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Testing in Support of On-Site Storage 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. It is desirable to use this same waste packaging for interim on-site storage in non-hardened buildings. To meet the safety concerns for this storage the Pipe Overpack Container has been subjected to a series of tests at Sandia National Laboratories in Albuquerque, New Mexico. In addition to the tests required to qualify the Pipe Overpack Container as a waste container for shipment in the TRUPACT-II several tests were performed solely for the purpose of qualifying the container for interim storage. This report will describe these tests and the packages' response to the tests.

Acknowledgments

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Testing in Support of On-Site Storage 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 the Pipe Overpack Container. It is desirable to use this same waste packaging for interim on-site storage in non-hardened buildings. To meet the safety concerns for this storage the Pipe Overpack Container has been subjected to a series of tests at Sandia National Laboratories in Albuquerque, New Mexico. In addition to the tests required to qualify the Pipe Overpack Container as a waste container for shipment in the TRUPACT-II, several tests were performed solely for the purpose of qualifying the container for interim storage. This report will describe these tests and the packages' response to the tests.

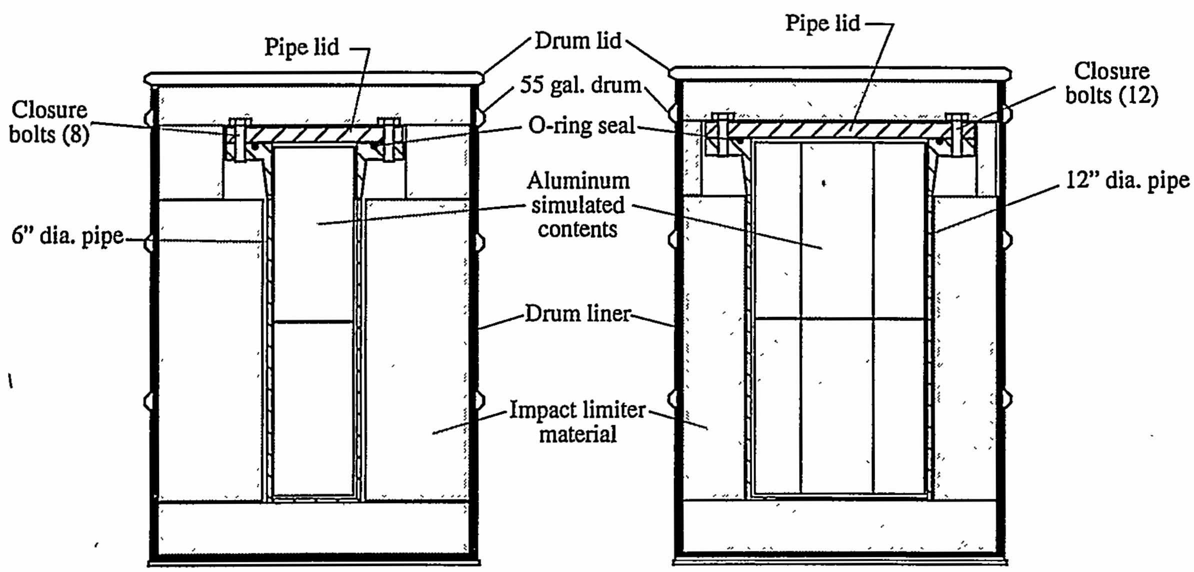


Figure 1: Diagram of the Pipe Overpack Container. The left figure is the 6" container and the right figure is the 12" container.

2. Tests Performed

The tests performed solely for the purpose of qualifying the Pipe Overpack Container for interim storage were a dynamic crush test, a bare pipe drop test, and an engulfing pool fire test. Each of these tests is described below.

2.1. *Dynamic Crush Test*

In the dynamic crush test the Pipe Overpack container is placed on an essentially unyielding target in an upright position. A 500 kg (1100 pound) steel plate 1 meter square is dropped from 9 meters onto the package. The resulting impact velocity is 13.3 m/s (30 MPH). In the tests performed at the 185 foot drop tower facility in Technical Area III at Sandia the plate is guided until just above the package, at which time it is allowed to free-fall the remaining distance. Due to guide-wire friction the initial height of the plate above the package is increased to give a resulting impact velocity of 13.3 m/s. Tests were performed with the package in an upright orientation as this is the orientation they will be in during storage and the test is designed to simulate loading on the package if the roof of the storage building were to collapse onto the package. Figure 2 shows a photograph of the test set-up.

