DEVELOPMENT OF THE HALFPACK PACKAGING FOR OPTIMIZED SHIPMENT OF CONTACT-HANDLED TRANSURANIC WASTE TO THE WASTE ISOLATION PILOT PLANT

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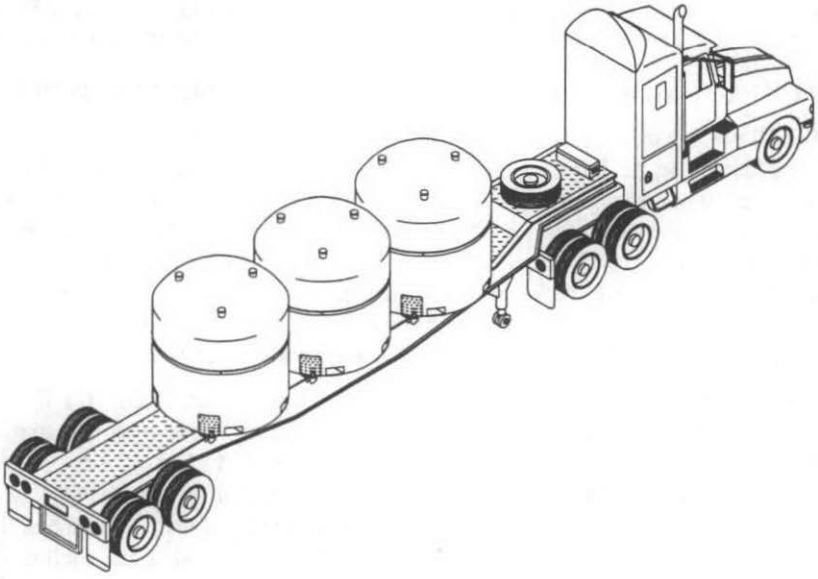


SUMMARY

Several different transportation packaging designs will be utilized for making shipments of transuranic waste to the Waste Isolation Pilot Plant (WIPP) in Carlsbad, New Mexico, USA. Although all such packages require certification by the United States Nuclear Regulatory Commission (USNRC), currently only the TRUPACT-II packaging has been granted USNRC certification (originally licensed in 1989 under USNRC Certificate of Compliance 71-9218). Initial shipments to WIPP will rely on the TRUPACT-II packaging since it is the only currently licensed package system capable of transporting large quantities of Contact-Handled Transuranic (CH-TRU) waste. Two additional packagings are currently under development to more efficiently transport CH-TRU waste and to allow the transport of Remote-Handled Transuranic (RH-TRU) waste to WIPP: the HALFPACK and 72-B packagings, respectively. This paper specifically addresses the design and licensing of the HALFPACK packaging. Additional information is available regarding the design and testing of the TRUPACT-II packaging.

BENEFIT OF THE NEW HALFPACK PACKAGING

The TRUPACT-II packaging is designed to transport a maximum of 7,265 pounds (3,295 kg) of CH-TRU waste in three different payload configurations: 1) fourteen (in two layers of seven), 55-gallon (208 l) drums, 2) two Standard Waste Boxes (SWBs), or 3) one, Ten Drum Overpack (TDOP). The TRUPACT-II packaging is optimized for shipments of fourteen, 55-gallon (208 l) drums averaging 500 pounds (227 kgs) per 55-gallon (208 l) drum, which comprises the majority of waste in drums to be transported to the WIPP site. However, a significant number of drums exist that exceed the 500 pound (227 kg) average, weighing up to 1,000 pounds (454 kg) each. Hence, the HALFPACK packaging is optimized for shipments of seven, 55-gallon (208 l) drums averaging 1,000 pounds per 55-gallon (208 l) drum. Further, damaged 55-gallon (208 l) drums will be overpacked in either SWBs, or 79-gallon (299 l), 83-gallon (314 l), or 85-gallon (322 l) drums. Thus, in addition to the heavier 55-gallon (208 l) drum payloads, the HALFPACK packaging is optimally designed to transport four, 79- (299 l), 83- (314 l), or 85-gallon (322 l) drums. Up to three TRUPACT-II or HALFPACK packages may be transported on a specially designed, exclusive use semi-trailer with a gross vehicle weight limit not to exceed 80,000 pounds (36,287 kg) for "legal weight" truck transport within the continental United States.

