

# Test Report for DPP-1 Regulatory Compliance Testing Volume 1 – Main Report



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Nuclear Energy and Fuel Cycle Division

**TEST REPORT FOR DPP-1 REGULATORY COMPLIANCE TESTING**  
**VOLUME 1 – MAIN REPORT**

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April 2022

Prepared for the  
Consolidated Nuclear Security, LLC Management and Operating Contractor for  
The Y-12 National Security Complex and Pantex Plant

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## ABBREVIATIONS

ANSI	American National Standards Institute
BTU	British thermal unit
CFR	US Code of Federal Regulations
CG	center of gravity
CGoBC	center of gravity over bottom corner
CGoTC	center of gravity over top corner
CNS	Consolidated Nuclear Security, LLC
CV	containment vessel
DAQ	data acquisition
DOE	US Department of Energy
DPP-1	Defense Programs Package-1
FEP	fluorinated ethylene propylene
FL	flange line
HAC	hypothetical accident conditions
HSST	hollow structural steel
Hz	hertz
I/O	input/output
ISO	International Organization for Standardization
M&TE	measuring and test equipment
NCT	normal conditions of transport
NDE	nondestructive examination
NDT	nondestructive testing
NNSA	National Nuclear Security Administration
NPT	National Pipe Thread
NTRC	National Transportation Research Center
ORNL	Oak Ridge National Laboratory
PCC	Pit Convenience Canister
PCMT	pressure change measurement test
PEF	Package Evaluation Facility
PHC	preheat chamber
PTP	Package Testing Program
QA	quality assurance
QAPD	quality assurance program description
RFWD	request for waiver or deviation
RHAC	Research Hazard Assessment Control
SARP	safety analysis report for packaging
SBMS	Standards-Based Management System
SG	safety guide
SOW	statement of work
SST/SGT	Safe-Secure Trailer/Safeguards Transporter
SwRI	Southwest Research Institute
TC	thermocouple
TL	temperature-indicating label
TPCR	test plan change request
TTAC	Technical Testing Analysis Center
TU	test unit
USB	universal serial bus
Y-12	Y-12 National Security Complex



#### REVISION HISTORY

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## **ABSTRACT**

Consolidated Nuclear Security, LLC (CNS), the management and operating contractor for the Y-12 National Security Complex (Y-12) for the National Nuclear Security Administration (NNSA), is currently responsible for the regulatory testing of a new Type B fissile material shipping package called the Defense Programs Package (DPP)-1. The DPP-1 is a drum packaging with an inner liner and a removable lid. Both the drum body and the lid are filled with an impact-limiting, thermal-insulating material that protects the inner containment vessel (CV) during normal conditions of transport (NCT) and hypothetical accident conditions (HAC) as defined by 10 US code of Federal Regulations (CFR) 71. In fiscal year 2021, the Oak Ridge National Laboratory (ORNL) Package Testing Program (PTP), located at the National Transportation Research Center (NTRC), conducted Type B performance tests as prescribed in Title 10 Code of Federal Regulations Part 71 (10 CFR 71) on seven DPP-1 prototype units. This test report documents test unit (TU) preparation, pretest condition, conditioning of each TU, NCT and HAC testing, and posttest measurements and observations made of the damage resulting from these tests.

## **1. INTRODUCTION**

Y-12 National Security Complex (Y-12) is developing a new Type B radioactive material shipping package for the Defense Package Program. The package is designated as the Defense Programs Package (DPP)-1 shipping package. To support the certification of the DPP-1 package design, Consolidated Nuclear Security, LLC (CNS) contracted the Oak Ridge National Laboratory (ORNL) Package Testing Program (PTP) to perform independent testing of the DPP-1 to the requirements of 10 US Code of Federal Regulations (CFR) Part 71. The ORNL Package Testing Program (PTP) conducted the tests according to a test plan (ORNL/NTRC-092 2021) which was approved by Y-12. Test activities and test results are reported in this document. These test results will be used in the preparation of the DPP-1 package Safety Analysis Report for Packaging (SARP).

Seven DPP-1 packages were tested to demonstrate compliance with the requirements of 10 CFR Part 71.71, Normal Conditions of Transport (NCT), and 10 CFR Part 71.73, Hypothetical Accident Conditions (HAC). The packages were identified by sequential designation numbers of test unit (TU)-1 through TU-7.

TUs -1 through -6 were subjected to the NCT and HAC tests. The containment vessel (CV) for TU-7 was subjected to the HAC 15 m (50 ft) immersion test only. All NCT tests were performed on TU-6. HAC drop and thermal tests were performed on all TUs except TU-7. Test matrices are presented in Section 1.3.

Section 2 describes the pretesting activities; Section 3 describes the NCT tests performed and the results; Section 4 describes the HAC tests and the results; and Section 5 describes disassembly, subsequent leak and immersion tests, and inspection and posttest measurements.

### **1.1 DESCRIPTION OF QUALITY ASSURANCE ACTIVITIES**

The ORNL Quality Assurance Program Description (QAPD) addresses the criteria requirements identified in DOE Order 414.1D, Quality Assurance, and 10 CFR 831.122, Quality Assurance Criteria. Quality principles and methodologies are integrated and flow down to management systems within the ORNL Standards-Based Management System (SBMS).

ORNL's PTP Quality Assurance Program is under the direction of the Nuclear Energy and Fuel Cycle Division. All testing performed by the PTP is conducted under the PTP Quality Assurance Program Plan,

PTP-QA-001/NTRC-PRF-QAP-001, Rev. 5, Integrated Document Management System ID 018050 and the PTP-MGMT-005, Rev 0, Integrated Document Management System ID 026584.

ORNL's PTP follows 10 CFR 71.71, 10 CFR 71.73, 10 CFR 71 Subpart H, and SG-600 requirements and is documented in an ORNL test plan, *Test Plan for DPP-1 Regulatory Compliance Testing*, ORNL/NTRC-092, Rev. 0, and PTP's operating procedures. The safety aspects of the activities described in this report are detailed in ORNL's Research Hazard Assessment and Control (RHAC) Research Safety Summary (RSS), *General Use and Packaging Testing Activities Conducted at the Packaging Evaluation Facility (1082)* and *Thermal Testing of Type B Packages at Offsite Thermal Facility (2416)*.

The ORNL UT-Battelle LLC Package Testing Program performed testing of customer-furnished TUs -1 through -6 and TU-7. The TUs were assembled, instrumented, inspected, and tested per CNS MPO 4300165073, 10 CFR 71 Subpart H, and Section 4 of NNSA Safety Guide SG-600 Rev. 2 – September 2007 – Regulatory Compliance Testing of NNSA Type B Packages, and PTP-MGMT-005, DPP-1 QAP Rev. 0 - Quality Assurance Plan for DPP-1 Regulatory Compliance Testing. PTP's QAP complies with DOE Order 460.1D, Packaging and Transportation Safety, Subparagraph 4.a.(3), Quality Assurance, 10 CFR Part 71, Subpart H and ASME NQA-1-2008, 1a-2009 Addenda.

Each TU was inspected and tested in accordance with CNS-Y12 Statement of Work (SOW) 802586-0007 000 00, including CNS Request for Waiver or Deviation (RFWD) 4300165073-0001, 0002, 0003, and 0004, and CNS-approved ORNL/NTRC-092 Test Plan Change Requests TPCR-001 through TPCR-009. All testing was performed in accordance with ORNL Package Testing Program Quality Assurance Plan (QAP) PTP-QA-001 / NTRC-PEF-QAP-001, Rev. 5, with applicable quality assurance (QA) procedures. Measuring and test equipment (M&TE) used for testing was calibrated and certified by accredited organizations meeting the International Organization for Standardization (ISO) 17025 accreditation traceable to the National Institute of Standards or Y-12 approved equal prior to use.

Test plan activities are documented in PTP Test Report ORNL/NTRC-095 Rev. 0 Volumes 1, 2, and 3.

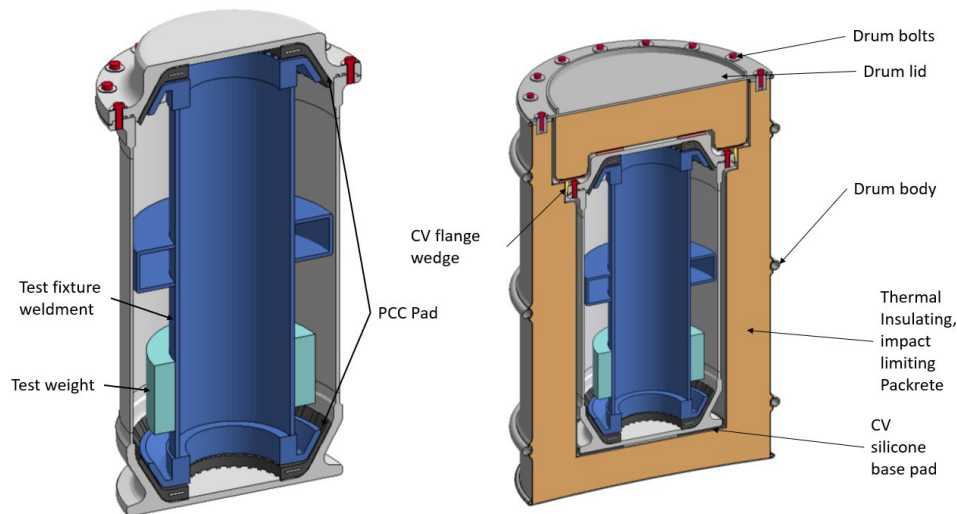
## **1.2 DESCRIPTION OF THE DPP-1 SHIPPING PACKAGE**

All TUs were full-scale units. Each TU package contains a drum body, a drum body lid, a CV, a CV silicone base pad, a CV flange wedge, a test fixture weldment with weight set and Pit Convenience Canister (PCC) pad sets (Figure 1-1). Inside the CV, the TUs contained one of two unique test weights: (1) a light test weight or (2) a heavy test weight. TUs -1, -3, -4, -5, and -6 contained heavy test weights, and TU-2 contained the light test weight (Figure 1-2), whereas TU-7 did not contain any test weight or test fixture weldment. TUs 1 through 7 were manufactured per the DPP-1 drawings DD-M802586-0001. The TUs are approximately 43 in. in height and 27 in. in diameter. The CV for TU-7 was used for the 15 m (50 ft) immersion test. The CV for TU-7 did not contain a content assembly. The TU-7 drum assembly was used to calibrate the burn test as a setup unit. This allowed the operators to have a practice run at loading the TU within the allowable time.

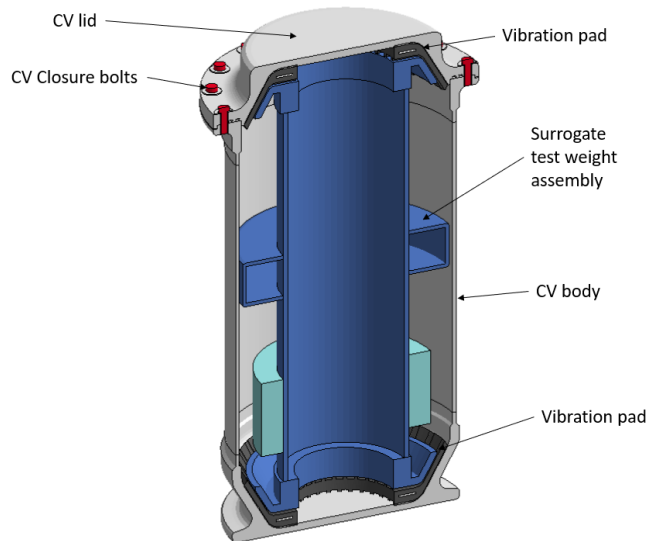
The drum overpack included a stainless-steel outer drum containing a stainless-steel inner liner. Packcrete was poured into the annulus formed between the stainless-steel inner liner and the outer drum. This assembly also contained a drum lid weldment, a CV flange wedge, a CV base pad, and fastening hardware.

The CV consists of a stainless-steel body, a stainless-steel lid, fastening hardware, a leak port brass plug, and O-rings. The CVs of TUs -1, -3, -4, -5, and -6 were loaded with a heavy surrogate test weight set. The test weight content assemblies were then lifted and placed into the CV using swivel hoist rings that were threaded into the top of the content assembly. The lifting hardware was removed prior to closure. The content configuration of TU-2 consists of a light surrogate test weight. The light test weight content assembly was then lifted and placed into the CV using swivel hoist rings that were threaded into the top of the content assembly. The lifting hardware was removed prior to closure. The drawing and serial numbers for each test weight content assembly component for TU-1 through TU-6 are shown below.

- TU-1, heavy test content assembly in the low position
  - DD-M802586-0003, Section B-B
- TU-2, light test content assembly in the low position
  - DD-M802586-0004, Section A-A
- TU-3, heavy test content assembly in the high position
  - DD-M802586-0003, Section A-A
- TU-4, heavy test content assembly in the low position
  - DD-M802586-0003, Section B-B
- TU-5, heavy test content assembly in the high position
  - DD-M802586-0003, Section B-B
- TU-6, heavy test content assembly in the low position
  - DD-M802586-0003, Section A-A



**Figure 1-1. Cutaway of the DPP-1 package.**



**Figure 1-2. CV cutaway for TUs -1 through -6.**

### **1.3 DPP-1 TEST MATRIX**

Table 1-1 summarizes the order in which the tests were performed on each TU, along with the general orientation of each TU when it underwent drop, crush, and puncture testing. The numbers under each TU column indicate the sequence in which the tests were conducted. The NCT tests preceded the HAC tests.

TU-6 was subjected to the HAC tests and NCT tests. TU-6 was subjected to the vibration test in accordance with 10 CFR 71.71 (c)(5), the compression test in accordance with 10 CFR 71.71 (c)(9), and the penetration test in accordance with 10 CFR 71.71 (c)(10). TUs -2, -3, -4, and -6 were subjected to the water spray test in accordance with 10 CFR 71.71 (c)(6) and the 1.2 m (4 ft) NCT free drop tests in accordance with 10 CFR 71.71 (C)(7), followed by the full sequence of HAC tests. The 1.2 m (4 ft) NCT free drop, 9 m (30 ft) HAC free drop in accordance with 10 CFR 71.73 (c)(1), the 9 m (30 ft) HAC crush test in accordance with 10 CFR 71.73 (c)(2), and 1 m (3.3 ft) HAC puncture tests in accordance with 10 CFR 71.73 (c)(3) were conducted at -40°F for TUs -1 and -5. TUs -2, -3, -4, and -6 were tested at ambient temperature. Additionally, assemblies TU-1 through -6 were exposed to a thermal test in accordance with 10 CFR 71.73 (c)(4), as well as the 0.9 m (3 ft) water immersion test in accordance with 10 CFR 71.73 (c)(5). The drum body assembly from TU-7 was used as a setup unit for the thermal test in accordance with 10 CFR 71.73 (c)(4). The CV from TU-7 was tested in accordance with the 10 CFR 71.73 (c)(6) for the 15 m (50 ft) water immersion test. The CV for TUs -1 through -7 were preshipment leak tested and helium leak tested in accordance with American National Standards Institute (ANSI) N14.5-2014 Sections 7.5 and 7.6.

**Table 1-1. Sequence of tests and processes for DPP-1 TUs**

	TU-1	TU-2	TU-3	TU-4	TU-5	TU-6	TU-7
Regulatory test	HAC	HAC	HAC	HAC	HAC	NCT/HAC	-
Temperature	Cold	Ambient	Ambient	Ambient	Cold	Ambient	Ambient
Test weight	Heavy	Light	Heavy	Heavy	Heavy	Heavy	None
Test weight CG	Low	Low	High	Low	High	Low	-
Drop orientation	Side	Side	Top	CGoTC <sup>a</sup> 56.4°	22.0°	22.0°	-
<b>Preparation</b>							
Mark outside	1	1	1	1	1	1	1
Disassemble	2	2	2	2	2	2	2
Mark parts and subassemblies	3	3	3	3	3	3	
Install TLs <sup>b</sup>	4	4	4	4	4	4	
Weigh parts and assemblies	5	5	5	5	5	5	3
Leak test CVs (operational)	6	6	6	6	6	6	4
Assemble	7	7	7	7	7	7	
Install impact accelerometers	8	8			8		
Install vibration accelerometer						8	
Chill TU (-40°F)	9				9		
<b>NCT TEST</b>							
Vibration, 10 CFR 71.71 (c)(5)						9	
Remove accelerometer and capture data; seal accelerometer connectors						10	
Water spray, 10 CFR 71.71 (c)(6)		9	8	8		11	
Install impact accelerometers						12	
4 ft (1.2 m) drop, 10 CFR 71.71 (c)(7)	10	10	9	9	10	13	
Remove accelerometer and capture data						14	
Compression, 10 CFR 71.71 (c)(9)						15	
Penetration, 10 CFR 71.71 (c)(10)						16	
Install impact accelerometers						17	

**Table 1-1. Sequence of tests and processes for DPP-1 TUs (continued)**

	TU-1	TU-2	TU-3	TU-4	TU-5	TU-6	TU-7
<b>HAC TEST</b>							
30 ft (9 m) drop, 10 CFR 71.73 (c)(1)	11	11	10	10	11	18	
Crush, 10 CFR 71.73 (c)(2)	12	12	11	11	12	19	
Puncture, 10 CFR 71.73 (c)(3)	13	13	12	12	13	20	
Measure deformations	14	14	13	13	14	21	
Remove DLs and capture data	15	15	14	14	15	22	
Install TCs <sup>c</sup> on drum and preheat	16	16	15	15	16	23	
Thermal test, 10 CFR 71.73 (c)(4)	17	17	16	16	17	24	
Capture TC data	18	18	17	17	18	25	
	TU-1	TU-2	TU-3	TU-4	TU-5	TU-6	TU-7
Regulatory test	HAC	HAC	HAC	HAC	HAC	NCT/HAC	-
Temperature	Cold	Ambient	Ambient	Ambient	Cold	Ambient	Ambient
Test weight	Heavy	Light	Heavy	Heavy	Heavy	Heavy	None
Test weight CG	Low	Low	High	Low	High	Low	-
Drop orientation	Side	Side	Top	CGoTC 56.4°	22.0°	22.0°	-
<b>Posttest Inspection</b>							
Disassemble down to CV	19	19	18	18	19	26	
Record and log TLs	20	20	19	19	20	27	
Leak test CVs (operational)	21	21	20	20	21	28	
Leak test CV (He)	22	22	21	21	22	29	
3 ft (0.9 m) immersion, 10 CFR 71.73 (c)(5)	23	23	22	22	23	30	
50 ft (15 m) immersion, 10 CFR 71.73 (c)(6)							5
Disassemble CV	24	24	23	23	24	31	6
Inspect for water	25	25	24	24	25	32	7
Remove test content assembly	26	26	25	25	26	33	
Read TLs and inspect	27	27	26	26	27	34	

<sup>a</sup> CGoTC = center of gravity over top corner orientation

<sup>b</sup> TL = temperature-indicating label

<sup>c</sup> TC = thermocouple

## 1.4 TEST DATA RECORDS

Volumes 1, 2, and 3 of this report document the tests performed and the measurements observed from the DPP-1 testing. The general data types for these tests are as follows:

- manually derived measurements and observations,
- automatically recorded temperatures from the thermal testing,
- digital still photography,
- accelerometer in MATLAB data files, and
- video and high-speed motion photography of drop tests.

The primary recording media for each of the general types of data are as follows:

- procedure checklists and data sheets for data, measurements, and observations,
- computer files (Excel spreadsheets) for the temperature records,
- computer files (JPG format) for the digital photography,
- computer files (MPG, WMV, or AVI format) for the video and motion photography, and
- accelerometer data in a MATLAB data file format or equivalent user-friendly data file.

The completed data sheets and procedure checklists have been scanned into a digital format. The still photography, scanned data sheets, and field-marked test plan are attached to this document as appendices in separate volumes (Volumes 2 and 3). There is an appendix of photographs and an appendix of completed data sheets and procedure checklists for each TU. Additionally, Appendix O contains the field-marked version of the test plan. Table 1-2 below lists the appendices for each TU.

**Table 1-2. List of appendices for photos and data sheets by TU**

<b>TU</b>	<b>Photo appendix (Volume 2)</b>	<b>Data sheet and procedure checklist appendix (Volume 3)</b>
TU-1	A	H
TU-2	B	I
TU-3	C	J
TU-4	D	K
TU-5	E	L
TU-6	F	M
TU-7	G	N
N/A		O <sup>a</sup>

<sup>a</sup>Appendix O contains the field-marked version of the test plan.



## **2. PRETESTING ACTIVITIES**

Several activities were required to prepare the units for testing. These activities focused on documenting the initial condition of each TU, installing data acquisition (DAQ) devices such as temperature-indicating labels (TLs) and accelerometers in various locations on the TUs, and assembling each certification TU per operational procedures as provided by the CNS Y-12 National Security Complex Packaging and Transportation Engineering SOW 802586-0007 000 00, September 26, 2019, including CNS Y-12 Handling, Assembly, and Disassembly Instructions for Test Units, RP 802586-0005 000 00 (January 2021), and ORNL PTP Test Plan for DPP-1 Regulatory Compliance Testing (ORNL/NTRC-092).

The pretest activities are listed below:

- Visual inspection of TUs and all components
- Disassembly and marking of all components
- Pretest weighing of TU
- Content and CV assembly, weighing, and installation of TLs
- Operational leak test
- Assembly of drum body and TLs, and weighing of assembled TU
- Accelerometer installation

### **2.1 DESCRIPTION OF TEST UNITS**

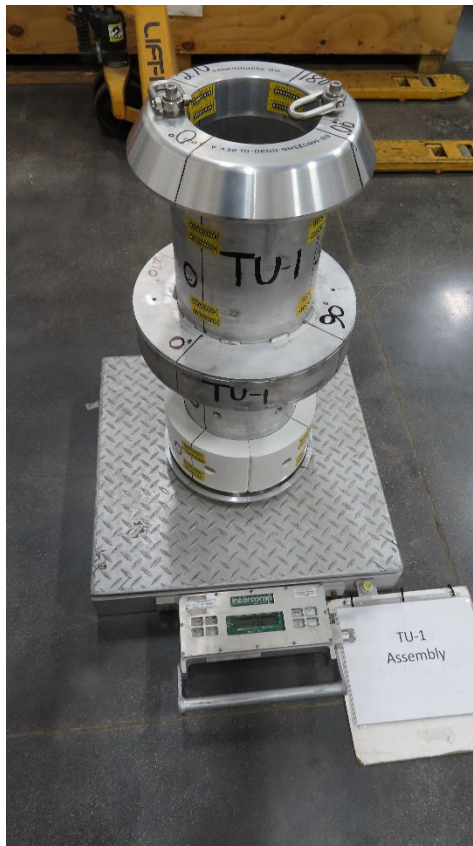
#### **2.1.1 Content and CV Assembly**

The TUs were full-scale DPP-1 packages loaded with surrogate (mock) contents in the CVs. For TUs -1 through -6, the surrogate content assembly consisted of a lower PCC pad (conductive silicone rubber), a test fixture weldment, test weights with fasteners, and an upper PCC pad (conductive silicone rubber). TLs were installed on the TU-1 surrogate test assembly in accordance with the test plan, and the weight of TU-1 was 114 lb (Figure 2-1). TU-1 internal TLs are shown in Figure 6. Before the surrogate content assembly was lowered into the CV, all surfaces of the CV were cleaned with isopropyl alcohol, and 28 TLs were installed on the interior and exterior surfaces of the CV (Figure 2-3 and Figure 2-4).

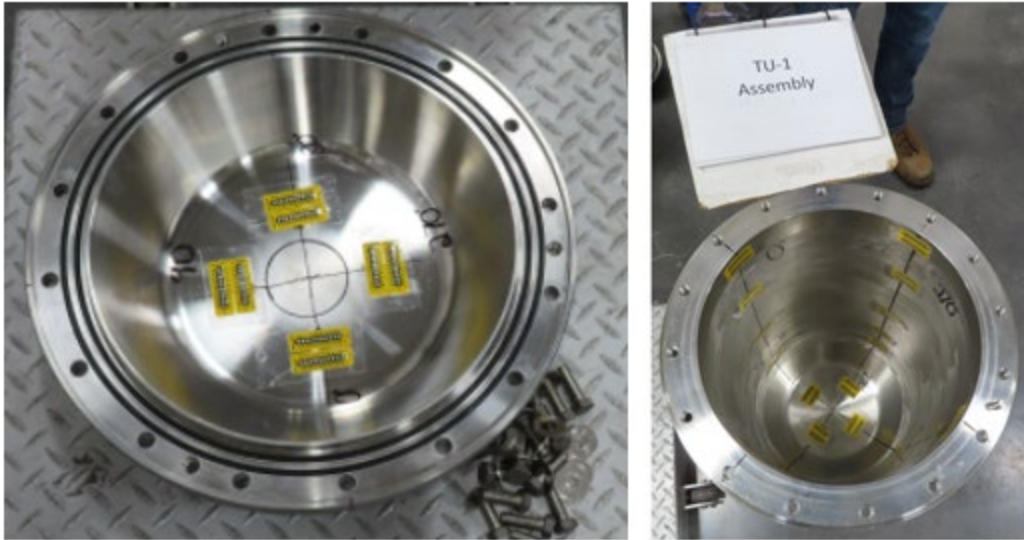
A complete description of the TL locations for all TUs is provided in Section 5.8, including sketches. After the TLs were installed, the components from the surrogate content assembly were assembled according to the test plan and the Y-12 assembly document. Prior to assembly, all items were thoroughly cleaned with isopropyl alcohol and allowed to dry. The lower PCC pad was placed in the bottom of the CV. The surrogate content assembly was then placed into the CV using the overhead crane (Figure 2-4). The upper PCC pad was placed on top of the test content assembly. The inner and outer O-rings were cleaned with isopropyl alcohol, and the CV lid was placed on the CV body. The 16 ½ in.-13 × 1 ½ in. hex head fasteners and ½ in. washers were installed and tightened on the CV body in the following sequence using torque wrench ORNL ID A001096, calibration due 2/10/2022. The torque values listed below for the final pass were recorded on Test Form 11:

1. Hand tightens in a circular pattern.
2. First pass, torque to  $20 \pm 1$  ft-lb following the numbering sequence on the CV lid.
3. Second pass, torque to  $35 \pm 2$  ft-lb following the numbering sequence on the CV lid; and
4. Last pass, verify torque of  $35 \pm 2$  ft-lb in a circular pattern around the CV lid.

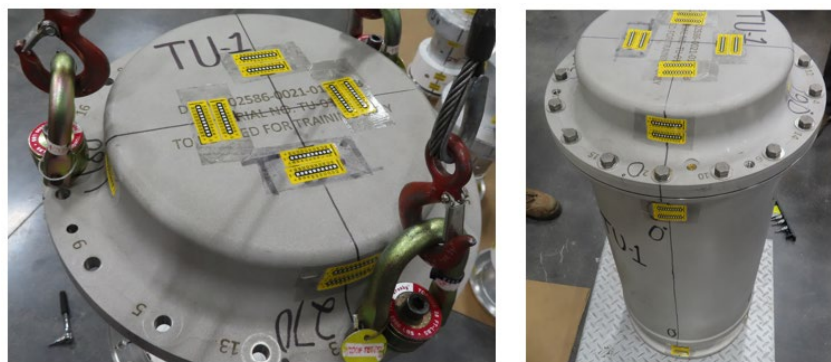
The fully assembled CV was then weighed, and the weight of  $\sim 382$  lb was recorded in Test Form 1 (Figure 2-5).



**Figure 2-1. TU-1 surrogate test assembly weight.**



**Figure 2-2. TU-1 CV internal temperature labels.**



**Figure 2-3. TU-1 CV external temperature labels.**



**Figure 2-4. Lowering TU-1 surrogate test assembly in CV.**



**Figure 2-5. TU-1 fully assembled CV.**

For TUs -2 through -6, the surrogate test weight was assembled in the same manner as that used for TU-1. The TU-2 surrogate test weight was assembled using the light test weight as shown in Figure 2-6. The weight of the TU-2 surrogate test weight assembly was 55 lb. The CVs for TUs -2 through -6 were cleaned with isopropyl alcohol, and TLs were installed on the internal and external surfaces of the CV. The locations of the TLs for TUs -2 through -6 were the same as those used for TU-1. The surrogate test weights were assembled and lowered into the CV with the PCC pads per the ORNL Test Plan (ORNL/NTRC-092) and the Y-12 assembly procedure (Figure 2-7). The CV O-rings were cleaned, and the CV lids were secured on the CV body with the CV fasteners per the sequence detailed in Section 2.1.1.





Figure 2-6. TU-2 light weight surrogate test weight.



Figure 2-7. TU-2 surrogate test weight assembly in the CV.

As stated above, TUs -1, -3, -4, -5, and -6 were loaded with heavy surrogate test weights as opposed to the light surrogate test weight inside TU-2. The placement of the heavy weights also varied, thus yielding different locations for the TU centers of gravity (CGs). Table 2-1 shows the test weight configuration inside each CV and identifies the CG locations for each TU. The CG locations were provided by Y-12 and were not measured or independently verified by ORNL PTP personnel.

**Table 2-1. Test weight weldment for each TU (units = in.)**

	TU-1	TU-2	TU-3	TU-4	TU-5	TU-6	TU-7
Heavy surrogate test weight	✓		✓	✓	✓	✓	
Light surrogate test weight		✓					
CV assembly	✓	✓	✓	✓	✓	✓	
Location of CG (in. from base of drum assembly)	Low 22.4	Low 23.2	High 22.8	Low 22.4	High 22.8	Low 22.4	N/A

## 2.2 MARKINGS FOR TESTING

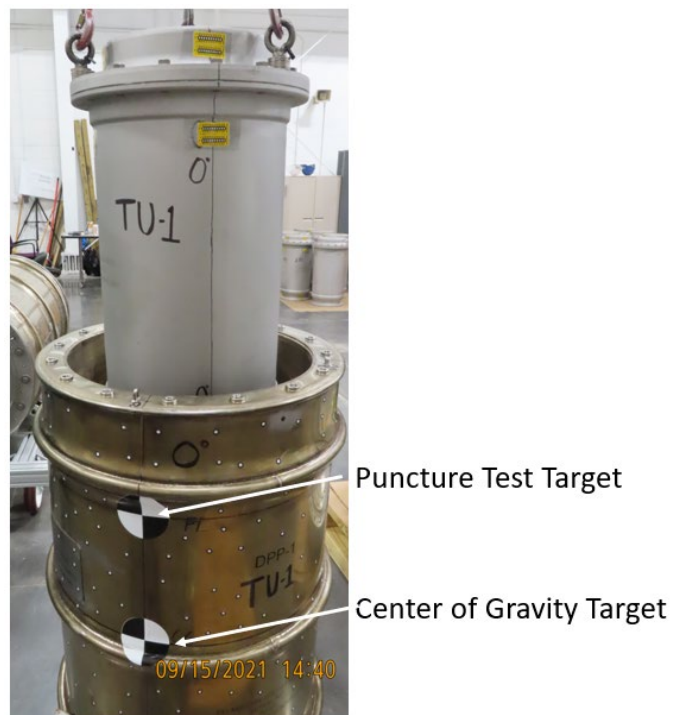
The outer surfaces of TUs -1 through -6 and the TU-7 packaging assemblies were marked by ORNL as follows.

- The TU numbers (TUs -1 through -7) were marked on the outer surfaces of the drum weldment assemblies, CV bodies, lids, and content assembly components.
- Four axial lines were marked in each quad body of the drum, drum liner, CV, and surrogate test weight assembly every 90°, with the 0° line located at the drum's outer surface weld seam line. The axial markings increased in a counterclockwise direction when viewed from above (Figure 2-8).
- The TUs were marked with a circumferential line at the CG. The intersection of this circumferential line and the 0° axial line was marked with a 3 in. target symbol, and the letters *CG* were marked adjacent to the symbol. Figure 2-9 shows the target symbols for TU-1.
- TU-1 was marked with circumferential line to indicate the location of the puncture test target. The puncture target symbol for TUs -1 and -5 was 8.75 in. from the top of the drum along the 0° line; for TU-2 it was 23.2 in. from the bottom of the drum along the 0° line; for TU-3 it was at the center of the drum lid; for TU-4 it was located at CGoTC along the 0° line, and for TU-6 was 22.4 in. from the bottom of the drum along the 0° line.
- TU-6 was marked with a circumferential line to indicate the location of the penetration test target. The penetration target symbol for TU-6 was 8.75 in. from the top of the drum along the 0° line (Figure 2-9).
- The bottom side of each CV lid was marked with a 3 in. diameter circle in the center to indicate the area that must be free of TLs to avoid interference with the leak test port that will be drilled into the lid for the posttest helium leak test (Figure 2-10).
- The top and bottom sides of the CV lids were marked with radial lines at 0, 90, 180, and 270°. The 0° line passes through one of the CV bolt holes (Figure 2-10).

- The top side of the surrogate content was marked with radial lines 0, 90, 180, and 270° (Figure 2-11).



**Figure 2-8. TU axial markings.**



**Figure 2-9. Drum body CG and CV flange line (FL) puncture target symbols.**



**Figure 2-10. CV lid markings.**

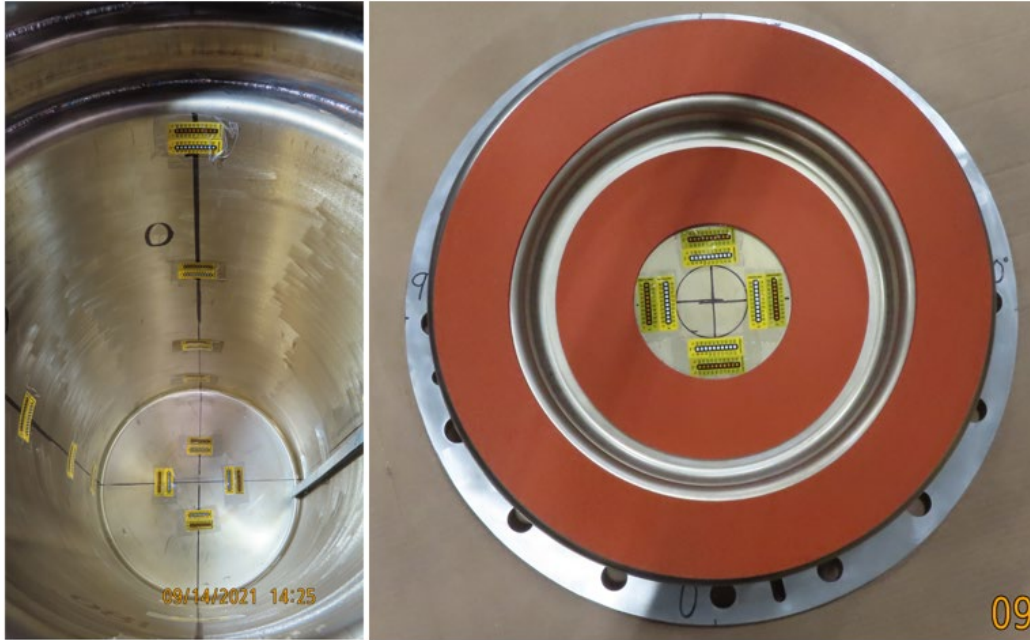


**Figure 2-11. Surrogate test weight markings.**

## **2.3 INSTRUMENTATION ASSEMBLY**

Prior to assembly, numerous TLs were applied to the TU components. For TUs -1 through -6, 72 full-range label sets were placed side by side to measure the maximum temperature reached between 105 and 380°F (41 and 193°C) in 10°F increments. These TLs were affixed to the interior and exterior surfaces of the CV (Figure 2-2 and Figure 2-5) and on the internal surfaces of the drum liner and drum lid (Figure 2-12). Figure 5-3 in the test plan (ORNL/NTRC-092) states that the drum lid TLs should be placed 2.0 in. from the center of the lid. However, the presence of the foam prevented this, so the TLs for all TUs were placed 1.5 in. from the center of the drum lid. The TLs were covered with high-temperature Teflon tape, and 36 TL sets were placed on the test content assembly (Figure 2-11).





**Figure 2-12. Drum liner TLs.**

Each label was affixed at a specific location, and an additional strip of high-temperature Teflon tape was placed over each label to ensure that it would remain in place and legible during the thermal test. Details of TL locations are discussed in Section 5.8.

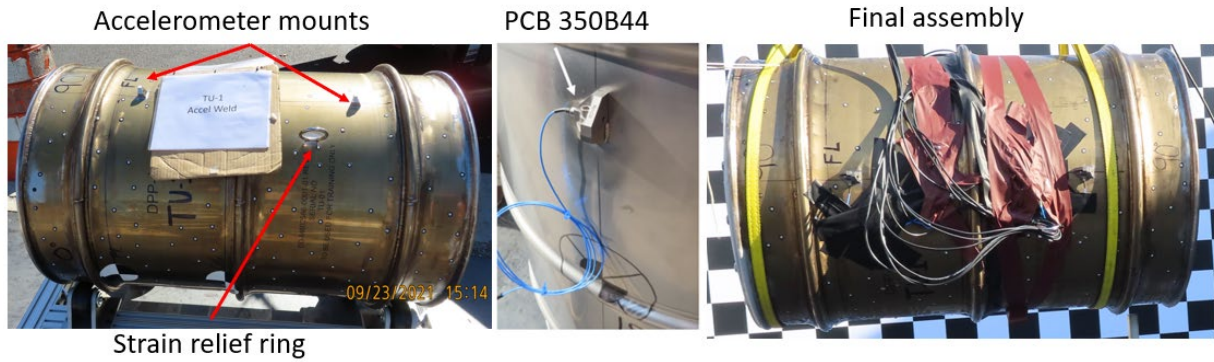
In addition to the use of TLs, after the structural testing and just prior to the thermal testing, thermocouples (TCs) were placed on the surfaces of the TUs. The TCs were fit underneath welded TC clips. Four TCs were placed at mid-height on the exterior of each TU along the 0°, 90°, 180°, and 270° lines, and two TCs were also placed at the center of the bottom and top of each TU. Refer to Table 2-2 for the placement location of TCs on the exterior drum assembly.

**Table 2-2. Thermocouple attachment locations**

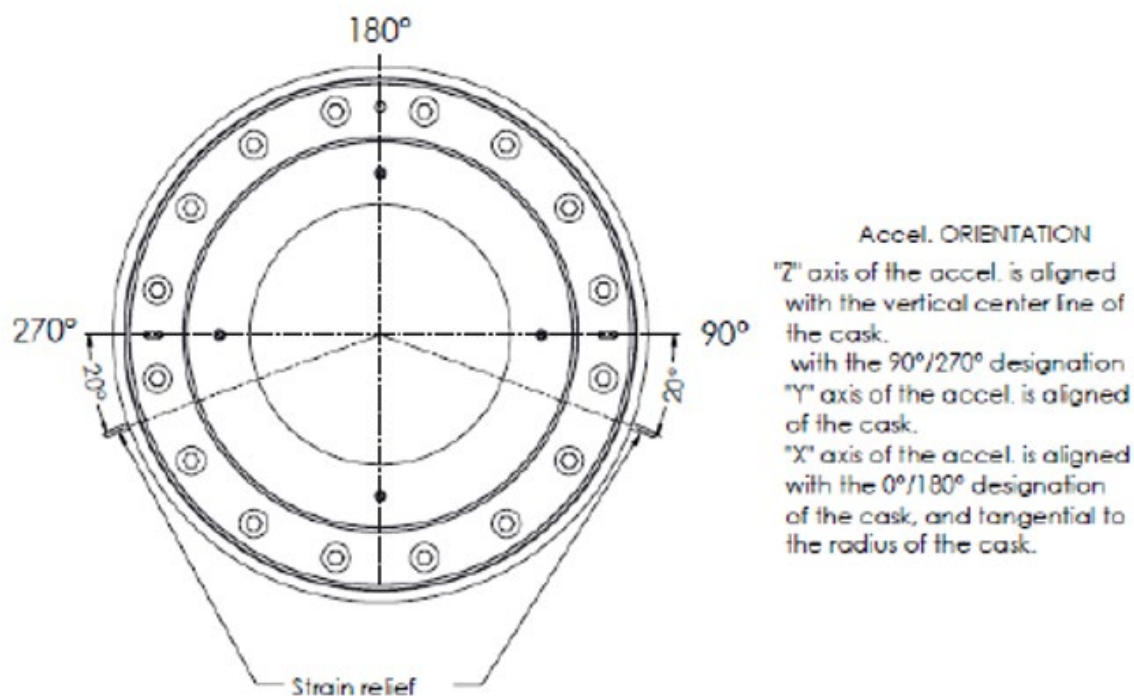
Thermocouple tip locations outside the drum assembly				
External drum assembly (clip)	0°	90°	180°	270°
Top (clip)	1	-	-	-
Side (clip)	2	3	4	5
Bottom (clip)	6	-	-	-

Prior to the NCT free drop and HAC tests, TUs -1, -2, -5, and -6 were instrumented with PCB 350B44 triaxial accelerometers. A mounting block with a through-hole was fillet welded to the exterior surface of the drum. The accelerometers were then bolted onto the mounting block with a two-part epoxy to ensure secure mounting. The accelerometer wires were strain relieved through the strain relief ring to ensure that the drop test would be successfully recorded (Figure 2-13). After the accelerometers were installed, they were all tested to ensure they were working properly. See Figure 2-15 through Figure 2-19 for the exact locations and orientations of the accelerometers for each TU. The local coordinate systems of each accelerometer are shown in Figure 2-14 through Figure 2-19. The accelerometers were mounted so that the vertical z-axis was always oriented in the vertical center line of the TU. The y-axis was oriented such

that the direction vector was aligned with the 0–180° plane of the TU. All wires on the package were taped to the package surface to reduce the shock loading from the instrumentation wires.



**Figure 2-13. TU accelerometer instrumentation.**



#### TU-1, TU-2, TU-5, TU-6 ACCEL/SR LOCATION

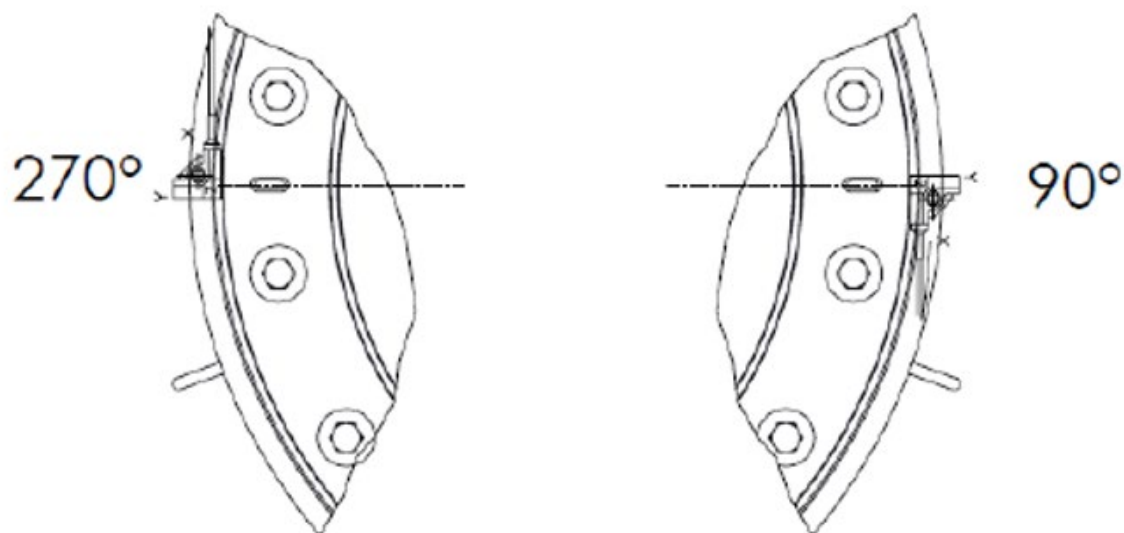


Figure 2-14. Accelerometer placement for TUs -1, -2, -5, and -6.

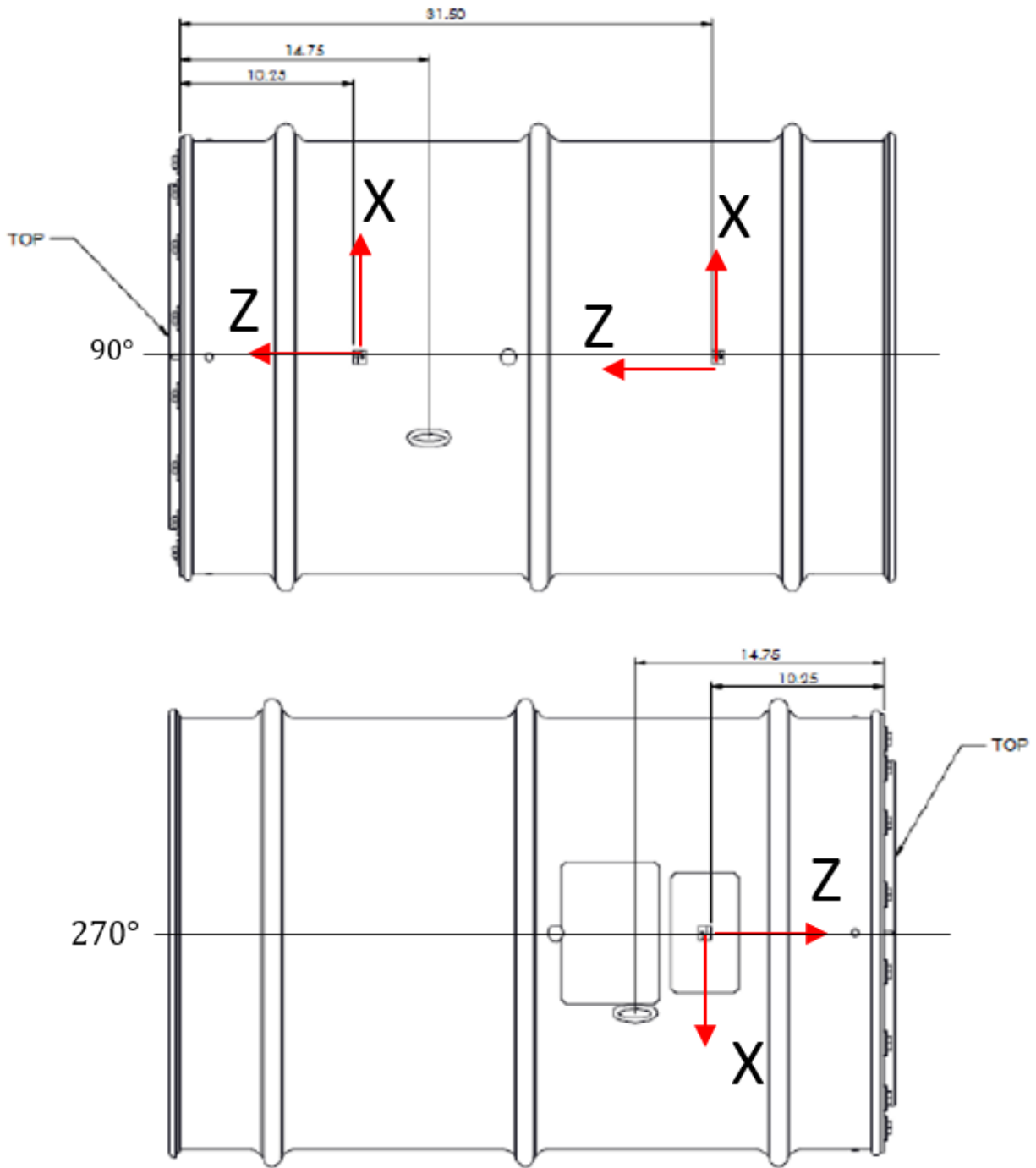
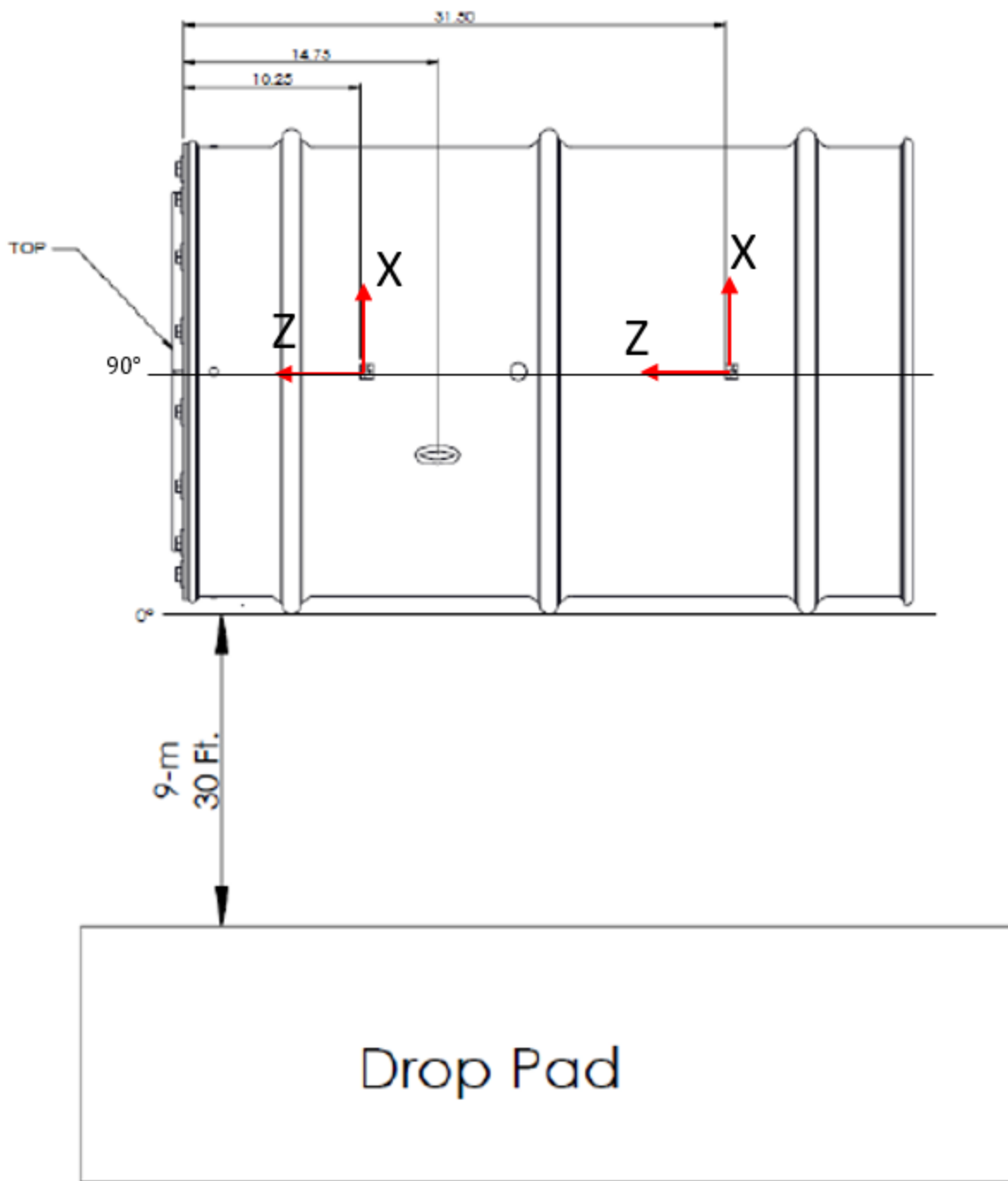


Figure 2-15. Accelerometer placement for TUs -1, -2, -5, and -6.



TU-1 and TU-2 SIDE DROP 0°

Figure 2-16. Accelerometer placement and drop orientation for TUs -1 and -2.

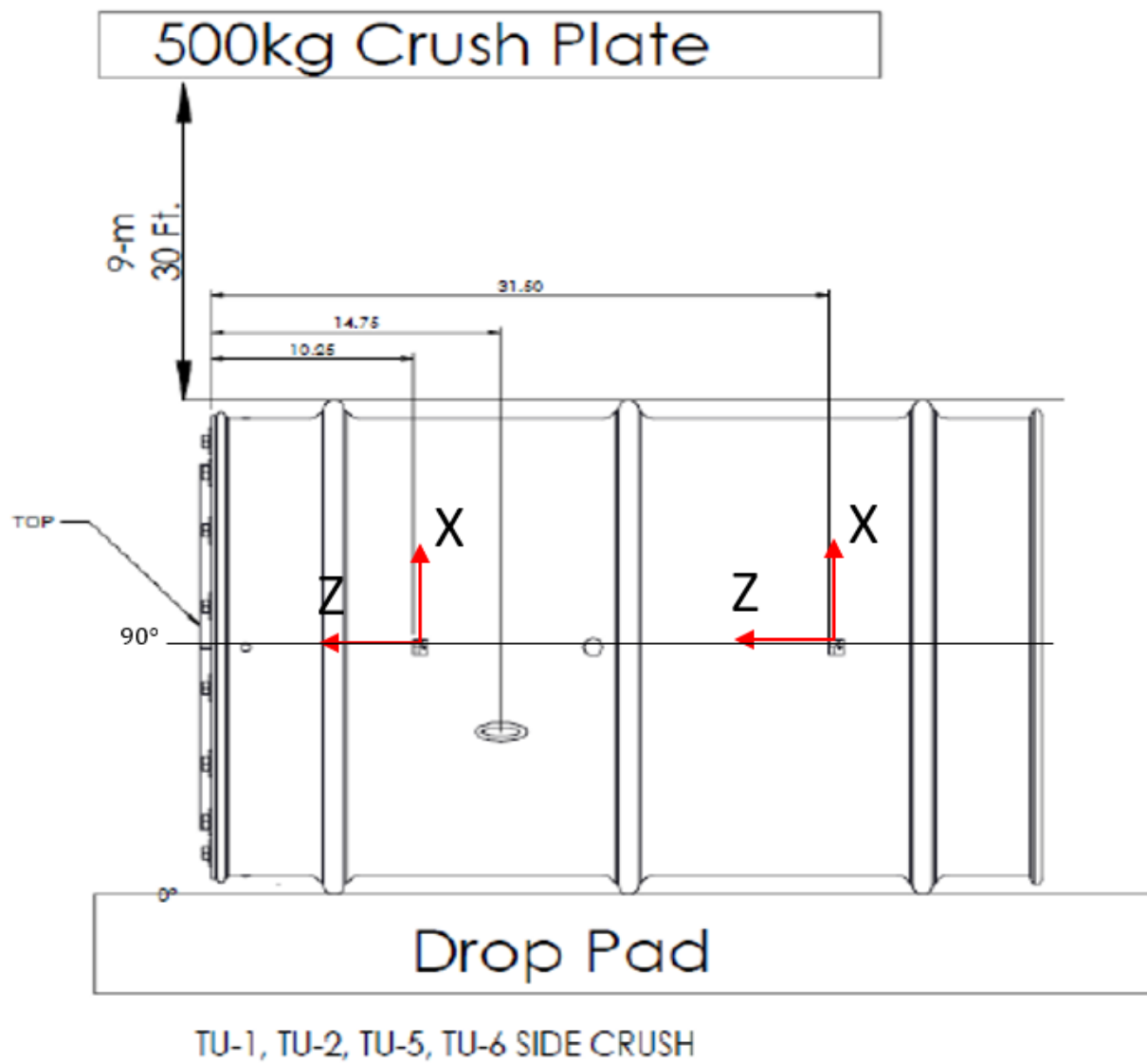
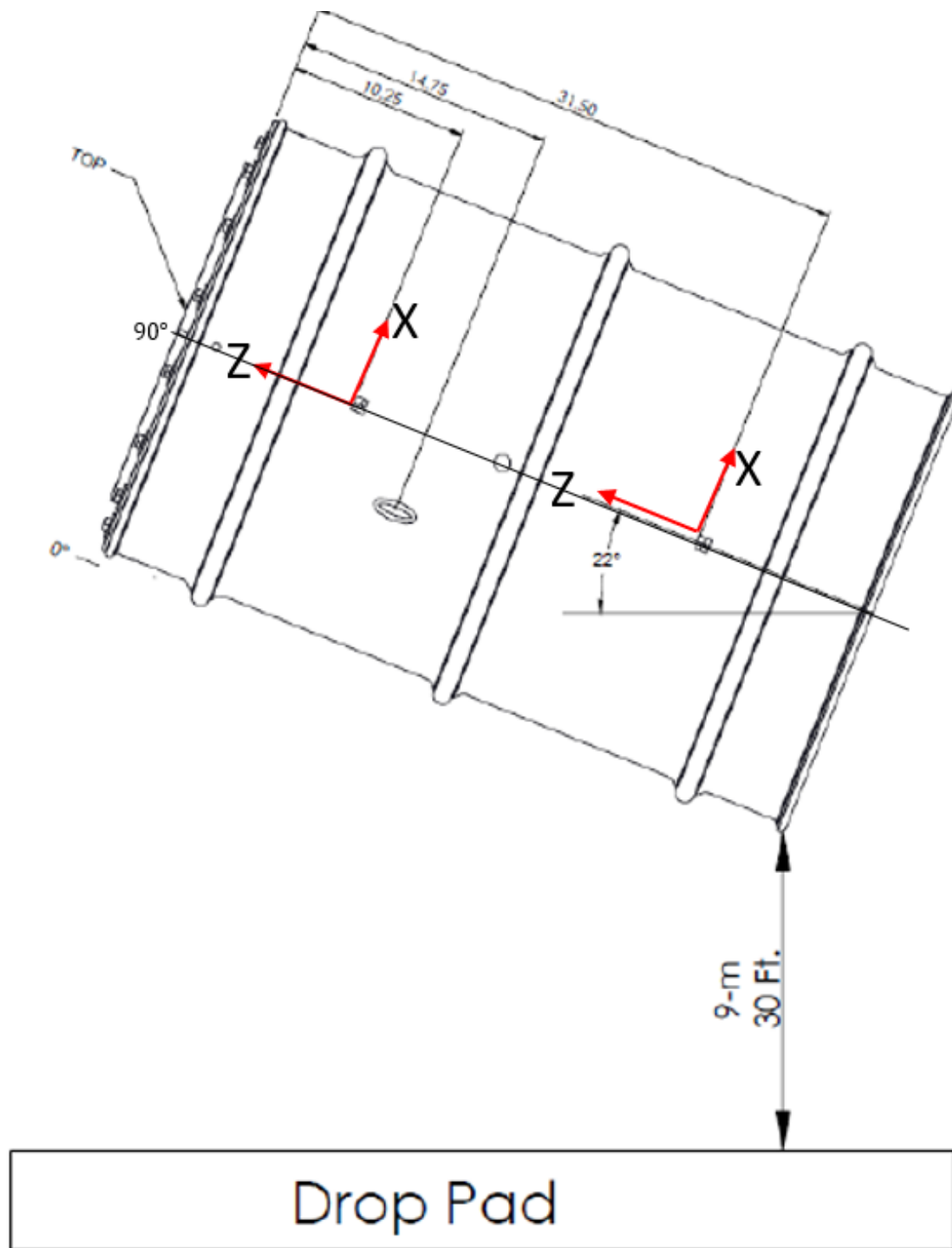
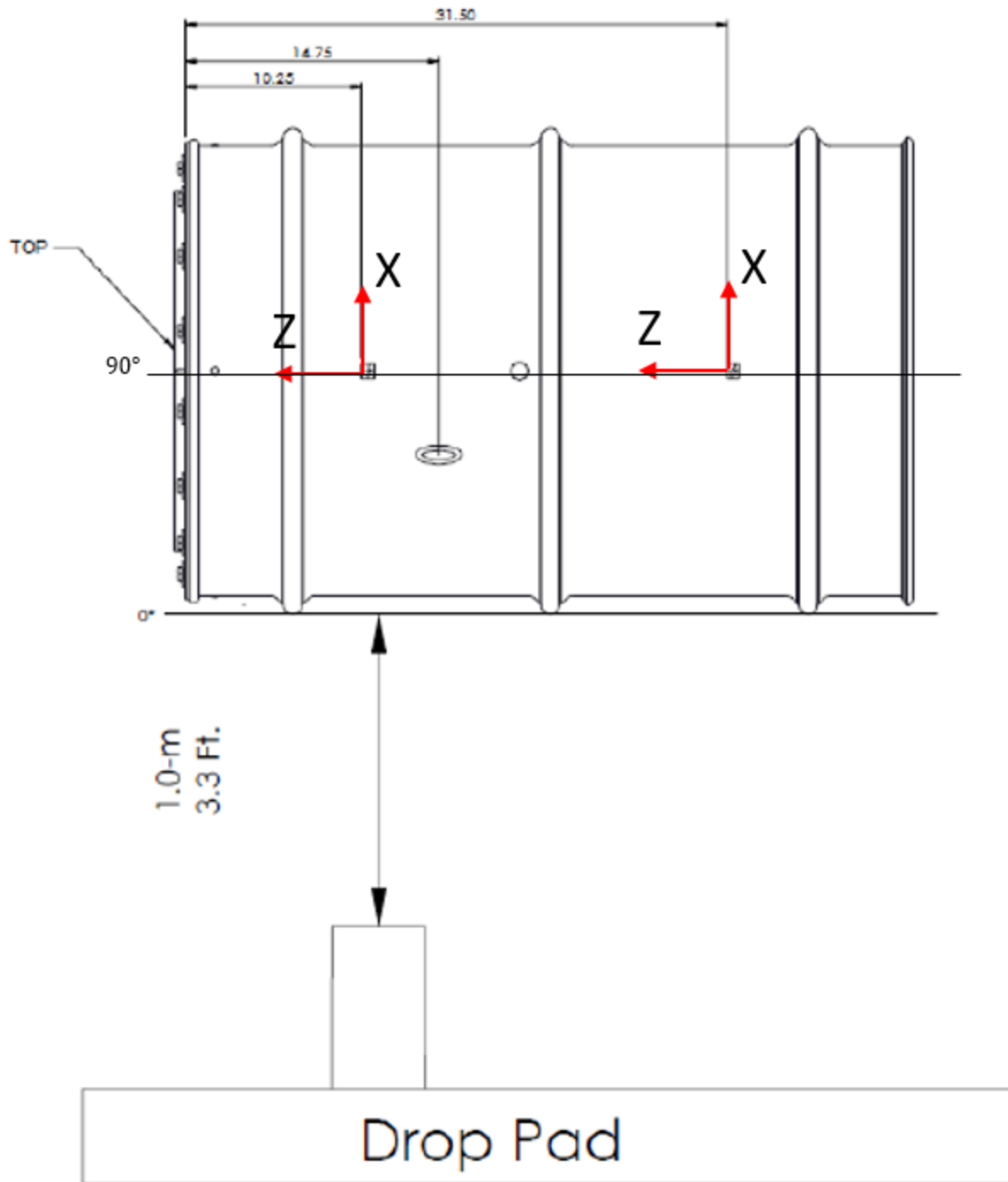


Figure 2-17. Accelerometer placement for TUs -1, -2, -5, and -6.



TU-5 and TU-6 SIDE DROP 22°

Figure 2-18. Accelerometer placement and drop orientation for TUs -5 and -6.



TU-1, TU-2, TU-5, and TU-6 PUNCTURE DROP SIDE 0°

Figure 2-19. Accelerometer placement and drop orientation for TUs -1, -2, -5, and -6.

### 2.3.1 Data Acquisition Description

The DAQ hardware and software consisted of an M+P brand VibPilot 8 channel instrument that acquired the data at a 102.4 kHz digitizing rate, and the Machine Analyzer software was used with the hardware



box. Signal conditioning, anti-alias filtering, continuity checks, and all other issues necessary for proper digitizing of analog data are included in the VibPilot instrumentation box and the associated software (Figure 2-20). The unit is controlled through a universal serial bus (USB) interface and streams the data to storage through this same input/output (I/O) path.

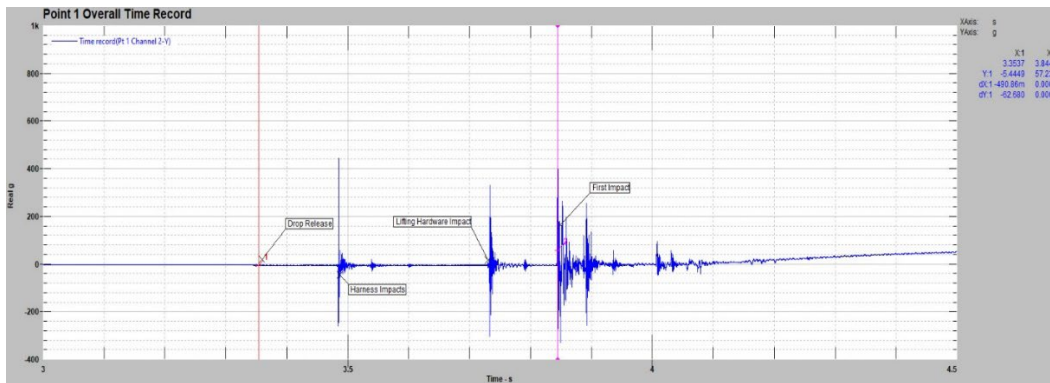


**Figure 2-20. VibPilot hardware with calibration stickers and signal input cabling.**

Once the data were digitized and processed, they were stored on the laptop's local disk in a streaming format that is proprietary to M+P hardware and software. These data will be converted to MATLAB format for long-term storage and universal access at the end of the project. The entire setup for DAQ is shown in Figure 2-21. The data are plotted out on a graph and annotated to the note features measured by the accelerometers during the drop and impact (Figure 2-22).



**Figure 2-21. DAQ setup with laptop and VibPilot software.**



**Figure 2-22. Typical acceleration data graph.**

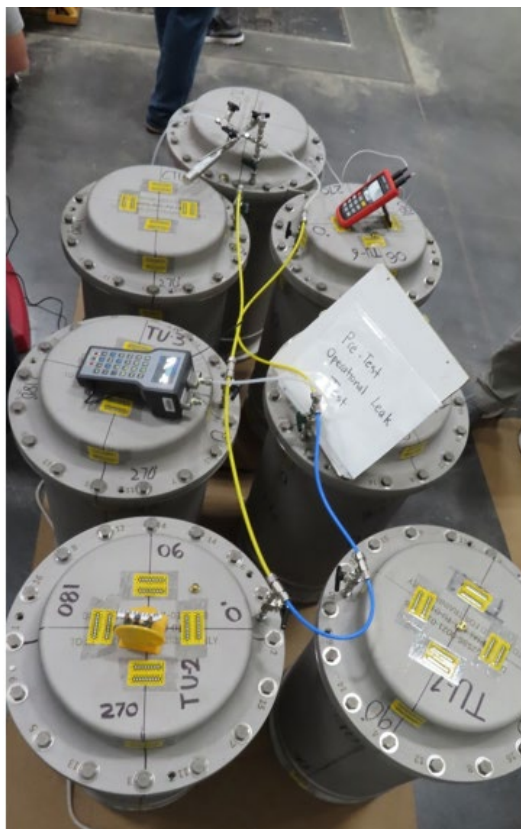
The title in the upper lefthand area describes the graph and the point number. Three accelerometers are mounted on each TU. Point 1 is always the point farthest from the base of the container structure, regardless of the drop orientation. Point 2 is the closest to the base structure, and it is necessary to reference the orientation of the drop to properly interpret the results of the signal plots. The text just below the title provides the point number and the channel number used on the VibPilot hardware and the axis of orientation for that channel. The annotations on the actual trace describe the event(s) that caused the feature shown. The vertical lines are cursors marking the *X* (acceleration) and *Y* (time) coordinates at that point. Those values are shown at the far right in blue text. The peak acceleration after the labeled first impact is the second impact with the nonyielding base plate that is caused by the container bouncing.

Using the formula of  $\text{Distance} = \frac{1}{2} \text{Acceleration} \times (\text{Time})^2$ , a 4 ft drop should impact the ground in about 0.5 seconds. Between the cursors from release to impact, the several large shocks indicated are not caused by the ground impact. Instead, the clevis, shackle, and strapping strike the container near Point 1 prior to ground impact, as can be seen in the high-speed video. These features are labeled as *lifting fixture noise* and do not contribute to this container's energy input.

## 2.4 PRETEST OPERATIONAL LEAK TEST

Prior to the final assembly of the CV into the outer drum, the O-ring seals of the CV assembly of all TUs were leak tested using an Ashcroft HQS-2 leak tester. Before leak testing, the volume between the O-rings was exposed to a vacuum for a minimum of 4 hr to clean out any impurities and moisture that could impact the leak test. The leak tester pressurizes the volume between the O-rings, uses a calibrated pressure transducer to measure the pressure drop over the test period, and then computes a leak rate (Figure 2-23). The CVs were tested in accordance with ANSI N14.5-2014, Section 7.6. The instrument was set to a test sensitivity of  $\leq 1 \times 10^{-3}$  atm-cc/sec. If the CV O-rings are installed and functioning properly, then the leak rate will not be detectable. The acceptable criterion as defined by ANSI N14.5 is "no detectable leakage when tested to a sensitivity  $1 \times 10^{-3}$  ref · cm<sup>3</sup>/s."

The pressure module pressurizes the volume between the O-rings and then uses a very precise pressure transducer to measure the pressure drop over the test period. The pressure change measurement test (PCMT) leak test calculator was used by the ORNL level III leak tester to calculate the leak rate and sensitivity.



**Figure 2-23. Initial operational leak test for TU CVs.**

The leakage rates are summarized in Table 2-3. All leakage rate data and calculations resulting from the tests are documented in Appendix U. Additionally, when the leak test data were compared with the ANSI standard, the results showed a leak rate of 0.0 atm-cc/s (no detectable leak) with a sensitivity  $\leq 1 \times 10^{-3}$  atm-cc/s.

**Table 2-3. Pretest leak rate for the TU CV**

ID	Leak Rate (atm-cc/s)	Sensitivity (atm-cc/s)
TU-1	0.00	9.90E-04
TU-2	0.00	6.53E-04
TU-3	0.00	9.84E-04
TU-4	0.00	8.45E-04
TU-5	0.00	9.84E-04
TU-6	0.00	9.94E-04
TU-7	0.00	8.56E-04

## 2.5 PACKAGE ASSEMBLY

Prior to assembly of the drum overpack, numerous temperature indicating labels (TLs) were applied to the TU components. For TUs -1 through -6, 24 label sets of Omega TL-10-190 and TL-10-290 were placed side by side to measure the temperature between 190 and 380°F (88 and 193°C) in 10°F increments. The

TLs were affixed to the interior surface of the drum liner and bottom surface of the drum lid (Figure 2-12) in accordance with the test plan. The TLs were covered with high-temperature Teflon tape.

The test weights were attached to the test fixture weldment by following the guidelines in Section 5.1.2.1 of the test plan (ORNL/NTRC-092 rev 0). The test weights were attached to the test fixture weldment using hex head fasteners which were torqued to  $25 \pm 2$  ft-lb. This process was completed using torque wrench ORNL ID A001096, calibration due 2/10/2022.

Test forms 2 and 11 were used to document the final assembly of the CV, including the insertion of the test content assembly and the PCC pads (Figure 2-24). The CV closure bolts were tightened according to the following sequence using torque wrench ORNL ID A001096, calibration due 2/10/2022, and the torque values for the final pass were recorded on Test Form 11:

1. Hand tighten and snug-up in a circular pattern around the CV lid.
2. First pass, torque to  $20 \pm 1$  ft-lb following the numbering sequence around the CV lid.
3. Second pass, torque to  $35 \pm 2$  ft-lb following the numbering sequence around the CV lid.
4. Last pass, verify torque of  $35 \pm 2$  ft-lb following the numbering sequence around the CV lid.

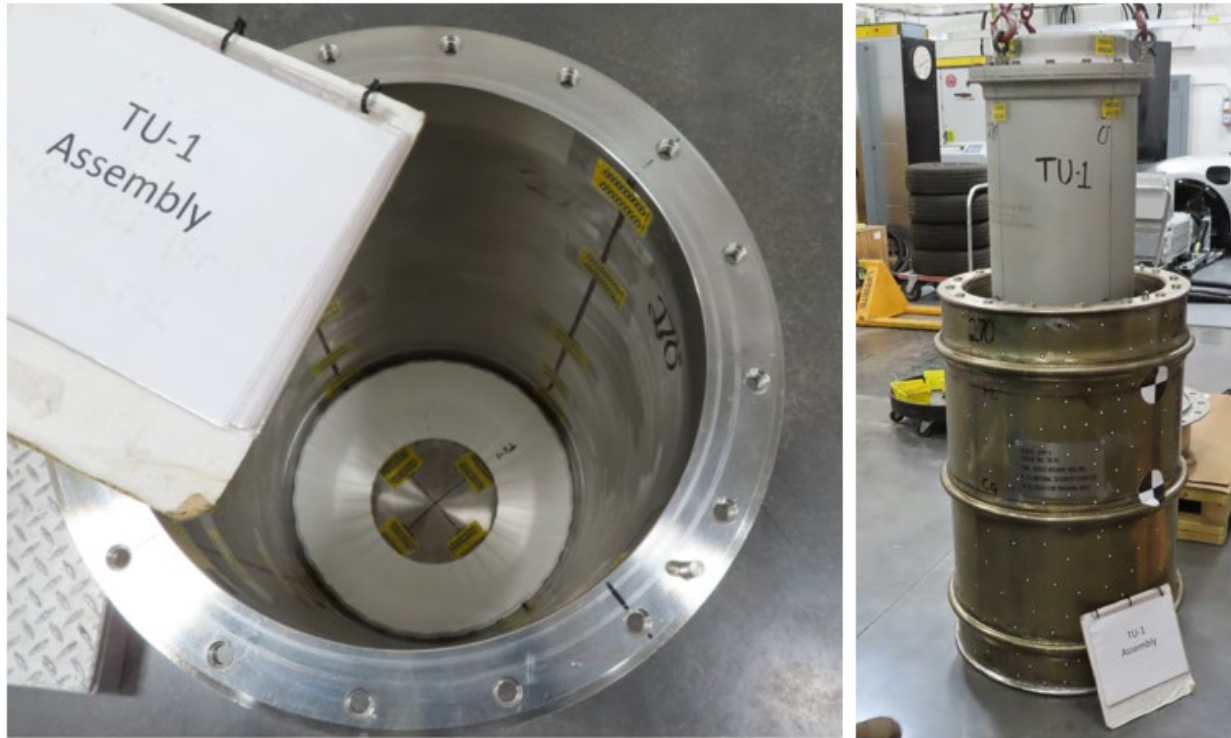


**Figure 2-24. TU-1 CV assembly.**

Test Forms 3 and 10 were used to document final assembly of the test package, including placement of the CV base pad, the CV, and the CV flange wedge into the drum body (Figure 2-25), drum lid installation, and weighing. During CV and drum assembly, all axial lines of the test weight content

assembly, CV, and drum body were aligned before the final closure of the drum lid (Figure 2-26). The total weight of each assembled TU is given in Table 2-4 through Table 2-9 and was recorded on Test Form 1. The drum lid closure bolts were tightened per the following sequence using torque wrench ORNL ID A001096, calibration due 2/10/2022, and the torque values for the final pass were recorded on Test Form 10:

1. Hand tighten and snug-up in a circular pattern around the drum lid.
2. First pass, torque to  $35 \pm 2$  ft-lb following the numbering sequence around the drum lid.
3. Last pass, verify torque of  $35 \pm 2$  ft-lb following the numbering sequence around the drum lid.



**Figure 2-25. CV lowered into drum body.**





Figure 2-26. Drum body assembly.

Table 2-4. Pretest and posttest weights for TU-1

Part name	Initial assembly weight (lb)	Post thermal weight (lb)	Change in weight (lb)
CV body	179	179	0
CV lid, screws, washers, and O-rings (together)	73	73	0
Test weight sets	66	67	1
Total test content assembly	114	115	1
PCC pad sets	15	15	0
CV assembly with test content	382	382	0
Drum body	380	378	-2
Drum lid assembly, screws, and washers (together)	103	103	0
CV base pad and CV flange wedge (together)	5	5	0
TU assembly	870	868	-2

Table 2-5. Pretest and posttest weights for TU-2

Part name	Initial assembly weight (lb)	Post thermal weight (lb)	Change in weight (lb)
CV body	181	181	0
CV lid, screws, washers, and O-rings (together)	72	72	0
Test weight sets	7	7	0
Total test content assembly	55	55	0
PCC pad sets	15	15	0
CV assembly with test content	323	323	0
Drum body	381	379	-2
Drum lid assembly, screws, and washers (together)	103	103	0
CV base pad and CV flange wedge (together)	5	5	0
TU assembly	811	810	-1

**Table 2-6. Pretest and posttest weights for TU-3**

<b>Part name</b>	<b>Initial assembly weight (lb)</b>	<b>Post thermal weight (lb)</b>	<b>Change in weight (lb)</b>
CV body	181	181	0
CV lid, screws, washers, and O-rings (together)	73	73	0
Test weight sets	66	66	0
Total test content assembly	114	114	0
PCC pad sets	15	15	0
CV assembly with test content	384	384	0
Drum body	382	380	-2
Drum lid assembly, screws, and washers (together)	103	103	0
CV base pad and CV flange wedge (together)	5	5	0
Test package assembly	873	871	-2

**Table 2-7. Pretest and posttest weights for TU-4**

<b>Part name</b>	<b>Initial assembly weight (lb)</b>	<b>Post thermal weight (lb)</b>	<b>Change in weight (lb)</b>
CV body	181	181	0
CV lid, screws, washers, and O-rings (together)	73	73	0
Test weight sets	66	66	0
Total test content assembly	114	114	0
PCC pad sets	15	15	0
CV assembly with test content	384	384	0
Drum body	381	378	-3
Drum lid assembly, screws, and washers (together)	103	103	0
CV base pad and CV flange wedge (together)	5	5	0
Test package assembly	874	870	-4

**Table 2-8. Pretest and posttest weights for TU-5**

<b>Part name</b>	<b>Initial assembly weight (lb)</b>	<b>Post thermal weight (lb)</b>	<b>Change in weight (lb)</b>
CV body	180	180	0
CV lid, screws, washers, and O-rings (together)	73	73	0
Test weight sets	67	66	-1
Total test content assembly	115	114	-1
PCC pad sets	15	15	0
CV assembly with test content	383	383	0
Drum body	377	376	-1
Drum lid assembly, screws, and washers (together)	102	100	-2
CV base pad and CV flange wedge (together)	5	5	0
Test package assembly	867	864	-3

**Table 2-9. Pretest and posttest weights for TU-6**

<b>Part name</b>	<b>Initial assembly weight (lb)</b>	<b>Post thermal weight (lb)</b>	<b>Change in weight (lb)</b>
CV body	180	180	0
CV lid, screws, washers, and O-rings (together)	73	73	0
Test weight sets	67	66	-1
Total test content assembly	115	114	-1
PCC pad sets	15	15	0
CV assembly with test content	383	383	0
Drum body	384	382	-2
Drum lid assembly, screws, and washers (together)	102	102	0
CV base pad and CV flange wedge (together)	5	5	0
Test package assembly	874	872	-2

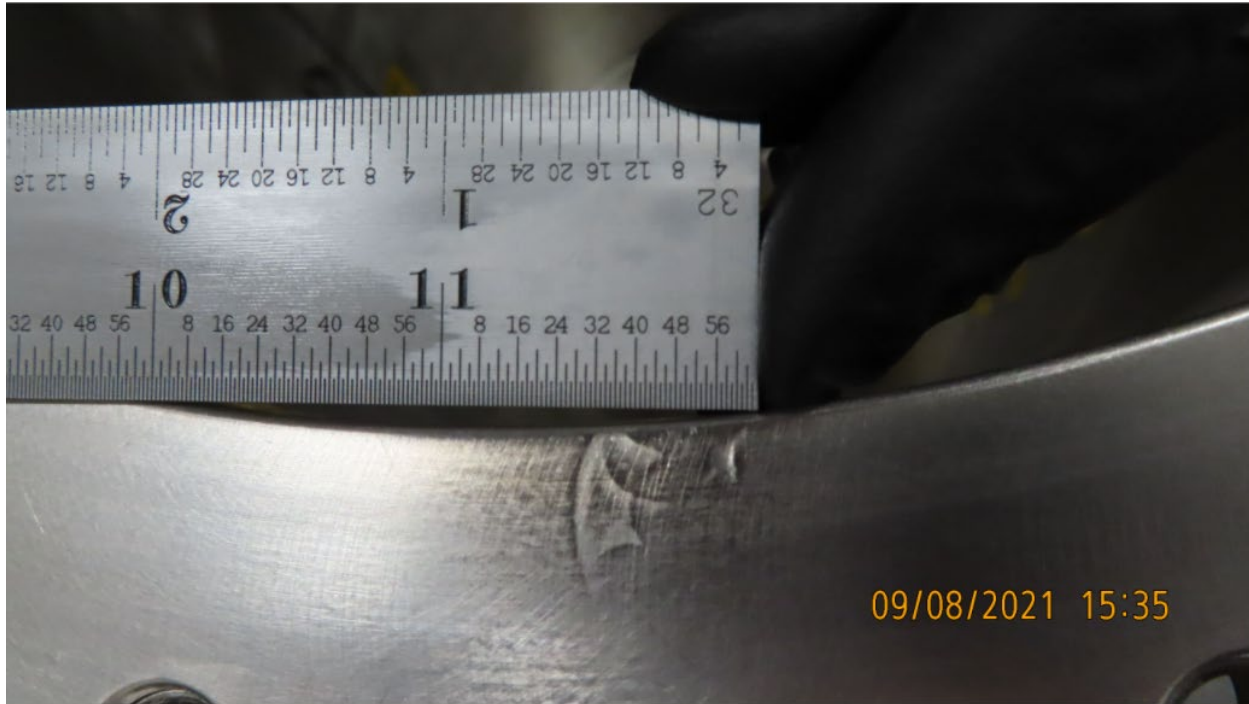
**Table 2-10. Pretest and posttest weights for TU-7**

<b>Part name</b>	<b>Initial assembly weight (lb)</b>	<b>Post thermal weight (lb)</b>	<b>Change in weight (lb)</b>
CV body	181	-	-
CV lid, screws, washers, and O-rings (together)	73	-	-
Test weight sets	-	-	-
PCC pad sets	-	-	-
CV assembly with test content	254	254	0
Drum body	-	-	-
Drum lid assembly, screws, and washers (together)	-	-	-
CV base pad and CV flange wedge (together)	-	-	-
Test package assembly	-	-	-

## 2.6 PACKAGE ASSEMBLY OBSERVATIONS

During the inspection and assembly process, any slight indentation, damage, or abnormal features were recorded in the lab notebook. It was noted that the TU-4 CV body had slight damage from fabrication near the inner O-ring sealing surface in the CV flange. This damage can be seen below in Figure 2-27. Out of abundance of caution, the CV for TU-4 was replaced with the pristine CV from TU-7. TU-4 (shown in Figure 2-27) was used for the 50 ft water immersion test, with acceptable results.





**Figure 2-27. TU-4 pretest damage (in.).**

## **2.7 CHILLING OF TU-1 AND TU-5**

Prior to the 4 ft NCT drop test and the HAC structural testing, TUs -1 and -5 were preconditioned to cold temperatures, and the chilling activities were documented on Test Form 4. TUs -1 and -5 were placed in an environmental chamber at the ORNL Technical Testing Analysis Center (TTAC) and chilled to -70°F (-56.7°C) for 24 hr and then -45°F (-42.7°C) for at least 48 hr, or until removed (Figure 2-28). The environmental chamber used to chill TUs is manufactured by ESPEC Model EWSX499-30NW (ORNL ID X185666, Serial No. 3240761). The chamber temperature ranged from -65 to +150°C.

At the conclusion of cooling, the TUs were wrapped in one layer of insulation and plastic wrap to keep them at their preconditioned temperature. The insulation was a polyurethane foam insulation sheet with perforated facing. The thickness of the insulation was 1 in., with a heat flow rate of 0.3 British thermal units (BTU) at 75°F. The units were transported to the National Transportation Research Center (NTRC) for structural testing. Figure 2-29 shows the TU being removed from the chamber, and Figure 2-30 shows the TU being wrapped with insulation. TU-1 was removed from the environmental chamber at 8:32 am on October 20, 2021, and then it was transported to the NTRC for NCT and HAC testing. The insulation was removed at 9:32 am on October 20, 2021, and the first NCT test started at 10:19 am on October 20, 2021. The NCT and HAC tests for TU-1 were completed at 11:25 am on October 20, 2021. TU-5 was removed from the environmental chamber at 12:55 pm on October 20, 2021, and then it was transported to the NTRC for NCT and HAC testing. The insulation was removed at 1:35 pm on October 20, 2021, and the first NCT test started at 2:00 pm on October 20, 2021. The NCT and HAC tests for TU-5 were completed at 3:23 pm on October 20, 2021. Both cold TUs that required NCT and HAC structural testing were completed within the 3-hour time constraint.

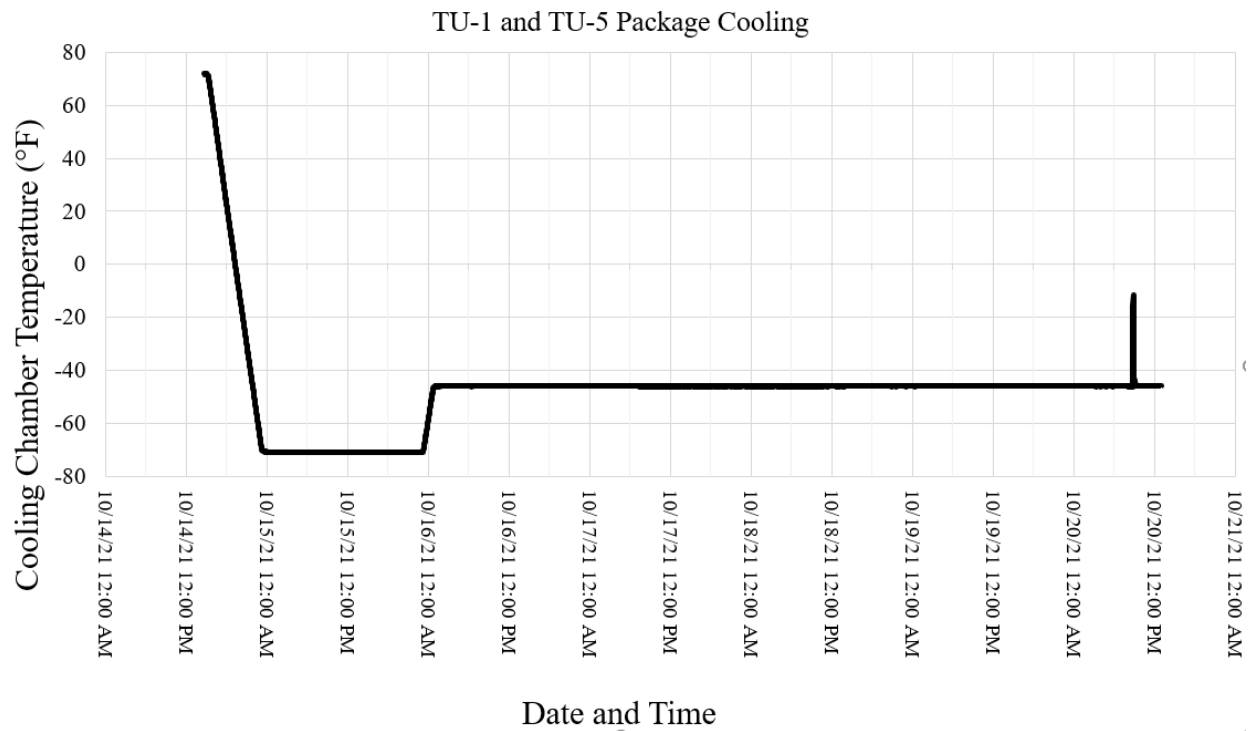


Figure 2-28. TU-1 and TU-5 chilling profile.



Figure 2-29. Removal and insulation of TU-1.



**Figure 2-30. Removal and insulation of TU-5.**

### **3. NCT TESTS**

The applicable NCT test sequence as specified in 10 CFR 71.71 includes a water spray test, a compression test, a vibration test, a penetration test, and a 1.2 m (4 ft) free drop test. Table 1-1 lists the NCT tests that were performed on the TUs and the sequence in which they were conducted. Because only TU-6 underwent the full series of NCT tests, it is used to guide the following discussion of the NCT test application. TUs -2, 3, -4, and -6 were subjected to the water spray test and the 4 ft drop test. TUs -1 through -6 were all subjected to the 4 ft drop.

#### **3.1 FULL NCT TEST SERIES**

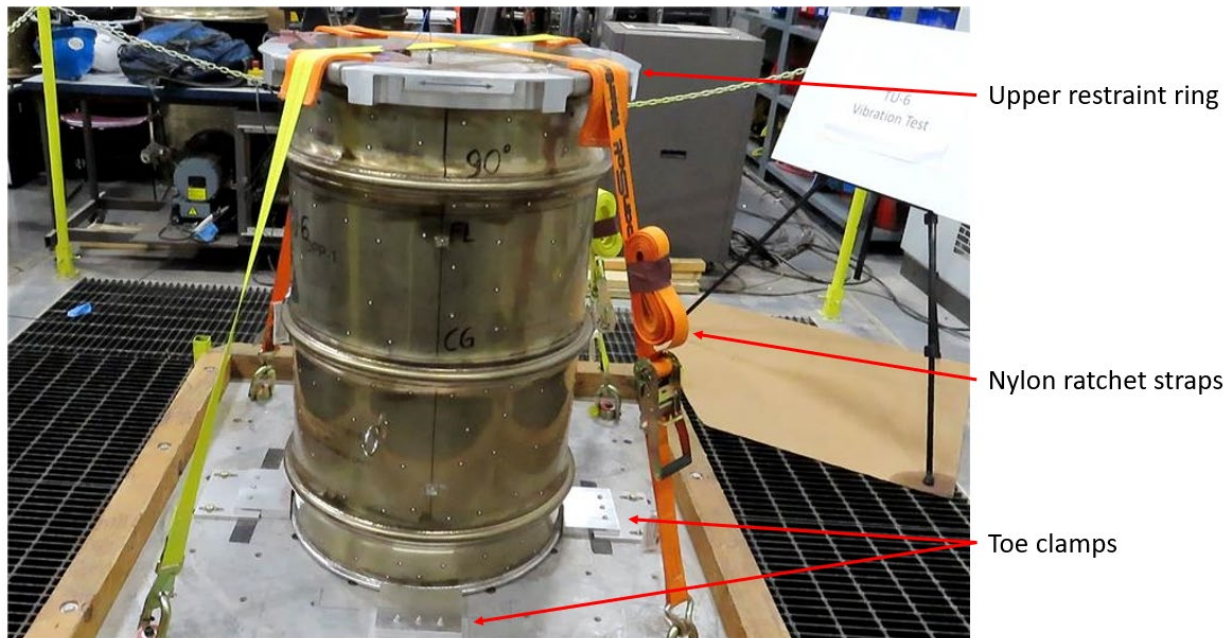
As noted above, TU-6 was subjected to all applicable NCT tests. This section discusses the NCT testing performed on all TUs. Drop testing is discussed in Section 3.4 because it was applied to all the TUs. TUs -1 and -5 were also exposed to an initial condition temperature prior to the NCT 4 ft drop test (Section 2.7).

#### **3.2 VIBRATION TEST (TU-6)**

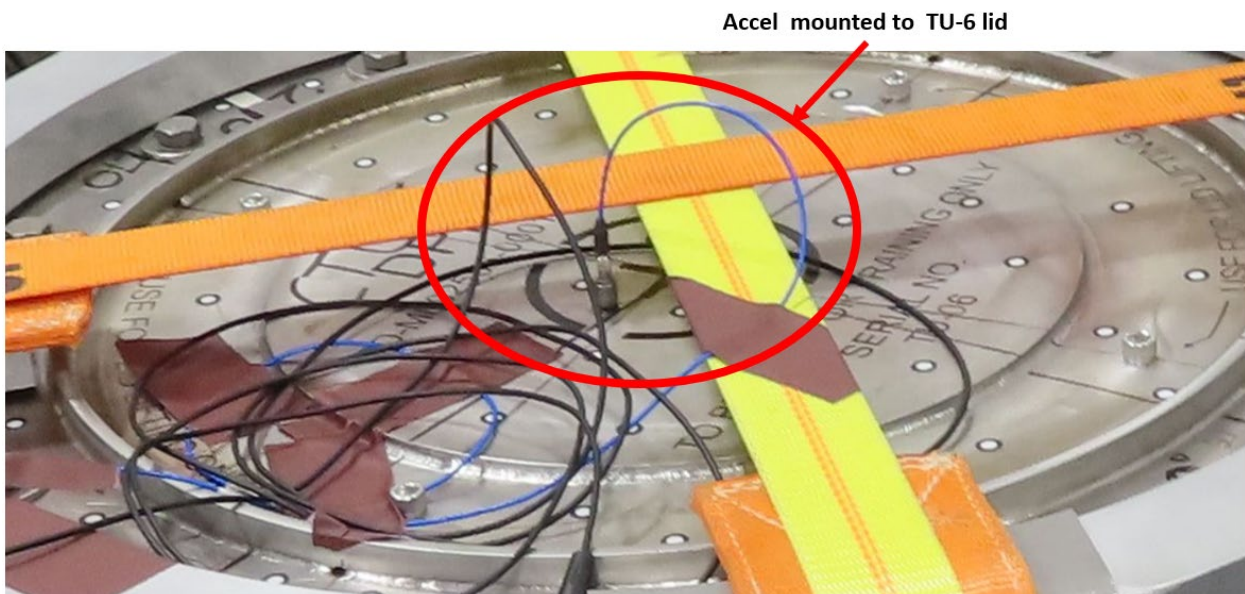
The vibration test for the DPP-1 package is designed to simulate the environmental effects of the vibration regime that the DPP-1 will experience during transport. A Lansmont model 10000-10 vibration table was used to perform the testing. A vibration spectrum simulating the Safe-Secure Trailer/Safeguards Transporter (SST/SGT) was used. The test was performed in accordance with 10 CFR 71.71(c)(5). The intensity and frequency of vibration events were designed to simulate about 1,000 miles of travel per hr of testing. The 4 hr test duration was conservative and should encompass any conceivable trip that the DPP-1 might undergo. The vibration controller was programmed to the power spectrum density shown in Table 3-1.

The vibration test was the first test for TU-6 per the test plan and test matrix. After package assembly and leak testing were complete, the TU was centered on the vibration table and securely strapped with an upper restraint ring, ratchet strap-style tie downs, and toe clamps (Figure 3-1). As shown in Figure 3-2, a single axis piezo electric accelerometer (PCB 352C68) was attached to the center of the TU-6 drum lid (serial #230190, calibration due 3/30/2022). The NCT vibration test was performed in accordance with PTP procedure PTP-PEF-06, Rev. 5. After the 4-hour vibration test, the TU was removed from the vibration table and inspected for damage. There was no apparent damage to the exterior of the packages. No additional assessment of package response was performed prior to performance of subsequent tests. Figure 3-3 shows the response of the TU when subjected to the 4-hour vibration power spectrum density input. The light blue line is the TU response when subjected to the power spectrum density (PSD) input. The response spikes at around 300 Hz because that is the natural frequency of the vibration table. The lower and upper bounds are the 6 dB bounds that trigger a shutdown of the shaker if the response is above or below those limits.





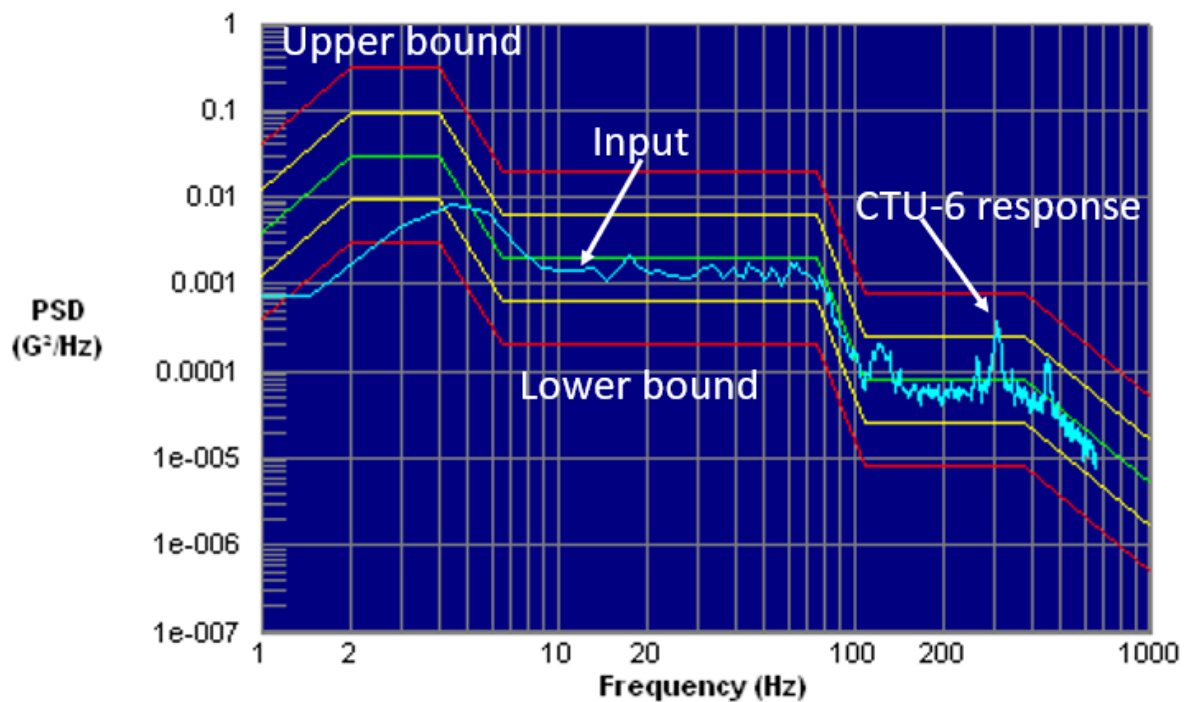
**Figure 3-1. DPP-1 TU-6 mounted on vibration table.**



**Figure 3-2. Accelerometer mounted to DPP-1 TU-6 lid.**

**Table 3-1. Vertical power spectrum density (PSD).**

Freq (Hz)	G <sup>2</sup> /Hz
1.0	4.0e-3
2.0	3.0e-2
4.0	3.0e-2
6.5	2.0e-3
75.0	2.0e-3
110.0	8.0e-5
380.0	8.0e-5
1,000.0	5.0e-6



**Figure 3-3. TU-6 response to the vibration spectrum.**

### 3.3 WATER SPRAY TEST

The DPP-1 TUs -2, -3, -4, and -6 were subjected to the NCT water spray test. The test was conducted on the outdoor drop pad next to the Package Evaluation Facility (PEF). The test was executed in accordance with PTP procedure PTP-PEF-05, Rev. 5, and in accordance with 10 CFR 71.71(c)(6). The water spray test was performed using a four-nozzle spray manifold, with the four nozzles directed to spray the top and the four quadrants of the TU (Figure 3-4). The water spray test on the package was conducted within 2.5 hr prior to the NCT 4 ft drop test and is noted on the test forms for subsequent tests. With a rain gauge positioned near the bottom of the TU (visible at the center of the package in Figure 3-4), the flow rate was measured to be >5 in./hr, because the rain gauge was filled with water in less than 1 hr. The depth of the rain gauge is 5 in. This amount of water exceeded the 10 CFR 71.71(6) requirement of at least 2 in. per hr. After the water spray test, the TUs were dried and prepared for NCT drop testing. The units were dried

with a cloth towel before the next test. See datasheets J, K, and L and Appendices C, D, and E for more information.



Figure 3-4. Water spray test setup for the DPP-1 packages.

### 3.4 FREE DROP TEST

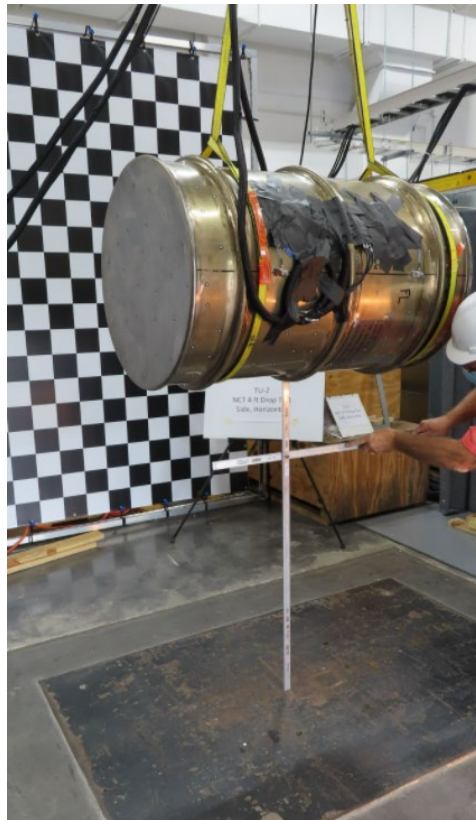
TUs -1 through -6 were subjected to the 1.2 m (4 ft) NCT drop test in accordance with 10 CFR 71.71(c)(7). As shown in Table 3-2, these units were dropped in various orientations. Deformation of each TU from the NCT drop test is described in this section. The total deformation from individual tests and cumulative deformation for all impact tests were recorded on Test Form 7 and reported in tabular form in Section 4.4. For TUs -1 and -5, only the cumulative damage is reported, because these TUs were chilled, so no measurements were taken between tests to expedite testing to meet the 3-hour test window requirement. The details of the NCT free drop test, including data on damage, measurements, and damage sketches for each package, are reported in Appendices H through M.

The NCT free drop tests on TUs -1 through -6 were carried out on the NTRC indoor or outdoor drop pad of the PEF. These drop pads provided the essentially unyielding surfaces for the NCT free drop tests (ORNL/NTRC-001, *Design and Certification of Targets for Drop Testing at the NTRC Package Research Facility*, Rev. 0). All NCT free drop tests were executed according to procedure PTP-PEF-08, Rev. 5. Table 3-2 shows the desired package orientation for each drop test and the orientation of each package achieved for the test.

Figure 3-5 shows a typical test setup for an NCT drop performed on the inside drop pad, and Figure 3-6 shows a typical setup for an NCT drop performed on the outdoor drop pad. The calibrated measuring bar (ORNL ID A000885, Calibration Expiration 2/24/2026) is used to determine the proper drop height and to assist in aligning the package to the center of the drop pad.

**Table 3-2. Planned vs. measured package orientation for NCT drop tests.**

TU	Desired orientation	Measured orientation
TU-1	Axis of package horizontal; 0° marking should contact drop pad first	Axis of package 0.4° from horizontal
TU-2	Axis of package horizontal; 0° marking should contact drop pad first	Axis of package 1.4° from horizontal
TU-3	Axis of package vertical, lid surface should contact drop pad first	Axis of package 0.2° from vertical
TU-4	CG over corner (56.4°), 0° toward drop pad, lid corner should contact drop pad first	Axis of package 55.1° from vertical
TU-5	Axis of package 22° from horizontal, slap down, bottom corner at 0° line should contact drop pad first	Axis of package 21.2° from horizontal
TU-6	Axis of package 22° from horizontal, slap down, bottom corner at 0° line should contact drop pad first	Axis of package 21.9° from horizontal



**Figure 3-5. Typical NCT free drop setup on indoor drop pad.**





**Figure 3-6. Typical NCT free drop setup on outdoor drop pad.**

### **3.4.1 TU-1**

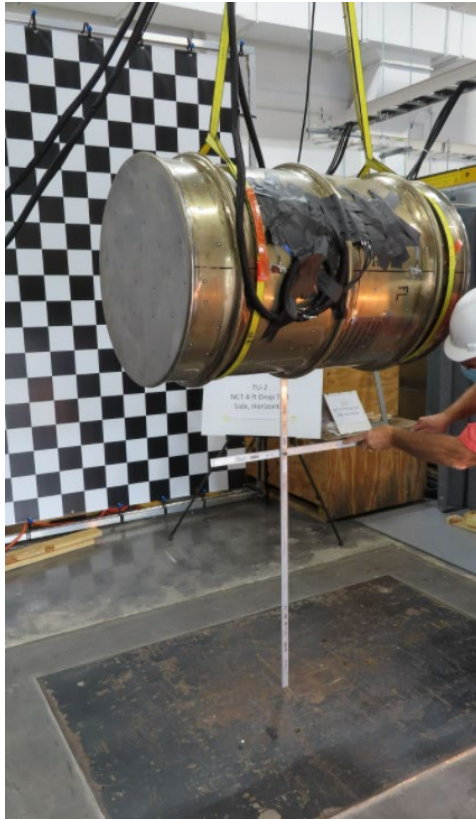
TU-1 was subjected to the NCT 1.2 m free drop test after being chilled. The TU was removed from the chiller (Serial number 3240761, calibration due 10/27/2021) on 10/20/2021 at 8:32 am, and the NCT free drop test was completed on 10/21/2021 at 10:19 am. TU-1 had a measured angle of  $0.4^\circ$  from horizontal, impacting on the  $0^\circ$  line, as shown in Figure 3-6. When rigged within angle tolerances, the package was rigged until the calibrated 1.2 m aluminum rod fit between the drop pad and the lowest point on the package. Because this package was chilled, damage measurements between the tests were not taken so that tests could be conducted as quickly as possible to minimize TU temperature changes. Dimensional measurements of this unit were taken after the package had completed all NCT and HAC structural tests; measurements are provided in Section 4.4. Besides the small flat edges along the  $0^\circ$  line, there was no other discernible damage on TU-1 after the 1.2 m impact test (Figure 3-7). The max g load was 595 g from Point 2 in the y direction on the  $90^\circ$  line. See the datasheet in Appendix H for more details and see Appendix A for additional photographs.



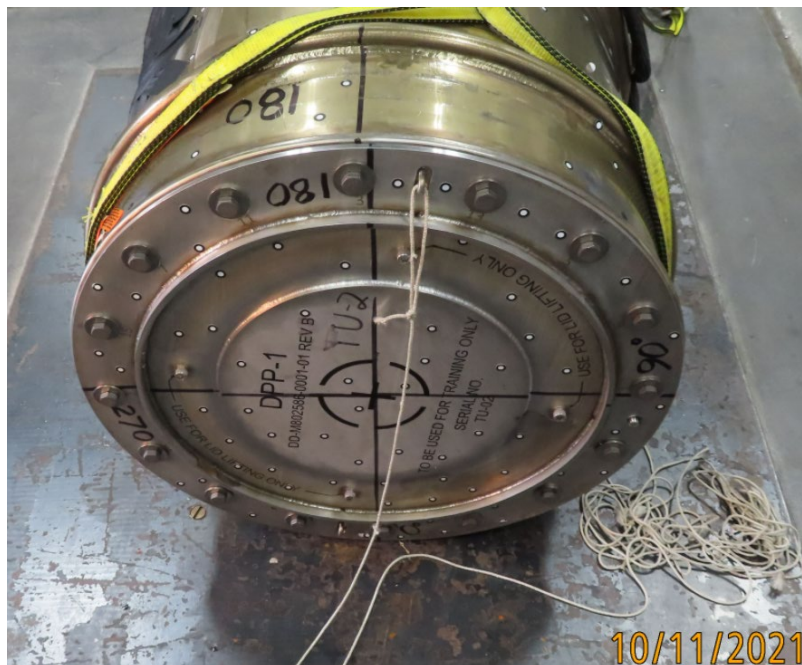
**Figure 3-7. Damage to TU-1 due to NCT 1.2 m drop test.**

### **3.4.2 TU-2**

TU-2 was subjected to the NCT 1.2 m free drop test after the water spray test. The water spray test was completed on 10/11/2021 at 12:08 pm, and the NCT free drop test was completed on 10/11/2021 at 2:10 pm. TU-2 had a measured angle of  $1.4^\circ$  from horizontal, impacting on the  $0^\circ$  line, as shown in Figure 3-8. When rigged within angle tolerances, the package was rigged until the calibrated 1.2 m aluminum rod (ORNL ID A000885, calibration due 2/24/2026) fit between the drop pad and the lowest point on the package. Dimensional measurements of this unit were taken between all NCT and HAC structural tests and are provided in Section 4.4. The only discernible damage on the exterior of TU-2 after the 1.2 m impact test were the flats that were introduced to the  $0^\circ$  line area for the top surface, top hoop, center hoop, bottom hoop, and bottom surface (Figure 3-9). The max g load was -513 g from Point 21 in the z direction on the  $270^\circ$  line. See the datasheet in Appendix I for more details and see Appendix B for additional photographs.



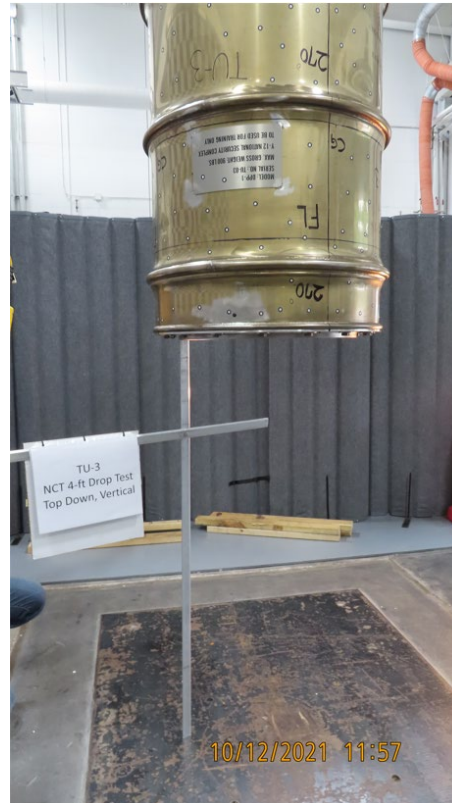
**Figure 3-8. TU-2 NCT 1.2 m free drop orientation.**



**Figure 3-9. Posttest visual inspection of TU-2 after NCT 1.2 m drop test.**

### 3.4.3 TU-3

TU-3 was subjected to the NCT 1.2 m free drop test after the water spray test. The water spray test was completed on 10/12/2021 at 10:28 am, and the NCT free drop test was completed on 10/12/2021 at 12:10 pm. TU-3 had a measured angle of  $0.2^\circ$  from vertical, impacting on the vertical top up orientation, as shown in Figure 3-10. When rigged within angle tolerances, the package was rigged until the calibrated 1.2 m aluminum rod (ORNL ID A000885, calibration due 2/24/2026) fit between the drop pad and the lowest point on the package. The impact caused no visual damage to the TU. See Section 4.4 for damage measurement details. See the datasheet in Appendix J for more details and see Appendix C for additional photographs. TU-3 was not instrumented with impact accelerometers.

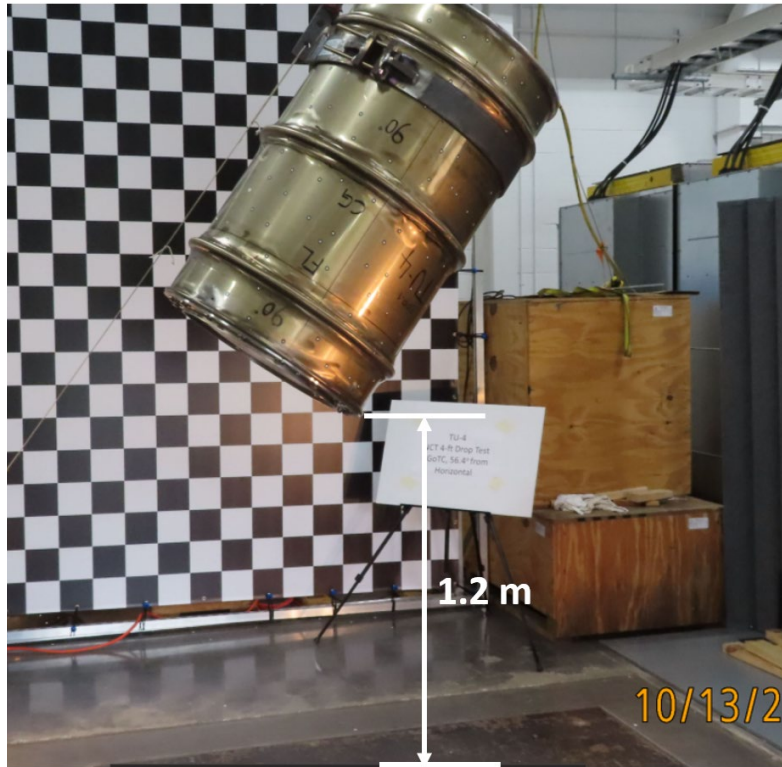


**Figure 3-10. TU-3 NCT 1.2 m free drop orientation.**

### 3.4.4 TU-4

TU-4 was subjected to the NCT 1.2 m free drop test after the water spray test. The water spray test was completed on 10/13/2021 at 10:32 am, and the NCT free drop test was completed on 10/13/2021 at 12:19 pm. TU-4 had a measured angle of  $55.1^\circ$  from horizontal, impacting on the top corner, as shown in Figure 3-11. When rigged within angle tolerances, the package was rigged until the calibrated 1.2 m aluminum rod (ORNL ID A000885, calibration due 2/24/2026) fit between the drop pad and the lowest point on the package. The impact created a small dent on the TU corner. See Section 4.4 for damage measurement details. See the datasheet in Appendix K for more details and see Appendix D for additional photographs. TU-4 was not instrumented with impact accelerometers.





**Figure 3-11. TU-4 NCT 1.2 m free drop orientation.**

### **3.4.5 TU-5**

TU-5 was subjected to the NCT 1.2 m free drop test after being chilled. The TU was removed from the chiller (Serial number 3240761, calibration due 10/27/2021) on 10/20/2021 at 12:55 pm, and the NCT free drop test was completed on 10/21/2021 at 2:00 pm. TU-5 had a measured angle  $21.2^\circ$  from horizontal, impacting on the  $0^\circ$  line, with the bottom corner impacting the pad first, as shown in Figure 3-12. When rigged within angle tolerances, the package was rigged until the calibrated 1.2 m aluminum rod (ORNL ID A000885, calibration due 2/24/2026) fit between the drop pad and the lowest point on the package. Because this package was chilled, damage measurements between the tests were not taken so that the tests could be conducted as quickly as possible to minimize TU temperature changes. Dimensional measurements of this unit were taken after the package had completed all NCT and HAC structural tests; measurements are provided in Section 4.4. The impact caused damage to the bottom corner of the TU at the  $0^\circ$  line (Figure 3-13). The max g load was -476 g from Point 2 in the  $x$  direction on the  $90^\circ$  line. See Section 4.4 for damage measurement details. See the datasheet in Appendix L for more details and see Appendix E for additional photographs.



**Figure 3-12. TU-5 NCT 1.2 m free drop orientation.**



**Figure 3-13. Damage to TU-5 from NCT free drop test.**

### 3.4.6 TU-6

TU-6 was subjected to the NCT 1.2 m free drop test after the water spray test. The water spray test was completed on 10/6/2021 at 2:30 pm, and the NCT free drop test was completed on 10/6/2021 at 4:20 pm. TU-6 had a measured angle of  $21.9^\circ$  from horizontal, impacting on the  $0^\circ$  line, with the bottom corner impacting the pad first, as shown in Figure 3-14. When rigged within angle tolerances, the package was rigged until the calibrated 1.2 m aluminum rod (ORNL ID A000885, calibration due 2/24/2021) fit between the drop pad and the lowest point on the package. The impact caused a flat spot to be formed at the bottom of the TU at the  $0^\circ$  line (Figure 3-15). The max g load was -491 g from Point 2 in the  $x$  direction on the  $90^\circ$  line. See Section 4.4 for damage measurement details. See the datasheet in Appendix M for more details, and see Appendix F for additional photographs.



**Figure 3-14. TU-6 NCT 1.2 m free drop orientation.**



**Figure 3-15. Damage to TU-6 from NCT free drop test.**

### **3.5 COMPRESSION TEST (TU-6)**

The compression test was performed on TU-6 using a Lansmont model 152 30K compression tester (ORNL ID1999, calibration due 3/30/2022) (Figure 3-16) using PTP-PEF-07 Rev. 5. In accordance with 10 CFR 71.71(c)(9), five times the maximum package weight of 900 lb, or 4,500 lb, was applied to the package (Figure 3-17). The test started at 11:25 am on 10/07/2021 and concluded at 11:27 am on 10/08/2021. The initial height of the package before the compression was 43  $\frac{1}{4}$  in. at the 0° line. After being compressed for 24 hr and 1 min, the package height at the 0° line was 43  $\frac{3}{16}$  in. See the data sheets in Appendices M and F for more details.





Figure 3-16. TU-6 in compression tester.

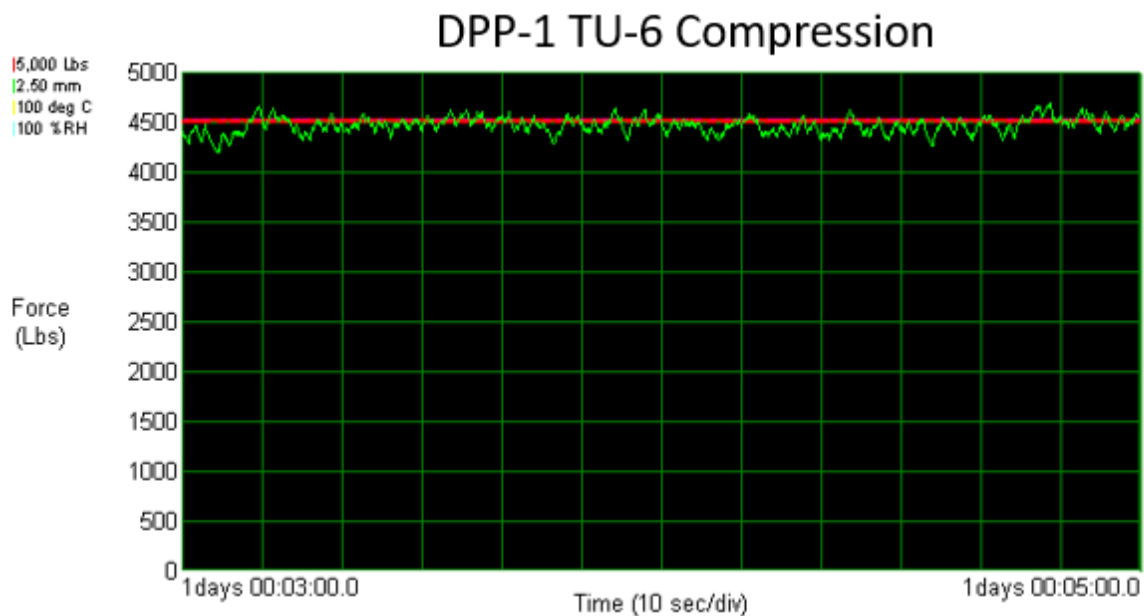
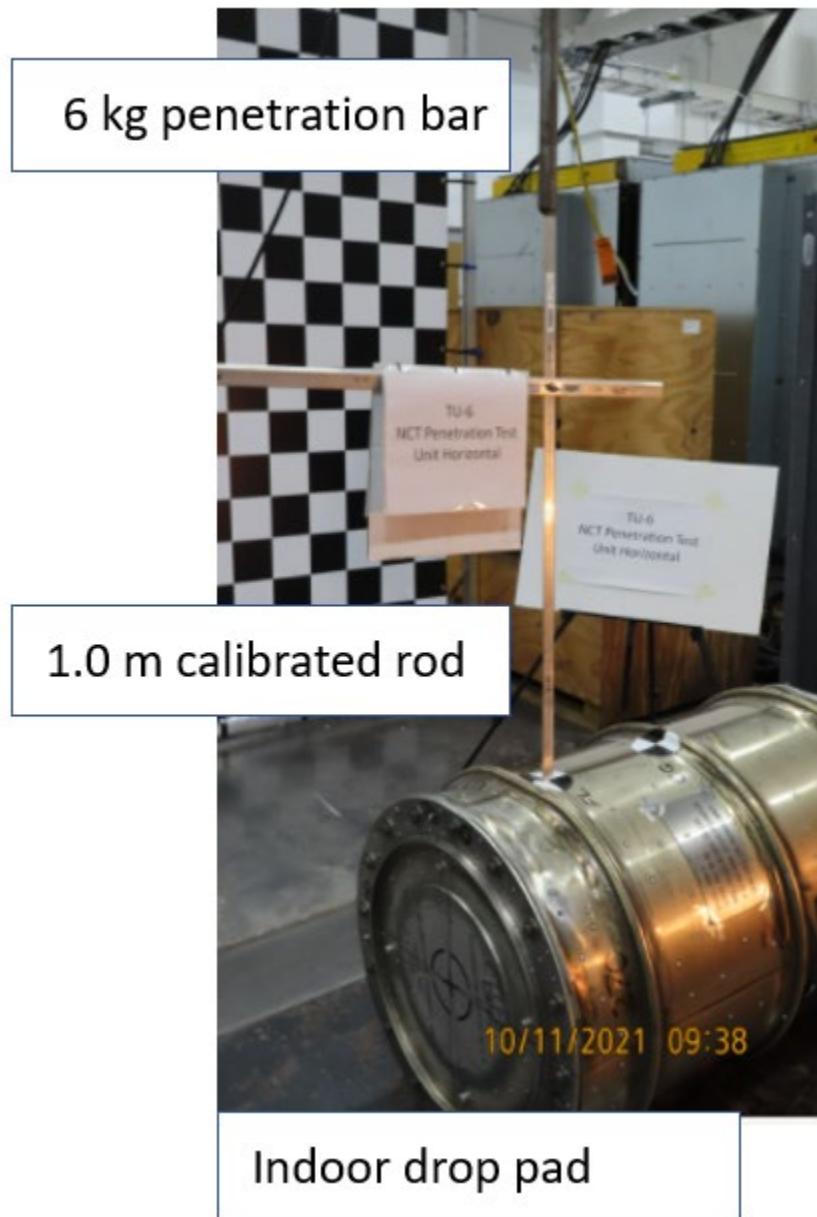


Figure 3-17. TU-6 compression force profile.

### 3.6 PENETRATION TEST (TU-6)

TU-6 was placed horizontally on the center of the indoor drop pad with the 0° line facing upward. The test was performed in accordance with 10 CFR 71.71(c)(10). The penetration test target was 8.75 in. from the top of the package along the weld seam line to the bottom surface of the penetration bar. The TU was constrained with wood blocks to prevent the package from rolling because of the impact from the penetration bar. The 6 kg penetration bar (ORNL ID A000884, calibration due 2/25/2026) was raised to 1 m (40 in.) above the intended contact point and measured with a 1 m aluminum rod (ORNL ID A001146, calibration due 2/24/26). The drop time was 9:52 am on 10/11/2021. Figure 3-18 shows the test setup for TU-6. The bar struck the package slightly off center from the intended impact point by 0.75 in. and

formed a minor dent (approximately 0.18 in. deep) in the package (Figure 3-19). See the data sheets in Appendices M and F for the test results.



**Figure 3-18. TU-6 penetration test setup.**



**Figure 3-19. TU-6 damage from penetration test.**

## 4. HAC TESTS

The 10 CFR 71.73 Hypothetical Accident Conditions (HAC) compliance testing sequence was performed on TUs -1 through -6. TUs -1 and -5 were chilled to below -45 °F before the structural tests were performed. Dimensional measurements were not taken between the tests for TUs -1 and -5 so that the TUs would remain cold as possible for all the tests. All TUs were subjected to the HAC free drop test, the HAC crush test, the HAC puncture test, followed by the thermal test at an offsite facility, and finally, the immersion test. Following each of the tests on TUs -2, -3, -4 and -6, dimensional measurements were made to document the damage. A summary of all the damage measurements taken is presented in Section 4.4.

### 4.1 HAC 9 M (30 FT) DROP TEST

Following the NCT drops, the TUs were subjected to the 9 m (30 ft) HAC drop test in accordance with 10 CFR 71.73(c)(1). The HAC drop tests were performed at the NTRC outdoor drop pad according to the PTP-PEF-10 Rev. 6 procedure. This pad provided the essentially unyielding surface required by the 10 CFR 71.73(c)(1) regulations. The construction of the drop pad is described in ORNL/NTRC-001, *Design and Certification of Targets for Drop Testing at the NTRC Package Research Facility*, Rev. 0. The packages were dropped in the orientations described in Table 4-1.

**Table 4-1. HAC 9 m drop test: desired package orientation vs. measured orientation**

TU	Desired orientation	Measured orientation
TU-1	Axis of package horizontal; 0° marking should contact drop pad first	Axis of package 0.1° from horizontal
TU-2	Axis of package horizontal; 0° marking should contact drop pad first	Axis of package 0.5° from horizontal
TU-3	Axis of package vertical, lid surface should contact drop pad first	Axis of package 0.0° from vertical
TU-4	CG over corner (56.4°), 0° toward drop pad, lid corner should contact drop pad first	Axis of package 54.8° from vertical
TU-5	Axis of package 22° from horizontal, slap down, bottom corner at 0° line should contact drop pad first	Axis of package 21.1° from horizontal
TU-6	Axis of package 22° from horizontal, slap down, bottom corner at 0° line should contact drop pad first	Axis of package 22.0° from horizontal

#### 4.1.1 TU-1

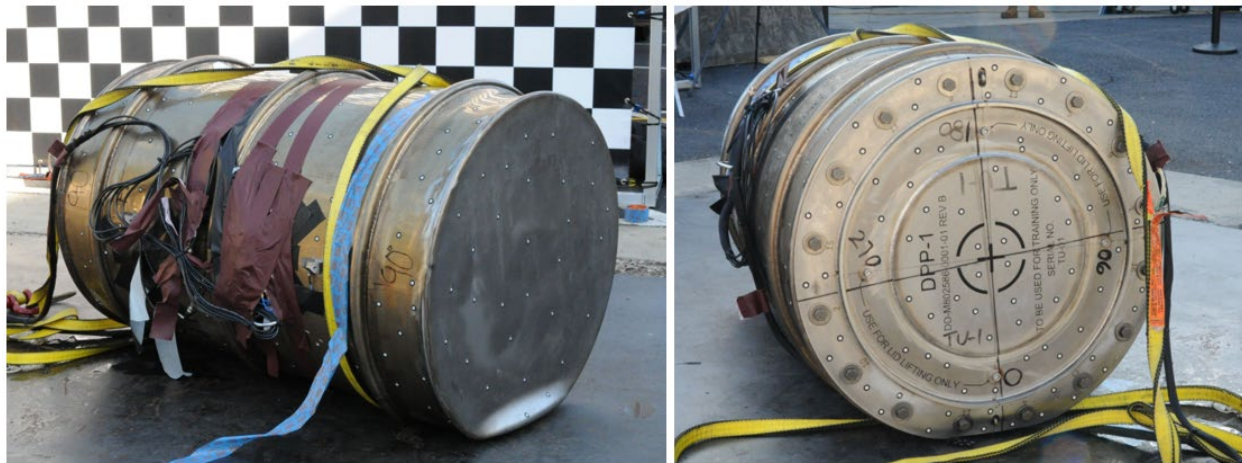
TU-1 was dropped with the axis of the package at an angle of 0.1° from horizontal on its 0° side from 9 m (Figure 4-1). The package had been chilled to -45°F prior to testing. To test the package while it was as cool as possible, the NCT drop, HAC drop, HAC crush, and HAC puncture tests were conducted promptly one after the other to complete all drop tests within the 3-hour window. The 9 m wire was attached to the lowest point on the package. The 9 m wire and plum bob length were verified with a 40 ft tape measure (ORNL ID A006327, calibration due 3/20/23) prior to use. Length was measured to be 360 in. When the TU was rigged within angle tolerances, the TU was raised until the plumb bob on the 9 m wire was just above the outdoor drop pad. The drop time was 10:30 am on 10/20/2021. Physical measurements of the intermediate damage were not taken. Only the cumulative damage at the end of these tests was measured. The cumulative damage and damage measurements are described in Section



4.4, which also includes damage measurement data. The general damage can be seen below in Figure 4-2. The max g load was -1,294 g from Point 2 in the x direction on the 90° line. See the datasheet in Appendix H for more details, and see Appendix A for additional photographs.



**Figure 4-1. TU-1 HAC free drop test orientation.**



**Figure 4-2. TU-1 HAC free drop damage.**

#### 4.1.2 TU-2

TU-2 was dropped with the axis of the package at an angle of  $0.5^\circ$  from horizontal on its  $0^\circ$  side from 9 m (Figure 4-3). The 9 m wire was attached to the lowest point on the package. When the TU was rigged within angle tolerances, the TU was raised until the plumb bob on the 9 m wire was just above the outdoor drop pad. The drop time was 9:16 am on 10/22/2021. The cumulative damage and damage measurements are described in Section 4.4. No loosened bolts were detected, and gross damage was detected and measured along the  $0^\circ$  line (Figure 4-4). See Section 4.4 for damage measurement data. The max g load was 2,422 g from Point 2 in the z direction on the  $270^\circ$  line. See the datasheet in Appendix I for more details, and see Appendix B for additional photographs.



Figure 4-3. TU-2 HAC free drop test orientation.





Figure 4-4. TU-2 HAC free drop damage.

#### 4.1.3 TU-3

TU-3 was dropped with the axis of the package at an angle of  $0.0^\circ$  from vertical, impacting on the vertical top-down orientation (Figure 4-5). The 9 m wire was attached to the lowest point on the package. When the TU was rigged within angle tolerances, the TU was raised until the plumb bob on the 9 m wire was just above the outdoor drop pad. The drop time was 8:45 am on 10/21/2021. This orientation caused the lid to impact the drop pad first. The impact created a slight buckle around the top rolled hoop area where it forms into the drum body (Figure 4-6). See the datasheet in Appendix J for more details, and see Appendix C for additional photographs.



**Figure 4-5. TU-3 HAC free drop test orientation.**





**Figure 4-6. TU-3 HAC free drop test damage.**

#### **4.1.4 TU-4**

TU-4 was dropped with the axis of the package at an angle of  $54.8^\circ$  from vertical, impacting on the CG over top corner orientation (Figure 4-7). The 9 m wire was attached to the lowest point on the package. When the TU was rigged within angle tolerances, the TU was raised until the plumb bob on the 9 m wire was just above the outdoor drop pad. The drop time was 9:09 am on 10/21/2021. This orientation caused the top corner of the drum lid to impact the drop pad first. The impact caused crumpling of the top corner to occur (Figure 4-8). See Section 4.4 for damage measurement data. See the datasheet in Appendix K for more details, and see Appendix D for additional photographs.



**Figure 4-7. TU-4 HAC free drop test orientation.**



**Figure 4-8. TU-4 HAC free drop test damage.**



#### 4.1.5 TU-5

TU-5 was dropped with the axis of the package at an angle of  $21.1^\circ$  from horizontal, impacting on the  $0^\circ$  line at the bottom corner (Figure 4-9). The package had been chilled to  $-45^\circ\text{F}$  prior to testing. To test the package while it was as cool as possible, the NCT drop, HAC drop, HAC crush, and HAC puncture tests were conducted promptly one after the other to complete all drop testing within the 3-hour window. The 9 m wire was attached to the lowest point on the package. When the TU was rigged within angle tolerances, the TU was raised until the plumb bob on the 9 m wire was just above the outdoor drop pad. The drop test time was 2:14 pm on 10/20/2021. This orientation caused the bottom corner of the package to impact the drop pad first. The impact completely deformed the bottom corner at the  $0^\circ$  line (Figure 4-10). See Section 4.4 for damage measurement data. An error occurred during the 30-foot HAC drop that resulted in the loss of accelerometer data. See Appendix E for additional photographs.



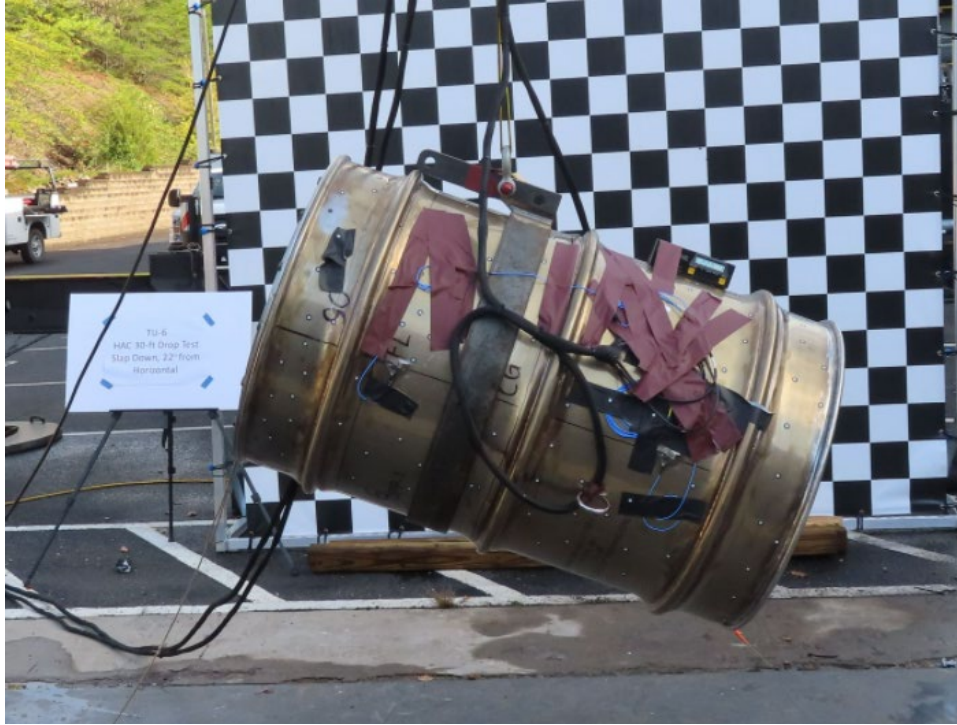
**Figure 4-9. TU-5 HAC free drop test orientation.**



**Figure 4-10. TU-5 HAC free drop test damage.**

#### **4.1.6 TU-6**

TU-6 was dropped with the axis of the package at an angle of  $22.0^\circ$  from horizontal, impacting on the  $0^\circ$  line at the bottom corner (Figure 4-11). The 9 m wire was attached to the lowest point on the package. When the TU was rigged within angle tolerances, the TU was raised until the plumb bob on the 9 m wire was just above the outdoor drop pad. The drop time was 9:55 am on 10/22/2021. This orientation caused the bottom corner of the package to impact the drop pad first. The impact deformed the drum bottom edge at the  $0^\circ$  line (Figure 4-12). See Section 4.4 for damage measurement data. An error occurred during the 30-foot HAC drop that resulted in the loss of accelerometer data. See Appendix F for additional photographs.



**Figure 4-11. TU-6 HAC free drop test orientation.**



**Figure 4-12. TU-6 HAC free drop test damage.**

## 4.2 HAC DYNAMIC CRUSH TEST

When a fissile material Type B package weights less than 500 kg and has an overall density less than 1,000 kg/m<sup>3</sup> (62.4 lb/ft<sup>3</sup>), 10 CFR 71.73 specifies that the dynamic crush test must follow the 9 m free drop test. Therefore, TUs -1 through -6 were subjected to the dynamic crush test in accordance with 10 CFR 71.73(c)(2) after being subjected to the 9 m free drop test. Table 4-2 shows the intended orientation of the TUs, as well as the actual orientation achieved during testing.

**Table 4-2. HAC Dynamic Crush test desired package orientation vs. measured orientation.**

TU	Desired orientation	Measured orientation
TU-1	Axis of package horizontal; 0° marking facing the drop pad. Crush plate CG over TU FL	0°–180° of crush plate 0.1° from horizontal 90°–270° of crush plate 0.6° from horizontal
TU-2	Axis of package horizontal; 0° marking facing the drop pad. Crush plate CG over TU CG.	0°–180° of crush plate 0.4° from horizontal 90°–270° of crush plate 0.3° from horizontal
TU-3	Axis of package vertical, lid surface facing the drop pad. Crush plate CG over TU CG	0°–180° of crush plate 0.9° from horizontal 90°–270° of crush plate 0.1° from horizontal
TU-4	CG over top corner (56.4°), 0° toward drop pad, lid corner facing the drop pad. Crush plate CG over TU CG	0°–180° of crush plate 0.3° from horizontal 90°–270° of crush plate 0.2° from horizontal TU-4 at 56.5° from horizontal
TU-5	Axis of package horizontal, 0° marking facing the drop pad. Crush plate CG over TU FL	0°–180° of crush plate 0.7° from horizontal 90°–270° of crush plate 0.4° from horizontal
TU-6	Axis of package horizontal, 0° marking facing the drop pad. Crush plate CG over TU FL	0°–180° of crush plate 0.5° from horizontal 90°–270° of crush plate 0.3° from horizontal

The crush test consisted of placing the TUs on the unyielding impact surface (i.e., drop pad) and dropping a 1 m × 1 m square 500 kg (1,100 lb) steel plate onto the package from a height of 9 m (30 ft). The 9 m height was measured by attaching a plumb bob to the bottom surface of the crush plate and lifting the crush plate until the plumb bob was directly over the package. The 9 m wire and plumb bob length were verified with 40 ft tape measure (ORNL ID A006327, calibration due 3/20/23) prior to use. Length was measured to be 360 in. The crush plate can be seen below in Figure 4-13. The HAC crush test was performed on the outdoor drop pad at the NTRC using PTP HAC crush test operating procedure PTP-PEF-11, Rev. 6.





**Figure 4-13. Crush plate used for HAC dynamic crush testing.**

#### **4.2.1 TU-1**

TU-1 was chilled and set horizontally on the drop test pad with the previously damaged 0° side down, and the crush plate was placed such that its CG was over the FL (8.75 in. from the top of drum), as shown in Figure 4-14. Once positioned, the crush plate was hoisted 9 m (30 ft), as shown below in Figure 4-15. The previous 30 ft slap-down drop test caused the package to be positioned 3° from the intended 180° line. The drop time was at 10:53 am on 10/20/2021. The same process was repeated for the crush test of all the units, TUs -1 through -6. The max g load was -1,197 g from Point 1 in the y direction on the 90° line. The package had been chilled to -45°F prior to testing. To test the package while it was as cool as possible, the NCT drop, HAC drop, HAC crush, and HAC puncture tests were conducted promptly one after the other to complete all drop testing within the 3-hour window. Physical measurements of the intermediate damage were not performed. Only cumulative damage at the end of the tests was recorded. See the datasheet in Appendix H for more details, and see Appendix A for additional photographs. After the crush test, flats were created on the top surface, the top rolling hoop, and the middle rolling hoop as seen below in Figure 4-16. The flats were recorded on Test Form 7 and can be seen in Table 4-10.



**Figure 4-14. Crush plate CG placed over the FL line of TU-1.**



**Figure 4-15. Typical crush plate 9 m (30 ft) hoisting.**





**Figure 4-16. Post-crush damage to TU-1.**

#### **4.2.2 TU-2**

TU-2 was set horizontally on the drop test pad, with the previously damaged 0° side down, and the crush plate was placed such that its CG was over the drum CG, as shown in Figure 4-17. The drop time was 1:25 pm on 10/22/2021. TU-2 experienced damage to the top surface, the top rolling hoop, the center rolling hoop, the lower rolling hoop, and the bottom surface. The crush damage resulted in flats on all the listed areas which can be seen below in Figure 4-18. The measurements of the flats were recorded on Test Form 7 and can be seen in Table 4-11. The max g load was 1,572 g from Point 1 in the y direction on the 90° line. See the datasheet in Appendix I for more details, and see Appendix B for additional photographs.



**Figure 4-17. Crush plate CG aligned of TU-2 CG.**



**Figure 4-18. Crush plate CG aligned with TU-2 CG.**

#### **4.2.3 TU-3**

TU-3 was placed on the drop pad in a vertical position with the lid facing down, as shown in Figure 4-19. The crush plate was oriented such that its CG was over the CG of the TU. Then the angle of the crush plate was measured to be  $0.1^\circ$  from horizontal and was then hoisted to 9 m (30 ft) above the TU. The drop time was at 10:14 am on 10/21/2021. The crush test for TU-3 caused the TU to experience buckling and compression of the outer drum in the region between the lower rolling hoop and the lower surface, which can be seen below in Figure 4-20. The measurements were recorded on Test Form 7 and can be seen in Table 4-12. See the datasheet in Appendix J for more details, and see Appendix C for additional photographs.



**Figure 4-19. Crush plate CG aligned with CG of TU-3.**



**Figure 4-20. Post crush test results for TU-3.**

#### **4.2.4 TU-4**

TU-4 was positioned on the drop test pad with the lid down and the package  $56.5^\circ$  from horizontal, as shown below in Figure 4-21. The angle was achieved using ratcheting straps that were anchored to the drop test pad. In Figure 4-21, it is possible to see that leather lab coats were placed on the ratchet straps to prevent the straps from recoiling upon impact from the crush plate. This positioned the CG of TU-4 over the top corner. The crush plate was then positioned such that its CG would be directly over the CG of TU-4. The drop test time was at 11:26 am on 10/21/2021. Upon completion of the TU-4 crush test, the deformation measurements were recorded on Test Form 7 and can be seen in Table 4-13. The damage created a buckled-in section at the base of the drum body near the  $180^\circ$  region. The damage can be seen



below in Figure 4-22. See the datasheet in Appendix K for more details, and see Appendix D for additional photographs.



**Figure 4-21. TU-4 positioned CG over top corner.**



**Figure 4-22. TU-4 post crush test impact damage.**

#### 4.2.5 TU-5

TU-5 was a chilled unit and set horizontally on the drop test pad with the previously damaged 0° side down, and the crush plate CG was placed over the TU FL (8.75 in. from the top of the drum) as shown in Figure 4-23. Prior damage from the previous 30 ft slap-down drop test caused the package to be positioned 7.6° from the intended 180° line. Drop time was at 2:40 pm on 10/20/2021. The package had been chilled to -45°F prior to testing. To test the package while it was as cool as possible, the NCT drop, HAC drop, HAC crush, and HAC puncture tests were conducted promptly one after the other to complete all drop testing within the 3-hour window. Upon release, the crush plate struck the 180° line area of TU-5 which caused immediate deformation of the drum, creating flats in the top surface, top rolling hoop, and center rolling hoop, as seen in Figure 4-24. The impact also caused the weld around the top plate on the drum lid to fail. This failure allowed the drum lid top plate to open and remain open, which allowed for 0.775 lb of Packcrete to spill out of the drum lid onto the drop pad. This unexpected event caused a test plan change request (TPCR-007) to be initiated as an URGENT intent change. The testing oversight team halted work to discuss the path forward. Because this was a chilled unit, the testing oversight team agreed to complete the last test (puncture) before the 3-hour time limit expired, with the planned puncture location at the drum seam weld and FL. Additional detail of the damage can be seen in Figure 4-25, Figure 4-26, and Figure 4-27. The remainder of the testing was completed, and the post-drop damages were recorded on Test Form 7. The information can be reviewed in Table 4-14. The max g load was 1,605 g from Point 2 in the z direction on the 90° line. See the datasheet in Appendix L for more details and see Appendix E for additional photographs.



Figure 4-23. Crush plate CG placed over the CG line of TU-5.



**Figure 4-24. Post crush damage to TU-5.**





Figure 4-25. Post crush damage to TU-5.



Figure 4-26. Post crush damage to TU-5.



Figure 4-27. Post crush damage to TU-5.

#### 4.2.6 TU-6

TU-6 was positioned horizontally on the drop test pad, as close as possible for the 0° line to face the drop test pad. Because of prior damage, the package was rotated such that the intended impact was off (~10°) from the 180° line, as shown in Figure 4-28. The CG of the crush plate was positioned over the FL of TU-6, as seen in Figure 4-29. The drop test time was 2:51 pm on 10/22/2021.

Upon release, the crush test plate struck TU-6, as expected. This caused damage to the upper surface, the upper rolling hoop, and the center rolling hoop (Figure 4-30). This caused flats to form in each of the areas. These results were recorded on Test Form 7 and can be seen in Table 4-15. The max g load was 2,121 g from Point 2 in the y direction on the 90° line. See the datasheet in Appendix M for more details, and see Appendix F for additional photographs.

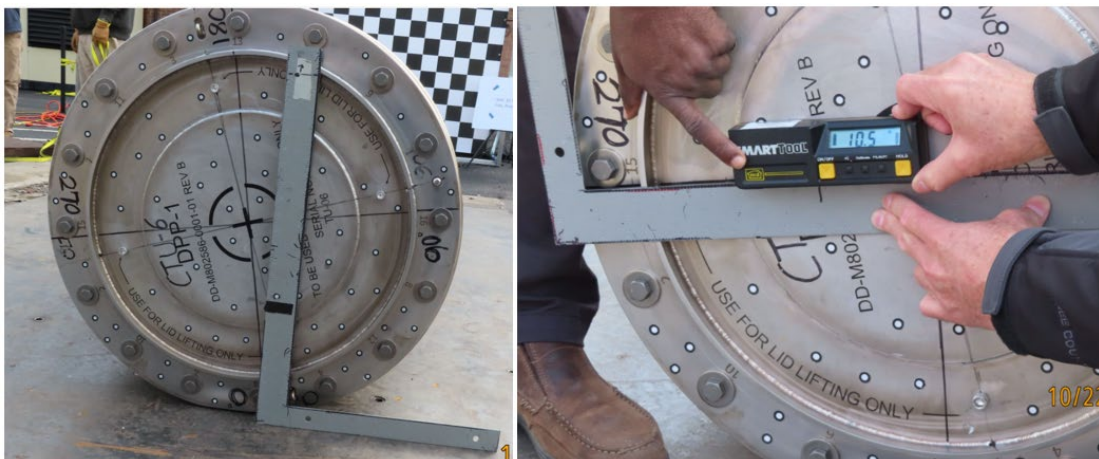


Figure 4-28. Orientation of TU-6.





**Figure 4-29. Crush test plate CG positioned over TU-6 FL.**



**Figure 4-30. Damage to TU-6 post crush test.**

### **4.3 HAC PUNCTURE TEST**

Following the HAC crush tests, the TUs were subjected to the HAC puncture test in accordance with 10 CFR 71.73(c)(3). HAC puncture testing was performed at the PEF indoor drop pad using procedure PTP-

PEF-12, Rev. 5. For each test, the package was raised to a height of 1 m (40 in.) above a 15 cm (6 in.) diameter steel puncture bar that was bolted to the steel-impacting surface of the drop pad. When all the TUs were rigged within angle tolerance, the package was lifted until the calibrated 1 m rod (ORNL ID A001146, calibration due 2/24/2026) fit in between the top of the puncture bar and the lowest point on the package. The packages were dropped in the orientations described in Table 4-3.

**Table 4-3. HAC 1 m puncture test desired package orientation vs. measured orientation.**

<b>TU</b>	<b>Desired orientation</b>	<b>Measured orientation</b>
TU-1	Axis of package horizontal; 0° marking should contact puncture bar first at the FL	Axis of package 0.8° from horizontal
TU-2	Axis of package horizontal; 0° marking should contact puncture bar first at the drum CG	Axis of package 1.3° from horizontal
TU-3	Axis of package vertical, lid surface should contact puncture bar first at drum lid CG	Axis of package 0.2° from vertical
TU-4	Axis of package CG over top corner (56.4°), 0° toward drop pad, lid corner should contact puncture bar first	Axis of package 52.3° from vertical
TU-5	Axis of package horizontal, flange line over bar, 0° line should contact puncture bar first	Axis of package .2° from horizontal
TU-6	Axis of package horizontal, 0° line should contact puncture bar first at CG point (22.4" from the drum bottom)	Axis of package 0.3° from horizontal

#### **4.3.1 TU-1**

TU-1 was puncture tested in the horizontal orientation with the 0° line facing the puncture bar. The TU was rigged and lifted such that the impact point of the package was above the center of the puncture bar. Per the test plan and the SOW, the impact point for TU-1 was located at the CV FL, 8¾ in. from the top surface of the package along the 0° line. The puncture test impact target was identified with a 3 in. target symbol (Figure 4-31). The puncture test resulted in a 6 in. diameter dent on the drum shell. No other failure or gross deformation was observed (Figure 4-32). See Section 4.4 for damage measurement data. The puncture test was completed at 11:25 am on 10/20/2021. The total time elapsed from when TU-1 was removed from the environmental chamber to when the HAC tests were completed was 2 hr, 53 min. The max g load was -87 g from Point 1 in the y direction on the 270° line. See the datasheet in Appendix H for more details, and see Appendix A for additional photographs.



**Figure 4-31. Setup for the puncture test of TU-1.**



**Figure 4-32. Puncture test damage for TU-1.**



### 4.3.2 TU-2

TU-2 was puncture tested in the horizontal orientation, with the 0° line facing the puncture bar. The TU was rigged and lifted such that the impact point, the CG of the package, was above the center of the puncture bar. The impact point for TU was located at 23.2 in. from the bottom surface of the package along the 0° line. The puncture test impact target was identified with a 3 in. target symbol (Figure 4-33). The puncture test resulted in a 6 in. diameter dent on the drum shell; no other failure or gross deformation was observed (Figure 4-34). See Section 4.4 for damage measurement data. The puncture test was completed at 3:25 pm on 10/22/2021. The max g load was -63 g from Point 1 in the x direction on the 90° line. See the datasheet in Appendix I for more details, and see Appendix B for additional photographs.

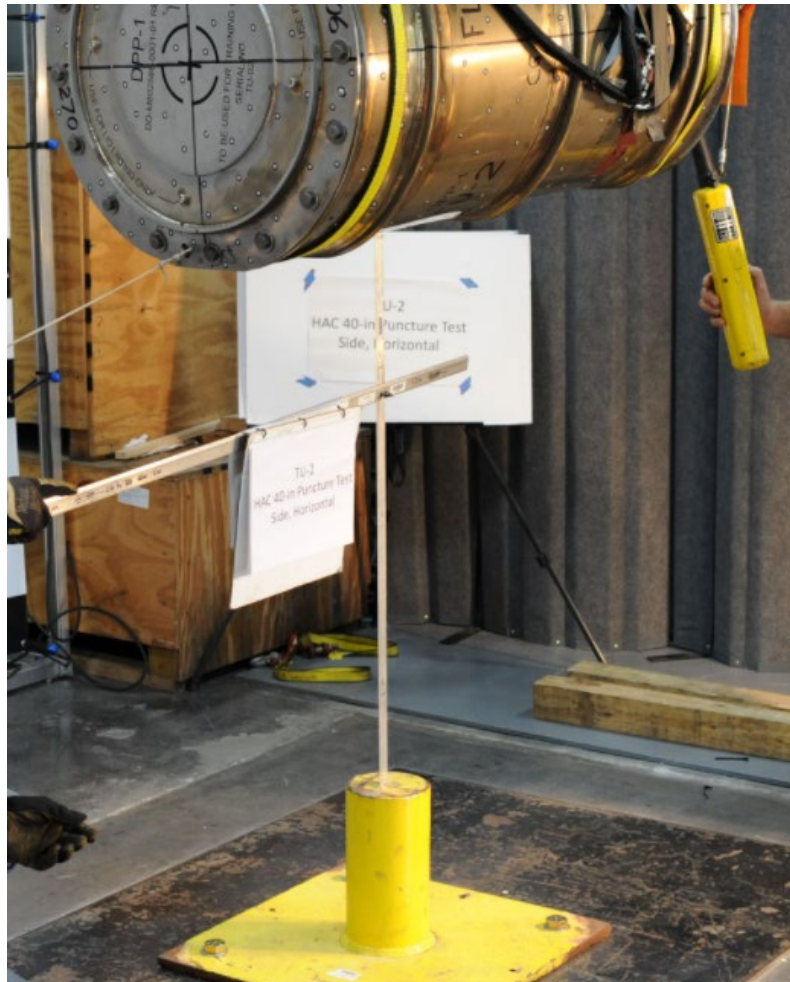
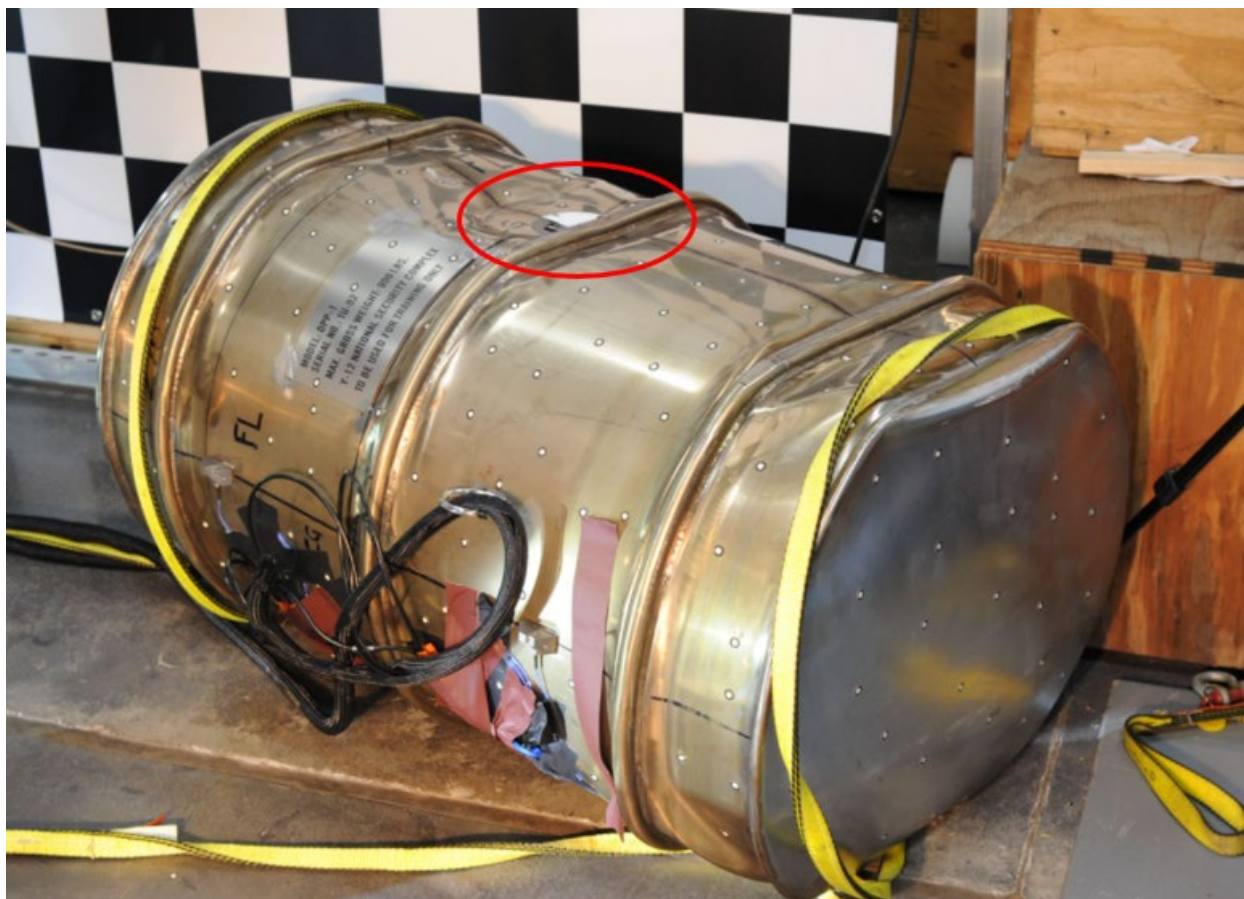


Figure 4-33. Setup for the puncture test of TU-2.





**Figure 4-34. Puncture test damage for TU-2.**

### **4.3.3 TU-3**

TU-3 was puncture tested in the vertical orientation, with the top surface of the package facing the puncture bar. The TU was rigged and lifted such that the impact point of the package was above the center of the puncture bar. The impact point for TU was located at the center of the top surface of the package (Figure 4-35). The puncture test impact target was identified with a 3 in. target symbol. The puncture test was completed at 1:45 pm on 10/21/2021. The puncture test resulted in a 6 in. diameter dent on the drum base; no other failure or gross deformation was observed (Figure 4-36). See Section 4.4 for damage measurement data. See the datasheet in Appendix J for more details, and see Appendix C for additional photographs.



**Figure 4-35. Setup for the puncture test of TU-3.**



**Figure 4-36. Puncture test damage for TU-3.**

#### 4.3.4 TU-4

TU-4 was puncture tested in the vertical orientation, with the top surface of the package facing the puncture bar. The TU was planned to be rigged and lifted such that the impact point of the package was the CG over the top corner directly above the puncture bar. For this, the angle of the package was required to be  $56.4^\circ$  from horizontal. However, because of the preexisting damage to the package, the lifting fixture could only achieve an angle of  $52.3^\circ$ , which was outside the  $\pm 2^\circ$  allowable tolerance by  $2.1^\circ$ . Test plan change request (TPCR-008) was initiated as an URGENT intent change because the damage occurred during drop testing. The testing oversight team agreed to accept this angle and continue with the testing. The TU impact point was located as close to the required location as possible (Figure 4-37). The drop test time was 2:53 pm on 10/21/2021. The puncture test resulted in a 6 in. diameter dent on the drum lid, as well as a crack in the bolt guard weld that measured 3.704 in.; no other failure or gross deformation was observed (Figure 4-38). The bolt guard is an external weld, and the incident did not lead to any loss of internal Packcrete from within the drum lid. See Section 4.4 for damage measurement data. See the datasheet in Appendix K for more details, and see Appendix D for additional photographs.



**Figure 4-37. Setup for the puncture test of TU-4.**



**Figure 4-38. Puncture test damage for TU-4.**



#### 4.3.5 TU-5

TU-5 was puncture tested with the axis of the package at an angle of  $0.2^\circ$  from horizontal, with the  $0^\circ$  line facing the puncture bar. The TU was rigged and lifted such that the impact point of the package, the CV, was above the center of the puncture bar (Figure 4-39). The puncture test impact target was identified with a 3 in. target symbol 8.75 in. from the top of the TU. The puncture test resulted in a primary impact, causing a 6 in. dent in the CV FL (Figure 4-40). See Section 4.4 for damage measurement data. The max g load was -117 g from Point 2 in the z direction on the  $90^\circ$  line. See the datasheet in Appendix L for more details, and see Appendix E for additional photographs. TU-5 was removed from the chilled environmental chamber at 12:55 pm on 10/20/2021. The puncture test was completed at 3:23 pm on 10/20/2021, within the 3-hour requirement.

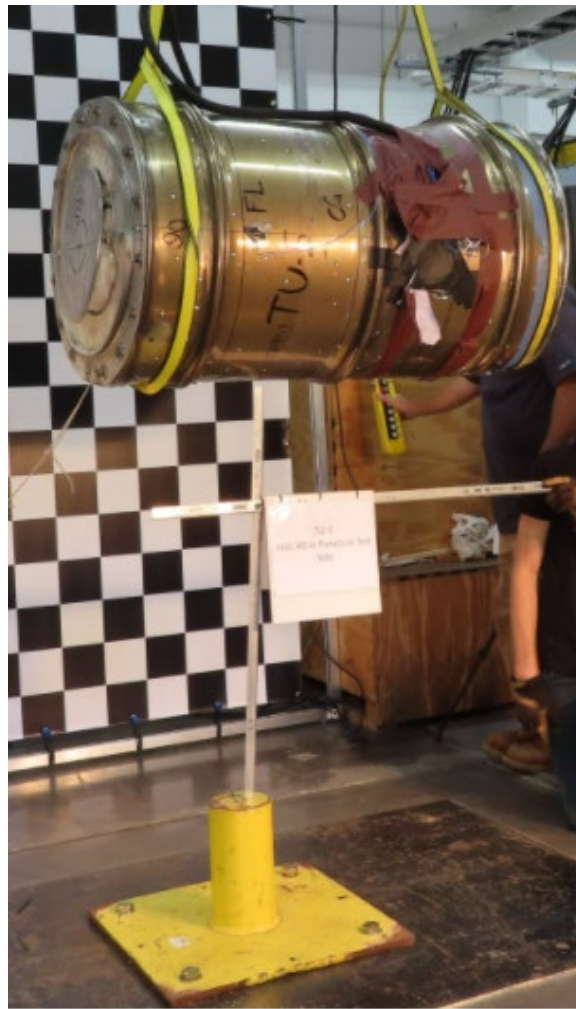
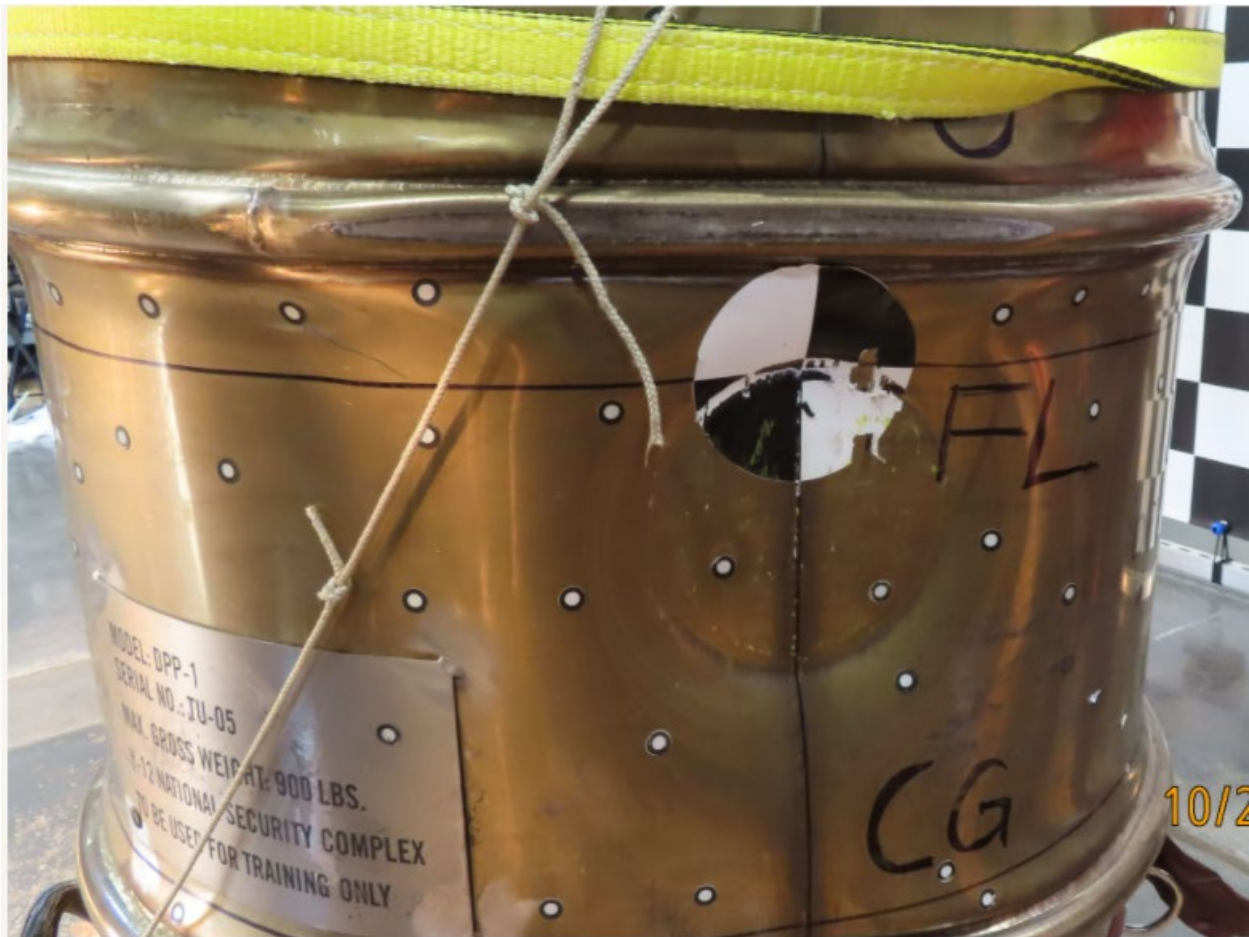


Figure 4-39. Setup for the puncture test of TU-5.



**Figure 4-40. Puncture test damage for TU-5.**

#### **4.3.6 TU-6**

TU-6 was puncture tested with the axis of the package at an angle of  $0.3^\circ$  from horizontal, such that the center of the puncture target symbol, located at the CG, would impact the puncture bar (Figure 4-41). The TU was rigged and lifted such that the calibrated 1 m aluminum rod (ORNL ID A001146, calibration due 2/24/2026) was below the lowest point on the package. The puncture test impact target was identified with a 3 in. target symbol. The drop test time was 2:51 pm on 10/22/2022. The puncture test resulted in a primary impact, causing a 6 in. diameter dent; no other failure or gross deformation was observed (Figure 4-42). See Section 4.4 for damage measurement data. The max g load was 157 g from Point 2 in the y direction on the  $90^\circ$  line. See the datasheet in Appendix M for more details and see Appendix F for additional photographs.



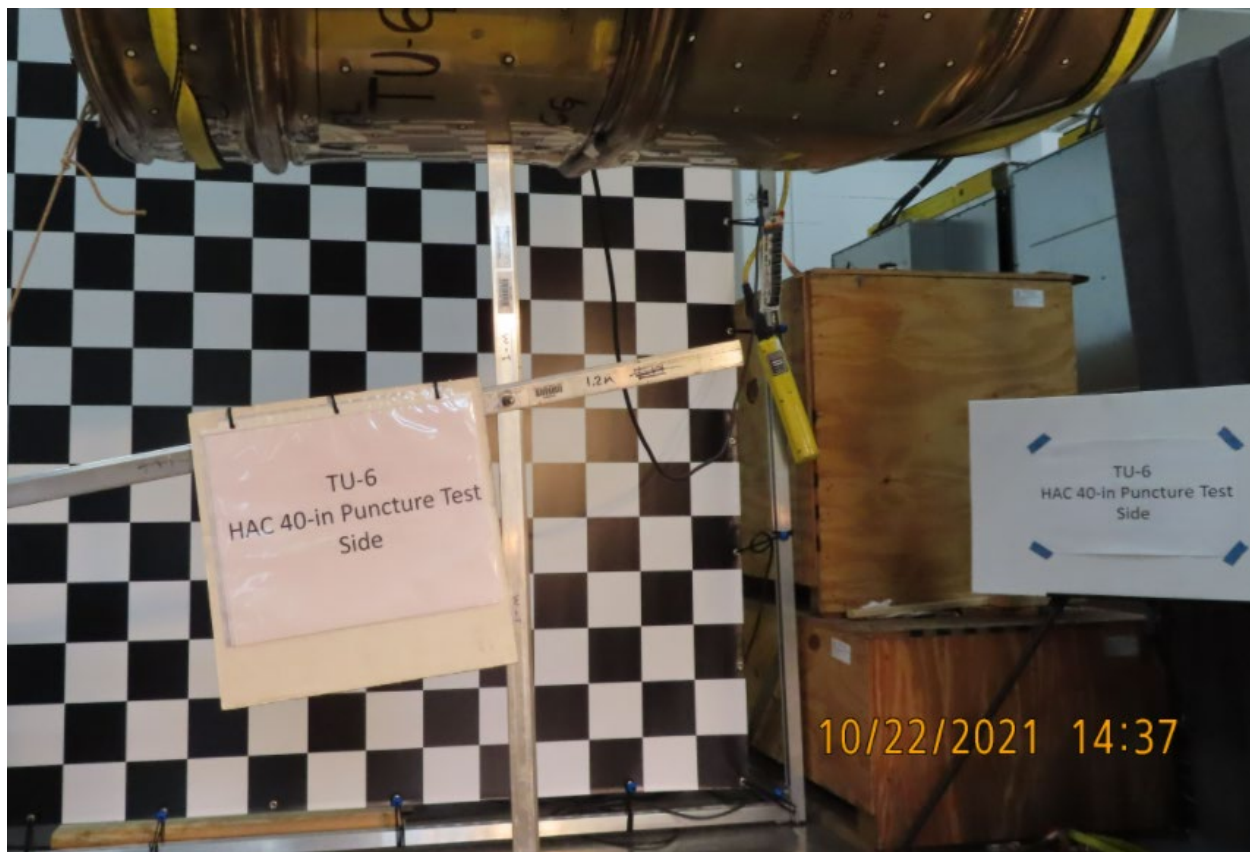


Figure 4-41. Setup for the puncture test of TU-6.



Figure 4-42. Setup for the puncture test of TU-6.

#### 4.4 SUMMARY OF DAMAGE FROM IMPACT TESTS

To quantify the damage from the impact testing, the diameters of the TU drums were measured across the 0–180° and 90–270° planes on each TU subjected to HAC testing (TUs -1 through -6). Figure 4-43 shows the five locations along the side of each TU where their diameters were measured, as well as the width of flattening measurement. The height of each TU was measured from the bottom of the 0, 90, 180, and 270° locations to the top. The width of flattening from impact testing was measured at five locations along the package on the impacted sides. The measurement data were recorded on Test Form 7 and are summarized in Table 4-4 through Table 4-15. The total change is the difference of the last measurement to the initial measurement.

Some measurements were not taken on TUs that did not incur damage because of the various orientations during testing. For instance, side flattening at the 180° line did not occur for all TUs for the free drop because the TU was subjected to impact along the 0° line. Additionally, for TUs -1 and -5, which were cooled prior to testing, measurements were not taken between the NCT and HAC free drop tests; nor were they taken between the HAC free drop, crush tests, and puncture tests. This ensured that tests were performed as quickly as possible after removal from the environmental chamber unit.

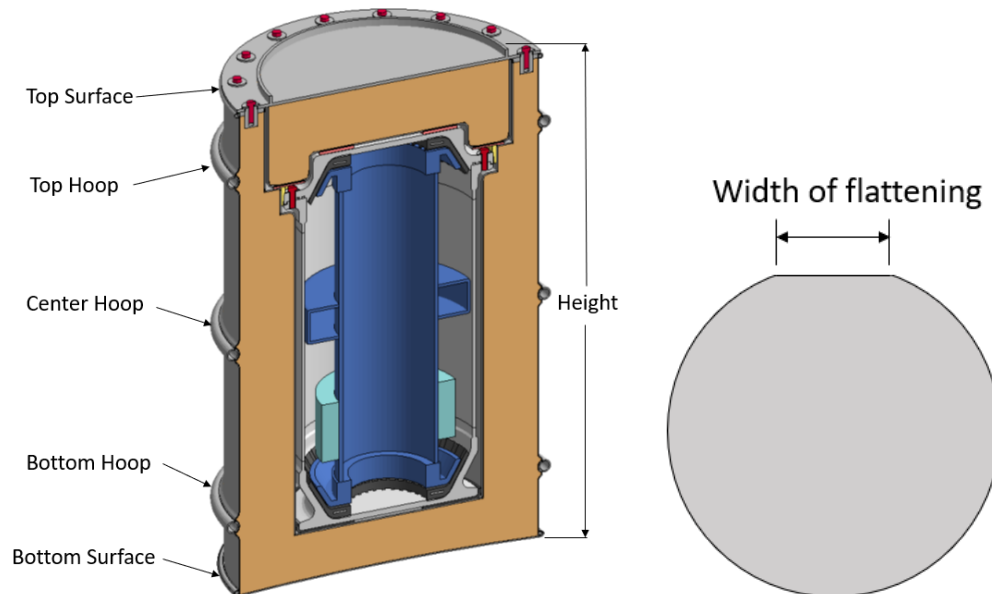


Figure 4-43. Measurement locations on TU exteriors.

Table 4-4. Summary of TU-1 measurement changes (units = in.)

TU-1	Height				Diameter 0° to 180°					Diameter 90° to 270°				
	0°	90°	180°	270°	Top surface	Top hoop	Center hoop	Bottom hoop	Bottom surface	Top surface	Top hoop	Center hoop	Bottom hoop	Bottom surface
Pretest	43 1/4	43 3/16	43 1/8	43 1/8	26 7/8	28 1/16	28 3/16	28 3/16	27 1/16	26 13/16	28	28 1/4	28 1/4	27 1/8
Posttest	44 1/8	43 7/16	42 13/16	43 5/8	25 1/16	25 1/8	24 1/4	25 5/16	25 1/2	27	28 1/8	29 1/4	28 5/8	27 1/8
Change	7/8	1/4	-5/16	1/2	-1 13/16	-2 15/16	-3 15/16	-2 7/8	-1 9/16	3/16	5/8	1	3/8	0

Table 4-5. Summary of measurement changes of TU-2 (units = in.)

TU-2	Height				Diameter 0° to 180°					Diameter 90° to 270°				
	0°	90°	180°	270°	Top surface	Top hoop	Center hoop	Bottom hoop	Bottom surface	Top surface	Top hoop	Center hoop	Bottom hoop	Bottom surface
Initial assembly	43 1/8	43 1/8	43 3/16	43 3/16	26 13/16	27 15/16	28	27 15/16	27	26 3/4	28 1/8	28 1/8	28 1/16	27 1/16
Post 1.2 m drop	43 1/4	43 1/8	43 1/4	43 3/16	26 9/16	27 1/2	27 3/8	27 3/8	26 15/16	26 3/4	28	28 1/16	27 15/16	27
Change	1/8	0	1/16	0	- 1/4	-7/16	-3/8	-5/16	-1/16	0	-1/8	-1/16	-1/8	-1/16
Post 9 m drop	44 9/16	43 13/16	42 15/16	43 3/4	26 1/4	27	28 11/16	26 3/8	25 5/8	26 7/8	28 1/4	28 3/8	28 3/16	27 1/8
Change	1 5/16	1 1/16	-5/16	9/16	-5/16	-1/2	1 1/16	-1 1/4	-1 5/16	1/8	1/4	5/16	1/4	1/8
Post crush test	44 3/4	43 9/16	42 3/8	43 3/8	25 3/4	25 3/4	24 1/4	22	24 9/16	26 13/16	28 1/2	29 5/16	29 5/16	27 1/8
Change	3/16	-1/4	-9/16	-3/8	-1 1/4	-1 1/4	-4 7/16	-4 3/8	-1 1/16	-1/16	1/4	1 5/16	1 1/8	0
Post puncture test	44 3/4	43 9/16	42 5/16	43 5/8	25 13/16	25 3/4	23 13/16	22	24 1/2	26 15/16	28 1/2	29 1/4	23/8	27 1/16
Change	3/16	-1/4	-5/8	-1/8	-7/16	-1 1/4	-4 7/8	-4 3/8	-1 1/8	1/16	1/4	7/8	1 3/16	-1/16
<b>Total change</b>	1 5/8	7/16	-7/8	7/16	-1	-2 3/16	-4 3/16	-5 15/16	-2 1/2	3/16	3/8	1 1/8	1 5/16	0

Table 4-6. Summary of measurement changes of TU-3 (units = in.)

