A DRY STORAGE CASK FOR UTILIZATION OF

WESF CESIUM-137 SOURCES

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ABSTRACT

A dry storage cask for 12 Waste Encapsulation and Storage Facility (WESF) cesium-137 capsules has been designed, fabricated, and tested in Rockwell International's Gamma Irradiation Facility (GIF). The cask, made of lead-filled steel, consists of a 27-cm x 27-cm x 59-cm chamber and a remotely operated rolling lid. The capsules are stored in a removable basket within the chamber, with individual lifting straps to remove them for experiments. Heat generated by the sources (~3.2 kW) is removed by natural air convection through multiangled steel tubes embedded in the lead base and lid. Temperature and radiation levels measured on the outside surfaces of the cask are in reasonable agreement with those predicted by the conservative design calculations. The cask is not intended for transportation, but provides a safe method of storage that is very convenient for routine use of the sources.

BACKGROUND AND INTRODUCTION

The Rockwell International Gamma Irradiation Facility (GIF) is a panoramic dry storage irradiator located in Canoga Park, California. The facility includes a walk-in gamma cell and an operating gallery, two three-degrees-of-freedom manipulators to handle remotely the sources and components, a lead glass viewing window, and other ancillary equipment (Fig. 1). The GIF has shielding capability exceeding that required for the current inventory of cobalt-60 (~30 kCi) and the newly added cesium-137 (~650 kCi) isotopes.

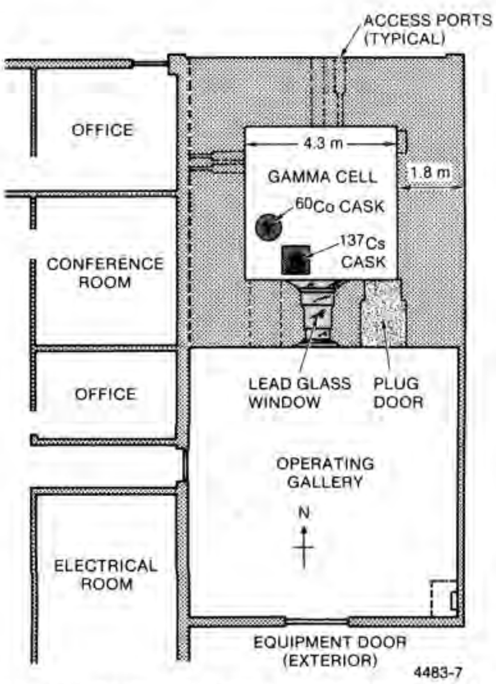

Fig. 1. Rockwell Gamma Irradiation Facility.

The GIF has been in routine operation as a research, development, demonstration, and test facility since 1966. The purpose of the new dry storage cask is to store safely the ~650 kCi of the cesium-137 contained in 12 Waste Encapsulation and Storage Facility (WESF) capsules recently furnished by the U.S. Department of Energy (DOE). The previous inventory of cobalt-60, in the form of 48 standard pins, is stored in a separate dry storage cask. This paper describes the design features of the new cask, its incorporation into the GIF, and the analyses and verification of the thermal and radiation parameters applicable to the cask.

DESCRIPTION

WESF Capsules

The cesium-137 capsules are manufactured, filled with cesium chloride, encapsulated, and stored at WESF at Rockwell Hanford, Richland, Washington, under a documented quality control program (Refs. 1 and 2). Each WESF capsule consists of solid, melt-cast CsCl surrounded by two welded Type 316L stainless steel capsules, each with a wall thickness of 0.35 cm (0.136 in.). A typical capsule assembly is shown in Fig. 2, along with dimensions and other relevant data. Each complete capsule assembly weighs ~7.7 kg (17 lb).

Thermal outputs of the 12 WESF capsules were measured at the Rockwell International Hot Laboratory using a calorimeter supplied by WESF before their installation in the GIF. Results showed that, as of 1 November 1985, the heat generated by the individual capsules ranged from 251 to 285 W and the corresponding radioactivity therefore ranged from 52.7 to 59.7 kCi for a total of 3.2 kW and 665.6 kCi, respectively.

