TRUPACT-II - THE STORY OF SUCCESS

Thomas W. Halverson
Westinghouse Electric Corporation
Waste Isolation Division
Waste Isolation Pilot Plant (WIPP*)
Carlsbad, New Mexico

ABSTRACT

The Transuranic Package Transporter-II (TRUPACT-II) will be a Nuclear Regulatory Commission (NRC)-certified package used to transport transuranic waste from U.S. Department of Energy (DOE) generator sites nationwide to the Waste Isolation Pilot Plant. TRUPACT-II is a unique package designed to maximize payload weight and volume. It is a soft yielding package utilizing a user-friendly closure mechanism. TRUPACT-II was designed and tested in record time and underwent extensive testing to satisfy the regulatory requirements imposed by the NRC.

INTRODUCTION

The Transuranic Package Transporter-II (TRUPACT-II) package was designed to transport contact-handled (CH) transuranic (TRU) radioactive waste from the U.S. Department of Energy (DOE) generation and storage sites to the Waste Isolation Pilot Plant (WIPP) in New Mexico. TRUPACT-II was designed to maximize payload weight and volume, and it employs a novel seal and closure mechanism designed to facilitate loading and unloading. The TRUPACT-II fleet will be the largest fleet of certified transporters ever built (consisting of some 51 packages carried three per trailer).

The Nuclear Regulatory Commission (NRC), which is expected to issue the Certificate of Compliance for TRUPACT-II later in 1989, has required a rigorous physical testing program for TRUPACT-II rather than relying on the computer models that have been acceptable for packages that they licensed in the past.

BACKGROUND

The TRUPACT-II program began with the placement of a contract with Nuclear Packaging Corporation of Federal Way, WA, for the design, certification, and fabrication of a package meeting all requirements for a DOE Type B package as required by 10 CFR 71 regulations. The contract was signed in September 1987, and design work began immediately. In order to meet the proposed schedule of certification by October 1988, to support WIPP's opening, communications and meetings with the NRC were started immediately. Due to the schedule imposed and the novel design of the closure mechanism and because the package was of a soft yielding design, extensive testing was required. This testing consisted of bench, reduced-scale, and individual component tests to verify design features and provide immediate feedback and confirmation of materials selection.