TU-3	Height				Diameter 0° to 180°					Diameter 90° to 270°				
	0°	90°	180°	270°	Top surface	Top hoop	Center hoop	Bottom hoop	Bottom surface	Top surface	Top hoop	Center hoop	Bottom hoop	Bottom surface
Initial assembly	43 <sup>3</sup> / <sub>16</sub>	43 <sup>1</sup> / <sub>4</sub>	43 <sup>1</sup> / <sub>8</sub>	43 <sup>3</sup> / <sub>8</sub>	26 <sup>3</sup> / <sub>4</sub>	28 <sup>1</sup> / <sub>16</sub>	28	28	27	26 <sup>3</sup> / <sub>4</sub>	28 <sup>1</sup> / <sub>16</sub>	27 <sup>15</sup> / <sub>16</sub>	28 <sup>1</sup> / <sub>16</sub>	27 <sup>1</sup> / <sub>8</sub>
Post 1.2 m Drop	43 <sup>1</sup> / <sub>16</sub>	43 <sup>3</sup> / <sub>16</sub>	43 <sup>1</sup> / <sub>16</sub>	43 <sup>3</sup> / <sub>16</sub>	26 <sup>3</sup> / <sub>4</sub>	28 <sup>1</sup> / <sub>16</sub>	27 <sup>7</sup> / <sub>8</sub>	27 <sup>7</sup> / <sub>8</sub>	26 <sup>15</sup> / <sub>16</sub>	26 <sup>13</sup> / <sub>16</sub>	28 <sup>1</sup> / <sub>16</sub>	28	28 <sup>1</sup> / <sub>16</sub>	27 <sup>1</sup> / <sub>16</sub>
Change	- <sup>1</sup> / <sub>8</sub>	- <sup>1</sup> / <sub>16</sub>	- <sup>1</sup> / <sub>16</sub>	<sup>1</sup> / <sub>16</sub>	0	0	- <sup>1</sup> / <sub>8</sub>	- <sup>1</sup> / <sub>8</sub>	- <sup>1</sup> / <sub>16</sub>	<sup>1</sup> / <sub>16</sub>	0	<sup>1</sup> / <sub>16</sub>	0	- <sup>1</sup> / <sub>16</sub>
Post 9 m drop	42 <sup>9</sup> / <sub>16</sub>	42 <sup>9</sup> / <sub>16</sub>	42 <sup>1</sup> / <sub>2</sub>	42 <sup>11</sup> / <sub>16</sub>	26 <sup>7</sup> / <sub>8</sub>	28 <sup>1</sup> / <sub>16</sub>	28	27 <sup>15</sup> / <sub>16</sub>	27	26 <sup>3</sup> / <sub>4</sub>	28 <sup>1</sup> / <sub>8</sub>	28 <sup>1</sup> / <sub>16</sub>	28 <sup>3</sup> / <sub>16</sub>	27 <sup>1</sup> / <sub>16</sub>
Change	- <sup>1</sup> / <sub>2</sub>	- <sup>5</sup> / <sub>8</sub>	- <sup>9</sup> / <sub>16</sub>	- <sup>1</sup> / <sub>2</sub>	<sup>1</sup> / <sub>8</sub>	0	<sup>1</sup> / <sub>8</sub>	<sup>1</sup> / <sub>16</sub>	<sup>1</sup> / <sub>16</sub>	- <sup>1</sup> / <sub>16</sub>	<sup>1</sup> / <sub>16</sub>	<sup>1</sup> / <sub>16</sub>	<sup>1</sup> / <sub>8</sub>	0
Post crush test	40 <sup>13</sup> / <sub>16</sub>	40 <sup>9</sup> / <sub>16</sub>	39 <sup>7</sup> / <sub>8</sub>	40 <sup>1</sup> / <sub>8</sub>	26 <sup>13</sup> / <sub>16</sub>	28	27 <sup>7</sup> / <sub>8</sub>	27 <sup>7</sup> / <sub>8</sub>	26 <sup>7</sup> / <sub>8</sub>	26 <sup>13</sup> / <sub>16</sub>	28 <sup>1</sup> / <sub>16</sub>	28	28 <sup>3</sup> / <sub>16</sub>	28 <sup>1</sup> / <sub>8</sub>
Change	-1 <sup>3</sup> / <sub>4</sub>	-2	-2 <sup>5</sup> / <sub>8</sub>	-2 <sup>9</sup> / <sub>16</sub>	- <sup>1</sup> / <sub>16</sub>	- <sup>1</sup> / <sub>16</sub>	- <sup>1</sup> / <sub>8</sub>	- <sup>1</sup> / <sub>16</sub>	- <sup>1</sup> / <sub>8</sub>	<sup>1</sup> / <sub>16</sub>	- <sup>1</sup> / <sub>16</sub>	- <sup>1</sup> / <sub>16</sub>	0	1 <sup>1</sup> / <sub>16</sub>
Post puncture test	41	40 <sup>1</sup> / <sub>16</sub>	39 <sup>13</sup> / <sub>16</sub>	40 <sup>1</sup> / <sub>16</sub>	26 <sup>13</sup> / <sub>16</sub>	28	27 <sup>7</sup> / <sub>8</sub>	27 <sup>3</sup> / <sub>4</sub>	26 <sup>7</sup> / <sub>8</sub>	26 <sup>3</sup> / <sub>4</sub>	28	28	28 <sup>1</sup> / <sub>8</sub>	27 <sup>1</sup> / <sub>8</sub>
Change	- <sup>3</sup> / <sub>16</sub>	<sup>1</sup> / <sub>2</sub>	<sup>1</sup> / <sub>16</sub>	<sup>1</sup> / <sub>16</sub>	0	0	0	<sup>1</sup> / <sub>8</sub>	0	<sup>1</sup> / <sub>16</sub>	<sup>1</sup> / <sub>16</sub>	0	<sup>1</sup> / <sub>16</sub>	1
<b>Total change</b>	-2 <sup>3</sup> / <sub>16</sub>	-3 <sup>3</sup> / <sub>16</sub>	-3 <sup>5</sup> / <sub>16</sub>	-3 <sup>1</sup> / <sub>16</sub>	<sup>1</sup> / <sub>16</sub>	- <sup>1</sup> / <sub>16</sub>	- <sup>1</sup> / <sub>8</sub>	- <sup>1</sup> / <sub>4</sub>	- <sup>1</sup> / <sub>8</sub>	0	- <sup>1</sup> / <sub>16</sub>	<sup>1</sup> / <sub>16</sub>	<sup>1</sup> / <sub>16</sub>	0

Table 4-7. Summary of measurement changes of TU-4 (units = in.)

TU-4	Height				Diameter 0° to 180°					Diameter 90° to 270°				
	0°	90°	180°	270°	Top surface	Top hoop	Center hoop	Bottom hoop	Bottom surface	Top surface	Top hoop	Center hoop	Bottom hoop	Bottom surface
Initial assembly	43 <sup>3</sup> / <sub>16</sub>	43 <sup>3</sup> / <sub>16</sub>	43 <sup>5</sup> / <sub>16</sub>	43 <sup>3</sup> / <sub>16</sub>	26 <sup>3</sup> / <sub>4</sub>	27 <sup>1</sup> / <sub>16</sub>	28 <sup>1</sup> / <sub>16</sub>	28 <sup>1</sup> / <sub>16</sub>	25 <sup>15</sup> / <sub>16</sub>	26 <sup>3</sup> / <sub>4</sub>	28 <sup>1</sup> / <sub>8</sub>	28 <sup>3</sup> / <sub>16</sub>	28 <sup>3</sup> / <sub>16</sub>	27
Post 1.2 m drop	43 <sup>5</sup> / <sub>16</sub>	43 <sup>1</sup> / <sub>16</sub>	43 <sup>1</sup> / <sub>4</sub>	43 <sup>1</sup> / <sub>4</sub>	26 <sup>1</sup> / <sub>2</sub>	28	28	27 <sup>13</sup> / <sub>16</sub>	26 <sup>7</sup> / <sub>8</sub>	26 <sup>5</sup> / <sub>8</sub>	27 <sup>13</sup> / <sub>16</sub>	28 <sup>1</sup> / <sub>16</sub>	28 <sup>1</sup> / <sub>4</sub>	27 <sup>3</sup> / <sub>16</sub>
Change	<sup>1</sup> / <sub>8</sub>	- <sup>1</sup> / <sub>8</sub>	- <sup>1</sup> / <sub>16</sub>	<sup>1</sup> / <sub>16</sub>	- <sup>1</sup> / <sub>4</sub>	<sup>15</sup> / <sub>16</sub>	- <sup>1</sup> / <sub>16</sub>	- <sup>1</sup> / <sub>4</sub>	<sup>15</sup> / <sub>16</sub>	- <sup>1</sup> / <sub>8</sub>	- <sup>5</sup> / <sub>16</sub>	- <sup>1</sup> / <sub>8</sub>	<sup>1</sup> / <sub>16</sub>	<sup>3</sup> / <sub>16</sub>
Post 9 m drop	42	43	43 <sup>3</sup> / <sub>8</sub>	43 <sup>3</sup> / <sub>16</sub>	28 <sup>1</sup> / <sub>4</sub>	28	27 <sup>15</sup> / <sub>16</sub>	27 <sup>7</sup> / <sub>8</sub>	26 <sup>3</sup> / <sub>4</sub>	26 <sup>3</sup> / <sub>4</sub>	28 <sup>1</sup> / <sub>8</sub>	28 <sup>3</sup> / <sub>16</sub>	28 <sup>1</sup> / <sub>4</sub>	27 <sup>1</sup> / <sub>4</sub>
Change	-1 <sup>5</sup> / <sub>16</sub>	- <sup>1</sup> / <sub>16</sub>	<sup>1</sup> / <sub>8</sub>	- <sup>1</sup> / <sub>16</sub>	1 <sup>3</sup> / <sub>4</sub>	0	- <sup>1</sup> / <sub>16</sub>	<sup>1</sup> / <sub>16</sub>	- <sup>1</sup> / <sub>8</sub>	<sup>1</sup> / <sub>8</sub>	<sup>5</sup> / <sub>16</sub>	<sup>1</sup> / <sub>8</sub>	0	<sup>1</sup> / <sub>16</sub>
Post crush Test	42	42 <sup>11</sup> / <sub>16</sub>	42 <sup>13</sup> / <sub>16</sub>	42 <sup>15</sup> / <sub>16</sub>	26 <sup>1</sup> / <sub>4</sub>	27 <sup>5</sup> / <sub>8</sub>	27 <sup>3</sup> / <sub>4</sub>	26 <sup>15</sup> / <sub>16</sub>	-	26 <sup>5</sup> / <sub>8</sub>	28 <sup>3</sup> / <sub>16</sub>	28 <sup>1</sup> / <sub>4</sub>	28 <sup>5</sup> / <sub>8</sub>	27 <sup>1</sup> / <sub>4</sub>
Change	0	<sup>5</sup> / <sub>16</sub>	<sup>9</sup> / <sub>16</sub>	<sup>1</sup> / <sub>4</sub>	2	<sup>3</sup> / <sub>8</sub>	<sup>3</sup> / <sub>16</sub>	<sup>15</sup> / <sub>16</sub>	-	<sup>1</sup> / <sub>8</sub>	- <sup>1</sup> / <sub>16</sub>	- <sup>1</sup> / <sub>16</sub>	- <sup>3</sup> / <sub>8</sub>	0
Post puncture test	41 <sup>15</sup> / <sub>16</sub>	42 <sup>13</sup> / <sub>16</sub>	42 <sup>11</sup> / <sub>16</sub>	42 <sup>15</sup> / <sub>16</sub>	25 <sup>7</sup> / <sub>8</sub>	27 <sup>11</sup> / <sub>16</sub>	27 <sup>13</sup> / <sub>16</sub>	27 <sup>1</sup> / <sub>8</sub>	-	26 <sup>3</sup> / <sub>4</sub>	26 <sup>3</sup> / <sub>4</sub>	28 <sup>1</sup> / <sub>8</sub>	28 <sup>5</sup> / <sub>8</sub>	27 <sup>1</sup> / <sub>4</sub>
Change	- <sup>1</sup> / <sub>16</sub>	- <sup>3</sup> / <sub>16</sub>	- <sup>11</sup> / <sub>16</sub>	- <sup>1</sup> / <sub>4</sub>	-2 <sup>3</sup> / <sub>8</sub>	- <sup>5</sup> / <sub>16</sub>	- <sup>1</sup> / <sub>8</sub>	- <sup>3</sup> / <sub>4</sub>	-	0	-1 <sup>3</sup> / <sub>8</sub>	- <sup>1</sup> / <sub>16</sub>	<sup>3</sup> / <sub>8</sub>	0
<b>Total change</b>	-1 <sup>1</sup> / <sub>4</sub>	- <sup>3</sup> / <sub>8</sub>	- <sup>5</sup> / <sub>8</sub>	- <sup>1</sup> / <sub>4</sub>	- <sup>7</sup> / <sub>8</sub>	<sup>5</sup> / <sub>8</sub>	- <sup>1</sup> / <sub>4</sub>	- <sup>15</sup> / <sub>16</sub>	-	0	-1 <sup>3</sup> / <sub>8</sub>	- <sup>1</sup> / <sub>16</sub>	<sup>7</sup> / <sub>16</sub>	<sup>1</sup> / <sub>4</sub>

Table 4-8. Summary of measurement changes of TU-5 (units = in.)

TU-5	Height				Diameter 0° to 180°					Diameter 90° to 270°				
	0°	90°	180°	270°	Top surface	Top hoop	Center hoop	Bottom hoop	Bottom surface	Top surface	Top hoop	Center hoop	Bottom hoop	Bottom surface
Pretest	43 <sup>3</sup> / <sub>16</sub>	43 <sup>3</sup> / <sub>16</sub>	43 <sup>1</sup> / <sub>4</sub>	43 <sup>3</sup> / <sub>16</sub>	26 <sup>3</sup> / <sub>4</sub>	28	28	28	27 <sup>1</sup> / <sub>16</sub>	26 <sup>7</sup> / <sub>8</sub>	28 <sup>1</sup> / <sub>8</sub>	28 <sup>1</sup> / <sub>8</sub>	28 <sup>1</sup> / <sub>8</sub>	27 <sup>1</sup> / <sub>8</sub>
Posttest	43 <sup>15</sup> / <sub>16</sub>	43 <sup>3</sup> / <sub>16</sub>	43 <sup>1</sup> / <sub>8</sub>	43 <sup>1</sup> / <sub>8</sub>	25 <sup>1</sup> / <sub>4</sub>	25 <sup>1</sup> / <sub>4</sub>	24 <sup>5</sup> / <sub>8</sub>	25 <sup>11</sup> / <sub>16</sub>	N/A	27 <sup>7</sup> / <sub>16</sub>	28 <sup>3</sup> / <sub>4</sub>	28 <sup>15</sup> / <sub>16</sub>	28 <sup>5</sup> / <sub>8</sub>	27 <sup>1</sup> / <sub>8</sub>
Change	<sup>3</sup> / <sub>4</sub>	0	- <sup>1</sup> / <sub>8</sub>	- <sup>1</sup> / <sub>16</sub>	-1 <sup>1</sup> / <sub>2</sub>	-2 <sup>3</sup> / <sub>4</sub>	-3 <sup>3</sup> / <sub>8</sub>	-2 <sup>5</sup> / <sub>16</sub>	N/A	<sup>9</sup> / <sub>16</sub>	<sup>5</sup> / <sub>8</sub>	<sup>13</sup> / <sub>16</sub>	<sup>1</sup> / <sub>2</sub>	0

Table 4-9. Summary of measurement changes of TU-6 (units = in.)

TU-6	Height				Diameter 0° to 180°					Diameter° to 270°				
	0°	90°	180°	270°	Top surface	Top hoop	Center hoop	Bottom hoop	Bottom surface	Top surface	Top hoop	Center hoop	Bottom hoop	Bottom surface
Initial assembly	43 <sup>1</sup> / <sub>8</sub>	43 <sup>1</sup> / <sub>8</sub>	43 <sup>1</sup> / <sub>16</sub>	43 <sup>1</sup> / <sub>16</sub>	26 <sup>7</sup> / <sub>8</sub>	28 <sup>1</sup> / <sub>8</sub>	28 <sup>1</sup> / <sub>16</sub>	28 <sup>1</sup> / <sub>16</sub>	26 <sup>13</sup> / <sub>16</sub>	26 <sup>3</sup> / <sub>4</sub>	28 <sup>1</sup> / <sub>16</sub>	28 <sup>1</sup> / <sub>4</sub>	28 <sup>1</sup> / <sub>4</sub>	27 <sup>1</sup> / <sub>8</sub>
Post 1.2 m drop	43 <sup>1</sup> / <sub>4</sub>	43 <sup>3</sup> / <sub>16</sub>	43 <sup>1</sup> / <sub>16</sub>	43 <sup>1</sup> / <sub>8</sub>	26 <sup>9</sup> / <sub>16</sub>	27 <sup>5</sup> / <sub>8</sub>	27 <sup>15</sup> / <sub>16</sub>	27 <sup>7</sup> / <sub>8</sub>	25 <sup>13</sup> / <sub>16</sub>	26 <sup>3</sup> / <sub>4</sub>	28 <sup>1</sup> / <sub>16</sub>	28 <sup>3</sup> / <sub>16</sub>	28 <sup>5</sup> / <sub>16</sub>	27 <sup>1</sup> / <sub>16</sub>
Change	<sup>1</sup> / <sub>8</sub>	<sup>1</sup> / <sub>16</sub>	0	<sup>1</sup> / <sub>16</sub>	- <sup>5</sup> / <sub>16</sub>	- <sup>1</sup> / <sub>2</sub>	- <sup>1</sup> / <sub>8</sub>	- <sup>3</sup> / <sub>16</sub>	-1	0	0	- <sup>1</sup> / <sub>16</sub>	<sup>1</sup> / <sub>16</sub>	- <sup>1</sup> / <sub>16</sub>
Post 9 m drop	43 <sup>11</sup> / <sub>16</sub>	43 <sup>1</sup> / <sub>8</sub>	42 <sup>15</sup> / <sub>16</sub>	43 <sup>5</sup> / <sub>8</sub>	26 <sup>1</sup> / <sub>2</sub>	27 <sup>5</sup> / <sub>16</sub>	27 <sup>1</sup> / <sub>4</sub>	26 <sup>1</sup> / <sub>4</sub>	-	26 <sup>7</sup> / <sub>8</sub>	28 <sup>1</sup> / <sub>4</sub>	28 <sup>3</sup> / <sub>8</sub>	28 <sup>9</sup> / <sub>16</sub>	27 <sup>1</sup> / <sub>16</sub>
Change	<sup>7</sup> / <sub>16</sub>	- <sup>1</sup> / <sub>16</sub>	- <sup>1</sup> / <sub>8</sub>	<sup>1</sup> / <sub>2</sub>	- <sup>1</sup> / <sub>16</sub>	- <sup>5</sup> / <sub>16</sub>	- <sup>11</sup> / <sub>16</sub>	-1 <sup>5</sup> / <sub>8</sub>	-	<sup>1</sup> / <sub>8</sub>	<sup>3</sup> / <sub>16</sub>	<sup>3</sup> / <sub>16</sub>	<sup>1</sup> / <sub>4</sub>	0
Post crush test	43 <sup>13</sup> / <sub>16</sub>	43 <sup>1</sup> / <sub>8</sub>	42 <sup>7</sup> / <sub>8</sub>	43 <sup>3</sup> / <sub>8</sub>	25 <sup>5</sup> / <sub>8</sub>	25 <sup>11</sup> / <sub>16</sub>	24 <sup>7</sup> / <sub>8</sub>	26	-	27 <sup>1</sup> / <sub>16</sub>	28 <sup>5</sup> / <sub>8</sub>	29 <sup>1</sup> / <sub>16</sub>	28 <sup>13</sup> / <sub>16</sub>	27 <sup>1</sup> / <sub>8</sub>
Change	<sup>1</sup> / <sub>8</sub>	0	- <sup>1</sup> / <sub>16</sub>	- <sup>1</sup> / <sub>4</sub>	- <sup>7</sup> / <sub>8</sub>	-1 <sup>5</sup> / <sub>8</sub>	-2 <sup>3</sup> / <sub>8</sub>	- <sup>1</sup> / <sub>4</sub>	-	<sup>3</sup> / <sub>16</sub>	<sup>3</sup> / <sub>8</sub>	<sup>11</sup> / <sub>16</sub>	<sup>1</sup> / <sub>4</sub>	<sup>1</sup> / <sub>16</sub>
Post puncture test	43 <sup>13</sup> / <sub>16</sub>	43 <sup>3</sup> / <sub>16</sub>	42 <sup>15</sup> / <sub>16</sub>	43 <sup>1</sup> / <sub>4</sub>	25 <sup>5</sup> / <sub>8</sub>	25 <sup>9</sup> / <sub>16</sub>	24 <sup>7</sup> / <sub>16</sub>	25 <sup>7</sup> / <sub>8</sub>	-	27	28 <sup>9</sup> / <sub>16</sub>	29	28 <sup>3</sup> / <sub>4</sub>	26 <sup>15</sup> / <sub>16</sub>
Change	0	<sup>1</sup> / <sub>16</sub>	<sup>1</sup> / <sub>16</sub>	- <sup>1</sup> / <sub>8</sub>	0	- <sup>1</sup> / <sub>8</sub>	- <sup>7</sup> / <sub>16</sub>	- <sup>1</sup> / <sub>8</sub>	-	- <sup>1</sup> / <sub>16</sub>	- <sup>1</sup> / <sub>16</sub>	- <sup>1</sup> / <sub>16</sub>	- <sup>1</sup> / <sub>16</sub>	- <sup>3</sup> / <sub>16</sub>
<b>Total change</b>	<sup>11</sup> / <sub>16</sub>	<sup>1</sup> / <sub>16</sub>	- <sup>1</sup> / <sub>8</sub>	<sup>3</sup> / <sub>16</sub>	-1 <sup>1</sup> / <sub>4</sub>	-2 <sup>9</sup> / <sub>16</sub>	-3 <sup>5</sup> / <sub>8</sub>	-2 <sup>3</sup> / <sub>16</sub>	-1	<sup>1</sup> / <sub>4</sub>	<sup>1</sup> / <sub>2</sub>	<sup>3</sup> / <sub>4</sub>	<sup>1</sup> / <sub>2</sub>	- <sup>3</sup> / <sub>16</sub>



Table 4-10. Measurement of the width of flats for TU-1 (units = in.)

TU-1	Flats width at 0° line					Flats width at 180° line				
	Top surface	Top hoop	Center hoop	Bottom Hoop	Bottom surface	Top surface	Top hoop	Center hoop	Bottom hoop	Bottom surface
Post puncture test	6.303	12.148	11.668	14.071	12.727	5.458	10.324	13.976	-	-

Table 4-11. Measurement of the width of flats for TU-2 (units = in.)

TU-2	Flats width at 0° line					Flats width at 180° line				
	Top surface	Top hoop	Center hoop	Bottom hoop	Bottom surface	Top surface	Top hoop	Center hoop	Bottom hoop	Bottom surface
Post 1.2 m drop	2.706	6.693	5.008	5.010	3.349	0	0	0	0	0
Post 9 m drop	5.74	9.783	11.46	12.844	12.261	0	0	0	0	0
Change	3.034	3.09	6.452	7.834	8.912	0	0	0	0	0
Post crush test	0	0	0	0	0	5.685	8.784	13.539	19.875	0
Change						5.685	8.784	13.539	19.875	0
Post puncture test	0	0	0	0	0	0	0	0	0	0
Change	0	0	0	0	0	0	0	0	0	0
<b>Total change</b>	5.74	9.783	11.46	12.844	12.261	5.685	8.784	13.539	19.875	0

Table 4-12. Measurement of the width of flats for TU-3 (units = in.)

TU-3	Flats width at 0° line					Flats width at 180° line				
	Top surface	Top hoop	Center hoop	Bottom hoop	Bottom surface	Top surface	Top hoop	Center hoop	Bottom hoop	Bottom surface
Post 1.2 m drop	0	0	0	0	0	0	0	0	0	0
Post 9 m drop	0	0	0	0	0	0	0	0	0	0
Change	0	0	0	0	0	0	0	0	0	0
Post puncture test	0	0	0	1.451	0	0	0	0	0	0
Change	0	0	0	1.451	0	0	0	0	0	0
<b>Total change</b>	0	0	0	1.451	0	0	0	0	0	0

**Table 4-13. Measurement of the width of flats for TU-4 (units = in.)**

TU-4	Flats width at 0° line					Flats width at 180° line				
	Top surface	Top hoop	Center hoop	Bottom hoop	Bottom surface	Top surface	Top hoop	Center hoop	Bottom hoop	Bottom surface
Post 1.2 m drop	0	2.041	2.539	4.329	0	0	0	0	0	0
Post 9 m drop	0	2.088	2.575	4.341	7.304	2.625	4.435	0	0	0
Change	0	0.047	0.036	0.012	7.304	2.625	4.435	0	0	0
Post crush test	0	2.088	2.575	4.341	7.304	2.625	6.206	0	0	0
Change	0	0	0	0	0	0	1.771	0	0	0
Post puncture test	0	2.088	2.575	4.341	7.304	2.625	6.206	0	0	0
Change	0	0	0	0	0	0	1.771	0	0	0
<b>Total change</b>	0	2.088	2.575	4.341	7.304	2.625	6.206	0	0	0

**Table 4-14. Measurement of the width of flats for TU-5 (units = in.)**

TU-5	Flats width at 0° line					Flats width at 180° line				
	Top surface	Top hoop	Center hoop	Bottom hoop	Bottom surface	Top surface	Top hoop	Center hoop	Bottom hoop	Bottom surface
Post puncture test	6.843	11.504	12.229	15.014	17.415	6.256	11.302	13.897	-	-

**Table 4-15. Measurement of the width of flats for TU-6 (units = in.)**

TU-6	Flats width at 0° line					Flats width at 180° line				
	Top Surface	Top hoop	Center hoop	Bottom hoop	Bottom surface	Top surface	Top hoop	Center hoop	Bottom hoop	Bottom surface
Post 1.2 m drop	4.178	6.891	2.538	1.864	11.85	0	0	0	0	0
Post 9 m drop	7.439	10.383	8.542	14.812	17.704	0	0	0	0	0
Change	3.261	3.492	6.004	12.948	5.854	0	0	0	0	0
Post crush test	8.17	11.421	11.402	14.764	17.693	6.314	10.996	13.719	0	0
Change	4.909	7.929	2.86	-0.048	-0.011	6.314	10.996	0	0	0
Post puncture test	8.17	11.421	11.402	14.764	7.304	2.625	10.996	13.719	0	0
Change	0	1.038	2.86	-0.048	17.693	6.314	0	0	0	0
<b>Total change</b>	8.17	11.421	11.402	14.764	17.693	6.314	10.996	13.719	0	0

Table 4-16 summarizes the maximum g loading recorded from the triaxial accelerometers. Point 1 in the table refers to the topmost accelerometer (closest to the drum lid) and Point 2 is the bottommost accelerometer (closest to the bottom surface). The maximum g load for the entire testing campaign was from the TU-2 30 ft drop in the z direction.

**Table 4-16. Maximum acceleration for each TU**

TU #	NCT 4 ft drop		HAC 30 ft drop		HAC crush test		HAC 1 m puncture	
	max G	Location	max G	Location	max G	Location	max G	Location
TU-1	595	Point 2Y	-1294	Point 2x	-1197	Point 1y	-87	Point 1y
TU-2	-513	Point 2Z	2422	Point 2z	1572	Point 1y	-63	Point 1x
TU-5	-476	Point 2X	N/A	N/A	-1605	Point 2z	-117	Point 2z
TU-6	-491	Point 2X	N/A	N/A	2121	Point 2y	157	Point 2z

#### 4.5 HAC THERMAL TEST

The HAC thermal test requirements are given in 10 CFR 71.73(c)(4). For the DPP-1 TUs, a furnace located at the Southwest Research Institute (SwRI) in San Antonio, Texas, was used for the HAC thermal testing. The test method used was based on and closely followed ASTM E2230-13, *Standard Practice for Thermal Qualification of Type B Packages for Radioactive Material*.

#### 4.6 FURNACE DESCRIPTION

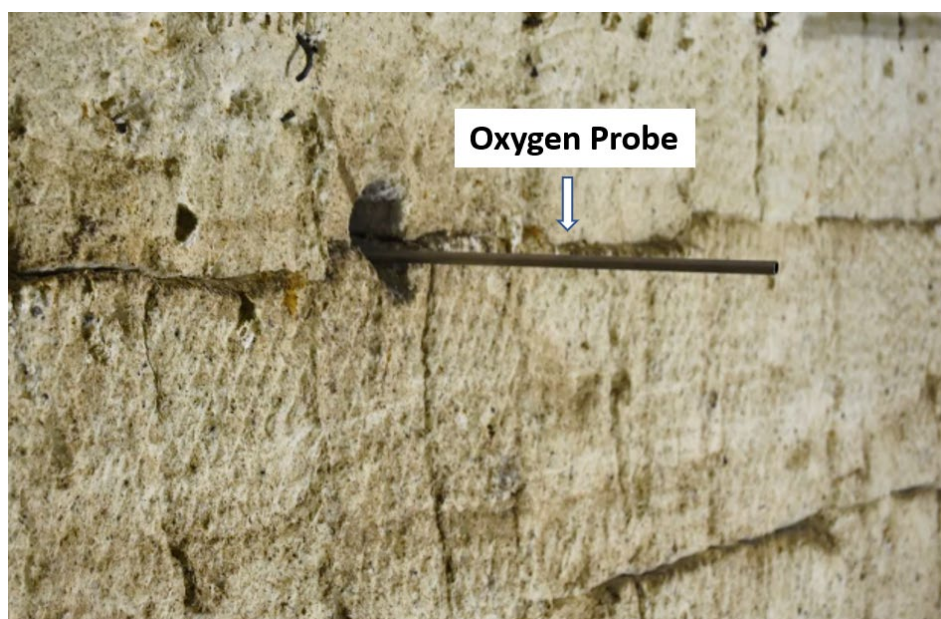
Thermal testing of the DPP-1 TUs was performed in the Large-Horizontal Furnace at SwRI in San Antonio, Texas. The furnace is in Building 159, SwRI's Fire Resistance Test Facility. The furnace is a natural gas-fueled furnace 16 × 12 × 8 ft work zone with a removable roof. The facility has a small access door on its front side (Figure 4-44). The estimated heating design load is 10 tons, with an operating temperature range of 1,400–2,100°F (790–1,149°C).

SwRI's Large-Horizontal Furnace is equipped with 14 pre-mixed air-natural gas burners located within the furnace walls. The burners are controlled by a variable-ratio gas/air regulator. Regulated natural gas enters the furnace at the nozzle of each burner, and a constant air supply is provided to the nozzle by a blower unit. The gaseous products of combustion exit the furnace through exhaust risers located along the furnace walls, which pull the exhaust through channels built underneath the furnace floor. Eighteen calibrated TCs were installed on the walls, floor, and ceiling of the furnace. The TCs were inserted through the walls and ceiling of the furnace, except for the TCs located on the floor and test stand. The furnace wall TC tips were located so that the bead of the TC is on the surface of the furnace wall. The TC tips were covered with a firestop putty, Pyro Putty.

To ensure that the furnace environment did not become oxygen-deprived during the thermal test, the oxygen concentration within the furnace was measured and recorded throughout the furnace exposure periods. A sampling probe was located nominally 2 ft from the right (north) furnace wall (Figure 4-45). The sampling probe was connected to a pump which drew the cooled gases through a Servomex paramagnetic oxygen analyzer. The analyzer was connected to SwRI's DAQ system and recorded through each furnace exposure test.



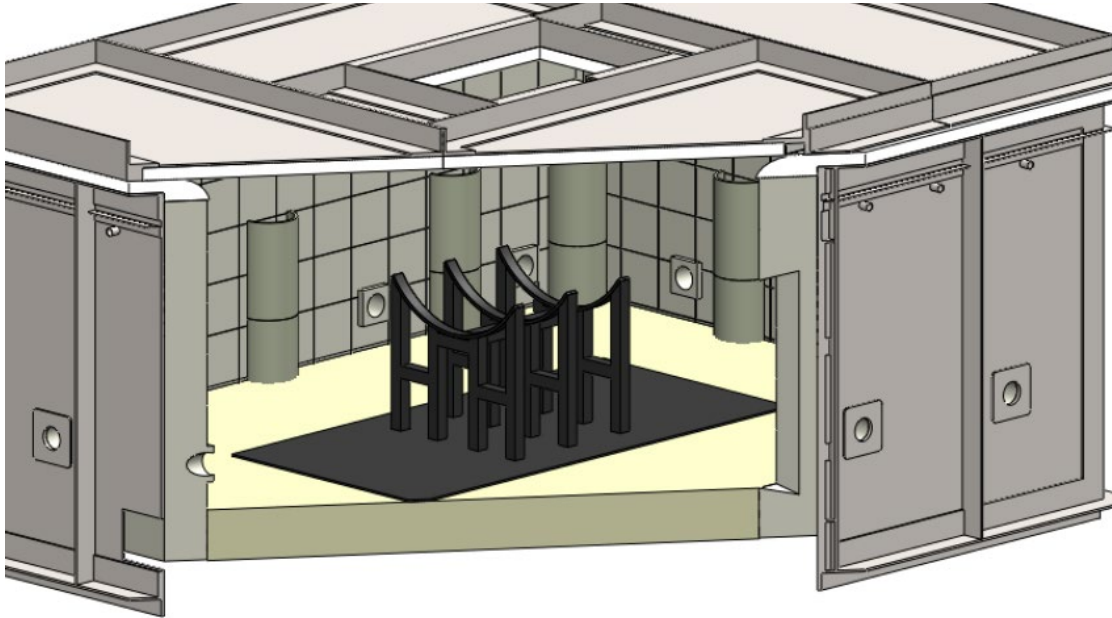
**Figure 4-44. SwRI Large Horizontal Furnace (lid removed).**



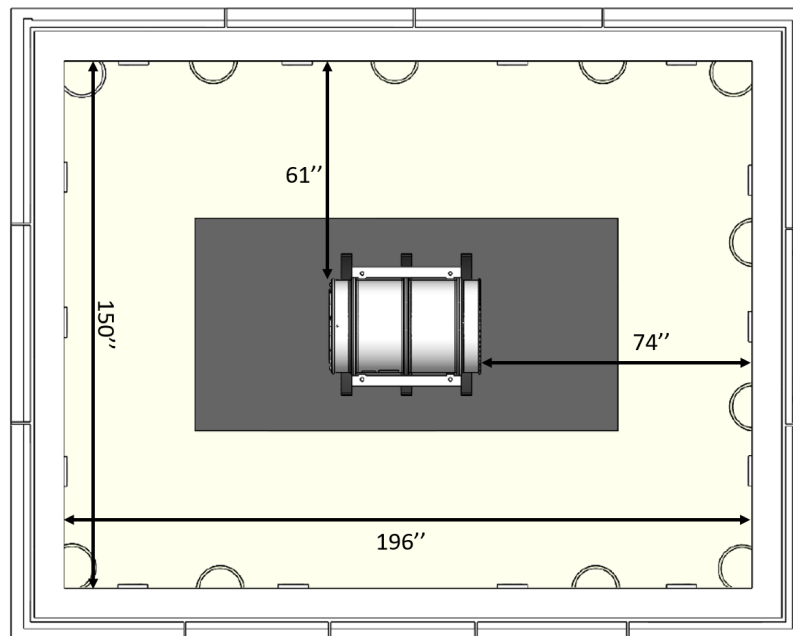
**Figure 4-45. Oxygen concentration sampling probe.**

Furnaces used for performing the HAC thermal testing are required to operate in very tight temperature ranges with relatively light loads. In addition, a thorough understanding of the thermal environment surrounding the TU is required. Considerable additional instrumentation must be installed for monitoring during testing. The large-horizontal furnace at SwRI was no exception, and to perform the DPP-1 testing, the furnace underwent several temporary additions and modifications. To implement the necessary physical modifications, a 5 ft × 10 ft × 0.5 in. thick steel plate was placed on the center of the furnace floor to provide a secure, flat surface. The test stand was welded onto the floor plate that is centered in the

furnace (Figure 4-46). The test stand was manufactured from 3 in.  $\times$  3 in.  $\times$   $\frac{1}{4}$  in. hollow structural steel (HSST). During testing, the TUs were centered on the test stand, and during thermal testing, the TUs were centered inside the furnace. The bottom surface of the TU was 74 in. from the right wall, and the drum outer shell was 61 in. from the back furnace wall (Figure 4-47).



**Figure 4-46. Test stand dimensions with TU.**



**Figure 4-47. TU placement in furnace.**

A computer-based thermal monitoring system developed and calibrated by ORNL was used to monitor the furnace environment and the TUs during these tests. This system provides 224 data channels that are continuously logged to a data file (Figure 4-48). Figure 4-49 illustrates the thermal test instrumentation



setup. The package and furnace TCs were bundled with a steel wire. The TC bundle length was then connected to a portable TC connector box, which was then connected to the DAQ unit. The DAQ unit transferred data to the laptop via an ethernet cable (Figure 4-49). During the test runs, the system was set to log data every 15 seconds from each data channel. The TCs used for DPP-1 thermal testing were calibrated before use and were 0.062 in. diameter Type K TCs that were 50 ft in length. These lightweight TCs provide a very rapid response to changes in temperature, which in turn provides a very accurate picture of the furnace and TU thermal behavior.

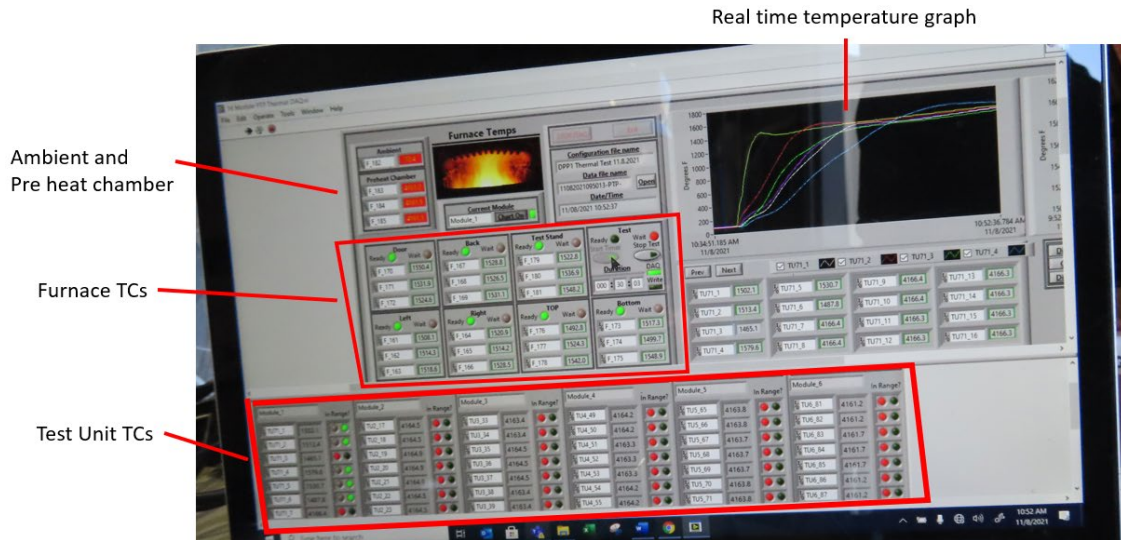


Figure 4-48. Package Testing Program thermal DAQ system.

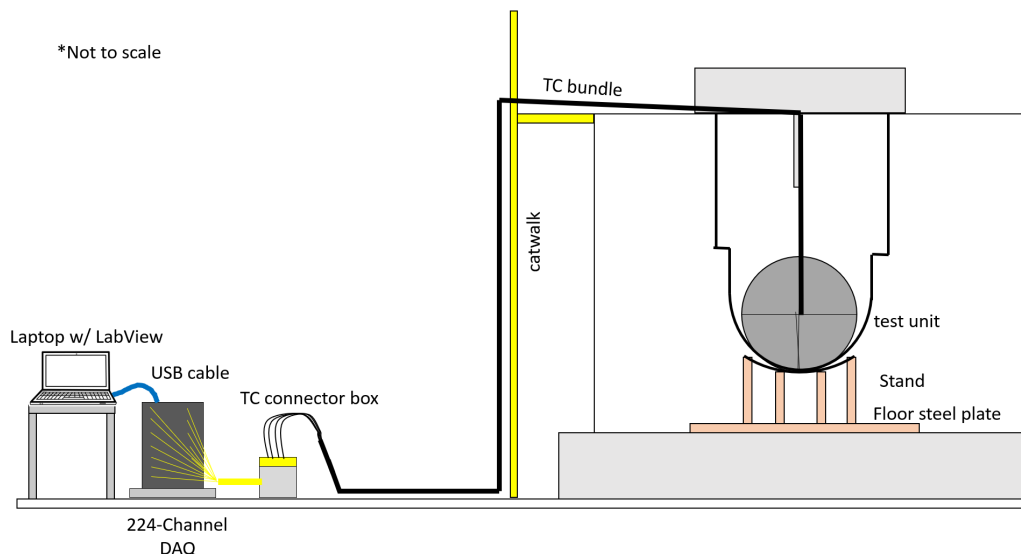
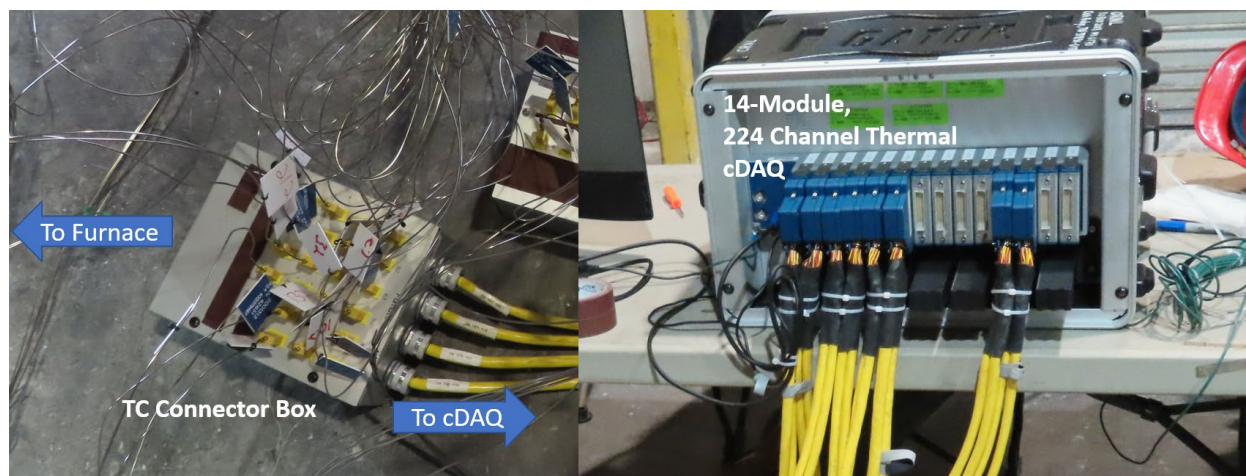


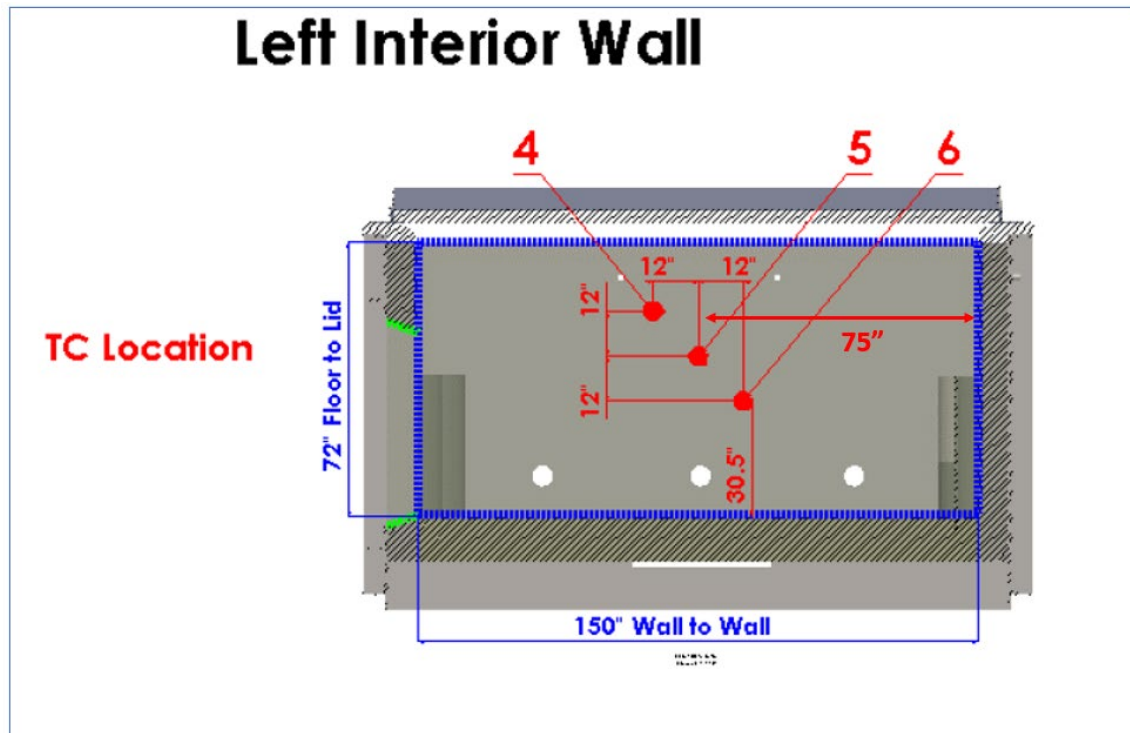
Figure 4-49. Thermal testing instrumentation setup.



**Figure 4-50. Thermocouple connector box.**

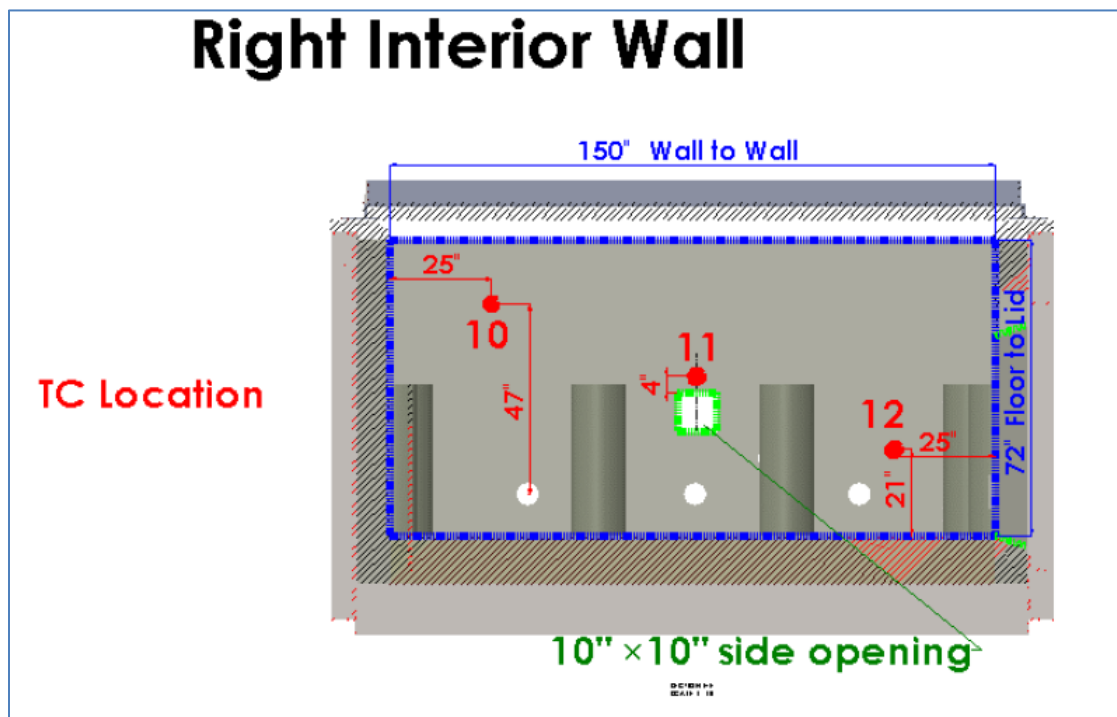
To monitor the furnace environment during testing, 18 TCs were installed on all furnace surfaces, and 3 TCs were installed on the test stand. Figure 4-51 shows the location of the TCs in the left wall, where TC #5 is centered on the wall. Figure 4-52 shows the location of TCs on the right wall, and Figure 4-53 and Figure 4-54 show the location of TCs on the back and front walls, respectively. Locations in the furnace are referenced from a position looking into the furnace from the front. Figure 4-55 illustrates the TC locations on the furnace floor and test stand. Figure 4-56 illustrates the approximate location of the TCs on the furnace ceiling. The TCs were inserted through the outside of the furnace wall, with the tip of the TC going through the wall thickness and resting near the surface of the inner furnace wall. Three TCs were installed on the steel floor plate. These TCs were aligned along the axis of the TU as it sat on the test stand (Figure 4-57). Finally, three TCs were attached to the test stand—one on each side of the test stand, and one in the middle (Figure 4-57). The floor plate and test stand TCs were attached with metal clips that were tack welded to the surface, and the TC tips were tucked under the metal clips and covered with pyro putty.

A set point temperature of 1,580°F (860°C) was used to consistently keep all furnace TCs above 1,475°F (802°C). Once furnace preparations were completed, several practice loadings were performed on the cold furnace to ensure that the TUs could be loaded onto the test stand and rapidly unloaded from the furnace to minimize the cooling that would occur while the roof was open. After the cold load/unload practice was completed, the furnace was ignited. Once ignited, the furnace was preheated for more than 12 hr before testing was initiated.



**Figure 4-51. Approximate location of three thermocouples in the left wall of the furnace.**

*\*Note: front of furnace is to the left in this diagram.*



**Figure 4-52. Approximate location of three thermocouples in the right wall of the furnace.**

*\*Note: front of furnace is to the right in this diagram.*

## Rear Interior Wall

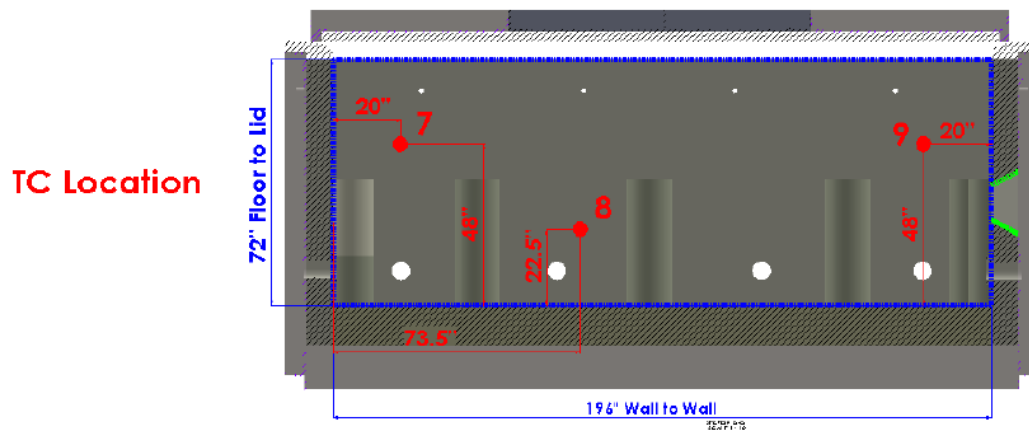


Figure 4-53. Approximate location of thermocouples on the back wall.

## Front Interior Wall

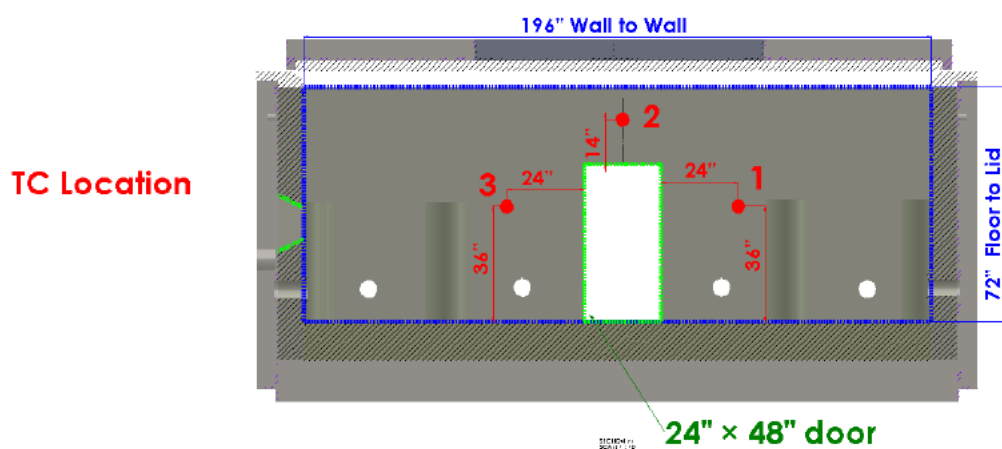
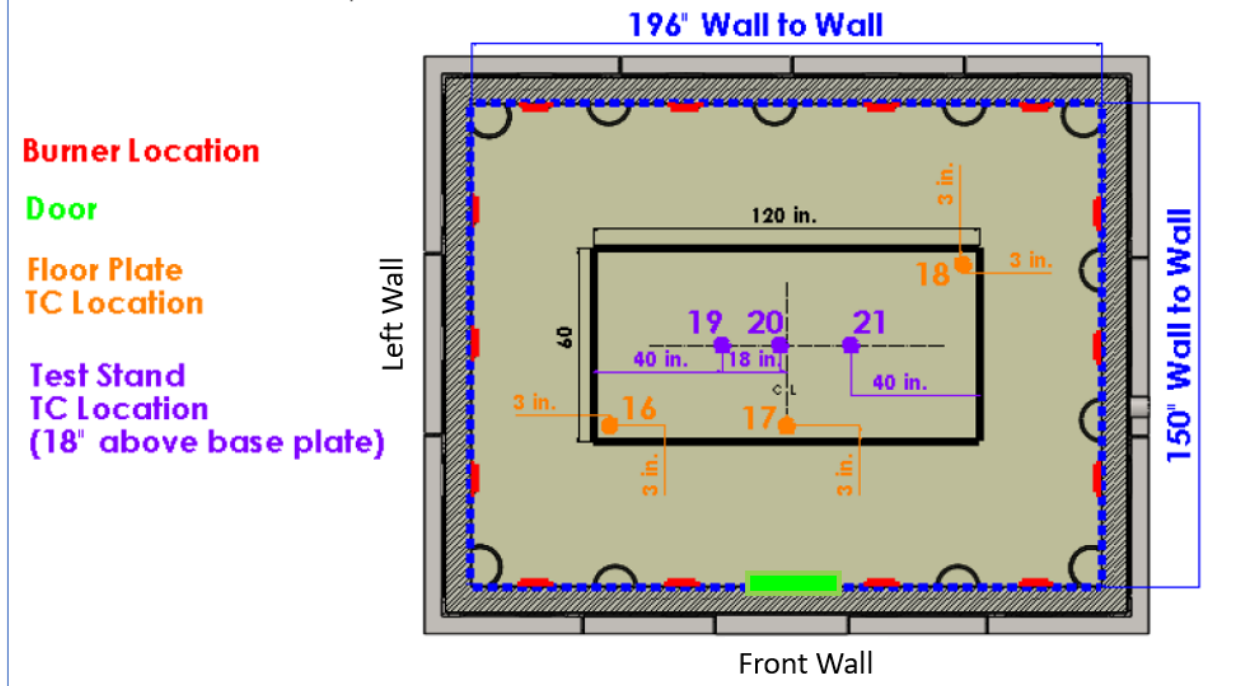
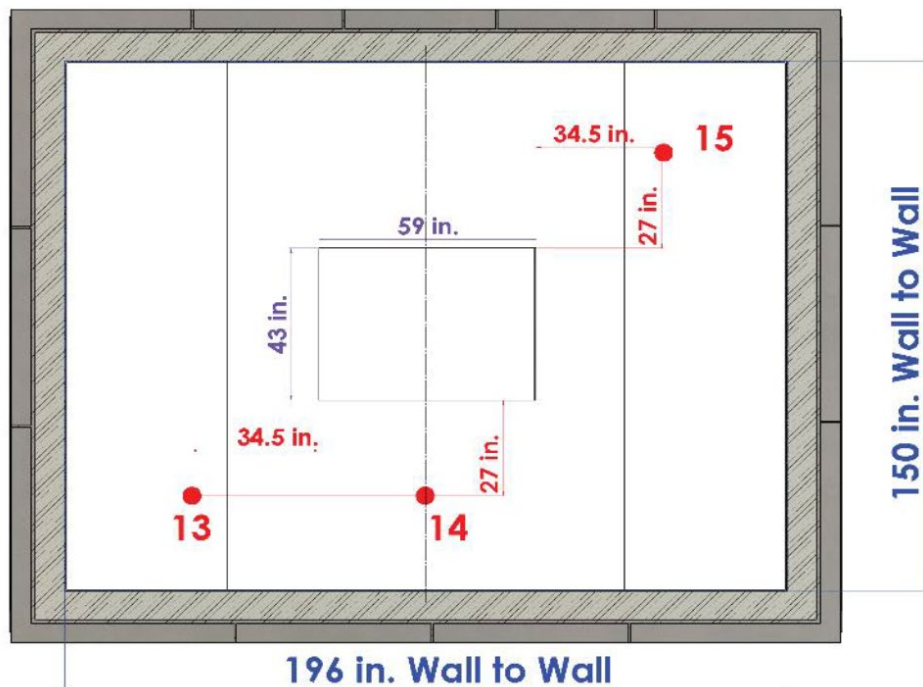


Figure 4-54. Approximate location of thermocouples on the front wall.

### Top-Down View



**Figure 4-55. Approximate location of thermocouples on the furnace floor.**



**Figure 4-56. Furnace interior ceiling thermocouple layout.**



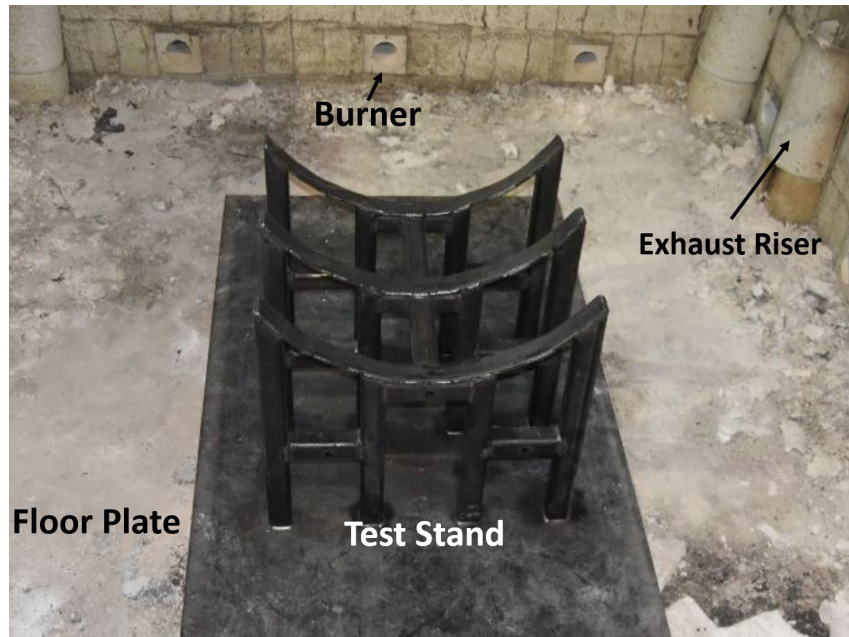


Figure 4-57. Furnace floor plate and test stand thermocouple layout.

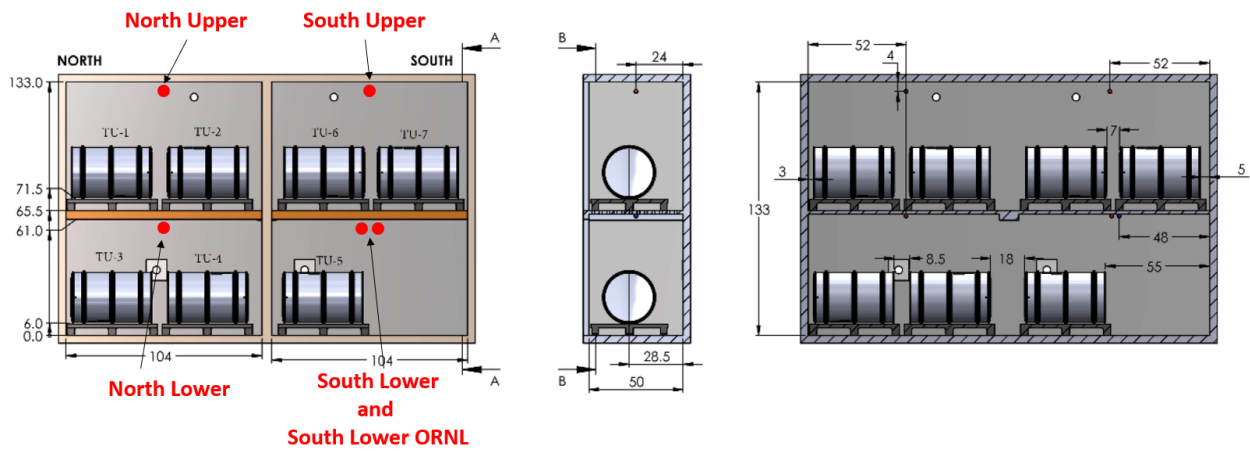
#### 4.7 TEST UNIT SETUP AND PREPARATION

All TUs were preheated to raise the internal temperature to above 38°C (100°F) by placing them in a 208 × 133 × 50 in. environmental chamber. Figure 4-58 shows the preheat chamber (PHC) with the TUs loaded. The PHC was heated with a Thermotron Model P-CH-810-LN2-204C heater provided by SwRI. The thermal DAQ System was set up and connected to the preheat chamber. Five TCs were installed inside the preheat chamber: north upper, north lower, south upper, south lower, and south lower ORNL (Figure 4-59). The south lower ORNL was provided by ORNL and was considered a redundant thermocouple. The heater maintained a constant output temperature to allow the packages within the chamber to remain above 150 and 100°F, as discussed below (Figure 4-60).

In accordance with the test plan for preheating, the temperature in the preheat chamber was to be maintained at a temperature above 66°C (150°F) for approximately 24 hr. The PHC was started at 12:12 pm on 11/5/2021. The set point was increased from 260 to 290°F to ensure that all TCs in the chamber were above 150°F. The 24 hr soak time at 150°F started at 3:45 pm on 11/5/2021 and ended at 3:45 pm on 11/6/2021. The preheat chamber temperature was lowered to maintain a temperature within the chamber at a minimum of 43°C (110°F) until all TUs were removed from the PHC (Figure 4-61).



Figure 4-58. TUs in preheat chamber.



South Lower and South Lower ORNL

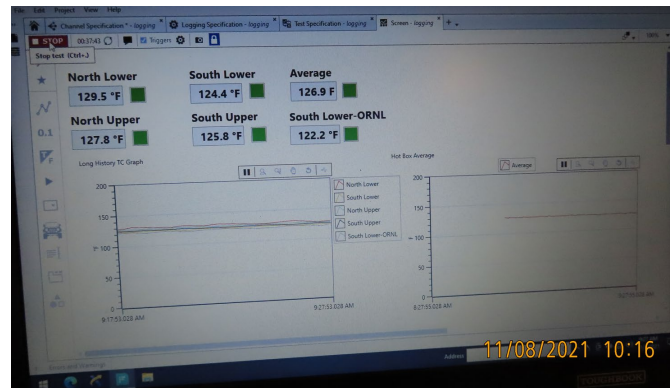
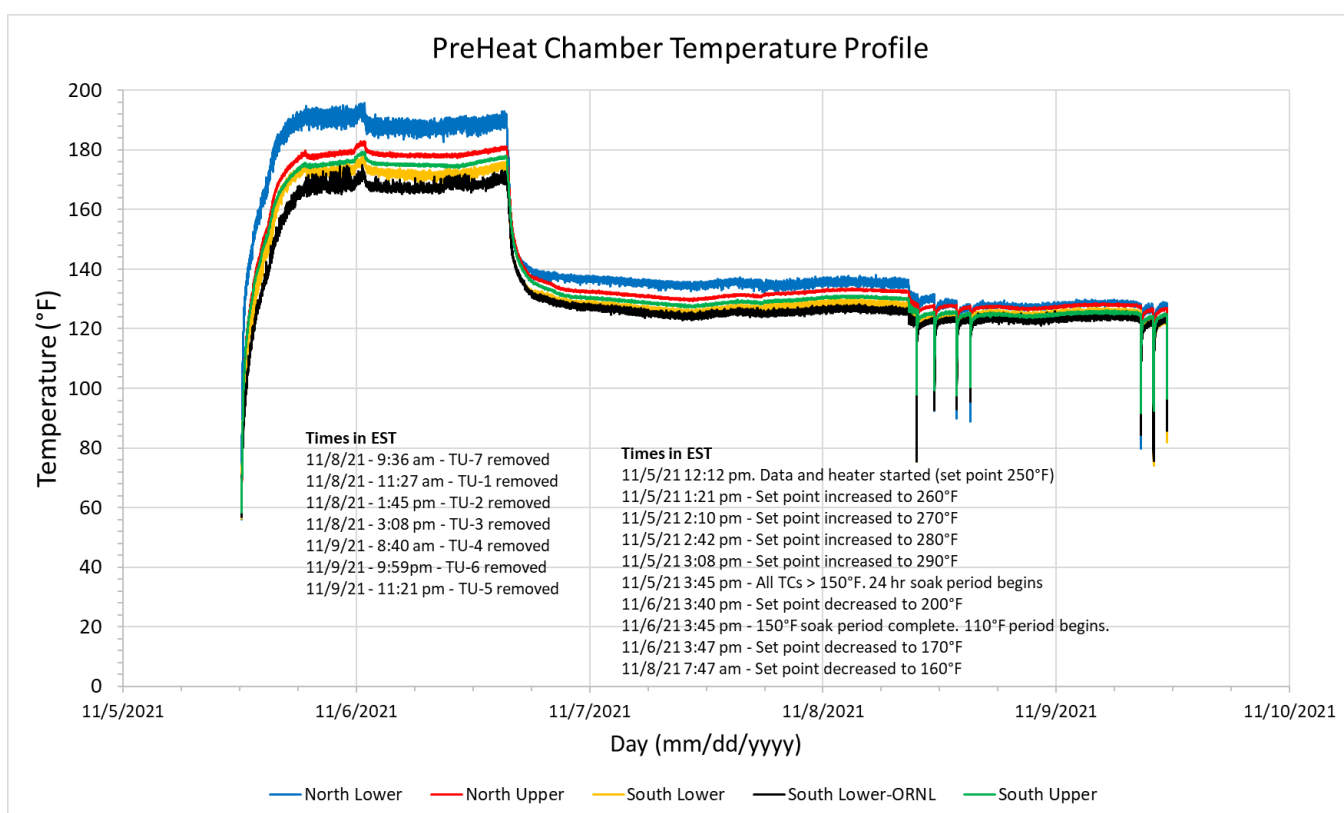


Figure 4-59. Preheat chamber thermocouple location and layout.



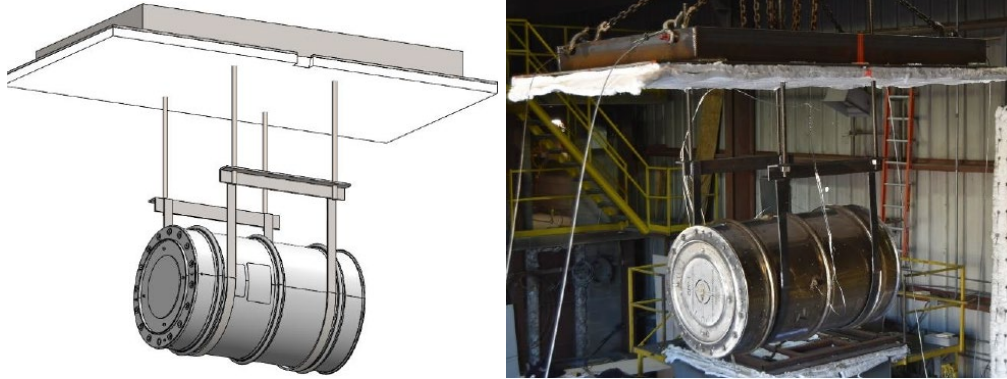
**Figure 4-60. Fully assembled preheat chamber.**



**Figure 4-61. Preheat chamber temperature profile.**

After preheating and just prior to loading a TU into the furnace, the TU was placed into the sample lifting fixture. The sample lifting fixture was composed of a removable furnace lid with two pieces of 2 in. wide plain carbon steel straps that were rolled into a semicircular shape, as shown in Figure 4-62. Four 1 in. diameter 304 stainless steel all-thread rods were used to connect the 2 in. metal straps to the removable furnace lid while also providing locations to level the TU and make vertical adjustments as needed. As assembled, the center of axis of each package was suspended nominally 54 in. below the surface of the removable lid.





**Figure 4-62. Sample lifting fixture.**

With the TU on the sample lifting fixture, six 0.062 in. diameter TCs were attached to the exterior surface of each package. One TC was located on the center of the package lid, one on the center of the package bottom, and four near the CG of the package at 0, 90, 180, and 270°. Metal retainer clips had previously been tack-welded to the drums to hold the TCs in place. The TC tips (Smalley Steel Ring, LS45375-1) were inserted underneath the metal clips and then wrapped around the metal clips. To eliminate any radiant viewing factor between the TCs and the furnace walls, the tips and metal clips were covered with a ceramic coating (Pyro-Putty® 1500, Figure 4-63). After installation and just prior to insertion of the TU into the furnace, the functionality of each TC was tested using a propane torch.

A temporary removable furnace lid remained in place over an opening on top of the furnace. The temporary lid measured nominally 53 × 68 in, and it was removed just before the TU was lowered into the furnace until the furnace lid rested over top of the furnace opening. Once the TU was fully seated in the furnace, it rested on a SwRI-fabricated test stand, as shown in Figure 4-64. Figure 4-65 shows the TU being loaded into the furnace, with the attached TCs described above visible.



**Figure 4-63. TU TC instrumentation.**



**Figure 4-64. TU on test stand in furnace during thermal test.**



**Figure 4-65. TU-2 wired with TCs, loading.**

## **4.8 THERMAL TESTING**

Packages were loaded into the furnace using the sample lifting fixture designed by SwRI (Figure 4-66). The chronological order of the thermal tests was TU-7, TU-1, TU-2, TU-3, TU-4, TU-6, and TU-5. The 31-minute thermal test for each TU did not begin until the criteria in the steps below were met.

1. At least five of the six external TCs on the TU were reading  $>1,475^{\circ}\text{F}$  ( $802^{\circ}\text{C}$ ).
2. At least 15 of the 18 TCs on the furnace surface were reading  $>1,475^{\circ}\text{F}$  ( $802^{\circ}\text{C}$ ), with at least two of the three TCs on each furnace surface reading  $>1,475^{\circ}\text{F}$  ( $802^{\circ}\text{C}$ ).
3. At least two of the three TCs on the test stand were reading  $>1,475^{\circ}\text{F}$  ( $802^{\circ}\text{C}$ ).
4. CNS staff agreed to proceed with the test.



The TUs required 2–3 min to reach the test temperature threshold. This meant that each TU was in the furnace environment for a total of 33–34 min.



**Figure 4-66. Sample lifting fixture used for TU insertion and extraction.**

Upon completion of the 31-minute test, each test package was removed from the furnace (Figure 4-67) and placed on a cooling stand where it was permitted to cool naturally (Figure 4-68). Loading and unloading cycles were videotaped and are available via electronic media. See the data sheets in the appendices of this document for more information.



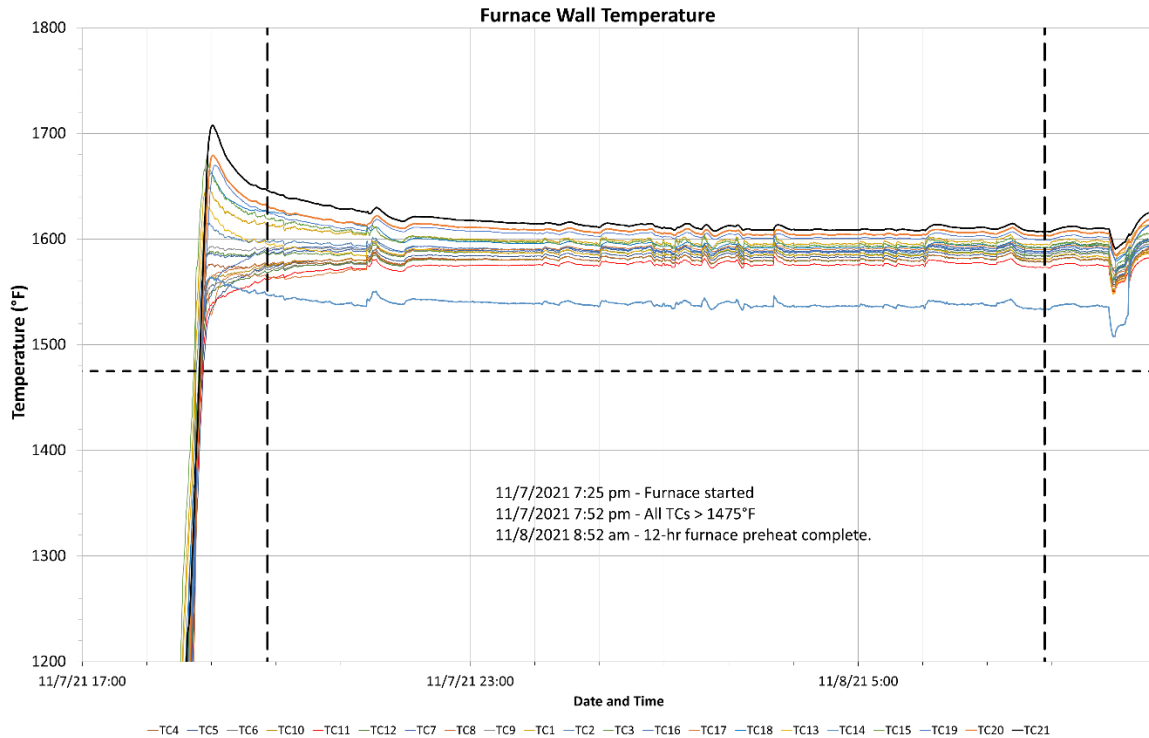
**Figure 4-67. TU removal from the furnace (TU-2).**



**Figure 4-68. TU cooling after thermal test (TU-1).**

#### **4.9 THERMAL TEST DATA**

Prior to subjecting the TUs to the thermal test, the furnace was preheated for 12 hr to ensure that the furnace was at a steady-state temperature with a full thermal soak of the furnace walls. The set point of the furnace was established at 1,575°F. The furnace preheat started at 7:25 pm CST on 11/7/2021. At 7:52 pm, all furnace TCs were above 1,475°F. The furnace was held at that temperature for the remainder of the 12 hr preheat time (Figure 4-69). Before subjecting TU-1 to the regulatory thermal test, the furnace was qualified with a DPP-1 drum body assembly (TU-7). TU-7 did not include the CV or the surrogate test weights. TU-7 was instrumented with six TCs and subjected to the preheat profile. The furnace was considered qualified when all the TCs in the furnace and on the surface of TU-7 were above 1,475°F for 31 min. A 45-min period was required between TUs to ensure the furnace was at steady state and met the temperature requirements after the top was closed.



**Figure 4-69. Furnace preheat profile.**

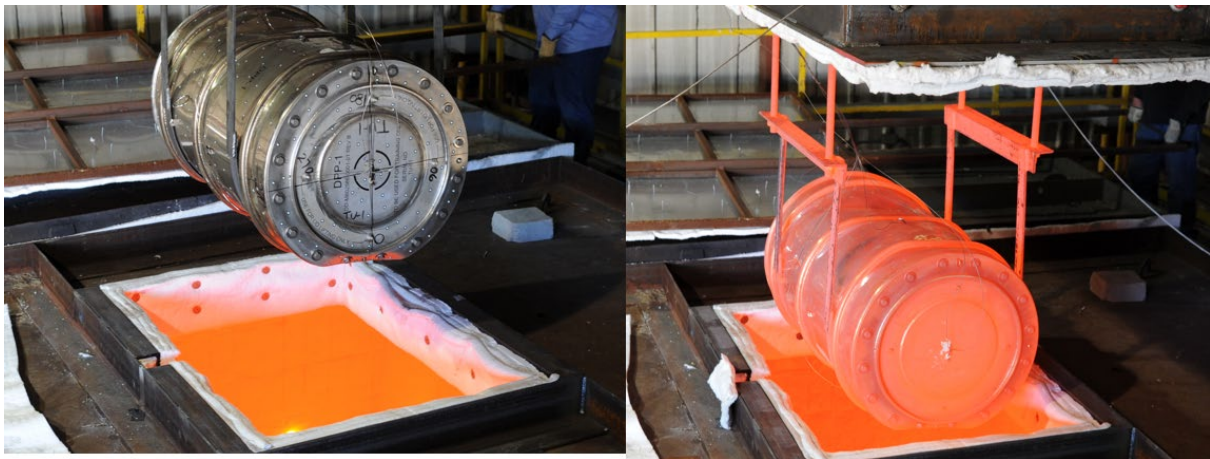
#### 4.9.1 TU-1

TU-1 was preheated per the preheat temperature profile in Figure 4-61. After preheating, the TU was removed from the preheat chamber, and the six external TCs were installed. The TC tips were covered with Pyro Putty and tested with a butane torch to ensure that the DAQ was receiving a signal from the TC. The unit was oriented horizontally, with the drum top facing the right interior wall of the furnace and the 0° axial line at a less than 5° counterclockwise orientation (Figure 4-70). The 5° angle ensured that the TC clip and the TC tip were not damaged during furnace loading and that the TC on the 0° line and CG intersection was not covered by the test stand. After the temporary furnace lid was removed, the unit was loaded into the furnace in 28 seconds. The 31-minute test began 3 min after loading. After the test was complete, the unit was removed from the furnace and placed on a cooling stand. The TU was glowing red hot after removal from the furnace Figure 4-71. The TU was allowed to passively cool while on the cooling stand. See the datasheet in Appendix H for more details and see Appendix A for additional photographs.





**Figure 4-70. TU-1 thermal test orientation.**



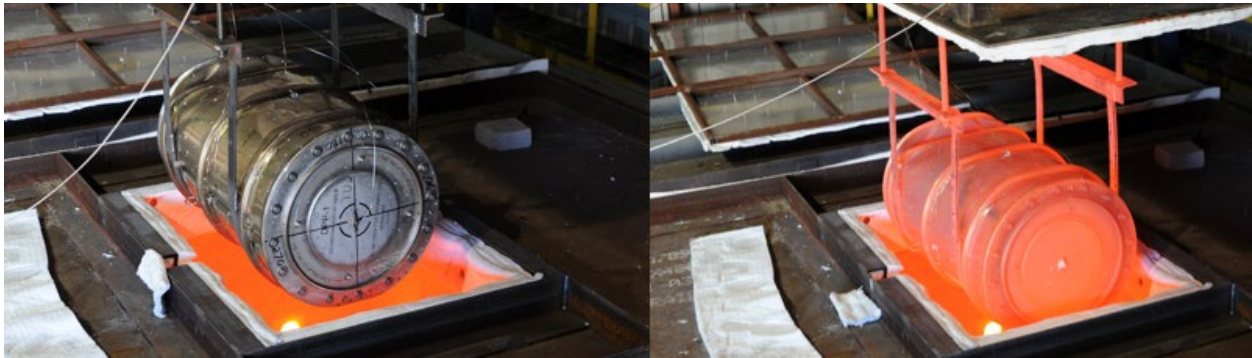
**Figure 4-71. TU-1 furnace loading and unloading.**

#### 4.9.2 TU-2

TU-2 was preheated per the preheat temperature profile in Figure 4-61. After preheating, the TU was removed from the preheat chamber, and the six external TCs were installed. The TC tips were covered with Pyro Putty and tested with a butane torch to ensure that the DAQ was receiving a signal from the TC. The unit was oriented horizontally, with the drum top facing the right interior wall of the furnace and the 0° axial line at a ~5° angle (Figure 4-72). The ~5° angle ensured that the TC clip and the TC tip were not damaged during furnace loading and the TC on the 0° line and that the CG intersection was not covered by the test stand. After the temporary furnace lid was removed, the unit was loaded into the furnace in 31 seconds. The 31-minute test began 3 minutes after loading. After the test was complete, the unit was removed from the furnace and placed on a cooling stand. The TU was glowing red hot after removal from the furnace Figure 4-73. The TU was allowed to passively cool while on the cooling stand. See the datasheet in Appendix I for more details, and see Appendix B for additional photographs.



**Figure 4-72. TU-2 thermal test orientation.**

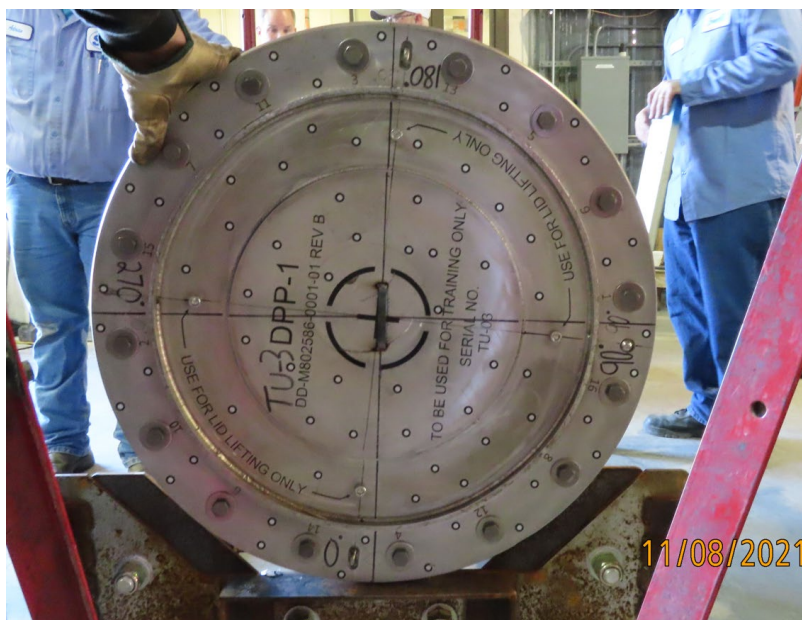


**Figure 4-73. TU-2 furnace loading and unloading.**

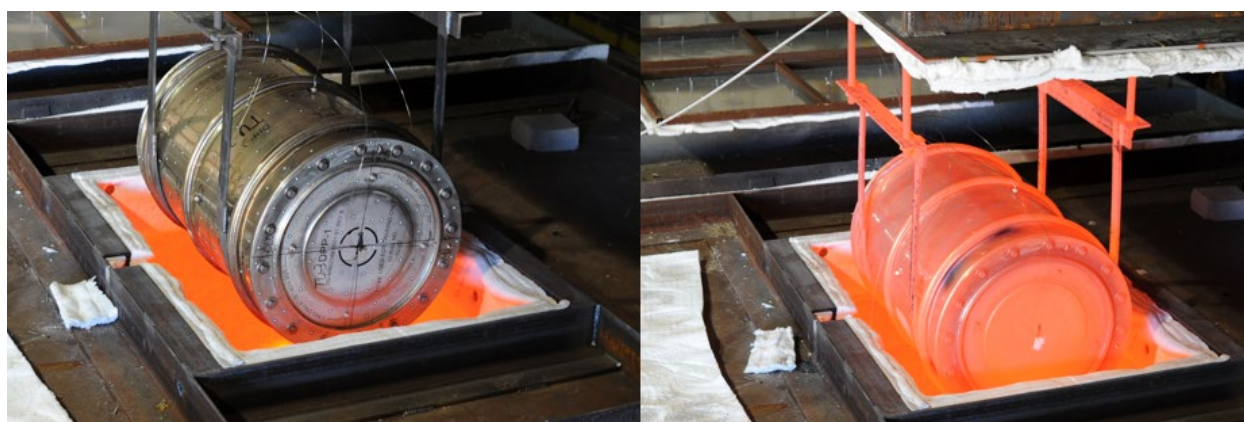
### 4.9.3 TU-3

TU-3 was preheated per the preheat temperature profile in Figure 4-61. After preheating, the TU was removed from the preheat chamber, and the six external TCs were installed. The TC tips were covered with Pyro Putty and tested with a butane torch to ensure that the DAQ was receiving a signal from the TC. The unit was oriented horizontally, with the drum top facing the right interior wall of the furnace and the 0° axial line at a ~5° angle (Figure 4-72). The ~5° angle ensured that the TC clip and the TC tip were not damaged during furnace loading and that the TC on the 0° and CG intersection line was not covered by the test stand. After the temporary furnace lid was removed, the unit was loaded into the furnace in 29 seconds. The 31-minute test began 2 min after loading. After the test was complete, the unit was removed from the furnace and placed on a cooling stand. There was significant smoke and flaming from the still-burning polyurethane foam in the package upon removal. The TU was glowing red hot after removal from the furnace Figure 4-75. The TU was allowed to passively cool while on the cooling stand. See the datasheet in Appendix J for more details, and see Appendix C for additional photographs.





**Figure 4-74. TU-3 thermal test orientation.**



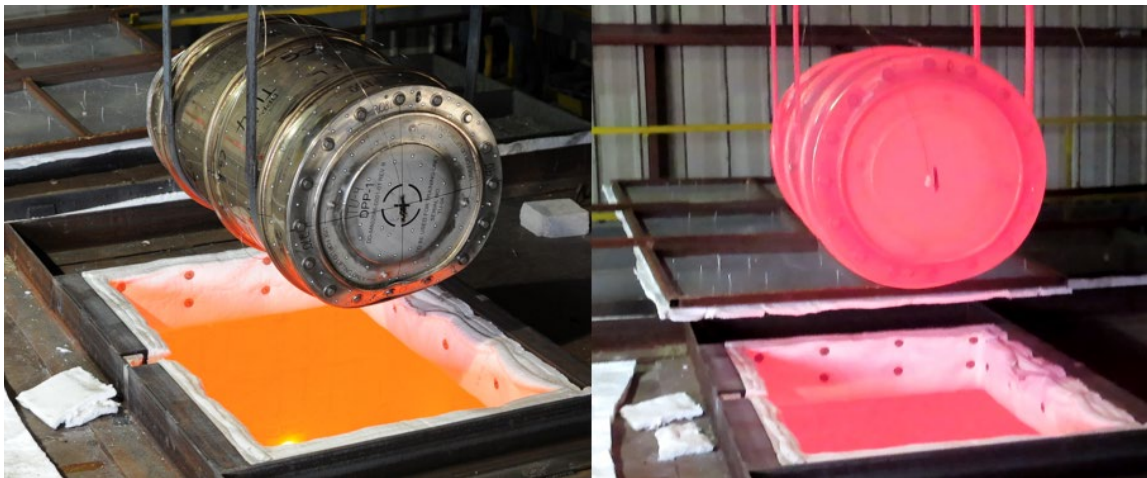
**Figure 4-75. TU-3 furnace loading and unloading.**

#### **4.9.4 TU-4**

TU-4 was preheated per the preheat temperature profile in Figure 4-61. After preheating, the TU was removed from the preheat chamber, and the six external TCs were installed. The TC tips were covered with Pyro Putty and tested with a butane torch to ensure that the DAQ was receiving a signal from the TC. The unit was oriented horizontally, with the drum top facing the right interior wall of the furnace and the 0° axial line at a ~5° angle (Figure 4-76). The ~5° angle ensured that the TC clip and the TC tip were not damaged during furnace loading and that the TC on the 0° and CG intersecting line was not covered by the test stand. After the temporary furnace lid was removed, the unit was loaded into the furnace in 30 seconds. The 31-minute test began 2 min after loading. After the test was complete, the unit was removed from the furnace and placed on a cooling stand. The TU was glowing red hot after removal from the furnace Figure 4-77. The TU was allowed to passively cool while on the cooling stand. See the datasheet in Appendix K for more details, and see Appendix D for additional photographs.



**Figure 4-76. TU-4 thermal test orientation.**



**Figure 4-77. TU-4 furnace loading and unloading.**

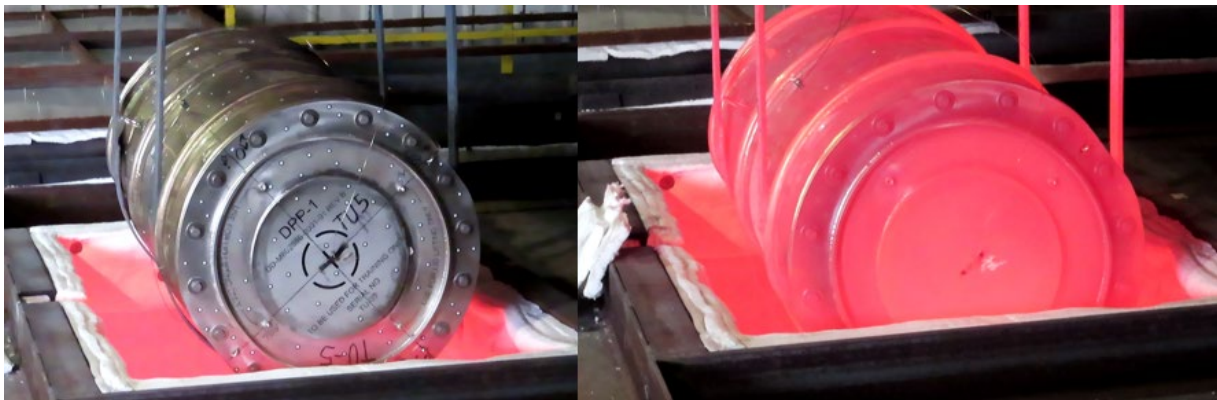
#### **4.9.5 TU-5**

TU-5 was preheated per the preheat temperature profile in Figure 4-61. After preheating, the TU was removed from the preheat chamber, and the six external TCs were installed. The TC tips were covered with Pyro Putty and tested with a butane torch to ensure that the DAQ was receiving a signal from the TC. The unit was oriented horizontally, with the drum top facing the right interior wall of the furnace and the 0° axial line at a ~45° angle (Figure 4-75). The ~45° angle ensured that the opening on the top of the drum lid was facing the furnace floor to allow for more heat to enter the drum body assembly. After the temporary furnace lid was removed, the unit was loaded into the furnace in 28 seconds. The 31-minute test began 3 min after loading. After the test was complete, the unit was removed from the furnace and placed on a cooling stand. The TU was glowing red hot after removal from the furnace Figure 4-79. The TU was allowed to passively cool while on the cooling stand. See the datasheet in Appendix L for more details, and see Appendix E for additional photographs.





**Figure 4-78. TU-5 thermal test orientation.**



**Figure 4-79. TU-5 furnace loading and unloading.**

#### 4.9.6 TU-6

TU-6 was preheated per the preheat temperature profile in Figure 4-61. After preheating, the TU was removed from the preheat chamber, and the six external TCs were installed. The TC tips were covered with Pyro Putty and tested with a butane torch to ensure that the DAQ was receiving a signal from the TC. The unit was oriented horizontally, with the drum top facing the right interior wall of the furnace and the 0° axial line at a ~5° angle (Figure 4-80). The ~5° angle ensured that the TC clip and the TC tip were not damaged during furnace loading and that the TC on the 0° line was not covered by the test stand. After the temporary furnace lid was removed, the unit was loaded into the furnace in 31 seconds. The 31-minute test began 2 min after loading. After the test was complete, the unit was removed from the furnace and placed on a cooling stand, as shown in Figure 4-81. The TU was allowed to passively cool while on the cooling stand. See the datasheet in Appendix M for more details, and see Appendix F for additional photographs.



**Figure 4-80. TU-6 thermal test orientation.**



**Figure 4-81. TU-6 furnace loading and unloading.**

Data from all the TCs were recorded at 15 second intervals. Graphs were generated for each TU. Each graph includes a horizontal line indicating the 800°C (1,475°F) minimum temperature of the HAC test criteria. The ambient temperature and the time stamp for each thermal test are in Figure 4-79. Throughout the test week, the ambient temperature ranged from 56 to 96°F. The graphs for each TU show the furnace TCs immediately after the TU was inserted until after the TU was removed (Figure 4-83 and Figure 4-84). In Figure 4-83, the connection from TC-4 was unstable, which resulted in signal loss for no more than 15 seconds. Figure 4-85 through Figure 4-91 show the TU's external TC readings throughout the thermal test. The time axis of the package TCs shows the actual time of day and not elapsed time. Finally, Figure 4-92 displays the oxygen concentration in the furnace for all thermal tests. For all tests, the oxygen percentage in the furnace drops to about 12% when the gas burners are on to raise the temperature above 1,475°F. When the furnace reached 1475°F, the oxygen percentage was between 14% and 15%. The oxygen concentration was measured to ensure that the conditions in the furnace were not oxygen deprived and to ensure natural combustion.

To simplify the graph legends, thermal recorded channel designations are used. Table 4-17 shows the thermocouple locations, the channel identification, and the TC identification for the furnace surfaces.

**Table 4-17. Mapping TC location to DAQ channel number**

<b>Furnace TC location</b>	<b>Channel identification</b>	<b>TC identification</b>
Front wall right	F_170	TC1
Front wall center	F_171	TC2
Front wall left	F_172	TC3
Left wall left	F_161	TC4
Left wall center	F_162	TC5
Left wall right	F_163	TC6
Rear wall left	F_167	TC7
Rear wall center	F_168	TC8
Rear wall right	F_169	TC9
Right wall left	F_164	TC10
Right wall center	F_165	TC11
Right wall right	F_166	TC12
Ceiling left	F_176	TC13
Ceiling center	F_177	TC14
Ceiling right	F_178	TC15
Floor plate left	F_173	TC16
Floor plate center	F_174	TC17
Floor plate right	F_175	TC18
Test stand left	F_179	TC19
Test stand center	F_180	TC20
Test stand right	F_181	TC21



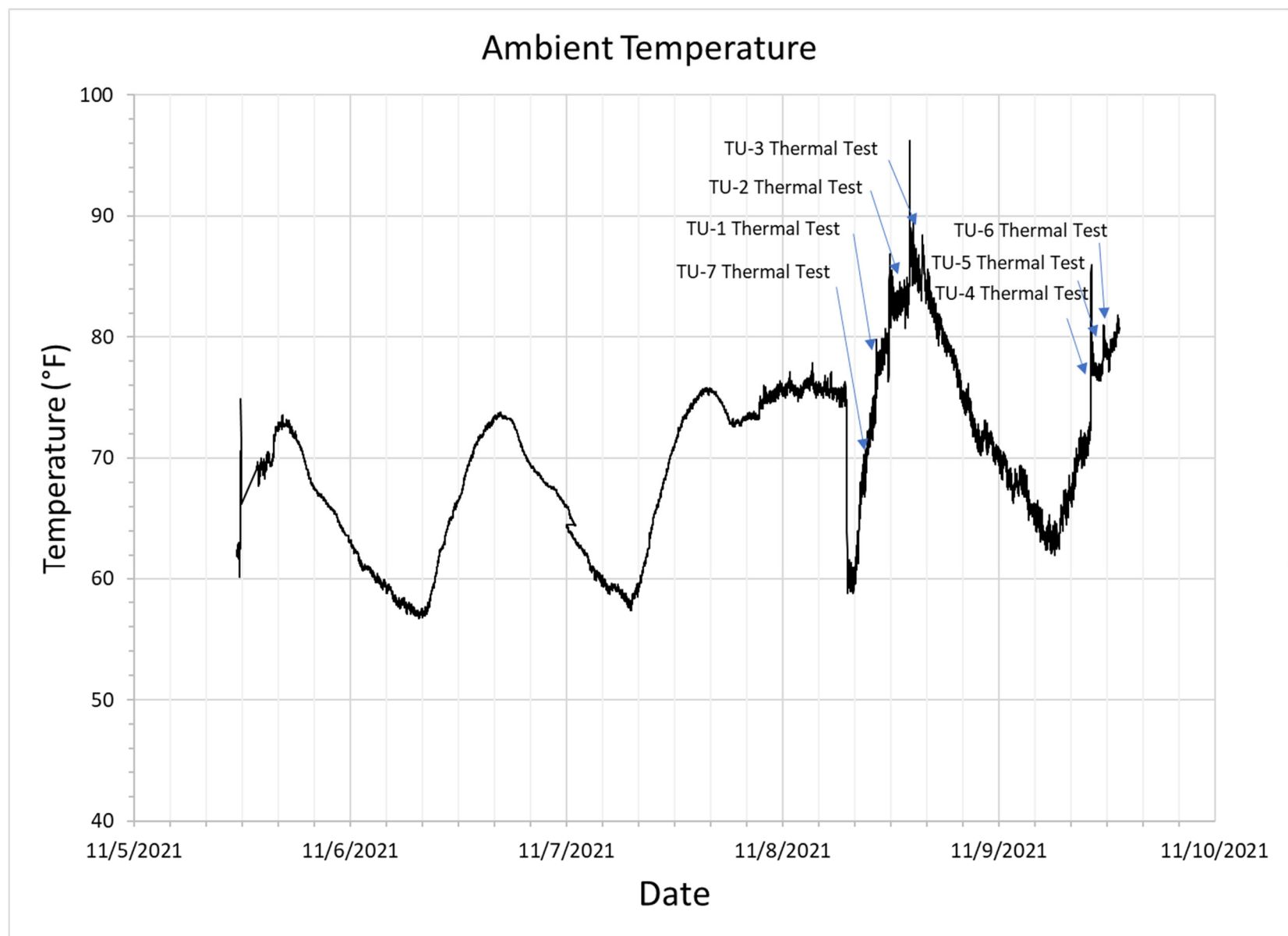


Figure 4-82. Ambient temperature in furnace facility.

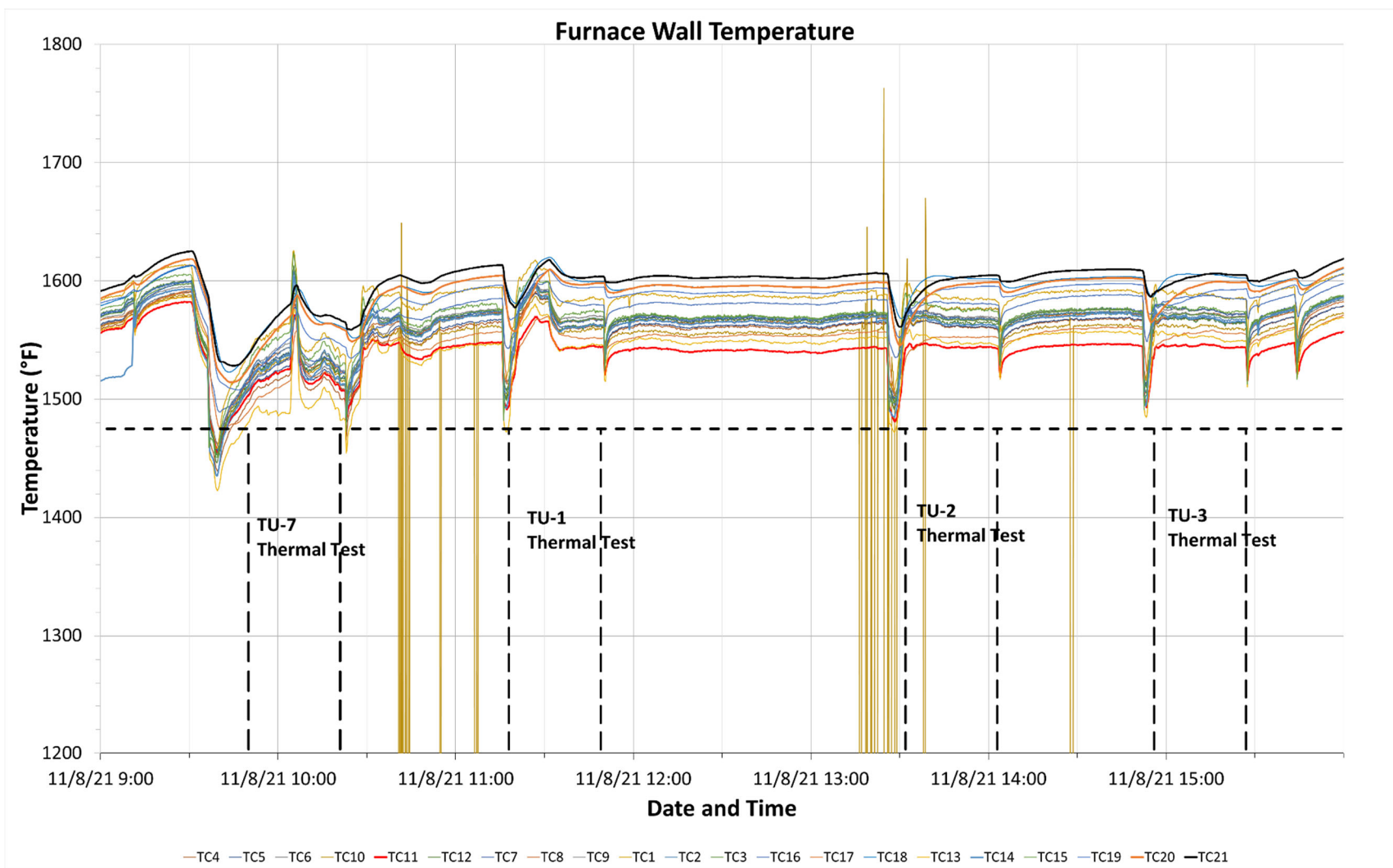


Figure 4-83. Furnace wall temperatures for TUs -7, -1, -2, and -3.

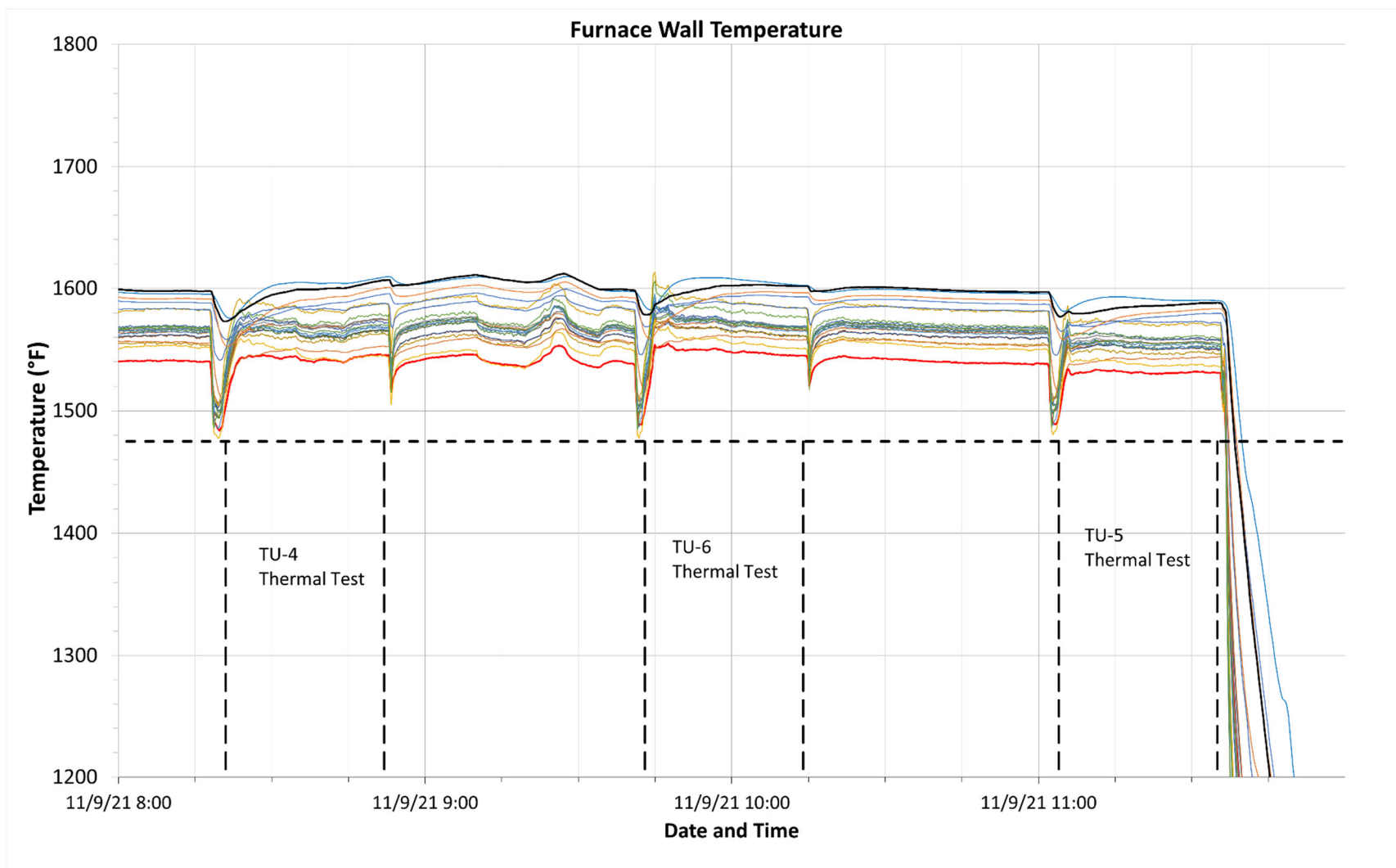


Figure 4-84. Furnace wall temperatures for TUs -4, -6, and -5.

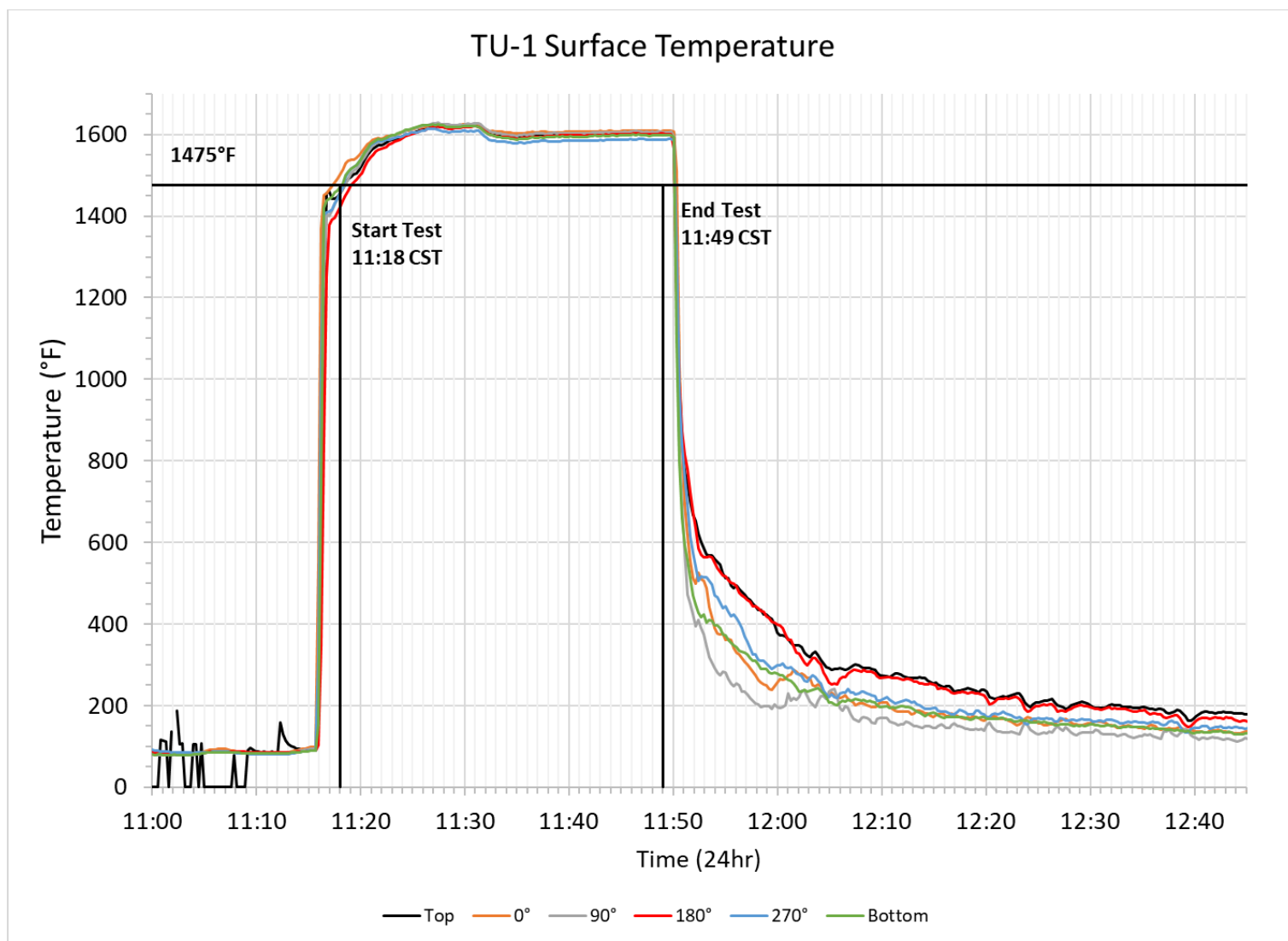


Figure 4-85. TU-1 package surface temperatures.

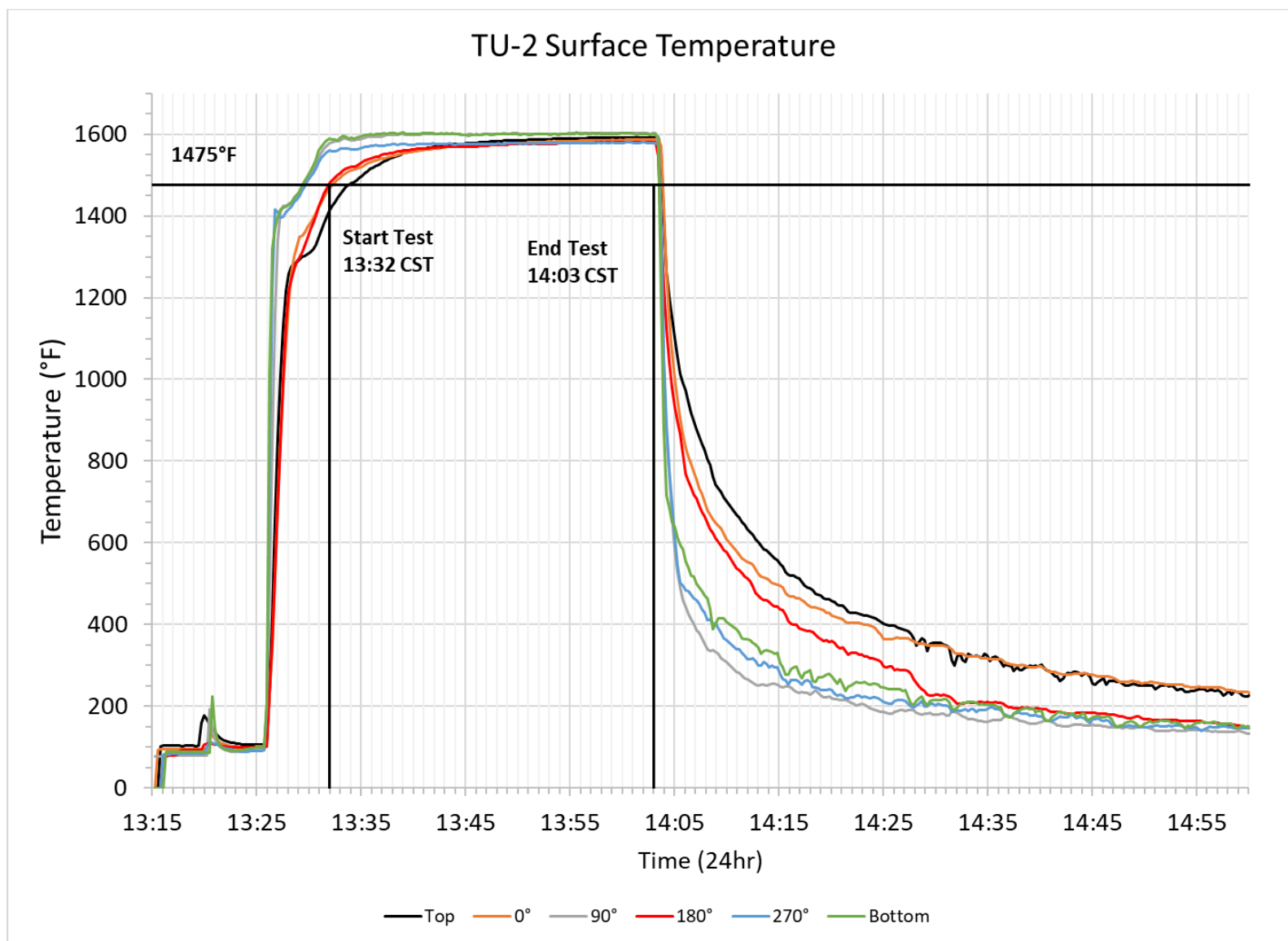


Figure 4-86. TU-2 package surface temperatures.



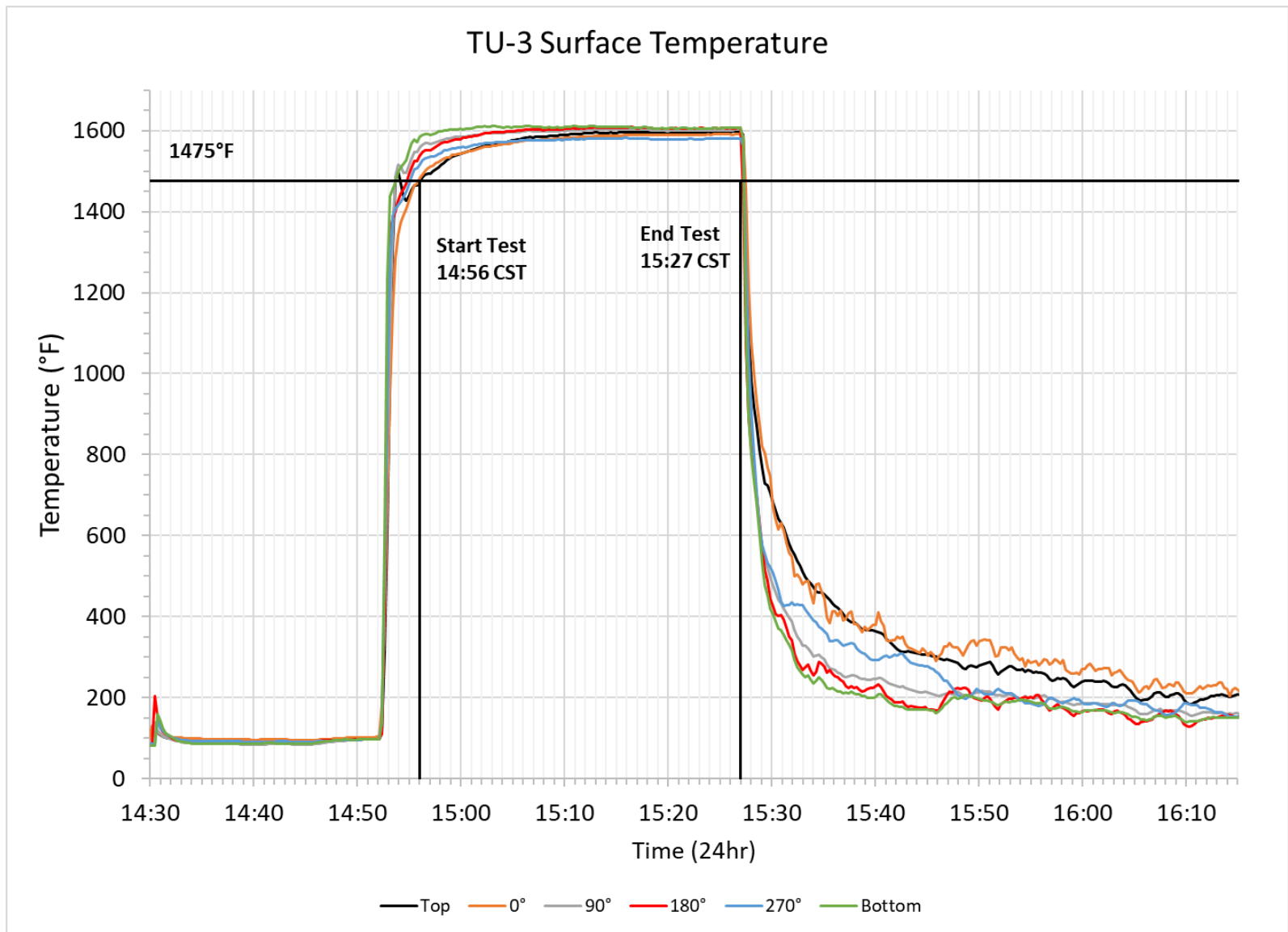


Figure 4-87. TU-3 package surface temperatures.

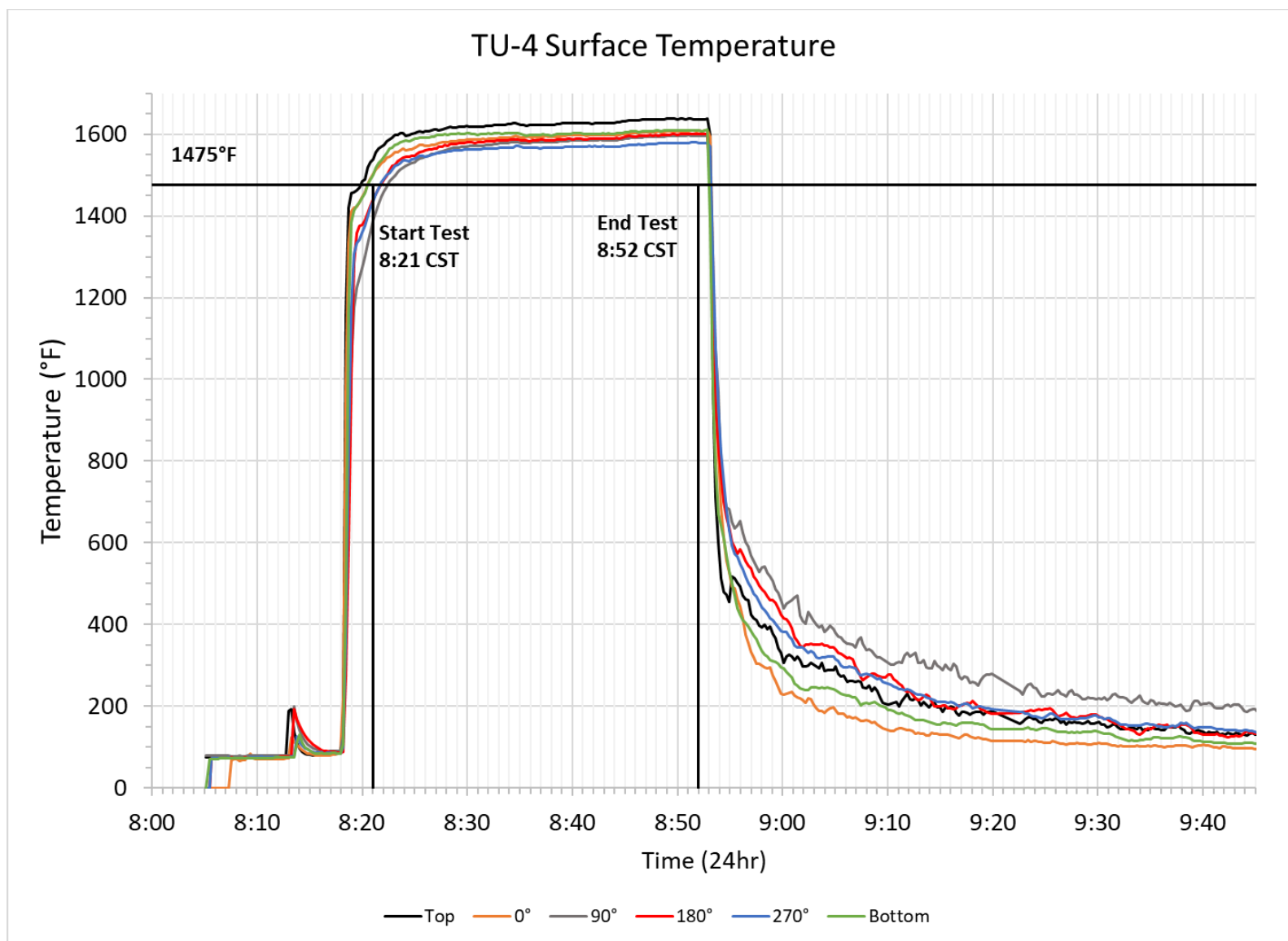


Figure 4-88. TU-4 package surface temperatures.

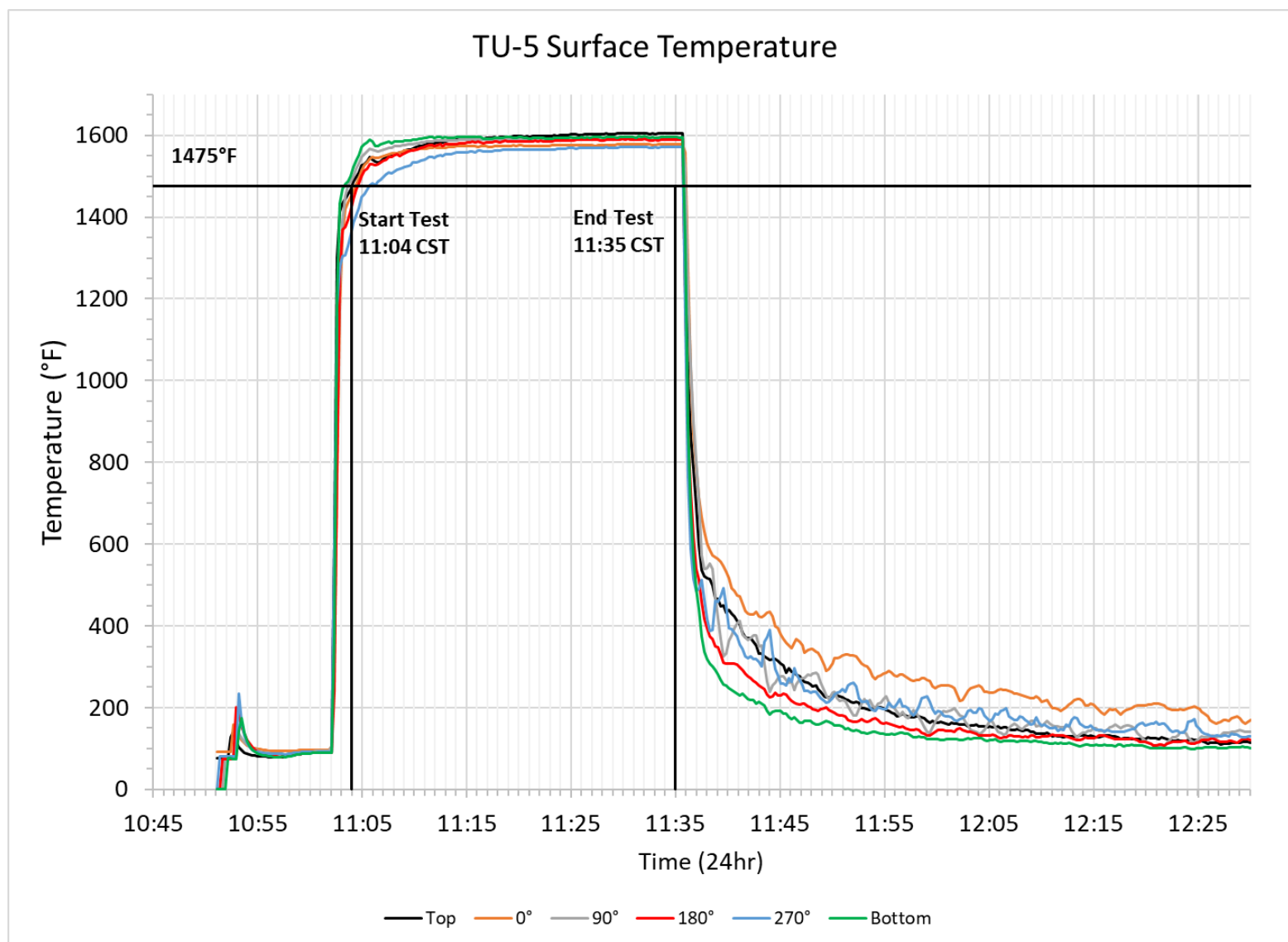


Figure 4-89. TU-5 package surface temperatures.

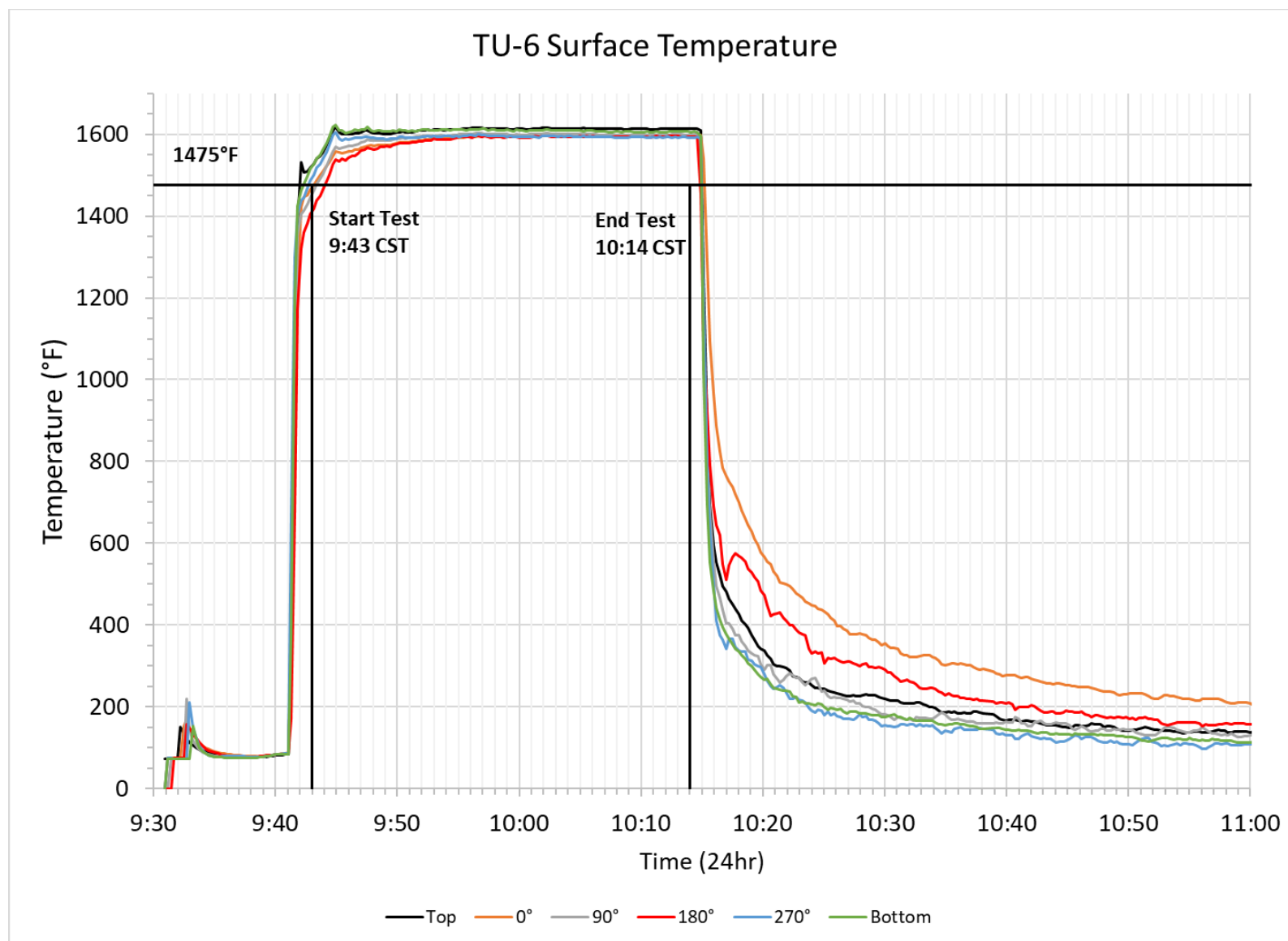


Figure 4-90. TU-6 package surface temperatures.

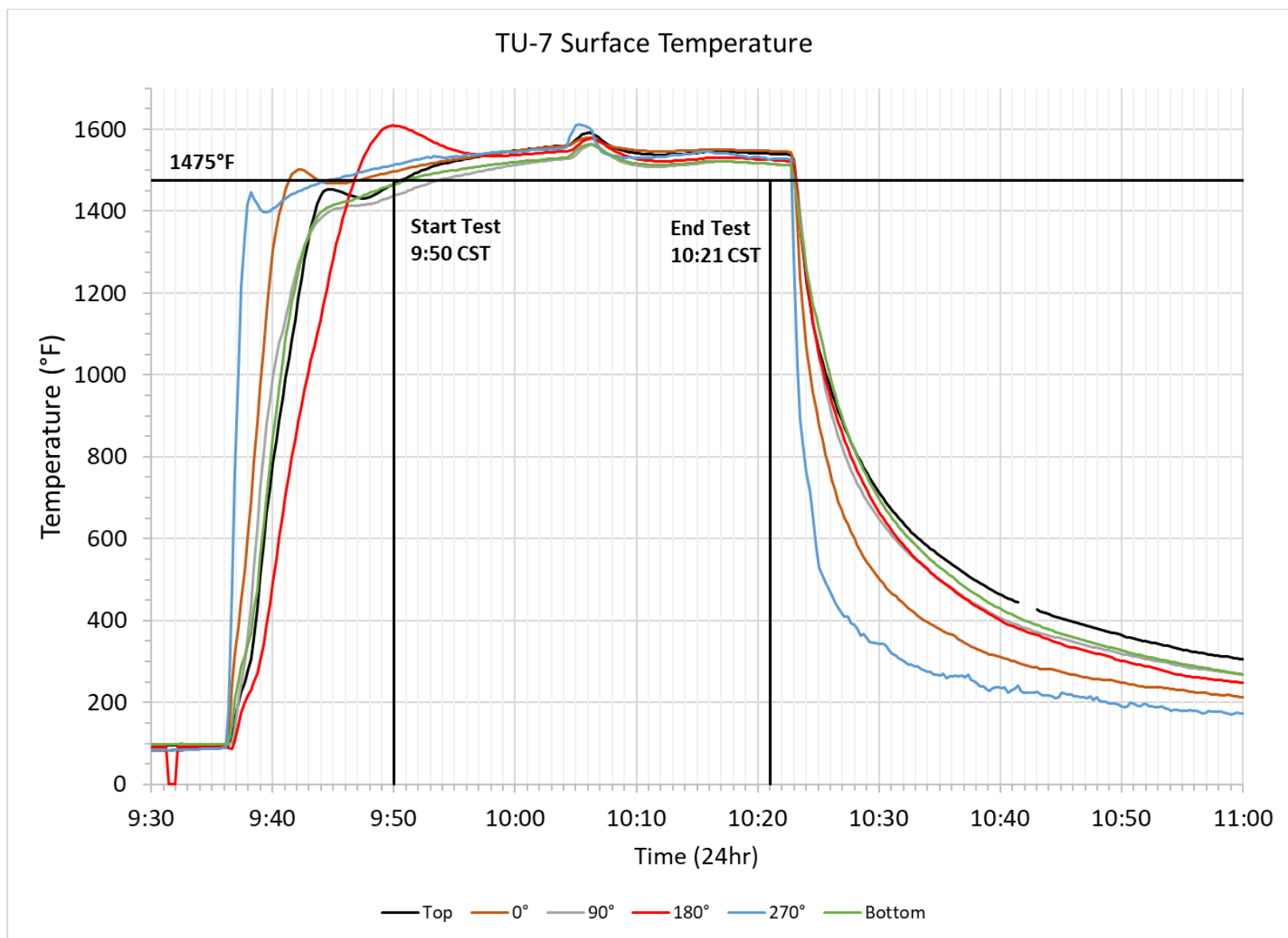
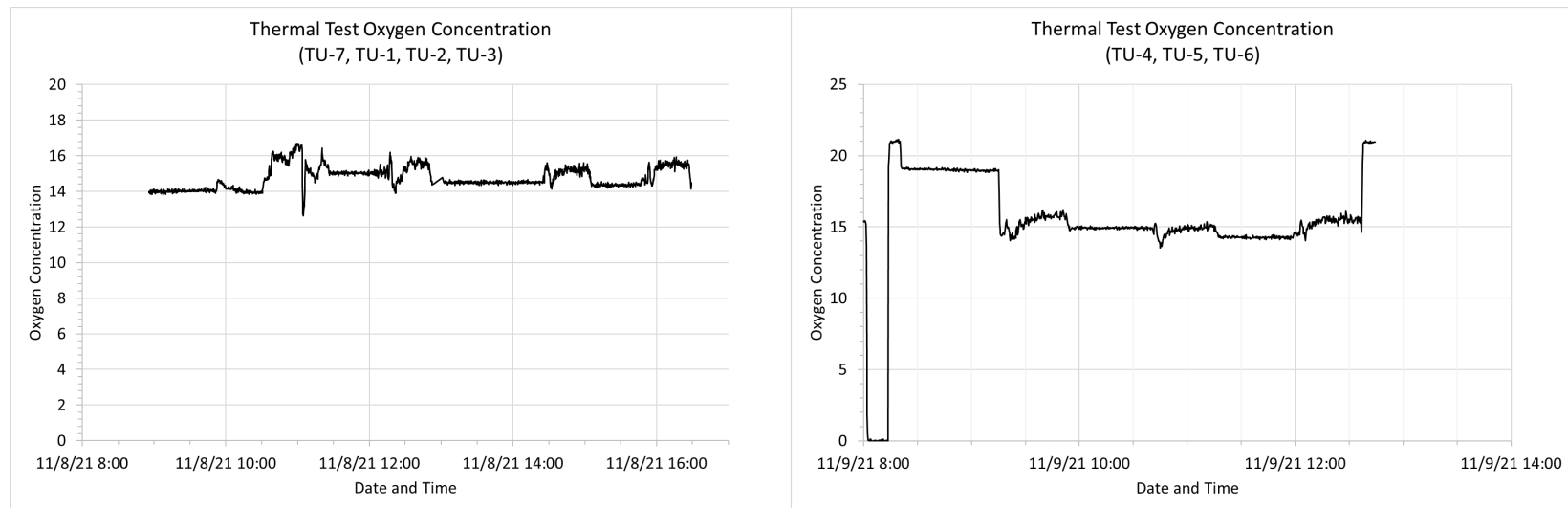


Figure 4-91. TU-7 package surface temperatures.





**Figure 4-92. Thermal test oxygen concentration.**

## 5. POST-HAC DISASSEMBLY AND INSPECTION

After being returned to the NTRC from the thermal test facility, the TUs were disassembled and inspected. The post-thermal weights of each TU were recorded on Test Form 1. The drums were either disassembled or cut open, and photographic records of the process were taken. Each TU was visually inspected, and the condition of the package and any observations were recorded on the test forms. Photographs were taken of the disassembly process and any conditions that merited documenting.

The CVs of TUs -1 through -6 were removed in the reverse order of the assembly. The vertical impacts of TUs -2 and -3 caused interference between the drum body and drum lid. This interference prevented the drum lid from being removed freely. A prybar was used to remove the drum lids.

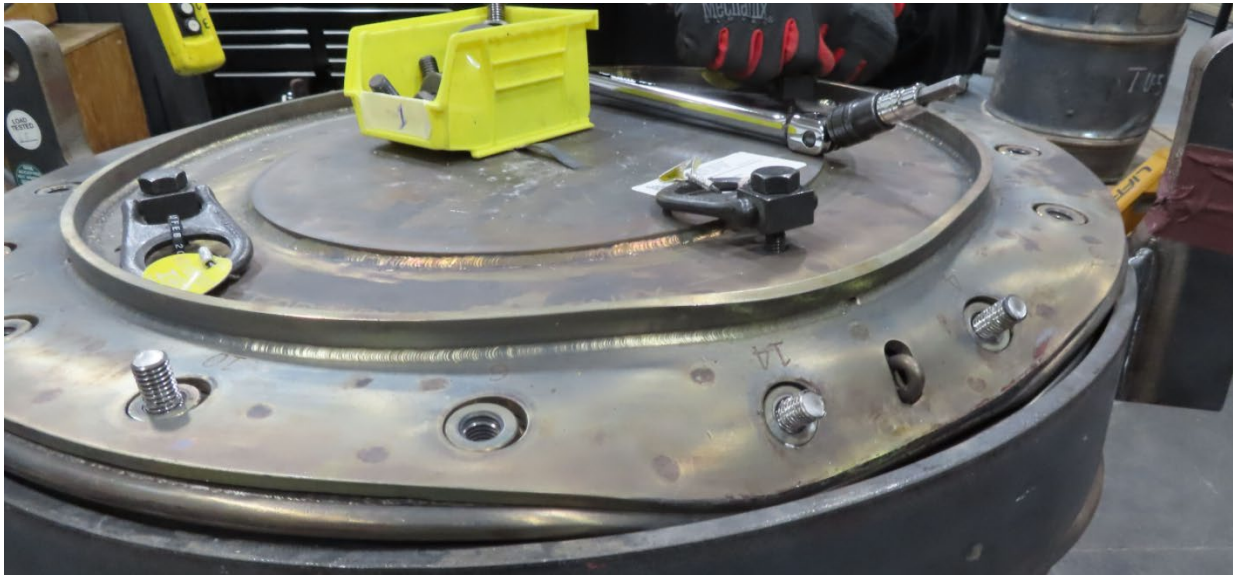
### 5.1 DRUM DISASSEMBLY OBSERVATIONS

TUs -1 through -6 were subjected to both 1.2 m and 9 m HAC tests, with impacts on the side, vertical, or corner from the free drop, crush test, and puncture test. To access the CV, TUs -1, -4, -5, and -6 all required that the top section of the drum body be cut away (Figure 5-1). The deformation of the drum body and drum lid created an interference that did not allow the drum lid to be removed.

The breakaway torque (in the loosening direction) for the drum lid bolts was between 0.0 and 103.8 ft-lb (Table 5-1 through Table 5-3). The loosening torque for some of the drum lid bolts increased because of temperature effects and gross deformation during impact, causing some drum lid bolts on TUs -1, -2, -5, and -6 to shear off from galling on the bolt threads (Figure 5-2). The breakaway torque values were recorded on Test Form 8.



Figure 5-1. TU-5 drum body cutting for lid removal.



**Figure 5-2. Sheared off drum lid bolt.**

**Table 5-1. Drum lid torque assembly and disassembly for TU-1 and TU-2 [ft-lb]**

<b>Bolt #</b>	<b>TU-1</b>			<b>TU-2</b>		
	<b>Assembly</b>	<b>Disassembly</b>	<b>Change</b>	<b>Assembly</b>	<b>Disassembly</b>	<b>Change</b>
<b>1</b>	34.6	32.2	-2.4	34.9	12.2	-22.7
<b>2</b>	35.6	33.7	-1.9	34.6	25.3	-9.3
<b>3</b>	34.5	37.3	2.8	34.8	8.0	-26.8
<b>4</b>	35.2	39.0	3.8	35.5	47.3	11.8
<b>5</b>	34.9	42.3	7.4	34.4	50.6	16.2
<b>6</b>	34.8	20.4	-14.4	35.4	51.0	15.6
<b>7</b>	35.9	26.3	-9.6	35.9	42.7	6.8
<b>8</b>	35.3	24.6	-10.7	34.9	57.1	22.2
<b>9</b>	35.2	51.3	16.1	35.3	14.9	-20.4
<b>10</b>	34.6	48.0	13.4	34.9	51.9	17.0
<b>11</b>	34.7	57.9	23.2	34.9	33.3	-1.6
<b>12</b>	34.6	42.9	8.3	34.6	50.9	16.3
<b>13</b>	34.8	41.9	7.1	34.9	50.5	15.6
<b>14</b>	34.9	57.1	22.2	34.6	52.1	17.5
<b>15</b>	35.0	48.5	13.5	34.8	34.9	0.1
<b>16</b>	34.6	37.4	2.8	35.5	44.4	8.9
<b>Average</b>	35.0	40.1	5.1	35.0	39.2	4.2
<b>Std Dev</b>	0.4	11.0	11.1	0.4	16.0	16.0

**Table 5-2. Drum lid torque assembly and disassembly for TU-3 and TU-4 [ft-lb].**

<b>Bolt #</b>	<b>TU-3</b>			<b>TU-4</b>		
	<b>Assembly</b>	<b>Disassembly</b>	<b>Change</b>	<b>Assembly</b>	<b>Disassembly</b>	<b>Change</b>
<b>1</b>	35.2	0.0	-35.2	35.4	45.3	9.9
<b>2</b>	35.2	13.0	-22.2	36.0	32.9	-3.1
<b>3</b>	34.9	9.2	-25.7	34.6	43.3	8.7
<b>4</b>	34.7	1.4	-33.3	34.9	11.2	-23.7
<b>5</b>	34.7	17.4	-17.3	35.7	46.5	10.8
<b>6</b>	35.2	12.9	-22.3	34.9	34.0	-0.9
<b>7</b>	35.3	10.5	-24.8	36.2	36.7	0.5
<b>8</b>	34.4	0.0	-34.4	34.3	28.7	-5.6
<b>9</b>	35.1	6.1	-29.0	34.8	35.5	0.7
<b>10</b>	35.6	7.3	-28.3	35.5	34.2	-1.3
<b>11</b>	35.0	10.6	-24.4	35.9	51.7	15.8
<b>12</b>	35.7	9.4	-26.3	35.4	7.2	-28.2
<b>13</b>	34.8	8.3	-26.5	34.7	60.5	25.8
<b>14</b>	34.7	12.0	-22.7	35.4	49.3	13.9
<b>15</b>	34.6	6.6	-28.0	35.6	41.4	5.8
<b>16</b>	35.3	0.0	-35.3	35.8	38.2	2.4
<b>Average</b>	35.0	7.8	-27.2	35.3	37.3	2.0
<b>Std Dev</b>	0.4	5.2	5.2	0.6	13.7	13.6



**Table 5-3. Drum lid torque assembly and disassembly for TU-5 and TU-6 [ft-lb].**

Bolt #	TU-5			TU-6		
	Assembly	Disassembly	Change	Assembly	Disassembly	Change
<b>1</b>	35.6	41.0	5.4	35.1	30.8	-4.3
<b>2</b>	34.9	34.7	-0.2	35.8	51.0	15.2
<b>3</b>	34.6	55.4	20.8	35.6	71.2	35.6
<b>4</b>	34.6	16.5	-18.1	35.3	26.5	-8.8
<b>5</b>	34.6	64.1	29.5	34.6	5.4	-29.2
<b>6</b>	34.9	49.0	14.1	36.0	56.5	20.5
<b>7</b>	34.3	9.4	-24.9	34.8	14.7	-20.1
<b>8</b>	35.9	19.5	-16.4	35.4	27.1	-8.3
<b>9</b>	35.9	47.2	11.3	35.8	69.6	33.8
<b>10</b>	35.1	41.0	5.9	34.8	55.7	20.9
<b>11</b>	35.7	53.9	18.2	35.9	53.2	17.3
<b>12</b>	35.2	33.1	-2.1	34.9	34.7	-0.2
<b>13</b>	35.2	103.8	68.6	34.9	84.6	49.7
<b>14</b>	35.2	97.3	62.1	34.9	99.5	64.6
<b>15</b>	35.2	39.1	3.9	36.3	35.6	-0.7
<b>16</b>	36.1	23.2	-12.9	35.1	36.5	1.4
<b>Average</b>	35.2	45.5	10.3	35.3	47.0	11.7
<b>Std Dev</b>	0.5	26.2	26.2	0.5	25.5	25.4

After the lid bolts were removed, a crowbar was used to remove the lids from TUs -2 and -3 because the drum's inner liner was interfering with the lid. TUs -1, -4, -5, and -6 were subjected to the horizontal and angular drop orientation, which resulted in extensive gross deformation of the drum's inner liner. As such, the drum liner could not be removed in the reverse order of assembly. To access the CV, an angle grinder was used to make a circumferential cut on the drum's outer shell at about 6 in. from the top of the drum lid (Figure 5-3). Once the drum's outer shell was removed (Figure 5-4), the Packcrete was removed to reveal the drum's inner liner (Figure 5-5). The inner liner was then cut off to reveal the top of the CV, and then the CV was lifted out (Figure 5-6).



Figure 5-3. TU-5 drum body being cut.



Figure 5-4. TU-5 drum circumferential cut complete.

Drum inner liner



**Figure 5-5. TU-5 drum Packcrete moved from circumferential cut area.**



**Figure 5-6. TU-5 CV removal.**

The CG of TU-4 was over the top corner at the 0° line, which resulted in deformation of the bolt guard, which caused a crack in the weld (Figure 5-7). The length of the crack was 3.704 in. For TUs -1 through -6, with the drum lids removed, it could be seen that the CV alignment to the drum liner had not visually moved and was noted as shown in Figure 5-8 and Figure 5-9. For TU-4, the foam pad on the bottom of the drum lid had separated from the lid (top left Figure 5-9).



**Figure 5-7. TU-4 crack at bolt guard.**



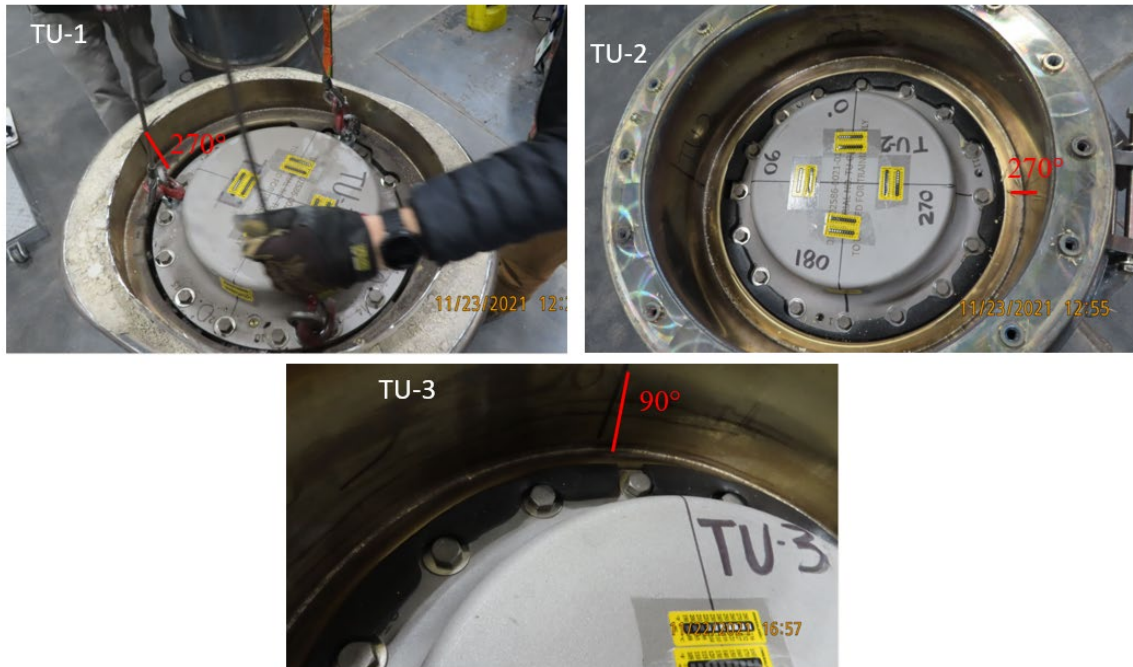


Figure 5-8. CV to drum liner alignment for TUs -1, -2, and -3.

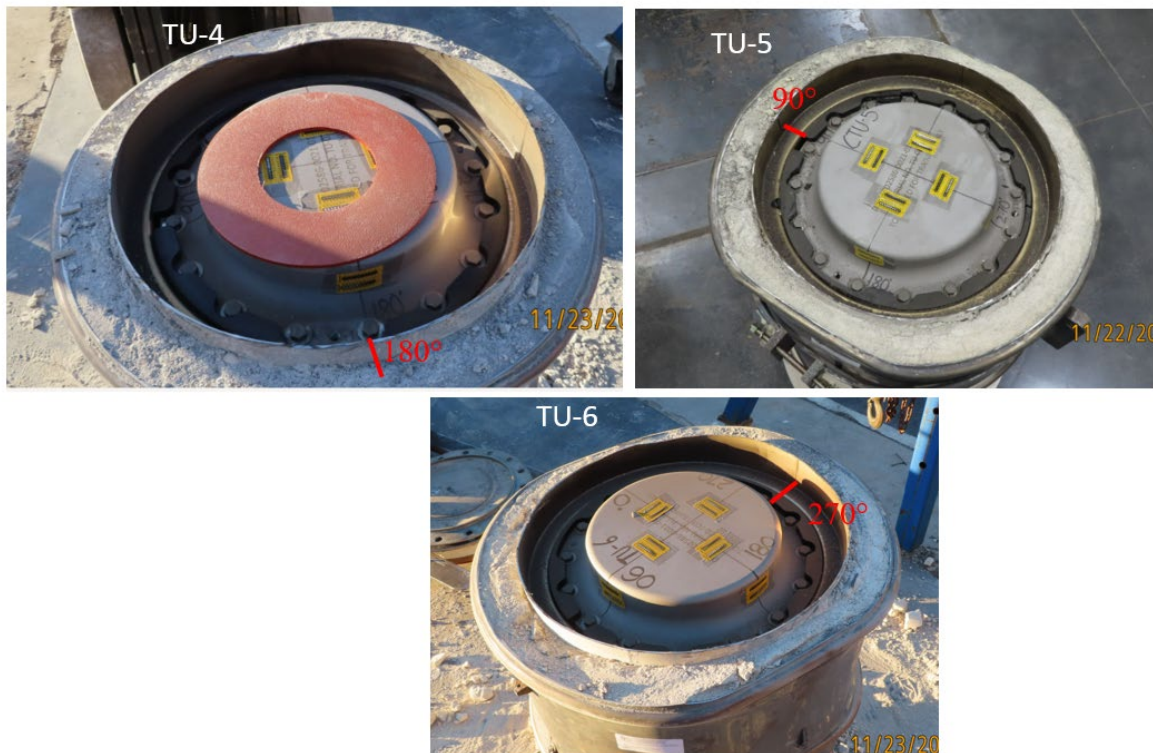


Figure 5-9. CV to drum liner alignment for TUs -4, -5, and -6.

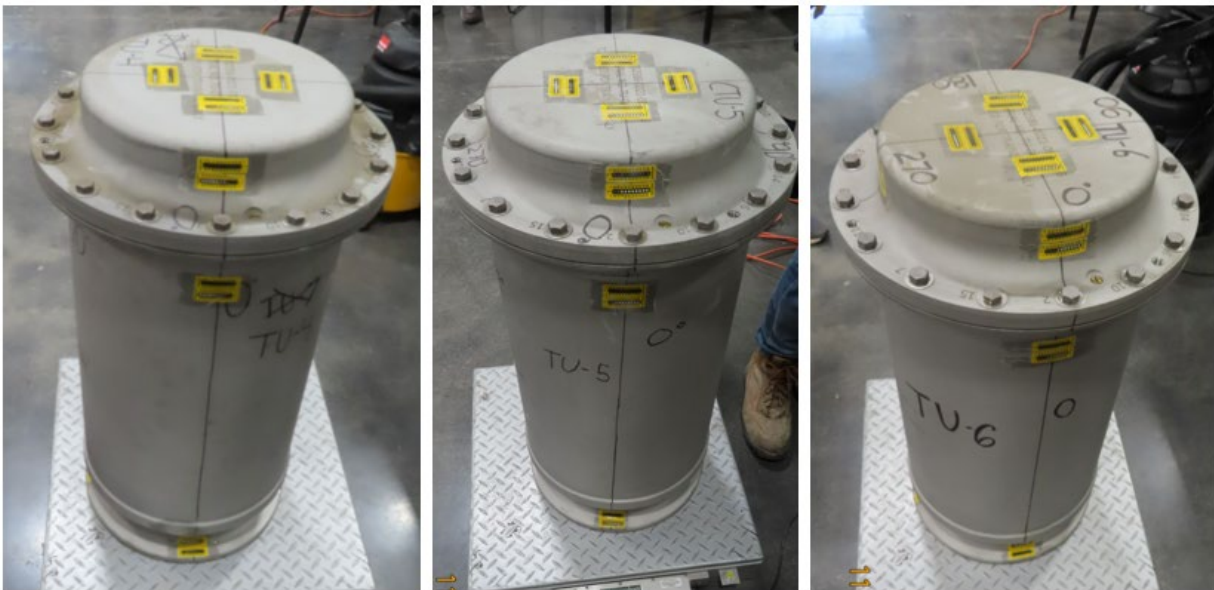
Once the CVs had been removed from all units, no discernible deformation or damage to the outer body of the CV was observed (Figure 5-10 and Figure 5-11). All temperature recording labels were intact and



legible. For TUs -1 through -6, the silicon pads on which the CVs rest were undamaged (Figure 5-12 and Figure 5-13). Upon opening the TUs, it was observed that all wedges that had been used to secure the CVs within the drum bodies were intact and still functioning. As shown in Figure 5-12, some of the wedges came apart when they were removed from their positions between the CV and drum body; however, they were still serving their function prior to removal.



**Figure 5-10. TUs -1, -2, and -3: CV posttest inspection.**



**Figure 5-11. TUs -4, -5, and -6: CV posttest inspection.**



**Figure 5-12. TUs -1, -2, and -3: CV posttest inspection.**



**Figure 5-13. TUs -4, -5, and -6: silicon CV bottom pad.**

## **5.2 POSTTEST LEAK TESTS**

After the CVs were removed from the drum body, they underwent the following two leak tests.

- Operational leak test of the CV O-rings
- Full containment boundary leak test with helium

## **5.3 POSTTEST OPERATIONAL LEAK TEST**

After the CVs were removed from the drum bodies, the CVs were leak tested using an Ashcroft HQS-2 pressure module (Figure 5-14) following NDE 70 – PCMT, Rev. 0 CN-0 ORNL IDMS 21075-0-0. These leakage rate tests were conducted in accordance with Section 7.6 of ANSI N14.5-2014. The acceptance criteria as defined in the ANSI standard stipulates that there should be no detectable leakage when tested to a sensitivity of at least  $1 \times 10^{-3}$  atm-cc/sec. If a CV successfully passes this test, then it indicates that the O-rings were installed and functioning properly. The pressure module pressurizes the volume between the O-rings and then uses a calibrated pressure transducer to measure the pressure drop over the test period. The PCMT leak test calculator computes a leakage rate. The instrument was set to a test sensitivity of  $\leq 1 \times 10^{-3}$  atm-cc/sec. A summary of the leakage rates is given in Table 5-4. All leakage rate data and calculation test results are documented in the appendices.

**Table 5-4. Posttest operational leak rate**

ID	Leak rate (atm-cc/sec)	Sensitivity (atm-cc/sec)
TU-1	0.00	8.94E-04
TU-2	0.00	8.46E-04
TU-3	0.00	8.42E-04
TU-4	0.00	8.44E-04
TU-5	0.00	8.44E-04
TU-6	0.00	8.50E-04



**Figure 5-14. DPP-1 post operational leak test.**

## **5.4 POSTTEST HELIUM LEAK TEST**

The CVs of TUs -1 through -6 were leak checked to a sensitivity of  $\leq 5 \times 10^{-8}$  atm-cc/s helium and an acceptance of  $\leq 2 \times 10^{-7}$  atm-cc/s helium using the ADIXEN ASM 340 leak test system. These leak tests were performed to NDE 70 - Hood (ORNL IDMS 21072) in accordance with Section 7.5 of ANSI N14.5-2014. To prepare for the test, a hole was drilled in the top of each CV body and was tapped for a 1/4 in. National Pipe Thread (NPT) tapered pipe thread. Lubricating grease was used during the CV threading process to ensure a near perpendicular threaded hole. A K-flange adapter was screwed into the hole with fast-setting epoxy to seal the threads. After the epoxy hardened, the mass spectrometer helium leak tester was connected to the adapter. The vacuum pump was then engaged, and over the course of 3–4 days, the volume of the CV was evacuated to  $< 1$  Torr. The CV was enclosed in a plastic bag and evacuated with a shop vacuum to reduce the ambient air in the bag. A constant flow of helium gas was introduced into the bag to ensure that the CV would remain bathed in helium during the test. Additionally, a hole was cut at the bottom of the bag, and an oxygen sensor was attached to measure the helium concentration in the plastic bag. The helium atmosphere was maintained for at least 6 min. Figure 5-15 shows a TU being subjected to the full containment boundary helium leak test. Complete data from these tests are given in Appendix U.





**Figure 5-15. TU undergoing post testing helium leak test.**

The posttest helium leak tests for all CVs were completed by an ORNL level III leak tester, and the CVs were found to meet the acceptance criteria. The leak rate slowly increased over time, indicating permeation of helium through the CV O-rings. Table 5-5 lists the helium leak rate, sensitivity, pressure, and temperature. The leak rate for all TUs was below  $2.0 \times 10^{-7}$  atm-cc/s helium, and the sensitivity was below  $5.0 \times 10^{-8}$  atm-cc/s helium. The internal pressure of the containment boundary for all TUs was below 50 milliTor. The pressure was achieved after subjecting the internal volume of the CV to a roughing vacuum pump for over 24 hr. See Appendix U for detailed information on the helium leak tests.

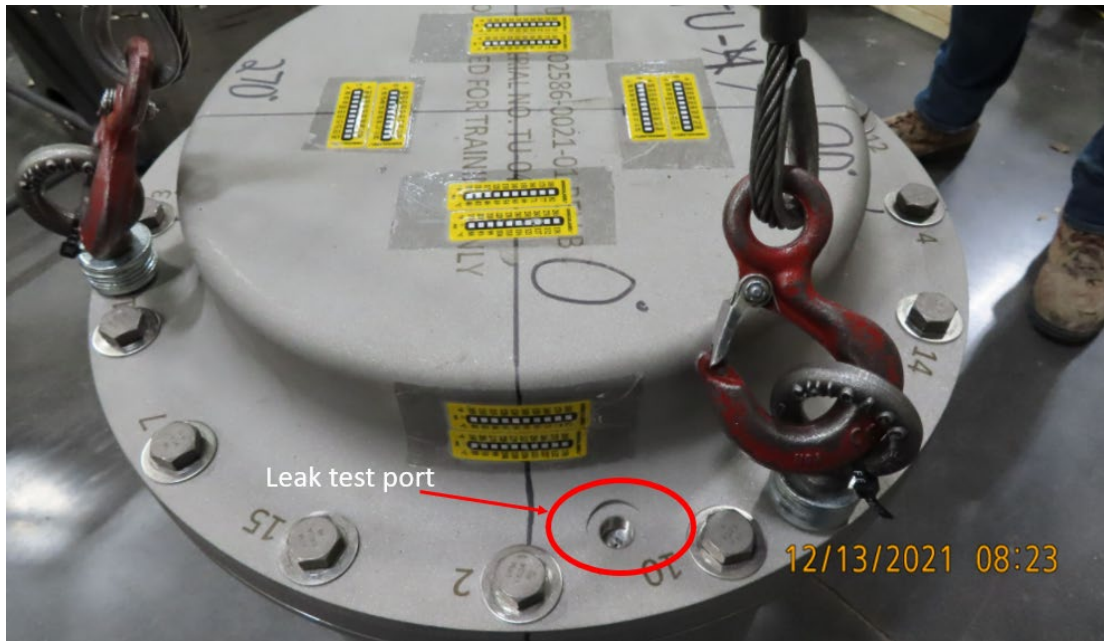
**Table 5-5. Posttest leak rate for the TU CVs**

ID	Leak rate (atm-cc/s)	Sensitivity (atm-cc/s)	Pressure mba (mTorr)	Temperature °C
TU-1	5.5E-08	2.0E-09	1.5E-02 (11.3)	19
TU-2	3.73E-08	2.0E-09	1.3E-02 (9.8)	17
TU-3	1.67E-08	2.0E-09	1.3E-02 (9.8)	17
TU-4	4.5E-08	2.0E-09	1.5E-02 (11.3)	19
TU-5	1.36E-07	2.0E-09	1.3E-2 (9.8)	17
TU-6	5.06E-08	2.0E-09	1.5E-02 (11.3)	19

## 5.5 15 M (50 FT) IMMERSION TEST (TU-7)

The CV of TU-7 was subjected to the 15 m immersion test per the test matrix in Table 1-1. The test was performed in accordance with PTP-PEF-15, Rev. 5, and 10 CFR 71.73(c)(6). Before the immersion test, the CV was removed from the drum assembly, and all interior and exterior surfaces were cleaned with isopropyl alcohol. The CV was reassembled and subjected to the pretest operational leak test (see Table 2-3 for leak test results of TU-7). The CV was subjected to an external hydrostatic pressurization to simulate the submersion of the CV in an open body of water at a depth of 15 m (50 ft) or an equivalent pressure of 21.7 psig. The test was executed at 25 psig to account for any pressure loss during the 8-hour test.

The CV leak test port between the O-rings was removed, and then the CV was lowered into a pressure vessel (Figure 5-17). The pressure vessel height was 6.5 ft (2 m), and the diameter was 2.5 ft (0.76 m), with a thickness of  $\frac{3}{8}$  in. (9.5 mm). The pressure vessel was used to submerge the CV, allowing for at least 0.3 m (1 ft) of depth from the top of the CV to the top surface of the pressure vessel flange. The pressure vessel contained a drain port on the underside and an O-ring groove on the top flange. The pressure vessel was half filled, TU-7 was lowered into the pressure vessel, and then the vessel was filled with water up to the top surface of the flange (Figure 5-17).



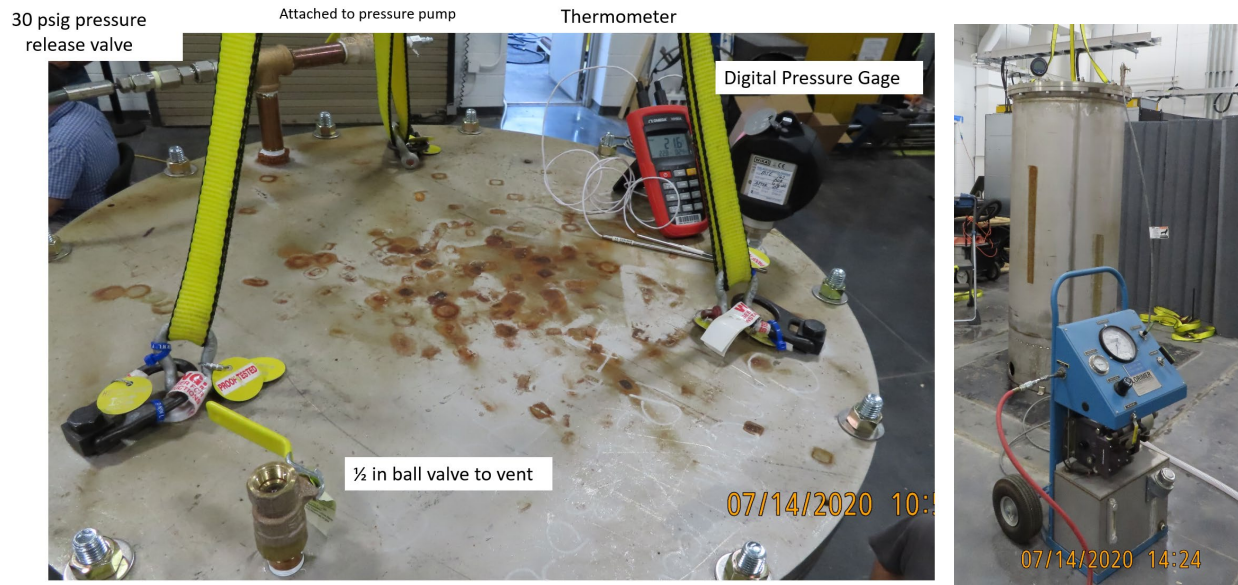
**Figure 5-16. TU-7 Leak test port removed.**





**Figure 5-17. TU-7 in water immersion pressure vessel.**

The lid to the vessel included three threaded ports on the top surface. One port was a  $\frac{1}{4}$  in. NPT to accept the installation of a 0–100 psi digital pressure gauge (ORNL ID 1A005UZNOK8, calibration due after each use). The second was fitted with a  $\frac{1}{2}$  in. ball valve to serve as a vent, and the third was fitted with a tube topped with a  $\frac{3}{4}$  in. NPT tee fitting (Figure 5-18). The tee accepted a certified pressure relief device set to 30 psig, whereas the opposite side accepted hose fittings from a pneumatically actuated pump attached through a  $\frac{3}{4}$  in. ball valve (Figure 5-19). A small amount of pressure was induced by compressive force while the lid bolts of the pressure vessel lid were tightened. Both ball valves were cycled to allow the pressurized water to be relieved from the vessel, eliminating any air gap. Pressure was then applied by the pneumatic pump to determine the adequacy of the O-ring seal and was vented again to ensure that any remaining air was removed.



**Figure 5-18. 15 m immersion test setup.**



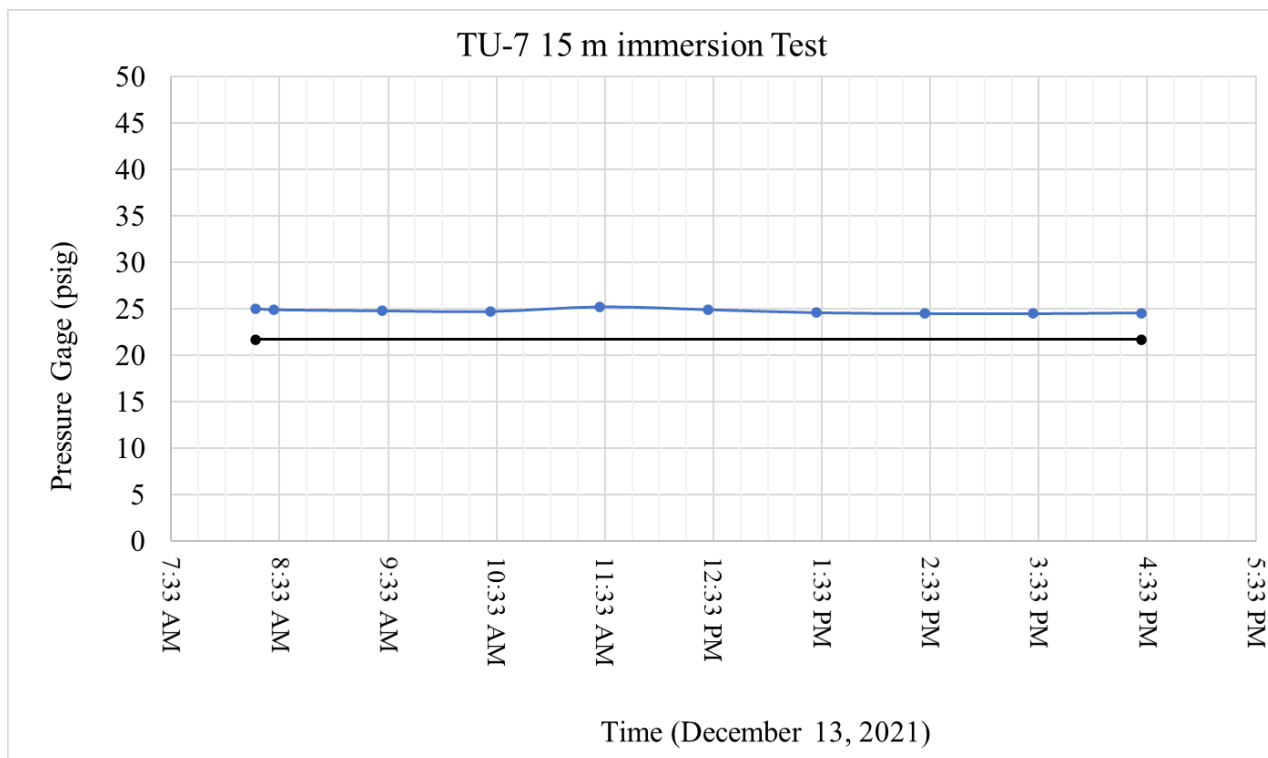
**Figure 5-19. Pneumatic pump for 15 m immersion test.**

Before pressurization, a calibrated temperature probe was inserted into the open 1/2 in. ball valve to measure the starting temperature of the water inside the test vessel. Once all was ready to proceed with pressurization, the pump was primed with shop air set to 60 psig at the source and adjusted by the pump regulator just high enough to allow for adequate cycle pressure. This pump drew from an onboard reservoir to pump water into the test vessel. The calibrated gauge atop the vessel lid was monitored during pressurization. Pressure was gradually brought up to a 25 psig test pressure over the course of approximately 10 min before the air supply was isolated; this was followed by isolation of the vessel from the pump water supply line. After a 30-minute observation and a loss of approximately 0.5 psig, pressure was increased to 25 psig to account for settling. The pressure was monitored continuously throughout the dwell time and increased as needed. After 8 hr, there had been a slight pressure rise due to temperature change (Figure 5-20). Pressure was released and the temperature was taken through the 1/2 in. valve before the container was removed from the test vessel for drying and inspection. The CV was removed from the

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pressure vessel and dried in accordance with the CV drying procedure in Test Form 14. The CV was dried, opened, and inspected for any signs of in-water leakage. Some water drops were observed between the inner and outer O-rings, but there were no traces of water found beyond the inner O-ring (Figure 5-21).

The pretest weight of TU-7 was 254 lb, and there was no presence of water inside the CV after the immersion test. The pretest and posttest torque values for the CV lid bolts are shown in Table 5-6 after the CV was subjected to the test defined in Section 5.5 and Table 1-1. The CV lid bolts pretest and break-away torque values were recorded on Test Forms 9 and 11.



**Figure 5-20. Pressure vessel gauge pressure for 15 m immersion test.**



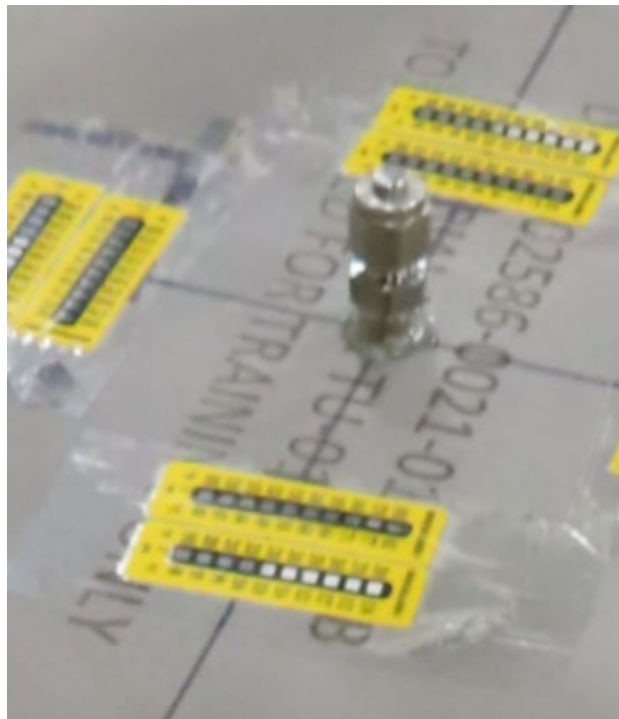
**Figure 5-21. TU-7 immersion test results.**

**Table 5-6. Pre- and post-torque values for TU-7 CV lid bolts [ft-lb]**

<b>Bolt #</b>	<b>TU-7</b>		
	<b>Assembly</b>	<b>Disassembly</b>	<b>Change</b>
<b>1</b>	35.5	26.6	-8.9
<b>2</b>	34.7	26.5	-8.2
<b>3</b>	35.3	30.8	-4.5
<b>4</b>	34.5	32.2	-2.3
<b>5</b>	35.9	30.7	-5.2
<b>6</b>	35.0	26.2	-8.8
<b>7</b>	34.8	30.7	-4.1
<b>8</b>	35.2	28.4	-6.8
<b>9</b>	35.4	28.0	-7.4
<b>10</b>	34.8	29.9	-4.9
<b>11</b>	35.4	30.8	-4.6
<b>12</b>	35.4	32.2	-3.2
<b>13</b>	34.5	35.9	1.4
<b>14</b>	34.8	33.1	-1.7
<b>15</b>	34.5	36.6	2.1
<b>16</b>	35.4	23.1	-12.3
<b>Average</b>	35.1	30.1	-5.0
<b>Std Dev</b>	0.4	3.6	3.8

## 5.6 0.9 M (3 FT) IMMERSION TEST

After the operational leak tests and helium leak tests were performed, TUs -1 through -6 were subjected to the HAC 0.9 m (3 ft) water immersion test in accordance with 10 CFR 71.73(c)(5). Prior to testing, the Swagelok-type fitting adapter on each CV was plugged with a watertight cap (Figure 5-22), and the CV leak test port between the O-rings was removed. The CVs were immersed under a head of water of at least 0.9 m (3 ft) for over 8 hr. The depth of the water was measured above the highest point of the CV and was determined to be between 40 and 41 in. with a 40-foot tape measure (ORNL ID A006327, calibration due 3/20/23). Figure 5-23 shows a CV in the water tank. At the conclusion of the immersion test, the CVs were removed from the water tank and dried using the procedure in Test Form 14 (Figure 5-24).



**Figure 5-22. Watertight cap on the CVs.**



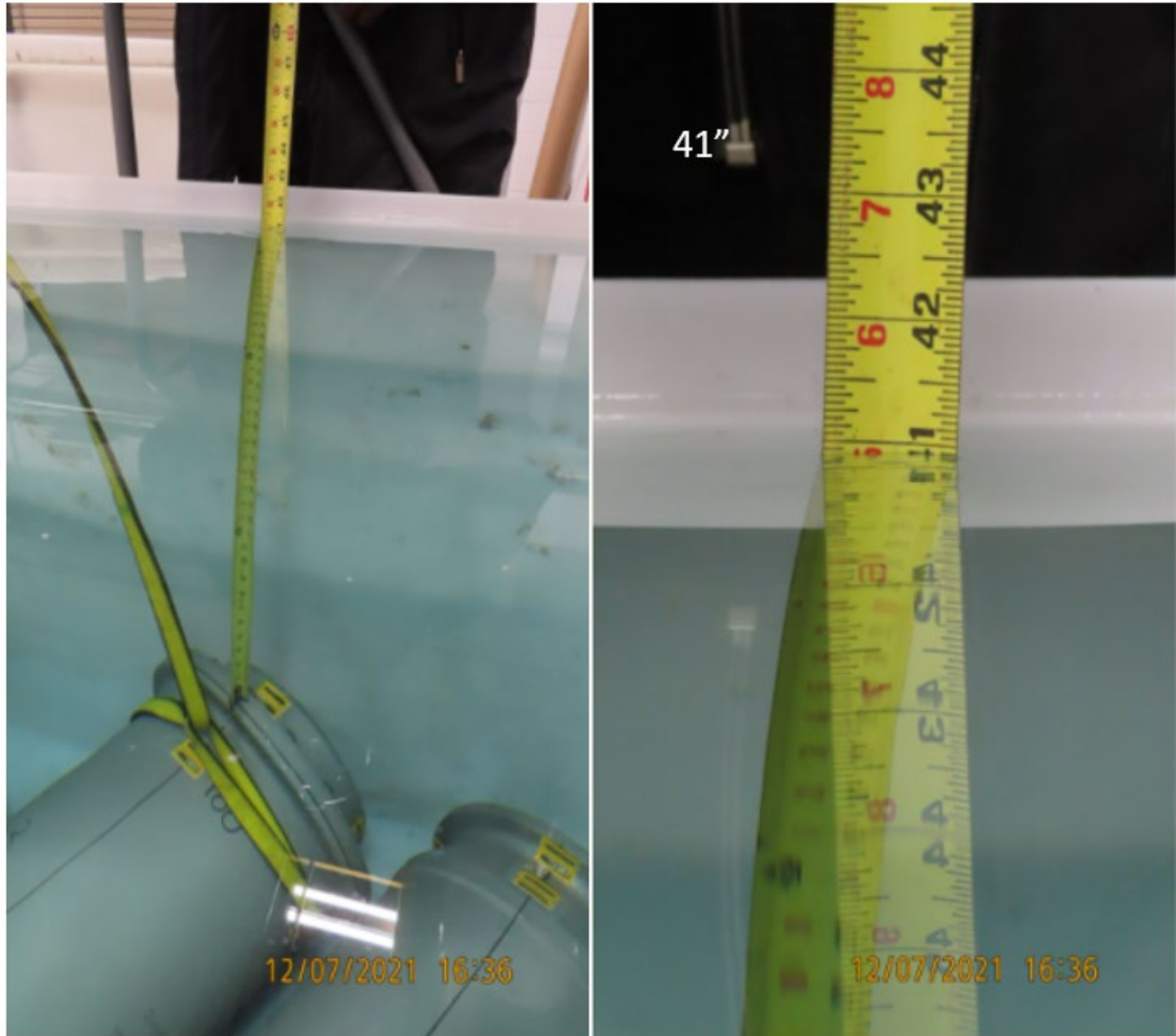


Figure 5-23. DPP-1 CV undergoing 3 ft immersion test.



