015-2030	791	11,865
		TOTAL	73,580

* Includes shipment of encapsulated cesium and strontium waste.

ASSESSMENT OF EXISTING CASKS

An assessment of truck and rail casks which are existing, or in-license, as potential candidates for the HLDW mission indicate that

1) small cavity diameters and excessive cavity lengths produce poor packaging efficiencies for the HLDW canister,
2) gamma and neutron shielding thicknesses are excessive, and
3) several units employ fin arrays to dissipate much higher thermal loadings than is available with HLDW.

It is concluded that none of the existing, or in-license, systems are suitable for HLDW transportation. This is not too surprising since most are designed to carry spent LWR fuel assemblies which are smaller in cross-section, longer and require greater shielding and heat dissipation when compared to HLDW canisters. It is appropriate therefore to design a transportation system specifically for the HLDW canister.

HLDW CASK DESIGN BASIS

The objective is to design a cask which satisfies the safety requirements for both the normal conditions and the hypothetical accident conditions of transport while maintaining economy of operation, reliability and simplicity. The designers also recognize that the mission life of 41 years (1989 - 2030) represents a very long period in a dynamic regulatory environment. The HLDW cask design is based on the following:

1. Rail will be the principal mode of transport.
2. The maximum GVW will be 263,000 Lbs.
3. The shipping and handling operations will be performed "dry".
4. The cask will provide all required containment functions.
5. The cask containment systems will be designed in accordance with ASME code rules for nuclear shipping packages currently being formulated.
6. The cask will meet the normal and accident criteria of the NRC and DOE regulations.

HLDW CASK DESIGN CONCEPT

One of the HLDW cask concepts currently under evaluation is a solid steel body cask of cylindrical design with a sealed, shielded inner lid and an outer impact lid. The cask body may be cast in steel or ductile nodular iron or fabricated by welding together one or more ring forgings to a forged base. The design concept being pursued is identified as a "convertible cask" and is shown in Figure 3.

An internal (replaceable) basket consists of an aluminum structure which contains cavities to receive the HLDW canisters. The cask wall consists of a minimum thickness of 158 mm (6.2 inches) steel corresponding to the shielding required for lowest activity fuel from Hanford. The basket of this cask is configured to carry 8 canisters. As the need arises to accommodate higher activity waste a basket of lesser capacity but with supplemental shielding replaces the original basket, as shown in Figure 4. In this way a single, flexible containment structure can be reconfigured so as to optimize the capacity and shielding to the site specific waste characteristics while requiring only one basic certified design.

The solid body cask is of such high integrity that a large "soft" external impact limiter structure is not required, thereby improving the cask handling characteristics and reducing the cask envelope dimensions. Only small internal energy absorbers are provided to protect the canisters from normal transportation and handling loads. Compact fins can be readily added for additional protection against the corner impact condition if required according to detailed analysis of the hypothetical accident condition.

The HLDW rail cask is carried horizontally on a flatbed rail car as shown in Figure 5. Cask handling and loading operations are performed dry. The cask is vertical top loading. Loading operations may be performed by transferring the cask into a remote, shielded loading cell or by rotating the cask 90° and engaging the top (closure) end of the cask with a sealed loading port through which the HLDW canisters are loaded into the cask.

SYSTEM COSTS

A basic cost analysis was performed to compare the "convertible cask" concept to a more conventional design. If a fixed capacity cask were utilized it would have to be designed for SRP fuel, require 229 mm steel shielding and have 5 canister capacity. A comparison of cask capital costs, operating costs and total number of casks is shown in the following Table 5. Capital costs were calculated based on acquisition of rail casks for $1.15 million each. Operation costs include only transportation costs and are based on an average one-way trip of 1000 miles, 85% cask availability, 15 day shipping cycle and a shipping cost of $8.50/CWT - 1000 miles with return included.