PACKAGE CONSTRUCTION

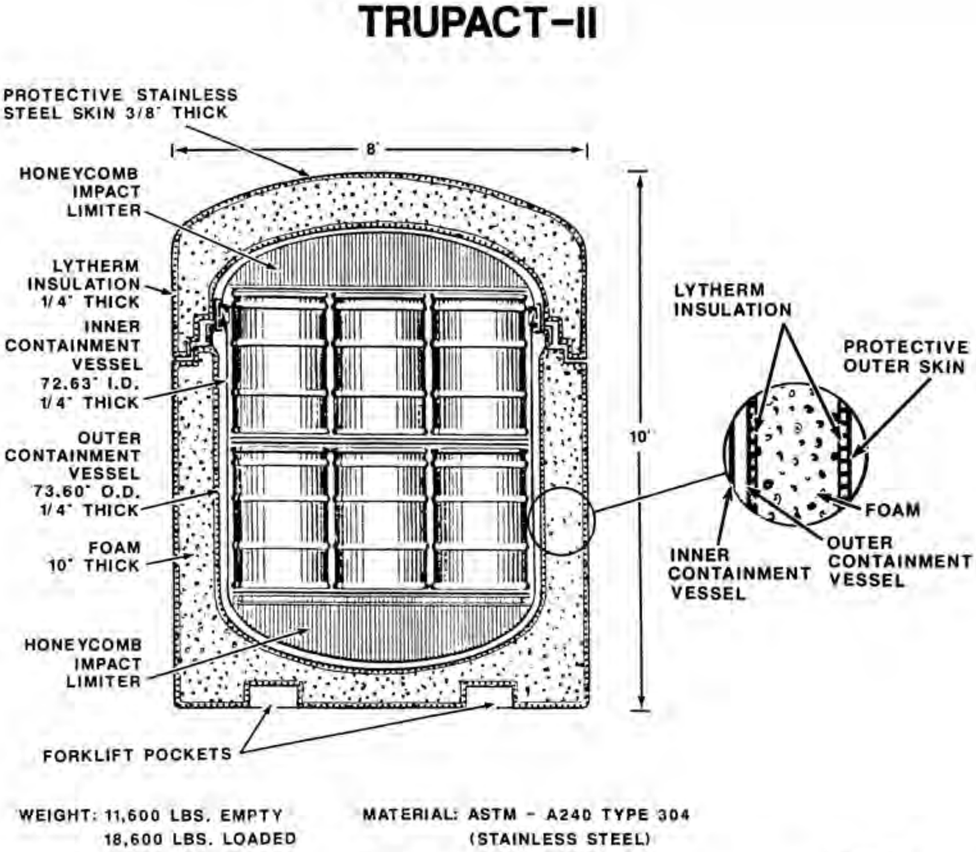
The TRUPACT-II (Fig. 1) is a doubly contained, non-vented package consisting of nested containment vessels, each with its own double 0-ring seal system. Both vessels are 304 stainless steel, the inner vessel being 0.635 cm thick and the outer vessel 0.476-cm thick. Surrounding the outer containment vessel (OCV) is 25.4-35.6 cm of high-density polyurethane foam. The foam acts as both an impact absorber and a thermal blanket for the inner vessels. The foam is then further surrounded by an outer skin of stainless steel. The skin is 0.635 cm thick on both the domed lid and lower section of the body, and is 0.375 cm thick for a distance of 106.7 cm both above and below the lock ring area to provide puncture resistance in the region of the 0-ring seals. TRUPACT-II also incorporates a novel closure mechanism. Unlike conventional casks using a bolted lid design typically requiring up to 72 bolts, TRUPACT-II utilizes a rotating lock ring (Fig. 2) with fingers and tabs being aligned when closed. This finger and tab concept is very similar to a pressure cooker closure system and is used on both the inner and outer lids. This closure mechanism is intended to facilitate opening and closing and thus, reduce personnel exposures during both loading and unloading operations. Operational checkouts of prototype units at the WIPP have resulted in total handling times of less than one hour per unit.

TRUPACT-II was designed to maximize the payload-carrying capability both in volume and weight. Each TRUPACT-II will accommodate fourteen 208-liter drums or two standard waste boxes for a total usable volume of 3.6 m3. An empty TRUPACT-II weighs approximately 5307 kg. The package will be certified to carry 3175 kg, with a combined payload limit of 8165 kg for the three TRUPACTs carried on each trailer. The total highway transport weight of the TRUPACTs, trailer, truck, and payload will be 36 288 kg and as such will meet all bridge and highway weight limits without requiring special permits. The TRUPACT will be certified by the Nuclear Regulatory Commission (NRC) as a U.S. Department of Transportation (DOT) Type B transport package.

HALF-SCALE TESTING

As a result of the half-scale tests performed to verify the puncture resistance of the package, the outer skin thickness was changed in the region of the O-ring seal. This was accomplished by making the outer skin 0.375-cm-thick

* Work supported by the U.S. Department of Energy Assistant Secretary for Defense Programs, Office of Defense Waste and Transportation Management, under DOE Contract No. DE-AC04-86AL31950.



189:2706

Fig. 1. TRUPACT - II.

stainless steel rather than 0.635-cm in the region of 0-ring seals. In addition to pin punch tests, 9.1-m drop tests, burn tests of the foam, and extensive testing of the 0-ring seals were done. These seal tests were done to verify leak tightness of the seals at various degrees of 0-ring compression and at various temperatures as well as the ability of the 0-rings to seal under extreme deformation. The 0-ring seal test program culminated by applying over 315 520 kg of force to a full-scale mock-up of the TRUPACT-II causing over 22.9 cm of change in the diameter. Even with this extreme deformation, the package remained leak-tight to the standard required by the NRC (1 x 10-7 cc/sec).

FULL-SCALE TESTING

10 CFR 71 regulations require that a package undergo a 0.9-m normal drop, a 9.1-m drop, a pin punch from a height of 1.0 m, a burn test of 30 minutes at 802 C, and a submersion test in water, with the package being leak-tight to 1 x 10-7 cc/sec when finished. Due to the unique nature of the TRUPACT-II seal and closure mechanism and the fact that TRUPACT-II is a soft yielding package, the NRC requested additional testing. Through sixteen meetings with the NRC, the testing sequence for TRUPACT-II certification was agreed to be six 9.1-m drop tests at various orientations, ten pin punches at various locations, one 9.1-m drop, and two burn tests, divided between the two packages. Additionally, the NRC requested that two of the 9.1-m drops being done with the package chilled to -29 C to verify seal performance at low temperatures.

