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	Test Report

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Project No.:	**02008.01.0000.00**	**Project Name:**	**INC OP-Raw Material Shipping Container**

Title: Test Report for the Industrial Nuclear Company Outer Package, Raw Material Shipping Container (OP-RMSC)

Summary:

This procedure documents the required free and puncture drop tests for qualifying the Industrial Nuclear Company (INC) OP-RMSC package to the requirements of Title 10, Code of Federal Regulations, Part 71 (10 CFR 71), *Packaging and Transportation of Radioactive Material*, as a radioactive material package. The results of these tests will be utilized as supporting documentation for INC's application to the US Nuclear Regulatory Commission to obtain a transportation license under Docket No. 71-9387.

Contains Unverified Input / Assumptions: **Yes:** ☐ **No:** ☒

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Revision History

Rev.	Changes
0	Initial Issue

Table of Contents

Page

1.0 SCOPE 4
2.0 REFERENCED DOCUMENTS 6
3.0 PURPOSE 6
4.0 CONFIGURATION OF CERTIFICATION TEST UNITS 9
5.0 TEST FACILITIES 9
6.0 TEST SEQUENCE AND RESULTS 10
6.1 Pre-Test Radiation Surveys of Test Units 10
6.2 Pre-Test Weight of Test Units 10
6.3 NCT and HAC Free Drops 11
6.3.1 NCT 4-Foot Top Down Free Drop (CTU-1, Test 1) 11
6.3.2 HAC 30-Foot Top Down Free Drop (CTU-1, Test 2) 11
6.3.3 HAC 30-Foot Side Free Drop (CTU-2, Test 3) 12
6.3.4 HAC 30-Foot CG-Over-Top Corner Free Drop (CTU-2, Test 4) 12
6.4 HAC Puncture Drops 12
6.4.1 HAC 40-Inch Top Down Puncture Drop (CTU-1, Test 5) 12
6.4.2 HAC 40-Inch Side Puncture Drop (CTU-2, Test 6) 13
6.4.3 HAC 40-Inch CG-Over-Top Corner Puncture Drop (CTU-2, Test 7) 13
6.5 Post-Test Weight of Test Units 14
6.6 Post-Test Disassembly of Test Units 14
6.7 Post-Test Radiation Surveys of Test Units 14
6.8 Testing Conclusions 15
APPENDIX A, TEST DATA SHEETS 16
APPENDIX B, OP-RMSC PACKAGE TEST UNIT PHOTOGRAPHS 31

1.0 SCOPE

This report documents the results of a series of tests to demonstrate that the Industrial Nuclear Company (INC) Model: Outer Package, Raw Material Shipping Container (OP-RMSC) satisfies the performance requirements specified in 10 CFR 71 (Reference 2.1) during normal and hypothetical accident conditions of transport. The tests were one (1) 4-foot (1.2-meter) free drop and three (3) 30-foot (9-meter) free drops onto an unyielding surface, and three (3) 40-inch (1-meter) drops onto a six-inch diameter steel puncture bar.

The OP-RMSC is a welded and bolted assembly that consists of an outer 18-inch diameter, Schedule 10S stainless steel pipe and an inner 10-inch diameter, Schedule 10S stainless steel pipe, which forms the payload cavity. The annular space between the inner and outer pipes is filled with approximately 17 pounds of rigid polyurethane foam that protects the payload, which is a Raw Material Shipping Container (RMSC). A 3/8-inch thick, 13¾ inch diameter stainless steel plate, which is secured with eight (8) 1/2-inch hex bolts, encloses the payload cavity. Above the inner lid, a 3/4-inch thick, 17½ inch diameter stainless steel lid is secured to the outer 18-inch diameter stainless steel pipe with eight (8) 1/2-inch hex head bolts. The outer lid is slotted to dissipate decay heat from the payload cavity. The maximum tare and gross weights of the OP-RMSC is 269 pounds and 645 pounds, respectively.

The RMSC payload consists of a welded outer 8-inch diameter Schedule 10S stainless steel pipe that surrounds a tungsten shield that contains a 1½ inch diameter × 3 inch high payload cavity. Above the payload cavity is a 4.2-inch diameter tungsten shield. The closure lid is secured to the body by six (6) hex bolts. The RMSC weighs approximately 376 pounds.

The testing of the OP-RMSC packaging was performed in accordance with the approved test procedure (Reference 2.2). The pre-tests, free drops, and post-tests were performed during the period of January 30, 2020 through July 22, 2020. As stated in the test procedure, two Certification Test Units (CTUs) were utilized in the testing. Figures 1-1 and 1-2 depict views of the OP-RMSC packaging and the RMSC payload, respectively.

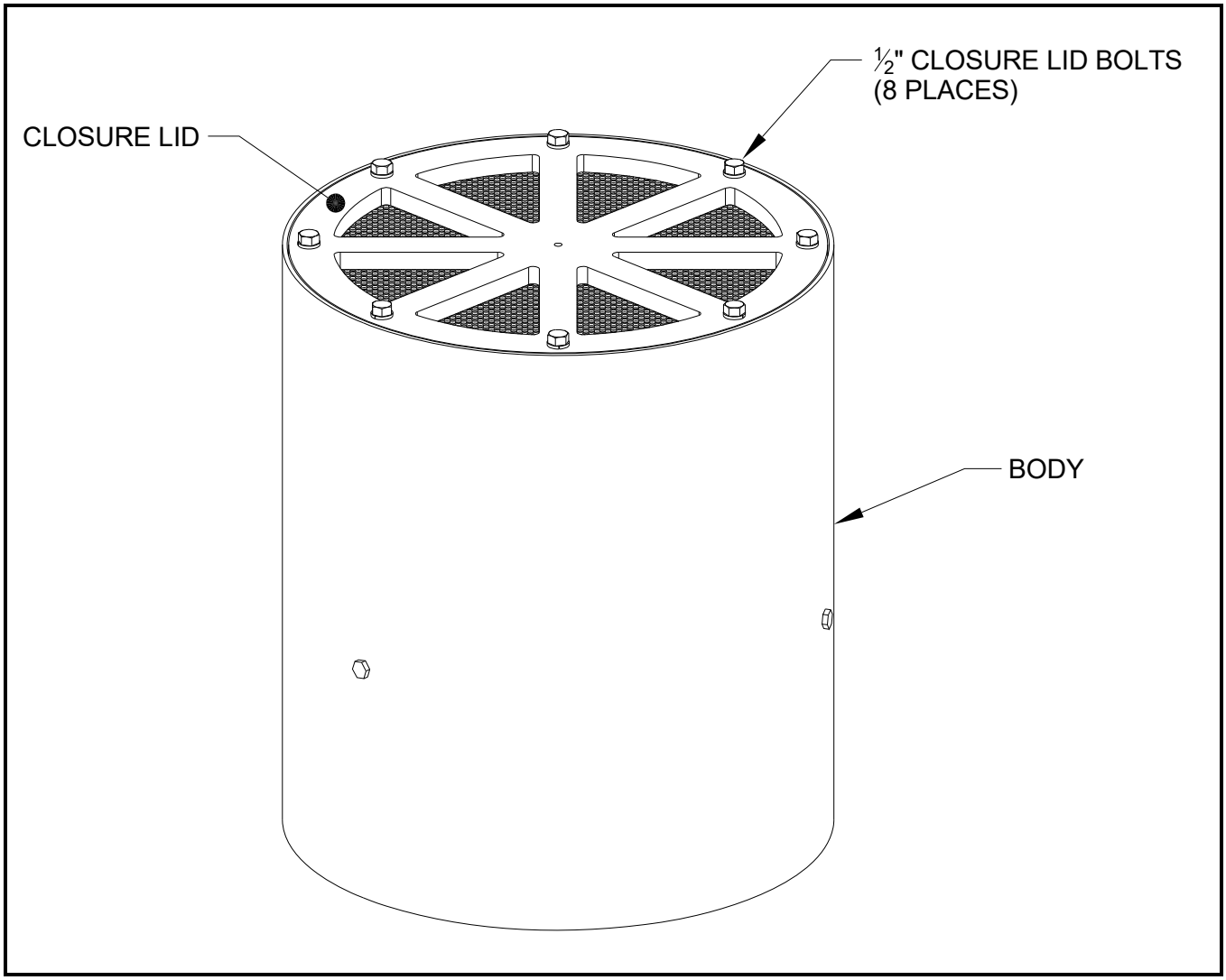


FIGURE 1-1 – INC Outer Package, Raw Material Shipping Container – Overall View

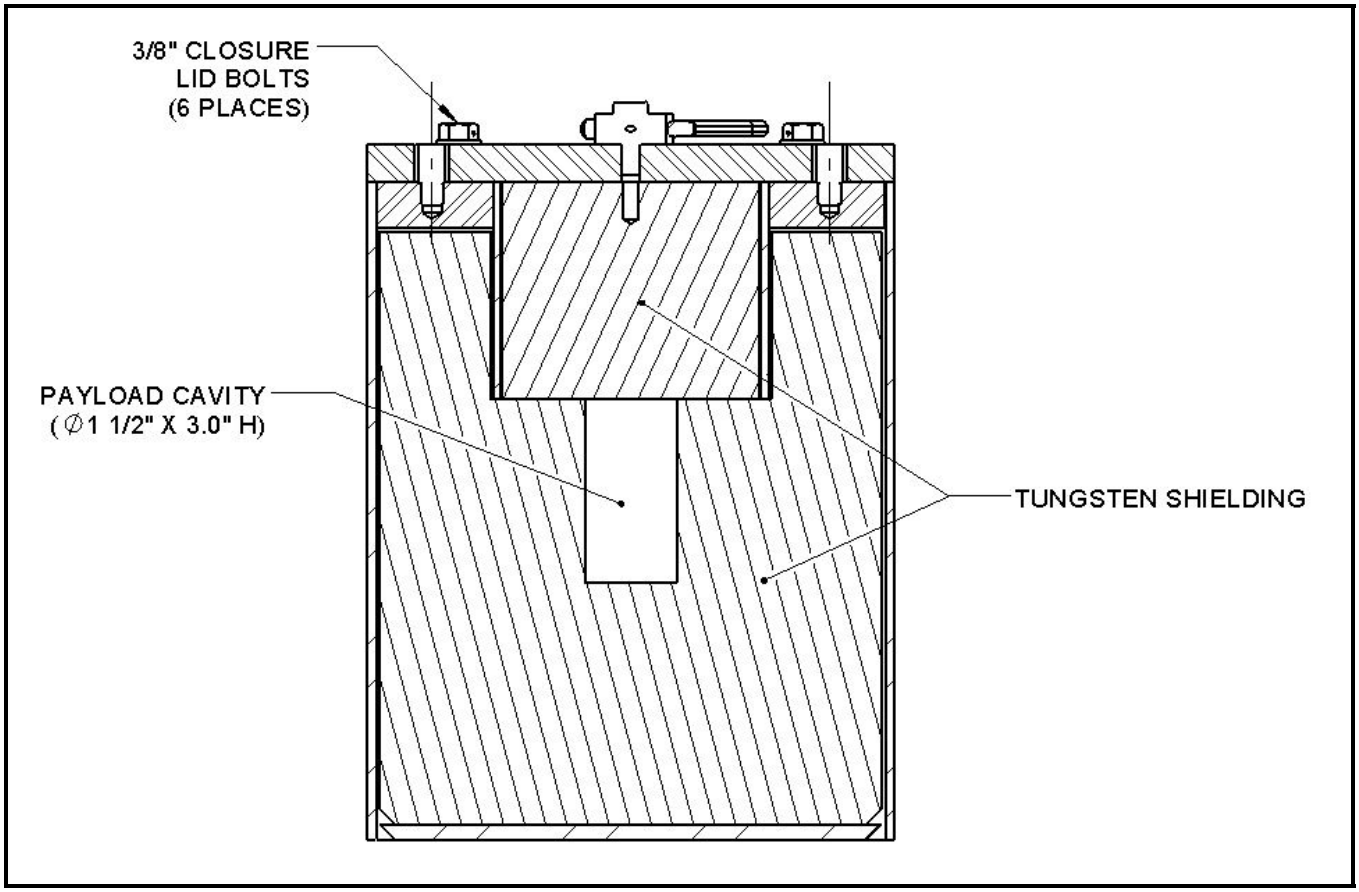


FIGURE 1-2 – INC RMSC Payload – Cross-Sectional View

2.0 REFERENCED DOCUMENTS

1. Title 10, Code of Federal Regulations, Part 71 (10 CFR 71), *Packaging and Transportation of Radioactive Material*, 1-1-2020 Edition.
2. Orano federal Services, *Test Procedure for the Industrial Nuclear Company Outer Package, Raw Material Shipping Container (OP-RMSC)*, TPR-3023104, Rev. 0, January 22, 2020.