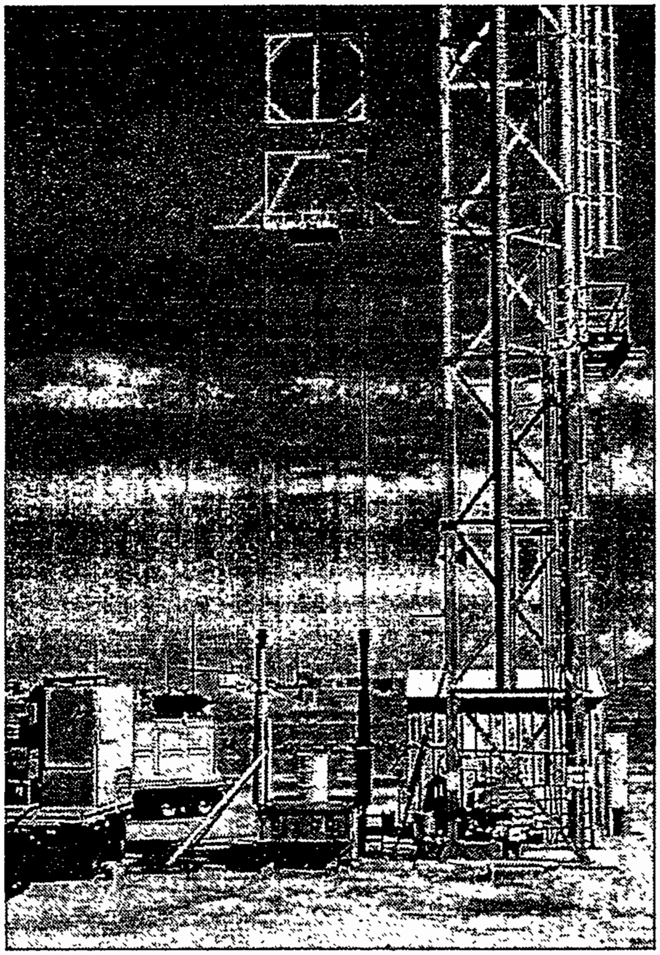


Figure 2: Test set-up for the dynamic crush tests of the pipe overpack container. The 500 kg steel plate is guided down most of the way, and then allowed to free-fall to impact the drum at a velocity of 13.3 m/s (30 MPH).

2.2. *Bare Pipe Drop Test*

This test consists of dropping the inner pipe containment vessel of the Pipe Overpack Container without the impact limiting overpack from 10 feet onto the essentially unyielding target. In the tests performed at the 185 foot drop tower facility in Technical Area III at Sandia the pipes were positioned 10 feet above the unyielding target and allowed to free-fall to impact. The tests were performed with the bolted closure of the pipe impacting the target first. These tests were performed to simulate a handling accident in which the pipe is dropped prior to being placed within the protective overpack. It also may be used to demonstrate safety for a scenario where the interim storage of the pipes are in racks without the protective overpack. Figure 3 shows a photograph of the test set-up.

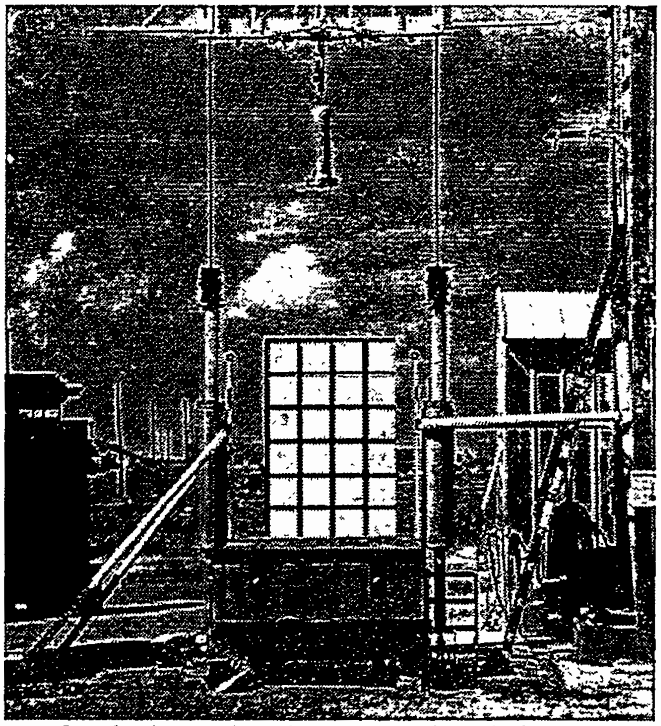


Figure 3: Test set-up for the bare pipe drops. The drop height is 10 feet. A 6" diameter pipe is shown here.

2.3. Engulfing Pool Fire Test

In this test four Pipe Overpack Containers were placed on an open support stand with one meter spacing between them in a square array. The bottom of the units were one meter above the surface of a 10 meter square pool of jet fuel floating on top of a layer of water at the Lurance Canyon pool fire test facility at Sandia National Laboratories. The pool has louvered wind shields around it to reduce the wind speed at the edge of the pool. The amount of fuel initially in the pool is slightly less than the amount generally required for a 30 minute fire. As the fire progresses additional fuel is added so the fire duration is 30 minutes. This type of fire test generally results on flame temperatures between 800° C and 1100° C. This test is performed to simulate the assault to the packages that would occur if there was a fire in the storage building. Figure 4 shows a photograph of the four packages on the support stand prior to the start of the fire.

