Type-B Drum Packages*

W.S. Edwards
Westinghouse Hanford Company

INTRODUCTION

The Type B Drum package is a container in which a single drum containing Type B quantities of radioactive material will be packaged for shipment. The Type B Drum containers are being developed to fill a void in the packaging and transportation capabilities of the U.S. Department of Energy (DOE), as no double containment packaging for single drums of Type B radioactive material is currently available. Several multiple-drum containers and shielded casks presently exist. However, the size and weight of these containers present multiple operational challenges for single-drum shipments. The Type B Drum containers will offer one unshielded version and, if needed, two shielded versions, and will provide for the option of either single or double containment. The primary users of the Type B Drum container will be any organization with a need to ship single drums of Type B radioactive material. Those users include laboratories, waste retrieval facilities, emergency response teams, and small facilities.

BACKGROUND

For more than 50 years, steel drums, typically 208 L and smaller, have been among the most widely used containers for shipment and storage of radioactive materials. As regulations developed more rigorous safety standards, traditional U. S. Department of Transportation Specification 17C or 17H drums became unsuitable for the shipment of Type B radioactive material. Instead of repackaging the Type B radioactive material into suitable containers, an overpack–the N55–was developed in the mid-1970s (Vectra 1994a). The N55 provides thermal protection and an impact limiter, but is not equipped with a leak-testable containment boundary or shielding. Under current regulations, without a containment boundary, the N55 cannot be used to overpack the majority of

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drums containing Type B radioactive material, which has led to the need for a suitable new single-drum container.

Several containers currently certified or in development will be able to ship multiple Type B drums during large shipping campaigns. If shielding is not required, the TRUPACT-II offers double containment with a capacity of 14 drums (Vectra 1989). The TRUPACT-II is designated as the principal container to ship contact-handled transuranic (TRU) waste drums to the Waste Isolation Pilot Plant (WIPP). For shipments requiring shielding, a number of containers are available, or are being developed, with single or double containment that will allow shipment of multiple drums. One of those containers is the NuPac 72-B, which is being developed specifically to support the TRU program (Vectra 1994b). It will provide for concurrent shipment of up to three drums of remote-handled TRU waste to the WIPP site.

Although each of these containers could be used to ship single drums of Type B radioactive material, the size and weight of multidrum containers, compounded by the necessity of using a special trailer in some cases, present operational and handling challenges for facilities needing to ship only a small number of drums. In addition, due to their size the multidrum containers allow lesser amounts of gas generation and individual drum weights than a single drum container. Therefore, the Type B Drum is being developed is to assist those facilities and make it possible to ship more existing drums without repackaging.

TYPE B DRUM PRELIMINARY DEVELOPMENT

The Transportation and Packaging Department within Westinghouse Hanford Company was tasked to develop the Type B Drum by the Office of Transportation, Emergency Management, and Analytical Services (EM-26), which is within the DOE Office of Environmental Management. The objective of this task is to fill a current packaging void by developing a Type B(U) container that facilitates the shipment of single drums containing Type B quantities of radioactive materials as defined by the U. S. Nuclear Regulatory Commission (NRC) in 10 CFR 71. In 1993, a feasibility study outlining some of the requirements for the Type B Drum package, including the potential users of such a package, was conducted (Weber 1993).

Based on the findings of the feasibility study and a survey of selected potential customers, conceptual designs were prepared in 1994 for both shielded and unshielded versions of the Type B Drum, which would overpack existing drums with volumes up to 208 L. All versions provide both single and double containment configurations, while the shielded versions will provide two different shielding thicknesses, 5.3 cm and 11.4 cm of steel. To reduce operational complexity, all versions will share design features to the maximum extent practicable.

The need for shielded versions of the Type B Drum may not be as great as the need for the unshielded version, since several shielded containers will be, or are currently, available to ship single drums of high-activity materials. Those containers include the

CNS 1-13G (NRC 1993), the GE-2000 (GE 1984), and the Pacific Nuclear (NuPac) 72-B (Vectra 1994b). These containers are currently in use or are under development by DOE programs, but are awkwardly heavy, ranging from 7,250 kg to 20,400 kg, which could make their use difficult at smaller sites with limited handling capabilities.

CONCEPTUAL DESIGN CRITERIA

Conceptual design criteria for both shielded and unshielded and 114 L and 208 L versions of the Type B Drum have been prepared by Westinghouse Electric Corporation's Nuclear Technology Division (Westinghouse 1994a and 1994b). Each version of the container provides for single and double containment configurations. Twelve different conceptual configurations for the Type B Drum were investigated, as shown in Table 1.

