NRF TRIGA Packaging

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INTRODUCTION

Training Reactor Isotopes, General Atomics (TRIGA)[1] Reactors are in use at 4 U.S. Department of Energy (DOE) complex facilities and at least 23 university, commercial, or Government facilities. All TRIGA reactor facilities are much smaller than commercial nuclear reactors, and the fuel elements, which are designed by General Atomics, are close to one-third the size of a commercial fuel element. The TRIGA fuel elements are inherently safe, based upon their design for use in training reactors. Currently, the only method of transport for the TRIGA fuel elements is by use of a large, approximately 30,000-lb (13,636-kg), transportation packaging. This packaging is not operationally feasible for use at the majority of the small TRIGA reactor facilities.

The development of the Neutron Radiography Facility (NRF) TRIGA packaging system began in October 1993. The Hanford Site NRF is being shut down and requires an operationally user-friendly transportation and storage packaging system for removal of the TRIGA fuel elements. The NRF TRIGA packaging system is designed to remotely remove the fuel from the reactor and transport the fuel to interim storage (up to 50 years) on the Hanford Site. The packaging system consists of a cask and an overpack. The overpack is used only for transport and is not necessary for storage. It was determined that it is economically feasible to design a packaging system that would meet the intent of U.S. Nuclear Regulatory Commission regulation 10 CFR 71 and long-term spent-fuel storage requirements as well as a small, lightweight, user-friendly cask for the small NRF. Design of the packaging system began in October 1993. Use of the NRF TRIGA cask began in September 1995, and complete defueling of the Hanford Site NRF is expected by December 1995. Therefore, less than 2 years were required to design, analyze, prepare Safety Analysis Report for Packaging (SARP [onsite]) documentation, and fabricate required casks and overpacks for the 99 fuel elements.

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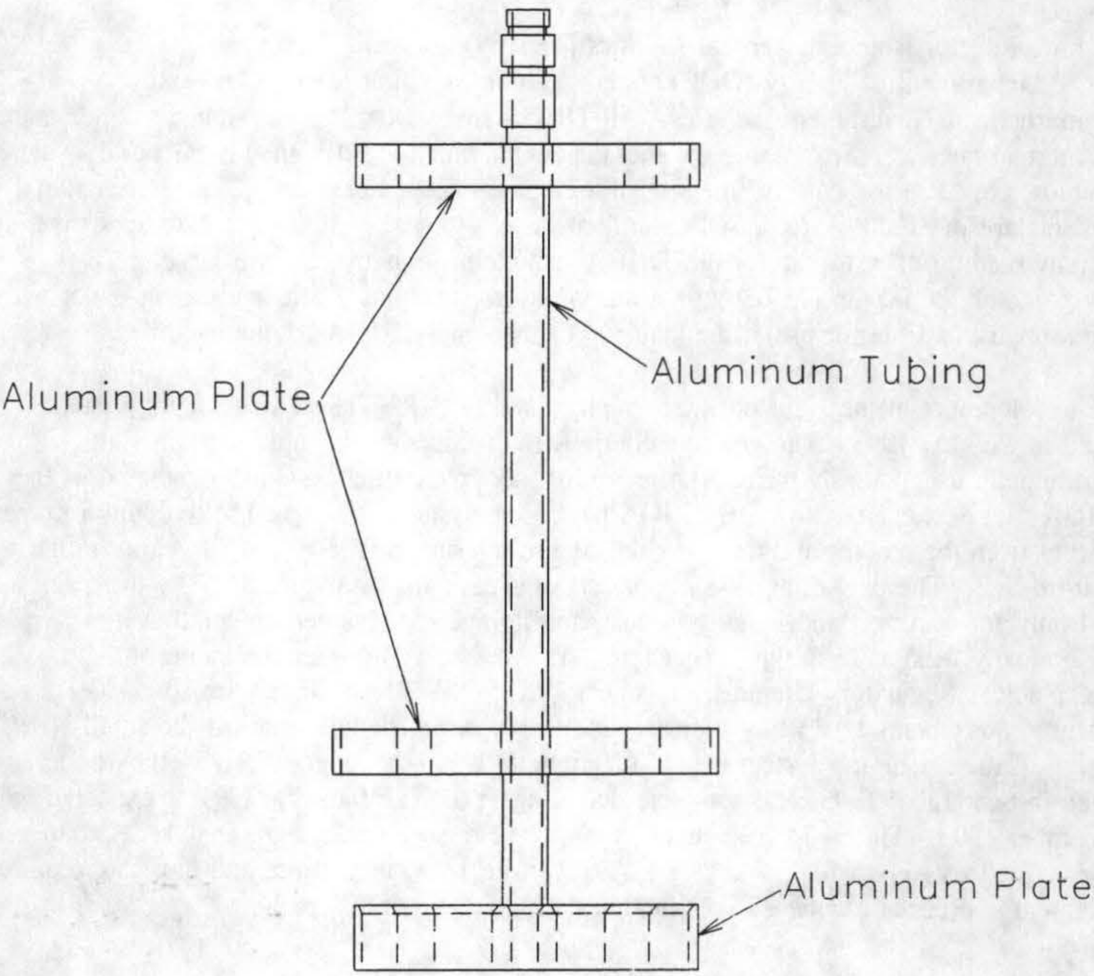
[1]TRIGA is a registered trademark of General Atomics.

