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The Challenges Associated with End-of-Life Transportation of Large Shielded Devices used in Medicine, Research and Industry

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Abstract

The Off-Site Source Recovery Program (OSRP), sponsored by the National Nuclear Security Administration's (NNSA) Office of Radiological Security (ORS), is a U.S. Government activity managed at Los Alamos National Laboratory and Idaho National Laboratory. OSRP's mission is to remove excess, unwanted, abandoned, or orphan radioactive sealed sources that pose a potential risk to public health, safety, and national security. To date, OSRP has recovered more than 250 large self-shielded devices, some of which were as old as 60 years.

There are a variety of transportation challenges associated with the age of the devices. The average age of the devices recovered is 32 years while the oldest is more than 60 years old. In many cases, the original means of transportation is no longer viable due to changes in the regulations for the transportation of radioactive material. In a few cases, the devices were originally transported before the introduction of the first edition of International Atomic Energy Agency (IAEA) Safety Series No. 6. In many cases, the devices are no longer supported by the original manufacturer and the original transport packages are no longer available. Additionally, questions about structural integrity due to age and or questionable storage locations in addition to missing documentation about device construction, shielding details, authorized source contents required for transport can pose a transportation problem for older devices.

In order to overcome some of the challenges discussed, two new packages have been designed to transport self-shielded devices. The LANL 435-B is an unshielded package that can transport a variety of different self-shielded devices. The LANL 380-B is a shielded package that is intended to transport devices that might be damaged or whose integrity cannot be confirmed. The features of these packages and how they help overcome some of the challenges will be discussed.

Introduction

The Off-Site Source Recovery Program (OSRP) is a U.S. Government activity sponsored by the National Nuclear Security Administration's (NNSA) Office of Radiological Security (ORS) and is managed at Los Alamos National Laboratory and Idaho National Laboratory.

OSRP has an NNSA sponsored mission to remove excess, unwanted, abandoned, or orphan radioactive sealed sources that pose a potential risk to national security, health, and safety.

The initial scope of the program included any sealed sources comprising Greater than Class C (GTCC) low-level radioactive waste [1]. However, since September 11, 2001, the mission expanded from environmental concerns to address broader public safety and national security requirements. As a result, OSRP moved from the Department of Energy's (DOE) Office of Environmental Management, to NNSA in 2003.

In addition to transuranic sources, the expanded OSRP mission now includes recovery of beta/gamma emitting sources, which are of concern to the International Atomic Energy Agency (IAEA), and the governments of many countries.

In total, OSRP has been able to recover more than 34,600 sources from more than 1200 sites in the USA and several other countries. These recoveries have resulted in more than 41 PBq (1.1 MCi) of radioactive material being removed and secured.

Included in these recoveries, were more than 250 large shielded devices used in Medicine, Research and Industry. These devices mostly contained IAEA Category 1 and 2 sources [2]. Most of the recovered devices were from the USA. All of the devices were no longer in use and many were beyond their useful lives.

The age of the recovered devices ranged from 5 to 60 years. Over this time period, the IAEA Regulations for the Safe Transport of Radioactive Material have undergone major revisions approximately every five years. As the IAEA Regulations have evolved, their adoption by member states has resulted in a decrease in the availability of certified transport packages. Therefore, transport packages that are certified to meet the current regulations are increasingly rare and expensive. The expense of renting a Type B transport package is a great burden on a licensee who, typically budgeting for initial procurement and licensing costs, does not anticipate recycle/disposal costs of sealed sources requiring Type B shipment. Therefore, to help alleviate these costs, NNSA/OSRP have been developing two Type B transport package designs to be certified by the USNRC for use domestically and internationally. One such NNSA/OSRP transport package has already received its Certificate of Compliance (COC) from the USNRC and the second is in the licensing phase and is anticipated to receive its COC in 2017.

Recovered Devices

The devices consist mostly of self-shielded devices such as calibrators, teletherapy devices and selfcontained irradiators for medical, research or industrial applications with a small percentage of the recoveries being sources used in pool irradiators. The isotopes contained in the sealed sources recovered from these devices primarily consist of Co-60, Cs-137 or Sr-90. The total activity of the recovered sources was approximately 28 PBq (761 kCi). All of the recovered devices were fabricated between 1956 and 2011, with the average age being 32 years. Figure 1 shows the age distribution of the recovered devices. The devices were fabricated by 15 different manufacturers from 5 countries.

