**DeBose, Michelle**

| | |
|---|---|
| **From:** | DeBose, Michelle |
| **Sent:** | Thursday, August 06, 2015 2:05 PM |
| **To:** | DeBose, Michelle |
| **Subject:** | FW: FW: Here the rest of it... |
| **Attachments:** | OP-100 SAR Rev 4 pg 57 - end.pdf; 665S (Second SAR Submittal).doc |

**From:** Allen, William
**Sent:** Thursday, August 06, 2015 12:22 PM
**To:** DeBose, Michelle
**Subject:** FW: FW: Here the rest of it...

Can you get the attached PDF of a partial SAR into ADAMS? I've attached a 665S for the submittal. Let me know if you have any questions. Chris

**From:** Mike Rose [mailto:MikeR@ir100.com]
**Sent:** Monday, August 03, 2015 2:02 PM
**To:** Allen, William
**Subject:** [External_Sender] FW: Here the rest of it...

Mr. Allen,

The rest of the story.

If you have any questions or concerns please do not hesitate to contact me at the information below.

Regards,

Mike Rose
QAM/ARSO
14320 Wicks Blvd
San Leandro, CA 94577
510-352-6767 ph
510-352-6772 fax
www.IR100.com

**From:** Ron M [mailto:rlm52@comcast.net]
**Sent:** Monday, August 03, 2015 10:38 AM
**To:** Mike Rose
**Subject:** Here the rest of it...

