

Physical Test Report for Drop Test of a 9974 Radioactive Material Shipping Packaging

by

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**PHYSICAL TEST REPORT FOR DROP TEST
OF A 9974 RADIOACTIVE MATERIAL SHIPPING PACKAGING (U)**

P. S. BLANTON

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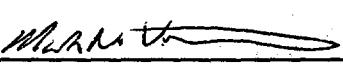
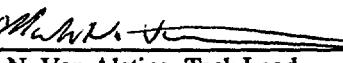
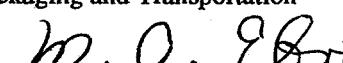
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EXECUTIVE SUMMARY

Drop testing of the 9974 radioactive material shipping package with simulated payloads was conducted to evaluate the response of the drum lid closure to the effects of a 30-foot drop followed by 40-inch puncture pin drop and a 40-inch puncture pin drop without a 30-foot drop. The shipping package was assembled per design drawings except that contents within the containment vessels were simulated using a solid steel bar and lead equivalent in weight to the calculated maximum content weight.

Undamaged packages with simulated contents were first subjected to two 40-inch puncture pin tests. An undamaged package was then subjected to a 30-foot drop onto an unyielding surface, that was designed to weaken the drum lid closure system. The package was turned upside down and oriented at an angle between 25 and 30 degrees from horizontal. It was then rotated slightly to maximize deformation around the closure lug while still maintaining the extension of the lugs from the package surface to allow maximum impact advantage for the subsequent 40-inch puncture pin drop. However, the 30-foot drop resulted in failure of the 9974 package drum closure and the sequential puncture pin test was not performed.

The undamaged 9974 package performed well during the puncture pin drop tests; however, it failed the 30-foot drop test.

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1.0 INTRODUCTION

This report presents the drop test results for the 9974 radioactive material shipping package being dropped onto 6-inch diameter, 40-inch long puncture pin. Also reported are the drop test results for a 30-foot impact that failed the drum confinement boundary. The purpose of these drops was to show that the package lid would remain attached to the drum.

Tests were performed in response to DOE EM-76 review Q5 questions that concerning the capability of the 9974 drum lid to remain in place under this test. One 9974 package was dropped three times utilizing the test drop orientations listed in Table 1.

1.1 *Packaging Orientation in Drop Test*

The response of the 9974 package was evaluated after each of the following drop tests:

Table 1: 9974 Package Drop Test ^(a)

Packaging Type	Procedure Designation	Drop Test Orientation
9974 - Two tests	FP-731 ^[1]	40-inch puncture pin drip, drum right-side up: tilted 10 degrees from vertical. Package impact on drum closure lug(s)
9974	F9-734 ^[2]	30-foot drop up-side down; package tilted 25-30 degrees from horizontal. Package impact on drum closure ring.

Note:

(a) Reference WSRC-RP-97-00444 for 9975 package drop test results.

1.2 *Packaging Drop Test Matrix*

The drop tests described in this report were performed for the 9974 package design. The tests were conducted in the period between October 9, 1997 and October 22, 1997 for the purpose of responding to DOE EM-76 Q5 certification questions for the 9972-9975 family of shipping packages. This report documents only the drop tests performed on the 9974 package.

2.0 DESCRIPTION OF PACKAGING

The 9974 package tested was fabricated and assembled in accordance with the appropriate design drawings^[3] as closely as possible but with some changes as noted below.

2.1 *Description of 9974 Package Assembly*

Figure 1 illustrates the 9974 package configuration as tested. Table 2 lists the 9974 assembly configuration used for these drop tests.

The gross package weight used for these tests was 673 lb. With the exception of a few missing inner component retainer bolts, one honeycomb spacer and the drum air shield, the tested package was assembled as per the design drawings.

The calculated content weight was simulated with a 44.4 lb. solid round bar of steel. The simulated content was firmly packed within a 9974 primary containment vessel.

The drum lid was closed in accordance with established procedure as referenced in the Safety Analysis Report - Packages 9968, 9972-9975 Packages.^[4] The lid closure ring was beaten repeatedly with a rubber mallet while the lug bolt was torqued to the required 50 ft-lb.