Challenge of Transporting Legacy Devices

Lack of Manufacturer's Support

Some devices have been in use for several decades. Over the course of their lifetimes, the devices may have been reloaded one or more times with a fresh source, either by the original device manufacturer or by a third-party source supplier. This is a common practice for teletherapy devices with Co-60 sources. Long half-life isotopes (for example Cs-137 with a half-life of 30 years) may be in use for several decades without replacing the sources.

Because the devices may be in service for several decades, the original device manufacturer provides valuable service such as routine maintenance and repairs. But the manufacturer also may provide very valuable support at the end of a device's life. If the original manufacturer has a currently certified Type B transport package, they can ship the device back to their facility for decommissioning. Sometimes, such as with teletherapy devices, the manufacturer may remove the sealed source from the device for shipment in a specialized transport package that is designed to interface with the device.

Unfortunately, many manufacturers lack the resources to develop Type B transport packages in accordance with today's regulations. In these cases, the devices may be "orphaned" due to a lack of transportation options. In other cases, the original manufacturer is no longer in operation and there may be no commercial means of transporting the retired device.

In some cases, even when a device manufacturer does not have a certified transport package, they may provide important support for transportation by providing missing sealed source certificates or other information related to the device.

Location of Devices

The location of a device sometimes presents a challenge. For example, some devices are located in countries or areas with little infrastructure. In some such countries, the local government has worked with the IAEA to consolidate retired devices in a secure facility. But once the devices have been secured, there is still a need to move the sealed sources to a permanent storage or disposal facility. To assist in this situation, the IAEA developed the Spent High-Activity Radioactive Sources (SHARS) mobile hot cell. The SHARS hot cell allows for the sources to be removed from devices, conditioned for transport, and loaded in to storage containers or transport packages if these are available.

At the other extreme, some devices are located in densely populated urban areas. Preparing a device for transport in such areas is sometimes challenging because space restrictions make it difficult to bring in heavy equipment such as a crane. Security of the device during the loading operation is sometimes a concern also. For these reasons, the loading of the device into a transport package is sometimes scheduled to happen late at night.

Lack of Transport Packages

Some device manufacturers have modern Type B packages designed and approved for transporting their devices in accordance with the current regulations for the transport of radioactive material. However, the original device manufacturers may only be able to ship approximately 1 in 3 of the recovered devices. The other 2/3 of the devices required another means of transport.

In some instances, the sources were removed from the device using a portable hot cell or other remote unloading process. The sources were then transported in approved "casks".

Many of the sources were shipped in packages approved for "generic contents", such as large waste packages. These waste packages are very large and often require dedicated trailers and may require special permitting because they exceed the normal limits for size and weight for road transportation. The use of these transport packages is very expensive and requires an unusual amount of logistical and technical support.

Evolving Regulations

Since the publishing of the first IAEA Regulations for the Safe Transportation of Radioactive Materials in 1961, the IAEA has continuously made changes to the Regulations. The important editions of the IAEA Regulations and the important changes are listed in Table 1.

The periodic changes to the regulations present a challenge because the revised regulations contain a provision that limits the extent to which older packages may be grandfathered. Eventually, older transport packages become obsolete and the options for transporting legacy devices become more restricted.

Figure 2 shows when the recovered devices were manufactured versus the changes in the IAEA Regulations. Of the 250 large beta-gamma devices recovered, 10 were fabricated and installed prior to the IAEA introducing test performance standards for transport packages under accident conditions. More than 50% of the devices were originally shipped prior to the adoption of the Quality Assurance requirements for transport packages. This has forced the device manufacturers to invest in the development of new transport packages. Unfortunately, as previously mentioned, this is an expensive undertaking and few manufacturers have successfully seen new package designs approved.

New Packaging Solutions

LANL Model 435-B

Having already recognized the problem, GTRI began work on the development of two type B transport packages in 2009. The first, the Model 435-B (Figure 3), was designed to address the need to accommodate both domestic USA and international recoveries. The 435-B was designed to transport device shields and the IAEA's Long Term Storage Shield (LTSS). The LTSS is designed to work with the IAEA's mobile hot cell. Using this mobile hot cell, sources can be removed from devices and placed in the LTSS in the field. Alternately, the sources being recovered may be left in their original shielded devices for transportation. In order to transport both the LTSS and the intact device shields an unshielded overpack-style transport package was developed.

