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# MANUFACTURE OF A LARGE TYPE B SHIPPING CONTAINER

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## ABSTRACT

The MD-2 Shipping Container was designed, developed, and certified by the Y-12 National Security Complex. This container will support the U. S. Department of Energy (DOE) fissile materials disposition programs for the next 20 years. This container was designed in 2006 and certified by the National Nuclear Security Administration (NNSA) in 2009. A contract to manufacture MD-2s was awarded in 2011 to Major Tool and Machine, Inc. of Indianapolis, IN, USA. Fabrication began in late 2011 and the first articles of the major safety component, the Containment Vessel, were completed in December 2012. First articles of the Confinement Boundary (drum assembly) were completed in March 2013.

Following extensive inspection of the first articles, the manufacturer was released to produce over 200 of these containers. The shipping container has an important role in the surplus Pu Disposition and MOX Programs. It was specifically designed to ship surplus items for conversion to MOX fuel. Implementation of this container will occur in several sites in the DOE complex to support this mission. As this container has a relatively large inner Containment Vessel, and is a qualified Type B container, it can be used for many other applications.

This paper discusses the detailed status of the current container fabrication. It also provides detailed design descriptions and dimensions of the container for those organizations who may wish to use the MD-2 for other material shipments.

## INTRODUCTION

The MD-2 is a Type B fissile shipping container. A cross-sectional view is seen on Figure 1 and the principle dimensions are shown on Figure 2. The maximum payload mass for the MD-2 is currently 120 lbs.  This can be increased by additional structural analysis and regulatory review and concurrence.