TABLE 5

SYSTEM COST ANALYSIS

Item	Fixed Design	Convertible Cask
Capacity (Canisters)	5	5 - 8
Shielding (mm steel)	229	229 - 158
Weight, Mt	80	80 - 87
Total Casks	38	27
Capital Costs ($1980\$X10^6$)	44	31
Operating Costs ($1980\$X10^6$)	297	201
Total Cost ($1980\$X10^6$)	341	232

Based on this simplified analysis, the convertible cask design reduces peak cask fleet requirements from 38 to 27 casks, and results in a 29% savings in capital cost and a 32% reduction in transportation costs. Overall cost advantage over the life of the program would amount to more than $100 million.

CONCLUSIONS

A reference design concept has been described for a system to transport High Level Defense Waste from solidification and packaging facilities to a federal repository. This system is characterized by the following features:

- High integrity solid body cask with dual lid,
- 80 metric ton rail cask suitable for a 4-axle flat bed transporter
- Uncomplicated design and dry handling permit efficient cask loading and unloading operations
- A convertible capacity design permits flexible and efficient packaging for multi-site utilization and lower overall costs.

Future program activity will be focused upon more detailed conceptual design, development of design criteria and system descriptions, systems safety analysis, and studies of in-plant handling operations to establish requirements for contact or remote handling.

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Fig. 1. Waste generating sites