Being an unshielded, leak tight package, the 435-B must take credit for the shielding of the inner packaging and ensure that, during normal transport conditions and in hypothetical accident scenarios, the source would not be exposed. The authorized contents for the initial certification of the 435-B includes the LTSS and several of the most popular devices registered with OSRP for recovery.

Testing of the 435-B took place in October 2012, this involved physical testing of a full scale prototype of the 435-B. By March of 2013, the Safety Analysis Report (SAR) was submitted to the US Nuclear Regulatory Commission (USNRC). The USNRC awarded the Certificate of Compliance (COC) number 9355 for the 435-B in July of 2014. In February of the following year, the United States Department of Transportation awarded the Certificate of Competent Authority (COCA) USA/9355/B(U)-96. Under these certificates, the 435-B is certified to transport the LTSS and several device shields with various activity limits based on the isotope and/or shield being used. Fabrication of the first two 435-B packages began in November 2016.

When in use, the 435-B will be a versatile transport package. The 435-B is certified to be transported by truck, rail, ship or air. It has a maximum weight of 4,580 kg (10,100 lbs) and an overall size of 211 cm (83 inches) tall by 178 cm (70 inches) in diameter so it will not be subject to overweight/oversize regulations. This will allow access to urban areas that may not be accessible with larger transport packages. The internal cavity dimensions are 152 cm (60 inches) high by 110.5 cm (43.5 inches) in diameter, allowing room to accommodate a variety of future payloads. The maximum device weight is 1,588 kg (3,500 lbs). Since the 435-B is leak tight, there is no requirement for the sources to be certified to meet the requirements of Special Form. However, all material shipped within the 435-B currently must be encapsulated.

The 435-B payload is currently limited to the LTSS and a small list of self-shielding devices. The approved isotopes are listed in Table 2 and the maximum decay heat is 200 W. NNSA/OSRP is currently working on adding future certified content to make the transport package as versatile as possible. The new content currently in development includes a shielded disposal liner for transporting sources for disposal and more self-shielded irradiators. Other future certifications will include more irradiators and Co60 teletherapy heads.

LANL Model 380-B

The 380-B is a large shielded transport package (Figure 4). This package will ship any device that fits within the physical internal dimensions of the cask, does not exceed the maximum payload weight of 4,537 kg (10,000 lbs), and is within the activity limits for the transport package. The proposed isotopes and their maximum activity are listed in Table 3. The maximum decay heat is 205 W.
Due to its size and weight, the 380-B may be difficult to deploy in certain areas, most notably large urban areas. Due to its weight, the 380-B will require a dedicated trailer (Figure 4) and will require oversize/overweight permits for road transport. Also due to size and weight and leak testing, the 380-B will be a more complex transport package to operate.
The Safety Analysis Report for the 380-B was submitted to the USNRC in April, 2016. Approval of the 380-B is expected in the summer of 2017.

Conclusion

Many aging devices containing radioactive sources are no longer in use. To properly decommission these devices, the sealed source must be safely and compliantly transported, either inside the device or by transferring the source to another shield. In either case, transport in an approved transport package is required. Unfortunately, due to the age of some of the devices, currently approved transport packages may not be available.

Some approved Type B packages exist. However, many of these transport packages were designed to transport either specific devices, materials, or waste that tend to limit them for the transportation of sealed sources. In addition, the high cost for the development of new transport packages has deterred many organizations from developing new packages. The cost of renting existing packages is very high.

In order to increase the availability of Type-B transport packages, NNSA’s ORS has developed two new Type B transport packages. These will be versatile in their ability to transport high-activity radioactive sealed sources.

Acknowledgments

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References

1. “*Waste Classification*”, U.S. Code of Federal Regulations, §61.55Subpart D, Part 61, Chapter 1, Title 10, “Energy”.
2. IAEA Safety Guide No. RS-G-1.9, “Categorization of Radioactive Sources”, Vienna, 2005.