3.0 PURPOSE

The purpose of the certification tests of the OP-RMSC package is to demonstrate that the shielding integrity of the RMSC payload is not affected by the normal conditions of transport (NCT) free drop tests per 10 CFR §71.71 or the subsequent hypothetical accident (HAC) condition free and puncture drop tests per 10 CFR §71.73. Integrity of the tungsten gamma shields was demonstrated via full-scale, NCT and HAC free drop testing. The test series also includes HAC puncture drop testing. Radiation surveys of each RMSC CTU were performed both prior to and following the specified test series in Reference 2.2. The test series is summarized in Table 3-1, and illustrated in Figures 3-1 and 3-2 for each CTU. A brief description of the test results is also provided in the table for each test.

Table 3-1 – Sequence of OP-RMSC Certification Testing

Test No.	Test Description (Certification Test Unit No.)	Test Unit Angular Orientation		Test Unit Temperature, °F (as measured)	Test Results
		Longitudinal Axis (0° = upright)	Circumferential Axis (0° = as marked)		
1	4 foot, Top Down (CTU-1)	180°	N/A	-22	No visible damage was observed.
2	30 foot, Top Down (CTU-1)	180°	N/A	-22	Inner lid bolts failed, resulting in lid contacting the closure lid. RMSC remained within the OP-RMSC. No other damaged observed.
3	30 foot, Side (CTU-2)	90°	0°	>169	Impact created ~4 inch wide flat along the side. One closure lid bolt failed. No other damaged observed.
4	30 foot, CG-over-Top Corner (CTU-2)	132°	180°	>171	Impact resulted in a ~1/2-inch fold on other shell. Five (5) of the closure lid bolts were sheared, with two (2) bolts remaining on opposite side. Closure lid remain attached.
5	Puncture drop, Top Down (CTU-1)	180°	N/A	92 - 94	Puncture bar impacted center of closure lid with no observed additional damage.
6	Puncture drop, Side (CTU-2)	90°	0°	84	Puncture bar struck side of package, resulting in small deformation of outer shell. No other damaged observed.
7	Puncture drop, CG-over-Top Corner (CTU-2)	138°	180°	100 - 103	Puncture bar struck outer shell/closure lid interface, resulting in a small “half-moon” deformed area. No other damaged observed.

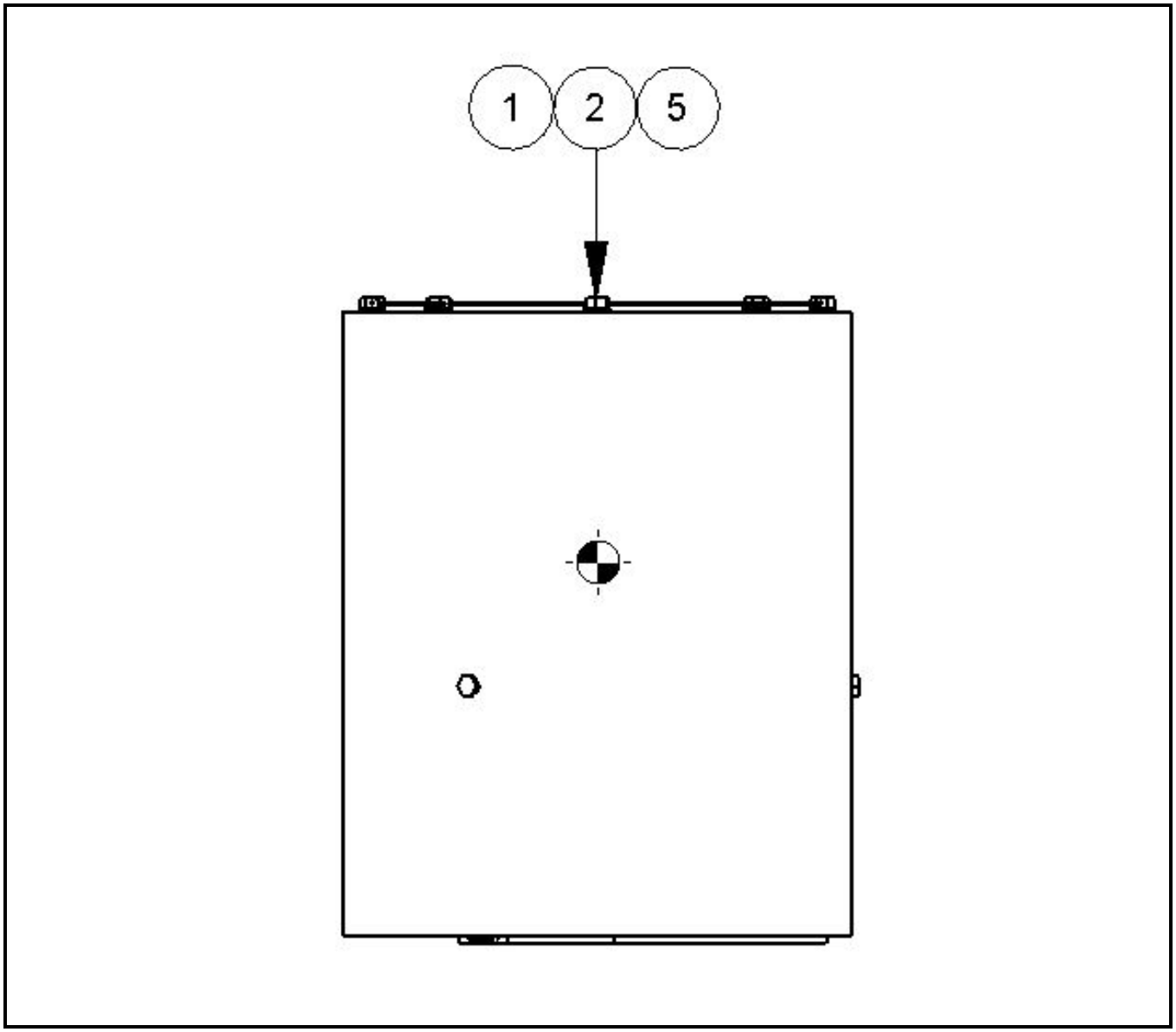


FIGURE 3-1 – Schematic Summary of CTU-1 Testing

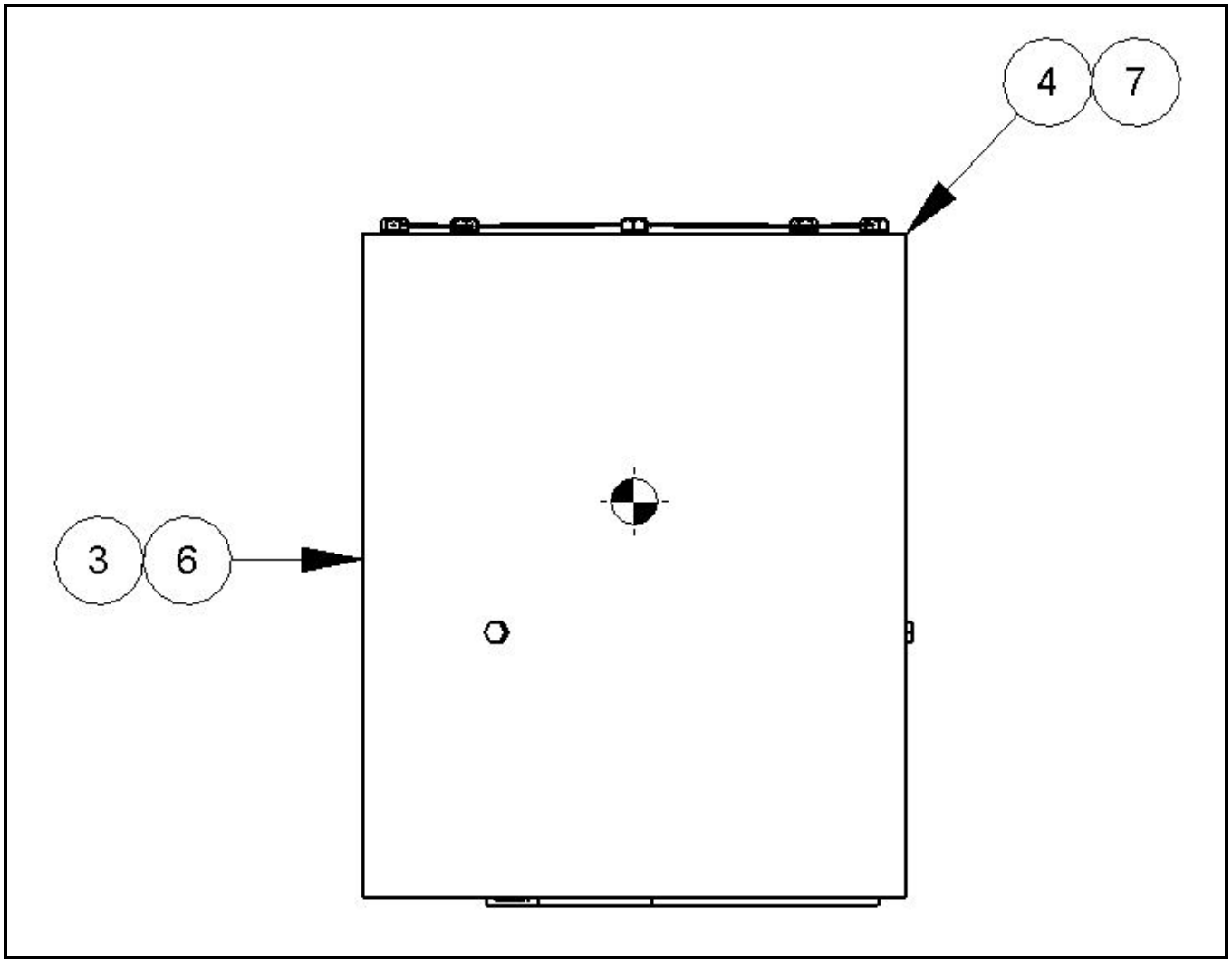


FIGURE 3-2 – Schematic Summary of CTU-2 Testing

4.0 CONFIGURATION OF CERTIFICATION TEST UNITS

The OP-RMSC CTUs were assembled with a RMSC payload in accordance with the approved INC packaging drawings. Dummy raw material source capsules and a holder were installed in each RMSC payload cavity.

