ABSTRACT

A large volume of contact-handled transuranic (CH TRU) nuclear waste has been generated and has accumulated at ten Department of Energy (DOE) facilities. Approximately 168,000 cubic meters of this waste has been targeted for shipment to the Waste Isolation Pilot Plant (WIPP) near Carlsbad, New Mexico. Shipment of all of this waste is expected to require more than 15,000 shipments, totalling approximately 38 million kilometers of travel.

The TRUPACT-II is a reusable package for shipment of CH TRU waste; it is designed in accordance with U.S. Nuclear Regulatory Commission (NRC) requirements for Type B packages found in 10 CFR 71. There are two separate levels of containment to permit shipment of plutonium in excess of 740 GBq per package. The packaging is a right circular cylinder in shape, with a domed top and a flat bottom; external dimensions are 240 centimeters in diameter and 309 centimeters high. The capacity of each TRUPACT-II is 3,182 kilograms of waste that can be loaded into 1) fourteen 210-1 drums; or 2) two 1.9 cubic meters standard waste boxes (SWBs). Three TRUPACT-II packages are transported on a custom designed semitrailer which is pulled by a conventional tractor for highway transport of CH TRU waste between DOE sites and to the WIPP near Carlsbad, New Mexico (2). The Safety Analysis Report (SAR) for the TRUPACT-II Package was initially submitted to the NRC in March 1989. Four revisions were issued during the period from May through August 1989. NRC certification of the package was received on August 30, 1989.

INTRODUCTION

Nuclear Packaging, Inc. (NuPac), Federal Way, Washington designed, built, and tested the TRUPACT-II package design for the DOE under a contract with Westinghouse Electric Corporation, Waste Isolation Division (WID), Carlsbad, New Mexico (2).

Full-scale compliance testing was performed at Sandia National Laboratories (SNL), Albuquerque, New Mexico. Testing began in July 1988 with a full-size test unit designated as Test Unit No. 1 (TU1) or the "Engineering Prototype." TU1 testing was completed in September 1988 and led to a number of design
enhancements to improve the performance of the package in the hypothetical accident condition testing per 10 CFR 71. These enhancements were implemented and tested using two full-scale Certification Test Units (CTU1 and CTU2). CTU1 and CTU2 testing was performed in December 1988 and January 1989. An additional design improvement resulted in the addition of a "wiper" O-ring to protect the ICV lid-to-body seal. This modification was tested on the third Certification Test Unit (CTU3) in April 1989.

PACKAGE DESCRIPTION

Outer Containment

The outer level of containment in TRUPACT-II is provided by a 4.8 - 6.4 millimeter thick stainless steel pressure vessel consisting of a cylindrical body, two ASME torispherical (flanged and dished) heads, and a set of closure rings which join together to form a double O-ring bore seal. This outer containment vessel (OCV) is surrounded by a layer of rigid closed-cell polyurethane foam approximately 25 centimeters thick and an external 6.4 - 9.6 millimeters thick stainless steel skin. Fork lift pockets are provided for handling. The cavity between the containment vessel and the outer skin is lined with a thin layer of ceramic fiber insulation prior to pouring the polyurethane foam in Fig. 1. The foam is an excellent impact-energy absorber which also retards heat input during the hypothetical fire accident condition. The foam is flame-resistant and self-extinguishing; thus, minor tearing of the OCA exterior skin is acceptable. The stainless steel/ceramic fiber/foam sandwich construction of the outer containment assembly (OCA) forms a tough, puncture resistant, and impact absorbing shell which cushions and insulates both containment vessels and their contents during normal and hypothetical accident conditions of transport (2).

FIG. 1. TRUPACT-II General Arrangement

Inner Containment

Nested concentrically inside the OCV is a separate and removable stainless steel inner containment vessel (ICV). Like the OCV, the ICV consists of a cylindrical body, two flanged and dished heads, and a set of closure rings with elastomer O-ring bore seals. The ICV usable interior volume is 184 centimeters in diameter and 192 centimeters high. Energy absorbing honeycomb spacers are located in the upper and lower heads to protect the heads from impact by the contents during the hypothetical accident drop conditions (2).

Thermal

The thermal design rating of the package is 40 watts internal decay heat maximum. This relatively low internal heat load is dissipated entirely by passive heat transfer. Computer models were developed to predict maximum temperatures resulting from the regulatory assumptions and internal heat generated by the payload. The predicted average drum centerline temperature
is 73°C for normal conditions of transport with a 40-watt internal decay heat evenly distributed among 14 drums, plus the regulatory solar load (2).

Pressure

Both the OCV and the ICV are designed to withstand 345 kPs of internal pressure. Each is tested "leak tight" per ANSI 14.5 (a leakage rate of 10E-7 scc/sec or less) for normal and hypothetical accident conditions of transport (2).

Shielding

The TRUPACT-II contains no special shielding due to the low dose rates from the contents (2).

Criticality

The TRUPACT-II does not require specific design features to provide neutron moderation and absorption for criticality control. Fissile materials in the payload are limited to an amount which ensures safely subcritical packages for normal and accident conditions (2).

Contents

CH TRU waste is characterized by having very small amounts of transuranic radioactivity contaminating a wide variety of materials. The waste typically consists of items like plastic, metal, glass, paper, salts, oxides, absorbents, filters, filter media, cloth, and cemented sludges. TRUPACT-II authorized methods for payload control (TRAMPAC) were developed and are included in the Safety Analysis Report for the TRUPACT-II Shipping Package. The DOE generator and storage sites will use the TRAMPAC to prepare payloads for shipment (2).