HALFPACK PACKAGING CONFIGURATION DETAILS AND DESIGN CONSIDERATIONS

Figures 1 and 2 contrast the overall configuration for the TRUPACT-II and HALFPACK packagings, with Figure 2 identifying the dimensional differences between the two designs. As evident from the figures, both designs consist of nested (double) containment vessels, with identical diametrical dimensions. The lids and closure devices for both the inner and outer containment vessels (ICV and OCV, respectively) for both packagings are identical. The primary difference between the TRUPACT-II and HALFPACK packagings is shortening of the inner and other vessel bodies by 30 inches (76.2 cm), a length somewhat less than the height of a 55-gallon (208 l) drum thereby allowing 85-gallon (322 l) drums to also fit within the HALFPACK packaging payload cavity.

Three other notable design changes are apparent when contrasting the TRUPACT-II and HALFPACK packagings: 1) lengthening of the 3/8 inch (1.0 cm) thick outer containment assembly (OCA) body outer shell from 12 inches (30.5 cm) to 18 inches (45.7 cm), 2) removal of a circumferential stiffening ring on the outside of the OCV (within the foam cavity), and 3) relocation of OCA body fire vents to be nearer the center of mass of the polyurethane foam. The six inch (15.2 cm) lengthening of the 3/8 inch (1.0 cm) thick OCA body outer shell is necessary for the HALFPACK packaging to avoid penetration of the hypothetical accident condition (HAC) puncture bar at a location closer to the closure seals than occurred during TRUPACT-II certification testing. The stiffening ring is included on the TRUPACT-II packaging to preclude buckling of the OCV shell when subjected to drop or external pressure loadings. With the shortening of the OCV shell to nearly half its original length, it is readily established that the stiffening ring is no longer needed for the HALFPACK packaging.

Another design consideration is determination of the maximum internal decay heat load. To expedite the certification process, the decay heat limit within the HALFPACK packaging is chosen to limit normal conditions of transport (NCT) maximum temperatures to those reported for the TRUPACT-II packaging. With smaller internal and external surface areas to reject decay heat, the 40 watt decay heat limit for the TRUPACT-II packaging is reduced to 30 watts for the HALFPACK packaging.