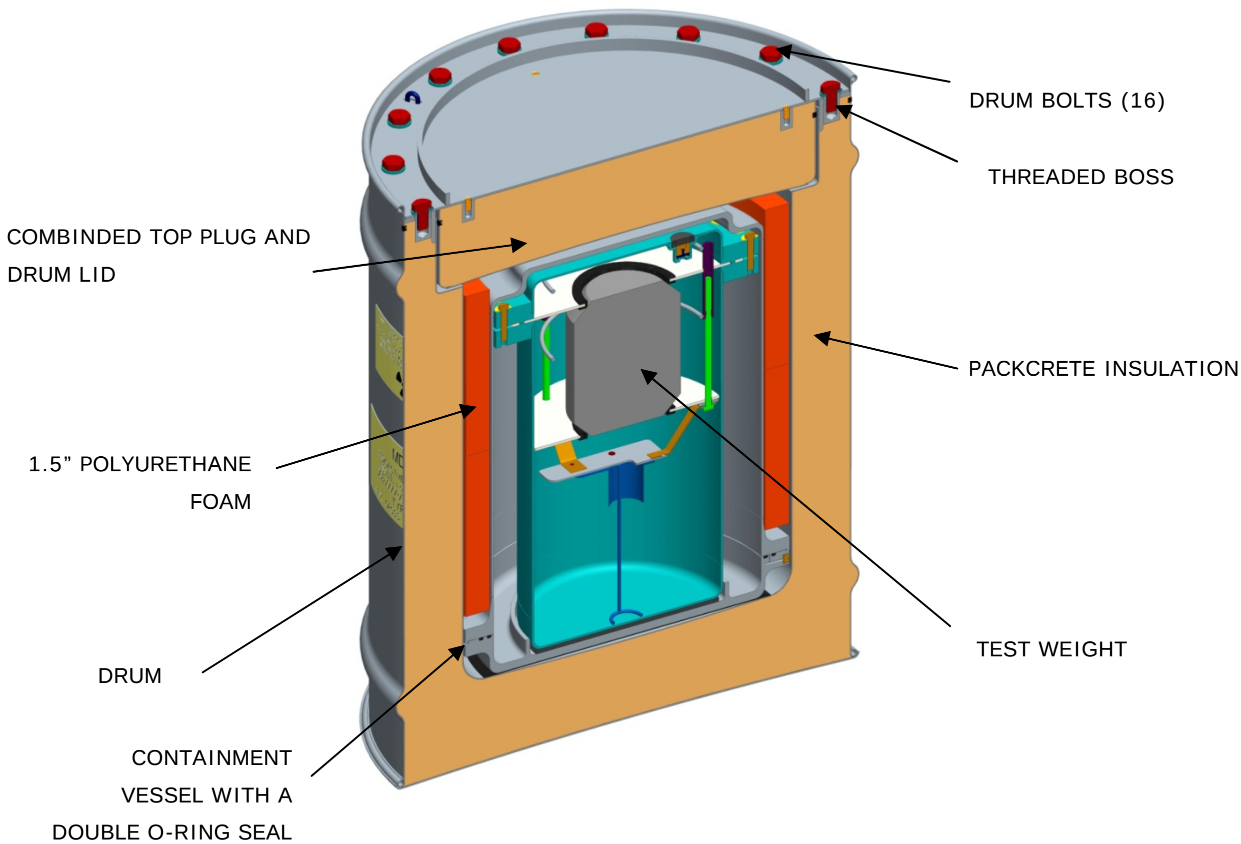


**Figure 1.  Section view of the MD-2 container.**

In general, Type B packages have two major systems, a confinement boundary and a containment boundary.  For the MD-2, the confinement boundary will consist of a drum, insulation, an inner liner, and a top drum lid integrated with the top plug.  This portion of the package is sometimes referred to as the overpack.  The containment boundary for the MD-2 will consist of a pressure vessel (or CV) and an O-ring seal.

## CONFINEMENT ASSEMBLY

The function of the confinement assembly is to maintain the position of and provide protection to the impact and thermal barrier surrounding the containment boundary when subject to NCT and HAC as defined in 10 CFR 71.71 and 71.73, respectively [1].  The visible portion of the confinement assembly will be a stainless steel drum (Figure 3) and a lid and top plug assembly (Figure 4).  In previous designs the drum lid and top plug assembly have been individual components.  For the MD-2, these features have been integrated into one assembly.