**Figure 5-24. CV drying and opening process.**

### 5.6.1 CV Immersion Test Observations

After the CV drying process was completed, the CVs were opened to remove the contents, gather available data, and look for signs of water in-leakage. The break-away torque values for the CV lid bolts were recorded on Test Form 9. With the CV lid raised about ¼ in. above the CV body, the outer surfaces of the CV flange and the outside of the outer O-ring were dried with paper towels.

For CVs TU -1 through -6, there were no detectable water drops inside the inner O-rings, and no water was detected inside the CV body. Therefore, the CVs passed the water immersion test (Table 5-7). See the test forms in appendices H-M for additional information.

**Table 5-7. Water Immersion test results**

Test	CTU-1	CTU-2	CTU-3	CTU-4	CTU-5	CTU-6
Water Immersion 10 CFR 71.75 (c)(5)	Passed	Passed	Passed	Passed	Passed	Passed

## 5.7 CV DISASSEMBLY OBSERVATIONS

After a successful drying process, the CVs were opened according to the opening process outlined in Test Form 12. During disassembly of the CVs, the breakaway torques that were required to remove each of the 16 closure bolts were measured and recorded on Test Form 9 after each CV was subjected to the tests defined in Sections 3 and 4 and Table 1-1. The recorded disassembly torque values for CVs TU -1 through -6 can be seen below in Table 5-8 and Table 5-9. These recorded disassembly torque values of the CVs' post-HAC tests can be compared with the torque values of TU-7 in Table 5-6, which was not subjected to the NCT or HAC structural and thermal tests. The CV lid bolts were initially torqued to 35 ft-lb. The CV lid bolts were removed in a numerical order sequence, starting with bolt number 1 and ending with bolt number 16.

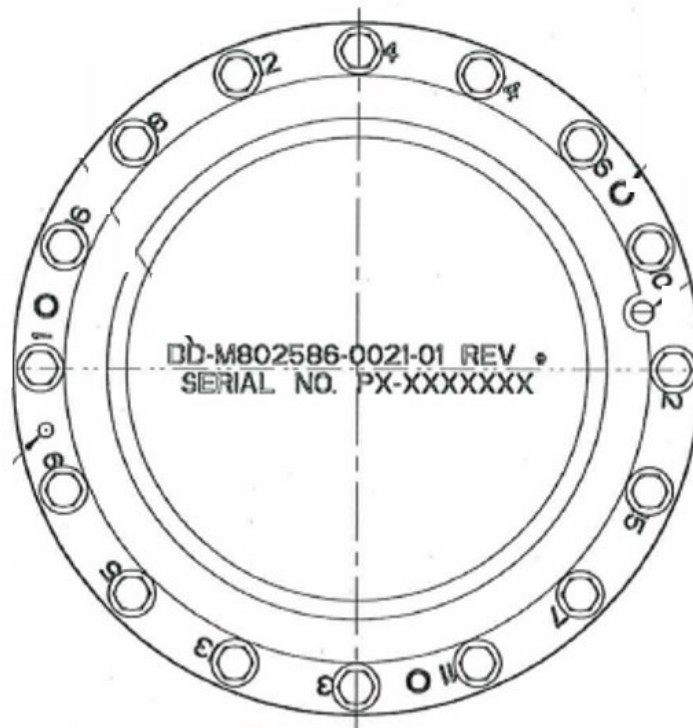


Figure 5-25. CV lid bolts.

**Table 5-8. CV lid bolts assembly and disassembly torque [ft-lb]**

Bolt #	TU-1			TU-2			TU-3		
	Assembly	Disassembly	Change	Assembly	Disassembly	Change	Assembly	Disassembly	Change
<b>1</b>	34.6	26.7	-7.9	35.2	23.3	-11.9	34.6	29.7	-4.9
<b>2</b>	34.6	13.7	-20.9	34.7	16.4	-18.3	35.0	26.9	-8.1
<b>3</b>	35.0	22.2	-12.8	34.6	30.7	-3.9	34.6	29.9	-4.7
<b>4</b>	35.2	24.9	-10.3	34.6	21.5	-13.1	34.4	32.0	-2.4
<b>5</b>	34.4	30.0	-4.4	35.9	28.5	-7.4	35.0	30.7	-4.3
<b>6</b>	34.7	23.6	-11.1	35.4	22.8	-12.6	34.6	23.9	-10.7
<b>7</b>	35.4	19.4	-16.0	34.7	27.5	-7.2	35.1	25.2	-9.9
<b>8</b>	34.4	26.0	-8.4	35.0	24.4	-10.6	36.4	30.3	-6.1
<b>9</b>	34.7	24.9	-9.8	34.8	26.6	-8.2	34.9	29.0	-5.9
<b>10</b>	34.8	22.1	-12.7	34.8	29.3	-5.5	35.3	25.8	-9.5
<b>11</b>	34.5	27.1	-7.4	34.4	28.5	-5.9	35.8	28.6	-7.2
<b>12</b>	35.1	26.2	-8.9	34.8	27.8	-7.0	34.7	27.4	-7.3
<b>13</b>	35.2	25.9	-9.3	34.8	37.7	2.9	36.0	26.7	-9.3
<b>14</b>	35.2	25.2	-10.0	34.9	36.0	1.1	35.7	25.6	-10.1
<b>15</b>	34.9	22.4	-12.5	35.2	39.5	4.3	34.9	25.5	-9.4
<b>16</b>	34.5	19.5	-15.0	35.2	38.2	3.0	35.1	35.5	0.4
<b>Average</b>	34.8	23.7	-11.1	34.9	28.7	-6.3	35.1	28.3	-6.8
<b>Std Dev</b>	0.3	3.9	3.9	0.4	6.5	6.5	0.6	3.0	3.1

**Table 5-9. CV lid bolts assembly and disassembly torque [ft-lb]**

Bolt #	TU-4			TU-5			TU-6		
	Assembly	Disassembly	Change	Assembly	Disassembly	Change	Assembly	Disassembly	Change
<b>1</b>	34.9	27.1	-7.8	35.0	24.2	-10.8	35.0	24.4	-10.6
<b>2</b>	35.0	11.1	-23.9	34.8	14.8	-20.0	34.6	8.7	-25.9
<b>3</b>	34.9	23.9	-11.0	35.4	22.5	-12.9	34.7	16.3	-18.4
<b>4</b>	34.6	24.7	-9.9	34.3	24.3	-10.0	35.1	20.7	-14.4
<b>5</b>	35.4	31.4	-4.0	36.0	27.6	-8.4	35.0	29.3	-5.7
<b>6</b>	35.4	29.5	-5.9	35.3	20.4	-14.9	34.5	29.2	-5.3
<b>7</b>	35.3	23.8	-11.5	34.8	24.7	-10.1	35.1	10.0	-25.1
<b>8</b>	35.0	35.9	0.9	34.6	24.3	-10.3	34.8	26.7	-8.1
<b>9</b>	35.3	32.0	-3.3	34.7	26.2	-8.5	35.3	29.0	-6.3
<b>10</b>	35.2	25.7	-9.5	34.7	22.2	-12.5	35.3	15.2	-20.1
<b>11</b>	34.8	27.3	-7.5	34.6	22.6	-12.0	34.6	25.1	-9.5
<b>12</b>	35.6	33.2	-2.4	35.1	23.3	-11.8	35.6	22.9	-12.7
<b>13</b>	35.3	34.0	-1.3	35.6	26.9	-8.7	34.8	36.5	1.7
<b>14</b>	35.5	35.9	0.4	34.6	23.1	-11.5	34.8	25.0	-9.8
<b>15</b>	34.8	33.5	-1.3	34.8	22.0	-12.8	34.9	16.4	-18.5
<b>16</b>	35.4	37.4	2.0	34.8	32.1	-2.7	34.8	34.8	0.0
<b>Average</b>	35.2	29.2	-6.0	34.9	23.8	-11.1	34.9	23.1	-11.8
<b>Std Dev</b>	0.3	6.6	6.5	0.4	3.7	3.6	0.3	8.1	8.1



### 5.7.1 TU-1 CV Observations

After completing the CV drying process documented on Test Form 12, the CV lid was removed from TU-1. The test weight assembly was noted as being aligned as originally placed and then was removed from the CV with the threaded holes on the top of the test weight assembly (Figure 5-26). Once the test weight assembly was removed, it was noted that there was no damage to the upper or lower silicon pads. The post-thermal weights were recorded on Test Form 6, as shown in Table 2-4. No other damage was observed on the remaining test weight assembly components or CV.



Figure 5-26. TU-1 test weight assembly removed from CV.

### 5.7.2 TU-2 CV Observations

After completing the CV drying process documented on Test Form 12, the CV lid was removed from TU-2. The test weight assembly was noted as being in the original placement orientation and then was removed from the CV with the threaded holes on the top of the test weight assembly (Figure 5-27). Once the test weight assembly was removed, it was noted that there was no damage to the upper or lower silicon pads. The post-thermal weights were recorded on Test Form 1 as shown in Table 2-5. No other damage was observed on the remaining test weight assembly components or CV.

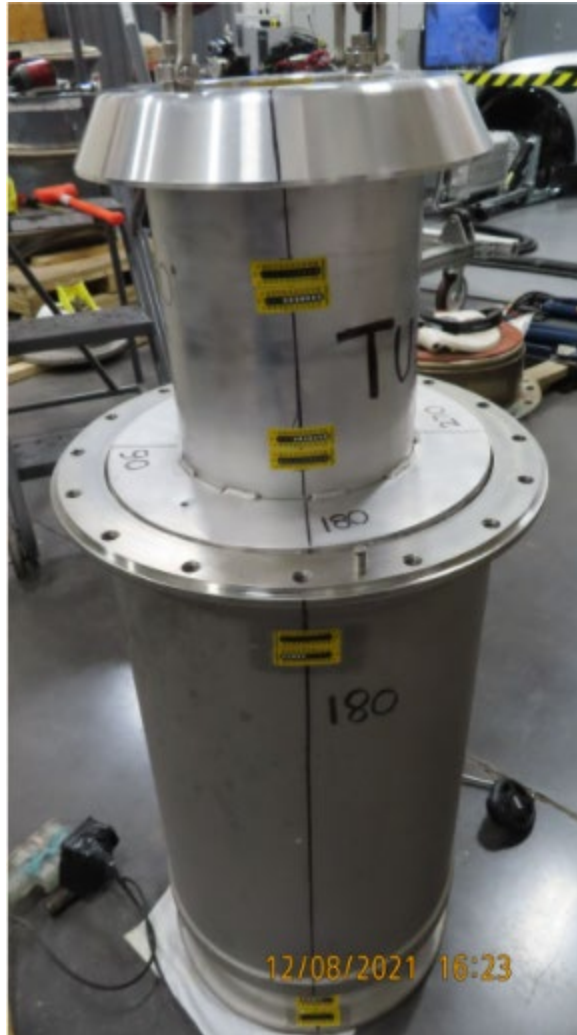
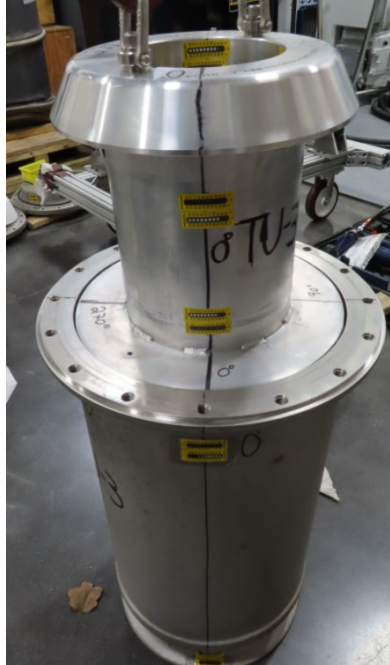


Figure 5-27. TU-2 test weight assembly removal.

### 5.7.3 TU-3 CV Observations

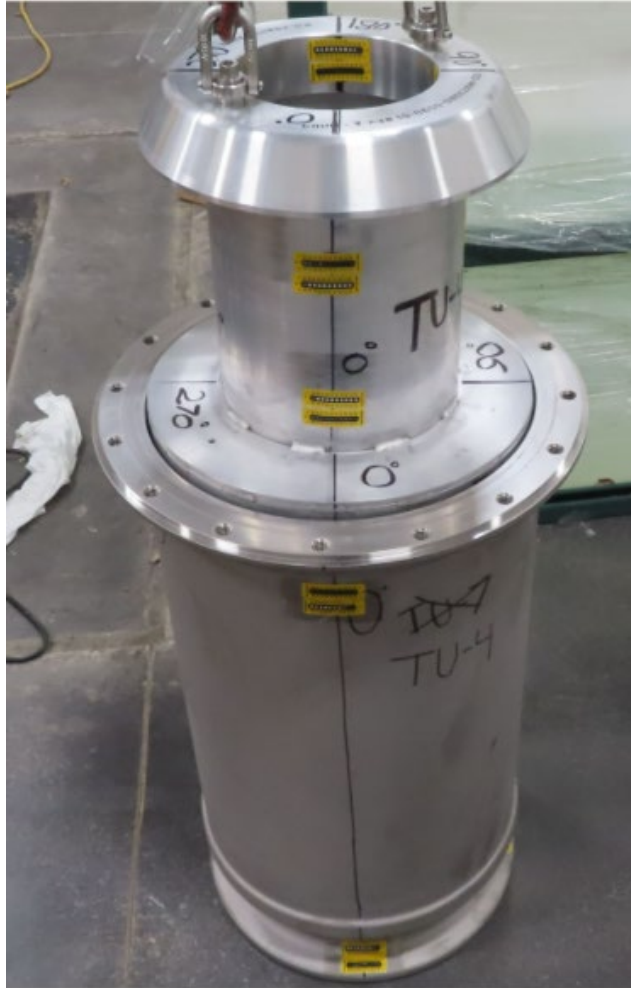
After completing the CV drying process documented on Test Form 12, the CV lid was removed from TU-3. The test weight assembly was noted as being in the original placement orientation and then was removed from the CV with the threaded holes on the top of the test weight assembly (Figure 5-28). Once the test weight assembly was removed, it was noted that there was no damage to the upper or lower silicon pads. The post-thermal weights were recorded on Test Form 1 as shown in Table 2-6. No other damage was observed on the remaining test weight assembly components or CV.



**Figure 5-28. TU-3 test weight assembly with CV during removal.**

#### **5.7.4 TU-4 CV Observations**

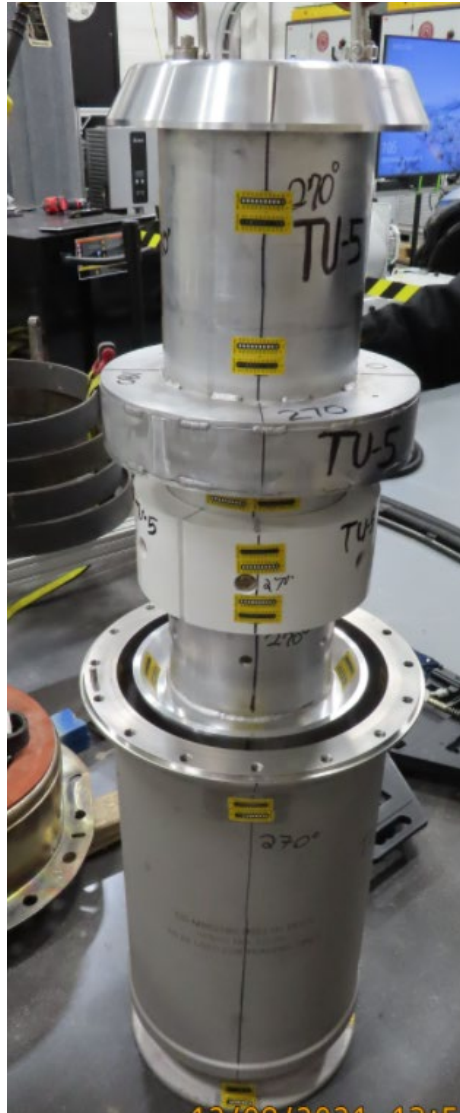
After completing the CV drying process documented on Test Form 12, the CV lid was removed from TU-4. The test weight assembly was noted as being in the original placement orientation and then was removed from the CV with the threaded holes on the top of the test weight assembly (Figure 5-29). Once the test weight assembly was removed, it was noted that there was no damage to the upper or lower silicon pads. The post-thermal weights were recorded on Test Form 1 as shown in Table 2-7. No other damage was observed on the remaining test weight assembly components or CV.



**Figure 5-29. TU-4 test weight assembly alignment during removal.**

### **5.7.5 TU-5 CV Observations**

After completing the CV drying process documented on Test Form 12, the CV lid was removed from TU-5. The test weight assembly was noted as being in the original placement orientation and then was removed from the CV with the threaded holes on the top of the test weight assembly (Figure 5-30). Once the test weight assembly was removed, it was noted that there was no damage to the upper or lower silicon pads. The post-thermal weights were recorded on Test Form 1 as shown in Table 2-8. No other damage was observed on the remaining test weight assembly components or CV.

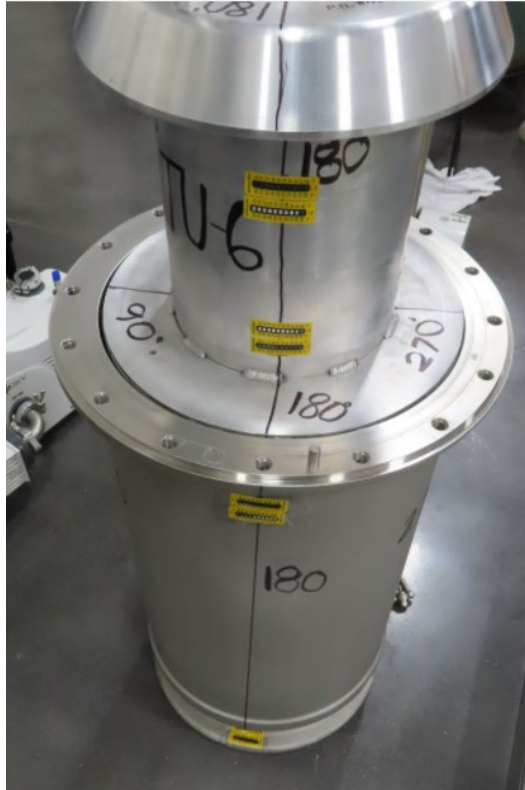


**Figure 5-30. TU-5 test weight assembly removal and posttest alignment.**

#### **5.7.6 TU-6 CV Observations**

After completing the CV drying process documented on Test Form 12, the CV lid was removed from TU-6. The test weight assembly was noted as being in the original placement orientation and then was removed from the CV with the threaded holes on the top of the test weight assembly (Figure 5-31). Once the test weight assembly was removed, it was noted that there was no damage to the upper or lower silicon pads. The post-thermal weights were recorded on Test Form 1 as shown in Table 2-9. No other damage was observed on the remaining test weight assembly components or CV.





**Figure 5-31. TU-6 test weight assembly post-alignment.**

## **5.8 TEMPERATURE-INDICATING LABEL RESULTS**

TLs were affixed to the drum body, drum body lid, CV body, and CV lid of TUs -1 through -6. The exterior of the CV body received 12 sets of TLs, and the CV lid exterior received 8 sets (Figure 5-32). The CV body interior received 24 sets of TLs, and the CV lid interior received 8 sets (Figure 5-33). The drum body received 20 sets of the TLs on the interior surfaces, and the drum lid received 4 sets of TLs (Figure 5-34). These labels indicated the maximum temperatures of the surfaces to which they were affixed for temperatures between 105 and 380°F (40 and 193°C) in increments of 10°F (5.5°C). The locations of the TLs were located as follows:

Exterior of the CV, 20 label sets of both, TL-10-105 and TL-10-190

- Four label sets placed circumferentially, 90° apart 2.5 in. below CV body flange
- Four label sets placed circumferentially, 90° apart at 0.75 in. above the CV base
- Four label sets placed circumferentially, 90° apart, 2.25 in. above the CV base
- Four label sets placed circumferentially, 90° apart, 2.0 in. away from the center of the CV lid
- Four label sets placed circumferentially, 90° apart, 6.6 in. away from the center of the CV lid

Interior of the CV, 28 label sets of both per CV, TL-10-105 and TL-10-190

- Four label sets placed circumferentially, 90° apart, 0.5 in. below CV flange
- Four label sets placed circumferentially, 90° apart, 6.0 in. below CV flange
- Four label sets placed circumferentially, 90° apart, 14.0 in. below CV flange
- Four label sets placed circumferentially, 90° apart, 3.75 in. above the CV base

- Four label sets placed circumferentially, 90° apart, 7.5 in. above the CV base
- Four label sets placed circumferentially, 90° apart, 2.0 in. away from the center of the CV lid
- Four label sets placed circumferentially, 90° apart, at the flange area of the CV lid

Test content assembly, 36 label sets of both per CV, TL-10-105 and TL-10-190

- Four label sets placed circumferentially, 90° apart, top end cap center
- Four label sets placed circumferentially, 90° apart, top end cap under flange
- Four label sets placed circumferentially, 90° apart, tube upper
- Four label sets placed circumferentially, 90° apart, tube middle
- Four label sets placed circumferentially, 90° apart, tube lower
- Four label sets placed circumferentially, 90° apart, bottom end cap under flange
- Four label sets placed circumferentially, 90° apart, bottom end cap center
- Four label sets placed circumferentially, 90° apart, weight upper
- Four label sets placed circumferentially, 90° apart, weight lower

Interior of the drum body, 24 sets, total of both TL-10-190 and TL-10-290

- Four label sets placed circumferentially, 90° apart, 1.75 in. above the base of the interior of the drum body
- Four label sets placed circumferentially, 90° apart, 8.0 in. above the base of the interior of the drum body
- Four label sets placed circumferentially, 90° apart, 17.0 in. above the base of the interior of the drum body
- Four label sets placed circumferentially, 90° apart, 26.0 in. above the base of the interior of the drum body
- Four label sets placed circumferentially, 90° apart, 2.0 in. away from the center of the bottom of the drum body
- Four label sets placed circumferentially, 90° apart, 2.0 in. away from the center of the drum body lid

TL sets on the CV and drum bodies were covered with high-temperature fluorinated ethylene propylene (FEP) tape (Teflon).

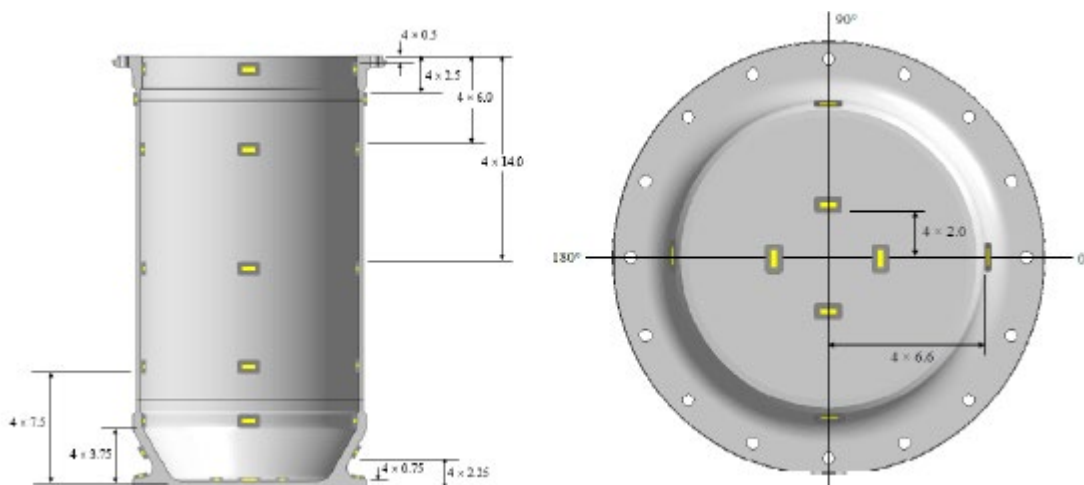
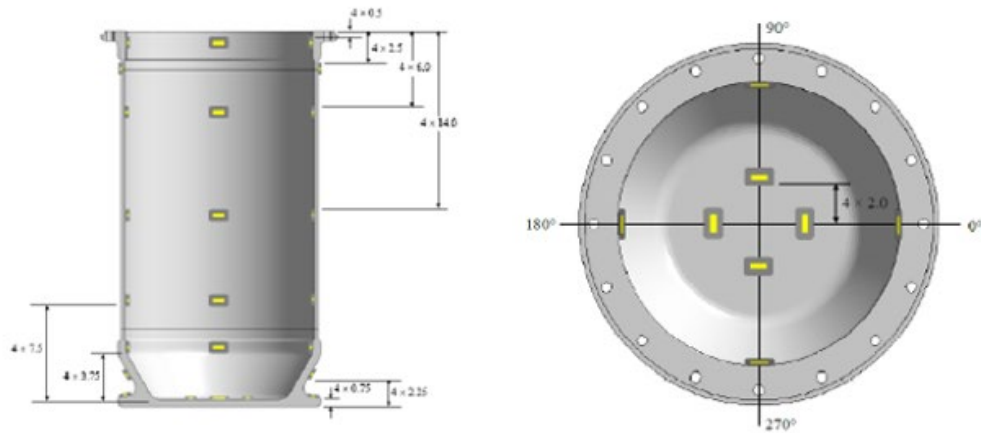
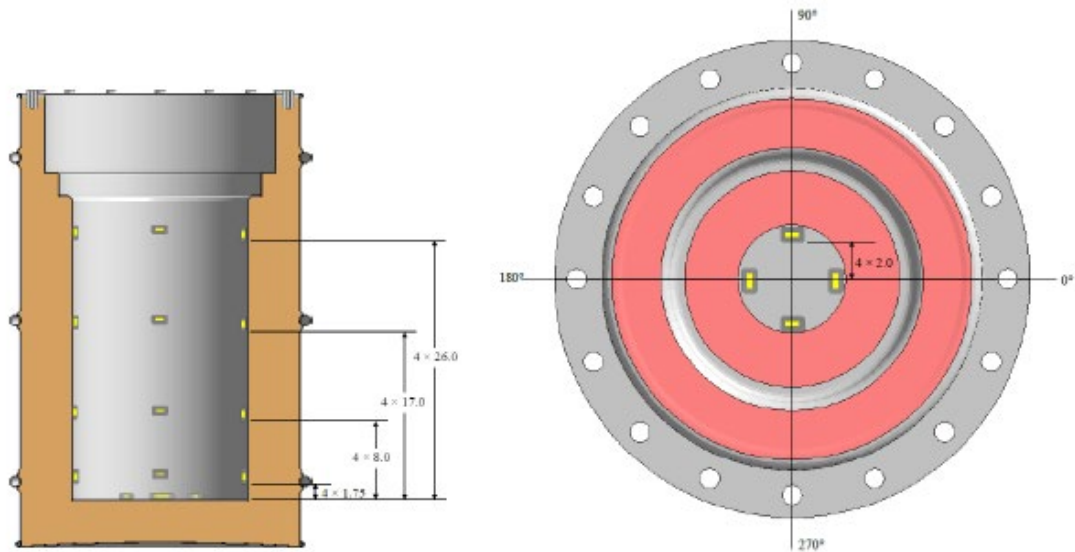


Figure 5-32. CV exterior body TL set locations.



**Figure 5-33. CV interior TL set locations.**



**Figure 5-34. TL set locations on interior of drum.**

For most CVs, the TL on the CV body flange was damaged from excessive scuffing from the drum inner liner. Actual temperature indicator readings on the exterior and interior of the CV, drum liner, and test content assembly are shown in Table 5-10 through Table 5-15. Temperature readings from the TLs were also recorded on Test Form 6 for each TU.

**Table 5-10. TU-1 temperature label results**

<b>Temperature indicator number location chart</b>				
<b>Test content assembly (TL-10-105, TL-10-190)</b>				
Location (outside)	0°	90°	180°	270°
Top end cap center	1 200°F	2 200°F	3 200°F	4 200°F
Top end cap under flange	5 200°F	6 200°F	7 200°F	8 200°F
Tube upper	9 200°F	10 200°F	11 200°F	12 200°F
Tube middle	13 200°F	14 200°F	15 200°F	16 200°F
Tube lower	17 200°F	18 200°F	19 200°F	20 200°F
Bottom end cap under flange	21 200°F	22 200°F	23 200°F	24 200°F
Bottom end cap center	25 200°F	26 200°F	27 200°F	28 200°F
Weight upper	29 200°F	30 200°F	31 200°F	32 200°F
Weight lower	33 200°F	34 200°F	35 200°F	36 200°F
<b>Interior of the CV (TL-10-105, TL-10-190)</b>				
CV lid center	37 220°F	38 220°F	39 210°F	40 220°F
CV body flange	41 210°F	42 210°F	43 210°F	44 210°F
CV wall upper	45 200°F	46 210°F	47 210°F	48 210°F
CV wall middle	49 200°F	50 200°F	51 210°F	52 210°F
CV wall lower	53 200°F	54 200°F	55 210°F	56 200°F
CV base neck	57 190°F	58 200°F	59 200°F	60 200°F
CV base center	61 190°F	62 190°F	63 200°F	64 190°F
<b>Exterior of the CV (TL-10-105, TL-10-190)</b>				
Lid center	65 220°F	66 220°F	67 220°F	68 220°F
Lid flange	69 220°F	70 220°F	71 220°F	72 220°F
Body flange	73 210°F	74 220°F	75 220°F	76 220°F
Base neck	77 200°F	78 200°F	79 200°F	80 200°F
Base toe	81 200°F	82 200°F	83 200°F	84 200°F
<b>Drum assembly (TL-10-190, TL-10-290)</b>				
Lid bottom	85 230°F	85 230°F	85 230°F	85 230°F
Cavity wall upper	89 230°F	90 250°F	91 250°F	92 240°F
Cavity wall middle	93 240°F	94 240°F	95 250°F	96 240°F
Cavity wall lower	97 230°F	98 240°F	99 240°F	100 230°F
Cavity wall lowest	101 200°F	102 230°F	103 230°F	104 220°F
Cavity bottom	105 200°F	106 210°F	107 210°F	108 210°F

**Table 5-11. TU-2 temperature label results**

<b>Temperature indicator number location chart</b>				
<b>Test content assembly (TL-10-105, TL-10-190)</b>				
Location (outside)	0°	90°	180°	270°
Top end cap center	1 210°F	2 210°F	3 210°F	4 210°F
Top end cap under flange	5 210°F	6 210°F	7 210°F	8 210°F
Tube upper	9 210°F	10 210°F	11 210°F	12 210°F
Tube middle	13 210°F	14 210°F	15 210°F	16 210°F
Tube lower	17 200°F	18 200°F	19 200°F	20 200°F
Bottom end cap under flange	21 210°F	22 210°F	23 210°F	24 210°F
Bottom end cap center	25 200°F	26 200°F	27 200°F	28 200°F
Weight upper	29 210°F	30 210°F	31 210°F	32 210°F
Weight lower	33 210°F	34 210°F	35 210°F	36 210°F
<b>Interior of the CV (TL-10-105, TL-10-190)</b>				
CV lid center	37 220°F	38 220°F	39 210°F	40 220°F
CV body flange	41 210°F	42 210°F	43 210°F	44 210°F
CV wall upper	45 200°F	46 210°F	47 210°F	48 210°F
CV wall middle	49 210°F	50 210°F	51 210°F	52 210°F
CV wall lower	53 210°F	54 210°F	55 210°F	56 210°F
CV base neck	57 200°F	58 200°F	59 210°F	60 200°F
CV base center	61 200°F	62 200°F	63 200°F	64 210°F
<b>Exterior of the CV (TL-10-105, TL-10-190)</b>				
Lid center	65 230°F	66 230°F	67 230°F	68 230°F
Lid flange	69 230°F	70 230°F	71 230°F	72 230°F
Body flange	73 230°F	74 230°F	75 230°F	76 230°F
Base neck	77 220°F	78 210°F	79 210°F	80 210°F
Base toe	81 220°F	82 210°F	83 210°F	84 210°F
<b>Drum assembly (TL-10-190, TL-10-290)</b>				
Lid bottom	85 230°F	85 230°F	85 230°F	85 230°F
Cavity wall upper	89 230°F	90 240°F	91 240°F	92 250°F
Cavity wall middle	93 230°F	94 240°F	95 250°F	96 250°F
Cavity wall lower	97 240°F	98 230°F	99 250°F	100 240°F
Cavity wall lowest	101 Damaged	102 230°F	103 Damaged	104 220°F
Cavity bottom	105 230°F	106 220°F	107 220°F	108 220°F



**Table 5-12. TU-3 temperature label results**

<b>Temperature indicator number location chart</b>				
<b>Test content assembly (TL-10-105, TL-10-190)</b>				
Location (outside)	0°	90°	180°	270°
Top end cap center	1 200°F	2 200°F	3 200°F	4 200°F
Top end cap under flange	5 200°F	6 200°F	7 200°F	8 200°F
Tube upper	9 200°F	10 200°F	11 200°F	12 200°F
Tube middle	13 200°F	14 200°F	15 200°F	16 200°F
Tube lower	17 190°F	18 190°F	19 190°F	20 190°F
Bottom end cap under flange	21 190°F	22 190°F	23 190°F	24 190°F
Bottom end cap center	25 180°F	26 190°F	27 180°F	28 190°F
Weight upper	29 190°F	30 190°F	31 190°F	32 190°F
Weight lower	33 190°F	34 190°F	35 190°F	36 190°F
<b>Interior of the CV (TL-10-105, TL-10-190)</b>				
CV lid center	37 210°F	38 210°F	39 210°F	40 210°F
CV body flange	41 200°F	42 210°F	43 210°F	44 210°F
CV wall upper	45 200°F	46 210°F	47 210°F	48 210°F
CV wall middle	49 200°F	50 200°F	51 210°F	52 200°F
CV wall lower	53 200°F	54 200°F	55 200°F	56 200°F
CV base neck	57 190°F	58 190°F	59 200°F	60 190°F
CV base center	61 190°F	62 190°F	63 190°F	64 190°F
<b>Exterior of the CV (TL-10-105, TL-10-190)</b>				
Lid center	65 210°F	66 210°F	67 210°F	68 210°F
Lid flange	69 210°F	70 210°F	71 220°F	72 210°F
Body flange	73 210°F	74 210°F	75 220°F	76 210°F
Base neck	77 200°F	78 200°F	79 200°F	80 200°F
Base toe	81 190°F	82 190°F	83 200°F	84 190°F
<b>Drum assembly (TL-10-190, TL-10-290)</b>				
Lid bottom	85 230°F	85 230°F	85 230°F	85 230°F
Cavity wall upper	89 230°F	90 230°F	91 240°F	92 240°F
Cavity wall middle	93 230°F	94 230°F	95 240°F	96 240°F
Cavity wall lower	97 240°F	98 230°F	99 240°F	100 240°F
Cavity wall lowest	101 230°F	102 220°F	103 230°F	104 220°F
Cavity bottom	105 210°F	106 210°F	107 200°F	108 200°F

**Table 5-13. TU-4 temperature label results**

<b>Temperature indicator number location chart</b>				
<b>Test content assembly (TL-10-105, TL-10-190)</b>				
Location (outside)	0°	90°	180°	270°
Top end cap center	1 190°F	2 190°F	3 190°F	4 190°F
Top end cap under flange	5 190°F	6 190°F	7 190°F	8 190°F
Tube upper	9 190°F	10 190°F	11 190°F	12 190°F
Tube middle	13 190°F	14 190°F	15 190°F	16 190°F
Tube lower	17 190°F	18 190°F	19 190°F	20 190°F
Bottom end cap under flange	21 180°F	22 180°F	23 180°F	24 180°F
Bottom end cap center	25 180°F	26 180°F	27 180°F	28 180°F
Weight upper	29 180°F	30 180°F	31 180°F	32 180°F
Weight lower	33 180°F	34 180°F	35 180°F	36 180°F
<b>Interior of the CV (TL-10-105, TL-10-190)</b>				
CV lid center	37 190°F	38 190°F	39 190°F	40 190°F
CV body flange	41 200°F	42 200°F	43 200°F	44 200°F
CV wall upper	45 200°F	46 200°F	47 200°F	48 200°F
CV wall middle	49 190°F	50 190°F	51 200°F	52 190°F
CV wall lower	53 190°F	54 190°F	55 190°F	56 190°F
CV base neck	57 180°F	58 190°F	59 190°F	60 180°F
CV base center	61 180°F	62 180°F	63 180°F	64 190°F
<b>Exterior of the CV (TL-10-105, TL-10-190)</b>				
Lid center	65 210°F	66 210°F	67 210°F	68 210°F
Lid flange	69 210°F	70 210°F	71 210°F	72 210°F
Body flange	73 210°F	74 210°F	75 210°F	76 210°F
Base neck	77 190°F	78 190°F	79 190°F	80 190°F
Base toe	81 190°F	82 190°F	83 190°F	84 190°F
<b>Drum assembly (TL-10-190, TL-10-290)</b>				
Lid bottom	85 230°F	85 230°F	85 230°F	85 230°F
Cavity wall upper	89 230°F	90 230°F	91 240°F	92 230°F
Cavity wall middle	93 230°F	94 230°F	95 240°F	96 230°F
Cavity wall lower	97 220°F	98 230°F	99 240°F	100 220°F
Cavity wall lowest	101 200°F	102 220°F	103 230°F	104 220°F
Cavity bottom	105 220°F	106 210°F	107 210°F	108 220°F

**Table 5-14. TU-5 temperature label results**

<b>Temperature indicator number location chart</b>				
<b>Test content assembly (TL-10-105, TL-10-190)</b>				
Location (outside)	0°	90°	180°	270°
Top end cap center	1 190°F	2 190°F	3 190°F	4 190°F
Top end cap under flange	5 190°F	6 180°F	7 180°F	8 190°F
Tube upper	9 180°F	10 180°F	11 180°F	12 180°F
Tube middle	13 180°F	14 180°F	15 180°F	16 180°F
Tube lower	17 180°F	18 180°F	19 180°F	20 180°F
Bottom end cap under flange	21 180°F	22 180°F	23 180°F	24 180°F
Bottom end cap center	25 180°F	26 180°F	27 180°F	28 180°F
Weight upper	29 180°F	30 180°F	31 180°F	32 180°F
Weight lower	33 180°F	34 180°F	35 180°F	36 180°F
<b>Interior of the CV (TL-10-105, TL-10-190)</b>				
CV lid center	37 190°F	38 190°F	39 190°F	40 190°F
CV body flange	41 200°F	42 200°F	43 200°F	44 200°F
CV wall upper	45 190°F	46 190°F	47 200°F	48 200°F
CV wall middle	49 190°F	50 190°F	51 190°F	52 190°F
CV wall lower	53 180°F	54 180°F	55 180°F	56 190°F
CV base neck	57 180°F	58 180°F	59 180°F	60 180°F
CV base center	61 180°F	62 180°F	63 180°F	64 180°F
<b>Exterior of the CV (TL-10-105, TL-10-190)</b>				
Lid center	65 200°F	66 200°F	67 200°F	68 200°F
Lid flange	69 200°F	70 200°F	71 200°F	72 200°F
Body flange	73 200°F	74 200°F	75 200°F	76 200°F
Base neck	77 180°F	78 180°F	79 190°F	80 190°F
Base toe	81 180°F	82 180°F	83 190°F	84 190°F
<b>Drum assembly (TL-10-190, TL-10-290)</b>				
Lid bottom	85 210°F	85 210°F	85 210°F	85 210°F
Cavity wall upper	89 220°F	90 220°F	91 230°F	92 230°F
Cavity wall middle	93 220°F	94 220°F	95 230°F	96 230°F
Cavity wall lower	97 220°F	98 210°F	99 230°F	100 230°F
Cavity wall lowest	101 210°F	102 210°F	103 220°F	104 220°F
Cavity bottom	105 210°F	106 210°F	107 210°F	108 210°F

**Table 5-15. TU-6 temperature label results**

<b>Temperature indicator number location chart</b>				
<b>Test content assembly (TL-10-105, TL-10-190)</b>				
Location (outside)	0°	90°	180°	270°
Top end cap center	1 190°F	2 190°F	3 190°F	4 190°F
Top end cap under flange	5 190°F	6 190°F	7 190°F	8 190°F
Tube upper	9 190°F	10 190°F	11 190°F	12 190°F
Tube middle	13 190°F	14 190°F	15 190°F	16 190°F
Tube lower	17 190°F	18 190°F	19 190°F	20 190°F
Bottom end cap under flange	21 190°F	22 190°F	23 190°F	24 190°F
Bottom end cap center	25 190°F	26 190°F	27 190°F	28 190°F
Weight upper	29 190°F	30 190°F	31 190°F	32 190°F
Weight lower	33 190°F	34 190°F	35 190°F	36 190°F
<b>Interior of the CV (TL-10-105, TL-10-190)</b>				
CV lid center	37 200°F	38 200°F	39 200°F	40 200°F
CV body flange	41 200°F	42 200°F	43 210°F	44 200°F
CV wall upper	45 200°F	46 200°F	47 210°F	48 200°F
CV wall middle	49 190°F	50 200°F	51 200°F	52 200°F
CV wall lower	53 190°F	54 190°F	55 200°F	56 190°F
CV base neck	57 180°F	58 190°F	59 190°F	60 190°F
CV base center	61 180°F	62 180°F	63 180°F	64 180°F
<b>Exterior of the CV (TL-10-105, TL-10-190)</b>				
Lid center	65 210°F	66 210°F	67 210°F	68 210°F
Lid flange	69 210°F	70 210°F	71 210°F	72 210°F
Body flange	73 210°F	74 210°F	75 210°F	76 210°F
Base neck	77 190°F	78 190°F	79 190°F	80 190°F
Base toe	81 190°F	82 190°F	83 190°F	84 190°F
<b>Drum assembly (TL-10-190, TL-10-290)</b>				
Lid bottom	85 220°F	85 220°F	85 230°F	85 230°F
Cavity wall upper	89 210°F	90 240°F	91 230°F	92 230°F
Cavity wall middle	93 220°F	94 230°F	95 240°F	96 230°F
Cavity wall lower	97 200°F	98 230°F	99 240°F	100 220°F
Cavity wall lowest	101 210°F	102 210°F	103 220°F	104 210°F
Cavity bottom	105 210°F	106 210°F	107 210°F	108 210°F

## 6. 3D SCANNER METROLOGY ANALYSIS OF DPP-1 TU-6

### 6.1 PRETEST MEASUREMENTS

Shipping packages damage analysis is traditionally performed using the tried-and-true method of manual measurements with conventional tools like straight-edge rulers, calipers, tapes, and visual inspection of damage points. This often introduces the challenge of ensuring that measurements are repeatable by different people tasked with measuring damage because of different perceptions of where damage starts and ends on a TU.

The package evaluation facility recently acquired a high-end 3D scanner as part of the DPP-1 testing campaign to investigate the potential of using 3D scanning technology to analyze gross damage to TUs after they have been subjected to the NCT and HAC drops. The use of 3D scanning technology has increased in the areas of accident investigation, reverse engineering, quality assurance inspection, and metrology analysis.

As part of the DPP-1 test campaign, all the TUs were scanned before any test was carried out (initial condition), and they were all scanned after each mandated test, except for TUs -1 and -5, which were preconditioned to a temperature of -45°F, and the time requirement for all tests to be completed did not permit for scanning after each test. The analysis presented below shows the results obtained on TU-6 before testing, after the penetration test, and after the 30 ft crush plate test.

### 6.2 TU-6 PRETEST MEASUREMENT COMPARISON

Before TU-6 was subjected to any NCT or HAC tests, it was scanned, and the dimensions were recorded as shown in Table 6-1. The scanned dimensions were compared with the dimensions obtained from direct measurement of TU-6. Figure 6-1 through Figure 6-3 illustrate the pretest dimensions as obtained from the 3D scanning software. As shown in Table 6-1, the measurements obtained using the scanners align with the direct measurements, except at a few locations.

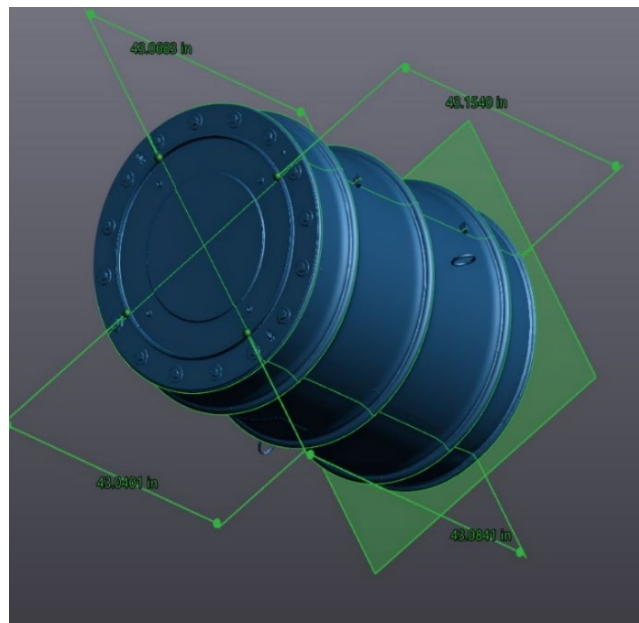
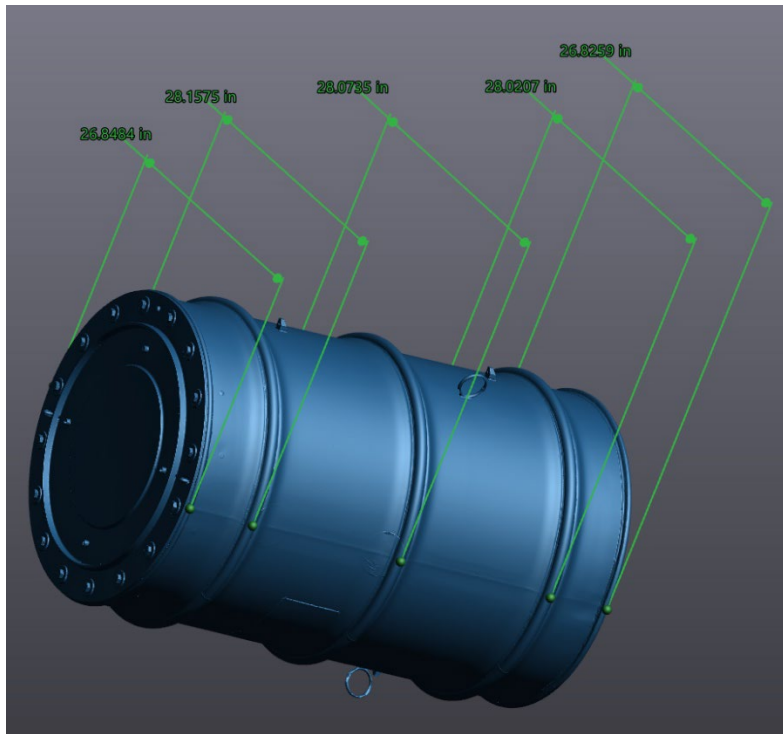
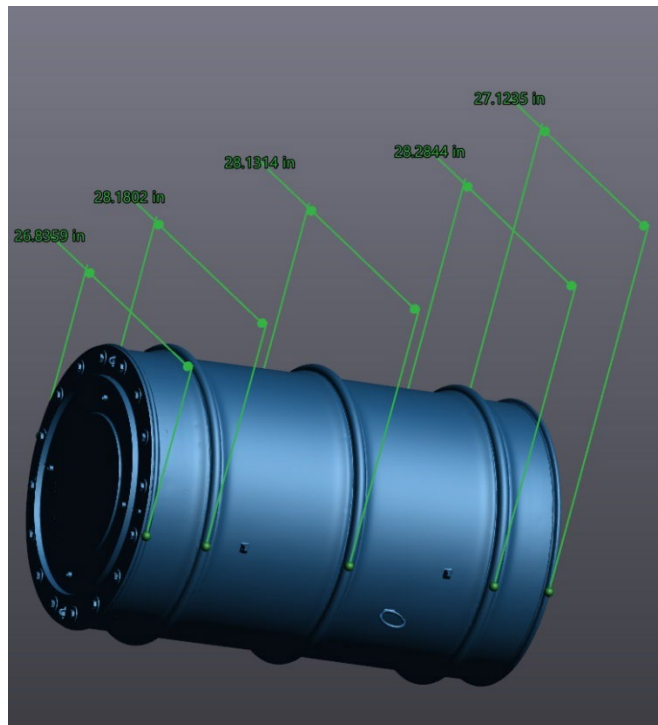


Figure 6-1. TU-6 pretest height dimensions.





**Figure 6-2. TU-6 radial dimension on 0° - 180° axes.**



**Figure 6-3. TU-6 radial dimension on 90° - 270° axes.**

**Table 6-1. TU-6 pretest dimension comparison**

<b>Vertical height (all dimensions in.)</b>					
<b>Position</b>	<b>Measured</b>	<b>Scanned</b>	<b>Drawing</b>	<b>D<sub>draw-measured</sub></b>	<b>D<sub>draw-scan</sub></b>
<b>0°</b>	43.125	43.084	43.01	-0.12	-0.07
<b>90°</b>	43.125	43.154	43.01	-0.12	-0.14
<b>180°</b>	43.063	43.068	43.01	-0.05	-0.06
<b>270°</b>	43.063	43.04	43.01	-0.05	-0.03
<b>Radial at 0° - 180°</b>					
<b>Top surface</b>	26.875	26.848	26.9	0.02	0.05
<b>Top rolling hoop</b>	28.125	28.158	28.24	0.11	0.08
<b>Center rolling hoop</b>	28.063	28.074	28.24	0.18	0.17
<b>Bottom rolling hoop</b>	28.063	28.021	28.24	0.18	0.22
<b>Bottom surface</b>	26.813	26.826	27.16	0.35	0.33
<b>Radial at 90° - 270°</b>					
<b>Top surface</b>	26.75	26.836	26.9	0.15	0.06
<b>Top rolling hoop</b>	28.063	28.18	28.24	0.18	0.06
<b>Center rolling hoop</b>	28.25	28.131	28.24	-0.01	0.11
<b>Bottom rolling hoop</b>	28.25	28.284	28.24	-0.01	-0.04
<b>Bottom surface</b>	27.125	27.124	27.16	0.04	0.04

### 6.3 TU-6 PENETRATION TEST ANALYSIS

One of the challenging measurements to obtain on a damaged TU is the depth of a dent caused during the NCT penetration and HAC puncture tests. There is no error-proof method except to rely on expert judgement to estimate curvature length and penetration depth. The 3D scanner technology dent analysis appears to be a more reliable method to obtain accurate, repeatable measurement of curved dents. After TU-6 was subjected to the penetration test, the unit was scanned and the 3D dent prolife analyzer was used to obtain depth profile of the penetration point. The result of the analysis is shown in Figure 6-4. In the dent profile analyzer, the initial scan of TU-6 was overlayed and aligned with the deformed TU-6 scan, and the profiler was then used to determine the difference in the surfaces at the point of penetration impact. Figure 6-5 shows a close-up view of the dent profile. Note that, apart from the depth, which can be read to be about 0.1837 in. at the deepest part of the profile, it also possible to measure the length of the depression at different points.

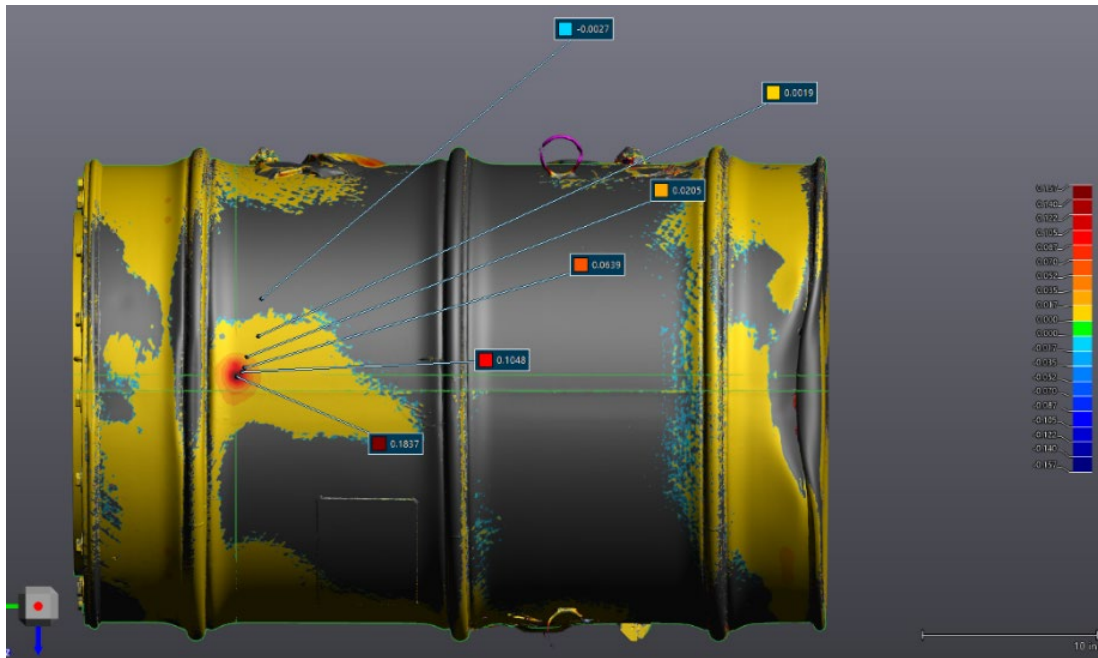


Figure 6-4. Dent profile of TU-6 after penetration test.

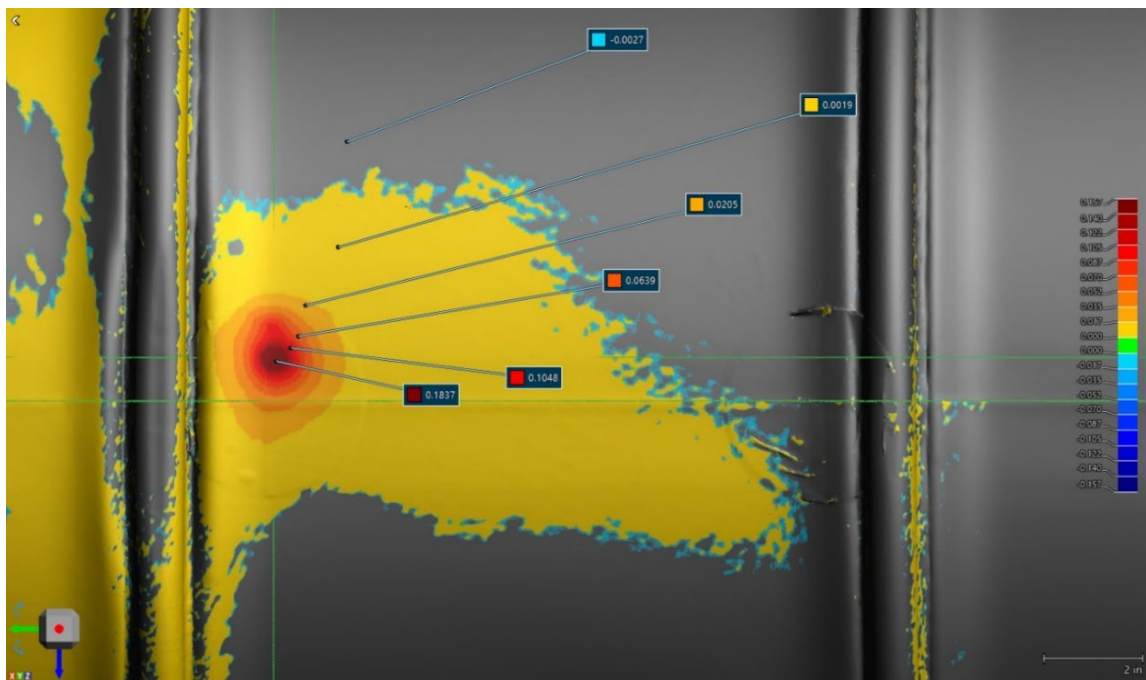


Figure 6-5. Close-up of TU-6 dent depth profile after the penetration test.

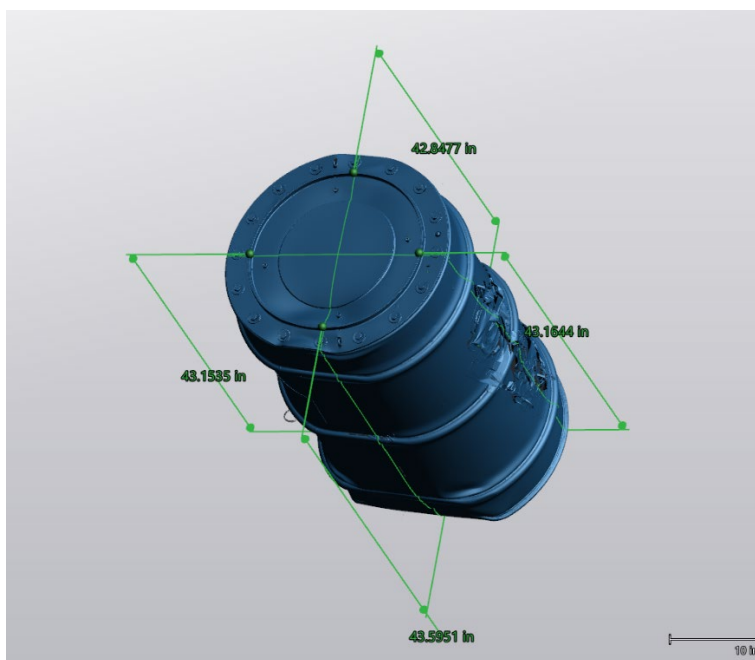
## 6.4 TU-6 CRUSH PLATE TEST RESULT

The full 3D scan of TU-6 was acquired after the HAC 30 ft crush plate test. Dimensions of the TU were obtained at almost the same locations as those used in the pretest locations. The obtained results are shown in Figure 6-6 through Figure 6-8. Table 6-2 through Table 6-4 show the results as compared to the measurements obtained before the crush plate test.

**Table 6-2. Comparison between measured and scanned height**

Vertical height (all dimensions in.)						
Position	Measured pre-drop	Scanned pre-drop	Measured after drop	Scanned after drop	Scanned (after - pre)	Measured (after - pre)
0°	43.125	43.084	43.813	43.595	0.51	0.69
90°	43.125	43.154	43.125	43.164	0.01	0.00
180°	43.063	43.068	42.875	42.848	-0.22	-0.19
270°	43.063	43.04	43.375	43.154	0.11	0.31

The height measurement is shown in Figure 6-6, and the comparison between the post-crush package height and the pre-crush package height measurements are shown in Table 6-2. Note that the changes in height dimensions for both methods are about the same.



**Figure 6-6. TU-6 height measurements after crush plate test.**

Table 6-3 shows a similar analysis for the radial dimensions. Figure 6-7 and Figure 6-8 show the scanned measurement of the flats along the 0° and 180° lines.

**Table 6-3. Comparison between measured and scanned radii**

<b>Radial dimension at 0° – 180° (all dimensions in.)</b>						
<b>Position</b>	<b>Measured pre-drop</b>	<b>Scanned pre-drop</b>	<b>Measured after drop</b>	<b>Scanned after drop</b>	<b>Scanned (after - pre)</b>	<b>Measured (after - pre)</b>
<b>Top surface</b>	26.875	26.848	25.625	25.546	-1.30	-1.25
<b>Top rolling hoop</b>	28.125	28.158	25.688	25.566	-2.59	-2.44
<b>Center rolling hoop</b>	28.063	28.074	24.875	24.737	-3.34	-3.19
<b>Bottom rolling hoop</b>	28.063	28.021	26	25.858	-2.16	-2.06
<b>Bottom surface</b>	26.813	26.826	N/A	N/A	N/A	N/A
<b>Radial dimension at 90° – 270° (all dimensions in.)</b>						
<b>Position</b>	<b>Measured pre-drop</b>	<b>Scanned pre-drop</b>	<b>Measured after drop</b>	<b>Scanned after drop</b>	<b>Scanned (after - pre)</b>	<b>Measured (after - pre)</b>
<b>Top surface</b>	26.75	26.836	27.063	27.087	0.25	0.31
<b>Top rolling hoop</b>	28.063	28.18	28.625	28.601	0.42	0.56
<b>Center rolling hoop</b>	28.25	28.131	29.063	29.076	0.95	0.81
<b>Bottom rolling hoop</b>	28.25	28.284	28.813	28.799	0.52	0.56
<b>Bottom surface</b>	27.125	27.124	27.125	27.116	-0.01	0.00

The bottom surface radial measurement at the 0° – 180° plane after the crush plate drop test could not be obtained because of out-of-plane orientation. As in the case of the height measurement, the differences here are also less than 1 in. A comparison analysis was conducted on the flats that were created from the crush plate's impact on TU-6 at 180° orientation and the resistance of the drop pad plate at 0°. The measured lengths are shown in Table 6-4. Figure 6-7 and Figure 6-8 show the scanned flat measurements.



Table 6-4. Flats created on TU-6 by crush plate's impact

Flats dimension at 0°			
Position	Measured after drop	Scanned after drop	Scanned (after - pre)
Top surface	8.17	7.811	0.36
Top rolling hoop	11.421	10.79	0.63
Center rolling hoop	11.402	11.197	0.21
Bottom rolling hoop	14.764	14.592	0.17
Bottom surface	17.693	17.744	-0.05
Flats dimension at 180°			
Position	Measured after drop	Scanned after drop	Scanned (after - pre)
Top surface	6.314	6.085	0.23
Top rolling hoop	10.996	10.7712	0.22
Center rolling hoop	13.719	13.658	0.06
Bottom rolling hoop	N/A	N/A	N/A
Bottom surface	N/A	N/A	N/A

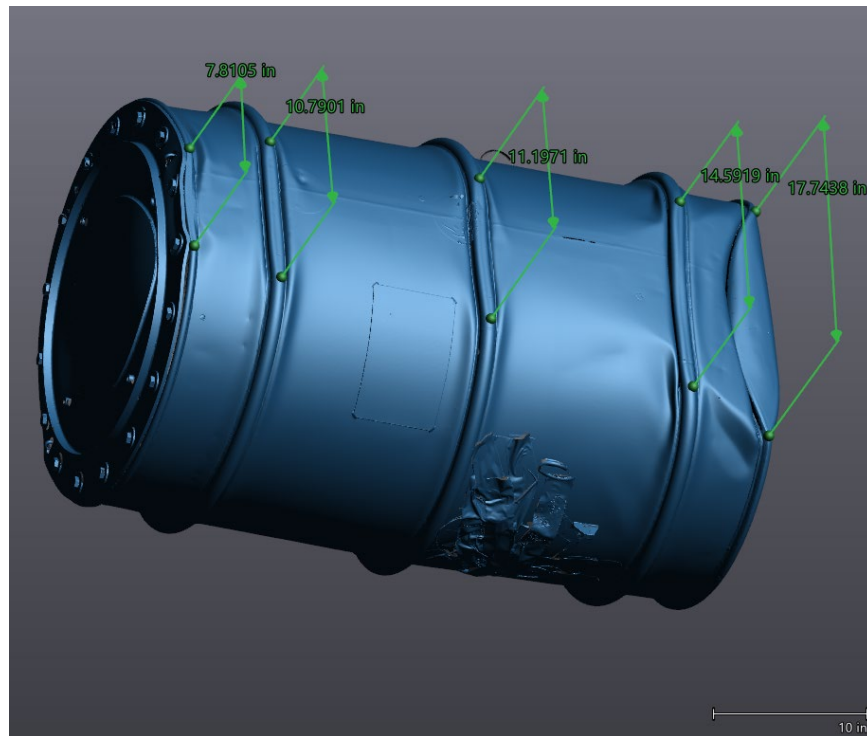
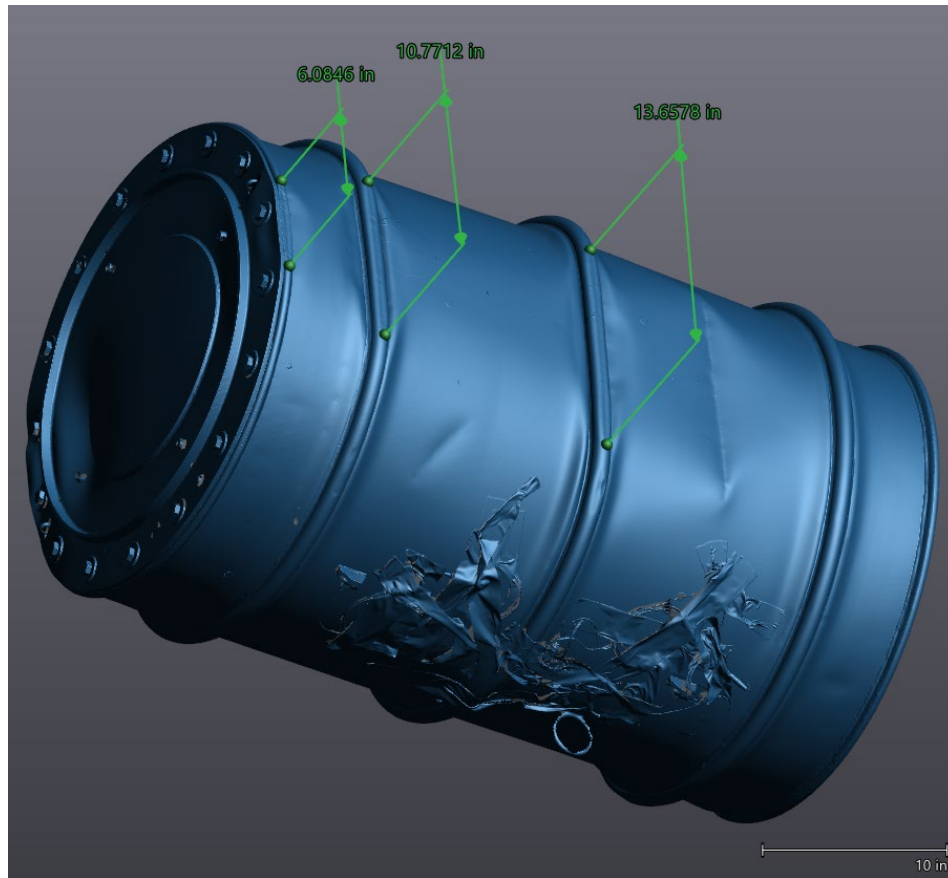
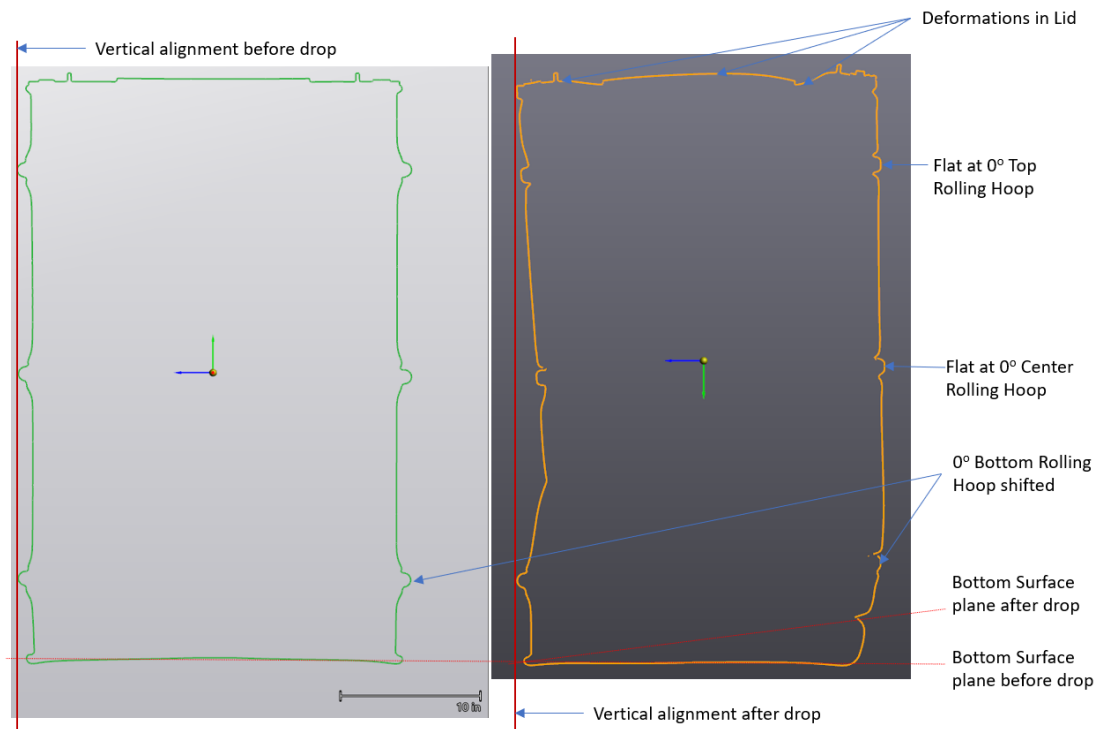


Figure 6-7. Flat surfaces on TU-6 created by crush plate's impact (shown 0°).



**Figure 6-8. Flat surfaces on TU-6 created by crush plate's impact (shown 180°).**

A cross section of TU-6 was taken along the 0° – 180° plane before the test series commenced. Another cross section was taken after the 30 ft crush plate test. Both cross sections are shown side-by-side in Figure 6-9 for comparison. The initial cross section was overlaid on the deformed TU-6 in Figure 6-10 for visual comparison.



**Figure 6-9. Initial and deformed cross section of TU-6.**



**Figure 6-10. Initial cross section overlaid on deformed TU-6.**

# Test Report for DPP-1 Regulatory Compliance Testing

## Volume 2 – Photos of TU-1, TU-2, TU-3, TU-4, TU-5, TU-6, & TU-7



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Oscar A. Martinez  
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Blake Van Hoy

**Approved for public release**

**April 2022**



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Nuclear Energy and Fuel Cycle Division

**Test Report for DPP-1 Regulatory Compliance Testing**  
**Volume 2 – Photos of TU-1, TU-2, TU-3, TU-4, TU-5, TU-6, and TU-7**

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## A. APPENDIX A – TU-1 PHOTOS

This section contains a collection of digital photos taken during testing of TU-1 of the DPP-1 package. The list below provides the sections into which the photos have been grouped. The subsequent pages provide the list of figures contained within this appendix.

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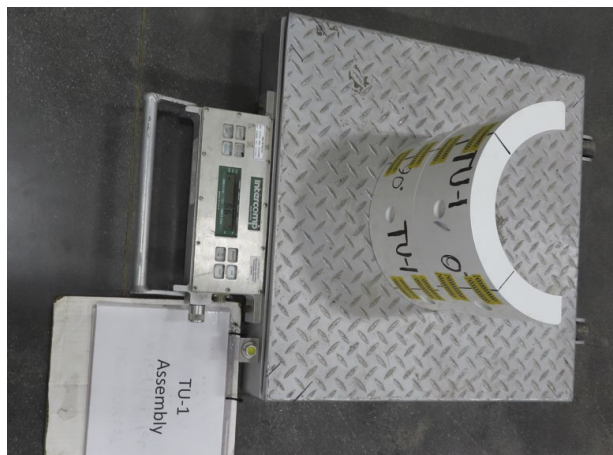
## A.1 TEST UNIT 1 ASSEMBLY

### A.1.1 CV Assembly

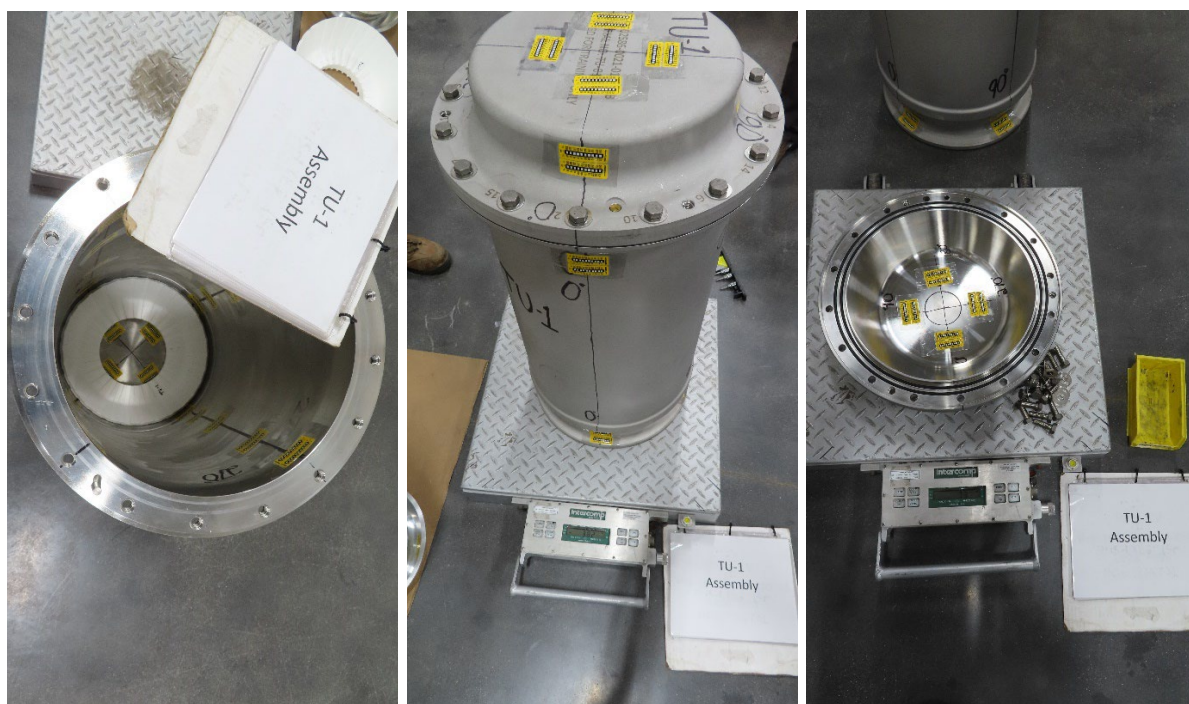


**Figure A-1 TU-1 test weight.**

## Appendix A – DPP-1 TU-1 Photos



**Figure A-2 TU-1 heavy test load**



**Figure A-3 TU-1 CV assembly, temperature indicating labels on body and lid.**

## Appendix A – DPP-1 TU-1 Photos

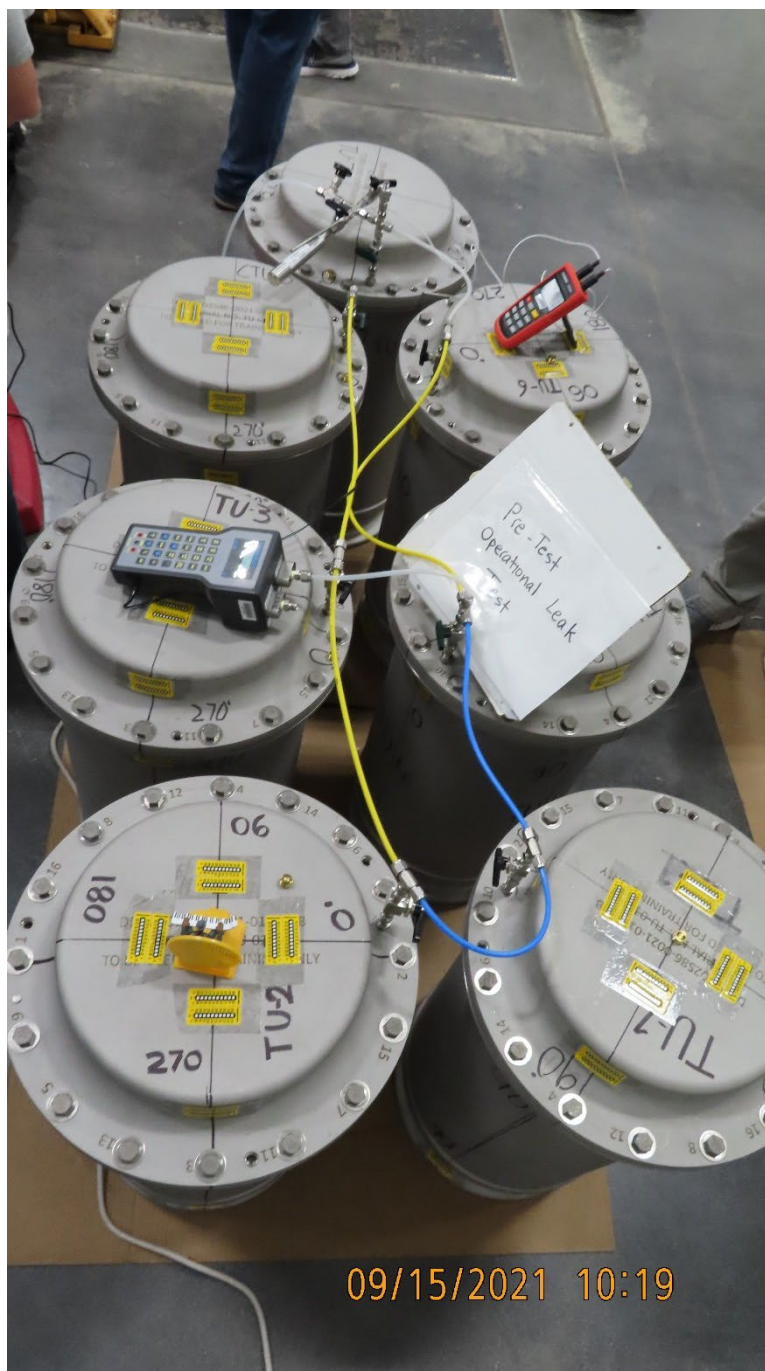


**Figure A-4 TU-1 CV assembly.**



**Figure A-5 TU-1 CV assembly weight.**





**Figure A-6 TU CVs Pre-Operational Leak Test.**

### A.1.2 Drum Body Assembly



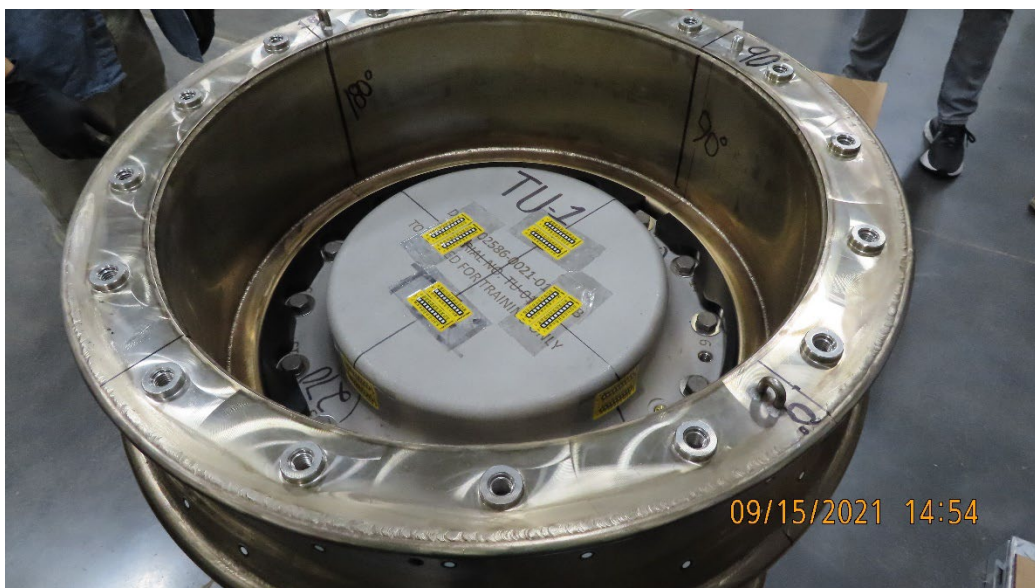
**Figure A-7 Drum body temperature labels and lid weighing**



**Figure A-8 Weighing drum body assembly components.**



## Appendix A – DPP-1 TU-1 Photos



**Figure A-9 CV lowered into TU-1 drum body.**



**Figure A-10 TU-1 fully assembled test unit.**

## A.2 NCT TESTING

### A.2.1 NCT 1.2-m Free Drop



**Figure A-11 TU-1 wrapped in insulation and before NCT 4-ft drop.**



**Figure A-12 Measuring drop orientation angle.**





**Figure A-13 Establishing 1.2-m height for NCT drop test.**



**Figure A-14 Package 1.2m free drop impact.**



**Figure A-15 Top lid NCT free drop damage.**



### A.3 HAC TESTING

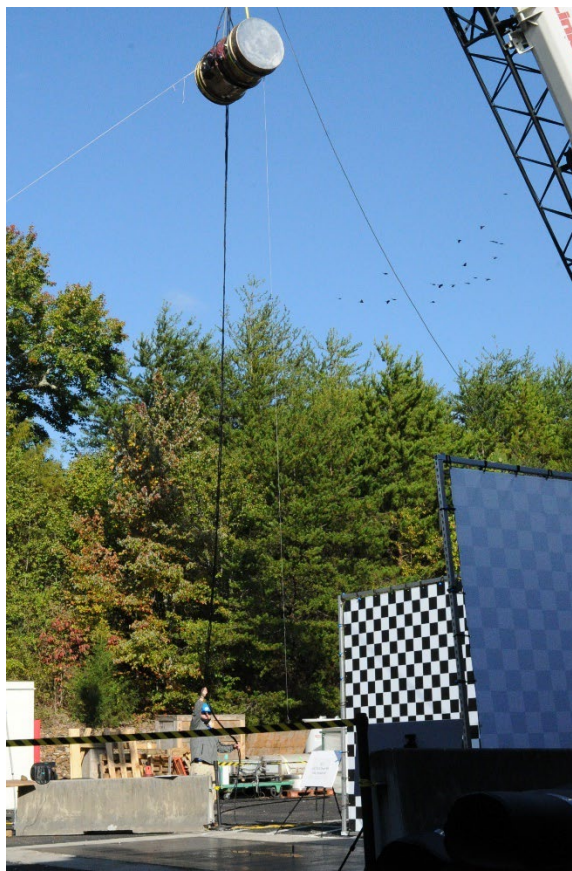
#### A.3.1 HAC 9-m Free Drop



**Figure A-16 TU-1 rigging and orientation set up for 9-m drop.**



## Appendix A – DPP-1 TU-1 Photos



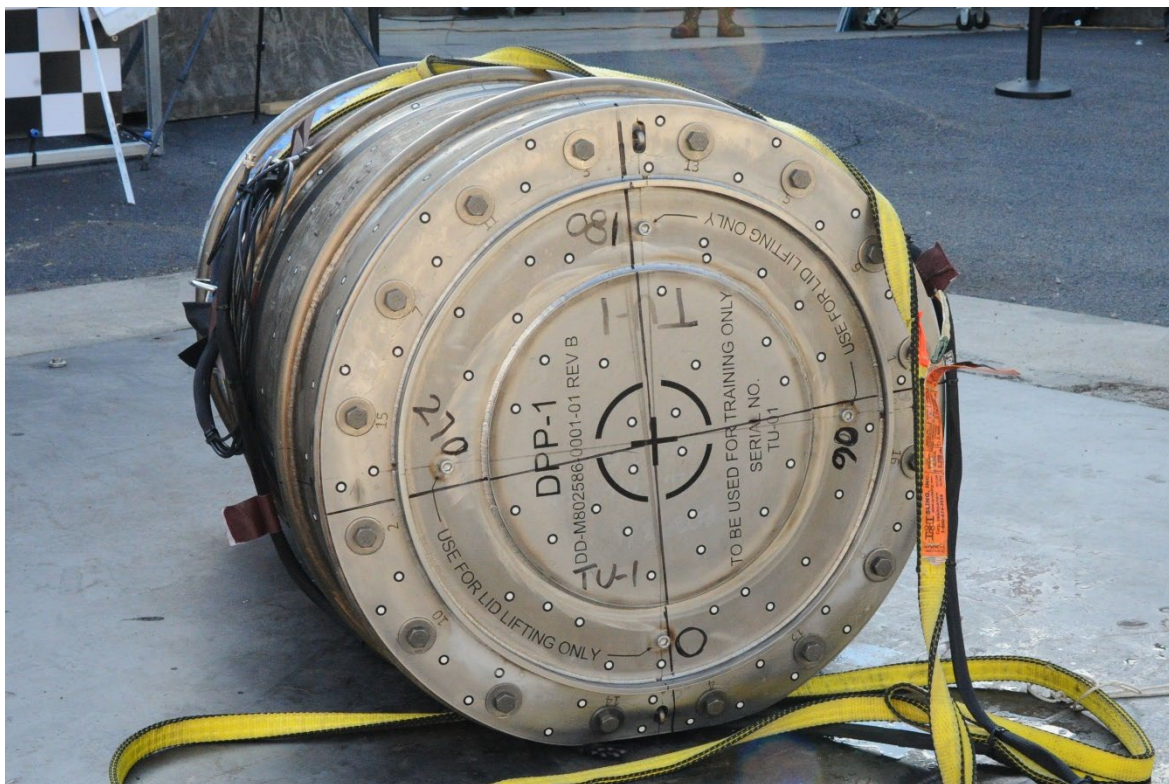
**Figure A-17 Package raised to 9-m and ready for drop test.**



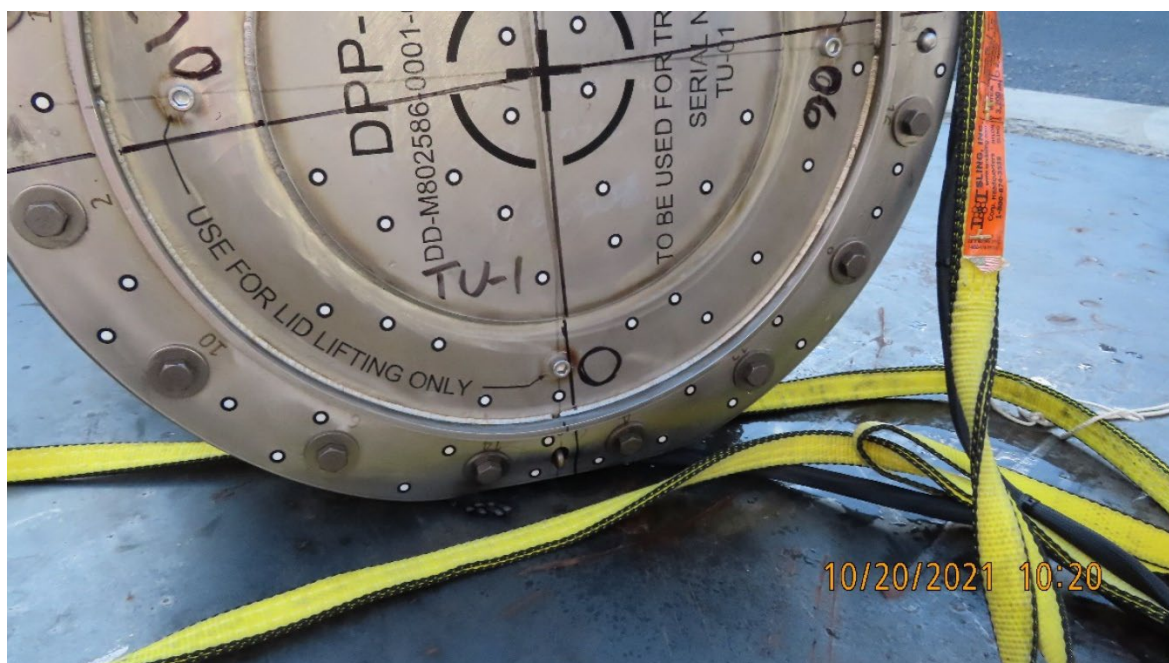
**Figure A-18 TU-1 HAC 9-m impact.**



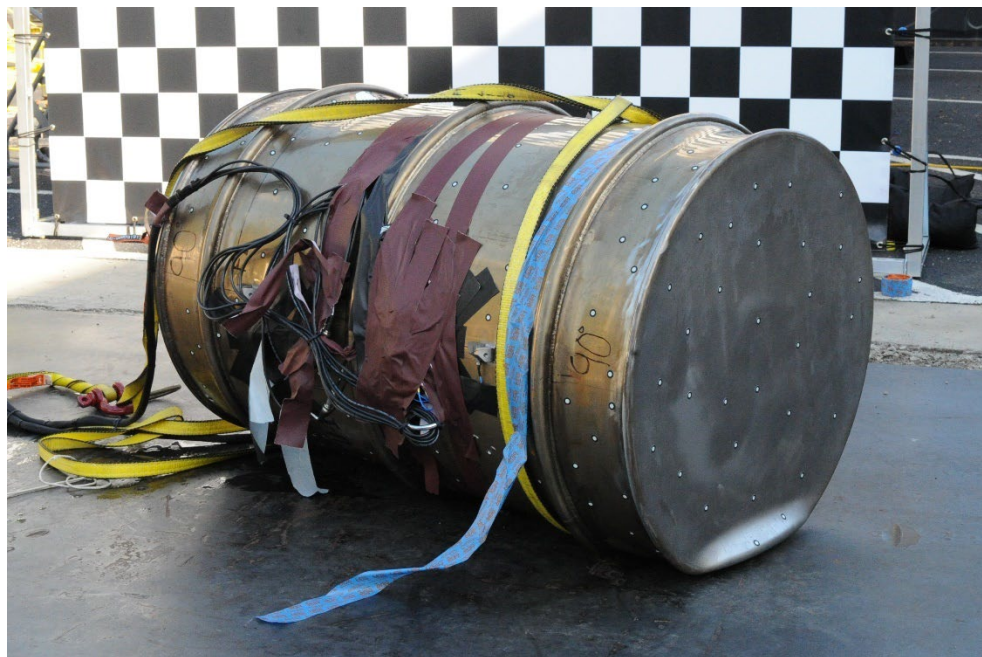
## Appendix A – DPP-1 TU-1 Photos



**Figure A-19 TU-1 HAC 9-m damage at 0° line.**



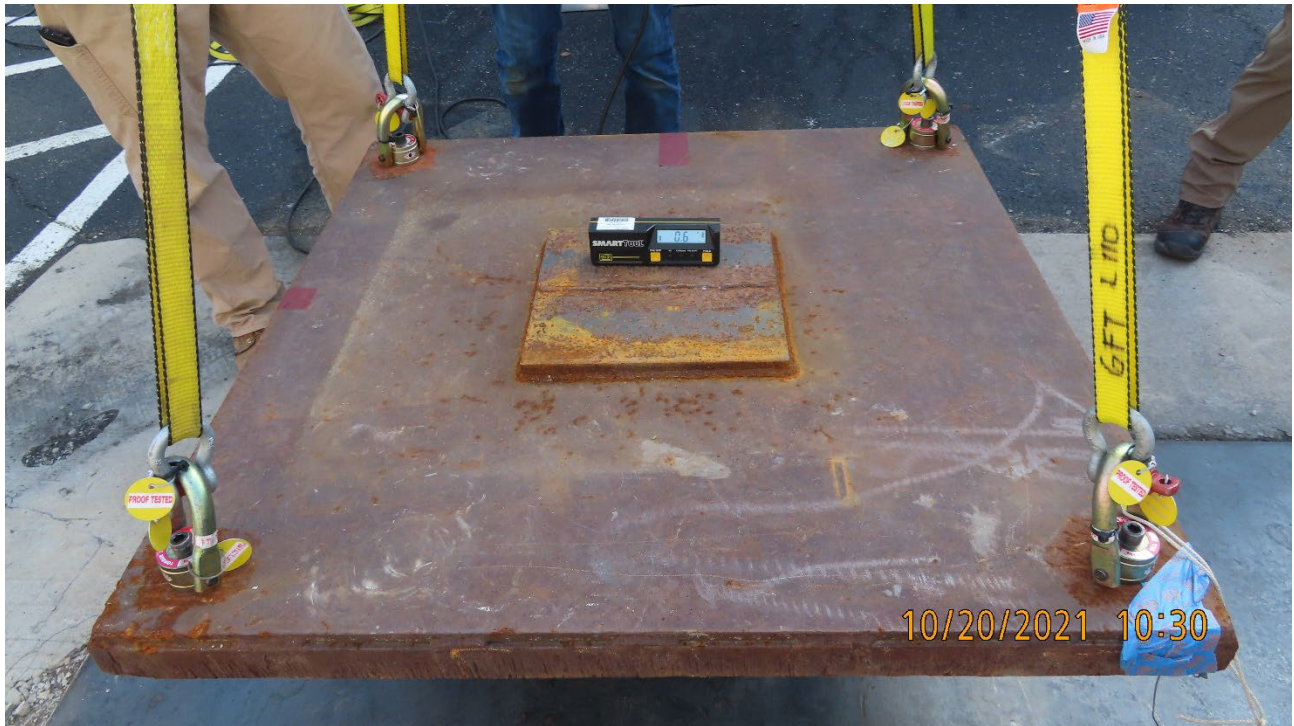
**Figure A-20 TU-1 Top lid HAC 9-m damage.**



**Figure A-21 TU-1 bottom drum HAC 9-m damage.**



### A.3.2 Crush Test



**Figure A-22 TU-1 crush plate rigging and orientation setup.**



**Figure A-23 TU-1 HAC 9-m crush impact**





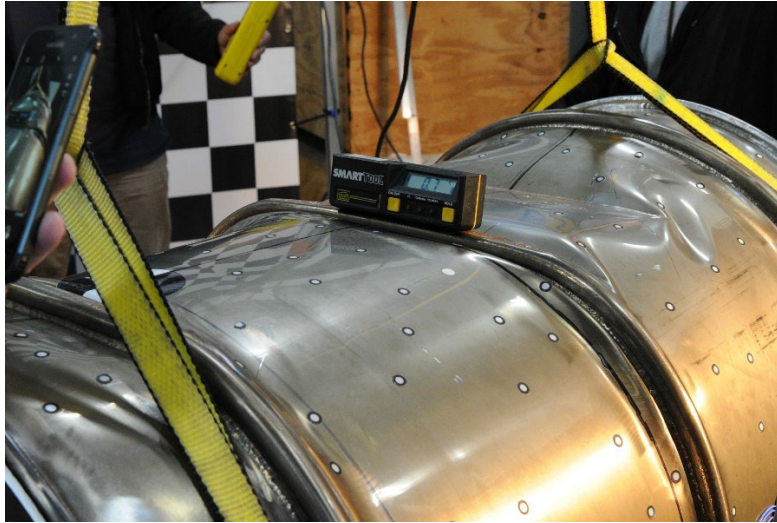
**Figure A-24 TU-1 HAC 9-m crush damage at top 0° - 180° line.**



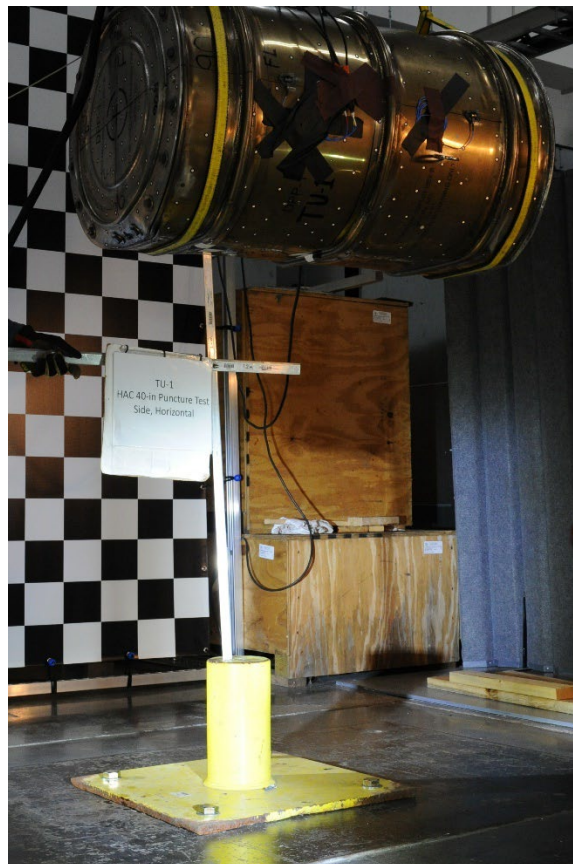
**Figure A-25 TU-1 HAC 9-m crush damage at bottom 0° - 180° line.**



### A.3.3 Puncture Test



**Figure A-26 TU-1 puncture test rigging and orientation setup.**



**Figure A-27 Aligning TU-1 over puncture bar and measuring 1-m height.**



**Figure A-28 TU-1 puncture test impact.**



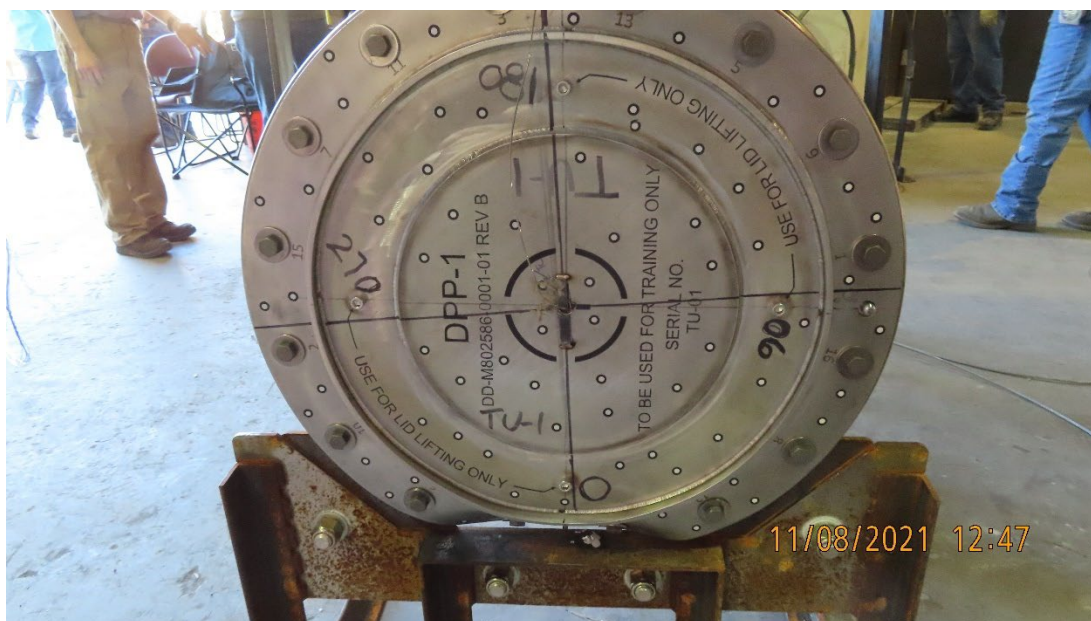
**Figure A-29 TU-1 puncture test damage.**



### A.3.4 Thermal Testing



**Figure A-30 TU-1 in pre-heat chamber.**



**Figure A-31 Thermocouples affixed to TU-1 prior to thermal testing.**

## Appendix A – DPP-1 TU-1 Photos

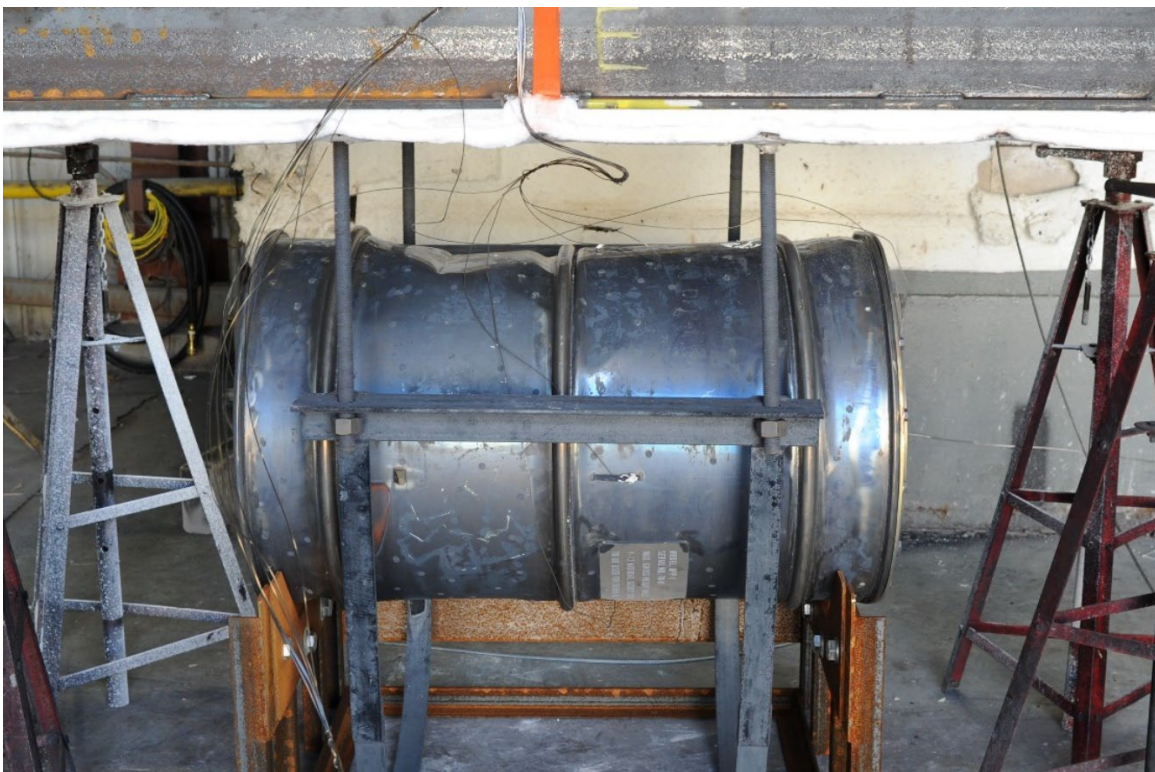


**Figure A-32 Loading TU-1 into furnace.**



**Figure A-33 TU-1 removed from furnace.**





**Figure A-34 TU-1 on cooling stand.**



## A.4 PACKAGE DISASSEMBLY

### A.4.1 Drum Body Disassembly

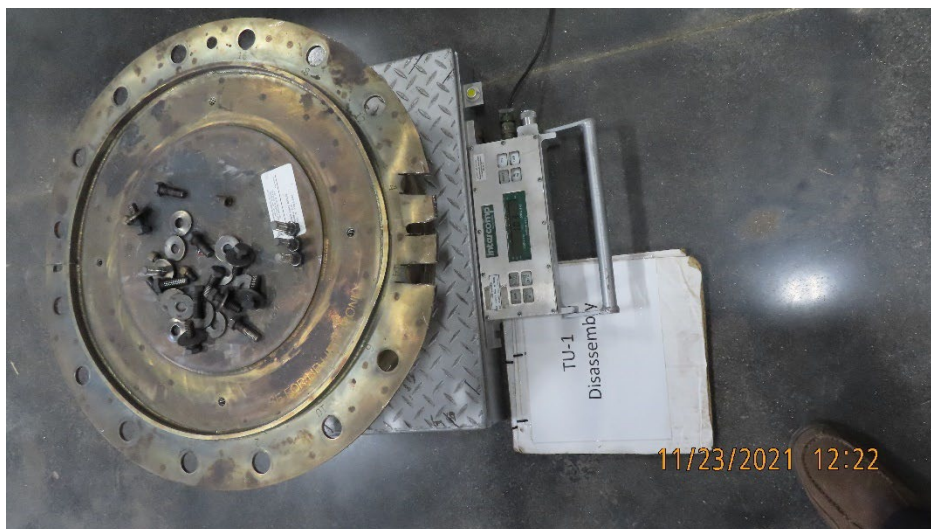


**Figure A-35 Post thermal weight measurement.**



**Figure A-36 TU-1 Drum body cut to remove lid and CV**

## Appendix A – DPP-1 TU-1 Photos



**Figure A-37 Drum lid weight measurement.**



**Figure A-38 TU-1 CV removal.**



**Figure A-39 Damage on CV flange wedge.**



**Figure A-40 CV post thermal weight.**



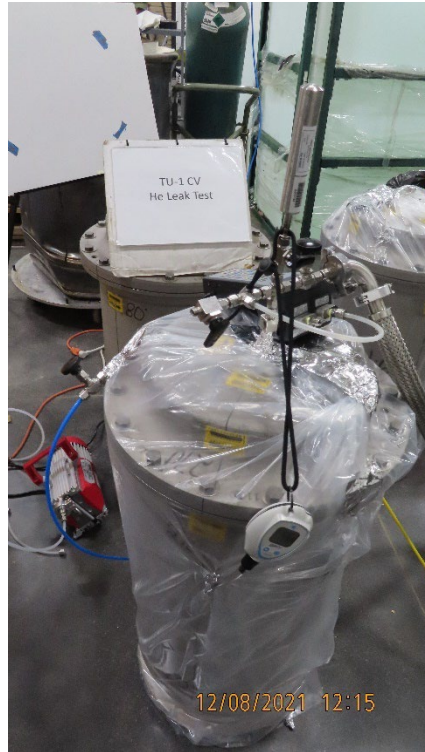
#### A.4.2 CV body leak testing



**Figure A-41 TU-1 post-test operational leak test (group setup).**

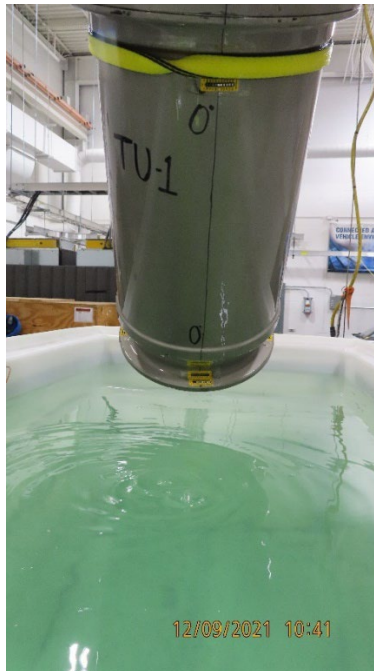


**Figure A-42 1/4" NPT tapered pipe thread on the CV.**



**Figure A-43 Post-test helium leak test.**

## **A.5 WATER IMMERSION**



**Figure A-44 Water immersion tank at the packaging lab.**

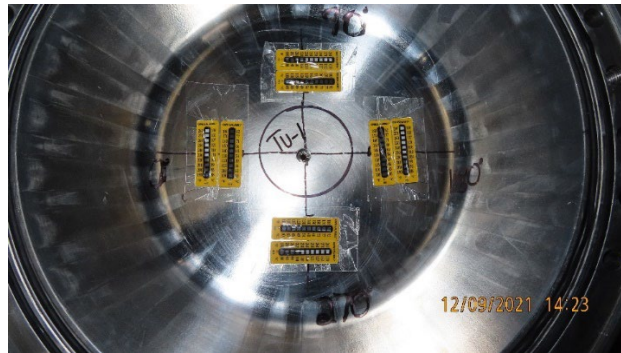


## Appendix A – DPP-1 TU-1 Photos



**Figure A-45 TU-1 CV weighed after water immersion.**

### A.6 CV DISASSEMBLY



**Figure A-46 TU-1 CV lid temp labels**



**Figure A-47 TU-1 Water droplets on CV flange outside of the inner O-Ring**



**Figure A-48 Removing test weight assembly from TU-1 CV.**

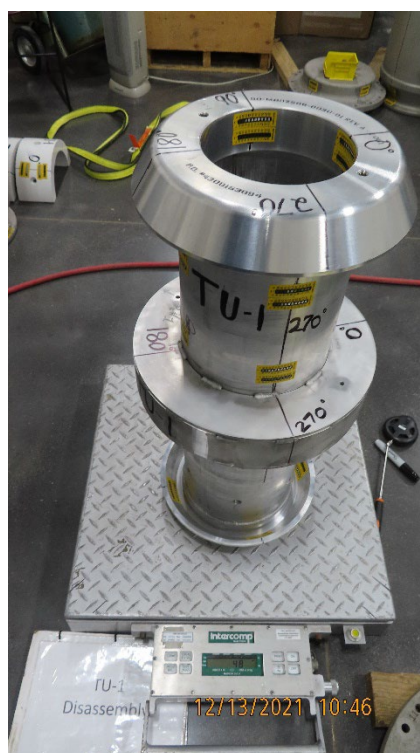


**Figure A-49 Post thermal weight of TU-1 test weight sets.**

## Appendix A – DPP-1 TU-1 Photos



**Figure A-50 TU-1 weldment PCC pads weight.**



**Figure A-51 TU-1 test fixture weldment post thermal test inspection**

**B. APPENDIX B – TU-2 PHOTOS**

This section contains a collection of digital photos taken during testing of TU-2 of the DPP-1 package. The list below provides the sections into which the photos have been grouped. The subsequent pages provide the list of figures contained within this appendix.

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Figure B-53 TU-2 test fixture weldment post thermal test inspection. .... B-31

## B.1 SECTION 1 –TEST UNIT 2 ASSEMBLY

### B.1.1 CV Assembly

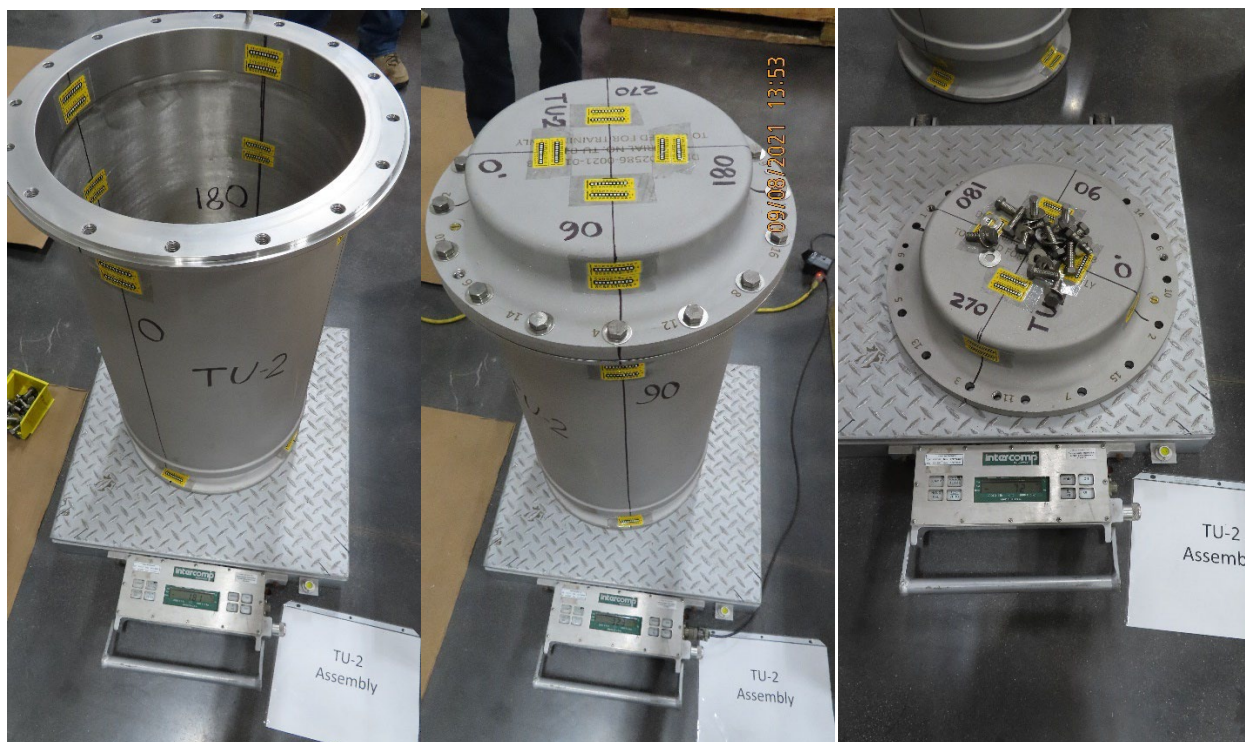


Figure B-1 TU-2 test weight.

## Appendix B – DPP-1 TU-2 Photos

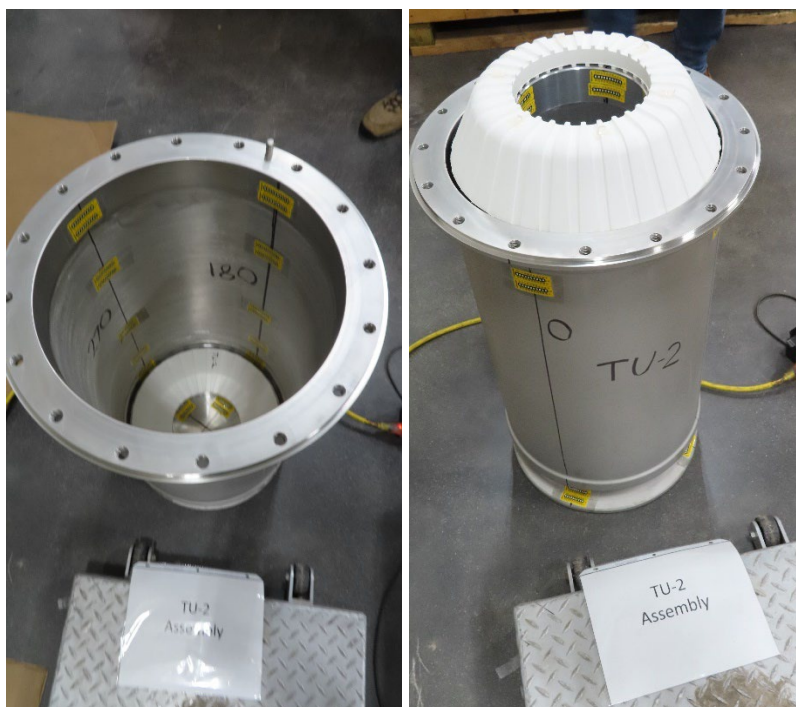


**Figure B-2 TU-2 light test load.**

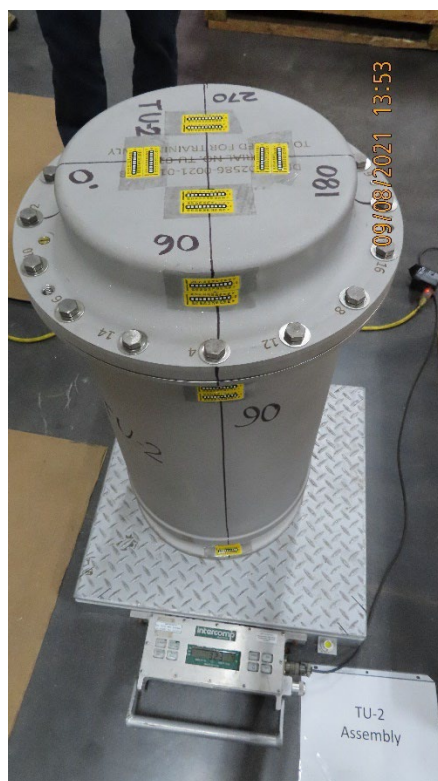


**Figure B-3 TU-2 CV assembly, temperature indicating labels on body and lid.**

## Appendix B – DPP-1 TU-2 Photos



**Figure B-4 TU-2 CV assembly.**



**Figure B-5 TU-2 CV assembly weight.**





**Figure B-6 TU-2 CV Pre-Operational Leak Test.**



## B.1.2 Drum Body Assembly

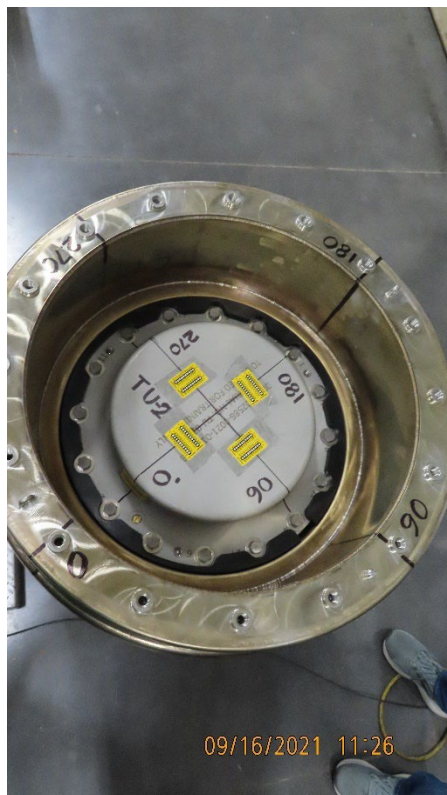


**Figure B-7 TU-2 drum body temperature labels and lid weighing.**



**Figure B-8 TU-2 drum body weighing.**

## Appendix B – DPP-1 TU-2 Photos



**Figure B-9 CV lowered into TU-2 drum body.**



**Figure B-10 TU-2 fully assembled test unit.**



## Appendix B – DPP-1 TU-2 Photos



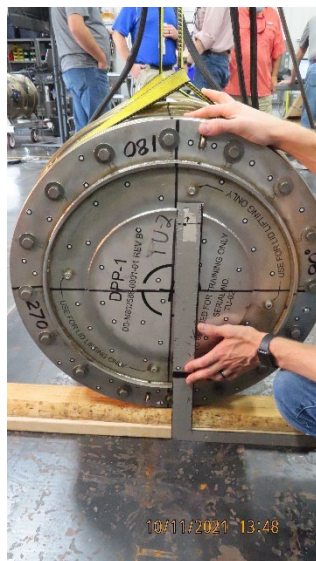
**Figure B-11 TU-2 Accel mounts weld.**



**Figure B-12 TU-2 Water spray test**

## B.2 NCT TESTING

### B.2.1 NCT 1.2-m Free Drop



**Figure B-13 TU-2 vertical alignment check.**



**Figure B-14 TU-2 measuring drop orientation angle.**





**Figure B-15 Establishing 1.2-m height for TU-2 NCT drop test.**



**Figure B-16 TU-2 1.2-m free drop impact.**



## Appendix B – DPP-1 TU-2 Photos



**Figure B-17 Top lid NCT free drop damage.**



**Figure B-18 Bottom surface NCT free drop damage.**

### B.3 HAC TESTING

#### B.3.1 HAC 9-m Free Drop



**Figure B-19 TU-2 rigging, and orientation set up for 9-m drop.**



**Figure B-20 TU-2 raised to 9-m and ready for drop test.**



## Appendix B – DPP-1 TU-2 Photos



**Figure B-21 Package HAC 9-m impact.**



**Figure B-22 TU-2 HAC 9-m damage at 0° line.**



**Figure B-23 TU-2 top lid HAC 9-m damage.**



**Figure B-24 TU-2 bottom drum HAC 9-m damage.**



### B.3.2 Crush Test



**Figure B-25 TU-2 crush plate rigging and orientation setup.**



**Figure B-26 TU-2 HAC 9-m crush impact.**





**Figure B-27 TU-2 HAC 9-m crush damage at top 0° – 180° line.**



**Figure B-28 TU-2 HAC 9-m crush damage at bottom 0° – 180° line.**



### B.3.3 Puncture Test



**Figure B-29 TU-2 puncture test rigging and orientation setup.**

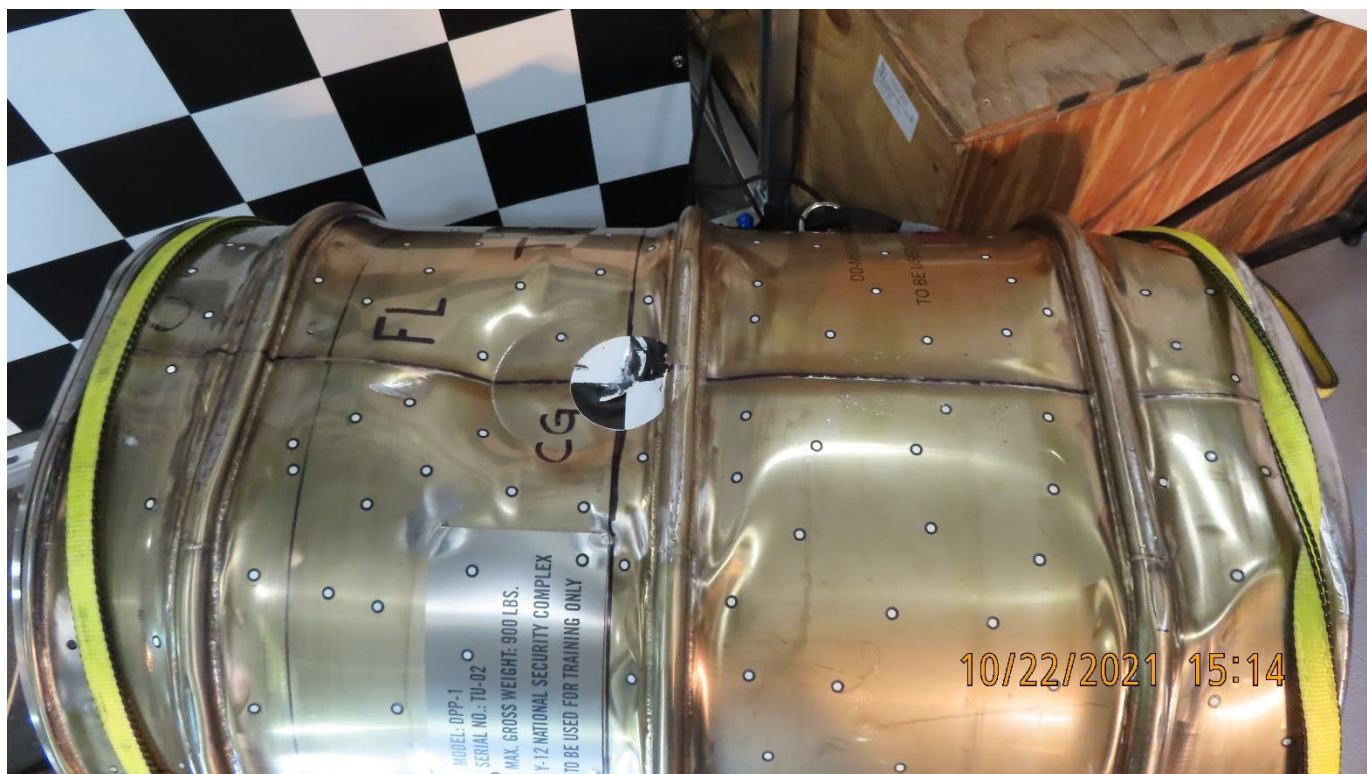


**Figure B-30 Aligning TU-2 over puncture bar and measuring 1-m height.**

## Appendix B – DPP-1 TU-2 Photos



**Figure B-31 TU-2 puncture test impact.**



**Figure B-32 TU-2 puncture test damage.**



### B.3.4 Thermal Testing

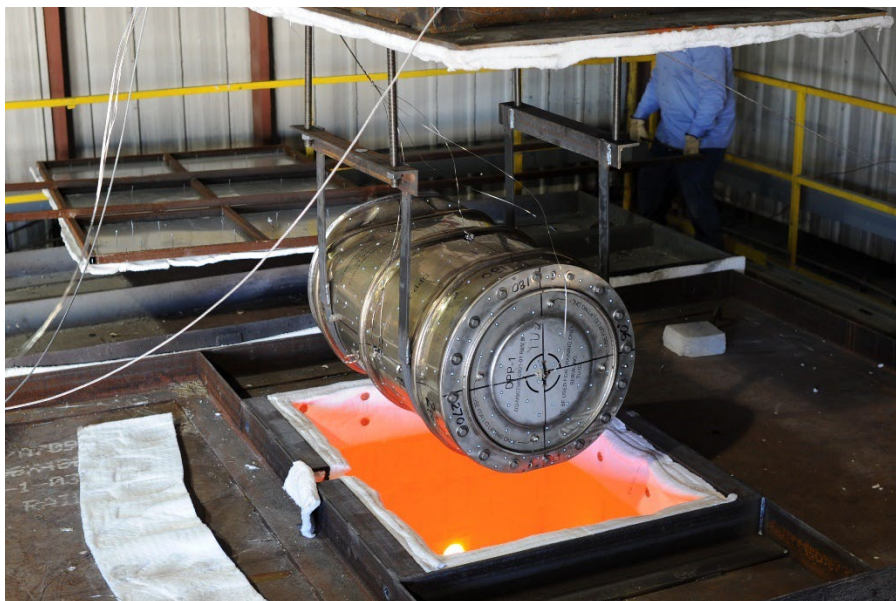


Figure B-33 TU-2 in pre-heat chamber.



Figure B-34 Thermocouples affixed to TU-2 prior to thermal testing.

## Appendix B – DPP-1 TU-2 Photos



**Figure B-35 Loading TU-2 into furnace.**



**Figure B-36 TU-2 removed from furnace.**





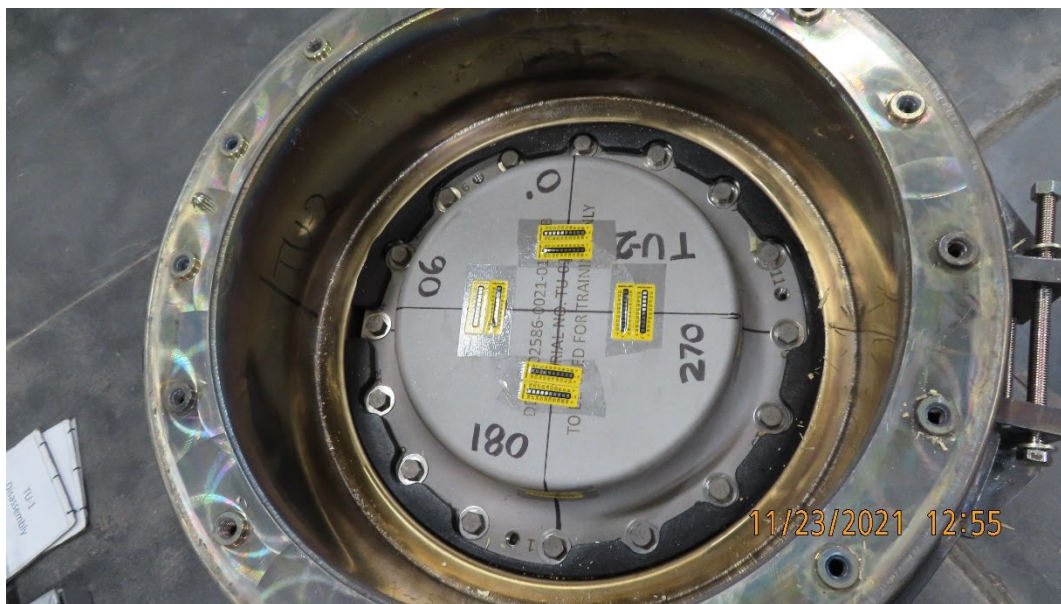
**Figure B-37 TU-2 on cooling stand.**

## B.4 PACKAGE DISASSEMBLY

### B.4.1 Drum Body Disassembly



**Figure B-38 Post thermal weight measurement.**



**Figure B-39 Drum lid removed.**



**Figure B-40 TU-2 drum lid weight measurement.**



**Figure B-41 TU-2 CV removal.**





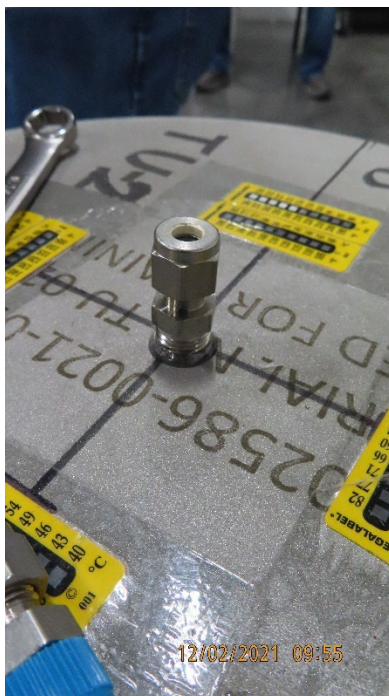
**Figure B-42 CV body post thermal weight.**

#### **B.4.2 CV body leak testing**

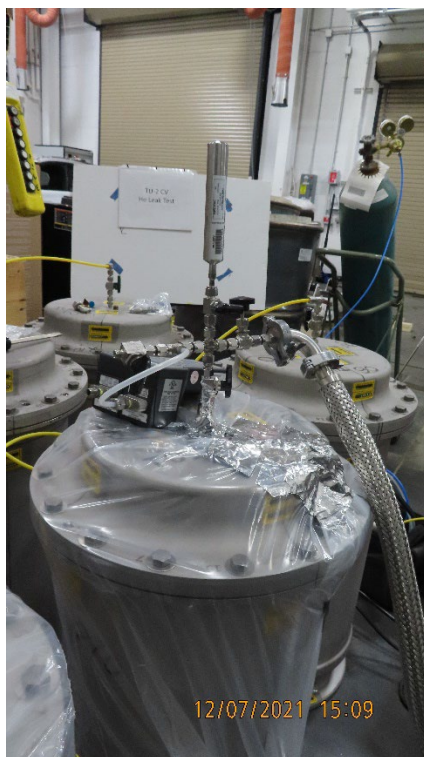


**Figure B-43 TU-2 post-test operational leak test (group setup).**



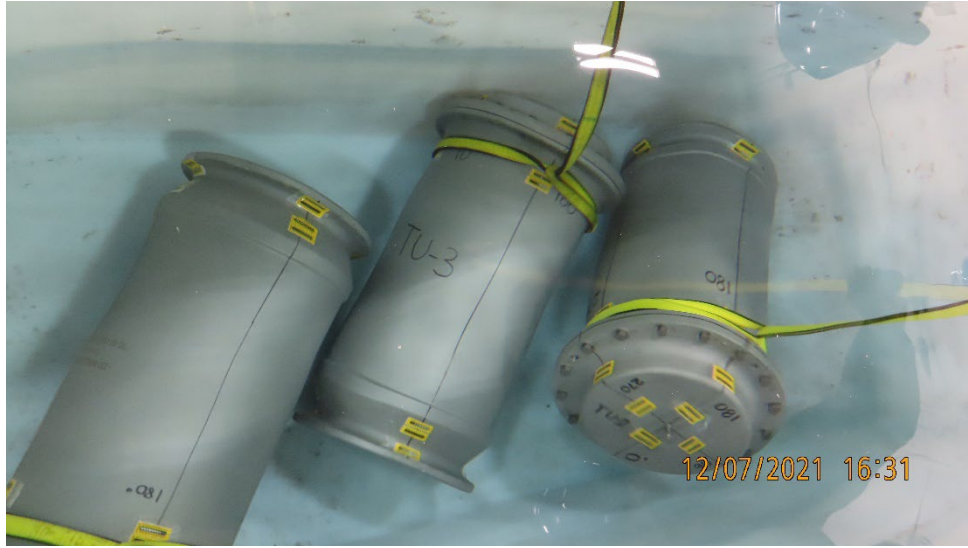


**Figure B-44 1/4" NPT tapered pipe thread on the CV.**

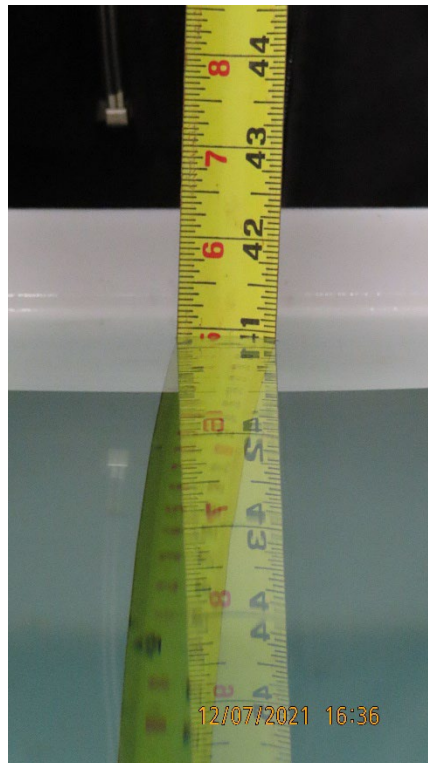


**Figure B-45 TU-2 Post-test helium leak test.**

## B.5 WATER IMMERSION



**Figure B-46 Test units in the water immersion tank at the packaging lab.**



**Figure B-47 Water immersion test water depth.**

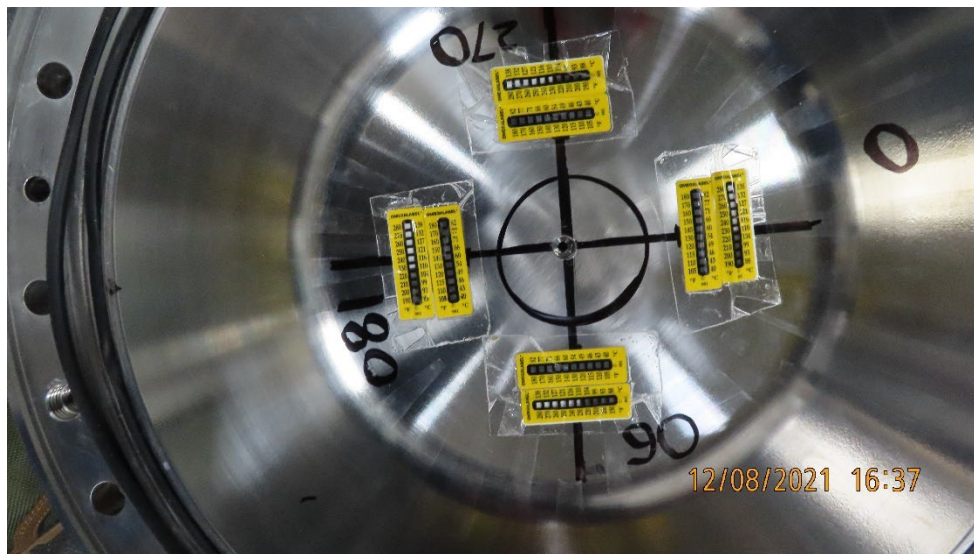


**Figure B-48 Removing TU-2 CV from water immersion tank.**

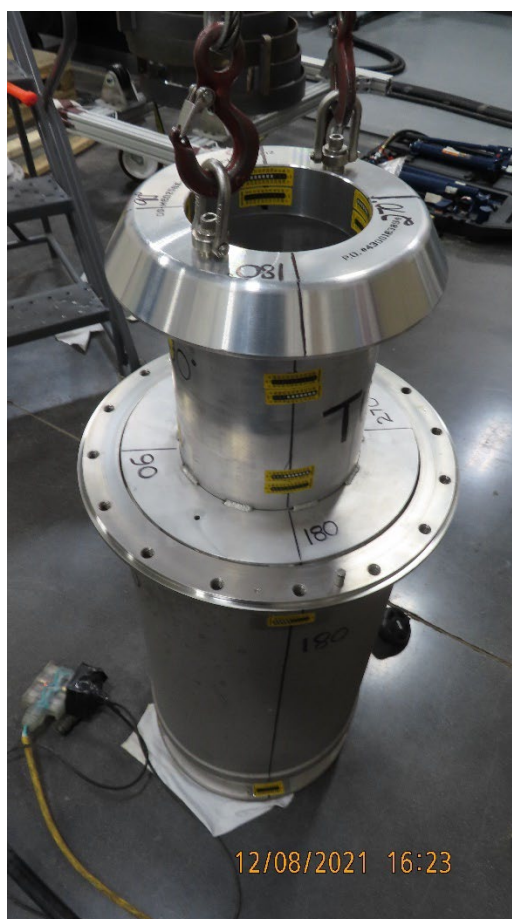


**Figure B-49 TU-2 weighed after the water immersion.**

## B.6 CV DISASSEMBLY



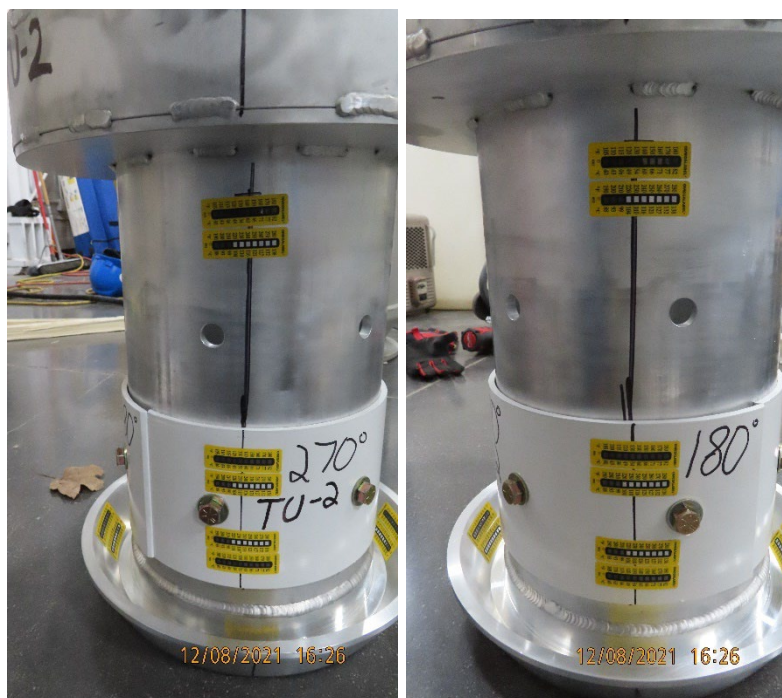
**Figure B-50 TU-2 CV lid temp labels.**



**Figure B-51 Removing test weight assembly from TU-2 CV.**



## Appendix B – DPP-1 TU-2 Photos



**Figure B-52 Temp labels on TU-2 test weight.**



**Figure B-53 TU-2 test fixture weldment post thermal test inspection.**

## C. APPENDIX C – TU-3 PHOTOS

This section contains a collection of digital photos taken during testing of TU-3 of the DPP-1 package. The list below provides the sections into which the photos have been grouped. The subsequent pages provide the list of figures contained within this appendix.

### Organization Table for Photo Record

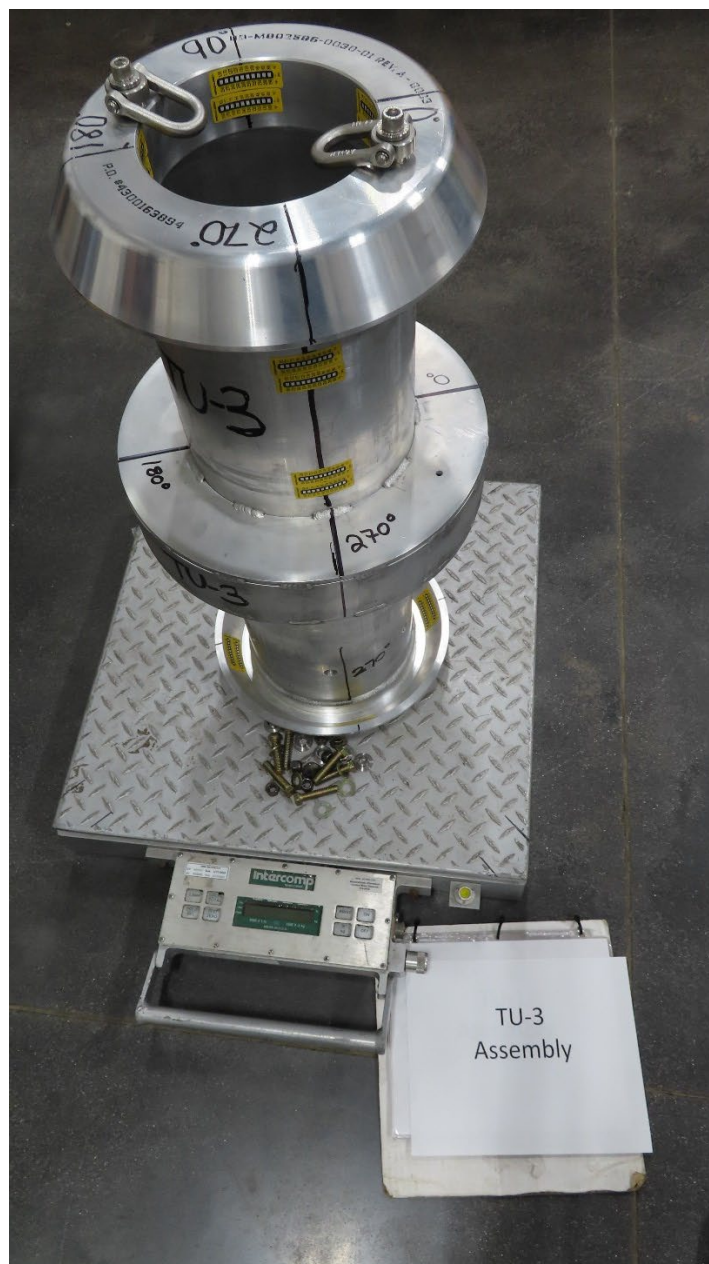
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## C.1 SECTION 1 –TEST UNIT 3 ASSEMBLY

### C.1.1 CV Assembly



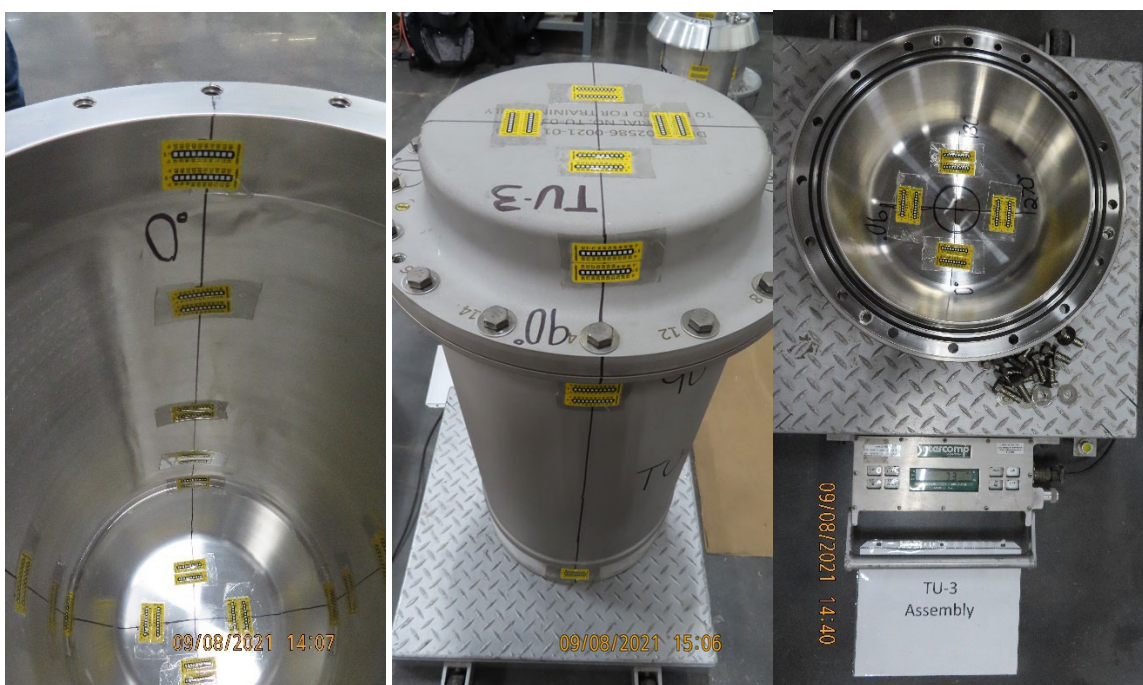
**Figure C-1 TU-3 test weight.**



## Appendix C – DPP-1 TU-3 Photos

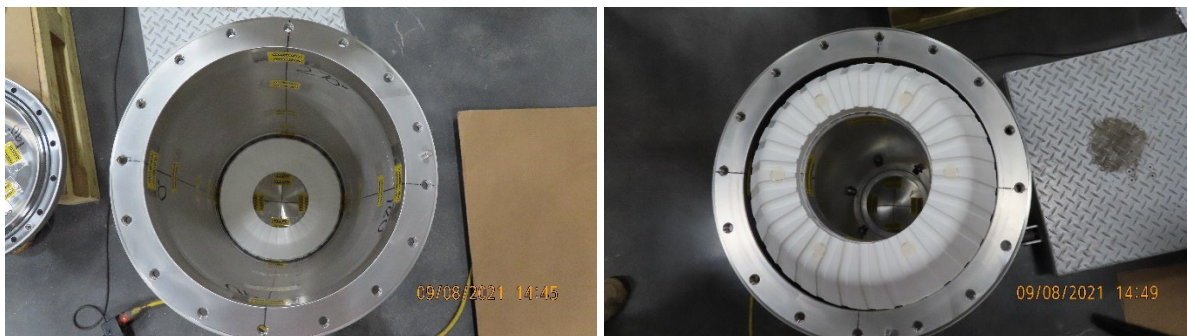


**Figure C-2 TU-3 heavy test load.**



**Figure C-3 CV assembly, temperature indicating labels on body and lid.**

## Appendix C – DPP-1 TU-3 Photos



**Figure C-4 TU-3 CV assembly.**



**Figure C-5 TU-3 CV assembly weight.**



**Figure C-6 TU CVs Pre-Operational Leak Test.**



## C.1.2 Drum Body Assembly

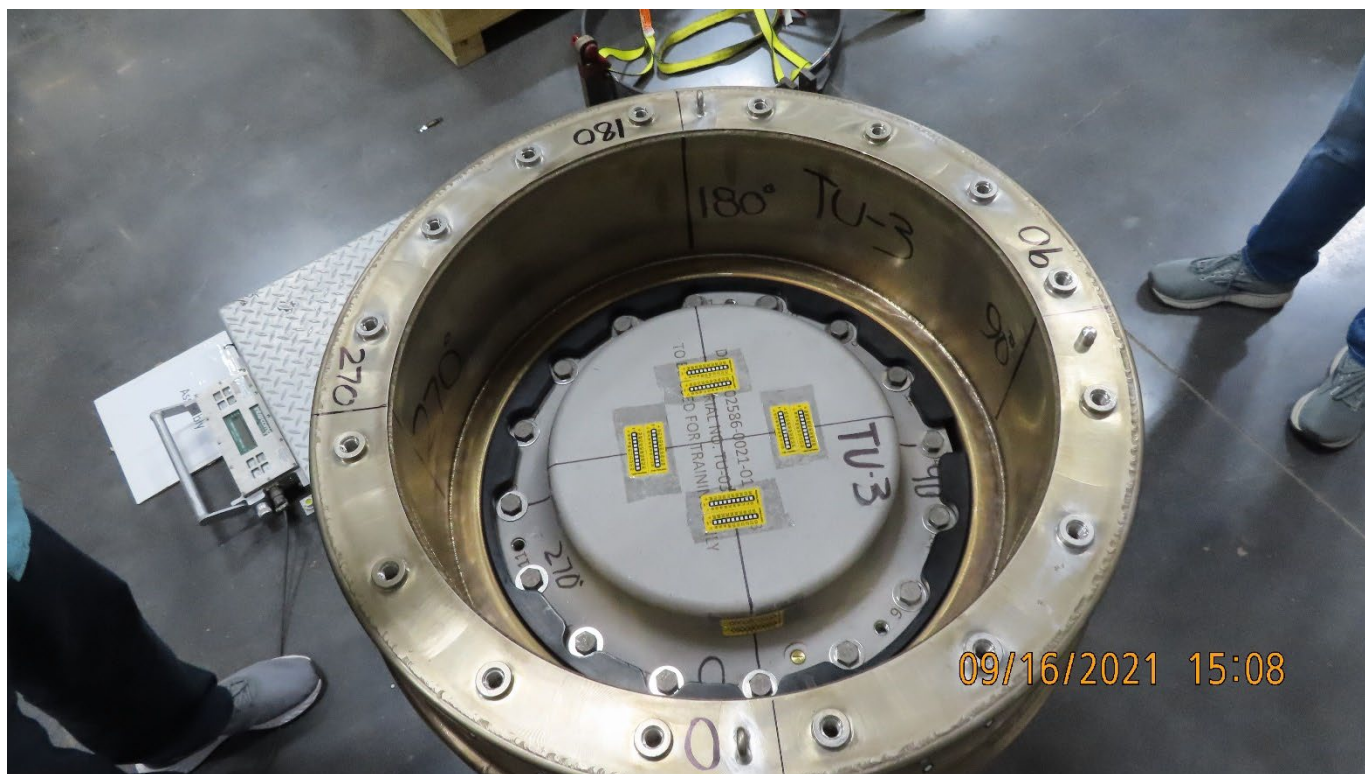


**Figure C-7 TU-3 drum body temperature labels and lid weighing.**



**Figure C-8 TU-3 drum body weighing.**





**Figure C-9 CV lowered into TU-3 drum body.**



**Figure C-10 TU-3 fully assembled weighed.**

## C.2 NCT TESTING

### C.2.1 NCT Water Spray Test



Figure C-11 TU-3 water spray test.

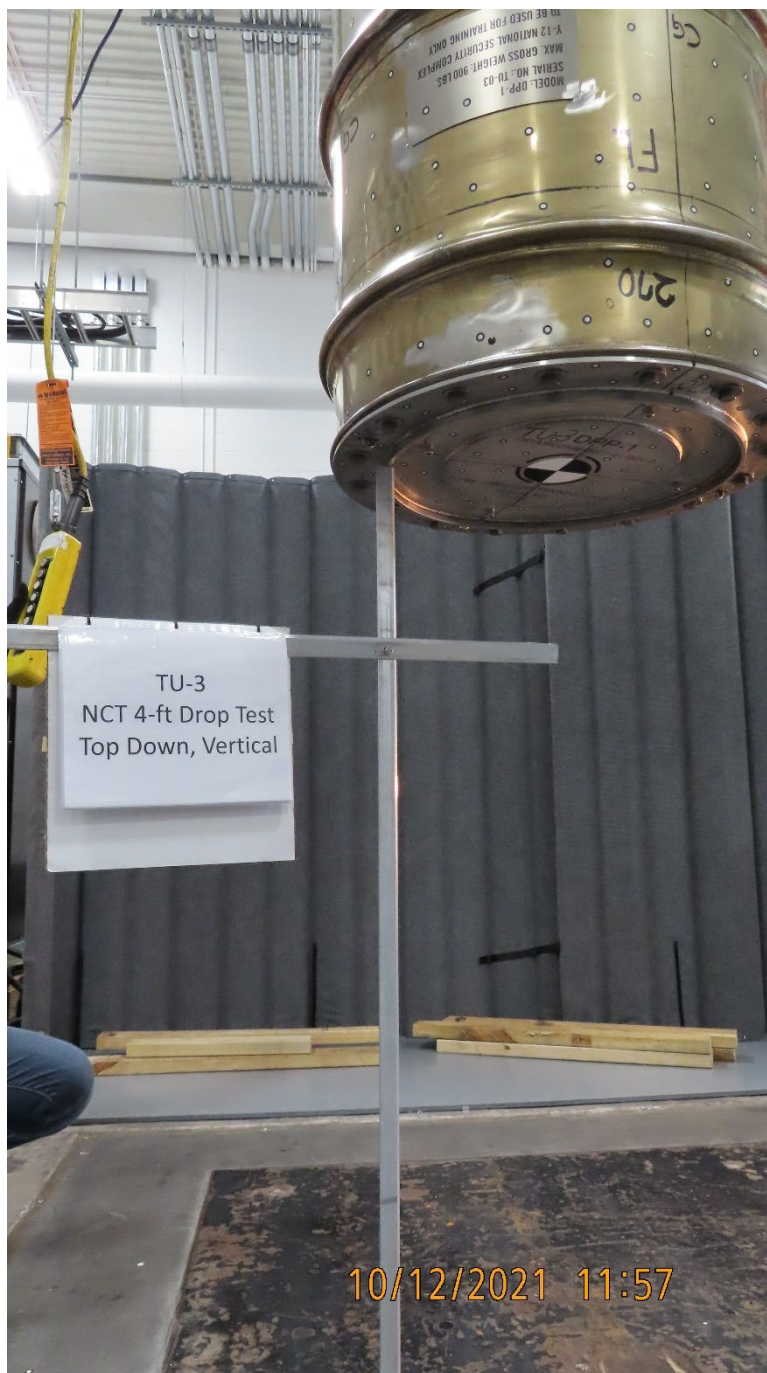
### C.2.2 NCT 1.2-m Free Drop



Figure C-12 Measuring TU-3 NCT 1.2-m drop orientation angle.



## Appendix C – DPP-1 TU-3 Photos



**Figure C-13 Establishing 1.2-m height for TU-3 NCT drop test.**

## Appendix C – DPP-1 TU-3 Photos



**Figure C-14 TU-3 1.2-m free drop impact.**



### C.3 HAC TESTING

#### C.3.1 HAC 9-m Free Drop



**Figure C-15 TU-3 rigging and orientation set up for 9-m HAC drop.**



**Figure C-16 Package raised to 9-m and ready for drop test.**

## Appendix C – DPP-1 TU-3 Photos



**Figure C-17 TU-3 HAC 9-m impact.**



**Figure C-18 TU-3 HAC 9-m damage near the top rolling hoop.**



### C.3.2 Crush Test



**Figure C-19 TU-3 crush plate rigging and orientation setup.**



**Figure C-20 Establishing 9-m height for HAC crush test.**



**Figure C-21 TU-3 HAC 9-m crush impact.**



**Figure C-22 TU-3 HAC 9-m crush damage at the bottom near 180° line.**



## Appendix C – DPP-1 TU-3 Photos

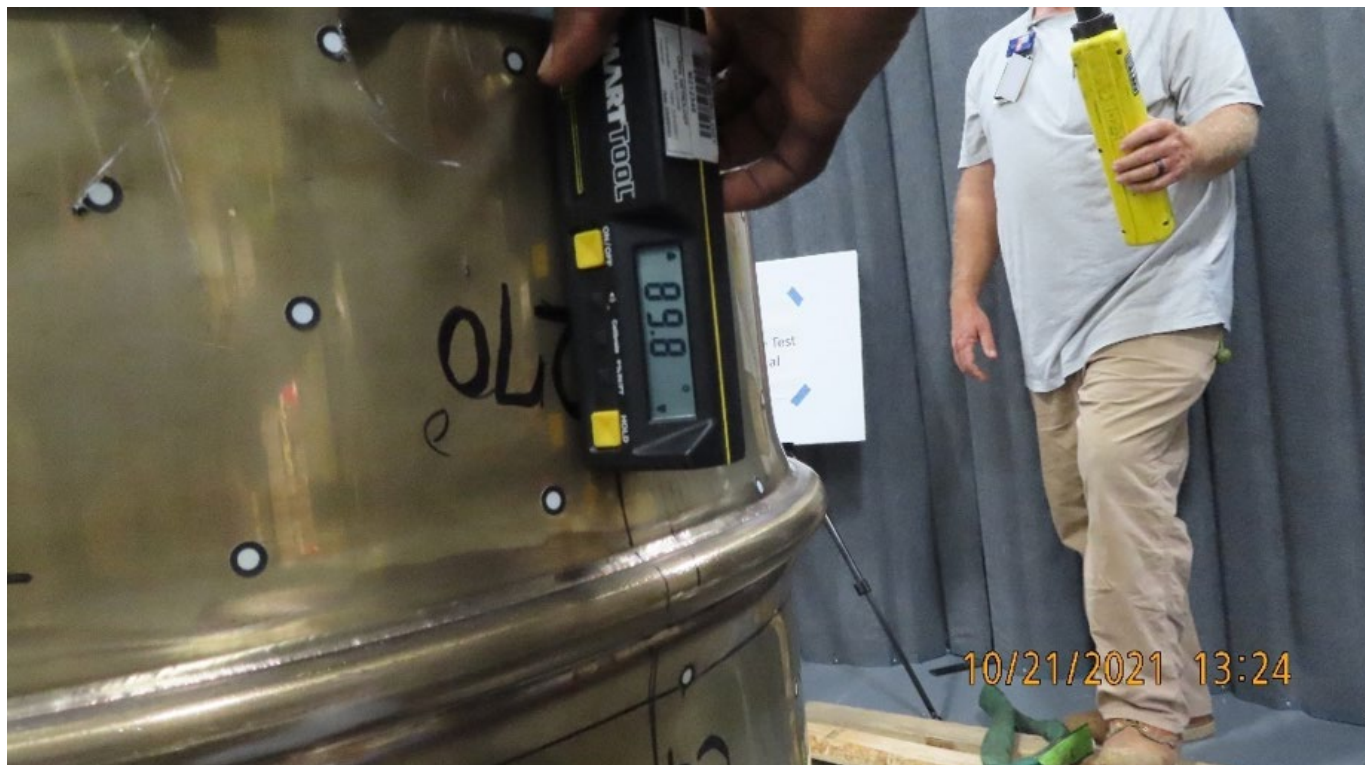


**Figure C-23 TU-3 HAC 9-m crush damage at the bottom near 90° line.**



**Figure C-24 TU-3 HAC 9-m crush damage at the bottom near 0° line.**

### C.3.3 Puncture Test



**Figure C-25 TU-3 puncture test rigging and orientation setup.**



**Figure C-26 Aligning TU-3 over puncture bar and measuring 1-m height.**



## Appendix C – DPP-1 TU-3 Photos



**Figure C-27 TU-3 puncture test impact.**



**Figure C-28 TU-3 puncture test damage.**

### C.3.4 Thermal Testing

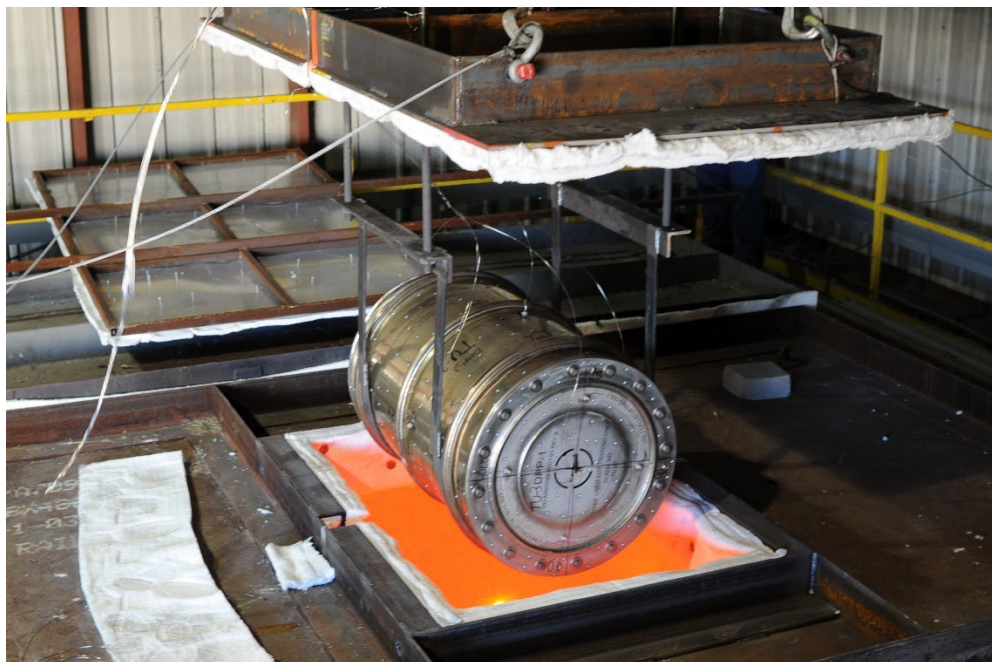


**Figure C-29 TU-3 in pre-heat chamber.**

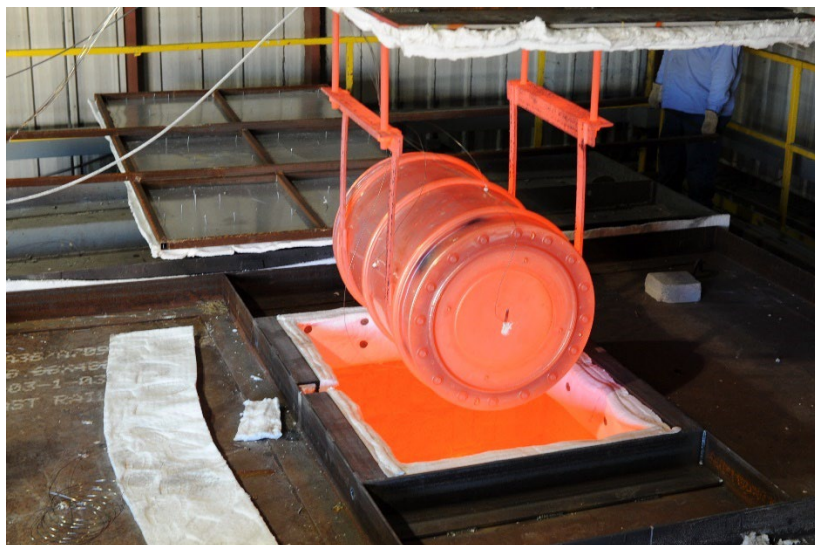


**Figure C-30 Thermocouples affixed to TU-3 prior to thermal testing.**

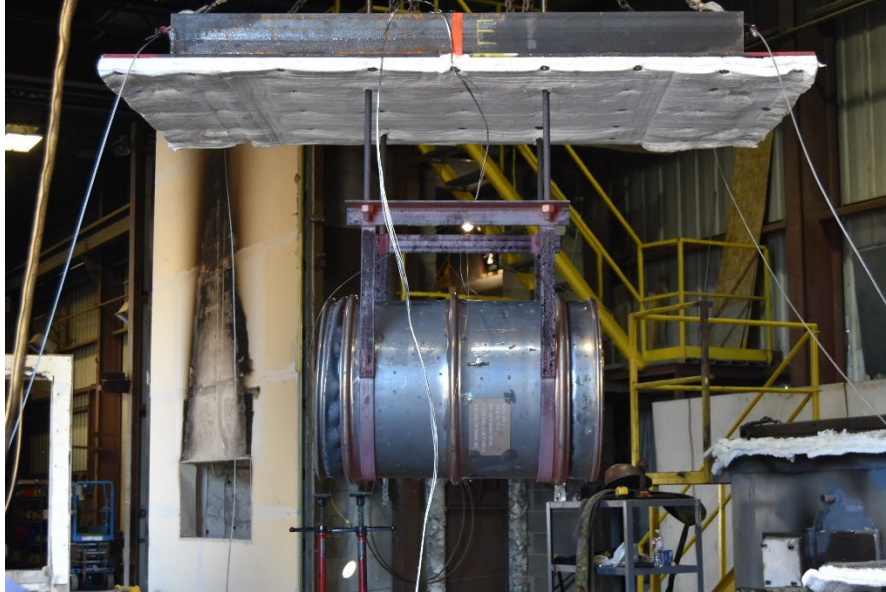




**Figure C-31 Loading TU-3 into furnace.**



**Figure C-32 TU-3 removed from furnace.**



**Figure C-33 TU-3 moved to cooling stand.**

## C.4 PACKAGE DISASSEMBLY

### C.4.1 Drum Body Disassembly



**Figure C-34 TU-3 post thermal weight measurement.**



**Figure C-35 Drum lid weight measurement.**





**Figure C-36 TU-3 CV removal.**



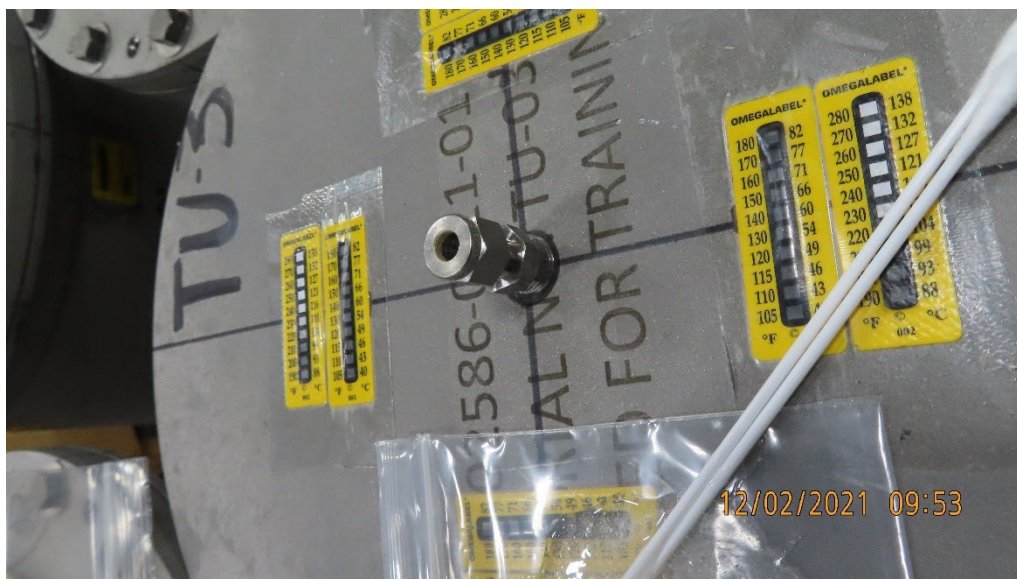
**Figure C-37 TU-3 CV post thermal weight.**



#### C.4.2 CV body leak testing



**Figure C-38 TU-3 post operational leak test (group setup).**

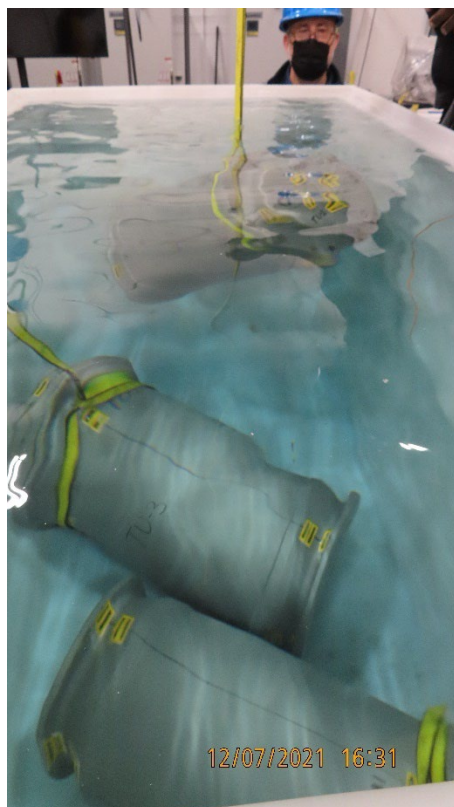


**Figure C-39 1/4" NPT tapered pipe thread on TU-3 CV lid.**

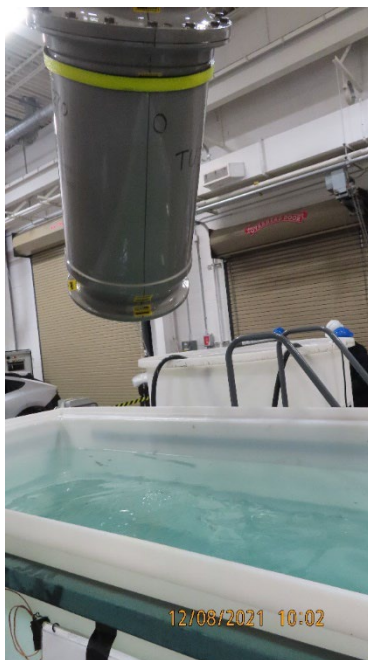


**Figure C-40 Post-test helium leak test.**

## **C.5 WATER IMMERSION**



**Figure C-41 TU-3 CV loaded into water immersion tank at the packaging lab.**



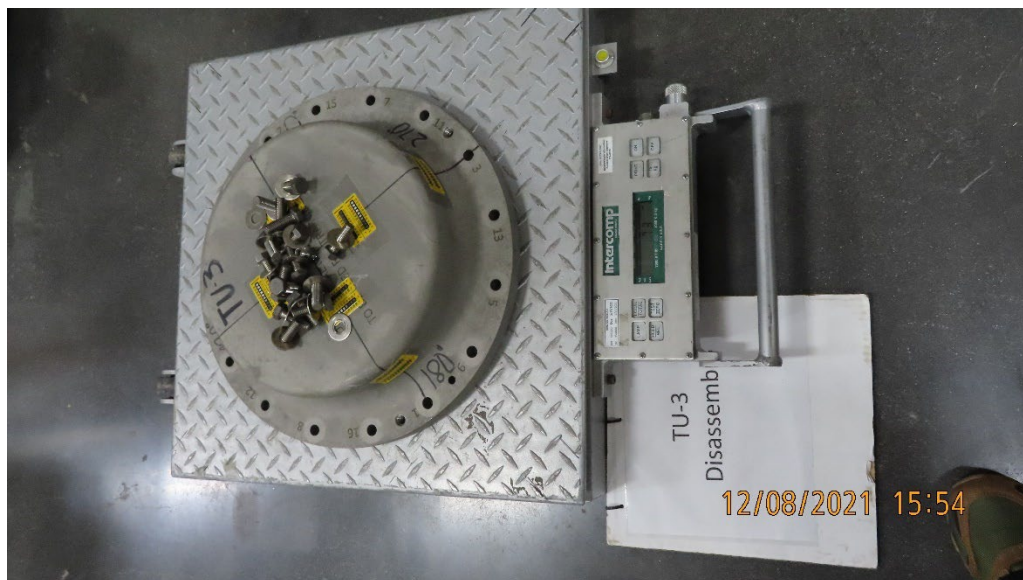
**Figure C-42 CV removal from water immersion tank.**



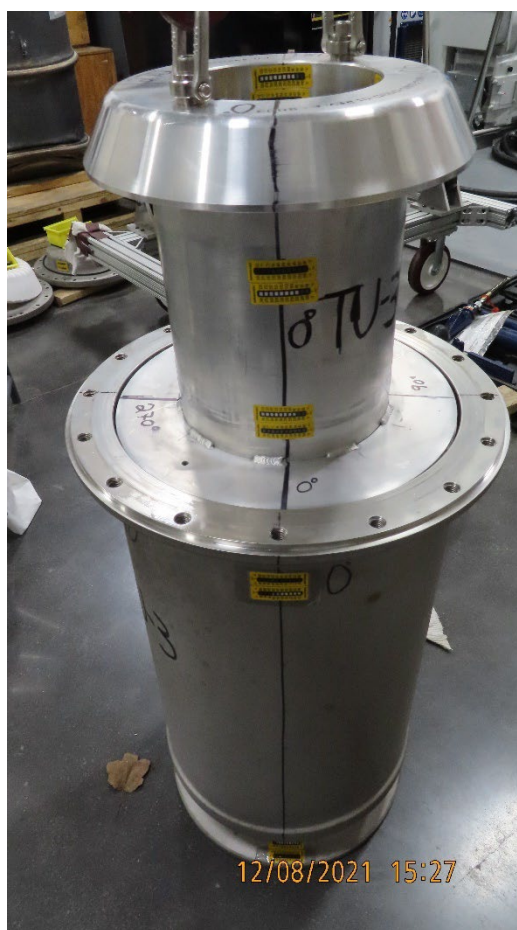
**Figure C-43 TU-3 CV weighed after water immersion.**



## C.6 CV DISASSEMBLY



**Figure C-44 TU-3 CV lid temperature labels and weight.**



**Figure C-45 Removing test weight assembly from TU-3 CV.**





**Figure C-46 TU-3 Test fixture weldment post thermal test weight.**



**Figure C-47 TU-3 CV body weight.**

**D. APPENDIX D – TU-4 PHOTOS**

This section contains a collection of digital photos taken during testing of TU-4 of the DPP-1 package. The list below provides the sections into which the photos have been grouped. The subsequent pages provide the list of figures contained within this appendix.

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## D.1 SECTION 1 –TEST UNIT 4 ASSEMBLY

### D.1.1 CV Assembly

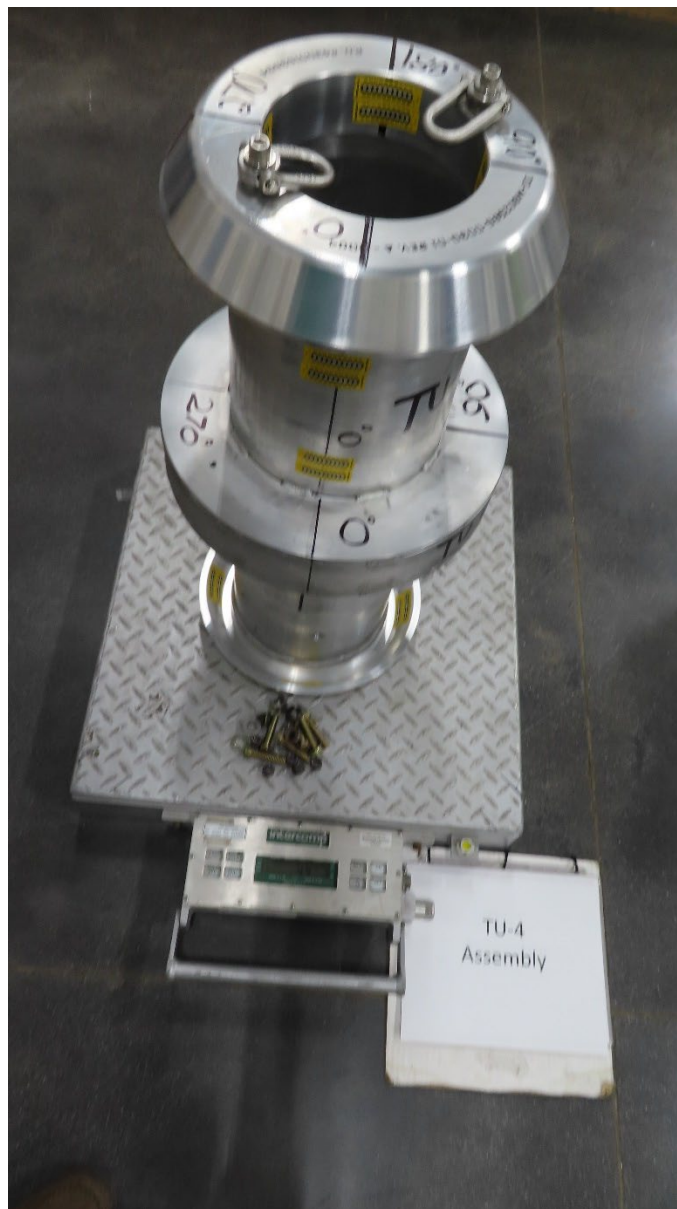
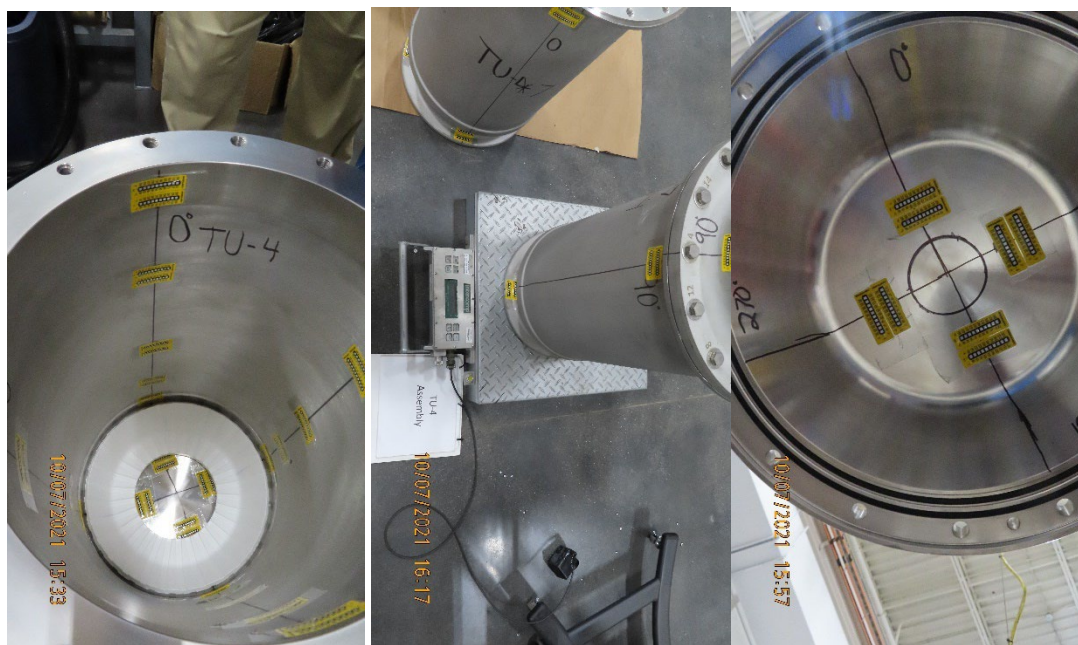


Figure D-1 TU-4 test weight.