Testing on Unit 1 began in July 1988, at Sandia National Laboratory, with the 0.9-m normal drop followed by numerous pin punches. When the package was dropped on the pin at the vent port location, more damage occurred than was observed during the half-scale testing or than was predicted by the designers. Although no leakage of the containment boundary occurred, significant foam and skin damage was seen. As a result, testing was suspended, and the package was modified by adding stiffening plates behind the outer skin at the seal test and vent port locations.

Testing resumed after modifications with a repeat of the test which had caused the damage. No further problems were encountered, and the remainder of the drop and pin punches were completed. The package was then subjected to a pool of fire consisting of 30 282 liters of JP 4 jet fuel.

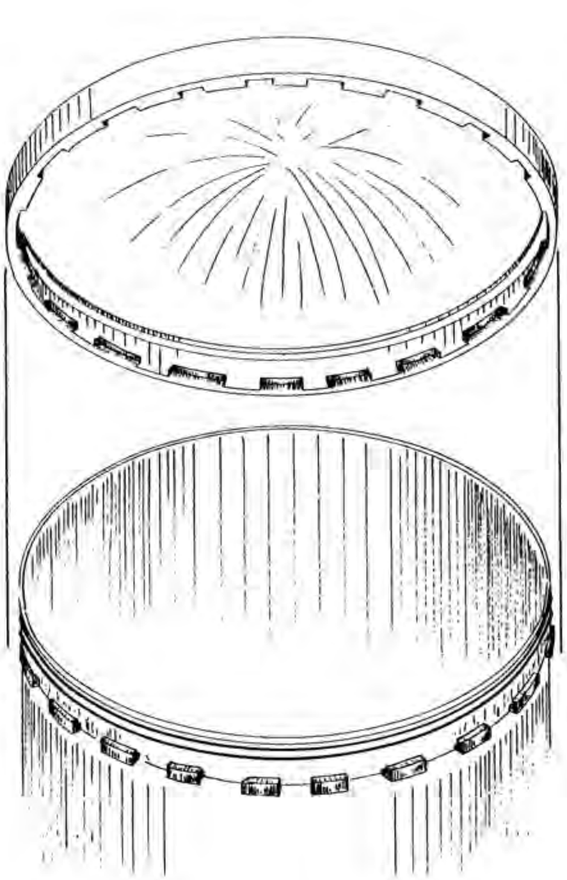


Fig. 2. TRUPACT-II Closure Mechanism.

Seal temperatures reached 116 C on the outer containment vessel 0-rings during the burn test.

The package was then taken to an environmental chamber where the outer skin and foam were removed, and the package was again chilled to -29 C for final leak testing. The OCV was found to be leak-tight to less than 1 x 10-7 cc/second as required. Leak tests on the inner containment vessel (ICV) were attempted with the vessel chilled to -29 C but were unsuccessful because the necessary vacuum could not be pulled for testing between the two 0-rings. A decision was made to remove the lid from the ICV and locate the problem. When the lid was removed, debris from the simulated payload was found lodged in the upper 0-ring. The 0-ring was removed, wiped, and reinstalled, and the leak test was performed at -29 C. The ICV was found to be leak-tight, however, the testing could not be declared successful even though the vessel was leak-tight because the lid had been removed and the 0-ring cleaned.

It was determined that the some of the 3175 kg of concrete used to simulate the payload had broken up during the testing and that some of the debris had lodged in the 0-ring groove and prevented a seal. A decision was made to modify the design and correct the problem. Following inspection of the package after the burn test, it was also decided to evaluate whether thermal enhancements could be made to the package to improve package performance.

Testing began immediately to find a debris shield for the 0-ring and to improve thermal performance. Another half-scale model was used to test proposed modifications. Various foam compositions were evaluated, both for crush strength and burn rate. Also, it was found that foam performance was based on the amount of crushing to which the foam was subjected. The addition of stiffening rings at strategic locations on the inside of the outer skin greatly reduced foam crushing and improved thermal performance.