Storage Cask

An isometric view of the dry storage cask for the 12 WESF capsules is shown in Fig. 3. The cask is a rectangular, lead-filled steel container with a sliding lead-filled steel lid. The storage chamber is 29 cm

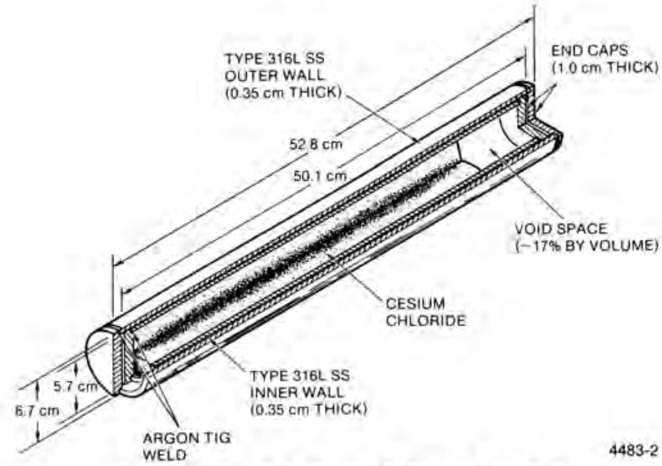

Fig. 2. WESF Cesium Chloride Capsule.

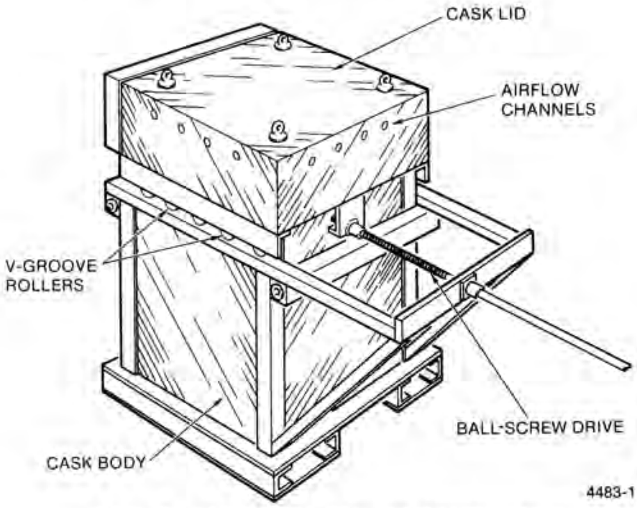

Fig. 3. Isometric View of Storage Cask.

(11.5 in.) square by 59 cm (23.4 in.) deep, and the external dimensions of the main body of the cask are ~64 cm (25 in.) square by ~91 cm (36 in.) high. The height including the lid is ~112 cm (44 in.). The shielding consists of 15 cm (6 in.) of lead on all four sides, 18 cm (7 in.) of lead in the lid, and 20 cm (8 in.) of lead on the bottom of the cask. Cross sections of the cask are shown in Figs. 4 and 5.

The main cask body was fabricated by pouring molten lead into a prefabricated steel encasement. Lead with 7% antimony content was used because of its enhanced creep-resistant properties. The encasement consists of 0.64-cm-thick carbon steel plates welded together and supported with welded angle and channel irons to withstand stresses caused by the lead pouring operation, lifting or moving of the cask, or potential seismic events.

Airflow channels were built into the cask to remove heat generated by the sources. Calculations showed that free convection of air flowing through a minimum of 45 cm^2 (7 in.^{2}) of airflow area in the cask cavity would maintain the temperature of the CsCl in the capsules below 380°C. In the actual cask, the airflow channels were much larger than this. At the bottom of the cask, the airflow channels between the baseplate and the bottom of the source chamber were formed with 16 steel tubes with an internal diameter (ID) of 3.8-cm, providing a total cross-sectional area of ~180 cm^2, four times the minimum of 45 cm^2 stated above. Each tube was constructed of five short