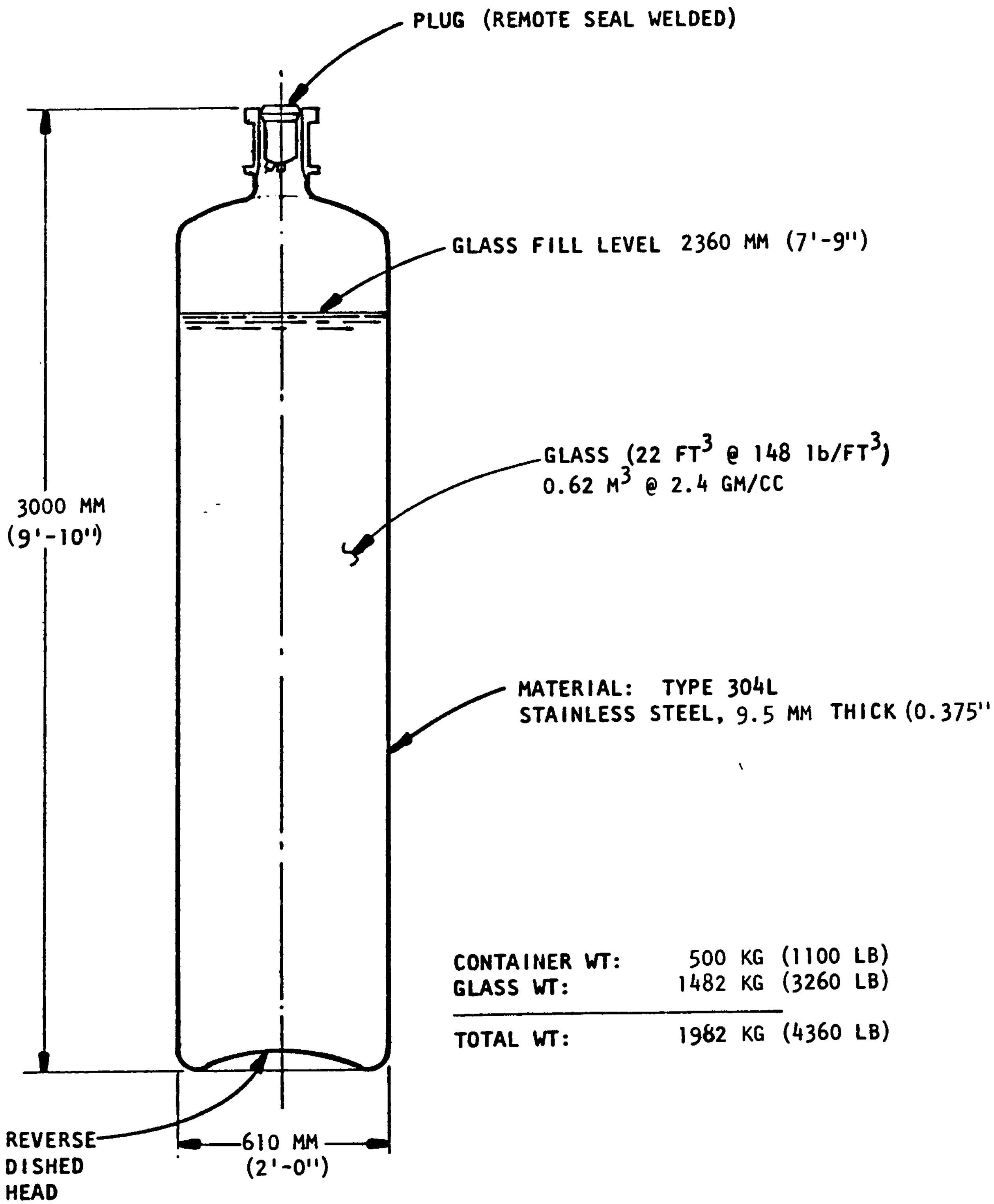

Fig. 2. Reference HLDW canister