## Appendix D – DPP-1 TU-4 Photos

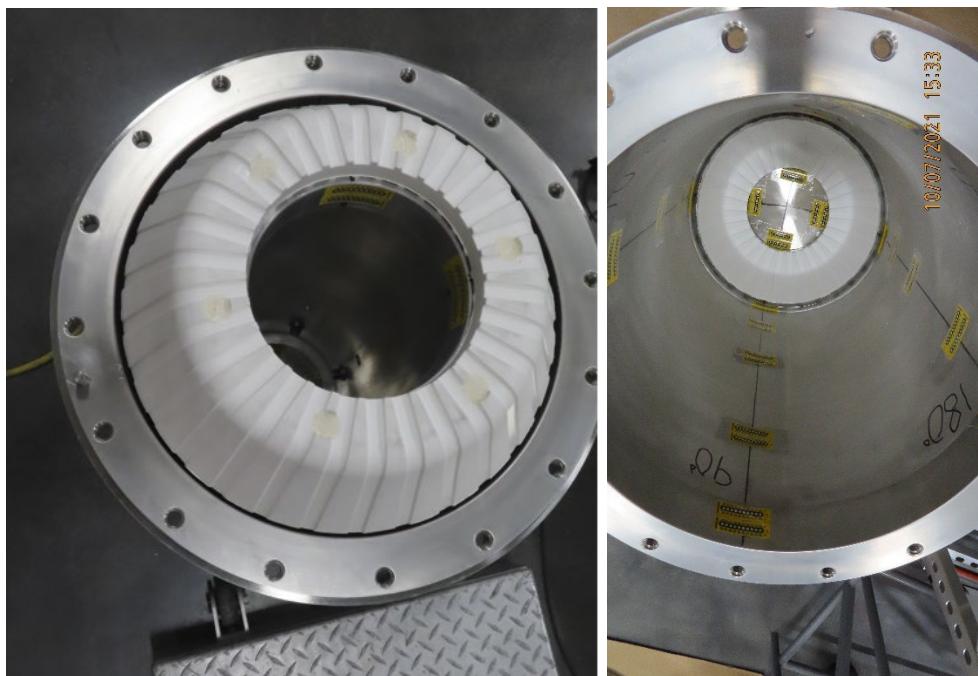


**Figure D-2 TU-4 heavy test load.**



**Figure D-3 TU-4 CV assembly, temperature indicating labels on body and lid.**

## Appendix D – DPP-1 TU-4 Photos

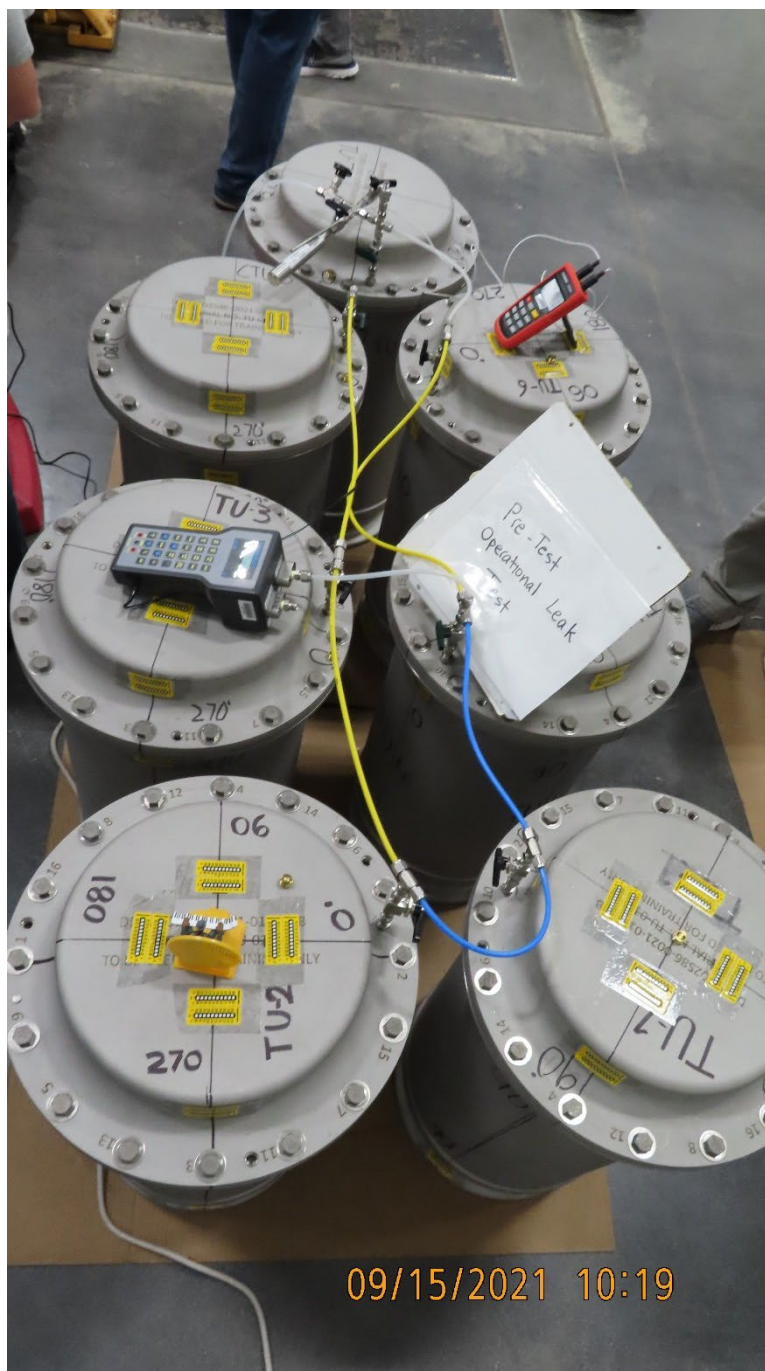


**Figure D-4 TU-4 CV assembly.**



**Figure D-5 TU-4 CV assembly weight.**

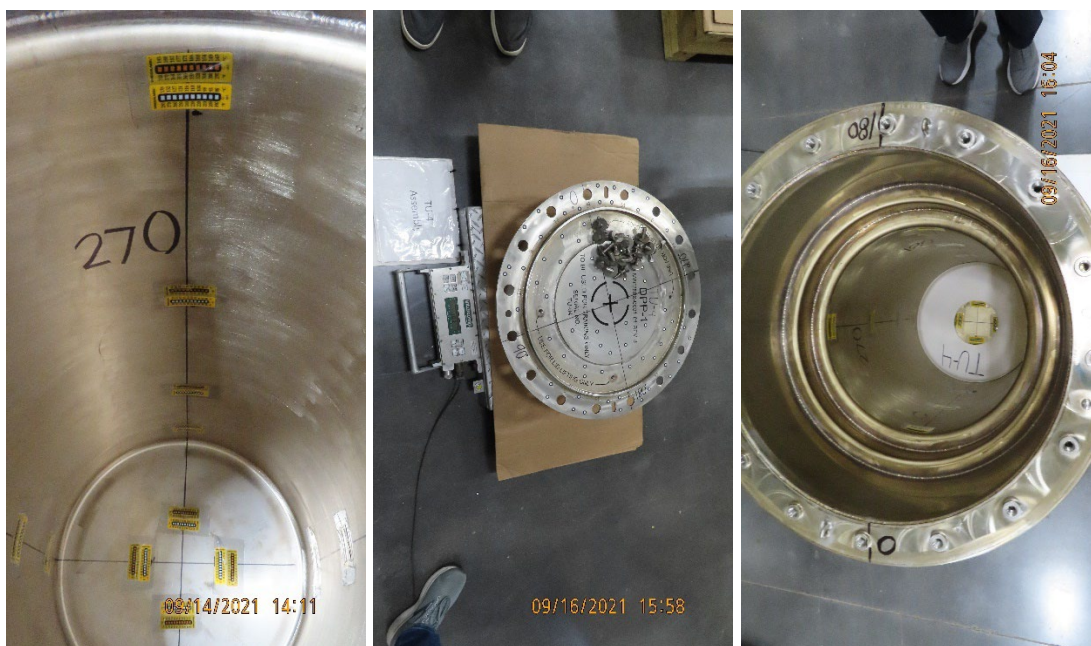




**Figure D-6 CV Pre-Operational Leak Test.**



### D.1.2 Drum Body Assembly



**Figure D-7 TU-4 drum body temperature labels and lid weighing.**



**Figure D-8 TU-4 drum body weighed.**

## Appendix D – DPP-1 TU-4 Photos



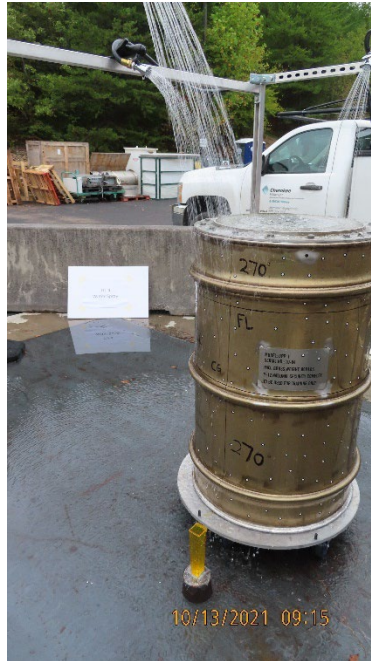
**Figure D-9 CV lowered into TU-4 drum body.**



**Figure D-10 TU-4 fully assembled.**

## D.2 NCT TESTING

### D.2.1 NCT Water Spray Test



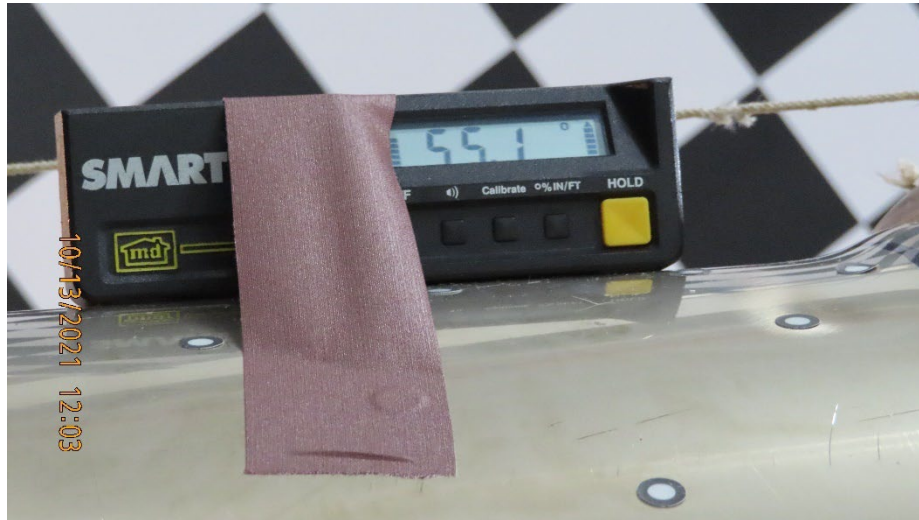
**Figure D-11 TU-4 water spray test.**



**Figure D-12 TU-4 water spray test ends.**



### D.2.2 NCT 1.2-m Free Drop



**Figure D-13 Establishing 1.2-m NCT drop orientation angle.**



**Figure D-14 Establishing 1.2-m height for NCT free drop test.**



## Appendix D – DPP-1 TU-4 Photos



**Figure D-15 TU-4 1.2-m NCT free drop test damage.**



**Figure D-16 TU-4 1.2-m NCT free drop test damage to top lid at 0° line.**

### D.3 HAC TESTING

#### D.3.1 HAC 9-m Free Drop



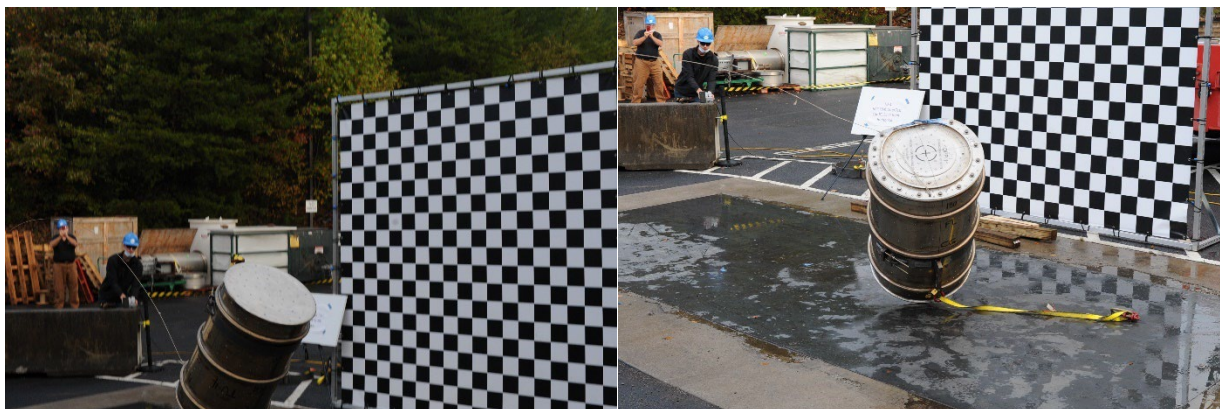
**Figure D-17 TU-4 rigging and orientation set up for 9-m HAC drop.**



**Figure D-18 TU-4 raised to 9-m and ready for drop test.**



Appendix D – DPP-1 TU-4 Photos



**Figure D-19 TU-4 HAC 9-m drop impact.**



**Figure D-20 TU-4 HAC damage at 0° line.**



**Figure D-21 TU-4 top lid HAC 9-m damage.**



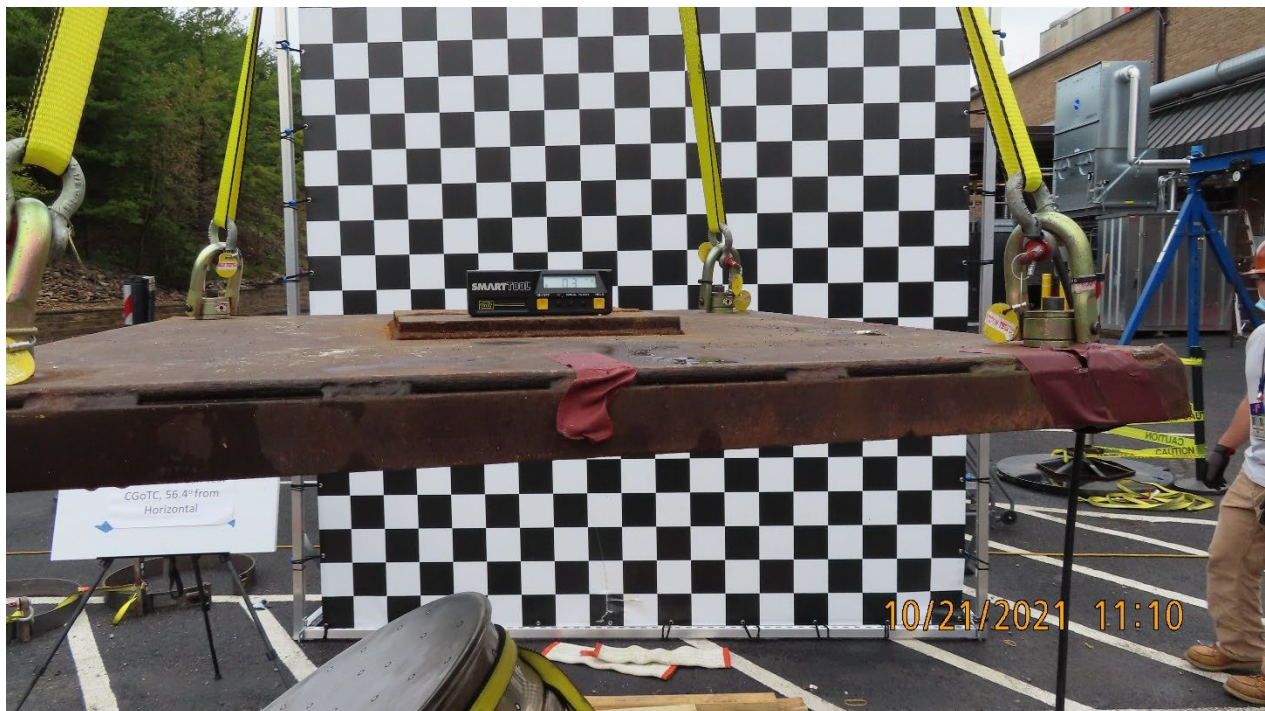
**Figure D-22 TU-4 drum bottom HAC 9-m damage.**



### D.3.2 Crush Test



**Figure D-23 TU-4 crush test setup**

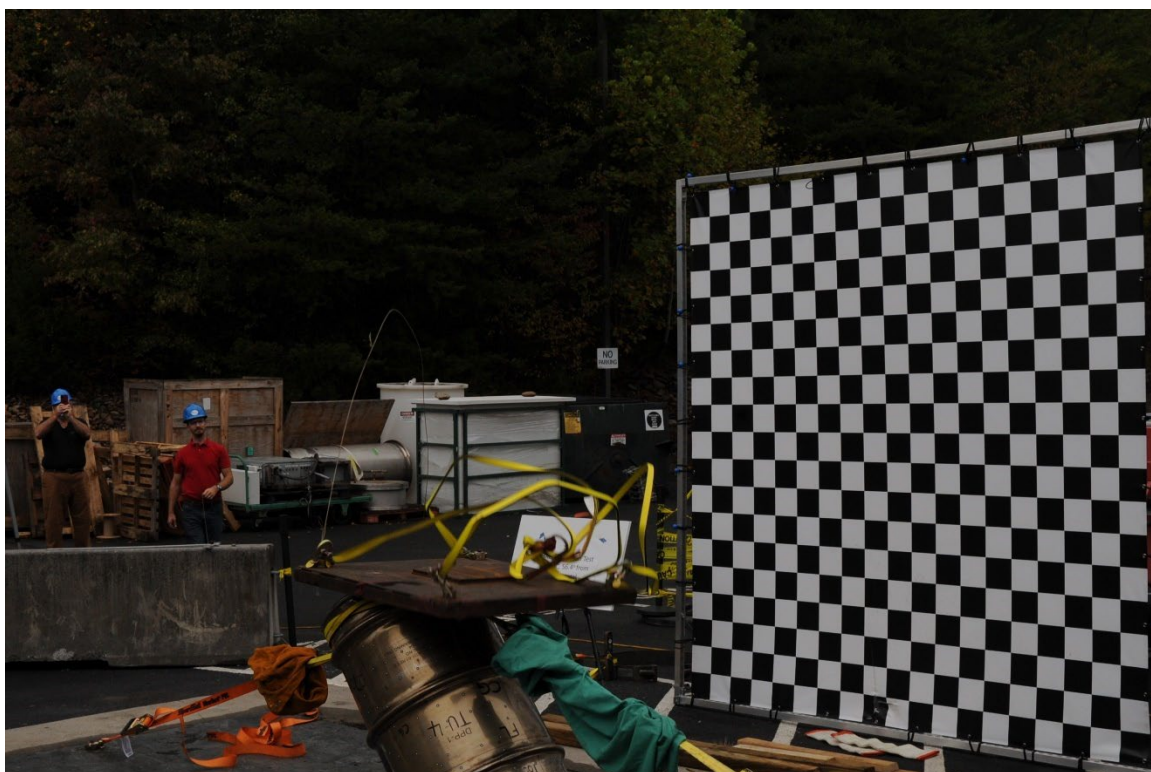


**Figure D-24 TU-4 crush plate rigging and orientation setup.**





**Figure D-25 Establishing 9-m height for crush plate above TU-4**



**Figure D-26 TU-4 HAC 9-m crush impact.**



**Figure D-27 TU-4 HAC 9-m crush damage at the bottom of drum.**



**Figure D-28 TU-4 HAC 9-m crush damage at the top of drum.**



### D.3.3 Puncture Test

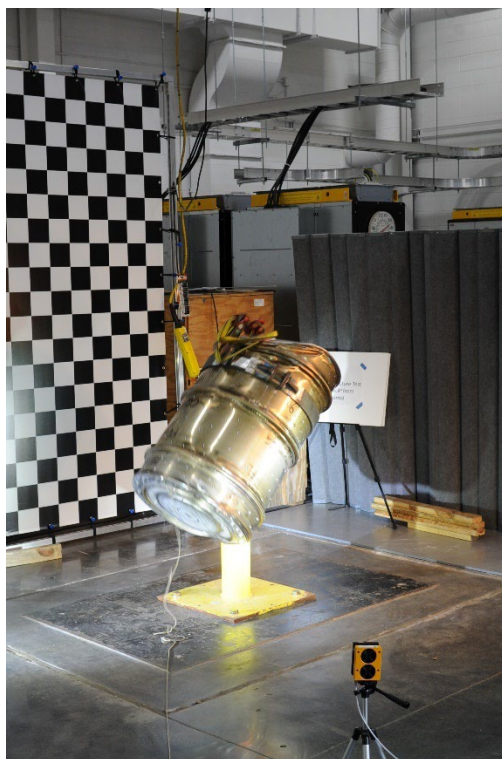


**Figure D-29 TU-4 puncture test rigging setup.**



**Figure D-30 Aligning TU-4 over puncture bar and measuring 1-m height.**





**Figure D-31 TU-4 puncture test impact.**



**Figure D-32 TU-4 puncture test damage.**

### D.3.4 Thermal Testing



**Figure D-33 TU-4 in pre-heat chamber.**



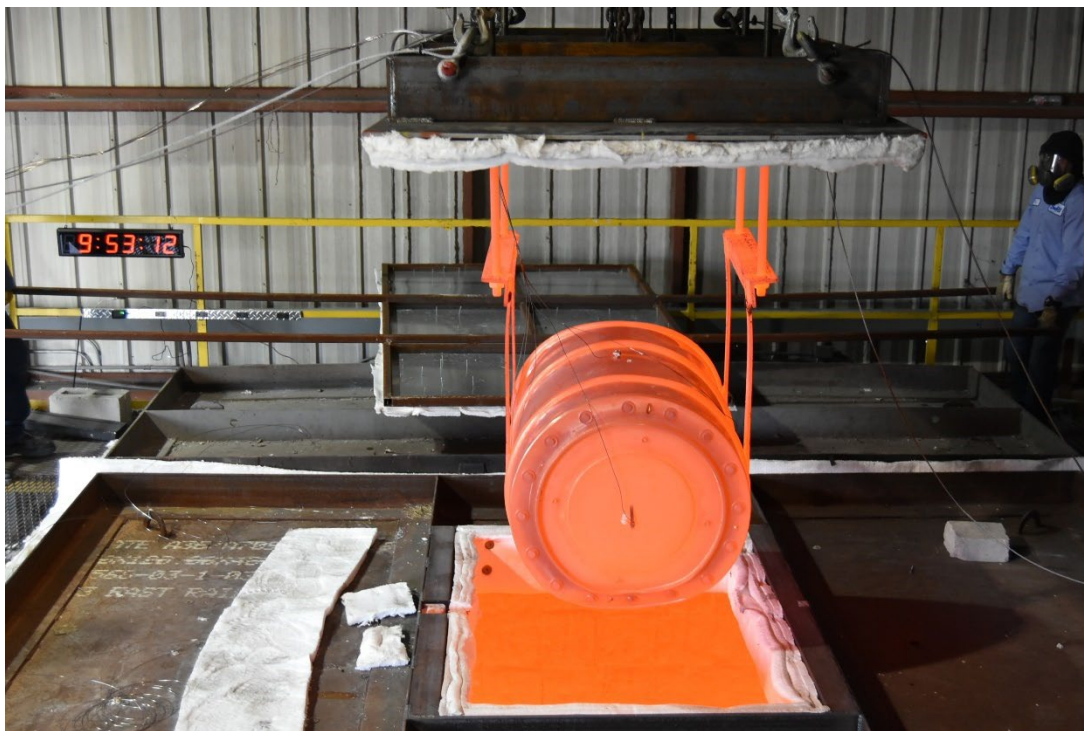
**Figure D-34 Thermocouples affixed to TU-4 prior to thermal testing.**



Appendix D – DPP-1 TU-4 Photos



**Figure D-35 Loading TU-4 into furnace.**



**Figure D-36 TU-4 removed from furnace.**



**Figure D-37 TU-4 on cooling stand.**



## D.4 PACKAGE DISASSEMBLY

### D.4.1 Drum Body Disassembly



**Figure D-38 Post thermal weight measurement.**



**Figure D-39 TU-4 drum body cut to remove lid and CV.**

## Appendix D – DPP-1 TU-4 Photos



**Figure D-40 TU-4 Drum lid weight measurement.**



**Figure D-41 TU-4 CV removal.**





**Figure D-42 TU-4 CV wedge and drum liner weighed.**

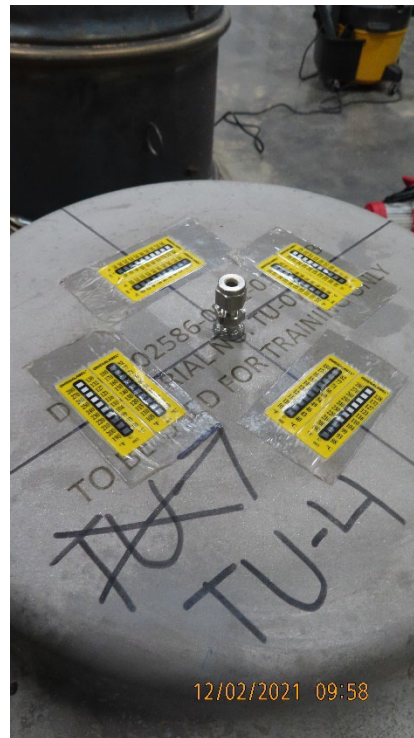


**Figure D-43 CV body post thermal weight.**

#### D.4.2 CV body leak testing

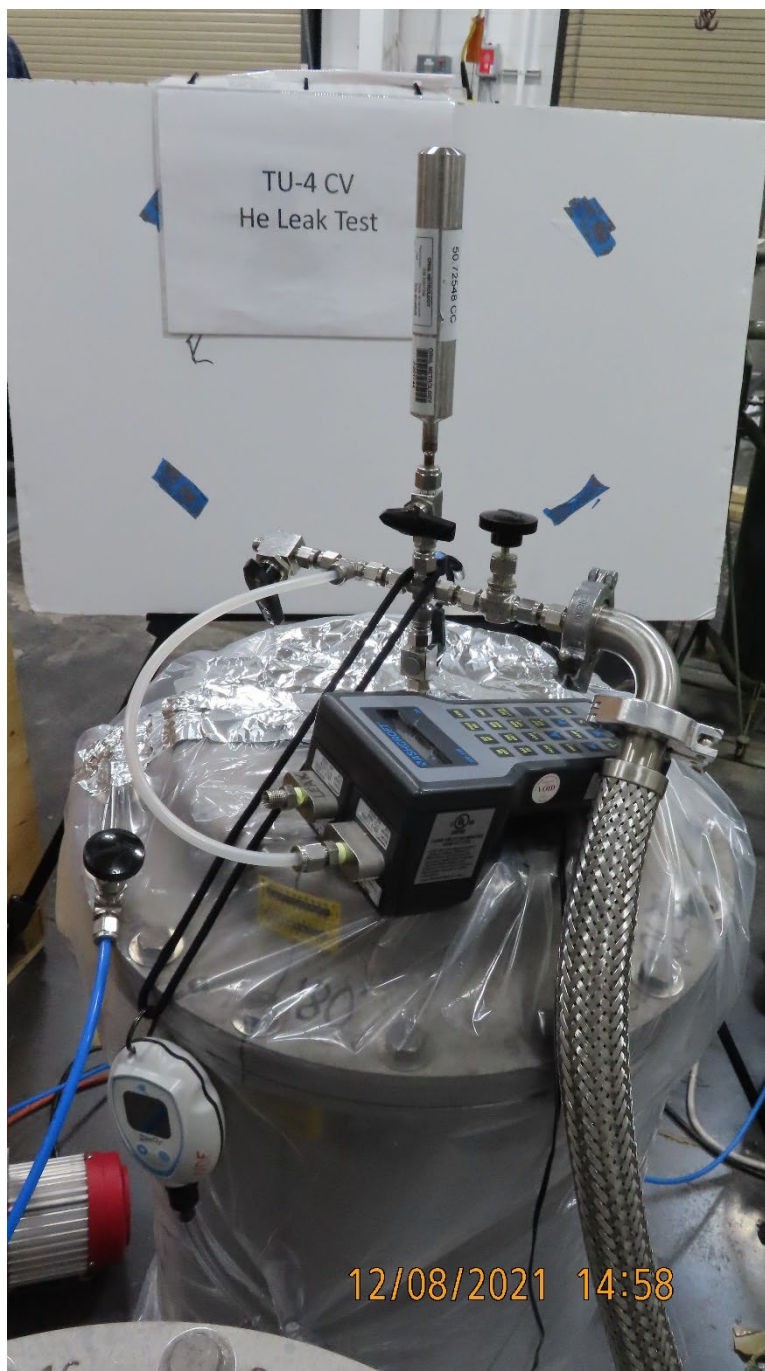


**Figure D-44 TU-4 post-test operational leak test (group setup).**



**Figure D-45 1/4" NPT tapered pipe thread on TU-4 CV.**



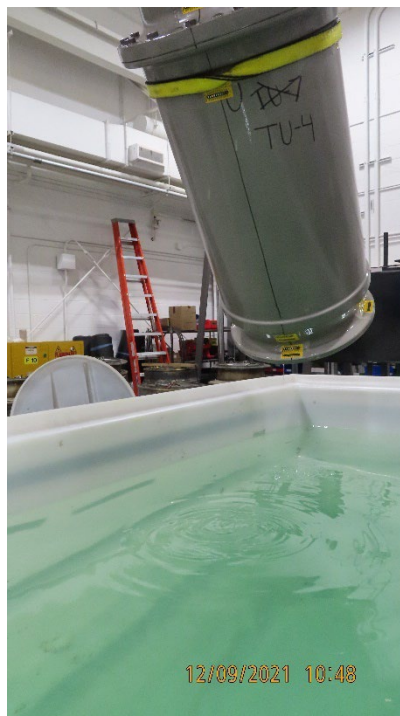


**Figure D-46 TU-4 CV post-test helium leak test.**

## D.5 WATER IMMERSION



**Figure D-47 TUs submerged in water immersion tank at the packaging lab.**

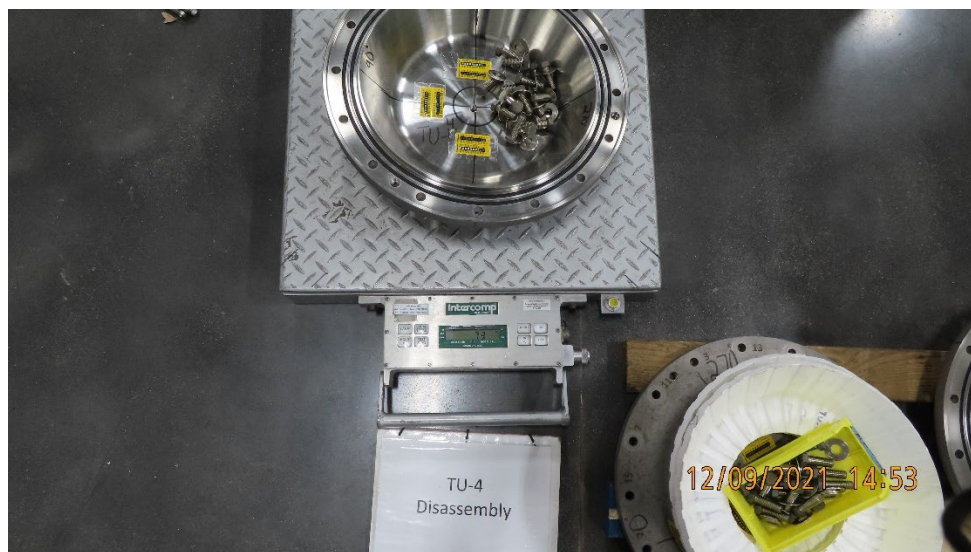


**Figure D-48 TU-4 CV removal from water immersion tank.**



**Figure D-49 TU-4 CV weighed after water immersion.**

## **D.6 CV DISASSEMBLY**



**Figure D-50 TU-4 CV temp. labels and weight.**





**Figure D-51 Removing test weight assembly from TU-4 CV.**

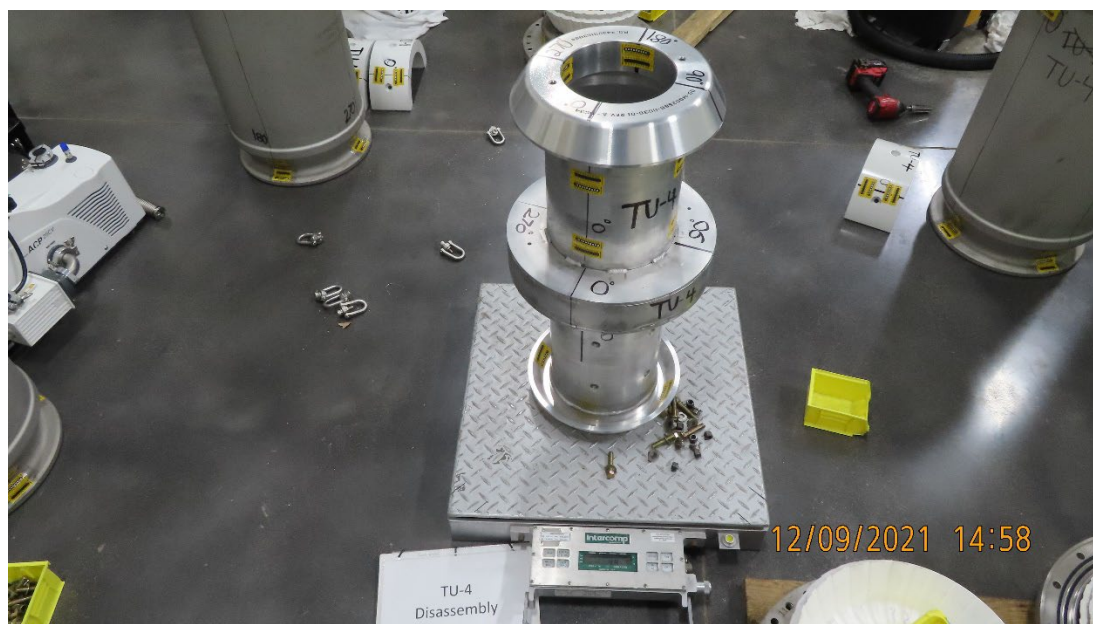


**Figure D-52 Post thermal weight of test load set.**





**Figure D-53 TU-4 CV weldment PCC pads weight.**



**Figure D-54 TU-4 test fixture weldment post thermal test inspection.**

**E. APPENDIX E – TU-5 PHOTOS**

This section contains a collection of digital photos taken during testing of TU-5 of the DPP-1 package. The list below provides the sections into which the photos have been grouped. The subsequent pages provide the list of figures contained within this appendix.

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## E.1 SECTION 1 –TEST UNIT 5 ASSEMBLY

### E.1.1 CV Assembly

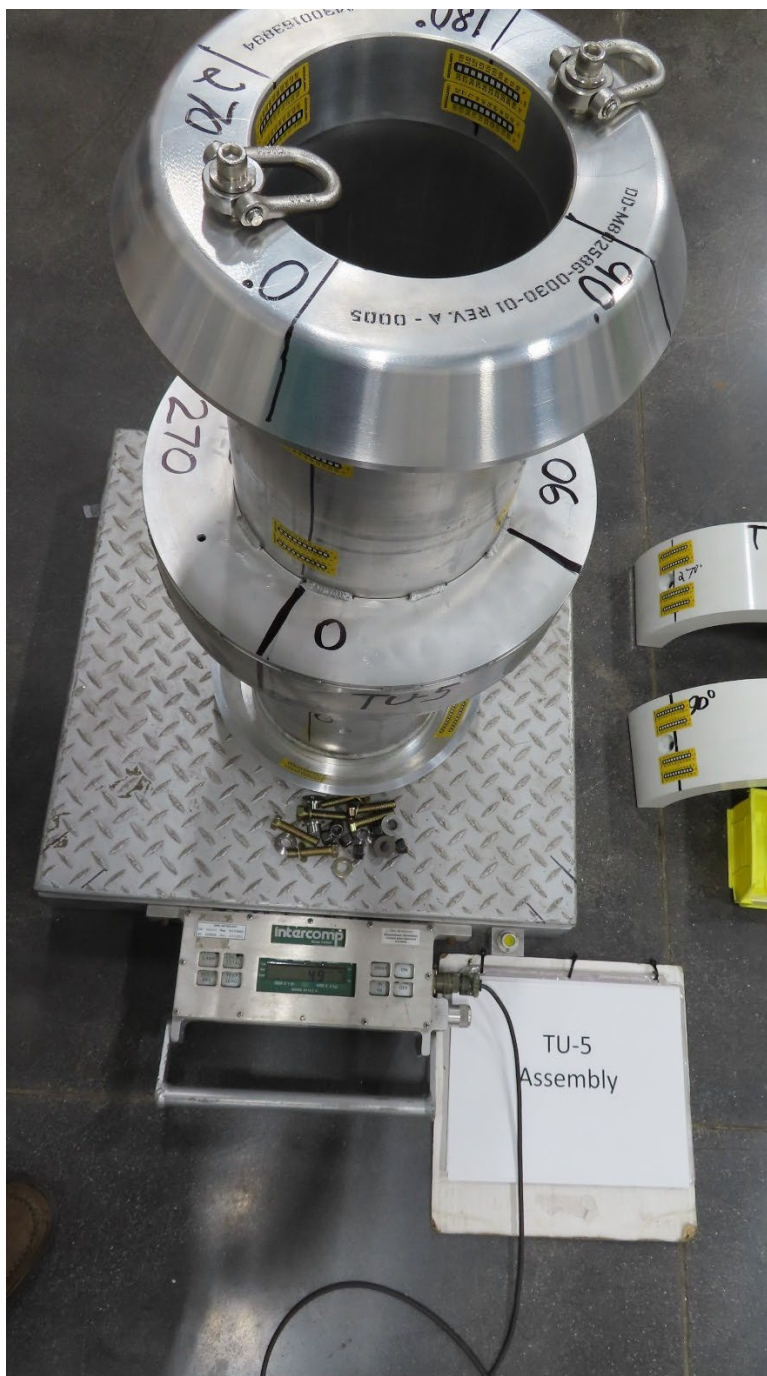


Figure E-1 TU-5 heavy test weight.

## Appendix E – DPP-1 TU-5 Photos



**Figure E-2 TU-5 heavy test load.**



**Figure E-3 CV assembly, non-basket content assembly in place.**



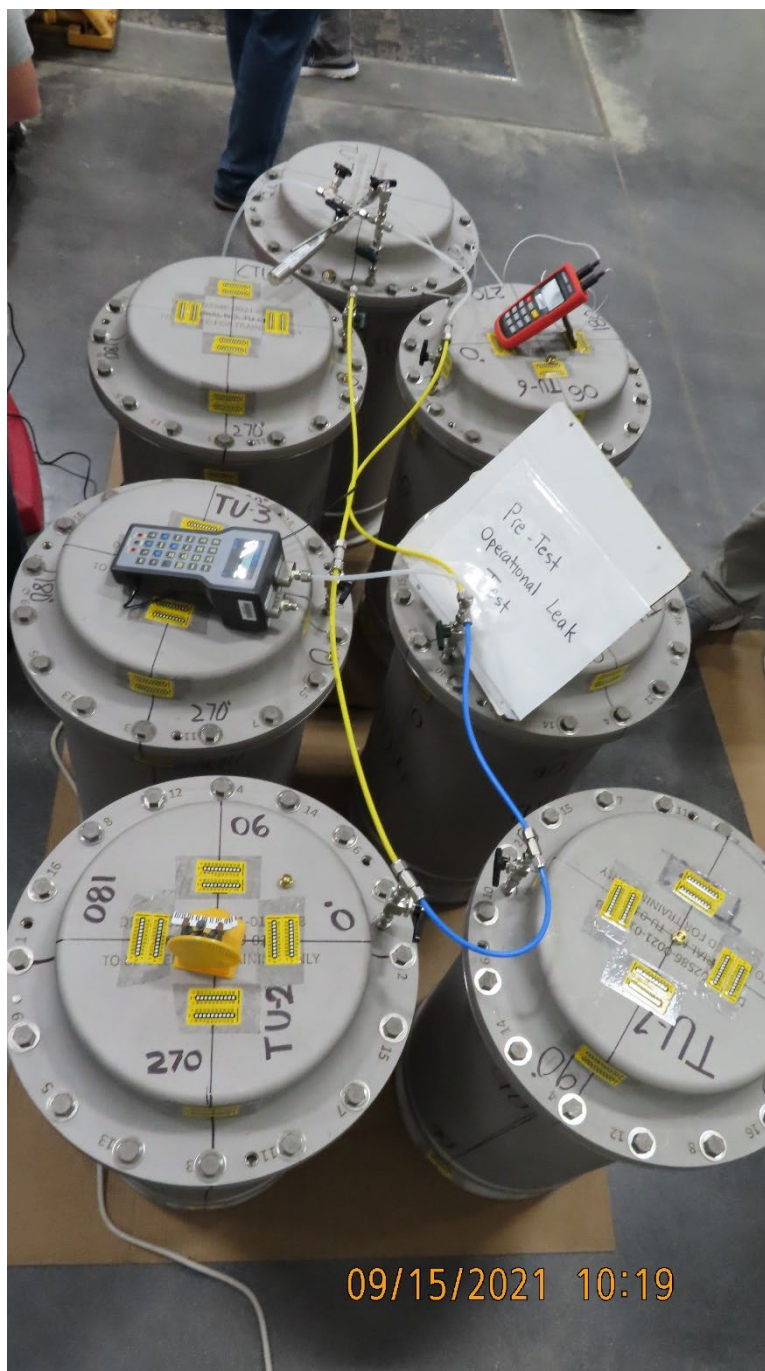
## Appendix E – DPP-1 TU-5 Photos



**Figure E-4 TU-5 CV assembly.**



**Figure E-5 TU-1 CV Assembly weight.**



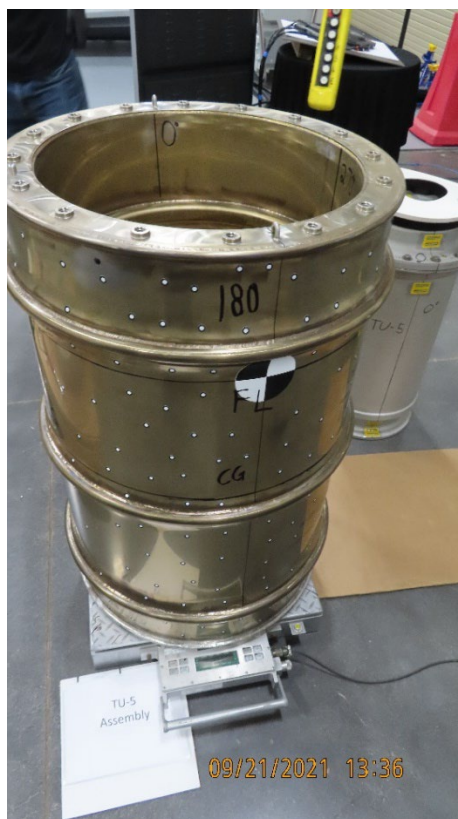
**Figure E-6 CV Pre-Operational Leak Test (group setup).**



### E.1.2 Drum Body Assembly



**Figure E-7 Drum body temperature labels and lid weighing.**



**Figure E-8 Weighing drum body assembly components.**

## Appendix E – DPP-1 TU-5 Photos



**Figure E-9 CV lowered into TU-5 drum body.**



**Figure E-10 TU-5 fully assembled test unit.**





**Figure E-11 TU-5 Accelerometer mounts welding operation.**

## E.2 NCT TESTING

### E.2.1 NCT 1.2-m Free Drop



**Figure E-12 TU-5 wrapped in insulation and before NCT 4-ft drop.**



**Figure E-13 Measuring drop orientation angle.**



## Appendix E – DPP-1 TU-5 Photos

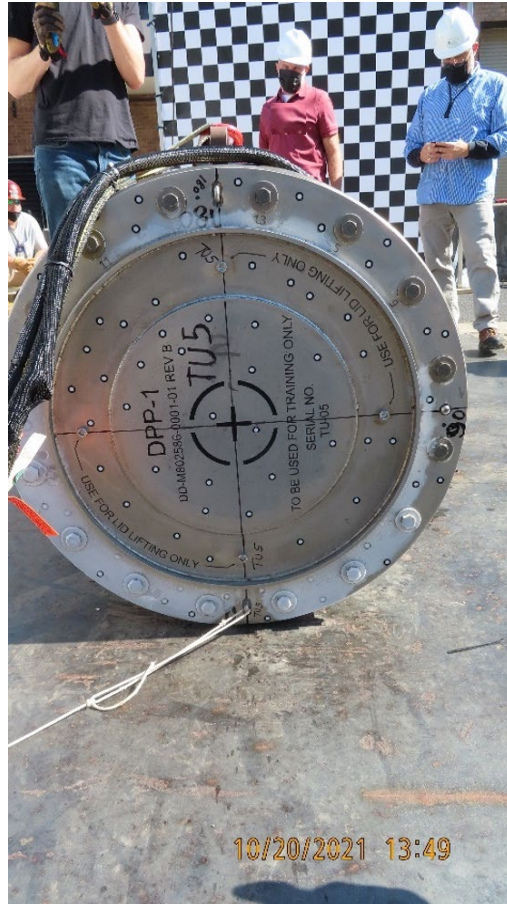


**Figure E-14 Establishing 1.2-m height for NCT free drop test.**



**Figure E-15 Package 1.2-m free drop just before impact.**

Appendix E – DPP-1 TU-5 Photos



**Figure E-16 TU-5 top lid free drop damage.**

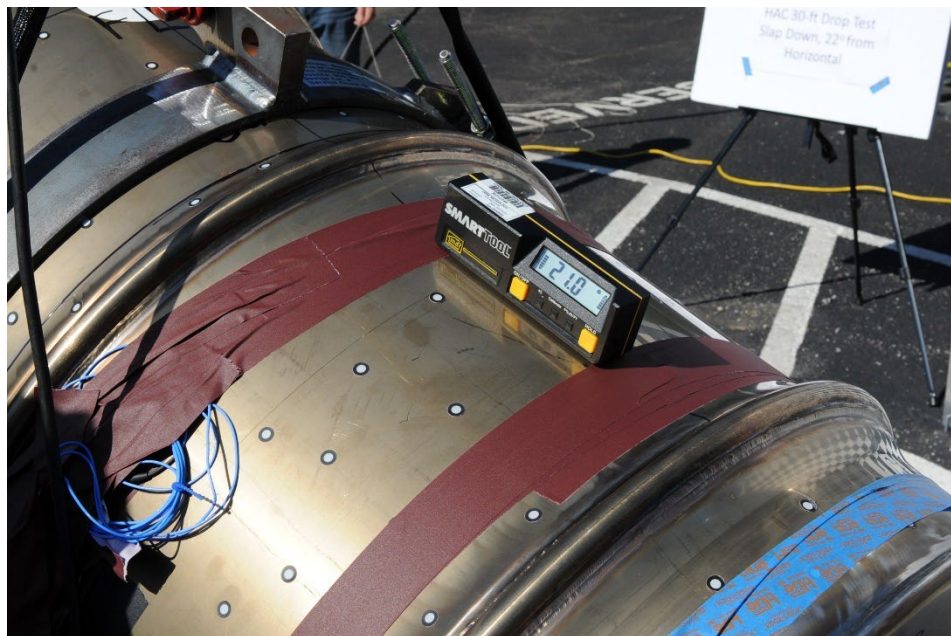


**Figure E-17 TU-5 bottom NCT free drop damage.**

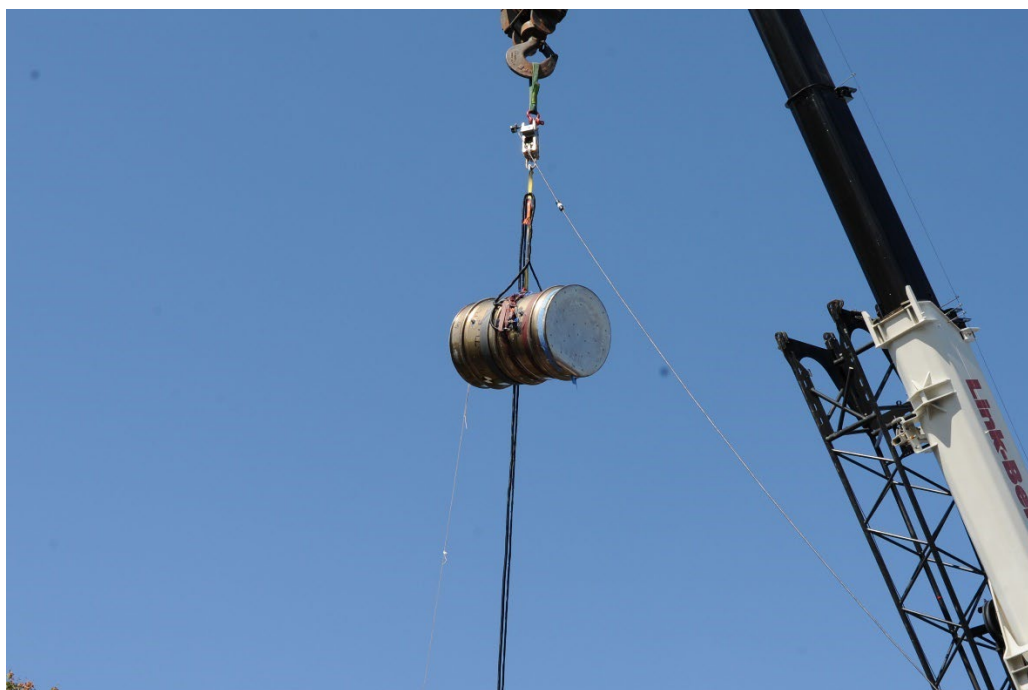


### E.3 HAC TESTING

#### E.3.1 HAC 9-m Free Drop



**Figure E-18 TU-5 rigging and orientation set up for 9-m HAC drop.**



**Figure E-19 TU-5 raised to 9-m and ready for drop test.**

## Appendix E – DPP-1 TU-5 Photos

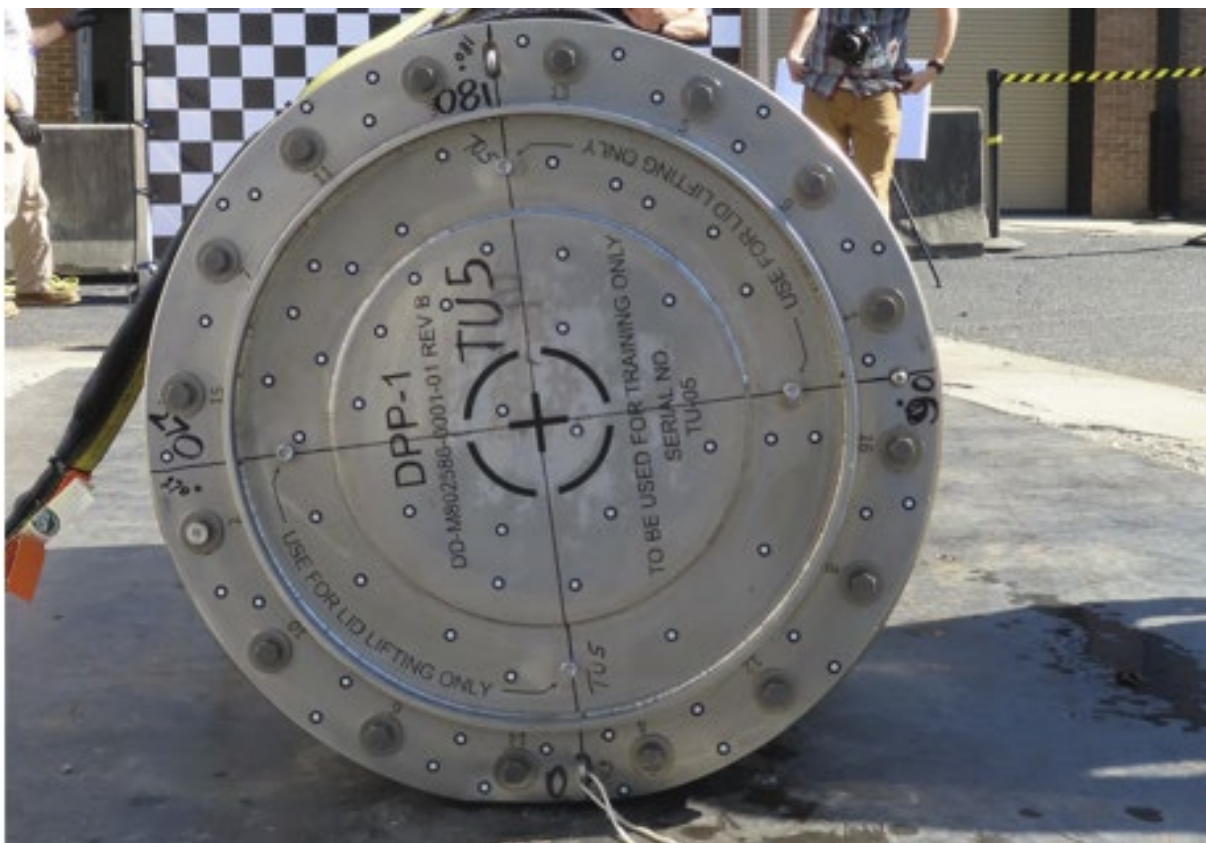


**Figure E-20 TU-5 HAC 9-m drop at impact and re-bounce.**



**Figure E-21 TU-5 HAC damage at 0° line.**





**Figure E-22 TU-5 top lid HAC 9-m damage.**



**Figure E-23 TU-5 drum bottom HAC 9-m damage.**

### E.3.2 Crush Test

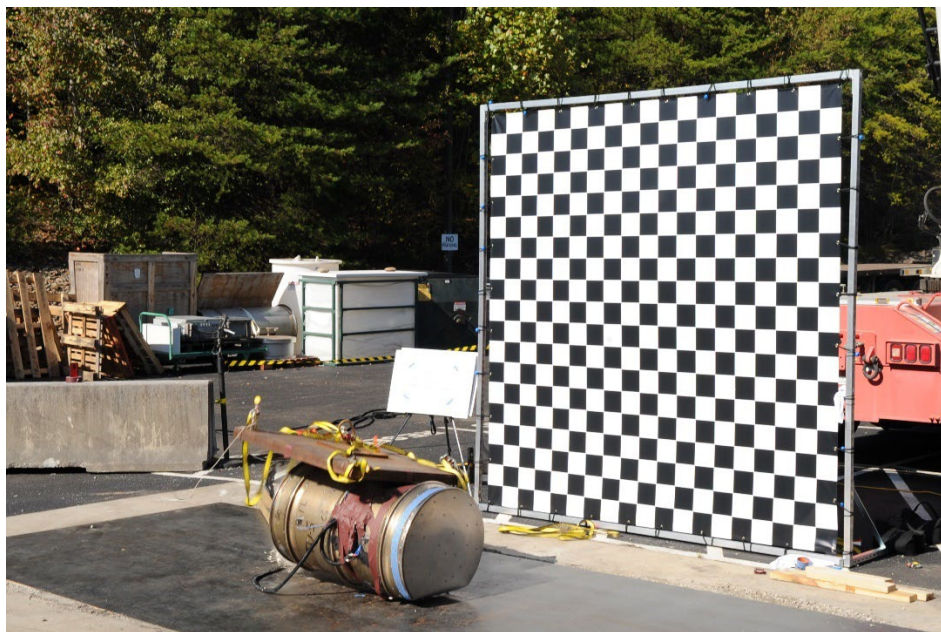


**Figure E-24 TU-5 crush plate rigging and orientation set up.**



**Figure E-25 Crush plate released from a height of 9-m above TU-5.**

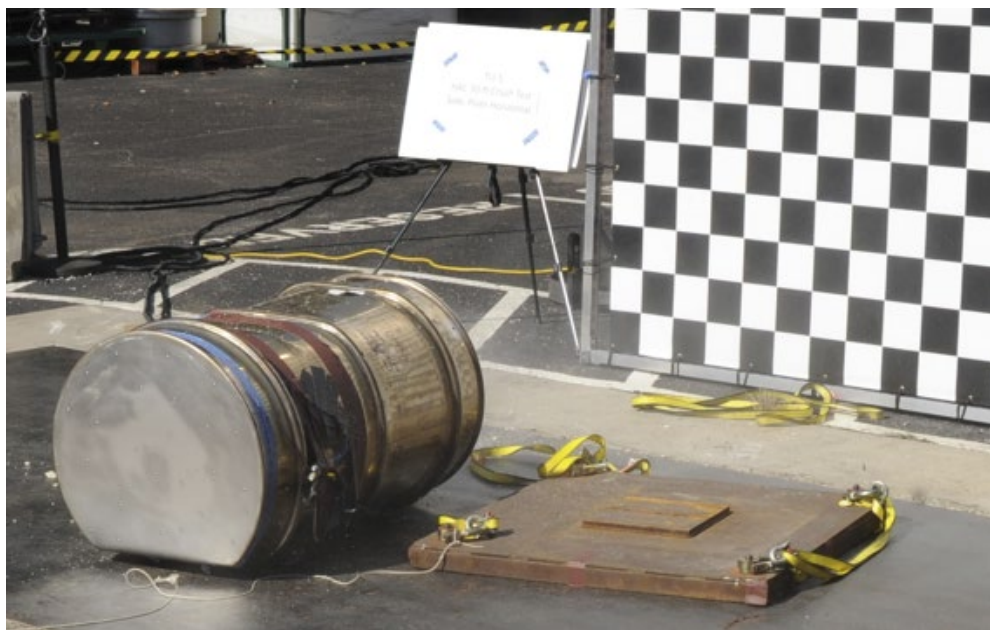




**Figure E-26 Crush plate – TU-5 impact moment.**



**Figure E-27 TU-5 drum lid cracked open and spilled packrete after crush plate impact.**



**Figure E-28 TU-5 crush test damage at the bottom.**



**Figure E-29 TU-5 Opening on the drum lid.**



### E.3.3 Puncture Test



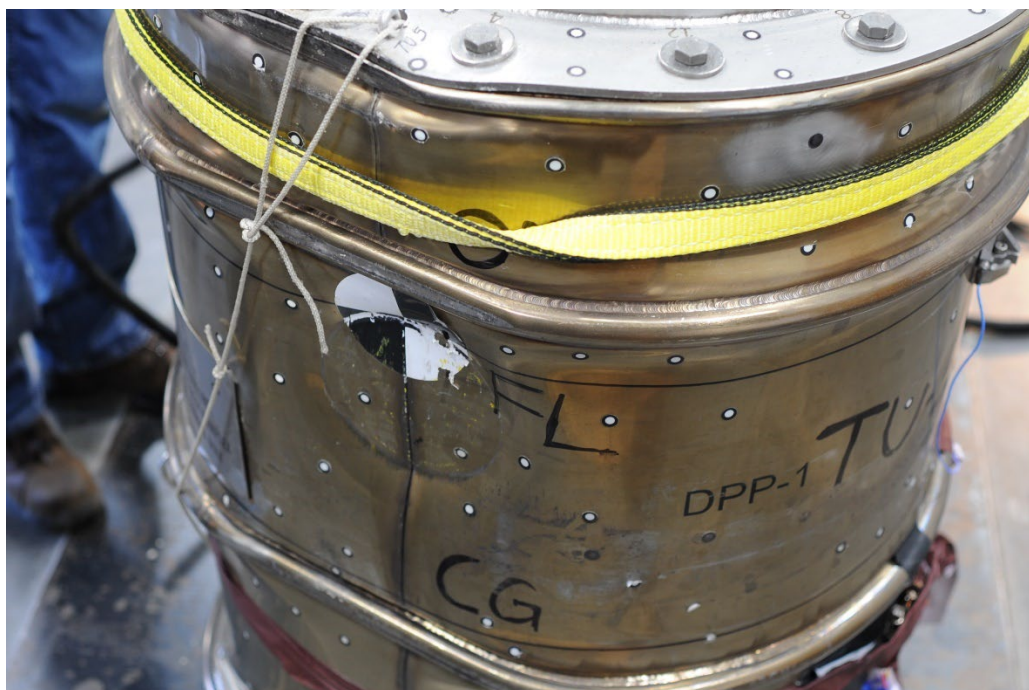
**Figure E-30 TU-5 puncture test rigging and orientation setup.**



**Figure E-31 Aligning TU-5 over puncture bar and measuring 1-m height.**



**Figure E-32 TU-5 puncture test impact.**



**Figure E-33 TU-5 puncture test damage.**



### E.3.4 Thermal Testing



Figure E-34 TU-5 in pre-heat chamber.



Figure E-35 Thermocouples affixed to TU-5 prior to thermal testing.



**Figure E-36 Loading TU-5 into furnace.**



**Figure E-37 TU-5 removed from furnace.**

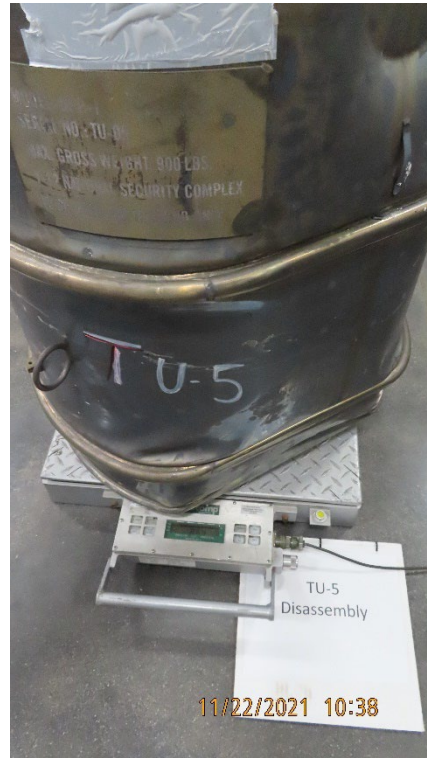




**Figure E-38 TU-5 on cooling stand.**

## E.4 PACKAGE DISASSEMBLY

### E.4.1 Drum Body Disassembly



**Figure E-39 TU-5 Post thermal weight measurement.**



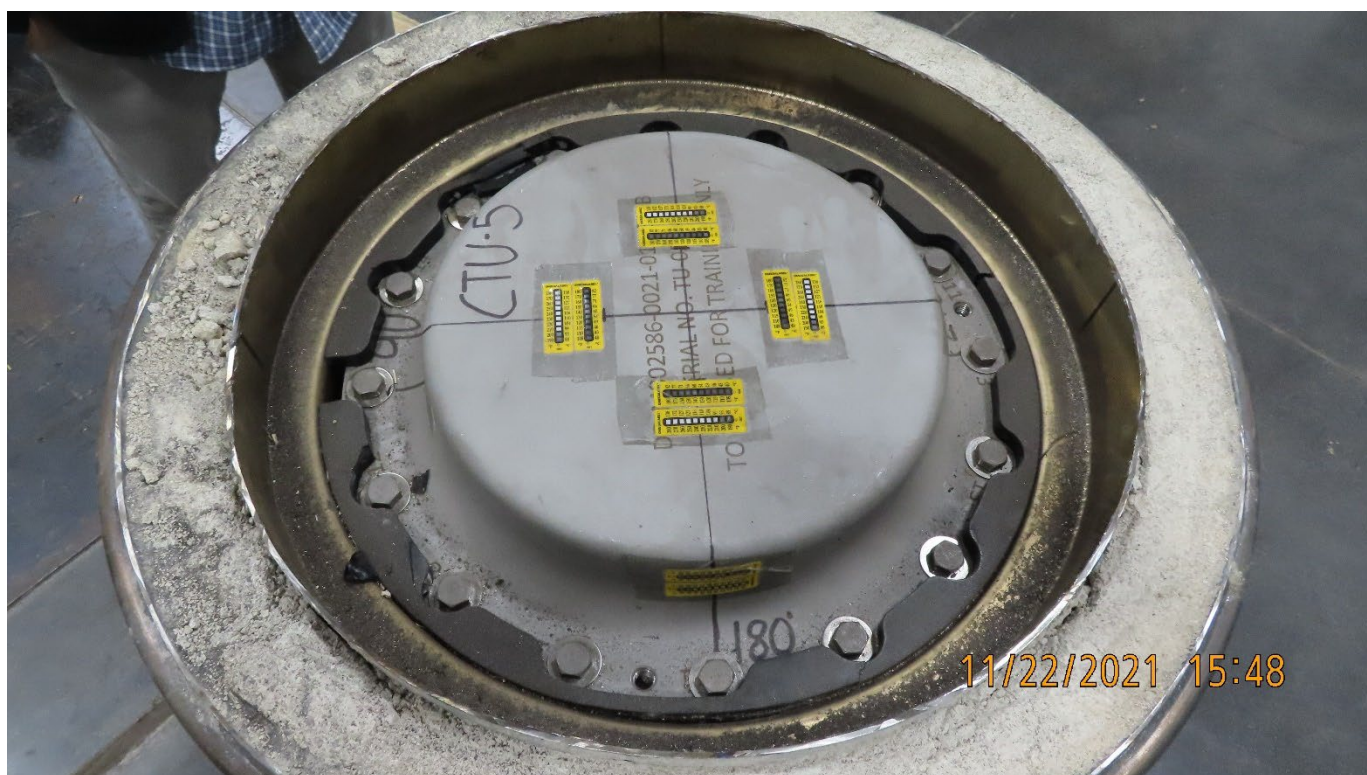
**Figure E-40 TU-5 drum body cut to remove lid and CV.**



## Appendix E – DPP-1 TU-5 Photos



**Figure E-41 Drum lid weight measurement.**



**Figure E-42 TU-5 CV orientation inside the drum.**



**Figure E-43 TU-5 CV removal from drum.**



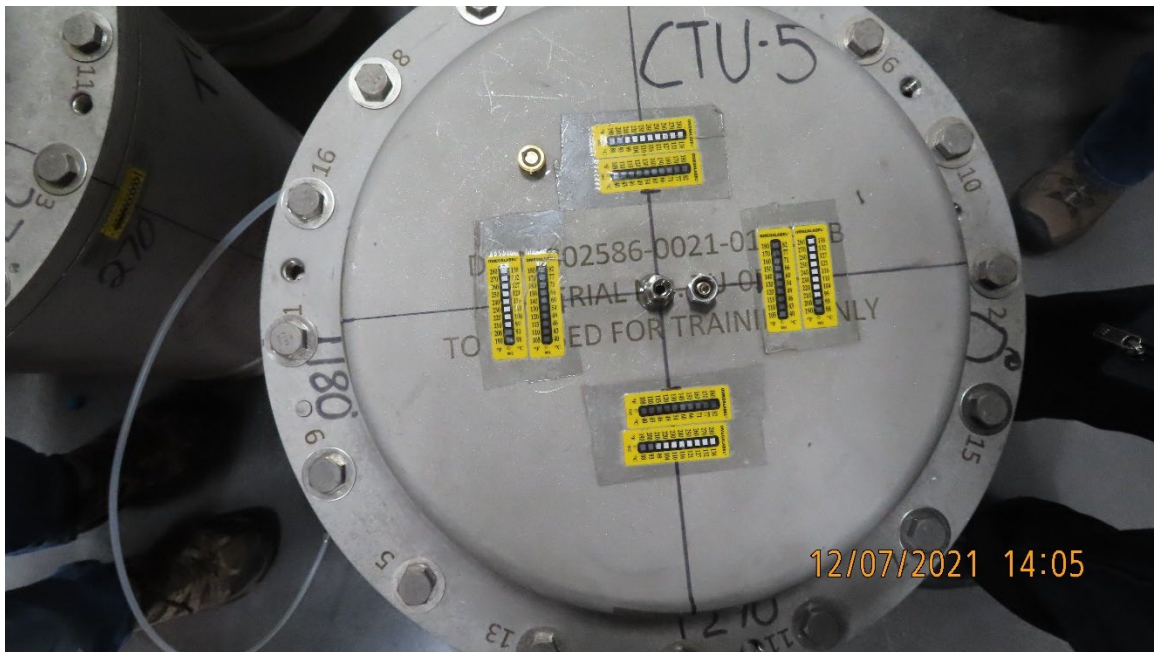
**Figure E-44 CV post thermal weight.**



#### E.4.2 CV body leak testing



**Figure E-45 TU-5 post-test operational leak test (group setup).**

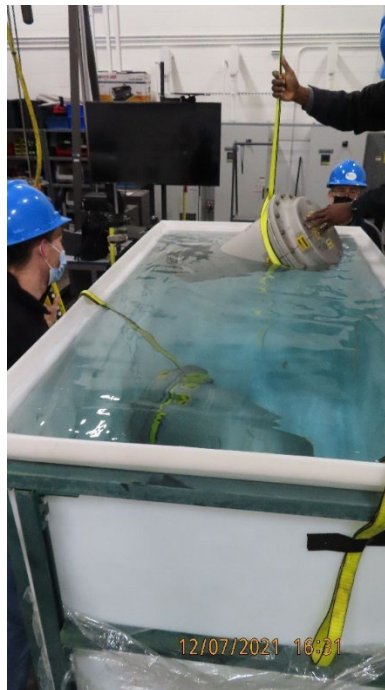


**Figure E-46 1/4" NPT tapered pipe thread on TU-5 CV.**

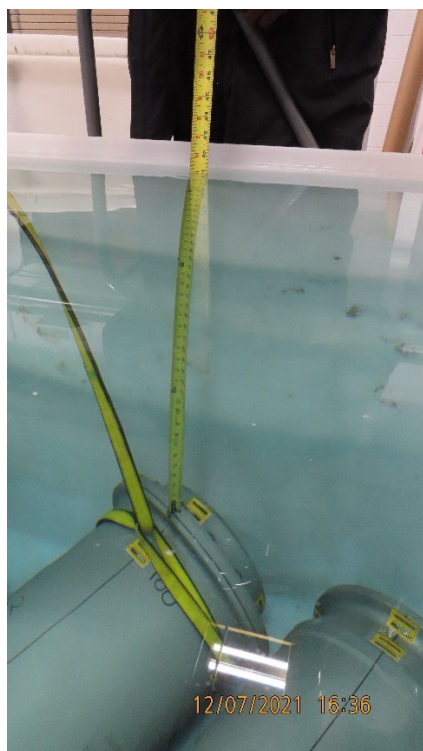


**Figure E-47 Post-test helium leak test.**

## **E.5 WATER IMMERSION**



**Figure E-48 Loading test unit CVs into water immersion tank at the packaging lab.**



**Figure E-49 TU CVs 41-in below water level.**



**Figure E-50 TU-5 CV weighed after water immersion.**



## E.6 CV DISASSEMBLY



**Figure E-51 TU-5 CV lid temperature labels.**



**Figure E-52 Water droplets outside of inner O-Ring of TU-5 CV flange.**



**Figure E-53 Removing test weight assembly from TU-5 CV.**



Appendix E – DPP-1 TU-5 Photos



**Figure E-54 TU-5 test fixture weldment PCC pads weight.**



**Figure E-55 TU-5 CV lid weight.**



**Figure E-56 TU-5 CV body weighed.**



**Figure E-57 TU-5 test fixture weldment post thermal test inspection.**

**F. APPENDIX F – TU-6 PHOTOS**

This section contains a collection of digital photos taken during testing of TU-6 of the DPP-1 package. The list below provides the sections into which the photos have been grouped. The subsequent pages provide the list of figures contained within this appendix.

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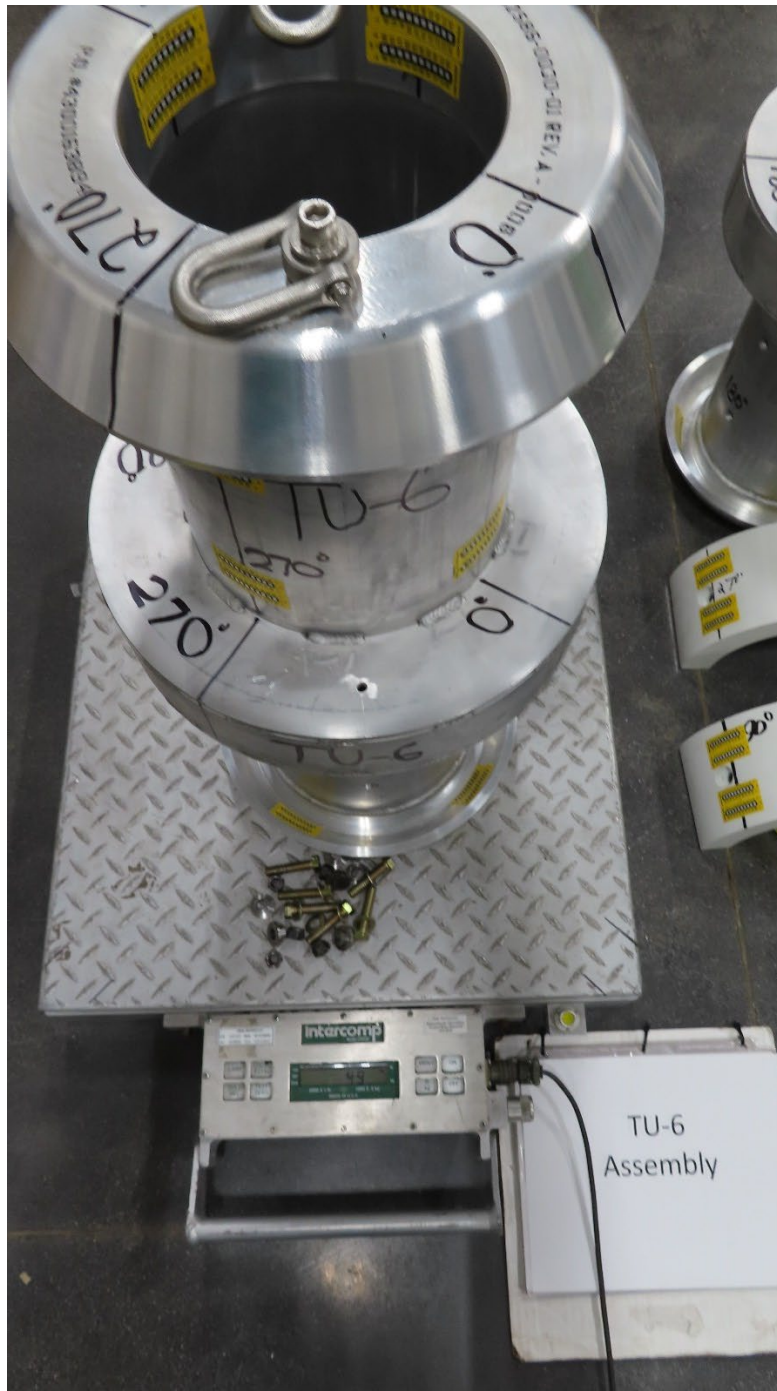


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## F.1 SECTION 1 –TEST UNIT 6 ASSEMBLY

### F.1.1 CV Assembly



**Figure F-1 TU-6 test weight.**

## Appendix F – DPP-1 TU-6 Photos



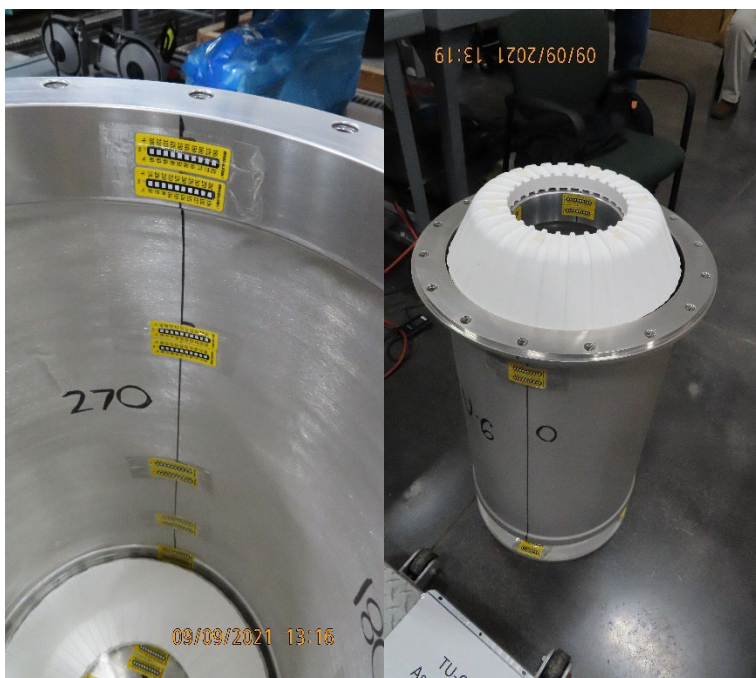
**Figure F-2 TU-6 heavy test load.**



**Figure F-3 TU-6 CV assembly, non-basket content assembly in place.**



## Appendix F – DPP-1 TU-6 Photos

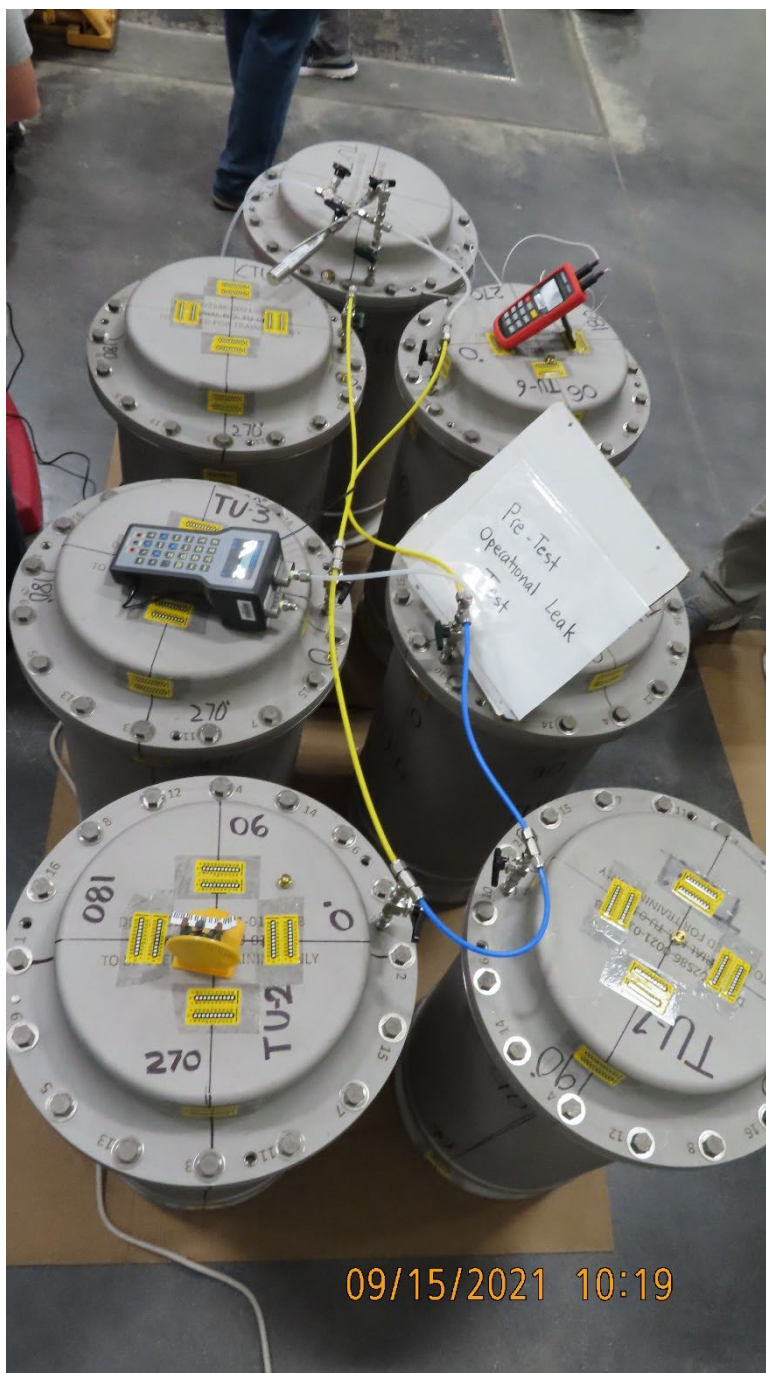


**Figure F-4 TU-6 CV assembly.**



**Figure F-5 TU-6 CV assembly weight.**



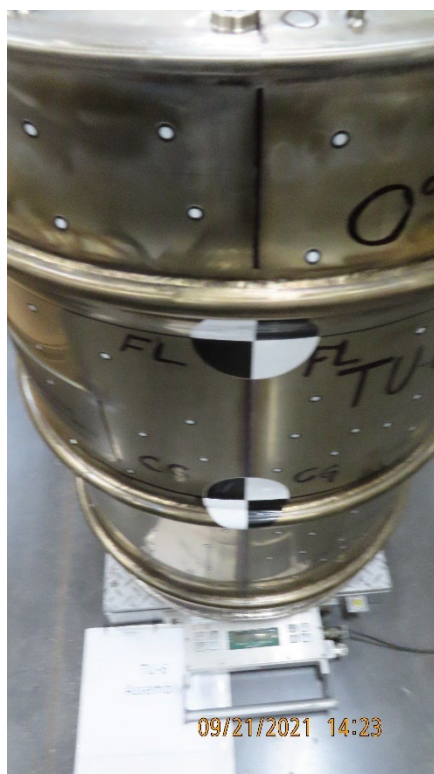


**Figure F-6 TU CVs Pre-Operational Leak Test.**

### F.1.2 Drum Body Assembly



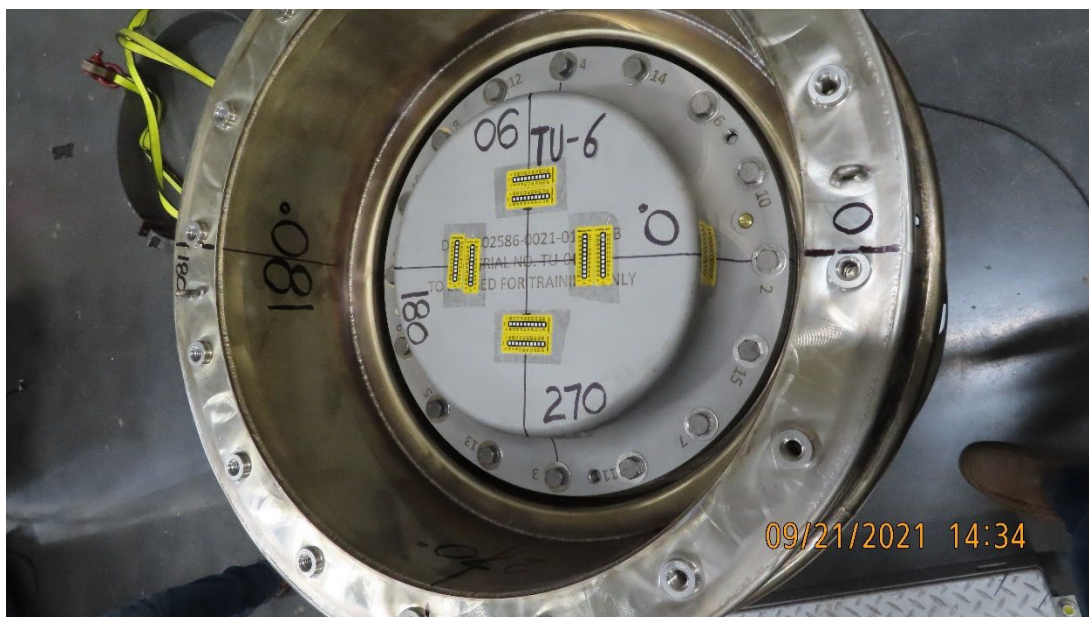
**Figure F-7 TU-6 drum body temperature labels and lid weighing.**



**Figure F-8 Fully assembled test unit.**



## Appendix F – DPP-1 TU-6 Photos



**Figure F-9 CV lowered into TU-6 drum body.**



**Figure F-10 TU-6 fully assembled.**



**Figure F-11 TU-6 accelerometer mounts welding operation.**

## **F.2 NCT TESTING**

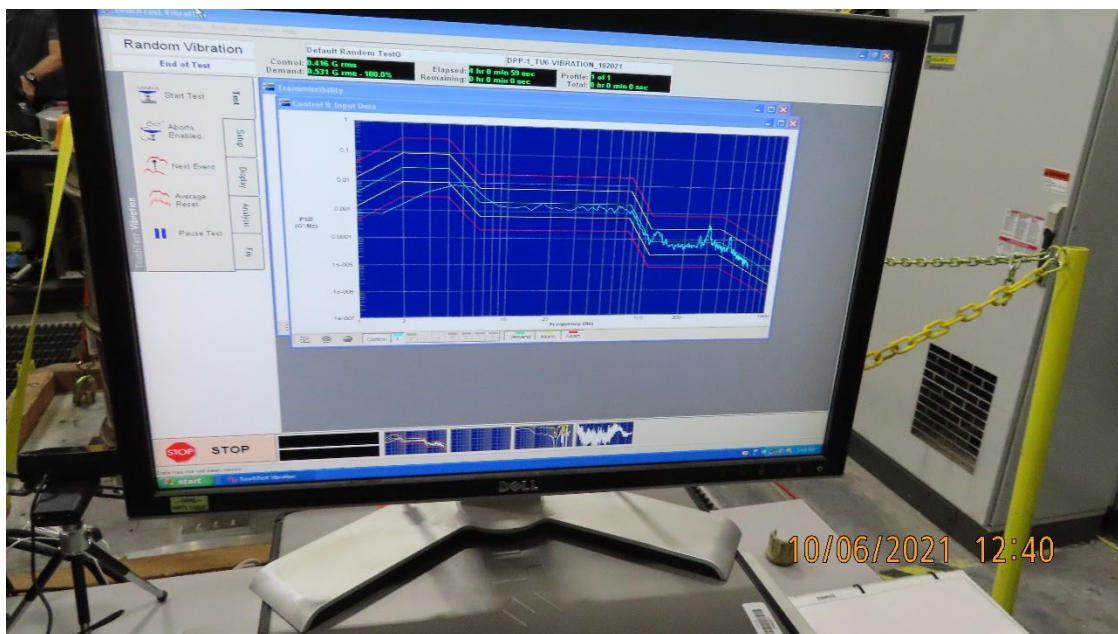
### **F.2.1 Vibration Test**



**Figure F-12 TU-6 mounted on package evaluation lab's vibration table.**



## Appendix F – DPP-1 TU-6 Photos



**Figure F-13 TU-6 vibration load profile.**

### F.2.2 NCT Water Spray Test

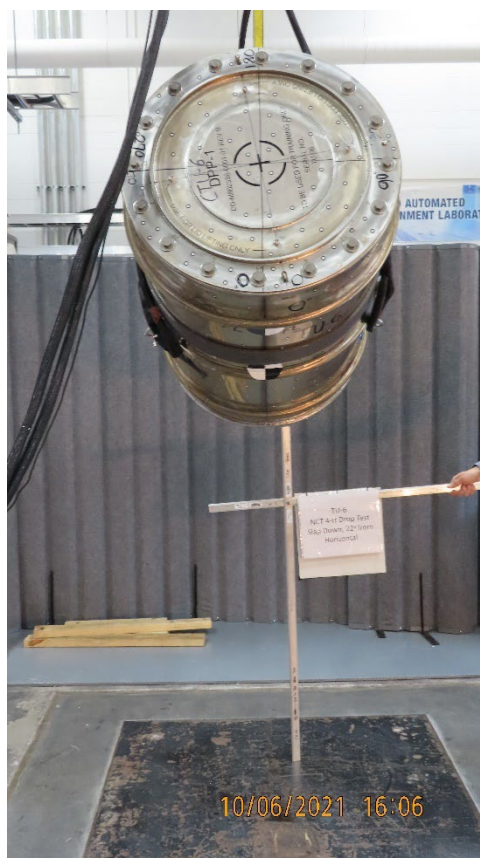


**Figure F-14 TU-6 water spray test.**

### F.2.3 NCT 1.2-m Free Drop



**Figure F-15 TU-6 NCT 1.2-m test measuring drop orientation angle.**



**Figure F-16 Establishing the 1.2-m height during TU-6 NCT free drop test.**



## Appendix F – DPP-1 TU-6 Photos



**Figure F-17 TU-6 NCT 1.2-m free drop impact.**



**Figure F-18 TU-6 NCT 1.2-m free drop damage at top lid.**



**Figure F-19 TU-6 NCT 1.2-m free drop damage at bottom of drum.**

#### **F.2.4 Compression Test**



**Figure F-20 TU-6 being set up for compression test.**



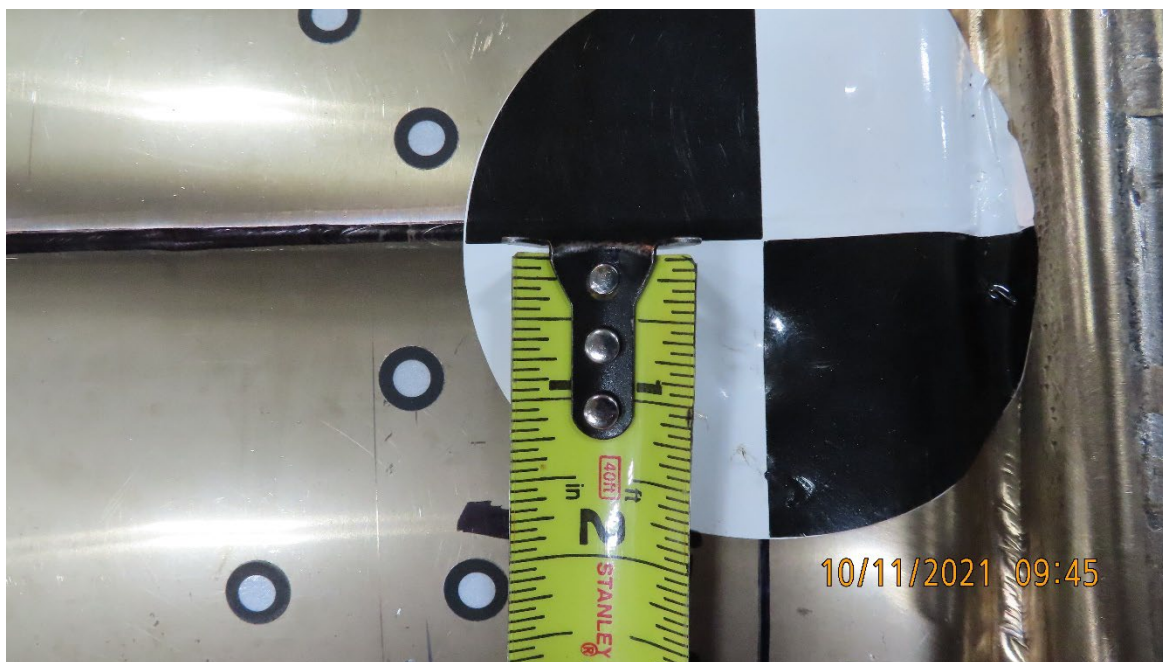


**Figure F-21 TU-6 compression test end.**

### **F.2.5 NCT Penetration Drop**



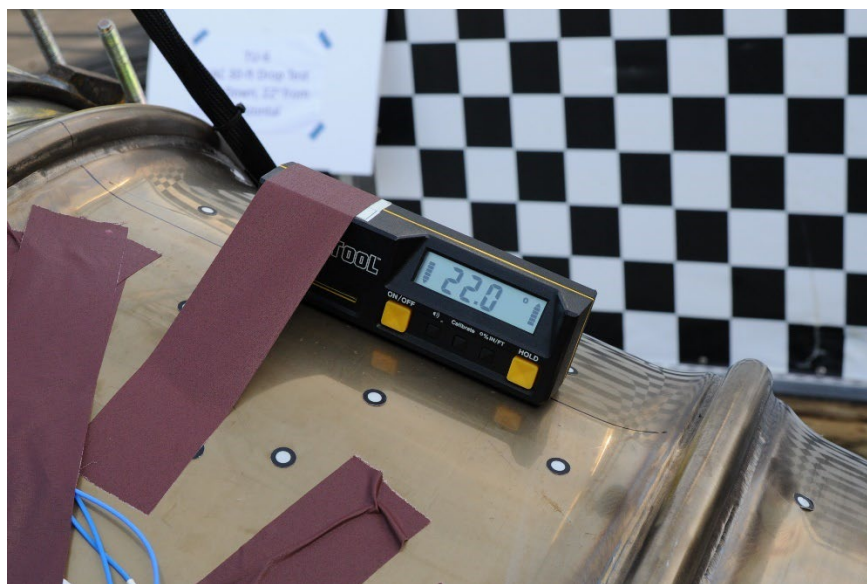
**Figure F-22 TU-6 NCT penetration test setup.**



**Figure F-23 TU-6 NCT penetration test damage.**

### **F.3 HAC TESTING**

#### **F.3.1 HAC 9-m Free Drop**

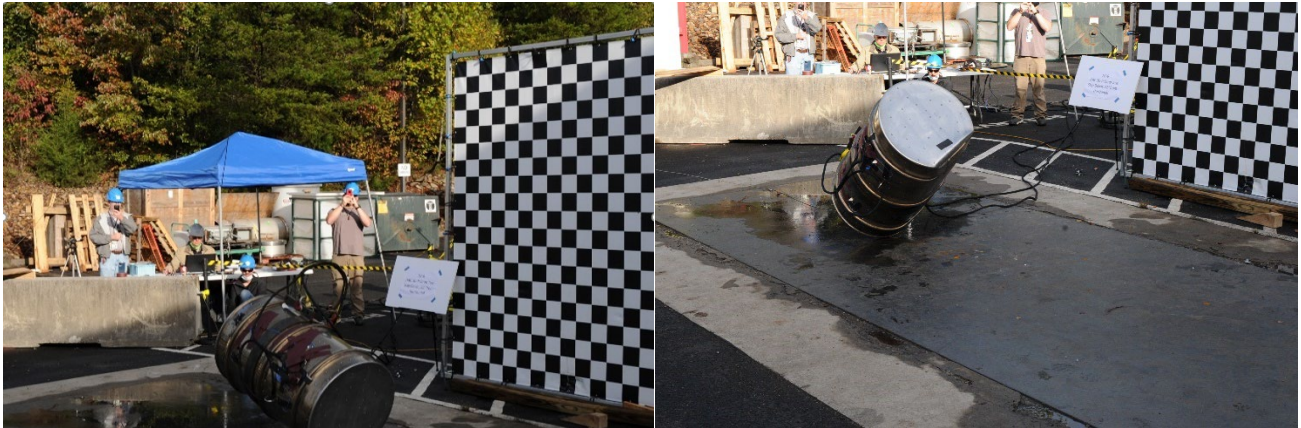


**Figure F-24 TU-6 rigging and orientation set up for 9-m HAC drop.**





**Figure F-25 Package raised to 9-m and ready for drop test.**



**Figure F-26 TU-6 initial impact and rebound during 9-m HAC drop.**



**Figure F-27 TU-6 HAC 9-m drop lid damage near 0° line.**



**Figure F-28 TU-6 HAC 9-m drop bottom damage near 0° line.**



### F.3.2 Crush Test



**Figure F-29 TU-6 crush plate rigging and orientation setup.**



**Figure F-30 TU-6 and crush plate alignment at required point of impact.**



**Figure F-31 Crush plate raised to 9-m above TU-6 before drop.**





**Figure F-32 TU-6 HAC 9-m crush plate impact.**

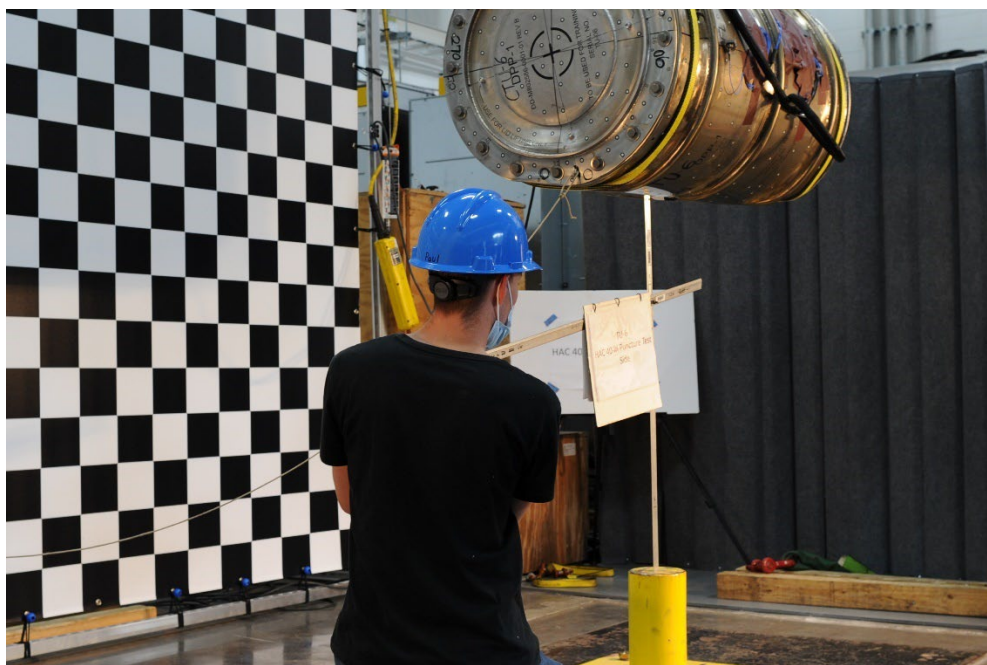


**Figure F-33 TU-6 HAC 9-m crush damage at top 0° – 180° line.**



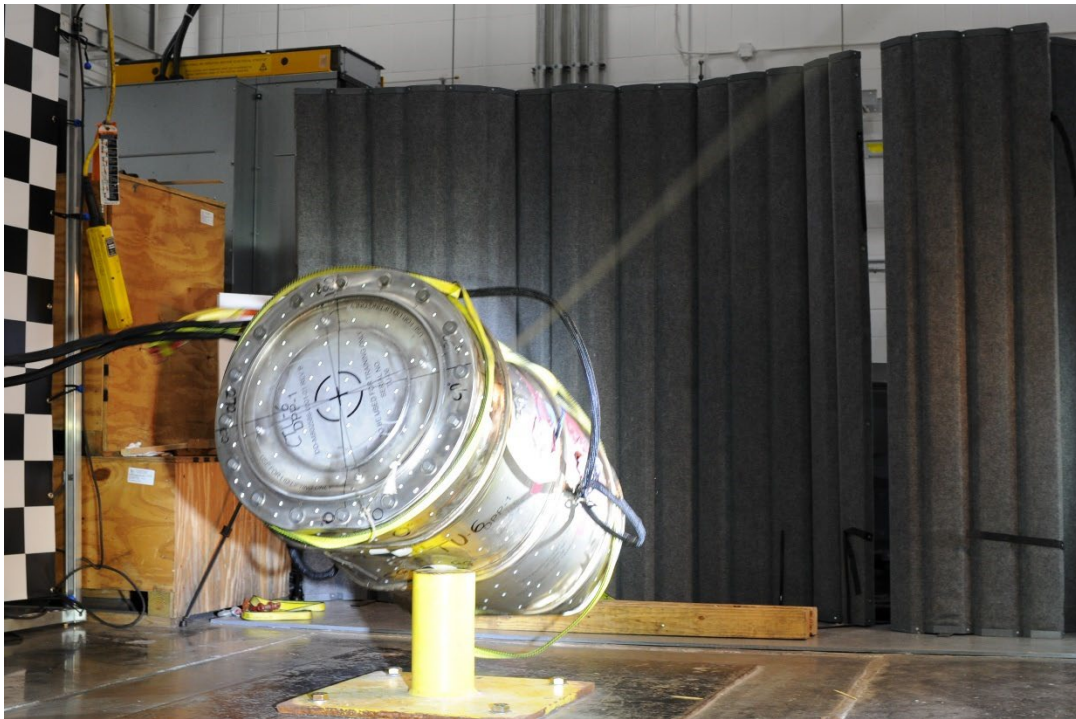
**Figure F-34 TU-6 HAC 9-m crush damage at bottom 0° – 180° line.**

### **F.3.3 Puncture Test**



**Figure F-35 TU-6 puncture test rigging and orientation setup.**





**Figure F-36 TU-6 impacting the puncture bar.**



**Figure F-37 TU-6 puncture bar damage.**



### F.3.4 Thermal Testing



Figure F-38 TU-6 in pre-heat chamber.

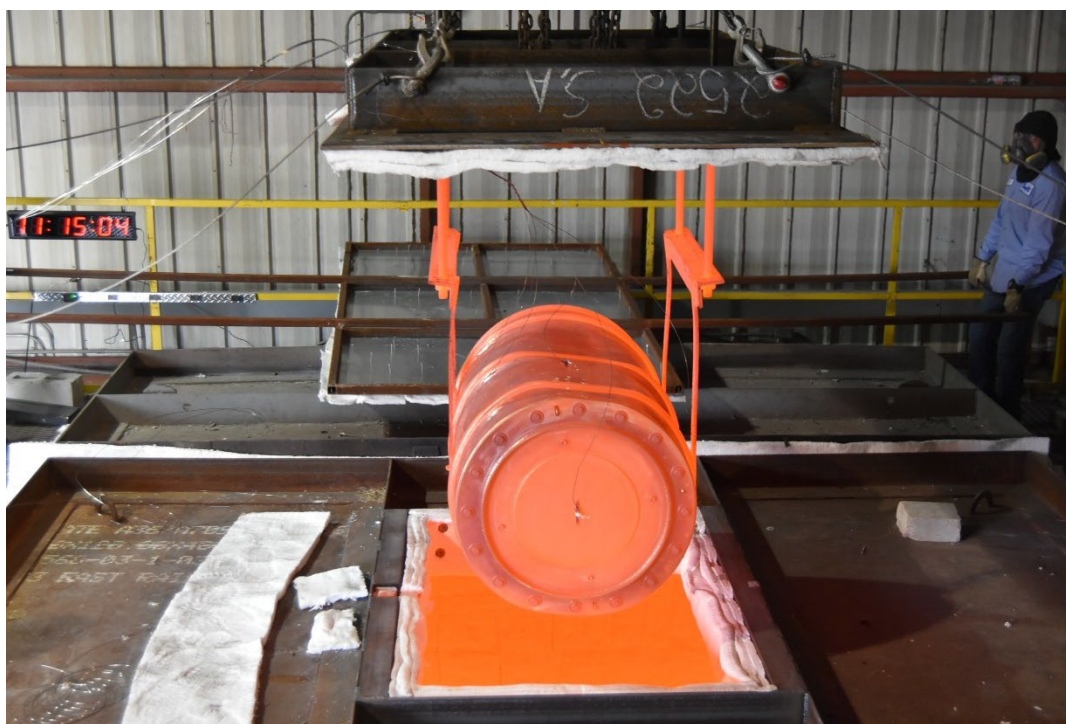


Figure F-39 Thermocouples affixed to TU-6 prior to thermal testing.

Appendix F – DPP-1 TU-6 Photos

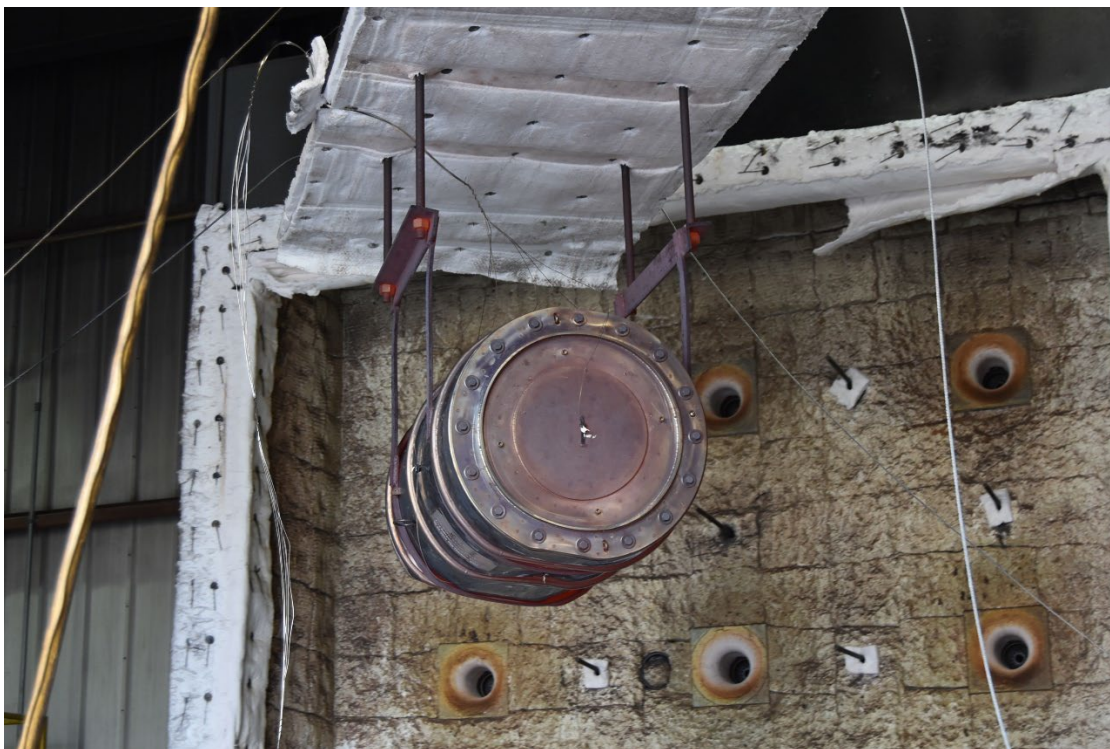


**Figure F-40 Loading TU-6 into furnace.**



**Figure F-41 TU-6 removed from furnace. Package Disassembly**





**Figure F-42 TU-6 being transferred to cooling station.**



**Figure F-43 TU-6 on cooling stand.**

## F.4 PACKAGE DISASSEMBLY

### F.4.1 Drum Body Disassembly

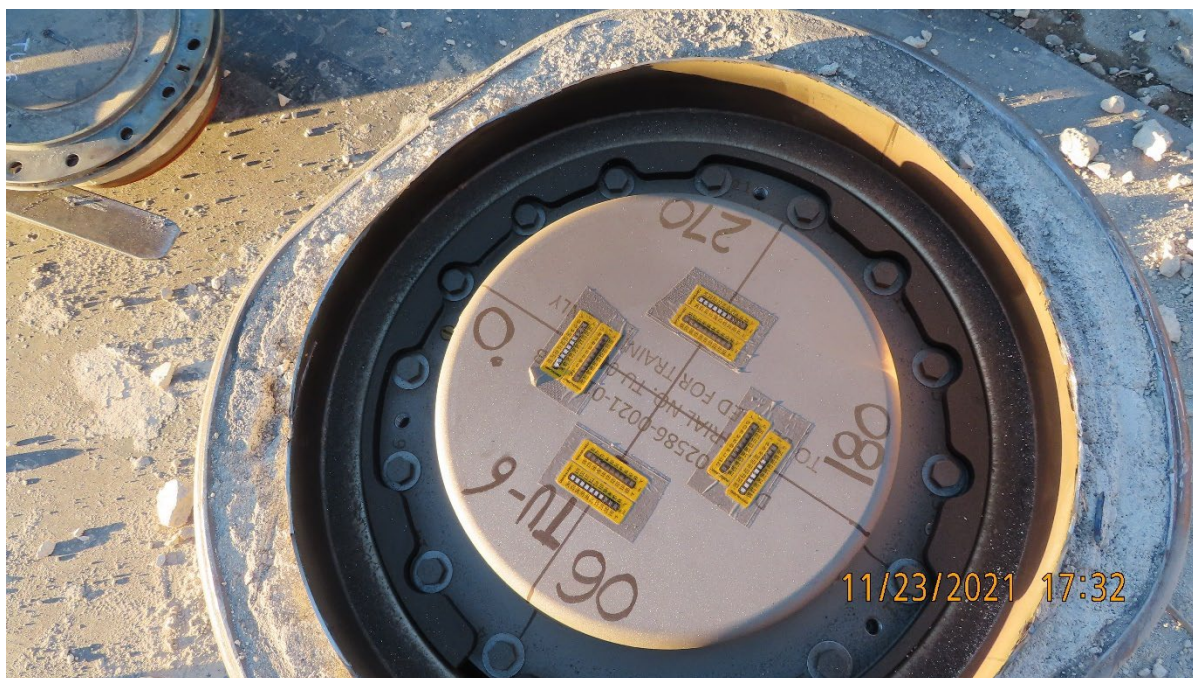


**Figure F-44 TU-6 Post thermal weight measurement.**



**Figure F-45 TU-6 drum body cut to remove lid and CV.**





**Figure F-46 TU-6 CV alignment before CV removal.**



**Figure F-47 TU-6 Drum lid weight measurement.**

Appendix F – DPP-1 TU-6 Photos

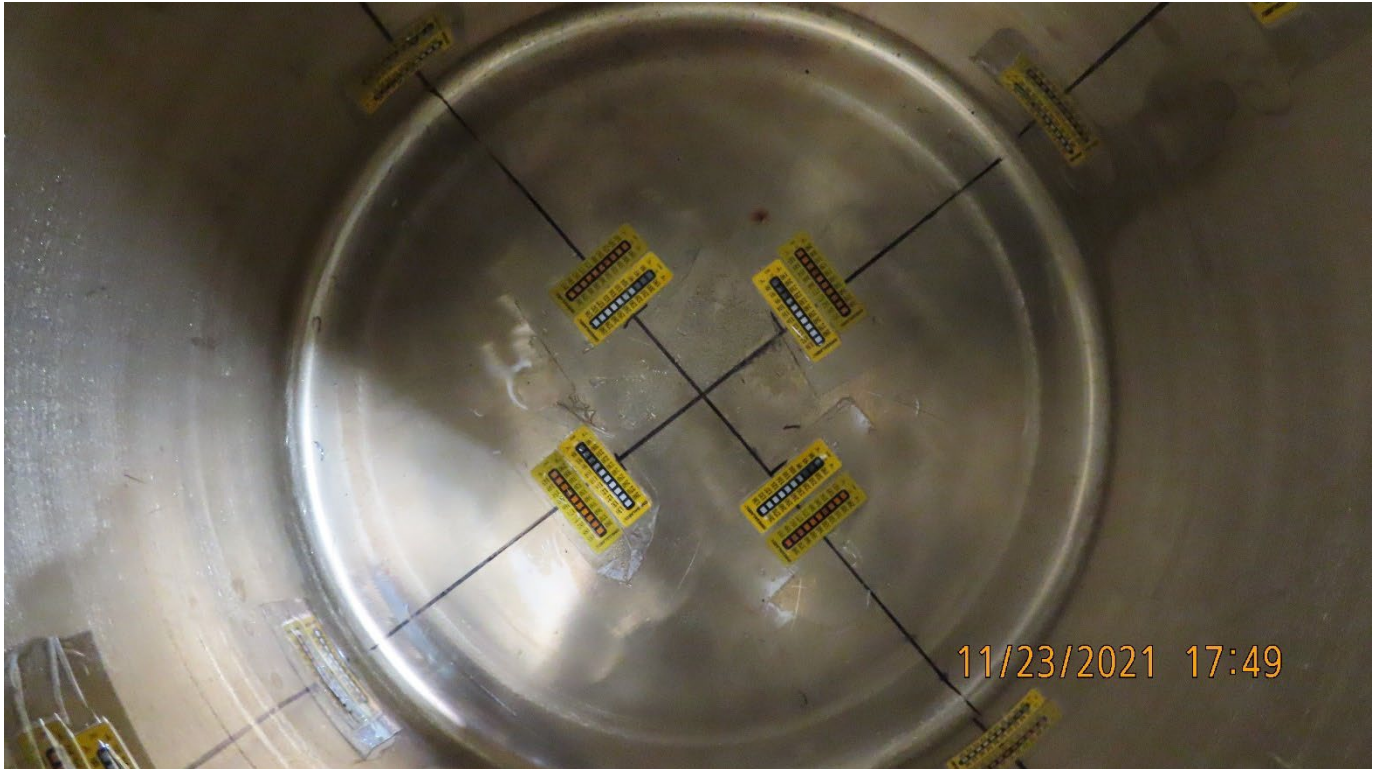


**Figure F-48 TU-6 CV removal.**



**Figure F-49 TU-6 CV post thermal weight.**





**Figure F-50 TU-6 temperature labels inside drum.**

#### **F.4.2 CV body leak testing**



**Figure F-51 TU-6 post-test operational leak test.**



**Figure F-52 1/4" NPT tapered pipe thread on the CV.**



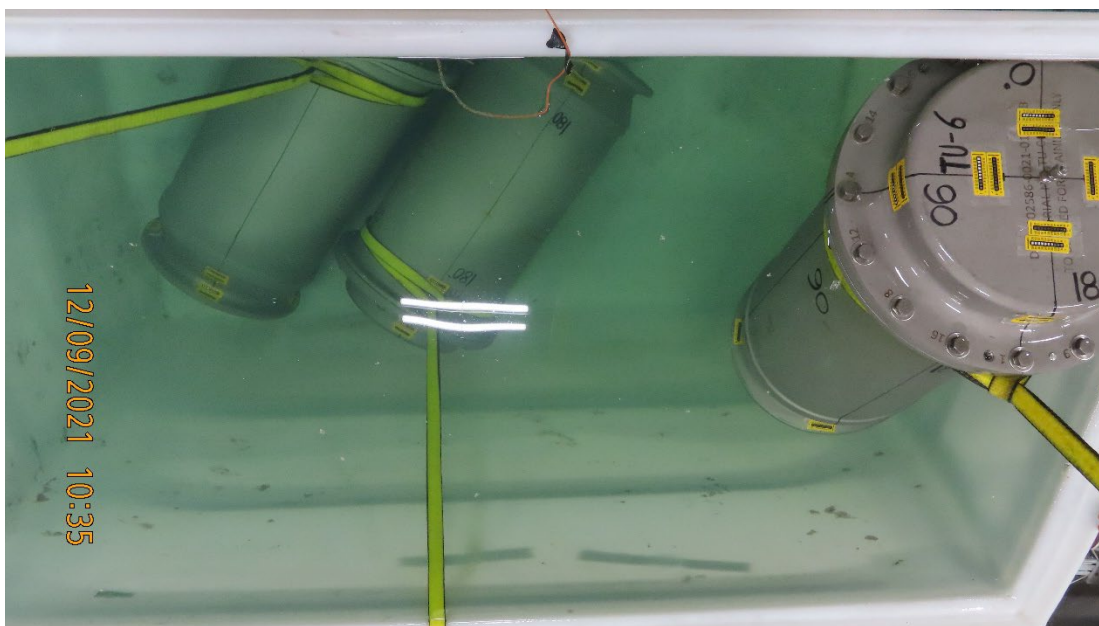
**Figure F-53 Post-test helium leak test.**



## F.5 WATER IMMERSION



**Figure F-54 TU-6 CV being placed in water immersion tank at the packaging lab.**



**Figure F-55 TU-6 CV removal from water immersion tank.**





**Figure F-56 TU-6 CV weighed after water immersion test.**

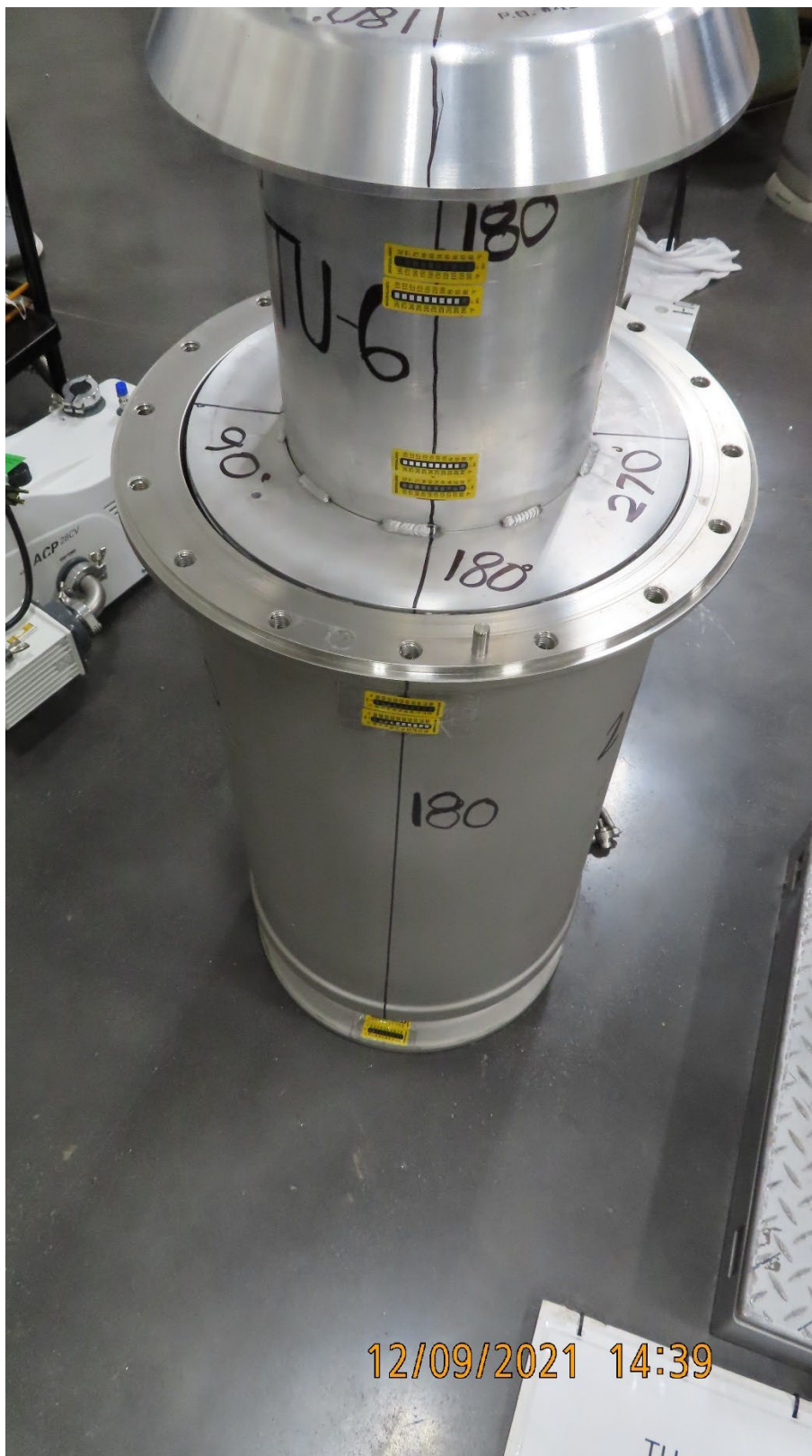
## F.6 CV DISASSEMBLY



**Figure F-57 TU-6 CV weighed.**

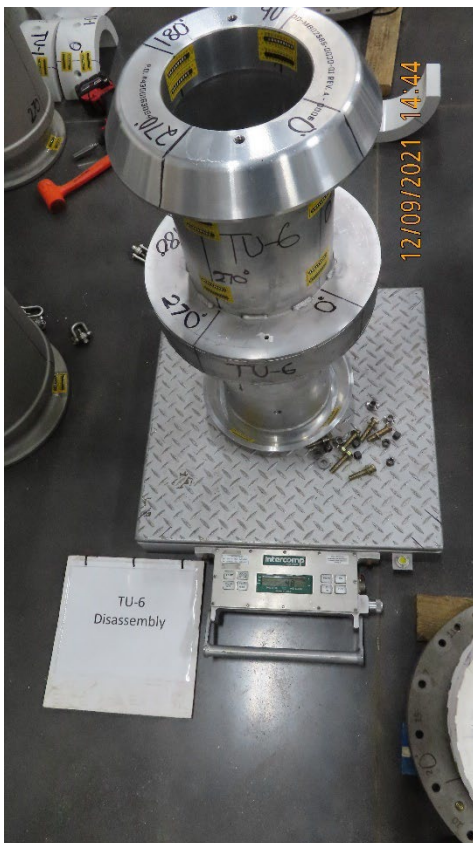


**Figure F-58 TU-6 weldment PCC pads weighed.**



**Figure F-59 Removing test weight assembly from TU-6 CV.**





**Figure F-60 TU-6 test fixture weldment post thermal test inspection.**



**Figure F-61 Post thermal test weight of TU-6 test load set.**

**G. APPENDIX G – TU-7 PHOTOS**

This section contains a collection of digital photos taken during testing of TU-7 of the DPP-1 package. The list below provides the sections into which the photos have been grouped. The subsequent pages provide the list of figures contained within this appendix.

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## G.1 TEST UNIT 7 ASSEMBLY

### G.1.1 CV Assembly



**Figure G-1 CV body weighed.**



**Figure G-2 CV lid weighed.**

### G.1.2 Thermal Operation Dry Runs



**Figure G-3 Thermocouple clips tack welded to TU-7.**



**Figure G-4 TU-7 placed on the stand in the furnace during dry-runs.**





**Figure G-5 Furnace roof closed during TU insertion dry run.**



**Figure G-6 TU-7 with thermocouples attached for furnace pre-qualification.**





**Figure G-7 TU-7 rigged for furnace insertion during thermal operation dry-runs.**



**Figure G-8 TU-7 inserted into the furnace for furnace qualification.**



**Figure G-9 TU-7 inside the furnace during furnace qualification test.**



**Figure G-10 TU-7 Removed from the furnace.**



## G.2 TU-7 CV WATER IMMERSION TEST



Figure G-11 TU-7 CV insertion into pressure tank.



Figure G-12 TU-7 CV 38.5-in below water level in the pressure tank.





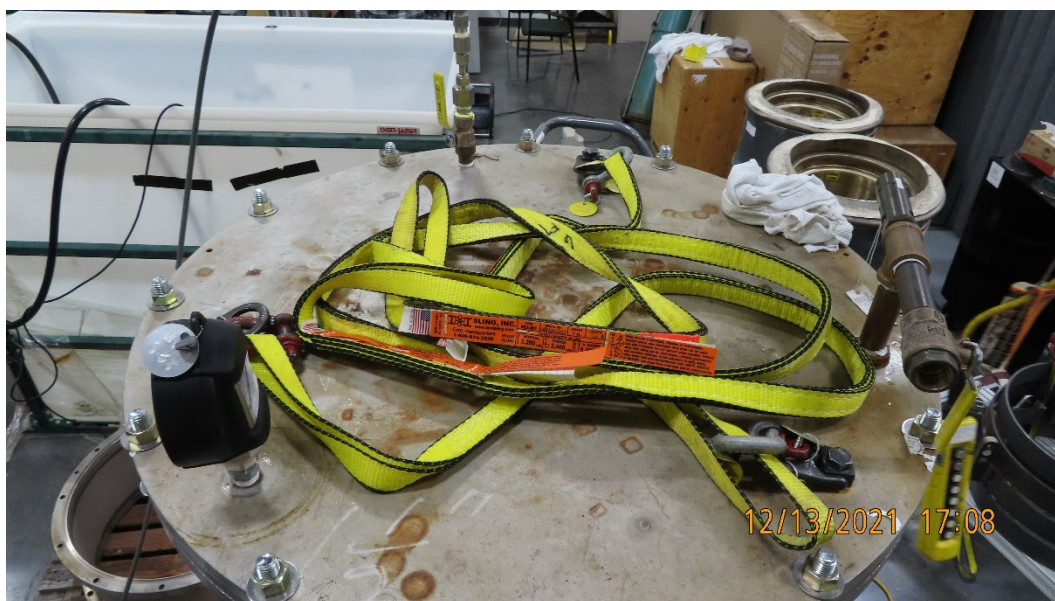
**Figure G-13** Water immersion test hydro pump and the pressure tank.



**Figure G-14 Pressure tank gauge at 23.55 psi.**



**Figure G-15 Pressure tank instrumentation.**



**Figure G-16 Pressure tank gauge and relief valve.**



**Figure G-17 TU-7 CV removal from pressure tank.**

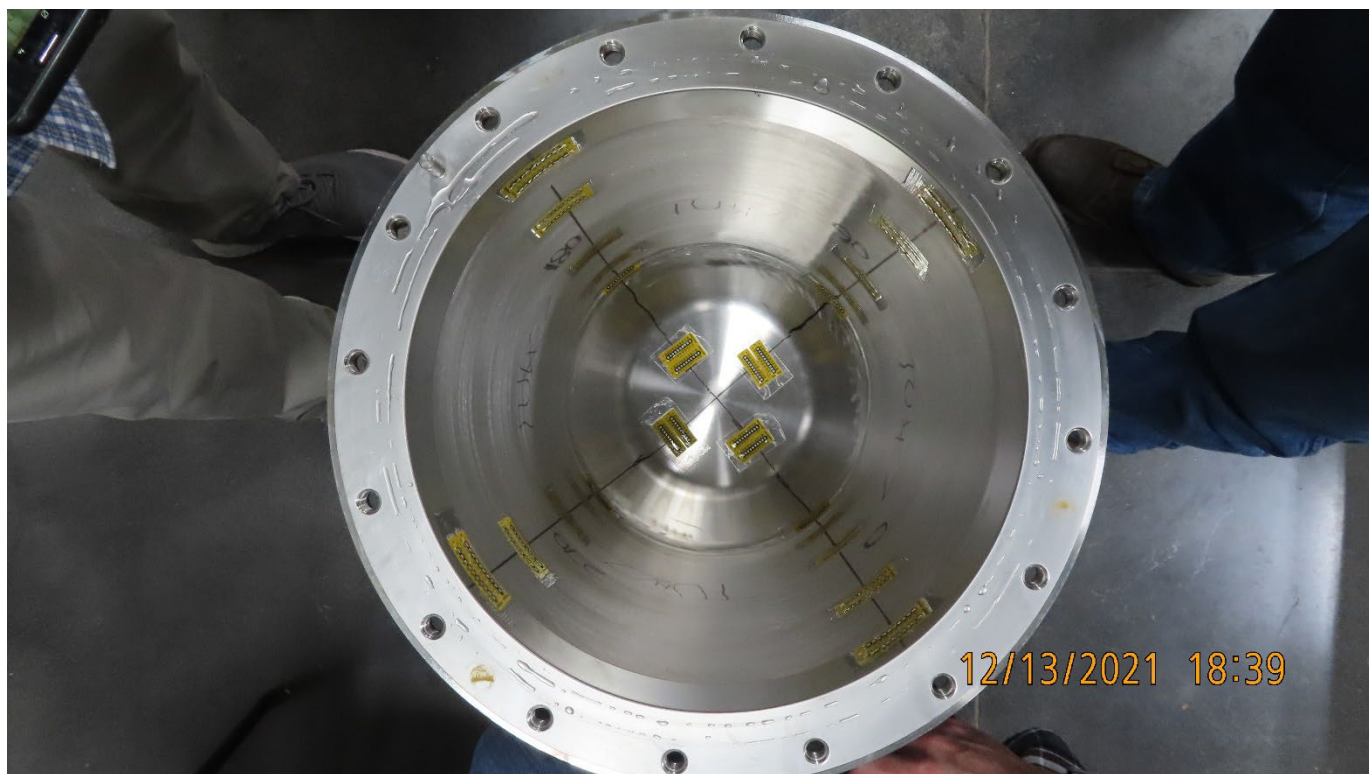




**Figure G-18 CV lid removed for water penetration inspection.**



**Figure G-19 Post water immersion test CV inspection.**



**Figure G-20 CV interior after 15-m water immersion test.**

# Test Report for DPP-1 Regulatory Compliance Testing

## Volume 3 – Test Forms, Test Plan, TPCRs, Test Journal, DPP-1 QAP Plan, RFWD, Leak Test Reports, M&TE, and Acceleration Data



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Oscar A. Martinez  
Abiodun Adeniyi  
Blake Van Hoy

**Approved for public release**

**April 2022**





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Nuclear Energy and Fuel Cycle Division

**Test Report for DPP-1 Regulatory Compliance Testing**  
**Volume 3 – Test Forms, Test Plan, TPCRs, Test Journal, DPP-1 QAP Plan, RFWD, Leak**  
**Test Reports, Acceleration Data, and M&TE**

Paul Nogradi, Oscar A. Martinez, Abiodun Adeniyi, Blake Van Hoy

Date Published: April 2022

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The Y-12 National Security Complex and Pantex Plant

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US DEPARTMENT OF ENERGY  
under contract DE-AC05-00OR22725

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## **H. APPENDIX TU-1 FORMS**

# TEST FORM 1 - COMPONENT WEIGHTS

Test Plan DPP-1

TU -1

Part Name	Initial Assembly	Post Thermal, Full Disassembly
	Weight (lbs.)	Weight (lbs.)
CV body	179	179
CV lid, screws, washers, and O-rings (together)	73	73
Test fixture weldment, screws, washers, nuts, bushing (together)	49-0.73 <sup>48.27</sup>	48
Test weight sets	66	67
PCC pad sets	15	15
CV assembly with test content (during reassembly)	382	382
Drum body	380	378
Drum lid assembly, screws, and washers (together)	103	103
CV base pad and CV flange wedge (together)	5	5
Test unit (TU) assembly	870	868

CV weight before immersion: 382 Lb  
 EQUIPMENT CV weight after immersion: 382 Lb.  
 Less than 10 pounds 10 lbs to 2000 lbs

Scale: N/A Expiration Date: N/A Scale: X502322 Expiration Date: 2/17/2022

Comments: 0.73 lb = swivel hoist ring on test fixture

I certify that the above tasks have been performed and that the observations and comments are correct.

[Signature]  
 Testing Technician

12/09/21  
 Date

M.B. Houston  
 Witness

12-09-2021  
 Date

Ross Wittenburg  
 CNS-Y12 STR

12/9/21  
 Date

[Signature]  
 CNS-Y12 QE

12/9/21  
 Date

\* Drum body weight estimated by calculation.



# TEST FORM 2 - ASSEMBLY OF THE CV

Test Plan DPP-1

TU 1

VERIFIED

TASK

RW 9/9/21  
RF 9/9/21

**HOLD POINT:** All payload components have been visually inspected, and Y-12 deems the shipping package acceptable for disassembly.

Verify and/or mark all components: content assembly, CV assembly, and drum assembly components with the corresponding test unit ID, axial lines, and impact targets symbols. Figure 4-1 - Figure 4-4.

Temperature labels have been affixed to the surface of the CV as shown in Figure 5-1, Figure 5-2.

None of the temperature indicators indicate exposure to a temperature in the measured range.

The CV body, CV lid, washers, and bolts were weighed and recorded in TEST FORM 1

RW 9/9/21  
RF 9/9/21

**HOLD POINT:** Y-12 has approved the markings.

The following assembly applies to TUs test fixture weldment content assembly

The surrogate test weight was weighed and recorded on TEST FORM 1 .

The loading test fixture weldment content assembly components were weighed and recorded on TEST FORM 1 .

Clean all surfaces with isopropyl alcohol and air dry

Place the PCC pad (silicone rubber) into CV body.

Place the test weight weldment into the CV body.

Place the PCC pad (silicone rubber) into the CV body on top of the test fixture weldment assembly.

RW 9/9/21  
RF 9/9/21

**HOLD POINT:** Y-12 witness torqueing of test fixture fastener hex head screws, washers, top hat bushings, and locknuts. The test weight and bolting locations that establish the low and high CG locations are documented in Attachment A. The hex head screws and locknuts shall be torqued to  $25 \pm 2$  ft-lb.

RW 9/9/21  
RF 9/9/21

**HOLD POINT:** Y-12 inspected the assembly of the non-test fixture weldment content assembly and verified weights

M&TE ID #: A001096 Calibration Due Date: 2/10/2022

Comments:

I certify that the above tasks have been performed and that the observations and comments are correct.

[Signature]  
Testing Technician  
Ross Whittenburg  
CNS-Y-12 STR

09/08/21  
Date  
9/9/21  
Date

M.B. Houston  
Witness  
[Signature]  
CNS-Y-12 QE

09-08-2021  
Date  
9/9/21  
Date

# TEST FORM 2 - ASSEMBLY OF THE CV

Test Plan DPP-1

TU -1

## All packages



The CV O-rings and sealing surfaces have been inspected for defects and found acceptable.



Clean all surfaces with isopropyl alcohol and air dry.



The CV O-rings have been installed onto the CV body.



**Note:** Screws and O-rings shall not be replaced without CNS approval. If replacements are authorized, they shall be documented in the test report where the replacements occurred.

The CV lid was lowered on the CV body and the CV screws shall be hand-tightened until the lid is in full contact with the flange, note that clamps may be used during this step. The CV screws shall be torqued in sequence following the numbers etched into the drum lid in three passes. first pass the screws shall be torqued to 19–21 ft-lb, during the second pass to 33–37 ft-lb, and during the third pass to 33–37 ft-lb. The final pass torque values shall be recorded.

Ambient temperature at closure is \_\_\_\_\_ °C ( 67.9 °F)

Measuring device A006681 Calibration Expiration Date 5/12/2022



Record assembly torque on TEST FORM 11.

RW 9/9/21

Torque wrench # A001096 Calibration Expiration Date 2/10/2022

RF 9/9/21

HOLD POINT: Y-12 inspected the assembly and closure of CV assemblies and verified weights.



The CV assembly has been weighed and the weight has been recorded on TEST FORM 1



The CV assembly has been leak tested (pre-test operational) in accordance with Sect. 7.6 of ANSI N14.5-2014 using the "A.5.2 gas pressure rise" method described in Table A-1 of N14.5-2014 and ORNL procedure NDE 70 Rev. 7, PCMT.

RW 9/23/21

RF 9/23/21

HOLD POINT: Y-12 has reviewed the leak test and the installation of the acceleration sensor mounts.



Photographs of the assembly have been taken\*.

Comments:

I certify that the above tasks have been performed and that the observations and comments are correct.

Testing Technician

Russ W. Hitterlunger  
CNS-Y-12 STR

09/08/21

Date

9/23/21  
Date

Witness

M. B. Hamilton  
Ryan Fisher  
CNS-Y-12 QE

09-08-2021

Date

9/23/21  
Date

\*All photographs/movies will be uniquely identified with test unit, date and time to ensure that the proper sequence can be reconstructed



# TEST FORM 3 - ASSEMBLY OF TEST PACKAGE

Test Plan DPP-1

TU- 1

VERIFIED

TASK

- ☒ Verify operational leak test is complete and form completed and tighten the CV lid leak test port plug per the following sequence: 1<sup>st</sup> pass hand tight, 2<sup>nd</sup> pass torque to 6-7 ft-lb.  
Torque wrench # A001320 Calibration Expiration Date 02-11-2022
- ☒ The exterior of the drum has been clearly marked "TU- 1 " and record the drum serial number if applicable:
- ☒ Verify all exterior markings on the TU. If marks are not legible or inadequate, the TA will remark the TU. Mark the 0°, 90°, 180°, 270° locations on the Drum Lid, and the inner and outside walls of the drum with a permanent marker.
- ☒ Install temperature labels on the inside of the drum body as shown in Figure 5-3.
- ☒ Clean all surface of the drum body with isopropyl alcohol and let air dry.
- ☒ The drum body, drum lid, bolts, washers, pads, were weighed and recorded on TEST FORM 1.
- ☒ Place the lower CV base pad into the drum body.
- ☒ Place the CV assembly into the drum body.
- ☒ The CV assembly has been loaded into the drum with the 0° rotated and aligned with 0° line on the drum. Ensure temperature labels are not damaged.
- ☒ Place the CV flange wedge between the CV flange and the drum body.
- ☒ The drum lid has been loaded into the drum with the 0° rotated and aligned with the 0° location on the drum.
- ☒ If necessary, apply thread lubricant to the drum closure bolts.
- ☒ The drum lid has been closed using the same screws that were removed during disassembly. The screws shall be torqued in sequence following the numbers etched into the drum lid in two passes. First, the screws shall be torqued until the lid is in full contact with the flange. Second, the screws shall be torqued to 33-37 ft-lb. .Record the assembled torque value on Test Form 10. **TPCR-04**  
Torque wrench #: A001096 Calibration Expiration Date: 02-10-2022
- ☒ The test package assembly has been weighed and the weight recorded on Test Form 1.
- ☒ Mount one (1) vibration accelerometer on the TU-6 drum lid center for NCT vibration monitoring according to the DPP-1 Accelerometer Mounting Procedure. Remove accelerometer after NCT Test. **TPCR-05**
- ☒ The accelerometer mounting blocks and restraint rings have been welded to the drum outer shell as specified in the DPP-1 Accelerometer Mounting Procedure. **TPCR-05**
- ☒ Install the accelerometers on TU-1, TU-2, TU-5, and TU-6 at the locations tspecified by the DPP-1 Accelerometer Mounting Procedure". **TPCR-05**
- ☒ The accelerometers were checked to ensure they were installed and functioning as intended after each installation. **HOLD POINT:** Y-12 has approval: CNS STR RMW 10/20/21, CNS QE RF 10/20/21
- ☒ Photographs of the assembly have been taken\*.

Comments:

I certify that the above tasks have been performed and that the observations and comments are correct.

Testing Technician

Date

Witness

Date

CNS-Y-12 STR

Date

CNS-Y-12 QE

Date

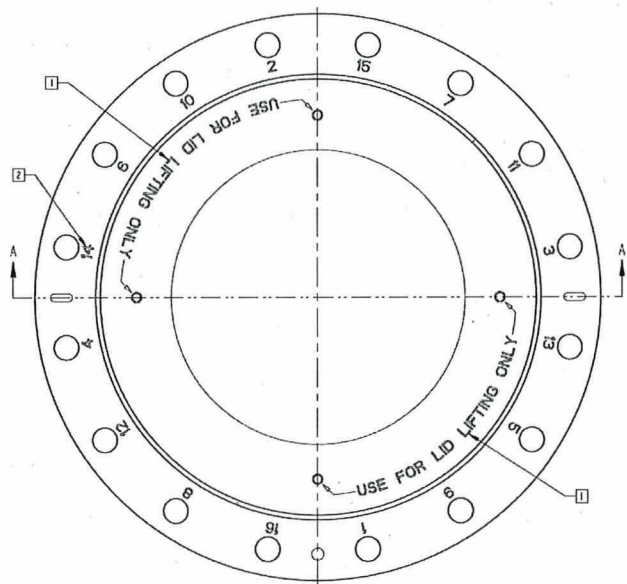
\*All photographs/movies will be uniquely identified with test unit, date and time to ensure that the proper sequence can be reconstructed.



# TEST FORM 10 –DRUM LID ASSEMBLY

Test Plan – DPP-1

TU-1



DPP-1 Drum Lid Assembly	
Bolt #	Torque assembly (ft-lbs.)
1	34.6
2	35.6
3	34.5
4	35.2
5	34.9
6	34.8
7	35.9
8	35.3
9	35.2
10	34.6
11	34.7
12	34.6
13	34.8
14	34.9
15	35.0
16	34.6

M&TE ID #: A00096 Calibration Due Date: 2/10/2022

M&TE ID #: \_\_\_\_\_ Calibration Due Date: \_\_\_\_\_

Comments:

I certify that the above tasks have been performed and that the observations and comments are correct.

[Signature]  
Testing Technician  
Ross W. Hittlerman  
CNS-Y-12 STR

9/15/21  
Date  
9/15/21  
Date

M. B. Houston  
Witness  
[Signature]  
CNS-Y-12 QE

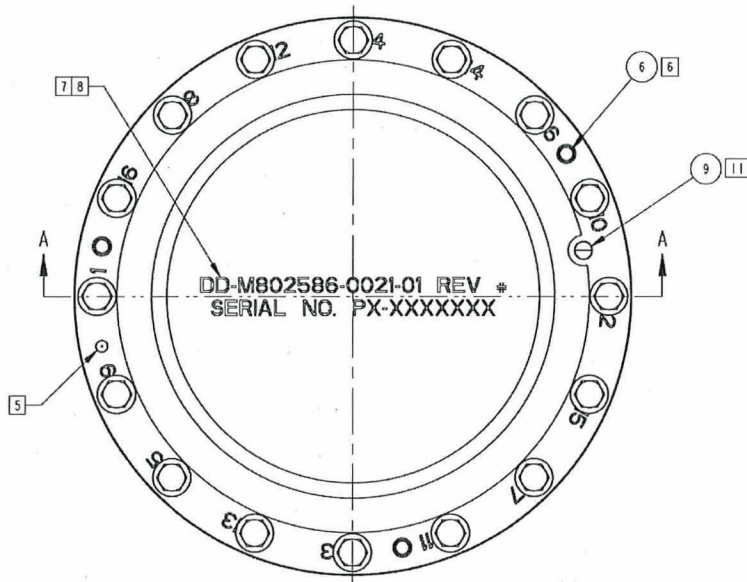
09-15-2021  
Date  
9/15/21  
Date

\*All photographs/movies will be uniquely identified with test unit, date and time to ensure that the proper sequence can be reconstructed

# TEST FORM 11 -CV LID ASSEMBLY

Test Plan - DPP-1

TU- 1



DPP-1 CV Lid Assembly	
Bolt #	Torque assembly (ft-lbs.)
1	34.6
2	34.6
3	35.0
4	35.2
5	34.4
6	34.7
7	35.4
8	34.4
9	34.7
10	34.8
11	34.5
12	35.1
13	35.2
14	35.2
15	34.9
16	34.5

M&TE ID #: A001096 Calibration Due Date: 2/10/2022

M&TE ID #: A006681 Calibration Due Date: 5/12/2022

Comments: 67.9°F - 9/8/2021

I certify that the above tasks have been performed and that the observations and comments are correct.

[Signature]  
Testing Technician  
Ron Whittaker  
CNS-Y-12 STR

9/08/21  
Date  
9/9/21  
Date

M.B. Hunter  
Witness  
[Signature]  
CNS-Y-12 QE

09-08-2021  
Date  
9/9/21  
Date

\*All photographs/movies will be uniquely identified with test unit, date and time to ensure that the proper sequence can be reconstructed

# TEST FORM 7 –TEST UNIT DIMENSIONS

Test Plan – DPP-1

TU- 1

Initial Assembly ☒  
Post 1.2-m Drop \_\_\_\_\_  
Post 9-m Drop \_\_\_\_\_  
Post Crush Test \_\_\_\_\_  
Post 1-m Puncture Test \_\_\_\_\_

Drum outer shell

*0AM 9/14/2021*

	0°	90°	180°	270°
Height <i>2"3</i>	<i>43 1/4</i>	<i>43 7/8</i>	<i>43 1/8</i>	<i>43 1/8</i>

*43 3/16*

DIAMETER	0° to 180°	90° to 270°
Top Surface <i>Ring</i>	<i>26 7/8</i>	<i>26 13/16</i>
Top Rolling hoop	<i>28 1/16</i>	<i>28</i>
Center Rolling hoop	<i>28 3/16</i>	<i>28 1/4</i>
Bottom Rolling hoop	<i>28 3/16</i>	<i>28 1/4</i>
Bottom Surface	<i>27 1/16</i>	<i>27 1/8</i>

Location	Flats width @ 0°	Flats width @ 180°
Top Surface		
Top Rolling hoop		
Center Rolling hoop	<i>N/A</i>	<i>N/A</i>
Bottom Rolling hoop		
Bottom Surface		

Sketch Drop Setup Here

*N/A*

Sketch Package Damage Here

*N/A*

M&TE ID #: *A006321* Calibration Due Date: *3/20/2023*

M&TE ID #: *A009110* Calibration Due Date: *3/23/2026*

Comments: *All dimensions above are in inches & "3.*

I certify that the above tasks have been performed and that the observations and comments are correct.

Testing Technician

Date

Witness

Date

CNS-Y-12 STR

Date

CNS-Y-12 QE

Date

\*All photographs/movies will be uniquely identified with test unit, date and time to ensure that the proper sequence can be reconstructed



## TEST FORM 4 - PACKAGE CHILLING RECORD

VERIFIED

TASK

- ✓ Record Environmental Chamber Manufacturer and Serial Number  
 Manufacturer: ESPEC (modul: EW SX 499-30NW) Serial Number: 3240761
- ✓ Identify Temperature Calibration Unit and verify calibration due date  
 Temperature Calibration Unit: VAISALA S/N: P4150350 Calibration Due Date: 10/27/2021
- ✓ Place Test Unit into Environmental Chamber. Date: 10/14/2021 Time: 2:25pm.
- ✓ Temperature Controller set to -70°F (-56.7°C).
- ✓ Package in chamber for at least 72 hours and at -70°F for 24 hours. Via program in VAISALA
- ✓ Reset Temperature Controller set to -45°F (-42.7°C). Date: 10/15/2021 Time: 11:59pm.
- ✓ Package in chamber at -45°F for at least 48 hours.
- ✓ Package removed from Chamber. Date: 10/20/2021 Time: 8:32am
- ✓ Package placed in insulated box for transport. Yes / No
- N/A Package packed in dry ice (optional): Yes / No
- ✓ Package unpacked from insulated box. Date: 10/20/2021 Time: 9:32am
- ✓ Photographs of the assembly have been taken\*. Yes / No

## Comments:

Temperature tolerance on VAISALA is  $\pm 2^{\circ}$   
10/20/2021  
\* Chamber door opened @ 8:32am, closed @ 8:34am.

\* MCH  
10-20-21

I certify that the above tasks have been performed and that the observations and comments are correct.

[Signature]  
 Testing Technician

10/20/21  
 Date

M. B. Newton  
 Witness

10-20-2021  
 Date

Ross Whittenburg  
 CNS-Y-12 STR

10/20/21  
 Date

[Signature]  
 CNS-Y-12 QE

10/20/21  
 Date

\*All photographs/movies will be uniquely identified with test unit, date and time to ensure that the proper sequence can be reconstructed

<b>ORNL</b> PACKAGE TESTING PROGRAM OAK RIDGE NATIONAL LABORATORY OAK RIDGE, TENNESSEE 37831 <small>The OFFICIAL COPY of this document is the on-line version. Before using a printed copy, verify that it is the most current version by checking the Revision ID against the on-line version</small>	<b>Operating Procedure for NCT Free Drop Test - Testing of Radioactive Material Packages</b>	Test Procedure: <b>PTP-PEF-08</b>	Rev. <b>5 CN2</b>
		Page: <b>7 / 8</b>	Issue Date: <b>12-10-20</b>
		Revision Date: <b>12-01-20</b>	Review by Date: <b>12-10-23</b>


## 6. Procedure Checklist

Test Plan: <b>ORNL/NTRC-092 R.O</b>	Test Unit: <b>1</b>
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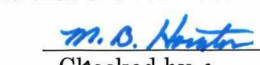

VERIFIED	TASK
✓	Verify that any equipment used meets the M&TE meets PTP-QA-013 requirements (§4.1).
N/A	Water Spray Test (PTP-PRF-05) has been completed within 2 hours before Drop Test. (§4.4)
✓	Have a photographer's clipboard with package name and test unit number. (§4.5)
✓	Attitude of the rigged and raised test unit is set. (§4.6)
✓	Photograph of the rigging arrangements has been taken. (§4.6)
✓	Photograph of the measured drop angle has been taken. (§4.6)
✓	The test unit has been raised to the designated drop height. (§4.7)
✓	Photograph of the height measurement has been taken. (§4.7)
✓	Video camera(s) are setup and running to take video of the drop. (§4.8)
✓	The release mechanism has been plugged into power outlet. (§4.8)
✓	Countdown, Release the test unit, unplug release mechanism. (§4.8)
✓	Videos camera stopped. (§4.9)
✓	Photographs of the resulting damage were taken. (§4.9)
✓	Ambient temperature recorded. (§4.11)
✓	Date and time of test recorded. (§4.11)
✓	Sign and date checklist and data forms (§4.12).

Comments: **NONE. MON 10-20-2021**

I certify that the above tasks have been performed and that the observations and comments are correct.

  
 Test Engineer  
 Ross Whittenburg

**10/20/21**  
 Date  
**10/20/21**

  
 Checked by  


**10-20-2021**  
 Date  
**10/20/21**

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		Page:	Issue Date:
		Revision Date:	Review by Date:
		<b>PTP-PEF-08</b>	<b>5 CN2</b>
		8 / 8	12-10-20
		12-01-20	12-10-23

## 7. Data Sheet

Test Plan: <u>ORNL/NTRC-092 R.O</u>	Test Unit: <u>1</u>
--	------------------------

VERIFIED

TASK

✓ M&TE ID A000885 Calibration due date 2/24/2026 (\$4.1) 10/20

✓ N/A Water Spray Test (PTP-PRF-05) Time completed: 3/20/2021 (\$4.4)

✓ Intended attitude and angle of the test unit 0° to horizontal. Tolerance  $\pm 2^\circ$  (\$4.6)

✓ Attitude Description: 0° facing pad, 180° facing tip, 4ft. (\$4.6)

✓ Measured attitude and angle of the test unit 0.4° degrees. (\$4.6)

✓ Level number 11212348 Calibration Exp. Date 2/23/2022 (\$4.6) 2/24/2026

✓ Height above the drop pad 4ft. Measuring device A000885 (\$4.6) 2/20/2023

✓ Ambient temperature: 53.2 °C (°F) Measuring device A006324 (\$4.11) 10/20

✓ Date and Time of Drop Test: 10/20/2021 @ 10:19 (\$4.11)

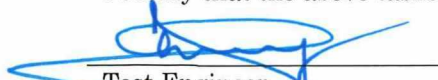

Testing Damage Observations: See TU-1 Test Form 7 for sketch.

Bulges on the bottom @ 0°: MCH 10-20-21

Comments: Dimensions for damage are recorded on Test Form 7 for

TU-1. MCH 10-20-21

I certify that the above tasks have been performed and that the observations and comments are correct.

 Test Engineer <u>Ros Whittier</u>	<u>10/20/21</u> Date <u>10/20/21</u>	 Checked by <u>10/20/21</u>	<u>10/20/21</u> Date
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		<b>PTP-PEF-10</b>	<b>6 CN-3</b>
		Page: 6 / 7	Issue Date: 02-18-2021
		Revision Date: 02-18-2021	Review by Date: 02-18-2024

## 6. Procedure Checklist

Test Plan:

*ORNL/NTRC-092 Rev. 0*

Test Unit:

*1*

VERIFIED

TASK

- ☒ Verify that any equipment used meets the M&TE meets PTP-QA-013 requirements (§4.1).
- ☒ Have a photographer's clipboard with package name and test unit number. (§4.4)
- ☒ Attitude of the rigged test unit is set. (§4.5)
- ☒ Photograph of the rigging arrangements has been taken. (§4.5)
- ☒ Photograph of the measured drop angle has been taken. (§4.5)
- ☒ The test unit has been raised to the designated drop height. (§4.7)
- ☒ Photograph of the height measurement has been taken. (§4.7)
- ☒ Remove plumb bob from test specimen. (§4.7)
- ☒ Video camera(s) are setup and running to take video of the drop. (§4.8)
- ☒ The release mechanism has been plugged into power outlet. (§4.8)
- ☒ Countdown, Release the test unit, unplug release mechanism. (§4.8)
- ☒ Videos camera stopped. (§4.9)
- ☒ Date and time of test were recorded. (§4.10)
- ☒ The ambient temperature has been recorded. (§4.10)
- ☒ Photographs of the resulting damage were taken. (§4.11)
- ☒ Sign and date checklist and data forms (§4.12).

Comments: *NONE.*

I certify that the above tasks have been performed and that the observations and comments are correct.

Testing Technician

*Paul W. Hittler*  
Customer

Date

*10/20/21*  
Date

Witness

*M.B. Houston*  
Customer

Date

*10-20-2021*  
Date

<b>ORNL</b> PACKAGE TESTING PROGRAM OAK RIDGE NATIONAL LABORATORY OAK RIDGE, TENNESSEE 37831 <small>The OFFICIAL COPY of this document is the on-line version. Before using a printed copy, verify that it is the most current version by checking the Revision ID against the on-line version</small>	Operating Procedure for HAC Drop Test - Testing of Radioactive Material Packages	Test Procedure: <b>PTP-PEF-10</b>	Rev. <b>6 CN-3</b>
		Page: 7 / 7	Issue Date: 02-18-2021
		Revision Date: 02-18-2021	Review by Date: 02-18-2024

## 7. Data Sheet

Test Plan: ORNL/NTRC-092 R.0

Test Unit: 1

VERIFIED

TASK

- ✓ Intended attitude of the test unit 0°. Tolerance  $\pm$  2° (§4.2)
- ✓ Attitude Description: Horizontal, 0° to the pad, 180° facing up (§4.2)
- ✓ Measured attitude of the test unit 0.1° degrees. (§4.4)
- ✓ Level number M242348 Calibration Exp. Date 2/23/2022 (§4.4)
- ✓ Height above the drop pad 30ft Measuring device A006327 (§4.6) 3/30/2023
- ✓ Date and Time of Drop Test: 10/20/2021 @ 10:30am (§4.9)
- ✓ Ambient temperature: MAN 10-20-21 55.1°F °C ( 55.1° °F)
- Measuring device A006681 (§4.9)

Testing Damage Observations:

Comments:

I certify that the above tasks have been performed and that the observations and comments are correct.

Testing Technician

Date

Witness

Date

Customer

Date

Customer

Date

<b>ORNL</b> PACKAGE TESTING PROGRAM OAK RIDGE NATIONAL LABORATORY OAK RIDGE, TENNESSEE 37831 <small>The OFFICIAL COPY of this document is the on-line version. Before using a printed copy, verify that it is the most current version by checking the Revision ID against the on-line version</small>	<b>Operating Procedure for HAC Crush Test - Testing of Radioactive Material Packages</b>	Test Procedure: <b>PTP-PEF-11</b>	Rev. <b>6 CN-3</b>
		Page: <b>5 / 6</b>	Issue Date: <b>02-18-2021</b>
		Revision Date: <b>02-18-2021</b>	Review by Date: <b>02-18-2024</b>

## 6 Procedure Checklist

Test Plan:

*ORNL/NTRC-092 R.O*

Test Unit:

*1*

VERIFIED

TASK

- ☒ Verify that any equipment used meets the M&TE meets PTP-QA-013 requirements (§4.1).
- ☒ Have a photographer's clipboard with package name and test unit number. (§4.4)
- ☒ Attitude of the test unit is set. (§4.5)
- ☒ Photograph of the attitude has been taken. (§4.5)
- ☒ Photograph of the measured angle has been taken. (§4.5)
- ☒ The crush plate has been raised to the designated drop height and located over the target point. (§4.7)
- ☒ Photograph of the set position has been taken. (§4.7)
- ☒ Remove plumb bob from crush plate. (§4.7)
- ☒ Video camera(s) are setup and running to take video of the drop. (§4.8)
- ☒ The release mechanism has been plugged into power outlet. (§4.8)
- ☒ Countdown, Release the crush plate, unplug release mechanism. (§4.8)
- ☒ Videos camera stopped. (§4.9)
- ☒ Date and time of test recorded. (§4.10)
- ☒ The ambient temperature has been recorded. (§4.10)
- ☒ Photographs of the resulting damage were taken. (§4.11)
- ☒ Sign and date checklist and data forms (§4.11).

Comments: *NONE*

I certify that the above tasks have been performed and that the observations and comments are correct.

Testing Technician

*Ross Whittenburg*  
Customer

*10/20/21*  
Date

*10/20/21*  
Date

Witness

*M. D. Hunter*  
*Ryan F. Ho*  
Customer

*10/20/2021*  
Date

*10/20/21*  
Date



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		Page: <b>6 / 6</b>	Issue Date: <b>02-18-2021</b>
		Revision Date: <b>02-18-2021</b>	Review by Date: <b>02-18-2024</b>

## 7. Data Sheet

Test Plan:

ORNL/NTRC 92.RD

Test Unit:

VERIFIED

TASK

☒ Intended attitude of the test unit 0° Tolerance ± 2° (§4.6)  
☒ Attitude Description: Horizontal, 0° facing pad, (80° facing up). (§4.3)  
☒ Measured attitude of the test unit \_\_\_\_\_ degrees. (§4.5)  
☒ Level number M212348 Calibration Exp. Date 2/23/2022 (§4.5)  
☒ Height above the target: 9-m (30-ft) Measuring device A006327 due 3/30/2023 (§4.7)  
☒ Date and Time of Crush Test: 10/20/2021 10:53 am (§4.10)  
☒ Ambient temperature: 58.8°F (\_\_\_\_ °C (\_\_\_\_ °F))  
 Thermometer M&TE ID/Cal. Due Date: A006681 due 5/12/2022 (§4.10)

Testing Damage Observations:

(Level 0-180 0.1°)  
90°-270 0.6°

Comments:

I certify that the above tasks have been performed and that the observations and comments are correct.

Testing Technician

Ross Whittaker  
Customer

10/20/21  
Date

10/20/21  
Date

M.B. Hunter  
Witness

[Signature]  
Customer

10/20/2021  
Date

10/20/21  
Date

<b>ORNL</b> PACKAGE TESTING PROGRAM OAK RIDGE NATIONAL LABORATORY OAK RIDGE, TENNESSEE 37831 <small>The OFFICIAL COPY of this document is the on-line version. Before using a printed copy, verify that it is the most current version by checking the Revision ID against the on-line version</small>	Operating Procedure for <b>HAC Puncture Test - Testing of          Radioactive Material Packages</b>	Test Procedure: <b>PTP-PEF-12</b>	Rev. <b>5 CN 2</b>
		Page: <b>6 / 7</b>	Issue Date: <b>12-14-20</b>
		Revision Date: <b>12-01-20</b>	Review by Date: <b>12-14-23</b>


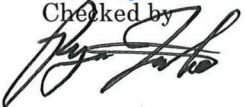
## • Procedure Checklist

Test Plan: <b>ORNL/NTRC-092 R.O</b>	Test Unit: <b>1</b>
--	------------------------

VERIFIED	TASK
<input checked="" type="checkbox"/>	Verify that any equipment used meets the M&TE meets PTP-QA-013 requirements (§4.1).
<input checked="" type="checkbox"/>	Have a photographer's clipboard with package name and test unit number. (§4.4)
<input checked="" type="checkbox"/>	Attitude of the rigged test unit is set. (§4.5)
<input checked="" type="checkbox"/>	Photograph of the rigging arrangements has been taken. (§4.5)
<input checked="" type="checkbox"/>	Photograph of the measured drop angle has been taken. (§4.5)
<input checked="" type="checkbox"/>	The test unit has been raised to the designated drop height. (§4.6)
<input checked="" type="checkbox"/>	Photograph of the height measurement has been taken. (§4.6)
<input checked="" type="checkbox"/>	Video camera(s) are setup and running to take video of the drop. (§4.7)
<input checked="" type="checkbox"/>	The release mechanism has been plugged into power outlet. (§4.7)
<input checked="" type="checkbox"/>	Countdown, Release the test unit, unplug release mechanism. (§4.7)
<input checked="" type="checkbox"/>	Videos camera stopped. (§4.8)
<input checked="" type="checkbox"/>	Date and time of test recorded. (§4.9)
<input checked="" type="checkbox"/>	The ambient temperature has been recorded. (§4.10)
<input checked="" type="checkbox"/>	Photographs of the resulting damage were taken. (§4.11)
<input checked="" type="checkbox"/>	Sign and date checklist and data forms (§4.12).

Comments: **NONE.**

I certify that the above tasks have been performed and that the observations and comments are correct.

 Test Engineer <b>Ross Whitteby</b>	<b>10/20/21</b> Date <b>10/20/21</b>	<b>M.B. Hunter</b> Checked by 	<b>10-20-2021</b> Date <b>10/20/21</b>
--	--	--	--

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## 6. Data Sheet

Test Plan: <b>ORNL/NTRC-092 R.O</b>	Test Unit: <b>1</b>
--	------------------------

VERIFIED

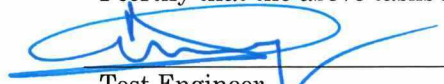
TASK

<input checked="" type="checkbox"/>	M&TE ID <b>A000883</b> Calibration due date <b>3/15/2023</b> (§4.1).
<input checked="" type="checkbox"/>	Intended attitude of the test unit <b>0°</b> . Tolerance $\pm$ <b>2°</b> (§4.5)
<input checked="" type="checkbox"/>	Measured attitude of the test unit <b>0.8°</b> degrees. (§4.5)
<input checked="" type="checkbox"/>	Attitude Description: <b>Horizontal opening bar. PL @ bar</b> (§4.3)
<input checked="" type="checkbox"/>	Level number <b>M212348</b> Calibration Exp. Date <b>2/23/2022</b> (§4.5)
<input checked="" type="checkbox"/>	Height above the puncture bar <b>40 in</b> Measuring device <b>A001146</b> due <b>2/24/2026</b> (§4.6)
<input checked="" type="checkbox"/>	Date and Time of Drop Test: <b>10/20/2021 @ 11:25am</b> (§4.9)
<input checked="" type="checkbox"/>	Ambient temperature: <b>59.8°F</b> <sup>mon 10-20-2021</sup> <b>59.8°F</b> °C ( ) °F
	Measuring device <b>A006681</b> due <b>5/12/2022</b> (§4.10)

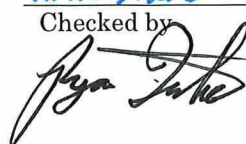
Testing Damage Observations:

Comments: **Puncture bar : A000883 due 3/15/2023**

I certify that the above tasks have been performed and that the observations and comments are correct.

  
 Test Engineer  
**Paul Whitham**

**10/20/21**  
 Date  
**10/20/21**

**M.B. Harter**  
 Checked by  


**10/20/2021**  
 Date  
**10/20/21**



# TEST FORM 7 - TEST UNIT DIMENSIONS

Test Plan - DPP-1

TU- 1

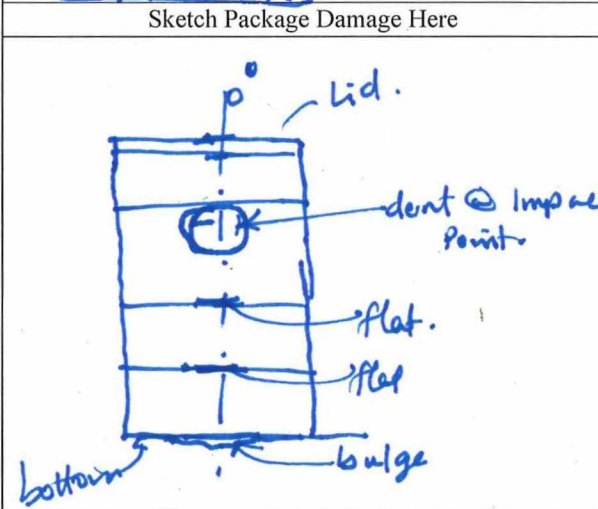
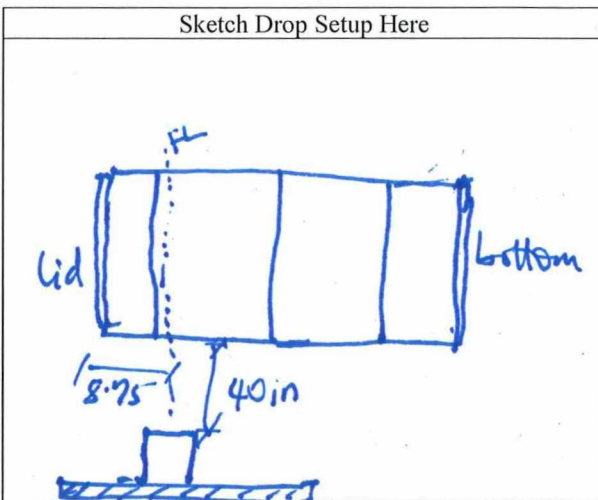
Initial Assembly \_\_\_\_\_  
 Post 1.2-m Drop ✓  
 Post 9-m Drop ✓  
 Post Crush Test ✓  
 Post 1-m Puncture Test ✓

## Drum outer shell

	0°	90°	180°	270°
Height	44 1/8	43 7/16	42 13/16	43 5/8

DIAMETER	0° to 180°	90° to 270°
Top Surface	25 1/16	27
Top Rolling hoop	25 1/8	28 5/8
Center Rolling hoop	24 1/4	29 1/4
Bottom Rolling hoop	25 15/16	28 5/8
Bottom Surface	25 1/2	27 1/8

Location	Flats width @ 0°	Flats width @ 180°
Top Surface	12.148	10.324
Top Rolling hoop	11.668	13.976
Center Rolling hoop	14.071	N/A
Bottom Rolling hoop	12.727	N/A
Bottom Surface		



M&TE ID #: A001319 Calibration Due Date: 02/23/2022

M&TE ID #: N/A Calibration Due Date: N/A

Comments: Bulge on the bottom @ 0°.

I certify that the above tasks have been performed and that the observations and comments are correct.

[Signature]  
 Testing Technician  
Russ Whittaker  
 CNS-Y-12 STR

10/20/21  
 Date  
10/20/21  
 Date

M. B. Hamilton  
 Witness  
[Signature]  
 CNS-Y-12 QE

10-20-2021  
 Date  
10/20/21  
 Date

\*All photographs/movies will be uniquely identified with test unit, date and time to ensure that the proper sequence can be reconstructed

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		<b>PTP-PEF-13</b>	<b>7 CN-0</b>
		Page 10 / 12	Issue Date: 03-10-2021
		Revision Date: 03-10-2021	Review by Date: 03-10-2024

### Attachment 1 - HAC Thermal Test Checklist

Test Plan:

**ORNL/NTRC-092 R.O**

Test Unit:

**1**

VERIFIED

TASK

☒

Ensure test equipment is calibrated, calibration records are acceptable, and that Attachments 1 and 2 records have been initiated prior to testing. Prepare photographers clipboard. (§4.1a, b, c & d)

☒

Set up the thermal DAQ and test all TC channels with a calibrated heat source. The acceptable range to test the thermocouples is 0°F - 150°F. (§4.2a)

☒

The thermocouple mounting clip material and installation is acceptable and per customer requirements, test plan, or approved work instruction. (§4.2b)

☒

TU's have been preheated per customer requirements, test plan or approved work instruction. NOTE: When no customer requirements are given, preheat shall be ~ 66°C (150°F) for a minimum of 24 hours and then soaked at ~ 43°C (110°F) for a minimum of 24 hours. **Record pre-heat acceptance on Attachment 2. (§4.2c)**

☒

Unless specified otherwise by the customer requirements, test plan, or approved work instruction, the furnace layout has proved capable of loading tests units within 90 seconds. (§4.3a)

☒

Floor plate(s) material(s) and test stand(s) are of the approved design and are installed at the location specified by the customer, test plan or approved work instruction. All TCs have been labeled, installed in the furnace, connected to DAQ and tested. The furnace opening can operate without causing damage to thermocouple wires. Photographs have been taken of the furnace set up. (§4.3b, 4.3c-4.3d)

☒

The furnace pre-heat soak time has been achieved (minimum temperature of 860°C (1580°F) for a minimum of 24 hours) and the DAQ is recording TC temperatures every 15 seconds. If needed, adjust the furnace set point to maintain a constant temperature of 1580°F. (§4.3e)

Comments: \_\_\_\_\_

I certify that the above tasks have been performed and that the observations and comments are correct.

Testing Technician

**Ross Whittenburg**  
Customer

**11/08/21**

Date

**11/8/21**

Date

**M.B. Hamilton**

PTP QR Witness

**Phyllis Smith**  
Customer

**11-08-2021**

Date

**11/8/21**

Date



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		<b>PTP-PEF-13</b>	<b>7 CN-0</b>
		Page 11 / 12	Issue Date: 03-10-2021
		Revision Date: 03-10-2021	Review by Date: 03-10-2024

### Attachment 1 - HAC Thermal Test Checklist (continued)

Test Plan:

ORNL/NTRC-092 R-0

Test Unit:

1

VERIFIED

TASK

- ✓ **Furnace Soak** - A room temperature test specimen, instrumented with thermocouples was placed into the hot furnace. The test unit thermocouples and the furnace thermocouples (including the thermocouple that controls the furnace temperature) were monitored with the cDAQ to ensure the furnace was capable of achieving the requirements specified per the test plan. The test specimen will remain in the furnace for a period specified by customer requirements, test plan, or the approved work instruction. When no requirements are given, the test specimen will remain in the furnace for 30 minutes after 5 of 6 of the thermocouples on the test specimen surface, 2 out of 3 thermocouples on the test stand, and 2 of 3 thermocouples on each furnace wall reach 1475°F. **Record acceptance on Attachment 2. (§4.4.a)**
- ✓ **Test Unit Preparation** - Weld the thermocouple clips to the TU's before starting the preheat. Pre-heat per test plan requirements. Document pre-heat for the test unit on Attachment 2. Upon acceptance of pre-heat requirements for the test specimen, remove the test specimen from the pre-heat chamber and install TCs. Test all thermocouples with a heat source. (§4.2b & 4.4b)
- ✓ **Ready to Test** - Open the furnace opening. Load the test specimen on the furnace test stand. Unless specified otherwise by the customer requirements, test plan or work instruction, place the test specimen onto the test stand in a horizontal position with the test specimen lid facing the right furnace sidewall and the 0° line is facing down (facing the furnace floor). (§4.4.c)
- ✓ **Beginning the Test** - Loading can begin when the furnace has met the required preheat time. **Record the Test Start Time on Attachment 2.** The 30 minute test shall start when the following conditions have been met.
  - 5 of 6 of the thermocouples on the test specimen surface must reach 1475°F or greater and,
  - 2 out of 3 thermocouples on the test stand must reach 1475°F or greater and,
  - 2 of 3 thermocouples on each furnace wall have reached 1475°F or greater. (§4.4a)
- ✓ **Test Completion - Record the Test Stop Time on Attachment 2.** Immediately following the timed test and the thermal requirements are met, immediately remove the test specimen from the furnace and place the specimen in an area where it will not be exposed to artificial cooling. Record notes regarding smoke and/or flames emanating from the test specimen on Attachment 2. (§4.3c)
- ✓ All Photographs and/or videos for the entire test setup have been taken. (§4.3c)

Comments:

I certify that the above tasks have been performed and that the observations and comments are correct.

11-18-21 m.b.h.	11/08/21	M.B. Houston	11-08-2021
Testing Technician	Date	PTP QR Witness	Date
Ross W. Jettler	11/8/21	[Signature]	11/8/21
Customer	Date	Customer	Date



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		Page	Issue Date:
		Revision Date:	Review by Date:
		PTP-PEF-13	7 CN-0
		12 / 12	03-10-2021
		03-10-2021	03-10-2024

## Attachment 2 - HAC Thermal Test Data Sheet

Test Plan:

ORNL/NTRC-092 R.O

Test Unit:

1

VERIFIED

TASK

✓

The test unit has been preheated to over 38°C (100°F). (§4.2c)

Pre-heat Start date/time: 3:45 am/pm (CT) @ 11/05/2021

Pre-heat End date/time: 10:28 am/pm (CT) @ 11/08/2021

Final Pre-heat temperature: 710°F

✓

Furnace Soak Time prior to testing - Unless otherwise specified by the customer requirements, test plan or work instructions, preheat the furnace at a temperature of 860°C (1580°F) for a minimum of 24 hours. Record the time/date the soak time began and the time/date the soak time was reached (§ 4.3.e):

Time soak time begins: Date/Time: 11/07/2021 am/pm @ 6:52pm (CT)

Time soak time reached: Date/Time: 11/08/2021 am/pm @ 6:52am (CT)

✓

The test unit has been placed in the furnace, on the support stand, at: (§4.4d)

Furnace door opened time: 11:15am Furnace door Closed time: 11:16am

Total time taken to open and Close furnace door: ~1 min

✓

Unless otherwise specified by the customer requirements, test plan or work instructions, the 30-minute timed test starts after 5 out of 6 test unit thermocouples and 15 of 18 furnace thermocouples reach the test temperature of 801°C (1475°F).

Enter the Test Start Time: 11:18 am/pm (§4.4e & 4.4f)

✓

The test unit was removed from the furnace and allowed to cool naturally. (§4.4f)

Enter the Test End Time: 11:49 am/pm

N/A

The test unit stopped outgassing (flames) at am/pm (§4.4f)

Outgassing/burnout elapsed time was minutes. (§4.4f)

Comments: Furnace pre-heat was for 12 hours.

I certify that the above tasks have been performed and that the observations and comments are correct.

Testing Technician

Date

Witness

Date

Customer

Date

Customer

Date

# TEST FORM 5 - POST-THERMAL TESTING INSPECTION

Test Plan DPP-1

TU 1

## VERIFIED

## TASK

- ☒ Following the thermal test and after passive cooling, the test package was weighed, and recorded on TEST FORM 1.
- ☒ The drum, drum lid, bolts, and washers have been visually examined to determine the extent of the testing damage. Observations: None after thermal test.
- ☒ The camera(s) are set up to take photographs\* and/or videotape of the damage due to testing.
- ☒ The drum lid has been removed and the condition of the exposed parts have been visually examined for damage and the condition has been recorded. Record the exposed temperature indicator blackout reading on TEST FORM 6. Record the torque values needed to loosen the drum lid weldment screws on TEST FORM #8. Observations: Bolt #10, #14 & #4 Sheared, after break away for ghe
- ☒ The CV assembly and contents have been removed in the reverse assembly order and visually examined for damage. Record the exposed temperature indicator blackout readings on TEST FORM 6. Observations: SEE TEST FORM 6.
- ☒ The CV assembly has been weighed and the weight recorded on TEST FORM 1.
- ☒ Use NDE 70 Rev. 7 for the CV post-test operational leak check and for the full containment boundary leak check and PTP-PEF-14 for the 0.9 m (3 ft). immersion test or PTP-PEF-15 for the 15 m immersion test. The leak test port plug shall be removed for these tests.   
RW 12/13/21  
BF 12/13/21  
HOLD POINT: Y-12 has approved the CV drying process.
- ☒ After immersion test the CV was dried using the CNS approved process (fans, plant air pressure, mild heat, vacuum suction, etc.) as shown in TEST FORM 12. The flange joint and space between the O-rings was dried by the approved process prior to opening the CV.
- ☒ Disassemble the CV. Record torque value needed to loosen CV screws on TEST FORM 9.
- ☒ If water is present inside the O-rings, stop work, inform CNS, and comment observations below.
- ☒ Read the temperature labels from the CV. Record the temperature indicators' blackout readings on TEST FORM 6.
- ☒ The content test fixture weldment assembly was removed from the CV and the weight was recorded on TEST FORM 1.
- ☒ The content test fixture weldment assembly was disassembled in the reverse assembly order.
- ☒ Loaded test fixture weldment content assembly: Remove the contents in the following order, loading test fixture weldment assembly using nylon springs, PCC silicone rubber pad, test weight weldment, lower PCC silicone rubber pad. CV silicone rubber pad.
- ☒ All loose parts will be placed in separate plastic bags, marked with test unit identification, tape closed, and prepared for storage with the test package.
- ☒ Mark and reassemble the test package to the extent possible for shipment.
- ☒ \*Photographs and/or video of the damage resulting from the testing have been taken.