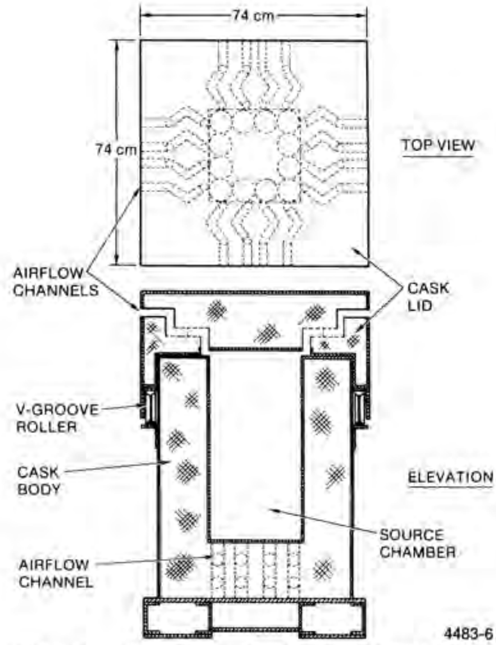

Fig. 4. Top View of Lid and Elevation Cross Section of Storage Cask.

Fig. 5. Top View of Storage Cask Without Lid.

sections welded together at approximately 90° angles to prevent streaming of gamma radiation out of the bottom of the cask. Lead filled the space around the tubes.

Sixteen additional airflow channels, formed with 2.5-cm (~1-in.) ID tubes, were incorporated into the lid, which is also shown in Fig. 4. Molten lead was poured into the steel container and around the tubes to form an 18-cm (7-in.) thick shield. The combined cross-sectional area of the 16 upper airflow channels and the spacing between the lid and the cask main body is ~160 cm^2 (25 in.^{2}), again much larger than required to maintain the CsCl below the arbitrary temperature of 380°C. As was the case for the lower airflow channels, the tubes in the lid also contain several sharp bends to prevent radiation streaming. As shown in Figs. 3 and 4, the lid is supported on V-groove rollers to allow the lid to roll to a location beside the cask. Four eyebolts on the top of the lid were used for lifting the lid onto the top of the cask, and for supporting the lid while the rollers were being attached.

Seismic and operational considerations led to the choice of a rolling rather than a lifting lid for opening and closing the cask. An earthquake, if it were to occur during operational use of the capsules, could potentially cause a lifting-type lid to swing and perhaps break the lifting cable, or compromise the integrity of the source capsules. It is also conceivable that the lifting-type lid, upon impact caused by an earthquake, could be deformed sufficiently so as not to fit into the cask, or worse, might jam into the cask without sufficiently shielding the sources. In the case of a rolling lid, however, even if the lid were damaged by a fall onto the floor, a temporary shell cover (always kept available inside the cell) can be remotely filled with lead shot after being remotely placed on the top of the cask. Finally, the rolling lid also enhances the full use of the GIF manipulators for movement of the sources from their storage positions.

The rolling lid is operated remotely using a motor drive located outside the cell. The rotary motion of the drive motor is transmitted through the cell wall by means of steel rods and gears which, in turn, is translated into linear movement at the lid by means of a ball-screw actuator. A slip clutch in the transmission prevents overextension of the lid in case of failure of limiting switches installed to limit lid travel. The operation of both the cobalt and cesium storage cask lids can be performed manually from the operating gallery in case of power failure.

Fabrication of the steel encasement and the lead pouring operations were performed in accordance with standard Rockwell International Quality Assurance (QA) procedures. Routine QA inspections verified that no measurable voids were present from the lead pouring operations. This was further confirmed by radiation measurements taken after the installation of the 12 capsules which showed no radiation "hot spots."

Figure 6 shows a photograph of the cask installed in the GIF.

Fig. 6. Dry Storage Cask in the Gamma Irradiation Facility with a Dummy WESF Capsule on Top.

Auxiliary Equipment

Figure 7 shows the internal basket for holding the WESF capsules within the cask chamber. Eight capsule-positioning tubes and a central lifting bar act as both guide and support when loading the individual capsules into the cask. The eyebolt attached to the lifting bar permits the complete basket to be partially lifted out of the storage chamber for easier access or for inspection of the capsules.