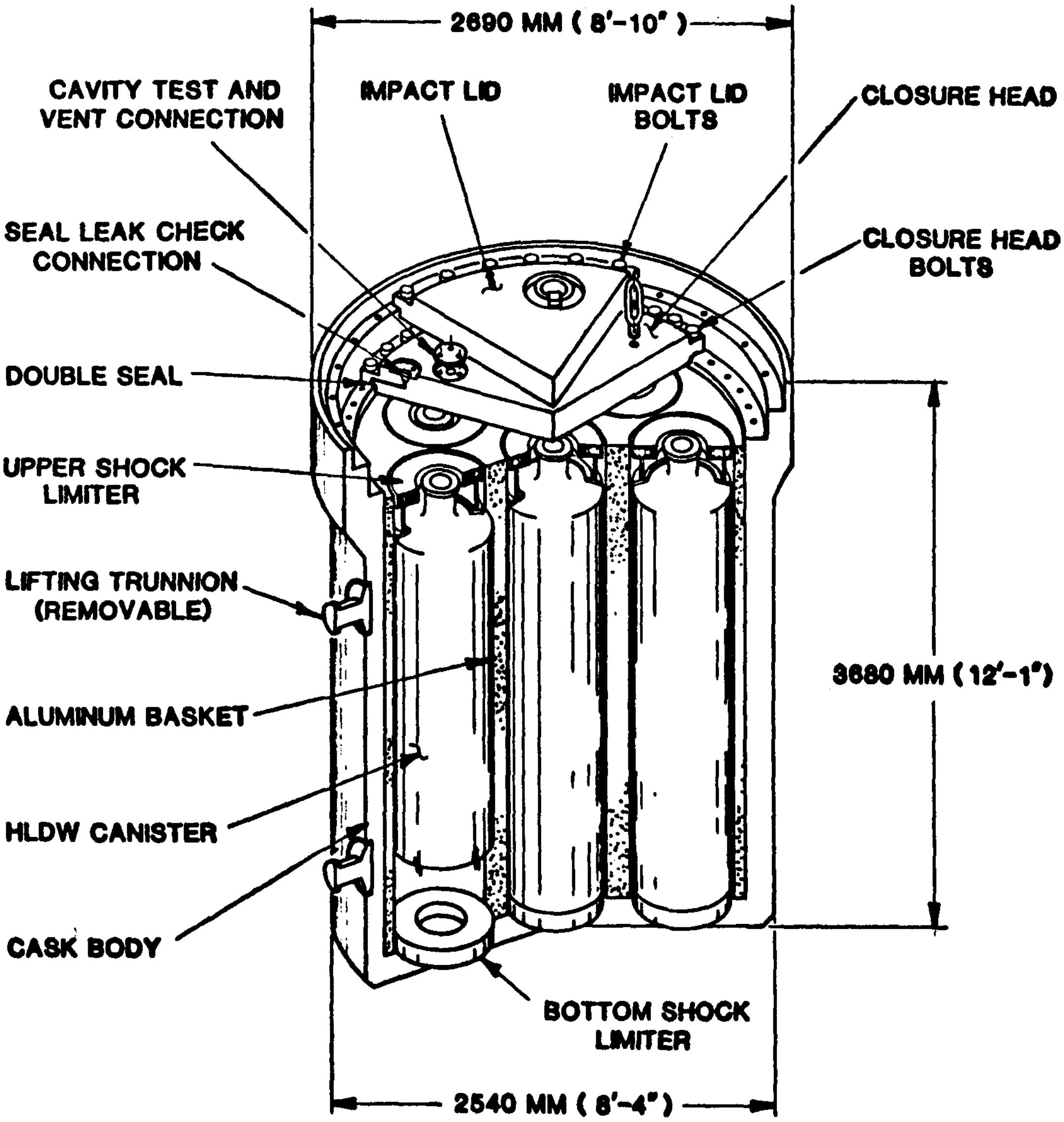

Fig. 3. HLDW Rail cask (8 cannister capacity)