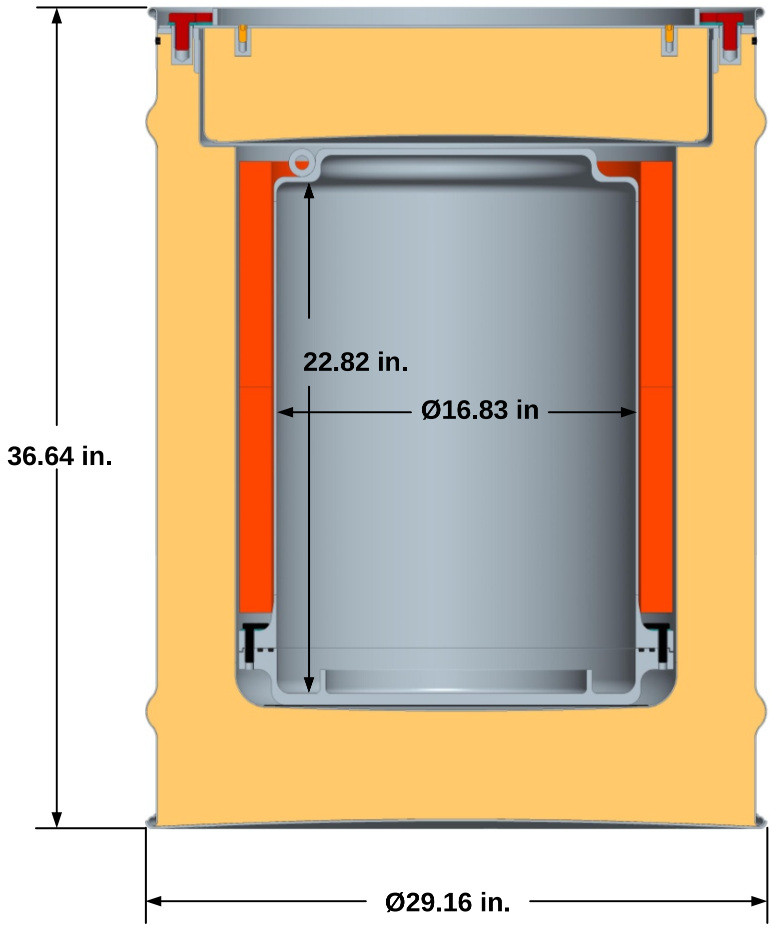


**Figure 2. Principle dimensions of the MD-2 container.**

The current working design employs a modified 80-gal military standard drum with approximate dimensions of 29.16 in. diameter and 36.64 in. height. Changing the height of the 80-gal drum from an Aindustry standard@ of about 31 in. to about 36.64 in. was done to accommodate the additional height of the containment vessel. The modifications include the attachment of angle iron at the top of the drum. The angle iron serves as a place for the lid bolts to attach as well as an anchor for the inner liner. Bosses are welded to the angle iron at 16 locations radial around the drum (Figure 5). These bosses will be drilled and tapped to accept heli-coil threaded inserts. Instead of using weld studs to attach the drum lid, high strength bolts will be employed.

Open ended drums are purchased to spec and then modified by adding the inner liner, insulation and bottom lid. Figure 6 shows some of these supplies that are purchased by the fabricator. Inner liners are initially spun parts that are fabricated into the liner assembly (Figure 7).

**Figure 3. Confinement assembly bodies awaiting insulation.**

**Figure 4. Top Plug and lid (lid is hollow, awaiting insulation).**

**Figure 5. Confinement assembly upper flange and liner detail.**

**Figure 6.  Supplies for confinement assemblies.**

**Figure 7.  Confinement assembly liner detail.**

## CONTAINMENT BOUNDARY

The primary function of this boundary, or CV, is to maintain containment of the radioactive materials being shipped. This is accomplished through the use of a stainless steel vessel body and bottom with an elastomeric O-ring seal at their attachment (Figure 8). To conform to 10 CFR 71 requirements, whole body leak rates must be maintained under normal and accident scenarios. For plutonium materials, for which the MD-2 is primarily being designed, whole body leak rates less than 1 x $10^{-7}$ ref $cm^3/s$ must be maintained.

The MD-2 CV will be manufactured from ASME Section III qualified material. The requirements of Section III are such that the costs of qualified material are greatly elevated over similar nonqualified materials; therefore, the use of qualified material is minimized where possible. The current working design uses several bolts to attach the CV body to the CV lid. These bolts engage replaceable heli-coils such that stripped threads may be easily replaced. This type of closure maximizes the usable height inside the CV, allowing maximum efficiency as required for this package.

The MD-2 CV uses a thin-walled concept, fabricated by rolling and welding stainless steel plate for the cylindrical section of the CV body (Figure 9). Rolling sheet stock allows the designer to specify the internal diameter and wall thickness with smaller manufacturing tolerances (on the order of +/- 0.030 in.).

The base of the CV is machined from a stainless steel forging. Double O-rings are located in the CV bottom (Figure 10).


**Figure 8. Containment vessel base and lid.**

**Figure 9. Containment vessel lid showing welded construction.**

**Figure 10. Containment vessel base and O-rings.**

Various forging used in the fabrication of the CVs are shown in Figure 11. The first 5 articles for inspection have been completed and are shown in Figure 12. Other views of the CVs are shown in Figure 13.