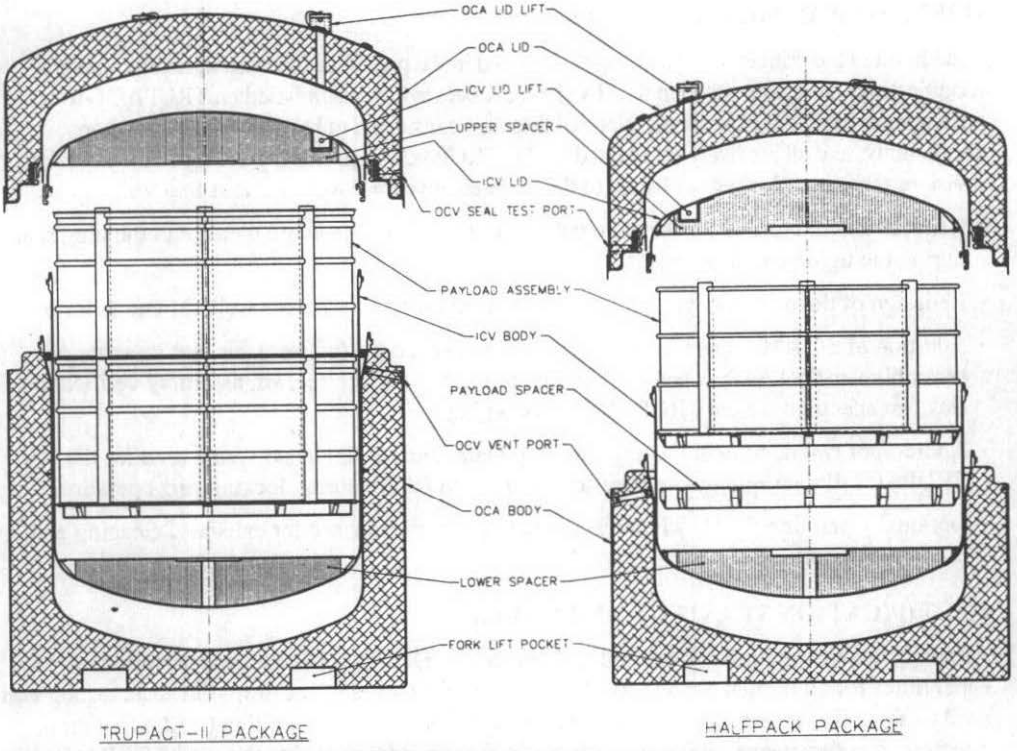


Figure 1 HALFPACK/TRUPACT-II Packaging Major Component Identification

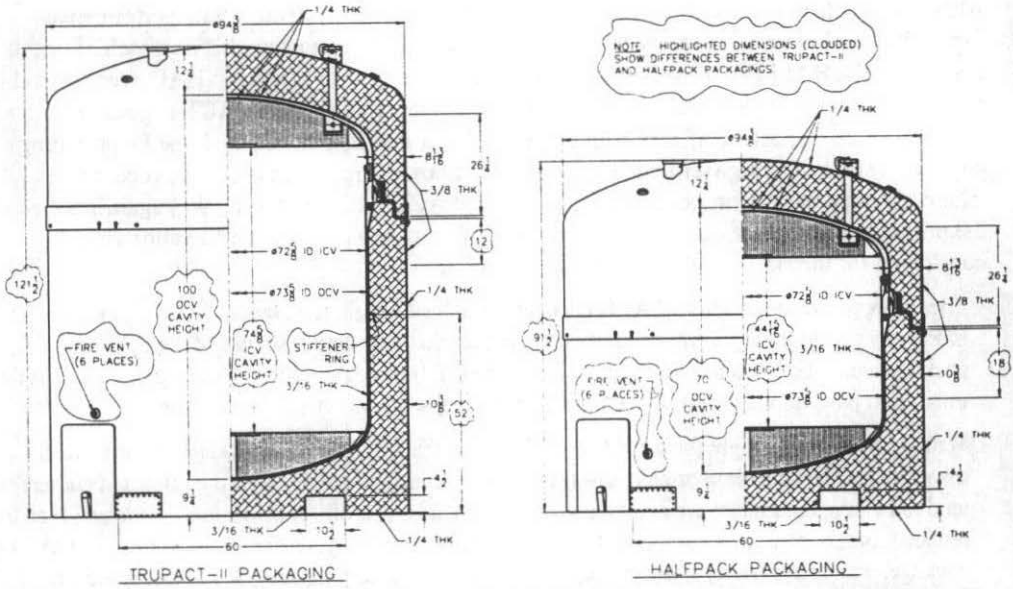


Figure 2 HALFPACK/TRUPACT-II Packaging Design Comparison (dimensions in inches)

OPERATIONAL IMPROVEMENTS

In addition to the primary design changes identified in the preceding discussion, several minor modifications are incorporated in the HALFPACK packaging design based on TRUPACT-II packaging operational experience. None of these are considered to have any significance on certifiability, and all are likely be adopted for the TRUPACT-II packaging during future licensing revisions for that packaging. A listing of the representative improvements is as follows.

