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Testing in Support of Transportation of Residues in the Pipe Overpack Container

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Abstract

The disposition of the large back-log of plutonium residues at the Rocky Flats Environmental Technology Site (Rocky Flats) will require interim storage and subsequent shipment to a waste repository. Current plans call for disposal at the Waste Isolation Pilot Plant (WIPP) and the transportation to WIPP in the TRUPACT-II. The transportation phase will require the residues to be packaged in a container that is more robust than a standard 55-gallon waste drum. Rocky Flats has designed the Pipe Overpack Container to meet this need. The tests described here were performed to qualify the Pipe Overpack Container as a waste container for shipment in the TRUPACT-II. Using a more robust container will assure the fissile material in each container can not be mixed with the fissile material from the other containers and will provide criticality control. This will allow an increase in the payload of the TRUPACT-II from 325 fissile gram equivalents to 2800 fissile gram equivalents.

Acknowledgments

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Testing in Support of Transportation of Residues in the Pipe Overpack Container

1. Introduction

The disposition of the large back-log of plutonium residues at the Rocky Flats Environmental Technology Site (Rocky Flats) will require interim storage and subsequent shipment to a waste repository. Current plans call for disposal at the Waste Isolation Pilot Plant (WIPP) and the transportation to WIPP in the TRUPACT-II. The transportation phase will require the residues to be packaged in a container that is more robust than a standard 55-gallon waste drum. Rocky Flats has designed the Pipe Overpack Container to meet this need. Figure 1 shows a section through the center of both versions of the Pipe Overpack Container. The tests described here were performed to qualify the Pipe Overpack Container as a waste container for shipment in the TRUPACT-II. Using a more robust container will assure the fissile material in each container can not be mixed with the fissile material from the other containers, providing criticality control. This will allow an increase in the payload of the TRUPACT-II from 325 fissile gram equivalents to 2800 fissile gram equivalents.

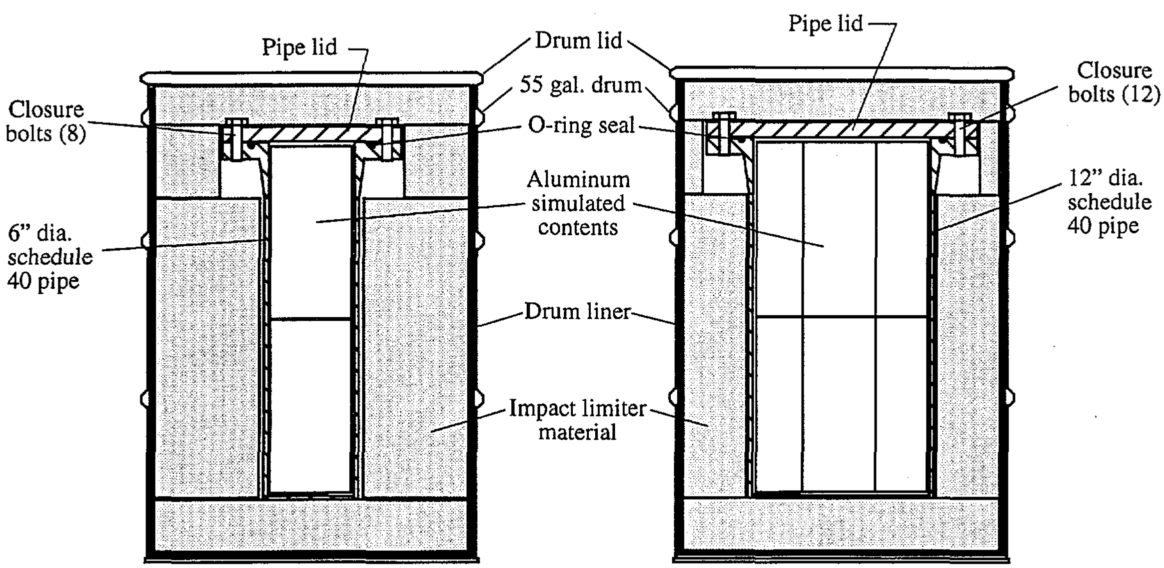


Figure 1: Diagram of the Pipe Overpack Container. The left figure is the 6" container and the right figure is the 12" container.