3.0 DROP TEST METHODS AND EXAMINATION PROCEDURES

The 9974 package was subjected to two drop test conditions designed to disengage the drum lid from the body of the drum. The drop test conditions and orientations are specified in test procedures.^[1, 2]

3.1 Test Methods for 9974 Packaging

Two tests were made with the 9974 package angled 10 degrees from vertical and aligned 40 inches above a 6-inch diameter puncture pin to hit the drum lug(s) solidly. A new closure ring was used for each test. Figure 2 schematically presents the orientation of the 40-inch puncture pin tests. Two plumb lines were used to align the package and puncture pin for the test.

Figure 2 illustrates the orientation of the 9974 package for the 30-foot drop test. The 9974 package was inclined at approximately 30 degrees from horizontal in an inverted position and dropped 30 feet onto a rigid drop pad. The purpose of the test was to weaken the drum ring and the drum ring closure lug assembly prior to a puncture pin drop. Following the 30-foot drop, the damaged package was to be dropped from a position 40 inches above the surface of a 6-inch diameter 40-inch long puncture pin as illustrated schematically in Figure 2. The puncture drop was designed to impact the weakened drum closure lugs from below in an attempt to fail the lid. However, failure of the 9974 confinement boundary after the 30-foot drop negated the value of a sequential puncture test, and the puncture drop was not performed.

3.2 Pre- and Post-Drop Test Examination Methods

The results of the drop tests were documented using dimensional measurements and photography of the external condition of the package. Video recordings were taken to document the actual drop impact and Packaging response. Pre- and post-drop examination procedures are specified in the test procedures.

4.0 DROP TEST RESULTS

The physical damage imparted to the external components of the shipping package resulting from the drop tests is reported below. Internal package damage was not evaluated.

4.1 Drop Test Results for 9974 Packaging

The 9974 package performed well in the non-sequential puncture testing. The 40-inch puncture drop did little to damage to the drum closure lugs, and the lid remained secured to the package. However, the 30-foot drop resulted in partial detachment of the drum lid and, hence, failure.

4.1.1 Puncture Pin Drop Results

Two 40-inch drop tests were performed. The first drop, the package was oriented so that both lugs would

strike the pin solidly. For the second drop test, package was oriented so that only one lug would strike the pin. The measured deformations from these impacts are given in Table 3. Measurement methods are illustrated in Figure 3.

The non-sequential 40-inch puncture pin drop tests produced very little drum deformation. The deformation that did occur was located just around the closure lugs as shown in Figure 4. As shown, the lugs rotate upwards slightly. As the lugs rotate upward, this causes the ring to deform plastically as can be seen in Figure 4. Depending on whether both lugs or only one lug is impacted, the deformation of the closure ring is only evident 2 to 4 inches away from the lug assembly, respectively. The body of the drum received no visible damage from the drop. Video review of the impact does not indicate any potential lid failure.

The minimal upward movement of the lugs appears to be somewhat proportional to the distance between the drum lid and the ring extensions which are attached to the drum closure ring above each lug. These extensions are welded to the closure ring and wrap over the edge of the drum. Figure 4 shows these extensions. Because the physical distance between the bottom of the extensions and the top of the drum lid is small (on average 0.34 inches), the distance the extensions can travel due to the puncture impact is limited, except during the most direct hits. More direct impacts to the lugs tend to just embed them into the drum. The closure ring extensions above the non-threaded lug and threaded lug moved 0.2 inches and 0.17 inches, respectively, as measured from the center of each extension to the lid. Table 4 compares the lug and the ring extensions displacement changes following each drop.

Of more importance other than physical measurements taken, is the general observation that the drum closure is not breached and further, that very little damage is done to the lug connection due the 40-inch puncture pin drop. This conclusion is supported by observations from a series of 40-inch puncture pin drops that included the drop tests reported above and three other drop tests using a 9975 package (with one of these being damaged first by a 30-foot drop).

Following all drop tests, the lug welds and the ring extension welds showed no signs of failure. The bolt showed no signs of damage.

4.1.2 30-Foot Drop Results

Figure 5 presents photographs of the package following the 30-foot drop. The package impacted the pad as planned. Upon impact, the drum rotated about the impacted drum chime and slapped down on the steel pad. As the package rebounded, it kicked backwards while simultaneously rotating bottom-upward. The package struck the steel pad again in nearly the same orientation but many inches from its original impact area. Upon the second impact, the drum again rotated about the top chime and slapped down. Following the second slap, the drum skidded backwards and came to a rest 11 inches back from the second impact area.

The 30-foot impact produced a 12-inch wide flattened area along the drum edge. The initial impact on to the pad caused the lid to detach from the drum approximately 90%. If not for the lug assembly, the lid may have completely disengaged from the drum.