5.0 TEST FACILITIES

The free drop testing was performed utilizing a horizontal concrete slab, which is approximately 9-12 inches thick × 10 feet × 15 feet. The concrete slab is setting on a parking lot concrete slab that has an approximate thickness of 9½ inches. A 2 inch × 48 inch × 48 inch steel plate was placed on top of the concrete slab, grouted, and secured to the concrete slab by four (4) 5/8-inch anchor bolts. To increase the effective mass of the impact surface, a 5 inch thick steel plate was placed on top of the 2 inch thick plate and welded to the grouted plate. Considering only the

concrete directly underneath the steel plates as being effective with a total thickness of 18½ inches for the concrete slabs, the mass of the drop pad (concrete and steel plates) is conservatively estimated to be 8,100 lb_m, which is more than 10 times the mass of the OP-RMSC CTUs. Based on these characteristics, the drop pad satisfied the requirement of 10 CFR §§71.71 and 71.73 for an essentially unyielding, horizontal surface.

The puncture bar assembly was a ∅6-inch × 25½ inch long solid steel bar that was vertically oriented and welded to a steel base plate with dimensions of 3/4-inch thick × 12 inch × 12 inch. The top circumferential edge of the bar had a radius of not more than 1/4 inch. The 24-inch minimum free length of the bar ensures an adequate length to potentially cause maximum damage to the CTU as required by 10 CFR §71.73(c)(3). Following the completion of the 30-foot free drop tests, the 3/4-inch base plate of the puncture bar assembly was welded to the 5-inch thick steel plate on the drop pad to ensure that the puncture bar was restrained for the puncture drop tests.

6.0 TEST SEQUENCE AND RESULTS

The following sections discuss and summarize the test sequence and results of the OP-RMSC certification test units as subjected to the test specified in the test procedure (Reference 2.2).

6.1 Pre-Test Radiation Surveys of Test Units

Prior to the free and puncture drop testing, each RMSC CTU was surveyed utilizing Ir-192 active radioactive sources in accordance with the test procedure. The strength of the sources on the day of the surveys was 5,714 Curies (Ci) [211 TBq]. Since the RMSC is designed for a maximum of 16,000 Ci [592 TBq] of Ir-192 isotope, the measured values were adjusted upward by the ratio of 16,000/5,714 or 2.80 to determine the dose rate for the maximum strength for each of the four (4) raw material capsules. Note that the INC radiation monitor utilized for performing the radiation surveys is calibrated to the surface of the monitor. Therefore, no correction of the measured dose is required to compensate for a gap between the monitor surface and the actual surface of the radiation detector (i.e., detector volume error). The results of the surveys for the maximum payload of 16,000 Ci [592 TBq] are presented in Table 6-1.

Table 6-1 – Pre-Test Radiation Surveys of RMSC CTUs

Test Unit Number (Serial Number)	Maximum Dose Rate [Top/Bottom/Side] (mrem/hr)								
	Surface			1-meter			2-meters		
CTU-1 (1)	11	11	112	0	0	0	0	0	0
CTU-2 (1)	14	11	115	0	0	3	0	0	0

6.2 Pre-Test Weight of Test Units

Prior to performing the free drop testing, each OP-RMSC CTU assembly was weighed. The recorded weights are listed in Table 6-2.

Table 6-2 – OP-RMSC CTU Pre-Test Weight

Test Unit Number	Serial Number	Weight (lb)
CTU-1	1	646
CTU-2	1	647

6.3 NCT and HAC Free Drops

With the exception of Test No. 1, which was a 4-foot (1.2-meter) drop, all free drops were HAC 30-foot (9-meter) free drops. Orientations for each test unit are schematically illustrated in Figures 3-1 (CTU-1) and 3-2 (CTU-2). The completed data sheet for each free drop test is provided in Appendix A.

6.3.1 NCT 4-Foot Top Down Free Drop (CTU-1, Test 1)

As shown in Figure 3-1 for Test Number 1, the CTU was oriented vertically with the top down with respect to the impact pad. The following list summarizes the test parameters:

- verified longitudinal angle as 180° ±1°
- verified drop height as 4 feet (1.2 meter), +2/-0 inches
- measured surface temperature of inner shell wall as -22 °F at time of test
- conducted test at 6:37 p.m. on Tuesday, 7/7/2020

The package rebounded (bounced) upon impact off the drop pad, and remained upright. No external damage was noted. Figures B.1.1-X photo-documents Test Number 1 for CTU-1.

6.3.2 HAC 30-Foot Top Down Free Drop (CTU-1, Test 2)

As shown in Figure 3-1 for Test Number 2, the CTU was oriented vertically with the top down with respect to the impact pad. The following list summarizes the test parameters:

- verified longitudinal angle as 180° ±1°
- verified drop height as 30 feet (9 meter), +3/-0 inches
- measured surface temperature of inner shell wall as -22 °F at time of test
- conducted test at 6:48 p.m. on Tuesday, 7/7/2020

The package impacted the drop pad and did not rebound (bounce). The package remained upright on drop pad. No external damage was noted. All of the bolts securing the inner lid failed, allowing the inner lid to separate from the body and contact the closure lid. The RMSC payload remained within the OP-RMSC. Figures B.1.2-X photo-documents Test Number 2 for CTU-1.

6.3.3 HAC 30-Foot Side Free Drop (CTU-2, Test 3)

As shown in Figure 3-2 for Test Number 3, the CTU was oriented parallel to the horizontal impact surface (longitudinal angle 90º, circumferential angle 0°). The following list summarizes the test parameters:

- verified longitudinal angle as 90° ±1°
- verified circumferential angle as 0° ±2°
- verified drop height as 30 feet (9 meter), +3/-0 inches
- measured surface temperature of inner shell wall greater than 169 °F at time of test
- conducted test at 11:01 a.m. on Tuesday, 7/7/2020

The package rebounded (bounced) upon impact off the drop pad, and fell to its side. Impact created a ~4 inch wide flat along the side of the outer shell. One closure lid bolt on the impact side failed. No other external damage was noted. Figures B.1.3-X photo-documents Test Number 2 for CTU-2.

6.3.4 HAC 30-Foot CG-Over-Top Corner Free Drop (CTU-2, Test 4)

As shown in Figure 3-2 for Test Number 3, the CTU was oriented 48º with respect to the horizontal impact surface (longitudinal angle 132º, circumferential angle 180°). The following list summarizes the test parameters:

- verified longitudinal angle as 132° ±1°
- verified circumferential angle as 180° ±2°
- verified drop height as 30 feet (9 meter), +3/-0 inches
- measured surface temperature of inner shell wall greater than 171 °F at time of test
- conducted test at 11:25 a.m. on Tuesday, 7/7/2020

The package rebounded (bounced) upon impact off the drop pad, and fell to its side. The impact produced a ~1/2 inch buckle/fold on the outer shell. Five (5) of the remaining seven (7) closure lid bolts failed. However, the closure lid did not separate from the body. No other damage was visible or noted. Figures B.1.4-X photo-documents Test Number 2 for CTU-2.

6.4 HAC Puncture Drops

All puncture drops were HAC 40-inch (1-meter) drops. Orientations for each test unit are schematically illustrated in Figures 3-1 (CTU-1) and 3-2 (CTU-2). The completed data sheet for each puncture drop test is provided in Appendix A.

6.4.1 HAC 40-Inch Top Down Puncture Drop (CTU-1, Test 5)

As shown in Figure 3-1 for Test Number 5, the CTU was oriented vertically with the top down with respect to the impact pad. The following list summarizes the test parameters:

- verified longitudinal angle as 180° ±1°
- verified drop height as 40 inch (1 meter), +2/-0 inches
- measured surface temperature of outer shell of OP-RMSC as 92 - 94 °F at time of test
- conducted test at 10:55 a.m. on Wednesday, 7/8/2020

The package rebounded (bounced) upon impact off the drop pad, and fell to its side. No damage was observed from the impact. Figures B.1.5-X photo-documents Test Number 5 for CTU-1.

6.4.2 HAC 40-Inch Side Puncture Drop (CTU-2, Test 6)

As shown in Figure 3-2 for Test Number 6, the CTU was oriented parallel to the horizontal impact surface (longitudinal angle 90º, circumferential angle 0°). The following list summarizes the test parameters:

- verified longitudinal angle as 90° ±1°
- verified circumferential angle as 0° ±2°
- verified drop height as 40 inch (1 meter), +2/-0 inches
- measured surface temperature of outer shell of OP-RMSC as 84 °F at time of test
- conducted test at 11:30 a.m. on Wednesday, 7/8/2020

The package rebounded (bounced) off the puncture bar immediately following impact. The impact struck the previous damage from the 30-foot free drop, resulting in a small deformed area of the outer shell. No other external damage was noted. Figures B.1.6-X photo-documents Test Number 6 for CTU-2.

6.4.3 HAC 40-Inch CG-Over-Top Corner Puncture Drop (CTU-2, Test 7)

As shown in Figure 3-2 for Test Number 7, the CTU was oriented 42º with respect to the horizontal impact surface (longitudinal angle 138º, circumferential angle 180°). The following list summarizes the test parameters:

- verified longitudinal angle as 138° ±2°
- verified circumferential angle as 180° ±1°
- verified drop height as 40 inch (1 meter), +2/-0 inches
- measured surface temperature of outer shell of OP-RMSC as 100 - 103 °F at time of test
- conducted test at 11:58 a.m. on Wednesday, 7/8/2020

The package rebounded (bounced) off the puncture bar immediately following impact. The impact struck the previous damage from the 30-foot free drop with no measureable deformation. No other external damage was noted. Figures B.1.7-X photo-documents Test Number 7 for CTU-2.

6.5 Post-Test Weight of Test Units

Subsequent to the free and puncture drop testing, each OP-RMSC CTU assembly was weighed prior opening/disassembly. The recorded weights are listed in Table 6-3.

Table 6-3 – OP-RMSC CTU Post-Test Weight

Test Unit Number	Serial Number	Weight (lb)
CTU-1	1	645
CTU-2	1	645

6.6 Post-Test Disassembly of Test Units

Both OP-RMSC CTUs were disassembled to access and remove the RMSC payloads. For CTU-1, the center of the inner lid was deformed from the 30-foot top down free drop by the alloy hoist ring on the RMSC payload lid. Similarly, the same deformation of the inner lid of CTU-2 was observed from the 30-foot CG-over-top corner free drop. The alloy hoist ring bolt was also sheared from the RMSC payload lid due to the impact. For the 30-foot side free drop, the inner shell of CTU-2 was deformed by the RMSC payload, which shifted the RMSC payload off center in the cavity. After removal from the OP-RMSC body, no exterior damage was observed for either RMSC payload. Additionally, there was no damage to the four (4) dummy special form capsules or the capsule holder after the removal of the RMSC lid.