2. Tests Performed

The tests performed for the purpose of qualifying the Pipe Overpack Container as a waste container to be shipped in the TRUPACT-II transportation container are 30 MPH impacts of two drum stacks in an end-on orientation and two 7-packs of drums in a side-on orientation inside of a TRUPACT-II inner containment vessel (ICV). Each of these tests is described below.

2.1. Two Drum Stack Impact Tests

In the two drum stack tests, two Pipe Overpack containers are strapped together in an upright orientation. The two drums are then inverted and raised to a height to allow impact at a velocity equivalent to the velocity obtained in a free drop from 9 meters (13.3 m/s or 30 MPH), the drop height required for hypothetical accident testing of transportation packages in 10CFR71. Since these drops are conducted by guiding the drums to just above the impact point on the essentially unyielding target, the actual drop height is slightly higher than 9 meters to take into account guide-wire friction. These tests were performed at the 185 foot drop tower facility in Technical Area III at Sandia National Laboratories. Tests were performed in the end-on orientation to simulate the response the Pipe Overpack Containers would exhibit during an end drop of the TRUPACT-II. Tests were performed with a 6" Pipe Overpack Container on top of a 6" Pipe Overpack Container, with a 12" Pipe Overpack Container on top of a 12" Pipe Overpack Container, and with a 12" Pipe Overpack Container on top of a 6" Pipe Overpack Container. These configurations simulate a full TRUPACT-II load of 6" Pipe Overpack Containers, a full load of 12" Pipe Overpack Containers, and a mixed load of 12" and 6" Pipe Overpack Containers. Figure 2 shows a photograph of the test set-up.

2.2. TRUPACT-II Inner Containment Vessel Drop

This test consists of dropping the Inner Containment Vessel (ICV) of a TRUPACT-II loaded with a 7-pack of 12" Pipe Overpack Containers and a 7-pack of 6" Pipe Overpack Containers onto the essentially unyielding target at the Aerial Cable Facility at Sandia National Laboratories. The ICV is a 3/16" thick stainless steel shell with a bore seal and lock ring closure. This test was performed

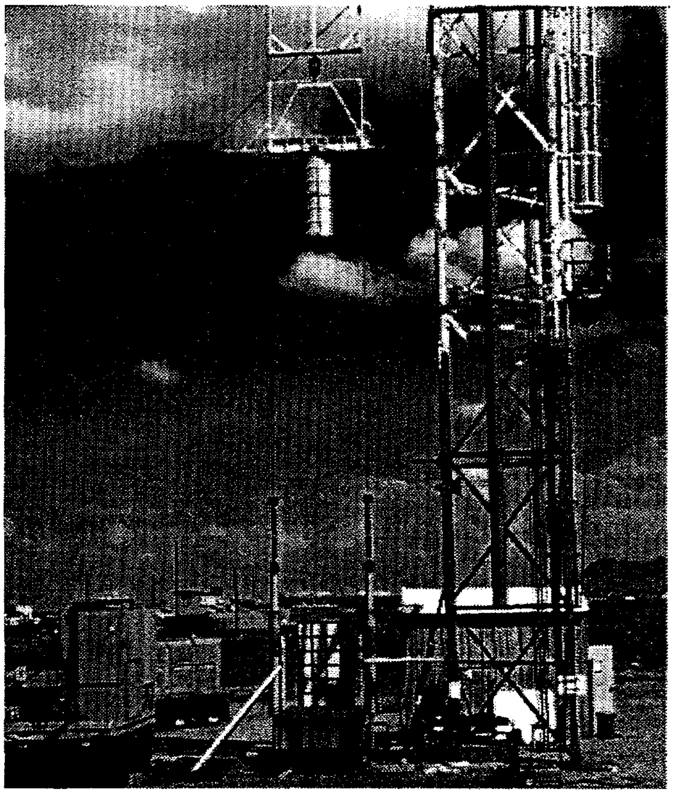


Figure 2: Test set-up for the two drum stack tests of the Pipe Overpack Container. The containers impact on the closure end with a velocity of 13.3 m/s (30 MPH).

to simulate the response of the Pipe Overpack Containers to a side drop of the TRUPACT-II. The unit was rigged so the slightly larger diameter lid would impact at the same time as the bottom. Figure 3 shows the pipe overpack containers being loaded into the TRUPACT-II ICV and Figure 4 shows a photograph of the ICV ready to be dropped.