After extensive testing, it was decided that the addition of a silicon rubber debris shield would prevent debris from contacting the 0-ring; that two stiffening rings added above and below the closure ring would provide rigidity; and that the addition of a 0.635-cm-thick insulating material on the inside of the outer skin and around the OCV, virtually encapsulating the foam, would greatly reduce the foam burn-up rate.

Test Unit 2 was modified to incorporate those design changes, and another test unit was built to complete the prescribed tests. Testing resumed in December 1988, with Unit 2. This package was subjected to a 0.9-m drop, three 9.1-m drops, five pin punches, and a pool fire. After all testing was completed, the package was chilled to -29 C, and both the ICV and OCV were found to be leak-tight. Post-test examination revealed that the debris shield prevented any material from contacting the 0-rings, even though the same payload was used, and additional loose dirt was deliberately placed in the ICV to verify that the debris shield was effective. Also, it was found that the addition of the insulating materials greatly reduced foam burning, with uncharred foam remaining in all areas of the ICV after the fire test.

Unit 3 testing began in January 1989, and consisted of a complete repeat of the failed Unit 1 test sequence. The tests performed on Unit 3 were three 9.1-m drops, two of which were done with the package chilled -29 C. Six pin punches were also performed, including a repeat of one of the pin punches performed on Unit 2. Examination of slow-motion photography on Unit 2 disclosed that during one of the pin punches the pin may have been too short, resulting in the package striking the ground before all the damage could be inflicted on the package. The test was repeated with a longer pin on Unit 3 to remove any doubt. The package was then subjected to a pool fire.

After the package had again been chilled to -29 C, the OCV seals were tested and found to be leak-tight. When attempts were made to pull a vacuum between the ICV O-rings to verify leak-tightness, they were unsuccessful. Further testing found that the lower O-ring was leak-tight to less than 1 x 10-7 cc/sec as required; therefore, no radioactive material could have been released from the package had it been a real shipment. Removal of the ICV lid revealed that water had saturated the silicon foam debris shield which in turn had fractured during the 9.1-m drops. This fracturing allowed debris into the upper O-ring. The O-ring was cleaned and reinstalled and the ICV was found to be leak-tight.

Further testing revealed that the debris in the O-ring was due to water freezing in the debris shield. The water was from moisture condensed out of the air which was pumped through the package to aid cooling the package to the required -29 C before testing could begin. Ceiling clearance in the environmental chamber used to cool the package required that the package be laid on its side during cooling. This position allowed the condensed water to enter the debris shield, which then caused the failure. Had the package been cooled without circulating air into the ICV or had the package been chilled upright, the leak tests would have been successful.

The debris shield was redesigned by adding a third O-ring on the inside flange of the ICV lid to act as a water-tight seal, preventing either water or debris from contacting the primary O-ring. The NRC requested that the tests be redone on a fourth test package with the exception of the burn test, to verify that debris shield redesign was successful.

The fourth package was tested and the debris shield and package design verified by successful leak testing of both the OCV and ICV O-rings.

The SARP has been submitted to the NRC for review and certification is anticipated by May 1989.

CONCLUSION

The TRUPACT-II fleet will be the largest fleet of certified transporters ever built (consisting of some 51 packages carried three per trailer). They were designed to maximize payload weight and volume and to carry Department of Energy defense generated transuranic waste from ten sites nationwide to the WIPP in New Mexico. The package employs a novel seal and closure mechanisms designed to facilitate loading and unloading.

The package was designed and tested, and a SARP was submitted on an extremely tight schedule to support WIPP's opening. Whether it is the uniqueness of the package, fleet size, type of waste being carried, or the tight schedules, the testing requested by the NRC was far greater than required for any previous package. Certification testing consisted of multiple 9.1-m drops, pin punches and burn tests, at temperature extremes of -29 C to 49 C, with the package pressurized at its maximum operating pressure. This degree of over testing for whatever reason, makes the budgeting and scheduling task associated with the development and certification of new packaging difficult at best.

It is hoped that one of the reasons cited above is the reason for the extensive testing required and that it is not a sign of things to come for future packages.