# TRANSPORTATION PACKAGES TO SUPPORT SAVANNAH RIVER SITE MISSIONS

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## ABSTRACT

The Savannah River Site's missions have expanded from primarily a defense mission to one that includes environmental cleanup and the stabilization, storage, and preparation for final disposition of nuclear materials [1]. The development of packaging and the transportation of radioactive materials are playing an ever-increasing role in the successful completion of the site's missions. The three strategic SRS mission areas are 1) nuclear materials stewardship, 2) environmental stewardship, and 3) nuclear weapons stockpile stewardship. The materials and components that need to be shipped, and associated packaging, will be described for each of the mission areas. The diverse range of materials requiring shipment include spent fuel, irradiated target assemblies, excess plutonium and uranium materials, high level waste canisters, transuranic wastes, mixed and low level wastes, and nuclear weapons stockpile materials and components. Since many of these materials have been in prolonged storage or resulted from disassembly of components, the composition, size and shape of the materials present packaging and certification challenges that need to be met. Over 30 different packaging designs are required to support the site's missions. Approximately 15 inbound shipping-legs transport materials into the Savannah River Site and the same number (15) of outgoing shipment-legs are carrying materials from the site for further processing or permanent disposal.

## INTRODUCTION

The Savannah River Site (SRS) is one of several government-owned, contractor-operated sites in the U.S. Department of Energy's (DOE) nuclear defense complex. During the Cold War era, SRS was primarily a nuclear materials production site supporting a strong nuclear deterrent. While the need remains for a strong nuclear deterrent, the site's missions have expanded to include the stabilization, storage, and preparation for final disposal of nuclear materials, environmental cleanup, and natural resource management. In the past, SRS has produced nuclear materials, processed them, and shipped them to other sites for further use. This production process resulted in similar materials being shipped to the same locations year after year. The number of radioactive material package designs needed to support past missions was less than the number that is needed today. Today's missions involve a new generation of materials that includes many of the original materials that have been modified in form and composition. Many of these materials and components are being returned to the site for stabilization, storage, and preparation for final disposal. The size, shape, form, and composition of these materials and components are often different than the original materials shipped from SRS. Consequently, considerable effort is required to prepare these materials for shipment, to identify (or develop) appropriate packaging, and to obtain approvals in accordance with the Department of Transportation (DOT) and Nuclear Regulatory Commission (NRC)

regulations [2,3]. Furthermore, many of the nuclear materials identified for return to SRS will be stored for extended periods of time in the transportation packaging prior to processing. This requires the package to be evaluated under storage as well as the transportation conditions.

In this paper the shipments to and from SRS are grouped into the nuclear materials, environmental, and nuclear weapons stockpile stewardship areas. In each stewardship area the inbound shipments, outbound shipments, and package development considerations are discussed. Nuclear materials stewardship involves the management of excess nuclear materials, including transportation, stabilization, storage, and disposition to support nuclear nonproliferation. The materials in this program include components from dismantled weapons, residues from weapons processing activities, spent nuclear fuel, and other legacy materials. Environmental stewardship involves management, treatment, and disposal of radioactive, hazardous, and non-radioactive wastes resulting from past, present, and future operations. Nuclear weapons stockpile stewardship emphasizes the maintenance of the nuclear weapons stockpile. SRS supports the stockpile by ensuring the safe and reliable recycle, delivery, and management of tritium resources, and by assisting in the development of alternatives for large-scale plutonium pit production capability, if required. Figure 1 illustrates the three mission areas and defines the inbound and outbound shipment-legs.