Figure 3: Two seven-packs of Pipe Overpack Containers being loaded into the ICV.

Figure 4: TRUPACT-II ICV ready to be dropped from 30 feet.

3. Package Utilization

The tests described above used a total of 20 Pipe Overpack Containers. Six of these units were dummy units with the correct mass and stiffness, but were not leak checked. These units were used for mass in the top three positions of each 7-pack for the ICV drop. Half of the Pipe Overpack Containers used were 6" diameter and half of them were 12" diameter. All of the test containers had pipes that were spun formed in a single process to make the bottom integral with the pipe sides. Table 1 shows the matrix of the containers used for each test. All of the pipes used Ultratech filters and all of the drums used NFT filters with stainless steel housings and carbon media. Filters are used in the pipes and drums to eliminate the possibility for hydrogen build-up within the containers, a requirement for disposal at WIPP. Figures 5 and 6 show the position of each of the containers in the drop tests for the end-on and ICV drops, respectively.

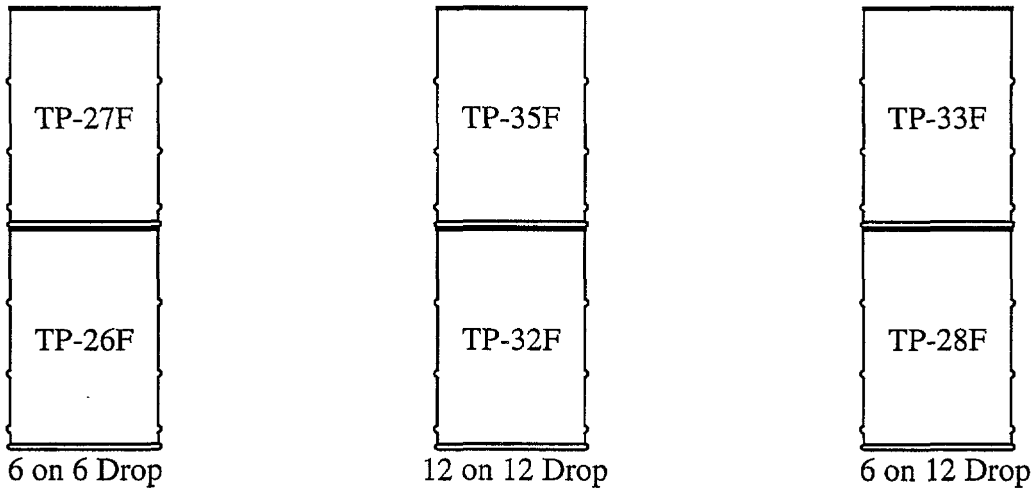


Figure 5: Package positions for the two-drum stack drop tests. All of the drums have their closure ends down.