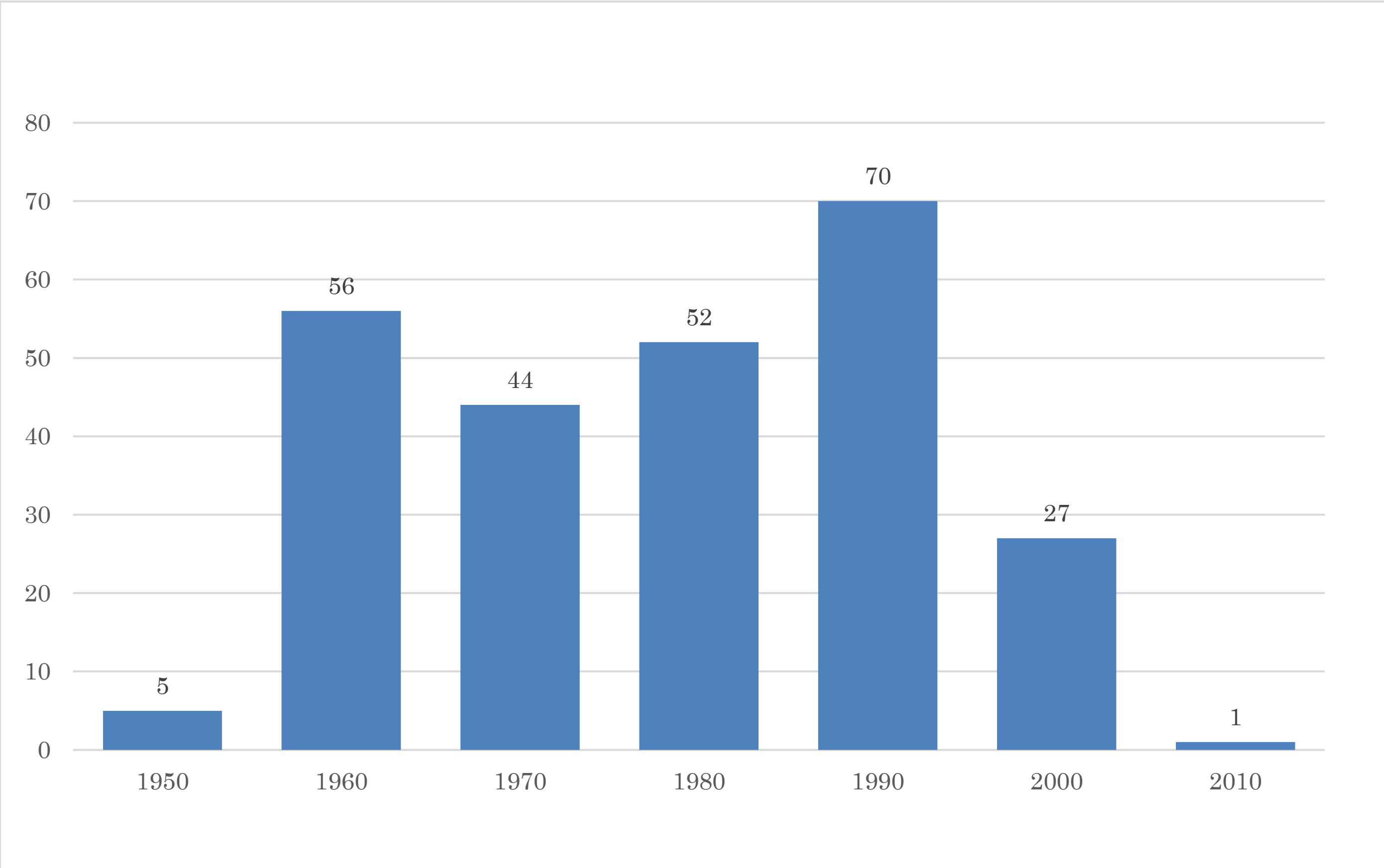

Figure 1: Number of Devices Fabricated by Decade

Year	Change to IAEA Regulations
1961	First editions of the Regulations
1964	Introduction of package performance test requirements (accident conditions: 9m drop, 1 m puncture, 30 minute fire)
1967	Specifications for Type B ambient and test conditions
1973	Compliance Assurance introduced
1985	Quality Assurance introduced, 200 m immersion test for INF, Dynamic crush test for Type B
1996	Type C package introduced

Table 1: Evolution of the IAEA Regulations for the Safe Transport of Radioactive Material