Figures B.2-X photo-documents the post-test disassembly of the OP-RMSC CTUs.

6.7 Post-Test Radiation Surveys of Test Units

Subsequent to the free and puncture drop testing, each RMSC CTU was surveyed utilizing Ir-192 active radioactive sources in accordance with the test procedure. The strength of the sources on the day of the surveys was 4,297 Curies (Ci) [159 TBq]. Since the RMSC payload is designed for a maximum of 16,000 Ci [592 TBq] of Ir-192 isotope, the measured values were adjusted upward by the ratio of 16,000/4,297 or 3.724 to determine the total dose rate for the maximum strength for each of the four (4) raw material capsules. As with the pre-test measurements, there were no corrections for the INC radiation monitor utilized for performing the radiation surveys as it was calibrated to the surface of the monitor. The results of the surveys for the maximum payload of 16,000 Ci [592 TBq] are presented in Table 6-2.

Table 6-2 – Post-Test Radiation Surveys of RMSC CTUs

Test Unit Number (Serial Number)	Maximum Dose Rate [Top/Bottom/Side] (mrem/hr)								
	Surface			1-meter			2-meters		
CTU-1 (1)	15	19	123	4	0	4	0	0	0
CTU-2 (1)	11	15	123	4	4	4	0	0	0

6.8 Testing Conclusions

Based on the tests performed, the OP-RMSC packaging design satisfied the requirements of 10 CFR §§71.71, *Normal Conditions of Transport*, and §§71.73, *Hypothetical Accident Conditions*. This conclusion is based on the following facts:

- the RMSC payload was fully retained with in the OP-RMSC packaging during all of the NCT and HAC drop tests
- there was no loss of shielding effectiveness in either of the test units
- there was no damage to the radioactive special form capsules or capsule holder
- there were no failures of any of the structural welds

APPENDIX A
TEST DATA SHEETS

DATA SHEET 1.1
OP-RMSC Packaging Weight, Pre-Test

Test Unit Information

Certification Test Unit Number	Serial Number	Date
CTU-1	1	1/30/2020

Instrumentation Records

Load Cell/Scale Description	Serial Number	Calibration Due Date
METTLER TOLEDO	PMC0014	11/6/2020

OP-RMSC Package Weight

OP-RMSC Unit Weight,(lb)
646.2

Test Conductor and Quality Assurance Signatures

	Printed Name	Date
Test Conductor Signature	GARY CLARK	1/30/2020
QA Signature	Michael Schuster	1/30/2020

DATA SHEET 1.1
OP-RMSC Packaging Weight, Pre-Test

Test Unit Information

Certification Test Unit Number	Serial Number	Date
CTU-2	R1 JZP 1/13/2020	1/30/20

Instrumentation Records

Load Cell/Scale Description	Serial Number	Calibration Due Date
METTLER TOLEDO	PMC 0014	11/6/2020

OP-RMSC Package Weight

OP-RMSC Unit Weight,(lb)
646.8

Test Conductor and Quality Assurance Signatures

	Printed Name	Date
Test Conductor Signature	GARY CLARK	1/30/2020
QA Signature	Michael Schuster	1/30/2020

DATA SHEET 1.2
OP-RMSC Packaging Weight, Post-Test

Test Unit Information

CTU-1	1	7/8/2020
Certification Test Unit Number	*Serial Number*	*Date*

Instrumentation Records

GSE SCALE MODEL 350	524122	8/2020
Load Cell/Scale Description	*Serial Number*	*Calibration Due Date*

OP-RMSC Package Weight

645

OP-RMSC Unit Weight,(lb)

Test Conductor and Quality Assurance Signatures

Gary Clark	GARY CLARK	7/8/2020
Test Conductor Signature	*Printed Name*	*Date*
Michael Schuster	Michael Schuster	7/8/2020
QA Signature	*Printed Name*	*Date*

DATA SHEET 1.2
OP-RMSC Packaging Weight, Post-Test

Test Unit Information

Certification Test Unit Number	Serial Number	Date
CTU-2	1	7/8/2020

Instrumentation Records

Load Cell/Scale Description	Serial Number	Calibration Due Date
GSE SCALE MODEL 350	524122	8/2020

OP-RMSC Package Weight

OP-RMSC Unit Weight,(lb)
645

Test Conductor and Quality Assurance Signatures

	Printed Name	Date
Test Conductor Signature	GARY CLARK	7/8/2020
QA Signature	Michael Schuster	7/8/2020

DATE SHEET 2.1
Radiation Profile of RMSC, Pre-Test

Test Unit Information

Test Unit Number	Serial Number	Date
CTU-1 (RMSC)	1	1/30/2020

Instrumentation Records

Radiation Monitor Description	Serial Number	Calibration Due Date
MODEL 4	900816	3/25/2020
Secondary Radiation Monitor Description	Serial Number	Calibration Due Date
N/A	N/A	N/A

Pre-Test Radiation Profile Record

Maximum Surface Dose Rate Reading, End/Side (mrem/hr): 40	Maximum Surface Dose Rate Reading, Top/Bottom (mrem/hr): 4/4
Maximum 2-inch Dose Rate Reading, End/Side (mrem/hr): 19	Maximum 2-inch Dose Rate Reading, Top/Bottom (mrem/hr): 2/2
Maximum 1-m Dose Rate Reading, End/Side (mrem/hr): 0	Maximum 1-m Dose Rate Reading, Top/Bottom (mrem/hr): 0/0
Maximum 2-m Dose Rate Reading, End/Side (mrem/hr): 0	Maximum 2-m Dose Rate Reading, Top/Bottom (mrem/hr): 0/0

Radiation Source Location

Datum for Measuring	Distance from Datum (in)	Comments
SURFACE	N/A	DETECTOR COMPENSATED FOR DISTANCE

Radiation Sources Information

Capsule Serial Numbers	Isotope Source	Total Capsule Source Strength (Ci)
374, 375, 378 HXC 1/30/2020	Ir-192	5,714

Technician and Quality Assurance Signatures

	Printed Name	Date
Technician Signature	JOSE ZARATE	1/30/2020
QA Signature	Printed Name	1/30/2020
Michael Schuster		Date

DATE SHEET 2.1
Radiation Profile of RMSC, Pre-Test

Test Unit Information		
CTU-2 (RMSC)	2	1/30/2020
Test Unit Number	*Serial Number*	*Date*

Instrumentation Records		
MODEL 4	900816	3/25/2020
Radiation Monitor Description	*Serial Number*	*Calibration Due Date*
N/A	N/A	N/A
Secondary Radiation Monitor Description	*Serial Number*	*Calibration Due Date*

Pre-Test Radiation Profile Record	
41	5/4
Maximum Surface Dose Rate Reading, End/Side (mrem/hr)	*Maximum Surface Dose Rate Reading, Top/Bottom (mrem/hr)*
18	2/3
Maximum 2-inch Dose Rate Reading, End/Side (mrem/hr)	*Maximum 2-inch Dose Rate Reading, Top/Bottom (mrem/hr)*
1	Ø/Ø
Maximum 1-m Dose Rate Reading, End/Side (mrem/hr)	*Maximum 1-m Dose Rate Reading, Top/Bottom (mrem/hr)*
Ø	Ø/Ø
Maximum 2-m Dose Rate Reading, End/Side (mrem/hr)	*Maximum 2-m Dose Rate Reading, Top/Bottom (mrem/hr)*

Radiation Source Location		
SURFACE	N/A	DETECTOR COMPENSATED FOR DISTANCE
Datum for Measuring	*Distance from Datum (in)*	*Comments*

Radiation Sources Information		
374/375/378	Ir-192	5,714
Capsule Serial Numbers	*Isotope Source*	*Total Capsule Source Strength (Ci)*

Technician and Quality Assurance Signatures		
[signature]	JOSE ZARATE	1/30/2020
Technician Signature	*Printed Name*	*Date*
[signature]	Michael Schuster	1/30/2020
QA Signature	*Printed Name*	*Date*

DATE SHEET 2.2
Radiation Profile of RMSC, Post-Test

Test Unit Information

Test Unit Number	Serial Number	Date
CTU-1 (RMSC)	1	7/22/2020

Instrumentation Records

MODEL 4	900816	10/27/2020
Radiation Monitor Description	*Serial Number*	*Calibration Due Date*
N/A	N/A	N/A
Secondary Radiation Monitor Description	*Serial Number*	*Calibration Due Date*

Post-Test Radiation Profile Record

33	415
Maximum Surface Dose Rate Reading, End/Side (mrem/hr)	*Maximum Surface Dose Rate Reading, Top/Bottom (mrem/hr)*
14	2/2
Maximum 2-inch Dose Rate Reading, End/Side (mrem/hr)	*Maximum 2-inch Dose Rate Reading, Top/Bottom (mrem/hr)*
1	1/0
Maximum 1-m Dose Rate Reading, End/Side (mrem/hr)	*Maximum 1-m Dose Rate Reading, Top/Bottom (mrem/hr)*
0	0
Maximum 2-m Dose Rate Reading, End/Side (mrem/hr)	*Maximum 2-m Dose Rate Reading, Top/Bottom (mrem/hr)*

Radiation Source Location

SURFACE	N/A	DETECTOR COMPENSATE FOR DISTANCE
Datum for Measuring	*Distance from Datum (in)*	*Comments*

Radiation Sources Information

A6112, A6113	IR-192	4,297
Capsule Serial Numbers	*Isotope Source*	*Total Capsule Source Strength (Ci)*

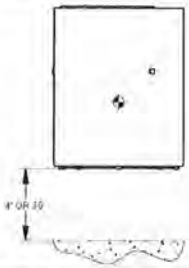
Technician and Quality Assurance Signatures

Jose Zarate	JOSE ZARATE	7-22-2020
Technician Signature	*Printed Name*	*Date*
Michael Schuster	Michael Schuster	7-22-2020
QA Signature	*Printed Name*	*Date*

DATA SHEET 3.1
Test 1, CTU-1, 4-Foot Free Drop, Top Down

Test Unit Information

CTU-1	1	7/7/2020
Certification Test Unit Number	*Serial Number*	*Date*



48"
Drop Height

180°
Longitudinal Angle

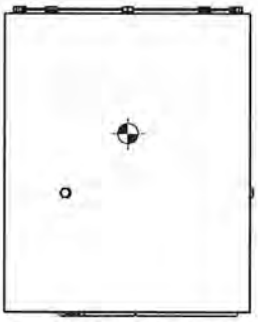
N/A
Circumferential Angle

Test Records

95	-22	18:37
Ambient Temperature (°F)	*CTU Temperature (°F)*	*Test Time (hh:mm)*

Post-Test Records

Record Visible Damage Using Figure Below



NO IMPACT DAMAGE.

Record Additional Comments Below and/or a Separate Page

CTU STRUCK PAD, BOUNCED ONCE, AND THEN STAYED UPRIGHT. NO VISIBLE DAMAGE WAS OBSERVED.