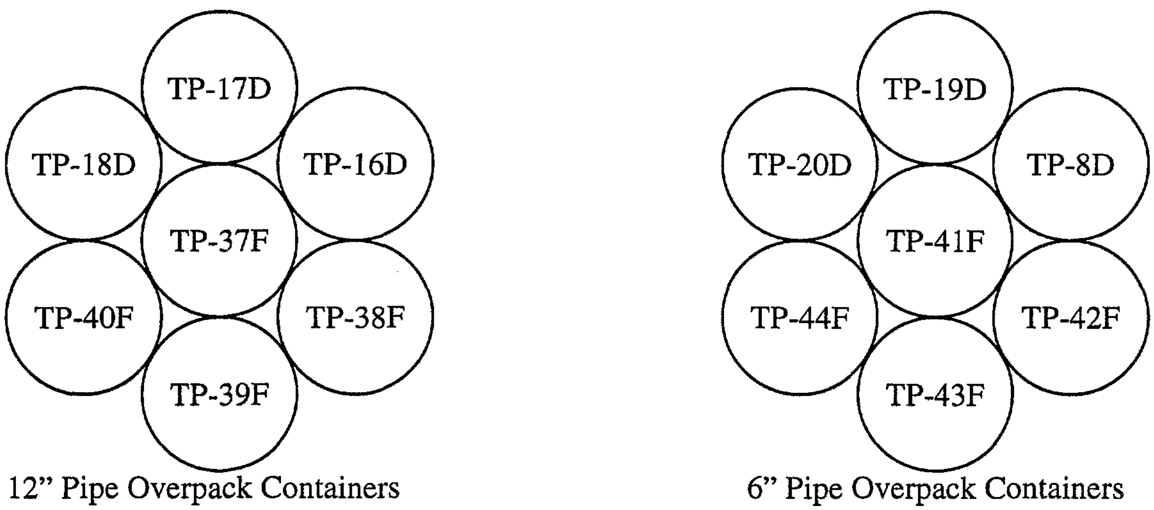


Figure 6: Package positions for the ICV drop tests. The seven-pack with 12" pipes was loaded in the bottom of the ICV and the seven-pack with 6" pipes was loaded in the top.

Table 1: Test Matrix for Pipe Overpack Container Tests

Test Unit	Type	Test	Test Unit	Type	Test
TP-26F	6" formed	6 on 6 drop	TP-41F	6" formed	ICV drop
TP-27F	6" formed	6 on 6 drop	TP-42F	6" formed	ICV drop
TP-32F	12" formed	12 on 12 drop	TP-43F	6" formed	ICV drop
TP-35F	12" formed	12 on 12 drop	TP-44F	6" formed	ICV drop
TP-28F	6" formed	6 on 12 drop	TP-16D	12" dummy	ICV drop
TP-33F	12" formed	6 on 12 drop	TP-17D	12" dummy	ICV drop
TP-37F	12" formed	ICV drop	TP-18D	12" dummy	ICV drop
TP-38F	12" formed	ICV drop	TP-8D	6" dummy	ICV drop
TP-39F	12" formed	ICV drop	TP-19D	6" dummy	ICV drop
TP-40F	12" formed	ICV drop	TP-20D	6" dummy	ICV drop