3. Package Utilization

The tests described above used a total of 8 Pipe Overpack Containers and 2 pipe inner containment vessels. Half of these pipes were 6" diameter and half of the pipes were 12" diameter. For the

Figure 4: Four pipe overpack containers in position for the engulfing pool fire test.

dynamic crush and fire tests, pipes with welded bottoms and pipes with formed bottoms were used. For the bare pipe drops only pipes with welded bottoms were used. Table 1 shows the matrix of the pipes used for each test. The table also shows the configuration of O-rings and filters used in the assembly of each of the Pipe Overpack Containers and pipe containment vessels.

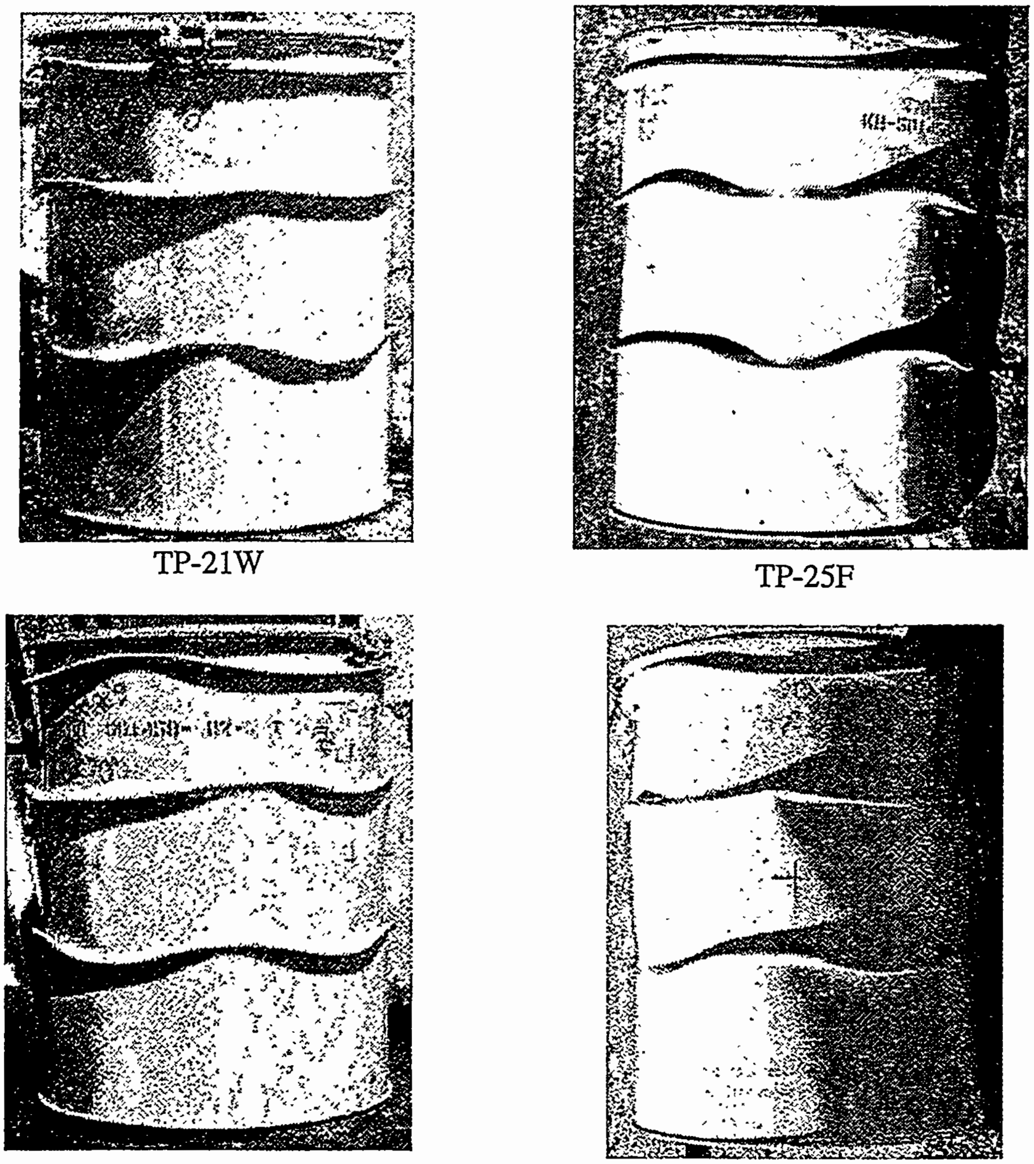
Table 1: Test Matrix for Pipe Overpack Container Tests