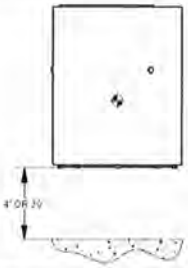
Test Conductor and Quality Assurance Signatures

Gary Clark	GARY CLARK	7/7/2020
Test Conductor Signature	*Printed Name*	*Date*
QA Signature	Michael Schuster	7/7/2020
	Printed Name	*Date*

DATA SHEET 3.2
Test 2, CTU-1, 30-Foot Free Drop, Top Down

Test Unit Information

CTU-1	1	7/7/2020
Certification Test Unit Number	*Serial Number*	*Date*



30'
Drop Height

180°
Longitudinal Angle

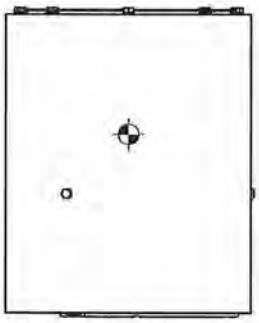
N/A
Circumferential Angle

Test Records

95	-22	18:48
Ambient Temperature (°F)	*CTU Temperature (°F)*	*Test Time (hh:mm)*

Post-Test Records

Record Visible Damage Using Figure Below



NO IMPACT DAMAGE

Record Additional Comments Below and/or a Separate Page

CTU STRUCK PAD WITH NO REBOUND. NO VISIBLE DAMAGE TO IMPACTED TOP. INNER LID BOLTS FAILED, ALLOWING INNER LID TO CONTACT CLOSURE LID.

Test Conductor and Quality Assurance Signatures

Gary Clark	GARY CLARK	7/7/2020
Test Conductor Signature	*Printed Name*	*Date*
[illegible]	Michael Schuster	7/7/2020
QA Signature	*Printed Name*	*Date*

Orano Federal Services

Title: Test Procedure for the INC OP-RMSC Package

Doc./Rev.: TPR-3023104-000

Project: 02008.01.0000.00 INC OP-Raw Material Shipping Container **Page 32 of 36**

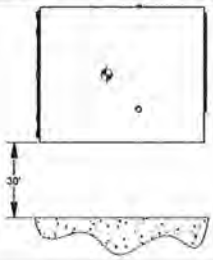
GXO CTU-2 7/7/2020

DATA SHEET 3.3

Test 3, ~~CTU-1~~, 30-Foot Free Drop, Side

Test Unit Information

CTU-2	1	7/7/2020
Certification Test Unit Number	*Serial Number*	*Date*



30'-2" *Drop Height*

90° *Longitudinal Angle*

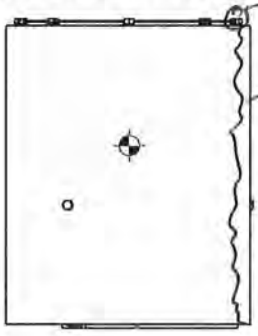
0° *Circumferential Angle*

Test Records

80	1694	11:01
Ambient Temperature (°F)	*CTU Temperature (°F)*	*Test Time (hh:mm)*

Post-Test Records

Record Visible Damage Using Figure Below



Record Additional Comments Below and/or a Separate Page

IMPACT CREATED ~4" WIDE FLAT ALONG SIDE. ONE CLOSURE LID BOLT WAS SHEARED OFF. NO OTHER DAMAGE WAS OBSERVED.

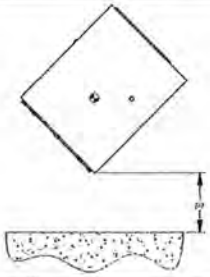
Test Conductor and Quality Assurance Signatures

Gary Clark	GARY CLARK	7/7/2020
Test Conductor Signature	*Printed Name*	*Date*
QA Signature	Michael Schuster	7/7/2020
	Printed Name	*Date*

DATA SHEET 3.4
Test 4, CTU-2, 30-Foot Free Drop, CG-Over-Top Corner

Test Unit Information

CTU-2	1	7/7/2020
Certification Test Unit Number	*Serial Number*	*Date*



30'-1"
Drop Height

132°
Longitudinal Angle

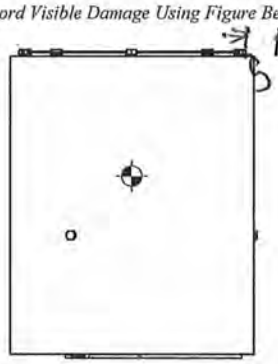
180°
Circumferential Angle

Test Records

85	171+	11:25
Ambient Temperature (°F)	*CTU Temperature (°F)*	*Test Time (hh:mm)*

Post-Test Records

Record Visible Damage Using Figure Below



Record Additional Comments Below and/or a Separate Page

IMPACT SHEARED (5) FIVE CLOSURE LID BOLTS WITH TWO BOLTS REMAINING ON OPPOSITE SIDE, IMPACT CREATED ~1/2 FOLD ON OUTER SHELL. CLOSURE LID DID NOT SEPARATE FROM BODY.

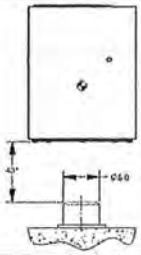
Test Conductor and Quality Assurance Signatures

Gary Clark	GARY CLARK	7/7/2020
Test Conductor Signature	*Printed Name*	*Date*
Michael Schuster	Michael Schuster	7/7/2020
QA Signature	*Printed Name*	*Date*

DATA SHEET 3.5
Test 5, CTU-1, Puncture Drop, Top Down

Test Unit Information

CTU-1	1	7/8/2020
Certification Test Unit Number	*Serial Number*	*Date*



40"
Drop Height

180°
Longitudinal Angle

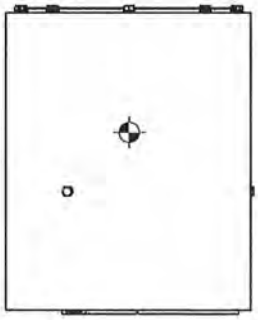
N/A
Circumferential Angle

Test Records

87	92-94	10:55
Ambient Temperature (°F)	*CTU Temperature (°F)*	*Test Time (hh:mm)*

Post-Test Records

Record Visible Damage Using Figure Below



Record Additional Comments Below and/or a Separate Page

PUNCTURE BAR STRUCK CENTER OF CLOSURE LID, NO DAMAGE WAS OBSERVED FROM IMPACT.

Test Conductor and Quality Assurance Signatures

Gary Clark	GARY CLARK	7/8/2020
Test Conductor Signature	*Printed Name*	*Date*
Michael Schuster	Michael Schuster	7/8/2020
QA Signature	*Printed Name*	*Date*

Orano Federal Services

Title: Test Procedure for the INC OP-RMSC Package

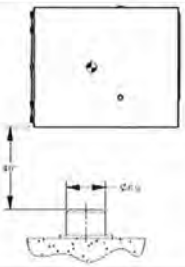
Doc./Rev.: TPR-3023104-000

Project: 02008.01.0000.00 INC OP-Raw Material Shipping Container **Page 35 of 36**

DATA SHEET 3.6
Test 6, CTU-2, Puncture Drop, Side

Test Unit Information

CTU-2	1	7/8/2020
Certification Test Unit Number	*Serial Number*	*Date*



40"
Drop Height

90°
Longitudinal Angle

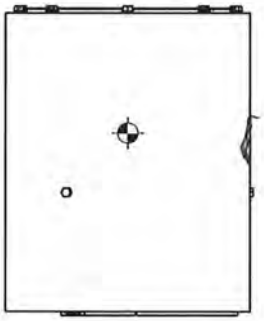
0°
Circumferential Angle

Test Records

89	84	11:30
Ambient Temperature (°F)	*CTU Temperature (°F)*	*Test Time (hh:mm)*

Post-Test Records

Record Visible Damage Using Figure Below



Record Additional Comments Below and/or a Separate Page

CTU STRUCK BAR, THEN FELL OFF ONTO PAD. SMALL SCUFF MARK ON OUTER SHELL FROM BAR, WITH A VERY SMALL DIMPLE. NO OTHER DAMAGE OBSERVED.

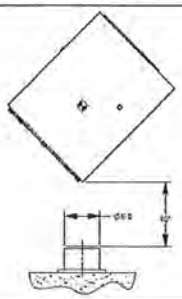
Test Conductor and Quality Assurance Signatures

Gary Clark	GARY CLARK	7/8/2020
Test Conductor Signature	*Printed Name*	*Date*
QA Signature	Michael Schuster	7/8/2020
	Printed Name	*Date*

DATA SHEET 3.7
Test 7, CTU-2, Puncture Drop, CG-Over-Top Corner

Test Unit Information

CTU-2	1	7/8/2020
Certification Test Unit Number	*Serial Number*	*Date*



40"
Drop Height

138°
Longitudinal Angle

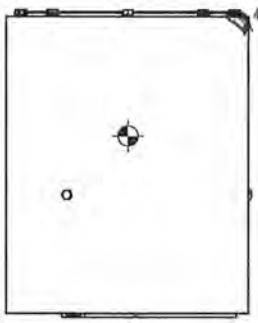
180°
Circumferential Angle

Test Records

91	100-103	11:58
Ambient Temperature (°F)	*CTU Temperature (°F)*	*Test Time (hh:mm)*

Post-Test Records

Record Visible Damage Using Figure Below



Record Additional Comments Below and/or a Separate Page

PUNCTURE BAR STRUCK OUTER SHELL / CLOSURE LID INTERFACE, RESULTING IN A SMALL DEFORMED AREA WITH A "HALF-MOON" SHAPE.

Test Conductor and Quality Assurance Signatures

Gary Clark	GARY CLARK	7/8/2020
Test Conductor Signature	*Printed Name*	*Date*
QA Signature	Michael Schuster	7/8/2020
	Printed Name	*Date*

APPENDIX B

OP-RMSC PACKAGE TEST UNIT PHOTOGRAPHS

The following section provides photo-documentation of the OP-RMSC package certification test units during free and puncture drop test, and post-test disassembly. Photographs are found utilizing the following figure-number nomenclature, where “X” is a unique figure number starting with number 1:

- Figures B.1.Y-X – Drop Tests
  - Figures B.1.1-X – NCT 4-Foot Top Down Free Drop Test (Test 1)
  - Figures B.1.2-X – HAC 30-Foot Top Down Free Drop Test (Test 2)
  - Figures B.1.3-X – HAC 30-Foot Side Free Drop Test (Test 3)
  - Figures B.1.4-X – HAC 30-Foot CG-Over-Top Corner Free Drop Test (Test 4)
  - Figures B.1.5-X – HAC 40-Inch Top Down Puncture Test (Test 5)
  - Figures B.1.6-X – HAC 40-Inch Side Puncture Drop Test (Test 6)
  - Figures B.1.7-X – HAC 40-Inch CG-Over-Top Corner Puncture Drop Test (Test 7)
- Figures B.2-X – Post-Test Disassembly of Test Units

Figures B.1.1
NCT 4-Foot Top Down Free Drop (Test No. 1)

FIGURE B.1.1-1 – Test Unit Immediately Prior to NCT 4-Foot Top Down Drop

FIGURE B.1.1-2 – Test Unit at Impact, NCT 4-Foot Top Down Drop

FIGURE B.1.1-3– Close-up View of Top/Side Following NCT 4-Foot Top Down Drop

Figures B.1.2

HAC 30-Foot Top Down Free Drop (Test No. 2)