- Reduced seating torque for the vent and seal test port plugs to avoid damage to the plug seats during the tightening process.
- Redesign of the ICV honeycomb end spacer attachments to preclude weld fatigue failures.
- Addition of a 1×10^{-3} specific cubic centimeters per second (scc/sec), air, gas pressure rise assembly verification leak test as an option to the 1×10^{-7} scc/sec, air, assembly verification leak test specified for the TRUPACT-II packaging.
- Addition of two additional locking ring stop plates since a single stop plate used for the TRUPACT-II packaging closure system is prone to failure during locking ring operation.
- Optionally painting the HALFPACK packaging exterior surface for enhanced cleaning and decontamination.

CERTIFICATION STRATEGY AND ISSUES

Although analytic methods were used to demonstrate TRUPACT-II package performance capabilities for all normal conditions of transport (NCT), except free drop, full scale testing was used to address the much more demanding hypothetical accident condition (HAC) free drop, puncture, and fire events. Extensive testing for these conditions led to the final TRUPACT-II packaging design configuration. Consequently, certification of the TRUPACT-II package is considered to have been achieved by test.

Although certification testing is an excellent way to conclusively demonstrate performance capability, final margins of safety typically go unquantified when using this approach. For this reason, for the HALFPACK packaging, unless package response to a given HAC event is readily shown to be less bounding than the corresponding response of the TRUPACT-II package, a certain amount of HALFPACK testing is inevitable. It may also be realized that by providing physical test results for governing HAC load conditions, the regulatory review process is inherently expedited. Consequently, for the HALFPACK program, testing was again selected as the primary performance demonstration method. The more significant certification issues considered for the HALFPACK packaging are as follows.

- The desire to maximize HALFPACK packaging payload weight (i.e., seven, 1,000 pound drums) inherently precludes the ability to easily demonstrate that side drop response of the HALFPACK package would be less significant than the TRUPACT-II package. Without testing, it was clear that maximum payload weight would be limited to an overly conservative, lower value.
- With a lower gross weight for the HALPACK versus the TRUPACT-II package, deformations associated with stable drop orientations (i.e., with the center of gravity over the impacted corner) tend to be less, but impact accelerations tend to be greater. Careful consideration was also given to a reduced rotational moment of inertia for the HALFPACK package as compared to the TRUPACT-II package, which could lead to higher slapdown impacts. Subsequent analyses demonstrate the TRUPACT-II package bounds the HALFPACK package for all slapdown orientations.

- The relative positions of the package center of gravity and initially impacted feature of interest in many puncture events is different for the HALFPACK package versus the TRUPACT-II package. From TRUPACT-II package certification testing, the angle of attack of the puncture bar relative to the impacted surface of the package is known to be a critical parameter.
- With 1,000 pound payload drums (versus 500 pounds (227 kgs) for the TRUPACT-II package) immediately adjacent to the package closure devices, the potential for payload induced damage to the closure region is significantly greater for the HALFPACK versus the TRUPACT-II package.
- Subsequent to initial certification of the TRUPACT-II package, the applicable NRC regulations were revised to require the effects of solar heating following the fire event.

In an effort to minimize the extent of testing that would clearly be required, several meetings were held with the USNRC prior to finalizing test details. This process led to a limited set of test orientations and limited amount of test instrumentation. Planned testing details are provided in the following sections.

Several other miscellaneous certification issues also came up during early meetings with the USNRC. Most are a result of the TRUPACT-II packaging design being originally licensed in 1989, whereas the current regulations are applicable to the HALFPACK packaging design. Representative is the need for an improved, performance based polyurethane foam specification.

HALFPACK PACKAGE PERFORMANCE COMPARED WITH THE TRUPACT-II

To initially establish how the HALFPACK package responds to HAC events compared to the TRUPACT-II package, a full scale, engineering test unit (ETU) was created from an existing TRUPACT-II training unit by shortening the packaging body by 30 inches (76.2 cm). Three, NCT free drops, three, HAC free drops, four HAC puncture drops, and a HAC fire test were performed. Key results from the testing are as follows.