Each capsule is secured with a stainless steel hose clamp and wire assembly to enable lifting with the GIF manipulators. A commercially available load hook is attached to both manipulators permitting the manipulators to lift loads up to 45 kg (an individual capsule weighs only ~8 kg).

The cask lid is provided with a mechanical safety latch visible from the cell viewing window. The latch is secured each time the lid is closed before cell entry. A locking pin and padlock are also inserted in the drive train, between the cask lid and the slip clutch, to prevent inadvertent opening of the lid.

Minor modifications were made to the existing safety systems for the GIF (interlocks, alarms, etc.), and the operating and emergency procedures for the GIF were revised to accommodate the use of the new cask and its 12 WESF capsules.

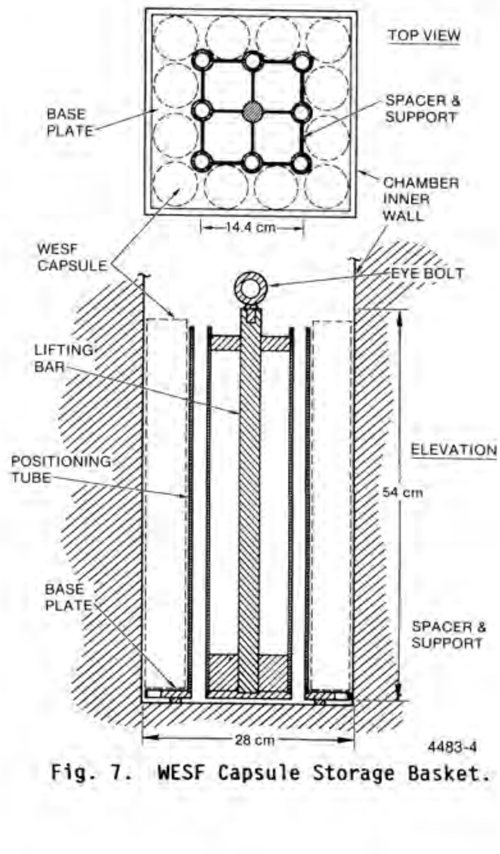

Fig. 7. WESF Capsule Storage Basket.

Verification of Radiation and Thermal Analyses

The effectiveness of the bulk shielding provided by the 15 cm-thick lead and the steel surrounding the lead was determined by treating the individual capsules as line sources. The gamma energy fluxes were determined using the linear absorption coefficients for CsCl, lead and steel (Ref. 3) and using a double exponential approximation to the buildup factors (Ref. 4). This resulted in a calculated maximum dose rate of 25 mR/h on the surface of the cask with all 12 capsules in place. Radiation measurements after installing the capsules showed ~15-mR/h dose rates on the cask surface and verified conservatism employed in the design calculations. The measurements also showed no increased dose rates at the air flow channels and at the lid interface.

A Rockwell-proprietary two-dimensional heat transfer code was used to calculate and verify the adequacy of the natural convection airflow channels provided in the cask and its lid for the removal of the heat generated by the 12 capsules. The calculations were performed under the following conservative assumptions and conditions:

- 3.6-kW heat generation (the 12 capsules generated 3.2 kW)
- 45-cm^2 airflow cross-sectional area (the minimum was 160 cm^2)
- An air gap exists between the outer surface of the melt-cast CsCl and the inner surface of the inner capsule.

The resulting calculations showed a maximum cask surface temperature of 143°C. Actual measurements showed a maximum of 84°C, demonstrating that the conditions and assumptions used in the two-dimensional calculation were indeed conservative.

Licensing

The GIF is operated under a State of California (an Agreement State of the U.S. Nuclear Regulatory Commission) license, which grants considerable flexibility and discretion to conduct a wide variety of R&D activities. The license was amended to include the 12 WESF capsules.

SUMMARY AND CONCLUSIONS

The dry storage cask as designed and built meets all the requirements for the safe storage and use of the 12 WESF cesium-137 source capsules. The cask is not intended for transportation. It provides a convenient means for routine use of the cesium sources and, thus, fulfills an important objective of DOE's By-products Utilization Program.

ACKNOWLEDGMENT

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