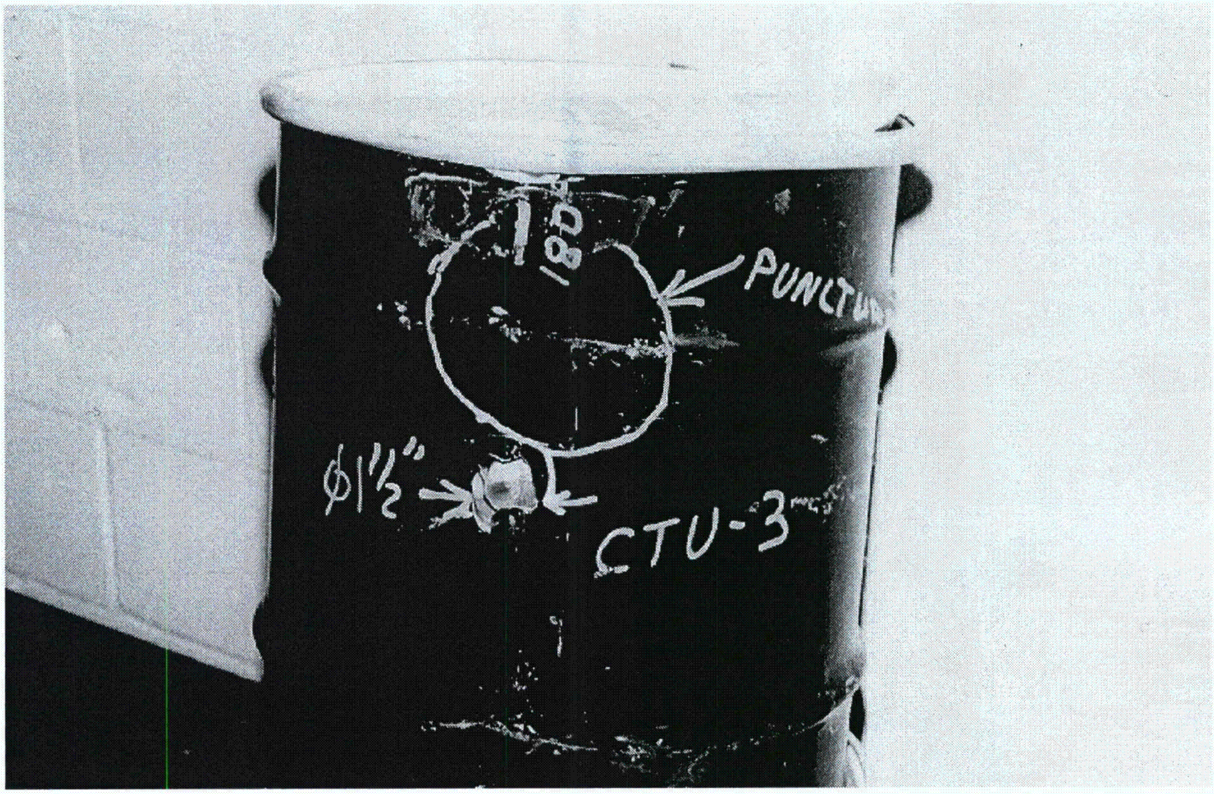


**Figure 2.12.1-23** – CTU-3 Puncture Drop Test No. 8: Damage to Drum Shell

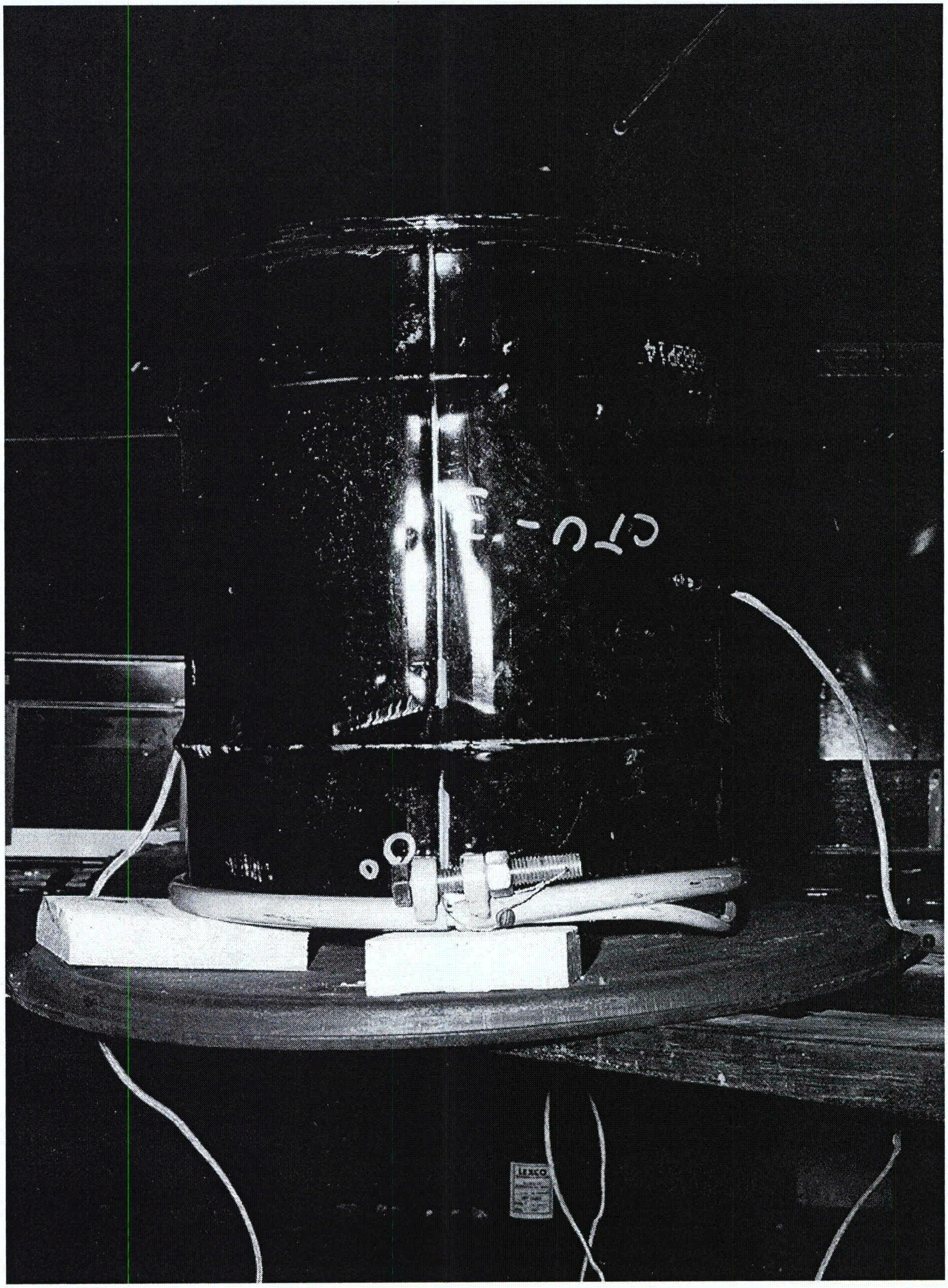

**Figure 2.12.1-24** – CTU-3 Thermal Test No. 11 Just Prior to Insertion Into Oven

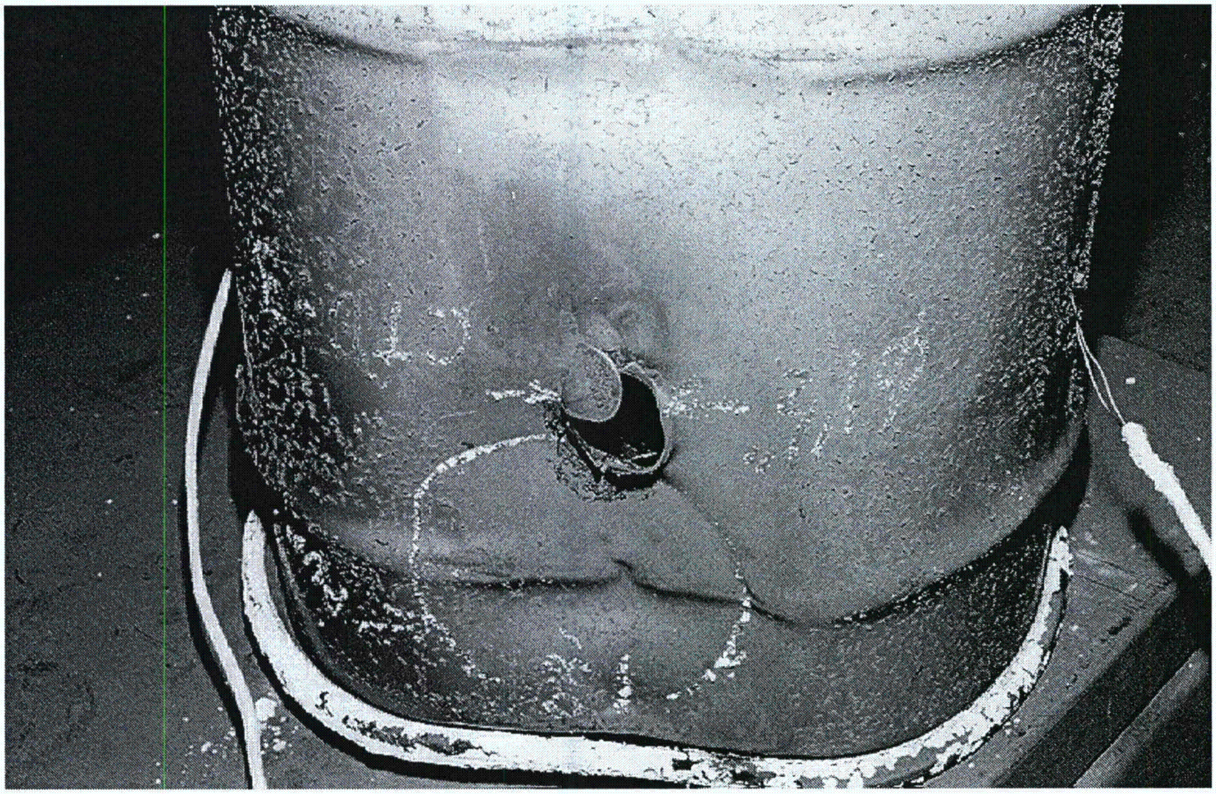

**Figure 2.12.1-25** – CTU-3 Thermal Test No. 11 Immediately Upon Removal from Oven

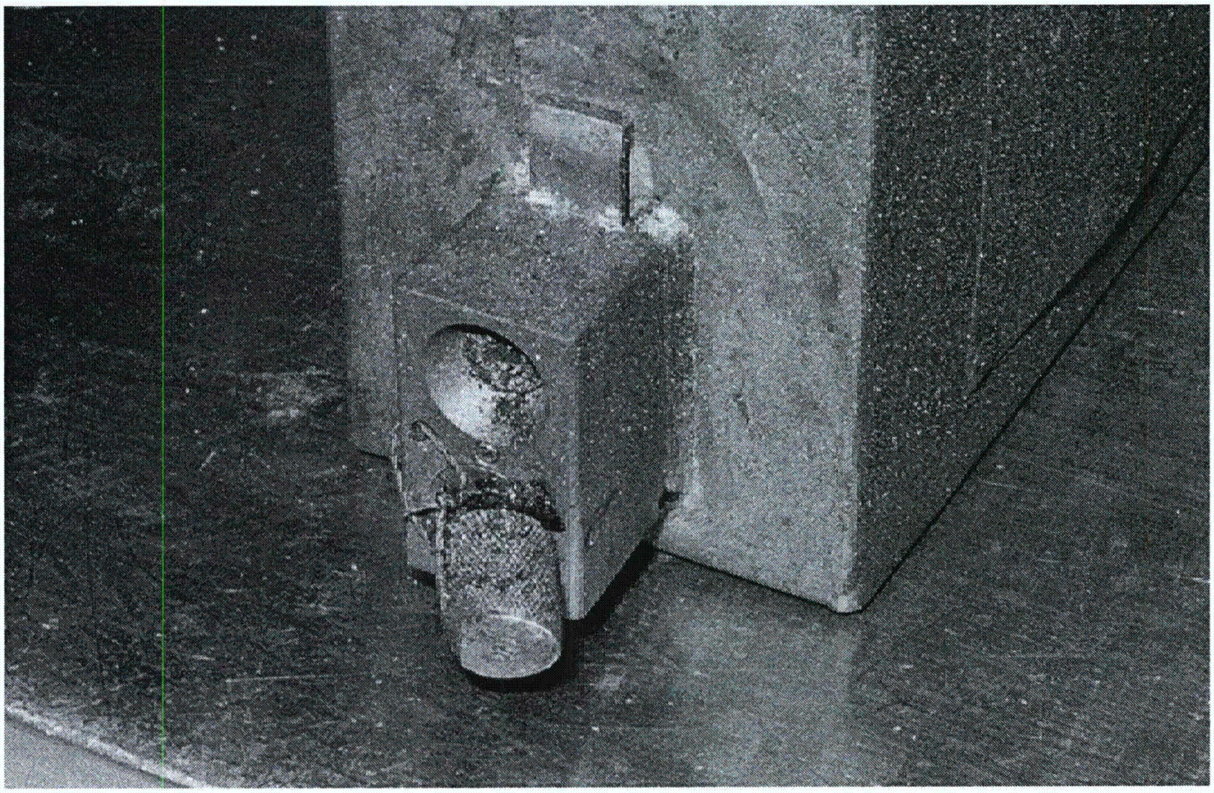

**Figure 2.12.1-26** – CTU-3 Post-Test Disassembly: Damaged Lock Box Dust Cap

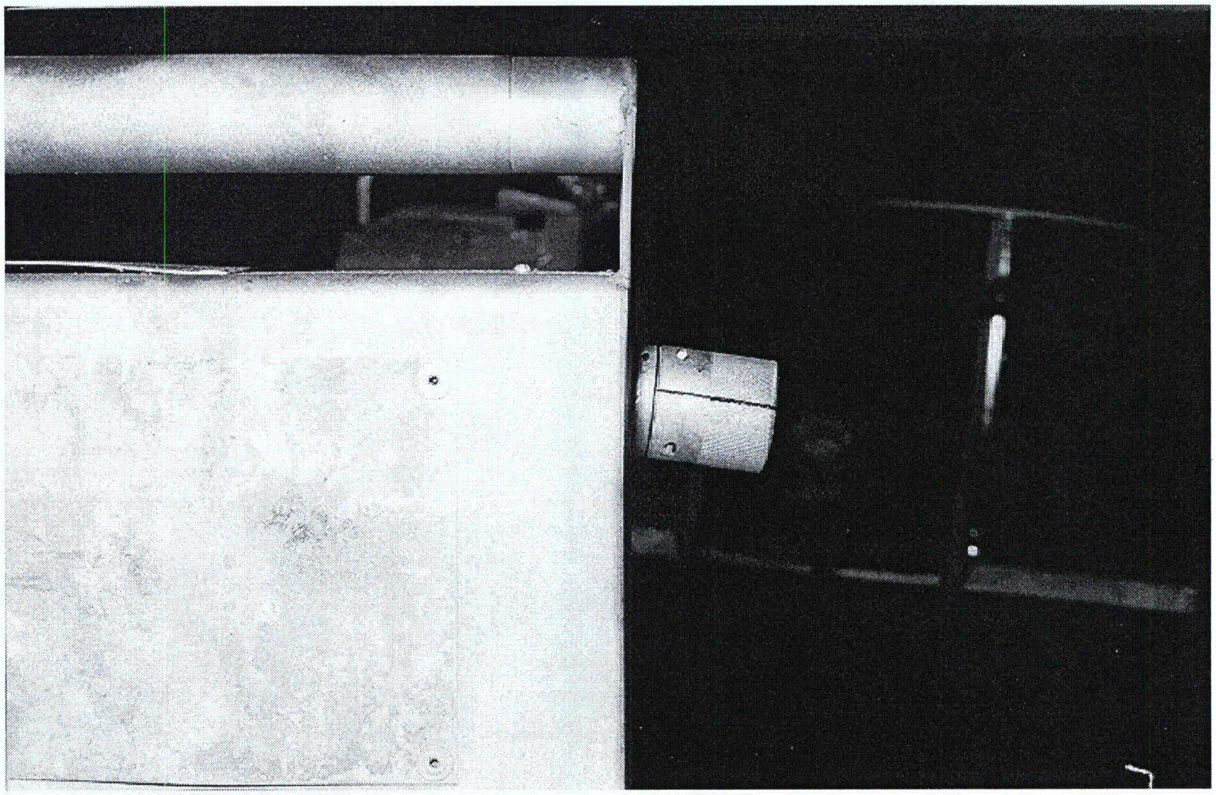

**Figure 2.12.1-27** – CTU-3 Post-Test Disassembly: Damaged Safety Plug

**Figure 2.12.1-28** – CTU-3 Post-Test Disassembly: Illustrating Polyurethane Foam Char

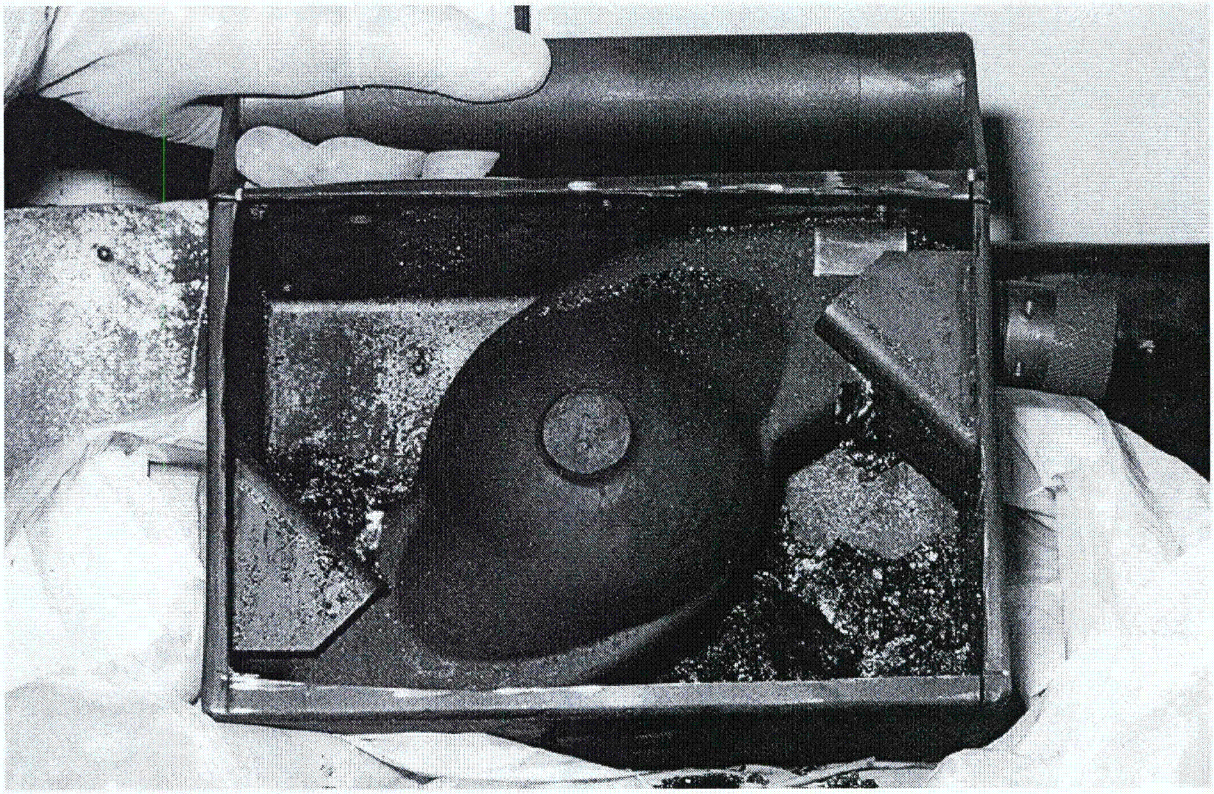

**Figure 2.12.1-29** – CTU-3 Post-Test Disassembly: Interior Cavity with Foam Debris Removed

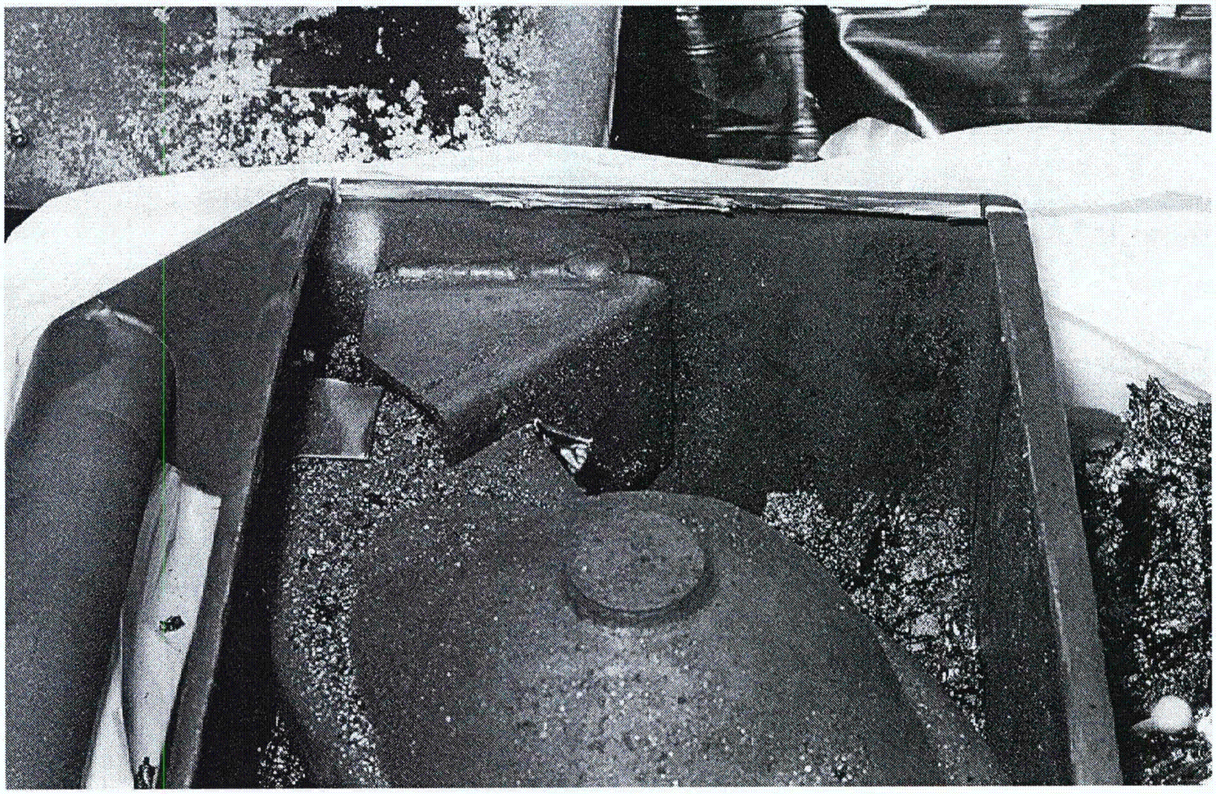

**Figure 2.12.1-30** – CTU-3 Post-Test Disassembly: DU Support Bracket /Welds and Copper Shims

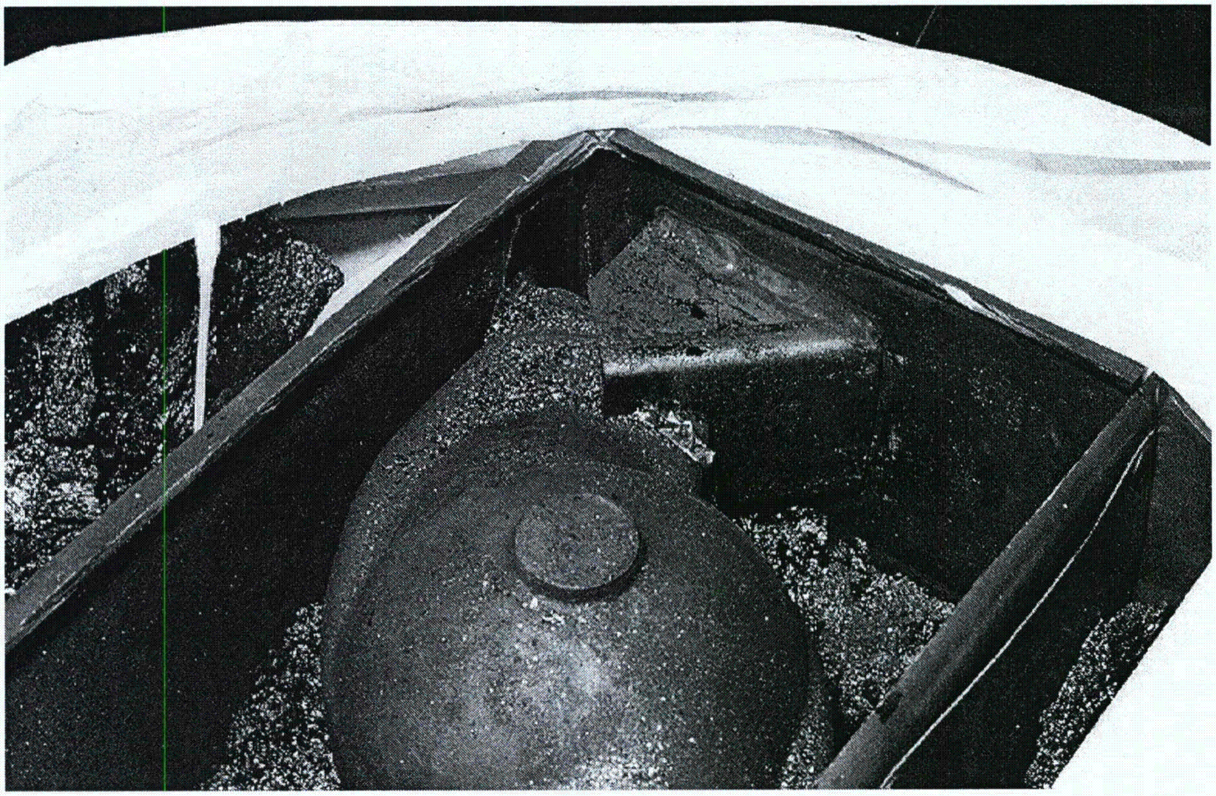

**Figure 2.12.1-31** – CTU-3 Post-Test Disassembly: DU Support Bracket /Welds and Copper Shims


**Figure 2.12.1-32** – CTU-4 Free Drop Test No. 6: CG Over Closure Bolt

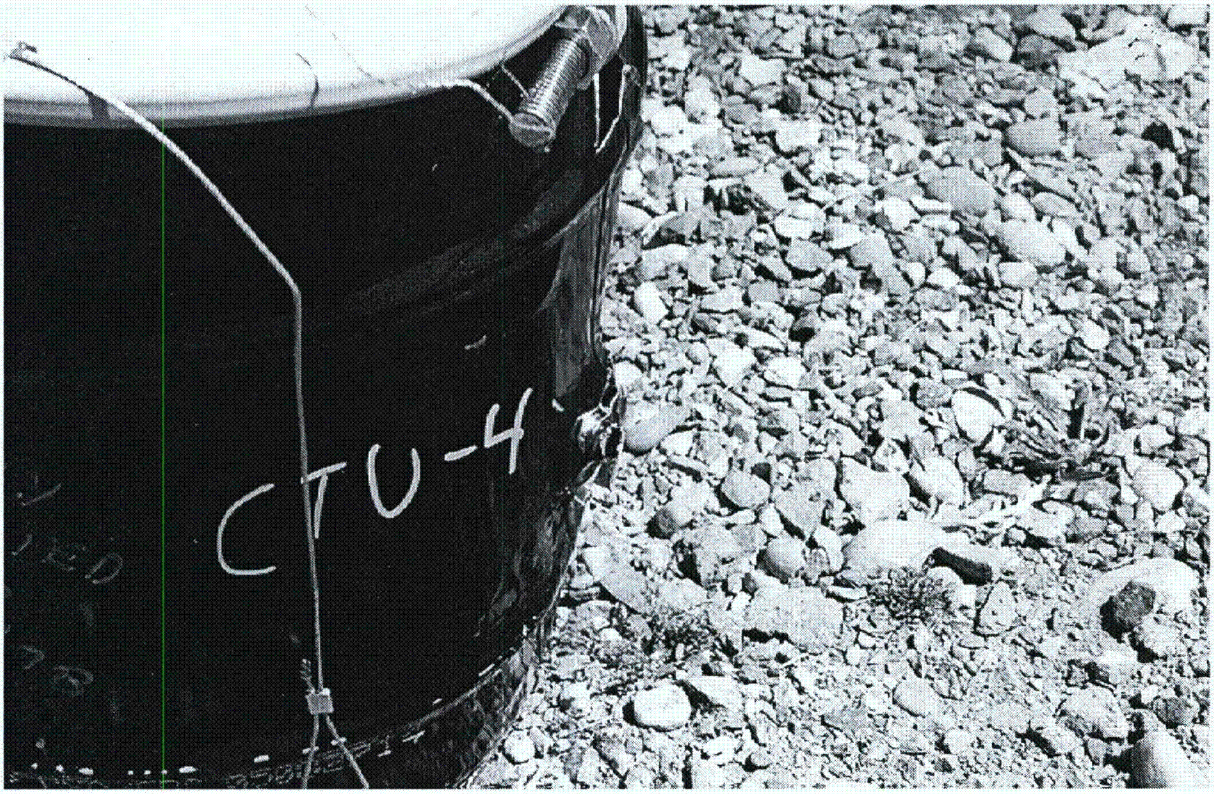


**Figure 2.12.1-33** – CTU-4 Free Drop Test No. 6: Overall Damage View

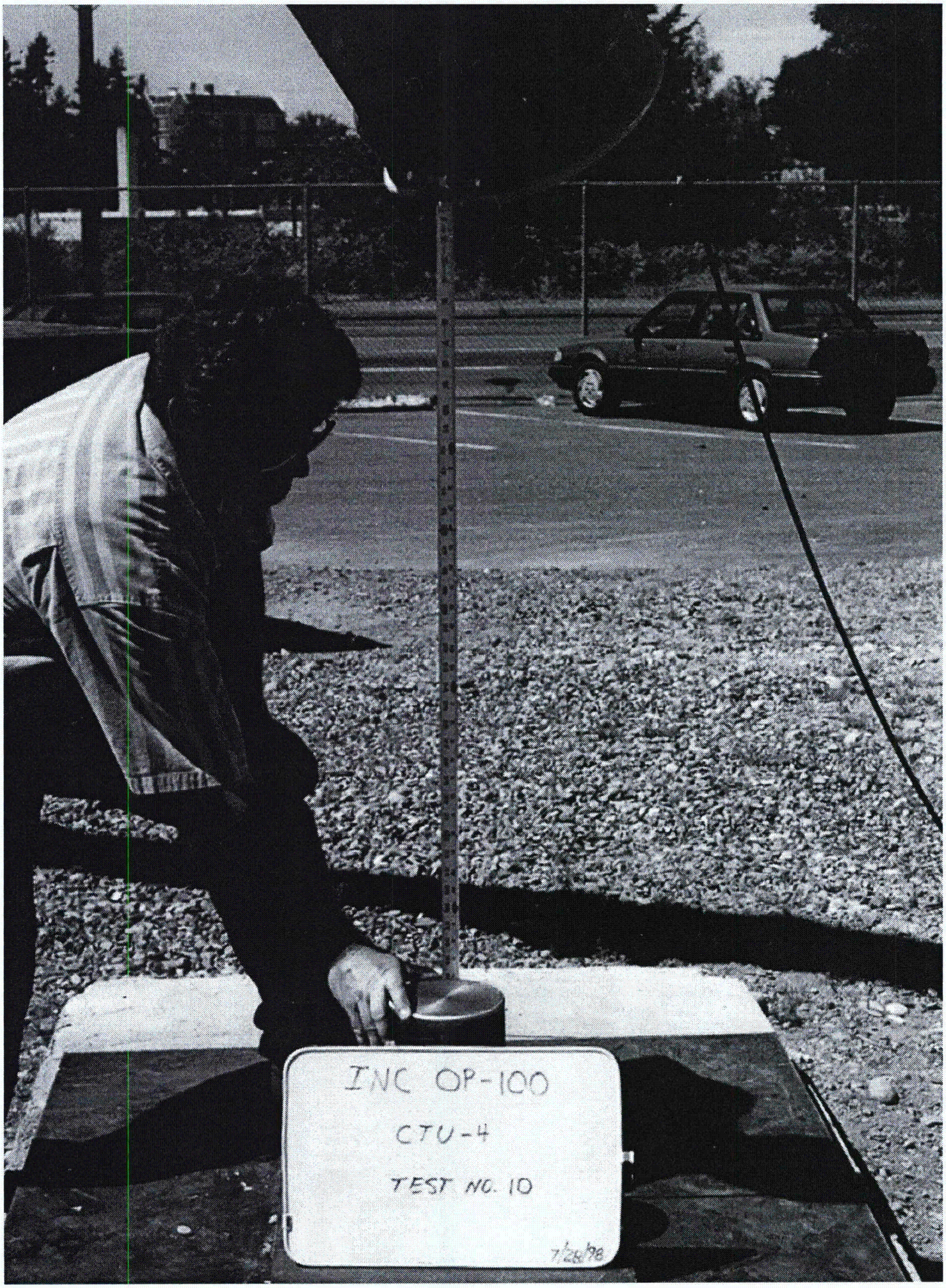