Table 1. Type B Drum Configurations

SHIELDING CONFIGURATION (cm steel)	SINGLE CONTAINMENT		DOUBLE CONTAINMENT	
	114 L drum	208 L drum	114 L drum	208 L drum
0 (Unshielded)	X	X	X	X
5.3	X	X	X	X
11.4	X	X	X	X

All configurations of the Type B Drum share a number of design features. The drums are positioned within the appropriate 304 stainless steel containment vessel using an 6061-T6 aluminum honeycomb material. This container is then placed within the outer container (in the case of the double containment options), and similarly positioned by aluminum honeycomb material. Each of the containment boundaries are at least 6 mm thick. The outermost containment vessel consists of an inner 304 stainless steel container, a layer of polyurethane foam, and a 3-mm stainless steel skin.

Structural Evaluation

The Type B Drums will be required to withstand the normal and hypothetical accident conditions specified in 10 CFR 71. For conceptual design purposes, it was judged that the 9-meter drop and the puncture bar accident cases would define the package configuration and containment shell thicknesses, as these cases cause the largest and most concentrated loads on the outer containment. Bottom and side drop cases have larger available foam areas for crushing and absorbing energy, which limit the load acting on the containment.

Structural analysis performed for the conceptual design study primarily focused on the outer containment of the unshielded cask for a number of reasons:

- There is a greater need for the unshielded cask, and therefore, it was the most appropriate cask on which to dedicate the bulk of the conceptual design effort.

- Shielded cask containments should not be as severely stressed since the structural rigidity of the thick steel radiological shield will protect the structural integrity of the containment.

- The outer vessel must maintain its leak-tight integrity and meet specific stress limits for the most severe applied loads.

- The inner containment is protected by the outer containment for the most severe applied load cases.

Three different configurations for the outer containment heads were modeled and investigated. These were a flat head with square corners, a dished (torospherical) head, and a flat head with rounded corners.

Results of the analyses indicate that a containment cylinder with 6 mm thick walls and a 9-mm thick top and bottom with 76-mm radius corners would meet maximum stress criteria. Similarly, it was determined that this design would withstand the hypothetical puncture test.

Radiological Analysis

The packages were evaluated to determine the allowable contents for normal shipment, which include radiation readings not exceeding 200 mR/hr on contact and 10 mR/hr one meter from the surface. The drum dose rates listed below were calculated with the most conservative case of a point source in a zero density drum within the single containment version of each Type B Drum configuration.

Analysis performed for both shielded and unshielded package designs generated estimates of the maximum amounts of gamma-producing radioactivity and drum exterior dose rates that can be handled. For the unshielded cask, it was determined that 208-L drums reading below about 300 mR/hr, and 114-L drums reading below about 450 mR/hr can be handled for standard shipments. For the shielded designs, the version with 5.3 cm of shielding can accommodate drums reading up to 1-2 R/hr, and the version with 11.4 cm of shielding can handle most drums reading up to 10 R/hr for ^{60}Co and up to 30 R/hr for ^{137}Cs for standard shipments. The controlling factor for all standard shipments and versions of the Type B Drum is the 10 mR/hr dose rate at 1 meter. Shipment via exclusive use transport would increase the allowable radiation levels by approximately a factor of two.

Thermal Analysis

The conceptual design report draws an analogy between the Type B Drum and the TRUPACT-II. Since the TRUPACT-II can transport material with up to 40 W internal heat generation, all Type B Drum configurations were analyzed for a 40 W internal source, with solar insolation and the hypothetical fire accident from 10 CFR 71. In all cases, the Type B Drum conceptual designs were satisfactory.

In the case of radionuclides that produce gamma rays, the heat generation will be small for the allowable quantities. For example, the heat generation from 20 Ci of ^{137}Cs (much more than could be contained in the unshielded cask), with as much as 200 Ci of ^{90}Sr, would still have less than 1 W of total heat generation. However, if the drum contains appreciable amounts of actinides, the heat generation could be larger than 40 W. For example, slightly over 2 g of ^{238}Pu generates 40 W. However, ^{238}Pu has an unusually high heat production rate and is relatively uncommon. Most other actinide heat production rates are much lower than ^{238}Pu, so heat generation rates greater than several watts are not expected for materials that satisfy criticality limitations.

Criticality Analysis

Conceptual design efforts targeted the development of a Fissile Class I packaging. Pending characterization of the TRU waste, the fissile composition is represented as ^{239}Pu. For both the shielded and unshielded containers, the limiting case was determined to be an infinite array of damaged containers with no reflection and cylindrical geometry for the fuel region. For this limiting case, the ^{239}Pu limits were 175 g and 200 g for the unshielded and shielded packages, respectively. Additional analyses beyond those performed in the conceptual design will be performed to increase the allowable fissile loading per package.