Comments: Drum body weight estimated by calculation. The drum was cut up to remove the CV. It was impossible to get the true weight

I certify that the above tasks have been performed and that the observations and comments are correct.

[Signature]  
Testing Technician  
Baro Whitteley  
CNS-Y-12 STR

12/13/21  
Date  
12/13/21  
Date

M. B. Hunter  
Witness  
[Signature]  
CNS-Y-12 QE

12-13-2021  
Date  
12/13/21  
Date

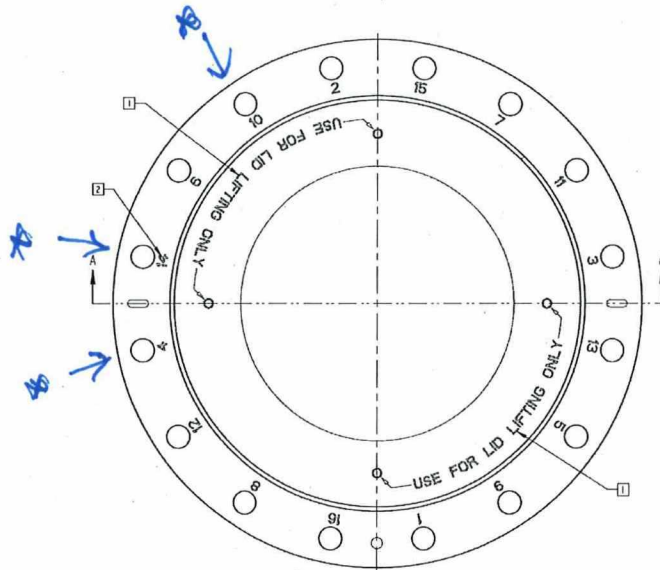
\*All photographs/movies will be uniquely identified with test unit, date and time to ensure that the proper sequence can be reconstructed.



# TEST FORM 8 –DRUM LID DISASSEMBLY

Test Plan – DPP-1

TU- 1



DPP-1 Lid Disassembly	
Bolt #	Torque Removal (ft-lbs.)
1	32.2
2	33.7
3	37.3
4	39.0
5	42.3
6	20.4
7	26.3
8	24.6
9	51.3
10	48.0
11	57.9
12	42.9
13	41.9
14	57.1
15	48.5
16	37.4

M&TE ID #: A001096 Calibration Due Date: 2/10/2022

M&TE ID #: A006681 Calibration Due Date: 5/12/2022

Comments: Ambient temperature: 65.3°F

\* Bolts at #10, #14 & #4 Sheared, after break-away torque.

I certify that the above tasks have been performed and that the observations and comments are correct.

[Signature]  
Testing Technician  
Bob Whittenburg  
CNS-Y-12 STR

11/23/21  
Date  
11/23/21  
Date

M.B. Hunter  
Witness  
[Signature]  
CNS-Y-12 QE

11-23-2021  
Date  
11/23/21  
Date

\*All photographs/movies will be uniquely identified with test unit, date and time to ensure that the proper sequence can be reconstructed



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		Page: <b>5 / 6</b>	Issue Date: <b>12-14-20</b>
		Revision Date: <b>1-03-20</b>	Review By Date: <b>12-14-23</b>

## 6. Procedure Checklist

Test Plan:

*ORNL/NTRC-092.0*

Test Unit:

*1*

VERIFIED

TASK

- ☒ Verify that any equipment used meets the M&TE meets PTP-QA-013 requirements (§4.1).
- ☒ Have a photographer's clipboard with package name and test unit number. (§4.3)
- ☒ The test unit has been lowered to the bottom of the tank in designated orientation. (§4.6)
- ☒ The depth to the highest point of the test unit has been measured and is at least 0.9-m (3-ft). (§4.6)
- ☒ Photograph of the depth measurement has been taken. (§4.6)
- ☒ Record the water and ambient temperature. (§4.6)
- ☒ Start date and time has been noted. (§4.7)
- ☒ Test unit has been removed from the tank. (§4.8)
- ☒ End date and time has been noted. (§4.8)
- ☒ Record the water and ambient temperature. (§4.8)
- ☒ Thoroughly dry the test unit and make sure it is completely dry before opening. (§4.9)
- ☒ Open the test unit and record-breaking torque values during removal, if required. (§4.10)
- ☒ Inspect for water in-leakage or structural damage. (§4.10)
- ☒ Photographs of any resulting damage or lack thereof were taken. (§4.10)
- ☒ Sign and date checklist and data forms (§4.12).

Comments:

I certify that the above tasks have been performed and that the observations and comments are correct.

Test Engineer

*Ross Whittenburg*

Date

*12/9/21*

Checked by

*M. B. Haskin*  
*[Signature]*

Date

*12-09-2021*  
*12/9/21*

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		Page:	Issue Date:
		Revision Date:	Review By Date:
		<b>PTP-PEF-14</b>	<b>5 CN 2</b>
		6 / 6	12-14-20
		1-03-20	12-14-23

## 7. Data Sheet

Test Plan:  
ORNL/NTRC-092.0

Test Unit: 1

VERIFIED

TASK

- ✓ M&TE ID A006327 Calibration due date A006327 due 3/20/2023 (§4.1).
- ✓ Intended attitude of the test unit in tank (e.g. on side) 0° down (§4.4)
- ✓ Depth of water above the test unit 40.5 in Measuring device A006327 due 3/20/2023 (§4.6)
- ✓ Start Date and Time of Immersion Test: 12/08/2021 @ 4:30pm (§4.7)
- ✓ Water temperature: 68.5°F °C (   °F) Measuring device A006681 (§4.6) due 5/12/2022
- ✓ Ambient temperature: 61.9°F °C (   °F) Measuring device A006681 (§4.8)
- ✓ End Date and Time of Immersion Test: 12/09/2021 @ 10:00am (§4.8)
- ✓ Water temperature: 68.5°F °C (   °F) Measuring device A006681 (§4.8)
- ✓ Ambient temperature: 61.9°F °C (   °F) Measuring device A006681 (§4.8)
- ✓ Detected in-leakage of water: (YES/NO) NO (§4.10)
- ✓ Detected structural damage: (YES/NO) NO (§4.10)

Testing Damage Observations:

Comments:

I certify that the above tasks have been performed and that the observations and comments are correct.

Test Engineer:

Ross Whittenburg

Date

12/9/21

Checked by

M.B. Hunter

Date

12-09-2021  
12/9/21

# TEST FORM 12 –CV DRYING PROCEDURE

Test Plan – DPP-1

TU- 1

VERIFIED

TASK

- ✓ ORNL will remove the CV's from the immersion tank after a minimum of 8 hours.
- ✓ The CV's will be placed on the worktable in a vertical position.
- ✓ A shop vac will be used to blow out any water out of the CV flanges.
- ✓ The external surface of the CV will be dried with cloth and paper towels.
- ✓ ORNL will attach a vacuum to the CV flange O-ring port and supply a vacuum to remove most of the water between the inner and outer O-rings.
- ✓ After about 1 hour of air drying under forced hot air convection, an air compressor or compressed air can, or shop air will be used to blow out any water left in between the CV O-rings.
- ✓ The CV bolts will be loosened and removed, and the breakaway torque will be recorded on Test Form 9.
- ✓ The CV top lid will be lifted about a 1/8<sup>th</sup> -in and cloth and paper towels will be used to wipe the surfaces of the internal CV flanges outboard of the outer O-ring.
- ✓ A visual inspection of the internal surface of the CV flange will be done.
- ✓ ORNL and CNS will verify that water droplets are not visible on the inside of the Inner O-ring.
- ✓ After CNS approval, the CV lid will be completely removed from the CV base.

Comments:

I certify that the above tasks have been performed and that the observations and comments are correct.

Testing Technician

Drew Whitte  
CNS-Y-12 STR

Date

12/09/21  
Date

Witness

M.B. Hunter  
CNS-Y-12 QE

Date

12-09-2021  
Date

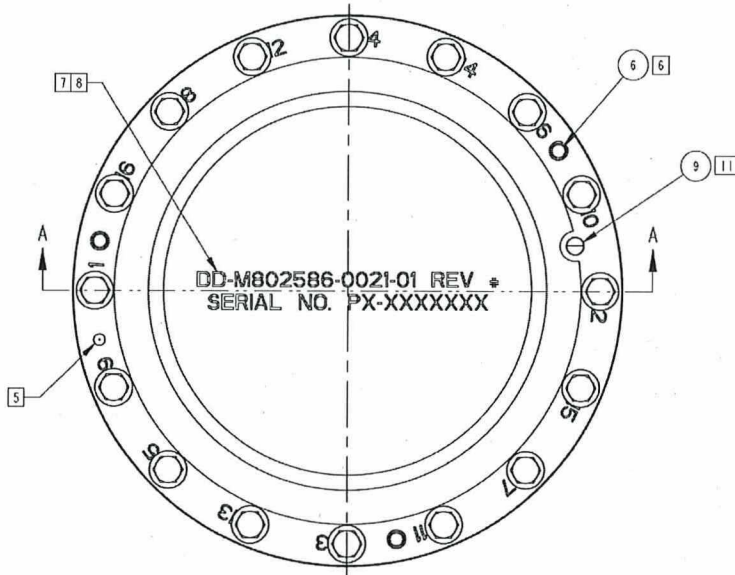
\*All photographs/movies will be uniquely identified with test unit, date and time to ensure that the proper sequence can be reconstructed



# TEST FORM 9 –CV LID DISASSEMBLY

Test Plan – DPP-1

TU- 1



DPP-1 CV Lid Disassembly	
Bolt #	Torque Removal (ft-lbs.)
1	26.7
2	13.7
3	22.2
4	24.9
5	30.0
6	23.6
7	19.4
8	26.0
9	24.9
10	22.1
11	27.1
12	26.2
13	25.9
14	25.2
15	22.4
16	19.5

M&TE ID #: A001096 Calibration Due Date: 2/10/2022

M&TE ID #: N/A Calibration Due Date: N/A

Comments:

I certify that the above tasks have been performed and that the observations and comments are correct.

[Signature]  
Testing Technician  
Ross Whittenburg  
CNS-Y-12 STR

12/09/21  
Date  
12/9/21  
Date

M. B. Hunter  
Witness  
[Signature]  
CNS-Y-12 QE

12-09-2021  
Date  
12/9/21  
Date

\*All photographs/movies will be uniquely identified with test unit, date and time to ensure that the proper sequence can be reconstructed

# TEST FORM 6 - TEMPERATURE INDICATOR READINGS

Test Plan DPP-1

TU 1

A visual inspection of each temperature indicator on the package consisting of those indicators inside the CV, outside the CV, and on the drum-liner will be made. The values of the blackouts that occurred will be recorded below.

TEMPERATURE INDICATOR NUMBER LOCATION CHART				
TEST CONTENT ASSEMBLY (TL-10-105, TL-10-190)				
Location (outside)	0°	90°	180°	270°
Top end cap center	1 200 °F	2 200 °F	3 200 °F	4 200 °F
Top end cap under flange	5 200 °F	6 200 °F	7 200 °F	8 200 °F
Tube upper	9 200 °F	10 200 °F	11 200 °F	12 200 °F
Tube middle	13 200 °F	14 200 °F	15 200 °F	16 200 °F
Tube lower	17 200 °F	18 200 °F	19 200 °F	20 200 °F
Bottom end cap under flange	21 200 °F	22 200 °F	23 200 °F	24 200 °F
Bottom end cap center	25 200 °F	26 200 °F	27 200 °F	28 200 °F
Weight upper	29 200 °F	30 200 °F	31 200 °F	32 200 °F
Weight lower	33 200 °F	34 200 °F	35 200 °F	36 200 °F
INTERIOR OF THE CV (TL-10-105, TL-10-190)				
CV lid center	37 220 °F	38 220 °F	39 210 °F	40 220 °F
CV body flange	41 200 °F	42 210 °F	43 210 °F	44 210 °F
CV wall upper	45 200 °F	46 210 °F	47 210 °F	48 210 °F
CV wall middle	49 200 °F	50 200 °F	51 210 °F	52 210 °F
CV wall lower	53 200 °F	54 200 °F	55 210 °F	56 200 °F
CV base neck	57 200 °F	58 200 °F	59 200 °F	60 200 °F
CV base center	61 190 °F	62 190 °F	63 200 °F	64 190 °F
EXTERIOR OF THE CV (TL-10-105, TL-10-190)				
Lid center	65 220 °F	66 220 °F	67 220 °F	68 220 °F
Lid flange	69 220 °F	70 220 °F	71 220 °F	72 220 °F
Body flange	73 210 °F	74 220 °F	75 220 °F	76 220 °F
Base neck	77 200 °F	78 200 °F	79 200 °F	80 200 °F
Base toe	81 200 °F	82 200 °F	83 200 °F	84 200 °F
DRUM ASSEMBLY (TL-10-190, TL-10-290)				
Lid bottom	85 230 °F	86 230 °F	87 230 °F	88 230 °F
Cavity wall upper	89 230 °F	90 250 °F	91 250 °F	92 240 °F
Cavity wall middle	93 240 °F	94 240 °F	95 250 °F	96 240 °F
Cavity wall lower	97 230 °F	98 240 °F	99 240 °F	100 230 °F
Cavity wall lowest	101 200 °F	102 230 °F	103 230 °F	104 220 °F
Cavity bottom	105 200 °F	106 210 °F	107 210 °F	108 210 °F

Comments:

I certify that the above tasks have been performed and that the observations and comments are correct.

Testing Technician

Date

Witness

Date

CNS-Y-12 STR

Date

CNS-Y-12 QE

Date

\*All photographs/movies will be uniquely identified with test unit, date and time to ensure that the proper sequence can be reconstructed



# TEST FORM 15 -WITNESS AND HOLD POINTS

Test Plan DPP-1

TU 1

The following applicable CNS hold points activities shall not start until written approval to proceed has been given from the CNS STR via e-mail. Additional hold points may be included when CNS reviews the approval data documents and as the work is being performed. The purpose of each hold point is to give the TA, STR, and QE an opportunity to (1) evaluate what has happened since the previous hold point, (2) evaluate previous lessons learned on the activities that follow, and (3) make an informed decision to proceed.

NO.	DESCRIPTION	TU NO.	TYPE	CNS INITIAL
1	<u>Initial package disassembly</u> Witness the disassembly, can be waived by a DA representative	1,2,3,4,5,6,7	Witness, Hold	RW RF
2	<u>pre-test operational leakage rate test</u> Witness the pre-test operational leakage rate test per ANSI N14.5, section 7.6, after final closure (and before commencing testing sequence)	1,2,3,4,5,6,7	Witness, Hold	
2.1	<u>pre-test operational leakage rate test acceptance</u> Inspection to verify the pre-test operational leakage rate test has met acceptance criteria <b>Subsequent reassembly sequence shall not commence until acceptable result is produced.</b>	1,2,3,4,5,6,7	Hold	
3	<u>Initial package reassembly</u> Witness the reassembly of the contents, CV, vibration pads, drum lid, instrumentation, and all associated fastening hardware	1,2,3,4,5,6,7	Witness	
3.1	<u>Initial Package Reassembly</u> Inspection and observation to verify the reassembly procedure has been followed according to supplied direction. <b>Subsequent testing sequence shall not commence until reassembly steps have been confirmed as acceptable.</b>	1,2,3,4,5,6,7	Hold	
4	<u>NCT vibration/shock test</u> Witness the NCT vibration/shock testing activities, including all preliminary setup, can be waived by a DA representative	6	Witness	
5	<u>NCT thermal pre-treatment</u> Witness the NCT thermal pre-treatment activities, including all preliminary setup, can be waived by a DA representative	1,2,3,4,5,6	Witness	
6	<u>NCT water spray test</u> Witness the NCT water spray test activities, including all preliminary setup, can be waived by a DA representative	2,3,4,6	Witness, Hold	
7	<u>NCT free drop (4 ft) test</u> Witness the NCT free drop (4 ft) test activities, including all preliminary setup, can be waived by a DA representative	1,2,3,4,5,6	Witness	
7.1	<u>NCT free drop (4 ft) test, critical parameters</u> Inspection to verify the critical parameters defining the NCT free drop (4 ft) test meet all requirements <b>Completion of NCT free drop (4 ft) test shall not commence until all critical parameters have been verified.</b>	1,2,3,4,5,6	Hold	



8	<u>NCT penetration test</u> Witness the NCT penetration test activities, including all preliminary setup, can be waived by a DA representative	6	Witness	RW RF
8.1	<u>NCT penetration test, critical parameters</u> Inspection to verify the critical parameters defining the NCT penetration test meet all requirements	6	Hold	
	<b>Completion of NCT penetration test shall not commence until all critical parameters have been verified.</b>			
9	<u>NCT compression test</u> Witness the NCT compression test activities, including all preliminary setup, can be waived by a DA representative	6	Witness	
9.1	<u>NCT compression test, critical parameters</u> Inspection to verify the critical parameters defining the NCT compression test meet all requirements	6	Hold	
	<b>Completion of NCT compression test shall not commence until all critical parameters have been verified</b>			
10	<u>HAC thermal pre-treatment</u> Witness the HAC thermal pre-treatment activities, including all preliminary setup, can be waived by a DA representative	1,5	Witness	
11	<u>HAC free drop (30 ft) test</u> Witness the HAC free drop (30 ft) test activities, including all preliminary setup, can be waived by a DA representative	1,2,3,4,5,6	Witness	
11.1	<u>HAC free drop (30 ft) test, critical parameters</u> Inspection to verify the critical parameters defining the HAC free drop (30 ft) test meet all requirements	1,2,3,4,5,6	Hold	
	<b>Completion of HAC free drop (30 ft) test shall not commence until all critical parameters have been verified.</b>			
11.2	<u>HAC free drop (30 ft) test, damage determination</u> Inspection to verify that the damage inflicted during the HAC free drop (30 ft) test is as expected, if unexpected damage is present, modifications to the subsequent HAC Crush (30 ft) test will be defined	1,2,3,4,5,6	Hold	
	<b>Testing shall not commence until new specification of HAC Crush (30 ft) test has been agreed-upon and adopted by the TA.</b>			
12	<u>HAC crush (30 ft) test</u> Witness the HAC crush (30 ft) test activities, including all preliminary setup, can be waived by a DA representative	1,2,3,4,5,6	Witness	
12.1	<u>HAC crush (30 ft) test, critical parameters</u> Inspection to verify the critical parameters defining the HAC crush (30 ft) test meet all requirements	1,2,3,4,5,6	Hold	
	<b>Completion of HAC crush (30 ft) test shall not commence until all critical parameters have been verified.</b>			
12.2	<u>HAC crush (30 ft) test, damage determination</u> Inspection to verify that the damage inflicted during the HAC crush (30 ft) test is as expected, if unexpected damage is present, modifications to the subsequent HAC Puncture drop (40 in ) test will be defined	1,2,3,4,5,6	Hold	
	<b>Testing shall not commence until new specification of HAC Puncture drop (40 in.) test has been agreed-upon and adopted by the TA.</b>			

13	<u>HAC Puncture drop (40 in.) test</u> Witness the HAC Puncture drop (40 in.) test activities, including all preliminary setup, can be waived by a DA representative	1,2,3,4,5,6	Witness	RW RF
13.1	<u>HAC Puncture drop (40 in.) test, critical parameters</u> Inspection to verify the critical parameters defining the HAC Puncture drop (40 in.) test meet all requirements	1,2,3,4,5,6	Hold	
<b>Completion of HAC Puncture drop (40 in.) test shall not commence until all critical parameters have been verified.</b>				
NO.	DESCRIPTION	TU NO.	TYPE	CNS INITIAL
14	<u>Thermal test, data collection hardware</u> Inspection to verify that all the thermocouple and hardware has been installed, or configured as specified and is operating correctly	1,2,3,4,5,6	Hold	RF
<b>Completion of supplementary thermal test shall not commence until hardware installation has been verified.</b>				
15	<u>HAC thermal test</u> Witness the HAC thermal test activities, including all preliminary setup, can be waived by a DA representative	1,2,3,4,5,6	Witness	
15	<u>Overpack Inspection and Disassembly</u> Witness the overpack inspection and disassembly process, including all preliminary setup, can be waived by a DA representative	1,2,3,4,5,6	Witness	
16	<u>Overpack Inspection and Disassembly</u> Inspection to verify that sufficient data and measurements have been collected from overpack and CV prior to drilling and tapping the CV lid for post-test leakage rate measurements	1,2,3,4,5,6	Hold	
<b>Post-test leakage rate activities, including all preliminary setup, shall not commence until hardware installation has been verified.</b>				
17	<u>post-test operational leakage rate test</u> Witness the post-test operational leakage rate test per ANSI N14.5, section 7.6, after completion of test activities (and before post-test full-boundary leakage rate test)	1,2,3,4,5,6	Witness	
18	<u>post-test full-boundary leakage rate test, drilling and tapping test port in CV lid</u> Witness the drilling and tapping of the leakage rate test port in the CV lid, after removal from the overpack assembly (and before completion of testing sequence)	1,2,3,4,5,6	Witness	
19	<u>post-test full-boundary leakage rate test</u> Witness the post-test full-boundary leakage rate test per ANSI N14.5, Section 7.5 This includes the sealing of the drilled and tapped hole in the CV lid after the leakage rate measurements have completed	1,2,3,4,5,6	Witness	
19.1	<u>Final containment vessel leakage rate test acceptance</u> Inspection to verify the "post-test" leakage rate test has met acceptance criteria	1,2,3,4,5,6	Hold	
<b>HAC immersion tests shall not commence until results are confirmed.</b>				

20	<u>HAC immersion test, fissile material packages</u> Witness the HAC immersion test, fissile material packages, activities, including preliminary setup, can be waived by a DA representative	1,2,3,4,5,6	Witness	RW RF
21	<u>HAC immersion test, all packages (undamaged)</u> Witness the HAC immersion test, all packages (undamaged), activities, including preliminary setup, can be waived by a DA representative	7	Witness	
22	<u>Opening containment vessel after HAC immersion test</u> Witness the opening of the containment vessel and inspection for retained moisture within the containment vessel cavity, including preliminary setup and verification that the external surface is complete dry, can be waived by a DA representative	1,2,3,4,5,6, 7	Witness	
NO.	DESCRIPTION	TU NO.	TYPE	CNS INITIAL
23	<u>Final external inspection results</u> Inspection of all external inspection results, to verify all specified dimensional and photographic records have been obtained, these records cannot be confirmed after the overpack assembly has been cut-open and so must be confirmed at this point  <b>Disassembly and cross section examination shall not commence until all external inspections have been completed and all necessary records have been collected. (if required)</b>	1,2,3,4,5,6, 7	Hold	RF
24	<u>Disassembly and cross section inspection</u> Witness the cutting, disassembly, and dissection of the overpack assembly (if required)	1,2,3,4,5,6, 7	Witness	
25	<u>Final cross section inspection results (if required)</u> Inspection of all cross-section inspection results, to verify all specified dimensional and photographic records have been obtained  <b>Completion of final data report shall not commence until all cross-section inspections have been completed and all necessary records have been collected. (if required)</b>	1,2,3,4,5,6, 7	Hold	
26	<u>Preliminary data package</u> Inspection of all preliminary test results, including data collected, photos and videos captured, and dimensions measured  <b>Shipment or disposal (as defined by the DA) of TU shall not commence until the preliminary data package has been reviewed and determined to be complete.</b>	1,2,3,4,5,6, 7	Hold	

Comments:

I certify that the above tasks have been performed and that the observations and comments are correct.

Testing Technician

Rosa Whittenburg  
CNS-Y-12 STR

Date

12/13/21  
Date

Witness

M. B. Hunter  
CNS-Y-12 QE

Date

12-13-2021  
Date

\*All photographs/movies will be uniquely identified with test unit, date and time to ensure that the proper sequence can be reconstructed



# TEST FORM 16 -PHOTOGRAPHY/VIDEO CHECKLIST

Test Plan DPP-1

CTU 1

At a minimum, the following events shall be captured by photography. If necessary, photos shall be taken from multiple perspectives to provide a clear understanding of the event being captured. Date and time will be stamped on all photographs.

## VERIFIED

## TASK

✓	Overpack assembly, containment vessel, and vibration pads after taking delivery and during disassembly
✓	Overpack assembly, containment vessel, and vibration pads (where applicable) during reassembly
✓	Drop testing pad, including appropriate dimensional references
✓	Puncture bar installed onto drop pad, including appropriate dimensional reference
✓	Penetration bar, including appropriate dimensional references
✓	Equipment, instrumentation, and general arrangement used for vibration/shock tests
✓	Equipment, instrumentation, and general arrangement used for free and Puncture drop tests
✓	Equipment, instrumentation, and general arrangement used for water spray tests
✓	Pre-test leakage rate tests: — Close-up views of CV before test, showing connection for CV lid leakage rate test port — Close-up views of CV during test, showing connections made to CV lid leakage rate test port — Test arrangement with CV during test, showing all connections made to CV
✓	NCT vibration/shock tests: — Test arrangement with the package installed onto the expander head or slip table — Attachment of tie-down chains or straps to top of package — Attachment of tie-down chains or straps to expander head or slip table
✓	NCT water spray tests: — Test arrangement with package before test, showing relative placement of water spray nozzles with respect to the package — Test arrangement with package during test, showing how the water is hitting the package — Test arrangement with package after test, showing evidence of water pooling or accumulation, if any — Rain gauge showing minimum allowable rainfall has been reached
✓	NCT free drop (4 ft) tests: — Test arrangement with package before test, showing the intended offset angle — Test arrangement with package before test, showing the intended drop height — Test arrangement with package after test, showing damaged package at final resting place — Close-up views of package after test, showing particular damage induced as a result of the NCT free drop (4 ft) test, including appropriate dimensional references
✓	NCT penetration tests: — Close-up views of package before test, showing intended point of impact — Test arrangement with package before test, showing supports and restraints that hold the package in place — Test arrangement with package before test, showing position and height of penetration bar, with respect to the package — Test arrangement with package after test, showing damaged package after penetration bar has made impact — Close-up views of package after test, showing particular damage induced as a result of the NCT penetration test, including appropriate dimensional references
✓	NCT compression tests: — If a compression tester machine is being used <ul style="list-style-type: none"> <li>• The relative arrangement of the package within the machine</li> <li>• The force read-out as indicated by the machine control system</li> </ul> — Test arrangement with package during test, showing weight having been applied to the package — Test arrangement with package after test, showing damaged package after weight has been removed (if any)

✓	<ul style="list-style-type: none"> <li>—Close-up views of package after test, showing any particular damage induced as a result of the NCT compression test, including evidence of bulging/buckling of the drum, bending/buckling of the drum bolt guard, and crushing/buckling of the fork pockets</li> </ul>
✓	<p>HAC free drop (30 ft) tests (check as performed)</p> <ul style="list-style-type: none"> <li>— Close-up views of package before test, showing intended point of initial impact</li> <li>— Test arrangement with package before test, showing the intended offset angle</li> <li>— Test arrangement with package before test, showing the intended drop height</li> <li>— Test arrangement with package after test, showing damaged package at final resting place</li> <li>— Close-up views of package after test, showing particular damage induced as a result of the HAC free drop (30 ft) test, including appropriate dimensional references</li> <li>— Close-up views of package after test, showing unexpected damage (if any), due to primary impact or any subsequent event</li> </ul>
✓	<p>HAC crush (30 ft) tests (check as performed)</p> <ul style="list-style-type: none"> <li>— Close-up views of package before test, showing intended point of initial impact</li> <li>— Test arrangement with package before test, showing the intended offset angle</li> <li>— Test arrangement with package before test, showing the intended drop height</li> <li>— Test arrangement with package after test, showing damaged package at final resting place</li> <li>— Close-up views of package after test, showing particular damage induced as a result of the HAC crush (30 ft) test, including appropriate dimensional references</li> <li>— Close-up views of package after test, showing unexpected damage (if any), due to primary impact or any subsequent event</li> </ul>
✓	<p>HAC Puncture drop (40 in ) tests</p> <ul style="list-style-type: none"> <li>—Close-up views of package before test, showing intended point of initial impact</li> <li>—Test arrangement with package before test, showing the intended offset angle</li> <li>—Test arrangement with package before test, showing the intended drop height</li> <li>—Test arrangement with package after test, showing damaged package at final resting place</li> <li>—Close-up views of package after test, showing particular damage induced as a result of the HAC puncture (1 m (40 in)) test, including appropriate dimensional references</li> <li>—Close-up views of package after test, showing unexpected damage (if any), due to primary impact or any subsequent event</li> </ul>
✓	<p>Supplementary and HAC thermal tests.</p> <ul style="list-style-type: none"> <li>—Views of relative spacing inside the furnace with door/trap open, with or without the package used as a dimensional point of reference, at hot or cold condition</li> <li>—Test arrangement with package before test, showing placement of the thermocouple attachments on the package exterior surface</li> <li>—Test arrangement with package after test, showing damaged/burned package after initial removal from the furnace/fire</li> <li>—Close-up views of package after test, showing any excessively damaged/burned parts (if any)</li> </ul>
✓	<p>HAC immersion-fissile material tests:</p> <ul style="list-style-type: none"> <li>– Test arrangement with CV before test, showing placement of the CV within the tank</li> <li>– Test arrangement with CV during test, showing measurement of submerged depth of CV below water line</li> <li>– Close-up views of CV after test, after removal of the CV lid, showing evidence of water ingress (if any)</li> </ul>
✓	<p>HAC immersion- 10CFR71(c)(6) package tests</p> <ul style="list-style-type: none"> <li>– Test arrangement with CV before test, showing placement of the CV within the tank or hydraulic pressure chamber</li> <li>– Test arrangement with CV during test, showing measurement of submerged depth of CV below water line (or, if a hydraulic pressure chamber is being used, the internal pressure read-out as indicated by the hydraulic control system or in-line pressure gauge)</li> <li>– Close-up views of CV after test, after removal of the CV lid, showing evidence of water ingress (if any)</li> </ul>



✓	<p>Post-test leakage rate tests:</p> <ul style="list-style-type: none"> <li>– Close-up views of CV before test, showing drilled/tapped connection for CV lid leakage rate test port</li> <li>– Close-up views of CV during test, showing connections made to CV lid leakage rate test port</li> <li>– Test arrangement with CV during test, showing all connections made to CV</li> </ul>
✓	<p>Initial teardown and inspection:</p> <ul style="list-style-type: none"> <li>– Close-up views of CV after removal from overpack assembly, showing any superficial and structural damage due to interaction with overpack assembly during test sequence (if any), including appropriate dimensional references ( cursory examination only)</li> <li>– Close-up views of all thermal temperature indicators, showing temperatures indicated and evidence of stretching/tearing (if any), including appropriate dimensional references</li> <li>– Close-up views of overpack assembly after removal of CV, showing any superficial and structural damage due to interaction with CV or drum lid during test sequence (if any), including appropriate dimensional references</li> <li>– Close-up views of drum lid after removal from overpack assembly, showing any superficial and structural damage due to interaction with the CV or overpack assembly, including appropriate dimensional references</li> </ul>
✓	<p>Final teardown and inspection:</p> <ul style="list-style-type: none"> <li>– Close-up views of the CV, showing superficial and structural damage to ANY component, internal and external surfaces (if any), including appropriate dimensional references (detailed examination)</li> <li>– Close-up views of components within the CV, showing superficial and structural damage to ANY component, internal and external surfaces (if any), including appropriate dimensional references (detailed examination)</li> <li>– Markings on the surfaces of the overpack assembly and drum lid, showing the intended cross section cuts, including appropriate dimensional references (if requires)</li> <li>– Overall views of overpack assembly and drum lid after cross section cuts have been made (if required)</li> <li>– Close-up views of overpack assembly and drum lid after cross section cuts have been made, showing damage to internal components, including the following: (if required) <ul style="list-style-type: none"> <li>• Extent of burned/charred or disintegrated impact-limiting foam</li> <li>• Extent of disintegration, cracking, or separation of impact-limiting block</li> <li>• Extent of damage to thermal insulating blanket and indication of total radial thickness</li> <li>• Relative dimensional changes of structural components (including but not limited to drum liner assembly, perforated ring, drum lid inner section)</li> <li>• Any cracked welds</li> <li>• Any scratched, dented, or stretched sheet metal</li> </ul> </li> </ul>

Comments:

I certify that the above tasks have been performed and that the observations and comments are correct.

  
Testing Technician  
  
CNS-Y-12 STR

12/13/21  
Date  
12/13/21  
Date

  
Witness  
  
CNS-Y-12 QE

12/13/2021  
Date  
12/13/21  
Date

\*All photographs/movies will be uniquely identified with test unit, date and time to ensure that the proper sequence can be reconstructed



## **I. APPENDIX TU-2 FORMS**

# TEST FORM 1 - COMPONENT WEIGHTS

Test Plan DPP-1

TU -2

Part Name	Initial Assembly	Post Thermal, Full Disassembly
	Weight (lbs.)	Weight (lbs.)
CV body	181	181
CV lid, screws, washers, and O-rings (together)	72	72
Test fixture weldment, screws, washers, nuts, bushing (together)	48	47
Test weight sets	7	7
PCC pad sets	15	15
CV assembly with test content (during reassembly)	323	323
Drum body	381	379
Drum lid assembly, screws, and washers (together)	103	103
CV base pad and CV flange wedge (together)	5	5
Test unit (TU) assembly	811	810

CV weight before immersion: 323 lb.

## EQUIPMENT

Less than 10 pounds

CV weight after immersion: 323 lb.

10 lbs to 2000 lbs

Scale: \_\_\_\_\_ Expiration Date: \_\_\_\_\_

Scale: x502322 Expiration Date: 2/17/2022

Comments: Test weight sets in the light fixture. little gap at 0° & 180°.  
Test plate did not flush with weldment

I certify that the above tasks have been performed and that the observations and comments are correct.



Testing Technician

12-08-2021

Date

M.B. Houston

Witness

12-08-2021

Date

Ross Whittenburg  
CNS-Y12 STR

12/8/21

Date

Ryan Zuko  
CNS-Y12 QE

12/8/21

Date

# TEST FORM 2 - ASSEMBLY OF THE CV

Test Plan DPP-1

TU -2

RW 9/9/21 ✓  
RF 9/9/21 ✓

## TASK

**HOLD POINT:** All payload components have been visually inspected, and Y-12 deems the shipping package acceptable for disassembly.

Verify and/or mark all components: content assembly, CV assembly, and drum assembly components with the corresponding test unit ID, axial lines, and impact targets symbols. Figure 4-1 - Figure 4-4.

Temperature labels have been affixed to the surface of the CV as shown in Figure 5-1, Figure 5-2.

None of the temperature indicators indicate exposure to a temperature in the measured range.

The CV body, CV lid, washers, and bolts were weighed and recorded in TEST FORM 1

**HOLD POINT:** Y-12 has approved the markings.

The following assembly applies to TUs test fixture weldment content assembly

The surrogate test weight was weighed and recorded on TEST FORM 1 .

The loading test fixture weldment content assembly components were weighed and recorded on TEST FORM 1 .

Clean all surfaces with isopropyl alcohol and air dry

Place the PCC pad (silicone rubber) into CV body.

Place the test weight weldment into the CV body.

Place the PCC pad (silicone rubber) into the CV body on top of the test fixture weldment assembly.

**HOLD POINT:** Y-12 witness torqueing of test fixture fastener hex head screws, washers, top hat bushings, and locknuts. The test weight and bolting locations that establish the low and high CG locations are documented in Attachment A. The hex head screws and locknuts shall be torqued to  $25 \pm 2$  ft-lb.

**HOLD POINT:** Y-12 inspected the assembly of the non-test fixture weldment content assembly and verified weights

M&TE ID #: A001096 Calibration Due Date: 2/10/2022

Comments:

I certify that the above tasks have been performed and that the observations and comments are correct.

[Signature]  
Testing Technician  
Press Whittenburg  
CNS-Y-12 STR

09-09-2021  
Date  
9/9/21  
Date

M.B. Hunter  
Witness  
[Signature]  
CNS-Y-12 QE

09-09-2021  
Date  
9/9/21  
Date



# TEST FORM 2 - ASSEMBLY OF THE CV

Test Plan DPP-1

TU -2

## All packages

☒ The CV O-rings and sealing surfaces have been inspected for defects and found acceptable.

☒ Clean all surfaces with isopropyl alcohol and air dry.

☒ The CV O-rings have been installed onto the CV body.

**Note:** Screws and O-rings shall not be replaced without CNS approval. If replacements are authorized, they shall be documented in the test report where the replacements occurred.

☒ The CV lid was lowered on the CV body and the CV screws shall be hand-tightened until the lid is in full contact with the flange, note that clamps may be used during this step. The CV screws shall be torqued in sequence following the numbers etched into the drum lid in three passes. first pass the screws shall be torqued to 19-21 ft-lb, during the second pass to 33-37 ft-lb, and during the third pass to 33-37 ft-lb. The final pass torque values shall be recorded.

Ambient temperature at closure is \_\_\_\_\_ °C ( 69.6 °F)

Measuring device A006681 Calibration Expiration Date 5/12/2022

Record assembly torque on TEST FORM 11.

Torque wrench # A001096 Calibration Expiration Date 2/10/2022

RW 9/9/21

RF 9/9/21

HOLD POINT: Y-12 inspected the assembly and closure of CV assemblies and verified weights.

The CV assembly has been weighed and the weight has been recorded on TEST FORM 1

The CV assembly has been leak tested (pre-test operational) in accordance with Sect. 7.6 of ANSI N14.5-2014 using the "A.5.2 gas pressure rise" method described in Table A-1 of N14.5-2014 and ORNL procedure NDE 70 Rev. 7, PCMT.

RW 9/23/21


RF 9/23/21

HOLD POINT: Y-12 has reviewed the leak test and the installation of the acceleration sensor mounts.


Photographs of the assembly have been taken\*.

Comments:

I certify that the above tasks have been performed and that the observations and comments are correct.

  
Testing Technician  
Ross Whittenlugin  
CNS-Y-12 STR

09-15-2021  
Date  
9/23/21  
Date

M. B. Hunter  
Witness  
  
CNS-Y-12 QE

09-15-2021  
Date  
9/23/21  
Date

\*All photographs/movies will be uniquely identified with test unit, date and time to ensure that the proper sequence can be reconstructed

# TEST FORM 3 - ASSEMBLY OF TEST PACKAGE

Test Plan DPP-1

TU- 2

VERIFIED	TASK
<u>✓</u>	Verify operational leak test is complete and form completed and tighten the CV lid leak test port plug per the following sequence: 1 <sup>st</sup> pass hand tight, 2 <sup>nd</sup> pass torque to 6-7 ft-lb. Torque wrench # <u>A001320</u> Calibration Expiration Date <u>02-11-2022</u>
<u>✓</u>	The exterior of the drum has been clearly marked "TU- <u>2</u> " and record the drum serial number if applicable:
<u>✓</u>	Verify all exterior markings on the TU. If marks are not legible or inadequate, the TA will remark the TU. Mark the 0°, 90°, 180°, 270° locations on the Drum Lid, and the inner and outside walls of the drum with a permanent marker.
<u>✓</u>	Install temperature labels on the inside of the drum body as shown in Figure 5-3.
<u>✓</u>	Clean all surface of the drum body with isopropyl alcohol and let air dry.
<u>✓</u>	The drum body, drum lid, bolts, washers, pads, were weighed and recorded on TEST FORM 1.
<u>✓</u>	Place the lower CV base pad into the drum body.
<u>✓</u>	Place the CV assembly into the drum body.
<u>✓</u>	The CV assembly has been loaded into the drum with the 0° rotated and aligned with 0° line on the drum. Ensure temperature labels are not damaged.
<u>✓</u>	Place the CV flange wedge between the CV flange and the drum body.
<u>✓</u>	The drum lid has been loaded into the drum with the 0° rotated and aligned with the 0° location on the drum.
<u>N/A</u>	If necessary, apply thread lubricant to the drum closure bolts.
<u>✓</u>	The drum lid has been closed using the same screws that were removed during disassembly. The screws shall be torqued in sequence following the numbers etched into the drum lid in two passes. First, the screws shall be torqued until the lid is in full contact with the flange. Second, the screws shall be torqued to 33-37 ft-lb. .Record the assembled torque value on Test Form 10. <b>TPCR-04</b> Torque wrench #: <u>A001096</u> Calibration Expiration Date: <u>02-10-2022</u>
<u>✓</u>	The test package assembly has been weighed and the weight recorded on Test Form 1.
<u>N/A</u>	Mount one (1) vibration accelerometer on the TU-6 drum lid center for NCT vibration monitoring according to the DPP-1 Accelerometer Mounting Procedure. Remove accelerometer after NCT Test. <b>TPCR-05</b>
<u>✓</u>	The accelerometer mounting blocks and restraint rings have been welded to the drum outer shell as specified in the DPP-1 Accelerometer Mounting Procedure. <b>TPCR-05</b>
<u>✓</u>	Install the accelerometers on TU-1, TU-2, TU-5, and TU-6 at the locations tspecified by the DPP-1 Accelerometer Mounting Procedure". <b>TPCR-05</b>
<u>RW</u> <u>✓</u>	The accelerometers were checked to ensure they were installed and functioning as intended after each installation. <b>HOLD POINT:</b> Y-12 has approval: CNS STR <u>RW 10/11/21</u> , CNS QE <u>RF 10/11/21</u>
<u>✓</u>	Photographs of the assembly have been taken*.

Comments:

I certify that the above tasks have been performed and that the observations and comments are correct.

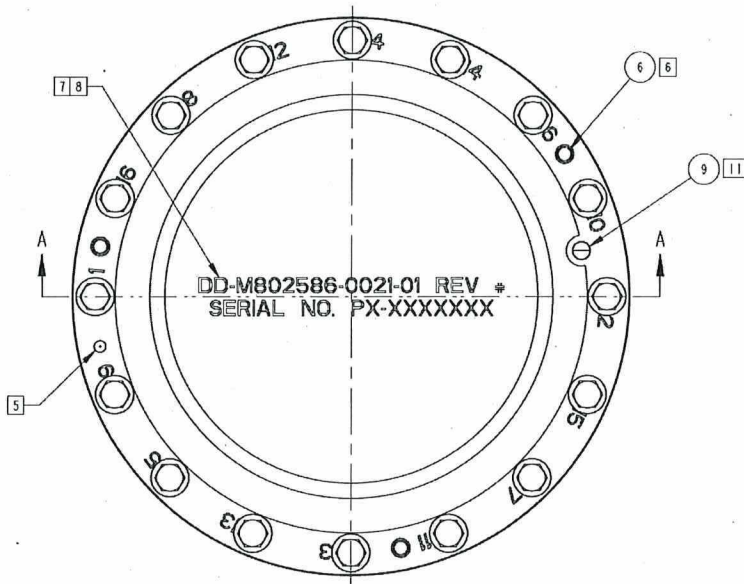
<u>[Signature]</u> Testing Technician	<u>10-11-2021</u> Date	<u>M.B. Hamilton</u> Witness	<u>10-11-2021</u> Date
<u>Ross Whittenberger</u> CNS-Y-12 STR	<u>10/11/21</u> Date	<u>[Signature]</u> CNS-Y-12 QE	<u>10/11/21</u> Date

\*All photographs/movies will be uniquely identified with test unit, date and time to ensure that the proper sequence can be reconstructed.

# TEST FORM 11 –CV LID ASSEMBLY

Test Plan – DPP-1

TU- 2



DPP-1 CV Lid Assembly	
Bolt #	Torque assembly (ft-lbs.)
1	35.2
2	34.7
3	34.6
4	34.6
5	35.9
6	35.4
7	34.7
8	34.9
9	34.8
10	34.8
11	34.4
12	34.8
13	34.8
14	34.9
15	35.2
16	35.2

M&TE ID #: A001096 Calibration Due Date: 2/10/2022

M&TE ID #: A006681 Calibration Due Date: 5/12/2022

Comments:

I certify that the above tasks have been performed and that the observations and comments are correct.

Testing Technician

Ross Whittier  
CNS-Y-12 STR

09-09-2021  
Date

9/9/21  
Date

Witness

M.B. Hunter  
R. Jick  
CNS-Y-12 QE

09-09-2021  
Date

9/9/21  
Date

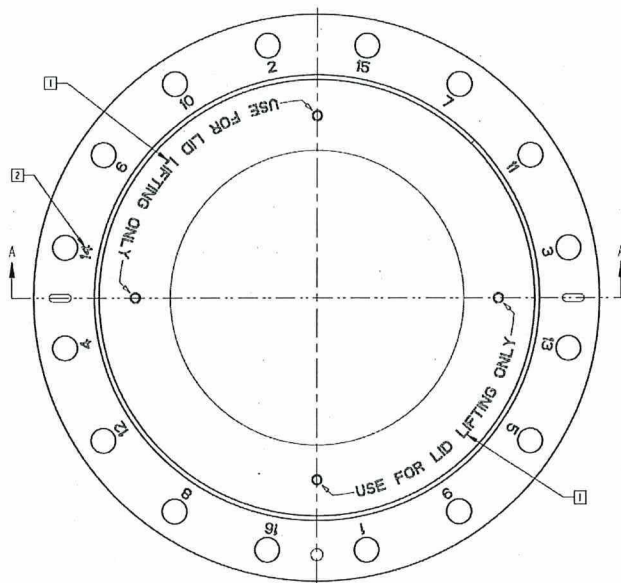
\*All photographs/movies will be uniquely identified with test unit, date and time to ensure that the proper sequence can be reconstructed



# TEST FORM 10 -DRUM LID ASSEMBLY

Test Plan - DPP-1

TU 2



DPP-1 Drum Lid Assembly	
Bolt #	Torque assembly (ft-lbs.)
1	34.7
2	34.6
3	34.8
4	35.5
5	34.4
6	35.4
7	35.9
8	34.9
9	35.3
10	34.9
11	34.9
12	34.6
13	34.9
14	34.6
15	34.8
16	35.5

M&TE ID #: A001096 Calibration Due Date: 2/10/2022

M&TE ID #: N/A Calibration Due Date: N/A

Comments:

I certify that the above tasks have been performed and that the observations and comments are correct.

[Signature]  
Testing Technician  
Ross Whittenburg  
CNS-Y-12 STR

09/16/2021  
Date  
9/16/21  
Date

M.B. Hunter  
Witness  
[Signature]  
CNS-Y-12 QE

09-16-2021  
Date  
9/16/21  
Date

\*All photographs/movies will be uniquely identified with test unit, date and time to ensure that the proper sequence can be reconstructed

# TEST FORM 7 - TEST UNIT DIMENSIONS

Test Plan - DPP-1

TU- 2

Initial Assembly ☒  
Post 1.2-m Drop ☐  
Post 9-m Drop ☐  
Post Crush Test ☐  
Post 1-m Puncture Test ☐

Drum outer shell

MAR 9/13/21

	0°	90°	180°	270°
Height [4"]	43 1/8	43 3/16	43 3/16	43 3/16

43 1/8

DIAMETER	0° to 180°	90° to 270°
Top Surface <u>Ring</u>	26 13/16	26 3/4
Top Rolling hoop	27 15/16	28 1/8
Center Rolling hoop	28	28 1/8
Bottom Rolling hoop	27 15/16	28 1/16
Bottom Surface	27	27 1/16

Location	Flats width @ 0°	Flats width @ 180°
Top Surface	N A	N A
Top Rolling hoop		
Center Rolling hoop		
Bottom Rolling hoop		
Bottom Surface		

Sketch Drop Setup Here

N/A

Sketch Package Damage Here

N/A

M&TE ID #: 1006327 Calibration Due Date: 03/20/2023

M&TE ID #: N/A Calibration Due Date: N/A

Comments: All dimensions above are in inches ["]

I certify that the above tasks have been performed and that the observations and comments are correct.

Testing Technician

Date

Witness

Date

Ross Whittenberger  
CNS-Y-12 STR

09-16-2021  
Date

MB. Hunter  
Ryan Lake  
CNS-Y-12 QE

09-16-2021  
Date

\*All photographs/movies will be uniquely identified with test unit, date and time to ensure that the proper sequence can be reconstructed

<b>ORNL</b> Package Testing Program OAK RIDGE NATIONAL LABORATORY OAK RIDGE, TENNESSEE 37831 <small>The OFFICIAL COPY of this document is the on-line version. Before using a printed copy, verify that it is the most current version by checking the Revision ID against the on-line version</small>	<b>Operating Procedure for NCT Water Spray Test – Testing of Radioactive Material Packages</b>	Test Procedure: <b>PTP-PEF-05</b>	Rev. <b>5-CN 2</b>
		Page: <b>5 / 6</b>	Issue Date: <b>12-14-20</b>
		Revision Date: <b>12-01-20</b>	Review by Date: <b>12-14-20</b>

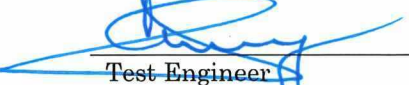
## 6. Procedure Checklist

Test Plan: <b>ORNL/NTRC</b> <b>ORNL/NTRC-092.R0</b> <b>MSH 10-11-21</b>	Test Unit: <b>2</b>
---	---------------------


VERIFIED	TASK
<input checked="" type="checkbox"/>	Water Spray apparatus has been assembled (§4.2).
<input checked="" type="checkbox"/>	Photographer's clipboard with package name and test unit number recorded (§4.2).
<input checked="" type="checkbox"/>	Test Unit placed properly in the water spray zone and spray function verified (§4.3).
<input checked="" type="checkbox"/>	Photograph of the test arrangement taken, documenting test unit identification (§4.3).
<input checked="" type="checkbox"/>	Place the rain gauge upright on the ground adjacent to the test specimen (§4.4).
<input checked="" type="checkbox"/>	Water spray has been started is spraying on the top and 4 sides, with a minimum rate of 2 in/hr (5 cm/hr) (§4.5).
<input checked="" type="checkbox"/>	Date and time of test has been recorded. (§4.5).
<input checked="" type="checkbox"/>	The ambient temperature has been recorded. (§4.6).
<input checked="" type="checkbox"/>	Water spray has been stopped after 1 hour, rain gauge reading has been recorded and any damage noted (§4.6).
<input checked="" type="checkbox"/>	End time of test has been recorded. (§4.6).
<input checked="" type="checkbox"/>	Photographs of the resulting damage (if any) were taken (§4.5).
<input checked="" type="checkbox"/>	Sign and date checklists (§4.7).

Comments:

I certify that the above tasks have been performed and that the observations and comments are correct.

  
 Test Engineer  
 Ross Whitlatch

10-11-2021  
 Date  
 10/11/21

  
 Checked by  
 Ryan Fisher

10-11-2021  
 Date  
 10/11/21



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		Page: 6 / 6	Issue Date: 12-14-20
		Revision Date: 12-01-20	Review by Date: 12-14-20

## 7. Data Sheet

Test Plan: <u>ORNL/NTRC-092 R.O</u>	Test Unit: <u>2.</u>
--	-------------------------

VERIFIED

TASK

- ✓ Start Date and Time of Water Spray Test: 10/11/2021 @ 11:05 am (§4.5)
- ✓ End Date and Time of Water Spray Test: 10/11/2021 @ 12:08 pm (§4.6)
- ✓ Rain Gauge Reading: 2.5 in (§4.6)
- ✓ Ambient temperature: 75.0 °C (75.0 °F) temp: at end : 75.0 °F
- Measuring device: A006681 (§4.6)

Testing Damage Observations:

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

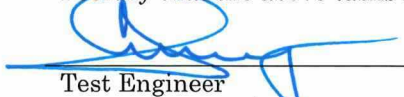
Comments:

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

I certify that the above tasks have been performed and that the observations and comments are correct.

  
 Test Engineer  
Ross Whittenburg

10-11-2021  
 Date  
10/11/21

M.B. Hunter  
 Checked by  


10-11-2021  
 Date  
10/11/21

<b>ORNL</b> PACKAGE TESTING PROGRAM OAK RIDGE NATIONAL LABORATORY OAK RIDGE, TENNESSEE 37831 <small>The OFFICIAL COPY of this document is the on-line version. Before using a printed copy, verify that it is the most current version by checking the Revision ID against the on-line version</small>	Operating Procedure for <b>NCT Free Drop Test - Testing of          Radioactive Material Packages</b>	Test Procedure: <b>PTP-PEF-08</b>	Rev. <b>5 CN2</b>
		Page: <b>7 / 8</b>	Issue Date: <b>12-10-20</b>
		Revision Date: <b>12-01-20</b>	Review by Date: <b>12-10-23</b>

## 6. Procedure Checklist

Test Plan:  
**ORNL/NTRC-092 R.O**

Test Unit:  
**2**

VERIFIED	TASK
<input checked="" type="checkbox"/>	Verify that any equipment used meets the M&TE meets PTP-QA-013 requirements (§4.1).
<input checked="" type="checkbox"/>	Water Spray Test (PTP-PRF-05) has been completed within 2 hours before Drop Test. (§4.4)
<input checked="" type="checkbox"/>	Have a photographer's clipboard with package name and test unit number. (§4.5)
<input checked="" type="checkbox"/>	Attitude of the rigged and raised test unit is set. (§4.6)
<input checked="" type="checkbox"/>	Photograph of the rigging arrangements has been taken. (§4.6)
<input checked="" type="checkbox"/>	Photograph of the measured drop angle has been taken. (§4.6)
<input checked="" type="checkbox"/>	The test unit has been raised to the designated drop height. (§4.7)
<input checked="" type="checkbox"/>	Photograph of the height measurement has been taken. (§4.7)
<input checked="" type="checkbox"/>	Video camera(s) are setup and running to take video of the drop. (§4.8)
<input checked="" type="checkbox"/>	The release mechanism has been plugged into power outlet. (§4.8)
<input checked="" type="checkbox"/>	Countdown, Release the test unit, unplug release mechanism. (§4.8)
<input checked="" type="checkbox"/>	Videos camera stopped. (§4.9)
<input checked="" type="checkbox"/>	Photographs of the resulting damage were taken. (§4.9)
<input checked="" type="checkbox"/>	Ambient temperature recorded. (§4.11)
<input checked="" type="checkbox"/>	Date and time of test recorded. (§4.11)
<input checked="" type="checkbox"/>	Sign and date checklist and data forms (§4.12).

Comments:

I certify that the above tasks have been performed and that the observations and comments are correct.

Test Engineer

*Ross Whittenburg*

**10-11-2021**

Date

**10/11/21**

Checked by

*M. S. Hunter*  
*Peter J. J. J.*

**10-11-2021**

Date

**10/11/21**

<b>ORNL</b> PACKAGE TESTING PROGRAM OAK RIDGE NATIONAL LABORATORY OAK RIDGE, TENNESSEE 37831 <small>The OFFICIAL COPY of this document is the on-line version. Before using a printed copy, verify that it is the most current version by checking the Revision ID against the on-line version</small>	Operating Procedure for NCT Free Drop Test - Testing of Radioactive Material Packages	Test Procedure:	Rev.
		Page:	Issue Date:
		Revision Date:	Review by Date:
		PTP-PEF-08	5 CN2
		8 / 8	12-10-20
		12-01-20	12-10-23

## 7. Data Sheet

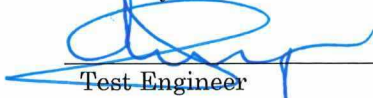
Test Plan: <u>ORNL/NTRC-092 R.O</u>	Test Unit: <u>2</u>
--	------------------------

VERIFIED	TASK
<input checked="" type="checkbox"/>	M&TE ID <u>A000885</u> Calibration due date <u>2/24/2026</u> (§4.1)
<input checked="" type="checkbox"/>	Water Spray Test (PTP-PRF-05) Time completed: <u>12:08 pm</u> <sup>10/11/2021</sup> (§4.4)
<input checked="" type="checkbox"/>	Intended attitude and angle of the test unit <u>0°</u> Tolerance $\pm$ <u>2°</u> (§4.6)
<input checked="" type="checkbox"/>	Attitude Description: <u>horizontal 0° line down</u> (§4.6)
<input checked="" type="checkbox"/>	Measured attitude and angle of the test unit <u>1.4°</u> degrees. (§4.6)
<input checked="" type="checkbox"/>	Level number <u>M212348</u> Calibration Exp. Date <u>2/23/2021</u> (§4.6)
<input checked="" type="checkbox"/>	Height above the drop pad <u>1.2m</u> Measuring device <u>A000885</u> (§4.6)
<input checked="" type="checkbox"/>	Ambient temperature: <u>72.5</u> °C ( <u>72.5</u> °F) Measuring device <u>A0006681</u> <sup>2AM 10/11/21</sup> (§4.11)
<input checked="" type="checkbox"/>	Date and Time of Drop Test: <u>10/11/2021 2:10 pm</u> (§4.11) <u>A006681</u>

Testing Damage Observations: A000885 2/24/2026 A006681 5/12/2022  
A000  
2AM 10/11/21

Comments: Some minor flats on the drum rollers.  
3D scan after test.

I certify that the above tasks have been performed and that the observations and comments are correct.

	<u>10-11-2021</u>	<u>M.B. Hunter</u>	<u>10-11-2021</u>
Test Engineer	Date	Checked by	Date
<u>Ross Whiteley</u>	<u>10/11/21</u>	<u>[Signature]</u>	<u>10/11/21</u>



# TEST FORM 7 –TEST UNIT DIMENSIONS

Test Plan – DPP-1

TU- 2.

Initial Assembly \_\_\_\_\_  
 Post 1.2-m Drop ✓  
 Post 9-m Drop \_\_\_\_\_  
 Post Crush Test \_\_\_\_\_  
 Post 1-m Puncture Test \_\_\_\_\_

## Drum outer shell

	0°	90°	180°	270°
Height	43 1/4	43 1/8	43 1/4	43 3/16

DIAMETER	0° to 180°	90° to 270°
Top Surface	26 9/16	26 3/4
Top Rolling hoop	27 1/2	28
Center Rolling hoop	27 5/8	28 1/16
Bottom Rolling hoop	27 5/8	27 5/16
Bottom Surface	26 15/16	27

Location	Flats width @ 0°	Flats width @ 180°
Top Surface	2.706	N/A
Top Rolling hoop	6.693	N/A
Center Rolling hoop	5.008	N/A
Bottom Rolling hoop	5.01	N/A
Bottom Surface	3.349	N/A

Sketch Drop Setup Here

Sketch Package Damage Here

M&TE ID #: A006327 Calibration Due Date: 3/20/2023

M&TE ID #: A001319 Calibration Due Date: 2/23/2022

Comments: End Drum lid: 1.719 in flat  
Asi idis

I certify that the above tasks have been performed and that the observations and comments are correct.

[Signature]  
 Testing Technician  
Ross Whittenburg  
 CNS-Y-12 STR

10-13-2021  
 Date  
10/12/21  
 Date

M.B. Houston  
 Witness  
[Signature]  
 CNS-Y-12 QE

10-13-2021  
 Date  
10/12/21  
 Date

\*All photographs/movies will be uniquely identified with test unit, date and time to ensure that the proper sequence can be reconstructed

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		Page: <b>6 / 7</b>	Issue Date: <b>02-18-2021</b>
		Revision Date: <b>02-18-2021</b>	Review by Date: <b>02-18-2024</b>

## 6. Procedure Checklist

Test Plan:

**ORNL/NTRC-092 R-0**

Test Unit:

**2**


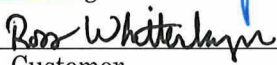
VERIFIED

TASK

- ☒ Verify that any equipment used meets the M&TE meets PTP-QA-013 requirements (§4.1).
- ☒ Have a photographer's clipboard with package name and test unit number. (§4.4)
- ☒ Attitude of the rigged test unit is set. (§4.5)
- ☒ Photograph of the rigging arrangements has been taken. (§4.5)
- ☒ Photograph of the measured drop angle has been taken. (§4.5)
- ☒ The test unit has been raised to the designated drop height. (§4.7)
- ☒ Photograph of the height measurement has been taken. (§4.7)
- ☒ Remove plumb bob from test specimen. (§4.7)
- ☒ Video camera(s) are setup and running to take video of the drop. (§4.8)
- ☒ The release mechanism has been plugged into power outlet. (§4.8)
- ☒ Countdown, Release the test unit, unplug release mechanism. (§4.8)
- ☒ Videos camera stopped. (§4.9)
- ☒ Date and time of test were recorded. (§4.10)
- ☒ The ambient temperature has been recorded. (§4.10)
- ☒ Photographs of the resulting damage were taken. (§4.11)
- ☒ Sign and date checklist and data forms (§4.12).

Comments: **NONE.**

I certify that the above tasks have been performed and that the observations and comments are correct.

  
 Testing Technician  
  
 Customer

**10-22-2021**  
 Date  
**10/22/21**  
 Date

  
 Witness  
  
 Customer

**10-22-2021**  
**10-23-2021**  
 Date **MON 10-22-21**  
**10/22/21**  
 Date

<b>ORNL</b> PACKAGE TESTING PROGRAM OAK RIDGE NATIONAL LABORATORY OAK RIDGE, TENNESSEE 37831 <small>The OFFICIAL COPY of this document is the on-line version. Before using a printed copy, verify that it is the most current version by checking the Revision ID against the on-line version.</small>	Operating Procedure for <b>HAC Drop Test - Testing of          Radioactive Material Packages</b>	Test Procedure: <b>PTP-PEF-10</b>	Rev. <b>6 CN-3</b>
		Page: <b>7 / 7</b>	Issue Date: <b>02-18-2021</b>
		Revision Date: <b>02-18-2021</b>	Review by Date: <b>02-18-2024</b>

## 7. Data Sheet

Test Plan: ORNL/NTRC-092 R.O

Test Unit: 2

VERIFIED

TASK

- ✓ Intended attitude of the test unit 0° Tolerance ± 2° (§4.2)
- ✓ Attitude Description: 3° ft. horizontal, 0° face pad drop. (§4.2)
- ✓ Measured attitude of the test unit 0.5° degrees. (§4.4)
- ✓ Level number M212348 Calibration Exp. Date 2/28/2022 (§4.4)
- ✓ Height above the drop pad A006327 Measuring device 3/20/2023 (§4.6)
- ✓ Date and Time of Drop Test: 10/22/2021 @ 9:16am. (§4.9)
- ✓ Ambient temperature: 54.3°F °C (\_\_\_\_ °F)
- Measuring device A006681 (§4.9) due 5/12/2022

Testing Damage Observations:

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

Comments:

\_\_\_\_\_

\_\_\_\_\_

I certify that the above tasks have been performed and that the observations and comments are correct.

[Signature]  
Testing Technician

10-22-2021

Date

M.B. Hamlin

Witness

10-22-2021

Date

Ross Whittenburg  
Customer

10/22/21  
Date

[Signature]  
Customer

10/22/21  
Date



# TEST FORM 7 - TEST UNIT DIMENSIONS

Test Plan - DPP-1

TU- 2

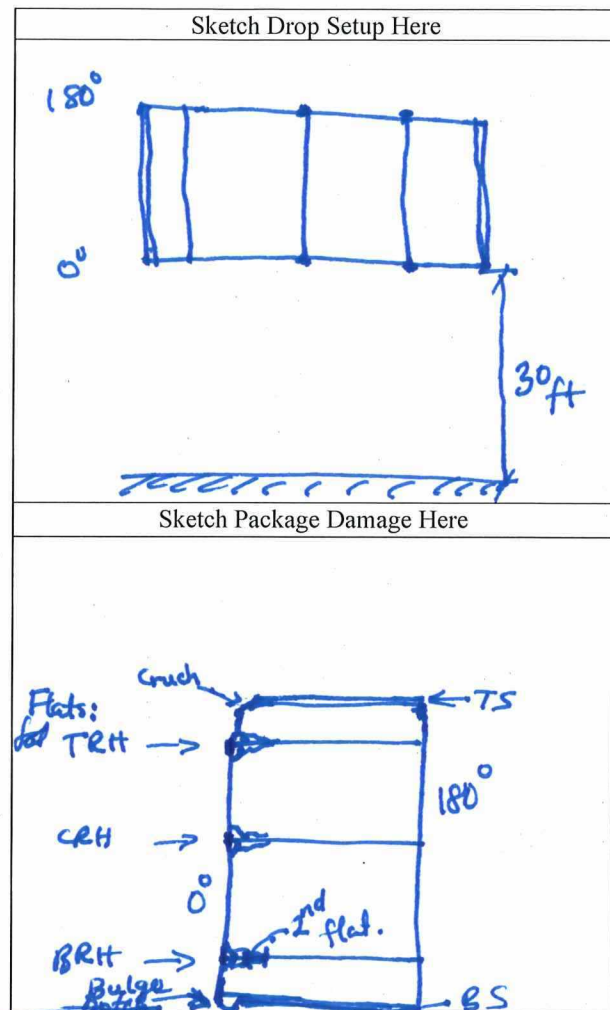
Initial Assembly \_\_\_\_\_  
 Post 1.2-m Drop \_\_\_\_\_  
 Post 9-m Drop ✓ \_\_\_\_\_  
 Post Crush Test \_\_\_\_\_  
 Post 1-m Puncture Test \_\_\_\_\_

## Drum outer shell

	0°	90°	180°	270°
Height	44 <sup>9</sup> / <sub>16</sub>	43 <sup>13</sup> / <sub>16</sub>	42 <sup>15</sup> / <sub>16</sub>	43 <sup>3</sup> / <sub>4</sub>

DIAMETER	0° to 180°	90° to 270°
Top Surface	26 <sup>1</sup> / <sub>4</sub>	26 <sup>7</sup> / <sub>8</sub>
Top Rolling hoop	27	28 <sup>1</sup> / <sub>4</sub>
Center Rolling hoop	26 <sup>11</sup> / <sub>16</sub>	28 <sup>3</sup> / <sub>8</sub>
Bottom Rolling hoop	26 <sup>3</sup> / <sub>8</sub>	28 <sup>3</sup> / <sub>16</sub>
Bottom Surface	25 <sup>5</sup> / <sub>8</sub>	27 <sup>1</sup> / <sub>8</sub>

Location	Flats width @ 0°	Flats width @ 180°
Top Surface	5.711	
Top Rolling hoop	9.783	
Center Rolling hoop	11.460	
Bottom Rolling hoop	12.844	
Bottom Surface	12.261	



M&TE ID #: A006327 Calibration Due Date: 2/20/2023

M&TE ID #: A001319 Calibration Due Date: 2/23/2022

Comments: Bulge @ 0° on bottom surface. 2nd flat on Bottom rolling hoop: 2.34 in

I certify that the above tasks have been performed and that the observations and comments are correct.

10-22-2021  
 Testing Technician Ross Whittenburg Date 10/22/21  
 CNS-Y-12 STR

M.B. Hamilton  
 Witness [Signature] Date 10/22/21  
 CNS-Y-12 QE

10-22-2021  
 Date 10/22/21

\*All photographs/movies will be uniquely identified with test unit, date and time to ensure that the proper sequence can be reconstructed

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		Page: <b>5 / 6</b>	Issue Date: <b>02-18-2021</b>
		Revision Date: <b>02-18-2021</b>	Review by Date: <b>02-18-2024</b>

## 6 Procedure Checklist

Test Plan:

ORNL/NTRC-092 R.6

Test Unit:

2

VERIFIED

TASK

- ☒ Verify that any equipment used meets the M&TE meets PTP-QA-013 requirements (§4.1).
- ☒ Have a photographer's clipboard with package name and test unit number. (§4.4)
- ☒ Attitude of the test unit is set. (§4.5)
- ☒ Photograph of the attitude has been taken. (§4.5)
- ☒ Photograph of the measured angle has been taken. (§4.5)
- ☒ The crush plate has been raised to the designated drop height and located over the target point. (§4.7)
- ☒ Photograph of the set position has been taken. (§4.7)
- ☒ Remove plumb bob from crush plate. (§4.7)
- ☒ Video camera(s) are setup and running to take video of the drop. (§4.8)
- ☒ The release mechanism has been plugged into power outlet. (§4.8)
- ☒ Countdown, Release the crush plate, unplug release mechanism. (§4.8)
- ☒ Videos camera stopped. (§4.9)
- ☒ Date and time of test recorded. (§4.10)
- ☒ The ambient temperature has been recorded. (§4.10)
- ☒ Photographs of the resulting damage were taken. (§4.11)
- ☐ Sign and date checklist and data forms (§4.11).

Comments:

I certify that the above tasks have been performed and that the observations and comments are correct.

Testing Technician

Ross Whittenberger  
Customer

10-22-2021  
Date

10/22/21  
Date

Witness

Phyllis Fisher  
Customer

10-22-2021  
Date

10/22/21  
Date

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		Page: <b>6 / 6</b>	Issue Date: <b>02-18-2021</b>
		Revision Date: <b>02-18-2021</b>	Review by Date: <b>02-18-2024</b>

## 7. Data Sheet

Test Plan:

ORNL/NTRC-092 R.0

Test Unit:

2

VERIFIED

TASK

- ☒ Intended attitude of the test unit 0° Tolerance ± 2° (§4.6)
- ☒ Attitude Description: the 30 ft drop, crush, 0° to pad, 180° to plate. (§4.3)
- ☒ Measured attitude of the test unit 0.9° degrees. (§4.5)
- ☒ Level number M212348 Calibration Exp. Date 2/23/2022 (§4.5)
- ☒ Height above the target: 9-m (30-ft) Measuring device 1006327 due: 3/20/2023 (§4.7)
- ☒ Date and Time of Crush Test: 10/22/2021 @ 1:25pm (§4.10)
- ☒ Ambient temperature: 66.5°F °C ( \_\_\_\_\_ °F)
- Thermometer M&TE ID/Cal. Due Date: A006681 5/12/2022 (§4.10)

Testing Damage Observations:

Plate : 0-180 : 0.4° , 90-270 : 0.3°  
plate C.G. on unit C.G.

Comments:

I certify that the above tasks have been performed and that the observations and comments are correct.

Testing Technician

Prosser W. Hattenbury  
Customer

10-22-2021  
Date

10/22/21  
Date

Witness

M.B. Houston  
[Signature]  
Customer

10-22-2021  
Date

10/22/21  
Date



# TEST FORM 7 –TEST UNIT DIMENSIONS

Test Plan – DPP-1

TU- 2

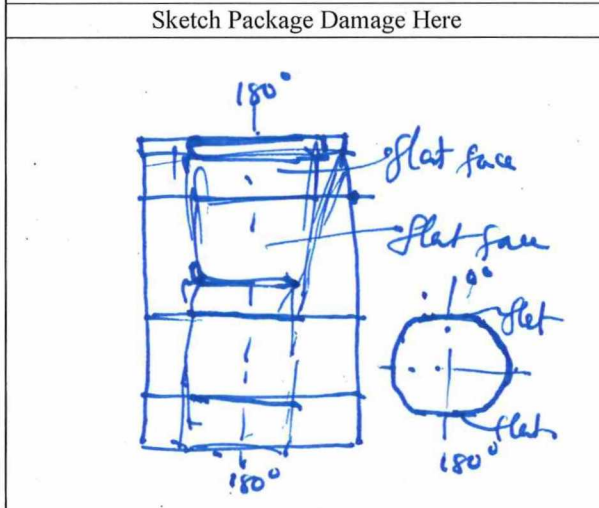
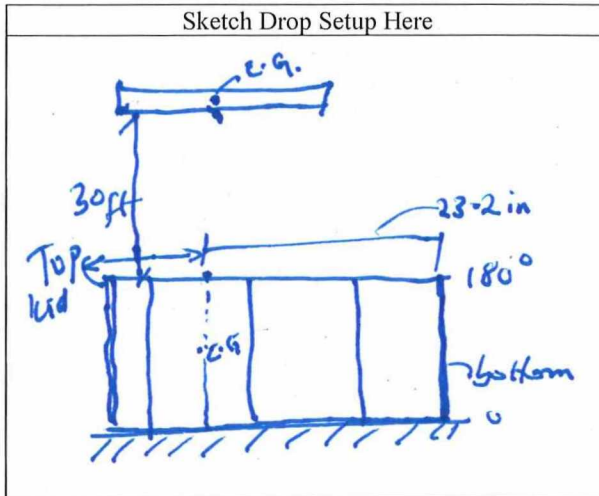
Initial Assembly \_\_\_\_\_  
 Post 1.2-m Drop \_\_\_\_\_  
 Post 9-m Drop \_\_\_\_\_  
 Post Crush Test ✓  
 Post 1-m Puncture Test \_\_\_\_\_

## Drum outer shell

	0°	90°	180°	270°
Height	44 3/4"	43 9/16"	42 3/8"	43 3/8"

DIAMETER	0° to 180°	90° to 270°
Top Surface	25 3/4"	26 13/16"
Top Rolling hoop	25 3/4"	28 1/2"
Center Rolling hoop	24 1/4"	29 5/16"
Bottom Rolling hoop	22"	29 5/16"
Bottom Surface	24 9/16"	27 1/8"

Location	Flats width @ 0°	Flats width @ 180°
Top Surface		5.685
Top Rolling hoop		8.784
Center Rolling hoop		13.539
Bottom Rolling hoop		19 7/8" TAPE MEASURE
Bottom Surface	N/A	N/A



M&TE ID #: \_\_\_\_\_ Calibration Due Date: \_\_\_\_\_

M&TE ID #: \_\_\_\_\_ Calibration Due Date: \_\_\_\_\_

Comments:

I certify that the above tasks have been performed and that the observations and comments are correct.

Testing Technician

Paul W. Hester  
 CNS-Y-12 STR

10-22-2021  
 Date

10/22/21  
 Date

Witness

M.B. Houston  
 CNS-Y-12 QE

10-22-2021  
 Date

10/22/21  
 Date

\*All photographs/movies will be uniquely identified with test unit, date and time to ensure that the proper sequence can be reconstructed

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		Page: <b>6 / 7</b>	Issue Date: <b>12-14-20</b>
		Revision Date: <b>12-01-20</b>	Review by Date: <b>12-14-23</b>

## • Procedure Checklist

Test Plan: <b>ORNL/NTRC-092 R.O</b>	Test Unit: <b>2</b>
--	---------------------

VERIFIED	TASK
<input checked="" type="checkbox"/>	Verify that any equipment used meets the M&TE meets PTP-QA-013 requirements (§4.1).
<input checked="" type="checkbox"/>	Have a photographer's clipboard with package name and test unit number. (§4.4)
<input checked="" type="checkbox"/>	Attitude of the rigged test unit is set. (§4.5)
<input checked="" type="checkbox"/>	Photograph of the rigging arrangements has been taken. (§4.5)
<input checked="" type="checkbox"/>	Photograph of the measured drop angle has been taken. (§4.5)
<input checked="" type="checkbox"/>	The test unit has been raised to the designated drop height. (§4.6)
<input checked="" type="checkbox"/>	Photograph of the height measurement has been taken. (§4.6)
<input checked="" type="checkbox"/>	Video camera(s) are setup and running to take video of the drop. (§4.7)
<input checked="" type="checkbox"/>	The release mechanism has been plugged into power outlet. (§4.7)
<input checked="" type="checkbox"/>	Countdown, Release the test unit, unplug release mechanism. (§4.7)
<input checked="" type="checkbox"/>	Videos camera stopped. (§4.8)
<input checked="" type="checkbox"/>	Date and time of test recorded. (§4.9)
<input checked="" type="checkbox"/>	The ambient temperature has been recorded. (§4.10)
<input checked="" type="checkbox"/>	Photographs of the resulting damage were taken. (§4.11)
<input checked="" type="checkbox"/>	Sign and date checklist and data forms (§4.12).

Comments:

I certify that the above tasks have been performed and that the observations and comments are correct.

Test Engineer

**ROSS WHITTENLAYN**

**10-22-2021**

Date

**10/22/21**

Checked by

**Mya John**

**10-22-2021**

Date

**10/22/21**

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		Page:	Issue Date:
		Revision Date:	Review by Date:
		PTP-PEF-12	5 CN 2
		7 / 7	12-14-20
		12-01-20	12-14-23

## 6. Data Sheet

Test Plan:

ORNL/NTRC-092 R.0

Test Unit:

2

VERIFIED

TASK

- ✓ M&TE ID A001146 Calibration due date 2/24/2026 (§4.1).
- ✓ Intended attitude of the test unit 0° Tolerance ± 2° (§4.5)
- ✓ Measured attitude of the test unit 1.3° degrees. (§4.5)
- ✓ Attitude Description: Horizontal, 0° facing Puncture bar 40 in below (§4.3)
- ✓ Level number M212348 Calibration Exp. Date 2/23/2022 (§4.5)
- ✓ Height above the puncture bar 40 in Measuring device A001146 due 2/24/2026 (§4.6)
- ✓ Date and Time of Drop Test: 10/22/2021 @ 3:25pm (§4.9)
- ✓ Ambient temperature: 63.3°F °C ( \_\_\_\_\_ °F)
- Measuring device A006681 due 5/12/2022 (§4.10)

Testing Damage Observations:

Comments:

I certify that the above tasks have been performed and that the observations and comments are correct.

Test Engineer:

Ross Whittaker

Date

10/22/21

Checked by

M.B. Hunter  
[Signature]

Date

10/22/21



# TEST FORM 7 - TEST UNIT DIMENSIONS

Test Plan - DPP-1

TU- 2

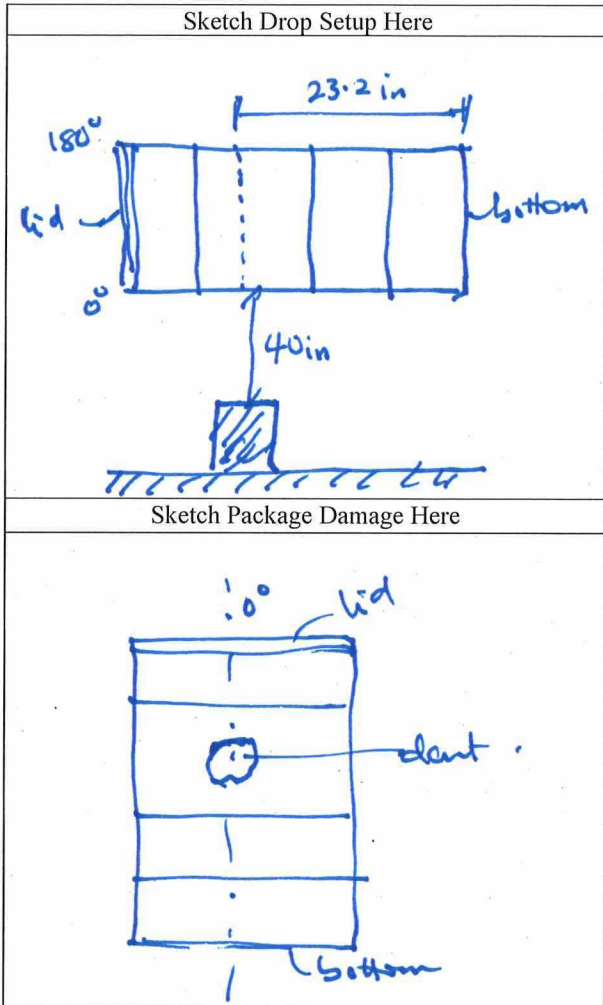
Initial Assembly \_\_\_\_\_  
 Post 1.2-m Drop \_\_\_\_\_  
 Post 9-m Drop \_\_\_\_\_  
 Post Crush Test \_\_\_\_\_  
 Post 1-m Puncture Test ✓

## Drum outer shell

	0°	90°	180°	270°
Height	44 3/4	43 9/16	42 5/16	43 5/8

DIAMETER	0° to 180°	90° to 270°
Top Surface	25 13/16	26 15/16
Top Rolling hoop	25 3/4	28 1/2
Center Rolling hoop	23 13/16	29 1/4
Bottom Rolling hoop	22	29 3/8
Bottom Surface	24 1/2	27 1/6

Location	Flats width @ 0°	Flats width @ 180°
Top Surface		
Top Rolling hoop		
Center Rolling hoop	N A	N A
Bottom Rolling hoop		
Bottom Surface		



M&TE ID #: A006327 Calibration Due Date: 3/20/2023

M&TE ID #: \_\_\_\_\_ Calibration Due Date: \_\_\_\_\_

Comments:

I certify that the above tasks have been performed and that the observations and comments are correct.

[Signature]  
 Testing Technician  
Ross W. Hattenberg  
 CNS-Y-12 STR

10-22-2021  
 Date  
10/22/21  
 Date

M.B. Houston  
 Witness  
[Signature]  
 CNS-Y-12 QE

10-22-2021  
 Date  
10/22/21  
 Date

\*All photographs/movies will be uniquely identified with test unit, date and time to ensure that the proper sequence can be reconstructed

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		Page 10 / 12	Issue Date: 03-10-2021
		Revision Date: 03-10-2021	Review by Date: 03-10-2024

### Attachment 1 - HAC Thermal Test Checklist

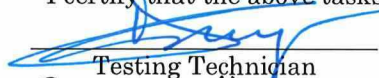
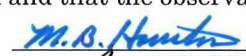

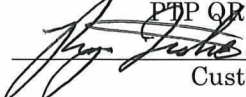
Test Plan: ORNL/NTRC-092 R.O

Test Unit: 2

VERIFIED	TASK
<input checked="" type="checkbox"/>	Ensure test equipment is calibrated, calibration records are acceptable, and that Attachments 1 and 2 records have been initiated prior to testing. Prepare photographers clipboard. (§4.1a, b, c & d)
<input checked="" type="checkbox"/>	Set up the thermal DAQ and test all TC channels with a calibrated heat source. The acceptable range to test the thermocouples is 0°F - 150°F. (§4.2a)
<input checked="" type="checkbox"/>	The thermocouple mounting clip material and installation is acceptable and per customer requirements, test plan, or approved work instruction. (§4.2b)
<input checked="" type="checkbox"/>	TU's have been preheated per customer requirements, test plan or approved work instruction. NOTE: When no customer requirements are given, preheat shall be ~ 66°C (150°F) for a minimum of 24 hours and then soaked at ~ 43°C (110°F) for a minimum of 24 hours. <b>Record pre-heat acceptance on Attachment 2. (§4.2c)</b>
<input checked="" type="checkbox"/>	Unless specified otherwise by the customer requirements, test plan, or approved work instruction, the furnace layout has proved capable of loading tests units within 90 seconds. (§4.3a)
<input checked="" type="checkbox"/>	Floor plate(s) material(s) and test stand(s) are of the approved design and are installed at the location specified by the customer, test plan or approved work instruction. All TCs have been labeled, installed in the furnace, connected to DAQ and tested. The furnace opening can operate without causing damage to thermocouple wires. Photographs have been taken of the furnace set up. (§4.3b, 4.3c-4.3d)
<input checked="" type="checkbox"/>	The furnace pre-heat soak time has been achieved (minimum temperature of 860°C (1580°F) for a minimum of 24 hours) and the DAQ is recording TC temperatures every 15 seconds. If needed, adjust the furnace set point to maintain a constant temperature of 1580°F. (§4.3e)

Comments: \_\_\_\_\_

I certify that the above tasks have been performed and that the observations and comments are correct.

	<u>11-08-2021</u>		<u>11-08-2021</u>
Testing Technician	Date	PTP QR Witness	Date
	<u>11/8/21</u>		<u>11/8/21</u>
Customer	Date	Customer	Date



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		<b>PTP-PEF-13</b>	<b>7 CN-0</b>
		Page 11 / 12	Issue Date: 03-10-2021
		Revision Date: 03-10-2021	Review by Date: 03-10-2024

### Attachment 1 - HAC Thermal Test Checklist (continued)

Test Plan:

ORNL/NTRC-092 R.O

Test Unit:

2

VERIFIED

TASK

- ✓ **Furnace Soak** - A room temperature test specimen, instrumented with thermocouples was placed into the hot furnace. The test unit thermocouples and the furnace thermocouples (including the thermocouple that controls the furnace temperature) were monitored with the cDAQ to ensure the furnace was capable of achieving the requirements specified per the test plan. The test specimen will remain in the furnace for a period specified by customer requirements, test plan, or the approved work instruction. When no requirements are given, the test specimen will remain in the furnace for 30 minutes after 5 of 6 of the thermocouples on the test specimen surface, 2 out of 3 thermocouples on the test stand, and 2 of 3 thermocouples on each furnace wall reach 1475°F. **Record acceptance on Attachment 2. (§4.4.a)**
- ✓ **Test Unit Preparation** – Weld the thermocouple clips to the TU's before starting the preheat. Pre-heat per test plan requirements. Document pre-heat for the test unit on Attachment 2. Upon acceptance of pre-heat requirements for the test specimen, remove the test specimen from the pre-heat chamber and install TCs. Test all thermocouples with a heat source. **(§4.2b & 4.4b)**
- ✓ **Ready to Test** - Open the furnace opening. Load the test specimen on the furnace test stand. Unless specified otherwise by the customer requirements, test plan or work instruction, place the test specimen onto the test stand in a horizontal position with the test specimen lid facing the right furnace sidewall and the 0° line is facing down (facing the furnace floor). **(§4.4.c)**
- ✓ **Beginning the Test** - Loading can begin when the furnace has met the required preheat time. **Record the Test Start Time on Attachment 2.** The 30 minute test shall start when the following conditions have been met.
  - 5 of 6 of the thermocouples on the test specimen surface must reach 1475°F or greater and,
  - 2 out of 3 thermocouples on the test stand must reach 1475°F or greater and,
  - 2 of 3 thermocouples on each furnace wall have reached 1475°F or greater. **(§4.4a)**
- ✓ **Test Completion - Record the Test Stop Time on Attachment 2.** Immediately following the timed test and the thermal requirements are met, immediately remove the test specimen from the furnace and place the specimen in an area where it will not be exposed to artificial cooling. Record notes regarding smoke and/or flames emanating from the test specimen on Attachment 2. **(§4.3c)**
- ✓ All Photographs and/or videos for the entire test setup have been taken. **(§4.3c)**

Comments:

I certify that the above tasks have been performed and that the observations and comments are correct.

Testing Technician

11-08-2021  
Date

PTP OR Witness

11-08-2021  
Date

Ross Whittenburg  
Customer

11/8/21  
Date

Customer

11/8/21  
Date



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		Page	Issue Date:
		Revision Date:	Review by Date:
		<b>PTP-PEF-13</b>	<b>7 CN-0</b>
		12 / 12	03-10-2021
		03-10-2021	03-10-2024

## Attachment 2 - HAC Thermal Test Data Sheet

Test Plan: <u>ORNL/NTRC-092 R.0</u>	Test Unit: <u>2</u>
--	---------------------

VERIFIED

TASK

- ✓ The test unit has been preheated to over 38°C (100°F). (§4.2c)  
 Pre-heat Start date/time: 3:45 am/pm (CT) @ 11/05/2021  
 Pre-heat End date/time: 12:45 am/pm (CT) @ 11/08/2021  
 Final Pre-heat temperature: 2110°F
- ✓ Furnace Soak Time prior to testing - Unless otherwise specified by the customer requirements, test plan or work instructions, preheat the furnace at a temperature of 860°C (1580°F) for a minimum of 24 hours. Record the time/date the soak time began and the time/date the soak time was reached (§ 4.3.e):  
 Time soak time begins: Date/Time: 11/07/2021 @ 6:52pm (CT)  
 Time soak time reached: Date/Time: 11/08/2021 @ 6:52am (CT)
- ✓ The test unit has been placed in the furnace, on the support stand, at: (§4.4d)  
 Furnace door opened time: 1:25pm Furnace door Closed time: 1:26pm  
 Total time taken to open and Close furnace door: ~1min
- ✓ Unless otherwise specified by the customer requirements, test plan or work instructions, the 30-minute timed test starts after 5 out of 6 test unit thermocouples and 15 of 18 furnace thermocouples reach the test temperature of 801°C (1475°F).  
 Enter the Test Start Time: 1:32 am/pm (§4.4e & 4.4f)
- ✓ The test unit was removed from the furnace and allowed to cool naturally. (§4.4f)  
 Enter the Test End Time: 2:03 am/pm
- N/A The test unit stopped outgassing (flames) at \_\_\_\_\_ am/pm (§4.4f)  
 Outgassing/burnout elapsed time was \_\_\_\_\_ minutes. (§4.4f)

Comments: Furnace pre-heat time was 12 hours.

I certify that the above tasks have been performed and that the observations and comments are correct.

<u>[Signature]</u> Testing Technician	<u>11-08-2021</u> Date	<u>M.B. Houston</u> Witness	<u>11-08-2021</u> Date
<u>Ross W. Hollenburger</u> Customer	<u>11/8/21</u> Date	<u>[Signature]</u> Customer	<u>11/8/21</u> Date

# TEST FORM 5 - POST-THERMAL TESTING INSPECTION

Test Plan DPP-1

TU 2

## VERIFIED

## TASK

- ☒ Following the thermal test and after passive cooling, the test package was weighed, and recorded on TEST FORM 1.
- ☒ The drum, drum lid, bolts, and washers have been visually examined to determine the extent of the testing damage. Observations: \_\_\_\_\_
- ☒ The camera(s) are set up to take photographs\* and/or videotape of the damage due to testing.
- ☒ The drum lid has been removed and the condition of the exposed parts have been visually examined for damage and the condition has been recorded. Record the exposed temperature indicator blackout reading on TEST FORM 6. Record the torque values needed to loosen the drum lid weldment screws on TEST FORM 1-18  
Observations: Bolt #4 broken after break-away torque
- ☒ The CV assembly and contents have been removed in the reverse assembly order and visually examined for damage. Record the exposed temperature indicator blackout readings on TEST FORM 6  
Observations: \_\_\_\_\_
- ☒ The CV assembly has been weighed and the weight recorded on TEST FORM 1.
- ☒ Use NDE 70 Rev. 7 for the CV post-test operational leak check and for the full containment boundary leak check and PTP-PEF-14 for the 0.9 m (3 ft). immersion test or PTP-PEF-15 for the 15 m immersion test. The leak test port plug shall be removed for these tests.  
HOLD POINT: Y-12 has approved the CV drying process.
- ☒ After immersion test the CV was dried using the CNS approved process (fans, plant air pressure, mild heat, vacuum suction, etc.) as shown in TEST FORM 12. The flange joint and space between the O-rings was dried by the approved process prior to opening the CV.
- ☒ Disassemble the CV. Record torque value needed to loosen CV screws on TEST FORM 9.
- ☒ If water is present inside the O-rings, stop work, inform CNS, and comment observations below.
- ☒ Read the temperature labels from the CV. Record the temperature indicators' blackout readings on TEST FORM 6
- ☒ The content test fixture weldment assembly was removed from the CV and the weight was recorded on TEST FORM 1.
- ☒ The content test fixture weldment assembly was disassembled in the reverse assembly order.
- ☒ Loaded test fixture weldment content assembly: Remove the contents in the following order, loading test fixture weldment assembly using nylon springs, PCC silicone rubber pad, test weight weldment, lower PCC silicone rubber pad. CV silicone rubber pad.
- ☒ All loose parts will be placed in separate plastic bags, marked with test unit identification, tape closed, and prepared for storage with the test package.
- ☒ Mark and reassemble the test package to the extent possible for shipment.
- ☒ \*Photographs and/or video of the damage resulting from the testing have been taken.

Comments: Little Condensation noticed at the bottom of drum below the CV pad.  
There is buckle on inner liner @ 180°.

I certify that the above tasks have been performed and that the observations and comments are correct.

Testing Technician

Ross Whittenburg  
CNS-Y-12 STR

Date

12/8/21  
Date

Witness

M.B. Hunter  
CNS-Y-12 QE

Date

12/8/21  
Date

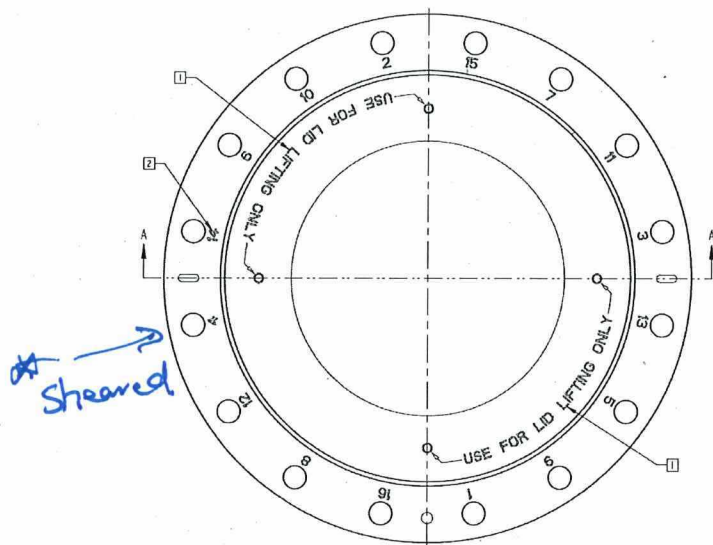
\*All photographs/movies will be uniquely identified with test unit, date and time to ensure that the proper sequence can be reconstructed.



# TEST FORM 8 –DRUM LID DISASSEMBLY

Test Plan – DPP-1

TU- 2



DPP-1 Lid Disassembly	
Bolt #	Torque Removal (ft-lbs.)
1	12.2
2	25.3
3	48.0
4	47.3
5	50.6
6	51.0
7	42.7
8	57.1
9	14.9
10	51.9
11	33.3
12	50.9
13	50.5
14	52.1
15	34.9
16	44.4

M&TE ID #: A061096 Calibration Due Date: 2/10/2022

M&TE ID #: A006681 Calibration Due Date: 5/12/2022

Comments: Ambient temperature 56.0°F

Bolt @ #4 Sheared after break-away torque.

I certify that the above tasks have been performed and that the observations and comments are correct.

Testing Technician

Ross W. Hutterlugh  
CNS-Y-12 STR

11-22-2021

Date

11/23/21

Date

Witness

M.B. Hutterlugh  
Ry. Fols  
CNS-Y-12 QE

11-23-2021

Date

11/23/21

Date

\*All photographs/movies will be uniquely identified with test unit, date and time to ensure that the proper sequence can be reconstructed



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		Page: <b>5 / 6</b>	Issue Date: <b>12-14-20</b>
		Revision Date: <b>1-03-20</b>	Review By Date: <b>12-14-23</b>

## 6. Procedure Checklist

Test Plan:

*ORNL/NTRC-092-0*

Test Unit:

*2*

VERIFIED

TASK

- ☒ Verify that any equipment used meets the M&TE meets PTP-QA-013 requirements (§4.1).
- ☒ Have a photographer's clipboard with package name and test unit number. (§4.3)
- ☒ The test unit has been lowered to the bottom of the tank in designated orientation. (§4.6)
- ☒ The depth to the highest point of the test unit has been measured and is at least 0.9-m (3-ft). (§4.6)
- ☒ Photograph of the depth measurement has been taken. (§4.6)
- ☒ Record the water and ambient temperature. (§4.6)
- ☒ Start date and time has been noted. (§4.7)
- ☒ Test unit has been removed from the tank. (§4.8)
- ☒ End date and time has been noted. (§4.8)
- ☒ Record the water and ambient temperature. (§4.8)
- ☒ Thoroughly dry the test unit and make sure it is completely dry before opening. (§4.9)
- ☒ *MBH 12-08-21*  
Open the test unit and record-breaking torque values during removal, if required. (§4.10)
- ☒ Inspect for water in-leakage or structural damage. (§4.10)
- ☒ Photographs of any resulting damage or lack thereof were taken. (§4.10)
- ☐ Sign and date checklist and data forms (§4.12).

Comments:

I certify that the above tasks have been performed and that the observations and comments are correct.

Test Engineer

*Ross Whitely*

Date

*12/8/21*

Checked by

*M.B. Hornum*  
*Mya Fisher*

Date

*12/8/21*

<b>ORNL</b> PACKAGE TESTING PROGRAM OAK RIDGE NATIONAL LABORATORY OAK RIDGE, TENNESSEE 37831 <small>The OFFICIAL COPY of this document is the on-line version. Before using a printed copy, verify that it is the most current version by checking the Revision ID against the on-line version</small>	Operating Procedure for <b>HAC 0.9 Meter Immersion Test -          Testing of Radioactive Material          Packages</b>	Test Procedure: <b>PTP-PEF-14</b>	Rev. <b>5 CN 2</b>
		Page: <b>6 / 6</b>	Issue Date: <b>12-14-20</b>
		Revision Date: <b>1-03-20</b>	Review By Date: <b>12-14-23</b>

## 7. Data Sheet

Test Plan: <b>ORNL/NTRC-092.0</b>	Test Unit: <b>2</b>
--------------------------------------	------------------------

VERIFIED

TASK

- ☒ M&TE ID **A006327** Calibration due date **3/20/2023** (§4.1).
- ☒ Intended attitude of the test unit in tank (e.g. on side) **on side** (§4.4)
- ☒ Depth of water above the test unit **41 in** Measuring device **A006327 due 3/20/2021** (§4.6)
- ☒ Start Date and Time of Immersion Test: **12/07/2021 @ 3:50pm** (§4.7)
- ☒ Water temperature: **20.5°F** Measuring device **A006681 due 5/12/2022** (§4.6)
- ☒ Ambient temperature: **58.7°F** Measuring device **A006681 due 5/12/2022** (§4.8)
- ☒ End Date and Time of Immersion Test: **12/08/2021 @ 09:15 am** (§4.8)
- ☒ Water temperature: **20.5°F** Measuring device **A006681 due 5/12/2022** (§4.8)
- ☒ Ambient temperature: **60.2°F** Measuring device **A006681 due 5/12/2022** (§4.8)
- ☒ Detected in-leakage of water: (YES/NO) **NO** (§4.10)
- ☒ Detected structural damage: (YES/NO) **NO** (§4.10)

Testing Damage Observations:

Comments:

I certify that the above tasks have been performed and that the observations and comments are correct.

Test Engineer

**Ron Whittaker**

**12-08-2021**

Date

**12/8/21**

**M. B. Hunter**

Checked by

**Ryan Gato**

**12/08/2021**

Date

**12/8/21**

# TEST FORM 12 –CV DRYING PROCEDURE

Test Plan – DPP-1

TU- 2

VERIFIED

TASK

- ☒ ORNL will remove the CV's from the immersion tank after a minimum of 8 hours.
- ☒ The CV's will be placed on the worktable in a vertical position.
- ☒ A shop vac will be used to blow out any water out of the CV flanges.
- ☒ The external surface of the CV will be dried with cloth and paper towels.
- ☒ ORNL will attach a vacuum to the CV flange O-ring port and supply a vacuum to remove most of the water between the inner and outer O-rings.
- ☒ After about 1 hour of air drying under forced hot air convection, an air compressor or compressed air can, or shop air will be used to blow out any water left in between the CV O-rings.
- ☒ The CV bolts will be loosened and removed, and the breakaway torque will be recorded on Test Form 9.
- ☒ The CV top lid will be lifted about a 1/8<sup>th</sup> -in and cloth and paper towels will be used to wipe the surfaces of the internal CV flanges outboard of the outer O-ring.
- ☒ A visual inspection of the internal surface of the CV flange will be done.
- ☒ ORNL and CNS will verify that water droplets are not visible on the inside of the Inner O-ring.
- ☒ After CNS approval, the CV lid will be completely removed from the CV base.

Comments: NONE.

I certify that the above tasks have been performed and that the observations and comments are correct.

Testing Technician

Ross Whittembury  
CNS-Y-12 STR

12/08/2021  
Date

12/8/21  
Date

Witness

M.B. Houston  
[Signature]  
CNS-Y-12 QE

Date

12/8/21  
Date

\*All photographs/movies will be uniquely identified with test unit, date and time to ensure that the proper sequence can be reconstructed

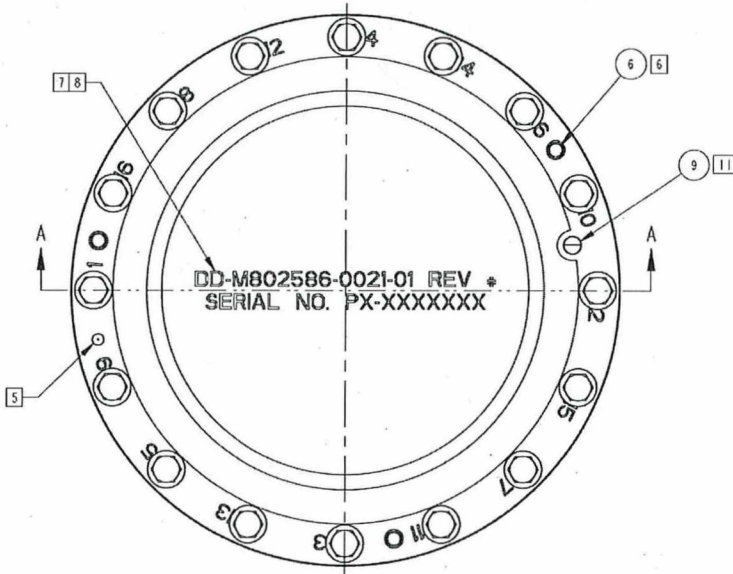


# TEST FORM 9 -CV LID DISASSEMBLY

Test Plan - DPP-1

TU-

2



DPP-1 CV Lid Disassembly	
Bolt #	Torque Removal (ft-lbs.)
1	23.3
2	16.4
3	30.7
4	21.5
5	28.5
6	22.8
7	27.5
8	24.4
9	26.6
10	29.3
11	28.5
12	27.8
13	37.7
14	36.0
15	39.5
16	38.2

M&TE ID #: A001096 Calibration Due Date: 2/10/2022

M&TE ID #: \_\_\_\_\_ Calibration Due Date: \_\_\_\_\_

Comments: No condensation on the inside of the CV. No water inside of the inner O-Ring.  
Lid opened @ 11:15am  
Indentation on CV flange from eye-bolts.

I certify that the above tasks have been performed and that the observations and comments are correct.

[Signature]  
 Testing Technician  
Ross W. Miller  
 CNS-Y-12 STR

12-08-2021  
 Date  
12/8/21  
 Date

M.D. Hunter  
 Witness  
[Signature]  
 CNS-Y-12 QE

12/08/2021  
 Date  
12/8/21  
 Date

\*All photographs/movies will be uniquely identified with test unit, date and time to ensure that the proper sequence can be reconstructed

# TEST FORM 6 - TEMPERATURE INDICATOR READINGS

Test Plan DPP-1

TU 2

A visual inspection of each temperature indicator on the package consisting of those indicators inside the CV, outside the CV, and on the drum-liner will be made. The values of the blackouts that occurred will be recorded below.

TEMPERATURE INDICATOR NUMBER LOCATION CHART				
TEST CONTENT ASSEMBLY (TL-10-105, TL-10-190)				
Location (outside)	0°	90°	180°	270°
Top end cap center	1 210 °F	2 210 °F	3 210 °F	4 210 °F
Top end cap under flange	5 210 °F	6 210 °F	7 210 °F	8 210 °F
Tube upper	9 210 °F	10 210 °F	11 210 °F	12 210 °F
Tube middle	13 210 °F	14 210 °F	15 210 °F	16 210 °F
Tube lower	17 210 °F	18 210 °F	19 210 °F	20 210 °F
Bottom end cap under flange	21 200 °F	22 200 °F	23 200 °F	24 200 °F
Bottom end cap center	25 200 °F	26 200 °F	27 200 °F	28 200 °F
Weight upper	29 210 °F	30 210 °F	31 210 °F	32 210 °F
Weight lower	33 210 °F	34 210 °F	35 210 °F	36 210 °F
INTERIOR OF THE CV (TL-10-105, TL-10-190)				
CV lid center	37 220 °F	38 220 °F	39 220 °F	40 220 °F
CV body flange	41 210 °F	42 210 °F	43 210 °F	44 210 °F
CV wall upper	45 210 °F	46 210 °F	47 210 °F	48 210 °F
CV wall middle	49 210 °F	50 210 °F	51 210 °F	52 210 °F
CV wall lower	53 210 °F	54 210 °F	55 210 °F	56 210 °F
CV base neck	57 200 °F	58 200 °F	59 210 °F	60 200 °F
CV base center	61 200 °F	62 200 °F	63 200 °F	64 210 °F
EXTERIOR OF THE CV (TL-10-105, TL-10-190)				
Lid center	65 230 °F	66 230 °F	67 230 °F	68 230 °F
Lid flange	69 230 °F	70 230 °F	71 230 °F	72 230 °F
Body flange	73 230 °F	74 230 °F	75 230 °F	76 230 °F
Base neck	77 220 °F	78 210 °F	79 210 °F	80 210 °F
Base toe	81 220 °F	82 210 °F	83 210 °F	84 210 °F
DRUM ASSEMBLY (TL-10-190, TL-10-290)				
Lid bottom	85 230 °F	86 230 °F	87 230 °F	88 230 °F
Cavity wall upper	89 230 °F	90 240 °F	91 240 °F	92 250 °F
Cavity wall middle	93 230 °F	94 240 °F	95 250 °F	96 250 °F
Cavity wall lower	97 240 °F	98 230 °F	99 250 °F	100 250 °F
Cavity wall lowest	101 Damaged °F	102 230 °F	103 Damaged °F	104 220 °F
Cavity bottom	105 230 °F	106 220 °F	107 220 °F	108 220 °F

Comments: NONE.

I certify that the above tasks have been performed and that the observations and comments are correct.

Testing Technician

Ron Whittenburg  
CNS-Y-12 STR

Date 12-08-21

12/8/21  
Date

Witness

M. B. Hunter  
CNS-Y-12 QE

Date

12/8/21  
Date

\*All photographs/movies will be uniquely identified with test unit, date and time to ensure that the proper sequence can be reconstructed



# TEST FORM 15 -WITNESS AND HOLD POINTS

Test Plan DPP-1

TU 2

The following applicable CNS hold points activities shall not start until written approval to proceed has been given from the CNS STR via e-mail. Additional hold points may be included when CNS reviews the approval data documents and as the work is being performed. The purpose of each hold point is to give the TA, STR, and QE an opportunity to (1) evaluate what has happened since the previous hold point, (2) evaluate previous lessons learned on the activities that follow, and (3) make an informed decision to proceed.

NO.	DESCRIPTION	TU NO.	TYPE	CNS INITIAL
1	<u>Initial package disassembly</u> Witness the disassembly, can be waived by a DA representative	1,2,3,4,5,6, 7	Witness, Hold	RW RF
2	<u>pre-test operational leakage rate test</u> Witness the pre-test operational leakage rate test per ANSI N14.5, section 7.6, after final closure (and before commencing testing sequence)	1,2,3,4,5,6, 7	Witness, Hold	
2.1	<u>pre-test operational leakage rate test acceptance</u> Inspection to verify the pre-test operational leakage rate test has met acceptance criteria <b>Subsequent reassembly sequence shall not commence until acceptable result is produced.</b>	1,2,3,4,5,6, 7	Hold	
3	<u>Initial package reassembly</u> Witness the reassembly of the contents, CV, vibration pads, drum lid, instrumentation, and all associated fastening hardware	1,2,3,4,5,6, 7	Witness	
3.1	<u>Initial Package Reassembly</u> Inspection and observation to verify the reassembly procedure has been followed according to supplied direction. <b>Subsequent testing sequence shall not commence until reassembly steps have been confirmed as acceptable.</b>	1,2,3,4,5,6, 7	Hold	
4	<u>NCT vibration/shock test</u> Witness the NCT vibration/shock testing activities, including all preliminary setup, can be waived by a DA representative	6	Witness	
5	<u>NCT thermal pre-treatment</u> Witness the NCT thermal pre-treatment activities, including all preliminary setup, can be waived by a DA representative	1,2,3,4,5,6	Witness	
6	<u>NCT water spray test</u> Witness the NCT water spray test activities, including all preliminary setup, can be waived by a DA representative	2,3,4,6	Witness, Hold	
7	<u>NCT free drop (4 ft) test</u> Witness the NCT free drop (4 ft) test activities, including all preliminary setup, can be waived by a DA representative	1,2,3,4,5,6	Witness	
7.1	<u>NCT free drop (4 ft) test, critical parameters</u> Inspection to verify the critical parameters defining the NCT free drop (4 ft) test meet all requirements <b>Completion of NCT free drop (4 ft) test shall not commence until all critical parameters have been verified.</b>	1,2,3,4,5,6	Hold	



13	<u>HAC Puncture drop (40 in.) test</u> Witness the HAC Puncture drop (40 in.) test activities, including all preliminary setup, can be waived by a DA representative	1,2,3,4,5,6	Witness	RW RF
13.1	<u>HAC Puncture drop (40 in.) test, critical parameters</u> Inspection to verify the critical parameters defining the HAC Puncture drop (40 in.) test meet all requirements  <b>Completion of HAC Puncture drop (40 in.) test shall not commence until all critical parameters have been verified.</b>	1,2,3,4,5,6	Hold	
NO.	DESCRIPTION	TU NO.	TYPE	CNS INITIAL
14	<u>Thermal test, data collection hardware</u> Inspection to verify that all the thermocouple and hardware has been installed, or configured as specified and is operating correctly  <b>Completion of supplementary thermal test shall not commence until hardware installation has been verified.</b>	1,2,3,4,5,6	Hold	RF
15	<u>HAC thermal test</u> Witness the HAC thermal test activities, including all preliminary setup, can be waived by a DA representative	1,2,3,4,5,6	Witness	
15	<u>Overpack Inspection and Disassembly</u> Witness the overpack inspection and disassembly process. including all preliminary setup, can be waived by a DA representative	1,2,3,4,5,6	Witness	
16	<u>Overpack Inspection and Disassembly</u> Inspection to verify that sufficient data and measurements have been collected from overpack and CV prior to drilling and tapping the CV lid for post-test leakage rate measurements  <b>Post-test leakage rate activities, including all preliminary setup, shall not commence until hardware installation has been verified.</b>	1,2,3,4,5,6	Hold	
17	<u>post-test operational leakage rate test</u> Witness the post-test operational leakage rate test per ANSI N14.5, section 7.6, after completion of test activities (and before post-test full-boundary leakage rate test)	1,2,3,4,5,6	Witness	
18	<u>post-test full-boundary leakage rate test, drilling and tapping test port in CV lid</u> Witness the drilling and tapping of the leakage rate test port in the CV lid, after removal from the overpack assembly (and before completion of testing sequence)	1,2,3,4,5,6	Witness	
19	<u>post-test full-boundary leakage rate test</u> Witness the post-test full-boundary leakage rate test per ANSI N14.5, Section 7.5. This includes the sealing of the drilled and tapped hole in the CV lid after the leakage rate measurements have completed	1,2,3,4,5,6	Witness	
19.1	<u>Final containment vessel leakage rate test acceptance</u> Inspection to verify the "post-test" leakage rate test has met acceptance criteria  <b>HAC immersion tests shall not commence until results are confirmed.</b>	1,2,3,4,5,6	Hold	

8	<u>NCT penetration test</u>	6	Witness	RW	RF
	Witness the NCT penetration test activities, including all preliminary setup, can be waived by a DA representative				
8.1	<u>NCT penetration test, critical parameters</u>	6	Hold		
	Inspection to verify the critical parameters defining the NCT penetration test meet all requirements				
	<b>Completion of NCT penetration test shall not commence until all critical parameters have been verified.</b>				
9	<u>NCT compression test</u>	6	Witness		
	Witness the NCT compression test activities, including all preliminary setup, can be waived by a DA representative				
9.1	<u>NCT compression test, critical parameters</u>	6	Hold		
	Inspection to verify the critical parameters defining the NCT compression test meet all requirements				
	<b>Completion of NCT compression test shall not commence until all critical parameters have been verified.</b>				
10	<u>HAC thermal pre-treatment</u>	1,5	Witness		
	Witness the HAC thermal pre-treatment activities, including all preliminary setup, can be waived by a DA representative				
11	<u>HAC free drop (30 ft) test</u>	1,2,3,4,5,6	Witness		
	Witness the HAC free drop (30 ft) test activities, including all preliminary setup, can be waived by a DA representative				
11.1	<u>HAC free drop (30 ft) test, critical parameters</u>	1,2,3,4,5,6	Hold		
	Inspection to verify the critical parameters defining the HAC free drop (30 ft) test meet all requirements				
	<b>Completion of HAC free drop (30 ft) test shall not commence until all critical parameters have been verified.</b>				
11.2	<u>HAC free drop (30 ft) test, damage determination</u>	1,2,3,4,5,6	Hold		
	Inspection to verify that the damage inflicted during the HAC free drop (30 ft) test is as expected, if unexpected damage is present, modifications to the subsequent HAC Crush (30 ft) test will be defined				
	<b>Testing shall not commence until new specification of HAC Crush (30 ft) test has been agreed-upon and adopted by the TA.</b>				
12	<u>HAC crush (30 ft) test</u>	1,2,3,4,5,6	Witness		
	Witness the HAC crush (30 ft) test activities, including all preliminary setup, can be waived by a DA representative				
12.1	<u>HAC crush (30 ft) test, critical parameters</u>	1,2,3,4,5,6	Hold		
	Inspection to verify the critical parameters defining the HAC crush (30 ft) test meet all requirements				
	<b>Completion of HAC crush (30 ft) test shall not commence until all critical parameters have been verified.</b>				
12.2	<u>HAC crush (30 ft) test, damage determination</u>	1,2,3,4,5,6	Hold		
	Inspection to verify that the damage inflicted during the HAC crush (30 ft) test is as expected, if unexpected damage is present, modifications to the subsequent HAC Puncture drop (40 in.) test will be defined				
	<b>Testing shall not commence until new specification of HAC Puncture drop (40 in.) test has been agreed-upon and adopted by the TA.</b>				

20	<u>HAC immersion test, fissile material packages</u> Witness the HAC immersion test, fissile material packages, activities, including preliminary setup, can be waived by a DA representative	1,2,3,4,5,6	Witness	RW RF
21	<u>HAC immersion test, all packages (undamaged)</u> Witness the HAC immersion test, all packages (undamaged), activities, including preliminary setup, can be waived by a DA representative	7	Witness	
22	<u>Opening containment vessel after HAC immersion test</u> Witness the opening of the containment vessel and inspection for 7 retained moisture within the containment vessel cavity, including preliminary setup and verification that the external surface is complete dry, can be waived by a DA representative	1,2,3,4,5,6, 7	Witness	
NO.	DESCRIPTION	TU NO.	TYPE	CNS INITIAL
23	<u>Final external inspection results</u> Inspection of all external inspection results, to verify all specified dimensional and photographic records have been obtained, these records cannot be confirmed after the overpack assembly has been cut-open and so must be confirmed at this point  <b>Disassembly and cross section examination shall not commence until all external inspections have been completed and all necessary records have been collected. (if required)</b>	1,2,3,4,5,6, 7	Hold	RF
24	<u>Disassembly and cross section inspection</u> Witness the cutting, disassembly, and dissection of the overpack assembly (if required)	1,2,3,4,5,6, 7	Witness	
25	<u>Final cross section inspection results (if required)</u> Inspection of all cross-section inspection results, to verify all specified dimensional and photographic records have been obtained  <b>Completion of final data report shall not commence until all cross-section inspections have been completed and all necessary records have been collected. (if required)</b>	1,2,3,4,5,6, 7	Hold	
26	<u>Preliminary data package</u> Inspection of all preliminary test results, including data collected, photos and videos captured, and dimensions measured  <b>Shipment or disposal (as defined by the DA) of TU shall not commence until the preliminary data package has been reviewed and determined to be complete.</b>	1,2,3,4,5,6, 7	Hold	

Comments:

I certify that the above tasks have been performed and that the observations and comments are correct.

Testing Technician

CNS-Y-12 STR

12/13/2021  
Date

12/13/21  
Date

Witness

CNS-Y-12 QE

12/13/2021  
Date

12/13/21  
Date

\*All photographs/movies will be uniquely identified with test unit, date and time to ensure that the proper sequence can be reconstructed



# TEST FORM 16 -PHOTOGRAPHY/VIDEO CHECKLIST

Test Plan DPP-1

CTU

2

At a minimum, the following events shall be captured by photography. If necessary, photos shall be taken from multiple perspectives to provide a clear understanding of the event being captured. Date and time will be stamped on all photographs.

VERIFIED

TASK

✓	Overpack assembly, containment vessel, and vibration pads after taking delivery and during disassembly
✓	Overpack assembly, containment vessel, and vibration pads (where applicable) during reassembly
✓	Drop testing pad, including appropriate dimensional references
✓	Puncture bar installed onto drop pad, including appropriate dimensional reference
✓	Penetration bar, including appropriate dimensional references
✓	Equipment, instrumentation, and general arrangement used for vibration/shock tests
✓	Equipment, instrumentation, and general arrangement used for free and Puncture drop tests
✓	Equipment, instrumentation, and general arrangement used for water spray tests
✓	Pre-test leakage rate tests: — Close-up views of CV before test, showing connection for CV lid leakage rate test port — Close-up views of CV during test, showing connections made to CV lid leakage rate test port — Test arrangement with CV during test, showing all connections made to CV
✓	NCT vibration/shock tests: — Test arrangement with the package installed onto the expander head or slip table — Attachment of tie-down chains or straps to top of package — Attachment of tie-down chains or straps to expander head or slip table
✓	NCT water spray tests: — Test arrangement with package before test, showing relative placement of water spray nozzles with respect to the package — Test arrangement with package during test, showing how the water is hitting the package — Test arrangement with package after test, showing evidence of water pooling or accumulation, if any — Rain gauge showing minimum allowable rainfall has been reached
✓	NCT free drop (4 ft) tests: — Test arrangement with package before test, showing the intended offset angle — Test arrangement with package before test, showing the intended drop height — Test arrangement with package after test, showing damaged package at final resting place — Close-up views of package after test, showing particular damage induced as a result of the NCT free drop (4 ft) test, including appropriate dimensional references
✓	NCT penetration tests: — Close-up views of package before test, showing intended point of impact — Test arrangement with package before test, showing supports and restraints that hold the package in place — Test arrangement with package before test, showing position and height of penetration bar, with respect to the package — Test arrangement with package after test, showing damaged package after penetration bar has made impact — Close-up views of package after test, showing particular damage induced as a result of the NCT penetration test, including appropriate dimensional references
✓	NCT compression tests: — If a compression tester machine is being used <ul style="list-style-type: none"> <li>• The relative arrangement of the package within the machine</li> <li>• The force read-out as indicated by the machine control system</li> </ul> — Test arrangement with package during test, showing weight having been applied to the package — Test arrangement with package after test, showing damaged package after weight has been removed (if any)

✓	<ul style="list-style-type: none"> <li>—Close-up views of package after test, showing any particular damage induced as a result of the NCT compression test, including evidence of bulging/buckling of the drum, bending/buckling of the drum bolt guard, and crushing/buckling of the fork pockets</li> </ul>
✓	<p>HAC free drop (30 ft) tests: (check as performed)</p> <ul style="list-style-type: none"> <li>— Close-up views of package before test, showing intended point of initial impact</li> <li>— Test arrangement with package before test, showing the intended offset angle</li> <li>— Test arrangement with package before test, showing the intended drop height</li> <li>— Test arrangement with package after test, showing damaged package at final resting place</li> <li>— Close-up views of package after test, showing particular damage induced as a result of the HAC free drop (30 ft) test, including appropriate dimensional references</li> <li>— Close-up views of package after test, showing unexpected damage (if any), due to primary impact or any subsequent event</li> </ul>
✓	<p>HAC crush (30 ft) tests: (check as performed)</p> <ul style="list-style-type: none"> <li>— Close-up views of package before test, showing intended point of initial impact</li> <li>— Test arrangement with package before test, showing the intended offset angle</li> <li>— Test arrangement with package before test, showing the intended drop height</li> <li>— Test arrangement with package after test, showing damaged package at final resting place</li> <li>— Close-up views of package after test, showing particular damage induced as a result of the HAC crush (30 ft) test, including appropriate dimensional references</li> <li>— Close-up views of package after test, showing unexpected damage (if any), due to primary impact or any subsequent event</li> </ul>
✓	<p>HAC Puncture drop (40 in.) tests:</p> <ul style="list-style-type: none"> <li>—Close-up views of package before test, showing intended point of initial impact</li> <li>—Test arrangement with package before test, showing the intended offset angle</li> <li>—Test arrangement with package before test, showing the intended drop height</li> <li>—Test arrangement with package after test, showing damaged package at final resting place</li> <li>—Close-up views of package after test, showing particular damage induced as a result of the HAC puncture (1 m (40 in)) test, including appropriate dimensional references</li> <li>—Close-up views of package after test, showing unexpected damage (if any), due to primary impact or any subsequent event</li> </ul>
✓	<p>Supplementary and HAC thermal tests:</p> <ul style="list-style-type: none"> <li>—Views of relative spacing inside the furnace with door/trap open, with or without the package used as a dimensional point of reference, at hot or cold condition</li> <li>—Test arrangement with package before test, showing placement of thermocouple attachments on the package exterior surface</li> <li>—Test arrangement with package after test, showing damaged/burned package after initial removal from the furnace/fire</li> <li>—Close-up views of package after test, showing any excessively damaged/burned parts (if any)</li> </ul>
✓	<p>HAC immersion-fissile material tests:</p> <ul style="list-style-type: none"> <li>— Test arrangement with CV before test, showing placement of the CV within the tank</li> <li>— Test arrangement with CV during test, showing measurement of submerged depth of CV below water line</li> <li>— Close-up views of CV after test, after removal of the CV lid, showing evidence of water ingress (if any)</li> </ul>
✓	<p>HAC immersion- 10CFR71(c)(6) package tests</p> <ul style="list-style-type: none"> <li>— Test arrangement with CV before test, showing placement of the CV within the tank or hydraulic pressure chamber</li> <li>— Test arrangement with CV during test, showing measurement of submerged depth of CV below water line (or, if a hydraulic pressure chamber is being used, the internal pressure read-out as indicated by the hydraulic control system or in-line pressure gauge)</li> <li>— Close-up views of CV after test, after removal of the CV lid, showing evidence of water ingress (if any)</li> </ul>



✓	<p>Post-test leakage rate tests:</p> <ul style="list-style-type: none"> <li>– Close-up views of CV before test, showing drilled/tapped connection for CV lid leakage rate test port</li> <li>– Close-up views of CV during test, showing connections made to CV lid leakage rate test port</li> <li>– Test arrangement with CV during test, showing all connections made to CV</li> </ul>
✓	<p>Initial teardown and inspection:</p> <ul style="list-style-type: none"> <li>– Close-up views of CV after removal from overpack assembly, showing any superficial and structural damage due to interaction with overpack assembly during test sequence (if any), including appropriate dimensional references ( cursory examination only)</li> <li>– Close-up views of all thermal temperature indicators, showing temperatures indicated and evidence of stretching/tearing (if any), including appropriate dimensional references</li> <li>– Close-up views of overpack assembly after removal of CV, showing any superficial and structural damage due to interaction with CV or drum lid during test sequence (if any), including appropriate dimensional references</li> <li>– Close-up views of drum lid after removal from overpack assembly, showing any superficial and structural damage due to interaction with the CV or overpack assembly, including appropriate dimensional references</li> </ul>
✓	<p>Final teardown and inspection:</p> <ul style="list-style-type: none"> <li>– Close-up views of the CV, showing superficial and structural damage to ANY component, internal and external surfaces (if any), including appropriate dimensional references (detailed examination)</li> <li>– Close-up views of components within the CV, showing superficial and structural damage to ANY component, internal and external surfaces (if any), including appropriate dimensional references (detailed examination)</li> <li>– Markings on the surfaces of the overpack assembly and drum lid, showing the intended cross section cuts, including appropriate dimensional references (if requires)</li> <li>– Overall views of overpack assembly and drum lid after cross section cuts have been made (if required)</li> <li>– Close-up views of overpack assembly and drum lid after cross section cuts have been made, showing damage to internal components, including the following: (if required) <ul style="list-style-type: none"> <li>• Extent of burned/charred or disintegrated impact-limiting foam</li> <li>• Extent of disintegration, cracking, or separation of impact-limiting block</li> <li>• Extent of damage to thermal insulating blanket and indication of total radial thickness</li> <li>• Relative dimensional changes of structural components (including but not limited to drum liner assembly, perforated ring, drum lid inner section)</li> <li>• Any cracked welds</li> <li>• Any scratched, dented, or stretched sheet metal</li> </ul> </li> </ul>

Comments:

I certify that the above tasks have been performed and that the observations and comments are correct.

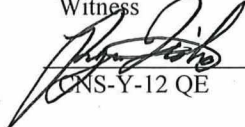
  
Testing Technician

  
CNS-Y-12 STR

12/13/2021  
Date

12/13/21  
Date

  
Witness

  
CNS-Y-12 QE

12/13/2021  
Date

12/13/21  
Date

\*All photographs/movies will be uniquely identified with test unit, date and time to ensure that the proper sequence can be reconstructed



## **J. APPENDIX TU-3 FORMS**

# TEST FORM 1 - COMPONENT WEIGHTS

Test Plan DPP-1

TU -3

Part Name	Initial Assembly	Post Thermal, Full Disassembly
	Weight (lbs.)	Weight (lbs.)
CV body	181	181
CV lid, screws, washers, and O-rings (together)	73	73
Test fixture weldment, screws, washers, nuts, bushing (together)	48 49 9/7/21	48
Test weight sets	66	66
PCC pad sets	15	15
CV assembly with test content (during reassembly)	384	384
Drum body	382	380
Drum lid assembly, screws, and washers (together)	103	103
CV base pad and CV flange wedge (together)	5	5
Test unit (TU) assembly	873	871

## EQUIPMENT

Less than 10 pounds

CV weight before immersion: 384 lb.  
CV weight after immersion: 384 lb.

10 lbs to 2000 lbs

Scale: N/A

Expiration Date: N/A

Scale: X502322

Expiration Date: 2/17/2022

Comments:

I certify that the above tasks have been performed and that the observations and comments are correct.

Testing Technician

12-08-2021

Date

Witness

12-08-2021

Date

Ross Whittenburg  
CNS-Y12 STR

12/8/21

Date

Ryan Jones  
CNS-Y12 QE

12/8/21

Date

# TEST FORM 2 - ASSEMBLY OF THE CV

Test Plan DPP-1

TU -3

## TASK

VERIFIED

RW 9/9/21  
RF 9/9/21

**HOLD POINT:** All payload components have been visually inspected, and Y-12 deems the shipping package acceptable for disassembly.

Verify and/or mark all components: content assembly, CV assembly, and drum assembly components with the corresponding test unit ID, axial lines, and impact targets symbols. Figure 4-1 - Figure 4-4.

Temperature labels have been affixed to the surface of the CV as shown in Figure 5-1, Figure 5-2.

None of the temperature indicators indicate exposure to a temperature in the measured range.

The CV body, CV lid, washers, and bolts were weighed and recorded in TEST FORM 1

**HOLD POINT:** Y-12 has approved the markings.

The following assembly applies to TUs test fixture weldment content assembly

The surrogate test weight was weighed and recorded on TEST FORM 1 .

The loading test fixture weldment content assembly components were weighed and recorded on TEST FORM 1 .

Clean all surfaces with isopropyl alcohol and air dry

Place the PCC pad (silicone rubber) into CV body.

Place the test weight weldment into the CV body.

Place the PCC pad (silicone rubber) into the CV body on top of the test fixture weldment assembly.

**HOLD POINT:** Y-12 witness torquing of test fixture fastener hex head screws, washers, top hat bushings, and locknuts. The test weight and bolting locations that establish the low and high CG locations are documented in Attachment A. The hex head screws and locknuts shall be torqued to  $25 \pm 2$  ft-lb.

**HOLD POINT:** Y-12 inspected the assembly of the non-test fixture weldment content assembly and verified weights

M&TE ID #: A001096 Calibration Due Date: 2/10/2022

Comments:

I certify that the above tasks have been performed and that the observations and comments are correct.

Testing Technician

Ross Whittaker  
CNS-Y-12 STR

09-09-2021

Date

9/9/21

Date

MB Houten

Witness

Ryan J. Houten  
CNS-Y-12 QE

09-09-2021

Date

9/9/21

Date



# TEST FORM 2 - ASSEMBLY OF THE CV

Test Plan DPP-1

TU -3

## All packages

☒ The CV O-rings and sealing surfaces have been inspected for defects and found acceptable.

☒ Clean all surfaces with isopropyl alcohol and air dry.

☒ The CV O-rings have been installed onto the CV body.

**Note:** Screws and O-rings shall not be replaced without CNS approval. If replacements are authorized, they shall be documented in the test report where the replacements occurred.

☒ The CV lid was lowered on the CV body and the CV screws shall be hand-tightened until the lid is in full contact with the flange, note that clamps may be used during this step. The CV screws shall be torqued in sequence following the numbers etched into the drum lid in three passes. first pass the screws shall be torqued to 19-21 ft-lb, during the second pass to 33-37 ft-lb, and during the third pass to 33-37 ft-lb. The final pass torque values shall be recorded.

Ambient temperature at closure is 71.5 °C (71.5 °F)

Measuring device A006681 Calibration Expiration Date 5/12/2022

Record assembly torque on TEST FORM 11.

Torque wrench # A001096 Calibration Expiration Date 2/10/2022

HOLD POINT: Y-12 inspected the assembly and closure of CV assemblies and verified weights.

☒ The CV assembly has been weighed and the weight has been recorded on TEST FORM 1

☒ The CV assembly has been leak tested (pre-test operational) in accordance with Sect. 7.6 of ANSI N14.5-2014 using the "A.5.2 gas pressure rise" method described in Table A-1 of N14.5-2014 and ORNL procedure NDE 70 Rev. 7, PCMT.

HOLD POINT: Y-12 has reviewed the leak test and the installation of the acceleration sensor mounts.

☒ Photographs of the assembly have been taken\*.

Comments:

I certify that the above tasks have been performed and that the observations and comments are correct.

Testing Technician

Ross Whittenlanger  
CNS-Y-12 STR

Date

09-15-2021  
9/15/21  
Date

Witness

MB Hunter  
Ryan Jobe  
CNS-Y-12 QE

Date

09-15-2021  
9/15/21  
Date

\*All photographs/movies will be uniquely identified with test unit, date and time to ensure that the proper sequence can be reconstructed

# TEST FORM 3 - ASSEMBLY OF TEST PACKAGE

Test Plan DPP-1

TU- 3

VERIFIED

TASK

- ☒ Verify operational leak test is complete and form completed and tighten the CV lid leak test port plug per the following sequence: 1<sup>st</sup> pass hand tight, 2<sup>nd</sup> pass torque to 6-7 ft-lb.  
Torque wrench # A001320 Calibration Expiration Date 02-11-2022
- ☒ The exterior of the drum has been clearly marked "TU- 3 " and record the drum serial number if applicable:
- ☒ Verify all exterior markings on the TU. If marks are not legible or inadequate, the TA will remark the TU. Mark the 0°, 90°, 180°, 270° locations on the Drum Lid, and the inner and outside walls of the drum with a permanent marker.
- ☒ Install temperature labels on the inside of the drum body as shown in Figure 5-3.
- ☒ Clean all surface of the drum body with isopropyl alcohol and let air dry.
- ☒ The drum body, drum lid, bolts, washers, pads, were weighed and recorded on TEST FORM 1.
- ☒ Place the lower CV base pad into the drum body.
- ☒ Place the CV assembly into the drum body.
- ☒ The CV assembly has been loaded into the drum with the 0° rotated and aligned with 0° line on the drum. Ensure temperature labels are not damaged.
- ☒ Place the CV flange wedge between the CV flange and the drum body.
- ☒ The drum lid has been loaded into the drum with the 0° rotated and aligned with the 0° location on the drum.
- ☒ If necessary, apply thread lubricant to the drum closure bolts.
- ☒ The drum lid has been closed using the same screws that were removed during disassembly. The screws shall be torqued in sequence following the numbers etched into the drum lid in two passes. First, the screws shall be torqued until the lid is in full contact with the flange. Second, the screws shall be torqued to 33-37 ft-lb. .Record the assembled torque value on Test Form 10. **TPCR-04**  
Torque wrench #: \_\_\_\_\_ Calibration Expiration Date: \_\_\_\_\_
- ☒ The test package assembly has been weighed and the weight recorded on Test Form 1.
- ☒ Mount one (1) vibration accelerometer on the TU-6 drum lid center for NCT vibration monitoring according to the DPP-1 Accelerometer Mounting Procedure. Remove accelerometer after NCT Test. **TPCR-05**
- ☒ The accelerometer mounting blocks and restraint rings have been welded to the drum outer shell as specified in the DPP-1 Accelerometer Mounting Procedure. **TPCR-05**
- ☒ Install the accelerometers on TU-1, TU-2, TU-5, and TU-6 at the locations tspecified by the DPP-1 Accelerometer Mounting Procedure". **TPCR-05**
- ☒ The accelerometers were checked to ensure they were installed and functioning as intended after each installation. **HOLD POINT:** Y-12 has approval: CNS STR N/A RW 10/11/21, CNS QE N/A RF 10/11/21  
Photographs of the assembly have been taken\*.

Comments:

I certify that the above tasks have been performed and that the observations and comments are correct.

Testing Technician

Date

Witness

Date

CNS-Y-12 STR

Date

CNS-Y-12 QE

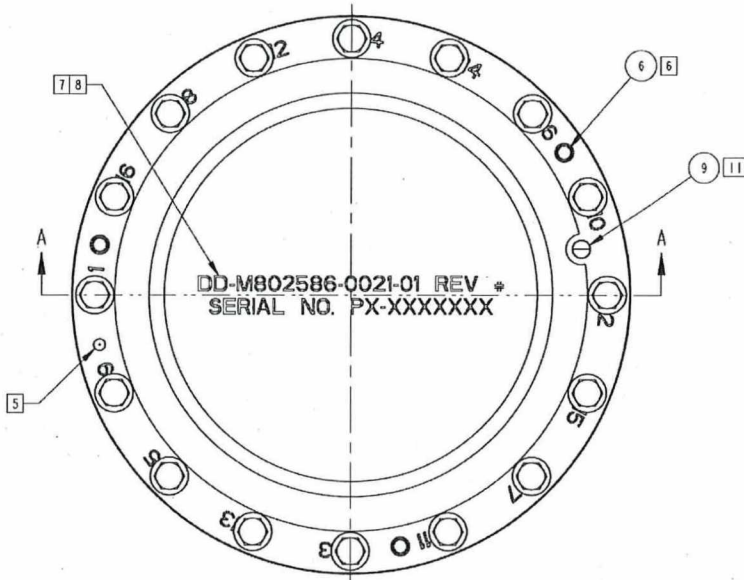
Date

\*All photographs/movies will be uniquely identified with test unit, date and time to ensure that the proper sequence can be reconstructed.

# TEST FORM 11 –CV LID ASSEMBLY

Test Plan – DPP-1

TU-3



DPP-1 CV Lid Assembly	
Bolt #	Torque assembly (ft-lbs.)
1	34.6
2	35.0
3	34.6
4	34.4
5	35.0
6	34.6
7	35.1
8	36.4
9	34.9
10	35.3
11	35.8
12	34.7
13	36.0
14	35.7
15	34.9
16	35.1

M&TE ID #: A001096 Calibration Due Date: 2/10/2022

M&TE ID #: A006681 Calibration Due Date: 3/12/2022

Comments:

I certify that the above tasks have been performed and that the observations and comments are correct.

[Signature]  
Testing Technician  
Ross W. Hurlinger  
CNS-Y-12 STR

09/09/2021  
Date  
9/9/21  
Date

M. B. Hunter  
Witness  
[Signature]  
CNS-Y-12 QE

09-09-2021  
Date  
9/9/21  
Date

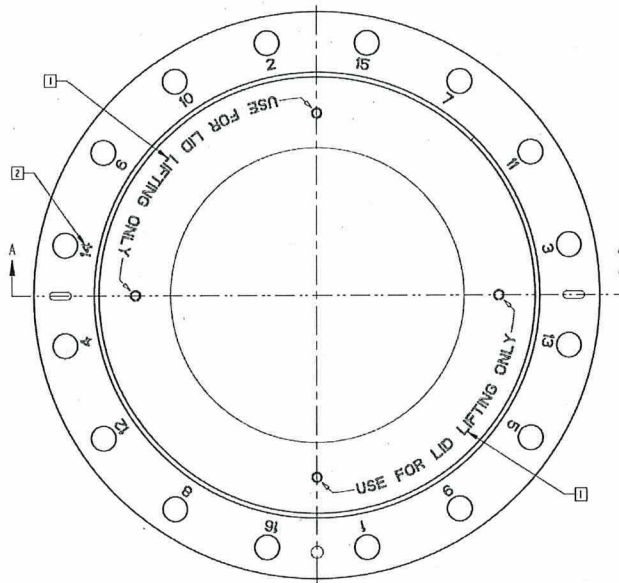
\*All photographs/movies will be uniquely identified with test unit, date and time to ensure that the proper sequence can be reconstructed



# TEST FORM 10 –DRUM LID ASSEMBLY

Test Plan – DPP-1

TU- 3



DPP-1 Drum Lid Assembly	
Bolt #	Torque assembly (ft-lbs.)
1	35.2
2	35.2
3	34.9
4	34.7
5	34.7
6	35.2
7	35.3
8	34.4
9	35.1
10	35.6
11	35.0
12	35.7
13	34.8
14	34.7
15	34.6
16	35.3

M&TE ID #: A001096 Calibration Due Date: 2/10/2022

M&TE ID #: \_\_\_\_\_ Calibration Due Date: \_\_\_\_\_

Comments: \_\_\_\_\_

I certify that the above tasks have been performed and that the observations and comments are correct.

*[Signature]*  
Testing Technician  
*Ross Whittenburg*  
CNS-Y-12 STR

09-16-2021  
Date  
9/16/21  
Date

*[Signature]*  
Witness  
*[Signature]*  
CNS-Y-12 QE

09-16-2021  
Date  
9/16/21  
Date

\*All photographs/movies will be uniquely identified with test unit, date and time to ensure that the proper sequence can be reconstructed

# TEST FORM 7 –TEST UNIT DIMENSIONS

Test Plan – DPP-1

TU- 3

Initial Assembly  
Post 1.2-m Drop  
Post 9-m Drop  
Post Crush Test  
Post 1-m Puncture Test

✓

## Drum outer shell

	0°	90°	180°	270°
Height	43 <sup>3</sup> / <sub>16</sub>	43 <sup>1</sup> / <sub>4</sub>	43 <sup>1</sup> / <sub>8</sub>	43 <sup>1</sup> / <sub>8</sub>

DIAMETER	0° to 180°	90° to 270°
Top Surface	26 <sup>3</sup> / <sub>4</sub>	26 <sup>3</sup> / <sub>4</sub>
Top Rolling hoop	28 <sup>1</sup> / <sub>16</sub>	28 <sup>1</sup> / <sub>16</sub>
Center Rolling hoop	28	27 <sup>15</sup> / <sub>16</sub>
Bottom Rolling hoop	28	28 <sup>1</sup> / <sub>16</sub>
Bottom Surface	27	27 <sup>1</sup> / <sub>8</sub>

Location	Flats width @ 0°	Flats width @ 180°
Top Surface		
Top Rolling hoop		
Center Rolling hoop	N/A	N/A
Bottom Rolling hoop		
Bottom Surface		

Sketch Drop Setup Here

N/A

Sketch Package Damage Here

N/A

M&TE ID #: A006327 Calibration Due Date: 3/20/2023

M&TE ID #: \_\_\_\_\_ Calibration Due Date: \_\_\_\_\_

Comments: All units are in inches.

I certify that the above tasks have been performed and that the observations and comments are correct.

Testing Technician

09-16-2021  
Date

Witness

09-16-2021  
Date

Ross Whitham  
CNS-Y-12 STR

9/16/21  
Date

[Signature]  
CNS-Y-12 QE

9/16/21  
Date

\*All photographs/movies will be uniquely identified with test unit, date and time to ensure that the proper sequence can be reconstructed

<b>ORNL</b> Package Testing Program OAK RIDGE NATIONAL LABORATORY OAK RIDGE, TENNESSEE 37831 <small>The OFFICIAL COPY of this document is the on-line version. Before using a printed copy, verify that it is the most current version by checking the Revision ID against the on-line version</small>	<b>Operating Procedure for NCT Water Spray Test – Testing of Radioactive Material Packages</b>	Test Procedure: <b>PTP-PEF-05</b>	Rev. <b>5-CN 2</b>
		Page: <b>5 / 6</b>	Issue Date: <b>12-14-20</b>
		Revision Date: <b>12-01-20</b>	Review by Date: <b>12-14-20</b>

## 6. Procedure Checklist

Test Plan:  
**ORNL/NTRC-092 R.O**

Test Unit: **3**


VERIFIED

TASK

- ☒ Water Spray apparatus has been assembled (§4.2).
- ☒ Photographer's clipboard with package name and test unit number recorded (§4.2).
- ☒ Test Unit placed properly in the water spray zone and spray function verified (§4.3).
- ☒ Photograph of the test arrangement taken, documenting test unit identification (§4.3).
- ☒ Place the rain gauge upright on the ground adjacent to the test specimen (§4.4).
- ☒ Water spray has been started is spraying on the top and 4 sides, with a minimum rate of 2 in/hr (5 cm/hr) (§4.5).
- ☒ Date and time of test has been recorded. (§4.5).
- ☒ The ambient temperature has been recorded. (§4.6).
- ☒ Water spray has been stopped after 1 hour, rain gauge reading has been recorded and any damage noted (§4.6).
- ☒ End time of test has been recorded. (§4.6).
- ☒ Photographs of the resulting damage (if any) were taken (§4.5).
- ☒ Sign and date checklists (§4.7).

Comments:

I certify that the above tasks have been performed and that the observations and comments are correct.

  
 Test Engineer  
**Ron Whitledge**

**10-12-2021**  
~~10-11-2021~~  
 Date  
**10/12/21**

**10-12-2021**  
~~10-11-2021~~  
 Checked by  
**MB Hunter**  
**Pyran Jisha** 10/12/21

**10-12-2021**  
~~10-11-2021~~  
 Date  
**MBH 10-12-21**



<b>ORNL</b> Package Testing Program OAK RIDGE NATIONAL LABORATORY OAK RIDGE, TENNESSEE 37831 <small>The OFFICIAL COPY of this document is the on-line version. Before using a printed copy, verify that it is the most current version by checking the Revision ID against the on-line version</small>	<b>Operating Procedure for NCT Water Spray Test – Testing of Radioactive Material Packages</b>	Test Procedure:	Rev.
		<b>PTP-PEF-05</b>	<b>5-CN 2</b>
		Page:	Issue Date:
		6 / 6	12-14-20
		Revision Date:	Review by Date:
		12-01-20	12-14-20

## 7. Data Sheet

Test Plan:  
ORNL/NTRC-092 R-0

Test Unit: 3

VERIFIED

TASK

- ✓ Start Date and Time of Water Spray Test: 10/12/2021 09:25am (§4.5)
- ✓ End Date and Time of Water Spray Test: 10/12/2021 @ 10:28am (§4.6) Abi 10/12/2021
- ✓ Rain Gauge Reading: 4" (§4.6)
- ✓ Ambient temperature: 66.8°F (66.8°F) MASH 10-12-21
- Measuring device: A006681 (§4.6) due: 5/12/2022

Testing Damage Observations:

Comments:

I certify that the above tasks have been performed and that the observations and comments are correct.

Test Engineer

Ross Whittebury

10-12-2021

Date

10/12/21

Checked by

[Signature]

10-12-2021

Date

10/12/21

<b>ORNL</b> PACKAGE TESTING PROGRAM OAK RIDGE NATIONAL LABORATORY OAK RIDGE, TENNESSEE 37831 <small>The OFFICIAL COPY of this document is the on-line version. Before using a printed copy, verify that it is the most current version by checking the Revision ID against the on-line version</small>	<b>Operating Procedure for NCT Free Drop Test - Testing of Radioactive Material Packages</b>	Test Procedure: <b>PTP-PEF-08</b>	Rev. <b>5 CN2</b>
		Page: <b>7 / 8</b>	Issue Date: <b>12-10-20</b>
		Revision Date: <b>12-01-20</b>	Review by Date: <b>12-10-23</b>

## 6. Procedure Checklist

Test Plan: <b>ORNL/NTRC-092 R.D</b>	Test Unit: <b>3</b>
--	---------------------

VERIFIED	TASK
<input checked="" type="checkbox"/>	Verify that any equipment used meets the M&TE meets PTP-QA-013 requirements (§4.1).
<input checked="" type="checkbox"/>	Water Spray Test (PTP-PRF-05) has been completed within 2 hours before Drop Test. (§4.4)
<input checked="" type="checkbox"/>	Have a photographer's clipboard with package name and test unit number. (§4.5)
<input checked="" type="checkbox"/>	Attitude of the rigged and raised test unit is set. (§4.6)
<input checked="" type="checkbox"/>	Photograph of the rigging arrangements has been taken. (§4.6)
<input checked="" type="checkbox"/>	Photograph of the measured drop angle has been taken. (§4.6)
<input checked="" type="checkbox"/>	The test unit has been raised to the designated drop height. (§4.7)
<input checked="" type="checkbox"/>	Photograph of the height measurement has been taken. (§4.7)
<input checked="" type="checkbox"/>	Video camera(s) are setup and running to take video of the drop. (§4.8)
<input checked="" type="checkbox"/>	The release mechanism has been plugged into power outlet. (§4.8)
<input checked="" type="checkbox"/>	Countdown, Release the test unit, unplug release mechanism. (§4.8)
<input checked="" type="checkbox"/>	Videos camera stopped. (§4.9)
<input checked="" type="checkbox"/>	Photographs of the resulting damage were taken. (§4.9)
<input checked="" type="checkbox"/>	Ambient temperature recorded. (§4.11)
<input checked="" type="checkbox"/>	Date and time of test recorded. (§4.11)
<input checked="" type="checkbox"/>	Sign and date checklist and data forms (§4.12).

Comments:

I certify that the above tasks have been performed and that the observations and comments are correct.

Test Engineer

*Ross Whitlatch*

Date

*10/12/21*

Checked by

*MB Hunter*  
*Juan Zito*

Date

*10/12/21*

<b>ORNL</b> PACKAGE TESTING PROGRAM OAK RIDGE NATIONAL LABORATORY OAK RIDGE, TENNESSEE 37831 <small>The OFFICIAL COPY of this document is the on-line version. Before using a printed copy, verify that it is the most current version by checking the Revision ID against the on-line version</small>	<b>Operating Procedure for NCT Free Drop Test - Testing of Radioactive Material Packages</b>	Test Procedure:	Rev.
		<b>PTP-PEF-08</b>	<b>5 CN2</b>
		Page:	Issue Date:
		8 / 8	12-10-20
		Revision Date:	Review by Date:
		12-01-20	12-10-23

## 7. Data Sheet

Test Plan: <b>ORNL/NTRC-092 R.O</b>	Test Unit: <b>3</b>
--	---------------------

VERIFIED	TASK
<input checked="" type="checkbox"/>	M&TE ID <b>A000885</b> Calibration due date <b>2/24/2026</b> (§4.1)
<input checked="" type="checkbox"/>	Water Spray Test (PTP-PRF-05) Time completed: <b>10:28am</b> (§4.4)
<input checked="" type="checkbox"/>	Intended attitude and angle of the test unit <b>0°</b> . Tolerance $\pm 2^\circ$ (§4.6)
<input checked="" type="checkbox"/>	Attitude Description: <b>Top down, vertical drop.</b> (§4.6)
<input checked="" type="checkbox"/>	Measured attitude and angle of the test unit <b>1.2m @ 0.2°</b> degrees. (§4.6)
<input checked="" type="checkbox"/>	Level number <b>M212348</b> Calibration Exp. Date <b>2/23/2022</b> (§4.6)
<input checked="" type="checkbox"/>	Height above the drop pad <b>1.2m</b> Measuring device <b>A000885</b> (§4.6)
<input checked="" type="checkbox"/>	Ambient temperature: <b>68.3°F</b> Measuring device <b>A006681</b> (§4.11) <b>due: 5/12/2022</b>
<input checked="" type="checkbox"/>	Date and Time of Drop Test: <b>10/12/2021 @ 12:10pm</b> (§4.11)

Testing Damage Observations: **Horizontal alignment checked @ 0-180 0-0°**  
**@ 90-270 0-2°**

Comments:

I certify that the above tasks have been performed and that the observations and comments are correct.

Test Engineer

**Ross Whitaker**

**10-12-2021**

Date

**10/12/21**

Checked by

**John Jones**

**10-12-2021**

Date

**10/12/21**



# TEST FORM 7 -TEST UNIT DIMENSIONS

Test Plan - DPP-1

TU-

3

Initial Assembly  
Post 1.2-m Drop  
Post 9-m Drop  
Post Crush Test  
Post 1-m Puncture Test

✓

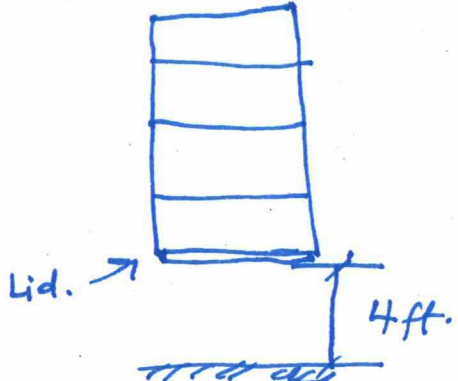
## Drum outer shell

	0°	90°	180°	270°
Height	43 1/16	43 3/16	43 1/16	43 3/16

DIAMETER	0° to 180°	90° to 270°
Top Surface	26 3/4	26 13/16
Top Rolling hoop	28 1/16	28 1/16
Center Rolling hoop	27 7/8	28
Bottom Rolling hoop	27 7/8	28 1/16
Bottom Surface	26 15/16	27 1/16

Location	Flats width @ 0°	Flats width @ 180°
Top Surface	N/A	N/A
Top Rolling hoop	N/A	N/A
Center Rolling hoop	N/A	N/A
Bottom Rolling hoop	N/A	N/A
Bottom Surface	N/A	N/A

Sketch Drop Setup Here



Sketch Package Damage Here

No observable physical damage

M&TE ID #: A006327 Calibration Due Date: 3/20/2023

M&TE ID #: N/A Calibration Due Date: N/A

Comments:

I certify that the above tasks have been performed and that the observations and comments are correct.

Testing Technician

Ross W. Hutterling  
CNS-Y-12 STR

10-13-2021  
Date

10/13/21  
Date

Witness

10/13/21  
Date

10/13/2021  
Date

10/13/21  
Date

\*All photographs/movies will be uniquely identified with test unit, date and time to ensure that the proper sequence can be reconstructed

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		Page: <b>6 / 7</b>	Issue Date: <b>02-18-2021</b>
		Revision Date: <b>02-18-2021</b>	Review by Date: <b>02-18-2024</b>

## 6. Procedure Checklist

Test Plan:

ORNL/NTRC-092 R-0

Test Unit:

3

VERIFIED

TASK

- ☒ Verify that any equipment used meets the M&TE meets PTP-QA-013 requirements (§4.1).
- ☒ Have a photographer's clipboard with package name and test unit number. (§4.4)
- ☒ Attitude of the rigged test unit is set. (§4.5)
- ☒ Photograph of the rigging arrangements has been taken. (§4.5)
- ☒ Photograph of the measured drop angle has been taken. (§4.5)
- ☒ The test unit has been raised to the designated drop height. (§4.7)
- ☒ Photograph of the height measurement has been taken. (§4.7)
- ☒ Remove plumb bob from test specimen. (§4.7)
- ☒ Video camera(s) are setup and running to take video of the drop. (§4.8)
- ☒ The release mechanism has been plugged into power outlet. (§4.8)
- ☒ Countdown, Release the test unit, unplug release mechanism. (§4.8)
- ☒ Videos camera stopped. (§4.9)
- ☒ Date and time of test were recorded. (§4.10)
- ☒ The ambient temperature has been recorded. (§4.10)
- ☒ Photographs of the resulting damage were taken. (§4.11)
- ☒ Sign and date checklist and data forms (§4.12).

Comments:

I certify that the above tasks have been performed and that the observations and comments are correct.

Testing Technician

Ross Whittenburg  
Customer

10-21-2021

Date

10/21/21

Date

Witness

MB/Howard  
Customer

10-21-2021

Date

10/21/21

Date

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		Page: 7 / 7	Issue Date: 02-18-2021
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## 7. Data Sheet

Test Plan:

ORNL/NTRC-092 R.0

Test Unit:

3

VERIFIED

TASK

✓ Intended attitude of the test unit 0°. Tolerance ± 2° (§4.2)

✓ Attitude Description: Vertical drop, lid face down (§4.2)

✓ Measured attitude of the test unit 0.2° degrees. (§4.4)

✓ Level number M212348 Calibration Exp. Date 2/23/2022 (§4.4)

✓ Height above the drop pad 30 ft Measuring device A006327 (§4.6) 2/20/2023

✓ Date and Time of Drop Test: 10/21/2021 @ 8:45am (§4.9)

✓ Ambient temperature: 61.5°F °C (\_\_\_\_ °F)

Measuring device A006681 (§4.9) due 1.5/12/2022

Testing Damage Observations:

Orientation: 90° - 270° 0.2° 0° ± 180° 0.2

Comments:

I certify that the above tasks have been performed and that the observations and comments are correct.

Testing Technician

Ross Whittle  
Customer

10-21-2021

Date

10/21/21

Date

M.B. Hester

Witness

[Signature]  
Customer

10-21-2021

Date

10/21/21

Date



# TEST FORM 7 –TEST UNIT DIMENSIONS

Test Plan – DPP-1

TU- 3

Initial Assembly \_\_\_\_\_  
 Post 1.2-m Drop \_\_\_\_\_  
 Post 9-m Drop ✓  
 Post Crush Test \_\_\_\_\_  
 Post 1-m Puncture Test \_\_\_\_\_

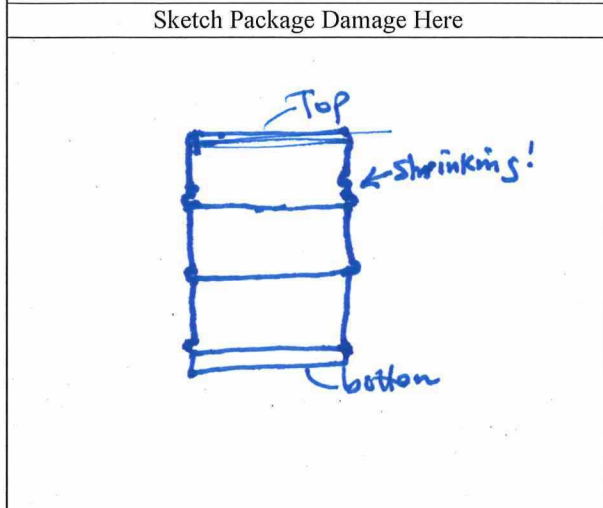
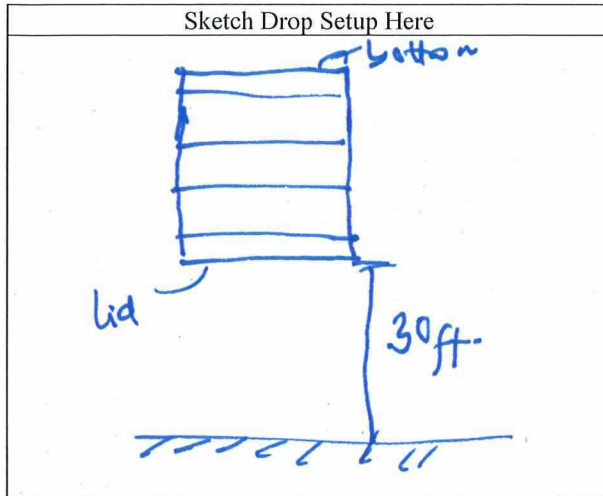
## Drum outer shell

	0°	90°	180°	270°
Height	42 9/16	42 7/16	42 1/2	42 11/16

NA 10/20/21

DIAMETER	0° to 180°	90° to 270°
Top Surface	26 7/8	26 3/4
Top Rolling hoop	28 1/16	28 1/8
Center Rolling hoop	28	28 1/16
Bottom Rolling hoop	27 15/16	28 3/16
Bottom Surface	27	27 1/16

Location	Flats width @ 0°	Flats width @ 180°
Top Surface	NA	NA
Top Rolling hoop	NA	NA
Center Rolling hoop	NA	NA
Bottom Rolling hoop	NA	NA
Bottom Surface	NA	NA



M&TE ID #: A006327 Calibration Due Date: 3/20/2023

M&TE ID #: N/A Calibration Due Date: N/A

Comments:

I certify that the above tasks have been performed and that the observations and comments are correct.

Testing Technician

Poss Whittaker  
 CNS-Y-12 STR

10/21/2021  
 Date

10/21/21  
 Date

Witness

M. B. Houston  
[Signature]  
 CNS-Y-12 QE

10/21/2021  
 Date

10/21/21  
 Date

\*All photographs/movies will be uniquely identified with test unit, date and time to ensure that the proper sequence can be reconstructed

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		Revision Date: <b>02-18-2021</b>	Review by Date: <b>02-18-2024</b>

## 6 Procedure Checklist

Test Plan:

ORNL/NTRC-092 R-0

Test Unit:

3

VERIFIED

TASK

- ☒ Verify that any equipment used meets the M&TE meets PTP-QA-013 requirements (§4.1).
- ☒ Have a photographer's clipboard with package name and test unit number. (§4.4)
- ☒ Attitude of the test unit is set. (§4.5)
- ☒ Photograph of the attitude has been taken. (§4.5)
- ☒ Photograph of the measured angle has been taken. (§4.5)
- ☒ The crush plate has been raised to the designated drop height and located over the target point. (§4.7)
- ☒ Photograph of the set position has been taken. (§4.7)
- ☒ Remove plumb bob from crush plate. (§4.7)
- ☒ Video camera(s) are setup and running to take video of the drop. (§4.8)
- ☒ The release mechanism has been plugged into power outlet. (§4.8)
- ☒ Countdown, Release the crush plate, unplug release mechanism. (§4.8)
- ☒ Videos camera stopped. (§4.9)
- ☒ Date and time of test recorded. (§4.10)
- ☒ The ambient temperature has been recorded. (§4.10)
- ☒ Photographs of the resulting damage were taken. (§4.11)
- ☒ Sign and date checklist and data forms (§4.11).

Comments:

I certify that the above tasks have been performed and that the observations and comments are correct.

Testing Technician

Russ Wittenlauer  
Customer

10/21/2021  
Date

10/21/21  
Date

Witness

M.B. Houston  
Customer

10/21/2021  
Date

10/21/21  
Date

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		Page: <b>6 / 6</b>	Issue Date: <b>02-18-2021</b>
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## 7. Data Sheet

Test Plan:  
ORNL/NTRC-092.R.0

Test Unit:  
3

VERIFIED

TASK

☒ Intended attitude of the test unit 0° Tolerance  $\pm$  2° (§4.6)  
☒ Attitude Description: Lid on pad, 30ft crush plate drop. (§4.3)  
☒ Measured attitude of the test unit 0.9° x 0.10° degrees. (§4.5)  
☒ Level number M212348 Calibration Exp. Date 2/23/2022 (§4.5)  
☒ Height above the target: 9-m (30-ft) Measuring device 1006329 2/20/2023 (§4.7)  
☒ Date and Time of Crush Test: 10/21/2021 @ 10:14 am (§4.10)  
☒ Ambient temperature: 63.1°F °C ( \_\_\_\_\_ °F)  
 Thermometer M&TE ID/Cal. Due Date: 1006681 Due: 5/12/2022 (§4.10)

Testing Damage Observations:

Crush plate 10: None Drum pad: 0.7°, 0.2°, Plate: 0.9°, 0.1°

Comments:

I certify that the above tasks have been performed and that the observations and comments are correct.

Testing Technician

Ross Whittenburg  
Customer

10/21/2021  
Date

10/21/21  
Date

Witness

M.B. Hunter  
Customer

10/21/2021  
Date

10/21/21  
Date



# TEST FORM 7 –TEST UNIT DIMENSIONS

Test Plan – DPP-1

TU- 3

Initial Assembly \_\_\_\_\_  
 Post 1.2-m Drop \_\_\_\_\_  
 Post 9-m Drop \_\_\_\_\_  
 Post Crush Test ✓  
 Post 1-m Puncture Test \_\_\_\_\_

## Drum outer shell

	0°	90°	180°	270°
Height	40 <sup>13</sup> / <sub>16</sub>	40 <sup>9</sup> / <sub>16</sub>	39 <sup>7</sup> / <sub>8</sub>	40 <sup>1</sup> / <sub>8</sub>

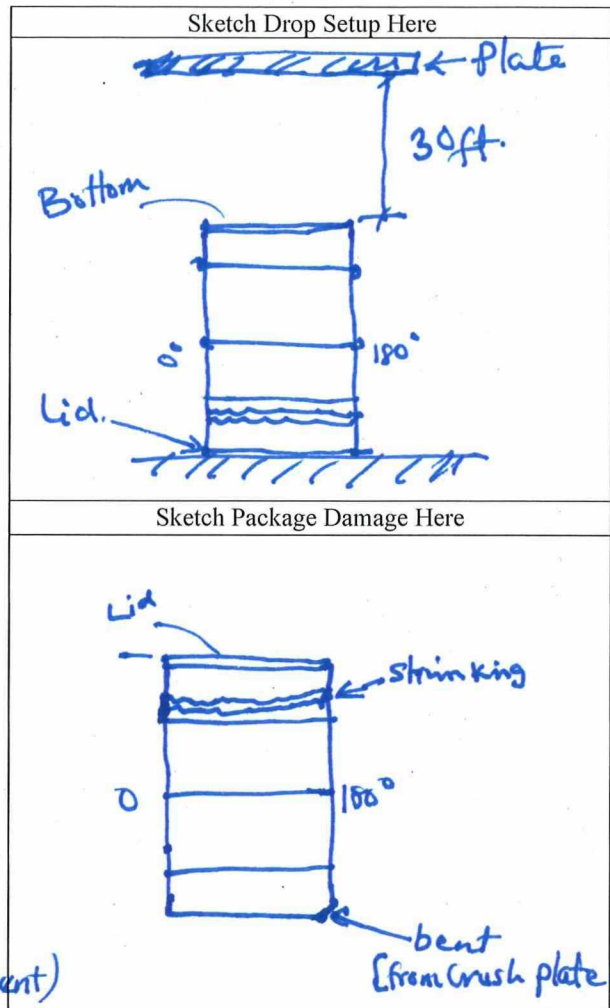
DIAMETER	0° to 180°	90° to 270°
Top Surface	26 <sup>13</sup> / <sub>16</sub>	26 <sup>13</sup> / <sub>16</sub>
Top Rolling hoop	28	28 <sup>1</sup> / <sub>16</sub>
Center Rolling hoop	27 <sup>7</sup> / <sub>8</sub>	28
Bottom Rolling hoop	27 <sup>7</sup> / <sub>8</sub>	28 <sup>3</sup> / <sub>16</sub>
Bottom Surface	26 <sup>1</sup> / <sub>8</sub>	28 <sup>1</sup> / <sub>8</sub>

Location	Flats width @ 0°	Flats width @ 180°
Top Surface	N/A	
Top Rolling hoop	N/A	
Center Rolling hoop	N/A	
Bottom Rolling hoop	N/A	
Bottom Surface	NA	12.881 (bent)

M&TE ID #: A006327 Calibration Due Date: 3/20/2023

M&TE ID #: \_\_\_\_\_ Calibration Due Date: \_\_\_\_\_

Comments:



I certify that the above tasks have been performed and that the observations and comments are correct.

Testing Technician

Ross Whittenburg  
 CNS-Y-12 STR

Date

10/21/21  
 Date

Witness

M.B. Houston  
 CNS-Y-12 QE

Date

10/21/21  
 Date

\*All photographs/movies will be uniquely identified with test unit, date and time to ensure that the proper sequence can be reconstructed

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		Page: <b>6 / 7</b>	Issue Date: <b>12-14-20</b>
		Revision Date: <b>12-01-20</b>	Review by Date: <b>12-14-23</b>

## • Procedure Checklist


Test Plan:  
**ORNL/NTRC-092 R.O**

Test Unit: **3**


VERIFIED	TASK
<input checked="" type="checkbox"/>	Verify that any equipment used meets the M&TE meets PTP-QA-013 requirements (§4.1).
<input checked="" type="checkbox"/>	Have a photographer's clipboard with package name and test unit number. (§4.4)
<input checked="" type="checkbox"/>	Attitude of the rigged test unit is set. (§4.5)
<input checked="" type="checkbox"/>	Photograph of the rigging arrangements has been taken. (§4.5)
<input checked="" type="checkbox"/>	Photograph of the measured drop angle has been taken. (§4.5)
<input checked="" type="checkbox"/>	The test unit has been raised to the designated drop height. (§4.6)
<input checked="" type="checkbox"/>	Photograph of the height measurement has been taken. (§4.6)
<input checked="" type="checkbox"/>	Video camera(s) are setup and running to take video of the drop. (§4.7)
<input checked="" type="checkbox"/>	The release mechanism has been plugged into power outlet. (§4.7)
<input checked="" type="checkbox"/>	Countdown, Release the test unit, unplug release mechanism. (§4.7)
<input checked="" type="checkbox"/>	Videos camera stopped. (§4.8)
<input checked="" type="checkbox"/>	Date and time of test recorded. (§4.9)
<input checked="" type="checkbox"/>	The ambient temperature has been recorded. (§4.10)
<input checked="" type="checkbox"/>	Photographs of the resulting damage were taken. (§4.11)
<input checked="" type="checkbox"/>	Sign and date checklist and data forms (§4.12).

Comments:

I certify that the above tasks have been performed and that the observations and comments are correct.

  
 Test Engineer  
**Poss Whittenburg**

**10/21/2021**  
 Date  
**10/21/21**

**MB/Hunter**  
 Checked by  


**10/21/2021**  
 Date  
**10/21/21**

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## 6. Data Sheet

Test Plan: <b>ORNL/NTRC-092. R.O.</b>	Test Unit: <b>3</b>
--	---------------------

VERIFIED	TASK
<input checked="" type="checkbox"/>	M&TE ID <b>A500883</b> Calibration due date <b>3/15/2023 (puncture bar)</b> (§4.1).
<input checked="" type="checkbox"/>	Intended attitude of the test unit <b>0°</b> Tolerance $\pm$ <b>2°</b> (§4.5)
<input checked="" type="checkbox"/>	Measured attitude of the test unit <b>89.8° on the vertical (0.2° off 10/21)</b> degrees. (§4.5) <b>(+5° on horizontal?)</b>
<input checked="" type="checkbox"/>	Attitude Description: <b>Ud down, CG over bar, vertical drop.</b> (§4.3)
<input checked="" type="checkbox"/>	Level number <b>M212348</b> Calibration Exp. Date <b>2/23/2022</b> (§4.5)
<input checked="" type="checkbox"/>	Height above the puncture bar <b>40 in</b> Measuring device <b>A501146</b> <b>due 2/24/2026</b> (§4.6)
<input checked="" type="checkbox"/>	Date and Time of Drop Test: <b>10/21/2021 @ 1:45pm</b> (§4.9)
<input checked="" type="checkbox"/>	Ambient temperature: <b>66.8°F</b> <b>mo 10-21-21</b> <b>66.8</b> °C (°F)
	Measuring device <b>A006681</b> <b>due 5/12/2022</b> (§4.10)
	Testing Damage Observations: <b>Bolt #1 at 90° loose. Hand tightened.</b>

Comments:

I certify that the above tasks have been performed and that the observations and comments are correct.

Test Engineer

**Ross Whittemore**

**10/21/2021**

Date

**10/21/21**

Checked by

**M.B. Houston**  
**Peggy J. Jucha**

**10/21/2021**

Date

**10/21/21**



# TEST FORM 7 –TEST UNIT DIMENSIONS

Test Plan – DPP-1

TU- 3

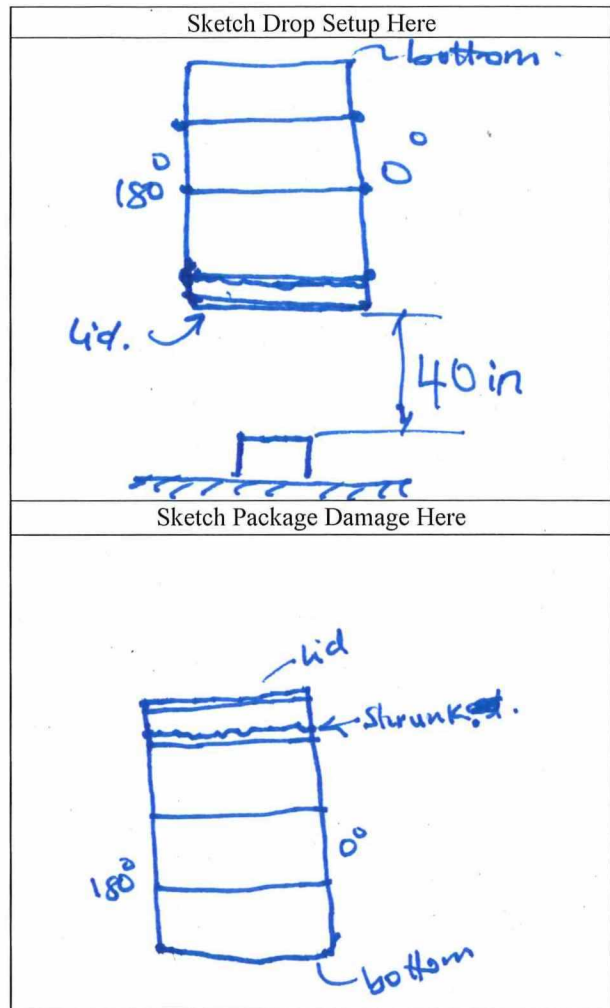
Initial Assembly \_\_\_\_\_  
 Post 1.2-m Drop \_\_\_\_\_  
 Post 9-m Drop \_\_\_\_\_  
 Post Crush Test \_\_\_\_\_  
 Post 1-m Puncture Test ✓

## Drum outer shell

	0°	90°	180°	270°
Height	41	40 <sup>11</sup> / <sub>16</sub>	39 <sup>13</sup> / <sub>16</sub>	40 <sup>11</sup> / <sub>16</sub>

DIAMETER	0° to 180°	90° to 270°
Top Surface	26 <sup>13</sup> / <sub>16</sub>	26 <sup>3</sup> / <sub>4</sub>
Top Rolling hoop	28	28
Center Rolling hoop	27 <sup>7</sup> / <sub>8</sub>	28
Bottom Rolling hoop	27 <sup>3</sup> / <sub>4</sub>	28 <sup>1</sup> / <sub>8</sub>
Bottom Surface	26 <sup>7</sup> / <sub>8</sub>	27 <sup>1</sup> / <sub>8</sub>

Location	Flats width @ 0°	Flats width @ 180°
Top Surface	NA	NA
Top Rolling hoop	NA	NA
Center Rolling hoop	NA	NA
Bottom Rolling hoop	1-451	NA
Bottom Surface	NA	NA



M&TE ID #: A006327 Calibration Due Date: 3/20/2023

M&TE ID #: A001319 Calibration Due Date: 2/23/2022

Comments: Unit bulged at bottom with shrinkage. Shrinkage btw Top surface and Top rolling hoop.  
 Damage on Lid reinforcement Ring 1-15/16" @ 0°-180°

I certify that the above tasks have been performed and that the observations and comments are correct.

Testing Technician

Peter W. Hutter

CNS-Y-12 STR

10-21-2021

Date

10/21/21

Date

Witness

John J. Hutter

CNS-Y-12 QE

10-21-2021

Date

10/21/21

Date

\*All photographs/movies will be uniquely identified with test unit, date and time to ensure that the proper sequence can be reconstructed

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### Attachment 1 - HAC Thermal Test Checklist

Test Plan:

ORNL/NTRC-092 R.0

Test Unit:

3

VERIFIED

TASK

✓

Ensure test equipment is calibrated, calibration records are acceptable, and that Attachments 1 and 2 records have been initiated prior to testing. Prepare photographers clipboard. (§4.1a, b, c & d)

✓

Set up the thermal DAQ and test all TC channels with a calibrated heat source. The acceptable range to test the thermocouples is 0°F - 150°F. (§4.2a)

✓

The thermocouple mounting clip material and installation is acceptable and per customer requirements, test plan, or approved work instruction. (§4.2b)

✓

TU's have been preheated per customer requirements, test plan or approved work instruction. NOTE: When no customer requirements are given, preheat shall be ~ 66°C (150°F) for a minimum of 24 hours and then soaked at ~ 43°C (110°F) for a minimum of 24 hours. **Record pre-heat acceptance on Attachment 2. (§4.2c)**

✓

Unless specified otherwise by the customer requirements, test plan, or approved work instruction, the furnace layout has proved capable of loading tests units within 90 seconds. (§4.3a)

✓

Floor plate(s) material(s) and test stand(s) are of the approved design and are installed at the location specified by the customer, test plan or approved work instruction. All TCs have been labeled, installed in the furnace, connected to DAQ and tested. The furnace opening can operate without causing damage to thermocouple wires. Photographs have been taken of the furnace set up. (§4.3b, 4.3c-4.3d)

✓

The furnace pre-heat soak time has been achieved (minimum temperature of 860°C (1580°F) for a minimum of 24 hours) and the DAQ is recording TC temperatures every 15 seconds. If needed, adjust the furnace set point to maintain a constant temperature of 1580°F. (§4.3e)

Comments: \_\_\_\_\_

I certify that the above tasks have been performed and that the observations and comments are correct.

Testing Technician

*Bar Whittaker*  
Customer

11-08-2021

Date

11/8/21

Date

*M. B. Hunter*

PTP QR Witness

*[Signature]*  
Customer

11-08-2021

Date

11/8/21

Date



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### Attachment 1 - HAC Thermal Test Checklist (continued)

Test Plan:

ORNL/NTRC-092 R.O.

Test Unit:

3

VERIFIED

TASK

- ✓ **Furnace Soak** - A room temperature test specimen, instrumented with thermocouples was placed into the hot furnace. The test unit thermocouples and the furnace thermocouples (including the thermocouple that controls the furnace temperature) were monitored with the cDAQ to ensure the furnace was capable of achieving the requirements specified per the test plan. The test specimen will remain in the furnace for a period specified by customer requirements, test plan, or the approved work instruction. When no requirements are given, the test specimen will remain in the furnace for 30 minutes after 5 of 6 of the thermocouples on the test specimen surface, 2 out of 3 thermocouples on the test stand, and 2 of 3 thermocouples on each furnace wall reach 1475°F. **Record acceptance on Attachment 2. (§4.4.a)**
- ✓ **Test Unit Preparation** – Weld the thermocouple clips to the TU's before starting the preheat. Pre-heat per test plan requirements. Document pre-heat for the test unit on Attachment 2. Upon acceptance of pre-heat requirements for the test specimen, remove the test specimen from the pre-heat chamber and install TCs. Test all thermocouples with a heat source. **(§4.2b & 4.4b)**
- ✓ **Ready to Test** - Open the furnace opening. Load the test specimen on the furnace test stand. Unless specified otherwise by the customer requirements, test plan or work instruction, place the test specimen onto the test stand in a horizontal position with the test specimen lid facing the right furnace sidewall and the 0° line is facing down (facing the furnace floor). **(§4.4.c)**
- ✓ **Beginning the Test** - Loading can begin when the furnace has met the required preheat time. **Record the Test Start Time on Attachment 2.** The 30 minute test shall start when the following conditions have been met.
  - 5 of 6 of the thermocouples on the test specimen surface must reach 1475°F or greater and,
  - 2 out of 3 thermocouples on the test stand must reach 1475°F or greater and,
  - 2 of 3 thermocouples on each furnace wall have reached 1475°F or greater. **(§4.4a)**
- ✓ **Test Completion - Record the Test Stop Time on Attachment 2.** Immediately following the timed test and the thermal requirements are met, immediately remove the test specimen from the furnace and place the specimen in an area where it will not be exposed to artificial cooling. Record notes regarding smoke and/or flames emanating from the test specimen on Attachment 2. **(§4.3c)**
- ✓ All Photographs and/or videos for the entire test setup have been taken. **(§4.3c)**

Comments:

I certify that the above tasks have been performed and that the observations and comments are correct.