Test Unit	Type	Test	Drum Filter	Pipe Filter	O-Ring
TP-21W	6" welded	dynamic crush	NFT, SST-C	Ultra, SST	EP 2-263
TP-25F	6" formed	dynamic crush	NFT, SST-C	Ultra, SST	EP 2-263
TP-29W	12" welded	dynamic crush	NFT, SST-C	Ultra, SST	EP 2-382
TP-36F	12" formed	dynamic crush	NFT, SST-C	Ultra, SST	EP 2-382
TP-22W	6" welded	fire test	NFT, Poly	Ultra, SST	EP 2-263
TP-24F	6" formed	fire test	NFT, SST-C	Ultra, SST	EP 2-263
TP-31W	12" welded	fire test	NFT, Poly	NFT, SST-SS	EP 2-382
TP-34F	12" formed	fire test	NFT, Poly	Ultra, SST	Si 2-382
TP-23W	6" welded	bare pipe drop	---	Ultra, SST	EP 2-263
TP-30W	12" welded	bare pipe drop	---	NFT, SST-SS	EP 2-382

4. Test Results

4.1. Dynamic Crush Test

The containers tested in the dynamic crush tests were one each of a 6" Pipe Overpack Container with welded pipe bottom, a 6" Pipe Overpack Container with formed pipe bottom, a 12" Pipe Overpack Container with welded pipe bottom, and a 12" Pipe Overpack Container with formed pipe bottom. These containers were test units TP-21W, TP-25F, TP-29W, and TP-36F, respectively. Table 2 shows the amount of crush for each of the packages. Each of these tests resulted in shortening of the Pipe Overpack Container by about 5 inches and collapse of all three of the drum chines. Figure 5 shows the deformed drums following the dynamic crush test. None of



TP-21W

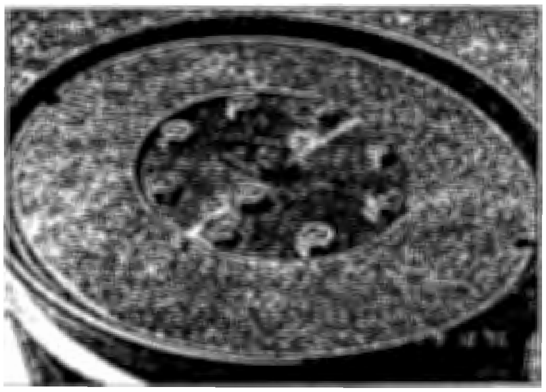
TP-25F

TP-29W

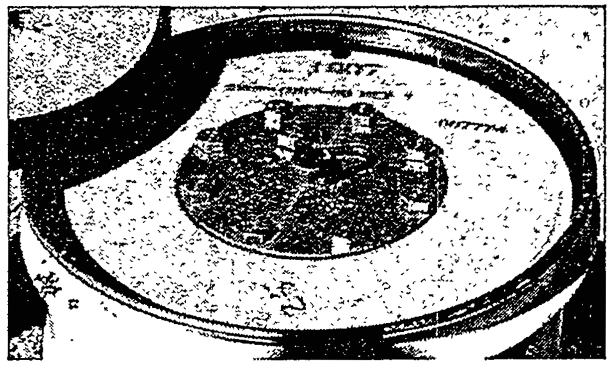
TP-36F

Figure 5: Deformed shapes of the pipe-overpack container drums following the dynamic crush tests.

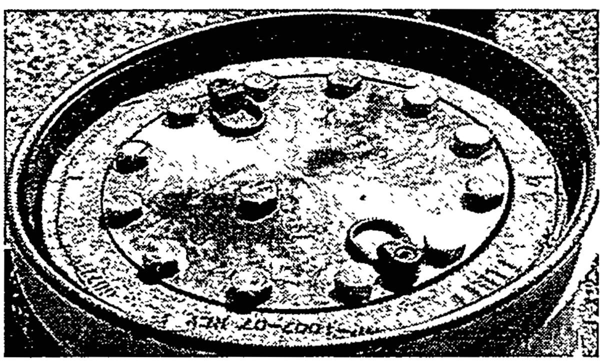
these tests deformed the pipe closures. Figure 6 shows the tops of each pipe following the dynamic crush tests. Each of the pipes was helium leak checked both before and after the tests. For both the 6" and the 12" Pipe Overpack Containers the container with the formed pipe crushed less than the container with the welded pipe. This is because the formed pipes are longer than the welded pipes. In the tests spacers were placed beneath the Pipe Overpack Container so the lid was in the same relative position. However, the spacer was of smaller size than the bottom of the pipe, and was pushed into the plywood layer beneath the pipe during the test. Figure 7 shows the spacers pushed into the plywood layer for TP-29W. Following the dynamic crush test all of the pipes were leak tight.