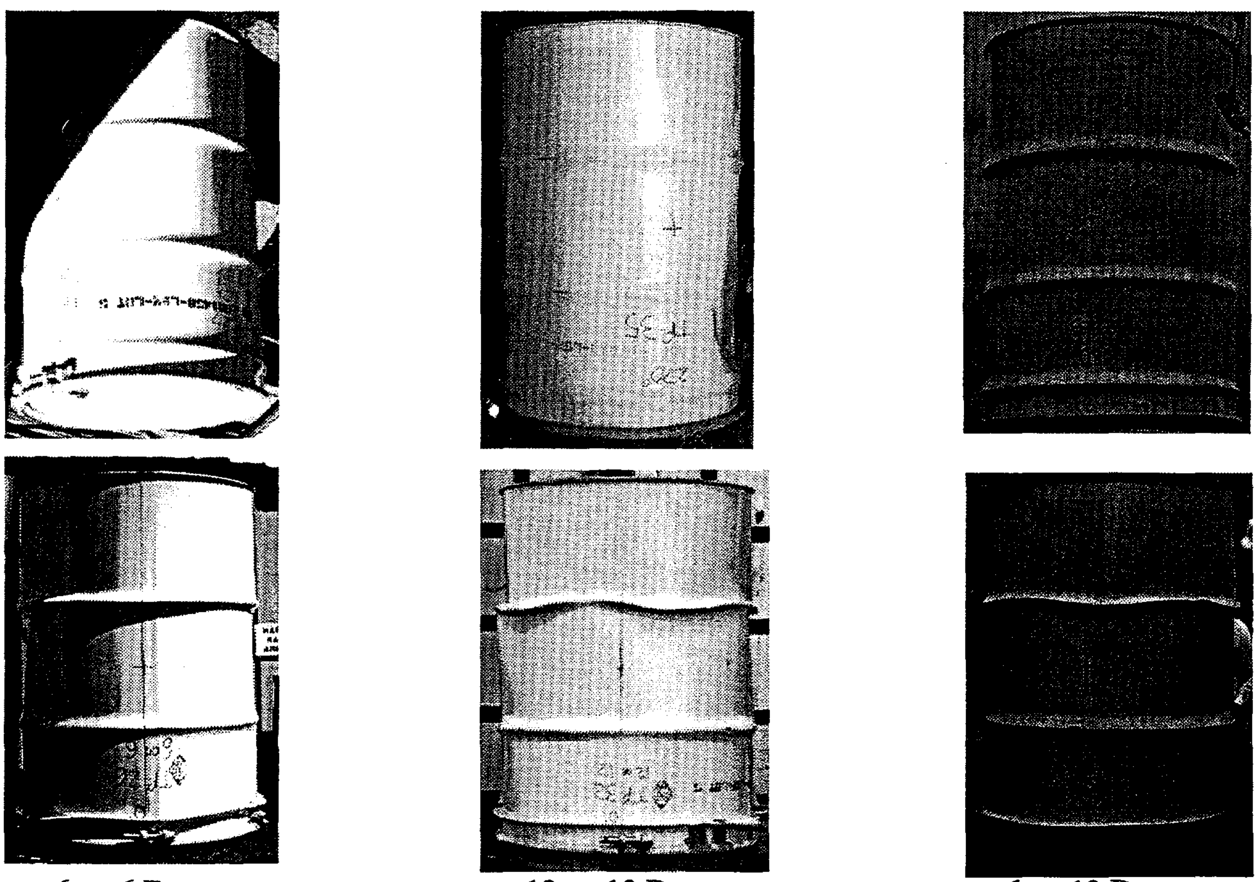
4. Test Results

4.1. Two Drum Stack Impact Tests

The two-drum-stack impact tests evaluated all possible configurations for end drop conditions in a fully loaded TRUPACT-II. If the entire load consists of 6" Pipe Overpack Containers a top drop of the TRUPACT-II will result in a 6" container on top of a 6" container. This is the 6 on 6 drop. The containers used for this test were TP-26F and TP-27F. In the loaded TRUPACT-II TP-26F would have been in the top layer of drums and TP-27F would have been in the bottom layer of drums. Because the accident simulated here is a top drop of the TRUPACT-II, TP-26F impacts the target in a top-down orientation with the top of TP-27F on the bottom of TP-26F. If the entire load consists of 12" Pipe Overpack Containers a top drop of the TRUPACT-II will result in a 12" container on top of a 12" container. This is the 12 on 12 drop. The containers used for this test were TP-32F and TP-35F. In the loaded TRUPACT-II TP-32F would have been in the top layer of drums and TP-35F would have been in the bottom layer of drums. Because the accident simulated here is a top drop of the TRUPACT-II, TP-32F impacts the target in a top-down orientation with the top of TP-35F on the bottom of TP-32F. If the TRUPACT-II was shipped with a mixed load of 6" and 12" Pipe Overpack Containers the load management requirements would force the seven-pack of 12" containers to be in the bottom layer and the seven-pack of 6" containers to be on the top. This is the 6 on 12 drop. The containers used for this test were TP-28F and TP-33F. In the loaded TRUPACT-II TP-28F would have been in the top layer of drums and TP-33F would have been in the bottom layer of drums. Because the accident simulated here is a top drop of the TRUPACT-II, TP-28F impacts the target in a top-down orientation with the top of TP-33F on the bottom of TP-28F. Table 2 shows the amount of crush for each of the packages at four circumferential locations. The 6 on 6 drop resulted in shortening of the Pipe Overpack Container that is compressed by about 2 inches and collapse of the drum chine nearest to the impact. The compressing Pipe Overpack container showed essentially no shortening. For both the 12 on 12 drop and the 6 on 12 drop, the compressed Pipe Overpack Container shortened by about 2.6 inches and collapse of the top and bottom drum chines. Figure 7 shows the deformed drums following the two-drum-stack tests. None of these tests deformed the pipe closures. Figure 8 shows the tops of each pipe following the dynamic crush tests. Each of the pipes was helium leak checked both before and after the tests. Following the tests all of the pipes were leak tight.