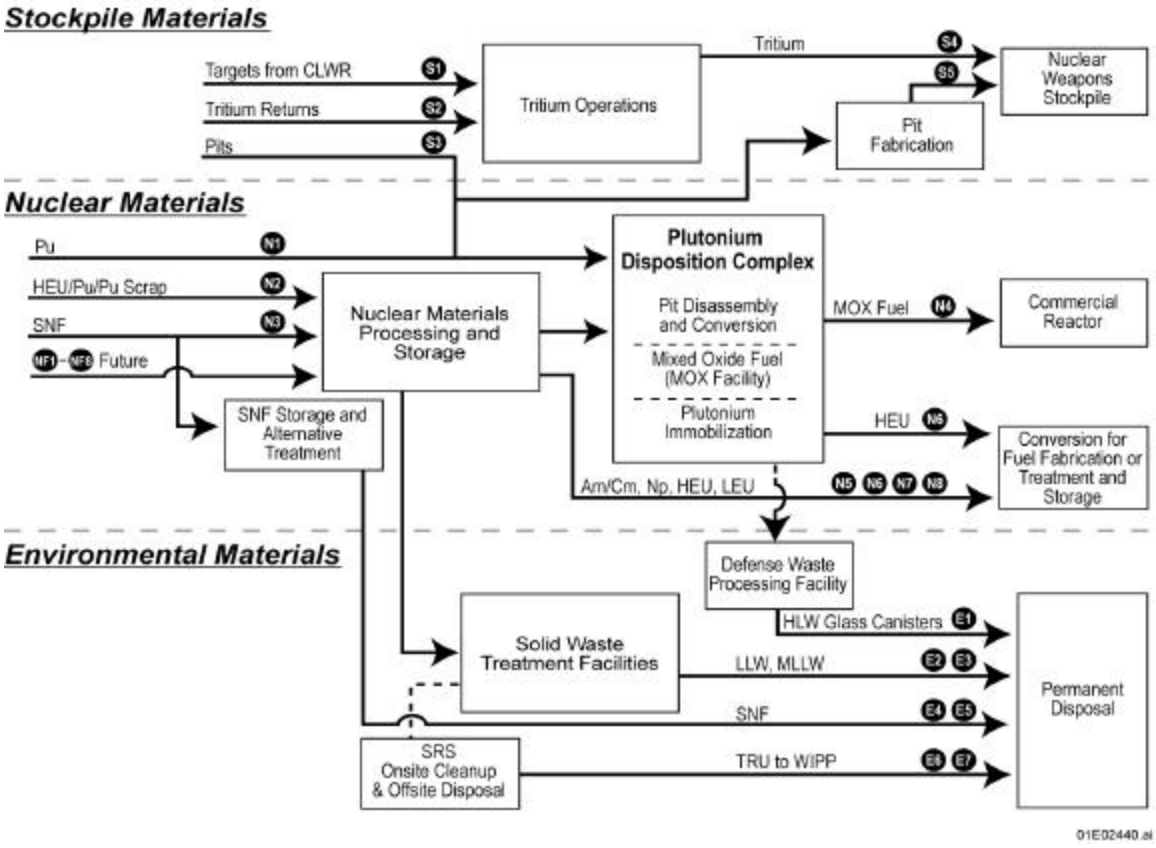


Figure 1. SRS Missions and Inbound and Outbound Shipments.

## NUCLEAR MATERIALS PACKAGING

The nuclear materials stewardship activities include the inbound shipment of approximately eleven groups of materials. These materials included plutonium (Pu), plutonium scrap, highly-enriched uranium (HEU), enriched uranium (EU), natural uranium solutions, EU components contaminated with plutonium, and spent nuclear fuel (SNF). Three different types of package designs are used to carry the inbound materials. The plutonium and uranium solid materials, and components, are packaged in cylindrical (drum-like) Type B packages with internal containment vessels. One such package, developed by SRS, is the model 9975 shown in Figure 2. The 9975 is a double containment package certified by the DOE for plutonium compounds and metals. The second type of package is a cargo tank motor vehicle for transport of natural uranium solutions. This is a DOT bulk packaging that meets DOT specification MC311 and is available from commercial vendors. The third type of package is used for shipment of research reactor fuel from foreign and domestic locations to the SRS. The casks of foreign origin are certified to International Atomic Energy Agency (IAEA) standards [4] while domestic casks are certified by the NRC to the Code of Federal Regulations, Title 10, Part 71 (10 CFR 71)[3]. The model GE-2000 SNF cask is illustrated in Figure 3.

There are package certification challenges in shipping many of the scrap, residue, and contaminated materials. Difficulty in fully characterizing legacy materials results in the need for the package designer to evaluate conservative bounding content descriptions. Uncertainty in content constituents (e.g. isotopes, impurities) often results in reduced payloads, which drives up transportation costs. Gas generated from the ionizing radiation and chemical reactions is an issue in any sealed shipping container, but is exacerbated for many of the non-pure materials (residues and scrap) shipped in small volume containment vessels. The licensing process for the model 9975 considered the affects of gas generation in detail. For much of the material shipped to SRS the gas generation effects are minimized by treating the material (before transportation) in accordance with the DOE Standard DOE-STD-3013 [5] for long term storage. This process includes a high temperature bake-out (calcining) followed by encapsulation of the material in welded stainless steel vessels with inert cover gas. The materials processed and packaged in accordance with the DOE-STD-3013 are then shipped in the transportation package.