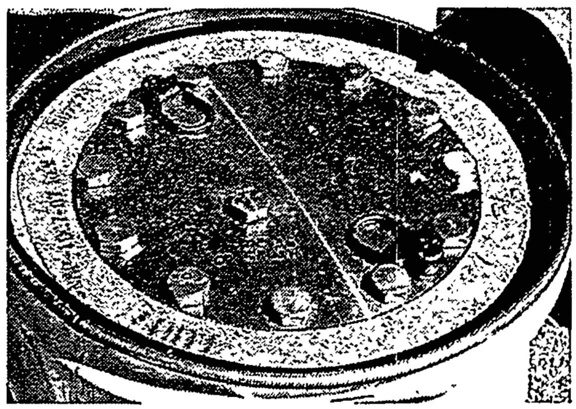
TP-21W



TP-25F



TP-29W



TP-36F

Figure 6: Closure ends of the pipe containers following the dynamic crush tests.

Table 2: Pipe Overpack Container Shortening as a Result of Dynamic Crush Tests

Test Unit	L 0°	L 90°	L 180°	L 270°	Average
TP-21W	5.00	5.06	5.00	5.00	5.02
TP-25F	4.69	5.00	4.94	4.88	4.88
TP-29W	4.94	5.00	4.88	5.19	5.00
TP-36F	4.44	4.69	4.63	4.32	4.52

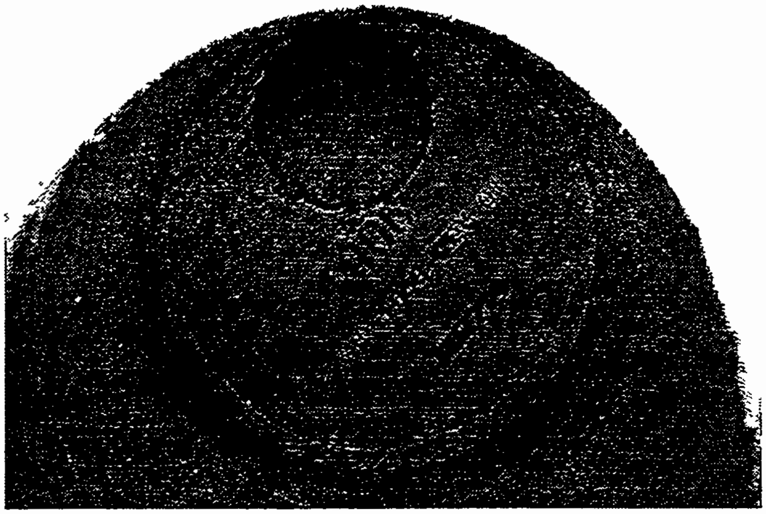
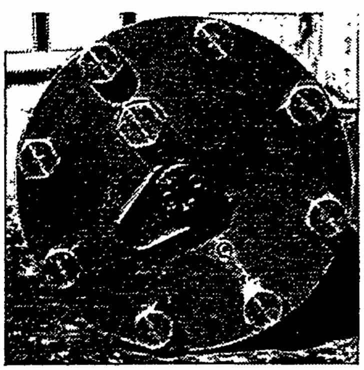


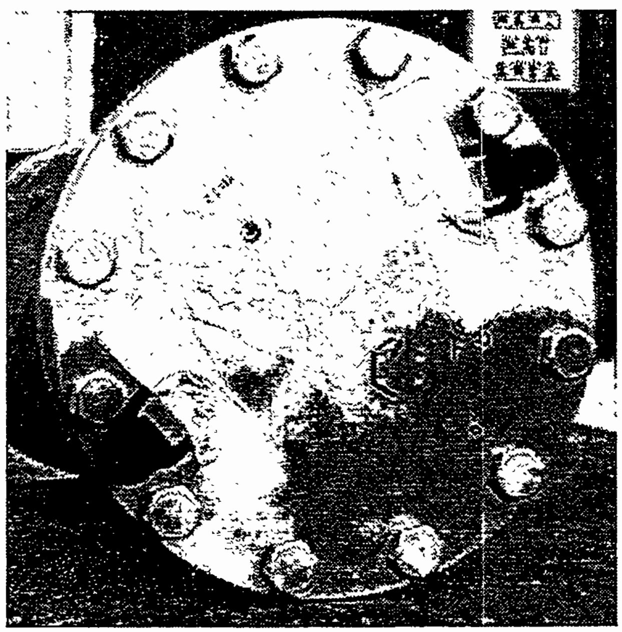
Figure 7: Inside of the pipe container following the dynamic crush tests. The small diameter spacer at the top of the photo was pushed into the plywood layer beneath the pipe for test unit TP-29W. A similar situation occurred for test unit TP-21W.