**Figure 2.12.1-34** – CTU-4 Puncture Drop Test No. 10 Setup

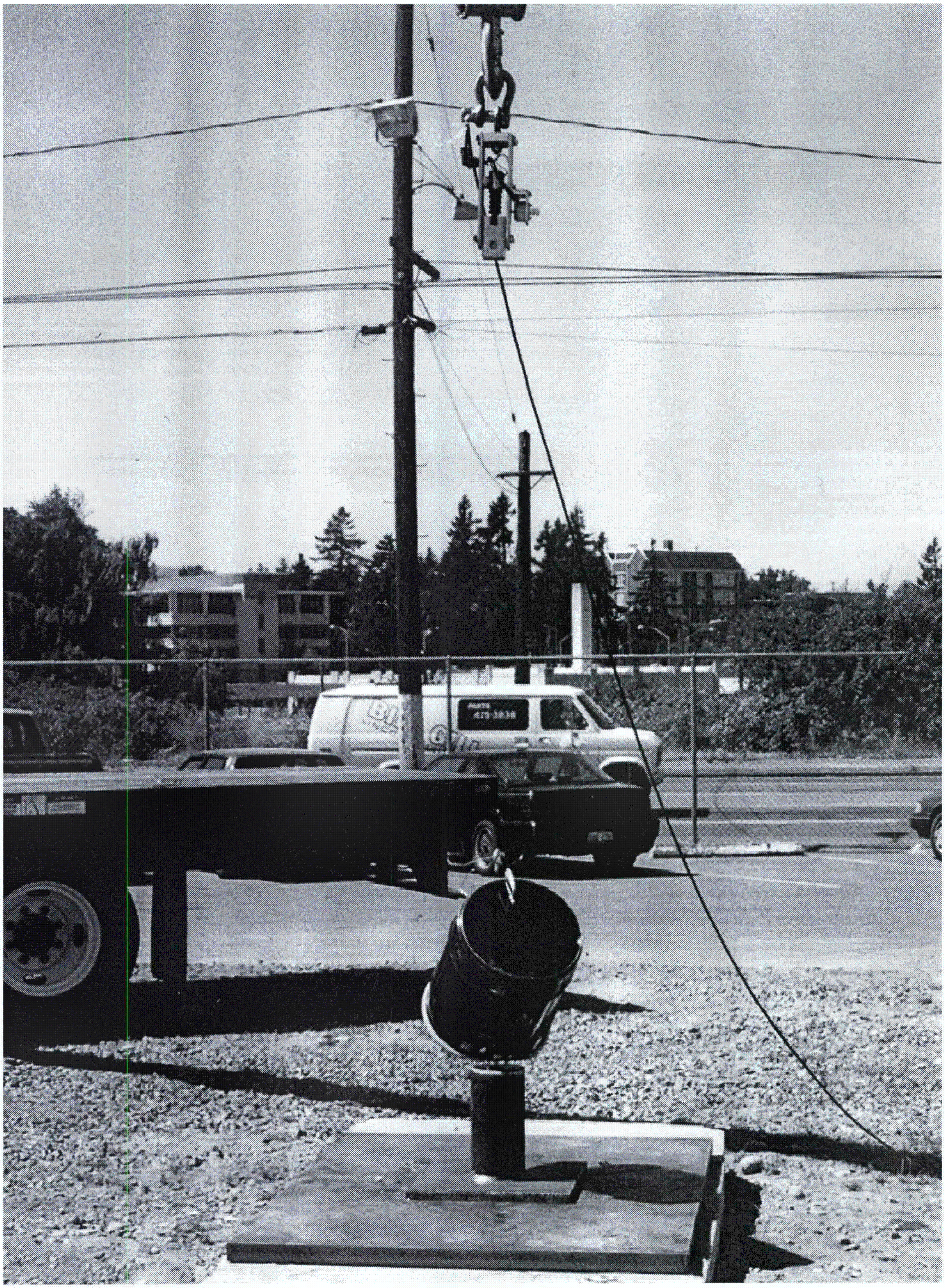

**Figure 2.12.1-35** – CTU-4 Puncture Drop Test No. 10 Immediately Prior to Impact

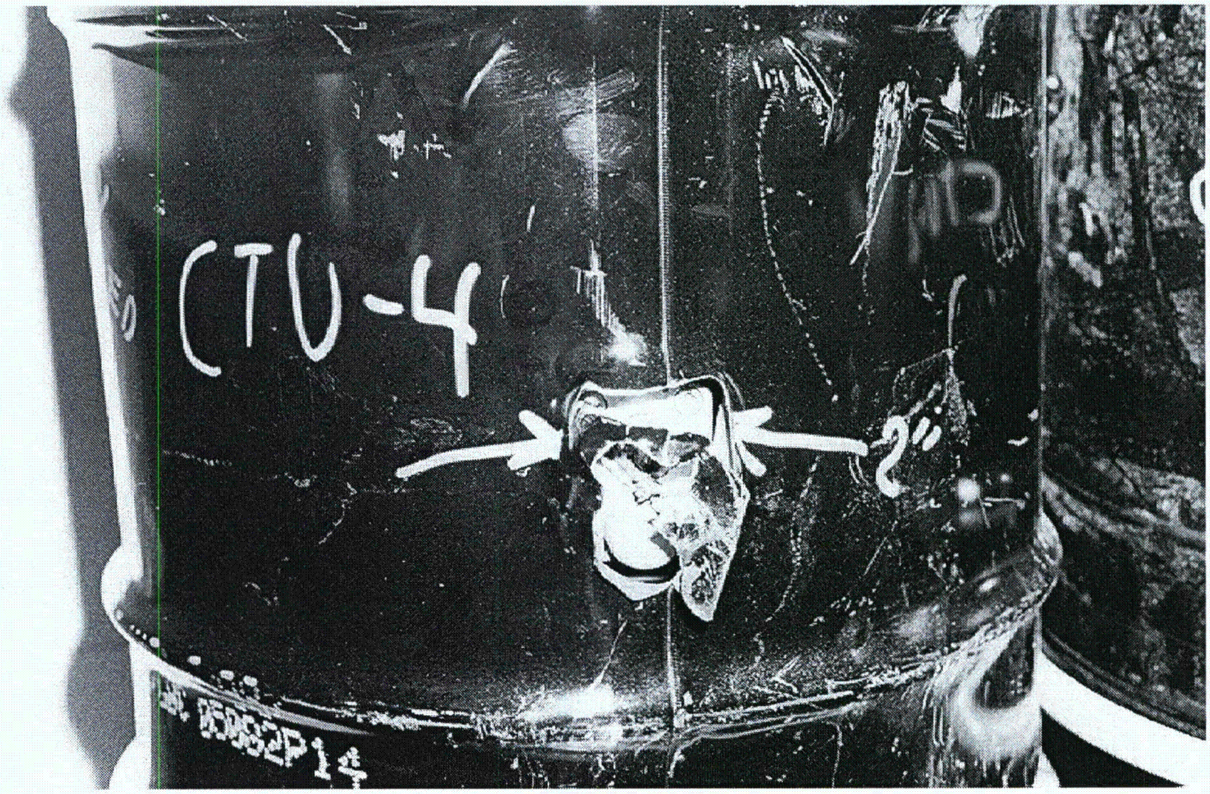


**Figure 2.12.1-36** – CTU-4 Puncture Drop Test No. 10: Damage to Drum Shell Due to Lock Box

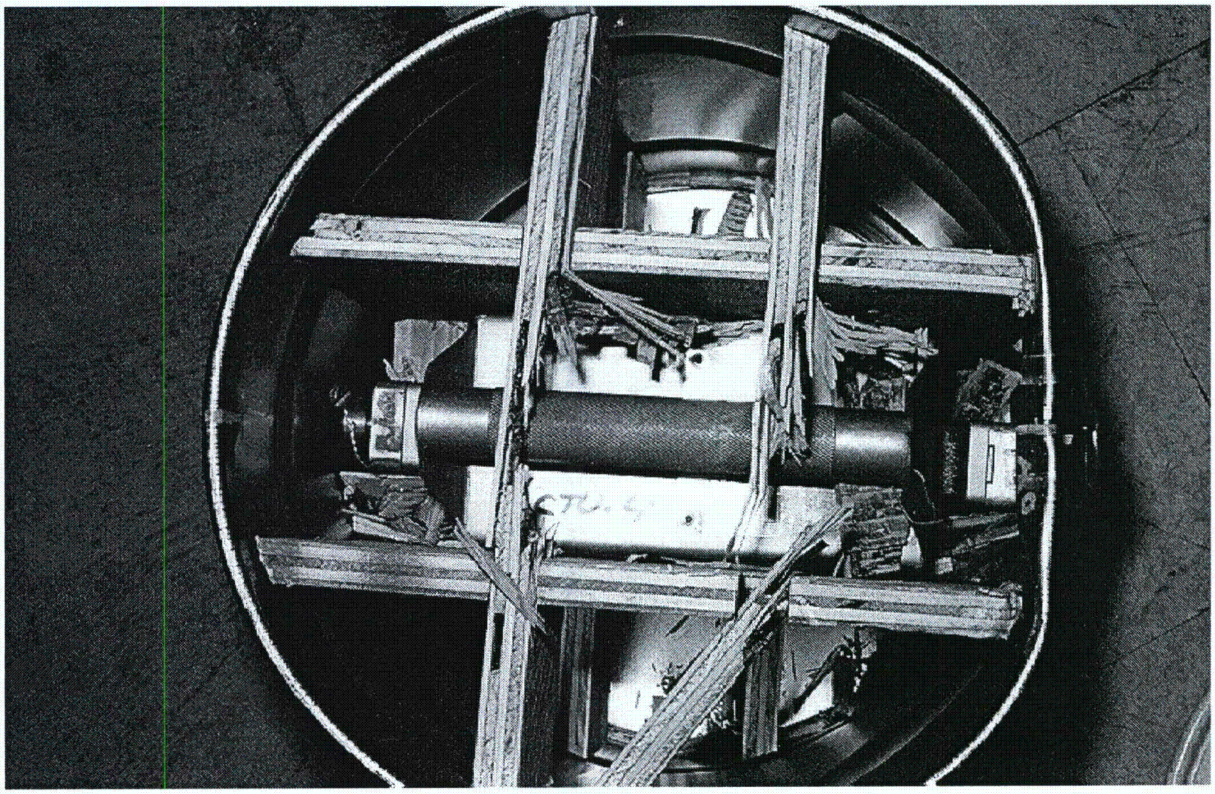

**Figure 2.12.1-37** – CTU-4 Post-Test Disassembly: Condition of Plywood Support Structure


**Figure 2.12.1-38** – CTU-4 Post-Test Disassembly: Condition of Handle

# 3.0 THERMAL EVALUATION

This chapter establishes the compliance of the OP-100 package transporting a payload of up to 120 Ci (4.44 TBq) of Ir-192 or Se-75 in special form with the thermal requirements of 10 CFR §71[8].

## 3.1 Description of Thermal Design

### 3.1.1 Design Features

The OP-100 package and the IR-100/IR-50 devices do not contain any specific thermal design features. The thermal performance of the package is demonstrated by test. Therefore, this section does not apply.

### 3.1.2 Content's Decay Heat

The OP-100 package may contain up to 120 Ci (4.44 TBq) of Ir-192 or Se-75 in special form. The radiolytic decay heat of Ir-192 is $7.03 \times 10^{-3}$ W/Ci[9]. The radiolytic decay heat of Se-75 is $2.41 \times 10^{-3}$ W/Ci[9]. Since the radiolytic decay heat of Ir-192 