Controlled parameters include restrictions on physical and chemical forms of the waste, chemical compatibility between constituents in the payload (and the package components), maximum pressure in the package during a 60-day transport period, potentially flammable gasses, layers of confinement, fissile material content, decay heat, weight, center of gravity, and dose rates for individual containers. Waste shipments can be shown to meet the TRAMPAC requirements by one of two ways: 1) show by analysis (without physically testing for each transportation parameter) that a particular waste container is safe for transport even under worst case conditions; and 2) test individual payload containers under normal transport conditions to verify compliance (2).

LICENSING APPROACH

Compliance with the requirements of 10 CFR 71 was demonstrated by a combination of analyses and testing. Normal conditions of transport (heat, cold, reduced external pressure, increased external pressure, vibration, water spray, free drop, and penetration) were all analyzed. Hypothetical accident conditions of transport, free drop, puncture and thermal were tested;
immersion was analyzed. Analyses and tests were performed for initial hypothetical accident conditions between -29°C and +38°C (2).

TESTING

Engineering Tests

Numerous bench tests were conducted to verify the performance of a variety of components associated with the TRUPACT-II design. These tests included characterizing the strength and thermal properties of the polyurethane foam, and comparing the sealing capability of various O-ring materials at temperatures between -29°C and +204°C. Foam/stainless steel combinations were tested in 3/10 scale to develop the outer shell for optimum puncture resistance and minimum weight. Free drop and puncture tests were performed on both 1/2 and 3/4 scale models to confirm the puncture resistance of the OCA outer body and domed head. A full-scale mock-up of the sealing area was destructively tested to demonstrate the effectiveness of the seal design during gross distortion of the head/body closure. A full-scale TRUPACT-II engineering prototype was tested, prior to the start of full-scale certification testing, to demonstrate the general worthiness of the design to withstand multiple sequences of the hypothetical accident conditions and a fully engulfing pool fire (2).

Certification Tests

Full-scale certification testing for the TRUPACT-II container was performed during the period from December 1988 to April 1989. The testing was performed at SNL under the direction of the NuPac test engineer. Representatives from DOE and Westinghouse were present during all of the testing; representatives from the NRC were present during portions of the testing.

CTU1, CTU2 and CTU3 were exposed to a variety of free drop, puncture bar, and fire events. Leakage rate testing of the containment boundaries was performed before, during, and after the test sequence on each test unit. Table I summarizes the test sequence performed on each test unit.

Table I. Test Sequence

CTU1 endured the imposed test sequence without any failures as indicated by successful post-test leakage rate testing and other inspections.

A failure was encountered on CTU2 in which debris fouled one of the ICV main O-ring seals and caused it to leak. This failure, however, did not result from the test sequence but from the cooling operation performed prior to the test sequence to achieve the necessary prerequisite temperatures. The cooling operation rendered the ICV debris shield inoperative prior to the test sequence and led to the failure. To resolve this, a wiper O-ring was added to the ICV to protect the debris shield prior to the test sequence. This modification was proven successful by the CTU3 testing which repeated the CTU2 sequence except for one puncture bar event and a fire test.
CTU3 endured its test sequence successfully without any containment failures and demonstrated adequacy of the modifications implemented as a result of the CTU2 testing.

Fig. 2 shows the drop test orientations for CTU1. Fig. 3 shows the orientations for CTU2 and CTU3, except CTU2 included a repeat of drop test number 2-7 from the CTU1 testing. This is not shown on Fig. 3. Fig. 4 is a photograph of the CTU2 thermal event fire testing.

Fig. 2. TRUPACT-II CTU1 Drop Test Orientations

Fig. 3. TRUPACT-II CTU2 and CTU3 Drop Test Orientations

Fig. 4. TRUPACT-II CTU2 Fire Testing - December 30, 1989

The regulations (10 CFR 71.73) for hypothetical accident condition testing require that the package be able to withstand the cumulative effects of a free drop, a puncture, and a thermal event at worst case initial temperatures and pressures. As shown in Table I, above, each test unit was exposed to multiple drop and puncture events at a number of orientations in each sequence. Thus, the cumulative effects of the TRUPACT-II testing were more severe than that required by the regulations. The multiple drop and puncture events subjected to each test unit were necessary to adequately test the structural features of the package and it was impractical to manufacture separate test units to accommodate each individual orientation. Therefore, the package had to be designed with conservatism with respect to the intent of the regulations in order to pass the testing.

A number of important lessons were learned from the testing. Perhaps the most important was that failures of test equipment (i.e., thermocouples, pressure lines, valves, gages, fittings, etc.) can indicate possible package failures and must be recognized as such to avoid confusion. Often in the testing, a piece of test hardware which failed caused the appearance of a package failure. Observers of the testing would conclude a package failure and later it would be found not to be the case.

CONCLUSIONS

The extensive testing which was more severe than regulatory requirements indicates that TRUPACT-II is conservatively designed for its application. The team work approach by personnel from DOE, WTD, SNL, and NuPac led to completion of the test program and NRC certification much faster than what typically would have occurred.

REFERENCES


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<td>12/4/88 - 12/14/88</td>
<td>1 0.9-m Side drop</td>
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<td></td>
<td>3 9.1-m Free drops</td>
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<tr>
<td></td>
<td></td>
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