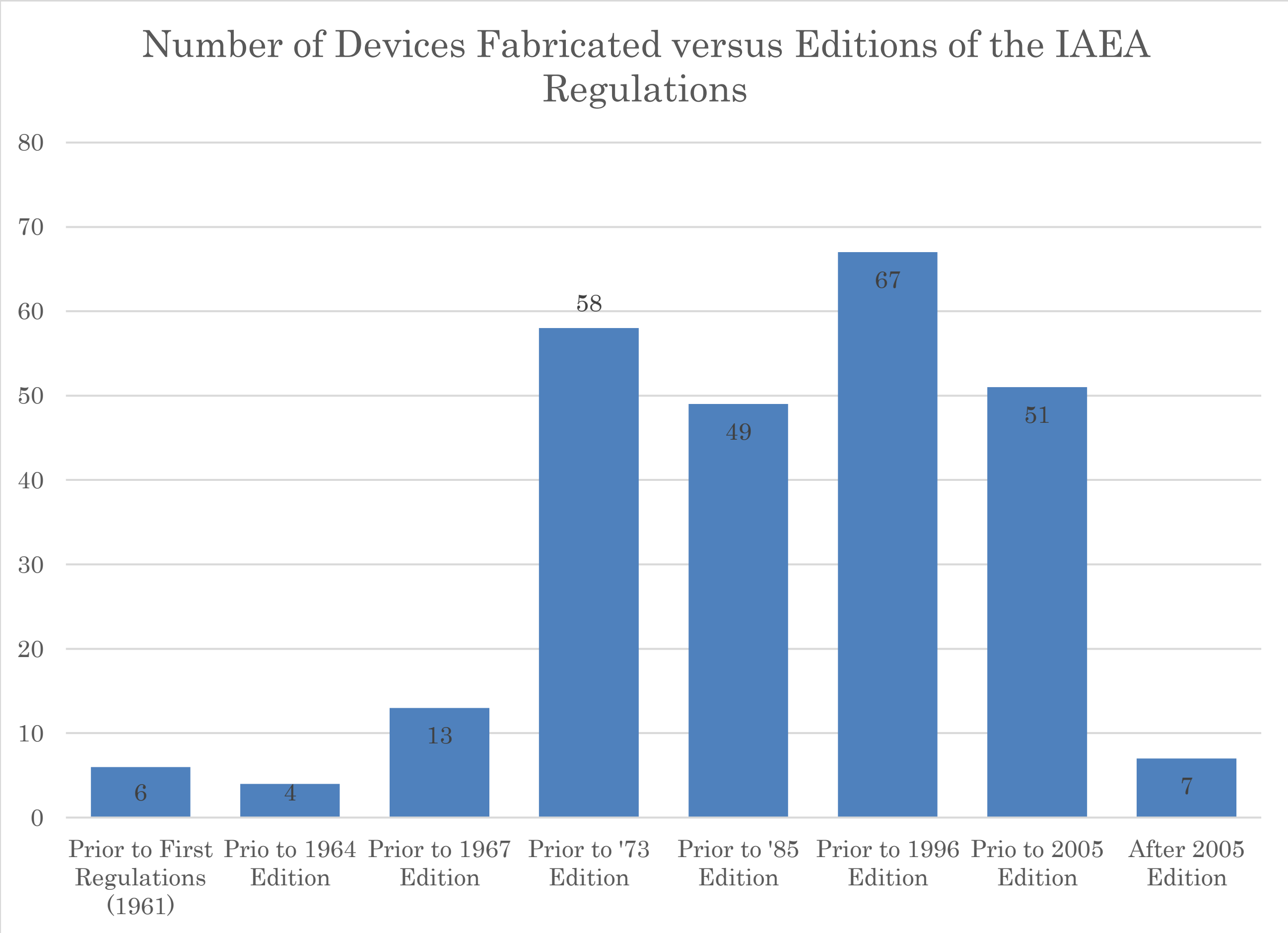

Figure 2: Number of Devices Fabricated versus Editions of the IAEA Regulations

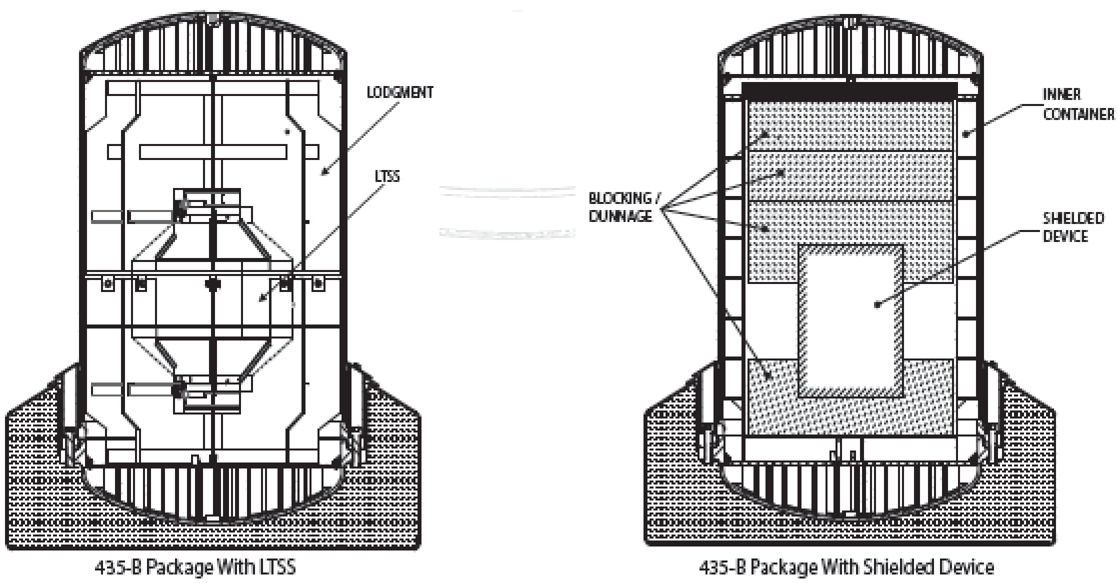

Figure 3: Model 435-B Transport Package

Nuclide	Maximum Activty, TBq (Ci)
Co60	480 TBq (12,970 Ci)
Cs137	518 TBq (14,000 Ci)
Sr90	37 TBq (1,000 Ci)
Ra226	740 GBq (20 Ci)
Ra226Be	48 GBq (1.3 Ci)
Am241	37 TBq (1,000 Ci)
Am241Be	244 GBq (6.6 Ci)
Ir192	7.4 TBq (200 Ci)
Se75	2.96 TBq(80 Ci)