- Side drop deformation for the HALFPACK package with a 7,000 pound (3,175 kg) payload is essentially identical to the TRUPACT-II package side drop damage; further reductions in payload weight are not necessary.
- From a consideration of puncture events, the 3/8 inch (1.0 cm) thick, OCA body shell is extended six inches (15.2 cm) to ensure that penetration of the HAC puncture bar for the HALFPACK package occurs no closer to the OCV seals than occurred for the TRUPACT-II package.
- Payload induced deformation in the HALFPACK package closure region is more extensive than observed for the TRUPACT-II package, but remains well within acceptable limits established in closure ring mock-up testing performed during development of the TRUPACT-II packaging design.
- All containment seals remained leaktight (i.e, leak rate less than 1×10^{-7} scc/sec, air) subsequent to the fire test.

FULL SCALE CERTIFICATION TESTING

Based on the results from the ETU testing and consideration of the results obtained from extensive testing previously performed on full scale TRUPACT-II packages, a set of certification tests is selected for the HALFPACK package program. This is done in conjunction with the USNRC in an effort to address potential issues prior to submittal of the licensing application. As with the engineering prototype test program, a HALFPACK certification test unit (CTU) is created from an existing TRUPACT-II training unit by shortening the body length by 30 inches (76.2 cm).

The success of TRUPACT-II package certification testing, combined with the similarity of the HALFPACK packaging to the TRUPACT-II packaging, will most likely result in significantly less HALFPACK package certification testing than for the TRUPACT-II package program. Figure 3 presents the test orientations planned for HALFPACK package certification testing in March, 1998, at Sandia National Laboratories in Albuquerque, New Mexico, USA. Figure 4 presents the far more extensive set of tests performed for certification of the TRUPACT-II packaging design. As indicated, the TRUPACT-II package testing program required two certification test units.

In addition to the significantly reduced number of tests, other test simplifications are also realized for the HALFPACK package. Although a variety of cold and ambient condition tests with various combinations of internal pressures within the inner and outer containment vessels were performed for TRUPACT-II package certification testing, ambient temperature tests without internal pressures are readily justified for HALFPACK package certification testing. In addition, although the TRUPACT-II package was preheated prior to the HAC fire test to maximize packaging temperature at the start of the HAC fire event, analysis is able to demonstrate that preheat is not needed for the HALFPACK package HAC fire test, even with the new regulatory requirement for solar heating following the HAC fire event. Instead, conservative thermal analyses are used to demonstrate that seal temperatures remain below allowable limits, even if the package is preheated prior to HAC fire testing. This approach is possible as a direct result of the large margins of safety against seal failure demonstrated during TRUPACT-II package certification testing (a measured temperature of 260 °F (127 °C) in the vicinity of the seals is 140 °F (78 °C) below the established seal material limit).

Accelerometer and thermocouple instrumentation used during TRUPACT-II certification testing is also eliminated, making the HALFPACK certification test much more of a "go/no-go" test, with acceptance being based on both inner and outer containment boundaries remaining leaktight subsequent to the HAC sequence of events. Besides the demonstration of leaktightness, the only post-test data of significance for HALFPACK certification testing, are packaging deformation measurements and readings from passive temperature indicating devices used in the vicinity of the closure seals. Successful full scale testing of the HALFPACK package certification unit, as described above, is the cornerstone for obtaining the required USNRC Certification of Compliance.