4.2. Bare Pipe Drop Test

The bare pipe drops subjected a 6" pipe with welded bottom (TP-23W) and a 12" pipe with welded bottom (TP-30W) to a free drop of 10 feet onto an essentially rigid target in an orientation so the lid strikes the target first. Figure 8 shows the tops of the two pipes following the tests. In these drops some of the bolts that attach the lid to the body of TP-30W lost sufficient torque so that they could be loosened by hand. However, the helium leak test of these pipes after the tests indicated they were still leak-tight.



TP-23W



TP-30W

Figure 8: Tops of pipes following the 10-foot drop of the bare pipes.

4.3. Engulfing Pool Fire Test

The Pipe Overpack Containers used in the pool fire test were test units that had not been previously subjected to mechanical testing. The Pipe Overpack Containers tested consisted of one each of a 6" Pipe Overpack Container with welded pipe bottom, a 6" Pipe Overpack Container with formed pipe bottom, a 12" Pipe Overpack Container with welded pipe bottom, and a 12" Pipe Overpack Container with formed pipe bottom. These containers were test units TP-22W, TP-24F, TP-31W, and TP-34F, respectively. Test units TP-22W, TP-31W and TP-34F all had polyethylene housed carbon media filters in the lid of the drums, while test unit TP-24F had a stainless steel housed carbon media filter in the drum lid. Figure 9 shows the fully developed fire. Note that none of the containers can be seen, as they are completely engulfed by flame. Early in the test (approximately 3 minutes) the lid from test unit TP-24F was blown off due to a build-up of pressure inside the drum from thermal decomposition of the drum liner and fiberboard. This is the only test unit that did not have a polyethylene filter housing on the drum lid. The other drums had the filter melt away or soften sufficiently that the pressure inside the drum could push them out and allow the drums to vent through the filter hole. Two of the drums (TP-22W and TP-31W) did build up sufficient internal pressure to cause the lids to bulge outward, but the lids stayed attached to the drums and provided a heat shield that protected the cane fiberboard from the fire. Figure 10 shows the Pipe Overpack Containers at the end of the fire test. Each of the pipe lids in the fire test had passive thermal indicators attached. For the drums where the lids stayed attached these indicators showed a peak temperature of less than 200° F, the lower limit of their indication range. Figure 11 shows the lids of the pipes following their removal from the drums. The polyethylene drum liners from all of the test units were completely destroyed in the fire, and the outer portions of the fiberboard were also burned. For the test units where the lid did not come off the fiberboard next to the pipe looked in pristine condition. The amount of weight loss in the fire tests was about 38 pounds for the drums with lids and about 93 pounds for the drum where the lid came off. Table 3 lists the

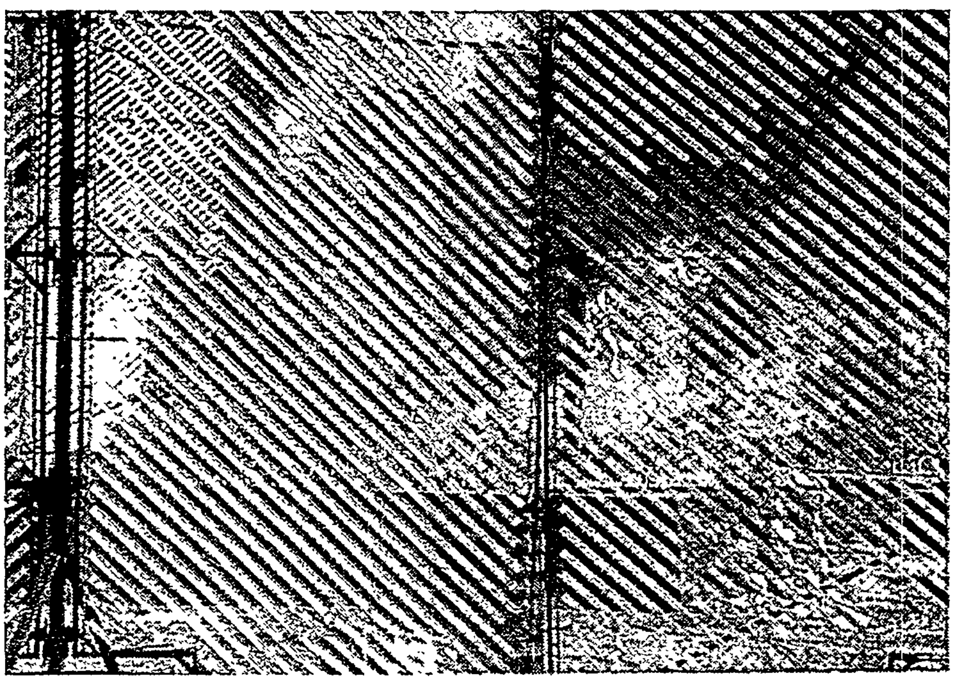


Figure 9: Fully developed, all engulfing, pool fire test of the Pipe Overpack Containers.