Testing Technician

Date

PTP QR Witness

Date

Customer

Date

Customer

Date



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## Attachment 2 - HAC Thermal Test Data Sheet

Test Plan:

ORNL/NTRC-092 R.O.

Test Unit:

3.

VERIFIED

TASK

✓

The test unit has been preheated to over 38°C (100°F). (§4.2c)

Pre-heat Start date/time: 3:45 am/pm (CT) @ 11/05/2021

Pre-heat End date/time: 2:09 am/pm CT @ 11/08/2021

Final Pre-heat temperature: 7110°F

✓

Furnace Soak Time prior to testing - Unless otherwise specified by the customer requirements, test plan or work instructions, preheat the furnace at a temperature of 860°C (1580°F) for a minimum of 24 hours. Record the time/date the soak time began and the time/date the soak time was reached (§ 4.3.e):

Time soak time begins: Date/Time: 11/07/2021 @ 6:52 pm (CT) .

Time soak time reached: Date/Time: 11/08/2021 @ 6:52 am (CT) .

✓

The test unit has been placed in the furnace, on the support stand, at: (§4.4d)

Furnace door opened time: 2:52 pm Furnace door Closed time: 2:52 pm

Total time taken to open and Close furnace door: ~1 min

✓

Unless otherwise specified by the customer requirements, test plan or work instructions, the 30-minute timed test starts after 5 out of 6 test unit thermocouples and 15 of 18 furnace thermocouples reach the test temperature of 801°C (1475°F).

Enter the Test Start Time: 2:56 pm am/pm (§4.4e & 4.4f)

✓

The test unit was removed from the furnace and allowed to cool naturally. (§4.4f)

Enter the Test End Time: 3:27 pm am/pm

N/A

The test unit stopped outgassing (flames) at am/pm (§4.4f)

Outgassing/burnout elapsed time was minutes. (§4.4f)

Comments: Furnace pre-heat lasted for 12 hours.

I certify that the above tasks have been performed and that the observations and comments are correct.

Testing Technician

Ron Whittaker

Customer

Date

11/8/21

Date

Witness

Customer

Date

11/8/21

Date

# TEST FORM 5 - POST-THERMAL TESTING INSPECTION

Test Plan DPP-1

TU 3

## VERIFIED

## TASK

- ☒ Following the thermal test and after passive cooling, the test package was weighed, and recorded on TEST FORM 1.
- ☒ The drum, drum lid, bolts, and washers have been visually examined to determine the extent of the testing damage. Observations: \_\_\_\_\_
- ☒ The camera(s) are set up to take photographs\* and/or videotape of the damage due to testing.
- ☒ The drum lid has been removed and the condition of the exposed parts have been visually examined for damage and the condition has been recorded. Record the exposed temperature indicator blackout reading on TEST FORM 6. Record the torque values needed to loosen the drum lid weldment screws on TEST FORM ~~6~~ #8. Observations: \_\_\_\_\_
- ☒ The CV assembly and contents have been removed in the reverse assembly order and visually examined for damage. Record the exposed temperature indicator blackout readings on TEST FORM 6. Observations: None
- ☒ The CV assembly has been weighed and the weight recorded on TEST FORM 1.
- ☒ Use NDE 70 Rev. 7 for the CV post-test operational leak check and for the full containment boundary leak check and PTP-PEF-14 for the 0.9 m (3 ft). immersion test or PTP-PEF-15 for the 15 m immersion test. The leak test port plug shall be removed for these tests. HOLD POINT: Y-12 has approved the CV drying process.
- ☒ After immersion test the CV was dried using the CNS approved process (fans, plant air pressure, mild heat, vacuum suction, etc.) as shown in TEST FORM 12. The flange joint and space between the O-rings was dried by the approved process prior to opening the CV.
- ☒ Disassemble the CV. Record torque value needed to loosen CV screws on TEST FORM 9.
- ☒ If water is present inside the O-rings, stop work, inform CNS, and comment observations below.
- ☒ Read the temperature labels from the CV. Record the temperature indicators' blackout readings on TEST FORM 6.
- ☒ The content test fixture weldment assembly was removed from the CV and the weight was recorded on TEST FORM 1.
- ☒ The content test fixture weldment assembly was disassembled in the reverse assembly order.
- ☒ Loaded test fixture weldment content assembly: Remove the contents in the following order, loading test fixture weldment assembly using nylon springs, PCC silicone rubber pad, test weight weldment, lower PCC silicone rubber pad. CV silicone rubber pad.
- ☒ All loose parts will be placed in separate plastic bags, marked with test unit identification, tape closed, and prepared for storage with the test package.
- ☒ Mark and reassemble the test package to the extent possible for shipment.
- ☒ \*Photographs and/or video of the damage resulting from the testing have been taken.

Comments: \_\_\_\_\_

I certify that the above tasks have been performed and that the observations and comments are correct.

Testing Technician

Ross Whittlebury

CNS-Y-12 STR

12-08-2021

Date

12/8/21

Date

M.B. Houston

Witness

[Signature]

CNS-Y-12 QE

12-08-2021

Date

12/8/21

Date

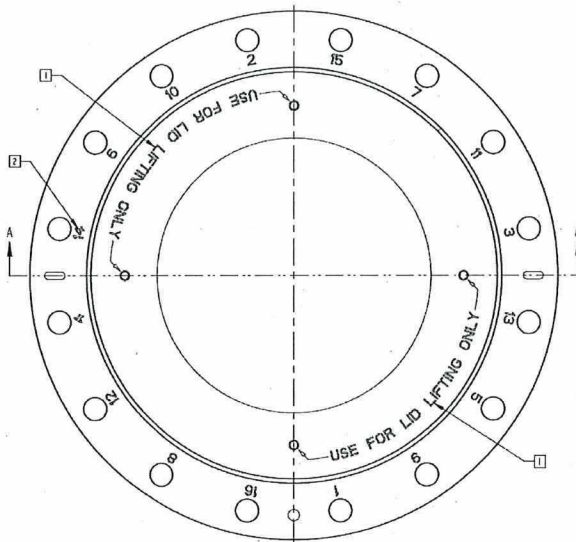
\*All photographs/movies will be uniquely identified with test unit, date and time to ensure that the proper sequence can be reconstructed.

# TEST FORM 8 –DRUM LID DISASSEMBLY

Test Plan – DPP-1

TU-

3



DPP-1 Lid Disassembly	
Bolt #	Torque Removal (ft-lbs.)
1	0 (hand release)
2	13.0
3	9.2
4	19.4
5	17.4
6	12.9
7	10.5
8	0 (hand release)
9	6.1
10	7.3
11	10.6
12	9.4
13	8.3
14	12
15	6.6
16	0 (hand release)

M&TE ID #: A001086 Calibration Due Date: 2/10/2022

M&TE ID #: A006681 Calibration Due Date: 5/12/2022

Comments: 11-22-21 mab 11 Ambient temp: 67.9°F

I certify that the above tasks have been performed and that the observations and comments are correct.

Testing Technician

Ross W. Whittlesberger

CNS-Y-12 STR

11-22-2021

Date

11/22/21

Date

Witness

[Signature]

CNS-Y-12 QE

11-22-2021

Date

11/22/21

Date

\*All photographs/movies will be uniquely identified with test unit, date and time to ensure that the proper sequence can be reconstructed



<b>ORNL</b> PACKAGE TESTING PROGRAM OAK RIDGE NATIONAL LABORATORY OAK RIDGE, TENNESSEE 37831 <small>The OFFICIAL COPY of this document is the on-line version. Before using a printed copy, verify that it is the most current version by checking the Revision ID against the on-line version</small>	<b>Operating Procedure for          HAC 0.9 Meter Immersion Test -          Testing of Radioactive Material          Packages</b>	Test Procedure: <b>PTP-PEF-14</b>	Rev. <b>5 CN 2</b>
		Page: <b>5 / 6</b>	Issue Date: <b>12-14-20</b>
		Revision Date: <b>1-03-20</b>	Review By Date: <b>12-14-23</b>

## 6. Procedure Checklist

Test Plan:

ORNL/NTRC-092.0

Test Unit:

3.

VERIFIED

TASK

- ☒ Verify that any equipment used meets the M&TE meets PTP-QA-013 requirements (§4.1).
- ☒ Have a photographer's clipboard with package name and test unit number. (§4.3)
- ☒ The test unit has been lowered to the bottom of the tank in designated orientation. (§4.6)
- ☒ The depth to the highest point of the test unit has been measured and is at least 0.9-m (3-ft). (§4.6)
- ☒ Photograph of the depth measurement has been taken. (§4.6)
- ☒ Record the water and ambient temperature. (§4.6)
- ☒ Start date and time has been noted. (§4.7)
- ☒ Test unit has been removed from the tank. (§4.8)
- ☒ End date and time has been noted. (§4.8)
- ☒ Record the water and ambient temperature. (§4.8)
- ☒ Thoroughly dry the test unit and make sure it is completely dry before opening. (§4.9)
- ☒ Open the test unit and record-breaking torque values during removal, if required. (§4.10)
- ☒ Inspect for water in-leakage or structural damage. (§4.10)
- ☒ Photographs of any resulting damage or lack thereof were taken. (§4.10)
- ☒ Sign and date checklist and data forms (§4.12).

Comments:

I certify that the above tasks have been performed and that the observations and comments are correct.

Test Engineer

Ron Whittlebury

Date

12/07/2021  
12/8/21

Checked by

M.B. / [Signature]

Date

12/07/2021  
12/8/21

<b>ORNL</b> PACKAGE TESTING PROGRAM OAK RIDGE NATIONAL LABORATORY OAK RIDGE, TENNESSEE 37831 <small>The OFFICIAL COPY of this document is the on-line version. Before using a printed copy, verify that it is the most current version by checking the Revision ID against the on-line version</small>	Operating Procedure for <b>HAC 0.9 Meter Immersion Test -          Testing of Radioactive Material          Packages</b>	Test Procedure: <b>PTP-PEF-14</b>	Rev. <b>5 CN 2</b>
		Page: <b>6 / 6</b>	Issue Date: <b>12-14-20</b>
		Revision Date: <b>1-03-20</b>	Review By Date: <b>12-14-23</b>

## 7. Data Sheet

Test Plan: <b>ORNL/NTRC-092.0</b>	Test Unit: <b>3</b>
--------------------------------------	------------------------

VERIFIED

TASK

- ✓ M&TE ID **A006327** Calibration due date **3/30/2023** (§4.1).
- ✓ Intended attitude of the test unit in tank (e.g. on side) **on side** (§4.4)
- ✓ Depth of water above the test unit **41 in** Measuring device **A006327** due **3/20/2021** (§4.6)
- ✓ Start Date and Time of Immersion Test: **12/07/2021 @ 3:50pm** (§4.7)
- ✓ Water temperature: **70.5°F** °C ( **20.5** °F) Measuring device **A006681** due **05/12/2022** (§4.6)
- ✓ Ambient temperature: **58.7°F** °C ( **15.0** °F) Measuring device **A006681** due **5/12/2022** (§4.8)
- ✓ End Date and Time of Immersion Test: **12/08/2021 @ 09:15 am** (§4.8)
- ✓ Water temperature: **70.5°F** °C ( **20.5** °F) Measuring device **A006681** due **5/12/2022** (§4.8)
- ✓ Ambient temperature: **60.7°F** °C ( **16.0** °F) Measuring device **A006681** due **5/12/2022** (§4.8)
- ✓ Detected in-leakage of water: (YES/NO) **NO** (§4.10)
- ✓ Detected structural damage: (YES/NO) **NO** (§4.10)

Testing Damage Observations:

Comments:

I certify that the above tasks have been performed and that the observations and comments are correct.

Test Engineer

**Ross Whittaker**

Date

**12/07/2021**

Checked by

**MB Houston**

Date

**12/07/2021**

**MBH 12/08/2021**

**12/8/21**

**Pyan Jaha**

**12/8/21**

**MBH 12/08/2021**

# TEST FORM 12 –CV DRYING PROCEDURE

Test Plan – DPP-1

TU- 3

VERIFIED

TASK

- ☒ ORNL will remove the CV's from the immersion tank after a minimum of 8 hours.
- ☒ The CV's will be placed on the worktable in a vertical position.
- ☒ A shop vac will be used to blow out any water out of the CV flanges.
- ☒ The external surface of the CV will be dried with cloth and paper towels.
- ☒ ORNL will attach a vacuum to the CV flange O-ring port and supply a vacuum to remove most of the water between the inner and outer O-rings.
- ☒ After about 1 hour of air drying under forced hot air convection, an air compressor or compressed air can, or shop air will be used to blow out any water left in between the CV O-rings.
- ☒ The CV bolts will be loosened and removed, and the breakaway torque will be recorded on Test Form 9.
- ☒ The CV top lid will be lifted about a 1/8<sup>th</sup> -in and cloth and paper towels will be used to wipe the surfaces of the internal CV flanges outboard of the outer O-ring.
- ☒ A visual inspection of the internal surface of the CV flange will be done.
- ☒ ORNL and CNS will verify that water droplets are not visible on the inside of the Inner O-ring.
- ☒ After CNS approval, the CV lid will be completely removed from the CV base.

Comments:

I certify that the above tasks have been performed and that the observations and comments are correct.

Testing Technician

CNS-Y-12 STR

12/08/2021

Date

12/8/21

Date

M.B. Houston

Witness

CNS-Y-12 QE

12/08/2021

Date

12/8/21

Date

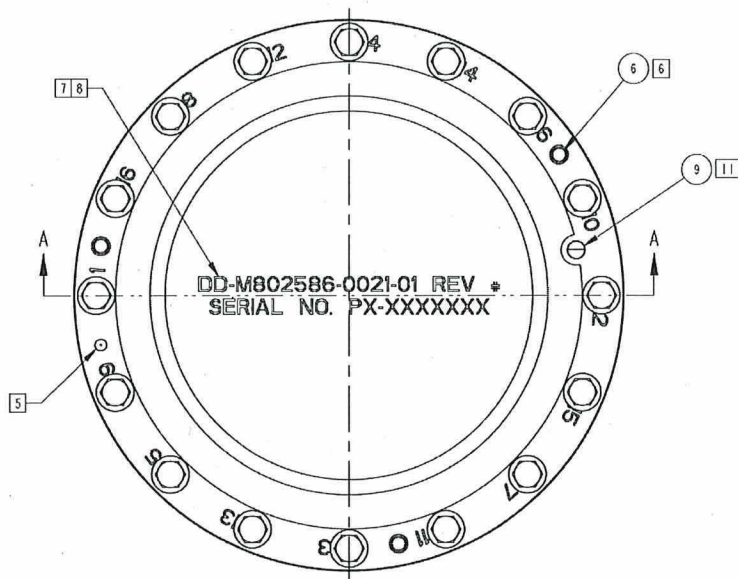
\*All photographs/movies will be uniquely identified with test unit, date and time to ensure that the proper sequence can be reconstructed



# TEST FORM 9 –CV LID DISASSEMBLY

Test Plan – DPP-1

TU- 3



DPP-1 CV Lid Disassembly	
Bolt #	Torque Removal (ft-lbs.)
1	29.7
2	26.9
3	29.9
4	32.0
5	30.7
6	23.9
7	25.2
8	30.3
9	29.0
10	25.8
11	28.6
12	27.4
13	26.7
14	25.6
15	25.5
16	35.5

M&TE ID #: A001096 Calibration Due Date: 2/10/2022

M&TE ID #: \_\_\_\_\_ Calibration Due Date: \_\_\_\_\_

Comments: No Condensation inside CV. No water on the inside of the  
Inner O-ring.  
Lid opened @ 11:10 am.

I certify that the above tasks have been performed and that the observations and comments are correct.

[Signature]  
 Testing Technician  
Ross Whittaker  
 CNS-Y-12 STR

12-08-2021  
 Date  
12/8/21  
 Date

[Signature]  
 Witness  
[Signature]  
 CNS-Y-12 QE

12-08-2021  
 Date  
12/8/21  
 Date

\*All photographs/movies will be uniquely identified with test unit, date and time to ensure that the proper sequence can be reconstructed

# TEST FORM 6 - TEMPERATURE INDICATOR READINGS

Test Plan DPP-1

TU 3

A visual inspection of each temperature indicator on the package consisting of those indicators inside the CV, outside the CV, and on the drum-liner will be made. The values of the blackouts that occurred will be recorded below.

TEMPERATURE INDICATOR NUMBER LOCATION CHART									
TEST CONTENT ASSEMBLY (TL-10-105, TL-10-190)									
Location (outside)	0°		90°		180°		270°		
Top end cap center	1	200 °F	2	200 °F	3	200 °F	4	200 °F	
Top end cap under flange	5	200 °F	6	200 °F	7	200 °F	8	200 °F	
Tube upper	9	200 °F	10	200 °F	11	200 °F	12	200 °F	
Tube middle	13	200 °F	14	200 °F	15	200 °F	16	200 °F	
Tube lower	17	190 °F	18	190 °F	19	190 °F	20	190 °F	
Bottom end cap under flange	21	190 °F	22	190 °F	23	190 °F	24	190 °F	
Bottom end cap center	25	180 °F	26	190 °F	27	180 °F	28	190 °F	
Weight upper	29	190 °F	30	190 °F	31	190 °F	32	190 °F	
Weight lower	33	190 °F	34	190 °F	35	190 °F	36	190 °F	
INTERIOR OF THE CV (TL-10-105, TL-10-190)									
CV lid center	37	210 °F	38	210 °F	39	210 °F	40	210 °F	
CV body flange	41	200 °F	42	210 °F	43	210 °F	44	210 °F	
CV wall upper	45	200 °F	46	210 °F	47	210 °F	48	210 °F	
CV wall middle	49	200 °F	50	200 °F	51	210 °F	52	200 °F	
CV wall lower	53	200 °F	54	200 °F	55	200 °F	56	200 °F	
CV base neck	57	190 °F	58	190 °F	59	200 °F	60	190 °F	
CV base center	61	190 °F	62	190 °F	63	190 °F	64	190 °F	
EXTERIOR OF THE CV (TL-10-105, TL-10-190)									
Lid center	65	210 °F	66	210 °F	67	210 °F	68	210 °F	
Lid flange	69	210 °F	70	210 °F	71	220 °F	72	210 °F	
Body flange	73	210 °F	74	210 °F	75	220 °F	76	210 °F	
Base neck	77	200 °F	78	200 °F	79	200 °F	80	200 °F	
Base toe	81	190 °F	82	190 °F	83	200 °F	84	190 °F	
DRUM ASSEMBLY (TL-10-190, TL-10-290)									
Lid bottom	85	230 °F	86	230 °F	87	230 °F	88	230 °F	
Cavity wall upper	89	230 °F	90	230 °F	91	240 °F	92	240 °F	
Cavity wall middle	93	230 °F	94	230 °F	95	240 °F	96	240 °F	
Cavity wall lower	97	240 °F	98	230 °F	99	240 °F	100	240 °F	
Cavity wall lowest	101	230 °F	102	220 °F	103	230 °F	104	220 °F	
Cavity bottom	105	210 °F	106	210 °F	107	200 °F	108	200 °F	

Comments:

I certify that the above tasks have been performed and that the observations and comments are correct.

Testing Technician

Date

Witness

Date

Ross Whittenburg  
CNS-Y-12 STR

12/8/21  
Date

M B Hunter  
CNS-Y-12 QE

12/8/21  
Date

\*All photographs/movies will be uniquely identified with test unit, date and time to ensure that the proper sequence can be reconstructed



# TEST FORM 15 -WITNESS AND HOLD POINTS

Test Plan DPP-1

TU -3

The following applicable CNS hold points activities shall not start until written approval to proceed has been given from the CNS STR via e-mail. Additional hold points may be included when CNS reviews the approval data documents and as the work is being performed. The purpose of each hold point is to give the TA, STR, and QE an opportunity to (1) evaluate what has happened since the previous hold point, (2) evaluate previous lessons learned on the activities that follow, and (3) make an informed decision to proceed.

NO.	DESCRIPTION	TU NO.	TYPE	CNS INITIAL
1	<u>Initial package disassembly</u> Witness the disassembly, can be waived by a DA representative	1,2,3,4,5,6, 7	Witness, Hold	RW RF
2	<u>pre-test operational leakage rate test</u> Witness the pre-test operational leakage rate test per ANSI N14.5, section 7.6, after final closure (and before commencing testing sequence)	1,2,3,4,5,6, 7	Witness, Hold	
2.1	<u>pre-test operational leakage rate test acceptance</u> Inspection to verify the pre-test operational leakage rate test has met acceptance criteria <b>Subsequent reassembly sequence shall not commence until acceptable result is produced.</b>	1,2,3,4,5,6, 7	Hold	
3	<u>Initial package reassembly</u> Witness the reassembly of the contents, CV, vibration pads, drum lid, instrumentation, and all associated fastening hardware	1,2,3,4,5,6, 7	Witness	
3.1	<u>Initial Package Reassembly</u> Inspection and observation to verify the reassembly procedure has been followed according to supplied direction. <b>Subsequent testing sequence shall not commence until reassembly steps have been confirmed as acceptable.</b>	1,2,3,4,5,6, 7	Hold	
4	<u>NCT vibration/shock test</u> Witness the NCT vibration/shock testing activities, including all preliminary setup, can be waived by a DA representative	6	Witness	
5	<u>NCT thermal pre-treatment</u> Witness the NCT thermal pre-treatment activities, including all preliminary setup, can be waived by a DA representative	1,2,3,4,5,6	Witness	
6	<u>NCT water spray test</u> Witness the NCT water spray test activities, including all preliminary setup, can be waived by a DA representative	2,3,4,6	Witness, Hold	
7	<u>NCT free drop (4 ft) test</u> Witness the NCT free drop (4 ft) test activities, including all preliminary setup, can be waived by a DA representative	1,2,3,4,5,6	Witness	
7.1	<u>NCT free drop (4 ft) test, critical parameters</u> Inspection to verify the critical parameters defining the NCT free drop (4 ft) test meet all requirements <b>Completion of NCT free drop (4 ft) test shall not commence until all critical parameters have been verified.</b>	1,2,3,4,5,6	Hold	



8	<u>NCT penetration test</u> Witness the NCT penetration test activities, including all preliminary setup, can be waived by a DA representative	6	Witness	RW	RF
8.1	<u>NCT penetration test, critical parameters</u> Inspection to verify the critical parameters defining the NCT penetration test meet all requirements	6	Hold		
	<b>Completion of NCT penetration test shall not commence until all critical parameters have been verified.</b>				
9	<u>NCT compression test</u> Witness the NCT compression test activities, including all preliminary setup, can be waived by a DA representative	6	Witness		
9.1	<u>NCT compression test, critical parameters</u> Inspection to verify the critical parameters defining the NCT compression test meet all requirements	6	Hold		
	<b>Completion of NCT compression test shall not commence until all critical parameters have been verified.</b>				
10	<u>HAC thermal pre-treatment</u> Witness the HAC thermal pre-treatment activities, including all preliminary setup, can be waived by a DA representative	1,5	Witness		
11	<u>HAC free drop (30 ft) test</u> Witness the HAC free drop (30 ft) test activities, including all preliminary setup, can be waived by a DA representative	1,2,3,4,5,6	Witness		
11.1	<u>HAC free drop (30 ft) test, critical parameters</u> Inspection to verify the critical parameters defining the HAC free drop (30 ft) test meet all requirements	1,2,3,4,5,6	Hold		
	<b>Completion of HAC free drop (30 ft) test shall not commence until all critical parameters have been verified.</b>				
11.2	<u>HAC free drop (30 ft) test, damage determination</u> Inspection to verify that the damage inflicted during the HAC free drop (30 ft) test is as expected, if unexpected damage is present, modifications to the subsequent HAC Crush (30 ft) test will be defined	1,2,3,4,5,6	Hold		
	<b>Testing shall not commence until new specification of HAC Crush (30 ft) test has been agreed-upon and adopted by the TA.</b>				
12	<u>HAC crush (30 ft) test</u> Witness the HAC crush (30 ft) test activities, including all preliminary setup, can be waived by a DA representative	1,2,3,4,5,6	Witness		
12.1	<u>HAC crush (30 ft) test, critical parameters</u> Inspection to verify the critical parameters defining the HAC crush (30 ft) test meet all requirements	1,2,3,4,5,6	Hold		
	<b>Completion of HAC crush (30 ft) test shall not commence until all critical parameters have been verified.</b>				
12.2	<u>HAC crush (30 ft) test, damage determination</u> Inspection to verify that the damage inflicted during the HAC crush (30 ft) test is as expected, if unexpected damage is present, modifications to the subsequent HAC Puncture drop (40 in.) test will be defined	1,2,3,4,5,6	Hold		
	<b>Testing shall not commence until new specification of HAC Puncture drop (40 in.) test has been agreed-upon and adopted by the TA.</b>				

13	<u>HAC Puncture drop (40 in.) test</u> Witness the HAC Puncture drop (40 in.) test activities, including all preliminary setup, can be waived by a DA representative	1,2,3,4,5,6	Witness	RW	RF
13.1	<u>HAC Puncture drop (40 in.) test, critical parameters</u> Inspection to verify the critical parameters defining the HAC Puncture drop (40 in.) test meet all requirements  <b>Completion of HAC Puncture drop (40 in.) test shall not commence until all critical parameters have been verified.</b>	1,2,3,4,5,6	Hold		
NO.	DESCRIPTION	TU NO.	TYPE	CNS INITIAL	
14	<u>Thermal test, data collection hardware</u> Inspection to verify that all the thermocouple and hardware has been installed, or configured as specified and is operating correctly  <b>Completion of supplementary thermal test shall not commence until hardware installation has been verified.</b>	1,2,3,4,5,6	Hold		
15	<u>HAC thermal test</u> Witness the HAC thermal test activities, including all preliminary setup, can be waived by a DA representative	1,2,3,4,5,6	Witness		
15	<u>Overpack Inspection and Disassembly</u> Witness the overpack inspection and disassembly process. including all preliminary setup, can be waived by a DA representative	1,2,3,4,5,6	Witness		
16	<u>Overpack Inspection and Disassembly</u> Inspection to verify that sufficient data and measurements have been collected from overpack and CV prior to drilling and tapping the CV lid for post-test leakage rate measurements  <b>Post-test leakage rate activities, including all preliminary setup, shall not commence until hardware installation has been verified.</b>	1,2,3,4,5,6	Hold		
17	<u>post-test operational leakage rate test</u> Witness the post-test operational leakage rate test per ANSI N14.5, section 7.6, after completion of test activities (and before post-test full-boundary leakage rate test)	1,2,3,4,5,6	Witness		
18	<u>post-test full-boundary leakage rate test, drilling and tapping test port in CV lid</u> Witness the drilling and tapping of the leakage rate test port in the CV lid, after removal from the overpack assembly (and before completion of testing sequence)	1,2,3,4,5,6	Witness		
19	<u>post-test full-boundary leakage rate test</u> Witness the post-test full-boundary leakage rate test per ANSI N14.5, Section 7.5 This includes the sealing of the drilled and tapped hole in the CV lid after the leak rate measurements have completed	1,2,3,4,5,6	Witness		
19.1	<u>Final containment vessel leakage rate test acceptance</u> Inspection to verify the "post-test" leakage rate test has met acceptance criteria  <b>HAC immersion tests shall not commence until results are confirmed.</b>	1,2,3,4,5,6	Hold		

20	<u>HAC immersion test, fissile material packages</u> Witness the HAC immersion test, fissile material packages, activities, including preliminary setup, can be waived by a DA representative	1,2,3,4,5,6	Witness	RW	RF
21	<u>HAC immersion test, all packages (undamaged)</u> Witness the HAC immersion test, all packages (undamaged), activities, including preliminary setup, can be waived by a DA representative	7	Witness		
22	<u>Opening containment vessel after HAC immersion test</u> Witness the opening of the containment vessel and inspection for 7 retained moisture within the containment vessel cavity, including preliminary setup and verification that the external surface is complete dry, can be waived by a DA representative	1,2,3,4,5,6, 7	Witness		
NO.	DESCRIPTION	TU NO.	TYPE	CNS INITIAL	
23	<u>Final external inspection results</u> Inspection of all external inspection results, to verify all specified dimensional and photographic records have been obtained, these records cannot be confirmed after the overpack assembly has been cut-open and so must be confirmed at this point  <b>Disassembly and cross section examination shall not commence until all external inspections have been completed and all necessary records have been collected. (if required)</b>	1,2,3,4,5,6, 7	Hold		
24	<u>Disassembly and cross section inspection</u> Witness the cutting, disassembly, and dissection of the overpack assembly (if required)	1,2,3,4,5,6, 7	Witness		
25	<u>Final cross section inspection results (if required)</u> Inspection of all cross-section inspection results, to verify all specified dimensional and photographic records have been obtained  <b>Completion of final data report shall not commence until all cross-section inspections have been completed and all necessary records have been collected. (if required)</b>	1,2,3,4,5,6, 7	Hold		
26	<u>Preliminary data package</u> Inspection of all preliminary test results, including data collected, photos and videos captured, and dimensions measured  <b>Shipment or disposal (as defined by the DA) of TU shall not commence until the preliminary data package has been reviewed and determined to be complete.</b>	1,2,3,4,5,6, 7	Hold		

Comments:

I certify that the above tasks have been performed and that the observations and comments are correct.

Testing Technician

*Ross Whittall*  
CNS-Y-12 STR

*12/13/2021*  
Date

*12/8/21*  
Date

Witness

*M.B. Houston*  
CNS-Y-12 QE

*12/13/2021*  
Date

*12/13/21*  
Date

\*All photographs/movies will be uniquely identified with test unit, date and time to ensure that the proper sequence can be reconstructed



✓	<ul style="list-style-type: none"> <li>—Close-up views of package after test, showing any particular damage induced as a result of the NCT compression test, including evidence of bulging/buckling of the drum, bending/buckling of the drum bolt guard, and crushing/buckling of the fork pockets</li> </ul>
✓	<p>HAC free drop (30 ft) tests: (check as performed)</p> <ul style="list-style-type: none"> <li>— Close-up views of package before test, showing intended point of initial impact</li> <li>— Test arrangement with package before test, showing the intended offset angle</li> <li>— Test arrangement with package before test, showing the intended drop height</li> <li>— Test arrangement with package after test, showing damaged package at final resting place</li> <li>— Close-up views of package after test, showing particular damage induced as a result of the HAC free drop (30 ft) test, including appropriate dimensional references</li> <li>— Close-up views of package after test, showing unexpected damage (if any), due to primary impact or any subsequent event</li> </ul>
✓	<p>HAC crush (30 ft) tests: (check as performed)</p> <ul style="list-style-type: none"> <li>— Close-up views of package before test, showing intended point of initial impact</li> <li>— Test arrangement with package before test, showing the intended offset angle</li> <li>— Test arrangement with package before test, showing the intended drop height</li> <li>— Test arrangement with package after test, showing damaged package at final resting place</li> <li>— Close-up views of package after test, showing particular damage induced as a result of the HAC crush (30 ft) test, including appropriate dimensional references</li> <li>— Close-up views of package after test, showing unexpected damage (if any), due to primary impact or any subsequent event</li> </ul>
✓	<p>HAC Puncture drop (40 in.) tests:</p> <ul style="list-style-type: none"> <li>—Close-up views of package before test, showing intended point of initial impact</li> <li>—Test arrangement with package before test, showing the intended offset angle</li> <li>—Test arrangement with package before test, showing the intended drop height</li> <li>—Test arrangement with package after test, showing damaged package at final resting place</li> <li>—Close-up views of package after test, showing particular damage induced as a result of the HAC puncture (1 m (40 in)) test, including appropriate dimensional references</li> <li>—Close-up views of package after test, showing unexpected damage (if any), due to primary impact or any subsequent event</li> </ul>
✓	<p>Supplementary and HAC thermal tests:</p> <ul style="list-style-type: none"> <li>—Views of relative spacing inside the furnace with door/trap open, with or without the package used as a dimensional point of reference, at hot or cold condition</li> <li>—Test arrangement with package before test, showing placement of thermocouple attachments on the package exterior surface</li> <li>—Test arrangement with package after test, showing damaged/burned package after initial removal from the furnace/fire</li> <li>—Close-up views of package after test, showing any excessively damaged/burned parts (if any)</li> </ul>
✓	<p>HAC immersion-fissile material tests:</p> <ul style="list-style-type: none"> <li>— Test arrangement with CV before test, showing placement of the CV within the tank</li> <li>— Test arrangement with CV during test, showing measurement of submerged depth of CV below water line</li> <li>— Close-up views of CV after test, after removal of the CV lid, showing evidence of water ingress (if any)</li> </ul>
✓	<p>HAC immersion- 10CFR71(c)(6) package tests</p> <ul style="list-style-type: none"> <li>— Test arrangement with CV before test, showing placement of the CV within the tank or hydraulic pressure chamber</li> <li>— Test arrangement with CV during test, showing measurement of submerged depth of CV below water line (or, if a hydraulic pressure chamber is being used, the internal pressure read-out as indicated by the hydraulic control system or in-line pressure gauge)</li> <li>— Close-up views of CV after test, after removal of the CV lid, showing evidence of water ingress (if any)</li> </ul>

# TEST FORM 16 -PHOTOGRAPHY/VIDEO CHECKLIST

Test Plan DPP-1

CTU -3

At a minimum, the following events shall be captured by photography. If necessary, photos shall be taken from multiple perspectives to provide a clear understanding of the event being captured. Date and time will be stamped on all photographs.

## VERIFIED

## TASK

✓	Overpack assembly, containment vessel, and vibration pads after taking delivery and during disassembly
✓	Overpack assembly, containment vessel, and vibration pads (where applicable) during reassembly
✓	Drop testing pad, including appropriate dimensional references
✓	Puncture bar installed onto drop pad, including appropriate dimensional reference
✓	Penetration bar, including appropriate dimensional references
✓	Equipment, instrumentation, and general arrangement used for vibration/shock tests
✓	Equipment, instrumentation, and general arrangement used for free and Puncture drop tests
✓	Equipment, instrumentation, and general arrangement used for water spray tests
✓	Pre-test leakage rate tests: — Close-up views of CV before test, showing connection for CV lid leakage rate test port — Close-up views of CV during test, showing connections made to CV lid leakage rate test port — Test arrangement with CV during test, showing all connections made to CV
✓	NCT vibration/shock tests: — Test arrangement with the package installed onto the expander head or slip table — Attachment of tie-down chains or straps to top of package — Attachment of tie-down chains or straps to expander head or slip table
✓	NCT water spray tests: — Test arrangement with package before test, showing relative placement of water spray nozzles with respect to the package — Test arrangement with package during test, showing how the water is hitting the package — Test arrangement with package after test, showing evidence of water pooling or accumulation, if any — Rain gauge showing minimum allowable rainfall has been reached
✓	NCT free drop (4 ft) tests: — Test arrangement with package before test, showing the intended offset angle — Test arrangement with package before test, showing the intended drop height — Test arrangement with package after test, showing damaged package at final resting place — Close-up views of package after test, showing particular damage induced as a result of the NCT free drop (4 ft) test, including appropriate dimensional references
✓	NCT penetration tests: — Close-up views of package before test, showing intended point of impact — Test arrangement with package before test, showing supports and restraints that hold the package in place — Test arrangement with package before test, showing position and height of penetration bar, with respect to the package — Test arrangement with package after test, showing damaged package after penetration bar has made impact — Close-up views of package after test, showing particular damage induced as a result of the NCT penetration test, including appropriate dimensional references
✓	NCT compression tests: — If a compression tester machine is being used • The relative arrangement of the package within the machine • The force read-out as indicated by the machine control system — Test arrangement with package during test, showing weight having been applied to the package — Test arrangement with package after test, showing damaged package after weight has been removed (if any)



✓	<p>Post-test leakage rate tests:</p> <ul style="list-style-type: none"> <li>– Close-up views of CV before test, showing drilled/tapped connection for CV lid leakage rate test port</li> <li>– Close-up views of CV during test, showing connections made to CV lid leakage rate test port</li> <li>– Test arrangement with CV during test, showing all connections made to CV</li> </ul>
✓	<p>Initial teardown and inspection:</p> <ul style="list-style-type: none"> <li>– Close-up views of CV after removal from overpack assembly, showing any superficial and structural damage due to interaction with overpack assembly during test sequence (if any), including appropriate dimensional references ( cursory examination only)</li> <li>– Close-up views of all thermal temperature indicators, showing temperatures indicated and evidence of stretching/tearing (if any), including appropriate dimensional references</li> <li>– Close-up views of overpack assembly after removal of CV, showing any superficial and structural damage due to interaction with CV or drum lid during test sequence (if any), including appropriate dimensional references</li> <li>– Close-up views of drum lid after removal from overpack assembly, showing any superficial and structural damage due to interaction with the CV or overpack assembly, including appropriate dimensional references</li> </ul>
✓	<p>Final teardown and inspection:</p> <ul style="list-style-type: none"> <li>– Close-up views of the CV, showing superficial and structural damage to ANY component, internal and external surfaces (if any), including appropriate dimensional references (detailed examination)</li> <li>– Close-up views of components within the CV, showing superficial and structural damage to ANY component, internal and external surfaces (if any), including appropriate dimensional references (detailed examination)</li> <li>– Markings on the surfaces of the overpack assembly and drum lid, showing the intended cross section cuts, including appropriate dimensional references (if requires)</li> <li>– Overall views of overpack assembly and drum lid after cross section cuts have been made (if required)</li> <li>– Close-up views of overpack assembly and drum lid after cross section cuts have been made, showing damage to internal components, including the following: (if required) <ul style="list-style-type: none"> <li>• Extent of burned/charred or disintegrated impact-limiting foam</li> <li>• Extent of disintegration, cracking, or separation of impact-limiting block</li> <li>• Extent of damage to thermal insulating blanket and indication of total radial thickness</li> <li>• Relative dimensional changes of structural components (including but not limited to drum liner assembly, perforated ring, drum lid inner section)</li> <li>• Any cracked welds</li> <li>• Any scratched, dented, or stretched sheet metal</li> </ul> </li> </ul>

Comments:

I certify that the above tasks have been performed and that the observations and comments are correct.

  
Testing Technician  
  
CNS-Y-12 STR

12/13/2021  
Date  
12/8/21  
Date

  
Witness  
  
CNS-Y-12 QE

12/13/2021  
Date  
12/15/21  
Date

\*All photographs/movies will be uniquely identified with test unit, date and time to ensure that the proper sequence can be reconstructed



## **K. APPENDIX TU-4 FORMS**

# TEST FORM 1 - COMPONENT WEIGHTS

Test Plan DPP-1

TU 4

Part Name	Initial Assembly	Post Thermal, Full Disassembly
	Weight (lbs.)	Weight (lbs.)
CV body	181	181
CV lid, screws, washers, and O-rings (together)	73	73
Test fixture weldment, screws, washers, nuts, bushing (together)	49	48
Test weight sets	66	66
PCC pad sets	15	15
CV assembly with test content (during reassembly)	384	384
Drum body	381	378
Drum lid assembly, screws, and washers (together)	103	103
CV base pad and CV flange wedge (together)	5	5
Test unit (TU) assembly	874	870

CV weight b/4 immersion: 384 Lb.  
EQUIPMENT CV weight after immersion: 384 Lb.  
Less than 10 pounds

10 lbs to 2000 lbs

Scale: N/A Expiration Date: N/A

Scale: X502322 Expiration Date: 2/17/2022

Comments:

I certify that the above tasks have been performed and that the observations and comments are correct.

  
 Testing Technician

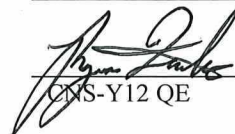
12-09-2021  
 Date

M.B. Houston  
 Witness

12-09-2021  
 Date

  
 CNS-Y12 STR

12/9/21  
 Date

  
 CNS-Y12 QE

12/9/21  
 Date

# TEST FORM 2 - ASSEMBLY OF THE CV

Test Plan DPP-1

TU 4

VERIFIED

TASK

✓ RW 9/9/21  
RF 9/9/21 **HOLD POINT:** All payload components have been visually inspected, and Y-12 deems the shipping package acceptable for disassembly.

✓ Verify and/or mark all components: content assembly, CV assembly, and drum assembly components with the corresponding test unit ID, axial lines, and impact targets symbols. Figure 4-1 - Figure 4-4.

✓ Temperature labels have been affixed to the surface of the CV as shown in Figure 5-1, Figure 5-2.

✓ None of the temperature indicators indicate exposure to a temperature in the measured range.

✓ The CV body, CV lid, washers, and bolts were weighed and recorded in TEST FORM 1

✓ RW 9/9/21  
RF 9/9/21 **HOLD POINT:** Y-12 has approved the markings.

The following assembly applies to TUs test fixture weldment content assembly

✓ The surrogate test weight was weighed and recorded on TEST FORM 1 .

✓ The loading test fixture weldment content assembly components were weighed and recorded on TEST FORM 1 .

✓ Clean all surfaces with isopropyl alcohol and air dry

✓ Place the PCC pad (silicone rubber) into CV body.

✓ Place the test weight weldment into the CV body.

✓ Place the PCC pad (silicone rubber) into the CV body on top of the test fixture weldment assembly.

✓ RW 9/9/21  
RF 9/9/21 **HOLD POINT:** Y-12 witness torquing of test fixture fastener hex head screws, washers, top hat bushings, and locknuts. The test weight and bolting locations that establish the low and high CG locations are documented in Attachment A. The hex head screws and locknuts shall be torqued to  $25 \pm 2$  ft-lb.

✓ RW 9/9/21  
RF 9/9/21 **HOLD POINT:** Y-12 inspected the assembly of the non-test fixture weldment content assembly and verified weights

M&TE ID #: A001096 Calibration Due Date: 2/10/2022

Comments:

I certify that the above tasks have been performed and that the observations and comments are correct.

Testing Technician

Ross Whittenlanger  
CNS-Y-12 STR

09-09-2021  
Date

9/9/21  
Date

M.B. Houston  
Witness

Ryan Zabo  
CNS-Y-12 QE

09-09-2021  
Date

9/9/21  
Date



# TEST FORM 2 - ASSEMBLY OF THE CV

Test Plan DPP-1

TU 4

## All packages

☒ The CV O-rings and sealing surfaces have been inspected for defects and found acceptable.

☒ Clean all surfaces with isopropyl alcohol and air dry.

☒ The CV O-rings have been installed onto the CV body.

**Note:** Screws and O-rings shall not be replaced without CNS approval. If replacements are authorized, they shall be documented in the test report where the replacements occurred.

☒ The CV lid was lowered on the CV body and the CV screws shall be hand-tightened until the lid is in full contact with the flange, note that clamps may be used during this step. The CV screws shall be torqued in sequence following the numbers etched into the drum lid in three passes. first pass the screws shall be torqued to 19-21 ft-lb, during the second pass to 33-37 ft-lb, and during the third pass to 33-37 ft-lb. The final pass torque values shall be recorded.

Ambient temperature at closure is \_\_\_\_\_ °C (70 °F)

Measuring device A006681 Calibration Expiration Date 5/12/2022

☒ Record assembly torque on TEST FORM 11.

Torque wrench # A001096 Calibration Expiration Date 2/10/2022

HOLD POINT: Y-12 inspected the assembly and closure of CV assemblies and verified weights.

☒ The CV assembly has been weighed and the weight has been recorded on TEST FORM 1

☒ The CV assembly has been leak tested (pre-test operational) in accordance with Sect. 7.6 of ANSI N14.5-2014 using the "A.5.2 gas pressure rise" method described in Table A-1 of N14.5-2014 and ORNL procedure NDE 70 Rev. 7, PCMT.

HOLD POINT: Y-12 has reviewed the leak test and the installation of the acceleration sensor mounts.

☒ Photographs of the assembly have been taken\*.

## Comments:

At the request of Y-12 as documented in TPCR-006 [ORNL/NTRC-092]

CV-4 body & lid was swapped with CV-7 body & lid.

\* Original CV-4 body had indentation @ the inner ring-dowel pin intersection.

I certify that the above tasks have been performed and that the observations and comments are correct.

Testing Technician

Ron Whittle  
CNS-Y-12 STR

10-12-2021 MON 10-12-2021

10-08-2021

Date

10/12/21

Date

Witness

M.B. Houston  
CNS-Y-12 QE

10-12-2021

10-08-2021

Date

10/12/21

Date

\*All photographs/movies will be uniquely identified with test unit, date and time to ensure that the proper sequence can be reconstructed

# TEST FORM 3 - ASSEMBLY OF TEST PACKAGE

Test Plan DPP-1

TU- 4

VERIFIED

TASK

- ☒ Verify operational leak test is complete and form completed and tighten the CV lid leak test port plug per the following sequence: 1<sup>st</sup> pass hand tight, 2<sup>nd</sup> pass torque to 6-7 ft-lb.  
Torque wrench # A001320 Calibration Expiration Date 02-11-2022
- ☒ The exterior of the drum has been clearly marked "TU- 4" and record the drum serial number if applicable:
- ☒ Verify all exterior markings on the TU. If marks are not legible or inadequate, the TA will remark the TU. Mark the 0°, 90°, 180°, 270° locations on the Drum Lid, and the inner and outside walls of the drum with a permanent marker.
- ☒ Install temperature labels on the inside of the drum body as shown in Figure 5-3.
- ☒ Clean all surface of the drum body with isopropyl alcohol and let air dry.
- ☒ The drum body, drum lid, bolts, washers, pads, were weighed and recorded on TEST FORM 1.
- ☒ Place the lower CV base pad into the drum body.
- ☒ Place the CV assembly into the drum body.
- ☒ The CV assembly has been loaded into the drum with the 0° rotated and aligned with 0° line on the drum. Ensure temperature labels are not damaged.
- ☒ Place the CV flange wedge between the CV flange and the drum body.
- ☒ The drum lid has been loaded into the drum with the 0° rotated and aligned with the 0° location on the drum.
- ☒ If necessary, apply thread lubricant to the drum closure bolts.
- ☒ The drum lid has been closed using the same screws that were removed during disassembly. The screws shall be torqued in sequence following the numbers etched into the drum lid in two passes. First, the screws shall be torqued until the lid is in full contact with the flange. Second, the screws shall be torqued to 33-37 ft-lb. Record the assembled torque value on Test Form 10. **TPCR-04**  
Torque wrench #: A001096 Calibration Expiration Date: 02-10-2022
- ☒ The test package assembly has been weighed and the weight recorded on Test Form 1.
- ☒ Mount one (1) vibration accelerometer on the TU-6 drum lid center for NCT vibration monitoring according to the DPP-1 Accelerometer Mounting Procedure. Remove accelerometer after NCT Test. **TPCR-05**
- ☒ The accelerometer mounting blocks and restraint rings have been welded to the drum outer shell as specified in the DPP-1 Accelerometer Mounting Procedure. **TPCR-05**
- ☒ Install the accelerometers on TU-1, TU-2, TU-5, and TU-6 at the locations specified by the DPP-1 Accelerometer Mounting Procedure". **TPCR-05**
- ☒ The accelerometers were checked to ensure they were installed and functioning as intended after each installation. **HOLD POINT:** Y-12 has approval: CNS STR N/A 10/12/21, CNS QE \_\_\_\_\_
- ☒ Photographs of the assembly have been taken\*.

Comments:

I certify that the above tasks have been performed and that the observations and comments are correct.

Testing Technician

Date

Witness

Date

CNS-Y-12 STR

Date

CNS-Y-12 QE

Date

\*All photographs/movies will be uniquely identified with test unit, date and time to ensure that the proper sequence can be reconstructed.



# TEST FORM 7 –TEST UNIT DIMENSIONS

Test Plan – DPP-1

TU- 4

Initial Assembly ✓  
 Post 1.2-m Drop \_\_\_\_\_  
 Post 9-m Drop \_\_\_\_\_  
 Post Crush Test \_\_\_\_\_  
 Post 1-m Puncture Test \_\_\_\_\_

## Drum outer shell

	0°	90°	180°	270°
Height	43 <sup>3</sup> / <sub>16</sub>	43 <sup>3</sup> / <sub>16</sub>	43 <sup>5</sup> / <sub>16</sub>	43 <sup>3</sup> / <sub>16</sub>

DIAMETER	0° to 180°	90° to 270°
Top Surface	26 <sup>3</sup> / <sub>4</sub>	26 <sup>3</sup> / <sub>4</sub>
Top Rolling hoop	28 <sup>1</sup> / <sub>16</sub>	28 <sup>1</sup> / <sub>8</sub>
Center Rolling hoop	28 <sup>1</sup> / <sub>16</sub>	28 <sup>3</sup> / <sub>16</sub>
Bottom Rolling hoop	28 <sup>1</sup> / <sub>16</sub>	28 <sup>3</sup> / <sub>16</sub>
Bottom Surface	26 <sup>15</sup> / <sub>16</sub>	27

Location	Flats width @ 0°	Flats width @ 180°
Top Surface		
Top Rolling hoop		
Center Rolling hoop	N/A	N/A
Bottom Rolling hoop	N/A	N/A
Bottom Surface		

Sketch Drop Setup Here

N/A

Sketch Package Damage Here

N/A

M&TE ID #: A006327 Calibration Due Date: 3/20/2023

M&TE ID #: N/A Calibration Due Date: N/A

Comments: All dimensions are in inches.

I certify that the above tasks have been performed and that the observations and comments are correct.

[Signature]  
 Testing Technician  
Ros Wittenlauer  
 CNS-Y-12 STR

10-12-2021  
 Date  
10/12/21  
 Date

M.B. Hamilton  
 Witness  
[Signature]  
 CNS-Y-12 QE

10-12-2021  
 Date  
10/12/21  
 Date

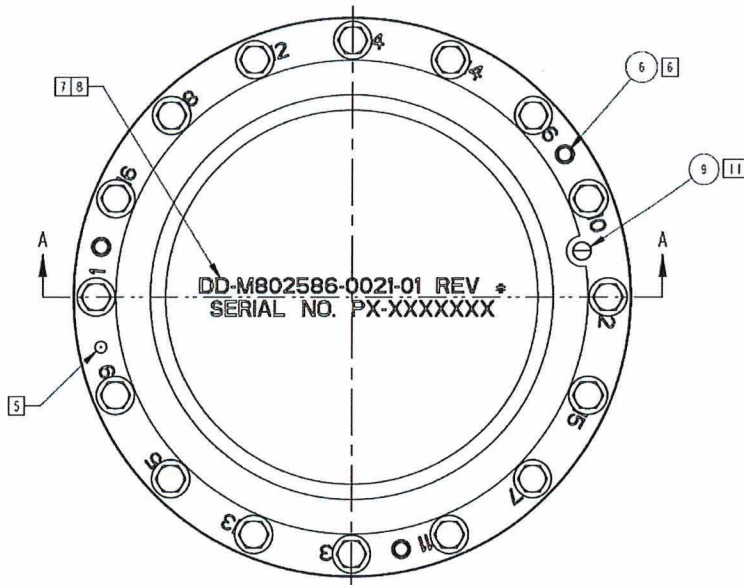
\*All photographs/movies will be uniquely identified with test unit, date and time to ensure that the proper sequence can be reconstructed



# TEST FORM 11 –CV LID ASSEMBLY

Test Plan – DPP-1

TU- 4



DPP-1 CV Lid Assembly	
Bolt #	Torque assembly (ft-lbs.)
1	34.9
2	35.0
3	34.9
4	34.6
5	35.4
6	35.4
7	35.3
8	35.0
9	35.3
10	35.2
11	34.8
12	35.6
13	35.3
14	35.5
15	34.8
16	35.4

M&TE ID #: A001096 Calibration Due Date: 2/10/2022

M&TE ID #: \_\_\_\_\_ Calibration Due Date: \_\_\_\_\_

Comments:

I certify that the above tasks have been performed and that the observations and comments are correct.

[Signature]  
Testing Technician  
Ross Witterdawn  
CNS-Y-12 STR

10-08-2021  
Date  
10/8/21  
Date

M.B. Hunter  
Witness  
[Signature]  
CNS-Y-12 QE

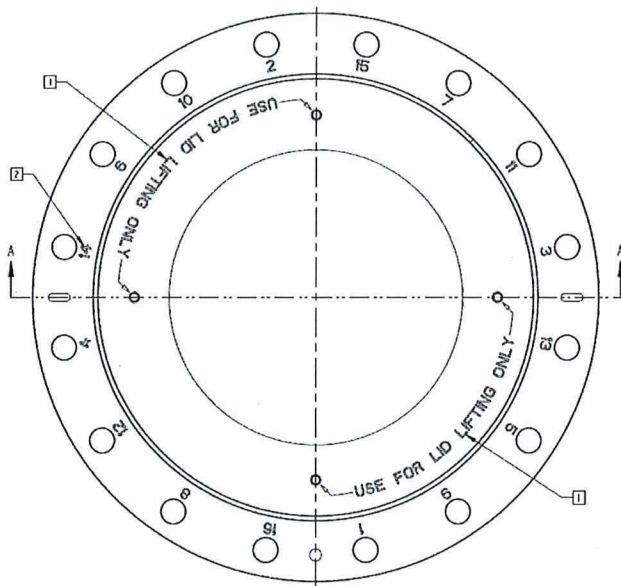
10-08-2021  
Date  
10/8/21  
Date

\*All photographs/movies will be uniquely identified with test unit, date and time to ensure that the proper sequence can be reconstructed

# TEST FORM 10 –DRUM LID ASSEMBLY

Test Plan – DPP-1

TU- 4



DPP-1 Drum Lid Assembly	
Bolt #	Torque assembly (ft-lbs.)
1	35.4
2	36.0
3	34.6
4	34.9
5	35.7
6	34.9
7	36.2
8	34.3
9	34.8
10	35.5
11	35.9
12	35.4
13	34.7
14	35.4
15	35.6
16	35.8

M&TE ID #: A001096 Calibration Due Date: 02/10/2022

M&TE ID #: A006681 Calibration Due Date: 05/12/2022 70.3°F  
MAN 10-12-2021

Comments:

I certify that the above tasks have been performed and that the observations and comments are correct.

Testing Technician

Ross W. Hutterley  
CNS-Y-12 STR

10-12-2021

Date

10/12/21

Date

Witness

M.B. Houston  
Jayna Fink  
CNS-Y-12 QE

10-12-2021

Date

10/13/21

Date

\*All photographs/movies will be uniquely identified with test unit, date and time to ensure that the proper sequence can be reconstructed

<b>ORNL</b> Package Testing Program OAK RIDGE NATIONAL LABORATORY OAK RIDGE, TENNESSEE 37831 <small>The OFFICIAL COPY of this document is the on-line version. Before using a printed copy, verify that it is the most current version by checking the Revision ID against the on-line version</small>	<b>Operating Procedure for          NCT Water Spray Test –          Testing of Radioactive Material          Packages</b>	Test Procedure:	Rev.
		<b>PTP-PEF-05</b>	<b>5-CN 2</b>
		Page:	Issue Date:
		5 / 6	12-14-20
		Revision Date:	Review by Date:
		12-01-20	12-14-20



## 6. Procedure Checklist

Test Plan: <b>ORNL/NTRC-092 R.0</b>	Test Unit: <b>4</b>
--	------------------------

VERIFIED	TASK
<input checked="" type="checkbox"/>	Water Spray apparatus has been assembled (§4.2).
<input checked="" type="checkbox"/>	Photographer's clipboard with package name and test unit number recorded (§4.2).
<input checked="" type="checkbox"/>	Test Unit placed properly in the water spray zone and spray function verified (§4.3).
<input checked="" type="checkbox"/>	Photograph of the test arrangement taken, documenting test unit identification (§4.3).
<input checked="" type="checkbox"/>	Place the rain gauge upright on the ground adjacent to the test specimen (§4.4).
<input checked="" type="checkbox"/>	Water spray has been started is spraying on the top and 4 sides, with a minimum rate of 2 in/hr (5 cm/hr) (§4.5).
<input checked="" type="checkbox"/>	Date and time of test has been recorded. (§4.5).
<input checked="" type="checkbox"/>	The ambient temperature has been recorded. (§4.6).
<input checked="" type="checkbox"/>	Water spray has been stopped after 1 hour, rain gauge reading has been recorded and any damage noted (§4.6).
<input checked="" type="checkbox"/>	End time of test has been recorded. (§4.6).
<input checked="" type="checkbox"/>	Photographs of the resulting damage (if any) were taken (§4.5).
<input checked="" type="checkbox"/>	Sign and date checklists (§4.7).

Comments:

I certify that the above tasks have been performed and that the observations and comments are correct.

 Test Engineer, <b>Ross Whittenberger</b>	<b>10-13-2021</b> Date <b>10/13/21</b>	<b>M. B. Hunter</b> Checked by 	<b>10-13-2021</b> Date <b>10/13/21</b>
--	--	---	--



<b>ORNL</b> Package Testing Program OAK RIDGE NATIONAL LABORATORY OAK RIDGE, TENNESSEE 37831 <small>The OFFICIAL COPY of this document is the on-line version. Before using a printed copy, verify that it is the most current version by checking the Revision ID against the on-line version</small>	<b>Operating Procedure for NCT Water Spray Test – Testing of Radioactive Material Packages</b>	Test Procedure:	Rev.
		<b>PTP-PEF-05</b>	<b>5-CN 2</b>
		Page:	Issue Date:
		6 / 6	12-14-20
		Revision Date:	Review by Date:
		12-01-20	12-14-20

## 7. Data Sheet

Test Plan: <u>ORNL/NTRC-092. R.0</u>	Test Unit: <u>4</u>
---	------------------------

VERIFIED

TASK

<u>✓</u>	Start Date and Time of Water Spray Test: <u>10/13/2021 @ 9:27 am.</u> (§4.5)
<u>✓</u>	End Date and Time of Water Spray Test: <u>10/13/2021 @ 10:32 am</u> (§4.6)
<u>✓</u>	Rain Gauge Reading: <u>(full) 5"</u> (§4.6)
<u>✓</u>	Ambient temperature: <u>67.7°F</u> (°C (°F))
	Measuring device: <u>A006681</u> (§4.6)

Testing Damage Observations: NONE.

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Comments: NONE.

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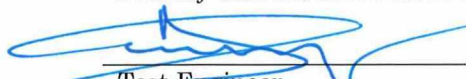


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I certify that the above tasks have been performed and that the observations and comments are correct.

	<u>10-13-2021</u>	<u>M.B. Hunter</u>	<u>10-13-2021</u>
Test Engineer	Date	Checked by	Date
<u>Peter Whittaker</u>	<u>10/13/21</u>	<u>[Signature]</u>	<u>10/13/21</u>

<b>ORNL</b> PACKAGE TESTING PROGRAM OAK RIDGE NATIONAL LABORATORY OAK RIDGE, TENNESSEE 37831 <small>The OFFICIAL COPY of this document is the on-line version. Before using a printed copy, verify that it is the most current version by checking the Revision ID against the on-line version</small>	<b>Operating Procedure for NCT Free Drop Test - Testing of Radioactive Material Packages</b>	Test Procedure:	Rev.
		<b>PTP-PEF-08</b>	<b>5 CN2</b>
		Page:	Issue Date:
		7 / 8	12-10-20
		Revision Date:	Review by Date:
		12-01-20	12-10-23

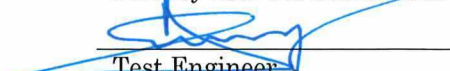
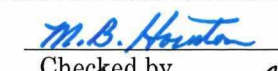
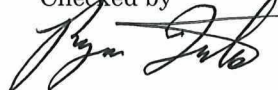
## 6. Procedure Checklist

Test Plan: <b>ORNL/NTRC-092 R.O</b>	Test Unit: <b>4</b>
--	------------------------

VERIFIED	TASK
<input checked="" type="checkbox"/>	Verify that any equipment used meets the M&TE meets PTP-QA-013 requirements (§4.1).
<input checked="" type="checkbox"/>	Water Spray Test (PTP-PRF-05) has been completed within 2 hours before Drop Test. (§4.4)
<input checked="" type="checkbox"/>	Have a photographer's clipboard with package name and test unit number. (§4.5)
<input checked="" type="checkbox"/>	Attitude of the rigged and raised test unit is set. (§4.6)
<input checked="" type="checkbox"/>	Photograph of the rigging arrangements has been taken. (§4.6)
<input checked="" type="checkbox"/>	Photograph of the measured drop angle has been taken. (§4.6)
<input checked="" type="checkbox"/>	The test unit has been raised to the designated drop height. (§4.7)
<input checked="" type="checkbox"/>	Photograph of the height measurement has been taken. (§4.7)
<input checked="" type="checkbox"/>	Video camera(s) are setup and running to take video of the drop. (§4.8)
<input checked="" type="checkbox"/>	The release mechanism has been plugged into power outlet. (§4.8)
<input checked="" type="checkbox"/>	Countdown, Release the test unit, unplug release mechanism. (§4.8)
<input checked="" type="checkbox"/>	Videos camera stopped. (§4.9)
<input checked="" type="checkbox"/>	Photographs of the resulting damage were taken. (§4.9)
<input checked="" type="checkbox"/>	Ambient temperature recorded. (§4.11)
<input checked="" type="checkbox"/>	Date and time of test recorded. (§4.11)
<input checked="" type="checkbox"/>	Sign and date checklist and data forms (§4.12).

Comments:

I certify that the above tasks have been performed and that the observations and comments are correct.

 Test Engineer <b>Ross Whittenlauer</b>	<b>10-13-2021</b> Date <b>10/13/21</b>	 Checked by 	<b>10-13-2021</b> Date <b>10/13/21</b>
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<b>ORNL</b> PACKAGE TESTING PROGRAM OAK RIDGE NATIONAL LABORATORY OAK RIDGE, TENNESSEE 37831 <small>The OFFICIAL COPY of this document is the on-line version. Before using a printed copy, verify that it is the most current version by checking the Revision ID against the on-line version</small>	Operating Procedure for <b>NCT Free Drop Test - Testing of          Radioactive Material Packages</b>	Test Procedure: <b>PTP-PEF-08</b>	Rev. <b>5 CN2</b>
		Page: 8 / 8	Issue Date: 12-10-20
		Revision Date: 12-01-20	Review by Date: 12-10-23

## 7. Data Sheet

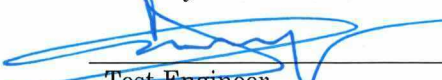
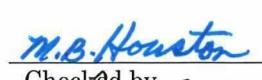
Test Plan: <b>ORNL/NTRC-092 R.O</b>	Test Unit: <b>4</b>
--	------------------------

VERIFIED	TASK
<input checked="" type="checkbox"/>	M&TE ID <b>A000885</b> Calibration due date <b>02-24-2026</b> (§4.1)
<input checked="" type="checkbox"/>	Water Spray Test (PTP-PRF-05) Time completed: <b>10:32am</b> . (§4.4)
<input checked="" type="checkbox"/>	Intended attitude and angle of the test unit <b>56.4°</b> . Tolerance $\pm 2^\circ$ . (§4.6)
<input checked="" type="checkbox"/>	Attitude Description: <b>4ft, CG OTC, lid facing down</b> (§4.6)
<input checked="" type="checkbox"/>	Measured attitude and angle of the test unit <b>55.1°</b> degrees. (§4.6)
<input checked="" type="checkbox"/>	Level number <b>M212348</b> Calibration Exp. Date <b>2/23/2022</b> (§4.6)
<input checked="" type="checkbox"/>	Height above the drop pad <b>4 ft</b> Measuring device <b>A000885</b> <b>due: 2/24/26</b> (§4.6)
<input checked="" type="checkbox"/>	Ambient temperature: <b>70.3°F</b> Measuring device <b>A006681</b> <b>due: 5/12/22</b> (§4.11)
<input checked="" type="checkbox"/>	Date and Time of Drop Test: <b>10/13/2021 @ 12:19pm</b> (§4.11)

Testing Damage Observations: **#4 bolt @ 0° orientation slightly bent, due to direct impact on drop pad.**

Comments: **NONE.**

I certify that the above tasks have been performed and that the observations and comments are correct.

 Test Engineer, <b>Ross Whittenlauer</b>	<b>10-13-2021</b> Date <b>10/13/21</b>	 Checked by <b>M.B. Houston</b>	<b>10-13-2021</b> Date <b>10/13/21</b>
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# TEST FORM 7 –TEST UNIT DIMENSIONS

Test Plan – DPP-1

TU- 4.

Initial Assembly  
Post 1.2-m Drop  
Post 9-m Drop  
Post Crush Test  
Post 1-m Puncture Test

✓  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

## Drum outer shell

	0°	90°	180°	270°
Height	43 <sup>5</sup> / <sub>16</sub>	43 <sup>1</sup> / <sub>16</sub>	43 <sup>1</sup> / <sub>4</sub>	43 <sup>1</sup> / <sub>4</sub>

DIAMETER	0° to 180°	90° to 270°
Top Surface	26 <sup>1</sup> / <sub>2</sub>	26 <sup>5</sup> / <sub>8</sub>
Top Rolling hoop	28	27 <sup>13</sup> / <sub>16</sub>
Center Rolling hoop	28	28 <sup>1</sup> / <sub>16</sub>
Bottom Rolling hoop	27 <sup>13</sup> / <sub>16</sub>	28 <sup>1</sup> / <sub>4</sub>
Bottom Surface	26 <sup>7</sup> / <sub>8</sub>	27 <sup>3</sup> / <sub>16</sub>

Location	Flats width @ 0°	Flats width @ 180°
Top Surface	N/A	N/A
Top Rolling hoop	2.041	N/A
Center Rolling hoop	2.539	N/A
Bottom Rolling hoop	4.329	N/A
Bottom Surface	N/A	N/A

Sketch Drop Setup Here

Sketch Package Damage Here

M&TE ID #: A006327 Calibration Due Date: 3/20/2023

M&TE ID #: N/A Calibration Due Date: N/A

Comments: Drum lid flat: deformed but no flat.

I certify that the above tasks have been performed and that the observations and comments are correct.

Testing Technician

Ross Whittlinger  
CNS-Y-12 STR

10-13-2021  
Date

10/13/21  
Date

M.B. Houston  
Witness

[Signature]  
CNS-Y-12 QE

10-13-2021  
Date

10/13/21  
Date

\*All photographs/movies will be uniquely identified with test unit, date and time to ensure that the proper sequence can be reconstructed

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		Page: <b>6 / 7</b>	Issue Date: <b>02-18-2021</b>
		Revision Date: <b>02-18-2021</b>	Review by Date: <b>02-18-2024</b>

## 6. Procedure Checklist

Test Plan:

*ORNL/NTRC-092 R.O*

Test Unit:

*4*

VERIFIED

TASK

- ☒ Verify that any equipment used meets the M&TE meets PTP-QA-013 requirements (§4.1).
- ☒ Have a photographer's clipboard with package name and test unit number. (§4.4)
- ☒ Attitude of the rigged test unit is set. (§4.5)
- ☒ Photograph of the rigging arrangements has been taken. (§4.5)
- ☒ Photograph of the measured drop angle has been taken. (§4.5)
- ☒ The test unit has been raised to the designated drop height. (§4.7)
- ☒ Photograph of the height measurement has been taken. (§4.7)
- ☒ Remove plumb bob from test specimen. (§4.7)
- ☒ Video camera(s) are setup and running to take video of the drop. (§4.8)
- ☒ The release mechanism has been plugged into power outlet. (§4.8)
- ☒ Countdown, Release the test unit, unplug release mechanism. (§4.8)
- ☒ Videos camera stopped. (§4.9)
- ☒ Date and time of test were recorded. (§4.10)
- ☒ The ambient temperature has been recorded. (§4.10)
- ☒ Photographs of the resulting damage were taken. (§4.11)
- ☒ Sign and date checklist and data forms (§4.12).

Comments:

I certify that the above tasks have been performed and that the observations and comments are correct.

Testing Technician

*Ross Whittaker*  
Customer

*10-21-2021*

Date

*10/21/21*  
Date

Witness

*M.B. Houston*  
*[Signature]*  
Customer

*10-21-2021*

Date

*10/21/21*  
Date

<b>ORNL</b> PACKAGE TESTING PROGRAM OAK RIDGE NATIONAL LABORATORY OAK RIDGE, TENNESSEE 37831 <small>The OFFICIAL COPY of this document is the on-line version. Before using a printed copy, verify that it is the most current version by checking the Revision ID against the on-line version</small>	Operating Procedure for HAC Drop Test - Testing of Radioactive Material Packages	Test Procedure: <b>PTP-PEF-10</b>	Rev. <b>6 CN-3</b>
		Page: 7 / 7	Issue Date: 02-18-2021
		Revision Date: 02-18-2021	Review by Date: 02-18-2024

## 7. Data Sheet

Test Plan: ORNL/NTRC-092 R.O

Test Unit: 4

VERIFIED

TASK

☒ Intended attitude of the test unit 56.4° Tolerance  $\pm$  2° (§4.2)

☒ Attitude Description: Lid down, Corner drop @ 56.4° (§4.2)

☒ Measured attitude of the test unit 54.8° degrees. (§4.4)

☒ Level number M212348 Calibration Exp. Date 2/23/2022 (§4.4)

☒ Height above the drop pad 30ft Measuring device A006327 @ 5/12/2022 (§4.6)

☒ Date and Time of Drop Test: 10/21/2021 @ 5/12/2022 (§4.9) drop time: 9:09am

☒ Ambient temperature: 60.8°F (60.8 °F) mon 10/21/21

Measuring device A006681 (§4.9)

Testing Damage Observations: SEE T4-Y TEST FORM 7.

Comments:

I certify that the above tasks have been performed and that the observations and comments are correct.

Testing Technician

Pross Whittlinger  
Customer

10/21/2021  
Date

10/21/21  
Date

Witness

Customer

10/21/2021  
Date

10/21/21  
Date



# TEST FORM 7 –TEST UNIT DIMENSIONS

Test Plan – DPP-1

TU- 4

Initial Assembly  
Post 1.2-m Drop  
Post 9-m Drop  
Post Crush Test  
Post 1-m Puncture Test

\_\_\_\_\_  
\_\_\_\_\_  
✓  
\_\_\_\_\_  
\_\_\_\_\_

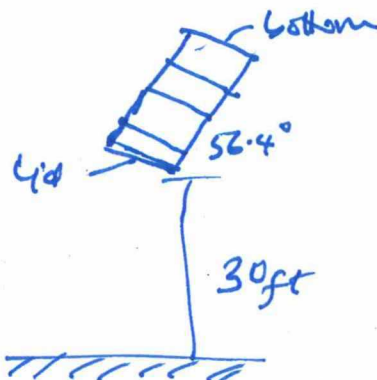
## Drum outer shell

	0°	90°	180°	270°
Height	42	43	43 3/8	43 3/16

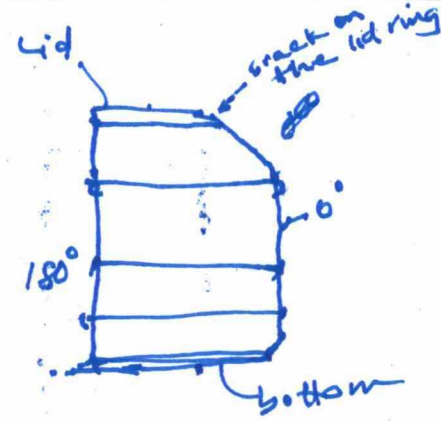
DIAMETER	0° to 180°	90° to 270°
Top Surface	26 1/4	26 3/4
Top Rolling hoop	28	28 1/8
Center Rolling hoop	27 15/16	28 3/16
Bottom Rolling hoop	27 7/8	28 1/4
Bottom Surface	26 3/4	27 1/4

Location	Flats width @ 0°	Flats width @ 180°
Top Surface	not accessible	2.625
Top Rolling hoop	2.088	4.435
Center Rolling hoop	2.575	—
Bottom Rolling hoop	4.341	—
Bottom Surface	7.304	—

Sketch Drop Setup Here



Sketch Package Damage Here



M&TE ID #: A001319 Calibration Due Date: 2/23/2022

M&TE ID #: N/A Calibration Due Date: N/A

Comments: Bolts #4, 12, & 14 has nick. TID link at 0° broken.  
Small crack on the lid ring.

I certify that the above tasks have been performed and that the observations and comments are correct.

[Signature]  
Testing Technician

10-22-2021  
Date

M.B. Houston  
Witness

10-22-2021  
Date

Ross Whittenburg  
CNS-Y-12 STR

10/22/21  
Date

[Signature]  
CNS-Y-12 QE

10/22/21  
Date

\*All photographs/movies will be uniquely identified with test unit, date and time to ensure that the proper sequence can be reconstructed

<b>ORNL</b> PACKAGE TESTING PROGRAM OAK RIDGE NATIONAL LABORATORY OAK RIDGE, TENNESSEE 37831 <small>The OFFICIAL COPY of this document is the on-line version. Before using a printed copy, verify that it is the most current version by checking the Revision ID against the on-line version</small>	<b>Operating Procedure for HAC Crush Test - Testing of Radioactive Material Packages</b>	Test Procedure: <b>PTP-PEF-11</b>	Rev. <b>6 CN-3</b>
		Page: <b>5 / 6</b>	Issue Date: <b>02-18-2021</b>
		Revision Date: <b>02-18-2021</b>	Review by Date: <b>02-18-2024</b>

## 6 Procedure Checklist

Test Plan:

*ORNL/NTRC-092 R.O*

Test Unit:

*4D*

VERIFIED

TASK

- ☒ Verify that any equipment used meets the M&TE meets PTP-QA-013 requirements (§4.1).
- ☒ Have a photographer's clipboard with package name and test unit number. (§4.4)
- ☒ Attitude of the test unit is set. (§4.5)
- ☒ Photograph of the attitude has been taken. (§4.5)
- ☒ Photograph of the measured angle has been taken. (§4.5)
- ☒ The crush plate has been raised to the designated drop height and located over the target point. (§4.7)
- ☒ Photograph of the set position has been taken. (§4.7)
- ☒ Remove plumb bob from crush plate. (§4.7)
- ☒ Video camera(s) are setup and running to take video of the drop. (§4.8)
- ☒ The release mechanism has been plugged into power outlet. (§4.8)
- ☒ Countdown, Release the crush plate, unplug release mechanism. (§4.8)
- ☒ Videos camera stopped. (§4.9)
- ☒ Date and time of test recorded. (§4.10)
- ☒ The ambient temperature has been recorded. (§4.10)
- ☒ Photographs of the resulting damage were taken. (§4.11)
- ☒ Sign and date checklist and data forms (§4.11).

Comments:

I certify that the above tasks have been performed and that the observations and comments are correct.

Testing Technician

*Ross Whittenburg*  
Customer

*10-31-2021*

Date

*10/21/21*

Date

*M.B. Houston*

Witness

*Ryan Job*  
Customer

*10-21-2021*

Date

*10/21/21*

Date

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		Page: <b>6 / 6</b>	Issue Date: <b>02-18-2021</b>
		Revision Date: <b>02-18-2021</b>	Review by Date: <b>02-18-2024</b>

## 7. Data Sheet

Test Plan:

ORNL/NTRC-092 R.0

Test Unit:

4

VERIFIED

TASK

- ✓ Intended attitude of the test unit 56.4° Tolerance ± 2° (§4.6)
- ✓ Attitude Description: Mid facing pcd at 0°, Tilt @ 56.4°, Plate 3 yft drop. (§4.3)
- ✓ Measured attitude of the test unit 56.5° degrees. (§4.5)
- ✓ Level number M202348 Calibration Exp. Date 2/23/2023 (§4.5)
- ✓ Height above the target: 9-m (30-ft) Measuring device A006327 (§4.7)
- ✓ Date and Time of Crush Test: 10/21/2021 @ 11:26 am (§4.10)
- ✓ Ambient temperature: 67.1°F °C (\_\_\_\_ °F)
- Thermometer M&TE ID/Cal. Due Date: A006681 @ 5/12/2022 (§4.10)

Testing Damage Observations:

Orientation on plate: 0.3, 0.2.

Comments: NONE.

I certify that the above tasks have been performed and that the observations and comments are correct.

Testing Technician

Ross Whittenlanger

Customer

10-21-2021

Date

10/21/21

Date

M.B. Hamilton

Witness

Ryan Fisher

Customer

10-21-2021

Date

10/21/21

Date



# TEST FORM 7 –TEST UNIT DIMENSIONS

Test Plan – DPP-1

TU- 4

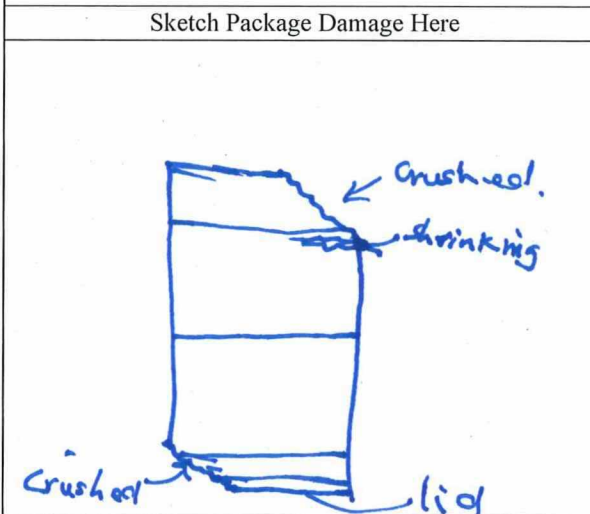
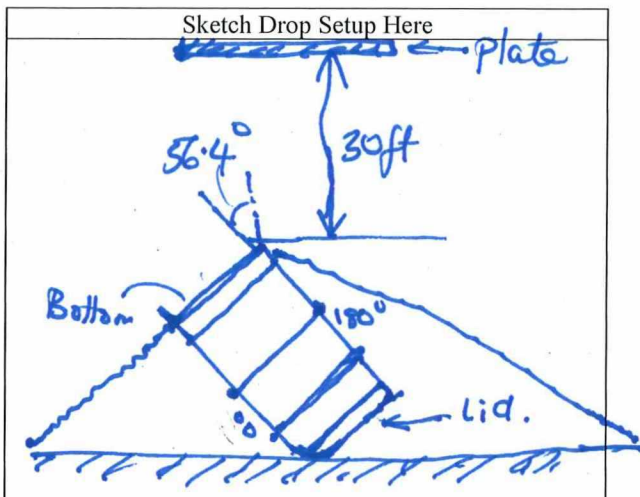
Initial Assembly \_\_\_\_\_  
 Post 1.2-m Drop \_\_\_\_\_  
 Post 9-m Drop \_\_\_\_\_  
 Post Crush Test ✓  
 Post 1-m Puncture Test \_\_\_\_\_

## Drum outer shell

	0°	90°	180°	270°
Height	42	42 11/16	42 13/16	42 15/16

DIAMETER	0° to 180°	90° to 270°
Top Surface	26 1/4	26 5/8
Top Rolling hoop	27 5/8	28 3/16
Center Rolling hoop	27 3/4	28 1/4
Bottom Rolling hoop	26 15/16	28 5/8
Bottom Surface	Not measurable	27 1/4

Location	Flats width @ 0°	Flats width @ 180°
Top Surface	NA	NA
Top Rolling hoop	NA	6.206
Center Rolling hoop	NA	NA
Bottom Rolling hoop	NA	NA
Bottom Surface	NA	NA



M&TE ID #: A006327 Calibration Due Date: 03/20/2023

M&TE ID #: N/A Calibration Due Date: N/A

Comments:

I certify that the above tasks have been performed and that the observations and comments are correct.

[Signature]  
 Testing Technician  
Ross Whittaker  
 CNS-Y-12 STR

10-21-2021  
 Date  
10/21/21  
 Date

M.B. Houston  
 Witness  
[Signature]  
 CNS-Y-12 QE

10-21-2021  
 Date  
10/21/21  
 Date

\*All photographs/movies will be uniquely identified with test unit, date and time to ensure that the proper sequence can be reconstructed

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		<b>PTP-PEF-12</b>	<b>5 CN 2</b>
		Page:	Issue Date:
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		Revision Date:	Review by Date:
		12-01-20	12-14-23

## • Procedure Checklist

Test Plan:

ORNL/NTRC-092 R.O

Test Unit:

4

VERIFIED

TASK

- ☒ Verify that any equipment used meets the M&TE meets PTP-QA-013 requirements (§4.1).
- ☒ Have a photographer's clipboard with package name and test unit number. (§4.4)
- ☒ Attitude of the rigged test unit is set. (§4.5)
- ☒ Photograph of the rigging arrangements has been taken. (§4.5)
- ☒ Photograph of the measured drop angle has been taken. (§4.5)
- ☒ The test unit has been raised to the designated drop height. (§4.6)
- ☒ Photograph of the height measurement has been taken. (§4.6)
- ☒ Video camera(s) are setup and running to take video of the drop. (§4.7)
- ☒ The release mechanism has been plugged into power outlet. (§4.7)
- ☒ Countdown, Release the test unit, unplug release mechanism. (§4.7)
- ☒ Videos camera stopped. (§4.8)
- ☒ Date and time of test recorded. (§4.9)
- ☒ The ambient temperature has been recorded. (§4.10)
- ☒ Photographs of the resulting damage were taken. (§4.11)
- ☒ Sign and date checklist and data forms (§4.12).

Comments: NONE.

I certify that the above tasks have been performed and that the observations and comments are correct.

Test Engineer

*Brax Whittenburg*

10-21-2021

Date

10/21/21

M. B. Houston

Checked by

*[Signature]*

10-21-2021

Date

10/21/21

<b>ORNL</b> PACKAGE TESTING PROGRAM OAK RIDGE NATIONAL LABORATORY OAK RIDGE, TENNESSEE 37831 <small>The OFFICIAL COPY of this document is the on-line version. Before using a printed copy, verify that it is the most current version by checking the Revision ID against the on-line version</small>	Operating Procedure for HAC Puncture Test - Testing of Radioactive Material Packages	Test Procedure:	Rev.
		Page:	Issue Date:
		Revision Date:	Review by Date:
		PTP-PEF-12	5 CN 2
		7 / 7	12-14-20
		12-01-20	12-14-23

## 6. Data Sheet

Test Plan: <u>ORNL/NTRC-092 R.O</u>	Test Unit: <u>4</u>
--	------------------------

VERIFIED	TASK
<input checked="" type="checkbox"/>	M&TE ID <u>A000883</u> Calibration due date <u>3/15/2023</u> ( <u>Puncture bar</u> ) (§4.1).
<input checked="" type="checkbox"/>	Intended attitude of the test unit <u>56.4°</u> Tolerance $\pm$ <u>2°</u> (§4.5)
<input checked="" type="checkbox"/>	Measured attitude of the test unit <u>52.3°</u> degrees. (§4.5)
<input checked="" type="checkbox"/>	Attitude Description: <u>Lid facing Puncture bar, Unit @ 52.3°</u> (§4.3)
<input checked="" type="checkbox"/>	Level number <u>M212348</u> Calibration Exp. Date <u>2/23/2022</u> (§4.5) <u>10/21/2021</u>
<input checked="" type="checkbox"/>	Height above the puncture bar <u>40 in</u> Measuring device <u>A001146</u> ( <u>2/24/2026</u> ) (§4.6)
<input checked="" type="checkbox"/>	Date and Time of Drop Test: <u>10/21/2021 @ 2:53pm</u> (§4.9)
<input checked="" type="checkbox"/>	Ambient temperature: <u>68.1°F</u> ( <u>68.1</u> °F) <u>MON 10-21-21</u>
	Measuring device <u>A006681</u> due: <u>5/12/2022</u> (§4.10)
	Testing Damage Observations: <u>Puncture bar ID: A000883 due: 3/15/2023</u>

Comments: lifting ship location moved (shifted down a bit due to damage on TC. Angle of drop 52.3° (instead of 56.4°)

I certify that the above tasks have been performed and that the observations and comments are correct.

Test Engineer  
Ross Whittenlanger

10-21-2021  
Date  
10/21/21

M.B. Houston  
Checked by  
[Signature]

10-21-2021  
Date  
10/21/21



# TEST FORM 7 - TEST UNIT DIMENSIONS

Test Plan - DPP-1

TU- 4

Initial Assembly \_\_\_\_\_  
 Post 1.2-m Drop \_\_\_\_\_  
 Post 9-m Drop \_\_\_\_\_  
 Post Crush Test \_\_\_\_\_  
 Post 1-m Puncture Test ✓

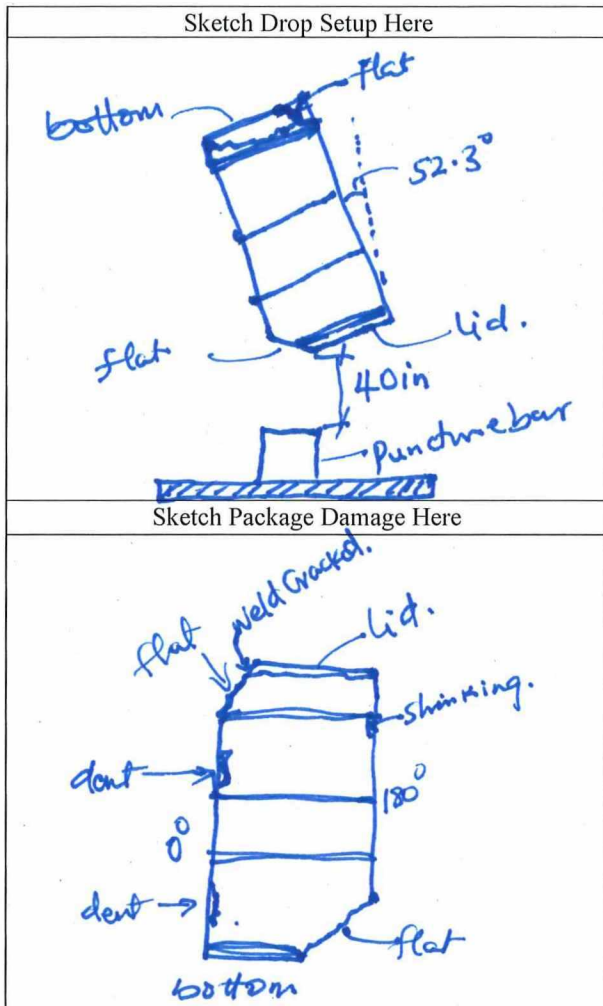
Drum outer shell

*from flat bottom.*

	0°	90°	180°	270°
Height	41 15/16	42 13/16	42 11/16	42 15/16

DIAMETER	0° to 180°	90° to 270°
Top Surface	25 7/8	26 3/4
Top Rolling hoop	27 11/16	28 4/8
Center Rolling hoop	27 13/16	28 5/16
Bottom Rolling hoop	27 1/8	28 5/8
Bottom Surface	not measurable	27 1/4

Location	Flats width @ 0°	Flats width @ 180°
Top Surface	N/A	N/A
Top Rolling hoop	N/A	N/A
Center Rolling hoop	N/A	N/A
Bottom Rolling hoop	N/A	N/A
Bottom Surface	N/A	N/A



M&TE ID #: A006327 Calibration Due Date: 3/20/2023

M&TE ID #: A00319 Calibration Due Date: 2/23/2022

Comments: Weld cracked on 0° line on lid's stiffening ring. Broken TLD ring near 0°, bolts # 4 and # 14.

Secondary hits: (1) Top rolling hoop @ 0° & (2) bottom rolling hoop @ 0° from lifting ring.

I certify that the above tasks have been performed and that the observations and comments are correct.

Testing Technician

Date

Witness

Date

Ross Whittenburg  
 CNS-Y-12 STR

10/21/21  
 Date

M.B. Houston  
 CNS-Y-12 QE

10/21/21  
 Date

\*All photographs/movies will be uniquely identified with test unit, date and time to ensure that the proper sequence can be reconstructed

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		<b>PTP-PEF-13</b>	<b>7 CN-0</b>
		Page 10 / 12	Issue Date: 03-10-2021
		Revision Date: 03-10-2021	Review by Date: 03-10-2024

### Attachment 1 - HAC Thermal Test Checklist

Test Plan:

ORNL/NTRC-095 Rev. 0

Test Unit:

4

VERIFIED

TASK

✓

Ensure test equipment is calibrated, calibration records are acceptable, and that Attachments 1 and 2 records have been initiated prior to testing. Prepare photographers clipboard. (§4.1a, b, c & d)

✓

Set up the thermal DAQ and test all TC channels with a calibrated heat source. The acceptable range to test the thermocouples is 0°F - 150°F. (§4.2a)

✓

The thermocouple mounting clip material and installation is acceptable and per customer requirements, test plan, or approved work instruction. (§4.2b)

✓

TU's have been preheated per customer requirements, test plan or approved work instruction. NOTE: When no customer requirements are given, preheat shall be ~ 66°C (150°F) for a minimum of 24 hours and then soaked at ~ 43°C (110°F) for a minimum of 24 hours. **Record pre-heat acceptance on Attachment 2.** (§4.2c)

✓

Unless specified otherwise by the customer requirements, test plan, or approved work instruction, the furnace layout has proved capable of loading tests units within 90 seconds. (§4.3a)

✓

Floor plate(s) material(s) and test stand(s) are of the approved design and are installed at the location specified by the customer, test plan or approved work instruction. All TCs have been labeled, installed in the furnace, connected to DAQ and tested. The furnace opening can operate without causing damage to thermocouple wires. Photographs have been taken of the furnace set up. (§4.3b, 4.3c-4.3d)

✓

The furnace pre-heat soak time has been achieved (minimum temperature of 860°C (1580°F) for a minimum of 24 hours) and the DAQ is recording TC temperatures every 15 seconds. If needed, adjust the furnace set point to maintain a constant temperature of 1580°F. (§4.3e)

Comments: NONE.

I certify that the above tasks have been performed and that the observations and comments are correct.

Testing Technician

*Ross Whittenburg*  
Customer

Date

11-09-2021

11/9/21  
Date

PTP QR Witness

*M. B. Houston*  
*Peggy Fisher*  
Customer

Date

11-09-2021

11/9/21  
Date



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		Page	Issue Date:
		Revision Date:	Review by Date:
		<b>PTP-PEF-13</b>	<b>7 CN-0</b>
		11 / 12	03-10-2021
		03-10-2021	03-10-2024

### Attachment 1 - HAC Thermal Test Checklist (continued)

Test Plan:

ORNL/NTRC-092 R.0

Test Unit:

4

VERIFIED

TASK

- ✓ **Furnace Soak** - A room temperature test specimen, instrumented with thermocouples was placed into the hot furnace. The test unit thermocouples and the furnace thermocouples (including the thermocouple that controls the furnace temperature) were monitored with the cDAQ to ensure the furnace was capable of achieving the requirements specified per the test plan. The test specimen will remain in the furnace for a period specified by customer requirements, test plan, or the approved work instruction. When no requirements are given, the test specimen will remain in the furnace for 30 minutes after 5 of 6 of the thermocouples on the test specimen surface, 2 out of 3 thermocouples on the test stand, and 2 of 3 thermocouples on each furnace wall reach 1475°F. **Record acceptance on Attachment 2. (§4.4.a)**
- ✓ **Test Unit Preparation** – Weld the thermocouple clips to the TU's before starting the preheat. Pre-heat per test plan requirements. Document pre-heat for the test unit on Attachment 2. Upon acceptance of pre-heat requirements for the test specimen, remove the test specimen from the pre-heat chamber and install TCs. Test all thermocouples with a heat source. **(§4.2b & 4.4b)**
- ✓ **Ready to Test** - Open the furnace opening. Load the test specimen on the furnace test stand. Unless specified otherwise by the customer requirements, test plan or work instruction, place the test specimen onto the test stand in a horizontal position with the test specimen lid facing the right furnace sidewall and the 0° line is facing down (facing the furnace floor). **(§4.4.c)**
- ✓ **Beginning the Test** - Loading can begin when the furnace has met the required preheat time. **Record the Test Start Time on Attachment 2.** The 30 minute test shall start when the following conditions have been met.
  - 5 of 6 of the thermocouples on the test specimen surface must reach 1475°F or greater and,
  - 2 out of 3 thermocouples on the test stand must reach 1475°F or greater and,
  - 2 of 3 thermocouples on each furnace wall have reached 1475°F or greater. **(§4.4a)**
- ✓ **Test Completion - Record the Test Stop Time on Attachment 2.** Immediately following the timed test and the thermal requirements are met, immediately remove the test specimen from the furnace and place the specimen in an area where it will not be exposed to artificial cooling. Record notes regarding smoke and/or flames emanating from the test specimen on Attachment 2. **(§4.3c)**
- ✓ All Photographs and/or videos for the entire test setup have been taken. **(§4.3c)**

Comments:

I certify that the above tasks have been performed and that the observations and comments are correct.

Testing Technician

Ross Whittenberger  
Customer

Date

11-09-2021  
11/9/21  
Date

PTP QR Witness

M.B. Houston  
[Signature]  
Customer

Date

11-09-2021  
11/9/21  
Date



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		Revision Date:	Review by Date:
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		12 / 12	03-10-2021
		03-10-2021	03-10-2024

## Attachment 2 - HAC Thermal Test Data Sheet

Test Plan:

ORNL/NTRC-092 R.O

Test Unit:

4

VERIFIED

TASK

✓

The test unit has been preheated to over 38°C (100°F). (§4.2c)

Pre-heat Start date/time: 3:45 am/pm (CT) @ 11/05/2021

Pre-heat End date/time: 7:41 am/pm (CT) @ 11/09/2021

Final Pre-heat temperature: > 110°F

✓

Furnace Soak Time prior to testing - Unless otherwise specified by the customer requirements, test plan or work instructions, preheat the furnace at a temperature of 860°C (1580°F) for a minimum of 24 hours. Record the time/date the soak time began and the time/date the soak time was reached (§ 4.3.e):

Time soak time begins: Date/Time: 3:27 pm (CT) @ 11/08/2021

Time soak time reached: Date/Time: 8:18 pm (CT) @ 11/09/2021

✓

The test unit has been placed in the furnace, on the support stand, at: (§4.4d)

Furnace door opened time: 8:18 am Furnace door Closed time: 8:18 am

Total time taken to open and Close furnace door: ✓ 1 min

✓

Unless otherwise specified by the customer requirements, test plan or work instructions, the 30-minute timed test starts after 5 out of 6 test unit thermocouples and 15 of 18 furnace thermocouples reach the test temperature of 801°C (1475°F).

Enter the Test Start Time: 8:21 am (CT) am/pm (§4.4e & 4.4f)

✓

The test unit was removed from the furnace and allowed to cool naturally. (§4.4f)

Enter the Test End Time: 8:52 am (CT) am/pm

N/A

The test unit stopped outgassing (flames) at ✓ am/pm (§4.4f)

Outgassing/burnout elapsed time was ✓ minutes. (§4.4f)

Comments: Furnace was soaked overnight after (TV-3) for a total of ~ 16 hours @ all TC, > 1580°F FAsi 11/11/21

I certify that the above tasks have been performed and that the observations and comments are correct.

Testing Technician

Ross Whittenburg

Customer

11-09-2021

Date

11/9/21

Date

M.B. Houston

Witness

[Signature]

Customer

11-09-2021

Date

11/9/21

Date

# TEST FORM 5 - POST-THERMAL TESTING INSPECTION

Test Plan DPP-1

TU 4

VERIFIED

TASK

- ☒ Following the thermal test and after passive cooling, the test package was weighed, and recorded on TEST FORM 1.
- ☒ The drum, drum lid, bolts, and washers have been visually examined to determine the extent of the testing damage. Observations: \_\_\_\_\_
- ☒ The camera(s) are set up to take photographs\* and/or videotape of the damage due to testing.
- ☒ The drum lid has been removed and the condition of the exposed parts have been visually examined for damage and the condition has been recorded. Record the exposed temperature indicator blackout reading on TEST FORM 6. Record the torque values needed to loosen the drum lid weldment screws on TEST FORM #8. Observations: Lid stuck, drum body & liner had to be cut.
- ☒ The CV assembly and contents have been removed in the reverse assembly order and visually examined for damage. Record the exposed temperature indicator blackout readings on TEST FORM 6. Observations: see Test Form 6
- ☒ The CV assembly has been weighed and the weight recorded on TEST FORM 1.
- ☒ Use NDE 70 Rev. 7 for the CV post-test operational leak check and for the full containment boundary leak check and PTP-PEF-14 for the 0.9 m (3 ft). immersion test or PTP-PEF-15 for the 15 m immersion test. The leak test port plug shall be removed for these tests. HOLD POINT: Y-12 has approved the CV drying process.
- ☒ After immersion test the CV was dried using the CNS approved process (fans, plant air pressure, mild heat, vacuum suction, etc.) as shown in TEST FORM 12. The flange joint and space between the O-rings was dried by the approved process prior to opening the CV.
- ☒ Disassemble the CV. Record torque value needed to loosen CV screws on TEST FORM 9.
- ☒ If water is present inside the O-rings, stop work, inform CNS, and comment observations below.
- ☒ Read the temperature labels from the CV. Record the temperature indicators' blackout readings on TEST FORM 6
- ☒ The content test fixture weldment assembly was removed from the CV and the weight was recorded on TEST FORM 1.
- ☒ The content test fixture weldment assembly was disassembled in the reverse assembly order.
- ☒ Loaded test fixture weldment content assembly: Remove the contents in the following order, loading test fixture weldment assembly using nylon springs, PCC silicone rubber pad, test weight weldment, lower PCC silicone rubber pad. CV silicone rubber pad.
- ☒ All loose parts will be placed in separate plastic bags, marked with test unit identification, tape closed, and prepared for storage with the test package.
- ☒ Mark and reassemble the test package to the extent possible for shipment.
- ☒ \*Photographs and/or video of the damage resulting from the testing have been taken.

RW 12/9/21  
RF 12/9/21

Comments: NONE.

I certify that the above tasks have been performed and that the observations and comments are correct.

Testing Technician

12-13-2021  
Date

M. B. Houston  
Witness

12-13-2021  
Date

Ross W. Whittenburg  
CNS-Y-12 STR

12/9/21  
Date

[Signature]  
CNS-Y-12 QE

12/9/21  
Date

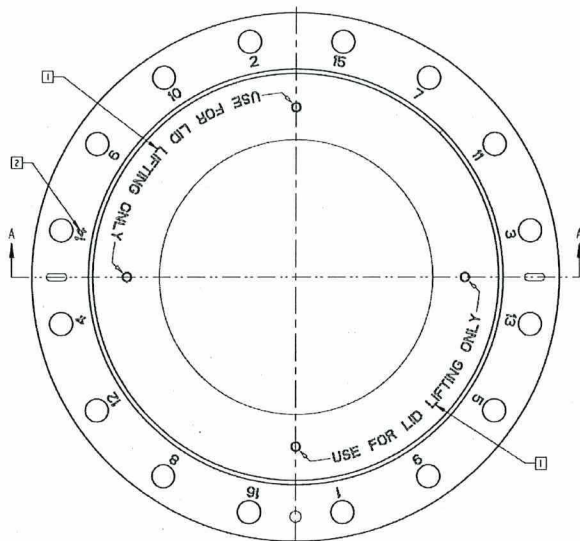
\*All photographs/movies will be uniquely identified with test unit, date and time to ensure that the proper sequence can be reconstructed.



# TEST FORM 8 -DRUM LID DISASSEMBLY

Test Plan - DPP-1

TU- 4



DPP-1 Lid Disassembly	
Bolt #	Torque Removal (ft-lbs.)
1	45.3
2	32.9
3	43.3
4	11.2
5	46.5
6	34.0
7	36.7
8	28.7
9	35.5
10	34.2
11	51.7
12	7.2
13	60.5
14	49.3
15	41.4
16	38.2

M&TE ID #: A001096 Calibration Due Date: 2/10/2022

M&TE ID #: A006681 Calibration Due Date: 5/12/2022

Comments: Ambient temperature 67.0 °F

I certify that the above tasks have been performed and that the observations and comments are correct.

Testing Technician

Ross Whittaker  
CNS-Y-12 STR

Date

11/23/21  
Date

Witness

M.B. Houston  
CNS-Y-12 QE

Date

11/23/21  
Date

\*All photographs/movies will be uniquely identified with test unit, date and time to ensure that the proper sequence can be reconstructed



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		Page: <b>5 / 6</b>	Issue Date: <b>12-14-20</b>
		Revision Date: <b>1-03-20</b>	Review By Date: <b>12-14-23</b>

## 6. Procedure Checklist

Test Plan:

*ORNL/NTRC-092.0*

Test Unit:

*4*

VERIFIED

TASK

- ☒ Verify that any equipment used meets the M&TE meets PTP-QA-013 requirements (§4.1).
- ☒ Have a photographer's clipboard with package name and test unit number. (§4.3)
- ☒ The test unit has been lowered to the bottom of the tank in designated orientation. (§4.6)
- ☒ The depth to the highest point of the test unit has been measured and is at least 0.9-m (3-ft). (§4.6)
- ☒ Photograph of the depth measurement has been taken. (§4.6)
- ☒ Record the water and ambient temperature. (§4.6)
- ☒ Start date and time has been noted. (§4.7)
- ☒ Test unit has been removed from the tank. (§4.8)
- ☒ End date and time has been noted. (§4.8)
- ☒ Record the water and ambient temperature. (§4.8)
- ☒ Thoroughly dry the test unit and make sure it is completely dry before opening. (§4.9)
- ☒ Open the test unit and record-breaking torque values during removal, if required. (§4.10)
- ☒ Inspect for water in-leakage or structural damage. (§4.10)
- ☒ Photographs of any resulting damage or lack thereof were taken. (§4.10)
- ☒ Sign and date checklist and data forms (§4.12).

Comments: *NONE.*

I certify that the above tasks have been performed and that the observations and comments are correct.

Test Engineer

*Ross Whittaker*

Date

*12/9/21*

Checked by

*M.B. Houston*  
*Phyllis J. Lee*

Date

*12/9/21*

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		Revision Date: <b>1-03-20</b>	Review By Date: <b>12-14-23</b>

## 7. Data Sheet

Test Plan:

ORNL/NTRC-092.0

Test Unit:

4

VERIFIED

TASK

- ☒ M&TE ID A006327 Calibration due date 3/20/2023 (§4.1).
- ☒ Intended attitude of the test unit in tank (e.g. on side) 0° down (§4.4)
- ☒ Depth of water above the test unit 40.5 in Measuring device A006327 due 3/20/2023 (§4.6)
- ☒ Start Date and Time of Immersion Test: 12/08/2021 @ 4:30pm (§4.7)
- ☒ Water temperature: 68.5°F °C ( 68.5°F ) Measuring device A006681 (§4.6) due: 5/12/2022
- ☒ Ambient temperature: 61.9°F °C ( 61.9°F ) Measuring device A006681 (§4.8)
- ☒ End Date and Time of Immersion Test: 12/09/2021 @ 10:00am (§4.8)
- ☒ Water temperature: 68.5°F °C ( 68.5°F ) Measuring device A006681 (§4.8)
- ☒ Ambient temperature: 61.9°F °C ( 61.9°F ) Measuring device A006681 (§4.8)
- ☒ Detected in-leakage of water: (YES/NO) NO (§4.10)
- ☒ Detected structural damage: (YES/NO) NO (§4.10)

Testing Damage Observations: No water leakage.

Comments: NONE.

I certify that the above tasks have been performed and that the observations and comments are correct.

Test Engineer

Ross Whittleluz

Date

12/9/21

Checked by

M.B. Hunter

Date

12/9/21

# TEST FORM 12 -CV DRYING PROCEDURE

Test Plan - DPP-1

TU- 4

VERIFIED

TASK

- ☒ ORNL will remove the CV's from the immersion tank after a minimum of 8 hours.
- ☒ The CV's will be placed on the worktable in a vertical position.
- ☒ A shop vac will be used to blow out any water out of the CV flanges.
- ☒ The external surface of the CV will be dried with cloth and paper towels.
- ☒ ORNL will attach a vacuum to the CV flange O-ring port and supply a vacuum to remove most of the water between the inner and outer O-rings.
- ☒ After about 1 hour of air drying under forced hot air convection, an air compressor or compressed air can, or shop air will be used to blow out any water left in between the CV O-rings.
- ☒ The CV bolts will be loosened and removed, and the breakaway torque will be recorded on Test Form 9.
- ☒ The CV top lid will be lifted about a 1/8<sup>th</sup> -in and cloth and paper towels will be used to wipe the surfaces of the internal CV flanges outboard of the outer O-ring.
- ☒ A visual inspection of the internal surface of the CV flange will be done.
- ☒ ORNL and CNS will verify that water droplets are not visible on the inside of the Inner O-ring.
- ☒ After CNS approval, the CV lid will be completely removed from the CV base.

Comments: NONE.

I certify that the above tasks have been performed and that the observations and comments are correct.

Testing Technician

Ross Whittaker  
CNS-Y-12 STR

12-09-2021

Date

12/9/21  
Date

M.B. Houston

Witness

[Signature]  
CNS-Y-12 QE

12-09-2021

Date

12/9/21  
Date

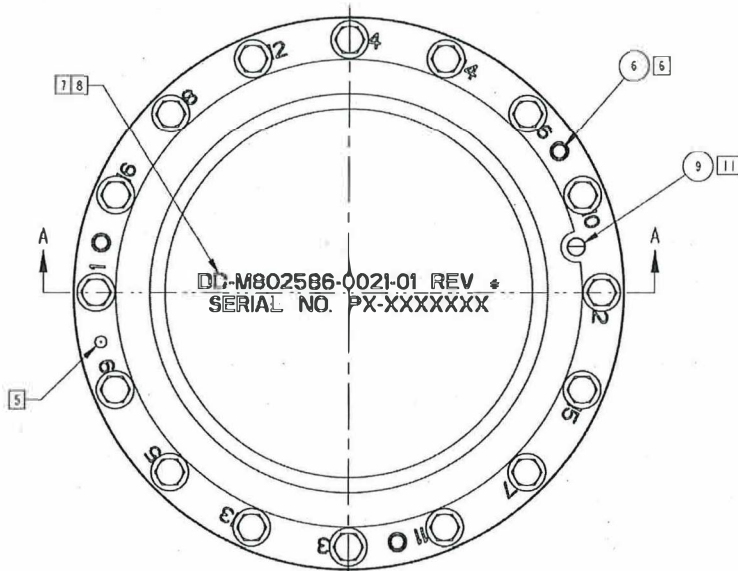
\*All photographs/movies will be uniquely identified with test unit, date and time to ensure that the proper sequence can be reconstructed



# TEST FORM 9 -CV LID DISASSEMBLY

Test Plan - DPP-1

TU- 4



DPP-1 CV Lid Disassembly	
Bolt #	Torque Removal (ft-lbs.)
1	27.1
2	11.1
3	23.9
4	24.7
5	31.4
6	29.5
7	23.8
8	35.9
9	32.0
10	25.7
11	27.3
12	33.2
13	34.0
14	35.9
15	33.5
16	37.4

M&TE ID #: A001096 Calibration Due Date: 2/10/2022

M&TE ID #: N/A Calibration Due Date: N/A

Comments: NONE

I certify that the above tasks have been performed and that the observations and comments are correct.

Testing Technician

Ross Whittenberger  
CNS-Y-12 STR

12-09-2021  
Date

12/9/21  
Date

Witness

M.O. Houston  
[Signature]  
CNS-Y-12 QE

12-09-2021  
Date

12/9/21  
Date

\*All photographs/movies will be uniquely identified with test unit, date and time to ensure that the proper sequence can be reconstructed

# TEST FORM 6 - TEMPERATURE INDICATOR READINGS

Test Plan DPP-1

TU 4

A visual inspection of each temperature indicator on the package consisting of those indicators inside the CV, outside the CV, and on the drum-liner will be made. The values of the blackouts that occurred will be recorded below.

TEMPERATURE INDICATOR NUMBER LOCATION CHART				
TEST CONTENT ASSEMBLY (TL-10-105, TL-10-190)				
Location (outside)	0°	90°	180°	270°
Top end cap center	1 190 °F	2 190 °F	3 190 °F	4 190 °F
Top end cap under flange	5 190 °F	6 190 °F	7 190 °F	8 190 °F
Tube upper	9 190 °F	10 190 °F	11 190 °F	12 190 °F
Tube middle	13 190 °F	14 190 °F	15 190 °F	16 190 °F
Tube lower	17 190 °F	18 190 °F	19 190 °F	20 190 °F
Bottom end cap under flange	21 180 °F	22 180 °F	23 180 °F	24 180 °F
Bottom end cap center	25 180 °F	26 180 °F	27 180 °F	28 180 °F
Weight upper	29 180 °F	30 180 °F	31 180 °F	32 180 °F
Weight lower	33 180 °F	34 180 °F	35 180 °F	36 180 °F
INTERIOR OF THE CV (TL-10-105, TL-10-190)				
CV lid center	37 190 °F	38 190 °F	39 190 °F	40 190 °F
CV body flange	41 200 °F	42 200 °F	43 200 °F	44 200 °F
CV wall upper	45 200 °F	46 200 °F	47 200 °F	48 200 °F
CV wall middle	49 190 °F	50 190 °F	51 200 °F	52 190 °F
CV wall lower	53 190 °F	54 190 °F	55 190 °F	56 190 °F
CV base neck	57 180 °F	58 190 °F	59 190 °F	60 180 °F
CV base center	61 180 °F	62 180 °F	63 180 °F	64 190 °F
EXTERIOR OF THE CV (TL-10-105, TL-10-190)				
Lid center	65 210 °F	66 210 °F	67 210 °F	68 210 °F
Lid flange	69 210 °F	70 210 °F	71 210 °F	72 210 °F
Body flange	73 210 °F	74 210 °F	75 210 °F	76 210 °F
Base neck	77 190 °F	78 190 °F	79 190 °F	80 190 °F
Base toe	81 190 °F	82 190 °F	83 190 °F	84 190 °F
DRUM ASSEMBLY (TL-10-190, TL-10-290)				
Lid bottom	85 230 °F	86 230 °F	87 230 °F	88 230 °F
Cavity wall upper	89 230 °F	90 230 °F	91 240 °F	92 230 °F
Cavity wall middle	93 230 °F	94 230 °F	95 240 °F	96 230 °F
Cavity wall lower	97 220 °F	98 230 °F	99 240 °F	100 220 °F
Cavity wall lowest	101 200 °F	102 220 °F	103 230 °F	104 220 °F
Cavity bottom	105 210 °F	106 210 °F	107 210 °F	108 220 °F

Comments:

I certify that the above tasks have been performed and that the observations and comments are correct.

Testing Technician

CNS-Y-12 STR

12-13-2021  
Date

12/13/21  
Date

Witness

CNS-Y-12 QE

12-13-2021  
Date

12/13/21  
Date

\*All photographs/movies will be uniquely identified with test unit, date and time to ensure that the proper sequence can be reconstructed



# TEST FORM 15 -WITNESS AND HOLD POINTS

Test Plan DPP-1

TU 4

The following applicable CNS hold points activities shall not start until written approval to proceed has been given from the CNS STR via e-mail. Additional hold points may be included when CNS reviews the approval data documents and as the work is being performed. The purpose of each hold point is to give the TA, STR, and QE an opportunity to (1) evaluate what has happened since the previous hold point, (2) evaluate previous lessons learned on the activities that follow, and (3) make an informed decision to proceed.

NO.	DESCRIPTION	TU NO.	TYPE	CNS INITIAL
1	<u>Initial package disassembly</u> Witness the disassembly, can be waived by a DA representative	1,2,3,4,5,6, 7	Witness, Hold	RW RF
2	<u>pre-test operational leakage rate test</u> Witness the pre-test operational leakage rate test per ANSI N14.5, section 7.6, after final closure (and before commencing testing sequence)	1,2,3,4,5,6, 7	Witness, Hold	
2.1	<u>pre-test operational leakage rate test acceptance</u> Inspection to verify the pre-test operational leakage rate test has met acceptance criteria <b>Subsequent reassembly sequence shall not commence until acceptable result is produced.</b>	1,2,3,4,5,6, 7	Hold	
3	<u>Initial package reassembly</u> Witness the reassembly of the contents, CV, vibration pads, drum lid, instrumentation, and all associated fastening hardware	1,2,3,4,5,6, 7	Witness	
3.1	<u>Initial Package Reassembly</u> Inspection and observation to verify the reassembly procedure has been followed according to supplied direction. <b>Subsequent testing sequence shall not commence until reassembly steps have been confirmed as acceptable.</b>	1,2,3,4,5,6, 7	Hold	
4	<u>NCT vibration/shock test</u> Witness the NCT vibration/shock testing activities, including all preliminary setup, can be waived by a DA representative	6	Witness	
5	<u>NCT thermal pre-treatment</u> Witness the NCT thermal pre-treatment activities, including all preliminary setup, can be waived by a DA representative	1,2,3,4,5,6	Witness	
6	<u>NCT water spray test</u> Witness the NCT water spray test activities, including all preliminary setup, can be waived by a DA representative	2,3,4,6	Witness, Hold	
7	<u>NCT free drop (4 ft) test</u> Witness the NCT free drop (4 ft) test activities, including all preliminary setup, can be waived by a DA representative	1,2,3,4,5,6	Witness	
7.1	<u>NCT free drop (4 ft) test, critical parameters</u> Inspection to verify the critical parameters defining the NCT free drop (4 ft) test meet all requirements <b>Completion of NCT free drop (4 ft) test shall not commence until all critical parameters have been verified.</b>	1,2,3,4,5,6	Hold	



8	<u>NCT penetration test</u> Witness the NCT penetration test activities, including all preliminary setup, can be waived by a DA representative	6	Witness	<b>RW</b>	<b>RF</b>
8.1	<u>NCT penetration test, critical parameters</u> Inspection to verify the critical parameters defining the NCT penetration test meet all requirements	6	Hold		
	<b>Completion of NCT penetration test shall not commence until all critical parameters have been verified.</b>				
9	<u>NCT compression test</u> Witness the NCT compression test activities, including all preliminary setup, can be waived by a DA representative	6	Witness		
9.1	<u>NCT compression test, critical parameters</u> Inspection to verify the critical parameters defining the NCT compression test meet all requirements	6	Hold		
	<b>Completion of NCT compression test shall not commence until all critical parameters have been verified</b>				
10	<u>HAC thermal pre-treatment</u> Witness the HAC thermal pre-treatment activities, including all preliminary setup, can be waived by a DA representative	1,5	Witness		
11	<u>HAC free drop (30 ft) test</u> Witness the HAC free drop (30 ft) test activities, including all preliminary setup, can be waived by a DA representative	1,2,3,4,5,6	Witness		
11.1	<u>HAC free drop (30 ft) test, critical parameters</u> Inspection to verify the critical parameters defining the HAC free drop (30 ft) test meet all requirements	1,2,3,4,5,6	Hold		
	<b>Completion of HAC free drop (30 ft) test shall not commence until all critical parameters have been verified.</b>				
11.2	<u>HAC free drop (30 ft) test, damage determination</u> Inspection to verify that the damage inflicted during the HAC free drop (30 ft) test is as expected, if unexpected damage is present, modifications to the subsequent HAC Crush (30 ft) test will be defined	1,2,3,4,5,6	Hold		
	<b>Testing shall not commence until new specification of HAC Crush (30 ft) test has been agreed-upon and adopted by the TA.</b>				
12	<u>HAC crush (30 ft) test</u> Witness the HAC crush (30 ft) test activities, including all preliminary setup, can be waived by a DA representative	1,2,3,4,5,6	Witness		
12.1	<u>HAC crush (30 ft) test, critical parameters</u> Inspection to verify the critical parameters defining the HAC crush (30 ft) test meet all requirements	1,2,3,4,5,6	Hold		
	<b>Completion of HAC crush (30 ft) test shall not commence until all critical parameters have been verified.</b>				
12.2	<u>HAC crush (30 ft) test, damage determination</u> Inspection to verify that the damage inflicted during the HAC crush (30 ft) test is as expected, if unexpected damage is present, modifications to the subsequent HAC Puncture drop (40 in.) test will be defined	1,2,3,4,5,6	Hold		
	<b>Testing shall not commence until new specification of HAC Puncture drop (40 in.) test has been agreed-upon and adopted by the TA.</b>				

13	<u>HAC Puncture drop (40 in.) test</u> Witness the HAC Puncture drop (40 in.) test activities, including all preliminary setup, can be waived by a DA representative	1,2,3,4,5,6	Witness	RW RF
13.1	<u>HAC Puncture drop (40 in.) test, critical parameters</u> Inspection to verify the critical parameters defining the HAC Puncture drop (40 in.) test meet all requirements  <b>Completion of HAC Puncture drop (40 in.) test shall not commence until all critical parameters have been verified.</b>	1,2,3,4,5,6	Hold	
NO.	DESCRIPTION	TU NO.	TYPE	CNS INITIAL
14	<u>Thermal test, data collection hardware</u> Inspection to verify that all the thermocouple and hardware has been installed, or configured as specified and is operating correctly  <b>Completion of supplementary thermal test shall not commence until hardware installation has been verified.</b>	1,2,3,4,5,6	Hold	
15	<u>HAC thermal test</u> Witness the HAC thermal test activities, including all preliminary setup, can be waived by a DA representative	1,2,3,4,5,6	Witness	
15	<u>Overpack Inspection and Disassembly</u> Witness the overpack inspection and disassembly process, including all preliminary setup, can be waived by a DA representative	1,2,3,4,5,6	Witness	
16	<u>Overpack Inspection and Disassembly</u> Inspection to verify that sufficient data and measurements have been collected from overpack and CV prior to drilling and tapping the CV lid for post-test leakage rate measurements  <b>Post-test leakage rate activities, including all preliminary setup, shall not commence until hardware installation has been verified.</b>	1,2,3,4,5,6	Hold	
17	<u>post-test operational leakage rate test</u> Witness the post-test operational leakage rate test per ANSI N14.5, section 7.6, after completion of test activities (and before post-test full-boundary leakage rate test)	1,2,3,4,5,6	Witness	
18	<u>post-test full-boundary leakage rate test, drilling and tapping test port in CV lid</u> Witness the drilling and tapping of the leakage rate test port in the CV lid, after removal from the overpack assembly (and before completion of testing sequence)	1,2,3,4,5,6	Witness	
19	<u>post-test full-boundary leakage rate test</u> Witness the post-test full-boundary leakage rate test per ANSI N14.5, Section 7.5. This includes the sealing of the drilled and tapped hole in the CV lid after the leakage rate measurements have completed	1,2,3,4,5,6	Witness	
19.1	<u>Final containment vessel leakage rate test acceptance</u> Inspection to verify the "post-test" leakage rate test has met acceptance criteria  <b>HAC immersion tests shall not commence until results are confirmed.</b>	1,2,3,4,5,6	Hold	

20	HAC immersion test, fissile material packages Witness the HAC immersion test, fissile material packages, activities, including preliminary setup, can be waived by a DA representative	1,2,3,4,5,6	Witness	RW	RF
21	HAC immersion test, all packages (undamaged) Witness the HAC immersion test, all packages (undamaged), activities, including preliminary setup, can be waived by a DA representative	7	Witness		
22	Opening containment vessel after HAC immersion test Witness the opening of the containment vessel and inspection for retained moisture within the containment vessel cavity, including preliminary setup and verification that the external surface is complete dry, can be waived by a DA representative	1,2,3,4,5,6, 7	Witness		
NO.	DESCRIPTION	TU NO.	TYPE	CNS INITIAL	
23	Final external inspection results Inspection of all external inspection results, to verify all specified dimensional and photographic records have been obtained, these records cannot be confirmed after the overpack assembly has been cut-open and so must be confirmed at this point  <b>Disassembly and cross section examination shall not commence until all external inspections have been completed and all necessary records have been collected. (if required)</b>	1,2,3,4,5,6, 7	Hold		
24	Disassembly and cross section inspection Witness the cutting, disassembly, and dissection of the overpack assembly (if required)	1,2,3,4,5,6, 7	Witness		
25	Final cross section inspection results (if required) Inspection of all cross-section inspection results, to verify all specified dimensional and photographic records have been obtained  <b>Completion of final data report shall not commence until all cross-section inspections have been completed and all necessary records have been collected. (if required)</b>	1,2,3,4,5,6, 7	Hold		
26	Preliminary data package Inspection of all preliminary test results, including data collected, photos and videos captured, and dimensions measured  <b>Shipment or disposal (as defined by the DA) of TU shall not commence until the preliminary data package has been reviewed and determined to be complete.</b>	1,2,3,4,5,6, 7	Hold		

Comments:

I certify that the above tasks have been performed and that the observations and comments are correct.

Testing Technician

CNS-Y-12 STR

12-13-2021

Date

12/13/21

Date

Witness

CNS-Y-12 QE

12-13-2021

Date

12/13/21

Date

\*All photographs/movies will be uniquely identified with test unit, date and time to ensure that the proper sequence can be reconstructed



# TEST FORM 16 -PHOTOGRAPHY/VIDEO CHECKLIST

Test Plan DPP-1

CTU 4

At a minimum, the following events shall be captured by photography. If necessary, photos shall be taken from multiple perspectives to provide a clear understanding of the event being captured. Date and time will be stamped on all photographs.

## VERIFIED

## TASK

✓	Overpack assembly, containment vessel, and vibration pads after taking delivery and during disassembly
✓	Overpack assembly, containment vessel, and vibration pads (where applicable) during reassembly
✓	Drop testing pad, including appropriate dimensional references
✓	Puncture bar installed onto drop pad, including appropriate dimensional reference
✓	Penetration bar, including appropriate dimensional references
✓	Equipment, instrumentation, and general arrangement used for vibration/shock tests
✓	Equipment, instrumentation, and general arrangement used for free and Puncture drop tests
✓	Equipment, instrumentation, and general arrangement used for water spray tests
✓	Pre-test leakage rate tests: — Close-up views of CV before test, showing connection for CV lid leakage rate test port — Close-up views of CV during test, showing connections made to CV lid leakage rate test port — Test arrangement with CV during test, showing all connections made to CV
✓	NCT vibration/shock tests: — Test arrangement with the package installed onto the expander head or slip table — Attachment of tie-down chains or straps to top of package — Attachment of tie-down chains or straps to expander head or slip table
✓	NCT water spray tests: — Test arrangement with package before test, showing relative placement of water spray nozzles with respect to the package — Test arrangement with package during test, showing how the water is hitting the package — Test arrangement with package after test, showing evidence of water pooling or accumulation, if any — Rain gauge showing minimum allowable rainfall has been reached
✓	NCT free drop (4 ft) tests: — Test arrangement with package before test, showing the intended offset angle — Test arrangement with package before test, showing the intended drop height — Test arrangement with package after test, showing damaged package at final resting place — Close-up views of package after test, showing particular damage induced as a result of the NCT free drop (4 ft) test, including appropriate dimensional references
✓	NCT penetration tests: — Close-up views of package before test, showing intended point of impact — Test arrangement with package before test, showing supports and restraints that hold the package in place — Test arrangement with package before test, showing position and height of penetration bar, with respect to the package — Test arrangement with package after test, showing damaged package after penetration bar has made impact — Close-up views of package after test, showing particular damage induced as a result of the NCT penetration test, including appropriate dimensional references
✓	NCT compression tests: — If a compression tester machine is being used <ul style="list-style-type: none"> <li>• The relative arrangement of the package within the machine</li> <li>• The force read-out as indicated by the machine control system</li> </ul> — Test arrangement with package during test, showing weight having been applied to the package — Test arrangement with package after test, showing damaged package after weight has been removed (if any)

✓	<ul style="list-style-type: none"> <li>—Close-up views of package after test, showing any particular damage induced as a result of the NCT compression test, including evidence of bulging/buckling of the drum, bending/buckling of the drum bolt guard, and crushing/buckling of the fork pockets</li> </ul>
✓	<p>HAC free drop (30 ft) tests (check as performed)</p> <ul style="list-style-type: none"> <li>— Close-up views of package before test, showing intended point of initial impact</li> <li>— Test arrangement with package before test, showing the intended offset angle</li> <li>— Test arrangement with package before test, showing the intended drop height</li> <li>— Test arrangement with package after test, showing damaged package at final resting place</li> <li>— Close-up views of package after test, showing particular damage induced as a result of the HAC free drop (30 ft) test, including appropriate dimensional references</li> <li>— Close-up views of package after test, showing unexpected damage (if any), due to primary impact or any subsequent event</li> </ul>
✓	<p>HAC crush (30 ft) tests (check as performed)</p> <ul style="list-style-type: none"> <li>— Close-up views of package before test, showing intended point of initial impact</li> <li>— Test arrangement with package before test, showing the intended offset angle</li> <li>— Test arrangement with package before test, showing the intended drop height</li> <li>— Test arrangement with package after test, showing damaged package at final resting place</li> <li>— Close-up views of package after test, showing particular damage induced as a result of the HAC crush (30 ft) test, including appropriate dimensional references</li> <li>— Close-up views of package after test, showing unexpected damage (if any), due to primary impact or any subsequent event</li> </ul>
✓	<p>HAC Puncture drop (40 in ) tests</p> <ul style="list-style-type: none"> <li>—Close-up views of package before test, showing intended point of initial impact</li> <li>—Test arrangement with package before test, showing the intended offset angle</li> <li>—Test arrangement with package before test, showing the intended drop height</li> <li>—Test arrangement with package after test, showing damaged package at final resting place</li> <li>—Close-up views of package after test, showing particular damage induced as a result of the HAC puncture (1 m (40 in)) test, including appropriate dimensional references</li> <li>—Close-up views of package after test, showing unexpected damage (if any), due to primary impact or any subsequent event</li> </ul>
✓	<p>Supplementary and HAC thermal tests.</p> <ul style="list-style-type: none"> <li>—Views of relative spacing inside the furnace with door/trap open, with or without the package used as a dimensional point of reference, at hot or cold condition</li> <li>—Test arrangement with package before test, showing placement of the thermocouple attachments on the package exterior surface</li> <li>—Test arrangement with package after test, showing damaged/burned package after initial removal from the furnace/fire</li> <li>—Close-up views of package after test, showing any excessively damaged/burned parts (if any)</li> </ul>
✓	<p>HAC immersion-fissile material tests</p> <ul style="list-style-type: none"> <li>— Test arrangement with CV before test, showing placement of the CV within the tank</li> <li>— Test arrangement with CV during test, showing measurement of submerged depth of CV below water line</li> <li>— Close-up views of CV after test, after removal of the CV lid, showing evidence of water ingress (if any)</li> </ul>
✓	<p>HAC immersion- 10CFR71(c)(6) package tests</p> <ul style="list-style-type: none"> <li>— Test arrangement with CV before test, showing placement of the CV within the tank or hydraulic pressure chamber</li> <li>— Test arrangement with CV during test, showing measurement of submerged depth of CV below water line (or, if a hydraulic pressure chamber is being used, the internal pressure read-out as indicated by the hydraulic control system or in-line pressure gauge)</li> <li>— Close-up views of CV after test, after removal of the CV lid, showing evidence of water ingress (if any)</li> </ul>

✓	<p>Post-test leakage rate tests:</p> <ul style="list-style-type: none"> <li>– Close-up views of CV before test, showing drilled/tapped connection for CV lid leakage rate test port</li> <li>– Close-up views of CV during test, showing connections made to CV lid leakage rate test port</li> <li>– Test arrangement with CV during test, showing all connections made to CV</li> </ul>
✓	<p>Initial teardown and inspection:</p> <ul style="list-style-type: none"> <li>– Close-up views of CV after removal from overpack assembly, showing any superficial and structural damage due to interaction with overpack assembly during test sequence (if any), including appropriate dimensional references ( cursory examination only)</li> <li>– Close-up views of all thermal temperature indicators, showing temperatures indicated and evidence of stretching/tearing (if any), including appropriate dimensional references</li> <li>– Close-up views of overpack assembly after removal of CV, showing any superficial and structural damage due to interaction with CV or drum lid during test sequence (if any), including appropriate dimensional references</li> <li>– Close-up views of drum lid after removal from overpack assembly, showing any superficial and structural damage due to interaction with the CV or overpack assembly, including appropriate dimensional references</li> </ul>
✓	<p>Final teardown and inspection:</p> <ul style="list-style-type: none"> <li>– Close-up views of the CV, showing superficial and structural damage to ANY component, internal and external surfaces (if any), including appropriate dimensional references (detailed examination)</li> <li>– Close-up views of components within the CV, showing superficial and structural damage to ANY component, internal and external surfaces (if any), including appropriate dimensional references (detailed examination)</li> <li>– Markings on the surfaces of the overpack assembly and drum lid, showing the intended cross section cuts, including appropriate dimensional references (if requires)</li> <li>– Overall views of overpack assembly and drum lid after cross section cuts have been made (if required)</li> <li>– Close-up views of overpack assembly and drum lid after cross section cuts have been made, showing damage to internal components, including the following: (if required) <ul style="list-style-type: none"> <li>• Extent of burned/charred or disintegrated impact-limiting foam</li> <li>• Extent of disintegration, cracking, or separation of impact-limiting block</li> <li>• Extent of damage to thermal insulating blanket and indication of total radial thickness</li> <li>• Relative dimensional changes of structural components (including but not limited to drum liner assembly, perforated ring, drum lid inner section)</li> <li>• Any cracked welds</li> <li>• Any scratched, dented, or stretched sheet metal</li> </ul> </li> </ul>

Comments:

I certify that the above tasks have been performed and that the observations and comments are correct.

Testing Technician

*Ross W. Hittler*  
CNS-Y-12 STR

*12-13-2021*

Date

*12/13/21*

Date

*M.B. Hunter*

Witness

*[Signature]*  
CNS-Y-12 QE

*12-13-2021*

Date

*12/13/21*

Date

\*All photographs/movies will be uniquely identified with test unit, date and time to ensure that the proper sequence can be reconstructed



## **L. APPENDIX TU-5 FORMS**

# TEST FORM 1 - COMPONENT WEIGHTS

Test Plan DPP-1

TU -5

Part Name	Initial Assembly	Post Thermal, Full Disassembly
	Weight (lbs.)	Weight (lbs.)
CV body	180	180
CV lid, screws, washers, and O-rings (together)	73	73
Test fixture weldment, screws, washers, nuts, bushing (together)	49	48
Test weight sets	AA 66 67 11-23-21 15	66
PCC pad sets	15	15
CV assembly with test content (during reassembly)	383	383
Drum body	377	376
Drum lid assembly, screws, and washers (together)	102	101 99 100 11-23-21
CV base pad and CV flange wedge (together)	5	5
Test unit (TU) assembly	867	864

## EQUIPMENT

Less than 10 pounds


CV weight before immersion: 383 lb.  
CV weight after ✓: 383 lb.  
10 lbs to 2000 lbs

Scale: N/A Expiration Date: N/A

Scale: X502322 Expiration Date: 2/17/2022

Comments: Drum body weight was estimated by calculation.

I certify that the above tasks have been performed and that the observations and comments are correct.

  
Testing Technician

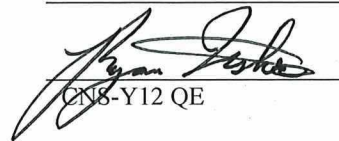
12-08-2021  
Date

M.B. Houston  
Witness

12-08-2021  
Date

  
CNS-Y12 STR

12/8/21  
Date

  
CNS-Y12 QE

12/8/21  
Date

# TEST FORM 2 - ASSEMBLY OF THE CV

Test Plan DPP-1

TU -5

VERIFIED

TASK

RW 9/9/21  
RF 9/9/21

**HOLD POINT:** All payload components have been visually inspected, and Y-12 deems the shipping package acceptable for disassembly.

Verify and/or mark all components: content assembly, CV assembly, and drum assembly components with the corresponding test unit ID, axial lines, and impact targets symbols. Figure 4-1 - Figure 4-4.

Temperature labels have been affixed to the surface of the CV as shown in Figure 5-1, Figure 5-2.

None of the temperature indicators indicate exposure to a temperature in the measured range.

The CV body, CV lid, washers, and bolts were weighed and recorded in TEST FORM 1

**HOLD POINT:** Y-12 has approved the markings.

The following assembly applies to TUs test fixture weldment content assembly

The surrogate test weight was weighed and recorded on TEST FORM 1 .

The loading test fixture weldment content assembly components were weighed and recorded on TEST FORM 1 .

Clean all surfaces with isopropyl alcohol and air dry

Place the PCC pad (silicone rubber) into CV body.

Place the test weight weldment into the CV body.

Place the PCC pad (silicone rubber) into the CV body on top of the test fixture weldment assembly.

**HOLD POINT:** Y-12 witness torqueing of test fixture fastener hex head screws, washers, top hat bushings, and locknuts. The test weight and bolting locations that establish the low and high CG locations are documented in Attachment A. The hex head screws and locknuts shall be torqued to  $25 \pm 2$  ft-lb.

**HOLD POINT:** Y-12 inspected the assembly of the non-test fixture weldment content assembly and verified weights

M&TE ID #: A001096 Calibration Due Date: 2/10/2022

Comments:

I certify that the above tasks have been performed and that the observations and comments are correct.

Testing Technician

Ross Whittaker  
CNS-Y-12 STR

Date

9/9/21  
Date

Witness

YMB Houston  
[Signature]  
CNS-Y-12 QE

Date

09-09-2021  
9/9/21  
Date



# TEST FORM 2 - ASSEMBLY OF THE CV

Test Plan DPP-1

TU -5

## All packages

☒ The CV O-rings and sealing surfaces have been inspected for defects and found acceptable.

☒ Clean all surfaces with isopropyl alcohol and air dry.

☒ The CV O-rings have been installed onto the CV body.

**Note:** Screws and O-rings shall not be replaced without CNS approval. If replacements are authorized, they shall be documented in the test report where the replacements occurred.

☒ The CV lid was lowered on the CV body and the CV screws shall be hand-tightened until the lid is in full contact with the flange, note that clamps may be used during this step. The CV screws shall be torqued in sequence following the numbers etched into the drum lid in three passes. first pass the screws shall be torqued to 19-21 ft-lb, during the second pass to 33-37 ft-lb, and during the third pass to 33-37 ft-lb. The final pass torque values shall be recorded.

Ambient temperature at closure is 70.1 °C (70.1 °F)

Measuring device A006681 Calibration Expiration Date 5/12/2022

☒ Record assembly torque on TEST FORM 11.

RW 9/9/21 Torque wrench # A001096 Calibration Expiration Date 2/10/2022

RF 9/9/21 HOLD POINT: Y-12 inspected the assembly and closure of CV assemblies and verified weights.

☒ The CV assembly has been weighed and the weight has been recorded on TEST FORM 1

☒ The CV assembly has been leak tested (pre-test operational) in accordance with Sect. 7.6 of ANSI N14.5-2014 using the "A.5.2 gas pressure rise" method described in Table A-1 of N14.5-2014 and ORNL procedure NDE 70 Rev. 7, PCMT.

RW 9/15/21  
RF 9/15/21 HOLD POINT: Y-12 has reviewed the leak test and the installation of the acceleration sensor mounts.

☒ Photographs of the assembly have been taken\*.

Comments:

NONE.

I certify that the above tasks have been performed and that the observations and comments are correct.

Testing Technician

Boon Whittebury  
CNS-Y-12 STR

09-15-2021

Date

9/15/21

Date

Witness

M.B. Houston

[Signature]

CNS-Y-12 QE

09-15-2021

Date

9/15/21

Date

\*All photographs/movies will be uniquely identified with test unit, date and time to ensure that the proper sequence can be reconstructed

# TEST FORM 3 - ASSEMBLY OF TEST PACKAGE

Test Plan DPP-1

TU- 5

VERIFIED

TASK

- ☒ Verify operational leak test is complete and form completed and tighten the CV lid leak test port plug per the following sequence: 1<sup>st</sup> pass hand tight, 2<sup>nd</sup> pass torque to 6-7 ft-lb.  
Torque wrench # A001320 Calibration Expiration Date 02-11-2022
- ☒ The exterior of the drum has been clearly marked "TU- 5" and record the drum serial number if applicable:
- ☒ Verify all exterior markings on the TU. If marks are not legible or inadequate, the TA will remark the TU. Mark the 0°, 90°, 180°, 270° locations on the Drum Lid, and the inner and outside walls of the drum with a permanent marker.
- ☒ Install temperature labels on the inside of the drum body as shown in Figure 5-3.
- ☒ Clean all surface of the drum body with isopropyl alcohol and let air dry.
- ☒ The drum body, drum lid, bolts, washers, pads, were weighed and recorded on TEST FORM 1.
- ☒ Place the lower CV base pad into the drum body.
- ☒ Place the CV assembly into the drum body.
- ☒ The CV assembly has been loaded into the drum with the 0° rotated and aligned with 0° line on the drum. Ensure temperature labels are not damaged.
- ☒ Place the CV flange wedge between the CV flange and the drum body.
- ☒ The drum lid has been loaded into the drum with the 0° rotated and aligned with the 0° location on the drum.
- ☒ If necessary, apply thread lubricant to the drum closure bolts.
- ☒ The drum lid has been closed using the same screws that were removed during disassembly. The screws shall be torqued in sequence following the numbers etched into the drum lid in two passes. First, the screws shall be torqued until the lid is in full contact with the flange. Second, the screws shall be torqued to 33-37 ft-lb. Record the assembled torque value on Test Form 10. **TPCR-04**  
Torque wrench #: A001096 Calibration Expiration Date: 02-10-2022
- ☒ The test package assembly has been weighed and the weight recorded on Test Form 1.
- ☒ Mount one (1) vibration accelerometer on the TU-6 drum lid center for NCT vibration monitoring according to the DPP-1 Accelerometer Mounting Procedure. Remove accelerometer after NCT Test. **TPCR-05**
- ☒ The accelerometer mounting blocks and restraint rings have been welded to the drum outer shell as specified in the DPP-1 Accelerometer Mounting Procedure. **TPCR-05**
- ☒ Install the accelerometers on TU-1, TU-2, TU-5, and TU-6 at the locations tspecified by the DPP-1 Accelerometer Mounting Procedure". **TPCR-05**
- ☒ The accelerometers were checked to ensure they were installed and functioning as intended after each installation. **HOLD POINT:** Y-12 has approval: CNS STR RW 10/20/21, CNS QE BF 10/20/21
- ☒ Photographs of the assembly have been taken\*.

Comments:

I certify that the above tasks have been performed and that the observations and comments are correct.

Testing Technician

Ross Whitlun  
CNS-Y-12 STR

09-15-2021  
Date

10/20/21  
Date

Witness

M.B. Houston  
CNS-Y-12 QE

09-15-2021  
Date

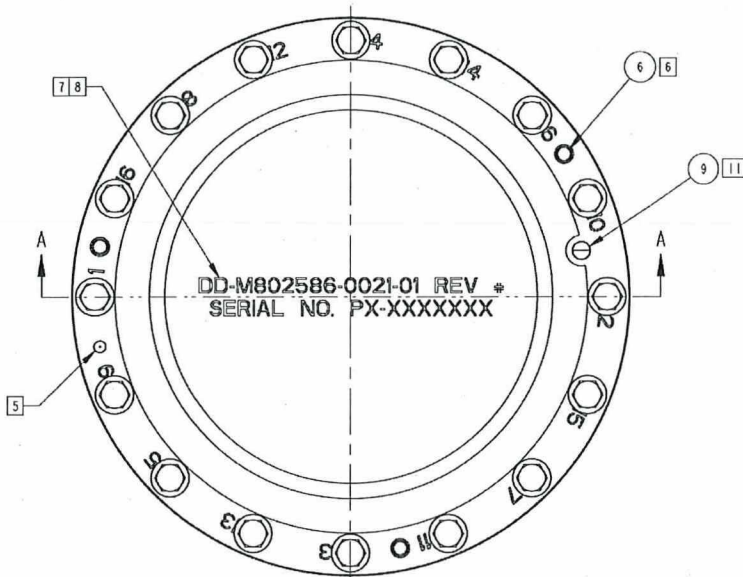
10/20/21  
Date

\*All photographs/movies will be uniquely identified with test unit, date and time to ensure that the proper sequence can be reconstructed.

# TEST FORM 11 -CV LID ASSEMBLY

Test Plan - DPP-1

TU- -5



DPP-1 CV Lid Assembly	
Bolt #	Torque assembly (ft-lbs.)
1	35.0
2	34.8
3	35.4
4	34.3
5	36.0
6	35.3
7	34.8
8	34.6
9	34.7
10	34.7
11	34.6
12	35.1
13	35.6
14	34.6
15	34.8
16	34.8

M&TE ID #: A001096 Calibration Due Date: 2/10/2022

M&TE ID #: A006681 Calibration Due Date: 5/12/2022

Comments:

I certify that the above tasks have been performed and that the observations and comments are correct.

Testing Technician

Ross Whittaker  
CNS-Y-12 STR

09-09-2021

Date

9/9/21

Date

Witness

M.B. Houston  
CNS-Y-12 QE

09-09-2021

Date

9/9/21

Date

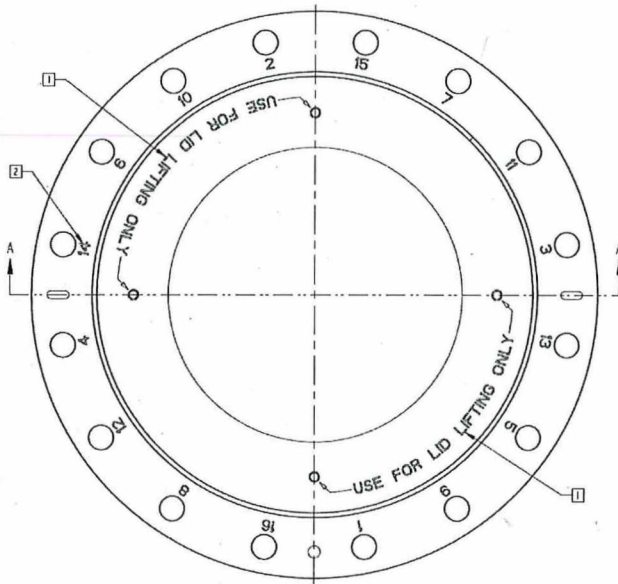
\*All photographs/movies will be uniquely identified with test unit, date and time to ensure that the proper sequence can be reconstructed



# TEST FORM 10 –DRUM LID ASSEMBLY

Test Plan – DPP-1

TU-5



DPP-1 Drum Lid Assembly	
Bolt #	Torque assembly (ft-lbs.)
1	35.6
2	34.9
3	34.6
4	34.6
5	34.6
6	34.9
7	34.3
8	35.9
9	35.9
10	35.1
11	35.7
12	35.2
13	35.2
14	35.2
15	35.2
16	36.1

M&TE ID #: A001096 Calibration Due Date: 02/10/2022

M&TE ID #: N/A Calibration Due Date: N/A

Comments:

I certify that the above tasks have been performed and that the observations and comments are correct.

Testing Technician

Ross Whittaker  
CNS-Y-12 STR

09-15-2021

Date

9/21/21  
Date

Witness

M.B. Houston  
[Signature]  
CNS-Y-12 QE

09-15-2021

Date

9/21/21  
Date

\*All photographs/movies will be uniquely identified with test unit, date and time to ensure that the proper sequence can be reconstructed

# TEST FORM 7 - TEST UNIT DIMENSIONS

Test Plan - DPP-1

TU- 5

Initial Assembly  
Post 1.2-m Drop  
Post 9-m Drop  
Post Crush Test  
Post 1-m Puncture Test

✓  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

Drum outer shell

	0°	90°	180°	270°
Height <u>[43]</u>	<u>43 3/16</u>	<u>43 3/16</u>	<u>43 1/4</u>	<u>43 3/16</u>

DIAMETER	0° to 180°	90° to 270°
Top Surface <u>Ring.</u>	<u>26 3/4</u>	<u>26 7/8</u>
Top Rolling hoop	<u>28</u>	<u>28 1/8</u>
Center Rolling hoop	<u>28</u>	<u>28 1/8</u>
Bottom Rolling hoop	<u>28</u>	<u>28 1/8</u>
Bottom Surface	<u>27 1/16</u>	<u>27 1/8</u>

Location	Flats width @ 0°	Flats width @ 180°
Top Surface		
Top Rolling hoop		
Center Rolling hoop	<u>N/A</u>	<u>N/A</u>
Bottom Rolling hoop		
Bottom Surface		

Sketch Drop Setup Here

N/A

Sketch Package Damage Here

N/A

M&TE ID #: A006327 Calibration Due Date: 3/20/2023

M&TE ID #: N/A Calibration Due Date: N/A

Comments: All dimensions above are in inches [13]

I certify that the above tasks have been performed and that the observations and comments are correct.

Testing Technician

Rose W. Hattley  
CNS-Y-12 STR

09-14-2021

Date

9/21/21

Date

Witness

M.B. Hamilton  
CNS-Y-12 QE

09-14-2021

Date

9/21/21

Date

\*All photographs/movies will be uniquely identified with test unit, date and time to ensure that the proper sequence can be reconstructed

# TEST FORM 4 - PACKAGE CHILLING RECORD

Test Plan DPP-1

TU-5

VERIFIED

TASK

- ☒ Record Environmental Chamber Manufacturer and Serial Number  
Manufacturer: ESPEC [EWSX499-30NW] Serial Number: 3240761
- ☒ Identify Temperature Calibration Unit and verify calibration due date  
Temperature Calibration Unit: VAISALA Calibration Due Date: 10/27/2021
- ☒ Place Test Unit into Environmental Chamber. Date: 10/14/2021 Time: 2:25pm
- ☒ Temperature Controller set to -70°F (-56.7°C).
- ☒ Package in chamber for at least 72 hours and at -70°F for 24 hours. via program in VAISALA
- ☒ Reset Temperature Controller set to -45°F (-42.7°C). Date: 10/15/2021 Time: 11:59pm 4th MBH 10-20-21 11th MBH 10-20-21
- ☒ Package in chamber at -45°F for at least 48 hours. (-43.24°C)
- ☒ Package removed from Chamber. Date: 10/20/2021 Time: 12:55pm
- ☒ Package placed in insulated box for transport. Yes/No
- ☒ Package packed in dry ice (optional): Yes/No N/A
- ☒ Package unpacked from insulated box. Date: 10/20/2021 Time: 1:35pm.
- ☒ Photographs of the assembly have been taken\*. Yes/No

Comments:

Temperature tolerance on VAISALA is  $\pm 2^{\circ}$   
Chamber opened @ 1:35pm, TU-5 removed and wrapped.

I certify that the above tasks have been performed and that the observations and comments are correct.

Testing Technician

Russ Whittely

CNS-Y-12 STR

10-20-2021

Date

10/20/21

Date

M.D. Houston

Witness

[Signature]

CNS-Y-12 QE

10-20-2021

Date

10/20/21

Date

\*All photographs/movies will be uniquely identified with test unit, date and time to ensure that the proper sequence can be reconstructed



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		Page: 7 / 8	Issue Date: 12-10-20
		Revision Date: 12-01-20	Review by Date: 12-10-23

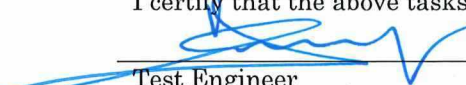
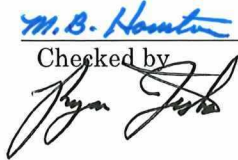
## 6. Procedure Checklist

Test Plan: <i>ORNL/NTRC-092 R.0</i>	Test Unit: <i>5</i>
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VERIFIED	TASK
<input checked="" type="checkbox"/>	Verify that any equipment used meets the M&TE meets PTP-QA-013 requirements (§4.1).
<i>N/A</i>	Water Spray Test (PTP-PRF-05) has been completed within 2 hours before Drop Test. (§4.4)
<input checked="" type="checkbox"/>	Have a photographer's clipboard with package name and test unit number. (§4.5)
<input checked="" type="checkbox"/>	Attitude of the rigged and raised test unit is set. (§4.6)
<input checked="" type="checkbox"/>	Photograph of the rigging arrangements has been taken. (§4.6)
<input checked="" type="checkbox"/>	Photograph of the measured drop angle has been taken. (§4.6)
<input checked="" type="checkbox"/>	The test unit has been raised to the designated drop height. (§4.7)
<input checked="" type="checkbox"/>	Photograph of the height measurement has been taken. (§4.7)
<input checked="" type="checkbox"/>	Video camera(s) are setup and running to take video of the drop. (§4.8)
<input checked="" type="checkbox"/>	The release mechanism has been plugged into power outlet. (§4.8)
<input checked="" type="checkbox"/>	Countdown, Release the test unit, unplug release mechanism. (§4.8)
<input checked="" type="checkbox"/>	Videos camera stopped. (§4.9)
<input checked="" type="checkbox"/>	Photographs of the resulting damage were taken. (§4.9)
<input checked="" type="checkbox"/>	Ambient temperature recorded. (§4.11)
<input checked="" type="checkbox"/>	Date and time of test recorded. (§4.11)
<input checked="" type="checkbox"/>	Sign and date checklist and data forms (§4.12).

Comments: *NONE*

I certify that the above tasks have been performed and that the observations and comments are correct.

 Test Engineer <i>Ron Whittenburg</i>	<i>10-20-21</i> Date <i>10/20/21</i>	 Checked by <i>M.B. Hamilton</i>	<i>10-20-2021</i> Date <i>10/20/21</i>
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<b>ORNL</b> PACKAGE TESTING PROGRAM OAK RIDGE NATIONAL LABORATORY OAK RIDGE, TENNESSEE 37831 <small>The OFFICIAL COPY of this document is the on-line version. Before using a printed copy, verify that it is the most current version by checking the Revision ID against the on-line version</small>	Operating Procedure for NCT Free Drop Test - Testing of Radioactive Material Packages	Test Procedure:	Rev.
		Page:	Issue Date:
		Revision Date:	Review by Date:
		PTP-PEF-08	5 CN2
		8 / 8	12-10-20
		12-01-20	12-10-23

## 7. Data Sheet


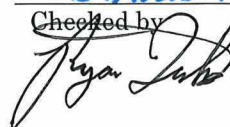
Test Plan: <u>ORNL/NTRC-092 R.0</u>	Test Unit: <u>5</u>
--	---------------------

VERIFIED	TASK
<u>✓</u>	M&TE ID <u>A000885</u> Calibration due date <u>2/24/2021</u> (§4.1)
<u>N/A</u>	Water Spray Test (PTP-PRF-05) Time completed: <u>N/A</u> (§4.4)
<u>✓</u>	Intended attitude and angle of the test unit <u>22° 20' 10/20/21</u> Tolerance ± <u>2</u> (§4.6)
<u>✓</u>	Attitude Description: <u>Slap down 22° bottom corner on pad. 0° facing pad.</u> (§4.6)
<u>✓</u>	Measured attitude and angle of the test unit <u>21.2°</u> degrees. (§4.6)
<u>✓</u>	Level number <u>M212348</u> Calibration Exp. Date <u>2/23/2022</u> (§4.6)
<u>✓</u>	Height above the drop pad <u>4ft</u> Measuring device <u>A000885</u> <u>due 2/24/2026</u> (§4.6)
<u>✓</u>	Ambient temperature: <u>75.0°F</u> (°C) Measuring device <u>A006681</u> (§4.11)
<u>✓</u>	Date and Time of Drop Test: <u>10/20/2021 @ 2:00pm</u> (§4.11)

Testing Damage Observations: See TU-5 Test Form 7 for sketch.  
gro center weld cracked. Crack extended from 180° to 90°  
270°. MBH 10-20-21

Comments: NONE.  
Package spilled out of container lid. MBH 10-20-21

I certify that the above tasks have been performed and that the observations and comments are correct.

 Test Engineer <u>Ross Whittaker</u>	<u>10-20-2021</u> Date <u>10/20/21</u>	<u>M.B. Houston</u> Checked by 	<u>10-20-2021</u> Date <u>10/20/21</u>
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		Page: <b>6 / 7</b>	Issue Date: <b>02-18-2021</b>
		Revision Date: <b>02-18-2021</b>	Review by Date: <b>02-18-2024</b>

## 6. Procedure Checklist

Test Plan: ORNL/NTRC-092 R.O

Test Unit: 5

VERIFIED	TASK
<input checked="" type="checkbox"/>	Verify that any equipment used meets the M&TE meets PTP-QA-013 requirements (§4.1).
<input checked="" type="checkbox"/>	Have a photographer's clipboard with package name and test unit number. (§4.4)
<input checked="" type="checkbox"/>	Attitude of the rigged test unit is set. (§4.5)
<input checked="" type="checkbox"/>	Photograph of the rigging arrangements has been taken. (§4.5)
<input checked="" type="checkbox"/>	Photograph of the measured drop angle has been taken. (§4.5)
<input checked="" type="checkbox"/>	The test unit has been raised to the designated drop height. (§4.7)
<input checked="" type="checkbox"/>	Photograph of the height measurement has been taken. (§4.7)
<input checked="" type="checkbox"/>	Remove plumb bob from test specimen. (§4.7)
<input checked="" type="checkbox"/>	Video camera(s) are setup and running to take video of the drop. (§4.8)
<input checked="" type="checkbox"/>	The release mechanism has been plugged into power outlet. (§4.8)
<input checked="" type="checkbox"/>	Countdown, Release the test unit, unplug release mechanism. (§4.8)
<input checked="" type="checkbox"/>	Videos camera stopped. (§4.9)
<input checked="" type="checkbox"/>	Date and time of test were recorded. (§4.10)
<input checked="" type="checkbox"/>	The ambient temperature has been recorded. (§4.10)
<input checked="" type="checkbox"/>	Photographs of the resulting damage were taken. (§4.11)
<input checked="" type="checkbox"/>	Sign and date checklist and data forms (§4.12).

Comments: NONE.

I certify that the above tasks have been performed and that the observations and comments are correct.

Testing Technician

Boo Whittaker  
Customer

10-20-2021

Date

10/20/21

Date

M.B. Hamilton

Witness

[Signature]  
Customer

10-20-2021

Date

10/20/21

Date



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		Page: <b>7 / 7</b>	Issue Date: <b>02-18-2021</b>
		Revision Date: <b>02-18-2021</b>	Review by Date: <b>02-18-2024</b>

## 7. Data Sheet

Test Plan:

ORNL/NTRC-092 R.0

Test Unit:

5

VERIFIED

TASK

- ✓ Intended attitude of the test unit 22°. Tolerance  $\pm$  2° (§4.2)
- ✓ Attitude Description: Slop down 22° from horizontal. (§4.2)
- ✓ Measured attitude of the test unit 21.1° degrees. (§4.4)
- ✓ Level number M212348 Calibration Exp. Date 2/23/2022 (§4.4)
- ✓ Height above the drop pad 30ft Measuring device A006327 (§4.6)
- ✓ Date and Time of Drop Test: 10/20/2021 @ 2:14pm (§4.9)
- ✓ Ambient temperature: 76.7°F / 76.7 °C ( MOH 10-20-2021 )  
Measuring device A006681 (§4.9)

Testing Damage Observations: NONE

Comments: all data from accels lost due to cable disconnection. A TPCR will be submitted to document this loss of data.

I certify that the above tasks have been performed and that the observations and comments are correct.

Testing Technician

Ron Whittaker  
Customer

10-20-2021

Date

10/20/21  
Date

Witness

Customer

10-20-2021

Date

10/20/21  
Date

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		Page: <b>5 / 6</b>	Issue Date: <b>02-18-2021</b>
		Revision Date: <b>02-18-2021</b>	Review by Date: <b>02-18-2024</b>

## 6 Procedure Checklist

Test Plan:

*ORNL/NTRC-092 R-0*

Test Unit:

*5*

### VERIFIED

### TASK

- ☒ Verify that any equipment used meets the M&TE meets PTP-QA-013 requirements (§4.1).
- ☒ Have a photographer's clipboard with package name and test unit number. (§4.4)
- ☒ Attitude of the test unit is set. (§4.5)
- ☒ Photograph of the attitude has been taken. (§4.5)
- ☒ Photograph of the measured angle has been taken. (§4.5)
- ☒ The crush plate has been raised to the designated drop height and located over the target point. (§4.7)
- ☒ Photograph of the set position has been taken. (§4.7)
- ☒ Remove plumb bob from crush plate. (§4.7)
- ☒ Video camera(s) are setup and running to take video of the drop. (§4.8)
- ☒ The release mechanism has been plugged into power outlet. (§4.8)
- ☒ Countdown, Release the crush plate, unplug release mechanism. (§4.8)
- ☒ Videos camera stopped. (§4.9)
- ☒ Date and time of test recorded. (§4.10)
- ☒ The ambient temperature has been recorded. (§4.10)
- ☒ Photographs of the resulting damage were taken. (§4.11)
- ☒ Sign and date checklist and data forms (§4.11).

Comments: *TU Lid center plate failed at weld seam 180°-90°-270°.*

I certify that the above tasks have been performed and that the observations and comments are correct.

Testing Technician

Date

Witness

Date

Customer

Date

Customer

Date

<b>ORNL</b> PACKAGE TESTING PROGRAM OAK RIDGE NATIONAL LABORATORY OAK RIDGE, TENNESSEE 37831 <small>The OFFICIAL COPY of this document is the on-line version. Before using a printed copy, verify that it is the most current version by checking the Revision ID against the on-line version</small>	Operating Procedure for <b>HAC Crush Test - Testing of          Radioactive Material Packages</b>	Test Procedure: <b>PTP-PEF-11</b>	Rev. <b>6 CN-3</b>
		Page: <b>6 / 6</b>	Issue Date: <b>02-18-2021</b>
		Revision Date: <b>02-18-2021</b>	Review by Date: <b>02-18-2024</b>

## 7. Data Sheet

Test Plan:

ORNL/NTRC-092 R.0

Test Unit:

5

VERIFIED

TASK

- ☒ Intended attitude of the test unit 0° Tolerance  $\pm 2^\circ$  (§4.6)
- ☒ Attitude Description: Vertical orientation off by 7.6° (§4.3)
- ☒ Measured attitude of the test unit 1° degrees. (§4.5)
- ☒ Level number M2123 48 Calibration Exp. Date 2/23/2022 (§4.5)
- ☒ Height above the target: 9-m (30-ft) Measuring device A006327 due 3/30/2023 (§4.7)
- ☒ Date and Time of Crush Test: 10/20/2021 @ 2:40pm (§4.10)
- ☒ Ambient temperature: 75.3°F (75.3 °F) MOH 10-20-21
- Thermometer M&TE ID/Cal. Due Date: A006681 due 5/12/2022 (§4.10)

Testing Damage Observations: (orientation: 0-180° : 0.7°, 90-270° .4°)  
TU-5: Weld at the center plate on the lid failed at 180° → 90° → 270°  
Package spilled out of the Test Unit. Spilled Package weighed 0.775 lb.

Comments: Y-12 decided to proceed with tests. A TPCR approved to be developed and signed later.

I certify that the above tasks have been performed and that the observations and comments are correct.

Testing Technician

Brian Whittely  
Customer

10-20-2021

Date

10/20/21

Date

M.B. Hunter

Witness

Ryan Felt  
Customer

10-20-2021

Date

10/20/21

Date



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		<b>PTP-PEF-12</b>	<b>5 CN 2</b>
		Page:	Issue Date:
		6 / 7	12-14-20
		Revision Date:	Review by Date:
		12-01-20	12-14-23

## • Procedure Checklist

Test Plan:

ORNL/NTRC 092 R.O

Test Unit:

5

VERIFIED

TASK

- ☒ Verify that any equipment used meets the M&TE meets PTP-QA-013 requirements (§4.1).
- ☒ Have a photographer's clipboard with package name and test unit number. (§4.4)
- ☒ Attitude of the rigged test unit is set. (§4.5)
- ☒ Photograph of the rigging arrangements has been taken. (§4.5)
- ☒ Photograph of the measured drop angle has been taken. (§4.5)
- ☒ The test unit has been raised to the designated drop height. (§4.6)
- ☒ Photograph of the height measurement has been taken. (§4.6)
- ☒ Video camera(s) are setup and running to take video of the drop. (§4.7)
- ☒ The release mechanism has been plugged into power outlet. (§4.7)
- ☒ Countdown, Release the test unit, unplug release mechanism. (§4.7)
- ☒ Videos camera stopped. (§4.8)
- ☒ Date and time of test recorded. (§4.9)
- ☒ The ambient temperature has been recorded. (§4.10)
- ☒ Photographs of the resulting damage were taken. (§4.11)
- ☒ Sign and date checklist and data forms (§4.12).

Comments: NONE.

I certify that the above tasks have been performed and that the observations and comments are correct.

Test Engineer

*Ross Whittaker*

10-20-2021

Date

10/20/21

Checked by

*M.B. Hunter*  
*Peter Fisher*

10-20-2021

Date

10/20/21

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		Page:	Issue Date:
		Revision Date:	Review by Date:
		<b>PTP-PEF-12</b>	<b>5 CN 2</b>
		7 / 7	12-14-20
		12-01-20	12-14-23

## 6. Data Sheet

Test Plan: <u>ORNL/NTRC-092 R.0</u>	Test Unit: <u>5</u>
--	---------------------

VERIFIED	TASK
<input checked="" type="checkbox"/>	M&TE ID <u>A001146</u> Calibration due date <u>2/24/2026</u> (§4.1).
<input checked="" type="checkbox"/>	Intended attitude of the test unit <u>0°</u> Tolerance $\pm$ <u>2°</u> (§4.5)
<input checked="" type="checkbox"/>	Measured attitude of the test unit <u>0.2°</u> degrees. (§4.5)
<input checked="" type="checkbox"/>	Attitude Description: <u>Horizontal, 0° at bar, FL @ bar</u> (§4.3)
<input checked="" type="checkbox"/>	Level number <u>M212348</u> Calibration Exp. Date <u>2/23/2022</u> (§4.5)
<input checked="" type="checkbox"/>	Height above the puncture bar <u>40 in</u> Measuring device <u>A001146</u> due <u>2/24/2026</u> (§4.6)
<input checked="" type="checkbox"/>	Date and Time of Drop Test: <u>10/20/2021 @ 3:23pm</u> (§4.9)
<input checked="" type="checkbox"/>	Ambient temperature: <u>70.2°F</u> / <u>70.2</u> °F Measuring device <u>A006681</u> due <u>5/12/2022</u> (§4.10)
	Testing Damage Observations: <u>See Tu-5 Data Sheet 7.</u>

Comments: NONE

I certify that the above tasks have been performed and that the observations and comments are correct.

Test Engineer

Ross Whittaker

10-20-2021

Date

10/20/21

Checked by

M.B. Houston

10-20-2021

Date

10/20/21

# TEST FORM 7 - TEST UNIT DIMENSIONS

Test Plan - DPP-1

TU- 5

## Initial Assembly

Post 1.2-m Drop

Post 9-m Drop

Post Crush Test

Post 1-m Puncture Test

✓  
✓  
✓  
✓

## Drum outer shell

	0°	90°	180°	270°
Height	43 15/16	43 3/16	43 1/8	43 1/8

DIAMETER	0° to 180°	90° to 270°
Top Surface	25 1/4	27 7/16
Top Rolling hoop	25 1/4	28 3/4
Center Rolling hoop	24 5/8	28 15/16
Bottom Rolling hoop	25 1/16	28 5/8
Bottom Surface	Not Measurable	27 1/8

Location	Flats width @ 0°	Flats width @ 180°
Top Surface	6.843	6.256
Top Rolling hoop	11.504	11.302
Center Rolling hoop	12.229	13.897
Bottom Rolling hoop	15.014	N/A
Bottom Surface	17.415	N/A

M&TE ID #: A001319 Calibration Due Date: 02/23/2022

M&TE ID #: N/A Calibration Due Date: N/A

Comments: Scale ID# A000

Empty bag: 0.058 lb. Lost Package + bag: 0.833 lb.

Package = 0.775 lb.

I certify that the above tasks have been performed and that the observations and comments are correct.

Testing Technician

Ron Whittaker  
CNS-Y-12 STR

10-20-2021

Date

10/20/21  
Date

Witness

M.B. Hunter  
[Signature]  
CNS-Y-12 QE

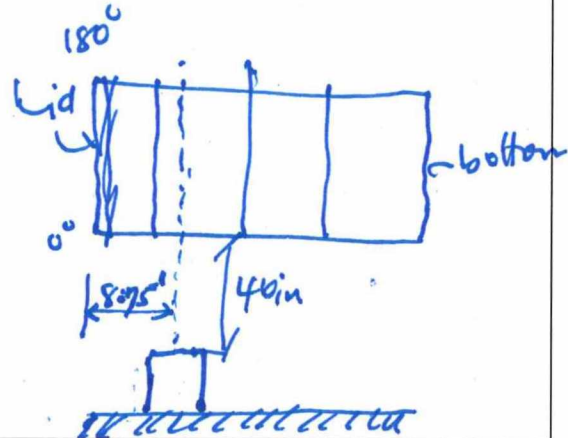
10-20-2021

Date

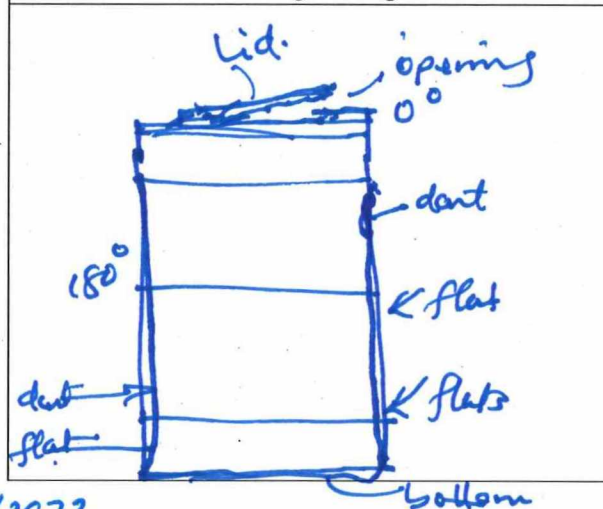
10/20/21  
Date

\*All photographs/movies will be uniquely identified with test unit, date and time to ensure that the proper sequence can be reconstructed

Sketch Drop Setup Here



Sketch Package Damage Here





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		Page	Issue Date:
		Revision Date:	Review by Date:
		<b>PTP-PEF-13</b>	<b>7 CN-0</b>
		10 / 12	03-10-2021
		03-10-2021	03-10-2024

### Attachment 1 - HAC Thermal Test Checklist

Test Plan: ORNL/NTRC-092 R.0

Test Unit: 5


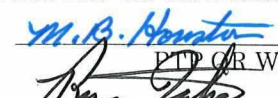
VERIFIED

TASK

- ☒ Ensure test equipment is calibrated, calibration records are acceptable, and that Attachments 1 and 2 records have been initiated prior to testing. Prepare photographers clipboard. (§4.1a, b, c & d)
- ☒ Set up the thermal DAQ and test all TC channels with a calibrated heat source. The acceptable range to test the thermocouples is 0°F - 150°F. (§4.2a)
- ☒ The thermocouple mounting clip material and installation is acceptable and per customer requirements, test plan, or approved work instruction. (§4.2b)
- ☒ TU's have been preheated per customer requirements, test plan or approved work instruction. NOTE: When no customer requirements are given, preheat shall be ~ 66°C (150°F) for a minimum of 24 hours and then soaked at ~ 43°C (110°F) for a minimum of 24 hours. **Record pre-heat acceptance on Attachment 2.** (§4.2c)
- ☒ Unless specified otherwise by the customer requirements, test plan, or approved work instruction, the furnace layout has proved capable of loading tests units within 90 seconds. (§4.3a)
- ☒ Floor plate(s) material(s) and test stand(s) are of the approved design and are installed at the location specified by the customer, test plan or approved work instruction. All TCs have been labeled, installed in the furnace, connected to DAQ and tested. The furnace opening can operate without causing damage to thermocouple wires. Photographs have been taken of the furnace set up. (§4.3b, 4.3c-4.3d)
- ☒ The furnace pre-heat soak time has been achieved (minimum temperature of 860°C (1580°F) for a minimum of 24 hours) and the DAQ is recording TC temperatures every 15 seconds. If needed, adjust the furnace set point to maintain a constant temperature of 1580°F. (§4.3e)

Comments: NONE

I certify that the above tasks have been performed and that the observations and comments are correct.

	<u>11-09-2021</u>		<u>11-09-2021</u>
Testing Technician	Date	PTP OR Witness	Date
<u>Ross Whitlatch</u>	<u>11/9/21</u>	<u>Ryan Duke</u>	<u>11/9/21</u>
Customer	Date	Customer	Date

<b>ORNL</b> PACKAGE TESTING PROGRAM OAK RIDGE NATIONAL LABORATORY OAK RIDGE, TENNESSEE 37831 <small>The OFFICIAL COPY of this document is the on-line version. Before using a printed copy, verify that it is the most current version by checking the Revision ID against the on-line version.</small>	Operating Procedure for <b>HAC Thermal Test - Testing of          Radioactive Material Packages</b>	Test Procedure:	Rev.
		PTP-PEF-13	7 CN-0
		Page 11 / 12	Issue Date: 03-10-2021
		Revision Date: 03-10-2021	Review by Date: 03-10-2024

### Attachment 1 - HAC Thermal Test Checklist (continued)

Test Plan:

ORNL/NTRC-092 R.O

Test Unit:

5

VERIFIED

TASK

- ✓ **Furnace Soak** - A room temperature test specimen, instrumented with thermocouples was placed into the hot furnace. The test unit thermocouples and the furnace thermocouples (including the thermocouple that controls the furnace temperature) were monitored with the cDAQ to ensure the furnace was capable of achieving the requirements specified per the test plan. The test specimen will remain in the furnace for a period specified by customer requirements, test plan, or the approved work instruction. When no requirements are given, the test specimen will remain in the furnace for 30 minutes after 5 of 6 of the thermocouples on the test specimen surface, 2 out of 3 thermocouples on the test stand, and 2 of 3 thermocouples on each furnace wall reach 1475°F. **Record acceptance on Attachment 2. (§4.4.a)**
  - ✓ **Test Unit Preparation** - Weld the thermocouple clips to the TU's before starting the preheat. Pre-heat per test plan requirements. Document pre-heat for the test unit on Attachment 2. Upon acceptance of pre-heat requirements for the test specimen, remove the test specimen from the pre-heat chamber and install TCs. Test all thermocouples with a heat source. (§4.2b & 4.4b)
  - ✓ **Ready to Test** - Open the furnace opening. Load the test specimen on the furnace test stand. Unless specified otherwise by the customer requirements, test plan or work instruction, place the test specimen onto the test stand in a horizontal position with the test specimen lid facing the right furnace sidewall and the 0° line is facing down (facing the furnace floor). (§4.4.c)
  - ✓ **Beginning the Test** - Loading can begin when the furnace has met the required preheat time. **Record the Test Start Time on Attachment 2.** The 30 minute test shall start when the following conditions have been met.
    - 5 of 6 of the thermocouples on the test specimen surface must reach 1475°F or greater and,
    - 2 out of 3 thermocouples on the test stand must reach 1475°F or greater and,
    - 2 of 3 thermocouples on each furnace wall have reached 1475°F or greater. (§4.4a)
  - ✓ **Test Completion** - **Record the Test Stop Time on Attachment 2.** Immediately following the timed test and the thermal requirements are met, immediately remove the test specimen from the furnace and place the specimen in an area where it will not be exposed to artificial cooling. Record notes regarding smoke and/or flames emanating from the test specimen on Attachment 2. (§4.3c)
- All Photographs and/or videos for the entire test setup have been taken. (§4.3c)

Comments:

TU-5 orientation = 45° due to damage (opening) on lid.

I certify that the above tasks have been performed and that the observations and comments are correct.

Testing Technician

11-09-2021

Date

PTP QR Witness

11-09-2021

Date

Customer

11/9/21  
Date

Customer

11/9/21  
Date



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		PTP-PEF-13	7 CN-0
		Page 12 / 12	Issue Date: 03-10-2021
		Revision Date: 03-10-2021	Review by Date: 03-10-2024

## Attachment 2 - HAC Thermal Test Data Sheet

Test Plan: ORNL/NTRC-092 R.O.

Test Unit: 5

VERIFIED

TASK

☒

The test unit has been preheated to over 38°C (100°F). (§4.2c)

Pre-heat Start date/time: 3:45<sup>CT</sup> am/pm @ 11/05/2021

Pre-heat End date/time: 10:22 am/pm (CT) @ 11/09/2021

Final Pre-heat temperature: 710°F

☒

Furnace Soak Time prior to testing - Unless otherwise specified by the customer requirements, test plan or work instructions, preheat the furnace at a temperature of 860°C (1580°F) for a minimum of 24 hours. Record the time/date the soak time began and the time/date the soak time was reached (§ 4.3.e):

Time soak time begins: Date/Time: 3:27 pm (CT) am/pm @ 11/08/2021

Time soak time reached: Date/Time: 8:18 am (CT) am/pm @ 11/09/2021

☒

The test unit has been placed in the furnace, on the support stand, at: (§4.4d)

Furnace door opened time: 11:02 am Furnace door Closed time: 11:02 am

Total time taken to open and Close furnace door: 5 min  
11-09-2021

☒

Unless otherwise specified by the customer requirements, test plan or work instructions, the 30-minute timed test starts after 5 out of 6 test unit thermocouples and 15 of 18 furnace thermocouples reach the test temperature of 801°C (1475°F).

Enter the Test Start Time: 11:04 am am/pm (§4.4e & 4.4f)

☒

The test unit was removed from the furnace and allowed to cool naturally. (§4.4f)

Enter the Test End Time: 11:35 am am/pm

N/A

The test unit stopped outgassing (flames) at                      am/pm (§4.4f)

Outgassing/burnout elapsed time was                      minutes. (§4.4f)

Comments: furnace was soaked overnight. All TCs > 1580°F

I certify that the above tasks have been performed and that the observations and comments are correct.

Testing Technician

Russ W. Hatten  
Customer

11-09-2021

Date

11/9/21

Date

M.B. Houston

Witness

[Signature]  
Customer

11-09-2021

Date

11/9/21

Date



# TEST FORM 5 - POST-THERMAL TESTING INSPECTION

Test Plan DPP-1

TU 5

VERIFIED

TASK

Following the thermal test and after passive cooling, the test package was weighed, and recorded on TEST FORM 1.

The drum, drum lid, bolts, and washers have been visually examined to determine the extent of the testing damage. Observations: No additional physical damage after thermal test

The camera(s) are set up to take photographs\* and/or videotape of the damage due to testing.

The drum lid has been removed and the condition of the exposed parts have been visually examined for damage and the condition has been recorded. Record the exposed temperature indicator blackout reading on TEST FORM 6. Record the torque values needed to loosen the drum lid weldment screws on TEST FORM 1. #8

Observations: Lid stuck, had to cut drum body & liner.

The CV assembly and contents have been removed in the reverse assembly order and visually examined for damage. Record the exposed temperature indicator blackout readings on TEST FORM 6

Observations: None.

The CV assembly has been weighed and the weight recorded on TEST FORM 1.

Use NDE 70 Rev. 7 for the CV post-test operational leak check and for the full containment boundary leak check and PTP-PEF-14 for the 0.9 m (3 ft). immersion test or PTP-PEF-15 for the 15 m immersion test. The leak test port plug shall be removed for these tests.

HOLD POINT: Y-12 has approved the CV drying process.

After immersion test the CV was dried using the CNS approved process (fans, plant air pressure, mild heat, vacuum suction, etc.) as shown in TEST FORM 12. The flange joint and space between the O-rings was dried by the approved process prior to opening the CV.

Disassemble the CV. Record torque value needed to loosen CV screws on TEST FORM 9.

If water is present inside the O-rings, stop work, inform CNS, and comment observations below.

Read the temperature labels from the CV. Record the temperature indicators' blackout readings on TEST FORM 6

The content test fixture weldment assembly was removed from the CV and the weight was recorded on TEST FORM 1.

The content test fixture weldment assembly was disassembled in the reverse assembly order.

Loaded test fixture weldment content assembly: Remove the contents in the following order, loading test fixture weldment assembly using nylon springs, PCC silicone rubber pad, test weight weldment, lower PCC silicone rubber pad. CV silicone rubber pad.