is greater than the radiolytic decay heat of Se-75, the heatload of the Ir-192 payload bounds the Se-75 payload. Therefore, the maximum decay heat load for the package is therefore 0.84 W (2.87 Btu/hr), which is negligible.

### 3.1.3 Summary Tables of Temperatures

The maximum surface temperature of the OP-100 package is 136.9 °F, as documented in Appendix 3.6.1, *Determination of Maximum Surface Temperature for OP-100 Package*, in full sunlight.

### 3.1.4 Summary Tables of Maximum Pressures

The containment of the OP-100 package is provided by the special form payload. Gas can freely move from the internal cavity to the environment during all phases of operation. Therefore, there are no internal pressures to be determined, since the OP-100 package does not contain any pressure boundaries.

## 3.2 Material Properties and Component Specifications

### 3.2.1 Material Properties

The OP-100 packaging is constructed of a 10-gallon carbon steel drum, with a 20-gauge (0.0359 inch) thick body and lid. The drum lid is attached to the body with a 12-gauge (0.105 inch) thick

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[8] Title 10, Code of Federal Regulations, Part 71 (10 CFR 71), *Packaging and Transportation of Radioactive Material*, 1-1-15 Edition.

[9] *ORIGEN-S Decay Data Library and Half-Life Uncertainties*, O. W. Hermann, P. R. Daniel, and J. C. Ryman, Oak Ridge National Laboratory, ORNL/TM-13624, September 1998.

carbon steel closure ring, which is secured with a 5/8-inch × 4 inch hex bolt and nut. A plywood support structure positions the device in the center of the drum cavity.

The IR-100 Exposure Device and the IR-50 Source Changer are constructed of a 12-gauge (0.105 inch) thick stainless steel outer skin surrounding polyurethane foam and a depleted uranium gamma shield. Since the structural integrity of the package is established by testing, the only pertinent temperature limits on the components is established by their melting temperatures for the fire based Hypothetical Accident Condition (HAC). The melting temperatures for uranium and stainless steel are 2,071 °F and 2,800 °F, respectively.

The payload was qualified per *Qualification of Special Form Radioactive Material*, in 10 CFR §71.75(b)(4).

### 3.2.2 Component Specifications

The OP-100 package does not contain any component or material that is important to the thermal performance of the package. The two primary structural materials are austenitic stainless steel and the DU shield. As noted in Section 2.1.2.2.1, *Brittle Fracture*, both materials have been tested to temperatures below -20 °F with no loss of structural or shielding capability.