PACKAGING DESCRIPTION

The cask consists of an aluminum basket structure housed inside a single-wall stainless steel inner container, which is inside a composite stainless steel/lead outer containment vessel. The overall cask dimensions are 37 in. (99 cm) in height and 16 in. (41 cm) in diameter. During transportation, the entire cask assembly is enclosed in an overpack, which serves as a shock absorber and thermal insulator during normal conditions of transport and hypothetical accident conditions. The overall overpack dimensions are 98 in. (249 cm) in height and 60 in. (152 cm) in diameter.

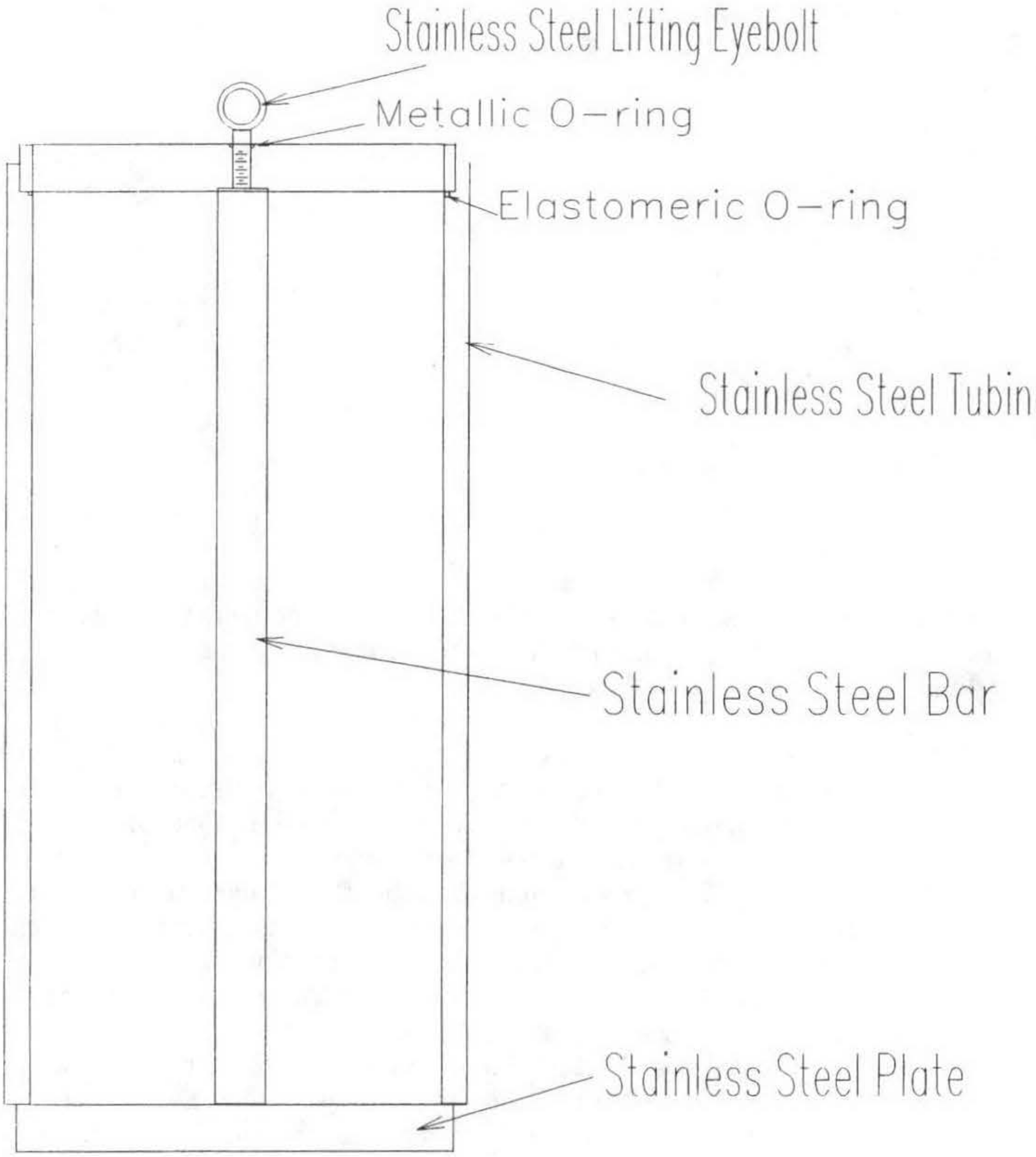
The aluminum basket (Figure 1) consists of three aluminum plates welded to an aluminum pipe. The basket provides a method of loading the fuel from the pool into the cask remotely. The basket also provides configuration control of the fuel elements within the inner container cavity.