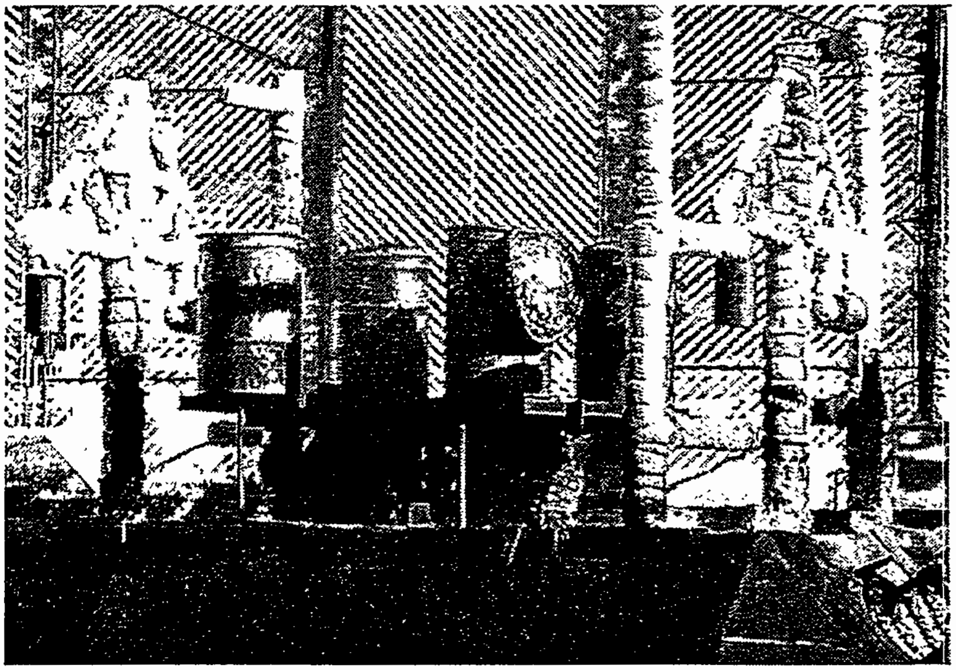
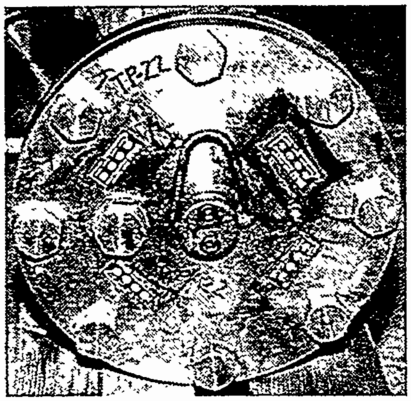


Figure 10: Pipe Overpack Containers at the end of the fire test. Note the lid hanging off of TP-24F and the bulged upward lids of TP-22W and TP-31W.

initial, final and loss of weight for each of the containers. When the lid came off test unit TP-24F the upper layers of fiberboard insulation also came out of the drum. This left the upper part of the pipe directly exposed to the fire, and the temperature of this pipe was sufficient to completely decompose the O-ring seal on the pipe and the gasket under the filter. Figure 12 shows the condition of the O-ring and gasket after disassembly of the pipe. All of the passive temperature indicators were completely burned off of the lid, and the aluminum tape that was over two of the indicators was melted away. This test unit had a post test leak rate of 24 cc/sec, approximately 3/4 of this leakage was between the lid and the pipe body and 1/4 of it was between the filter and the lid. All of the other pipes were leak-tight following the fire test.

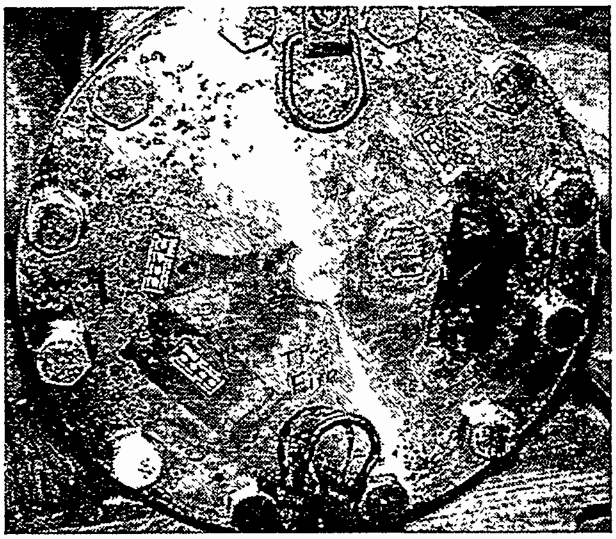
Table 3: Loss of Weight in Fire Test

Test Unit	Initial Weight (pounds)	Final Weight (pounds)	Loss of Weight (pounds)
TP-22W	167.75	129.50	38.25
TP-24F	168.75	75.50	93.25
TP-31W	142.15	105.00	37.15
TP-34F	143.80	103.00	40.80