## 3.3 Thermal Evaluation under Normal Conditions of Transport

This section presents the thermal evaluation of the OP-100 package under the normal conditions of transport (NCT) per 10 CFR §71.71.

### 3.3.1 Heat and Cold

Since the total decay heat load of the OP-100 package is less than 1 W (3 Btu/hr), a detailed analysis of the package and internals is unnecessary. The peak internal temperatures will very closely match those on the surface of the package.

Per 10 CFR §71.71(c)(1), the worst-case high temperature conditions for the package consist of an ambient temperature of 100 °F and maximum insolation. Under those conditions, the worst case surface temperature for the OP-100 package would be 137 °F, as documented in Appendix 3.6.

Given the negligible decay heat, the maximum temperature for all surfaces of the OP-100 package in shade with an ambient temperature of 100 °F (560 °R) is 100 °F (560 °R). This temperature is below the maximum acceptable surface temperature of 122 °F for non-exclusive use shipments as stipulated in 10 CFR §71.43(g). Similarly, the package temperature will be equal to ambient under the low temperature conditions of -20 °F and -40 °F.

### 3.3.2 Maximum Normal Operating Pressure

This section does not apply, since the OP-100 package does not contain any pressure boundaries. Therefore, there is no maximum normal operating pressure (MNOP) for the OP-100 package.

The containment of the OP-100 package is provided by the special form payload. Gas can freely move from the internal cavity to the environment during all phases of operation. Therefore, determination of internal pressures is not required.

### 3.3.3 Maximum Thermal Stresses

Due to the small size of the package and the negligible decay heat load, the thermal stresses within the package are negligible.

### 3.3.4 Evaluation of Package Performance for Normal Conditions of Transport

As discussed in the previous sections, all of the temperatures that may be experienced by the OP-100 package during normal conditions of transport are within acceptable limits.

## 3.4 Thermal Evaluation under Hypothetical Accident Conditions

The performance of the OP-100 package under Hypothetical Accident Conditions (HAC) was determined via testing in accordance with 10 CFR §71.73. Additional details are provided in the following sections.

### 3.4.1 Initial Conditions

A previously free and puncture dropped OP-100 certification test unit (CTU) package was placed into an oven and exposed to a forced convective environment that resulted in the average surface temperature of the package to at least 1,475 °F.

### 3.4.2 Fire Test Conditions

Following the introduction of air and indication of the package surface at a minimum of 1,475 °F, the package was maintained in the oven for 30 minutes. During the 30-minute test, the surface temperature varied between 1,470 °F and 1,627 °F. During heat-up, burning of the combustible materials was observed. Following the 30-minute test, the package was removed from the oven and allowed to cool in air.

A post-test examination of the package indicated that the both the plywood support structure and the polyurethane foam were completely consumed by the fire, adding its combustion energy to that of the forced convection from the oven. The depleted uranium shielding, and the outer skin of the package were not compromised or appreciably oxidized. Additionally, the peak temperatures recorded in the test were well below the melting temperatures of both stainless steel (2,800 °F) and uranium (2,071 °F).

A post-test radiation survey conducted subsequent to the fire test indicated little, if any, degradation in shielding capability.

The special form qualification of the payload certifies that it could withstand the fire test without degradation.

### 3.4.3 Maximum Temperatures and Pressures

Based the thermal tests performed on the OP-100 package, none of the components exceeds its temperature limit as described in Section 3.2.1, *Material Properties*. Specifically, the maximum recorded package temperatures fall more than 500 °F below the melting point of steel and uranium. Additionally, the special form payload does not exceed the temperatures for the special form certification tests.

The containment of the OP-100 package is provided by the special form payload. Gas can freely move from the internal cavity to the environment during all phases of operation, so determination of internal pressures is not required.

This verifies that the OP-100 package satisfies the HAC thermal requirements set forth by 10 CFR §71.73(c)(4).

### 3.4.4 Maximum Thermal Stresses

The effects of HAC thermal stresses were addressed by the fire test. No damage due to thermal stresses was found during post-test examination of the OP-100 CTU and the payload devices.

### 3.4.5 Accident Conditions for Fissile Material Packages for Air transport

This section does not apply, since the OP-100 package does not contain fissile material.

## 3.5 Appendix

### 3.5.1 Determination of Maximum Surface Temperature for OP-100 Package

PacTec Packaging Technology, Inc.

| | | | |
|---|---|---|---|
| *Prepared* | Paul F. Stevens [signature] | *Date* 6/28/99 | *Revision* 0 |
| *Reviewed* | Phil W. Noss [signature] | *Date* 6/28/99 | *Page* 1 *of* 7 |
| *Approved* | Gary L. Clark [signature] | *Date* 6/28/99 | *Project* 98005 |

*Title* Surface Temperature Calculation for INC OP-100 Package

## TABLE OF CONTENTS



## REVISION LOG

| Revision | Date | Item Revised | Reason for Revision |
|---|---|---|---|
| | | | |
| | | | |
| | | | |


***Packaging Technology, Inc.**, 4507-D Pacific Hwy East, Tacoma WA 98424-2633, ☎(253)922-1450 (253)922-1445*

**PacTec Calculation Sheet**

| | | | |
|---|---|---|---|
| *Prepared* Paul F. Stevens | PFS | *Date* 6/28/99 | *Revision* 0 |
| *Reviewed* Phil W. Noss | PWN | *Date* 6/23/99 | *Page* 2 of 7 |
| *Approved* Gary L. Clark | GL Clark | *Date* 6/28/99 | *Project* 98005 |

*Title* Surface Temperature Calculation for INC OP-100 Package

## 1.0 OBJECTIVE

The purpose of this calculation is to determine the peak surface temperatures on the Industrial Nuclear Company OP-100 Package due to solar radiation per the regulations of 10 CFR 71.71(c)(1).

## 2.0 REFERENCES


1) Code of Federal Regulations, Title 10, Part 71, Packaging and Transportation of Radioactive Materials, 1/1/98.
2) *Engineering Heat Transfer*, James R. Welty, John Wiley and Sons Publishing, New York, 1974.
3) Industrial Nuclear Company, *OP-100 Package*, Drawing OP-100-1.
4) *Handbook of Heat Transfer*, Warren M. Rohsenow and James P. Hartnett, McGraw Hill Book Company, New York, 1973.
5) *Principles of Heat Transfer*, Frank Kreith, Harper and Row Publishers, New York, 1973.


## 3.0 CALCULATION ASSUMPTIONS

- Conductance along the carbon steel outer skin of the package is conservatively assumed to be negligible.
- Solar radiation is assumed to be at a constant value that is 1/12th of the maximum solar radiation value as prescribed by 10 CFR 71.71(c)(1) (Reference 1).
- Ambient temperature is assumed to be at a constant temperature of 100°F (560 °R) per Reference 1.
- All surfaces, excepting the base, of the OP-100, experience turbulent natural convection.
- Decay heat from OP-100 payload is assumed to be negligible.

## 4.0 MATERIAL PROPERTIES

Since conduction is conservatively neglected for the purposes of this calculation, the only pertinent material properties are the emissivity and solar absorptivity of the paint on the exterior surface of the package.

Per Reference 3, the package may be painted yellow, or the lid and bottom of the package may be painted white, and its walls black. From Reference 4, page 3-22, the emissivity for white, silicone based paint, $\varepsilon_{white}$, is 0.75, while its solar absorptivity, $\alpha_{white}$, is 0.26. From the same source, the emissivity of black enamel paint, $\varepsilon_{black}$, is 0.84, and its absorptivity, $\alpha_{black}$, is 0.93. From Reference 5, page 237, the radiation properties of yellow paint are commensurate with those of white paint. Therefore, a drum with the white/black paint scheme will be the controlling case, as it will absorb more solar radiation and have higher temperatures than an all yellow drum.

Conductivity and kinematic viscosity of air affect convective heat transfer from the OP-100. These material properties are addressed by using simplified heat transfer equations for air as documented in Section 6.0.

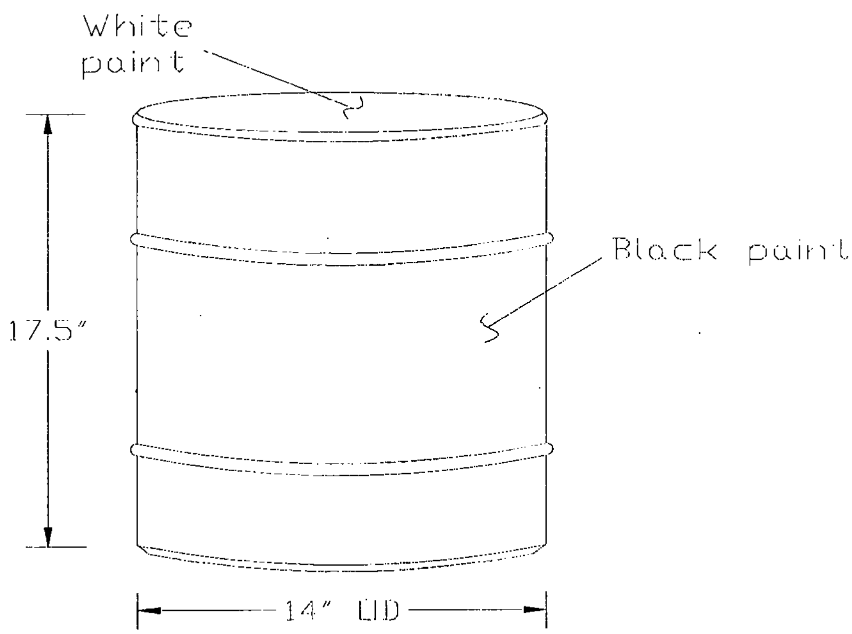
## 5.0 THERMAL LOADS

Since the decay heat source term of the OP-100 is negligible, the only pertinent thermal load is solar radiation (insolation). Per 10 CFR 71.71(c)(1) (Reference 1), the maximum insolation is as follows:

| Surface Orientation | Total Insolation for 12 Hour Period (gcal/cm$^2$) | Average Heat Flux (Btu/hr-ft$^2$) |
|---|---|---|
| Flat, horizontal (not base) | 800 | 245.7 |
| Flat, horizontal (base) | 0 | 0.0 |
| Flat, non-horizontal | 200 | 61.4 |
| Curved | 400 | 122.9 |

## 6.0 ANALYTICAL CALCULATIONS

The simplified dimensions of the OP-100 used in the analytical calculations are shown in the figure below and are derived from Reference 3.