**Figure 11. Containment vessel forgings.**

**Figure 12. Containment vessel first articles.**


**Figure 13. Containment vessel views.**

## MD-2 INSULATION

A key design feature for the MD-2 confinement assembly is the use of a fully encapsulated insulation material. It should be noted that while it is referred to as insulation material, this material provides energy absorption during drop, crush, and puncture testing as well as insulation during thermal testing. The use of an inner liner attached to the drum with angle iron creates an annular space, which is subsequently filled with an insulating material. The insulating material is poured into this cavity through the open bottom of the drum. The bottom lid is later welded in place, thereby encapsulating the insulation. Encapsulated insulation has been shown on other packages to reduce life-cycle costs by reducing package refurbishment and maintenance efforts over the package lifetime. The insulation designed for the MD-2 is a commercially available, inorganic material called Kaolite 1600™, which is basically is a mixture of Portland cement and vermiculite.

At the onset of this fabrication, the Kaolite 1600™ must undergo qualification testing before it is cast into a confinement assembly. During qualification, the MD-2 fabrication vendor could not achieve a successful final density (22.4 ± 3 lbs/ft$^3$). It was later determined that the supplier of this product modified the mixture slightly for economic reasons, and that was enough to disqualify the material for the MD-2. After many attempts, the supplier could not duplicate the original Kaolite 1600™ mixture that was in-spec for this shipping container. The only solution was for the MD-2 design agency to develop a similar material for this application. A material was developed (and named Packcrete) that uses similar raw ingredients as Kaolite 1600™.

Packcrete is a custom material made by mixing precise proportions of water, Portland cement, vermiculite, and other ingredients for a predetermined amount of time. The mixture is then poured into the confinement assembly body and allowed to cure. It is finally baked until the water has been eliminated and it achieves the desired density. While it is being poured, the MD-2 body is on a vibration table to allow the mixture to flow and entrained air bubbles to move toward the surface. Figure 14 shows this mixing and pouring operation.


**Figure 14. Mixing and pouring Packcrete.**

The MD-2 drum assembly is filled with insulation from the bottom. An inverted view of the drum body with inner liner installed, ready for insulation, is shown in Figure 15. Once the

Packcrete insulation is poured, the MD-2 will appear as in Figure 16. After curing and baking, a bottom lid is welded to the drum body, thus completing the confinement boundary assembly.

**Figure 15. MD-2 drum ready for insulation.**

**Figure 16. MD-2 after Packcrete pouring.**

## INSPECTION AND QUALIFICATION

The fabrication of MD-2 follows the requirements of ASME Nuclear Quality Assurance-1 (NQA-1) [2], where applicable. This Standard reflects industry experience and current understanding of the quality assurance requirements necessary to achieve safe, reliable, and efficient utilization of nuclear energy, and management and processing of radioactive materials. The Standard focuses on the achievement of results, emphasizes the role of the individual and line management in the achievement of quality, and fosters the application of these requirements in a manner consistent with the relative importance of the item or activity. Materials purchased for Category A and B components of the MD-2 container are also inspected per Commercial Grade Dedication requirements [Ref 1, Subpart H]. This includes all materials that are in the CV and that form the majority of the confinement (drum) assembly.

The MD-2 Container undergoes 100% dimensional inspections of the confinement and containment assemblies. The containment boundary also undergoes leak testing and hydrostatic pressure testing. The CV lifting lugs undergo a load test with five times the maximum projected weight of a loaded CV. All welds are inspected by an ASME-certified Authorized Nuclear Inspector.

## ACKNOWLEDGEMENTS

The authors wish to express their appreciation to the members of the Y-12 Packaging and Transportation Engineering Group, for their efforts in developing Packcrete insulation for use in the MD-2 shipping container. This material application enhances performance under normal and accident conditions.

## DISCLAIMER



## REFERENCES

1. U.S. Nuclear Regulatory Commission, Title 10, *Code of Federal Regulations*, Part 71, "Packaging and Transportation of Radioactive Material," Washington, D.C., 2004.

2. American Society of Mechanical Engineers, *Nuclear Quality Assurance – 1*, NQA-1, New York, NY, 2008.