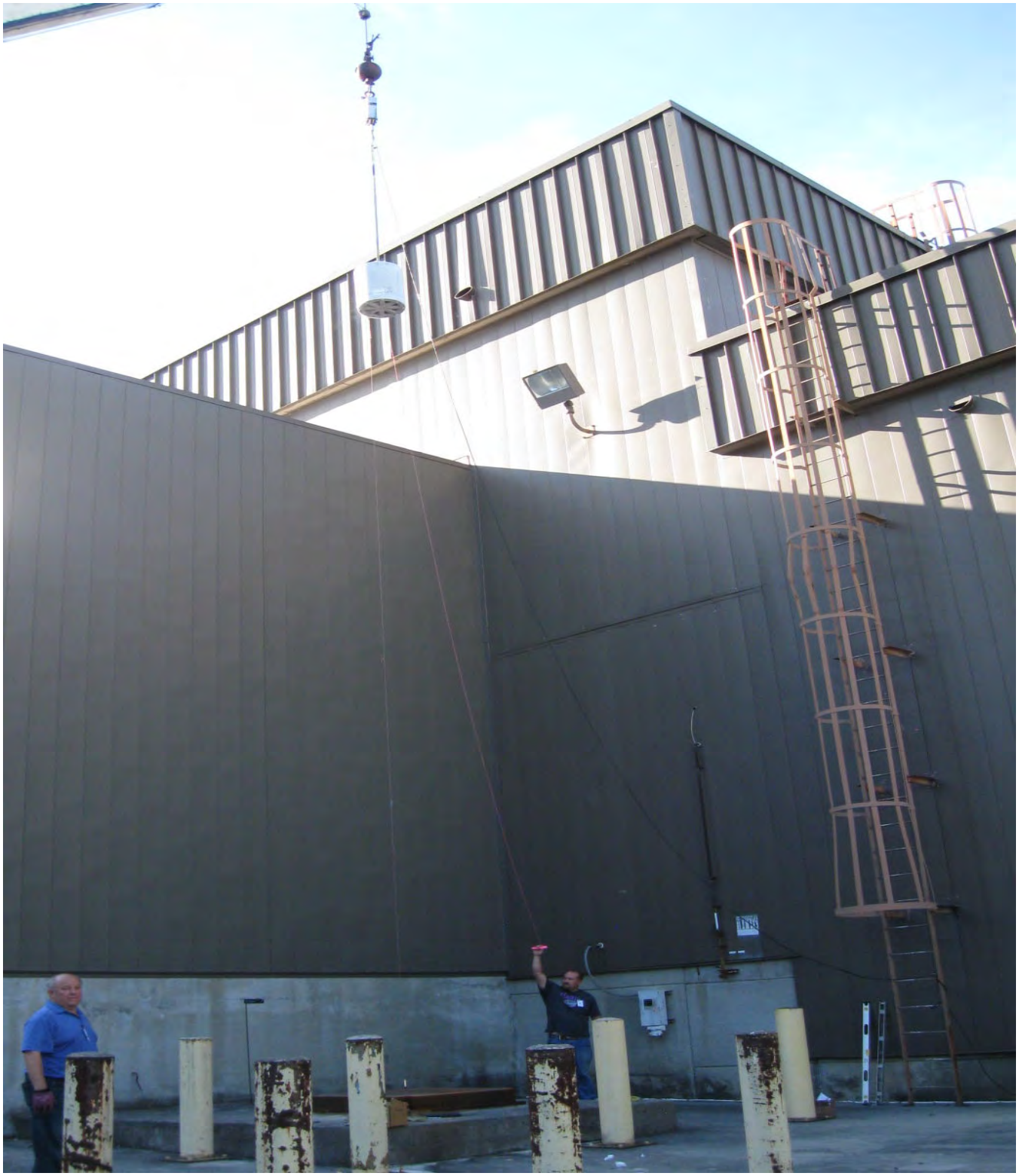


FIGURE B.1.2-1 – Test Unit Immediately Prior to HAC 30-Foot Top Down Drop

FIGURE B.1.2-2 – Test Unit at Impact, HAC 30-Foot Top Down Drop

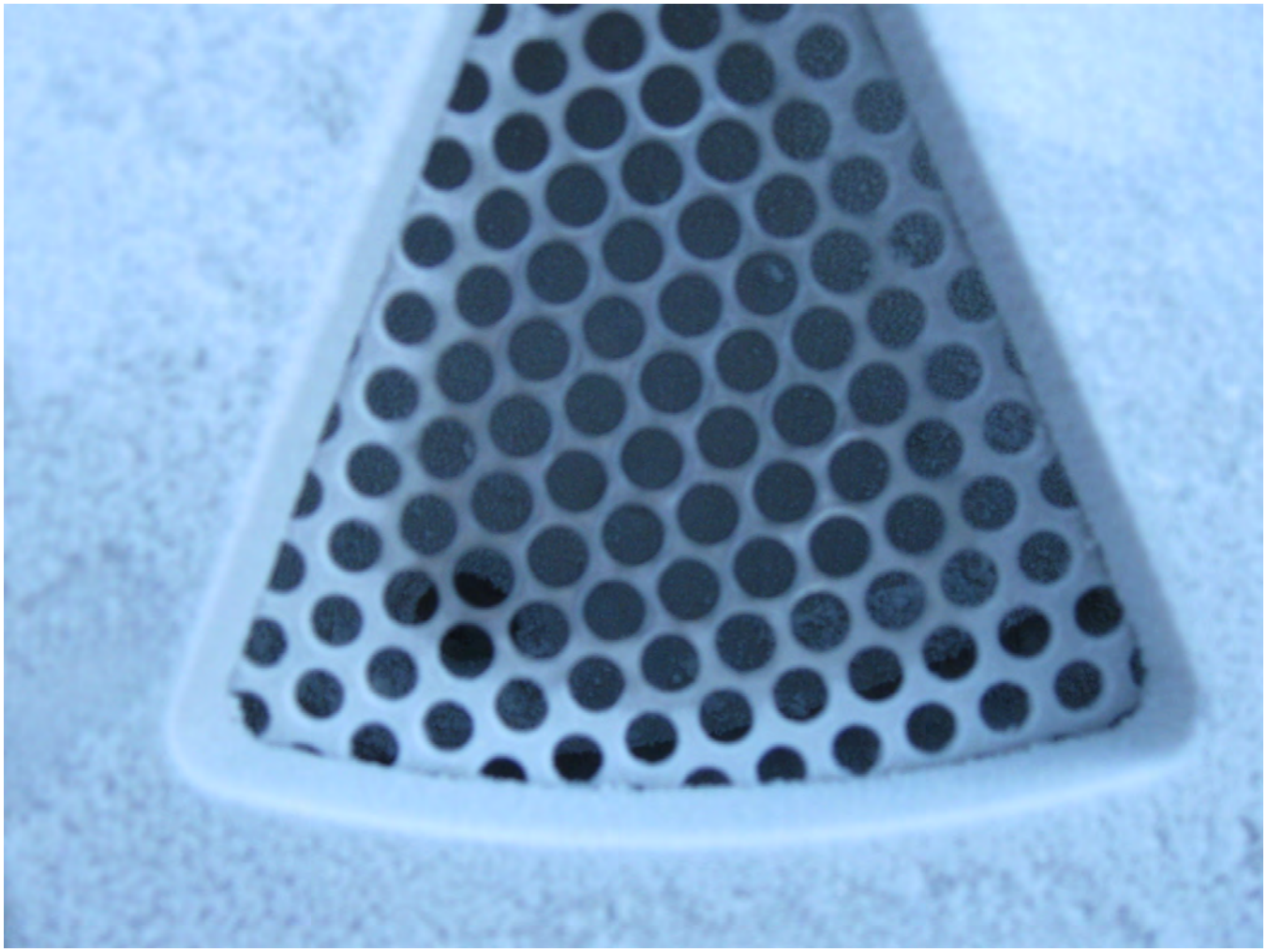


FIGURE B.1.2-3 – Close-up View of Failed Inner Lid Bolt, HAC 30-Foot Top Down Drop

Figures B.1.3

HAC 30-Foot Side Free Drop (Test No. 3)

FIGURE B.1.3-1 – Test Unit Immediately Prior to HAC 30-Foot Side Drop

FIGURE B.1.3-2 – Test Unit Immediately After HAC 30-Foot Side Drop

FIGURE B.1.3-3 – Close-up View of Deformed Side Flat (~4 inch Width), Failed Closure Lid Bolt, HAC 30-Foot Side Drop

Figures B.1.4

HAC 30-Foot CG-Over-Top Corner Free Drop (Test No. 4)

FIGURE B.1.4-1 – Test Unit Immediately Prior to HAC 30-Foot CG-Over-Top Corner Drop

FIGURE B.1.4-2 – Test Unit After HAC 30-Foot CG-Over-Top Corner Drop

FIGURE B.1.4-3 –View of Failed Closure Lid Bolts, Deformed Shell/Lid Interface, HAC 30-Foot CG-Over-Top Corner Drop

Figures B.1.5

HAC Puncture on Top Down (Test No. 5)

FIGURE B.1.5-1 – Test Unit Prior to HAC Puncture Drop on Top

FIGURE B.1.5-2 – Close-up View of Closure Lid After Puncture Drop

Figures B.1.6
HAC Puncture on Side (Test No. 6)