5.0 Conclusion

Tests conducted on 9974 packages consisted of two 40-inch free falls onto a regulatory puncture pin and a 30-foot fall onto a rigid surface. Results from the 40-inch puncture test support a conclusion that the 9974 package lid will not be disengaged by this drop test. However, results from the 30-foot drop that impacts the drum closure ring near the lug assembly revealed a here-to-fore unknown failure mode for the package design. Since the lid separated from the drum (a confinement boundary failure), the air shield above the

Celotex™ insulation would be exposed directly to the flames of a regulatory fire test - a condition which has not been tested.

6.0 References

1. Procedure for the 9974 and 9975 Shipping Package Drum Closure Puncture Tests, Procedure Number FP-731, Revision 0, October 1997, Westinghouse Savannah River Company. Job Folder #22479, Sub-folder "9965-9975 Round 5 Responses."
2. Procedure for the 9974 or 9975 Shipping Package Drum Closure Sequential 30 Foot Drop and Puncture Tests, Procedure Number FP-734, Revision 0, October 1997, Westinghouse Savannah River Company. Job Folder #22479, Sub-folder "9965-9975 Round 5 Responses."
3. Drawing R-R1-F-0004, Revision 1, "9974 Packaging Assembly (U)," Westinghouse Savannah River Company, Aiken, S. C.
4. Safety Analysis Report - Packages 9968, 9972-9975 Packages, WSRC-SA-7, Revision 3, Westinghouse Savannah River Company, Aiken, S. C.