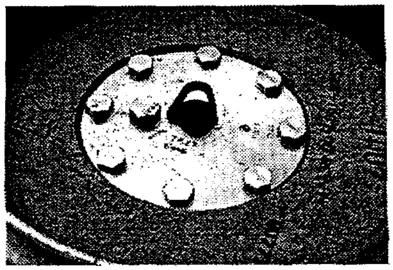
Table 2: Pipe Overpack Container Shortening as a Result of Two-Drum-Stack Tests

Test Unit	Shortening at 0° (inches)	Shortening at 90° (inches)	Shortening at 180° (inches)	Shortening at 270° (inches)	Average Shortening (inches)
TP-26F	2.00	1.88	1.94	2.00	1.95
TP-27F	0	0	0.13	0.06	0.05
TP-32F	2.75	3.00	2.44	2.25	2.61
TP-35F	0	0	0.06	0	0.02
TP-28F	2.94	2.94	2.31	2.44	2.66
TP-33F	0.06	0	0	0	0.02

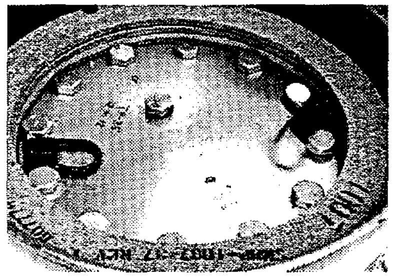


6 on 6 Drop 12 on 12 Drop 6 on 12 Drop

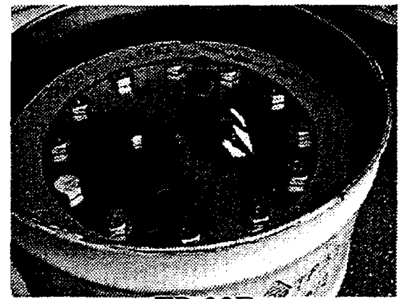
Figure 7: Deformed Pipe Overpack Containers following the two-drum-stack drop tests.



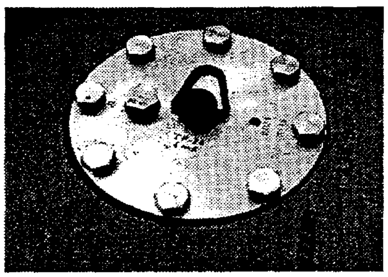
TP-27F



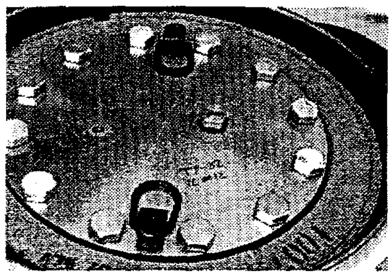
TP-35F



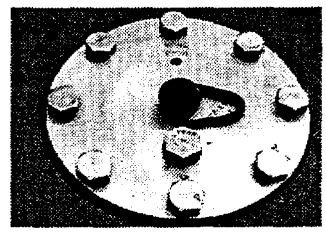
TP-33F



TP-26F



TP-32F



TP-28F

Figure 8: Tops of pipes following the two-drum-stack drop tests.

4.2. TRUPACT-II Inner Containment Vessel Drop

In this test a fully loaded TRUPACT-II ICV was subjected to a 30 foot drop onto an unyielding target. The ICV payload was a mixed load of 6 inch and 12 inch pipe overpack containers. The lower layer was made up of the 12 inch containers and the upper layer was made up of the 6 inch containers. In both layers there were only four containers that were leak tested. The other three containers were dummies, used to provide the correct weight and stiffness. The impact resulted in a slight flattening of the ICV at the impact point. This flattening was more noticeable on the closure end than on the bottom end. Figure 9 shows the deformations in the ICV prior to opening it to remove the Pipe Overpack Containers. During removal of the ICV lid the 6" Pipe Overpack Containers fell out of the ICV. Figure 10 shows the 12" Pipe Overpack Containers before they were removed from the ICV. As can be seen in this figure the test resulted in substantial crushing of the drums at the bottom of the seven-pack. The results for the 6" Pipe Overpack Containers were similar. Figure 11 shows the most damaged 6" and 12" containers. The damage to the 12" container is more severe than the damage to the 6" container because of the much larger weight of the containers above it during the drop. This level of damage to the drum did not lead to any damage of the internal pipe containers. Figure 12 shows the top of the pipes after the drum lids were removed. The maximum deformation for all of the drums from the ICV drop is listed in Table 3.