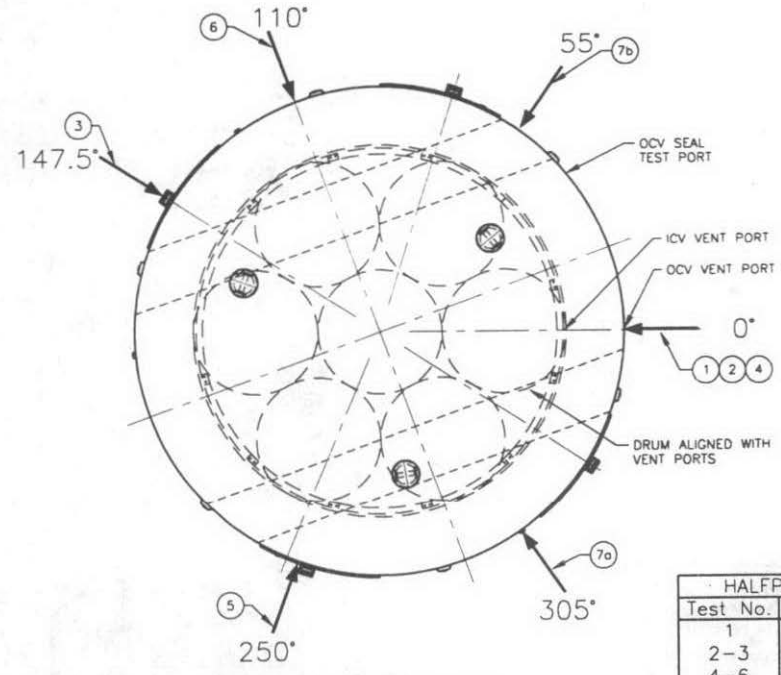
CONCLUSION

A new packaging design (HALFPACK) has been developed by shortening and otherwise modestly modifying an existing, USNRC licensed design (TRUPACT-II). The HALFPACK Safety Analysis Report (SAR) is now in final preparation for submittal to the USNRC. Due to the strong similarities to the previously licensed TRUPACT-II packaging, plus extensive and successful HAC testing of both package designs, the NRC certification process is expected to be very straightforward. The flexibility of having the HALFPACK package for handling seven heavy 55-gallon (208 l) drums, averaging 1,000 pounds each, in addition to the TRUPACT-II package for handling fourteen lighter 55-gallon (208 l) drums, averaging 500 pounds (227 kgs each, will significantly improve system operations and reduce the number of shipments of CH-TRU waste to the WIPP site that would be required if only the TRUPACT-II package is utilized.

REFERENCES

P. C. Gregory, S. A. Porter, *Design and Testing of TRUPACT-II*, Volume 1, Patram '89 Proceedings.

Title 10, Code of Federal Regulations, Part 71 (10 CFR 71), *Packaging and Transportation of Radioactive Materials*, 1996.



HALFPACK CTU NO. 1	
Test No.	Test Type
1	NCT Free Drop
2–3	HAC Free Drops
4–6	HAC Puncture Drops
7	HAC Fire