All loose parts will be placed in separate plastic bags, marked with test unit identification, tape closed, and prepared for storage with the test package.

Mark and reassemble the test package to the extent possible for shipment.

\*Photographs and/or video of the damage resulting from the testing have been taken.

Comments: Torque values (break-away) recorded on test form #8 not #1.

I certify that the above tasks have been performed and that the observations and comments are correct.

Testing Technician

Rosa Whitehimer  
CNS-Y-12 STR

12-09-2021

Date

12/8/21

Date

M.B. Houston

Witness

[Signature]  
CNS-Y-12 QE

12-09-2021

Date

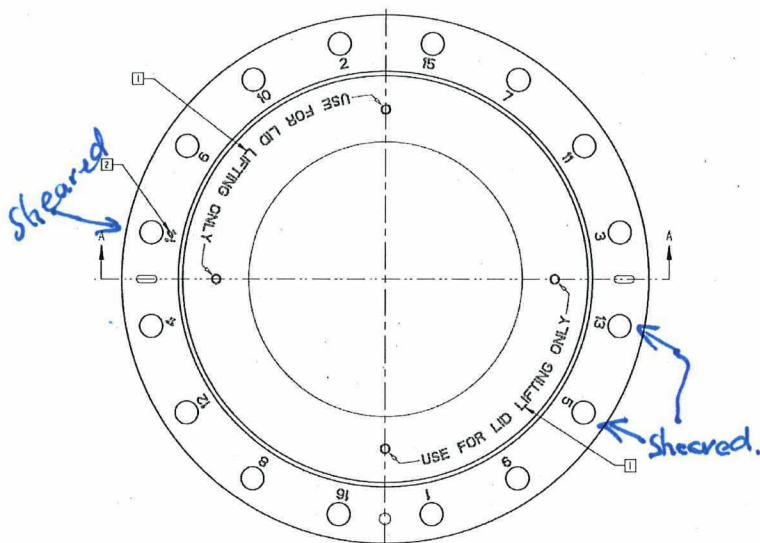
12/8/21  
Date

\*All photographs/movies will be uniquely identified with test unit, date and time to ensure that the proper sequence can be reconstructed.

# TEST FORM 8 –DRUM LID DISASSEMBLY

Test Plan – DPP-1

TU- 5



DPP-1 Lid Disassembly	
Bolt #	Torque Removal (ft-lbs.)
1	41.0
2	34.7
3	55.4
4	16.5
5	64.1
6	49.0
7	9.4
8	19.5
9	47.2
10	41.0
11	53.9
12	33.1
13	103.8
14	97.3
15	39.1
16	23.2

M&TE ID #: A001096 Calibration Due Date: 2/10/2022

M&TE ID #: A006681 Calibration Due Date: 5/12/2022

Comments: Ambient temp: 67.5 °F

Bolt @ #5 Sheared off after the break-away torque.

Bolt @ #13 and #14 also Sheared off after the break-away torque.

I certify that the above tasks have been performed and that the observations and comments are correct.

Testing Technician

Ron Whittaker

CNS-Y-12 STR

11-22-2021

Date

11/22/21

Date

Witness

[Signature]

CNS-Y-12 QE

11-22-2021

Date

11/22/21

Date

\*All photographs/movies will be uniquely identified with test unit, date and time to ensure that the proper sequence can be reconstructed

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		<b>PTP-PEF-14</b>	<b>5 CN 2</b>
		Page:	Issue Date:
		<b>5 / 6</b>	<b>12-14-20</b>
		Revision Date:	Review By Date:
		<b>1-03-20</b>	<b>12-14-23</b>

## 6. Procedure Checklist

Test Plan:

**ORNL/NTRC-092.0**

Test Unit:

**5**

VERIFIED

TASK

- ☒ Verify that any equipment used meets the M&TE meets PTP-QA-013 requirements (§4.1).
- ☒ Have a photographer's clipboard with package name and test unit number. (§4.3)
- ☒ The test unit has been lowered to the bottom of the tank in designated orientation. (§4.6)
- ☒ The depth to the highest point of the test unit has been measured and is at least 0.9-m (3-ft). (§4.6)
- ☒ Photograph of the depth measurement has been taken. (§4.6)
- ☒ Record the water and ambient temperature. (§4.6)
- ☒ Start date and time has been noted. (§4.7)
- ☒ Test unit has been removed from the tank. (§4.8)
- ☒ End date and time has been noted. (§4.8)
- ☒ Record the water and ambient temperature. (§4.8)
- ☒ Thoroughly dry the test unit and make sure it is completely dry before opening. (§4.9)
- ☒ Open the test unit and record-breaking torque values during removal, if required. (§4.10)
- ☒ Inspect for water in-leakage or structural damage. (§4.10)
- ☒ Photographs of any resulting damage or lack thereof were taken. (§4.10)
- ☒ Sign and date checklist and data forms (§4.12).

Comments: **NONE**

I certify that the above tasks have been performed and that the observations and comments are correct.

Test Engineer

**Ron Whitaker**

Date

**12/8/21**

Checked by

**M.B. Houston**  
**Jayna Zabo**

Date

**12/8/21**



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		Page: <b>6 / 6</b>	Issue Date: <b>12-14-20</b>
		Revision Date: <b>1-03-20</b>	Review By Date: <b>12-14-23</b>

## 7. Data Sheet

Test Plan: <b>ORNL/NTRC-092.0</b>	Test Unit: <b>5</b>
--------------------------------------	------------------------

VERIFIED

TASK

<input checked="" type="checkbox"/>	M&TE ID <b>A006327</b> Calibration due date <b>3/20/2023</b> (§4.1).
<input checked="" type="checkbox"/>	Intended attitude of the test unit in tank (e.g. on side) <b>on side</b> (§4.4)
<input checked="" type="checkbox"/>	Depth of water above the test unit <b>41 in</b> Measuring device <b>A006327 due 3/20/2021</b> (§4.6)
<input checked="" type="checkbox"/>	Start Date and Time of Immersion Test: <b>12/07/2021 3:50pm</b> (§4.7)
<input checked="" type="checkbox"/>	Water temperature: <b>70.5 F</b> °C ( <b>70.5</b> °F) Measuring device <b>A006681</b> <b>DUE: 05-12-2022</b> (§4.6)
<input checked="" type="checkbox"/>	Ambient temperature: <b>58.7</b> °C ( <b>58.7</b> °F) Measuring device <b>A006681</b> <b>DUE: 05-12-2022</b> (§4.8)
<input checked="" type="checkbox"/>	End Date and Time of Immersion Test: <b>12/08/2021 9:15am</b> (§4.8)
<input checked="" type="checkbox"/>	Water temperature: <b>70.5 F</b> °C ( <b>70.5</b> °F) Measuring device <b>A006681</b> <b>DUE: 05-12-2022</b> (§4.8)
<input checked="" type="checkbox"/>	Ambient temperature: <b>60.7 F</b> °C ( <b>60.7</b> °F) Measuring device <b>A006681</b> <b>DUE: 05-12-2022</b> (§4.8)
<input checked="" type="checkbox"/>	Detected in-leakage of water: (YES/NO) <b>NO</b> (§4.10)
<input checked="" type="checkbox"/>	Detected structural damage: (YES/NO) <b>NO</b> (§4.10)

Testing Damage Observations:

**N/A**

Comments: **NO LEAKAGE DETECTED.**

I certify that the above tasks have been performed and that the observations and comments are correct.

Test Engineer

**Ross Whittaker**

**12-08-2021**

Date

**12/8/21**

Checked by

**M.B. Hamilton**

**12-08-2021**

Date

**12/8/21**

# TEST FORM 12 –CV DRYING PROCEDURE

Test Plan – DPP-1

TU- 5

VERIFIED

TASK

- ☒ ORNL will remove the CV's from the immersion tank after a minimum of 8 hours.
- ☒ The CV's will be placed on the worktable in a vertical position.
- ☒ A shop vac will be used to blow out any water out of the CV flanges.
- ☒ The external surface of the CV will be dried with cloth and paper towels.
- ☒ ORNL will attach a vacuum to the CV flange O-ring port and supply a vacuum to remove most of the water between the inner and outer O-rings.
- ☒ After about 1 hour of air drying under forced hot air convection, an air compressor or compressed air can, or shop air will be used to blow out any water left in between the CV O-rings.
- ☒ The CV bolts will be loosened and removed, and the breakaway torque will be recorded on Test Form 9.
- ☒ The CV top lid will be lifted about a 1/8<sup>th</sup> -in and cloth and paper towels will be used to wipe the surfaces of the internal CV flanges outboard of the outer O-ring.
- ☒ A visual inspection of the internal surface of the CV flange will be done.
- ☒ ORNL and CNS will verify that water droplets are not visible on the inside of the Inner O-ring.
- ☒ After CNS approval, the CV lid will be completely removed from the CV base.

Comments:

I certify that the above tasks have been performed and that the observations and comments are correct.

Testing Technician

Ross Whittaker  
CNS-Y-12 STR

12-08-2021  
Date

12/8/21  
Date

Witness

M.B. Hunter  
[Signature]  
CNS-Y-12 QE

12-08-2021  
Date

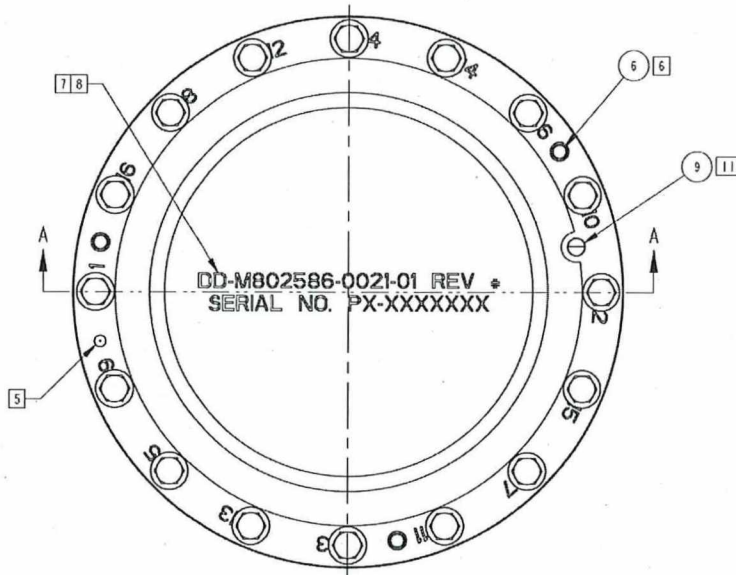
12/8/21  
Date

\*All photographs/movies will be uniquely identified with test unit, date and time to ensure that the proper sequence can be reconstructed

# TEST FORM 9 -CV LID DISASSEMBLY

Test Plan - DPP-1

TU- 5



DPP-1 CV Lid Disassembly	
Bolt #	Torque Removal (ft-lbs.)
1	24.2
2	14.8
3	22.5
4	24.3
5	27.6
6	20.4
7	24.7
8	24.3
9	26.2
10	22.2
11	22.6
12	23.3
13	26.9
14	23.1
15	22.0
16	32.1

M&TE ID #: A001096 Calibration Due Date: 2/10/2022

M&TE ID #: N/A Calibration Due Date: N/A

Comments: No condensation inside the CV. No water on the inside of the inner O-ring. Both O-rings pulled out of the groove in the lid. Lid opened @ 10:52 am.

I certify that the above tasks have been performed and that the observations and comments are correct.

Testing Technician

Ross Whittely  
CNS-Y-12 STR

12-08-2021  
Date

12/8/21  
Date

Witness

M.B. Hamilton  
CNS-Y-12 QE

12-08-2021  
Date

12/8/21  
Date

\*All photographs/movies will be uniquely identified with test unit, date and time to ensure that the proper sequence can be reconstructed



# TEST FORM 6 - TEMPERATURE INDICATOR READINGS

Test Plan DPP-1

TU 5

A visual inspection of each temperature indicator on the package consisting of those indicators inside the CV, outside the CV, and on the drum-liner will be made. The values of the blackouts that occurred will be recorded below.

TEMPERATURE INDICATOR NUMBER LOCATION CHART				
TEST CONTENT ASSEMBLY (TL-10-105, TL-10-190)				
Location (outside)	0°	90°	180°	270°
Top end cap center	1 190 °F	2 190 °F	3 190 °F	4 190 °F
Top end cap under flange	5 190 °F	6 180 °F	7 180 °F	8 190 °F
Tube upper	9 180 °F	10 180 °F	11 180 °F	12 180 °F
Tube middle	13 180 °F	14 180 °F	15 180 °F	16 180 °F
Tube lower	17 180 °F	18 180 °F	19 180 °F	20 180 °F
Bottom end cap under flange	21 180 °F	22 180 °F	23 180 °F	24 180 °F
Bottom end cap center	25 180 °F	26 180 °F	27 180 °F	28 180 °F
Weight upper	29 180 °F	30 180 °F	31 180 °F	32 180 °F
Weight lower	33 180 °F	34 180 °F	35 180 °F	36 180 °F
INTERIOR OF THE CV (TL-10-105, TL-10-190)				
CV lid center	37 190 °F	38 190 °F	39 190 °F	40 190 °F
CV body flange	41 200 °F	42 200 °F	43 200 °F	44 200 °F
CV wall upper	45 190 °F	46 190 °F	47 200 °F	48 200 °F
CV wall middle	49 190 °F	50 190 °F	51 190 °F	52 190 °F
CV wall lower	53 180 °F	54 180 °F	55 180 °F	56 190 °F
CV base neck	57 180 °F	58 180 °F	59 180 °F	60 180 °F
CV base center	180 61 200 °F	62 180 °F	63 180 °F	64 180 °F
EXTERIOR OF THE CV (TL-10-105, TL-10-190)				
Lid center	65 200 °F	66 200 °F	67 200 °F	68 200 °F
Lid flange	69 200 °F	70 200 °F	71 200 °F	72 200 °F
Body flange	73 200 °F	74 200 °F	75 200 °F	76 200 °F
Base neck	77 180 °F	78 180 °F	79 190 °F	80 190 °F
Base toe	81 180 °F	82 180 °F	83 190 °F	84 190 °F
DRUM ASSEMBLY (TL-10-190, TL-10-290)				
Lid bottom	85 210 °F	86 210 °F	87 210 °F	88 210 °F
Cavity wall upper	89 220 °F	90 220 °F	91 230 °F	92 230 °F
Cavity wall middle	93 220 °F	94 220 °F	95 230 °F	96 230 °F
Cavity wall lower	97 220 °F	98 210 °F	99 230 °F	100 230 °F
Cavity wall lowest	101 210 °F	102 210 °F	103 220 °F	104 220 °F
Cavity bottom	105 210 °F	106 210 °F	107 210 °F	108 210 °F

Comments: NONE.

I certify that the above tasks have been performed and that the observations and comments are correct.

Testing Technician

Date

Witness

Date

CNS-Y-12 STR

Date

CNS-Y-12 QE

Date

\*All photographs/movies will be uniquely identified with test unit, date and time to ensure that the proper sequence can be reconstructed

# TEST FORM 15 -WITNESS AND HOLD POINTS

Test Plan DPP-1

TU 5

The following applicable CNS hold points activities shall not start until written approval to proceed has been given from the CNS STR via e-mail. Additional hold points may be included when CNS reviews the approval data documents and as the work is being performed. The purpose of each hold point is to give the TA, STR, and QE an opportunity to (1) evaluate what has happened since the previous hold point, (2) evaluate previous lessons learned on the activities that follow, and (3) make an informed decision to proceed.

NO.	DESCRIPTION	TU NO.	TYPE	CNS INITIAL
1	<u>Initial package disassembly</u> Witness the disassembly, can be waived by a DA representative	1,2,3,4,5,6, 7	Witness, Hold	RW RF
2	<u>pre-test operational leakage rate test</u> Witness the pre-test operational leakage rate test per ANSI N14.5, section 7.6, after final closure (and before commencing testing sequence)	1,2,3,4,5,6, 7	Witness, Hold	
2.1	<u>pre-test operational leakage rate test acceptance</u> Inspection to verify the pre-test operational leakage rate test has met acceptance criteria <b>Subsequent reassembly sequence shall not commence until acceptable result is produced.</b>	1,2,3,4,5,6, 7	Hold	
3	<u>Initial package reassembly</u> Witness the reassembly of the contents, CV, vibration pads, drum lid, instrumentation, and all associated fastening hardware	1,2,3,4,5,6, 7	Witness	
3.1	<u>Initial Package Reassembly</u> Inspection and observation to verify the reassembly procedure has been followed according to supplied direction. <b>Subsequent testing sequence shall not commence until reassembly steps have been confirmed as acceptable.</b>	1,2,3,4,5,6, 7	Hold	
4	<u>NCT vibration/shock test</u> Witness the NCT vibration/shock testing activities, including all preliminary setup, can be waived by a DA representative	6	Witness	
5	<u>NCT thermal pre-treatment</u> Witness the NCT thermal pre-treatment activities, including all preliminary setup, can be waived by a DA representative	1,2,3,4,5,6	Witness	
6	<u>NCT water spray test</u> Witness the NCT water spray test activities, including all preliminary setup, can be waived by a DA representative	2,3,4,6	Witness, Hold	
7	<u>NCT free drop (4 ft) test</u> Witness the NCT free drop (4 ft) test activities, including all preliminary setup, can be waived by a DA representative	1,2,3,4,5,6	Witness	
7.1	<u>NCT free drop (4 ft) test, critical parameters</u> Inspection to verify the critical parameters defining the NCT free drop (4 ft) test meet all requirements <b>Completion of NCT free drop (4 ft) test shall not commence until all critical parameters have been verified.</b>	1,2,3,4,5,6	Hold	



8	<u>NCT penetration test</u> Witness the NCT penetration test activities, including all preliminary setup, can be waived by a DA representative	6	Witness	RW	RF
8.1	<u>NCT penetration test, critical parameters</u> Inspection to verify the critical parameters defining the NCT penetration test meet all requirements	6	Hold		
<b>Completion of NCT penetration test shall not commence until all critical parameters have been verified.</b>					
9	<u>NCT compression test</u> Witness the NCT compression test activities, including all preliminary setup, can be waived by a DA representative	6	Witness		
9.1	<u>NCT compression test, critical parameters</u> Inspection to verify the critical parameters defining the NCT compression test meet all requirements	6	Hold		
<b>Completion of NCT compression test shall not commence until all critical parameters have been verified</b>					
10	<u>HAC thermal pre-treatment</u> Witness the HAC thermal pre-treatment activities, including all preliminary setup, can be waived by a DA representative	1,5	Witness		
11	<u>HAC free drop (30 ft) test</u> Witness the HAC free drop (30 ft) test activities, including all preliminary setup, can be waived by a DA representative	1,2,3,4,5,6	Witness		
11.1	<u>HAC free drop (30 ft) test, critical parameters</u> Inspection to verify the critical parameters defining the HAC free drop (30 ft) test meet all requirements	1,2,3,4,5,6	Hold		
<b>Completion of HAC free drop (30 ft) test shall not commence until all critical parameters have been verified.</b>					
11.2	<u>HAC free drop (30 ft) test, damage determination</u> Inspection to verify that the damage inflicted during the HAC free drop (30 ft) test is as expected, if unexpected damage is present, modifications to the subsequent HAC Crush (30 ft) test will be defined	1,2,3,4,5,6	Hold		
<b>Testing shall not commence until new specification of HAC Crush (30 ft) test has been agreed-upon and adopted by the TA.</b>					
12	<u>HAC crush (30 ft) test</u> Witness the HAC crush (30 ft) test activities, including all preliminary setup, can be waived by a DA representative	1,2,3,4,5,6	Witness		
12.1	<u>HAC crush (30 ft) test, critical parameters</u> Inspection to verify the critical parameters defining the HAC crush (30 ft) test meet all requirements	1,2,3,4,5,6	Hold		
<b>Completion of HAC crush (30 ft) test shall not commence until all critical parameters have been verified.</b>					
12.2	<u>HAC crush (30 ft) test, damage determination</u> Inspection to verify that the damage inflicted during the HAC crush (30 ft) test is as expected, if unexpected damage is present, modifications to the subsequent HAC Puncture drop (40 in.) test will be defined	1,2,3,4,5,6	Hold		
<b>Testing shall not commence until new specification of HAC Puncture drop (40 in.) test has been agreed-upon and adopted by the TA.</b>					



13	<u>HAC Puncture drop (40 in.) test</u> Witness the HAC Puncture drop (40 in.) test activities, including all preliminary setup, can be waived by a DA representative	1,2,3,4,5,6	Witness	RW	RF
13.1	<u>HAC Puncture drop (40 in.) test, critical parameters</u> Inspection to verify the critical parameters defining the HAC Puncture drop (40 in.) test meet all requirements	1,2,3,4,5,6	Hold		
<b>Completion of HAC Puncture drop (40 in.) test shall not commence until all critical parameters have been verified.</b>					
NO.	DESCRIPTION	TU NO.	TYPE	CNS INITIAL	
14	<u>Thermal test, data collection hardware</u> Inspection to verify that all the thermocouple and hardware has been installed, or configured as specified and is operating correctly	1,2,3,4,5,6	Hold		
<b>Completion of supplementary thermal test shall not commence until hardware installation has been verified.</b>					
15	<u>HAC thermal test</u> Witness the HAC thermal test activities, including all preliminary setup, can be waived by a DA representative	1,2,3,4,5,6	Witness		
15	<u>Overpack Inspection and Disassembly</u> Witness the overpack inspection and disassembly process, including all preliminary setup, can be waived by a DA representative	1,2,3,4,5,6	Witness		
16	<u>Overpack Inspection and Disassembly</u> Inspection to verify that sufficient data and measurements have been collected from overpack and CV prior to drilling and tapping the CV lid for post-test leakage rate measurements	1,2,3,4,5,6	Hold		
<b>Post-test leakage rate activities, including all preliminary setup, shall not commence until hardware installation has been verified.</b>					
17	<u>post-test operational leakage rate test</u> Witness the post-test operational leakage rate test per ANSI N14.5, section 7.6, after completion of test activities (and before post-test full-boundary leakage rate test)	1,2,3,4,5,6	Witness		
18	<u>post-test full-boundary leakage rate test, drilling and tapping test port in CV lid</u> Witness the drilling and tapping of the leakage rate test port in the CV lid, after removal from the overpack assembly (and before completion of testing sequence)	1,2,3,4,5,6	Witness		
19	<u>post-test full-boundary leakage rate test</u> Witness the post-test full-boundary leakage rate test per ANSI N14.5, Section 7.5 This includes the sealing of the drilled and tapped hole in the CV lid after the leak rate measurements have completed	1,2,3,4,5,6	Witness		
19.1	<u>Final containment vessel leakage rate test acceptance</u> Inspection to verify the "post-test" leakage rate test has met acceptance criteria	1,2,3,4,5,6	Hold		
<b>HAC immersion tests shall not commence until results are confirmed.</b>					

20	<u>HAC immersion test, fissile material packages</u> Witness the HAC immersion test, fissile material packages, activities, including preliminary setup, can be waived by a DA representative	1,2,3,4,5,6	Witness	RW	RF
21	<u>HAC immersion test, all packages (undamaged)</u> Witness the HAC immersion test, all packages (undamaged), activities, including preliminary setup, can be waived by a DA representative	7	Witness		
22	<u>Opening containment vessel after HAC immersion test</u> Witness the opening of the containment vessel and inspection for retained moisture within the containment vessel cavity, including preliminary setup and verification that the external surface is complete dry, can be waived by a DA representative	1,2,3,4,5,6, 7	Witness		
NO.	DESCRIPTION	TU NO.	TYPE	CNS INITIAL	
23	<u>Final external inspection results</u> Inspection of all external inspection results, to verify all specified dimensional and photographic records have been obtained, these records cannot be confirmed after the overpack assembly has been cut-open and so must be confirmed at this point  <b>Disassembly and cross section examination shall not commence until all external inspections have been completed and all necessary records have been collected. (if required)</b>	1,2,3,4,5,6, 7	Hold		
24	<u>Disassembly and cross section inspection</u> Witness the cutting, disassembly, and dissection of the overpack assembly (if required)	1,2,3,4,5,6, 7	Witness		
25	<u>Final cross section inspection results (if required)</u> Inspection of all cross-section inspection results, to verify all specified dimensional and photographic records have been obtained  <b>Completion of final data report shall not commence until all cross-section inspections have been completed and all necessary records have been collected. (if required)</b>	1,2,3,4,5,6, 7	Hold		
26	<u>Preliminary data package</u> Inspection of all preliminary test results, including data collected, photos and videos captured, and dimensions measured  <b>Shipment or disposal (as defined by the DA) of TU shall not commence until the preliminary data package has been reviewed and determined to be complete.</b>	1,2,3,4,5,6, 7	Hold		

Comments:

I certify that the above tasks have been performed and that the observations and comments are correct.

Testing Technician

CNS-Y-12 STR

12-13-2021  
Date

12/8/21  
Date

Witness

CNS-Y-12 QE

12-13-2021  
Date

12/8/21  
Date

\*All photographs/movies will be uniquely identified with test unit, date and time to ensure that the proper sequence can be reconstructed

# TEST FORM 16 -**PHOTOGRAPHY/VIDEO CHECKLIST**

Test Plan DPP-1

CTU 5

At a minimum, the following events shall be captured by photography. If necessary, photos shall be taken from multiple perspectives to provide a clear understanding of the event being captured. Date and time will be stamped on all photographs.

VERIFIED

TASK

✓	Overpack assembly, containment vessel, and vibration pads after taking delivery and during disassembly
✓	Overpack assembly, containment vessel, and vibration pads (where applicable) during reassembly
✓	Drop testing pad, including appropriate dimensional references
✓	Puncture bar installed onto drop pad, including appropriate dimensional reference
✓	Penetration bar, including appropriate dimensional references
✓	Equipment, instrumentation, and general arrangement used for vibration/shock tests
✓	Equipment, instrumentation, and general arrangement used for free and Puncture drop tests
✓	Equipment, instrumentation, and general arrangement used for water spray tests
✓	Pre-test leakage rate tests: — Close-up views of CV before test, showing connection for CV lid leakage rate test port — Close-up views of CV during test, showing connections made to CV lid leakage rate test port — Test arrangement with CV during test, showing all connections made to CV
✓	NCT vibration/shock tests: — Test arrangement with the package installed onto the expander head or slip table — Attachment of tie-down chains or straps to top of package — Attachment of tie-down chains or straps to expander head or slip table
✓	NCT water spray tests: — Test arrangement with package before test, showing relative placement of water spray nozzles with respect to the package — Test arrangement with package during test, showing how the water is hitting the package — Test arrangement with package after test, showing evidence of water pooling or accumulation, if any — Rain gauge showing minimum allowable rainfall has been reached
✓	NCT free drop (4 ft) tests: — Test arrangement with package before test, showing the intended offset angle — Test arrangement with package before test, showing the intended drop height — Test arrangement with package after test, showing damaged package at final resting place — Close-up views of package after test, showing particular damage induced as a result of the NCT free drop (4 ft) test, including appropriate dimensional references
✓	NCT penetration tests: — Close-up views of package before test, showing intended point of impact — Test arrangement with package before test, showing supports and restraints that hold the package in place — Test arrangement with package before test, showing position and height of penetration bar, with respect to the package — Test arrangement with package after test, showing damaged package after penetration bar has made impact — Close-up views of package after test, showing particular damage induced as a result of the NCT penetration test, including appropriate dimensional references
✓	NCT compression tests: — If a compression tester machine is being used <ul style="list-style-type: none"> <li>• The relative arrangement of the package within the machine</li> <li>• The force read-out as indicated by the machine control system</li> </ul> — Test arrangement with package during test, showing weight having been applied to the package — Test arrangement with package after test, showing damaged package after weight has been removed (if any)



✓	<ul style="list-style-type: none"> <li>—Close-up views of package after test, showing any particular damage induced as a result of the NCT compression test, including evidence of bulging/buckling of the drum, bending/buckling of the drum bolt guard, and crushing/buckling of the fork pockets</li> </ul>
✓	<p>HAC free drop (30 ft) tests: (check as performed)</p> <ul style="list-style-type: none"> <li>— Close-up views of package before test, showing intended point of initial impact</li> <li>— Test arrangement with package before test, showing the intended offset angle</li> <li>— Test arrangement with package before test, showing the intended drop height</li> <li>— Test arrangement with package after test, showing damaged package at final resting place</li> <li>— Close-up views of package after test, showing particular damage induced as a result of the HAC free drop (30 ft) test, including appropriate dimensional references</li> <li>— Close-up views of package after test, showing unexpected damage (if any), due to primary impact or any subsequent event</li> </ul>
✓	<p>HAC crush (30 ft) tests: (check as performed)</p> <ul style="list-style-type: none"> <li>— Close-up views of package before test, showing intended point of initial impact</li> <li>— Test arrangement with package before test, showing the intended offset angle</li> <li>— Test arrangement with package before test, showing the intended drop height</li> <li>— Test arrangement with package after test, showing damaged package at final resting place</li> <li>— Close-up views of package after test, showing particular damage induced as a result of the HAC crush (30 ft) test, including appropriate dimensional references</li> <li>— Close-up views of package after test, showing unexpected damage (if any), due to primary impact or any subsequent event</li> </ul>
✓	<p>HAC Puncture drop (40 in.) tests:</p> <ul style="list-style-type: none"> <li>—Close-up views of package before test, showing intended point of initial impact</li> <li>—Test arrangement with package before test, showing the intended offset angle</li> <li>—Test arrangement with package before test, showing the intended drop height</li> <li>—Test arrangement with package after test, showing damaged package at final resting place</li> <li>—Close-up views of package after test, showing particular damage induced as a result of the HAC puncture (1 m (40 in)) test, including appropriate dimensional references</li> <li>—Close-up views of package after test, showing unexpected damage (if any), due to primary impact or any subsequent event</li> </ul>
✓	<p>Supplementary and HAC thermal tests:</p> <ul style="list-style-type: none"> <li>—Views of relative spacing inside the furnace with door/trap open, with or without the package used as a dimensional point of reference, at hot or cold condition</li> <li>—Test arrangement with package before test, showing placement of thermocouple attachments on the package exterior surface</li> <li>—Test arrangement with package after test, showing damaged/burned package after initial removal from the furnace/fire</li> <li>—Close-up views of package after test, showing any excessively damaged/burned parts (if any)</li> </ul>
✓	<p>HAC immersion-fissile material tests:</p> <ul style="list-style-type: none"> <li>— Test arrangement with CV before test, showing placement of the CV within the tank</li> <li>— Test arrangement with CV during test, showing measurement of submerged depth of CV below water line</li> <li>— Close-up views of CV after test, after removal of the CV lid, showing evidence of water ingress (if any)</li> </ul>
✓	<p>HAC immersion- 10CFR71(c)(6) package tests</p> <ul style="list-style-type: none"> <li>— Test arrangement with CV before test, showing placement of the CV within the tank or hydraulic pressure chamber</li> <li>— Test arrangement with CV during test, showing measurement of submerged depth of CV below water line (or, if a hydraulic pressure chamber is being used, the internal pressure read-out as indicated by the hydraulic control system or in-line pressure gauge)</li> <li>— Close-up views of CV after test, after removal of the CV lid, showing evidence of water ingress (if any)</li> </ul>

✓	<p>Post-test leakage rate tests:</p> <ul style="list-style-type: none"> <li>– Close-up views of CV before test, showing drilled/tapped connection for CV lid leakage rate test port</li> <li>– Close-up views of CV during test, showing connections made to CV lid leakage rate test port</li> <li>– Test arrangement with CV during test, showing all connections made to CV</li> </ul>
✓	<p>Initial teardown and inspection:</p> <ul style="list-style-type: none"> <li>– Close-up views of CV after removal from overpack assembly, showing any superficial and structural damage due to interaction with overpack assembly during test sequence (if any), including appropriate dimensional references ( cursory examination only)</li> <li>– Close-up views of all thermal temperature indicators, showing temperatures indicated and evidence of stretching/tearing (if any), including appropriate dimensional references</li> <li>– Close-up views of overpack assembly after removal of CV, showing any superficial and structural damage due to interaction with CV or drum lid during test sequence (if any), including appropriate dimensional references</li> <li>– Close-up views of drum lid after removal from overpack assembly, showing any superficial and structural damage due to interaction with the CV or overpack assembly, including appropriate dimensional references</li> </ul>
✓	<p>Final teardown and inspection:</p> <ul style="list-style-type: none"> <li>– Close-up views of the CV, showing superficial and structural damage to ANY component, internal and external surfaces (if any), including appropriate dimensional references (detailed examination)</li> <li>– Close-up views of components within the CV, showing superficial and structural damage to ANY component, internal and external surfaces (if any), including appropriate dimensional references (detailed examination)</li> <li>– Markings on the surfaces of the overpack assembly and drum lid, showing the intended cross section cuts, including appropriate dimensional references (if requires)</li> <li>– Overall views of overpack assembly and drum lid after cross section cuts have been made (if required)</li> <li>– Close-up views of overpack assembly and drum lid after cross section cuts have been made, showing damage to internal components, including the following: (if required) <ul style="list-style-type: none"> <li>• Extent of burned/charred or disintegrated impact-limiting foam</li> <li>• Extent of disintegration, cracking, or separation of impact-limiting block</li> <li>• Extent of damage to thermal insulating blanket and indication of total radial thickness</li> <li>• Relative dimensional changes of structural components (including but not limited to drum liner assembly, perforated ring, drum lid inner section)</li> <li>• Any cracked welds</li> <li>• Any scratched, dented, or stretched sheet metal</li> </ul> </li> </ul>

Comments:

I certify that the above tasks have been performed and that the observations and comments are correct.

Testing Technician

*Ross Whittebury*  
CNS-Y-12 STR

12-13-2021

Date

12/8/21  
Date

Witness

*M.B. Houston*  
CNS-Y-12 QE

12-13-2021

Date

12/8/21  
Date

\*All photographs/movies will be uniquely identified with test unit, date and time to ensure that the proper sequence can be reconstructed

## **M. APPENDIX TU-6 FORMS**



# TEST FORM 1 - COMPONENT WEIGHTS

Test Plan DPP-1

TU -6

Part Name	Initial Assembly	Post Thermal, Full Disassembly
	Weight (lbs.)	Weight (lbs.)
CV body	180	180
CV lid, screws, washers, and O-rings (together)	73	73
Test fixture weldment, screws, washers, nuts, bushing (together)	49.	48
Test weight sets	67	66
PCC pad sets	15	15
CV assembly with test content (during reassembly)	383	383
Drum body	384	382
Drum lid assembly, screws, and washers (together)	102	102
CV base pad and CV flange wedge (together)	5	5
Test unit (TU) assembly	874	872

CV weight before immersion: 384 lb.  
 EQUIPMENT CV weight after immersion: 384 lb.  
 Less than 10 pounds 10 lbs to 2000 lbs

Scale: N/A Expiration Date: N/A

Scale: X502322 Expiration Date: 2/17/2022

Comments:

I certify that the above tasks have been performed and that the observations and comments are correct.

  
 Testing Technician

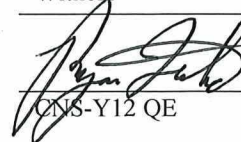
12-09-2021  
 Date

M.A. Houston  
 Witness

12-09-2021  
 Date

  
 CNS-Y12 STR

12/9/21  
 Date

  
 CNS-Y12 QE

12/9/21  
 Date

# TEST FORM 2 - ASSEMBLY OF THE CV

Test Plan DPP-1

TU -6

VERIFIED

TASK

RW 9/9/21  
RF 9/9/21

**HOLD POINT:** All payload components have been visually inspected, and Y-12 deems the shipping package acceptable for disassembly.

Verify and/or mark all components: content assembly, CV assembly, and drum assembly components with the corresponding test unit ID, axial lines, and impact targets symbols. Figure 4-1 - Figure 4-4.

Temperature labels have been affixed to the surface of the CV as shown in Figure 5-1, Figure 5-2.

None of the temperature indicators indicate exposure to a temperature in the measured range.

The CV body, CV lid, washers, and bolts were weighed and recorded in TEST FORM 1

RW 9/9/21  
RF 9/9/21

**HOLD POINT:** Y-12 has approved the markings.

The following assembly applies to TUs test fixture weldment content assembly

The surrogate test weight was weighed and recorded on TEST FORM 1 .

The loading test fixture weldment content assembly components were weighed and recorded on TEST FORM 1 .

Clean all surfaces with isopropyl alcohol and air dry

Place the PCC pad (silicone rubber) into CV body.

Place the test weight weldment into the CV body.

Place the PCC pad (silicone rubber) into the CV body on top of the test fixture weldment assembly.

RW 9/9/21  
RF 9/9/21

**HOLD POINT:** Y-12 witness torquing of test fixture fastener hex head screws, washers, top hat bushings, and locknuts. The test weight and bolting locations that establish the low and high CG locations are documented in Attachment A. The hex head screws and locknuts shall be torqued to  $25 \pm 2$  ft-lb.

RW 9/9/21  
RF 9/9/21

**HOLD POINT:** Y-12 inspected the assembly of the non-test fixture weldment content assembly and verified weights

M&TE ID #: A001096 Calibration Due Date: 2/10/2022

Comments:

I certify that the above tasks have been performed and that the observations and comments are correct.

Testing Technician

Ross W. Hutter  
CNS-Y-12 STR

09-09-2021

Date

9/9/21

Date

M.B. Hunter

Witness

[Signature]  
CNS-Y-12 QE

09-09-2021

Date

9/9/21

Date

# TEST FORM 2 - ASSEMBLY OF THE CV

Test Plan DPP-1

TU -6

## All packages

✓

The CV O-rings and sealing surfaces have been inspected for defects and found acceptable.

✓

Clean all surfaces with isopropyl alcohol and air dry.

✓

The CV O-rings have been installed onto the CV body.

✓

**Note:** Screws and O-rings shall not be replaced without CNS approval. If replacements are authorized, they shall be documented in the test report where the replacements occurred.

The CV lid was lowered on the CV body and the CV screws shall be hand-tightened until the lid is in full contact with the flange, note that clamps may be used during this step. The CV screws shall be torqued in sequence following the numbers etched into the drum lid in three passes. first pass the screws shall be torqued to 19-21 ft-lb, during the second pass to 33-37 ft-lb, and during the third pass to 33-37 ft-lb. The final pass torque values shall be recorded.

Ambient temperature at closure is \_\_\_\_\_ °C (71.7 °F)

Measuring device A006681 Calibration Expiration Date 5/12/2022

✓  
RW 9/9/21

Record assembly torque on TEST FORM 11.

Torque wrench # A001096 Calibration Expiration Date 2/10/2022

✓  
RF 9/9/21

HOLD POINT: Y-12 inspected the assembly and closure of CV assemblies and verified weights.

✓

The CV assembly has been weighed and the weight has been recorded on TEST FORM 1

✓  
RW 9/15/21

The CV assembly has been leak tested (pre-test operational) in accordance with Sect. 7.6 of ANSI N14.5-2014 using the "A.5.2 gas pressure rise" method described in Table A-1 of N14.5-2014 and ORNL procedure NDE 70 Rev. 7, PCMT.

✓  
RW 9/15/21

HOLD POINT: Y-12 has reviewed the leak test and the installation of the acceleration sensor mounts.

✓

Photographs of the assembly have been taken\*.

Comments:

I certify that the above tasks have been performed and that the observations and comments are correct.

[Signature]  
Testing Technician  
Ross Whittaker  
CNS-Y-12 STR

09-15-2021  
09-09-2021  
Date 9/15/21  
Date

M.B. Hunter  
Witness  
[Signature]  
CNS-Y-12 QE

09-15-2021  
09-09-2021  
Date 9/9/21  
Date

\*All photographs/movies will be uniquely identified with test unit, date and time to ensure that the proper sequence can be reconstructed



# TEST FORM 3 - ASSEMBLY OF TEST PACKAGE

Test Plan DPP-1

TU- 6

VERIFIED	TASK
<input checked="" type="checkbox"/>	Verify operational leak test is complete and form completed and tighten the CV lid leak test port plug per the following sequence: 1 <sup>st</sup> pass hand tight, 2 <sup>nd</sup> pass torque to 6-7 ft-lb. Torque wrench # <u>A001320</u> Calibration Expiration Date <u>02-11-2022</u>
<input checked="" type="checkbox"/>	The exterior of the drum has been clearly marked "TU- <u>6</u> " and record the drum serial number if applicable:
<input checked="" type="checkbox"/>	Verify all exterior markings on the TU. If marks are not legible or inadequate, the TA will remark the TU. Mark the 0°, 90°, 180°, 270° locations on the Drum Lid, and the inner and outside walls of the drum with a permanent marker.
<input checked="" type="checkbox"/>	Install temperature labels on the inside of the drum body as shown in Figure 5-3.
<input checked="" type="checkbox"/>	Clean all surface of the drum body with isopropyl alcohol and let air dry.
<input checked="" type="checkbox"/>	The drum body, drum lid, bolts, washers, pads, were weighed and recorded on TEST FORM 1.
<input checked="" type="checkbox"/>	Place the lower CV base pad into the drum body.
<input checked="" type="checkbox"/>	Place the CV assembly into the drum body.
<input checked="" type="checkbox"/>	The CV assembly has been loaded into the drum with the 0° rotated and aligned with 0° line on the drum. Ensure temperature labels are not damaged.
<input checked="" type="checkbox"/>	Place the CV flange wedge between the CV flange and the drum body.
<input checked="" type="checkbox"/>	The drum lid has been loaded into the drum with the 0° rotated and aligned with the 0° location on the drum.
<u>N/A</u>	If necessary, apply thread lubricant to the drum closure bolts.
<input checked="" type="checkbox"/>	The drum lid has been closed using the same screws that were removed during disassembly. The screws shall be torqued in sequence following the numbers etched into the drum lid in two passes. First, the screws shall be torqued until the lid is in full contact with the flange. Second, the screws shall be torqued to 33-37 ft-lb. Record the assembled torque value on Test Form 10. <b>TPCR-04</b> Torque wrench #: <u>A001096</u> Calibration Expiration Date: <u>02-10-2022</u>
<input checked="" type="checkbox"/>	The test package assembly has been weighed and the weight recorded on Test Form 1.
<input checked="" type="checkbox"/>	Mount one (1) vibration accelerometer on the TU-6 drum lid center for NCT vibration monitoring according to the DPP-1 Accelerometer Mounting Procedure. Remove accelerometer after NCT Test. <b>TPCR-05</b>
<input checked="" type="checkbox"/>	The accelerometer mounting blocks and restraint rings have been welded to the drum outer shell as specified in the DPP-1 Accelerometer Mounting Procedure. <b>TPCR-05</b>
<input checked="" type="checkbox"/>	Install the accelerometers on TU-1, TU-2, TU-5, and TU-6 at the locations tspecified by the DPP-1 Accelerometer Mounting Procedure". <b>TPCR-05</b>
<input checked="" type="checkbox"/>	The accelerometers were checked to ensure they were installed and functioning as intended after each installation. <b>HOLD POINT:</b> Y-12 has approval: CNS STR <u>RW 10/22/21</u> , CNS QE _____
<input checked="" type="checkbox"/>	Photographs of the assembly have been taken*.

Comments:

I certify that the above tasks have been performed and that the observations and comments are correct.

Testing Technician

Ross Whittenburg  
CNS-Y-12 STR

Date

10/22/21  
Date

Witness

[Signature]  
CNS-Y-12 QE

Date

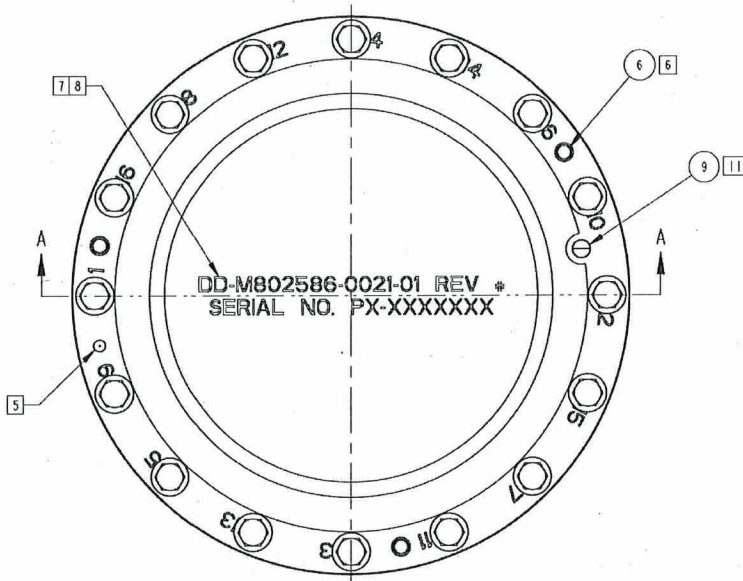
10/22/21  
Date

\*All photographs/movies will be uniquely identified with test unit, date and time to ensure that the proper sequence can be reconstructed.

# TEST FORM 11 -CV LID ASSEMBLY

Test Plan - DPP-1

TU 16



DPP-1 CV Lid Assembly	
Bolt #	Torque assembly (ft-lbs.)
1	35.0
2	34.6
3	34.7
4	35.1
5	35.0
6	34.5
7	35.1
8	34.8
9	35.3
10	35.3
11	34.6
12	35.6
13	34.8
14	34.8
15	34.9
16	34.8

M&TE ID #: A001096 Calibration Due Date: 2/10/2022

M&TE ID #: A006681 Calibration Due Date: 5/12/2022

Comments:

N  
A MAN 10-08-2021 MAN  
9-9-21

I certify that the above tasks have been performed and that the observations and comments are correct.

[Signature]  
Testing Technician  
Ross W. Hittenlanger  
CNS-Y-12 STR

09-09-2021  
10-08-2021 MAN 9-9-21  
Date 9/9/21 Witness [Signature]  
Date 9/9/21 CNS-Y-12 QE

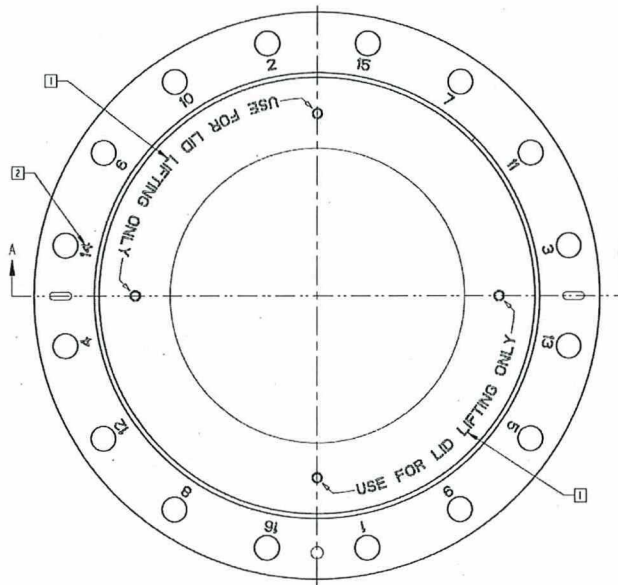
09-09-2021  
10-08-2021 MAN  
Date 9/9/21 9-9-21

\*All photographs/movies will be uniquely identified with test unit, date and time to ensure that the proper sequence can be reconstructed

# TEST FORM 10 -DRUM LID ASSEMBLY

Test Plan - DPP-1

TU-6



DPP-1 Drum Lid Assembly	
Bolt #	Torque assembly (ft-lbs.)
1	35.1
2	35.8
3	35.6
4	35.3
5	34.6
6	36.0
7	34.8
8	35.4
9	35.8
10	34.8
11	35.9
12	34.9
13	34.9
14	34.7
15	36.3
16	35.1

M&TE ID #: A001096 Calibration Due Date: 02/10/2022

M&TE ID #: A006687 <sup>MAN</sup> A006681 Calibration Due Date: 05/12/2022

Comments:

I certify that the above tasks have been performed and that the observations and comments are correct.

Roar Whitham  
Testing Technician  
CNS-Y-12 STR

09-21-21  
10-12-2021  
Date  
9/21/21  
Date

M.B. Houston  
Witness  
Ryan J. J...  
CNS-Y-12 QE

09-21-21  
10-12-2021  
Date  
9/21/21  
Date

\*All photographs/movies will be uniquely identified with test unit, date and time to ensure that the proper sequence can be reconstructed



# TEST FORM 7 –TEST UNIT DIMENSIONS

Test Plan – DPP-1

TU- 6

Initial Assembly ☒  
 Post 1.2-m Drop \_\_\_\_\_  
 Post 9-m Drop \_\_\_\_\_  
 Post Crush Test \_\_\_\_\_  
 Post 1-m Puncture Test \_\_\_\_\_

## Drum outer shell

	0°	90°	180°	270°
Height	43 <sup>1</sup> / <sub>8</sub>	43 <sup>1</sup> / <sub>8</sub>	43 <sup>1</sup> / <sub>16</sub>	43 <sup>1</sup> / <sub>16</sub>

DIAMETER	0° to 180°	90° to 270°
Top Surface	26 <sup>7</sup> / <sub>8</sub>	26 <sup>3</sup> / <sub>4</sub>
Top Rolling hoop	28 <sup>1</sup> / <sub>8</sub>	28 <sup>1</sup> / <sub>16</sub>
Center Rolling hoop	28 <sup>1</sup> / <sub>16</sub>	28 <sup>1</sup> / <sub>4</sub>
Bottom Rolling hoop	28 <sup>1</sup> / <sub>16</sub>	28 <sup>1</sup> / <sub>4</sub>
Bottom Surface	26 <sup>13</sup> / <sub>16</sub>	27 <sup>1</sup> / <sub>8</sub>

Location	Flats width @ 0°	Flats width @ 180°
Top Surface		
Top Rolling hoop		
Center Rolling hoop	N/A	N/A
Bottom Rolling hoop		
Bottom Surface		

Sketch Drop Setup Here

N/A

Sketch Package Damage Here

N/A

M&TE ID #: A006327 Calibration Due Date: 3/20/2023

M&TE ID #: \_\_\_\_\_ Calibration Due Date: \_\_\_\_\_

Comments: All measurements are in inches.

I certify that the above tasks have been performed and that the observations and comments are correct.

Testing Technician

Ross Whittaker  
 CNS-Y-12 STR

Date

9/21/21  
 Date

Witness

M.B. Hunter  
 CNS-Y-12 QE

Date

9/21/21  
 Date

\*All photographs/movies will be uniquely identified with test unit, date and time to ensure that the proper sequence can be reconstructed

<b>ORNL</b> Package Testing Program OAK RIDGE NATIONAL LABORATORY OAK RIDGE, TENNESSEE 37831 <small>The OFFICIAL COPY of this document is the on-line version. Before using a printed copy, verify that it is the most current version by checking the Revision ID against the on-line version</small>	<b>Operating Procedure for NCT Vibration Test - Testing of Radioactive Material Packages</b>	Test Procedure: <b>PTP-PEF-06</b>	Rev. <b>5 CN 2</b>
		Page: <b>5 / 6</b>	Issue Date: <b>12-23-2023</b>
		Revision Date: <b>12-01-2020</b>	Review by Date: <b>12-01-2023</b>

## 6. Procedure Checklist

Test Plan: **ORNL/NTRC-092 R.0**

Test Unit: **6**

VERIFIED

TASK

- ☒ Verify that the Vibration Systems meets the M&TE meets PTP-QA-013 requirements (§4.1).
- ☒ Prepare photographer's clipboard with package name and test unit number (§4.3).
- ☒ Package has been placed in the center of the vibration table (§4.4).
- ☒ Package has been secured to the vibration table, if required (§4.4).
- ☒ Photograph of the package in place has been taken (§4.5).
- ☒ Vibration table controller has been programmed for applied vibration and duration per Procedure PTP-PRF-16, using specifications outlined in the **Test Plan** (§4.6).
- ☒ Ambient temperature recorded. (§4.7) **MTE: A006681 DUE: 5/12/2022 / 67°F**
- ☒ Vibration test initiated per program (§4.7).
- ☒ Record vibration test information on Data Sheet (§4.8).
- ☒ Vibration test successfully completed per program; results printed (§4.9).
- ☒ Test specimen removed from vibration table and examined for damage (§4.10).
- ☒ **N/A** Photographs of any observed damage completed and recorded on Data Sheet (§4.10).
- ☒ Sign and date checklist and data forms (§4.11).

Comments:

I certify that the above tasks have been performed and that the observations and comments are correct.

Test Engineer

**Ross Whittenburg**

**10-06-2021**

Date

**10/6/21**

Checked by

**Myra J. [Signature]**

**10-06-2021**

Date

**10/6/21**

<b>ORNL</b> Package Testing Program OAK RIDGE NATIONAL LABORATORY OAK RIDGE, TENNESSEE 37831 <small>The OFFICIAL COPY of this document is the on-line version. Before using a printed copy, verify that it is the most current version by checking the Revision ID against the on-line version</small>	Operating Procedure for NCT Vibration Test - Testing of Radioactive Material Packages	Test Procedure: <b>PTP-PEF-06</b>	Rev. <b>5 CN 2</b>
		Page: <b>6 / 6</b>	Issue Date: <b>12-23-2023</b>
		Revision Date: <b>12-01-2020</b>	Review by Date: <b>12-01-2023</b>

## 7. Data Sheet

Test Plan: <b>ORNL/NTRC-092 R.D</b>	Test Unit: <b>6</b>
--	------------------------

VERIFIED

TASK

✓ M&TE ID **S/N 10795658** Calibration due date **03/30/2022** (§4.1).  
**Model: 10K-TTV 2**

✓ Ambient temperature: \_\_\_\_\_ °C ( **67** °F) (§4.7)

✓ Start Date and Time: **10/6/21 @ 8:50 am** (§4.7) **stop: 12:51 pm**

**N/A** The DOT Bounce test has been performed for one hour. (§4.8)

OR

✓ The random vibration test has been performed for **4** hour(s). (§4.8)  
 The PSD for this test was as follows:

Frequency	PSD
1	0.004
2	0.03
4	0.03
6.5	0.002
25	0.002
110	0.00008
380	0.00008
1000	0.000005

✓ End Date and Time: **10/6/21 @ 12:51 pm** (§4.9)

**N/A** Vibration controller test printout attached: \_\_\_\_\_ Y / N (§4.9)

Testing Damage Observations: **Straps remained tight. No observable damage on TH. Accel remained attached.**

Comments: **Accel model # J352C68 S/N: 230190.**  
**\* Vibration Controller test printout to be plotted in excel \***

I certify that the above tasks have been performed and that the observations and comments are correct.

Test Engineer

**Ross Whittaker**

**10-06-2021**  
Date

**10/6/21**

Checked by

**M.B. Hunter**  
**Juan J. Soto**

**10-06-2021**  
Date

**10/6/21**



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		Page: <b>5 / 6</b>	Issue Date: <b>12-14-20</b>
		Revision Date: <b>12-01-20</b>	Review by Date: <b>12-14-20</b>

## 6. Procedure Checklist

Test Plan:

**ORNL/NTRC -092 R.O**

Test Unit:

**6**

VERIFIED

TASK

- ☒ Water Spray apparatus has been assembled (§4.2).
- ☒ Photographer's clipboard with package name and test unit number recorded (§4.2).
- ☒ Test Unit placed properly in the water spray zone and spray function verified (§4.3).
- ☒ Photograph of the test arrangement taken, documenting test unit identification (§4.3).
- ☒ Place the rain gauge upright on the ground adjacent to the test specimen (§4.4).
- ☒ Water spray has been started is spraying on the top and 4 sides, with a minimum rate of 2 in/hr (5 cm/hr) (§4.5).
- ☒ Date and time of test has been recorded. (§4.5).
- ☒ The ambient temperature has been recorded. (§4.6).
- ☒ Water spray has been stopped after 1 hour, rain gauge reading has been recorded and any damage noted (§4.6).
- ☒ End time of test has been recorded. (§4.6).
- ☒ Photographs of the resulting damage (if any) were taken (§4.5).
- ☒ Sign and date checklists (§4.7).

Comments:

I certify that the above tasks have been performed and that the observations and comments are correct.

Test Engineer.

*Ross W. Hiltner*

**10-06-2021**

Date

**10/6/21**

Checked by

*Y.M.S. Hiltner*

**10-06-2021**

Date

**10/6/21**

<b>ORNL</b> Package Testing Program OAK RIDGE NATIONAL LABORATORY OAK RIDGE, TENNESSEE 37831 <small>The OFFICIAL COPY of this document is the on-line version. Before using a printed copy, verify that it is the most current version by checking the Revision ID against the on-line version</small>	<b>Operating Procedure for NCT Water Spray Test – Testing of Radioactive Material Packages</b>	Test Procedure: <b>PTP-PEF-05</b>	Rev. <b>5-CN 2</b>
		Page: <b>6 / 6</b>	Issue Date: <b>12-14-20</b>
		Revision Date: <b>12-01-20</b>	Review by Date: <b>12-14-20</b>

## 7. Data Sheet

Test Plan: <b>ORNL/NTRC-092 R.0</b>	Test Unit: <b>6</b>
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VERIFIED	TASK
<input checked="" type="checkbox"/>	Start Date and Time of Water Spray Test: <b>10/6/21 @ 1:30pm</b> (§4.5)
<input checked="" type="checkbox"/>	End Date and Time of Water Spray Test: <b>10/6/21 @ 2:30pm</b> (§4.6)
<input checked="" type="checkbox"/>	Rain Gauge Reading: <b>5" (full)</b> , (§4.6)
<input checked="" type="checkbox"/>	Ambient temperature: <b>N/A</b> °C ( <b>78</b> °F)
	Measuring device: <b>A006681</b> (§4.6)

Testing Damage Observations: **No discernible damage**

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Comments:

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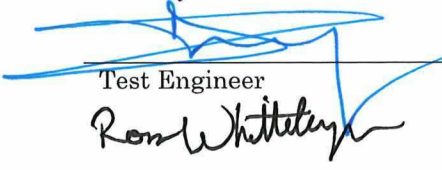
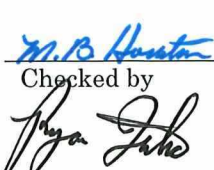


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I certify that the above tasks have been performed and that the observations and comments are correct.

	<b>10-06-2021</b>		<b>10-06-2021</b>
Test Engineer	Date	Checked by	Date
<b>Ron Whitley</b>	<b>10/6/21</b>	<b>Phya Jahn</b>	<b>10/6/21</b>

<b>ORNL</b> PACKAGE TESTING PROGRAM OAK RIDGE NATIONAL LABORATORY OAK RIDGE, TENNESSEE 37831 <small>The OFFICIAL COPY of this document is the on-line version. Before using a printed copy, verify that it is the most current version by checking the Revision ID against the on-line version</small>	<b>Operating Procedure for NCT Free Drop Test - Testing of Radioactive Material Packages</b>	Test Procedure:	Rev.
		<b>PTP-PEF-08</b>	<b>5 CN2</b>
		Page:	Issue Date:
		7 / 8	12-10-20
		Revision Date:	Review by Date:
		12-01-20	12-10-23

## 6. Procedure Checklist

Test Plan:

ORNL/NTRC-092 R.0

Test Unit:

6

VERIFIED

TASK

- ☒ Verify that any equipment used meets the M&TE meets PTP-QA-013 requirements (§4.1).
- ☒ Water Spray Test (PTP-PRF-05) has been completed within 2 hours before Drop Test. (§4.4)
- ☒ Have a photographer's clipboard with package name and test unit number. (§4.5)
- ☐ Attitude of the rigged and raised test unit is set. (§4.6)
- ☒ Photograph of the rigging arrangements has been taken. (§4.6)
- ☒ Photograph of the measured drop angle has been taken. (§4.6)
- ☒ The test unit has been raised to the designated drop height. (§4.7)
- ☒ Photograph of the height measurement has been taken. (§4.7)
- ☒ Video camera(s) are setup and running to take video of the drop. (§4.8)
- ☒ The release mechanism has been plugged into power outlet. (§4.8)
- ☒ Countdown, Release the test unit, unplug release mechanism. (§4.8)
- ☒ Videos camera stopped. (§4.9)
- ☒ Photographs of the resulting damage were taken. (§4.9)
- ☒ Ambient temperature recorded. (§4.11)
- ☒ Date and time of test recorded. (§4.11)
- ☒ Sign and date checklist and data forms (§4.12).

Comments:

I certify that the above tasks have been performed and that the observations and comments are correct.

Test Engineer

Ross Whittle

10-06-2021

Date

10/6/21

Checked by

John F. [Signature]

10-06-2021

Date

10/6/21



<b>ORNL</b> PACKAGE TESTING PROGRAM OAK RIDGE NATIONAL LABORATORY OAK RIDGE, TENNESSEE 37831 <small>The OFFICIAL COPY of this document is the on-line version. Before using a printed copy, verify that it is the most current version by checking the Revision ID against the on-line version</small>	Operating Procedure for <b>NCT Free Drop Test - Testing of          Radioactive Material Packages</b>	Test Procedure: <b>PTP-PEF-08</b>	Rev. <b>5 CN2</b>
		Page: <b>8 / 8</b>	Issue Date: <b>12-10-20</b>
		Revision Date: <b>12-01-20</b>	Review by Date: <b>12-10-23</b>

## 7. Data Sheet

Test Plan: <b>ORNL/NTRC-092.R.O</b>	Test Unit: <b>6</b>
--	------------------------

VERIFIED

TASK

✓ AA 10-06-2021  
M&TE ID **M212348** Calibration due date **2/23/2022** (§4.1)

✓ Water Spray Test (PTP-PRF-05) Time completed: **2:30pm** (§4.4)

✓ Intended attitude and angle of the test unit **22°** Tolerance  $\pm 2^\circ$  (§4.6)

✓ Attitude Description: **0° orientation down Bottom Corner** (§4.6) **(Skipdown)**

✓ Measured attitude and angle of the test unit **21.9°** degrees (§4.6)

✓ Level number **M212348** Calibration Exp. Date **2/23/2022** (§4.6)

✓ Height above the drop pad **4ft.** Measuring device **A000885** (§4.6) **due: 2/24/2026**

✓ Ambient temperature: **73.6°F** Measuring device **A006681** (§4.11) **5/12/2022**

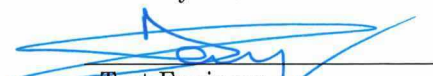
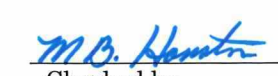
✓ Date and Time of Drop Test: **10/6/21 @ 4:20pm** (§4.11)

~~Height stick:~~ **N/A MCH 10-06-2021** **Abi 10-06-2021**

Testing Damage Observations:

Comments:

I certify that the above tasks have been performed and that the observations and comments are correct.

 Test Engineer <b>Ross Whittaker</b>	<b>10-06-2021</b> Date <b>10/6/21</b>	 Checked by <b>M.B. Hamlin</b>	<b>10-06-2021</b> Date <b>10/6/21</b>
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# TEST FORM 7 –TEST UNIT DIMENSIONS

Test Plan – DPP-1

TU- 6

Initial Assembly \_\_\_\_\_  
 Post 1.2-m Drop ✓  
 Post 9-m Drop \_\_\_\_\_  
 Post Crush Test \_\_\_\_\_  
 Post 1-m Puncture Test \_\_\_\_\_

## Drum outer shell

	0°	90°	180°	270°
Height	43 1/4	43 3/16	43 1/16	43 1/8

DIAMETER	0° to 180°	90° to 270°
Top Surface	26 1/2 26 9/16	26 3/4
Top Rolling hoop	27 5/8	28 1/16
Center Rolling hoop	27 15/16	28 3/16
Bottom Rolling hoop	27 7/8	28 5/16
Bottom Surface	25 13/16	27 1/16

Location	Flats width @ 0°	Flats width @ 180°
Top Surface	4.178	N/A
Top Rolling hoop	6.891	N/A
Center Rolling hoop	2.538	N/A
Bottom Rolling hoop	1.864	N/A
Bottom Surface	11.850	N/A

Sketch Drop Setup Here

Sketch Package Damage Here

M&TE ID #: A006321 Calibration Due Date: 3/20/23

M&TE ID #: A001319 Calibration Due Date: 2/23/22

Comments:

I certify that the above tasks have been performed and that the observations and comments are correct.

Testing Technician

Ross Whittey  
 CNS-Y-12 STR

Date

10/7/21  
 Date

Witness

M. B. Hunter  
 CNS-Y-12 QE

Date

10/7/21  
 Date

\*All photographs/movies will be uniquely identified with test unit, date and time to ensure that the proper sequence can be reconstructed

<b>ORNL</b> PACKAGE TESTING PROGRAM OAK RIDGE NATIONAL LABORATORY OAK RIDGE, TENNESSEE 37831 <small>The OFFICIAL COPY of this document is the on-line version. Before using a printed copy, verify that it is the most current version by checking the Revision ID against the on-line version</small>	Operating Procedure for NCT Compression Test - Testing of Radioactive Material Packages		Test Procedure:	Rev.
			<b>PTP-PEF-07</b>	<b>6 CN-0</b>
			Page:	Issue Date:
			5 / 6	02-18-21
			Revision Date:	Review by Date:
			02-18-2021	02-18-24

## 6. Procedure Checklist

VERIFIED

TASK

Test Plan:

ORNL/NTRC-092.R.O

Test Unit:

6

- ☒ Verify that the Compression system meets the M&TE PTP-QA-013 requirements. (§4.1)
- ☒ Initiate Test Checklist and Data Sheet. Record calculated load. (§4.2 & 4.3)
- ☒ Photographer's clipboard with package name and test unit number prepared. (§4.4)
- ☒ Package placed in the center of the compression tester base and upper platen lowered onto package top. Alternatively, package placed on sturdy horizontal surface for stacking test, and initial dead weight placed on top. (§4.5)
- ☒ Photograph of the test specimen test setup taken. (§4.6)
- ☒ Record height measurement of the package prior to loading on Test Data Sheet. (§4.6)
- ☒ Photograph of the height measurement taken. (§4.6)
- ☒ Program the compression tester to apply the required force and duration per Procedure PTP-PRF-17 and start the test. Record Test Date, Test Load and Test Start Time on Test Data Sheet. Alternatively, stack the remaining required dead weight onto the package top, completing the stack. (§4.7)
- ☒ Compression tester has successfully completed per program. Remove weight from Test Specimen. Alternatively, carefully remove the dead weight from the test specimen. Record test completion time and date on Test Data Sheet. (§4.9)
- ☒ Record final height measurement of the test specimen (post-test). (§4.8)
- ☒ Ambient temperature has been recorded (§4.9)
- ☒ Photograph of the post test height measurement taken. (§4.9)
- ☒ N/A Photographs of any other resulting damage taken. (§4.9)
- ☒ Sign and date checklist and data forms (§4.11).

Comments:

I certify that the above tasks have been performed and that the observations and comments are correct.

Testing Technician

Ross Witterlynn

Customer

10-08-2021

Date

10/8/21

Date

M. B. Houston

Witness

[Signature]

Customer

10-08-2021

Date

10/8/21

Date



<b>ORNL</b> PACKAGE TESTING PROGRAM OAK RIDGE NATIONAL LABORATORY OAK RIDGE, TENNESSEE 37831 <small>The OFFICIAL COPY of this document is the on-line version. Before using a printed copy, verify that it is the most current version by checking the Revision ID against the on-line version</small>	Operating Procedure for NCT Compression Test - Testing of Radioactive Material Packages	Test Procedure:	Rev.
		PTP-PEF-07	6 CN-0
		Page:	Issue Date:
		6 / 6	02-18-21
		Revision Date:	Review by Date:
		02-18-2021	02-18-24

## 7. Data Sheet

Test Plan: ORNL/NTRC-092 R.O

Test Unit: 6

VERIFIED

TASK

- ✓ M&TE ID 1999 Calibration due date 3/30/2022 (§4.1)
- ✓ Calculate and record the greater of 5 times the weight of the package OR 1.9 psi times the projected vertical area of the package. (§4.3)
- 5 × 900 = 4500 lbs.
- 1.9 psi × projected vertical area N/A = N/A lbs.
- ✓ Required Load to be applied to package 4500 lbs. (§4.3)
- ✓ Pre-Test Height Measurements: 0° 43 1/4 90° 43 3/16 180° 43 1/16 270° 43 1/8 (§4.6)
- ✓ Test Start Date and Time: 10/07/2021 @ 11:23 am (§4.7)
- ✓ Load applied at Start of Test: 4500 lbs. (§4.7)
- ✓ Test Completion Date and Time: 10/08/2021 @ 11:27 am (§4.8)
- ✓ Final Height Measurements: 0° 43 3/16 90° 43 1/16 180° 43 1/16 270° 43 1/8 (§4.8)
- ✓ Ambient temperature: 67.9°F (°C) Measuring device: A006681 (§4.9)

Testing Damage Observations: No physical damage observed.

Height recorded:	0°	90°	180°	270°
Before test:	43 1/4	43 3/16	43 1/16	43 1/8
after test:	43 3/16	43 1/8	43 1/16	43 1/8

Comments:

I certify that the above tasks have been performed and that the observations and comments are correct.

Testing Technician

Customer

10-08-2021  
Date

10/8/21  
Date

Witness

Customer

10-08-2021  
Date

10/8/21  
Date

<b>ORNL</b> PACKAGE TESTING PROGRAM OAK RIDGE NATIONAL LABORATORY OAK RIDGE, TENNESSEE 37831 <small>The OFFICIAL COPY of this document is the on-line version. Before using a printed copy, verify that it is the most current version by checking the Revision ID against the on-line version</small>	Operating Procedure for <b>NCT Penetration Test - Testing          of Radioactive Material          Packages</b>	Test Procedure: <b>PTP-PEF-09</b>	Rev. <b>6 CN-0</b>
		Page: <b>5 / 6</b>	Issue Date: <b>02-18-2021</b>
		Revision Date: <b>02-18-2021</b>	Review by Date: <b>02-18-2024</b>

## 6. Procedure Checklist

Test Plan:

**ORNL/NTRC-092 R.O**

Test Unit:

**6**

VERIFIED

TASK

- ☒ Penetration Bar meets requirements. (§3.0)
- ☒ Verify that any equipment used meets the M&TE meets PTP-QA-013 requirements. (§4.1).
- ☒ Initiate Test Checklist and Data Sheet. (§4.3)
- ☒ Have a photographer's clipboard with package name and test unit number. (§4.3)
- ☒ The package has been placed on the drop pad and blocked to keep from moving during test. (§4.5)
- ☒ The penetration bar has been suspended above and aligned to the target point on the package. (§4.6)
- ☒ Photograph of the target alignment has been taken. (§4.6)
- ☒ The penetration bar has been raised to the specified drop height above the target point. (§4.6)
- ☒ Photograph of the height measurement has been taken. (§4.7)
- ☒ Video camera(s) are setup and running to take video of the drop. (§4.8)
- ☒ The release mechanism has been plugged into power outlet. (§4.8)
- ☒ Countdown; release the test unit; unplug release mechanism.
- ☒ The penetration bar has impacted the package at the target point.
- ☒ Videos camera stopped. (§4.9)
- ☒ Date and Time of test recorded. (§4.01)
- ☒ Ambient temperature recorded. (§4.10)
- ☒ Photographs of the resulting damage were taken. (§4.11)
- ☒ Record damage observations on Test Data Sheet. (§4.12)
- ☒ Sign and date checklist and data forms (§4.13).

Comments:

I certify that the above tasks have been performed and that the observations and comments are correct.

Testing Technician

Customer

Date

**10-11-21**  
Date

Witness

Customer

Date

**10-11-21**  
Date

<b>ORNL</b> PACKAGE TESTING PROGRAM OAK RIDGE NATIONAL LABORATORY OAK RIDGE, TENNESSEE 37831 <small>The OFFICIAL COPY of this document is the on-line version. Before using a printed copy, verify that it is the most current version by checking the Revision ID against the on-line version</small>	Operating Procedure for NCT Penetration Test - Testing of Radioactive Material Packages	Test Procedure: <b>PTP-PEF-09</b>	Rev. <b>6 CN-0</b>
		Page: 6 / 6	Issue Date: 02-18-2021
		Revision Date: 02-18-2021	Review by Date: 02-18-2024

## 7. Data Sheet

Test Plan: <u>ORNL/NTRC-092, R.O</u>	Test Unit: <u>6</u>
---	------------------------

VERIFIED

TASK

- ☒ Penetration Bar M&TE ID: A000884 Calibration due date 2/25/2026 (§4.1)
  - ☒ Measuring Device M&TE ID: A001146 Calibration due date 2/24/2026 (§4.1)
  - ☒ Thermometer M&TE ID: A006681 Calibration due date 5/12/2022 (§4.1)
  - ☒ Description of the target point: Flange line @ 0° orientation. (§4.2)
  - ☒ Photographs taken of specimen before drop. (§4.5)
  - ☒ Drop Height (above the package) measurement: 1m (§4.6)
  - ☒ Photographs taken of specimen before drop. (§4.7)
  - ☒ Video camera rolling for the test. (§4.8)
  - ☒ Date and Start Time of Penetration Test: 10/11/2021 @ 9:52am (§4.10)
  - ☒ Ambient temperature: 65.6°F (§4.10) MTE ID: A006681 Due: 5/12/2022
  - ☒ Photographs damage observations after drop. (§4.12)
- Testing Damage Observations: Impact point @ 0.75" from center of the target.

Comments: Vertical alignment measurement checked with square ruler.  
Horizontal alignment measurement: M 212348 due 2/23/2022  
Weigh the puncture bar: 13.51 lbs. MTE ID: A000593 due: 2/17/2022

I certify that the above tasks have been performed and that the observations and comments are correct.

[Signature]  
 Testing Technician  
Rosa Whittaker  
 Customer

10-11-2021  
~~10-11-2022~~  
 Date MON 10-11-21  
10/11/21  
 Date

M.B. Houston  
 Witness  
[Signature]  
 Customer

10-11-2021  
~~10-11-2022~~  
 Date MON 10-11-21  
10/11/21  
 Date



<b>ORNL</b> PACKAGE TESTING PROGRAM OAK RIDGE NATIONAL LABORATORY OAK RIDGE, TENNESSEE 37831 <small>The OFFICIAL COPY of this document is the on-line version. Before using a printed copy, verify that it is the most current version by checking the Revision ID against the on-line version</small>	Operating Procedure for <b>HAC Drop Test - Testing of          Radioactive Material Packages</b>	Test Procedure: <b>PTP-PEF-10</b>	Rev. <b>6 CN-3</b>
		Page: <b>6 / 7</b>	Issue Date: <b>02-18-2021</b>
		Revision Date: <b>02-18-2021</b>	Review by Date: <b>02-18-2024</b>

## 6. Procedure Checklist

Test Plan:

**ORNL/NTRC-092 R.O**

Test Unit:

**6**


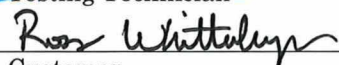
VERIFIED

TASK

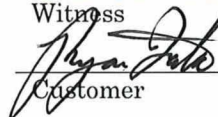
- ☒ Verify that any equipment used meets the M&TE meets PTP-QA-013 requirements (§4.1).
- ☒ Have a photographer's clipboard with package name and test unit number. (§4.4)
- ☒ Attitude of the rigged test unit is set. (§4.5)
- ☒ Photograph of the rigging arrangements has been taken. (§4.5)
- ☒ Photograph of the measured drop angle has been taken. (§4.5)
- ☒ The test unit has been raised to the designated drop height. (§4.7)
- ☒ Photograph of the height measurement has been taken. (§4.7)
- ☒ Remove plumb bob from test specimen. (§4.7)
- ☒ Video camera(s) are setup and running to take video of the drop. (§4.8)
- ☒ The release mechanism has been plugged into power outlet. (§4.8)
- ☒ Countdown, Release the test unit, unplug release mechanism. (§4.8)
- ☒ Videos camera stopped. (§4.9)
- ☒ Date and time of test were recorded. (§4.10)
- ☒ The ambient temperature has been recorded. (§4.10)
- ☒ Photographs of the resulting damage were taken. (§4.11)
- ☒ Sign and date checklist and data forms (§4.12).

Comments:

I certify that the above tasks have been performed and that the observations and comments are correct.

  
 Testing Technician  
  
 Customer

10-22-2021  
 Date  
10/22/21  
 Date

M. B. Hunter  
 Witness  
  
 Customer

10-22-2021  
 Date  
10/22/21  
 Date

<b>ORNL</b> PACKAGE TESTING PROGRAM OAK RIDGE NATIONAL LABORATORY OAK RIDGE, TENNESSEE 37831 <small>The OFFICIAL COPY of this document is the on-line version. Before using a printed copy, verify that it is the most current version by checking the Revision ID against the on-line version</small>	Operating Procedure for HAC Drop Test - Testing of Radioactive Material Packages	Test Procedure:	Rev.
		Page:	Issue Date:
		Revision Date:	Review by Date:
		<b>PTP-PEF-10</b>	<b>6 CN-3</b>
		7 / 7	02-18-2021
		02-18-2021	02-18-2024

## 7. Data Sheet

Test Plan:

ORNL/NTRC-092 R.0

Test Unit:

6

VERIFIED

TASK

- ✓ Intended attitude of the test unit 22°. Tolerance  $\pm$  2° (§4.2)
- ✓ Attitude Description: 30ft, 22° slapdown, 0° facing pad, bottom down. (§4.2)
- ✓ Measured attitude of the test unit 22° degrees. (§4.4)
- ✓ Level number M212348 Calibration Exp. Date 2/23/2022 (§4.4)
- ✓ Height above the drop pad A006327 Measuring device 3/20/2023 (§4.6)
- ✓ Date and Time of Drop Test: 10/22/2021 @ 9:55am (§4.9)
- ✓ Ambient temperature: 55.0°F (°C) N/A MCH 10-22-21
- Measuring device A006681 due: 5/12/2022 (§4.9)
- Testing Damage Observations: Flat @ bottom surface up to bottom rolling hoop.  
also secondary flat on bottom rolling hoop.

Comments:

I certify that the above tasks have been performed and that the observations and comments are correct.

Testing Technician

Customer

10-22-2021

Date

10/22/21

Date

M.B. Hunter

Witness

Customer

10-22-2021

Date

10/22/21

Date

See next page for revised sketch of this slap down angle.

# TEST FORM 7 –TEST UNIT DIMENSIONS

Test Plan – DPP-1

TU- 6

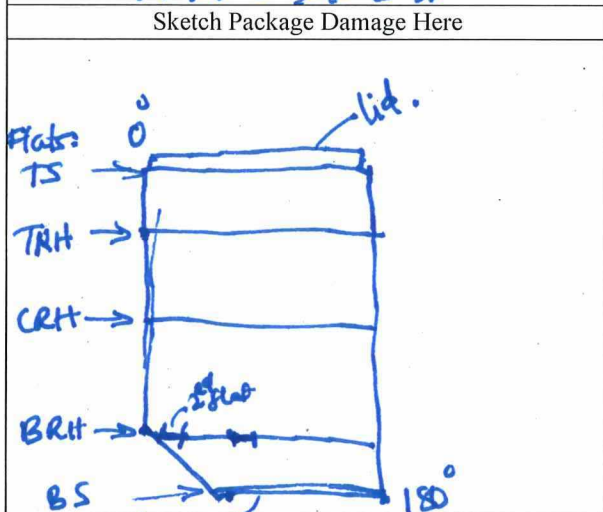
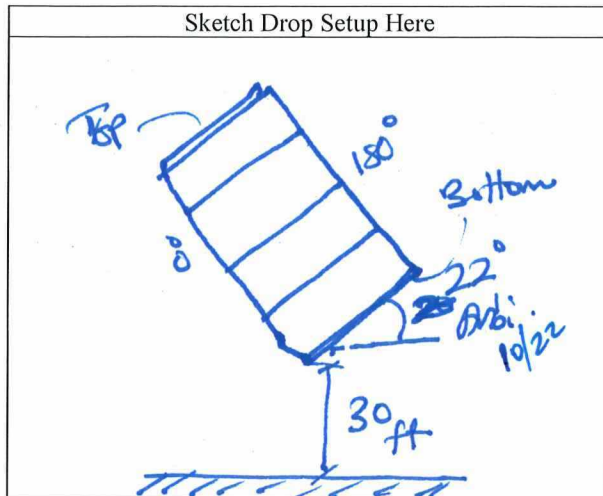
Initial Assembly \_\_\_\_\_  
 Post 1.2-m Drop \_\_\_\_\_  
 Post 9-m Drop ✓ \_\_\_\_\_  
 Post Crush Test \_\_\_\_\_  
 Post 1-m Puncture Test \_\_\_\_\_

## Drum outer shell

	0°	90°	180°	270°
Height	43 11/16	43 1/8	42 15/16	43 5/8

DIAMETER	0° to 180°	90° to 270°
Top Surface	26 1/2	26 7/8
Top Rolling hoop	27 5/16	28 1/4
Center Rolling hoop	27 1/4	28 3/8
Bottom Rolling hoop	26 1/4	28 9/16
Bottom Surface	Not measurable	27 1/16

Location	Flats width @ 0°	Flats width @ 180°
Top Surface	7.439	N/A
Top Rolling hoop	10.383	N/A
Center Rolling hoop	8.542	N/A
Bottom Rolling hoop	14.812	N/A
Bottom Surface	17.704	N/A



M&TE ID #: A006327 Calibration Due Date: 2/20/2023

M&TE ID #: A00319 Calibration Due Date: 2/23/2022

Comments: 2nd Flats @ Bottom Rolling hoop near 0° : 3.191

I certify that the above tasks have been performed and that the observations and comments are correct.

Testing Technician

10-22-2021  
 Date

Witness

10-22-2021  
 Date

Ross Whittaker  
 CNS-Y-12 STR

10/22/21  
 Date

John Felt  
 CNS-Y-12 QE

10/22/21  
 Date

\*All photographs/movies will be uniquely identified with test unit, date and time to ensure that the proper sequence can be reconstructed

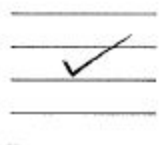


# TEST FORM 7 –TEST UNIT DIMENSIONS

“Sketch re-drawn because the slap down orientation sketched on the initial test form appears to be at 68° not the specified 22°”  
 Test Plan – DPP-1

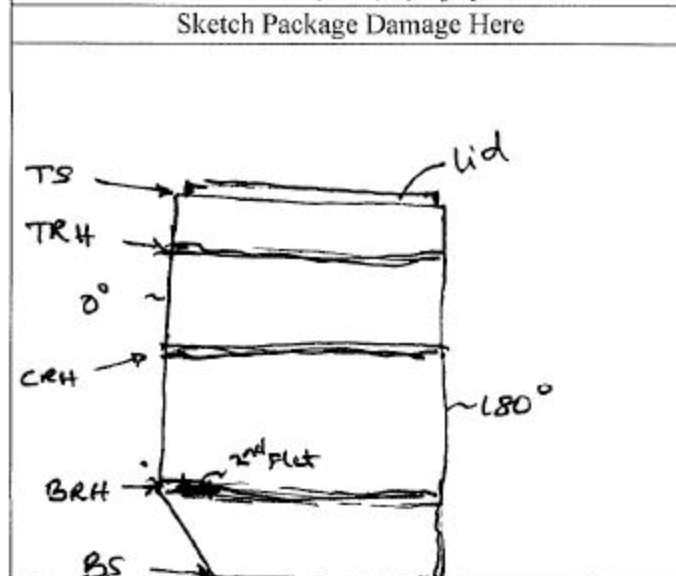
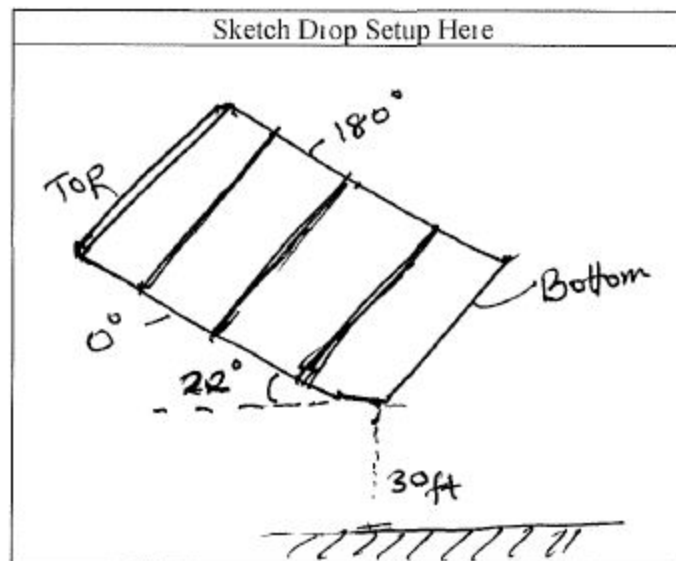
TU- 6

Initial Assembly  
 Post 1.2-m Drop  
 Post 9-m Drop  
 Post Crush Test  
 Post 1-m Puncture Test



Drum outer shell

	0°	90°	180°	270°
Height	43 11/16	43 1/8	42 15/16	43 5/8



DIAMETER	0° to 180°	90° to 270°
Top Surface	26 1/2	26 7/8
Top Rolling hoop	27 5/16	28 1/4
Center Rolling hoop	27 1/4	28 3/8
Bottom Rolling hoop	26 1/4	28 9/16
Bottom Surface	NOT MEASURABLE	27 1/16

Location	Flats width @ 0°	Flats width @ 180°
Top Surface	7.439	N/A
Top Rolling hoop	10.383	N/A
Center Rolling hoop	8.542	N/A
Bottom Rolling hoop	14.812	N/A
Bottom Surface	17.704	N/A

M&TE ID # A006327 Calibration Due Date: 2/20/2023

M&TE ID # A001319 Calibration Due Date: 2/23/2022

Comments

2nd Flt @ Bottom rolling hoop near 0°: 3.191"

This data sheet was revised for the sketch drop set-up drawing and sketch package damage drawing only. All dimensions remain unchanged.

All work was performed on 10/22/2021.

I certify that the above tasks have been performed and that the observations and comments are correct

Abiodun Idowu Adeniyi Digitally signed by Abiodun Idowu Adeniyi  
 Date: 2022.04.06 13:32:34 -04'00'

Testing Technician Date

Ross M (RWM) Whittenbarger Digitally signed by Ross M (RWM) Whittenbarger  
 Date: 2022.04.06 14:05:13 -04'00'

CNS-Y-12 STR Date

Michael B. Houston

Witness

Ryan J (RJF) Fisher

CNS-Y-12 QE

Digitally signed by Michael B. Houston  
 Date: 2022.04.06 13:04:57 -04'00'

Date

Digitally signed by Ryan J (RJF) Fisher  
 Date: 2022.04.06 15:18:39 -04'00'

Date

\*All photographs/movies will be uniquely identified with test unit, date and time to ensure that the proper sequence can be reconstructed

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		Page: <b>5 / 6</b>	Issue Date: <b>02-18-2021</b>
		Revision Date: <b>02-18-2021</b>	Review by Date: <b>02-18-2024</b>

## 6 Procedure Checklist



Test Plan: ORNL/NTRC-092 R.O

Test Unit: 6

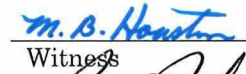
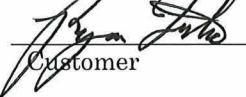
VERIFIED	TASK
<input checked="" type="checkbox"/>	Verify that any equipment used meets the M&TE meets PTP-QA-013 requirements (§4.1).
<input checked="" type="checkbox"/>	Have a photographer's clipboard with package name and test unit number. (§4.4)
<input checked="" type="checkbox"/>	Attitude of the test unit is set. (§4.5)
<input checked="" type="checkbox"/>	Photograph of the attitude has been taken. (§4.5)
<input checked="" type="checkbox"/>	Photograph of the measured angle has been taken. (§4.5)
<input checked="" type="checkbox"/>	The crush plate has been raised to the designated drop height and located over the target point. (§4.7)
<input checked="" type="checkbox"/>	Photograph of the set position has been taken. (§4.7)
<input checked="" type="checkbox"/>	Remove plumb bob from crush plate. (§4.7)
<input checked="" type="checkbox"/>	Video camera(s) are setup and running to take video of the drop. (§4.8)
<input checked="" type="checkbox"/>	The release mechanism has been plugged into power outlet. (§4.8)
<input checked="" type="checkbox"/>	Countdown, Release the crush plate, unplug release mechanism. (§4.8)
<input checked="" type="checkbox"/>	Videos camera stopped. (§4.9)
<input checked="" type="checkbox"/>	Date and time of test recorded. (§4.10)
<input checked="" type="checkbox"/>	The ambient temperature has been recorded. (§4.10)
<input checked="" type="checkbox"/>	Photographs of the resulting damage were taken. (§4.11)
<input checked="" type="checkbox"/>	Sign and date checklist and data forms (§4.11).

Comments:

I certify that the above tasks have been performed and that the observations and comments are correct.

  
 Testing Technician  
  
 Customer

10-22-2021  
 Date  
10/22/21  
 Date

  
 Witness  
  
 Customer

10-22-2021  
 Date  
10/22/21  
 Date

<b>ORNL</b> PACKAGE TESTING PROGRAM OAK RIDGE NATIONAL LABORATORY OAK RIDGE, TENNESSEE 37831 <small>The OFFICIAL COPY of this document is the on-line version. Before using a printed copy, verify that it is the most current version by checking the Revision ID against the on-line version</small>	Operating Procedure for <b>HAC Crush Test - Testing of          Radioactive Material Packages</b>	Test Procedure: <b>PTP-PEF-11</b>	Rev. <b>6 CN-3</b>
		Page: <b>6 / 6</b>	Issue Date: <b>02-18-2021</b>
		Revision Date: <b>02-18-2021</b>	Review by Date: <b>02-18-2024</b>

## 7. Data Sheet

Test Plan:

Test Unit:  
**6**

VERIFIED

TASK

- ☒ Intended attitude of the test unit 0°. Tolerance  $\pm$  2° (§4.6)
- ☒ Attitude Description: 0° on pad, Plate at 30° to hit 180° line @ FL. (§4.3)
- ☒ Measured attitude of the test unit 0.1° degrees. (§4.5)
- ☒ Level number M212348 Calibration Exp. Date 2/23/2022 (§4.5)
- ☒ Height above the target: 9-m (30-ft) Measuring device A006327 (§4.7) due: 3/20/2023
- ☒ Date and Time of Crush Test: 10/22/2021 @ 12:06pm (§4.10)
- ☒ Ambient temperature: 62.5°F (—°C) 10-22-2021
- Thermometer M&TE ID/Cal. Due Date: A006681 5/12/2022 (§4.10)

Testing Damage Observations:

\* Actual Setup for drop was 170°.  
Crush plate orientation: 0-180: 0.5° 90-270: 0.3°

Comments: See top minor damages. Unit laid on pad @ about 10° off from vertical on 0°-180°. Plate CG on FL.

I certify that the above tasks have been performed and that the observations and comments are correct.

Testing Technician

Rosa Whittenlanger

Customer

10-22-2021

Date

10/22/21

Date

Witness

M. B. Hamilton  
Jayna Zula

Customer

10-22-2021

Date

10/22/21

Date



# TEST FORM 7 - TEST UNIT DIMENSIONS

Test Plan - DPP-1

TU- 6

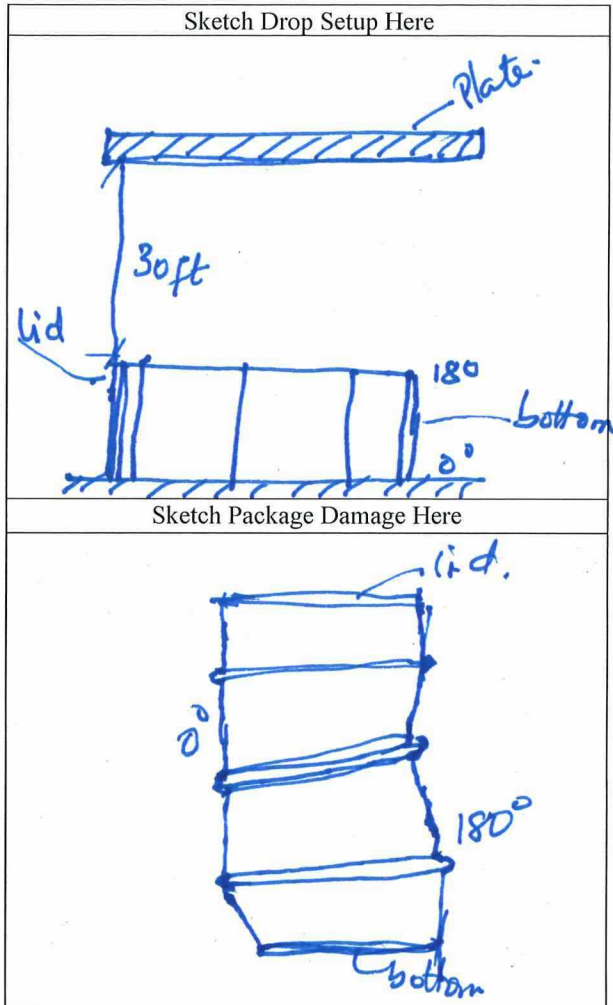
Initial Assembly \_\_\_\_\_  
Post 1.2-m Drop \_\_\_\_\_  
Post 9-m Drop \_\_\_\_\_  
Post Crush Test ✓  
Post 1-m Puncture Test \_\_\_\_\_

## Drum outer shell

	0°	90°	180°	270°
Height	43 13/16	43 1/8	42 7/8	43 3/8

DIAMETER	0° to 180°	90° to 270°
Top Surface	25 5/8	27 1/16
Top Rolling hoop	25 11/16	28 5/8
Center Rolling hoop	24 7/8	29 1/16
Bottom Rolling hoop	26	28 13/16
Bottom Surface	Not Measurable	27 1/8

Location	Flats width @ 0°	Flats width @ 180°
Top Surface	8.170	6.314
Top Rolling hoop	11.421	10.996
Center Rolling hoop	11.402	13.719
Bottom Rolling hoop	14.764	N/A
Bottom Surface	17.693	N/A



M&TE ID #: A006327 Calibration Due Date: 03-20-2023

M&TE ID #: N/A Calibration Due Date: N/A

## Comments:

3rd Weld crack @ 0° on drum lid's center plate. Weld Crack at 180° on (1 1/2") drum lid's center plate. No package release.  
2nd flat on Bottom rolling hoop: 3.214 new Bolts #4 x 12 in.

I certify that the above tasks have been performed and that the observations and comments are correct.

Testing Technician

Ross Whittenburg  
CNS-Y-12 STR

10-22-2021  
Date

10/22/21  
Date

Witness

M.B. Hunter  
CNS-Y-12 QE

10-22-2021  
Date

10/22/21  
Date

\*All photographs/movies will be uniquely identified with test unit, date and time to ensure that the proper sequence can be reconstructed

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		<b>PTP-PEF-12</b>	<b>5 CN 2</b>
		Page:	Issue Date:
		6 / 7	12-14-20
		Revision Date:	Review by Date:
		12-01-20	12-14-23

## • Procedure Checklist

Test Plan:

ORNL/NTRC-092 R.O

Test Unit:

6

VERIFIED

TASK

- ☒ Verify that any equipment used meets the M&TE meets PTP-QA-013 requirements (§4.1).
- ☒ Have a photographer's clipboard with package name and test unit number. (§4.4)
- ☒ Attitude of the rigged test unit is set. (§4.5)
- ☒ Photograph of the rigging arrangements has been taken. (§4.5)
- ☒ Photograph of the measured drop angle has been taken. (§4.5)
- ☒ The test unit has been raised to the designated drop height. (§4.6)
- ☒ Photograph of the height measurement has been taken. (§4.6)
- ☒ Video camera(s) are setup and running to take video of the drop. (§4.7)
- ☒ The release mechanism has been plugged into power outlet. (§4.7)
- ☒ Countdown, Release the test unit, unplug release mechanism. (§4.7)
- ☒ Videos camera stopped. (§4.8)
- ☒ Date and time of test recorded. (§4.9)
- ☒ The ambient temperature has been recorded. (§4.10)
- ☒ Photographs of the resulting damage were taken. (§4.11)
- ☒ Sign and date checklist and data forms (§4.12).

Comments:

I certify that the above tasks have been performed and that the observations and comments are correct.

Test Engineer

Ross Whitaker

10-22-2021

Date

10/22/21

Checked by

M.B. Houston

10-22-2021

Date

10/22/21

<b>ORNL</b> PACKAGE TESTING PROGRAM OAK RIDGE NATIONAL LABORATORY OAK RIDGE, TENNESSEE 37831 <small>The OFFICIAL COPY of this document is the on-line version. Before using a printed copy, verify that it is the most current version by checking the Revision ID against the on-line version</small>	Operating Procedure for HAC Puncture Test - Testing of Radioactive Material Packages	Test Procedure:	Rev.
		Page:	Issue Date:
		Revision Date:	Review by Date:
		PTP-PEF-12	5 CN 2
		7 / 7	12-14-20
		12-01-20	12-14-23

## 6. Data Sheet

Test Plan: <u>ORNL/NTRC-092.R0</u> <u>ORNL/NTRC-092.R0</u> <i>10/22</i>	Test Unit: <u>6</u>
--	---------------------

VERIFIED

TASK

✓ M&TE ID A001146 Calibration due date 2/24/2026 (§4.1).

✓ Intended attitude of the test unit 0° Tolerance  $\pm$  2° (§4.5)

✓ Measured attitude of the test unit 0.3° degrees. (§4.5)

✓ Attitude Description: 0° down, c.g. 40 in above puncture bar, unit Horizontal (§4.3)

✓ Level number M212348 Calibration Exp. Date 2/23/2022 (§4.5)

✓ Height above the puncture bar 40 in Measuring device A001146 *due 2/24/2026* (§4.6)

✓ Date and Time of Drop Test: 10/22/2021 @ 2:57pm (§4.9)

✓ Ambient temperature: 64.4°F °C (            °F) *MON 10-22-2021*

Measuring device A006681 *due 5/12/2022* (§4.10)

Testing Damage Observations:

Comments:

I certify that the above tasks have been performed and that the observations and comments are correct.

Test Engineer

*Rosa Whittaker*

10-22-2021

Date

10/22/21

*M. B. Hunter*

Checked by

*Ryan J. Gorb*

10-22-2021

Date

10/22/21



# TEST FORM 7 –TEST UNIT DIMENSIONS

Test Plan – DPP-1

TU- 6

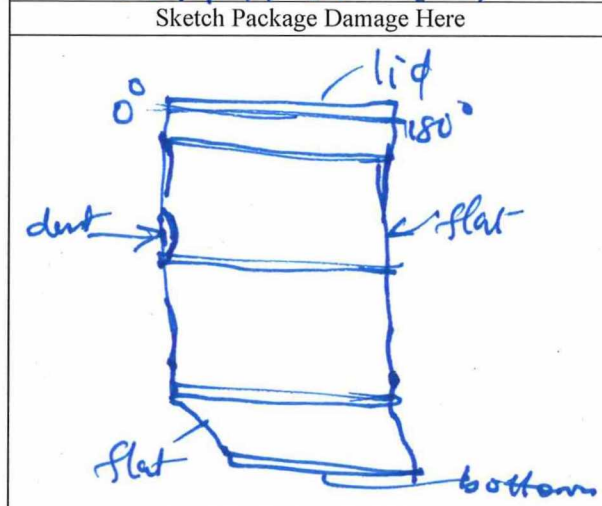
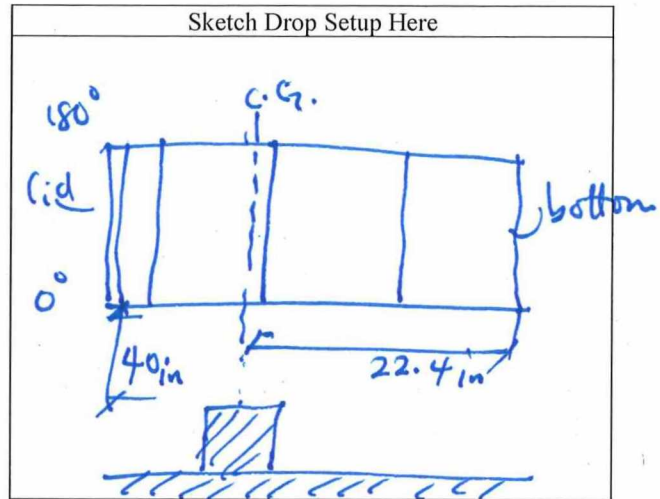
Initial Assembly \_\_\_\_\_  
 Post 1.2-m Drop \_\_\_\_\_  
 Post 9-m Drop \_\_\_\_\_  
 Post Crush Test \_\_\_\_\_  
 Post 1-m Puncture Test ✓

## Drum outer shell

	0°	90°	180°	270°
Height	43 <sup>13</sup> / <sub>16</sub>	43 <sup>3</sup> / <sub>16</sub>	42 <sup>15</sup> / <sub>16</sub>	43 <sup>1</sup> / <sub>4</sub>

DIAMETER	0° to 180°	90° to 270°
Top Surface	45 25 <sup>5</sup> / <sub>8</sub>	27
Top Rolling hoop	25 7 <sup>1</sup> / <sub>16</sub>	28 9 <sup>1</sup> / <sub>16</sub>
Center Rolling hoop	24 7 <sup>1</sup> / <sub>16</sub>	29
Bottom Rolling hoop	25 7 <sup>1</sup> / <sub>8</sub>	28 3 <sup>1</sup> / <sub>4</sub>
Bottom Surface	not measurable	26 13 <sup>1</sup> / <sub>16</sub>

Location	Flats width @ 0°	Flats width @ 180°
Top Surface	N/A	N/A
Top Rolling hoop	N/A	N/A
Center Rolling hoop	N/A	N/A
Bottom Rolling hoop	N/A	N/A
Bottom Surface	N/A	N/A



M&TE ID #: A006327 Calibration Due Date: 3/20/2023

M&TE ID #: N/A Calibration Due Date: N/A

Comments:

I certify that the above tasks have been performed and that the observations and comments are correct.

Testing Technician

10-22-2021  
Date

Witness

10-22-2021  
Date

CNS-Y-12 STR

10/22/21  
Date

CNS-Y-12 QE

10/22/21  
Date

\*All photographs/movies will be uniquely identified with test unit, date and time to ensure that the proper sequence can be reconstructed

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		PTP-PEF-13	7 CN-0
		Page 10 / 12	Issue Date: 03-10-2021
		Revision Date: 03-10-2021	Review by Date: 03-10-2024

### Attachment 1 - HAC Thermal Test Checklist

Test Plan:

ORNL/NTRC-092

R.O

Test Unit:

6

VERIFIED

TASK

- ✓ Ensure test equipment is calibrated, calibration records are acceptable, and that Attachments 1 and 2 records have been initiated prior to testing. Prepare photographers clipboard. (§4.1a, b, c & d)
- ✓ Set up the thermal DAQ and test all TC channels with a calibrated heat source. The acceptable range to test the thermocouples is 0°F - 150°F. (§4.2a)
- ✓ The thermocouple mounting clip material and installation is acceptable and per customer requirements, test plan, or approved work instruction. (§4.2b)
- ✓ TU's have been preheated per customer requirements, test plan or approved work instruction. NOTE: When no customer requirements are given, preheat shall be ~ 66°C (150°F) for a minimum of 24 hours and then soaked at ~ 43°C (110°F) for a minimum of 24 hours. **Record pre-heat acceptance on Attachment 2.** (§4.2c)
- ✓ Unless specified otherwise by the customer requirements, test plan, or approved work instruction, the furnace layout has proved capable of loading tests units within 90 seconds. (§4.3a)
- ✓ Floor plate(s) material(s) and test stand(s) are of the approved design and are installed at the location specified by the customer, test plan or approved work instruction. All TCs have been labeled, installed in the furnace, connected to DAQ and tested. The furnace opening can operate without causing damage to thermocouple wires. Photographs have been taken of the furnace set up. (§4.3b, 4.3c-4.3d)
- ✓ The furnace pre-heat soak time has been achieved (minimum temperature of 860°C (1580°F) for a minimum of 24 hours) and the DAQ is recording TC temperatures every 15 seconds. If needed, adjust the furnace set point to maintain a constant temperature of 1580°F. (§4.3e)

Comments: \_\_\_\_\_

I certify that the above tasks have been performed and that the observations and comments are correct.

Testing Technician

*Ross W. White*  
Customer

11-09-2021

Date

11/9/21

Date

*M. B. Hunter*

PTP QR Witness

*Jayna D. Hunter*  
Customer

11-09-2021

Date

11/9/21

Date



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		Page 11 / 12	Issue Date: 03-10-2021
		Revision Date: 03-10-2021	Review by Date: 03-10-2024

### Attachment 1 - HAC Thermal Test Checklist (continued)

Test Plan:

ORNL/NTRC-092 R.O

Test Unit:

6

VERIFIED

TASK

- ✓ **Furnace Soak** - A room temperature test specimen, instrumented with thermocouples was placed into the hot furnace. The test unit thermocouples and the furnace thermocouples (including the thermocouple that controls the furnace temperature) were monitored with the cDAQ to ensure the furnace was capable of achieving the requirements specified per the test plan. The test specimen will remain in the furnace for a period specified by customer requirements, test plan, or the approved work instruction. When no requirements are given, the test specimen will remain in the furnace for 30 minutes after 5 of 6 of the thermocouples on the test specimen surface, 2 out of 3 thermocouples on the test stand, and 2 of 3 thermocouples on each furnace wall reach 1475°F. **Record acceptance on Attachment 2. (§4.4.a)**
- ✓ **Test Unit Preparation** - Weld the thermocouple clips to the TU's before starting the preheat. Pre-heat per test plan requirements. Document pre-heat for the test unit on Attachment 2. Upon acceptance of pre-heat requirements for the test specimen, remove the test specimen from the pre-heat chamber and install TCs. Test all thermocouples with a heat source. **(§4.2b & 4.4b)**
- ✓ **Ready to Test** - Open the furnace opening. Load the test specimen on the furnace test stand. Unless specified otherwise by the customer requirements, test plan or work instruction, place the test specimen onto the test stand in a horizontal position with the test specimen lid facing the right furnace sidewall and the 0° line is facing down (facing the furnace floor). **(§4.4.c)**
- ✓ **Beginning the Test** - Loading can begin when the furnace has met the required preheat time. **Record the Test Start Time on Attachment 2.** The 30 minute test shall start when the following conditions have been met.
  - 5 of 6 of the thermocouples on the test specimen surface must reach 1475°F or greater and,
  - 2 out of 3 thermocouples on the test stand must reach 1475°F or greater and,
  - 2 of 3 thermocouples on each furnace wall have reached 1475°F or greater. **(§4.4a)**
- ✓ **Test Completion - Record the Test Stop Time on Attachment 2.** Immediately following the timed test and the thermal requirements are met, immediately remove the test specimen from the furnace and place the specimen in an area where it will not be exposed to artificial cooling. Record notes regarding smoke and/or flames emanating from the test specimen on Attachment 2. **(§4.3c)**
- ✓ All Photographs and/or videos for the entire test setup have been taken. **(§4.3c)**

Comments:

I certify that the above tasks have been performed and that the observations and comments are correct.

Testing Technician

Ross Whittle  
Customer

Date

11-09-2021  
11/9/21  
Date

PTP QR Witness

M.B. Houston  
J. J. J. J.  
Customer

Date

11-09-2021  
11/9/21  
Date



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		PTP-PEF-13	7 CN-0
		Page 12 / 12	Issue Date: 03-10-2021
		Revision Date: 03-10-2021	Review by Date: 03-10-2024

## Attachment 2 - HAC Thermal Test Data Sheet

Test Plan:

ORNL/NTRC-092 R.O

Test Unit:

6

VERIFIED

TASK

✓

The test unit has been preheated to over 38°C (100°F). (§4.2c)

Pre-heat Start date/time: 3:45 (CT) @ 11/05/2021 am/pm

Pre-heat End date/time: 9:00 am/pm @ 11/09/2021

Final Pre-heat temperature: > 110°F

✓

Furnace Soak Time prior to testing - Unless otherwise specified by the customer requirements, test plan or work instructions, preheat the furnace at a temperature of 860°C (1580°F) for a minimum of 24 hours. Record the time/date the soak time began and the time/date the soak time was reached (§ 4.3.e):

Time soak time begins: Date/Time: 3:29 pm CT @ 11/05/2021 am/pm

Time soak time reached: Date/Time: 8:18 pm CT @ 11/09/2021 am/pm

✓

The test unit has been placed in the furnace, on the support stand, at: (§4.4d)

Furnace door opened time: 9:40 am Furnace door Closed time: 9:41 am

Total time taken to open and Close furnace door: ≈ 1 min

✓

Unless otherwise specified by the customer requirements, test plan or work instructions, the 30-minute timed test starts after 5 out of 6 test unit thermocouples and 15 of 18 furnace thermocouples reach the test temperature of 801°C (1475°F).

Enter the Test Start Time: 9:43 am (CT) am/pm (§4.4e & 4.4f)

✓

The test unit was removed from the furnace and allowed to cool naturally. (§4.4f)

Enter the Test End Time: 10:14 am (CT) am/pm

N/A

The test unit stopped outgassing (flames) at \_\_\_\_\_ am/pm (§4.4f)

Outgassing/burnout elapsed time was \_\_\_\_\_ minutes. (§4.4f)

Comments: Furnace soaked overnight at all TCs > 1580°F.

I certify that the above tasks have been performed and that the observations and comments are correct.

Testing Technician

Russ W. Hittler

Customer

11-09-2021

Date

11/9/21

Date

M.B. Henders

Witness

J. J. J. J.

Customer

11-09-2021

Date

11/9/21

Date

# TEST FORM 5 - POST-THERMAL TESTING INSPECTION

Test Plan DPP-1

TU 6

## VERIFIED

## TASK

- ☒ Following the thermal test and after passive cooling, the test package was weighed, and recorded on TEST FORM 1.
- ☒ The drum, drum lid, bolts, and washers have been visually examined to determine the extent of the testing damage. Observations: No additional physical damage after thermal test
- ☒ The camera(s) are set up to take photographs\* and/or videotape of the damage due to testing.
- ☒ The drum lid has been removed and the condition of the exposed parts have been visually examined for damage and the condition has been recorded. Record the exposed temperature indicator blackout reading on TEST FORM 6. Record the torque values needed to loosen the drum lid weldment screws on TEST FORM #8. Observations: Lid stuck, had to cut drum body & liner
- ☒ The CV assembly and contents have been removed in the reverse assembly order and visually examined for damage. Record the exposed temperature indicator blackout readings on TEST FORM 6. Observations: see Test Form 6
- ☒ The CV assembly has been weighed and the weight recorded on TEST FORM 1.
- ☒ Use NDE 70 Rev. 7 for the CV post-test operational leak check and for the full containment boundary leak check and PTP-PEF-14 for the 0.9 m (3 ft). immersion test or PTP-PEF-15 for the 15 m immersion test. The leak test port plug shall be removed for these tests. **RW 12/9/21**  
HOLD POINT: Y-12 has approved the CV drying process.
- ☒ After immersion test the CV was dried using the CNS approved process (fans, plant air pressure, mild heat, vacuum suction, etc.) as shown in TEST FORM 12. The flange joint and space between the O-rings was dried by the approved process prior to opening the CV.
- ☒ Disassemble the CV. Record torque value needed to loosen CV screws on TEST FORM 9.
- ☒ If water is present inside the O-rings, stop work, inform CNS, and comment observations below.
- ☒ Read the temperature labels from the CV. Record the temperature indicators' blackout readings on TEST FORM 6.
- ☒ The content test fixture weldment assembly was removed from the CV and the weight was recorded on TEST FORM 1.
- ☒ The content test fixture weldment assembly was disassembled in the reverse assembly order.
- ☒ Loaded test fixture weldment content assembly: Remove the contents in the following order, loading test fixture weldment assembly using nylon springs, PCC silicone rubber pad, test weight weldment, lower PCC silicone rubber pad. CV silicone rubber pad.
- ☒ All loose parts will be placed in separate plastic bags, marked with test unit identification, tape closed, and prepared for storage with the test package.
- ☒ Mark and reassemble the test package to the extent possible for shipment.
- ☒ \*Photographs and/or video of the damage resulting from the testing have been taken.

Comments: Torque value (break away) recorded on Test form #8 not #1

I certify that the above tasks have been performed and that the observations and comments are correct.

Testing Technician

Brook Whittall  
CNS-Y-12 STR

12-13-2021

Date

12/13/21

Date

M. B. Houston

Witness

[Signature]  
CNS-Y-12 QE

12-13-2021

Date

12/13/21

Date

\*All photographs/movies will be uniquely identified with test unit, date and time to ensure that the proper sequence can be reconstructed.

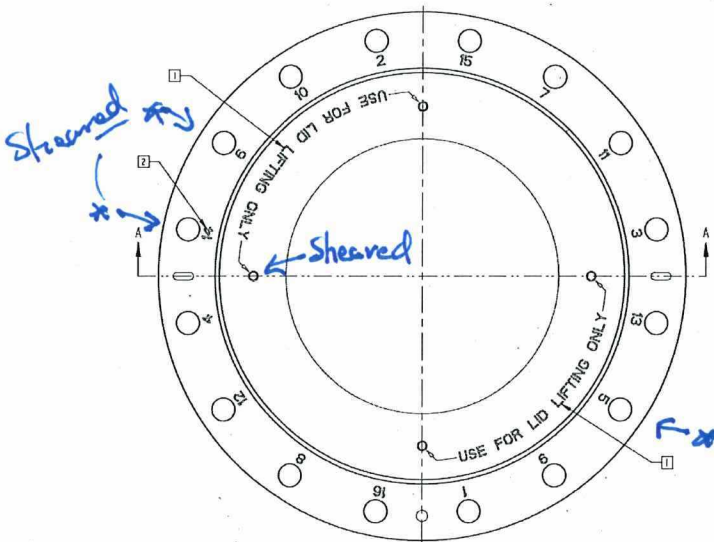


# TEST FORM 8 –DRUM LID DISASSEMBLY

Test Plan – DPP-1

TU- 6

DPP-1 Lid Disassembly	
Bolt #	Torque Removal (ft-lbs.)
1	30.8
2	51.0
3	71.2
4	26.5
5	5.4
6	56.5
7	14.7
8	27.1
9	69.6
10	55.7
11	53.2
12	34.7
13	84.6
14	99.5
15	35.6
16	36.5



M&TE ID #: A001096 Calibration Due Date: 2/10/2022

M&TE ID #: A006687 Calibration Due Date: 12/2/2022

Comments: Ambient temperature 58.1 °F

Bolts #14, #6 & #5 sheared after break-away torque.

Lid lifting hole bolt also sheared near bolt #14.

I certify that the above tasks have been performed and that the observations and comments are correct.

Testing Technician  
Ross Whittaker  
CNS-Y-12 STR

11-23-2021  
Date  
11/23/21  
Date

M.B. Hamilton  
Witness  
[Signature]  
CNS-Y-12 QE

11-23-2021  
Date  
11/23/21  
Date

\*All photographs/movies will be uniquely identified with test unit, date and time to ensure that the proper sequence can be reconstructed



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		Page: <b>5 / 6</b>	Issue Date: <b>12-14-20</b>
		Revision Date: <b>1-03-20</b>	Review By Date: <b>12-14-23</b>

## 6. Procedure Checklist

Test Plan:

**ORNL/NTRC-092.0**

Test Unit:

**6**

VERIFIED

TASK

- ☒ Verify that any equipment used meets the M&TE meets PTP-QA-013 requirements (§4.1).
- ☒ Have a photographer's clipboard with package name and test unit number. (§4.3)
- ☒ The test unit has been lowered to the bottom of the tank in designated orientation. (§4.6)
- ☒ The depth to the highest point of the test unit has been measured and is at least 0.9-m (3-ft). (§4.6)
- ☒ Photograph of the depth measurement has been taken. (§4.6)
- ☒ Record the water and ambient temperature. (§4.6)
- ☒ Start date and time has been noted. (§4.7)
- ☒ Test unit has been removed from the tank. (§4.8)
- ☒ End date and time has been noted. (§4.8)
- ☒ Record the water and ambient temperature. (§4.8)
- ☒ Thoroughly dry the test unit and make sure it is completely dry before opening. (§4.9)
- ☒ Open the test unit and record-breaking torque values during removal, if required. (§4.10)
- ☒ Inspect for water in-leakage or structural damage. (§4.10)
- ☒ Photographs of any resulting damage or lack thereof were taken. (§4.10)
- ☒ Sign and date checklist and data forms (§4.12).

Comments:

I certify that the above tasks have been performed and that the observations and comments are correct.

Test Engineer

**Ross Witterkay**

**12-09-2021**  
Date

**12/9/21**

Checked by

**John**

**12-09-2021**  
Date

**12/9/21**

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		Page: <b>6 / 6</b>	Issue Date: <b>12-14-20</b>
		Revision Date: <b>1-03-20</b>	Review By Date: <b>12-14-23</b>

## 7. Data Sheet

Test Plan: <b>ORNL/NTRC-092.0</b>	Test Unit: <b>6</b>
--------------------------------------	------------------------

VERIFIED

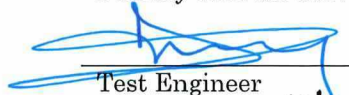
TASK

<input checked="" type="checkbox"/>	M&TE ID <b>A006327</b> Calibration due date <b>3/26/2023</b> (§4.1).
<input checked="" type="checkbox"/>	Intended attitude of the test unit in tank (e.g. on side) <b>0° down.</b> (§4.4)
<input checked="" type="checkbox"/>	Depth of water above the test unit <b>40.5" in</b> Measuring device <b>A006327</b> due <b>3/26/2023</b> (§4.6)
<input checked="" type="checkbox"/>	Start Date and Time of Immersion Test: <b>12/08/2021 @ 4:30 pm</b> (§4.7)
<input checked="" type="checkbox"/>	Water temperature: <b>68.5°F</b> °C ( <b>68.5°F</b> ) Measuring device <b>A006681</b> (§4.6) due: <b>5/12/2022</b>
<input checked="" type="checkbox"/>	Ambient temperature: <b>61.9°F</b> °C ( <b>61.9°F</b> ) Measuring device <b>A006681</b> (§4.8)
<input checked="" type="checkbox"/>	End Date and Time of Immersion Test: <b>12/09/2021 @ 10:00 am</b> (§4.8)
<input checked="" type="checkbox"/>	Water temperature: <b>68.5°F</b> °C ( <b>68.5°F</b> ) Measuring device <b>A006681</b> (§4.8)
<input checked="" type="checkbox"/>	Ambient temperature: <b>61.9°F</b> °C ( <b>61.9°F</b> ) Measuring device <b>A006681</b> (§4.8)
<input checked="" type="checkbox"/>	Detected in-leakage of water: (YES/NO) <b>NO</b> (§4.10)
<input checked="" type="checkbox"/>	Detected structural damage: (YES/NO) <b>NO</b> (§4.10)

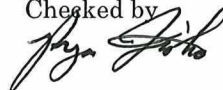
Testing Damage Observations:

Comments:

I certify that the above tasks have been performed and that the observations and comments are correct.

  
 Test Engineer  
**Ross Whittenburg**

**12-09-2021**  
 Date  
**12/9/21**

**M.B. Houston**  
 Checked by  


**12-09-2021**  
 Date  
**12/9/21**

# TEST FORM 12 –CV DRYING PROCEDURE

Test Plan – DPP-1

TU- 6

VERIFIED

TASK

- ☒ ORNL will remove the CV's from the immersion tank after a minimum of 8 hours.
- ☒ The CV's will be placed on the worktable in a vertical position.
- ☒ A shop vac will be used to blow out any water out of the CV flanges.
- ☒ The external surface of the CV will be dried with cloth and paper towels.
- ☒ ORNL will attach a vacuum to the CV flange O-ring port and supply a vacuum to remove most of the water between the inner and outer O-rings.
- ☒ After about 1 hour of air drying under forced hot air convection, an air compressor or compressed air can, or shop air will be used to blow out any water left in between the CV O-rings.
- ☒ The CV bolts will be loosened and removed, and the breakaway torque will be recorded on Test Form 9.
- ☒ The CV top lid will be lifted about a 1/8<sup>th</sup> -in and cloth and paper towels will be used to wipe the surfaces of the internal CV flanges outboard of the outer O-ring.
- ☒ A visual inspection of the internal surface of the CV flange will be done.
- ☒ ORNL and CNS will verify that water droplets are not visible on the inside of the Inner O-ring.
- ☒ After CNS approval, the CV lid will be completely removed from the CV base.

Comments:

I certify that the above tasks have been performed and that the observations and comments are correct.

Testing Technician

Ross Whittenlanger  
CNS-Y-12 STR

12-09-2021

Date

12/9/21

Date

M.B. Houston

Witness

[Signature]  
CNS-Y-12 QE

12-09-2021

Date

12/9/21

Date

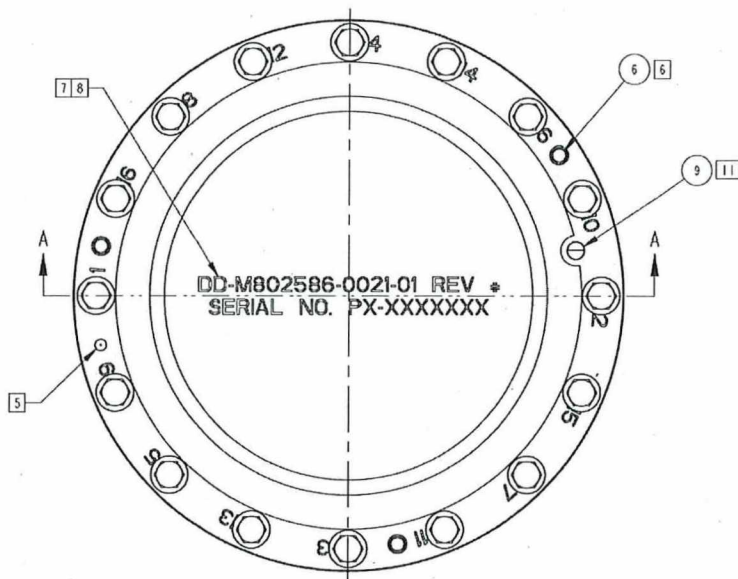
\*All photographs/movies will be uniquely identified with test unit, date and time to ensure that the proper sequence can be reconstructed



# TEST FORM 9 -CV LID DISASSEMBLY

Test Plan - DPP-1

TU- 6



DPP-1 CV Lid Disassembly	
Bolt #	Torque Removal (ft-lbs.)
1	24.4
2	8.7
3	16.3
4	20.7
5	29.3
6	29.2
7	10.0
8	26.7
9	29.0
10	15.2
11	25.1
12	22.9
13	36.5
14	25.0
15	16.4
16	34.8

M&TE ID #: A001096 Calibration Due Date: 2/10/2022

M&TE ID #: N/A Calibration Due Date: N/A

Comments:

I certify that the above tasks have been performed and that the observations and comments are correct.

Testing Technician

Ross Whittaker  
CNS-Y-12 STR

12-09-2021

Date

12/9/21

Date

M.B. Houston

Witness

[Signature]  
CNS-Y-12 QE

12-09-2021

Date

12/9/21

Date

\*All photographs/movies will be uniquely identified with test unit, date and time to ensure that the proper sequence can be reconstructed

# TEST FORM 6 - TEMPERATURE INDICATOR READINGS

Test Plan DPP-1

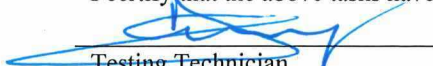

TU 6

A visual inspection of each temperature indicator on the package consisting of those indicators inside the CV, outside the CV, and on the drum-liner will be made. The values of the blackouts that occurred will be recorded below.

TEMPERATURE INDICATOR NUMBER LOCATION CHART				
TEST CONTENT ASSEMBLY (TL-10-105, TL-10-190)				
Location (outside)	0°	90°	180°	270°
Top end cap center	1 190 °F	2 190 °F	3 190 °F	4 190 °F
Top end cap under flange	5 190 °F	6 190 °F	7 190 °F	8 190 °F
Tube upper	9 190 °F	10 190 °F	11 190 °F	12 190 °F
Tube middle	13 190 °F	14 190 °F	15 190 °F	16 190 °F
Tube lower	17 190 °F	18 190 °F	19 190 °F	20 190 °F
Bottom end cap under flange	21 190 °F	22 190 °F	23 190 °F	24 190 °F
Bottom end cap center	25 190 °F	26 190 °F	27 190 °F	28 190 °F
Weight upper	29 190 °F	30 190 °F	31 190 °F	32 190 °F
Weight lower	33 190 °F	34 190 °F	35 190 °F	36 190 °F
INTERIOR OF THE CV (TL-10-105, TL-10-190)				
CV lid center	37 200 °F	38 200 °F	39 200 °F	40 200 °F
CV body flange	41 200 °F	42 200 °F	43 210 °F	44 200 °F
CV wall upper	45 200 °F	46 200 °F	47 210 °F	48 200 °F
CV wall middle	49 190 °F	50 200 °F	51 200 °F	52 200 °F
CV wall lower	53 190 °F	54 190 °F	55 200 °F	56 190 °F
CV base neck	57 180 °F	58 190 °F	59 190 °F	60 190 °F
CV base center	61 180 °F	62 180 °F	63 180 °F	64 180 °F
EXTERIOR OF THE CV (TL-10-105, TL-10-190)				
Lid center	65 210 °F	66 210 °F	67 210 °F	68 210 °F
Lid flange	69 210 °F	70 210 °F	71 210 °F	72 210 °F
Body flange	73 210 °F	74 210 °F	75 210 °F	76 210 °F
Base neck	77 190 °F	78 190 °F	79 190 °F	80 190 °F
Base toe	81 190 °F	82 190 °F	83 190 °F	84 190 °F
DRUM ASSEMBLY (TL-10-190, TL-10-290)				
Lid bottom	85 220 °F	86 220 °F	87 230 °F	88 230 °F
Cavity wall upper	89 210 °F	90 240 °F	91 230 °F	92 230 °F
Cavity wall middle	93 220 °F	94 230 °F	95 240 °F	96 230 °F
Cavity wall lower	97 210 °F	98 230 °F	99 240 °F	100 220 °F
Cavity wall lowest	101 210 °F	102 210 °F	103 220 °F	104 210 °F
Cavity bottom	105 210 °F	106 210 °F	107 210 °F	108 210 °F

Comments:

I certify that the above tasks have been performed and that the observations and comments are correct.

  
Testing Technician  
  
CNS-Y-12 STR

12-09-2021  
Date  
12/9/21  
Date

M. B. Hamilton  
Witness  
  
CNS-Y-12 QE

12-09-2021  
Date  
12/9/21  
Date

\*All photographs/movies will be uniquely identified with test unit, date and time to ensure that the proper sequence can be reconstructed



# TEST FORM 15 -WITNESS AND HOLD POINTS

Test Plan DPP-1

TU 6

The following applicable CNS hold points activities shall not start until written approval to proceed has been given from the CNS STR via e-mail. Additional hold points may be included when CNS reviews the approval data documents and as the work is being performed. The purpose of each hold point is to give the TA, STR, and QE an opportunity to (1) evaluate what has happened since the previous hold point, (2) evaluate previous lessons learned on the activities that follow, and (3) make an informed decision to proceed.

NO.	DESCRIPTION	TU NO.	TYPE	CNS INITIAL
1	<u>Initial package disassembly</u> Witness the disassembly, can be waived by a DA representative	1,2,3,4,5,6, 7	Witness, Hold	RW RF
2	<u>pre-test operational leakage rate test</u> Witness the pre-test operational leakage rate test per ANSI N14.5, section 7.6, after final closure (and before commencing testing sequence)	1,2,3,4,5,6, 7	Witness, Hold	
2.1	<u>pre-test operational leakage rate test acceptance</u> Inspection to verify the pre-test operational leakage rate test has met acceptance criteria <b>Subsequent reassembly sequence shall not commence until acceptable result is produced.</b>	1,2,3,4,5,6, 7	Hold	
3	<u>Initial package reassembly</u> Witness the reassembly of the contents, CV, vibration pads, drum lid, instrumentation, and all associated fastening hardware	1,2,3,4,5,6, 7	Witness	
3.1	<u>Initial Package Reassembly</u> Inspection and observation to verify the reassembly procedure has been followed according to supplied direction. <b>Subsequent testing sequence shall not commence until reassembly steps have been confirmed as acceptable.</b>	1,2,3,4,5,6, 7	Hold	
4	<u>NCT vibration/shock test</u> Witness the NCT vibration/shock testing activities, including all preliminary setup, can be waived by a DA representative	6	Witness	
5	<u>NCT thermal pre-treatment</u> Witness the NCT thermal pre-treatment activities, including all preliminary setup, can be waived by a DA representative	1,2,3,4,5,6	Witness	
6	<u>NCT water spray test</u> Witness the NCT water spray test activities, including all preliminary setup, can be waived by a DA representative	2,3,4,6	Witness, Hold	
7	<u>NCT free drop (4 ft) test</u> Witness the NCT free drop (4 ft) test activities, including all preliminary setup, can be waived by a DA representative	1,2,3,4,5,6	Witness	
7.1	<u>NCT free drop (4 ft) test, critical parameters</u> Inspection to verify the critical parameters defining the NCT free drop (4 ft) test meet all requirements <b>Completion of NCT free drop (4 ft) test shall not commence until all critical parameters have been verified.</b>	1,2,3,4,5,6	Hold	



8	<u>NCT penetration test</u> Witness the NCT penetration test activities, including all preliminary setup, can be waived by a DA representative	6	Witness	RW	RF
8.1	<u>NCT penetration test, critical parameters</u> Inspection to verify the critical parameters defining the NCT penetration test meet all requirements	6	Hold		
	<b>Completion of NCT penetration test shall not commence until all critical parameters have been verified.</b>				
9	<u>NCT compression test</u> Witness the NCT compression test activities, including all preliminary setup, can be waived by a DA representative	6	Witness		
9.1	<u>NCT compression test, critical parameters</u> Inspection to verify the critical parameters defining the NCT compression test meet all requirements	6	Hold		
	<b>Completion of NCT compression test shall not commence until all critical parameters have been verified</b>				
10	<u>HAC thermal pre-treatment</u> Witness the HAC thermal pre-treatment activities, including all preliminary setup, can be waived by a DA representative	1,5	Witness		
11	<u>HAC free drop (30 ft) test</u> Witness the HAC free drop (30 ft) test activities, including all preliminary setup, can be waived by a DA representative	1,2,3,4,5,6	Witness		
11.1	<u>HAC free drop (30 ft) test, critical parameters</u> Inspection to verify the critical parameters defining the HAC free drop (30 ft) test meet all requirements	1,2,3,4,5,6	Hold		
	<b>Completion of HAC free drop (30 ft) test shall not commence until all critical parameters have been verified.</b>				
11.2	<u>HAC free drop (30 ft) test, damage determination</u> Inspection to verify that the damage inflicted during the HAC free drop (30 ft) test is as expected, if unexpected damage is present, modifications to the subsequent HAC Crush (30 ft) test will be defined	1,2,3,4,5,6	Hold		
	<b>Testing shall not commence until new specification of HAC Crush (30 ft) test has been agreed-upon and adopted by the TA.</b>				
12	<u>HAC crush (30 ft) test</u> Witness the HAC crush (30 ft) test activities, including all preliminary setup, can be waived by a DA representative	1,2,3,4,5,6	Witness		
12.1	<u>HAC crush (30 ft) test, critical parameters</u> Inspection to verify the critical parameters defining the HAC crush (30 ft) test meet all requirements	1,2,3,4,5,6	Hold		
	<b>Completion of HAC crush (30 ft) test shall not commence until all critical parameters have been verified.</b>				
12.2	<u>HAC crush (30 ft) test, damage determination</u> Inspection to verify that the damage inflicted during the HAC crush (30 ft) test is as expected, if unexpected damage is present, modifications to the subsequent HAC Puncture drop (40 in.) test will be defined	1,2,3,4,5,6	Hold		
	<b>Testing shall not commence until new specification of HAC Puncture drop (40 in.) test has been agreed-upon and adopted by the TA.</b>				

13	<u>HAC Puncture drop (40 in.) test</u> Witness the HAC Puncture drop (40 in.) test activities, including all preliminary setup, can be waived by a DA representative	1,2,3,4,5,6	Witness	RW RF
13.1	<u>HAC Puncture drop (40 in.) test, critical parameters</u> Inspection to verify the critical parameters defining the HAC Puncture drop (40 in.) test meet all requirements	1,2,3,4,5,6	Hold	
<b>Completion of HAC Puncture drop (40 in.) test shall not commence until all critical parameters have been verified.</b>				
NO.	DESCRIPTION	TU NO.	TYPE	CNS INITIAL
14	<u>Thermal test, data collection hardware</u> Inspection to verify that all the thermocouple and hardware has been installed, or configured as specified and is operating correctly	1,2,3,4,5,6	Hold	
<b>Completion of supplementary thermal test shall not commence until hardware installation has been verified.</b>				
15	<u>HAC thermal test</u> Witness the HAC thermal test activities, including all preliminary setup, can be waived by a DA representative	1,2,3,4,5,6	Witness	
15	<u>Overpack Inspection and Disassembly</u> Witness the overpack inspection and disassembly process, including all preliminary setup, can be waived by a DA representative	1,2,3,4,5,6	Witness	
16	<u>Overpack Inspection and Disassembly</u> Inspection to verify that sufficient data and measurements have been collected from overpack and CV prior to drilling and tapping the CV lid for post-test leakage rate measurements	1,2,3,4,5,6	Hold	
<b>Post-test leakage rate activities, including all preliminary setup, shall not commence until hardware installation has been verified.</b>				
17	<u>post-test operational leakage rate test</u> Witness the post-test operational leakage rate test per ANSI N14.5, section 7.6, after completion of test activities (and before post-test full-boundary leakage rate test)	1,2,3,4,5,6	Witness	
18	<u>post-test full-boundary leakage rate test, drilling and tapping test port in CV lid</u> Witness the drilling and tapping of the leakage rate test port in the CV lid, after removal from the overpack assembly (and before completion of testing sequence)	1,2,3,4,5,6	Witness	
19	<u>post-test full-boundary leakage rate test</u> Witness the post-test full-boundary leakage rate test per ANSI N14.5, Section 7.5. This includes the sealing of the drilled and tapped hole in the CV lid after the leak rate measurements have completed	1,2,3,4,5,6	Witness	
19.1	<u>Final containment vessel leakage rate test acceptance</u> Inspection to verify the "post-test" leakage rate test has met acceptance criteria	1,2,3,4,5,6	Hold	
<b>HAC immersion tests shall not commence until results are confirmed.</b>				

20	<u>HAC immersion test, fissile material packages</u> Witness the HAC immersion test, fissile material packages, activities, including preliminary setup, can be waived by a DA representative	1,2,3,4,5,6	Witness	RW	RF
21	<u>HAC immersion test, all packages (undamaged)</u> Witness the HAC immersion test, all packages (undamaged), activities, including preliminary setup, can be waived by a DA representative	7	Witness		
22	<u>Opening containment vessel after HAC immersion test</u> Witness the opening of the containment vessel and inspection for retained moisture within the containment vessel cavity, including preliminary setup and verification that the external surface is complete dry, can be waived by a DA representative	1,2,3,4,5,6, 7	Witness		
NO.	DESCRIPTION	TU NO.	TYPE	CNS INITIAL	
23	<u>Final external inspection results</u> Inspection of all external inspection results, to verify all specified dimensional and photographic records have been obtained, these records cannot be confirmed after the overpack assembly has been cut-open and so must be confirmed at this point  <b>Disassembly and cross section examination shall not commence until all external inspections have been completed and all necessary records have been collected. (if required)</b>	1,2,3,4,5,6, 7	Hold		
24	<u>Disassembly and cross section inspection</u> Witness the cutting, disassembly, and dissection of the overpack assembly (if required)	1,2,3,4,5,6, 7	Witness		
25	<u>Final cross section inspection results (if required)</u> Inspection of all cross-section inspection results, to verify all specified dimensional and photographic records have been obtained  <b>Completion of final data report shall not commence until all cross-section inspections have been completed and all necessary records have been collected. (if required)</b>	1,2,3,4,5,6, 7	Hold		
26	<u>Preliminary data package</u> Inspection of all preliminary test results, including data collected, photos and videos captured, and dimensions measured  <b>Shipment or disposal (as defined by the DA) of TU shall not commence until the preliminary data package has been reviewed and determined to be complete.</b>	1,2,3,4,5,6, 7	Hold		

Comments:

I certify that the above tasks have been performed and that the observations and comments are correct.

Testing Technician

*Ron Whittenberger*  
CNS-Y-12 STR

*12-13-2021*

Date

*12/13/21*

Date

Witness

*M. B. Houston*  
*[Signature]*  
CNS-Y-12 QE

*12-13-2021*

Date

*12/13/21*

Date

\*All photographs/movies will be uniquely identified with test unit, date and time to ensure that the proper sequence can be reconstructed



# TEST FORM 16 -PHOTOGRAPHY/VIDEO CHECKLIST

Test Plan DPP-1

CTU 6

At a minimum, the following events shall be captured by photography. If necessary, photos shall be taken from multiple perspectives to provide a clear understanding of the event being captured. Date and time will be stamped on all photographs.

VERIFIED

TASK





✓	Overpack assembly, containment vessel, and vibration pads after taking delivery and during disassembly
✓	Overpack assembly, containment vessel, and vibration pads (where applicable) during reassembly
✓	Drop testing pad, including appropriate dimensional references
✓	Puncture bar installed onto drop pad, including appropriate dimensional reference
✓	Penetration bar, including appropriate dimensional references
✓	Equipment, instrumentation, and general arrangement used for vibration/shock tests
✓	Equipment, instrumentation, and general arrangement used for free and Puncture drop tests
✓	Equipment, instrumentation, and general arrangement used for water spray tests
✓	Pre-test leakage rate tests: <ul style="list-style-type: none"> <li>— Close-up views of CV before test, showing connection for CV lid leakage rate test port</li> <li>— Close-up views of CV during test, showing connections made to CV lid leakage rate test port</li> <li>— Test arrangement with CV during test, showing all connections made to CV</li> </ul>
✓	NCT vibration/shock tests: <ul style="list-style-type: none"> <li>— Test arrangement with the package installed onto the expander head or slip table</li> <li>— Attachment of tie-down chains or straps to top of package</li> <li>— Attachment of tie-down chains or straps to expander head or slip table</li> </ul>
✓	NCT water spray tests: <ul style="list-style-type: none"> <li>— Test arrangement with package before test, showing relative placement of water spray nozzles with respect to the package</li> <li>— Test arrangement with package during test, showing how the water is hitting the package</li> <li>— Test arrangement with package after test, showing evidence of water pooling or accumulation, if any</li> <li>— Rain gauge showing minimum allowable rainfall has been reached</li> </ul>
✓	NCT free drop (4 ft) tests: <ul style="list-style-type: none"> <li>— Test arrangement with package before test, showing the intended offset angle</li> <li>— Test arrangement with package before test, showing the intended drop height</li> <li>— Test arrangement with package after test, showing damaged package at final resting place</li> <li>— Close-up views of package after test, showing particular damage induced as a result of the NCT free drop (4 ft) test, including appropriate dimensional references</li> </ul>
✓	NCT penetration tests: <ul style="list-style-type: none"> <li>— Close-up views of package before test, showing intended point of impact</li> <li>— Test arrangement with package before test, showing supports and restraints that hold the package in place</li> <li>— Test arrangement with package before test, showing position and height of penetration bar, with respect to the package</li> <li>— Test arrangement with package after test, showing damaged package after penetration bar has made impact</li> <li>— Close-up views of package after test, showing particular damage induced as a result of the NCT penetration test, including appropriate dimensional references</li> </ul>
✓	NCT compression tests: <ul style="list-style-type: none"> <li>— If a compression tester machine is being used <ul style="list-style-type: none"> <li>• The relative arrangement of the package within the machine</li> <li>• The force read-out as indicated by the machine control system</li> </ul> </li> <li>— Test arrangement with package during test, showing weight having been applied to the package</li> <li>— Test arrangement with package after test, showing damaged package after weight has been removed (if any)</li> </ul>

✓	<ul style="list-style-type: none"> <li>—Close-up views of package after test, showing any particular damage induced as a result of the NCT compression test, including evidence of bulging/buckling of the drum, bending/buckling of the drum bolt guard, and crushing/buckling of the fork pockets</li> </ul>
✓	<p>HAC free drop (30 ft) tests (check as performed)</p> <ul style="list-style-type: none"> <li>— Close-up views of package before test, showing intended point of initial impact</li> <li>— Test arrangement with package before test, showing the intended offset angle</li> <li>— Test arrangement with package before test, showing the intended drop height</li> <li>— Test arrangement with package after test, showing damaged package at final resting place</li> <li>— Close-up views of package after test, showing particular damage induced as a result of the HAC free drop (30 ft) test, including appropriate dimensional references</li> <li>— Close-up views of package after test, showing unexpected damage (if any), due to primary impact or any subsequent event</li> </ul>
✓	<p>HAC crush (30 ft) tests (check as performed)</p> <ul style="list-style-type: none"> <li>— Close-up views of package before test, showing intended point of initial impact</li> <li>— Test arrangement with package before test, showing the intended offset angle</li> <li>— Test arrangement with package before test, showing the intended drop height</li> <li>— Test arrangement with package after test, showing damaged package at final resting place</li> <li>— Close-up views of package after test, showing particular damage induced as a result of the HAC crush (30 ft) test, including appropriate dimensional references</li> <li>— Close-up views of package after test, showing unexpected damage (if any), due to primary impact or any subsequent event</li> </ul>
✓	<p>HAC Puncture drop (40 in ) tests</p> <ul style="list-style-type: none"> <li>—Close-up views of package before test, showing intended point of initial impact</li> <li>—Test arrangement with package before test, showing the intended offset angle</li> <li>—Test arrangement with package before test, showing the intended drop height</li> <li>—Test arrangement with package after test, showing damaged package at final resting place</li> <li>—Close-up views of package after test, showing particular damage induced as a result of the HAC puncture (1 m (40 in)) test, including appropriate dimensional references</li> <li>—Close-up views of package after test, showing unexpected damage (if any), due to primary impact or any subsequent event</li> </ul>
✓	<p>Supplementary and HAC thermal tests</p> <ul style="list-style-type: none"> <li>—Views of relative spacing inside the furnace with door/trap open, with or without the package used as a dimensional point of reference, at hot or cold condition</li> <li>—Test arrangement with package before test, showing placement of thermocouple attachments on the package exterior surface</li> <li>—Test arrangement with package after test, showing damaged/burned package after initial removal from the furnace/fire</li> <li>—Close-up views of package after test, showing any excessively damaged/burned parts (if any)</li> </ul>
✓	<p>HAC immersion-fissile material tests</p> <ul style="list-style-type: none"> <li>— Test arrangement with CV before test, showing placement of the CV within the tank</li> <li>— Test arrangement with CV during test, showing measurement of submerged depth of CV below water line</li> <li>— Close-up views of CV after test, after removal of the CV lid, showing evidence of water ingress (if any)</li> </ul>
✓	<p>HAC immersion- 10CFR71(c)(6) package tests</p> <ul style="list-style-type: none"> <li>— Test arrangement with CV before test, showing placement of the CV within the tank or hydraulic pressure chamber</li> <li>— Test arrangement with CV during test, showing measurement of submerged depth of CV below water line (or, if a hydraulic pressure chamber is being used, the internal pressure read-out as indicated by the hydraulic control system or in-line pressure gauge)</li> <li>— Close-up views of CV after test, after removal of the CV lid, showing evidence of water ingress (if any)</li> </ul>

✓	<p>Post-test leakage rate tests:</p> <ul style="list-style-type: none"> <li>– Close-up views of CV before test, showing drilled/tapped connection for CV lid leakage rate test port</li> <li>– Close-up views of CV during test, showing connections made to CV lid leakage rate test port</li> <li>– Test arrangement with CV during test, showing all connections made to CV</li> </ul>
✓	<p>Initial teardown and inspection:</p> <ul style="list-style-type: none"> <li>– Close-up views of CV after removal from overpack assembly, showing any superficial and structural damage due to interaction with overpack assembly during test sequence (if any), including appropriate dimensional references ( cursory examination only)</li> <li>– Close-up views of all thermal temperature indicators, showing temperatures indicated and evidence of stretching/tearing (if any), including appropriate dimensional references</li> <li>– Close-up views of overpack assembly after removal of CV, showing any superficial and structural damage due to interaction with CV or drum lid during test sequence (if any), including appropriate dimensional references</li> <li>– Close-up views of drum lid after removal from overpack assembly, showing any superficial and structural damage due to interaction with the CV or overpack assembly, including appropriate dimensional references</li> </ul>
✓	<p>Final teardown and inspection:</p> <ul style="list-style-type: none"> <li>– Close-up views of the CV, showing superficial and structural damage to ANY component, internal and external surfaces (if any), including appropriate dimensional references (detailed examination)</li> <li>– Close-up views of components within the CV, showing superficial and structural damage to ANY component, internal and external surfaces (if any), including appropriate dimensional references (detailed examination)</li> <li>– Markings on the surfaces of the overpack assembly and drum lid, showing the intended cross section cuts, including appropriate dimensional references (if requires)</li> <li>– Overall views of overpack assembly and drum lid after cross section cuts have been made (if required)</li> <li>– Close-up views of overpack assembly and drum lid after cross section cuts have been made, showing damage to internal components, including the following: (if required) <ul style="list-style-type: none"> <li>• Extent of burned/charred or disintegrated impact-limiting foam</li> <li>• Extent of disintegration, cracking, or separation of impact-limiting block</li> <li>• Extent of damage to thermal insulating blanket and indication of total radial thickness</li> <li>• Relative dimensional changes of structural components (including but not limited to drum liner assembly, perforated ring, drum lid inner section)</li> <li>• Any cracked welds</li> <li>• Any scratched, dented, or stretched sheet metal</li> </ul> </li> </ul>

Comments:

I certify that the above tasks have been performed and that the observations and comments are correct.

 Testing Technician	<u>12-13-2021</u> Date	 Witness	<u>12-13-2021</u> Date
 CNS-Y-12 STR	<u>12/13/21</u> Date	 CNS-Y-12 QE	<u>12/13/21</u> Date

\*All photographs/movies will be uniquely identified with test unit, date and time to ensure that the proper sequence can be reconstructed



## **N. APPENDIX TU-7 FORMS**

# TEST FORM 1 - COMPONENT WEIGHTS

Test Plan DPP-1

TU -7

Part Name	Initial Assembly	Post Thermal, Full Disassembly
	Weight (lbs.)	Weight (lbs.)
CV body	181	N/A MOH 10-08-2021
CV lid, screws, washers, and O-rings (together)	73	
Test fixture weldment, screws, washers, nuts, bushing (together)	-	
Test weight sets	-	
PCC pad sets	-	
CV assembly with test content (during reassembly)	254	
Drum body	N/A MOH 10-08-2021	
Drum lid assembly, screws, and washers (together)		
CV base pad and CV flange wedge (together)		
Test unit (TU) assembly		

## EQUIPMENT

Less than 10 pounds

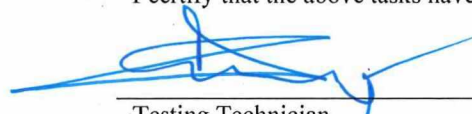

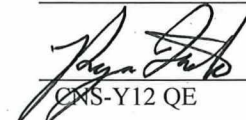
10 lbs to 2000 lbs

Scale: N/A Expiration Date: N/A

Scale: X502322 Expiration Date: 2/17/2022

Comments: \_\_\_\_\_

I certify that the above tasks have been performed and that the observations and comments are correct.

	<u>10-08-2021</u>	<u>MOH Hunter</u>	<u>10-08-2021</u>
Testing Technician	Date	Witness	Date
	<u>10/8/21</u>		<u>10/8/21</u>
CNS-Y12 STR	Date	CNS-Y12 QE	Date

# TEST FORM 2 - ASSEMBLY OF THE CV

Test Plan DPP-1

TU -7

VERIFIED  
RW 9/9/21  
RF 9/9/21

## TASK

**HOLD POINT:** All payload components have been visually inspected, and Y-12 deems the shipping package acceptable for disassembly.

Verify and/or mark all components: content assembly, CV assembly, and drum assembly components with the corresponding test unit ID, axial lines, and impact targets symbols. Figure 4-1 - Figure 4-4.

Temperature labels have been affixed to the surface of the CV as shown in Figure 5-1, Figure 5-2.

None of the temperature indicators indicate exposure to a temperature in the measured range.

The CV body, CV lid, washers, and bolts were weighed and recorded in TEST FORM 1

**HOLD POINT:** Y-12 has approved the markings.

The following assembly applies to TUs test fixture weldment content assembly

The surrogate test weight was weighed and recorded on TEST FORM 1 .

The loading test fixture weldment content assembly components were weighed and recorded on TEST FORM 1 .

Clean all surfaces with isopropyl alcohol and air dry

Place the PCC pad (silicone rubber) into CV body.

Place the test weight weldment into the CV body.

Place the PCC pad (silicone rubber) into the CV body on top of the test fixture weldment assembly.

**HOLD POINT:** Y-12 witness torqueing of test fixture fastener hex head screws, washers, top hat bushings, and locknuts. The test weight and bolting locations that establish the low and high CG locations are documented in Attachment A. The hex head screws and locknuts shall be torqued to  $25 \pm 2$  ft-lb.

**HOLD POINT:** Y-12 inspected the assembly of the non-test fixture weldment content assembly and verified weights

M&TE ID #: A001096 Calibration Due Date: 2/10/2022

Comments:

I certify that the above tasks have been performed and that the observations and comments are correct.

Testing Technician

CNS-Y-12 STR

10-08-2021  
Date

10/8/21  
Date

Witness

CNS-Y-12 QE

10-08-2021  
Date

10/8/21  
Date



# TEST FORM 2 - ASSEMBLY OF THE CV

Test Plan DPP-1

TU -7

## All packages

☒ The CV O-rings and sealing surfaces have been inspected for defects and found acceptable.

☒ Clean all surfaces with isopropyl alcohol and air dry.

☒ The CV O-rings have been installed onto the CV body.

**Note:** Screws and O-rings shall not be replaced without CNS approval. If replacements are authorized, they shall be documented in the test report where the replacements occurred.

☒ The CV lid was lowered on the CV body and the CV screws shall be hand-tightened until the lid is in full contact with the flange, note that clamps may be used during this step. The CV screws shall be torqued in sequence following the numbers etched into the drum lid in three passes. first pass the screws shall be torqued to 19-21 ft-lb, during the second pass to 33-37 ft-lb, and during the third pass to 33-37 ft-lb. The final pass torque values shall be recorded.

Ambient temperature at closure is 70.4 °C ( 70.4 °F)

Measuring device A006681 Calibration Expiration Date 5/12/2022

Record assembly torque on TEST FORM 11.

Torque wrench # A001096 Calibration Expiration Date 2/10/2022

HOLD POINT: Y-12 inspected the assembly and closure of CV assemblies and verified weights.

The CV assembly has been weighed and the weight has been recorded on TEST FORM 1

☒ The CV assembly has been leak tested (pre-test operational) in accordance with Sect. 7.6 of ANSI N14.5-2014 using the "A.5.2 gas pressure rise" method described in Table A-1 of N14.5-2014 and ORNL procedure NDE 70 Rev. 7, PCMT.

☒ HOLD POINT: Y-12 has reviewed the leak test and the installation of the acceleration sensor mounts. **\*Note 1**

☒ Photographs of the assembly have been taken\*.

## Comments:

**\* NOTE 1: TU7 did not have accelerometers.**

I certify that the above tasks have been performed and that the observations and comments are correct.

Testing Technician

Ross Whittenburg  
CNS-Y-12 STR

10-12-2021

Date

10/12/21

Date

M.B. Houston

Witness

[Signature]  
CNS-Y-12 QE

10-12-2021

Date

10/12/21

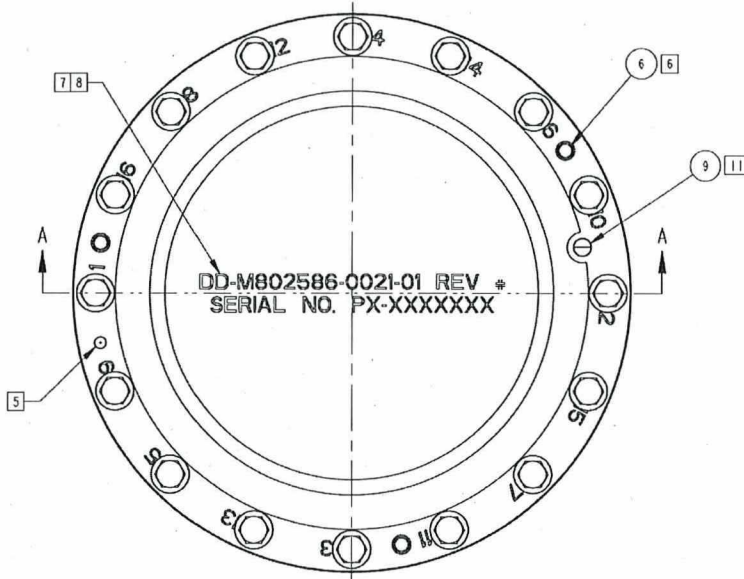
Date

\*All photographs/movies will be uniquely identified with test unit, date and time to ensure that the proper sequence can be reconstructed

# TEST FORM 11 –CV LID ASSEMBLY

Test Plan – DPP-1

TU- 7



DPP-1 CV Lid Assembly	
Bolt #	Torque assembly (ft-lbs.)
1	35.5
2	34.7
3	35.3
4	34.5
5	35.9
6	35.0
7	34.8
8	35.2
9	35.4
10	34.8
11	35.4
12	35.4
13	34.5
14	34.8
15	34.5
16	35.4

M&TE ID #: A001096 Calibration Due Date: 2/10/2022

M&TE ID #: A006681 Calibration Due Date: 5/12/2022

Comments:

I certify that the above tasks have been performed and that the observations and comments are correct.

Testing Technician

Ross Whitten  
CNS-Y-12 STR

10-08-2021

Date

10/8/21  
Date

Witness

M.B. Houston  
[Signature]  
CNS-Y-12 QE

10-08-2021

Date

10/8/21  
Date

\*All photographs/movies will be uniquely identified with test unit, date and time to ensure that the proper sequence can be reconstructed

<div>ORNL</div> <div>PACKAGE TESTING PROGRAM OAK RIDGE NATIONAL LABORATORY OAK RIDGE, TENNESSEE 37831</div> <div>The OFFICIAL COPY of this document is the on-line version. Before using a printed copy, verify that it is the most current version by checking the Revision ID against the on-line version.</div>	<div>Operating Procedure for HAC Thermal Test - Testing of Radioactive Material Packages</div>	Test Procedure:	Rev.
		PTP-PEF-13	7 CN-0
		Page 10 / 12	Issue Date: 03-10-2021
		Revision Date: 03-10-2021	Review by Date: 03-10-2024

### Attachment 1 - HAC Thermal Test Checklist

Test Plan:

ORNL/NTRC-092 R.0

Test Unit: 7

VERIFIED

TASK

- ☒ Ensure test equipment is calibrated, calibration records are acceptable, and that Attachments 1 and 2 records have been initiated prior to testing. Prepare photographers clipboard. (§4.1a, b, c & d)
- ☒ Set up the thermal DAQ and test all TC channels with a calibrated heat source. The acceptable range to test the thermocouples is 0°F - 150°F. (§4.2a)
- ☒ The thermocouple mounting clip material and installation is acceptable and per customer requirements, test plan, or approved work instruction. (§4.2b)
- ☒ TU's have been preheated per customer requirements, test plan or approved work instruction. NOTE: When no customer requirements are given, preheat shall be ~ 66°C (150°F) for a minimum of 24 hours and then soaked at ~ 43°C (110°F) for a minimum of 24 hours. **Record pre-heat acceptance on Attachment 2.** (§4.2c)
- ☒ Unless specified otherwise by the customer requirements, test plan, or approved work instruction, the furnace layout has proved capable of loading tests units within 90 seconds. (§4.3a)
- ☒ Floor plate(s) material(s) and test stand(s) are of the approved design and are installed at the location specified by the customer, test plan or approved work instruction. All TCs have been labeled, installed in the furnace, connected to DAQ and tested. The furnace opening can operate without causing damage to thermocouple wires. Photographs have been taken of the furnace set up. (§4.3b, 4.3c-4.3d)
- ☒ The furnace pre-heat soak time has been achieved (minimum temperature of 860°C (1580°F) for a minimum of 24 hours) and the DAQ is recording TC temperatures every 15 seconds. If needed, adjust the furnace set point to maintain a constant temperature of 1580°F. (§4.3e)

Comments: \_\_\_\_\_

I certify that the above tasks have been performed and that the observations and comments are correct.

Testing Technician

*Pro. Whittaker*  
Customer

11-08-2021

Date

11/8/21

Date

*M.B. Houston*

PTB QR Witness

*John Debo*  
Customer

11-08-2021

Date

11/8/21

Date



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		Page	Issue Date:
		Revision Date:	Review by Date:
		<b>PTP-PEF-13</b>	<b>7 CN-0</b>
		11 / 12	03-10-2021
		03-10-2021	03-10-2024

### Attachment 1 - HAC Thermal Test Checklist (continued)

Test Plan:

ORNL/NTRC-092 E.O.

Test Unit:

7

VERIFIED

TASK

✓ **Furnace Soak** - A room temperature test specimen, instrumented with thermocouples was placed into the hot furnace. The test unit thermocouples and the furnace thermocouples (including the thermocouple that controls the furnace temperature) were monitored with the cDAQ to ensure the furnace was capable of achieving the requirements specified per the test plan. The test specimen will remain in the furnace for a period specified by customer requirements, test plan, or the approved work instruction. When no requirements are given, the test specimen will remain in the furnace for 30 minutes after 5 of 6 of the thermocouples on the test specimen surface, 2 out of 3 thermocouples on the test stand, and 2 of 3 thermocouples on each furnace wall reach 1475°F. **Record acceptance on Attachment 2. (§4.4.a)**

✓ **Test Unit Preparation** - Weld the thermocouple clips to the TU's before starting the preheat. Pre-heat per test plan requirements. Document pre-heat for the test unit on Attachment 2. Upon acceptance of pre-heat requirements for the test specimen, remove the test specimen from the pre-heat chamber and install TCs. Test all thermocouples with a heat source. (§4.2b & 4.4b)

✓ **Ready to Test** - Open the furnace opening. Load the test specimen on the furnace test stand. Unless specified otherwise by the customer requirements, test plan or work instruction, place the test specimen onto the test stand in a horizontal position with the test specimen lid facing the right furnace sidewall and the 0° line is facing down (facing the furnace floor). (§4.4.c)

✓ **Beginning the Test** - Loading can begin when the furnace has met the required preheat time. **Record the Test Start Time on Attachment 2.** The 30 minute test shall start when the following conditions have been met.

- 5 of 6 of the thermocouples on the test specimen surface must reach 1475°F or greater and,
- 2 out of 3 thermocouples on the test stand must reach 1475°F or greater and,
- 2 of 3 thermocouples on each furnace wall have reached 1475°F or greater. (§4.4a)

✓ **Test Completion - Record the Test Stop Time on Attachment 2.** Immediately following the timed test and the thermal requirements are met, immediately remove the test specimen from the furnace and place the specimen in an area where it will not be exposed to artificial cooling. Record notes regarding smoke and/or flames emanating from the test specimen on Attachment 2. (§4.3c)

✓ All Photographs and/or videos for the entire test setup have been taken. (§4.3c)

Comments: TU-7 was used to qualify the furnace All TCs were required to be at or above set temperature.

I certify that the above tasks have been performed and that the observations and comments are correct.

Testing Technician

Rosa Whittaker  
Customer

11-08-2021

Date

11/8/21

Date

PTP QB Witness

M.B. Hunter  
Customer

11-08-2021

Date

11/8/21

Date

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		Page 12 / 12	Issue Date: 03-10-2021
		Revision Date: 03-10-2021	Review by Date: 03-10-2024

### Attachment 2 - HAC Thermal Test Data Sheet

Test Plan: ORNL/NTRC-092 R.O

Test Unit: 7

VERIFIED

TASK

✓

The test unit has been preheated to over 38°C (100°F). (§4.2c)

Pre-heat Start date/time: 3:45 am/pm CT @ 11/05/2021

Pre-heat End date/time: 8:37 am/pm CT @ 11/08/2021

Final Pre-heat temperature: >110°F

✓

12 hours →

Furnace Soak Time prior to testing - Unless otherwise specified by the customer requirements, test plan or work instructions, preheat the furnace at a temperature of 860°C (1580°F) for a minimum of 24 hours. Record the time/date the soak time began and the time/date the soak time was reached (§ 4.3.e):

Time soak time begins: Date/Time: 11/07/2021 @ 6:52 am/pm CT

Time soak time reached: Date/Time: 11/08/2021 @ 6:52 am/pm CT

✓

The test unit has been placed in the furnace, on the support stand, at: (§4.4d)

Furnace door opened time: 9:35 am Furnace door Closed time: 9:36 am

Total time taken to open and Close furnace door: ~1 min

✓

Unless otherwise specified by the customer requirements, test plan or work instructions, the 30-minute timed test starts after 5 out of 6 test unit thermocouples and 15 of 18 furnace thermocouples reach the test temperature of 801°C (1475°F).

Enter the Test Start Time: 9:50 am/pm (§4.4e & 4.4f)

✓

The test unit was removed from the furnace and allowed to cool naturally. (§4.4f)

Enter the Test End Time: 10:21 am/pm

N/A

The test unit stopped outgassing (flames) at                      am/pm (§4.4f)

Outgassing/burnout elapsed time was                      minutes. (§4.4f)

Comments: SWRI saw called out 12 hr of furnace pre-heat. This was agreed to by Y-12 & ORNL's Team. TP

I certify that the above tasks have been performed and that the observations and comments are correct.

Testing Technician

Ron Whittely  
Customer

11-08-2021

Date

11/8/21

Date

M.B. Houston

Witness

[Signature]  
Customer

11-08-2021

Date

11/8/21

Date



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		<b>PTP-PEF-15</b>	<b>5 CN 2</b>
		Page:	Issue Date:
		5 / 6	12-14-20
		Revision Date:	Review By Date:
		12-02-20	12-14-23

## 6. Procedure Checklist

Test Plan:

ORNL/NTRC-092.0

Test Unit:

7

VERIFIED

TASK

- ☒ Verify that any equipment used meets the M&TE meets PTP-QA-013 requirements (§4.1).
- ☒ Have a photographer's clipboard with package name and test unit number. (§4.3)
- ☒ The test unit has been lowered into chamber in designated orientation. (§4.6)
- ☒ The water depth to the highest point of the test unit has been measured and covers the test unit completely. (§4.6) OR In open body of water, test unit has been lowered to at least 15-m.
- ☒ Record pre-test water temperature and ambient temperature. (§4.6)
- ☒ Close the chamber and pressurize the chamber to 21.7 psig. (§4.6)
- ☒ Start date and time has been noted. (§4.7)
- ☒ Test time has expired. (§4.7)
- ☒ Vent the chamber to atmosphere. (§4.8)
- ☒ End date and time has been noted. (§4.8)
- ☒ Record post-test water temperature and ambient temperature. (§4.8)
- ☒ Test unit has been removed from the tank OR If performing test in an open body of water, the test specimen has been retrieved. (§4.8)
- ☒ Thoroughly dry the test unit and make sure it is dry before opening. (§4.9)
- ☒ Open the test unit and record-breaking torque values during removal, if required. (§4.10)
- ☒ Inspect for water in-leakage or structural damage. (§4.10)
- ☒ Photographs of any resulting damage or lack thereof were taken. (§4.10)
- ☒ Sign and date checklist and data forms (§4.11).

Comments:

I certify that the above tasks have been performed and that the observations and comments are correct.

Test Engineer

Ross Whittaker

Date

12/13/21

Checked by

M.B. Hamilton  
Ryan Felt

Date

12/13/21



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		12-02-20	12-14-23

## 7. Data Sheet

Test Plan:  
ORNL/NTRC-092.0

Test Unit: 7

VERIFIED

TASK

- ✓ M&TE ID A005945 Calibration due date 7/28/2022 (§4.1).
- ✓ Intended attitude of the test unit in tank (e.g. on side) Vertical (§4.4)
- ✓ Pressure in chamber 21.7 psig. Measuring device MTE 767 cal: 7/20/20 (§4.4)
- ✓ Depth of water above the test unit 38 1/4" Measuring device A006327 due: 3/20/2023 (§4.5)
- ✓ Water temperature: 17.6 °C (63.6 °F) Measuring device A005945 7/28/2022 (§4.6)
- ✓ Ambient temperature: 14.6 °C (59.6 °F) Measuring device A005945 (§4.6)
- ✓ Start Date and Time of Submersion Test: 12/13/2021 @ 8:20 am @ 21.7 psig (§4.7)
- ✓ End Date and Time of Submersion Test: 12/13/2021 @ 4:20 pm @ 23.53 psig (§4.7)
- ✓ Water temperature: 17.6 °C (63.8 °F) Measuring device A005945 7/28/2022 (§4.8)
- ✓ Ambient temperature: 14.4 °C (68.1 °F) Measuring device A005945 (§4.8)
- ✓ Detected in leakage of water: (YES/NO) NO (§4.10)
- ✓ Detected structural damage: (YES/NO) NO (§4.10)

Testing Damage Observations: Test Unit Out of water tank @ 4:38pm.  
Test unit opened @ 5:50pm on 12/13/2021

Comments:

I certify that the above tasks have been performed and that the observations and comments are correct.

Test Engineer

Ron Whittaker

Date

12/13/21

Checked by

Myra John

Date

12/15/21

# TEST FORM 12 -CV DRYING PROCEDURE

Test Plan - DPP-1

TU- 7

VERIFIED

TASK

- ☒ ORNL will remove the CV's from the immersion tank after a minimum of 8 hours.
- ☒ The CV's will be placed on the worktable in a vertical position.
- ☒ A shop vac will be used to blow out any water out of the CV flanges.
- ☒ The external surface of the CV will be dried with cloth and paper towels.
- ☒ ORNL will attach a vacuum to the CV flange O-ring port and supply a vacuum to remove most of the water between the inner and outer O-rings.
- ☒ After about 1 hour of air drying under forced hot air convection, an air compressor or compressed air can, or shop air will be used to blow out any water left in between the CV O-rings.
- ☒ The CV bolts will be loosened and removed, and the breakaway torque will be recorded on Test Form 9.
- ☒ The CV top lid will be lifted about a 1/8<sup>th</sup> -in and cloth and paper towels will be used to wipe the surfaces of the internal CV flanges outboard of the outer O-ring.
- ☒ A visual inspection of the internal surface of the CV flange will be done.
- ☒ ORNL and CNS will verify that water droplets are not visible on the inside of the Inner O-ring.
- ☒ After CNS approval, the CV lid will be completely removed from the CV base.

Comments:

I certify that the above tasks have been performed and that the observations and comments are correct.

Testing Technician

Ross Whittle  
CNS-Y-12 STR

12/13/2021  
Date

12/13/21  
Date

M. B. Hamilton  
Witness

John Fink  
CNS-Y-12 QE

12/13/2021  
Date

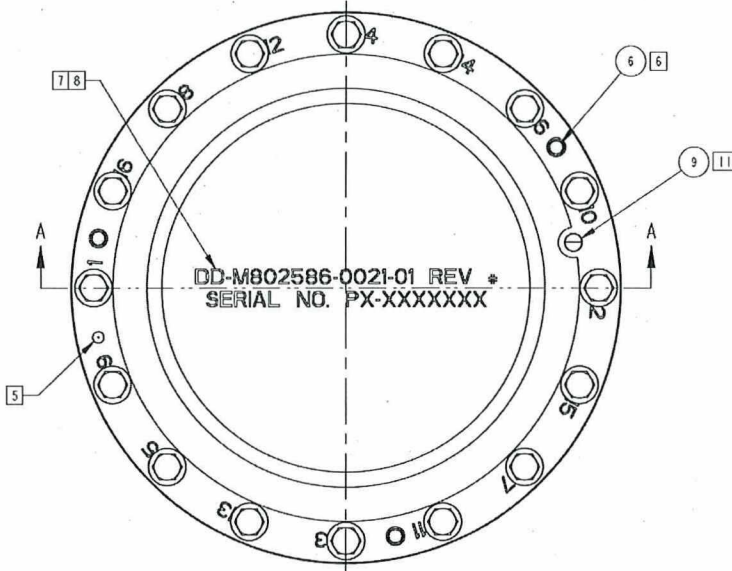
12/13/21  
Date

\*All photographs/movies will be uniquely identified with test unit, date and time to ensure that the proper sequence can be reconstructed

# TEST FORM 9 -CV LID DISASSEMBLY

Test Plan - DPP-1

TU- 7



DPP-1 CV Lid Disassembly	
Bolt #	Torque Removal (ft-lbs.)
1	<del>30.8</del>
2	26.5
3	30.8
4	32.2
5	30.7
6	26.2
7	30.7
8	28.4
9	28.0
10	29.9
11	30.8
12	32.2
13	35.9
14	33.1
15	36.6
16	23.1

26.6 -> 12/13/21 (six) 26.8 12/13/21

M&TE ID #: A001096 Calibration Due Date: 2/10/2022

M&TE ID #: A006681 Calibration Due Date: 5/12/2022

Comments: Ambient temp. 69.4 °F @ 5:50pm on 12/13/2021

I certify that the above tasks have been performed and that the observations and comments are correct.

[Signature]  
Testing Technician  
Ross Whittaker  
CNS-Y-12 STR

12/13/2021  
Date  
12/13/21  
Date

M.B. Hunter  
Witness  
[Signature]  
CNS-Y-12 QE

12/13/2021  
Date  
12/13/21  
Date

\*All photographs/movies will be uniquely identified with test unit, date and time to ensure that the proper sequence can be reconstructed



# TEST FORM 15 -WITNESS AND HOLD POINTS

Test Plan DPP-1

TU 7

The following applicable CNS hold points activities shall not start until written approval to proceed has been given from the CNS STR via e-mail. Additional hold points may be included when CNS reviews the approval data documents and as the work is being performed. The purpose of each hold point is to give the TA, STR, and QE an opportunity to (1) evaluate what has happened since the previous hold point, (2) evaluate previous lessons learned on the activities that follow, and (3) make an informed decision to proceed.

NO.	DESCRIPTION	TU NO.	TYPE	CNS INITIAL
1	<u>Initial package disassembly</u> Witness the disassembly, can be waived by a DA representative	1,2,3,4,5,6, 7	Witness, Hold	RW RF
2	<u>pre-test operational leakage rate test</u> Witness the pre-test operational leakage rate test per ANSI N14.5, section 7.6, after final closure (and before commencing testing sequence)	1,2,3,4,5,6, 7	Witness, Hold	
2.1	<u>pre-test operational leakage rate test acceptance</u> Inspection to verify the pre-test operational leakage rate test has met acceptance criteria <b>Subsequent reassembly sequence shall not commence until acceptable result is produced.</b>	1,2,3,4,5,6, 7	Hold	
3	<u>Initial package reassembly</u> Witness the reassembly of the contents, CV, vibration pads, drum lid, instrumentation, and all associated fastening hardware	1,2,3,4,5,6, 7	Witness	
3.1	<u>Initial Package Reassembly</u> Inspection and observation to verify the reassembly procedure has been followed according to supplied direction. <b>Subsequent testing sequence shall not commence until reassembly steps have been confirmed as acceptable.</b>	1,2,3,4,5,6, 7	Hold	
4	<u>NCT vibration/shock test</u> Witness the NCT vibration/shock testing activities, including all preliminary setup, can be waived by a DA representative	6	Witness	
5	<u>NCT thermal pre-treatment</u> Witness the NCT thermal pre-treatment activities, including all preliminary setup, can be waived by a DA representative	1,2,3,4,5,6	Witness	N/A
6	<u>NCT water spray test</u> Witness the NCT water spray test activities, including all preliminary setup, can be waived by a DA representative	2,3,4,6	Witness, Hold	N/A
7	<u>NCT free drop (4 ft) test</u> Witness the NCT free drop (4 ft) test activities, including all preliminary setup, can be waived by a DA representative	1,2,3,4,5,6	Witness	N/A
7.1	<u>NCT free drop (4 ft) test, critical parameters</u> Inspection to verify the critical parameters defining the NCT free drop (4 ft) test meet all requirements <b>Completion of NCT free drop (4 ft) test shall not commence until all critical parameters have been verified.</b>	1,2,3,4,5,6	Hold	N/A



8	<u>NCT penetration test</u> Witness the NCT penetration test activities, including all preliminary setup, can be waived by a DA representative	6	Witness
8.1	<u>NCT penetration test, critical parameters</u> Inspection to verify the critical parameters defining the NCT penetration test meet all requirements	6	Hold
<b>Completion of NCT penetration test shall not commence until all critical parameters have been verified.</b>			
9	<u>NCT compression test</u> Witness the NCT compression test activities, including all preliminary setup, can be waived by a DA representative	6	Witness
9.1	<u>NCT compression test, critical parameters</u> Inspection to verify the critical parameters defining the NCT compression test meet all requirements	6	Hold
<b>Completion of NCT compression test shall not commence until all critical parameters have been verified.</b>			
10	<u>HAC thermal pre-treatment</u> Witness the HAC thermal pre-treatment activities, including all preliminary setup, can be waived by a DA representative	1,5	Witness
11	<u>HAC free drop (30 ft) test</u> Witness the HAC free drop (30 ft) test activities, including all preliminary setup, can be waived by a DA representative	1,2,3,4,5,6	Witness
11.1	<u>HAC free drop (30 ft) test, critical parameters</u> Inspection to verify the critical parameters defining the HAC free drop (30 ft) test meet all requirements	1,2,3,4,5,6	Hold
<b>Completion of HAC free drop (30 ft) test shall not commence until all critical parameters have been verified.</b>			
11.2	<u>HAC free drop (30 ft) test, damage determination</u> Inspection to verify that the damage inflicted during the HAC free drop (30 ft) test is as expected, if unexpected damage is present, modifications to the subsequent HAC Crush (30 ft) test will be defined	1,2,3,4,5,6	Hold
<b>Testing shall not commence until new specification of HAC Crush (30 ft) test has been agreed-upon and adopted by the TA.</b>			
12	<u>HAC crush (30 ft) test</u> Witness the HAC crush (30 ft) test activities, including all preliminary setup, can be waived by a DA representative	1,2,3,4,5,6	Witness
12.1	<u>HAC crush (30 ft) test, critical parameters</u> Inspection to verify the critical parameters defining the HAC crush (30 ft) test meet all requirements	1,2,3,4,5,6	Hold
<b>Completion of HAC crush (30 ft) test shall not commence until all critical parameters have been verified.</b>			
12.2	<u>HAC crush (30 ft) test, damage determination</u> Inspection to verify that the damage inflicted during the HAC crush (30 ft) test is as expected, if unexpected damage is present, modifications to the subsequent HAC Puncture drop (40 in.) test will be defined	1,2,3,4,5,6	Hold
<b>Testing shall not commence until new specification of HAC Puncture drop (40 in.) test has been agreed-upon and adopted by the TA.</b>			

N/A



N/A



13	<u>HAC Puncture drop (40 in.) test</u> Witness the HAC Puncture drop (40 in.) test activities, including all preliminary setup, can be waived by a DA representative	1,2,3,4,5,6	Witness	N/A
13.1	<u>HAC Puncture drop (40 in.) test, critical parameters</u> Inspection to verify the critical parameters defining the HAC Puncture drop (40 in.) test meet all requirements	1,2,3,4,5,6	Hold	N/A
<b>Completion of HAC Puncture drop (40 in.) test shall not commence until all critical parameters have been verified.</b>				

NO.	DESCRIPTION	TU NO.	TYPE	CNS INITIAL
14	<u>Thermal test, data collection hardware</u> Inspection to verify that all the thermocouple and hardware has been installed, or configured as specified and is operating correctly  <b>Completion of supplementary thermal test shall not commence until hardware installation has been verified.</b>	1,2,3,4,5,6	Hold	RN RF
15	<u>HAC thermal test</u> Witness the HAC thermal test activities, including all preliminary setup, can be waived by a DA representative	1,2,3,4,5,6	Witness	
15	<u>Overpack Inspection and Disassembly</u> Witness the overpack inspection and disassembly process. including all preliminary setup, can be waived by a DA representative	1,2,3,4,5,6	Witness	
16	<u>Overpack Inspection and Disassembly</u> Inspection to verify that sufficient data and measurements have been collected from overpack and CV prior to drilling and tapping the CV lid for post-test leakage rate measurements  <b>Post-test leakage rate activities, including all preliminary setup, shall not commence until hardware installation has been verified.</b>	1,2,3,4,5,6	Hold	
17	<u>post-test operational leakage rate test</u> Witness the post-test operational leakage rate test per ANSI N14.5, section 7.6, after completion of test activities (and before post-test full-boundary leakage rate test)	1,2,3,4,5,6	Witness	↓ ↓
18	<u>post-test full-boundary leakage rate test, drilling and tapping test port in CV lid</u> Witness the drilling and tapping of the leakage rate test port in the CV lid, after removal from the overpack assembly (and before completion of testing sequence)	1,2,3,4,5,6	Witness	N/A
19	<u>post-test full-boundary leakage rate test</u> Witness the post-test full-boundary leakage rate test per ANSI N14.5, Section 7.5. This includes the sealing of the drilled and tapped hole in the CV lid after the leak rate measurements have completed	1,2,3,4,5,6	Witness	N/A
19.1	<u>Final containment vessel leakage rate test acceptance</u> Inspection to verify the "post-test" leakage rate test has met acceptance criteria  <b>HAC immersion tests shall not commence until results are confirmed.</b>	1,2,3,4,5,6	Hold	N/A



20	<u>HAC immersion test, fissile material packages</u> Witness the HAC immersion test, fissile material packages, activities, including preliminary setup, can be waived by a DA representative	1,2,3,4,5,6	Witness	N/A
21	<u>HAC immersion test, all packages (undamaged)</u> Witness the HAC immersion test, all packages (undamaged), activities, including preliminary setup, can be waived by a DA representative	7	Witness	RW RF ↓ ↓
22	<u>Opening containment vessel after HAC immersion test</u> Witness the opening of the containment vessel and inspection for retained moisture within the containment vessel cavity, including preliminary setup and verification that the external surface is complete dry, can be waived by a DA representative	1,2,3,4,5,6, 7	Witness	↓ ↓
NO.	DESCRIPTION	TU NO.	TYPE	CNS INITIAL
23	<u>Final external inspection results</u> Inspection of all external inspection results, to verify all specified dimensional and photographic records have been obtained, these records cannot be confirmed after the overpack assembly has been cut-open and so must be confirmed at this point  <b>Disassembly and cross section examination shall not commence until all external inspections have been completed and all necessary records have been collected. (if required)</b>	1,2,3,4,5,6, 7	Hold	RW RF ↓ ↓
24	<u>Disassembly and cross section inspection</u> Witness the cutting, disassembly, and dissection of the overpack assembly (if required)	1,2,3,4,5,6, 7	Witness	↓ ↓
25	<u>Final cross section inspection results (if required)</u> Inspection of all cross-section inspection results, to verify all specified dimensional and photographic records have been obtained  <b>Completion of final data report shall not commence until all cross-section inspections have been completed and all necessary records have been collected. (if required)</b>	1,2,3,4,5,6, 7	Hold	↓ ↓
26	<u>Preliminary data package</u> Inspection of all preliminary test results, including data collected, photos and videos captured, and dimensions measured  <b>Shipment or disposal (as defined by the DA) of TU shall not commence until the preliminary data package has been reviewed and determined to be complete.</b>	1,2,3,4,5,6, 7	Hold	↓ ↓

Comments:

I certify that the above tasks have been performed and that the observations and comments are correct.