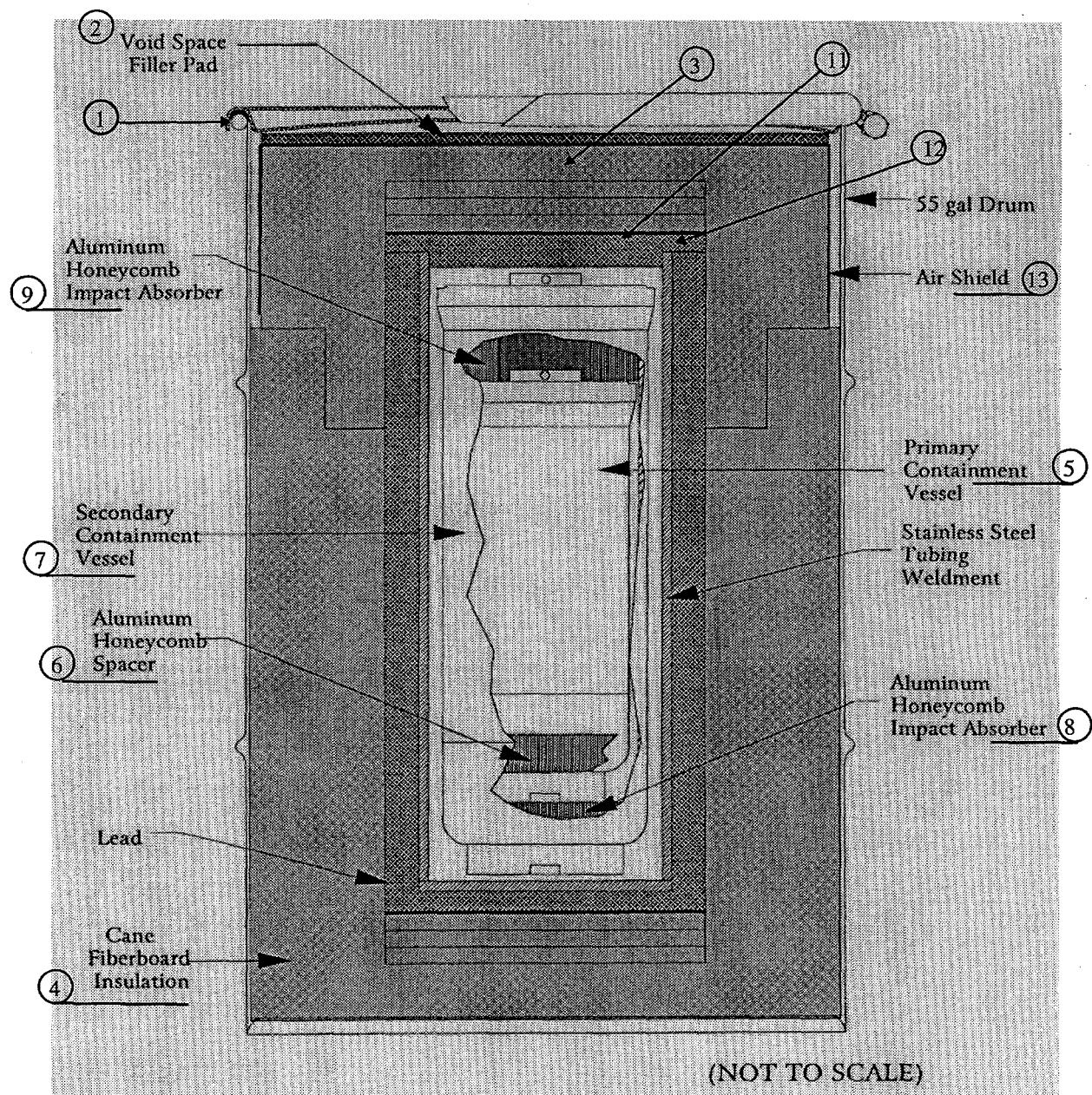


Figure 1: 9974 Packaging Assembly

Table 2: 9974 Packaging Assembly Checklist

9974 Tested Package Assembly Description		
Item* Number	Item Description	Checked if correct assembly item is used. If not, a description of the substitute item is provided.
1	9974 Drum Assembly	1. ✓
2	Firemaster encapsulated blanket	2. Not included; no substitute.
3	Insulation top subassembly	3. ✓
4	Insulation bottom subassembly	4. ✓
5	Primary Containment Vessel (PCV)	5. ✓
6	PCV bottom spacer	6. ✓
7	Secondary Containment Vessel (SCV)	7. ✓
8	SCV bottom spacer	8. ✓
9	SCV top Spacer	9. ✓
10	Shielding body subassembly	10. ✓
11	Shielding lid subassembly	11. ✓
12	1/2" hex head shielding lid bolts	12. Not included; no substitute
13	Air shield	13. Not included; no substitute

*Refer to Figure 1 for item number designations.