Outbound SRS shipments of nuclear materials include fuel and fuel raw materials for use in commercial nuclear reactors, and special isotopes of scientific value that will undergo further treatment. The packaging required for the outbound materials are also diverse in design. Mixed oxide (MOX) fuel will be shipped from SRS to commercial reactors in either commercially available Type (B)F unirradiated fuel packages certified by the NRC, or in a new package developed and certified by the DOE. High enriched uranium (HEU) solids and low enriched uranium (LEU) solutions will also be shipped in Type B packagings. The HEU solids will be shipped in cylindrical inner containment packages similar to the model 9975 shown in Figure 2. Shipment of the LEU solution is planned in a new 870-liter liquid packaging that is currently under development and will be certified by the NRC. Shipment of Americium and Curium (Am/Cm) will require a packaging

with gamma and neutron shielding, and heat removal capability. It is currently anticipated that a spent fuel cask will be used for Am/Cm shipments.

Development work to support the outbound package fleet includes completion and certification of the new Type B package for LEU solutions and development and certification of a new single containment package for HEU solid materials. The new HEU solids packaging will eventually replace the DOT 6M specification package. Shipment of special isotopes (Am/Cm and Neptunium) will require the amendment of these contents to currently certified package designs. A list of representative packages is given in Table 1. Table 2 is a comprehensive listing of all inbound and outbound materials (for all mission areas), and the associated package categories (e.g. Type A, Type B) needed to ship those materials.

| PACKAGE TYPE | EXISTING DESIGNS<br>Legend: Package name/Payload/Approval (Certificate) | PLANNED OR IN DEVELOPMENT |
|---|---|---|
| *TYPE B AND TYPE AF* | | |
| 1. Irradiated Fuel Cask | A. GE-2000/42 MTR/(USA/9228/B(U)F-85)<br>B. NAC-LWT/42 MTR/(USA/9225/(U)F-85) | 1.Rail Cask/HLW and SNF |
| 2. Unirradiated Fuel Boxes | A. WE-1/fuel assembly/(USA/9289/B(U)F-85) | |
| 3. Cylindrical Packaging with Inner Containment Vessels | A. 9975/4.4kg Pu/(USA/9975/B(U)F-85(DOE))<br>B. DT-22/U and Pu parts/(USA/95007/B(U)F-85(DOE-AL))<br>C. 5X22/HEU/(USA/9250/B(U)F-85)<br>D. FL/Pits/(USA/90023/B( )(DOE-AL)) | 1. Safekeg/Pu<br>2. DPP/Pits<br>3. ES-2100/HEU<br>4. DOT 6M Replacement/general |
| 4. Packages for Liquid or Gas | A. H1616/Tritium/(USA/91001/(B)-85(DOE-AL))<br>B. UC-609/Tritium/(USA/9932/(B)(DOE))<br>C. FL-10/10L Uranyl Solutions/(USA/9009/B( )F) | 1. Eco-Pak/EU solutions (870 l) |
| 5. Other Packaging | A. TRUPACT-II/TRU/(USA/9218/B(U)F-85)<br>B. Uranium Oxide Transport Unit/ U Oxide, 640kg/(USA/9288/AF-85) | 1. TRUPACT III/ large components<br>2. CLWR Target Cask/Targets |
| *TYPE A/INDUSTRIAL/STRONG-TIGHT/BULK* | | |
| 6. Steel Drums | A. 55 Gallon Drum, open head/400kg/ DOT 7A Type A<br>B. UN Drums/1A2,1A1,1H2,1H1 | |
| 7. Steel Boxes | A. 2.55m3 (90 ft3) & 1.27m3 (45 ft3)/DOT 7A Type A<br>B. 2.55m3 & 1.27m3/IP or Strong-Tight (ST)<br>C. 2.55m3 & 1.27m3/ST and IP-I meeting NTS rqmts. | |
| 8. Soft Sided Packaging | A. Lift Liner/7.3m3, 10,800kg/IP | |
| 9. Packaging for Liquid or Gas | A. Ground Water Sampling Truck/3400 l/IP<br>B. Modified Commercial Tritium Package/ 0.5L, tritium/DOT 7A Type A<br>C. DOT MC311 Cargo Tank Motor Vehicle/ Uranium solutions | |