FIGURE B.1.6-1 – Test Unit Prior to HAC Puncture Drop on Side

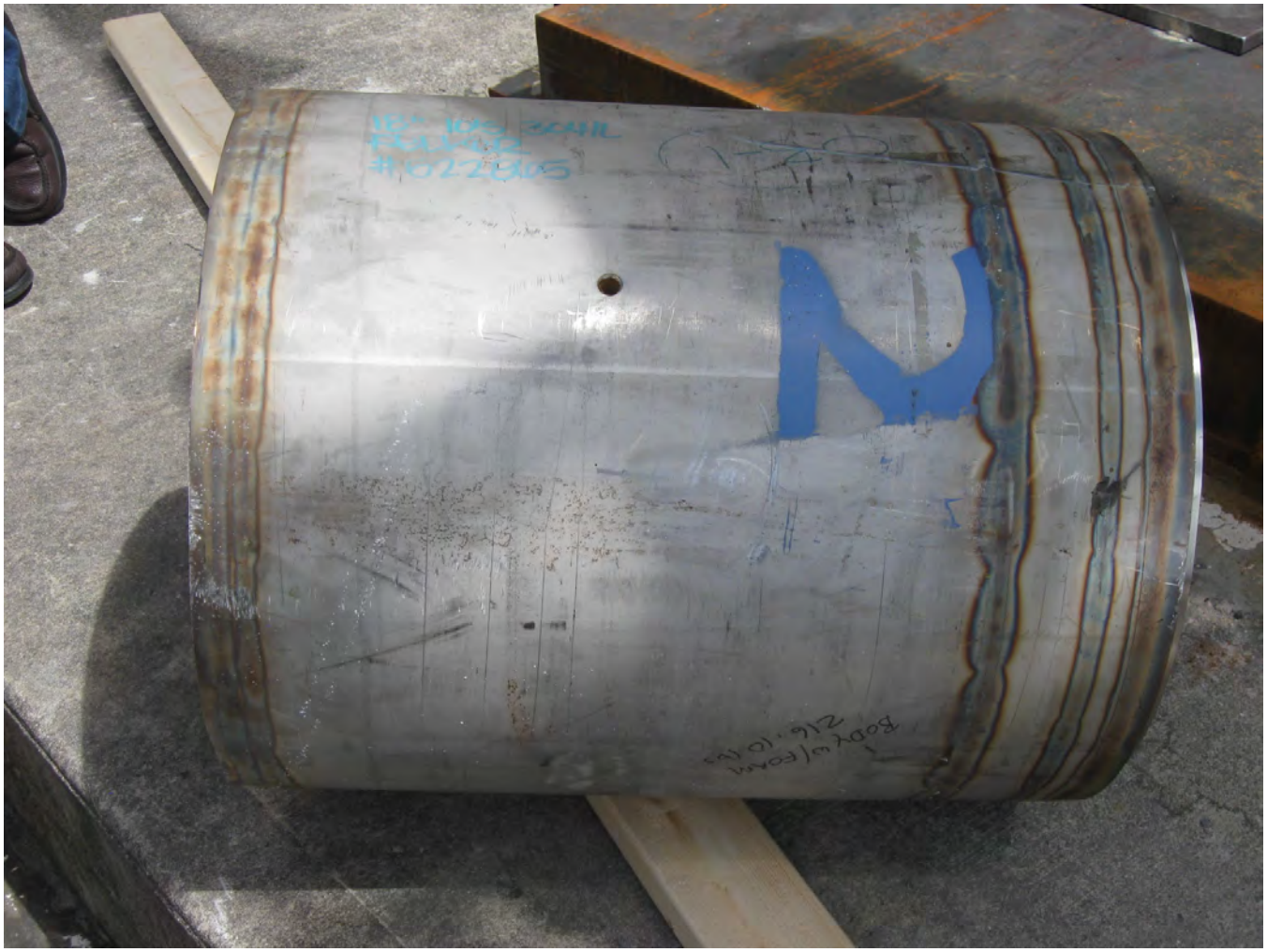


FIGURE B.1.6-2 – Close-up View of Side After Puncture Drop

Figures B.1.7
HAC Puncture on CG-Over Top Corner (Test No. 7)

FIGURE B.1.7-1 – Test Unit Prior to HAC Puncture Drop on CG-Over-Top Corner

FIGURE B.1.7-2 – Close-up View of Top Corner After Puncture Drop

Figures B.2
Post-Test Disassembly of Test Units

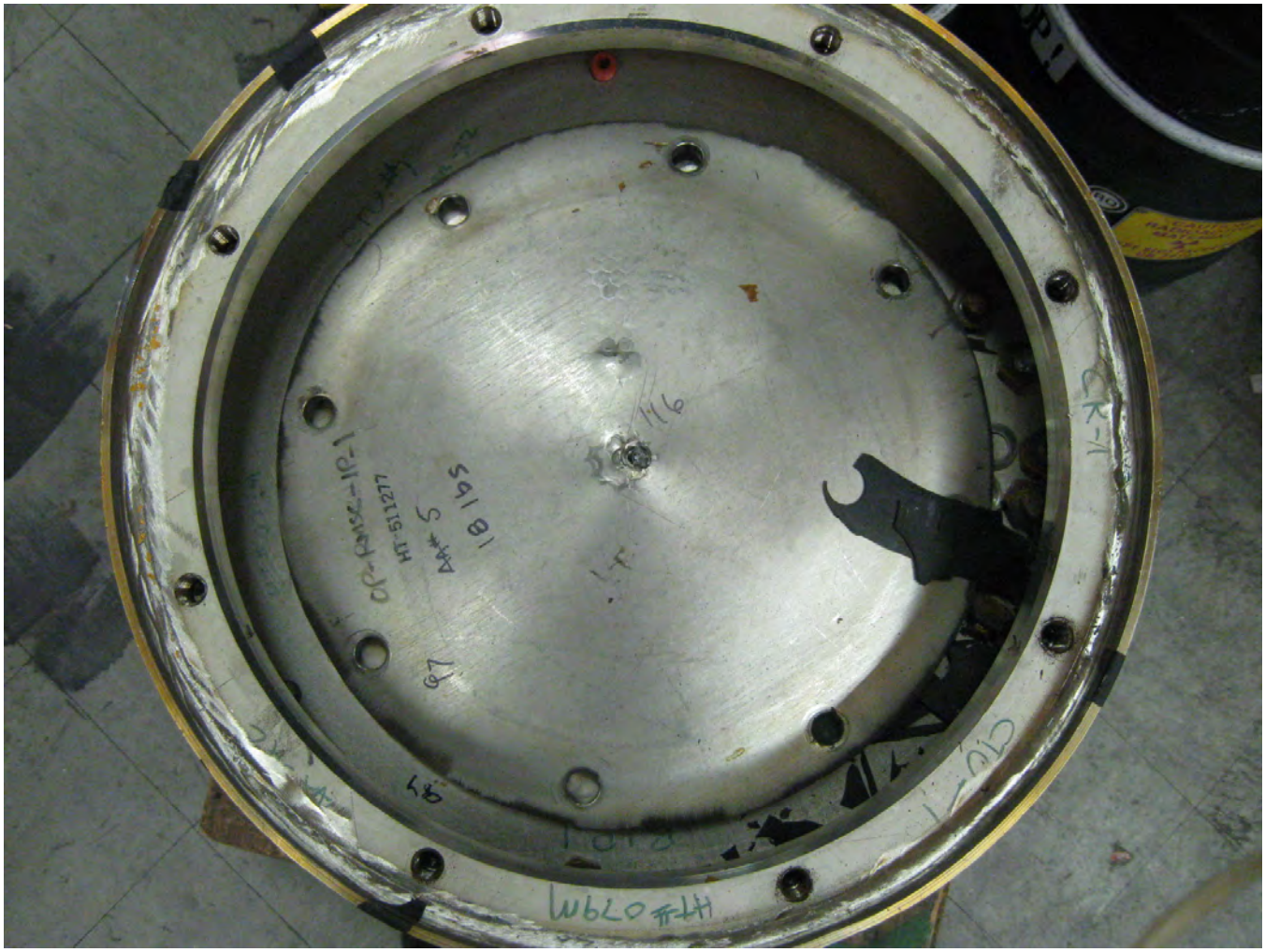


FIGURE B.2-1 – CTU-1 Post-Test Disassembly: View of Inner Lid w/ Failed Hex Bolts