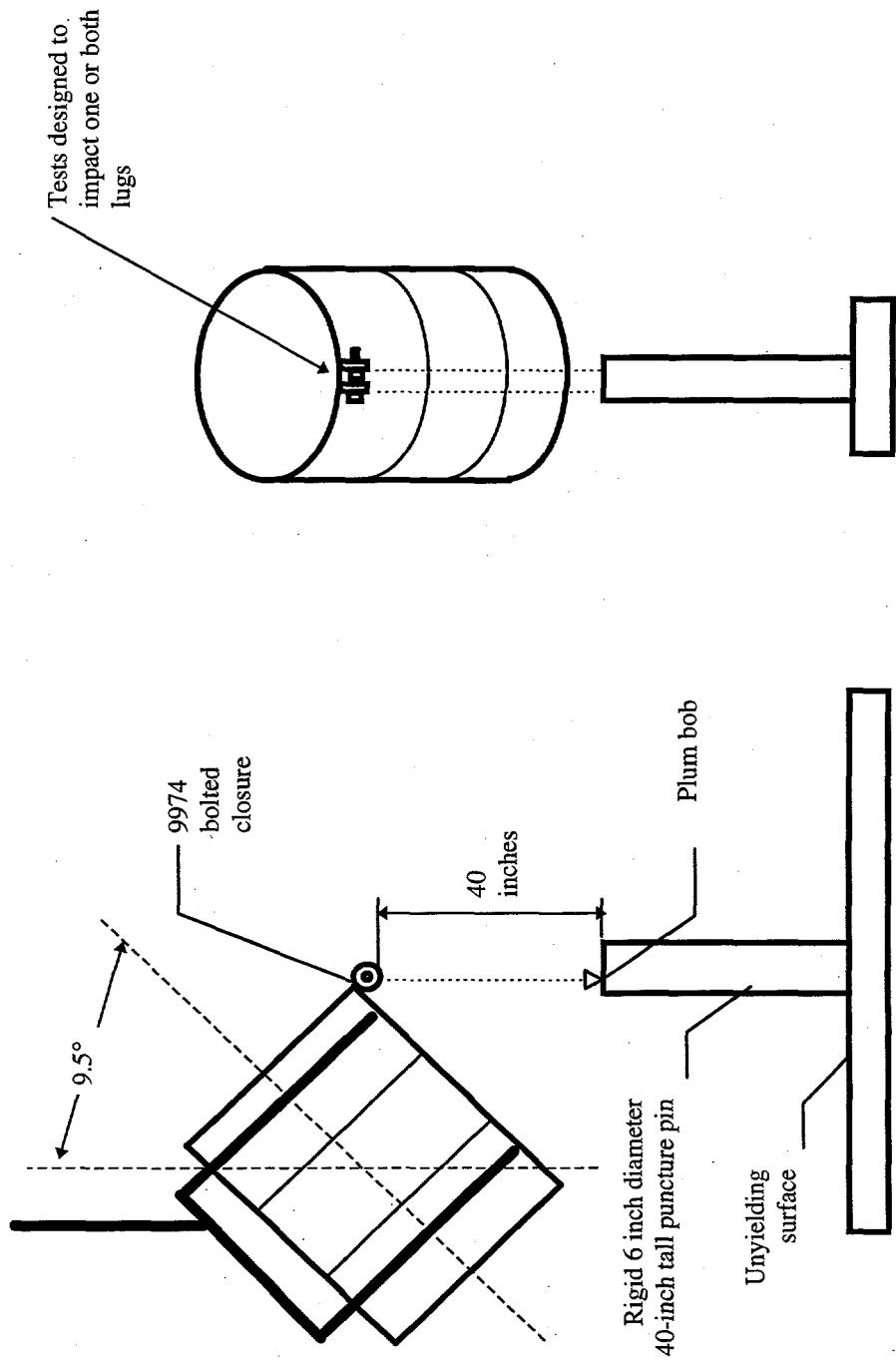


Figure 2: 9974 40-inch Puncture Pin Test Orientations

Table 3: 40-Inch Puncture Test Lug Displacement Results

40-Inch Puncture Pin Lug Displacement Results					
Drop Test Number ^(a)	Lug Impact Description on Pin	Threaded		Lug Displacement	