Special Nuclear Material	**Maximum Mass**
Pu238	75 g of Pu
Pu239	15 g of Pu
Pu239Be	15 g of Pu

Table 2: Model 435-B Authorized Isotopes

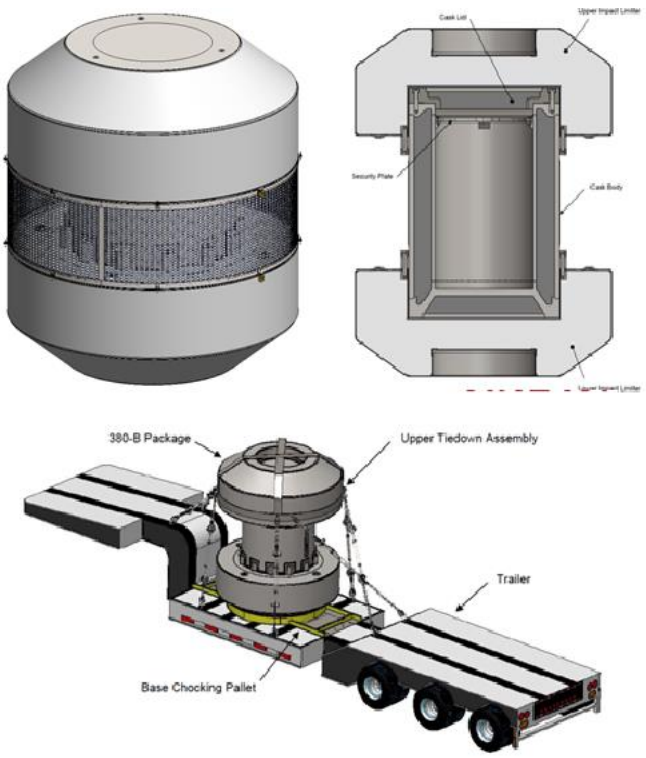

Figure 4: Model 380-B Transport Package

Nuclide	Maximum Activty
Co60	285 TBq (7,702 Ci)
Cs137	1,505 TBq (40,675 Ci)
Sr90	1,132 TBq (30,606 Ci)
Ra226	40.7 TBq (1,101 Ci)
Ra226Be	173 GBq (4.67 Ci)
Ir192	1,233 TBq (33,333) Ci

Table 3: Model 380-B Proposed Isotopes