Following the test, the O-ring seals on all of the containers were leak tight. However, for one package, TP-41F, there was a small leak in the gasket between the filter housing and the pipe container lid. This leak rate was 1.3×10^{-7} cc/sec measured with helium tracer gas. Before the test

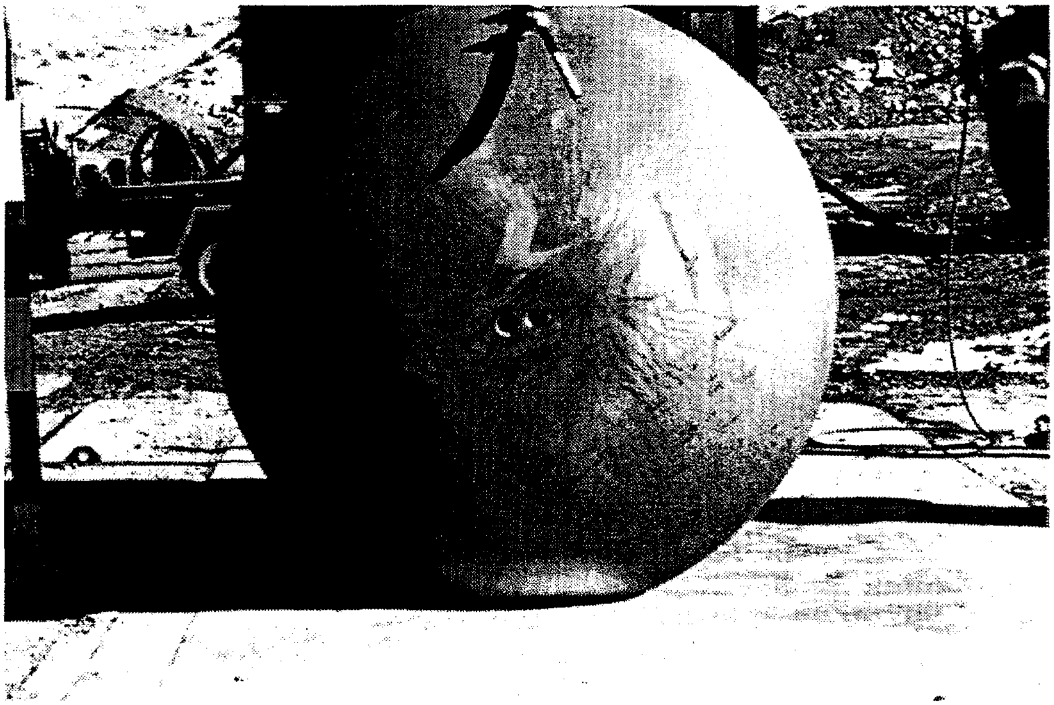
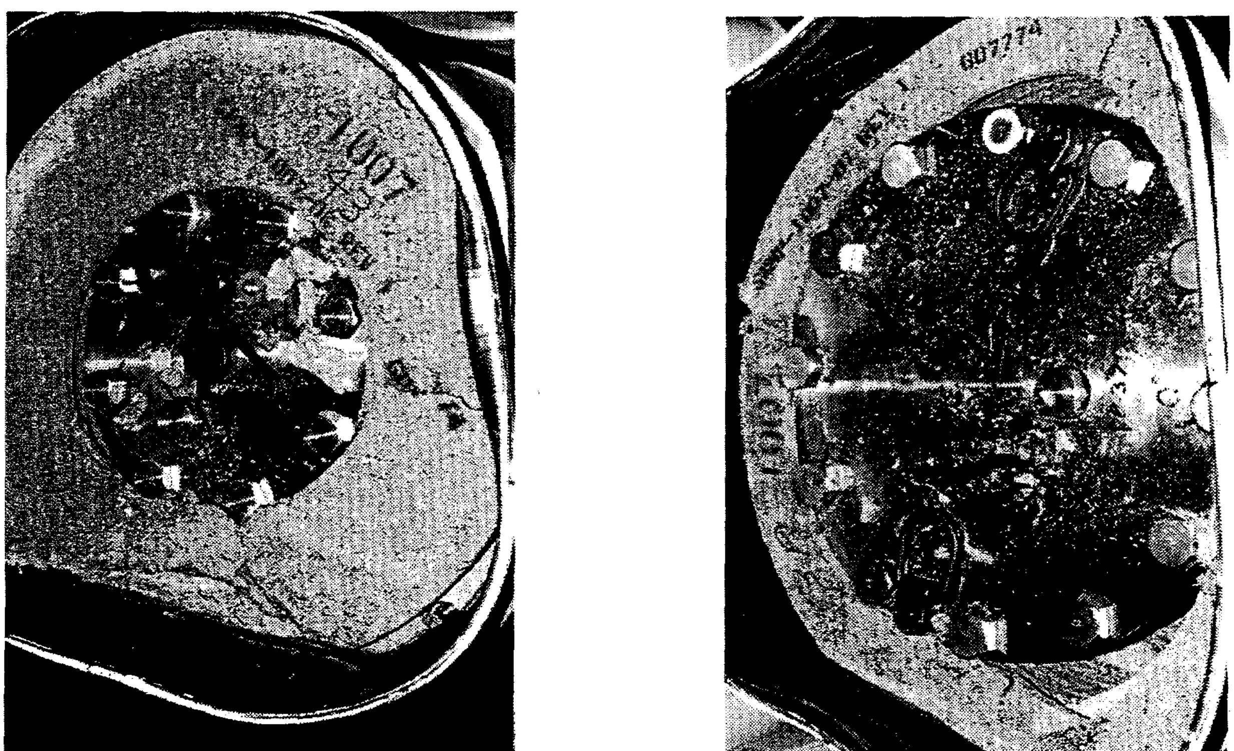