		Before	After	Before	After
FP-731-9974-2	Solid hit on Non-threaded lug; slight hit on threaded lug	1.40	1.66	1.48	1.64
FP-731-9974-1	Solid hit by both lugs	(not measured)	(not measured)	1.10	1.63

Notes:

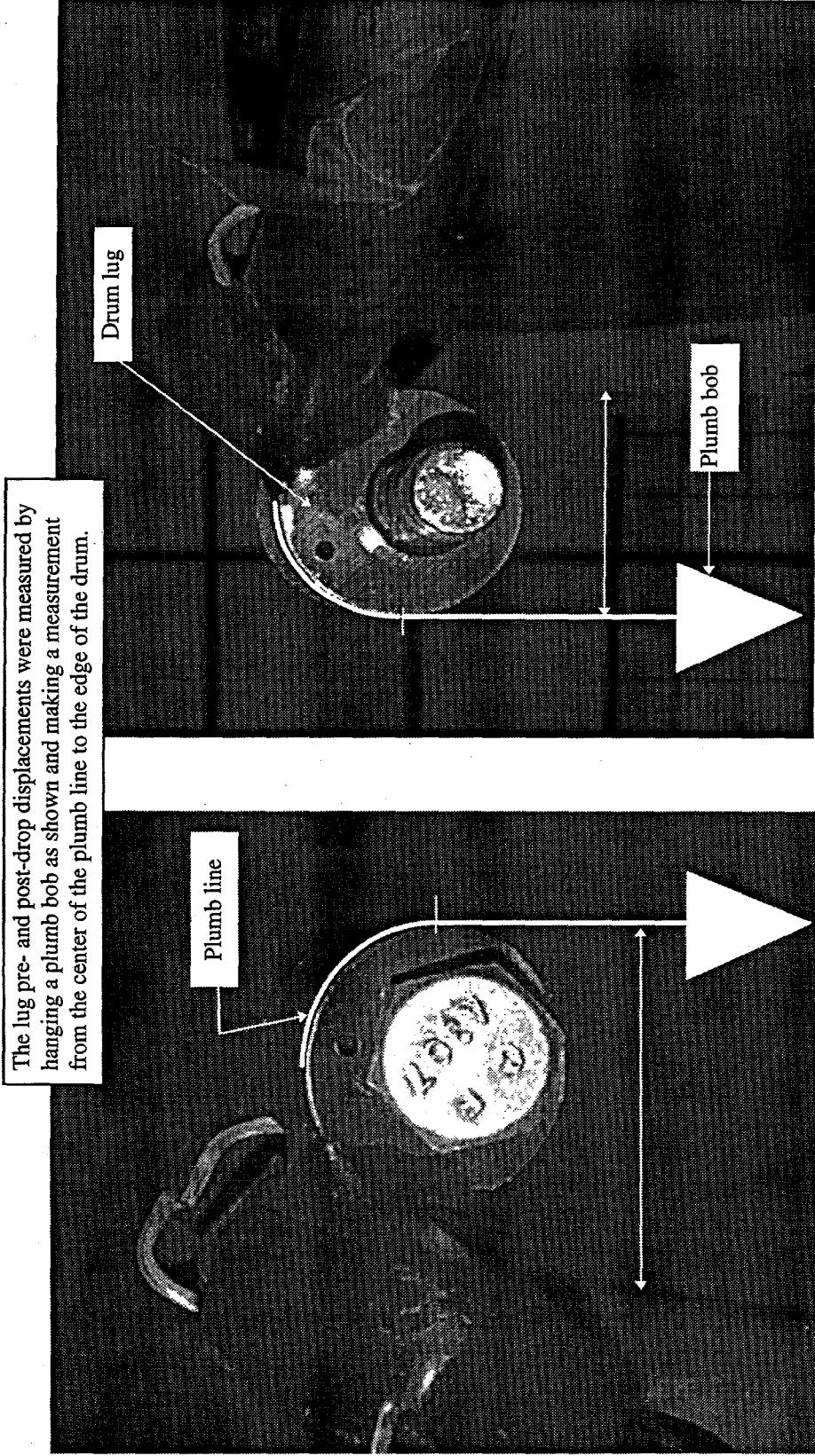
(a) Package not subjected to 30-foot drop.