Figure 1. NRF TRIGA* Fuel Cask Basket.



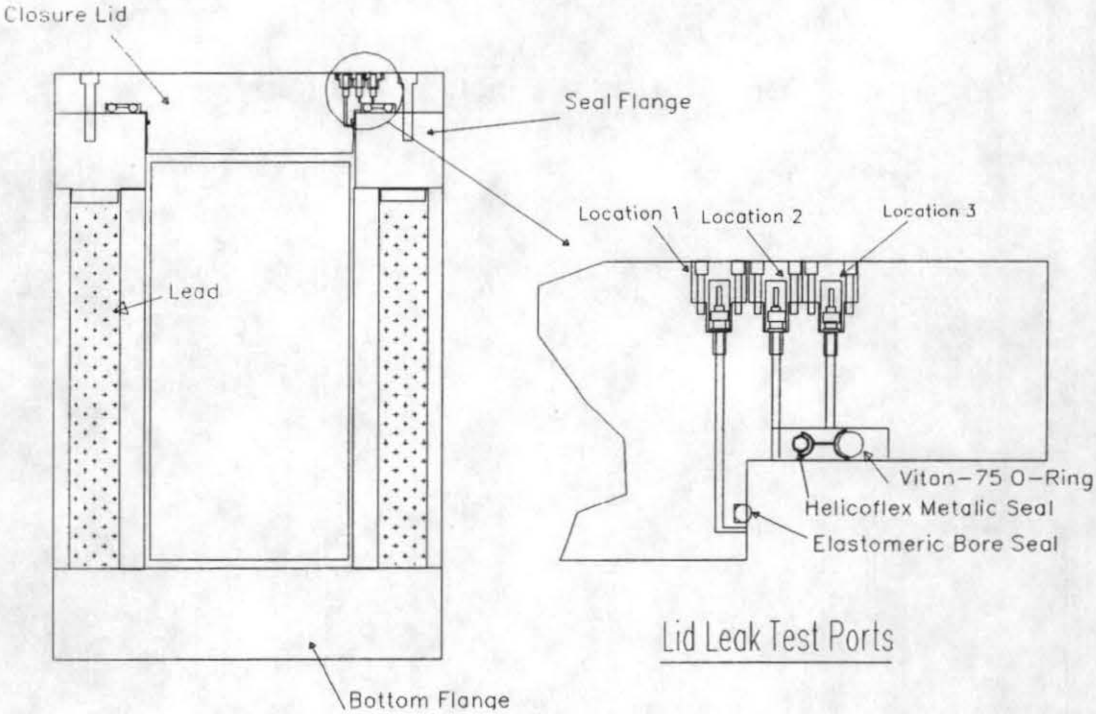
The inner container (Figure 2) has an elastomeric O-ring seal at the lid interface and serves as a confinement barrier for the fuel.

Figure 2. TRIGA® Cask Inner Vessel.



The outer containment vessel (Figure 3) consists of a 10.5-in. (27-cm) inner diameter, 0.75-in. (2-cm) thick stainless steel inner shell, which serves as primary containment, and a 16-in. (41-cm) outer diameter, 0.5-in. (1-cm) thick stainless steel outer shell. Both shells are welded at the bottom to a 4-in. (10-cm) thick, 16-in. (41-cm) diameter stainless steel plate. The 1.5-in. (4-cm) annulus between the two shells is filled with lead. This composite wall construction provides the necessary radiological shielding for 18 NRF TRIGA fuel elements. A 2.5-in. (6-cm) thick, 16-in. (41-cm) outer diameter, 10.5-in.

Figure 3. TRIGA® Cask Outer Containment Vessel.



(27-cm) inner diameter stainless steel ring is welded to the upper portion of both shells. This ring serves to encase the lead and provides the required seating/sealing surface for the outer vessel lid.