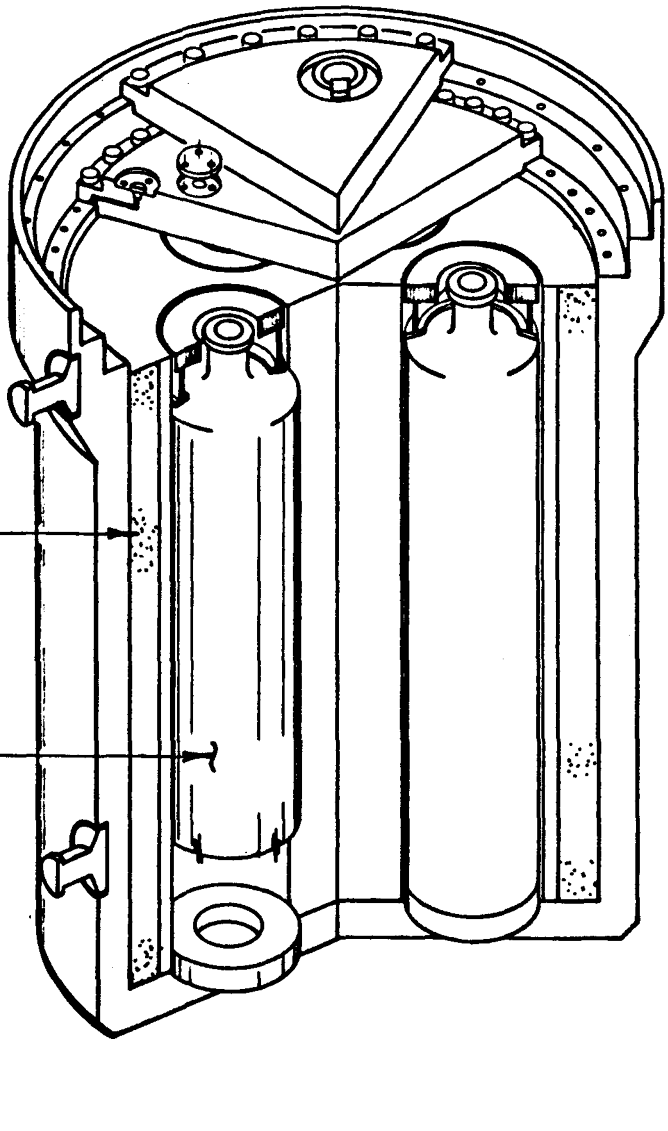

Fig. 4. HLDW Rail cask with 5 canister capacity and augmented shielding

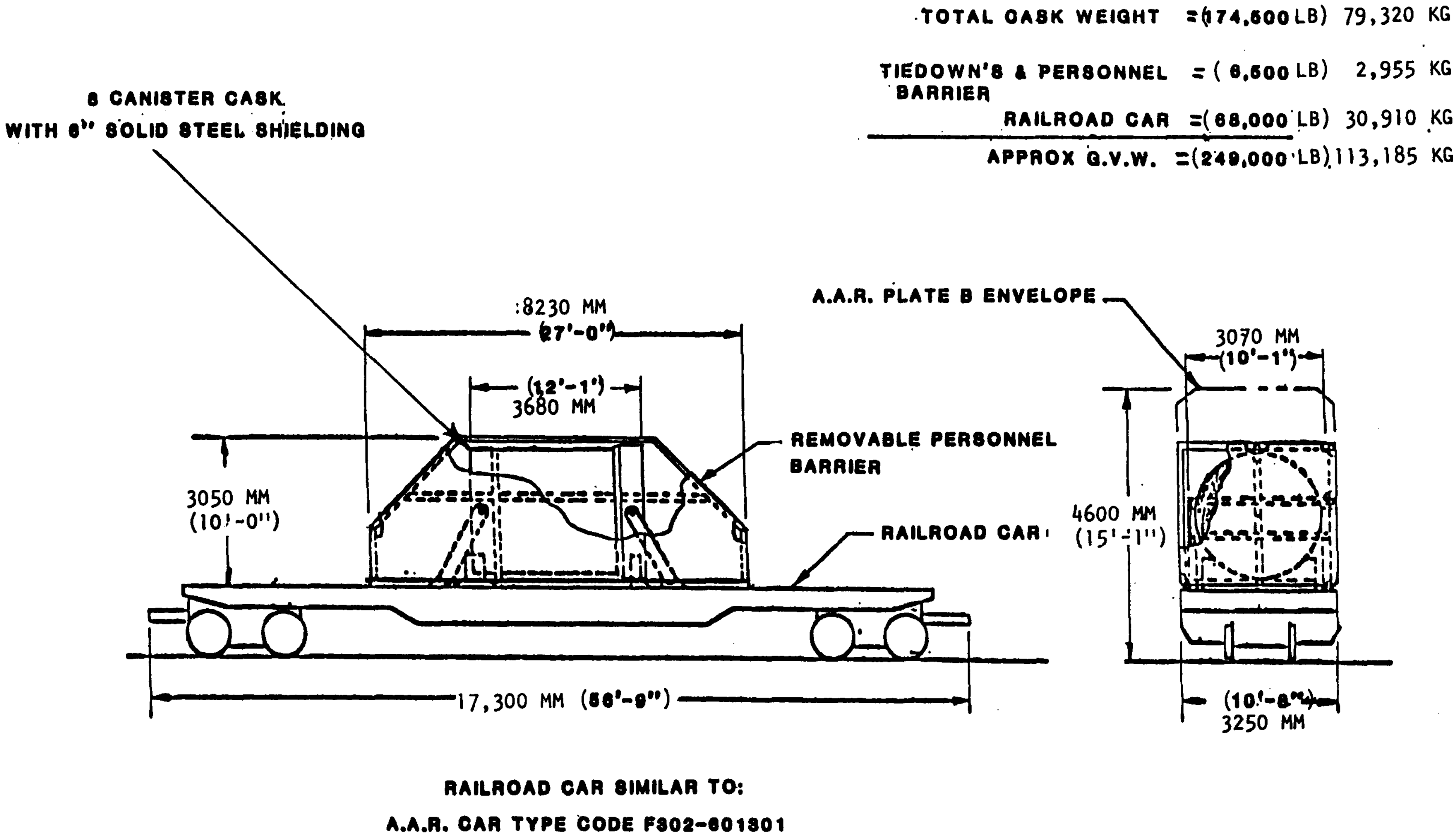

Fig. 5. High level defense waste railroad car cask transporter G.V.W. 263,000 lbs. max.