Table 4: Lug and Ring Extension Displacement Comparison
9974 Lug - Ring Extension Displacement Comparison
Following 40-inch Puncture Pin Drop

Drop Test Number ^(a)	Lug- Pin Impact Description	Lug - Extension Displacement Comparison	
		Threaded Side	Non-Threaded Side
FP-731-9974-2	Lug	Lug	Extension
FP-731-9974-1	Solid hit on Non-threaded lug; slight hit on threaded lug	0.26	0.265
	Solid hit by both lugs	0.53 (guess)	0.44
			0.53
			0.3

Notes:

(a) Package not subjected to 30 foot drop.



Lug Photographs are not of the 9974 but of the 9975 package following the FP-734-9975-2 test. The photographs display the method of puncture damage measurement of but only the nature of the actual damage to the 9974.

Figure 3: 9974 40-inch Puncture Test Lug Displacement Measurements

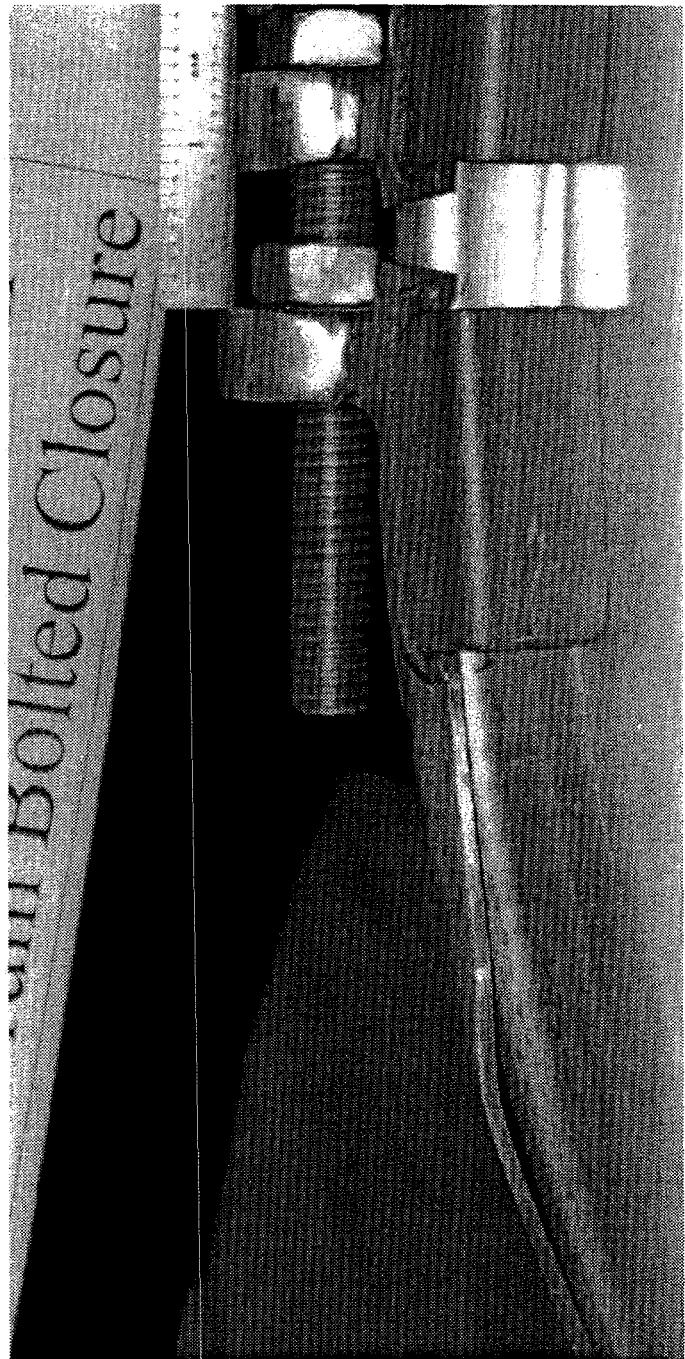
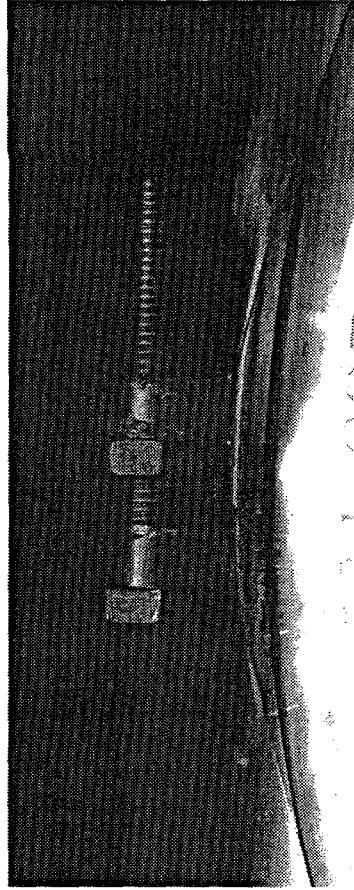
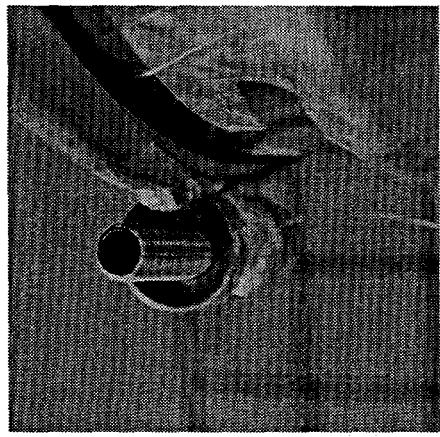