Figure 9: Damage to the ICV from the 30-foot drop test.

Figure 10: Damage to the seven-pack of 12" Pipe Overpack Containers during the ICV drop test.

TP-43F TP-39F

Figure 11: The most damaged Pipe Overpack Containers from the ICV drop.



TP-43F TP-39F

Figure 12: Tops of the two most damaged containers after the drum lids have been removed. In neither case is there any damage to the pipe container.

Table 3: Maximum Deformation for Drums Tested in the ICV Drop

Test Unit	Smallest Diameter[a] (inches)	Location on Drum
TP-41F	20.25	0° @ top chine
TP-42F	21.69	0° @ bottom lip
TP-43F	19.13	0° @ top chine
TP-44F	21.75	0° @ bottom lip
TP-8D	22.25	0° @ above bottom lip
TP-19D	21.88	0° @ above bottom lip
TP-20D	21.63	0° @ bottom lip
TP-37F	18.50	0° @ top lip
TP-38F	20.50	0° @ top lip
TP-39F	18.88	0° @ bottom chine
TP-40F	21.13	0° @ top chine
TP-16D	22.50	0° @ bottom lip
TP-17D	22.06	0° @ bottom lip
TP-18D	20.75	0° @ top lip

a. Nominal drum diameter is 22.5 inches.

an initial assembly of this unit had revealed a similar leak rate, and reassembly of the filter and gasket was required to make the package leak tight. After the post-test leak was discovered, the filter was removed and reinstalled with a new gasket. This resulted in a nearly identical leak rate. Visual inspection of the filter housing showed a fairly smooth surface that mates against the gasket with several minor, random scratches. Other filters inspected showed definite circular tool marks. Tool marks (grooves) in this configuration can improve the behavior of the seal. The original filter assembly also showed that the gasket was partially extruded from under the filter body due to tightening of the filter body. Circular grooves help retain a gasket in position and the other assemblies observed did not show the same degree of gasket extrusion evidenced for TP-41F. For these reasons it is believed the post-test leak rate observed for this unit was a result of a difference in the filter housing, and not a consequence of the ICV drop test. It should be noted that a $1.3x10^{-7}$ cc/sec helium leak rate is indication of a very small leak, and that escape of particulate material from the container would be extremely unlikely. The size of the gap required to produce a helium leak rate of this size is probably no larger than the pore size in the filters installed on the container. Because the Pipe Overpack Container is not a containment boundary, but rather a barrier for migration of fissile material to achieve criticallity control, a leak of this magnitude would not compromise the safety of the package.

5. Conclusions

The results from these tests can be used to determine the ability of the Pipe Overpack Container to provide an effective barrier against material release during transportation within the TRUPACT-II. None of the tests resulted in any significant change to the leak tightness of the containers. This indicates the Pipe Overpack Container would act as an effective barrier to fissile material migration during the regulatory hypothetical accident tests of the TRUPACT-II. All of these tests were conducted without the impact mitigation that would occur due to the foam and thermal insulation material used in the Outer Containment Vessel of the TRUPACT-II container. This added protection provides an increased factor of safety.

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