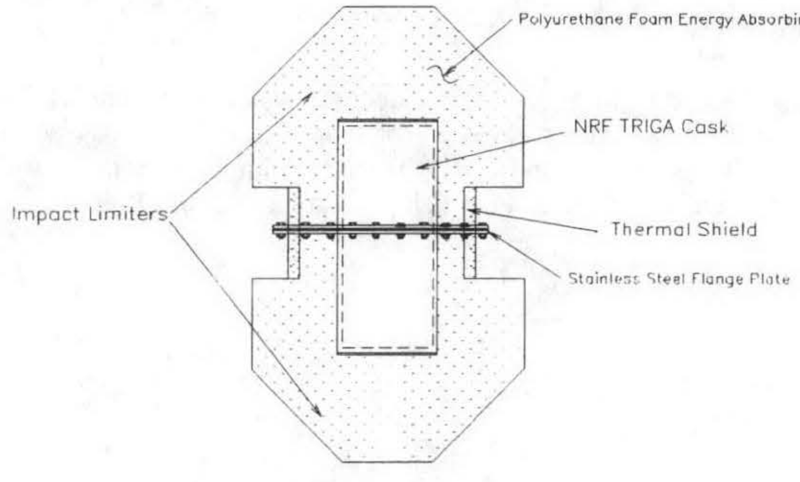
The cask lid consists of a 3.5-in. (9-cm) thick, 16-in. (41-cm) diameter stainless steel plate, with a machined step on the underside to facilitate remote placement of the lid onto the vessel and to restrict lateral movement of the lid. The seating surface of the lid has a machined O-ring groove to accommodate a leak-testable, combination metallic/elastomeric seal. This seal constitutes the "storage seal" to meet interim storage requirements. The perimeter of the stepped portion of the lid is machined with an O-ring groove, which houses the "transportation" containment seal. The "transportation" containment seal is a bore seal design, which consists of a single ethylene- propylene O-ring. This design ensures that containment is maintained after hypothetical accident conditions. To perform leak tests on both the storage and transportation seals, three 2.5-in. (6-cm) diameter countersunk ports are machined on the top side of the lid. One port penetrates the cask cavity (Location 1, Figure 3); one port penetrates the void space between the transportation seal and the storage seal (Location 2, Figure 3); and one port penetrates into the annulus between the elastomeric and metallic seal of the combination storage seal (Location 3, Figure 3). Each port is fitted with a Swagelok[2] quick-connect fitting to facilitate the helium backfilling/detecting processes to properly perform the leak tests.

[2]Swagelok is a registered trademark of SWAGELOK Quick-Connect Co.

The design leak rate of the cask is leaktight as specified in American National Standards Institute (ANSI) Standard ANSI N14.5 (ANSI 1987). A cover plate is placed over the fittings and is installed with six 0.25-in. (0.6 cm) cap screws. Each port also has a machined groove to accommodate a spring-energized metallic seal. The seal is compressed to the proper sealing specification by installation of the cover plate. The lid is secured to the outer containment vessel with 12 ASTM A540 0.5-in. (1-cm) cap screws.

The overpack (Figure 4) consists of two foam-filled impact limiters and a thermal shield. Carbon steel attachment bolts with cadmium plating are used to hold the top and bottom impact limiters together. The foam provides cushioning of the cask as well as thermal protection during the hypothetical accident conditions. The stainless steel skin maintains the integrity of the foam and provides resistance to the puncture drop prescribed for hypothetical accident conditions as specified in 10 CFR 71. The top impact limiter includes the thermal shield that extends 12 in. (30 cm) between the impact limiters when the overpack is assembled. The thermal shield includes a layer of ceramic fiber insulation sandwiched between two ASTM A240 stainless steel sheets. A closure flange is welded to the bottom of the thermal shield to provide a means of bolting the impact limiters together.

Figure 4. NRF TRIGA® Cask Overpack.



PACKAGING EVALUATIONS

A Hanford-specific SARP (onsite) was prepared and approved for the NRF TRIGA package. The NRF TRIGA package was determined analytically to meet all 10 CFR 71 normal condition of transport and hypothetical accident condition requirements. The contents evaluated in the NRF TRIGA SARP are Hanford Site specific. However, modifications could easily be incorporated to include a variety of other TRIGA element payloads to accommodate offsite applications for this packaging system.

CONCLUSIONS

The NRF TRIGA packaging (cask and overpack) provides an innovative and unique design for the dual purpose of long-term storage and transportation of TRIGA reactor fuel elements. Based upon the cask's small size and light weight, small TRIGA reactors will find it versatile for numerous refueling and fuel storage needs. The NRF TRIGA packaging design also provides the basis for developing a certifiable and economical packaging system for other TRIGA reactor facilities. The small size of the NRF TRIGA cask also accommodates placing the cask into a larger certified packaging for offsite transport. The Westinghouse Hanford Company NRF TRIGA packaging, as described above, can serve other DOE sites for their onsite use, and the design can be adapted to serve university reactor facilities, handling a variety of fuel payloads.

REFERENCES

10 CFR 71, *Code of Federal Regulations*, "Packaging and Transportation of Radioactive Material," 1994.

ANSI, *American National Standards for Radioactive Materials Leakage Tests on Packages for Shipment*, ANSI Standard N14.5, American National Standards Institute, New York, New York, 1987.

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