Determining the surface temperature of the OP-100 in the shade with an ambient temperature of 100 °F (560 °R) in accordance with 10 CFR 71.43(g) (Reference 1), which stipulates a maximum accessible surface temperature of 122 °F for non-exclusive use shipments, is a trivial exercise. Without a significant decay heat load, the OP-100 will have a surface temperature of 100 °F (560 °F), and thereby meets the requirements of 10 CFR 71.43(g).

The temperature for the curved, horizontal and vertical surfaces with maximum insolation can be found by solving the following heat balance equation for each of the three geometries:

$$\dot{Q}_{solar} = \dot{Q}_{radition} + \dot{Q}_{convection}$$

where

$Q_{solar}$ = Insolation value for the particular geometry · $\alpha_{surface}$ · Area

$Q_{radiation} = \sigma \cdot \varepsilon_{surface} \cdot \text{Area} \cdot (T^4_{surface} - T^4_{ambient})$, $\sigma = 0.1714 \times 10^{-8}$ Btu/hr-ft$^2$-°R$^4$

$Q_{convection} = h \cdot \text{Area}(T_{surface} - T_{ambient})$, h = free convection heat transfer coefficient

From Reference 2, pp. 252-3, the general form of h at one atmosphere and moderate temperatures is:

$$h = a\left(\frac{T_{surface} - T_{ambient}}{L}\right)^b$$

Where a, b and L vary based on surface geometry, orientation and whether the free convection is turbulent or laminar. Since turbulent free convection is less efficient, it is conservatively assumed for this analysis that all surfaces on the OP-100 will experience turbulent natural convection. The values for a, b and L for each orientation is presented below:

Simplified Turbulent Free Convection Equation Coefficients

| | Flat Vertical | Flat Horizontal | Curved |
|---|---|---|---|
| A | 0.19 | 0.22 | 0.18 |
| B | 1/3 | 1/3 | 1/3 |
| L | 1.0 | 1.0 | 1.0 |
| h= | $0.19\Delta T^{1/3}$ | $0.22\Delta T^{1/3}$ | $0.18\Delta T^{1/3}$ |

For a unit area, the energy balance equations for each of the orientation is:

**Flat Horizontal (non base)**

$$\dot{Q}_{solar} = 245.7 \cdot 0.26 = 63.9 \frac{Btu}{hr}$$

$$\dot{Q}_{radiation} = 0.1714x10^{-8} \cdot 0.75 \cdot (T_{surface}^4 - 560^4) = 1.29x10^{-9} \cdot (T_{surface}^4 - 560^4)$$

$$\dot{Q}_{convection} = 0.22 \cdot (T_{surface} - 560)^{1/3} \cdot (T_{surface} - 560) = 0.22 \cdot (T_{surface} - 560)^{4/3}$$

$T_{surface}$ = 596.9 °R or 136.9 °F

**Vertical**

$$\dot{Q}_{solar} = 61.4 \cdot 0.93 = 57.1 \frac{Btu}{hr}$$

$$\dot{Q}_{radiation} = 0.1714x10^{-8} \cdot 0.84 \cdot (T_{surface}^4 - 560^4) = 1.44x10^{-9} \cdot (T_{surface}^4 - 560^4)$$

$$\dot{Q}_{convection} = 0.19 \cdot (T_{surface} - 560)^{1/3} \cdot (T_{surface} - 560) = 0.19 \cdot (T_{surface} - 560)^{4/3}$$

$T_{surface}$ = 593.3 °R or 133.3 °F

**Curved**

All curved surfaces of the OP-100 are vertically oriented, and are addressed in the above vertical surface section.

**PacTec Calculation Sheet**

| | | | | | |
|---|---|---|---|---|---|
| *Prepared* | Paul F. Stevens | [signature] | *Date* 6/28/99 | *Revision* | 0 |
| *Reviewed* | Phil W. Noss | [signature] | *Date* 6/28/99 | *Page* | 7 *of* 7 |
| *Approved* | Gary L. Clark | [signature] | *Date* 6/28/99 | *Project* | 98005 |

*Title* Surface Temperature Calculation for INC OP-100 Package

## 7.0 SUMMARY OF RESULTS

The maximum temperature for all surfaces of the OP-100 in shade and an ambient temperature of 100 °F (560 °R) is 100 °F (560 °R), which satisfies the requirements of 10 CFR 71.43(g). Under peak insolation, the maximum predicted surface temperature of the sides of the OP-100 would be 133.3 °F (593.3 °R), and the maximum predicted temperature of the top of the OP-100 is 136.9 °F (596.9 °R).

# 4.0 CONTAINMENT

The OP-100 package is designed as a means of confinement for a special form Ir-192 or Se-75 source capsule. Containment of radioactive material is provided by the special form construction of the payload. The source capsules and their respective special form certification are as follows:

| Manufacture | Model Number | Certification Number |
|---|---|---|
| Industrial Nuclear Co., Inc. | A | USA/0297/S-96 |
| | 791 | USA/0393/S-96 |
| Source Production & Equipment Co., Inc. | VSe Source Capsule* | USA/0785/S-96 |

* Note: Source capsule is limited to a maximum of 120 Ci of Se-75 material.

Since the OP-100 packaging does not provide containment, subsequent sections of this chapter are not applicable.

# 5.0 SHIELDING EVALUATION

This section demonstrates the shielding capability of the IR-100 package design for the authorized special form contents. The shielding evaluation is demonstrated via prototypic testing in lieu of an analytical evaluation.

## 5.1 Description of Shielding Design

### 5.1.1 Design Features

The OP-100 package overpacks the IR-100 and IR-50 devices. Both the IR-100 and IR-50 devices are a welded structure that contains a depleted uranium (DU) gamma shield, which surrounds a titanium S–tube. A stainless steel special form capsule, which contains either 120 Ci (4.44 TBq) of Ir-192 or Se-75 isotope, is inserted into the S–tube via a pigtail assembly. The radioactive source is positioned at the center of the DU gamma shield to provide the maximum attenuation of the gamma radiation.

### 5.1.2 Summary Table of Maximum Radiation Levels

Table 5-1 provides the maximum measured external radiation levels for either an IR-100 or IR-50 device with the maximum payload content (120 Ci (4.44 TBq) Ir-192) for a non–exclusive use shipment. Note that the values were measured for devices outside of the OP-100 package.

**Table 5-1** - Maximum Measured External Radiation Levels (Non–Exclusive Use)

| Package Measurement Location | Normal Conditions of Transport | | Hypothetical Accident Conditions | |
|---|---|---|---|---|
| | Measured[1] mrem/hr (mSv/hr) | 10 CFR §71.47(a) Limit mrem/hr (mSv/hr) | Measured mrem/hr (mSv/hr) | 10 CFR §71.51(c)(2) Limit mrem/hr (mSv/hr) |
| **Surface** | 165 (1.65) | 200 (2) | N/A | N/A |
| **1 Meter from Surface** | 1.6 (0.016) | 10 (0.1) | 1.9 (0.019) | 1000 (10) |

## 5.2 Source Specification

### 5.2.1 Gamma Source

The radioactive content of the OP-100 package is limited to 120 Ci (4.44 TBq) of Ir-192 or Se-75 isotopes. As shown in Table 5-2, Ir-192 results in a higher unit dose than Se-75 per curie of activity. In addition, the photon energies of Ir-192 are higher than for Se-75 (0.280 MeV average). Therefore, the Ir-192 payload will bound the Se-75 payload for the 120 Ci (4.44 TBq) content. Since actual Ir-192 special form capsules are utilized to determine the acceptance of the DU gamma shielding, the tabulation of gamma decay source strengths for the special form capsules is not required for the OP-100 package.

### 5.2.2 Neutron Source

This section does not apply, since the OP-100 package does not contain fissile material.

**Table 5-2** – Specific Gamma Ray Constants for Iridium and Selenium Isotopes[11]

| Radionuclide | Specific Gamma Ray Constant ($R\text{-}m^2/hr\text{-}Ci$) |
|---|---|
| Iridium-192 | 0.460 |
| Selenium-75 | 0.203 |

## 5.3 Shielding Model

The shielding capability of the OP-100 package design is demonstrated by physical tests of prototypic packages. Therefore, no analytical shielding model of the package is performed.

## 5.4 Shielding Evaluation

### 5.4.1 Methods

The method utilized to demonstrate the shielding performance of the OP-100 package is via prototypic testing utilizing an IR-100 or IR-50 device with a special form capsule containing radioactive Ir-192 material.

### 5.4.2 Input and Output Data

This section does not apply, since the shielding performance of the OP-100 package is not performed analytically.

### 5.4.3 Flux-to-Dose-Rate Conversions

This section does not apply, since the shielding performance of the OP-100 package is not performed analytically.

### 5.4.4 External Radiation Levels

Following the specified tests of a prototypic package with a 120 Ci (4.44 TBq) of Ir-192 payload per 2.6, *Normal Conditions of Transport*, and 2.7, *Hypothetical Accident Conditions*, the maximum radiation level measured on the surface and at 1-meter of the IR-100 or IR-50 device is 165 mrem/hr (1.65 mSv/hr) and 1.9 mrem/hr (0.019 mSv/hr), respectively. As noted in Table 5-1, these levels are well below the regulatory limits of 10 CFR §71.47(a) and 10 CFR §71.51(a)(2).