Table 1. Summary of Representative Packages to Support SRS Missions

| SHIP-MENT LEG ** | DESCRIPTION | OTHER (1) | INDUST-RIAL | TYPE A | TYPE B |
|---|---|---|---|---|---|
| *Nuclear Materials* | | *Nuclear Materials Packaging** | | | |
| N1/I | Pu to SRS | | | | 3.A, 3.1 |
| N2/I | HEU/Pu/Pu scrap to SRS | | | | 3.A, 3.1 |
| N3/I | Offsite irradiated fuel to SRS | | | | 1.A, 1.B |
| N4/O | MOX fuel to commercial reactor | | | | 2.A |
| N5/O | LEU solution to commercial facility | | | | 4.1 |
| N6/O | HEU solid to DOE/commercial facility | | | | 3.C, 3.3 |
| N7/O | Am/Cm solid to DOE site for treatment | | | | 1.A |
| N8/O | Np solid to DOE site for treatment | | | | 3.A, 3.1, 3.3 |
| NF1/I | Off-specification HEU to SRS | | | | 3.3 |
| NF2/I | Natural uranium solution to SRS | 9.C | | | |
| NF3/I | EU contaminated with Pu to SRS | | | | 3.A, 3.1 |
| NF4/I | RFETS components to SRS | | | | 3.B, |
| NF5/I | EU components contaminated with Pu to SRS | | | | 3.B, 3.A, 3.1 |
| NF6/I | U-233 to SRS | | | | 3.3, 3.C |
| NF7/I | Low grade Pu oxide to SRS | | | | 3.A, 3.1 |
| NF8/I | Oak Ridge HEU to SRS | | | | 3.3, 3.C |
| *Environmental Materials* | | *Environmental Packaging** | | | |
| E1/O | HLW glass canisters to permanent disposal | | | | 1.1 |
| E2/O | LLW to treatment, permanent disposal | 7.B | 7.B | 7.A | |
| E3/O | MLLW to permanent disposal | 7.C | 7.C | 7.A | |
| E4/O | Treated AL clad SNF to permanent disposal | | | | 1.1 |
| E5/O | Non AL clad SNF to DOE site for treatment, permanent disposal | | | | 1.A |
| E6/O | TRU to permanent disposal | | | | 5.A |
| E7/O | Hazardous waste to treatment, permanent disposal | 7.B | | | |
| *Stockpile Materials* | | *Stockpile Packaging** | | | |
| S1/I | CLWR targets to SRS | | | | 5.2 |
| S2/I | Tritium returns to SRS | | | | 4.A |
| S3/I | Pits to SRS | | | | 3.D, 3.2 |
| S4/O | Tritium and components to stockpile | | | | 4.A |
| S5/O | Pit material to stockpile | | | | 3.2 |

**Inbound (I), Outbound (O), Future (F). *Refer to Table 1 for Packaging Description

Table 2. Inbound and Outbound Material Shipments and Packaging Categories.

**ENVIRONMENTAL PACKAGING**

All shipments supporting the environmental stewardship activities of SRS are outbound with the ultimate destination of permanent disposal. There are seven categories of outbound shipments identified in Table 2, including low level waste (LLW), mixed low level waste (MLLW), spent nuclear fuel, treated spent nuclear fuel in canisters, contact

handled transuranic waste (TRU), and vitrified high level waste (HLW) glass. A wide range of package designs is needed to ship the waste materials and SNF from SRS. The LLW and MLLW is generally categorized as low specific activity (LSA) radioactive material that is transported in 1.27 or 2.55 cubic meter carbon steel boxes that meet the DOT requirements for strong-tight or industrial packaging (IP). Waste package designs are typically subject to disposal criteria as well as transportation criteria. For example, the LLW boxes that are shipped to the Nevada Test Site (NTS) for permanent disposal are required to meet an NTS stacking criterion (required for burial) that is more stringent than the stacking criterion required by the DOT.

The vitrified HLW glass currently being produced in the Defense Waste Processing Facility (DWPF) at SRS is planned for permanent disposal at Yucca Mountain, Nevada. The transportation system planned for HLW, as well as SNF and treated SNF, will be a shielded rail cask capable of holding up to five 46 cm diameter by 305 cm long HLW or SNF canisters [6]. The fully loaded rail cask will weigh up to 136 MT. The SRS contact handled TRU waste is primarily job-control waste, including combinations of plastic, paper, rubber, glassware, filters, and used equipment from routine processing. The TRU waste will be sorted, segregated, and repackaged and then shipped to the Waste Isolation Pilot Plant (WIPP) in Carlsbad, New Mexico for permanent disposal. The transportation package for TRU (model TRUPACT-II) is a NRC certified Type B package with a payload capacity of 3,300 kg (14-55 gallon drums). One legal weight truck has the capacity to carry three fully loaded TRUPACT-II packages. Figure 5 shows the first shipment of TRUPACT-II packages leaving the SRS.