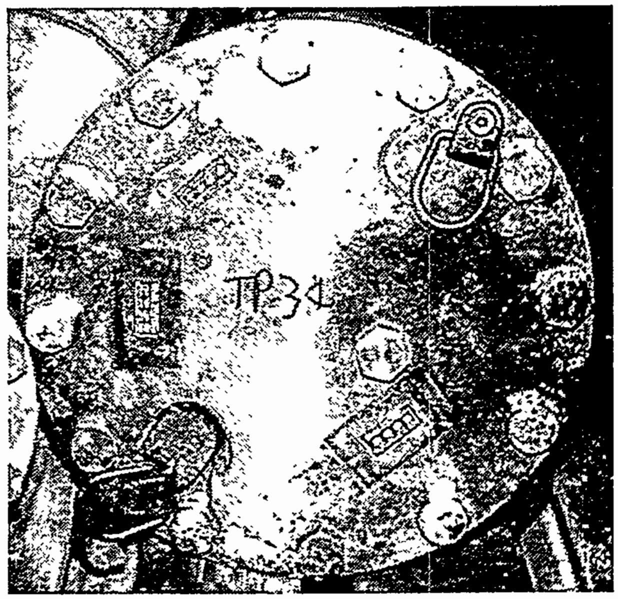


TP-22W

TP-24F



TP-31W



TP-34F

Figure 11: Tops of the pipes after removal from the drums. Note how the temperature indicators have been completely burned off of TP-24F and that none of the temperature indicating spots on the rest of the units have changed color, signifying a maximum temperature less than 200° F.

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 interim on-site storage. None of the mechanical tests resulted in any change to the leak tightness of the containers. In the thermal test only the unit that did not retain its lid had any significant change in temperature. Even this unit did not suffer a catastrophic failure. Only the O-ring and gasket for the filter were damaged by the extreme temperature experienced by this unit. Depending on the form of the contents, this unit would have releases ranging from none to only a small percentage of total radioactive material contents.

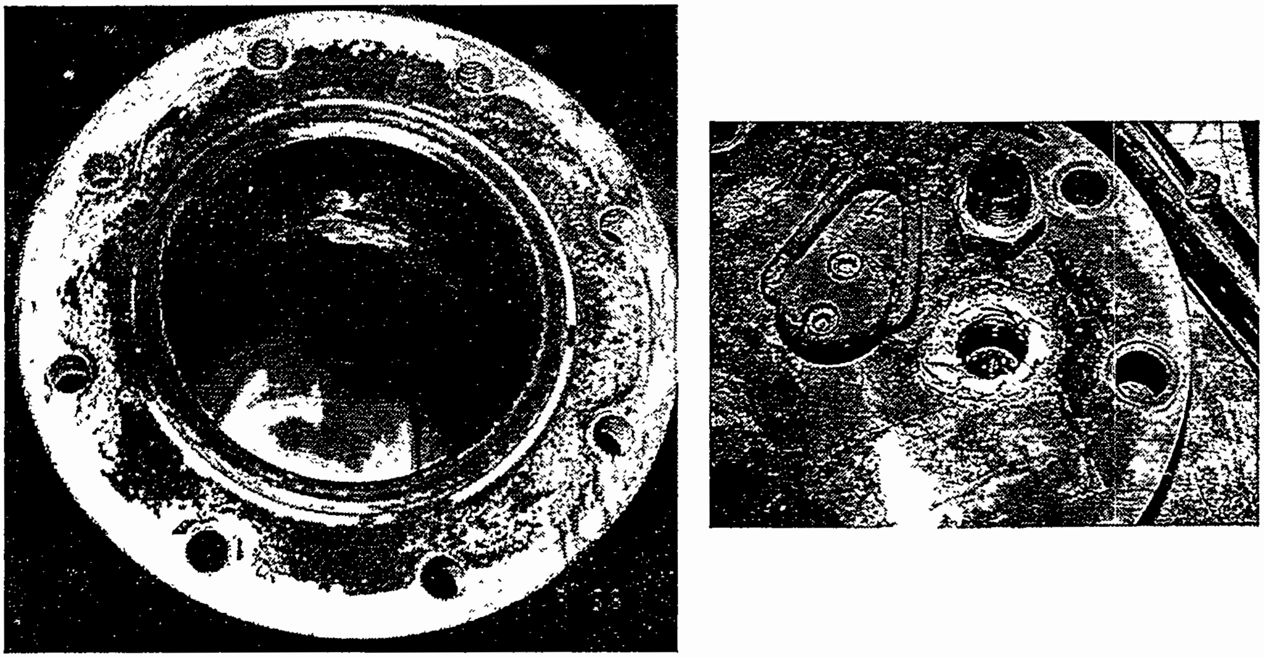


Figure 12: Condition of the O-ring and gasket from TP-24F after disassembly.

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