[11] "Exposure Rate Constants and Lead Shielding Values for Over 1,100 Radionuclides", David S. Smith and Michael G. Stabin, Department of Radiology and Radiological Sciences, Vanderbilt University, Nashville, TN, Health Physics Society Journal, March 2012 issue.

# 6.0 CRITICALITY EVALUATION

The OP-100 package does not transport fissile material; therefore, this section does not apply.

# 7.0 PACKAGE OPERATIONS

## 7.1 Package Loading

This section delineates the procedures for loading a payload into the OP-100 packaging. Hereafter, reference to specific OP-100 packaging components may be found in Appendix 1.3.1, General Arrangement Drawings, *OP-100 Package*.

### 7.1.1 Preparation of the OP-100 Package for Loading

1) Visually inspect the OP-100 package for damage and/or missing parts.
2) Visually inspect the device (i.e., IR-100 or IR-50) to be loaded into the OP-100 package.
3) Loosen and remove the closure ring bolt from the closure ring.
4) Remove the closure ring and the drum lid from the drum body.
5) Remove the two unsecured plywood cross members that allow an IR-100 or an IR-50 device to be positioned within the plywood support structure.
6) Remove the Safety Plug and the dust cover (IR-100) or the dust caps (IR-50). Check the threads for wear or damage.
7) Inspect the Lock Box for damage or missing set screws. Replace any damaged or missing set screws.
8) Prior to loading an active Ir-192 or Se-75 source into an IR-100 or IR-50, insert a dummy source pigtail and functionally test the automatic locking device to ensure that all components are operating properly. The IR-100 and IR-50 locking devices shall be checked prior to each use.
9) Pull (retract) the dummy pigtail. The Safety Latch Plate will pop-up and lock the dummy source in the stored position. Rotate the key to the locked position and remove the key.
10) Insert the key into the lock, retract (pull) the dummy source pigtail and rotate the key to the unlocked position. Manually depressed the Safety Latch Plate to the operate position and remove the dummy source pigtail.

### 7.1.2 Loading the Special Form Payload into the IR-100/IR-50

1) Place the special form Ir-192 or Se-75 source pigtail assembly into a source changer.
2) Connect the drive cable housing and the guide tube to the IR-100 device.
3) Crank the drive cable out through the guide tube and connect it to the Ir-192 or Se-75 source pigtail assembly. Connect the guide tube to the IR-50 device.
4) Unlock the IR-50 device and retract the Ir-192 or Se-75 source pigtail assembly into the IR-100 device.
5) Survey the package to ensure that the source is in the stored position. Rotate key to locked position and remove the key.

6) Disconnect drive cable and install the Safety Plug and dust cap (IR-100) or the dust caps (IR-50).
7) Install the Ir-192 or Se-75 source identification plate on the top of the IR-100 device.
8) When transported in an IR-50 device, attach the Ir-192 or Se-75 source identification plate to the tamper seal wire of the IR-50 device for transfer with the Ir-192 or Se-75 source to an IR-100 device.

### 7.1.3 Preparation for Transport

1) Install the two tamper-indicating seals (security wire/lead seals). For the IR-100 device, one tamper-indicating seal is located at the lock assembly; and the second is located at the Safety Plug. For the IR-50 device, the safety seals are located on each Lock Box and has a lock key attached.
2) Load the IR-100 or IR-50 device into the plywood support structure. Replace the two unsecured plywood cross members in their proper positions.
3) Replace drum lid.
4) Replace the closure ring and then the 5/8-inch × 4 inch closure ring hex bolt. As the hex bolt is tightened, ensure that the closure ring is fully seated around the circumference of the drum. Tighten the closure ring bolt to a snug tight condition.
5) Install the hex nut and tighten to a snug tight condition.
6) Install a tamper-indicating seal (security wire/lead seal) through the hex bolt.
7) Monitor external radiation per the guidelines of 49 CFR §173.441[12].
8) Determine the shielding transport index for the loaded package per the guidelines of 49 CFR §173.403.
9) Load the OP-100 package onto the transport vehicle.
10) Complete all necessary shipping papers in accordance with Subpart C of 49 CFR 172[13].
11) OP-100 package marking shall be in accordance with 10 CFR §71.85(c) and Subpart D of 49 CFR 172. Package labeling shall be in accordance with Subpart E of 49 CFR 172. Packaging placarding shall be in accordance with Subpart F of 49 CFR 172.

## 7.2 Package Unloading

This section delineates the procedures for unloading a payload into the OP-100 packaging. Hereafter, reference to specific OP-100 package components may be found in Appendix 1.3.1, General Arrangement Drawings, OP-100 *Package*.

[12] Title 49, Code of Federal Regulations, Part 173 (49 CFR 173), *Shippers-General Requirements for Shipments and Packagings*, 10-1-14 Edition.

[13] Title 49, Code of Federal Regulations, Part 172 (49 CFR 172), *Hazardous Materials Tables and Hazardous Communications Regulations*, 10-1-14 Edition.

### 7.2.1 Receipt of Package from Carrier

1) Remove the OP-100 package from the transport vehicle.
2) Monitor the external radiation to ensure that the OP-100 package was not damaged during shipment. If Radiation readings or surface radioactive contamination levels exceed allowable limits contact the Radiation Safety Officer for instructions.

### 7.2.2 Removal of Contents from the OP-100 Package

1) Remove the tamper indicating wire seal. If tamper indicating seal is missing or broken, call Radiation Safety Officer for instructions. The RSO will investigate the incident before proceeding.
2) Remove the hex nut, closure ring hex bolt, the closure ring, and lid.
3) Remove the two unsecured plywood cross members and remove the device (i.e., IR-100 or IR-50 device).
4) Remove the Safety Plug and the dust cap (IR-100) or the dust caps (IR-50).
5) Connect the drive cable housing and the guide tube to the package. Connect the guide tube to a source changer.
6) Unlock the IR-100 and IR-50 devices and extend the Ir-192 or Se-75 source pigtail assembly into the IR-50 device.
7) Secure the Ir-192 or Se-75 source pigtail assembly in the IR-50 device, lock, and remove the key.
8) Disconnect the drive cable from the IR-50 device and retract it.
9) Disconnect the guide tube from the IR-50 and the IR-100 devices. Install the dust caps on the IR-50 device, and the Safety Plug and dust cap on the IR-100 device. Remove the source identification from the IR-100 device and install it on the IR-50 device.

### 7.2.3 Final Package Preparations for Transport of Unloaded OP-100 Package

1) Complete all required shipping papers in accordance with Subpart C of 49 CFR 172.
2) OP-100 package marking shall be in accordance with 10 CFR §71.85(c) and Subpart D of 49 CFR 172. Package labeling shall be in accordance with Subpart E of 49 CFR 172. Packaging placarding shall be in accordance with Subpart F of 49 CFR 172.

## 7.3 Preparation of an Empty Package for Transport

Previously used and empty OP-100 packages shall be prepared and transported per the requirements of 49 CFR §173.426, Subpart I.

# 8.0 ACCEPTANCE TESTS AND MAINTENANCE PROGRAM

## 8.1 Acceptance Tests

Per the requirements of 10 CFR §71.85(c), this section discusses the inspections and tests to be performed prior to first use of the OP-100 package.

### 8.1.1 Visual Inspections and Measurements

All OP-100 package materials of construction and welds shall be examined in accordance with the requirements delineated on the drawings in Appendix 1.3.1, *General Arrangement Drawings*, per the requirements of 10 CFR §71.85(a).

### 8.1.2 Weld Examinations

All welds on the IR-100 and IR-50 devices shall be examined in accordance with the requirements delineated on the drawings in Appendix 1.3.1, *General Arrangement Drawings*, per the requirements of 10 CFR §71.85(a).

### 8.1.3 Structural and Pressure Tests

The OP-100 package does not contain any lifting/tie-down devices or pressure boundaries that require load testing.

### 8.1.4 Leakage Tests

The OP-100 package does not contain any seals or containment boundaries that require testing.

### 8.1.5 Component and Material Tests

The OP-100 package does not contain any additional components or materials that require acceptance testing.

### 8.1.6 Shielding Tests

A radiation profile is performed on each depleted uranium (DU) shield prior to being used in the fabrication of an IR-100 or IR-50 device. These measured survey results are ratioed upward to determine the expected radiation levels for the maximum authorize source strength of 120 Ci. Any radiation profile of a DU shield which results in a dose rate that exceeds the requirements of 49 CFR §173.441 with the maximum authorized payload shall not be utilized in the manufacture of an IR-100 or IR-50 device.

### 8.1.7 Thermal Tests

The OP-100 package does not contain any thermal features or systems that require testing. Therefore, this section does not apply.

### 8.1.8 Miscellaneous Tests

There are no additional acceptance tests required for the OP-100 packaging.

## 8.2 Maintenance Program

This section describes the maintenance program used to ensure continued performance of the OP-100 package.

### 8.2.1 Structural and Pressure Tests

The OP-100 package does not contain any lifting/tie-down devices or pressure boundaries that require load testing.

### 8.2.2 Leakage Tests

The OP-100 package does not contain any seals or containment boundaries that require testing.

### 8.2.3 Component and Material Tests

#### 8.2.3.1 Fasteners

All threaded components shall be inspected quarterly for deformed or stripped threads. Damaged components shall be repaired or replaced prior to further use.

#### 8.2.3.2 Lock Assembly

Prior to each use, inspect the lock assembly for restrained motion. Any motion or operational impairing shall be corrected prior to further use.

### 8.2.4 Thermal Tests

No thermal tests are necessary to ensure continued performance of the OP-100 packaging.

### 8.2.5 Miscellaneous Tests – Shielding

Prior to each shipment, a radiation survey is performed to ensure that the radiation dose levels do not exceed the requirements of 49 CFR §173.441. This survey confirms that the DU shield has maintained its shielding function.