Development activities to support environmental packages will include the design and certification of the new HLW/SNF rail cask system, as well as continuing efforts to maximize the TRUPACT-II payload. The size and configuration of the rail cask system will be similar to designs that are already certified by the NRC. Efforts to maximize the TRUPACT-II payload are currently focusing on methods to minimize the buildup of hydrogen gas generated by radiolytic decomposition of organic materials and chemical reactions within the payload.

**STOCKPILE PACKAGING**

The site's Nuclear Weapons Stockpile Stewardship mission includes maintaining technical expertise in tritium operations, production, and engineering to support the nations weapons stockpile. This also includes support of the long-range plutonium pit fabrication contingency. Inbound shipments of stockpile materials includes tritium, pits, and future tritium producing burnable absorber rods (TPBARS) that have been irradiated in a commercial reactor. The outbound shipments would include tritium and pits. Tritium is shipped in Type B packages either as a gas or a chemically bound solid. The model UC-609 certified by DOE and the model H1616, approved by DOE-Albuquerque, are two packages used for shipment of tritium. Pits have been shipped in the Type B model FL container approved by DOE-AL. The DOE is planning on replacing the model FL with two new Type B containers to support future shipments. Future shipment of TPBARS from commercial reactors to SRS will require a shielded cask similar in size and configuration to a spent fuel cask.

## SUMMARY

The successful completion of SRS missions requires shipment of nuclear materials, spent fuel, components, and waste. Nuclear materials from years of weapons production and research reactor spent nuclear fuel from the early years of the nuclear industry are now being brought back to the SRS for stabilization, storage, and preparation for final disposition. Waste materials including high level, TRU, mixed, and low level waste are beginning to be shipped out of the SRS for permanent disposal. Approved package designs meeting the DOT and NRC performance standards are generally available for most of the materials needing immediate shipment. Package development efforts are underway to enable shipment of future materials including HLW canisters, LEU solutions, uranium materials, weapon components, and irradiated target assemblies for future tritium production.

## REFERENCES

[1] Savannah River Site Long Range Comprehensive Plan, December 2000.

[2] U. S. Department of Transportation, Hazardous Material Regulations, Title 49 Code, of Federal Regulations (CFR), Subchapter C-Hazardous Material Regulations, Parts 107-180, Washington, D. C.

[3] U. S. Nuclear Regulatory Commission, Packaging and Transportation of Radioactive Material, Code of Federal Regulations, Title 10, Part 71, (10 CFR 71), Washington, D. C.

[4] Regulations for the Safe Transport of Radioactive Material (1996 Edition), IAEA Safety Series No. ST-1, International Atomic Energy Agency, Vienna, Austria.

[5] DOE-STD-3013-2000, "Stabilization, Packaging, and Storage of Plutonium-Bearing Materials", September 2000.

[6] Environmental Management Spent Nuclear Fuel Transportation System Design and Licensing Specifications, DOE/SNF/DSN-018, Rev. 0, May 2001.

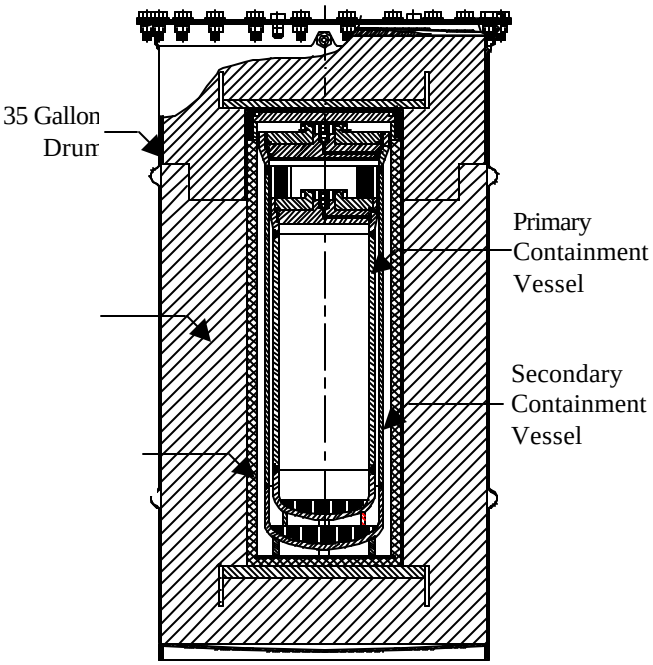


Figure 2. Model 9975 Type B Package for Plutonium Oxide and Metals.

Figure 4. Industrial Packages for LLW and MLLW.

Figure 3. Model GE-2000 for Spent Fuel Shipment.


Figure 5. Model TRUPACT-II for Shipment of TRU.