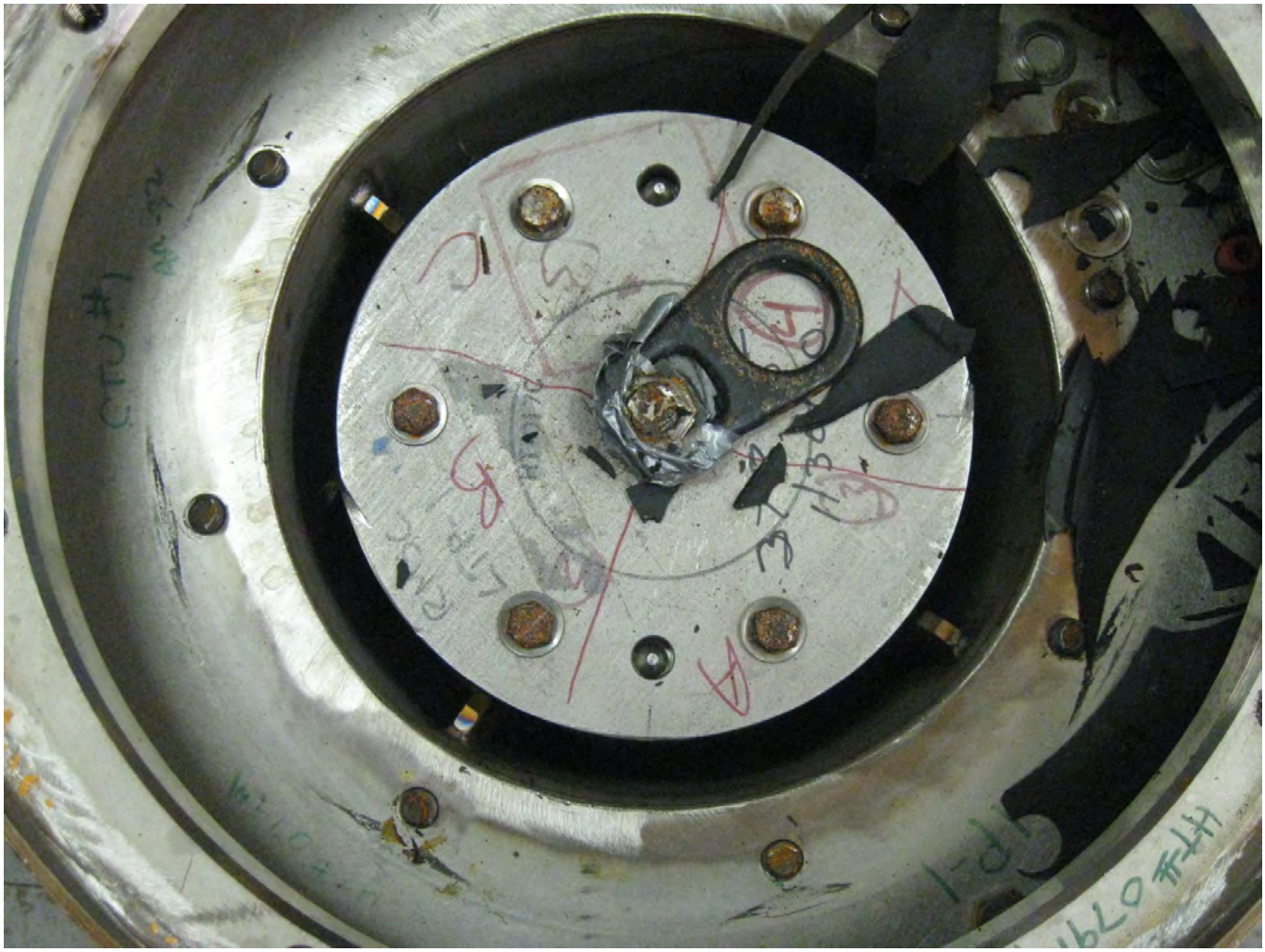


FIGURE B.2-2 – CTU-1 Post-Test Disassembly: View of RMSC Payload in Cavity

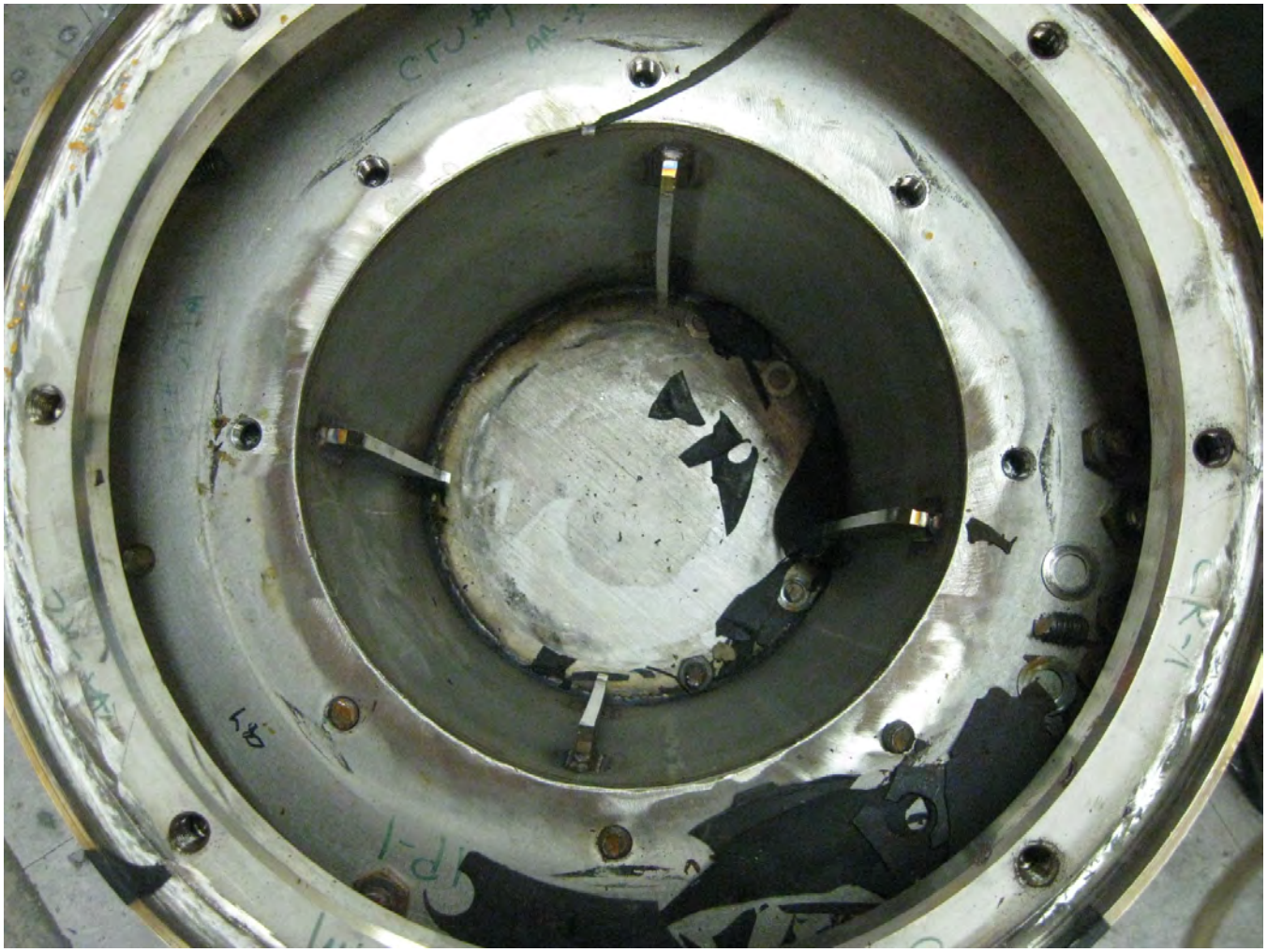


FIGURE B.2-3 – CTU-1 Post-Test Disassembly: View of OP-RMSC Payload Cavity

FIGURE B.2-4 – CTU-1 Post-Test Disassembly: Overall View of RMSC Payload

FIGURE B.2-5 – CTU-1 Post-Test Disassembly: View of Dummy Sources in RMSC Payload

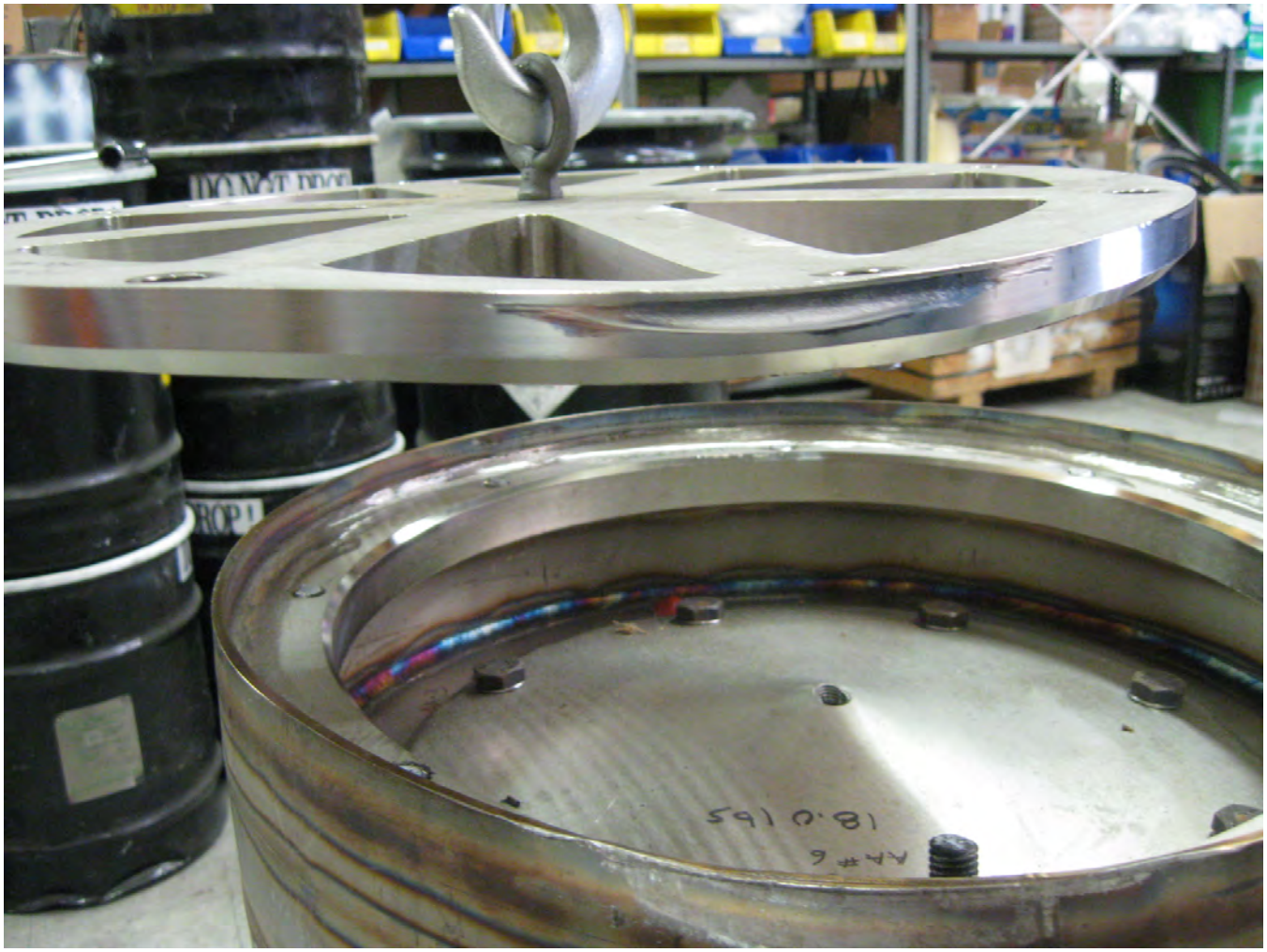


FIGURE B.2-6 – CTU-2 Post-Test Disassembly: View of OP-RMSC Closure Lid w/ CG-Over-Top Corner Impact Damage

FIGURE B.2-7 – CTU-2 Post-Test Disassembly: View of RMSC Payload w/ Sheared Hoist Ring Hex Bolt and CG-Over-Top Corner Impact Damage to Lid

FIGURE B.2-8 – CTU-2 Post-Test Disassembly: Overall View of RMSC Payload

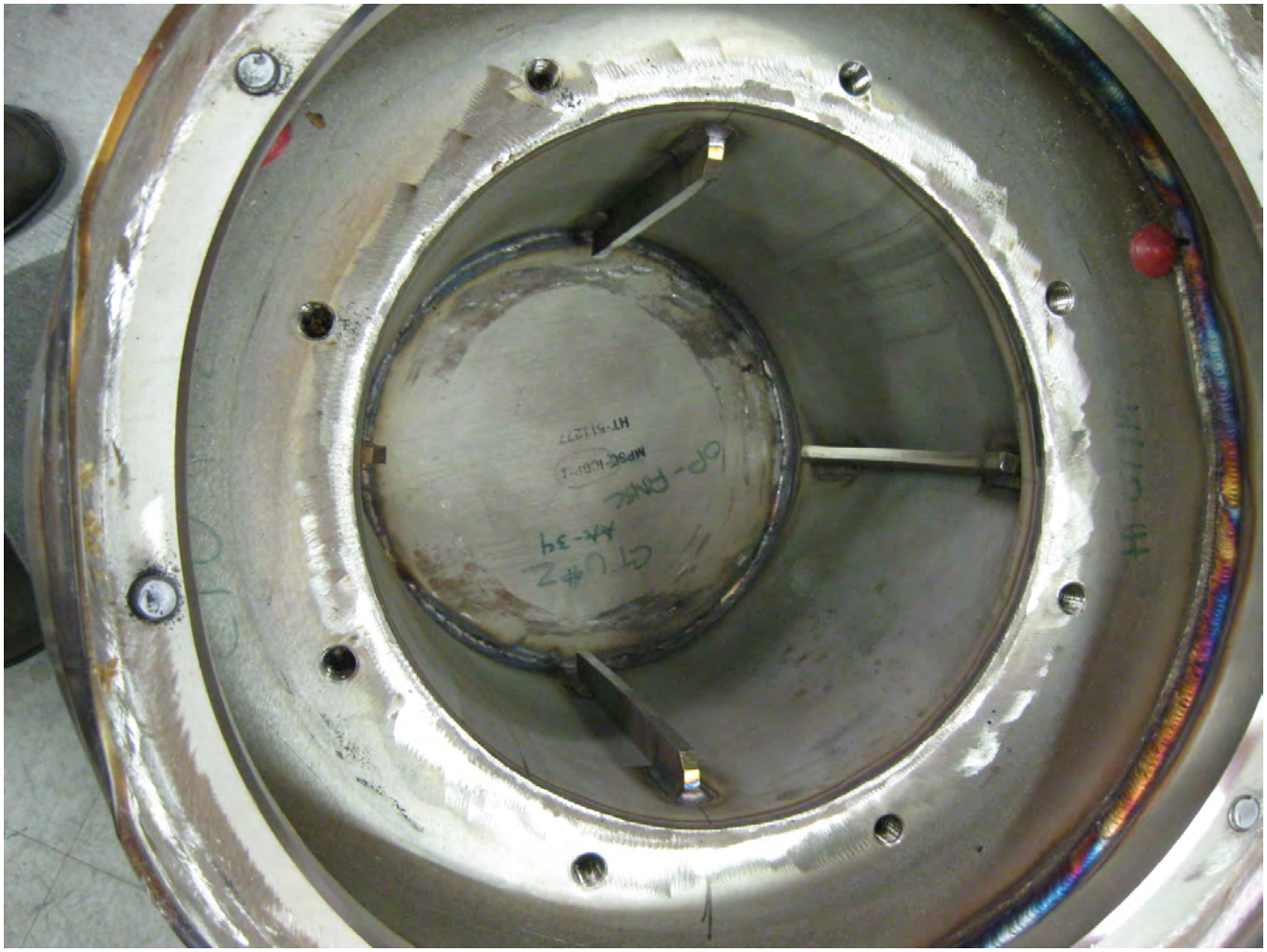


FIGURE B.2-9 – CTU-2 Post-Test Disassembly: View of OP-RMSC Cavity w/ Side Impact Damage to Inner Wall (Left Side)