Figure 4: 9974 40-inch Puncture Test Damages

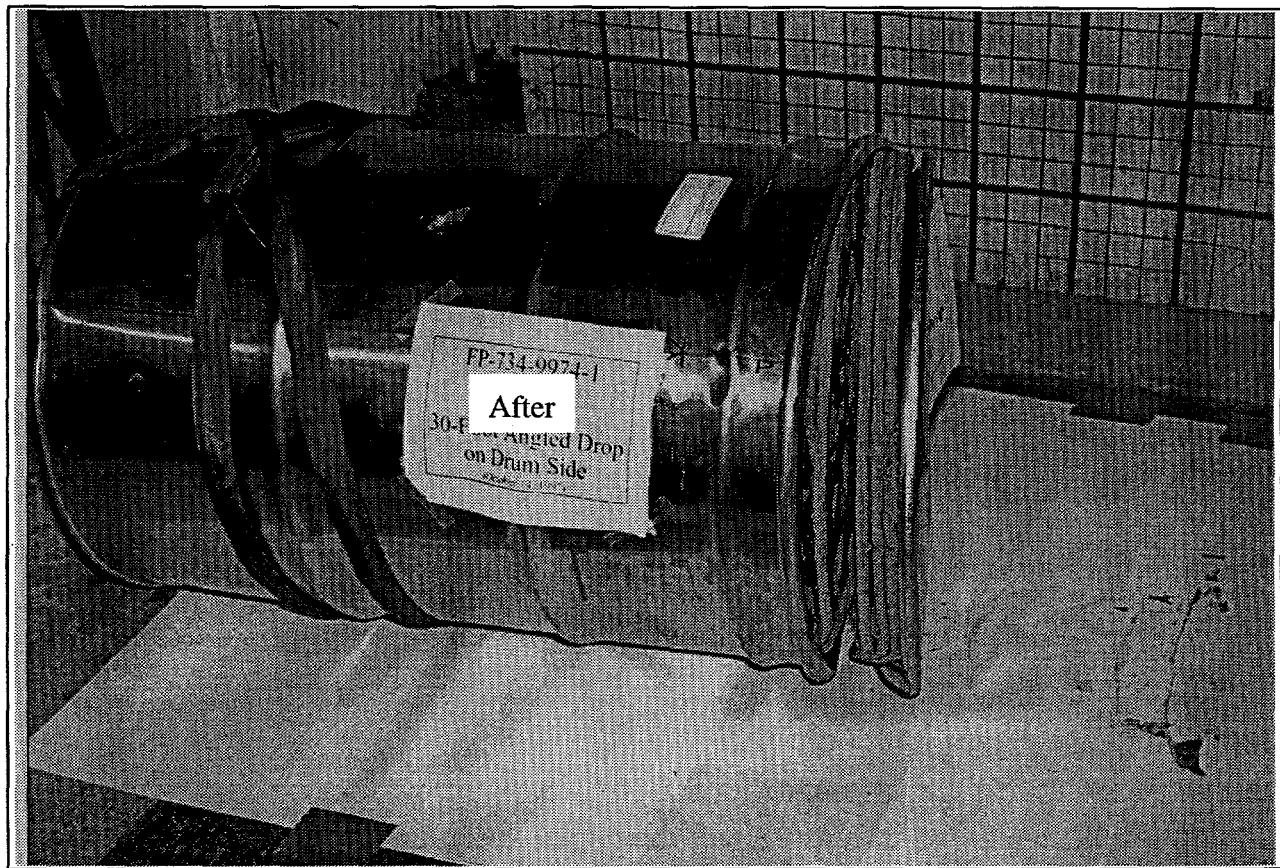
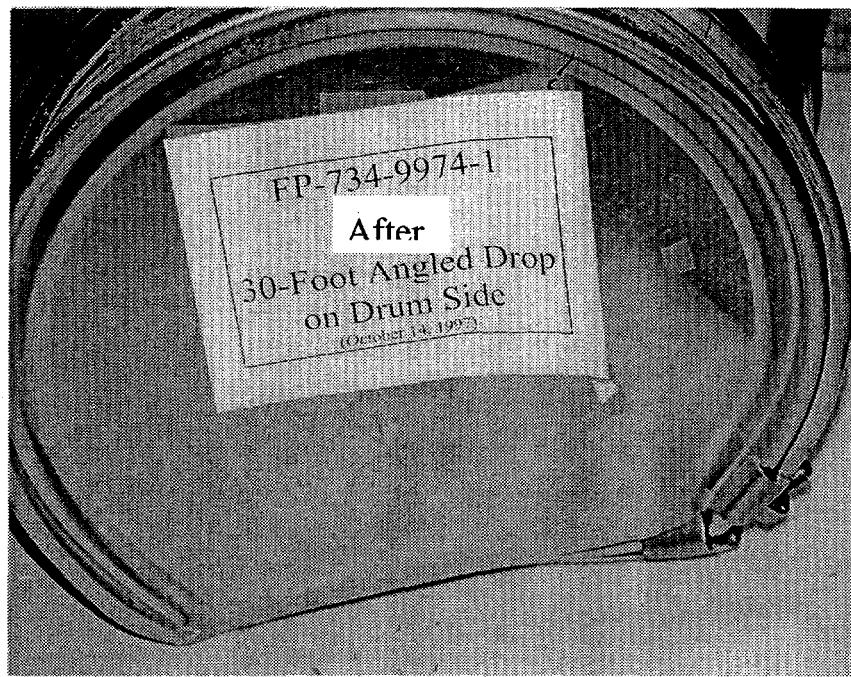


Figure 5: 9974 30-foot Drop Test Damages