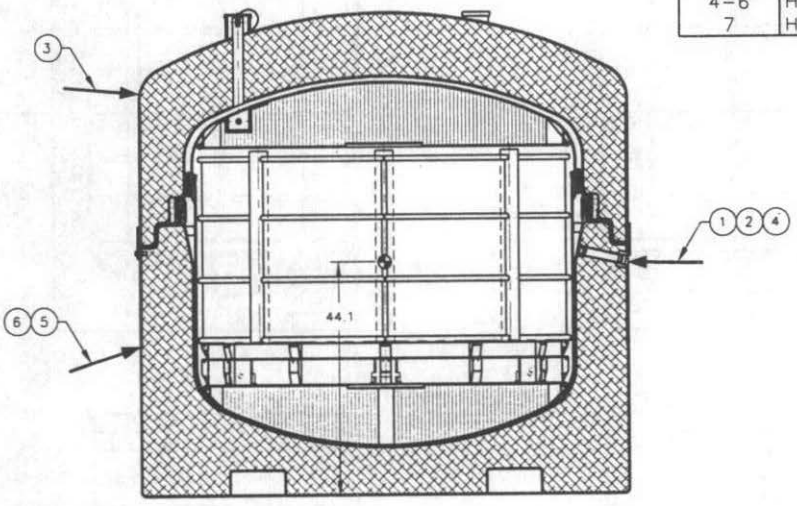
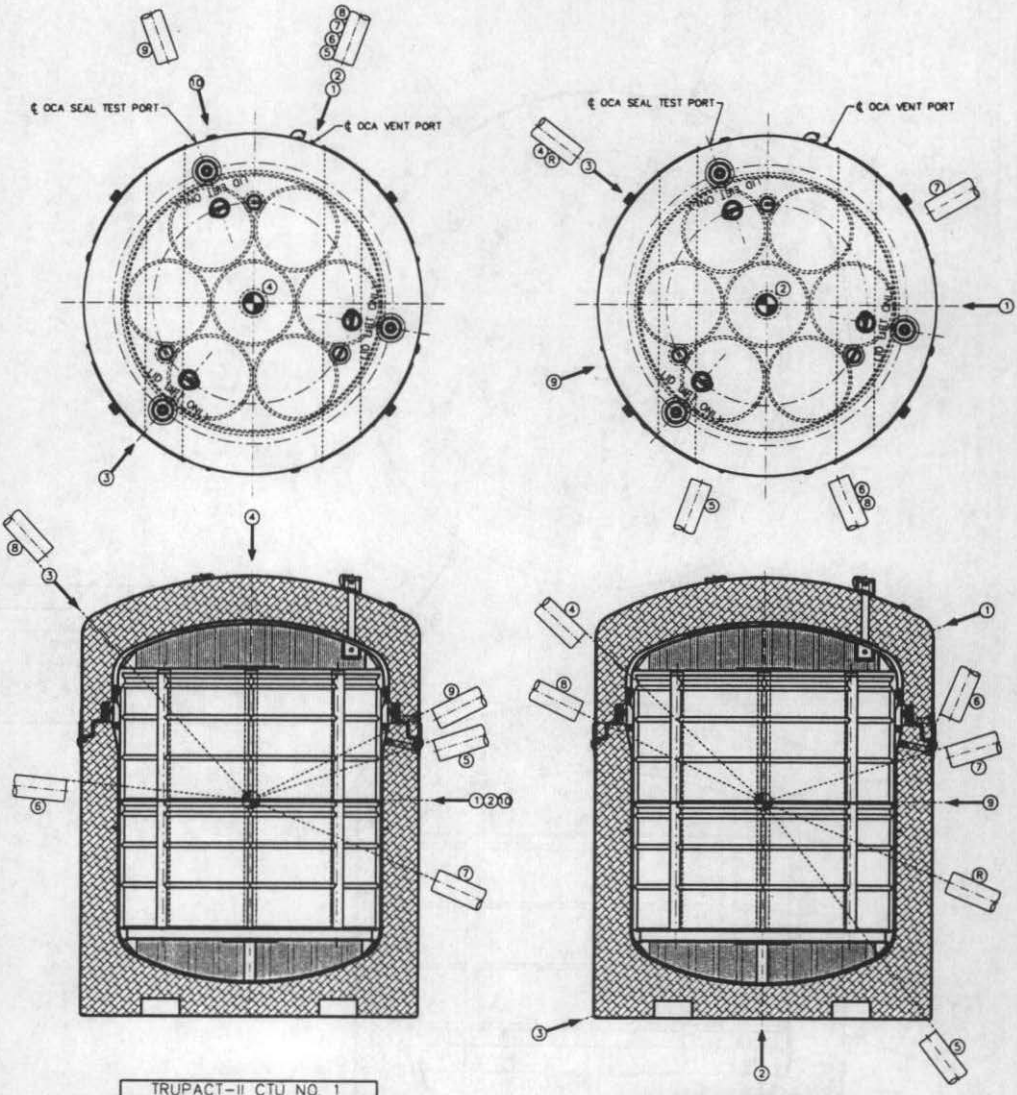


Figure 3 Certification Tests Planned for HALFPACK CTU No. 1



TRUPACT-II CTU NO. 1	
Test No.	Test Type
1	NCT Free Drop
2–4	HAC Free Drops
5–9	HAC Puncture Drops
10	HAC Fire

TRUPACT-II CTU NO. 2	
Test No.	Test Type
1–3	HAC Free Drops
4–8, R	HAC Puncture Drops
9	HAC Fire

Figure 4 Certification Tests Performed on TRUPACT-II CTUs No. 1 and 2

SESSION 4.3

Structural Materials