TYPE B DRUM SOURCE TERM

One mission for the Type B Drum may be the planned shipping campaign to dispose of TRU waste. In this program, the Type B Drum would be used as a shipping container for sites with small quantities of TRU waste. The TRU waste from smaller sites is expected to be shipped to a central collection point, where the individual drums will be consolidated into the TRUPACT-II for shipment to WIPP. Another source term for Type B Drum may be the DOE's inventory of excess plutonium that could be poisoned and vitrified, depending on the results of an on-going Environmental Impact Statement. The Type B Drum would be used to transport that material from the vitrification plant to its final burial site. Other possible contents include plutonium residue stored at the Rocky Flats Environmental Technology Site that is not on the TRUPACT-II allowable contents list due to either a high rate of gas generation or fissile material loading, assorted TRU waste that has a high rate of gas generation, or miscellaneous waste from various facilities that exceed Type A quantities of radioactivity in a single drum.

The final contents list will be determined through discussions with potential end-users. To date, personnel from WIPP, Sandia-Livermore, Rocky Flats, and Fernald have expressed varying levels of interest in the Type B Drum. Extensive discussions have already occurred with WIPP. WIPP is quite interested in the use of the Type B Drum to transport waste from the sites across the country that have small volumes of TRU waste (i.e., two or three drums) that do not have the special handling facilities or trained personnel available to handle the TRUPACT-II. WIPP has stated that the Type B Drum will be acceptable for the National TRU Program as long as it can transport the material on the allowable contents list for the TRUPACT-II container. WIPP stated that a 40 W thermal capability, a 455-kg payload capacity, and a fissile material loading of 200 g ^{239}Pu equivalent would suit the needs of the National TRU Program.

PACKAGING DESIGN CRITERIA

A packaging design criteria (PDC) was developed (Edwards et al. 1995) to be used as the basis for the final design of the Type B Drum. The PDC concentrates on the unshielded version, since it has the widest anticipated use within the DOE complex. The PDC lists the design parameters for the packaging, and builds on the conceptual design work previously completed. For example, the PDC lists the minimum inner cavity for the container, the allowable thermal loading for the contents, the performance tests that the packaging must survive, and acceptable materials of construction. Before some of the design parameters can be specified, a final, bounding source term must be determined. For the purposes of the PDC, the contents were determined to be plutonium residue material currently stored at Rocky Flats, vitrified weapons-grade plutonium, or miscellaneous TRU waste from across the DOE complex.

One change from the conceptual design that was incorporated into the PDC involves the fissile class of the packaging. The conceptual design was based on a Fissile Class I package. Some of the potential uses for the Type B Drum include high loadings of fissile material, especially plutonium. The fissile class of the final design will be based on the needs of the DOE complex. Gas generation, particularly hydrogen, by the contents of the Type B Drum may also effect the design. Hydrogen getters could be provided as a method to reduce the flammable gas buildup within the container, but are not likely to be accepted as the sole method of hydrogen control by the regulatory authorities (e.g., DOE or NRC). The Kansas City Plant performed some testing of the 1,4-bis (phenylethynyl) benzene (DEB) hydrogen getter to determine the suitability of the DEB getter for use in the Type B Drum and other packagings. Those tests demonstrate the DEB getter performs effectively even in the presence of known inhibitors (Schicker 1995) such as carbon monoxide.

The final source term for the Type B Drum will be based on the identified needs of the DOE complex, as discussed above. Structural, thermal, gas generation, criticality, and shielding calculations will be performed to determine the bounding source term for the packaging, which will be the basis for the final design. Once Type B Drum has been built, design parameters can be modified as necessary to satisfy needs that are not met by the initial design parameters.

Now that the packaging design criteria is complete, the next step will be to begin the final design and write the Safety Analysis Report for Packaging (SARP). Test units will be fabricated and tested as necessary to support completion of the SARP. At the current rate of funding, it will be 1998 or 1999 before the SARP for the Type B Drum can be submitted to DOE for review and approval.

CONCLUSION

If implemented, the unshielded package concept will have several advantages over other existing packages that are in use today. It would allow for single drum shipments. Based on the conceptual design's average gross package weight of 910 kg, and a truck trailer permitted payload of 18,200 kg, 20 of the unshielded packages could be transported by a single trailer truck. No special heavy duty equipment or rigging would be required for package handling. Finally, it will fill a gap in current DOE packaging capabilities, and allow for the shipment of single drums of Type B radioactive material.

While it appears that the DOE community could significantly benefit from the development of the Type B Drum, funding has proven to be an obstacle to timely completion. The current DOE philosophy of having each site provide for its own packaging needs has made it difficult to develop packagings such as Type B Drum which have DOE complex-wide application. The smaller sites which would most benefit from Type B Drum typically lack the resources necessary for its development. Sites large enough to develop such a package generally have other priorities since they will be able to use the TRUPACT-II. Until a DOE-Headquarters organization commits to funding the development of the Type B Drum, progress will remain sporadic and slow.

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