Testing Technician

CNS-Y-12 STR

12-13-2021

Date

12/13/21

Date

Witness

CNS-Y-12 QE

12-13-2021

Date

12/13/21

Date

\*All photographs/movies will be uniquely identified with test unit, date and time to ensure that the proper sequence can be reconstructed

# TEST FORM 16 -PHOTOGRAPHY/VIDEO CHECKLIST

Test Plan DPP-1

CTU 7

At a minimum, the following events shall be captured by photography. If necessary, photos shall be taken from multiple perspectives to provide a clear understanding of the event being captured. Date and time will be stamped on all photographs.

VERIFIED

TASK

✓	Overpack assembly, containment vessel, and vibration pads after taking delivery and during disassembly
✓	Overpack assembly, containment vessel, and vibration pads (where applicable) during reassembly
✓	Drop testing pad, including appropriate dimensional references
✓	Puncture bar installed onto drop pad, including appropriate dimensional reference
✓	Penetration bar, including appropriate dimensional references
✓	Equipment, instrumentation, and general arrangement used for vibration/shock tests
✓	Equipment, instrumentation, and general arrangement used for free and Puncture drop tests
✓	Equipment, instrumentation, and general arrangement used for water spray tests
✓	Pre-test leakage rate tests: — Close-up views of CV before test, showing connection for CV lid leakage rate test port — Close-up views of CV during test, showing connections made to CV lid leakage rate test port — Test arrangement with CV during test, showing all connections made to CV
✓	NCT vibration/shock tests: — Test arrangement with the package installed onto the expander head or slip table — Attachment of tie-down chains or straps to top of package — Attachment of tie-down chains or straps to expander head or slip table
✓	NCT water spray tests: — Test arrangement with package before test, showing relative placement of water spray nozzles with respect to the package — Test arrangement with package during test, showing how the water is hitting the package — Test arrangement with package after test, showing evidence of water pooling or accumulation, if any — Rain gauge showing minimum allowable rainfall has been reached
✓	NCT free drop (4 ft) tests: — Test arrangement with package before test, showing the intended offset angle — Test arrangement with package before test, showing the intended drop height — Test arrangement with package after test, showing damaged package at final resting place — Close-up views of package after test, showing particular damage induced as a result of the NCT free drop (4 ft) test, including appropriate dimensional references
✓	NCT penetration tests: — Close-up views of package before test, showing intended point of impact — Test arrangement with package before test, showing supports and restraints that hold the package in place — Test arrangement with package before test, showing position and height of penetration bar, with respect to the package — Test arrangement with package after test, showing damaged package after penetration bar has made impact — Close-up views of package after test, showing particular damage induced as a result of the NCT penetration test, including appropriate dimensional references
✓	NCT compression tests: — If a compression tester machine is being used • The relative arrangement of the package within the machine • The force read-out as indicated by the machine control system — Test arrangement with package during test, showing weight having been applied to the package — Test arrangement with package after test, showing damaged package after weight has been removed (if any)

✓	<ul style="list-style-type: none"> <li>— Close-up views of package after test, showing any particular damage induced as a result of the NCT compression test, including evidence of bulging/buckling of the drum, bending/buckling of the drum bolt guard, and crushing/buckling of the fork pockets</li> </ul>
✓	<p>HAC free drop (30 ft) tests (check as performed)</p> <ul style="list-style-type: none"> <li>— Close-up views of package before test, showing intended point of initial impact</li> <li>— Test arrangement with package before test, showing the intended offset angle</li> <li>— Test arrangement with package before test, showing the intended drop height</li> <li>— Test arrangement with package after test, showing damaged package at final resting place</li> <li>— Close-up views of package after test, showing particular damage induced as a result of the HAC free drop (30 ft) test, including appropriate dimensional references</li> <li>— Close-up views of package after test, showing unexpected damage (if any), due to primary impact or any subsequent event</li> </ul>
✓	<p>HAC crush (30 ft) tests (check as performed)</p> <ul style="list-style-type: none"> <li>— Close-up views of package before test, showing intended point of initial impact</li> <li>— Test arrangement with package before test, showing the intended offset angle</li> <li>— Test arrangement with package before test, showing the intended drop height</li> <li>— Test arrangement with package after test, showing damaged package at final resting place</li> <li>— Close-up views of package after test, showing particular damage induced as a result of the HAC crush (30 ft) test, including appropriate dimensional references</li> <li>— Close-up views of package after test, showing unexpected damage (if any), due to primary impact or any subsequent event</li> </ul>
✓	<p>HAC Puncture drop (40 in ) tests</p> <ul style="list-style-type: none"> <li>— Close-up views of package before test, showing intended point of initial impact</li> <li>— Test arrangement with package before test, showing the intended offset angle</li> <li>— Test arrangement with package before test, showing the intended drop height</li> <li>— Test arrangement with package after test, showing damaged package at final resting place</li> <li>— Close-up views of package after test, showing particular damage induced as a result of the HAC puncture (1 m (40 in)) test, including appropriate dimensional references</li> <li>— Close-up views of package after test, showing unexpected damage (if any), due to primary impact or any subsequent event</li> </ul>
✓	<p>Supplementary and HAC thermal tests</p> <ul style="list-style-type: none"> <li>— Views of relative spacing inside the furnace with door/trap open, with or without the package used as a dimensional point of reference, at hot or cold condition</li> <li>— Test arrangement with package before test, showing placement of the thermocouple attachments on the package exterior surface</li> <li>— Test arrangement with package after test, showing damaged/burned package after initial removal from the furnace/fire</li> <li>— Close-up views of package after test, showing any excessively damaged/burned parts (if any)</li> </ul>
✓	<p>HAC immersion-fissile material tests</p> <ul style="list-style-type: none"> <li>— Test arrangement with CV before test, showing placement of the CV within the tank</li> <li>— Test arrangement with CV during test, showing measurement of submerged depth of CV below water line</li> <li>— Close-up views of CV after test, after removal of the CV lid, showing evidence of water ingress (if any)</li> </ul>
✓	<p>HAC immersion- 10CFR71(c)(6) package tests</p> <ul style="list-style-type: none"> <li>— Test arrangement with CV before test, showing placement of the CV within the tank or hydraulic pressure chamber</li> <li>— Test arrangement with CV during test, showing measurement of submerged depth of CV below water line (or, if a hydraulic pressure chamber is being used, the internal pressure read-out as indicated by the hydraulic control system or in-line pressure gauge)</li> <li>— Close-up views of CV after test, after removal of the CV lid, showing evidence of water ingress (if any)</li> </ul>



✓	<p>Post-test leakage rate tests:</p> <ul style="list-style-type: none"> <li>– Close-up views of CV before test, showing drilled/tapped connection for CV lid leakage rate test port</li> <li>– Close-up views of CV during test, showing connections made to CV lid leakage rate test port</li> <li>– Test arrangement with CV during test, showing all connections made to CV</li> </ul>
✓	<p>Initial teardown and inspection:</p> <ul style="list-style-type: none"> <li>– Close-up views of CV after removal from overpack assembly, showing any superficial and structural damage due to interaction with overpack assembly during test sequence (if any), including appropriate dimensional references ( cursory examination only)</li> <li>– Close-up views of all thermal temperature indicators, showing temperatures indicated and evidence of stretching/tearing (if any), including appropriate dimensional references</li> <li>– Close-up views of overpack assembly after removal of CV, showing any superficial and structural damage due to interaction with CV or drum lid during test sequence (if any), including appropriate dimensional references</li> <li>– Close-up views of drum lid after removal from overpack assembly, showing any superficial and structural damage due to interaction with the CV or overpack assembly, including appropriate dimensional references</li> </ul>
✓	<p>Final teardown and inspection:</p> <ul style="list-style-type: none"> <li>– Close-up views of the CV, showing superficial and structural damage to ANY component, internal and external surfaces (if any), including appropriate dimensional references (detailed examination)</li> <li>– Close-up views of components within the CV, showing superficial and structural damage to ANY component, internal and external surfaces (if any), including appropriate dimensional references (detailed examination)</li> <li>– Markings on the surfaces of the overpack assembly and drum lid, showing the intended cross section cuts, including appropriate dimensional references (if requires)</li> <li>– Overall views of overpack assembly and drum lid after cross section cuts have been made (if required)</li> <li>– Close-up views of overpack assembly and drum lid after cross section cuts have been made, showing damage to internal components, including the following: (if required) <ul style="list-style-type: none"> <li>• Extent of burned/charred or disintegrated impact-limiting foam</li> <li>• Extent of disintegration, cracking, or separation of impact-limiting block</li> <li>• Extent of damage to thermal insulating blanket and indication of total radial thickness</li> <li>• Relative dimensional changes of structural components (including but not limited to drum liner assembly, perforated ring, drum lid inner section)</li> <li>• Any cracked welds</li> <li>• Any scratched, dented, or stretched sheet metal</li> </ul> </li> </ul>

Comments:

I certify that the above tasks have been performed and that the observations and comments are correct.

Testing Technician

*Ron Whittaker*  
CNS-Y-12 STR

*12-13-2021*

Date

*12/13/21*  
Date

Witness

*Michael B. Horvath*  
*[Signature]*  
CNS-Y-12 QE

*12-13-2021*

Date

*12/13/21*  
Date

\*All photographs/movies will be uniquely identified with test unit, date and time to ensure that the proper sequence can be reconstructed

## **O. APPENDIX TEST PLAN**

# **TEST PLAN FOR DPP-1 REGULATORY COMPLIANCE TESTING**

Prepared for the  
Consolidated Nuclear Security, LLC Management and Operating Contractor for  
The Y-12 National Security Complex and Pantex Plant

by  
Oak Ridge National Laboratory  
Nuclear Energy and Fuel Cycle Division  
Packaging Systems and Logistics Group  
managed by  
UT-Battelle  
for the  
U. S. DEPARTMENT OF ENERGY  
under contract  
DE-AC05-00OR22725



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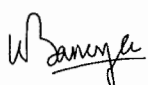
ISSUE DATE: March 31, 2021

## TEST PLAN FOR DPP-1 REGULATORY COMPLIANCE TESTING

Prepared for the  
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by  
Oak Ridge National Laboratory  
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Packaging Systems and Logistics Group  
managed by  
UT-Battelle  
for the  
U. S. DEPARTMENT OF ENERGY  
under contract  
DE-AC05-00OR22725

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## LIST OF ACRONYMS

ACC	Accelerometer
ANSI	American National Standards Institute
ASNT	American Society for Nondestructive Testing
CFR	Code of Federal Regulations
CG	center of gravity
CGoBC	Center of gravity over bottom corner
CGoTC	Center of gravity over top corner
CNS	Consolidated Nuclear Security, LL
CoC	Certificate of Conformance
CTR	Certified test report
CV	containment vessel
DA	design agency
DEF	data evaluation form
DOE	Department of Energy
DPP-1	Defense Programs Package-1
FEA	Finite element analysis
FL	marked location on outside of the drum along weld seam aligned with CV flange
FPS	Frames per second
GP	General Plastics Manufacturing Company
HAC	hypothetical accident conditions
IAEA	International Atomic Energy Agency
IOSD	Integrated Operations Systems Division
ISO	International Organization for Standardization
M&TE	Measuring & test equipment
NCR	Non-conformance report
NCT	normal conditions of transport
NDE	Nondestructive examination
NDT	nondestructive testing
NNSA	National Nuclear Security Administration
NQA	Nuclear Quality Assurance
NTRC	National Transportation Research Center
ORNL	Oak Ridge National Laboratory
OPT	Office of Packaging and Transportation
PAQ	Performance Analysis and Quality
PEF	Package Engineering Facility
PI	Principal investigator
PM	Project manager
PNNL	Pacific Northwest National Laboratory
PTE	Packaging and Transportation Engineering
PTP	Package Testing Program
QA	quality assurance
QASL	Quality Approved Supplier List
QAPP	Quality Assurance Program Plan
QCT	Quality conditions of transportation

QE	Quality Engineer
QR	Quality Representative
RFWD	Request for Waiver or Deviation
SG	Safety Guide
S&I	Surveillance and Inspection
SOW	statement of work
STR	subcontract technical representative
TA	testing agency
TE	test engineer
TC	thermocouple
TL	temperature label
TOT	testing oversight team
TPCR	test plan change request
TU	test unit
UT-B	University of Tennessee-Battelle
Y-12	Y-12 National Security Complex



## 1.0 ABSTRACT

Testing of prototype packages is performed to demonstrate compliance with selected requirements of Title 10, Code of Federal Regulations (CFR), Part 71.71, *Normal Conditions of Transport* (NCT), and Part 71.73, *Hypothetical Accident Conditions* (HAC) and to document the test activities and results in support of the preparation of the DPP-1 Shipping Package Safety Analysis Report for Packaging (SARP).

This test plan describes the testing activities for the DPP-1 shipping package. The activities and requirements in the test plan are in accordance with the requirements and activities stated in the CNS document SOW 802586-0007 000 00 *Statement of Work DPP-1 Regulatory Compliance Testing*, September 26, 2019 and approved Request for Waiver or Deviations (RFWD) included as attachments. The test plan consists of a series of NCT and HAC sequential tests that will be performed on multiple DPP-1 Test Units (TUs) containing various surrogate content configurations (see detailed configuration matrix in Table 3-1). One test unit (TU-6) will be subjected to the full 10 CFR 71.71 NCT and 10 CFR 71.73 HAC test series. TU-1 and TU-5 shall be chilled in a freezer for a minimum of 72 h, with the freezer set at -70°F for 24 h and -45°F for 48 h. The freezer setting shall remain on -45° until the test unit is removed for testing. Six test units will be subjected to the 10 CFR 71.71 NCT *Free drop* and 10 CFR 71.73 HAC test series. The containment vessels (CV) for TU-1 through TU-6 will undergo the pre-test operational leak test and will be subjected to the post-test operational leak test as well as post-test helium leak tests. The CV from TU-7 will only be subjected to the pre-test operational leak test. TU-1 through TU-6 will be subjected to vibration, water spray, NCT drop, compression, penetration, HAC drop, crush, puncture, thermal, and 3-ft immersion tests in accordance with matrix in Table 3-1. Finally, the empty CV from TU-7 will be subjected to the 10 CFR 71.73 (c)(6) 15 m (50 ft) water immersion test.

## 2.0 INTRODUCTION

The DPP-1 is a drum type packaging that has an inner liner and a removable lid. Both the drum body and lid are filled with an impact limiting and thermal insulating material called Packcrete that protects the containment vessel (CV) during normal conditions of transport (NCT) and hypothetical accident conditions (HAC) as defined by 10 CFR 71. Seven DPP-1 test units will be tested to demonstrate that the DPP-1 design complies with selected requirements of Title 10, Code of Federal Regulations (CFR), Part 71.71, *Normal Conditions of Transport* (NCT) and Part 71.73, *Hypothetical Accident Conditions* (HAC). These packagings with their surrogate payloads serve as the certification test units and will be identified by sequential designation numbers TU-1 through TU-7. Section 3.0 summarizes the tests and processes that each test unit will undergo. The test results of this test plan will be used in the preparation of the DPP-1 Package Safety Analysis Report for Packaging (SARP).

The DPP-1 package test units will be configured with heavy surrogate payloads (test weights) in each unit's containment vessel (CV) except for TU-2 which will have a light test weight. TU-1 through TU-6 will contain a test fixture weldment assembly inside the CV. The test fixture weldment configuration consists of a surrogate payload with test weight bolted to it. The weight and the center of gravity (CG) of the internal content will vary to bound the tested configurations. The test fixture weldment assembly is then placed in the CV. TU-7 is the 50 ft water immersion package.

Leak checking of each test unit's CV will be performed as follows:

- after loading the surrogate payload into the CVs (no test fixture in the CV of TU-7), each CV will be subjected to a pre-test operational leak check (sensitivity is  $\leq 1 \times 10^{-3}$  ref-cc/sec, acceptance is no detectable leak),
- following the specified series of NCT and HAC tests (see Section 3.0), the CVs will undergo a post-test operational leak test (sensitivity is  $\leq 1 \times 10^{-3}$  ref-cc/sec, acceptance is no detectable leak) and a full-body helium leak test to a sensitivity of  $\leq 5 \times 10^{-8}$  cc/sec He and acceptance value of  $\leq 1 \times 10^{-7}$  cc/sec air or  $\leq 2 \times 10^{-7}$  for He.

It should be noted that figures used throughout this test plan are only meant to clarify basic test information like drop angle and impact zone, etc. These drawings are not to scale and are not intended to be exact representations of the DPP-1 shipping package.

## 3.0 SUMMARY OF TESTS TO BE PERFORMED

- Four test units (TU-2, TU-3, TU-4, and TU-6) at various impact orientations will undergo a series of drop tests at ambient temperature.
- Two test units (TU-1 and TU-5) at different impact orientations will undergo a series of drop tests at -40°F cold temperature.
- One test unit (TU-6) will undergo both NCT and HAC testing. This includes a vibration and water spray test prior to the 4-ft drop test and a compression test and penetration test following the 4-ft drop test. A water spray test will also be performed on the ambient test units of TU-2, TU-3, and TU-4. For summary of all NCT/HAC tests, see table 3-1.

- Four test units (TU-1, TU-2, TU-5, and TU-6) will be instrumented with PCB piezotronics, accelerometers to collect acceleration data during the vibration and drop tests.
- Six test units will be furnace tested (TU-1 through TU-6). All test units subjected to the furnace test will have thermocouples (TC) installed on designated exterior surfaces of the drum body and lid. Temperature labels will be added as specified in Section 5.1.1
- The CV from one test unit (TU-7) will undergo a 50-ft water immersion test only and will not be subjected to any other tests.

Table 3-1 shows in numerical sequence, the tests and processes to be performed on each test unit. For a detailed test sequence see Table 5-3 through Table 5-9. The orientation for some of the tests is described by a short description. A cut-away view of the DPP-1 shipping package as assembled for testing is shown in Figure 3-1 and a 3D CAD view is shown in Figure 3-2.



**Table 3-1 Sequence of Tests for DPP-1 Test Units.**

	<b>TU-1</b>	<b>TU-2</b>	<b>TU-3</b>	<b>TU-4</b>	<b>TU-5</b>	<b>TU-6</b>	<b>TU-7</b>
Regulatory test	HAC <sup>a</sup>	HAC	HAC	HAC	HAC	NCT <sup>b</sup> /HAC	-
Temperature	Cold	Ambient	Ambient	Ambient	Cold	Ambient	Ambient
Test weight	Heavy	Light	Heavy	Heavy	Heavy	Heavy	None
Test weight CG <sup>c</sup>	Low	Low	High	Low	High	Low	-
Drop orientation	Side	Side	Top	CGoTC <sup>d</sup> 54.6 <sup>0</sup>	Slapdown 22 <sup>0</sup>	Slapdown 22 <sup>0</sup>	-
<b>Preparation</b>							
Mark outside	1	1	1	1	1	1	1
Disassemble	2	2	2	2	2	2	2
Mark part & subassemblies	3	3	3	3	3	3	
Install TLs <sup>e</sup>	4	4	4	4	4	4	
Weigh parts & assemblies	5	5	5	5	5	5	3
Leak test CVs <sup>f</sup> (operational)	6	6	6	6	6	6	4
Assemble	7	7	7	7	7	7	
Install Impact Accelerometers	8	8			8		
Install Vibration Accelerometer						8	
Chill test unit (-40°F)	9				9		
<b>NCT tests</b>							
Vibration, 10 CFR71.71 (c)(5)						9	
Remove accelerometer & capture data. Seal accelerometer connectors						10	
Water Spray, 10 CFR71.71 (c)(6)		9	8	8		11	
Install impact accelerometers						12	
4-ft (1.2-m) drop, 10 CFR71.71 (c)(7)	10	10	9	9	10	13	
Remove accelerometer & capture data						14	
Compression, 10 CFR71.71 (c)(9)						15	

	TU-1	TU-2	TU-3	TU-4	TU-5	TU-6	TU-7
Penetration, 10 CFR71.71 (c)(10)						16	
Install Impact Accelerometers						17	
<b>HAC tests</b>							
30-ft (9-m) drop, 10 CFR71.73 (c)(1)	11	11	10	10	11	18	
Crush, 10 CFR71.73 (c)(2)	12	12	11	11	12	19	
Puncture, 10 CFR71.73 (c)(3)	13	13	12	12	13	20	
Measure deformations	14	14	13	13	14	21	
Remove DLs & capture data	15	15	14	14	15	22	
Install TCs <sup>g</sup> on drum & preheat	16	16	15	15	16	23	
Thermal test	17	17	16	16	17	24	
Capture TC data	18	18	17	17	18	25	
<b>Post-test inspection</b>							
Disassemble down to CV	19	19	18	18	19	26	
Read TLs	20	20	19	19	20	27	
Leak test CV (operational)	21	21	20	20	21	28	
Leak test CV (He)	22	22	21	21	22	29	
3-ft CV immersion	23	23	22	22	23	30	
50-ft CV immersion							5
Disassemble CV	24	24	23	23	24	31	6
Inspect for water	25	25	24	24	25	32	7
Remove test content assembly	26	26	25	25	26	33	
Read TLs & inspect	27	27	26	26	27	34	

<sup>a</sup>HAC – hypothetical accident condition

<sup>d</sup>CGoTC – center of gravity over top corner

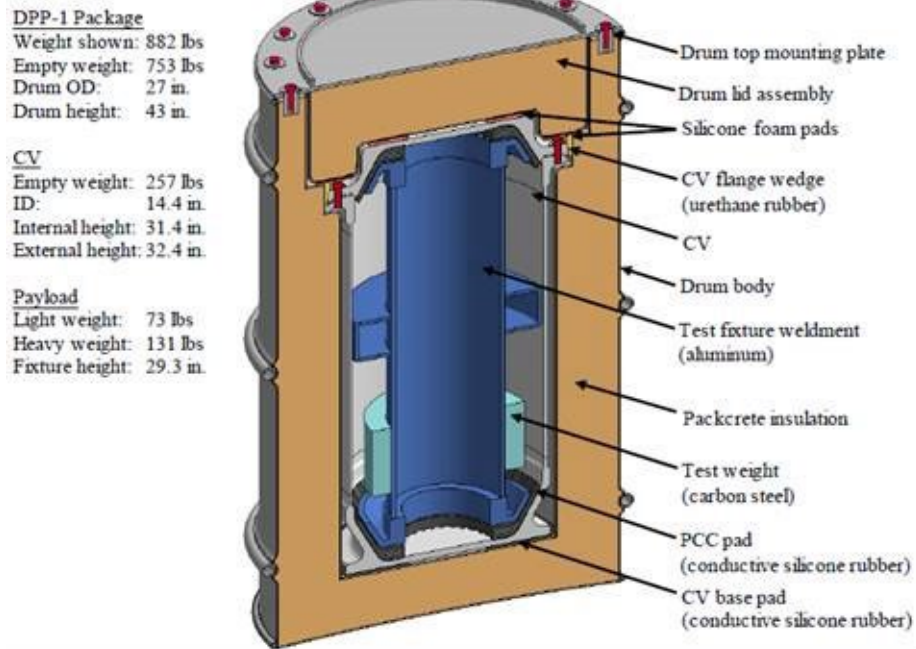
<sup>g</sup> TC - thermocouple

<sup>b</sup>NCT – normal conditions of transport

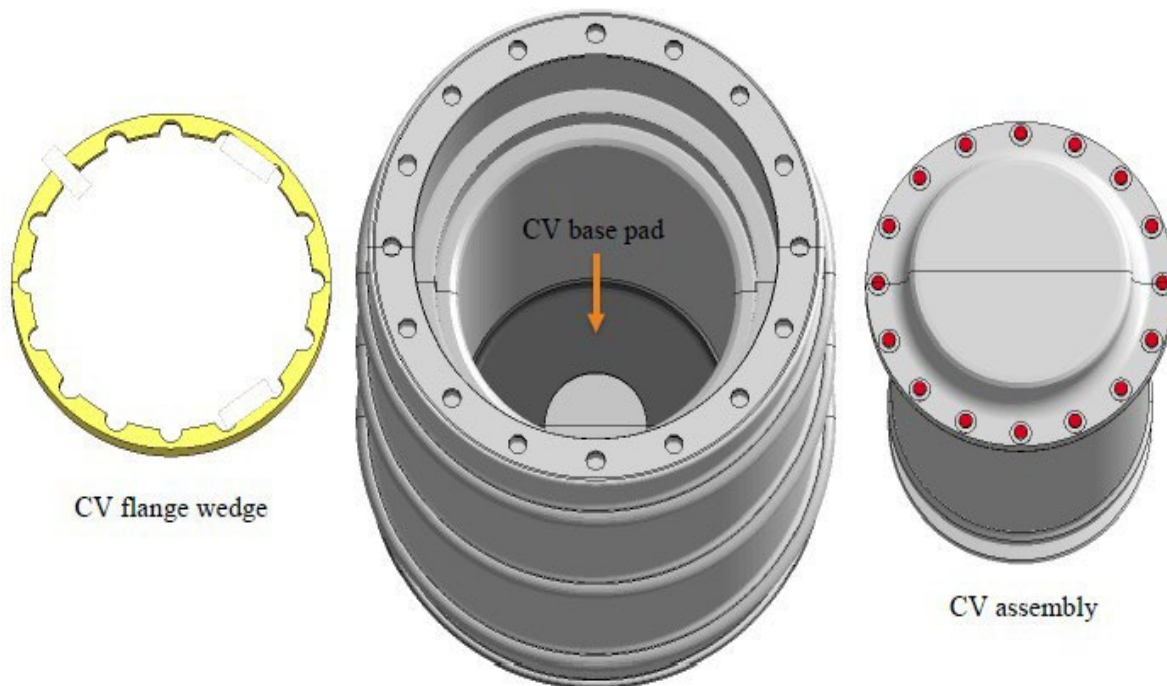
<sup>e</sup>TL – temperature label

<sup>c</sup>CG – center of gravity

<sup>f</sup>CV – containment vessel



**Figure 3-1 Cut-away view of DPP-1.**



**Figure 3-2 DPP-1 Shipping Package with containment vessel.**



## 4.0 TEST PLAN

This test plan describes the tests and data gathering to be performed by or under the supervision of the Oak Ridge National Laboratory (ORNL) Package Testing Program (PTP) for the Y-12 National Security Complex. Each individual test will be conducted in accordance with this test plan and the appropriate procedure listed in Section 5.0. The quality assurance (QA) aspects of activities in the test plan are controlled by the QA requirements of 10 CFR 71 Subpart H, DOE O 414.1D, ISO 9001-2015, and NQA-1-2008 (as supplemented by NQA-1a-2009 and NQA-1b-2011), *Quality Assurance Requirements for Nuclear Facility Applications*. The safety aspects of activities in this test plan are controlled by the ORNL Research Hazard Assessment and Control (RHAC) Research Safety Summary (RSS) 1082, titled “*General Use and Package Testing Activities Conducted in the NTRC Packaging Research Facility*” and RSS 2416 “Thermal Testing of Type B Packages Thermal Facility. Additionally, all testing is performed under the quality assurance plan outlined in PTP-QA-001/ NTRC-PEF-QAP-001, Rev. 5 entitled *Package Testing Program Quality Assurance Program Plan*. This plan is based on the QA requirements of 10 CFR 71 Subpart H. Additionally, handling, assembly, and disassembly of test units shall be conducted in accordance with approved procedure CNS Y-12 Document ID: RP 802586-0005 000 00, “DPP-1 Handling, Assembly, and Disassembly Instructions for Test Units”.

### 4.1 Description of Test Units

A total of seven test units will be subjected to a regulatory test. All test units are full-scale units and consist of a containment vessel (CV) assembly with the CV housed inside a confinement boundary assembly. The containment boundary is the volume in the CV that is constrained within the CV O-ring, CV lid, and CV body. The test units will be configured with surrogate payloads in the CV.

The confinement boundary includes a stainless-steel outer drum that contains a stainless-steel inner liner. Packcrete is cast into the annulus formed between the stainless-steel inner liner and the outer drum. This boundary also contains a drum lid/top plug weldment, vibration (conductive silicone rubber) dampening pads, and fastening hardware.

The CV consists of a stainless-steel CV body, CV base, fastening hardware, and O-rings. The CV of TU-1 through TU-6 contains the test fixture weldment content which consists of a surrogate payload which is attached to the test fixture weldment while outside of the CV. The test fixture weldment is then loaded into the CV. TU-7’s CV will be subjected to only the 50-ft immersion test and will be tested empty. The test units will be inspected for shipping damage upon arrival and compared to the DA’s drawings set (DD-M802586-0001-0029\_Combined\_07082020 and DD-M802586-0003 0033\_Combined\_07082020). The estimated weights in Table 4-1 are for material handling purposes. Actual weight will be determined during the assembly process.

**Table 4-1 Estimated weights of test units.**

TU-1	TU-2	TU-3	TU-4	TU-5	TU-6	TU-7
884 lbs.	826 lbs.	884 lbs.	884 lbs.	884 lbs.	884 lbs.	753 lbs.

#### 4.1.1 Markings for Testing

Each TU overpack will be marked at the fabrication facility. The outer surface of the drum body of all TUs will be marked with 4 axial lines, one every 90°, with 0° located at the drum weld seam increasing by 90° in a counterclockwise direction when viewed from above (Figure 4-1). The test units will also have a circumferential line marked at the package center of gravity and CV flange location. The intersection of each circumferential and axial line will be marked with a CG or FL symbol, as appropriate (See Figure 4-1). The CG location from the base of the drum to the center of the CG target symbols are provided in Table 4-2. All CG dimensions are from the bottom surface of the TU to the CG symbol. The internal parts will also be marked to indicate their alignment with the 0° markings on the outer drum. Additional markings on specific test units will be as follows:

- The test unit number (i.e., TU-1, TU-2, etc.) will be marked on each drum body lid as well as the drum assembly bodies, CV bodies, CV lids and test content assembly.
- TU-1 thru TU-6 will be marked the FL symbol at 8.75 in from the top edge of the drum lid.
- TU-1 thru TU-6 will have a puncture target symbol that will be used during the HAC 40-in (1 m) puncture test. The unit orientation and puncture target symbols placement will be as described below:
  - TU-1, 8.75 in from the top edge of the drum lid, cold, side drop, 0° line facing punch, FL (weld seam aligned with CV flange) over punch
  - TU-2, side drop, 0° line facing punch, CG over punch
  - TU-3, Center of the lid, end drop, lid facing punch, bottom facing up, CG over punch
  - TU-4, CG over corner drop, lid down, 0° line facing punch, CG over punch
  - TU-5, 8.75 in from the top edge of the drum lid, cold side drop, 0° line facing punch, FL (weld seam aligned with CV flange) over punch
  - TU-6, side drop, 0° line facing punch, CG over punch
- TU-6 will have a penetration bar target symbol located 8.75 in from the top edge of the drum lid along the weld seam aligned with the CV flange.
- Payload assemblies for the test units will be disassembled down to the CV surrogate content. Disassembled parts will be marked, tagged, and controlled so they remain with the test unit from which they came.
- The top side of the CV lids shall be marked with radial lines marking 0°, 90°, 180°, 270°. The 0° line shall pass through one of the CV bolt holes, Figure 4-2.
- The bottom side of the CV lids shall be marked with a 3-in diameter circle in the center. This will indicate the area that must be free of temperature labels to avoid interference with the leak test port that will be drilled into the lid for the post-test helium leak test, Figure 4-2.
- The CV body weldment shall be marked with longitudinal lines marking 0°, 90°, 180°, 270°. The text size shall be between 0.5-in to 2-in., Figure 4-2.
- The top side of the top plate of the TU-2 surrogate content shall be marked with radial lines marking 0°, 90°, 180°, 270°, Figure 4-3

- The top side of the top plate of the TU-1 and TU-3 thru TU-6 surrogate content loading test fixture weldment shall be marked with radial lines marking 0°, 90°, 180°, 270°, Figure 4-4.

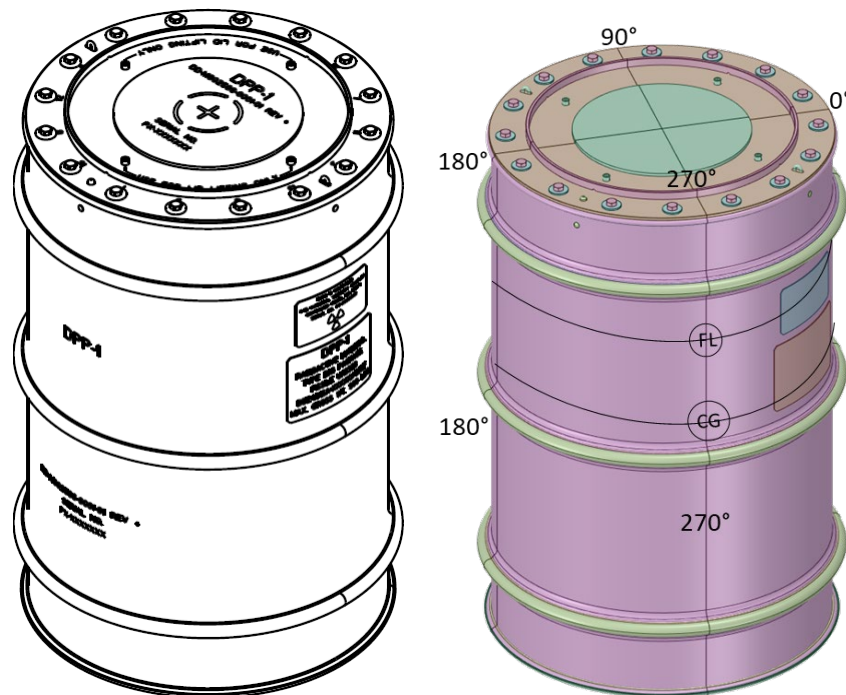
**Table 4-2 TU center of gravity.**

CG location measured from bottom of drum	Test Unit						
	1	2	3	4	5	6	7
Center of gravity	22.4 in	23.2 in	22.8 in	22.4 in	22.8 in	22.4 in	n/a

When initially assembled for testing, the 0° marking on the CVs, and 0° marking on the test weight contents, will be aligned with the 0° marking on the drum. The assembly process will be documented in the assembly test form and pictures will be taken during each step. It should be noted that some shifting of the CVs may occur, so there is no assurance this alignment will remain after initiation of testing.

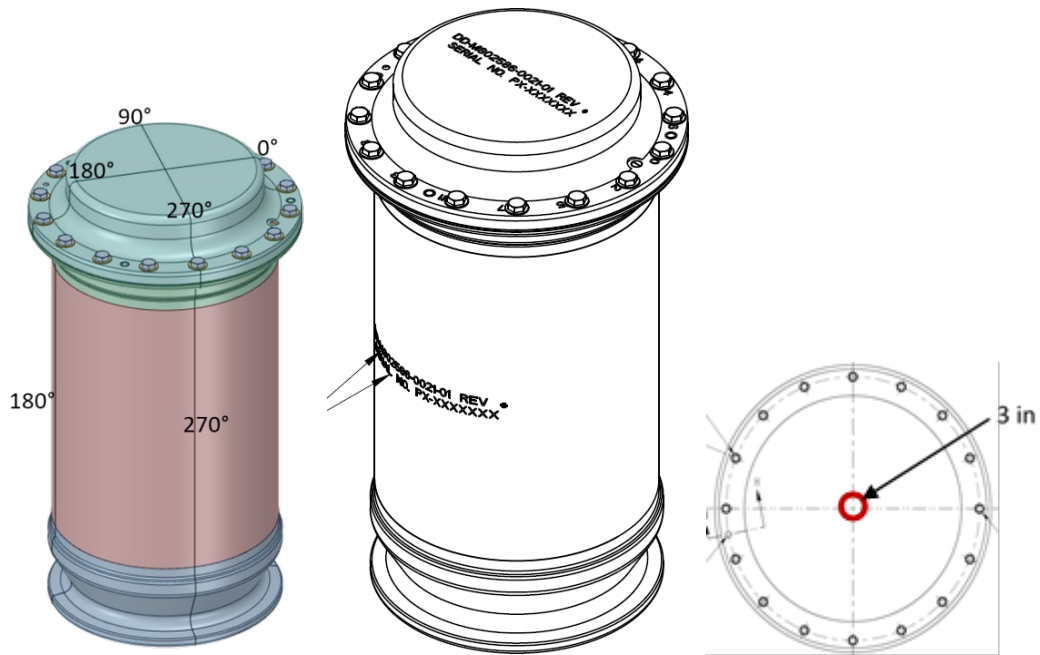
#### 4.1.2 Test Unit Weighing

After the units have been marked, the test unit components shall be weighed in accordance with TEST FORM 1 . Temperature indicating labels shall be attached as shown in Section 5.1.1 on components prior to CV assembly. Accelerometers shall be attached as shown in Section 5.1.4. After the test units have been instrumented, the various assemblies shall be weighed and recorded on TEST FORM 1 .

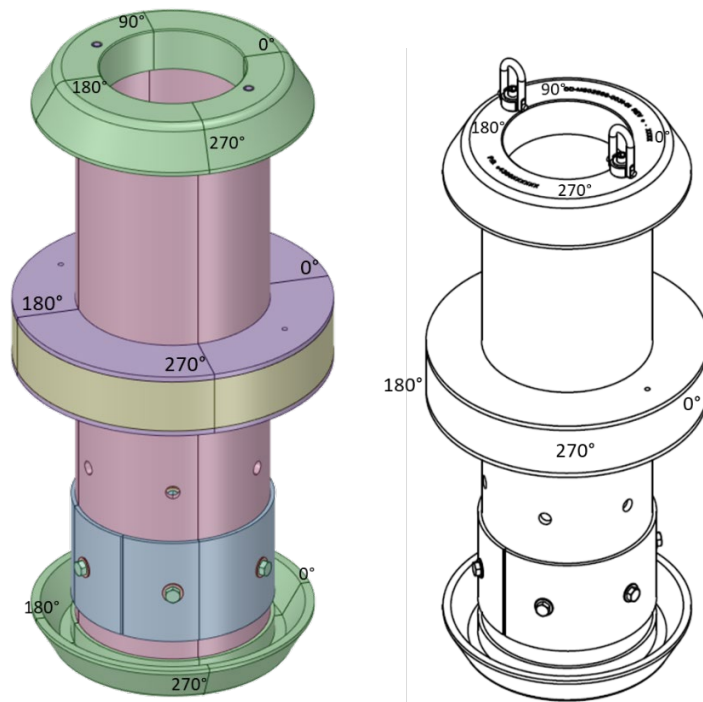


**Figure 4-1 Markings on DPP-1 outer drum body and lid (not to scale).**

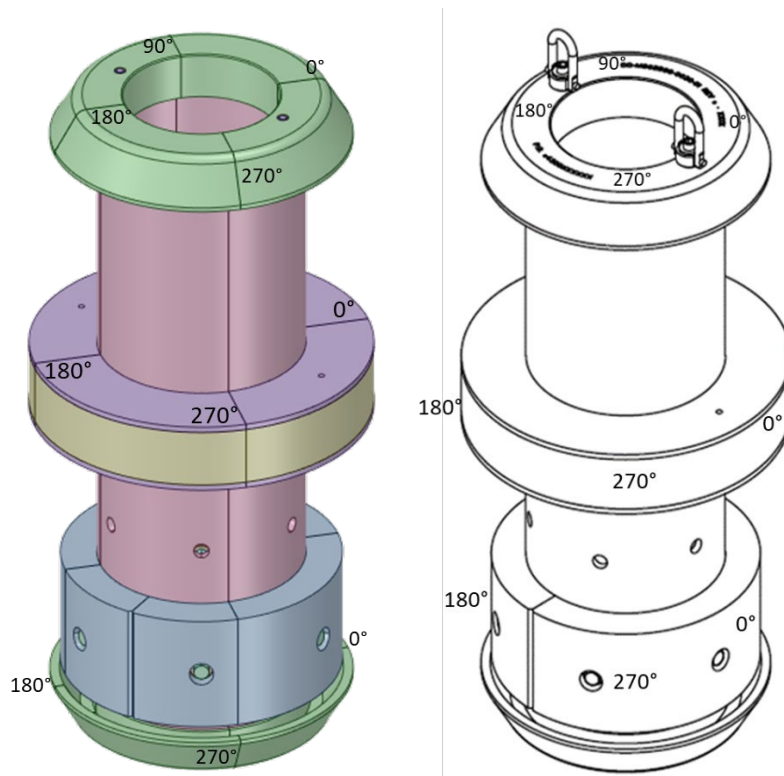




**Figure 4-2 CV body and lid markings.**



**Figure 4-3 Markings on TUs test fixture weldment with light weight.**



**Figure 4-4 Markings on TUs test fixture weldment with heavy weight.**

#### **4.1.3 Pre-Test Operational Leak Testing**

As sequentially designated in Table 3-1, operational leak tests will be performed on all CV assemblies before the initiation of testing and after the CVs have been fully assembled. These leak tests will be performed using the gas pressure rise leakage rate test and done in accordance with Section 7.6 of ANSI N14.5-2014 using the “A.5.2 gas pressure rise” method described in Table A-1 of ANSI N14.5-2014. The leak test will be to a reference leakage rate of  $\leq 1 \times 10^{-3}$  ref cc/sec to ensure the O-ring is operating as intended. If the leak rate is not met, the CV will be disassembled, the mating surfaces cleaned, inspected, reassembled, and retested.

#### **4.2 Initial Testing Conditions**

Unless otherwise noted in this test plan, the initial condition of the packages will be the ambient environmental conditions on the day of the test at the test location. TU-1 and TU-5 will be chilled prior to NCT and HAC testing. All test units subject to the thermal test shall be exposed to a 150°F climate-controlled environment for 24 hours, after which the environment temperature will be lowered to 110°F for a minimum of 24 hours. This pretreatment will be done prior to placing the units in the furnace.

##### **4.2.1 Test Temperatures Prior to Structural and Thermal Testing**

TU-1 and TU-5 are to be thermally conditioned to a uniform temperature preceding the NCT free drop tests. TU-1 and TU-5 shall be conditioned to -70°F for 24 hours, and then to -45°F for a minimum of 48 hours and until removed for testing. Prior to thermal testing, TU-1 thru TU-6 shall be subjected to a 150°F climate-controlled environment temperature

for 24 hours, after which the environment temperature shall be lowered to 110°F for a minimum of 24 hours.

Prior to the initiation of structural testing of TU-1 and TU-5, the units will be removed from the environmental chamber and placed in an insulated box or wrapped with insulating material. Once transported to the NTRC, sequential structural testing, as indicated above in Table 3-1, will be performed as quickly as possible. Between tests, every effort will be made to keep the package as cool as possible. All the free drop tests of TU-1 and TU-5 will be done within 3 hours. See TEST FORM 4 package chilling.

TU-1 thru TU-6 will be thermally conditioned at the thermal furnace contractor's site. A preheat chamber will be used to thermally precondition the units. The dimensions of the preheat chamber shall be large enough to preheat all 6 test units at the same time. The preheat chamber shall be heated with a gas or electrical heater which will supply the heat necessary to maintain the required temperature. The temperature will be controlled by an internal thermostat which will turn the heat source on and off as needed to maintain the temperature of the air in the preheat within the acceptable range. The temperature will be monitored with the calibrated PTP Thermal Data Acquisition system. Three thermocouples will be placed in the preheat chamber and a temperature will be recorded every 15 secs. A time versus temperature time history plot will be recorded during the preheat process. When test units are ready for thermal testing, they will be extracted from the pre-heat chamber, instrumented with the prescribed number of thermocouples, and inserted into the furnace.

#### **4.3 Normal Conditions of Transport (NCT) Tests**

The NCT tests stated in 10 CFR 71.71 specifies the testing and acceptance criteria to demonstrate adequate performance after exposure to *Normal Conditions of Transport*. The tests described in this section are to demonstrate compliance with the NCT requirements and will be performed in the sequence identified in Table 3-1. TU-1 through TU-6 will be subjected to the 4 ft (1.2 m) free fall NCT test and the full HAC test series. Only TU-6 will be subjected to the NCT vibration test, the NCT water spray test, penetration test, and compression test. Ambient TUs (TU-2, TU-3, TU-4, and TU-6) will be subjected to the water spray test.

##### **4.3.1 Vibration Test**

The DPP-1 package (TU-6) will be exposed to the NCT vibration test. The vibration controller will be programmed to run a random vibration test using a power density spectrum simulating the SST/SGT transportation system (SAND83-0480) and per Section 5.4.1. MIL-STD-810G method 514.6 Procedure 1, will be used as guidance for conducting the test through the vibration spectrum (Figure 5-9) and will be specific to the SST/SGT transport system rather than the general transportation spectrums specified by the MIL-STD-810G. The test duration will be four hours per the 10 CFR 71.71 requirement. The method to be utilized is referenced in Section 5.3.1.

##### **4.3.2 Water Spray Test**

The water spray test simulates at least 5 cm/hr (2-in/hr) of rainfall and is applied to impact all exposed surfaces. The spray will be performed between 1.5 and 2.5 hours prior to



any subsequent NCT testing and will be applied for at least 1 hour, as required in the 10 CFR 71.71(c)(6) requirement. This test will be performed on ambient units TU-2, TU-3, TU-4, and TU-6. The procedure to be utilized is referenced in Section 5.3.2.

#### **4.3.3 Free Drop Test**

The NCT free drop test is the drop of a package from 4 ft (1.2 m) onto an essentially unyielding horizontal surface in the orientation expected to produce the most damage. This test will be performed at the NTRC inside drop pad or the outside drop pad (Section 4.5). The impact location for each test unit will be as indicated in Table 3-1 and as described in Section 5.3.3. This test will be performed on TU-1 through TU-6. TU-1 and TU-5 will be tested as quickly as possible following removal from the environmental chamber described in Section 4.2 to ensure all NCT and HAC tests are completed within 3 hours.

#### **4.3.4 Compression Test**

TU-6 will be placed in the center of the compression tester platen in the upright position. The CFR requires a minimum axial compression force of 5 times the 900 lb. maximum gross weight of the test unit ( $4,500 \pm 25$  lbs.) applied uniformly to the top and bottom of the test unit for at least 24 hours. The procedure to be utilized is referenced in Section 5.3.4.

#### **4.3.5 Penetration Test**

The test unit will be impacted, as described in Section 5.3.5, with the hemispherical end of a vertical steel cylinder of 3.2 cm (1.25 in.) diameter and weighing 13 pounds when dropped from a height of at least 1 m (40 in). This test will be performed on TU-6. The impact target symbol shall be located 8.75 in from the top edge of the drum lid along the weld seam aligned with the CV flange.

### **4.4 Hypothetical Accident Conditions (HAC)**

After the NCT tests have been performed, the tests described in this section are to ensure compliance with requirements of 10 CFR 71.73, *Hypothetical Accident Conditions* (HAC) tests and will be performed in the sequence identified in Table 3-1. TU-1 through TU-6 will be subjected to the HAC tests: 9 m (30 ft) drop, 9 m (30 ft) crush test, puncture, thermal, and 3 ft immersion test. TU-7 containment vessel with no surrogate payload will be subjected to the 50 ft immersion test.

#### **4.4.1 Free Drop Test**

Test Units TU-1 through TU-6 will be subjected to the HAC free drop test from 9 m (30 ft) on to a flat, essentially unyielding, horizontal surface striking the surface in a position for which maximum damage is expected. Section 5.4.1 identifies the drop orientation for each test unit that is subjected to this test. The HAC drop test for TU-1 and TU-5 will be completed within 3 hours after removal from the environmental chamber.

#### **4.4.2 Crush Test**

Test Units TU-1 through TU-6 will be subjected to the HAC crush test. A crush plate will be dropped from 9 m (30 ft) on to the TUs placed on a flat, essentially unyielding, horizontal surface. The drop height must be from the highest point on the TU placed

according to the orientations specified in Section 5.4.2. The crush test for TU-1 and TU-5 will be completed within 3 hours after removal from the environmental chamber.

#### **4.4.3 Puncture Test**

TU-1 through TU-6 will each be subjected to a single puncture test. The test units subjected to the puncture test will be dropped 1 m (40 in) onto the upper end of a solid, vertically projected puncture bar (see Section 4.5) which is mounted on an essentially unyielding, horizontal surface. The impact location as well as drop angle for each test unit is described in Section 5.4.2. All puncture tests will be performed with the puncture bar mounted on either the inside drop pad or the outside drop pad. The puncture test for TU-1 and TU-5 will be completed within 3 hours after removal from the environmental chamber.

#### **4.4.4 Thermal Test**

TU-1 through TU-6 will be subjected to the thermal test. Thermal testing will be performed in accordance with 10 CFR 71.73(c)(4) using methods described in ASTM E2230-13 entitled *Standard Practice for Thermal Qualification of Type B Packages for Radioactive Material*. This method also complies with SG 140.1. Thermal testing of designated units will require preheating of the units so that the temperature throughout the test units exceeds 43.3°C (110°F) prior to testing. This will be accomplished by preheating the TUs at 150°F for 24 hours and then 110°F for an additional 24 hours and until the TU is removed for furnace testing. The test units will then be thermally tested according to Section 4.2 and Section 7.3 *Furnace Testing* of ASTM E2230-13. Specifically, the steady-state methodology described in Paragraph 7.3.4.3 of ASTM E2230-13 will be used.

#### **References:**

*Standard Practice for Thermal Qualification of Type B Packages for Radioactive Material*, ASTM E2230-13, ASTM International, West Conshohocken, PA, 2003.

*Combination Test/Analysis Method Used to Demonstrate Compliance to DOE Type B Packaging Thermal Test Requirements (30 Minute Fire Test)*, SG 140.1, United States Department of Energy, Albuquerque Field Office, Nuclear Explosive Division, Albuquerque, NM, February 10, 1992.

#### **4.4.5 Post-Test Operational Leak Testing**

As sequentially designated in Table 3-1, operational leak tests will be performed on the CV assemblies of TU-1 through TU-6 after the completion of structural and thermal testing. These leak tests will be performed in accordance with Sect. 7.6 of ANSI N14.5-2014 using the “A.5.2 gas pressure rise” method described in Table A-1. The sensitivity of the test will be  $\leq 1 \times 10^{-3}$  ref cc/sec with an acceptance value of no detectable leak.

#### **4.4.6 Post-Test Full Containment Boundary Helium Leak Test**

TU-1 through TU-6 will undergo a full containment boundary He leak test. The He leak test will be done in accordance with Sect. 7.5 ANSI N14.5-2014 using the “A.5.3 gas filled envelope” method described in Table A-1. These leakage rate tests will have a sensitivity of  $\leq 5 \times 10^{-8}$  cc/sec He in accordance with ANSI N14.5-2014 Table 1 – *Containment Boundary Test Requirement* and an acceptance value of  $\leq 2 \times 10^{-7}$  cc/sec He.

#### **4.4.7 Immersion Test 3 ft – Fissile material packages**

The containment vessel of TU-1 through TU-6 will be immersed under a head of water of at least 0.9 m (3 ft) or equivalent pressure, in the horizontal orientation for an 8-hour period. The leak test port plug (between the O-rings) shall be removed for this test. Following the test, the CV shall be placed in an upright orientation to prevent any water retained in the CV from leaking out. The exterior of the CV shall be dried following the procedure in TEST FORM 12 to ensure that no external water will leak inside of the CV during the opening process. The CV shall be opened within 2 hours of removal from the immersion environment. The presence of water inside the CV shall be determined by visual inspection of the internal surfaces of the CV, including the O-ring grooves, after the CV lid has been removed. After removal from the tank, the fitting in the lid of the CV shall be vented prior to loosening the closure bolts.

#### **4.4.8 Immersion Test 50 ft – TU-7**

The undamaged CV from TU-7 will be completely immersed in water under a head of pressure equivalent to at least 50 ft of water, in the horizontal orientation for an 8-hour period. Alternatively, if a 50 ft tank cannot be used, the containment vessel shall be subjected to an external pressure of water at 21.7 psig (150 kPag). The pressure head shall be measured with a pressure gage from the uppermost point of the CV when in it is in the vertical orientation. The CV shall be empty for this test and the leak test port plug will be removed from the CV prior to testing. After removal from the tank, the fitting in the lid of the CV shall be vented prior to loosening the closure bolts.

Following the test, the CV shall be placed in an upright orientation to prevent any water retained in the CV from leaking out. The exterior of the CV shall be dried to ensure that no external water will contaminate the inside of the CV during the opening process. The CV will be dried following the procedure in TEST FORM 12. The CV shall be opened within 2 hours of removal from the immersion environment. The presence of water inside the CV shall be determined by visual inspection of the internal surfaces of the CV, including the O-ring grooves, after the CV lid has been removed.

### **4.5 Measurement and Testing Equipment**

Prior to use, ORNL will recalibrate all equipment and ensure all calibration dates are current. Calibration data for all M&TE used in the testing process will be provided to CNS for review. CNS will review and inspect the calibration dates and calibration dates for all M&TE prior to use.

**Drop Pad** - The two drop pads that will be used for these tests are documented in *Design and of Targets for Drop Testing at the NTRC Package Research Facility Rev. 0*, May 2003, ORNL/NTRC-001. The document addresses dimensions, surface description, construction details, and the suitability of each drop pad as a flat, essentially unyielding surfaces for impact (target) pads. The inside drop pad has a steel impact surface and mass in excess of 15 tons and it is rated for packages weighing less than 3,000 lbs. The outside drop pad has a



steel impact surface and mass in excess of 140 tons and it is rated for packages weighing less than 30,000 lbs.

**Crush Test Plate** - On 7/18/2018 the dynamic crush weight was weighed on the scale described below. The weight was 504 kg (1,112 lbs.) which includes the weight of the hoist rings. The dimensions of the plate were measured using a commercial tape measure and were 1 m × 1 m (40 in × 40 in).

**Puncture Bar** - The Puncture bars that will be used in the HAC Puncture Test will be attached to the inside drop pad or the outside drop pad using four 1-in Grade 8 steel bolts with a minimum torque of 200 ft/lbs. each. One of two steel Puncture bars 15-cm (6-in) in diameter with an impact end edge radius of 6 mm (0.25 in) will be used (ORNL property numbers A000882 and A000883). The dimensions (diameter and impacting edge radius) were measured by ORNL metrology using equipment traceable to NIST.

**Platform Scales**— Two scales may be used to measure all weights required by this Test Plan. A Mettler XP32001LDR Serial Number 1129350702 (ORNL ID A000593) will be used for weight measurements up to 10 lbs. This scale has an accuracy of ±100 mg up to 6.400 kg and ±1 g up to 32.100 kg. The scale has been calibrated by the ORNL Metrology.

An Intercomp model number CW250 serial number 23192515 (ORNL ID X-502322) with a 2,000 lbs. (1,000 kg) capacity measured in 1 lb. (0.5 kg) increments will be used for weight measurements between 10 and 2000 lbs. The accuracy of the scale is ±1 division (e.g. 1 lb. or 0.5 kg). The scale has been calibrated by ORNL Metrology.

**Levels** - All angles of packages or rigging will be measured using Smart Level identification number 311-024-501 (ORNL ID M212347) or Smart Level identification number 311-006-501 (ORNL ID M212348). Both levels have been calibrated to ±0.1° by the ORNL Metrology Department.

**30 ft Plumb Bob** - The 9m (30 ft) measurement wire that will be used to establish the height of objects to be dropped, test units or the dynamic crush weight. Its length is to be verified just before the tests, with a commercial NIST calibrated 40-ft tape measure. The tape measure property number is A006327.

**1-m Aluminum Rod** – The 1-m aluminum rod that will be used to verify the minimum height of test units to be subjected to the Puncture test. The rod has an ORNL property number of A001146. The length of this aluminum rod has been verified, using calibration standards traceable to NIST, by the ORNL Metrology Laboratory to have a length of greater than 1 m. The rod was calibrated at room temperature.

**1.2-m Aluminum Rod** – The 1.2-m aluminum rod that will be used to verify the minimum height of test units to be subjected to the NCT free drop test. The rod has an ORNL property number of A000885. The length of this rod will be verified by ORNL metrology, using standards traceable to NIST, prior to use in this testing program. The rod was calibrated at room temperature.

**Torque Wrenches** - The torque wrenches that are used in the assembly and disassembly process are regularly calibrated. Table 4-3 below gives general information regarding each of the wrenches. Typically, click-stop type wrenches are used for assembly and gauge type are used for disassembly.

**Table 4-3 Torque wrench information**

Manufacturer and Model Number	Serial Number	ORNL ID number	Usable Torque Range	Type
Craftsman 44593	4020727674	M212114	25 – 250 in-lb <sub>f</sub>	Click stop
Armstrong 5-75	5051189664	A000199	15 – 75 ft-lb <sub>f</sub>	Click stop
Husky 39103	4010282626	M212113	10-100 ft-lb <sub>f</sub>	Click stop
Snap-On TECH2R100	0810601588	A001096	5-100 ft-lb <sub>f</sub>	Gauge
Proto Model 604C	DFG46092	A0002000	40 – 200 in-lbf	Click stop
Snap-On Model ATECH3FR250B	0519106058	A009107	1 – 250 in-lbf	Digital
Armstrong Model 64-405	0602606796	M212111	0 – 250 ft-lbf	Click stop

**Rigging** - All standard rigging used will have a current inspection.

**Leak Test Equipment** - Helium leak test and pressure change test equipment will be provided by the ORNL Level III leak test and ORNL F&O personnel. CNS will review the calibration information of all leak testing equipment prior to performing the leak tests.

**Environmental Chamber** - The environmental chamber used to chill test units is manufactured by Tenney Chamber Model 27STR, Serial No. 12533. The chamber has a temperature range from -60 ° to +160 °C. The chamber controller is manufactured by Vaisala, model HMT335, S/N: L3450145 (ORNL ID X185666. The refrigeration chamber's calibration will be verified, documented, and approved by CNS before use.

**Preheat Chamber** - The preheat chamber is heated by gas or electric heater controlled by an internal thermostat. The internal temperature is also monitored and logged by the Thermocouple Data Acquisition System.

**Thermocouple Data Acquisition System** - The data acquisition system consists of a personal computer, a bank of A/D converters for thermocouples, calibrated thermocouples, and controller software. The thermocouples are calibrated type K, 0.062-in. diameter, stainless sleeve, 50 ft long. This system has been assembled, programmed, and calibrated by ORNL Instrumentation and Controls Group. Prior to use the system's calibration is checked and adjusted as necessary by ORNL Metrology. The status of all equipment used will be up to date when used. If necessary, the equipment will undergo additional calibration to ensure it is qualified and working properly before the time of use. Prior to use CNS will review and approve the system. ORNL ID M303131.

**Temperature Indicating Labels** – The temperature indicating labels are Omega Temperature Indicating Strips. All the labels have peel off adhesive on the back and are simply stuck in the appropriate position and then typically covered with transparent high

temperature Teflon tape. The temperature indicating labels will either include a Certificate of Compliance from the manufacturer or a functional test data sheet from ORNL. The following temperature indicating labels will be used: TL-10-105, TL-10-190, and TL-10-290

**Furnace** – A heat treating furnace with an internal surface area of at least 10 times the package surface area and capable of sustaining a temperature of 1600°F will be used. Thermal testing will be performed at a suitable facility that meets the ASTM E2230-13 requirements. The furnace will be instrumented with no fewer than 18 thermocouples.

**Penetration Bar** – A steel bar 3.2 cm (1.25 in) OD. x 0.625 radius with a hemispherical end and a mass of 6 kg (13.0 lbs.) is used. The mass of the penetration bar will be verified using a calibrated scale prior to testing. The bar has an ORNL property number of A000884.

**Compression Tester** – The compression tester is a Lansmont Model 152-30K (S/N 15239/1999) capable of up to 30,000 lbs. compressive force. The compression tester has a force accuracy of  $\pm 0.1\%$  of force set point. The system is calibrated annually (or as needed) by the manufacturer. The status of all equipment used will be up to date when used. CNS will inspect, verify, and document the calibration status of the Compression tester before use.

**Vibration Table** – The vibration table is a Lansmont Model 10000-10 (S/N 10795658). It is capable of random vibration of 3200 lbs. from 10–200 Hz flat spectrum and sinusoidal vibration of up to 7800 lbs. with a maximum stroke of 2.5 in. The large table is 60 in.  $\times$  60 in., the small table is 34 in.  $\times$  34 in. The system is calibrated annually (or as needed) by the manufacturer. CNS will inspect, verify, and document the calibration status of the vibration table before use.

**Water Spray Test System** – The water spray test system is a 4-nozzle system constructed of PVC pipe or water hose. The nozzles are arranged to spray the top and all vertical surfaces of a package simultaneously. The system simulates a rainfall of greater than 5 cm/h (2 in./hour). An off the shelf (non-calibrated) rain gauge is used to measure simulated rainfall amount.

**Caliper** – A Mitutoyo America digital caliper will be used to measure the posttest package dimensions. The caliper model number is CD-18''C and the ORNL ID number is A001319. The calipers have a resolution of 0.0005 in.

**Tape Measure** – A Stanley 40-foot tape measure will be used to measure and verify the length of the plumb bob and package dimensions. The tape measure model number is 33-740 and the ORNL ID number is A006327. The tape measure has a resolution of 1/32 in. The calibration due date is 3/20/2023.

**Accelerometer Instrumentation** - The vibration and drop test instrumentation consists of triaxial accelerometer, personal computer, umbilical wire, and a data acquisition unit for the accelerometers. See Appendix B for the installation and operating manuals and the specification sheets for the accelerometers used to monitor vibration. The calibration status of all equipment used will be up to date when used.



## 4.6 Lifting and Handling of the DPP-1 Package

### 4.6.1 Lifting

During package preparation operations and testing activities, the DPP-1 packaging components will be manipulated during lifting and handling operations. The packages will be lifted in accordance with instructions and guidance listed in Appendix D: Handling, Assembly, and Disassembly Instructions for Test Units (RP-802586-0005 000 00). During testing a lifting ring fixture will be used to lift and orient the packages in accordance with the test plan. The lifting fixture is composed of A36 rolled steel with a thickness of 0.375 inches and a width of 3.5 inches, Figure 4-5. Two different lift ring designs will be used for package testing, one for vertical orientations and another for angled orientations. A bracket with multiple hole locations will be used to lift the package and obtain the specified orientations. The lift ring bolts will be tightened to compress the ring around the drum outer surface and lock it in place. The DPP-1 will be lifted in a horizontal orientation with two nylon slings attached to the package in a test fixture weldment choker rigging style and the lifting ring will be used for other orientations, Figure 4-6.



Figure 4-5 DPP-1 lift ring.

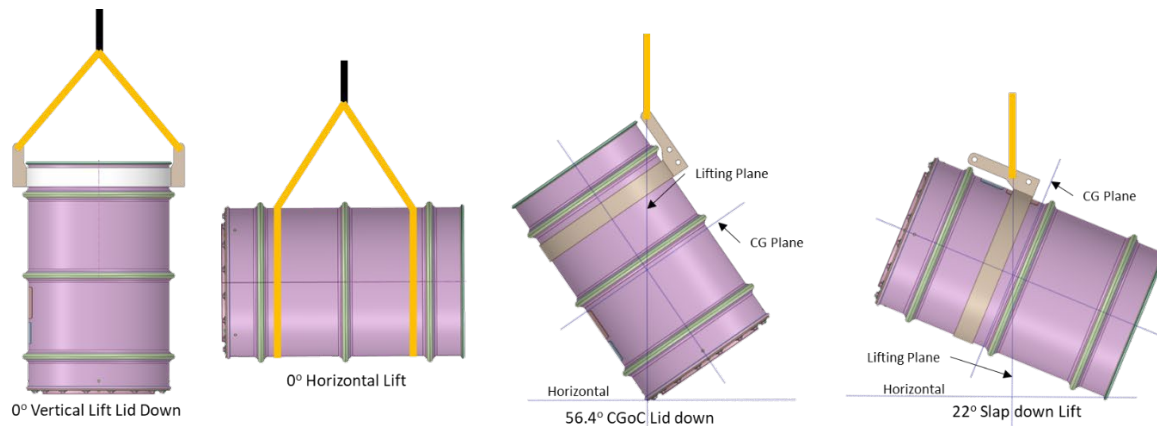


Figure 4-6 DPP-1 lift orientations with lifting ring.

#### 4.6.2 Handling

Handling refers to the lateral movement of the package and may support less than 50% of the total weight. The following guidelines will be used for handling (and lifting) the DPP-1 package during package preparation, testing, and posttest disassembly operations. Further instructions for lifting and handling operations can be found in Appendix D.

- The dual handle lifting ring will be used for normal (drum lid up) lifting and handling of the drum assembly, **with or without the CV assembly, packing materials, and surrogate content.**
- The single handle lift ring will be used for handling and inverting the drum assembly **without the CV assembly.** The weight of the drum assembly must be partially carried by another support near the top of the drum body.
- The dual handle lifting ring will be used for lifting and handling the drum assembly while inverted **without the CV assembly.**
- The threaded lifting features on the drum lid will be used for lifting the drum lid only.
- The threaded lifting features on the CV lid will be used for lifting and handling the CV lid alone and the CV assembly, **with or without the packing materials and surrogate content.**
- Slings will be used around the girth of the drum assembly during lifting and handling operations, **with or without the CV assembly, packing materials, and surrogate content.**
- The drum bolt guard will not be used for a single point lift but will be used with a girth strap.
- The closure holes on the CV lid will not be used for lifting.
- Drum lid closure holes will not be used for lifting.

#### 4.7 Changes to the Test Plan or Procedures

If there is a need to deviate from the approved test plan the PTP testing director shall request approval from the Y-12 subcontract technical representative (STR) using a test plan change request (TPCR) form. An electronic version of this form will be provided by the STR upon request. The affected approval data documents do not require revision unless specifically noted in the TPCR form. Change requests identified in the TPCR shall be marked as non-intent, URGENT intent, or ROUTINE intent.

Note 1: Any change that affects or changes what was intended is an “intent” change. Any changes that does not is a “non-intent” change. Most “non-intent” changes will be editorial in nature such as correcting errors or including clarifications where there is no intent to change or alter in any way what was intended. Changes that come up during execution of the tests are URGENT changes. Changes that come up during execution of the thermal tests are URGENT changes. Other changes are ROUTINE changes. On URGENT intent changes, the reason for the urgency as well as the concurrences/ approvals obtained by the STR must be included on the TPCR forms.

Note 2: “Non-intent” changes will be dispositioned by the STR, with no other approval from CNS required. URGENT intent changes will be dispositioned by the STR after other CNS signees on the test plan have given their concurrence (in person, by

phone, via email, or via another signee.) ROUTINE intent changes will be authorized by the STR after other CNS signees on the test plan have signed the TPCR form. PTP shall address URGENT and ROUTINE intent changes in the test report with the applicable test unit preparation or testing activity and shall refer to the applicable TPCR forms as authorized to deviate from the test plan.

Note 3: The TPCR process is used on anomalies to engage the proper stakeholders, document the situation, and document the disposition of path forward.

Note 4: If results from a test unit preparation activity or a testing activity are not as expected, the PTP staff will immediately stop work on that activity and notify the STR in person (phone or email). PTP shall address each situation in the test report and refer to the subject TPCR as authorization to proceed. The unexpected result will be described in the “reason for change” section of the form. The resolution or path forward will be described by CNS in the “required change” section of the form.

#### **4.8 Test Data and TPCR Forms**

All appropriate TPCR, test forms, procedure checklists and data sheets will be filled out during or immediately following each task or test. Test forms are used for test procedures that are unique to this test plan and are not covered by PTP procedures. Blank copies of the test forms are presented in Appendix A of this plan. Procedure checklists and data sheets are taken directly from PTP Procedures. Each test unit will have its own set of completed test forms, procedure checklists and data sheets. If the information requested on the form is not required, then "N/A" will be filled in the blank. The completed and signed test forms, procedure checklists and data sheets will be included in the master file of the *Test Report for DPP-I Regulatory Compliance Testing*.

A log and file of all approved TPCR forms will be kept and made available upon request to CNS during testing activities. All TPCR forms will be included in the Appendix of addendum of the test report.

A test journal to document daily test activities will be maintained by the PTP staff. At a minimum the journal will include who participated in the testing activity, what was done, when it was done, how it was done, etc.

#### **4.9 Photographs and Videotaping**

Digital photographs, videotaping, and/or filming will be taken of the arrangement of pretest conditions test process and the resulting damage to the test package for each phase of testing as necessary to document the tests.

PTP provided photography equipment and services

Cameras used for photographs shall be 16+ megapixel digital color cameras or better  
Video Cameras shall be at least 1920 x 1080 at 1000 frames per second.



The digital camera will be set to appropriate image quality and compression values in order to record images that retain sufficient detail of the items of interest in each image. Videotape will be taken of all NCT and HAC activities. Unless otherwise specified, all picture will be provided in \*.jpeg format and the video footage will be provided in \*.wmv or \*.mpg formats.

High-speed digital video will be taken of all HAC 9-m (30-ft) drop, HAC crush test, HAC Puncture drops for TU-1 through TU-6, and all NCT free drops. The high-speed video will be recorded against a white backdrop with a 6-in contrasting grid. The resolution and frames per second of the video will be adjusted depending on the environmental ambient light conditions. Two color high-speed cameras will be placed orthogonal of each other to simultaneously record the tests. In addition to manual measurement of TUs' dimensions before and after structural test, a 3D laser scanner measurement acquisition technology will also be deployed to supplement the manual method, these 3D acquired measurements are only for technology demonstration.

#### **4.10 Other Documentation**

A test report titled *Test Report of the DPP-1 Regulatory Compliance Testing* will document the test results as soon as possible following completion of testing. This test report will document the test activities based upon the supporting testing documentation, which includes tested packages, photographs, videotapes, computer data files, drawings, etc. Finally, the proper testing authority will sign the test report.

#### **4.11 Disposition of Tested Units**

After the testing is complete, the test units will be returned to Y-12 for disposition.

#### **4.12 Witness and Hold Points**

The witness and hold points shall be established to allow the design authority (DA) to observe and inspect elements critical to the success of the project. Witness point: an activity that shall not occur without the presence of a DA representative, the activity may proceed without official release from a DA representative. Hold point: an activity that shall not be allowed to proceed until released from hold by a DA representative.

### **5.0 Test Procedures**

The following test procedures will be used for the testing of the DPP-1 shipping package.

#### **5.1 Assembly Procedure**

Before assembly begins, the test units will be visually inspected to ensure that all required components are present, and no damage is observed. As needed, clean and remove all grease from all parts that are to be marked and labeled. Record the weights for the package's components on Test Form 1. The assembly of the test units will be documented on Test Form 3. Photograph each component of the package and package assembly step to document that the package has been properly assembled. Record the weight of the package's assemblies on TEST FORM 1.

As shown in Figure 4-1 and detailed in Section 4.1.1, all TUs overpack will be marked as specified in the SOW 802586-0007 000 00 by the testing authority (TA). The TA will confirm that the provided markings are sufficient for any tracking, data acquisition, or

reporting of test results. If markings are determined to be insufficient, the TA will make additional markings following consultation from Y-12. The CV will also be marked. The drums, lids, CVs, test weights, load test fixtures shall be marked with indelible ink in the following manner:

- Drum Lid
  - Radial markings 0°, 90°, 180°, 270° on the top side of the drum lid. The lid markings shall be in line with the drum markings.
- Drum Body
  - Longitudinal markings 0°, 90°, 180°, 270° marked CCW from the top. The 0° marking shall be in line with the drum seam weld.
  - Circular markings around the drum at the CG marking. For CG location of each TU see Table 4-2.
  - Circular markings around the drum at the FL. The FL marking shall be 8.75" from the top of the drum.
  - For TU-6, the puncture target shall be marked on the Drum Seam at 0° and 8.75" from the top of the drum.
- CV Lid
  - Radial markings 0°, 90°, 180°, 270° on the top side of the CV lid. The 0° line shall pass through CV bolt hole #2 next to the leak test port and markings shall be marked CCW from the top.
  - A 3 in diameter circle on the bottom side of the lid. This will indicate the area that must be free of temperature labels.
- CV Body Weldment
  - Longitudinal markings 0°, 90°, 180°, 270°. In line with markings on the lid.
- TU Test Weight
  - Radial markings 0°, 90°, 180°, 270° on the top side of the top plate
- TU Loading Test fixture weldment
  - Radial markings 0°, 90°, 180°, 270° on the top side of the top plate and CCW from the top.

### **5.1.1 Temperature Indicating Labels**

Temperature indicating labels that have been approved by Y12, will be used on the interior of the package to capture the highest reached temperature at that location. Install temperature indicating labels TL-10-105 and TL-10-190 together on CV bodies and CV bases for TU-1 through TU-6, as shown in Figure 5-1 and Figure 5-2, respectively. The location of the temperature indication labels on the CV are listed as follows:

- Exterior of CV – 20 label sets total of both per CV, TL-10-105 and TL-10-190 (Figure 5-1 & Figure 5-2)
- 4 label sets placed circumferentially, 90° apart on the CV body flange.
- 4 label sets placed circumferentially, 90° apart at the base neck of the CV.
- 4 label sets placed circumferentially, 90° apart, at the lid center.
- 4 label sets placed circumferentially, 90° apart, at the lid flange.
- 4 labels placed circumferentially, 90° apart, at the CV base toe.

Interior of the CV – 28 label sets of both, TL-10-105 and TL-10-190 (Figure 5-1& Figure 5-2)

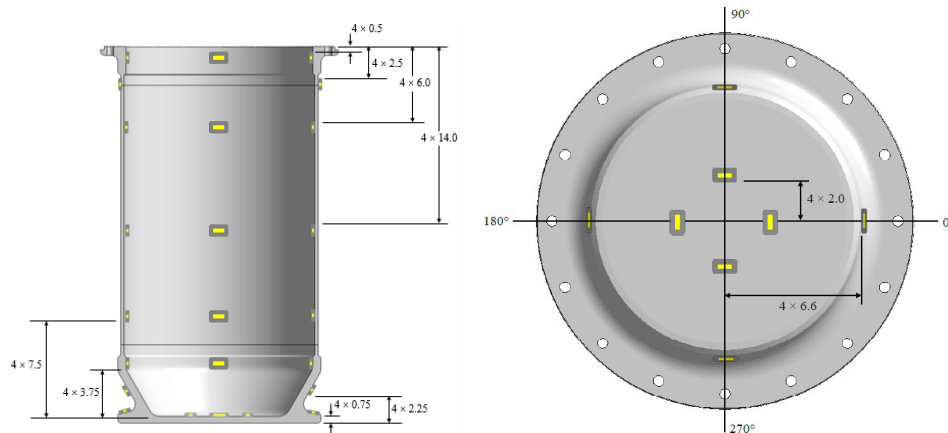
- 4 label sets placed circumferentially, 90° apart, at the CV lid center.
- 4 label sets placed circumferentially, 90° apart, at the body flange.
- 4 label sets placed circumferentially, 90° apart, at the wall upper.
- 4 label sets placed circumferentially, 90° apart, at the wall middle.
- 4 label sets placed circumferentially, 90° apart, at the wall lower.
- 4 label sets placed circumferentially, 90° apart, at the base neck.
- 4 label sets placed circumferentially, 90° apart, at the base center.

Interior of the Drum Body – 24 label sets total of both, TL-10-190 and TL-10-290 (Figure 5-3)

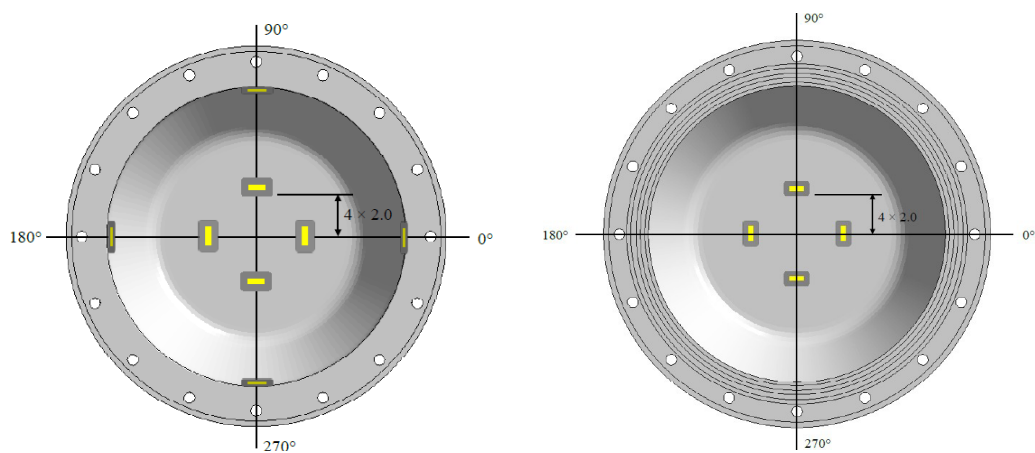
- 4 label sets placed circumferentially, 90° apart, at drum lid bottom.
- 4 label sets placed circumferentially, 90° apart, at the cavity wall upper.
- 4 label sets placed circumferentially, 90° apart, at the cavity wall middle.
- 4 label sets placed circumferentially, 90° apart, at the cavity wall lower.
- 4 label sets placed circumferentially, 90° apart, at the cavity wall lowest.
- 4 label sets placed circumferentially, 90° apart, at the cavity bottom.

Temperature indicating label sets on the CV and drum bodies will be covered with high temperature FEP tape (Teflon). During and after assembly, weigh parts as required and record on TEST FORM 1 .

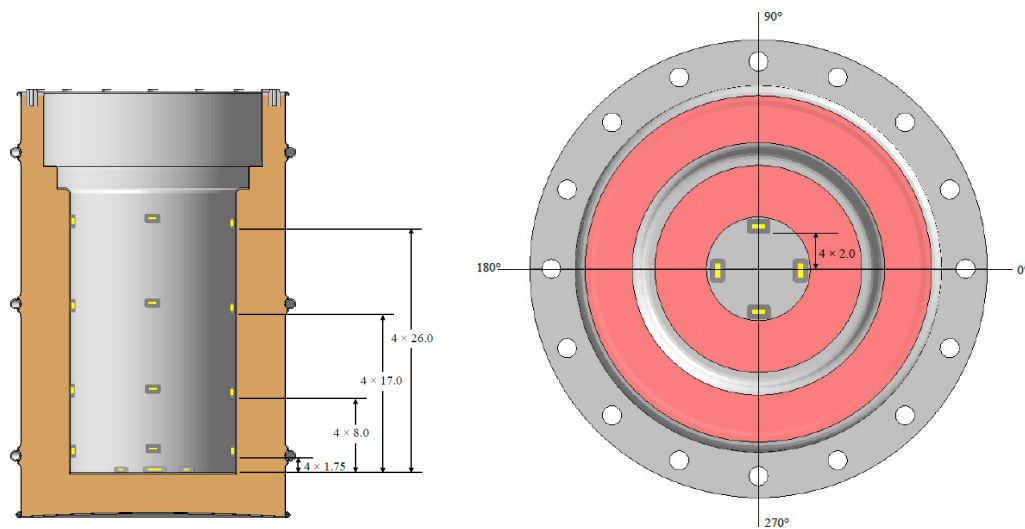




**Figure 5-1 CV body temperature indicating label set locations.**



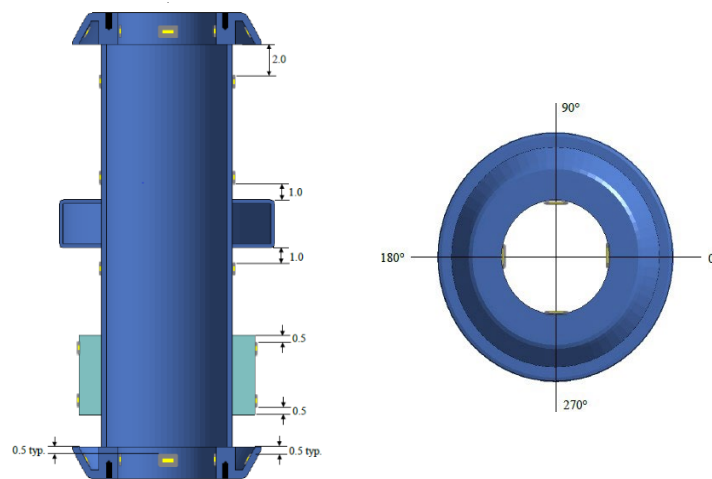
**Figure 5-2 CV interior temperature indicating label set locations.**



**Figure 5-3 Temperature label sets locations on interior of drum.**

Test content assembly's temperature label location – 36 label sets total of both, TL-10-190 and TL-10-290 (Figure 5-4)

- 4 label sets placed circumferentially, 90° apart, at the top end cap center.
- 4 label sets placed circumferentially, 90° apart, at the top end cap under flange.
- 4 label sets placed circumferentially, 90° apart, at the tube upper.
- 4 label sets placed circumferentially, 90° apart, at the tube middle.
- 4 label sets placed circumferentially, 90° apart, at the tube low.
- 4 label sets placed circumferentially, 90° apart, at the bottom end cap under flange.
- 4 label sets placed circumferentially, 90° apart, at the bottom end center.
- 4 label sets placed circumferentially, 90° apart, at the weight upper.
- 4 label sets placed circumferentially, 90° apart, at the weight lower.



**Figure 5-4 Temperature label locations for test content assemblies.**

## 5.1.2 Content Assembly

The test fixture weldment content assembly will be installed on TU-1 through TU-6 including the test weight. The following section will detail the assembly of the test fixture weldment content assembly using instructions and guidance listed in Appendix D: Handling, Assembly, and Disassembly Instructions for Test Units (RP-802586-0005 000 00).

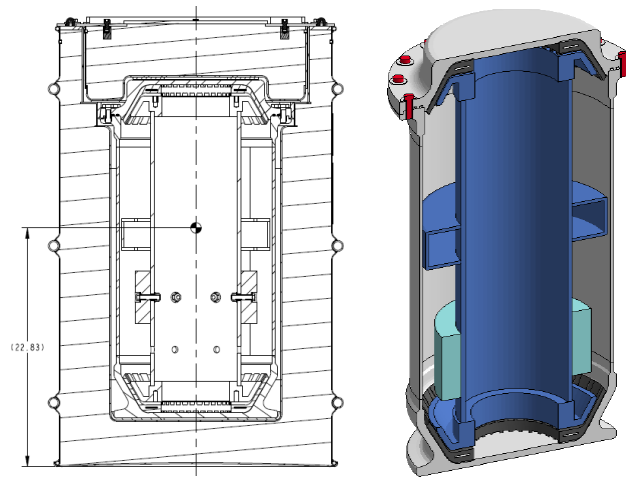
### 5.1.2.1 Test fixture weldment content assembly

The test fixture weldment content assembly and packing materials will be loaded in accordance with the following sequence. All components will be marked with the appropriate TU number before assembly. Additionally, all components will be visually inspected and cleaned before assembly.

1. All items will be visually inspected for any defects and cleaned. If any defects or damage is identified, the TA will stop work and notify the DA.
2. Place the lower CV PCC pad (by LLNL) inside the CV body.
3. Attach test weight (heavy/light) (DD-M802586-0033-02) to the test fixture weldment (DD-M802586-0032-01). 2 halves of each (heavy/light) will be required.

4. Secure the test weight to the test fixture weldment using the provided top hat bushing, flat washer, lock nut and hex head screws.
5. The hex head screws and locknuts shall be torqued to 25+/- 2 ft-lb.
6. Place the test weight content assembly (DD-M802586-0030-01) into the CV body. The test weight content weldment will be lifted by securely fastening adequately rated lifting devices and hardware to the threaded lifting features on the top plate of the test weight weldment.
7. Place the upper CV PCC pad (by LLNL) in the CV body on top of the test weight weldment.

The fully assembled test fixture weldment content assembly is shown in Figure 5-5.



**Figure 5-5 Assembled test fixture weldment content (CG will differ on TUs).**

### 5.1.3 CV Assembly

The DPP-1 CV will be assembled in accordance with the procedure listed below. All CV components will be visually inspected, cleaned, and marked with a TU identification number.

1. Install temperature indicating labels to the inside of the CV as shown in Figure 5-1, Figure 5-2 and per Section 5.1.1.
2. Place the surrogate content and packing materials into the CV body per Section 5.1.2.1 for TU-1 through TU-6.
3. Visually inspect and clean the O-ring inner grooves and sealing surface of the CV body.
4. Visually inspect and clean the inner and outer O-ring seals and apply a light coat of Dow Corning silicone -based high vacuum grease.
5. After cleaning, place the inner and outer O-ring seals onto the CV body.
6. Securely fasten an eye bolt to the three threaded lifting features on the CV lid and place the CV lid onto the CV body.
7. If necessary, apply thread lubricant to the CV closure bolts.
8. Place the CV closure bolts into the CV lid bolt holes and tighten per the following sequence. Record the last pass.
  - a. Hand tighten and snug-up in a circular pattern around the CV lid.



- b. First pass: torque to 19-21 ft-lb following the numbering sequence on the CV lid.
  - c. Second pass: torque to 33-37 ft-lb following numbering sequence on the CV lid.
  - d. Last pass: verify torque of 33-37 ft-lb following numbering sequence on the CV lid.
9. Install temperature indication labels to the exterior surface of the CV as shown in Figure 5-1 and described in Section 5.1.1

Document the assembly of the CV body on Test Form 3. Record the assembled weight on Test Form 1. Record the assembly torque of the CV lid on TEST FORM 11. After the CV has been fully assembled and temperature indicating labels have been installed per Figure 5-1 and Figure 5-2, each CV will receive and pass an operational leak test in accordance with Sect. 7.6 of ANSI 14.5-2014 using “A.5.2 gas pressure rise” method described in Table A.1. See Section 5.2. At the conclusion of the operation leak test, hand tighten the leak test port plug to the CV lid and then torque the port plug to 6 to 7 ft-lbf.

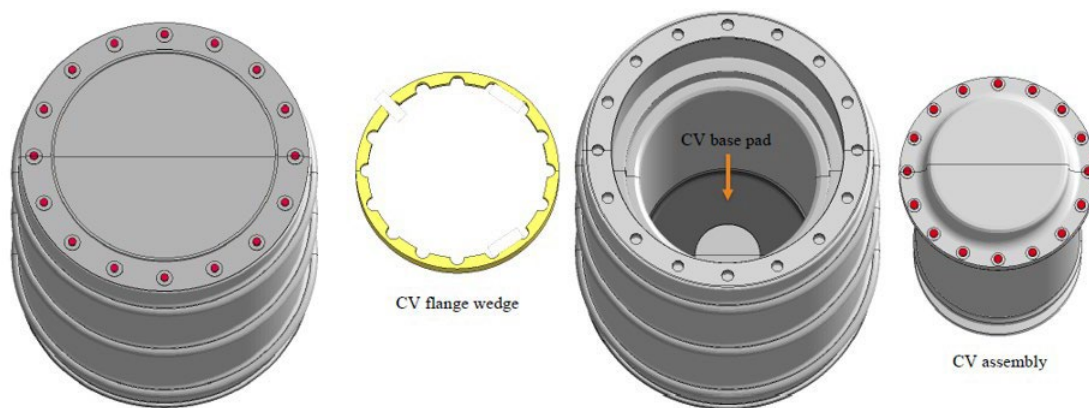
#### **5.1.4 Drum Assembly**

Visually inspect and clean the interior surface of the drum inner body and exterior surface of the CV. Affix the temperature indicating labels to the inner liner of the drum body assembly and to the drum lid weldment of the test units as shown in Figure 5-3. Cover each label with a piece of Teflon™ tape. Figure 5-6 shows some of the assembled components of the TU. The drum body will be assembled in the following sequence.

1. The CV base pad and the CV flange wedge shall be weighed and carefully placed inside the drum bodies, note that the flange wedge cannot be installed before the CV has been loaded into the drum.
2. The CV shall be placed in the drum such that the CV 0° line marking aligns with the 0° marking on the drum.
3. Place the CV flange wedge between the drum liner and the CV flange so that the temperature labels are not damaged.
4. Securely fasten eye bolts to the lifting features on the drum lid and lift the drum lid and place the drum lid on the drum body.
5. Visually inspect all drum lid washers and closure bolts. If necessary, apply thread lubricant (Teflon grease) to the drum closure bolts.
6. Place the drum lid closure bolts into the drum lid bolt holes and tighten per the following sequence.
  - a. Hand tighten the screws
  - b. First pass: screws shall be torqued until the lid is in full contact with the flange following the numbering sequence.
  - c. Second pass: screws shall be torqued to 33-37 ft-lb in following the numbering sequence around the drum lid.
7. Install the accelerometers on TU-1, TU-2, TU-5, and TU-6 according to the following specification:
  - a. On TU-1 and TU-2 install two accelerometers on the intersection of CG circumference and axial lines at 90° and 270°.

- b. On TU-5 install two accelerometers on the intersection of CG circumference and axial lines at 90° and 270°. Install one accelerometer on the drum lid center.
- c. On TU-6 install two accelerometers on the intersection of CG circumference and axial lines at 90° and 270°. Install one accelerometer on the drum lid center. For TU-6, a vibration accelerometer shall be installed on the drum lid center before the vibration test. **NOTE: The accelerometer will be removed before the water spray test if needed and reinstalled upon completion of the water spray test.**

Document the assembly of the drum body on TEST FORM 3. Record the assembled weight of the TU on TEST FORM 1. Record the assembly torque of the drum lid on TEST FORM 10.



**Figure 5-6 Closed test unit (some surrogate contents not shown).**

### **5.1.5 Instrumentation Assembly**

Prior to the vibration test, TU-6 will be instrumented with accelerometers to ensure the testing objectives are met. The test unit vibration response for TU-6 will be captured by an accelerometer vibration sensor. The accelerometer will be installed on the drum lid with a high strength and high temperature epoxy glue and allowed to cure per manufacturer's instructions or other form that is acceptable to CNS. This data sensor shall be removed before the water spray test.

Prior to the NCT free drop and HAC tests, TU-1, TU-2, TU-5, and TU-6 will be instrumented with triaxial accelerometers. A mounting block with a through hole will be spot welded to the exterior surface of the drum. The accelerometers will be bolted on the mounting block. The accelerometer wires will be strained relieved to ensure a successful recording of the drop test. After the accelerometers are installed, they will be checked to ensure that they are working properly. The accelerometers will be installed at locations to help protect the accelerometers and wires on the outside of the drum from secondary roll over damage during all drop tests. Tape may be used for additional protection to firmly affix the accelerometer cabling on the opposite side of the impact area.

After the NCT, HAC, and prior to the thermal test, six thermocouples will be installed on the exterior surface of the drum body and lid of TU-1 through TU-6. Four thermocouples will be located around the mid-section at the 0°, 90°, 180°, and 270° lines, one will be located on the center of the drum bottom, and one located in the center of the lid. Refer to Table 5-1 for placement location of TCs on the exterior drum assembly.

**Table 5-1 Thermocouple attachment locations (TU-1 through TU-6).**

<b>Thermocouple (TC) tip locations outside drum assembly (TU-1 through TU-6)</b>				
<b>External DA (clip)</b>	<b>0°</b>	<b>90°</b>	<b>180°</b>	<b>270°</b>
Drum top surface (clip)	1	-	-	-
Middle rolling hoop (clip)	2	3	4	5
Drum bottom surface (clip)	6	-	-	-

## **5.2 Operational Leak Check Test Procedure**

The O-ring seals of each CV assembly (TU-1 through TU-6, TU-7) will be leak tested before and after testing. TU-7 will not undergo a post test operational leak test. ORNL will ensure leak test devices are calibrated. Perform the leak check in accordance with ANSI N14.5-2014 using the “A.5.2 gas pressure rise” method described in Table A.1. This test will be performed prior to the helium leak test. Each CV will be at room temperature when conducting this test. This test will be performed according to ORNL Facilities and Operations procedure NDE 70 Rev. 7, *General Requirements for Leak Testing* and NDE 70 – PCMT, *Leak Testing – Pressure Change Measurement Test*. TEST FORM 13 and TEST FORM 14 shall be provided for application of this test for each test unit. The test forms will be signed by CNS.

## **5.3 Normal Conditions of Transportation Tests**

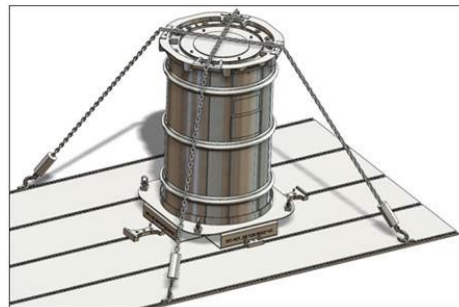
### **5.3.1 Vibration Test**

TU-6 will be subjected to the vibration test in accordance with 10 CFR 71.71(c)(5). Prior to the test, an accelerometer will be placed on the drum lid to record the response of the test unit when subjected to the vibration spectrum. To conduct the vibration test place the test unit on the center of the vibration table. The assembly of TU-6 will be similar to the other TUs. The test unit shall be secured to the test platform using a tie-down method similar to the one shown in Figure 5-7. The actual restraint ring that will be used has been designed specifically by SNL for the DPP-1 container. The restraint ring will be used in conjunction with toes clamps and nylon straps to secure the package to the vibration table (Figure 5-8). Program the vibration controller with the SST/SGT power density spectrum per Table 5-2 and Figure 5-9. The duration of the test will be set for four hours. This test will be performed according to PTP Procedure PTP-PEF-06, Rev. 5 CN-2 dated 12-01-2020 and testing results will be recorded on the procedure checklist and data sheet associated with this procedure.

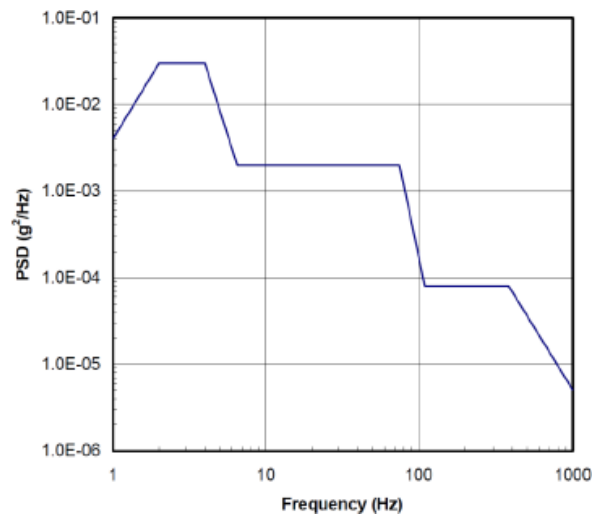




**Figure 5-7 Example of a restrained DPP-3 TU, DPP-1 will use a custom designed ring**



**Figure 5-8 DPP-1 with restraining ring (note: toe plates and vibration table will be different)**



**Figure 5-9 Power spectrum density for the DPP-1 package.**

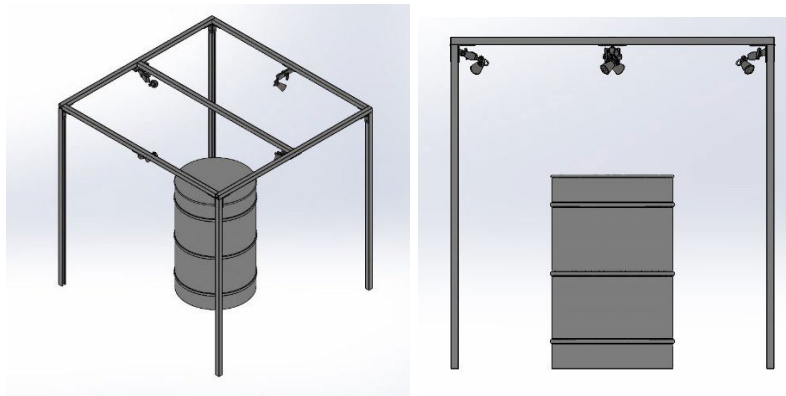
**Table 5-2 Vertical Acceleration Power Spectrum Density for Vibration Test**

Freq (Hz)	G²/Hz
1.0	4.0e-3
2.0	3.0e-2

4.0	3.0e-2
6.5	2.0e-3
75.0	2.0e-3
110.0	8.0e-5
380.0	8.0e-5
1000.0	5.0e-6

### 5.3.2 Water Spray Test

TU-2, TU-3, TU-4, and TU-6 will be subjected to the water spray test, Figure 5-10 in accordance with 10 CFR 71.71(c)(6). The water spray test for these TUs will be performed within 1.5 to 2.5 hours prior to the 4 ft NCT free drop test. The spray will be applied for at least 1 hour and the drum lid and drum body will be fully exposed to the water spray. These tests will be performed according to PTP Procedure PTP-PEF-05, Rev. 5 CN-2 dated 12-14-2020 and testing results will be recorded on the procedure checklist and data sheet associated with this procedure.



**Figure 5-10 Water spray test set up.**

### 5.3.3 NCT 1.2 m (4 ft) Free Drop

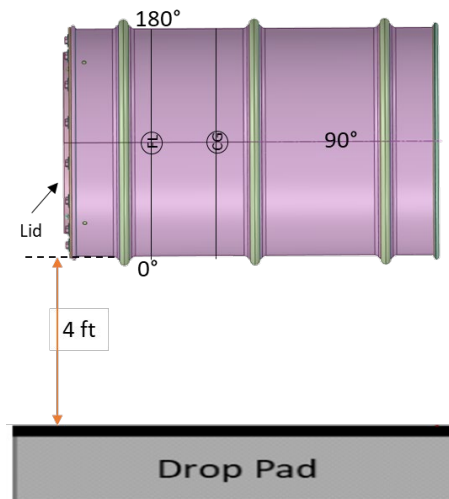
These drop tests will be performed between 1.5 and 2.5 hours after the completion of the water spray test at the NTRC on either the inside drop pad located in Room L-110 or the outside drop pad in accordance with 10 CFR 71.71(c)(7). These tests will be performed according to PTP Procedure PTP-PEF-08, Rev. 5 CN-2 dated 12-10-2020 and testing results will be recorded on the procedure checklist and data sheet associated with this procedure. TU-1 through TU-6 will be subjected to a 4 ft (1.2 m) drop test. The following paragraphs and figures describe and depict the orientation of each of the NCT drop tests.

TUs will be suspended with the orientations as described below:

- TU-1, cold, side drop, 0° line marking down, heavy test weight
- TU-2, ambient, side drop, 0° line marking down, light test weight
- TU-3, ambient, end drop, lid down, heavy test weight

- TU-4, ambient, CG over corner drop (56.4°), lid down, 0° line marking down, heavy test weight
- TU-5, cold, slap down (22°) drop, 0° line marking down, heavy test weight
- TU-6, ambient, slap down (22°) drop, 0° line marking down, heavy test weight

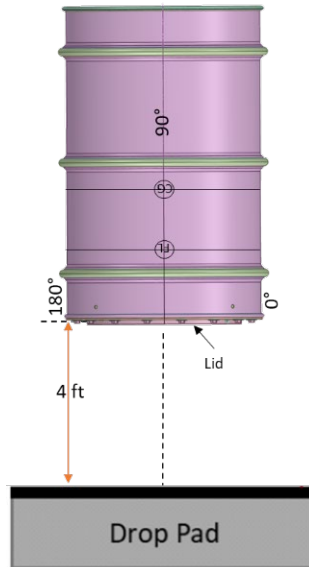
TU-1 and TU-2 will be suspended with the axis of the package horizontal, so that the 0° marking on the package will contact the drop pad first. With the test unit hanging free, measure the angle formed by the axis of the package and horizontal. This angle shall be  $0^\circ \pm 2^\circ$ . When rigged within angle tolerances, raise the test unit until the 4 ft. aluminum rod will just fit between the drop pad and the lowest point on the package. Figure 5-11 shows the orientation and drop dimensions for a sample TU. Since TU-1 and TU-5 will be cold, all tests on these units (4-ft drop, 30-ft drop, 30-ft crush test, and puncture test) will be completed within 3 hours of being removed from the climate-controlled chamber. When the camera crew and test personnel are ready, release the package. Dimensional measurements of damage for TU-1 and TU-5 will be done at the conclusion of the Puncture test.



**Figure 5-11 Orientation for TU-1 and TU-2 NCT 4-ft drop test.**

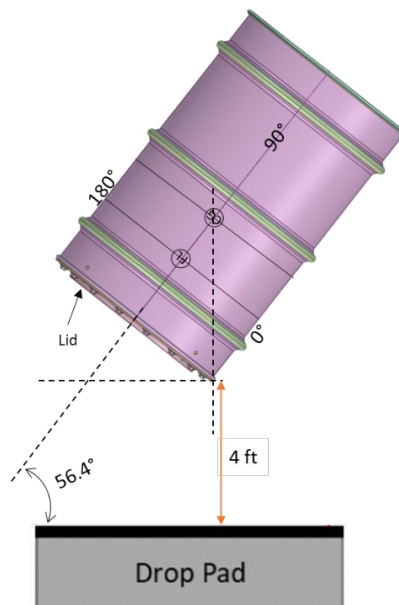
TU-3 will be suspended with the axis of the package vertical, so that the top of the package will contact the drop pad first (Figure 5-12). With the test unit hanging free, measure the angle formed by the axis of the package and horizontal. This angle shall be  $90^\circ \pm 2^\circ$ . When rigged within angle tolerances, raise the test unit until the 4 ft aluminum rod will just fit between the drop pad and the lowest point on the package. When camera crew and test personnel are ready, release the package.





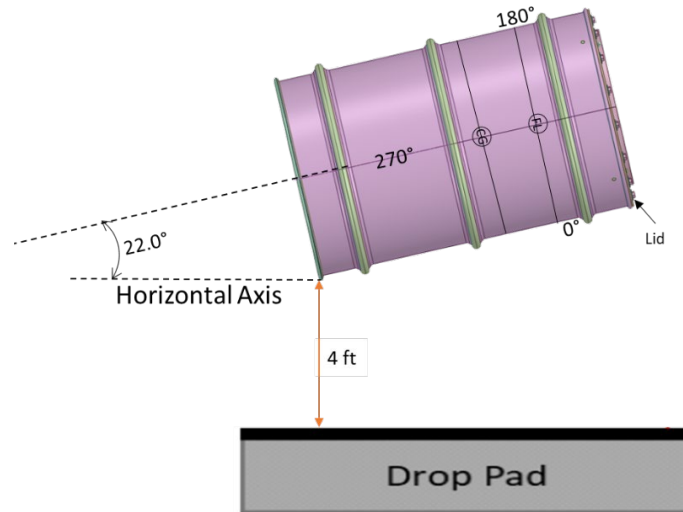
**Figure 5-12 Orientation for TU-3 NCT 4-ft drop test.**

TU-4 will be suspended such that the CG of the package is above the top edge of the package with the top of the package on the 0° line contacting the drop pad first (Figure 5-13). With the test unit hanging free, measure the angle formed by the axis of the package at the 180° line with respect to horizontal. This angle shall be  $56.4^{\circ} \pm 2^{\circ}$ . When rigged within angle tolerances, raise the test unit until the 4 ft aluminum rod will just fit between the drop pad and the lowest point on the package. When camera crew and test personnel are ready, release the package.



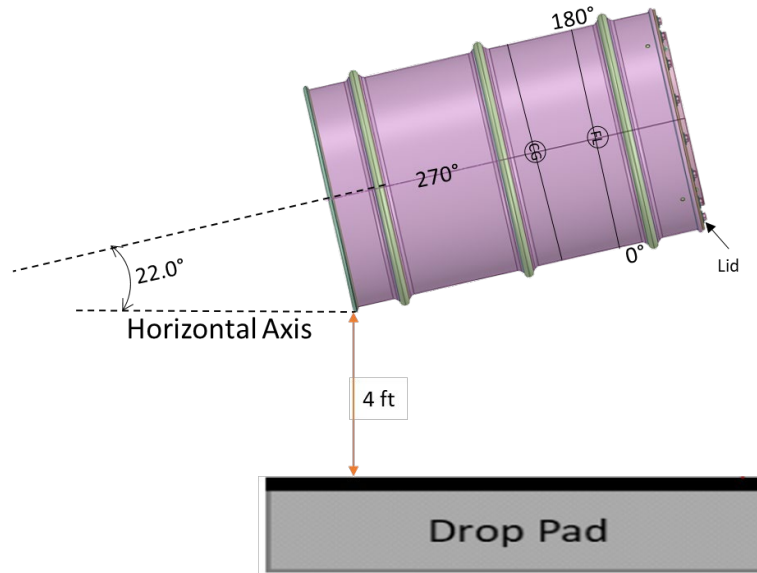
**Figure 5-13 Orientation for TU-4 NCT 4-ft drop test.**

TU-5 (temperature: cold) will be suspended such that the CG of the package is above the bottom edge of the package with the 0° line contacting the drop pad first (Figure 5-14). With the test unit hanging free, measure the angle formed by the axis of the package at the 0° line with respect to horizontal. This angle shall be  $22.0^\circ \pm 2^\circ$ . When rigged within angle tolerances, raise the test unit until the 4 ft aluminum rod will just fit between the drop pad and the lowest point on the package. When camera crew and test personnel are ready, release the package.



**Figure 5-14 Orientation for TU-5 NCT slap down test.**

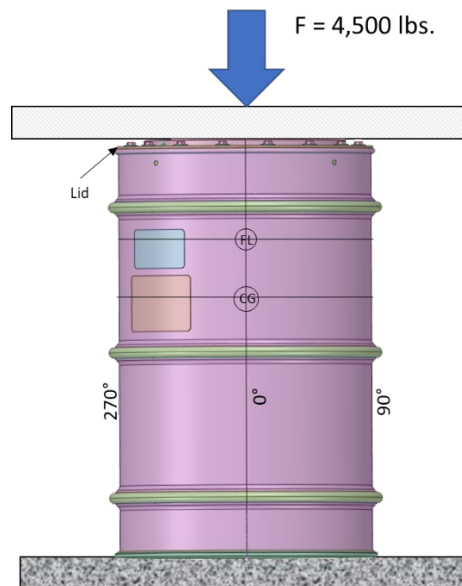
TU-6 (temperature: ambient) will be suspended such that the CG of the package is above the bottom edge of the package with the 0° line contacting the drop pad first (Figure 5-15). With the test unit hanging free, measure the angle formed by the axis of the package at the 0° line with respect to horizontal. This angle shall be  $22.0^\circ \pm 2^\circ$ . When rigged within angle tolerances, raise the test unit until the 4 ft aluminum rod will just fit between the drop pad and the lowest point on the package. When camera crew and test personnel are ready, release the package.



**Figure 5-15 Orientation for TU-6 NCT slap down test.**

#### 5.3.4 Compression Test

Place TU-6 in the center of the compression tester in the upright position (Figure 5-16). Select the heaviest package weight from all the test units. Per 4.3.4, calculate 5 times the mass of the heaviest test unit or  $4,500 \pm 25$  lbs., whichever is greater, and apply the force required to perform this test in accordance with 10 CFR 71.71(c)(9). Program the compression tester to apply the force for a minimum of 24 hours. This test will be performed according to PTP Procedure PTP-PEF-07, Rev. 6 CN-0 dated 02-18-2021 and testing results will be recorded on the procedure checklist and data sheet associated with this procedure.



**Figure 5-16 Compression test for TU-6.**



### 5.3.5 Penetration Test

Place TU-6 on its side on the drop pad with the longitudinal weld seam (FL) line up. Restrain the package as necessary to keep it from moving during the test. The most vulnerable area is considered to be on the drum weld seam near the CV flange. The impact area for this test shall be at the “FL” target where the 0° line marking intersects with the CV flange marking on the drum. This location is about 8.75 in from the top edge of the drum lid. Raise the Penetration Bar, with its longitudinal axis vertical, to at least 1 m (3.3 ft) above the contact point in accordance with 10 CFR 71.71(c)(10). The penetration bar has a diameter of 3.25 cm (1.25 in) and a total mass of 6 kg (13 lbs.). The contact point of the penetration bar will be located at 8.75 in from the top edge of the drum lid along the longitudinal weld seam line. Figure 5-17 shows the penetration test set up. This test will be performed according to PTP Procedure PTP-PEF-09, Rev. 6 CN-0 dated 02-18-2021 and testing results will be recorded on the procedure checklist and data sheet associated with this procedure.

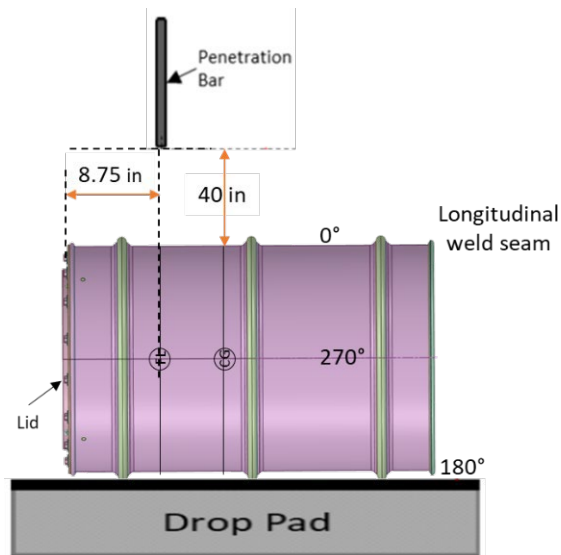


Figure 5-17 Orientation for TU-6 penetration test.

## 5.4 Hypothetical Accident Condition Tests

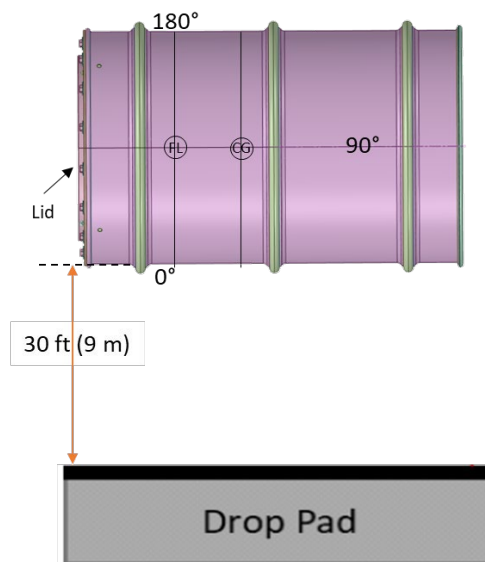
### 5.4.1 HAC 9-m (30-ft) Drop Test

These drop tests will be performed at the NTRC outside drop facility. TU-1 through TU-6 will be subjected to the 9-m (30-ft) drop test in accordance with 10 CFR 71.73(c)(1). The test units will be raised such that the lowest point on the package will be at least 9 m above the drop pad. During all HAC drop testing two color high-speed cameras (as fast as possible for the ambient light conditions, preferably at least 1,000 frames per second) will be located approximately 90° to each other in order to record the drop tests in orthogonal views. Still photographs and videos of the damaged areas of the test units will be taken to sufficiently document its condition following the tests. These tests will be performed according to PTP Procedure PTP-PEF-10, Rev. 6 CN-3 dated 02-18-2021 and testing results will be recorded on the procedure checklist and data sheet associated with this procedure. Before subjecting the packages to the HAC tests record the weight of each TU on TEST FORM 1

TUs will be suspended with the orientations as described below:

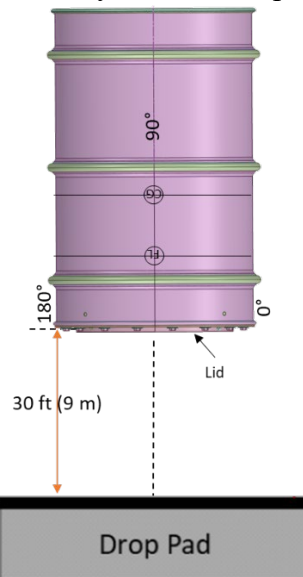
- TU-1, cold, side drop, 0° line marking down, heavy test weight
- TU-2, ambient, side drop, 0° line marking down, light test weight
- TU-3, ambient, end drop, lid down, heavy test weight
- TU-4, ambient, CG over corner drop, lid down, 56.4° from horizontal, heavy test weight
- TU-5, cold, slap down (22°) drop, 0° line marking down, heavy test weight
- TU-6, ambient, slap down (22°) drop, 0° line marking down, heavy test weight

TU-1 and TU-2 will be suspended such that the axis of the package is horizontal and the 0° markings on the package will contact the drop pad first. With the test unit hanging free, measure the angle formed by the axis of the package and horizontal. This angle should be  $0^\circ \pm 2^\circ$ . Figure 5-18 shows the orientation and drop dimensions for a sample TU. Since TU-1 and TU-5 will be cold, all tests on these units (4-ft drop, 30-ft drop, 30-ft crush test, and puncture test) will be completed within 3 hours of being removed from the climate-controlled chamber TU-1 and TU-5 will be prechilled at the ORNL main campus. When rigged within angle tolerances, raise the test unit until the plumb bob on the 9 m wire is just above the drop pad. After the correct height is obtained, remove the plumb bob. When camera crew and test personnel are ready, release the package. Dimensional measurements of damage for TU-1 and TU-5 will be done at the conclusion of the Puncture test.



**Figure 5-18 Orientation for TU-1 and TU-2 HAC 30-ft drop test.**

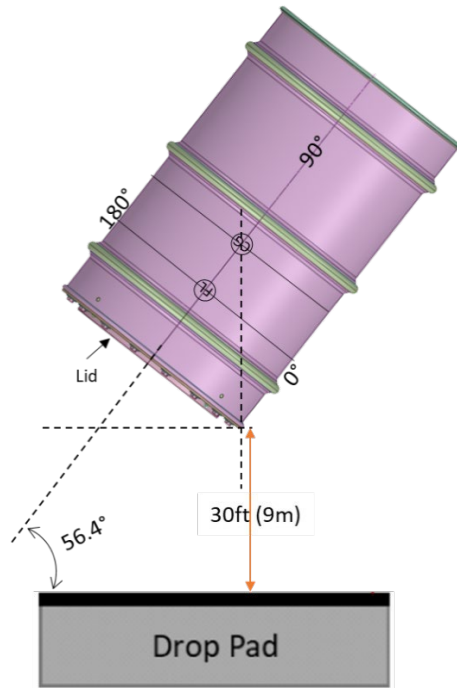
TU-3 will be suspended with the axis of the package vertical, so that the top of the package will contact the drop pad first, Figure 5-19. With the test unit hanging free, measure the angle formed by the axis of the package and horizontal. This angle shall be  $90^\circ \pm 2^\circ$ . When rigged within angle tolerances, raise the test unit until the plumb bob on the 9 m wire



**Figure 5-19 Orientation for TU-3 HAC 30-ft drop test.**

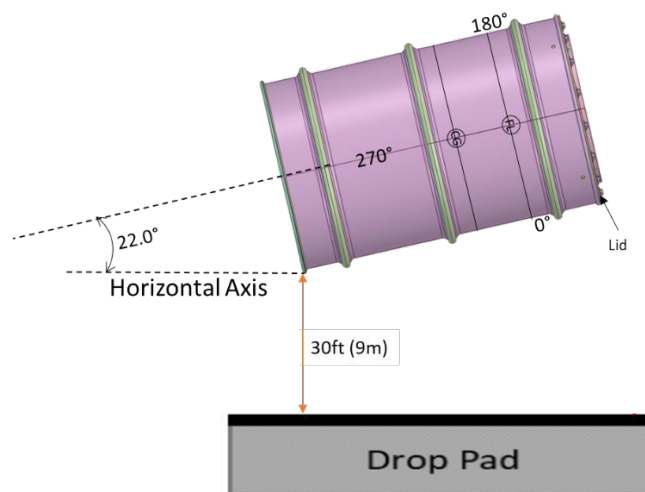
TU-4 will be suspended such that the CG of the package is above the top edge of the package with the top of the package on the 0° line contacting the drop pad first, Figure 5-20. With the test unit hanging free, measure the angle formed by the axis of the package at the 180° line with respect to horizontal. This angle shall be 56.4°±2°. When rigged within angle tolerances, raise the test unit until the plumb bob on the 9 m wire is just above the drop pad. After the correct height is obtained, remove the plum bob. When camera crew and test personnel are ready, release the package.





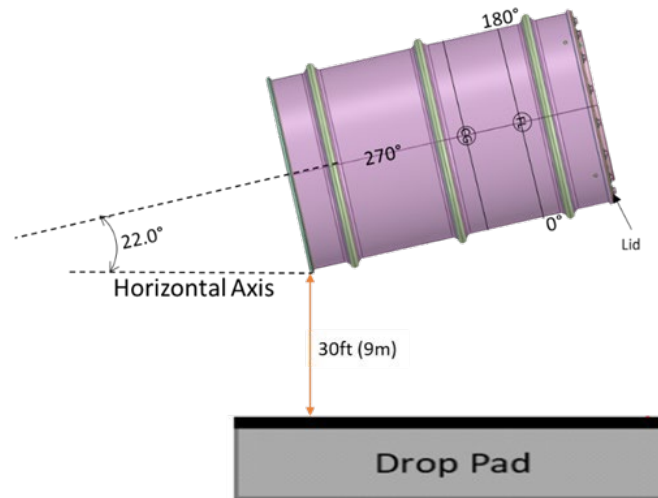
**Figure 5-20 Orientation for TU-4 HAC 30-ft drop test.**

TU-5 (temperature: cold) will be suspended such that the CG of the package is above the bottom edge of the package with the 0° line contacting the drop pad first, Figure 5-21. With the test unit hanging free, measure the angle formed by the axis of the package at the 0° line with respect to horizontal. This angle shall be  $22.0^\circ \pm 2^\circ$ . When rigged within angle tolerances, raise the test unit until the plumb bob on the 9 m wire is just above the drop pad. After the correct height is obtained, remove the plum bob. When camera crew and test personnel are ready, release the package.



**Figure 5-21 Orientation for TU-5 HAC 30-ft drop test.**

TU-6 (temperature: ambient) will be suspended such that the CG of the package is above the bottom edge of the package with the 0° line contacting the drop pad first, Figure 5-22. With the test unit hanging free, measure the angle formed by the axis of the package at the 0° line with respect to horizontal. This angle shall be  $22.0^\circ \pm 2^\circ$ . When rigged within angle tolerances, raise the test unit until the plumb bob on the 9 m wire is just above the drop pad. After the correct height is obtained, remove the plumb bob. When camera crew and test personnel are ready, release the package.



**Figure 5-22 Orientation for TU-6 HAC 30-ft drop test.**

#### 5.4.2 HAC 30-ft Crush Test

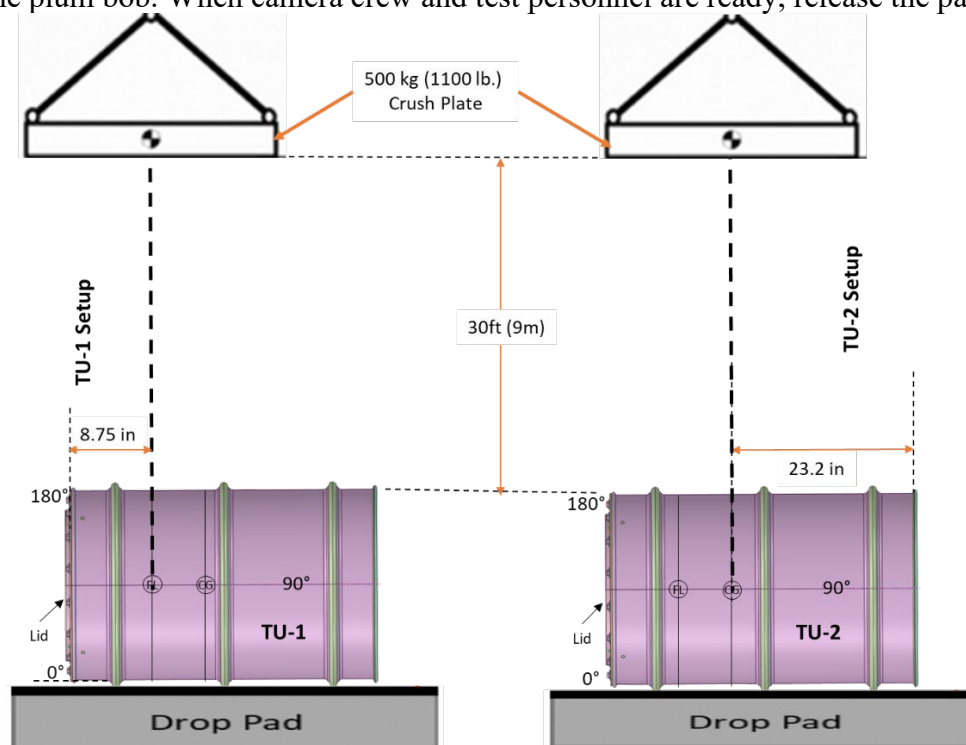
Following the 30-ft drop test, TU-1 through TU-6 shall be subjected to a 30-ft crush test in accordance with 10 CFR 71.73(c)(2). These drop tests will be performed at the NTRC outside drop facility, a crush plate weighing 500 kg (1,100 lb) will be raised such that the lowest point on the crush plate will be at least 9 m above the highest point of the test unit. During all HAC crush testing, two color high-speed cameras (as fast as possible for the ambient light conditions, preferably at least 1,000 frames per second) will be located approximately 90° to each other in order to record the drop tests in orthogonal views. Still photographs and videos of the damaged areas of the test units will be taken to sufficiently document its condition following the tests. These tests will be performed according to PTP Procedure PTP-PEF-11, Rev. 6 CN-3 dated 02-18-2021 and testing results will be recorded on the procedure checklist and data sheet associated with this procedure. Before subjecting the packages to the HAC tests, record the weight of each TU on TEST FORM 1. Since TU-1 and TU-5 will be cold, all tests on these units (4 ft drop, 30 ft drop, 30 ft crush test, and puncture test) will be completed within 3 hours of being removed from the climate-controlled chamber. TU-1 and TU-5 will be preconditioned at the ORNL main campus. Dimensional measurements of damage for TU-1 and TU-5 will be done at the conclusion of the puncture test.

TUs will be suspended with the orientations as described below:

- TU-1, cold, side drop, 0° line facing pad, 180° line facing plate, plate CG over FL

- TU-2, ambient, side drop, 0° line facing pad, 180° line facing plate, plate CG over package CG
- TU-3, ambient, end drop, lid facing down, bottom facing plate, plate CG over package CG
- TU-4, ambient, CG over corner drop, lid down, 0° line facing pad, 180° line facing plate, plate CG over package CG
- TU-5, cold, side drop, 0° line facing pad, 180° line facing plate, plate CG over FL
- TU-6, ambient, side drop, 0° line facing pad, 180° line facing plate, plate CG over FL

Figure 5-23 shows the orientation and crush dimensions for a TU-1 and TU-2. The TU will be placed on the drop pad with the 0° line facing the pad and the 180° line facing the crush plate. For TU-1, the CG of the crush plate will be aligned with the FL of TU-1. For TU-2, the CG of the crush plate will be aligned with the CG of TU-2. The crush plate will be rigged horizontally with the axis of the plate allowed to vary by drop angle  $0^\circ \pm 2^\circ$ . When rigged within angle tolerances, raise the crush plate until the attached plumb bob on the 9 m wire is just above the target location on the test unit. After the correct height is obtained, remove the plumb bob. When camera crew and test personnel are ready, release the package.

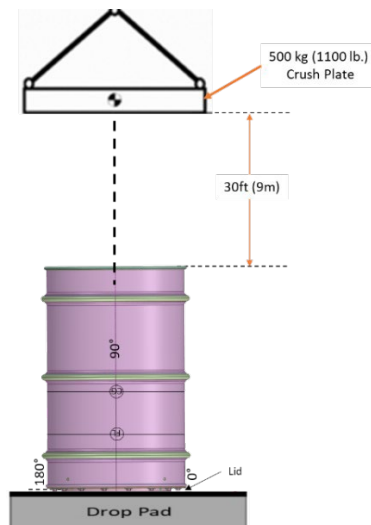


**Figure 5-23 Orientation for TU-1 and TU-2 HAC 30-ft crush test.**

Place TU-3 upright with the lid facing the drop pad and the bottom facing the crush plate, Figure 5-24. Place the TU on the pad such that the angle formed by the axis of the package and horizontal is  $0^\circ \pm 2^\circ$ . Align the crush plate's CG with the TU's CG and rig the plate such that the angle formed by the horizontal axis of the plate is  $0^\circ \pm 2^\circ$ . When rigged within angle tolerances, attach the plumb bob to the crush plate, raise the crush plate until

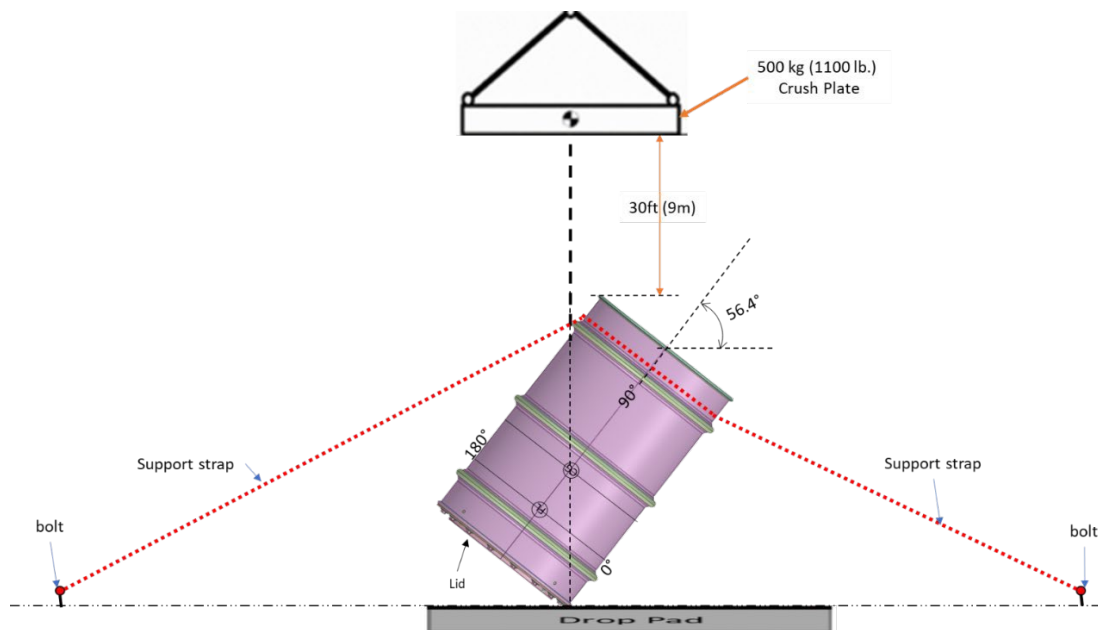


the plumb bob on the 9 m wire is just above the bottom of the test unit and aligned with CG of the drum. After the correct height is obtained, remove the plum bob. When camera crew and test personnel are ready, release the crush plate.



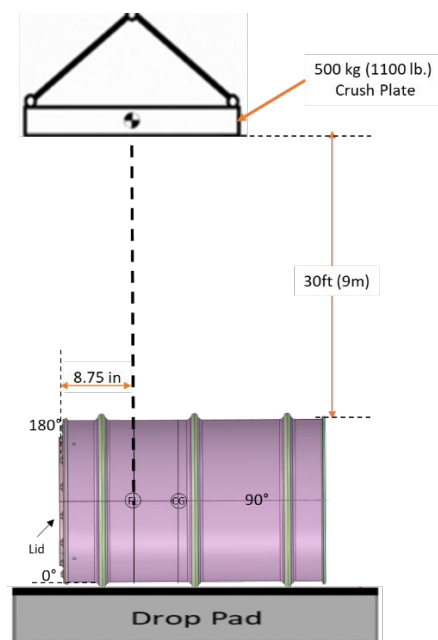
**Figure 5-24 Orientation for TU-3 HAC 30-ft crush test.**

TU-4 will be rigged as shown Figure 5-25, because of the expected damage to the drum edge from the 30 ft drop test, the TU will be supported with two ropes (or appropriate rigging hardware) attached to two appropriately rated rigging hardware, threaded to the drop pad. The TU will be placed on the pad such that the 0° line is facing the pad and the drum lid is facing the pad and the drum bottom is facing the crush plate. The angle formed by the axis of the TU and horizontal is  $56.4^{\circ} \pm 2^{\circ}$ . Align the crush plate with the TU and rig the plate such that the angle formed by the horizontal axis of the plate is  $0^{\circ} \pm 2^{\circ}$ . The CG of the plate must align to the CG of the TU. When rigged within angle tolerances, attach the plumb bob to the crush plate, raise the crush plate until the plumb bob on the 9 m wire is just above the bottom of the test unit and aligned with CG of the drum. After the correct height is obtained, remove the plum bob. When camera crew and test personnel are ready, release the crush plate.



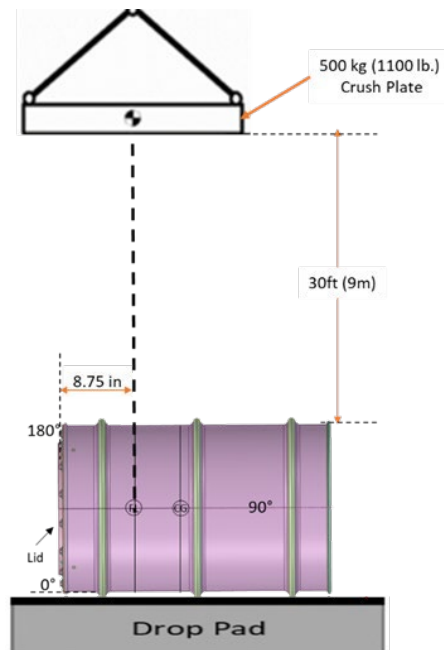
**Figure 5-25 Orientation for TU-4 HAC 30-ft crush test.**

TU-5 (temperature: cold), will be placed on the drop pad with the 0° line facing the pad and the 180° line facing the crush plate. The CG of the crush plate will be aligned with the FL at 180° line, Figure 5-26. Align the crush plate with the TU and rig the plate such that the angle formed by the horizontal axis of the plate is  $0^\circ \pm 2^\circ$  (or allow whatever the resulting angle is, due to damages from previous tests). When rigged within angle tolerances, attach the plumb bob to the crush plate, raise the crush plate until the plumb bob on the 9 m wire is just above the side of the test unit. After the correct height is obtained, remove the plumb bob. When camera crew and test personnel are ready, release the crush plate.



**Figure 5-26 Orientation for TU-5 HAC 30-ft crush test.**

TU-6 (temperature: ambient), will be placed on the drop pad with the 0° line facing the pad and the 180° line facing the crush plate. The CG of the crush plate will be aligned with the FL at 180° line, Figure 5-27. Align the crush plate with the TU and rig the plate such that the angle formed by the horizontal axis of the plate is 0°± 2° (or allow whatever the resulting angle is, due to damages from previous tests). When rigged within angle tolerances, attach the plumb bob to the crush plate, raise the crush plate until the plumb bob on the 9 m wire is just above the side of the test unit. After the correct height is obtained, remove the plum bob. When camera crew and test personnel are ready, release the crush plate.



**Figure 5-27 Orientation for TU-6 HAC 30-ft crush test.**

#### **5.4.3 HAC 1 m (40 in) Puncture Test**

Following the 9 m (30 ft) crush test, the puncture drop test will be performed at the NTRC inside drop pad or the outside drop pad in accordance with 10 CFR 71.73(c)(3). TU-1 through TU-6 will be subjected to the 1 m (40 in) Puncture test. The Puncture bar has a diameter of 15-cm (6 in) with a rounded edge of 6 mm (0.25 in) and length not less than 20 cm (8 in). The test units will be raised to a height where the lowest point of the test unit will be at least 1 m (40 in) above the steel punch bar. The 1-m aluminum rod will be used to measure the distance from the package to the punch. These tests will be performed according to PTP Procedure PTP-PEF-12, Rev. 5 CN-2 dated 12-14-2020 and testing results will be recorded on the procedure checklist and data sheet associated with this procedure.

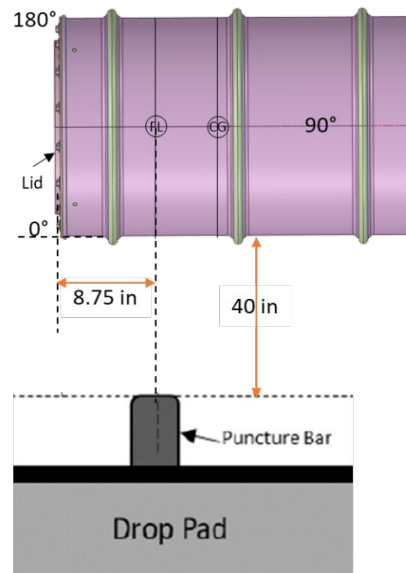
The following paragraphs and figures describe and depict the orientation of each of the NCT puncture tests.

TUs will be suspended with the orientations as described below:



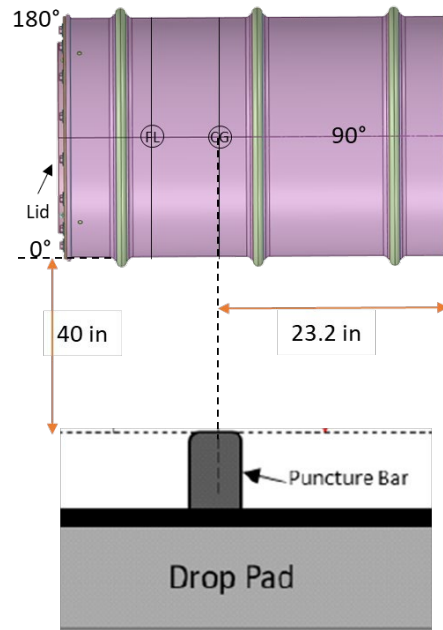
- TU-1, cold, side drop, 0° line facing punch, FL over punch
- TU-2, ambient, side drop, 0° line facing punch, CG over punch
- TU-3, ambient, end drop, lid facing punch, bottom facing up, CG over punch
- TU-4, ambient, CG over corner drop, lid down, 0° line facing punch, CG over punch
- TU-5, cold, side drop, 0° line facing punch, FL over punch
- TU-6, ambient, side drop, 0° line facing punch, CG over punch

TU-1 will be dropped in a horizontal orientation. TU-1's point of contact will be located at 8.75 in from the top edge of the drum lid along the 0° line marking to coincide with the FL point on the drum. Rig the test unit to be lifted with the axis of the package horizontal, and the 0° line facing the punch. With the test unit hanging free, measure the angle formed by the axis of the package and horizontal. This angle should be  $0^\circ \pm 2^\circ$ . When rigged within angle tolerances, raise the test unit until the 1 m (40 in) rod will just fit between the top of the punch and the lowest point on the package. Figure 5-28 shows the orientation and drop dimensions for the Puncture test of TU-1. Since TU-1 will be cold, all drop tests for TU-1 (4 ft, 30ft drop, 30 ft crush, and puncture test) will be completed in less than three (3) hours after the test unit is removed from the environmental chamber.



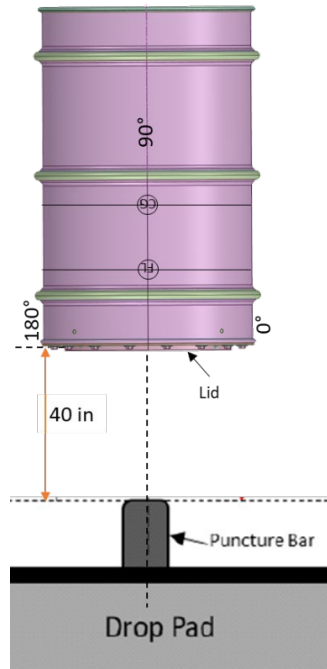
**Figure 5-28 Orientation for TU-1 HAC 1-m puncture test.**

TU-2 will be dropped in a horizontal orientation and the point of contact located at CG of the drum. Rig the test unit to be lifted with the axis of the package horizontal, and the 0° line facing the punch. With the test unit hanging free, measure the angle formed by the axis of the package and horizontal. This angle should be  $0^\circ \pm 2^\circ$ . When rigged within angle tolerances, raise the test unit until the 1 m (40 in) rod will just fit between the top of the punch and the lowest point on the package. Figure 5-29 shows the orientation and drop dimensions for the Puncture test of TU-2.



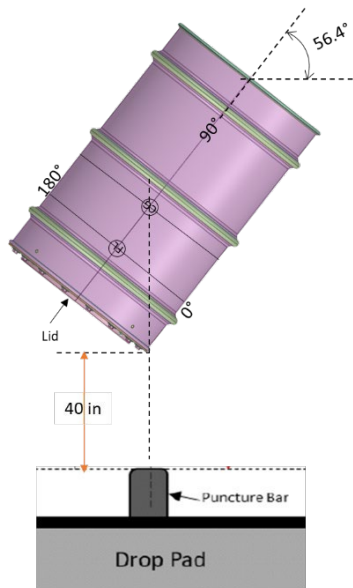
**Figure 5-29 Orientation for TU-2 HAC 1-m puncture test.**

TU-3 will be dropped in a vertical orientation with the CG of the package over the center of the Puncture bar and the top of the package facing the puncture bar. With the test unit hanging free, measure the angle formed by the axis of the package and horizontal. This angle should be  $90^\circ \pm 2^\circ$ . When rigged within angle tolerances, raise the test unit until the 1-m (40 in) rod will just fit between the top of the punch and the lowest point on the package. Figure 5-30 shows the orientation and drop dimensions for the Puncture test of TU-3.



**Figure 5-30 Orientation for TU-3 HAC 1-m puncture test.**

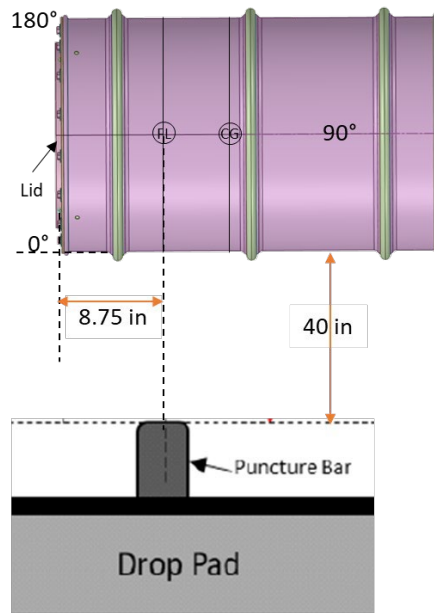
TU-4 will be dropped in a vertical orientation with the CG of the package over the center of the puncture bar and the top of the package facing the Puncture bar. With the test unit hanging free, measure the angle formed by the axis of the package and horizontal. This angle should be  $56.4^{\circ} \pm 2^{\circ}$ . When rigged within angle tolerances, raise the test unit until the 1 m (40 in) rod will just fit between the top of the punch and the lowest point on the package. Figure 5-31 shows the orientation and drop dimensions for the Puncture test of TU-4.



**Figure 5-31 Orientation for TU-4 HAC 1-m puncture test.**

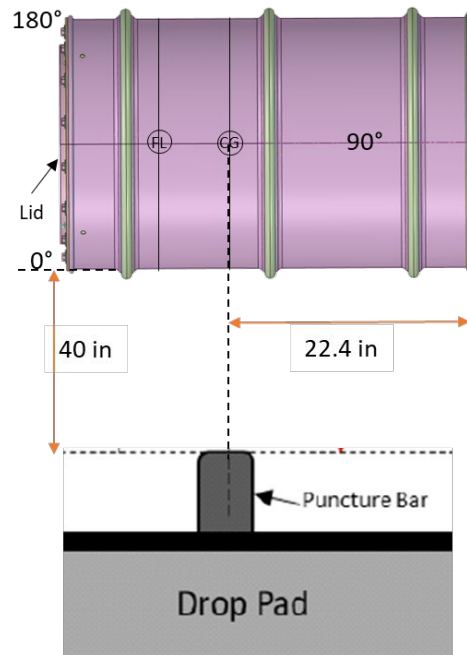


TU-5 will be suspended such that 0° line will contact the Puncture bar first. With the test unit hanging free, measure the angle formed by the axis of the package at the 180° line with respect to horizontal. This angle shall be  $0^\circ \pm 2^\circ$ . Align the FL (weld seam at CV flange) along the 0° line with the axis of the punch. When rigged within angle tolerances, raise the test unit until the 1 m (40 in) rod will just fit between the FL (weld seam at CV flange) point and the top of the punch. Figure 5-32 shows the orientation and the dimensions for the Puncture test of TU-5. When camera crew and test personnel are ready, release the package. Since TU-5 will be cold, all drop tests for TU-5 (4 ft, 30ft drop, 30 ft crush, and puncture test) will be completed in less than three (3) hours after the test unit is removed from the environmental chamber.



**Figure 5-32 Orientation for TU-5 HAC 1-m puncture test.**

TU-6 will be suspended such that the 0° line will contact the Puncture bar first. With the test unit hanging free, measure the angle formed by the axis of the package at the 180° line with respect to horizontal. This angle shall be  $0^\circ \pm 2^\circ$ . Align the CG along the 0° line with the axis of the punch. When rigged within angle tolerances, raise the test unit until the 1 m (40 in) rod will just fit between the CG and the top of the punch. Figure 5-33 shows the orientation and drop dimensions for the puncture test of TU-6. When camera crew and test personnel are ready, release the package.



**Figure 5-33 Orientation for TU-6 HAC 1-m puncture test.**

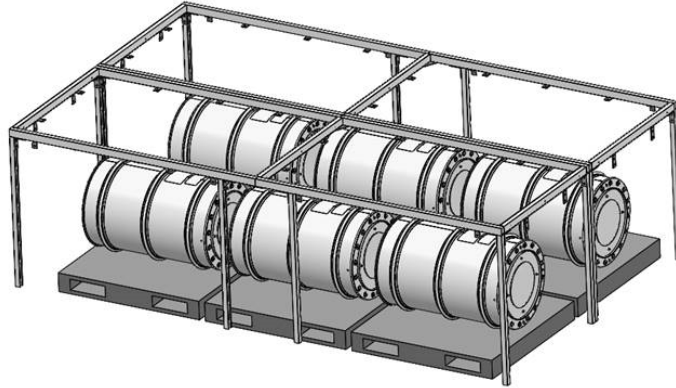
At the conclusion of each puncture test, record the damage observations on the procedure checklist.

#### **5.4.4 HAC 30-min, 800 °C Thermal Test**

Thermal testing will be performed at a suitable thermal test facility in accordance with 10 CFR 71.73(c)(4). TU-1 through TU-6 will be subjected to the 30 min, 800 °C thermal test. Thermocouples will be installed on the exterior of the drum body as stated in Section 5.1.4. Prior to the beginning of the HAC thermal test, each test package and the furnace will be configured as noted below. These tests will be performed according to PTP Procedure PTP-PEF-13, Rev. 6 CN-0 dated 03-10-2021 with PTP special instructions supplied to the Thermal Test Facility. PTP-PEF-13 and special instructions used for thermal testing will be submitted and approved by CNS prior to testing. Thermal test results will be recorded on the procedure checklist and other applicable documents required for testing. The furnace shall be pre-heated at >1475°F for 12 hours minimum prior to testing the first unit. The furnace shall be heated for at least 45 minutes minimum between tests and must meet the thermocouple criteria in this section.

Prior to placing the TUs in the furnace, a representative DPP-1 test unit (SDPP1 or TU-7) will be used to qualify the furnace. Six TCs will be installed on the exterior of the SDPP-1 unit; 1 on the lid center, 1 on the bottom center and 1 each at the intersection of the axial 0°, 90°, 180° and 270° lines and the middle of the SDPP1. All the TCs will be connected to the data acquisition and monitoring system. SDPP1 will be placed in the furnace. The furnace will be considered qualified and ready for burning the TUs when all TCs on the SDPP1 and furnace radiating surfaces are reading between 1475°F and 1600°F range within 12 min of closing the furnace and all TCs read within this range for the duration of the burn test.

Each test unit will be preheated to 150° F for 24 hours and then soaked at 110° F for an additional 24 hours. The test units will remain in the preheat chamber (Figure 5-34) until the test unit is removed for TC installation and thermal testing.



**Figure 5-34 DPP-1 preheat chamber.**

All test units will be placed in a horizontal orientation with the furnace floor, used for thermal testing. If possible, each package will be oriented such that the 0° line on the drums are facing the furnace floor and the lid of the drums is facing the right wall of the furnace. However, during past testing of similar drum-style packages, it has been found that orienting the packages in this manner may present safety problems due to the deformed nature of the packages after drop. During test preparation, a determination will be made regarding the stability of the units and the orientations that will be used during thermal testing will be based on this determination. The actual orientation will be documented in the test report.

The test units will be loaded and unloaded into the furnace in less than 90 seconds. The 31 min thermal test will begin when the following criteria has been met:

1. At least 5 of the 6 external thermocouples are reading > 1475°F.
2. At least 15 of the furnace surfaces thermocouples are reading > 1475°F.
3. At least 2 of the 3 thermocouples on each furnace surface is reading > 1475°F.
4. At least 2 thermocouples on the test stand are reading > 1475°F.
5. CNS personnel has agreed to proceed with the test.

At the conclusion of the thermal test, the test units will be placed on a cooling stand and allowed to passively cool. Cool down temperature of the test unit will be recorded for each unit until the temperatures for all TC's are below 100°F or after 6 hours from the end of the thermal test. During disassembly record the weight of each TU on TEST FORM 1

## **5.5 Disassembly, Leak, and Inspection Test Procedure**

### **5.5.1 Post-test Package Disassembly Procedure**

Follow TEST FORM 5 to disassemble the test units, record any testing damage on that form. Weigh the test package and record the weight on TEST FORM 1 . Take photographs



of and videotape each step of the disassembly process. Remove the CV, record its weight on TEST FORM 1 . Record all of the CV exterior and drum interior temperature indicator blackout readings on TEST FORM 6 as the test units are disassembled. Record any unexpected or unusual findings as the units are disassembled in the comment section on TEST FORM 5. Record the breakaway torque of the drum lid bolts.

Removal of the CVs from most if not all of the drums will be a challenging effort. Most drums will be highly deformed inward around the CV, making it impossible to remove the CVs from the lid opening. If necessary, the drum outer shell and drum liner will be cut with an angle grinder to allow for the safe removal of the CV.

## **5.5.2 Post-test Leak Test**

### **5.5.2.1 Operational Leak Check Test Procedure**

The O-ring seals of each CV assembly will be leak tested after testing. ORNL will ensure leak test devices are calibrated. Perform the leak check in accordance with ANSI N14.5-2014 using the “A.5.2 gas pressure rise” method described in Table A.1. The test requirement is no detected leakage when tested to a sensitivity of at least  $1\text{E-}3 \text{ atm-cm}^3/\text{s}$ . This test will be performed prior to the helium leak test. Each CV will be at room temperature when conducting this test. This test will be performed according to ORNL Facilities and Operations procedure NDE 70 Rev. 7, *General Requirements for Leak Testing* and NDE 70 – PCMT, *Leak Testing – Pressure Change Measurement Test*.

### **5.5.2.2 Full Containment Boundary Helium (He) Leak Test**

After the CV has been removed from the overpack the entire CV boundary of TU-1 through TU-6 will be tested to the fabrication leak check as described in *American National Standard for Radioactive Materials – Leakage Tests on Packages for Shipment* - ANSI N14.5-2014 using the “A.5.3 gas filled envelope” method described in Table A-1. These tests will be performed after the post-test operational leak test and before the water immersion test. The leak test port plug shall be removed for this test and each CV shall be at room temperature when conducting this test. This test will be performed according to ORNL Facilities and Operations procedure NDE 70 Rev. 7 CN0, *General Requirements for Leak Testing* and NDE 70 – Hood, *Mass Spectrometer Leak Testing – Hood Testing*. See sample leak TEST FORM 13 and TEST FORM 14 .

The leakage rate test will be performed with the hollow hex plug removed from the CV lid. For the CVs of TU-1 through TU-6, the specific method for implementing the leak check is as follows: Drill and tap the lid or body of the CV of each test unit to accept a 1/4 in. NPT tapered pipe thread. Note: liquid tapping fluid is not allowed but paste or jelly is acceptable. A K-flange adapter will be screwed into this hole with a fast setting epoxy on the threads. Apply epoxy resin to the threads of the adapter and screw it into the CV lid. After the epoxy hardens connect the mass spectrometer helium leak test equipment (approved per *NDE 70 EL*) to the adapter and evacuate the CV to  $<100 \text{ mTorr}$ . The CV will then be placed in a plastic bag and the plastic bag evacuated with a shop vacuum to reduce the ambient air in the bag. A constant flow of helium gas will then be introduced into the bag and allowed to “overflow” out a small exit hole near the bottom of the bag to ensure that the CV will

remain bathed in He during the test. The leak tester will be initially set to a sensitivity of  $5 \times 10^{-8}$  cc/sec He and the sensitivity will be adjusted as needed to determine the potential leak rate. The sensitivity of this test is  $\leq 5 \times 10^{-8}$  cc/sec He and the acceptance value is  $\leq 2 \times 10^{-7}$  cc/sec He. The helium atmosphere shall be 6 minutes minimum with He forced into the O-ring annulus and completed once the level III captures required data.

### 5.5.3 HAC 0.9-m (3-ft) Immersion Test– Fissile material packages

After acceptable leak test results, immerse the containment vessels of TU-1 through TU-6 under a head of water of at least 0.9-m (3-ft) or equivalent pressure, in the horizontal orientation for an 8-hour period (Figure 5-35) in accordance with 10 CFR 71.73(c)(5). The leak test port plug (between the O-rings) will be removed for this test. The NPT tapered pipe thread will be sealed with a watertight cap. After immersion, each CV will be dried, opened, and visually evaluated for signs of water. A process approved by CNS in advance (fans, plant air pressure, mild heat, vacuum suction, etc.) will be applied to the flange joint and space between the O-rings prior to opening each CV to ensure excess moisture has been removed. If water is present inside the inner O-ring upon opening, work will be stopped for this activity and the CNS STR will be contacted immediately. These tests will be performed according to PTP Procedure PTP-PEF-14, Rev. 5 CN-2 dated 12-14-2020 and testing results will be recorded on the procedure checklist and data sheet associated with this procedure. Record the weight of the CV before and after the 3 ft immersion test on TEST FORM 1

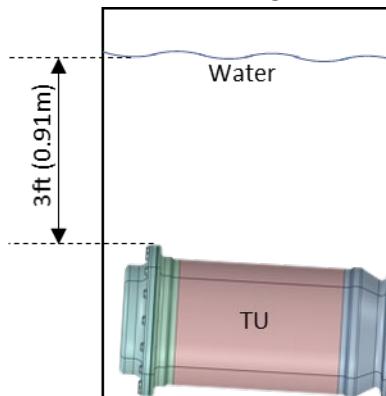
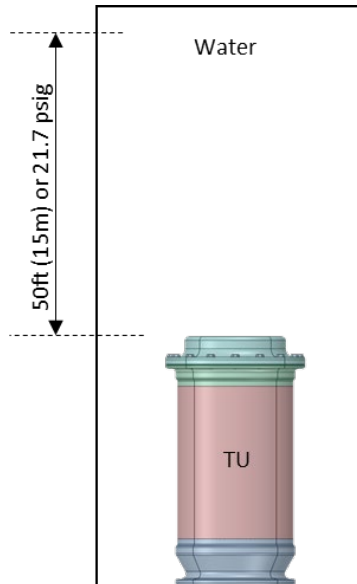


Figure 5-35 HAC – 1 m Immersion test for fissile materials.

### 5.5.4 HAC 15 m (50 ft) Immersion Test – TU-7 packages

After acceptable results from the operational leak test, TU-7 (CV only) will be immersed under a head of water of at least 15 m (50 ft), or equivalent pressure (21.7 psig) for an 8 hour period (Figure 5-36) in accordance with 10 CFR 71.73(c)(6). The leak test port plug (between the O-rings) will be removed for this test. The orientation of the CV during the immersion test will be upright (lid up). After immersion, CV will be dried, opened, and visually evaluated for signs of water. A process approved by CNS in advance (fans, plant air pressure, mild heat, vacuum suction, etc.) will be applied to the flange joint and space between the O-rings prior to opening each CV to ensure excess moisture has been removed. The CV drying process will be done in accordance with the CNS approved procedure in TEST FORM 12. If water is present inside the inner O-ring upon opening, work will be stopped for this activity and the CNS STR will be contacted immediately. This test will be performed according to PTP Procedure PTP-PEF-15, Rev. 5 CN-2 dated 12-14-2020 and

testing results will be recorded on the procedure checklist and data sheet associated with this procedure. Record the weight of the CV before and after the immersion 50 ft immersion test on TEST FORM 1



**Figure 5-36 HAC – 15 m Immersion test for fissile materials.**

#### **5.5.5 TU Disassembly Procedure**

Follow TEST FORM 5 to disassemble the TU down to the CV and read the temperature indicating labels from the inside of the drum liner and exterior surface of the CV. It is possible that the deformation of the drum's inner liner would prevent the CV from being removed from the drum using the normal process (i.e. lifting the CV out of the drum body after drum lid removal). Therefore, an angle grinder may be used to cut open the drum and the inner liner.

Record the temperature label readings on TEST FORM 6 and photograph each temp label reading. Record any unusual findings such as CV distortion, etc. on the comment space provided on TEST FORM 5. Record the breakaway torque of the CV lid bolts. Finally, record test unit dimensions on TEST FORM 7



## Detailed Sequence Summary of each Test Unit

Follow test procedures as described below for test units. All witness and hold points for CNS are identified in

**Table 5-3 Detailed Sequence Summary for TU-1**

Test Sequence	Test Title	Reference Figure(s)	Test Forms(s)	Comments and hold points
1	Assembly	Figure 5-5	Test Forms 1, 2, 3, 7, 10, 11	
2	Pre-test Operational leak test on CV	N/A	NDE 70 Rev. 7 -PCMT	$\leq 1 \times 10^{-3}$ ref-cc/sec, sensitivity no detectable leak, acceptance
3	Chill package		Test Form 4	-70°F (-56.7°C) @ 24hr, then -45°F (-42.7°C) @ 48hr
4	NCT 1.2-m drop	Figure 5-11	PTP-PEF-08	Side drop on 0° line
5	HAC 9-m drop	Figure 5-18	PTP-PEF-10	Side drop on 0° line
6	HAC 9-m crush	Figure 5-23	PTP-PEF-11	Side crush, 0° line on pad
7	1-m Puncture drop	Figure 5-28	PTP-PEF-12, Test Form 7 after HAC drops for cold unit	Side drop on 0° line
8	Thermal Pre-Heat	N/A	PTP-PEF-13	
9	Thermal Test	N/A	PTP-PEF-13	
10	Post-test Operational leak check and inspection of CV	N/A	NDE 70 Rev. 7 - PCMT	$\leq 1 \times 10^{-3}$ ref-cc/sec, sensitivity no detectable leak, acceptance
11	Full Containment Boundary He Leak Test	N/A	NDE 70 Rev. 7 - Hood	$\leq 5 \times 10^{-8}$ cc/sec He, sensitivity $\leq 2 \times 10^{-7}$ cc/sec He, acceptance
12	0.9-m immersion	Figure 5-35	PTP-PEF-14	
13	Disassembly	N/A	Test Forms 5, 6, 8, 9, 12, 13, 14	

Test Sequence	Test Title	Reference Figure(s)	Test Forms(s)	Comments
1	Assembly	Figure 5-5	Test Forms 1, 2, 3, 7, 10, 11	
2	Pre-test Operational leak test on CV	N/A	NDE 70 Rev. 7 - PCMT	$\leq 1 \times 10^{-3}$ ref-cc/sec, sensitivity no detectable leak, acceptance
3	Water Spray	Figure 5-10	PTP-PEF-05	Remove Accelerometer before water spray
4	NCT 1.2-m drop	Figure 5-11	PTP-PEF-08, Test Form 7	Side drop on 0° line
5	HAC 9-m drop	Figure 5-18	PTP-PEF-10, Test Form 7	Side drop on 0° line
6	HAC 9-m crush	Figure 5-23	PTP-PEF-11, Test Form 7	Side crush, 0° line on pad
7	1-m Puncture drop	Figure 5-29	PTP-PEF-12, Test Form 7	Side drop on 0° line
8	Thermal Pre-Heat	N/A	PTP-PEF-13	
9	Thermal Test	N/A	PTP-PEF-13	
10	Post-test Operational leak check and inspection of CV	N/A	NDE 70 Rev. 7 - PCMT	$\leq 1 \times 10^{-3}$ ref-cc/sec, sensitivity no detectable leak, acceptance
11	Full Containment Boundary He Leak Test	N/A	NDE 70 Rev. 7 - Hood	$\leq 5 \times 10^{-8}$ cc/sec He, sensitivity $\leq 2 \times 10^{-7}$ cc/sec He, acceptance
12	0.9-m immersion	Figure 5-35	PTP-PEF-14	
13	Disassembly	N/A	Test Forms 5, 6, 8, 9, 12, 13, 14	

Test Sequence	Test Title	Reference Figure(s)	Test Forms(s)	Comments
1	Assembly	Figure 5-5	Test Forms 1, 2, 3, 7, 10, 11	
2	Pre-test Operational leak test on CV	N/A	NDE 70 Rev. 7 -PCMT	$\leq 1 \times 10^{-3}$ ref-cc/sec, sensitivity no detectable leak, acceptance
3	Water Spray	Figure 5-10	PTP-PEF-05	
4	NCT 1.2-m drop	Figure 5-12	PTP-PEF-08, Test Form 7	Top down
5	HAC 9-m drop	Figure 5-19	PTP-PEF-10, Test Form 7	Top down
6	HAC 9-m crush	Figure 5-24	PTP-PEF-11, Test Form 7	Bottom up, Top on pad
7	1-m Puncture drop	Figure 5-30	PTP-PEF-12, Test Form 7	Top down
8	Thermal Pre-Heat	N/A	PTP-PEF-13	
9	Thermal Test	N/A	PTP-PEF-13	
10	Post-test Operational leak check and inspection of CV	N/A	NDE 70 Rev. 7 - PCMT	$\leq 1 \times 10^{-3}$ ref-cc/sec, sensitivity no detectable leak, acceptance
11	Full Containment Boundary He Leak Test	N/A	NDE 70 Rev. 7 - Hood	$\leq 5 \times 10^{-8}$ cc/sec He, sensitivity $\leq 2 \times 10^{-7}$ cc/sec He, acceptance
12	0.9-m immersion	Figure 5-35	PTP-PEF-14	
13	Disassembly	N/A	Test Forms 5, 6, 8, 9, 12, 13, 14	



Test Sequence	Test Title	Reference Figure(s)	Test Forms(s)	Comments
1	Assembly	Figure 5-5	Test Forms 1, 2, 3, 7, 10, 11	
2	Pre-test Operational leak test on CV	N/A	NDE 70 Rev. 7 -PCMT	$\leq 1 \times 10^{-3}$ ref-cc/sec, sensitivity no detectable leak, acceptance
3	Water Spray	Figure 5-10	PTP-PEF-05	
4	NCT 1.2-m drop	Figure 5-13	PTP-PEF-08, Test Form 7	CGoTC (56.4° from horizontal)
5	HAC 9-m drop	Figure 5-20	PTP-PEF-10, Test Form 7	CGoTC (56.4° from horizontal)
6	HAC 9-m crush	Figure 5-25	PTP-PEF-11, Test Form 7	CGoTC, 56.4° from horizontal Bottom facing crush plate
7	1-m Puncture drop	Figure 5-31	PTP-PEF-12, Test Form 7	CGoTC (56.4° from horizontal)
8	Thermal Pre-Heat	N/A	PTP-PEF-13	
9	Thermal Test	N/A	PTP-PEF-13	
10	Post-test Operational leak check and inspection of CV	N/A	NDE 70 Rev. 7 - PCMT	$\leq 1 \times 10^{-3}$ ref-cc/sec, sensitivity no detectable leak, acceptance
11	Full Containment Boundary He Leak Test	N/A	NDE 70 Rev. 7 - Hood	$\leq 5 \times 10^{-8}$ cc/sec He, sensitivity $\leq 2 \times 10^{-7}$ cc/sec He, acceptance
12	0.9-m immersion	Figure 5-35	PTP-PEF-14	
13	Disassembly	N/A	Test Forms 5, 6, 8, 9, 12, 13, 14	

Test Sequence	Test Title	Reference Figure(s)	Test Forms(s)	Comments
1	Assembly	Figure 5-5	Test Forms 1, 2, 3, 7, 10, 11	
2	Pre-test Operational leak test on CV	N/A	NDE 70 Rev. 7 -PCMT	$\leq 1 \times 10^{-3}$ ref-cc/sec, sensitivity no detectable leak, acceptance
3	Chill package	N/A	Test Form 4	-70°F (-56.7°C) @ 24hr, then -45°F (-42.7°C) @ 48hr
4	NCT 1.2-m drop	Figure 5-14	PTP-PEF-08	Slap down (22°)
5	HAC 9-m drop	Figure 5-21	PTP-PEF-10	Slap down (22°)
6	HAC 9-m crush	Figure 5-26	PTP-PEF-11	Side 0°
7	1-m Puncture drop	Figure 5-32	PTP-PEF-12, Test Form 7 after HAC drops for cold unit	Side 0°
8	Thermal Pre-Heat	N/A	PTP-PEF-13	
9	Thermal Test	N/A	PTP-PEF-13	
10	Post-test Operational leak check and inspection of CV	N/A	NDE 70 Rev. 7 - PCMT	$\leq 1 \times 10^{-3}$ ref-cc/sec, sensitivity no detectable leak, acceptance
11	Full Containment Boundary He Leak Test	N/A	NDE 70 Rev. 7 - Hood	$\leq 5 \times 10^{-8}$ cc/sec He, sensitivity $\leq 2 \times 10^{-7}$ cc/sec He, acceptance
12	0.9-m immersion	Figure 5-35	PTP-PEF-14	
13	Disassembly	N/A	Test Forms 5, 6, 8, 9, 12, 13, 14	

Test Sequence	Test Title	Reference Figure(s)	Test Forms(s)	Comments
1	Assembly		Test Forms 1, 2, 3, 7, 10, 11	
2	Pre-test Operational leak test on CV	N/A	NDE 70 Rev. 7 -PCMT	$\leq 1 \times 10^{-3}$ ref-cc/sec, sensitivity no detectable leak, acceptance
3	Vibration Test	N/A	PTP-PEF-06	
4	Water Spray	Figure 5-10	PTP-PEF-05	Remove Accelerometer before water spray
5	NCT 1.2-m drop	Figure 5-15	PTP-PEF-08, Test Form 7	Slap down (22°)
6	NCT penetration	Figure 5-17	PTP-PEF-09, Test Form 7	
7	NCT compression	Figure 5-16	PTP-PEF-07, Test Form 7	
8	HAC 9-m drop	Figure 5-22	PTP-PEF-10, Test Form 7	Slap down (22°)
9	HAC 9-m crush	Figure 5-27	PTP-PEF-11, Test Form 7	Side 0°
10	1-m Puncture drop	Figure 5-33	PTP-PEF-12, Test Form 7	Side 0°
11	Thermal Pre-Heat	N/A	PTP-PEF-13	
12	Thermal Test	N/A	PTP-PEF-13	
13	Post-test Operational leak check and inspection of CV	N/A	NDE 70 Rev. 7 - PCMT	$\leq 1 \times 10^{-3}$ ref-cc/sec, sensitivity no detectable leak, acceptance
14	Full Containment Boundary He Leak Test	N/A	NDE 70 Rev. 7 - Hood	$\leq 5 \times 10^{-8}$ cc/sec He, sensitivity $\leq 2 \times 10^{-7}$ cc/sec He, acceptance
15	0.9-m immersion	Figure 5-35	PTP-PEF-14	
16	Disassembly	N/A	Test Forms 5, 6, 8, 9, 12, 13, 14	



Test Sequence	Test Title	Reference Figure(s)	Test Forms(s)	Comments
1	Assembly	Figure 5-5	Test Forms 1, 2, 11	
2	Pre-test Operational leak test on CV	N/A	NDE 70 Rev. 7 -PCMT	$\leq 1 \times 10^{-3}$ ref-cc/sec, sensitivity no detectable leak, acceptance
3	15 m immersion	Figure 5-36	PTP-PEF-15	15 m immersion
4	Disassembly	N/A	Test Forms 5, 9, 12	

## **6.0 Appendix A, Test Forms**

### **Data Forms for the DPP-1 test units**

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# TEST FORM 1 - COMPONENT WEIGHTS

Test Plan DPP-1.

TU\_\_\_\_\_

Part Name	Initial Assembly	Post Thermal, Full Disassembly
	Weight (lbs.)	Weight (lbs.)
CV body		
CV lid, screws, washers, and O-rings (together)		
Test fixture weldment, screws, washers, nuts, bushing (together)		
Test weight sets		
PCC pad sets		
CV assembly with test content (during reassembly)		
Drum body		
Drum lid assembly, screws, and washers (together)		
CV base pad and CV flange wedge (together)		
Test unit (TU) assembly		

## EQUIPMENT

Less than 10 pounds

10 lbs to 2000 lbs

Scale:\_\_\_\_\_ Expiration Date: \_\_\_\_\_

Scale:\_\_\_\_\_ Expiration Date: \_\_\_\_\_

Comments:\_\_\_\_\_

I certify that the above tasks have been performed and that the observations and comments are correct.

_____	_____	_____	_____
Testing Technician	Date	Witness	Date
_____	_____	_____	_____
CNS-Y12 STR	Date	CNS-Y12 QE	Date

## TEST FORM 2 - ASSEMBLY OF THE CV

Test Plan DPP-1

TU \_\_\_\_\_

VERIFIED

TASK

- \_\_\_\_\_ **HOLD POINT:** All payload components have been visually inspected, and Y-12 deems the shipping package acceptable for disassembly.
- \_\_\_\_\_ Verify and/or mark all components: content assembly, CV assembly, and drum assembly components with the corresponding test unit ID, axial lines, and impact targets symbols. Figure 4-1 - Figure 4-4.
- \_\_\_\_\_ Temperature labels have been affixed to the surface of the CV as shown in Figure 5-1, Figure 5-2.
- \_\_\_\_\_ None of the temperature indicators indicate exposure to a temperature in the measured range.
- \_\_\_\_\_ The CV body, CV lid, washers, and bolts were weighed and recorded in TEST FORM 1
- \_\_\_\_\_ **HOLD POINT:** Y-12 has approved the markings.

### The following assembly applies to TUs test fixture weldment content assembly

- \_\_\_\_\_ The surrogate test weight was weighed and recorded on TEST FORM 1 .
- \_\_\_\_\_ The loading test fixture weldment content assembly components were weighed and recorded on TEST FORM 1 .
- \_\_\_\_\_ Clean all surfaces with isopropyl alcohol and air dry
- \_\_\_\_\_ Place the PCC pad (silicone rubber) into CV body.
- \_\_\_\_\_ Place the test weight weldment into the CV body.
- \_\_\_\_\_ Place the PCC pad (silicone rubber) into the CV body on top of the test fixture weldment assembly.
- \_\_\_\_\_ **HOLD POINT:** Y-12 witness torquing of test fixture fastener hex head screws, washers, top hat bushings, and locknuts. The test weight and bolting locations that establish the low and high CG locations are documented in Attachment A. The hex head screws and locknuts shall be torqued to  $25 \pm 2$  ft-lb.
- \_\_\_\_\_ **HOLD POINT:** Y-12 inspected the assembly of the non-test fixture weldment content assembly and verified weights

M&TE ID #: \_\_\_\_\_ Calibration Due Date: \_\_\_\_\_

*Comments:* \_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

I certify that the above tasks have been performed and that the observations and comments are correct.

\_\_\_\_\_  
Testing Technician

\_\_\_\_\_  
Date

\_\_\_\_\_  
Witness

\_\_\_\_\_  
Date

\_\_\_\_\_  
CNS-Y-12 STR

\_\_\_\_\_  
Date

\_\_\_\_\_  
CNS-Y-12 QE

\_\_\_\_\_  
Date

## TEST FORM 2 - ASSEMBLY OF THE CV

Test Plan DPP-1

TU \_\_\_\_\_

### All packages

\_\_\_\_\_ The CV O-rings and sealing surfaces have been inspected for defects and found acceptable.

\_\_\_\_\_ Clean all surfaces with isopropyl alcohol and air dry.

\_\_\_\_\_ The CV O-rings have been installed onto the CV body.

**Note:** Screws and O-rings shall not be replaced without CNS approval. If replacements are authorized, they shall be documented in the test report where the replacements occurred.

\_\_\_\_\_ The CV lid was lowered on the CV body and the CV screws shall be hand-tightened until the lid is in full contact with the flange, note that clamps may be used during this step. The CV screws shall be torqued in sequence following the numbers etched into the drum lid in three passes. first pass the screws shall be torqued to 19–21 ft-lb, during the second pass to 33–37 ft-lb, and during the third pass to 33–37 ft-lb. The final pass torque values shall be recorded.

Ambient temperature at closure is \_\_\_\_\_ °C (\_\_\_\_\_ °F)

Measuring device \_\_\_\_\_ Calibration Expiration Date \_\_\_\_\_

\_\_\_\_\_ Record assembly torque on TEST FORM 11.

Torque wrench # \_\_\_\_\_ Calibration Expiration Date \_\_\_\_\_

\_\_\_\_\_ HOLD POINT: Y-12 inspected the assembly and closure of CV assemblies and verified weights.

\_\_\_\_\_ The CV assembly has been weighed and the weight has been recorded on TEST FORM 1

\_\_\_\_\_ The CV assembly has been leak tested (pre-test operational) in accordance with Sect. 7.6 of ANSI N14.5-2014 using the “A.5.2 gas pressure rise” method described in Table A-1 of N14.5-2014 and ORNL procedure NDE 70 Rev. 7, PCMT.

\_\_\_\_\_ HOLD POINT: Y-12 has reviewed the leak test and the installation of the acceleration sensor mounts.

\_\_\_\_\_ Photographs of the assembly have been taken\*.

*Comments:*

I certify that the above tasks have been performed and that the observations and comments are correct.

\_\_\_\_\_  
Testing Technician

\_\_\_\_\_  
Date

\_\_\_\_\_  
Witness

\_\_\_\_\_  
Date

\_\_\_\_\_  
CNS-Y-12 STR

\_\_\_\_\_  
Date

\_\_\_\_\_  
CNS-Y-12 QE

\_\_\_\_\_  
Date

\*All photographs/movies will be uniquely identified with test unit, date and time to ensure that the proper sequence can be reconstructed



# TEST FORM 3 - ASSEMBLY OF TEST PACKAGE

Test Plan DPP-1

TU-\_\_\_\_\_

VERIFIED

TASK

\_\_\_\_\_  
Verify operational leak test is complete and form completed and tighten the CV lid leak test port plug per the following sequence: 1<sup>st</sup> pass hand tight, 2<sup>nd</sup> pass torque to 6-7 ft-lb.  
Torque wrench # \_\_\_\_\_ Calibration Expiration Date \_\_\_\_\_  
\_\_\_\_\_  
The exterior of the drum has been clearly marked "TU-\_\_\_\_\_" and record the drum serial number if applicable:  
\_\_\_\_\_  
Verify all exterior markings on the TU. If marks are not legible or inadequate, the TA will remark the TU. Mark the 0°, 90°, 180°, 270° locations on the Drum Lid, and the inner and outside walls of the drum with a permanent marker.  
\_\_\_\_\_  
Install temperature labels on the inside of the drum body as shown in Figure 5-3.  
\_\_\_\_\_  
Clean all surface of the drum body with isopropyl alcohol and let air dry.  
\_\_\_\_\_  
The drum body, drum lid, bolts, washers, pads, were weighed and recorded on TEST FORM 1 .  
\_\_\_\_\_  
Place the lower CV base pad into the drum body.  
\_\_\_\_\_  
Place the CV assembly into the drum body.  
\_\_\_\_\_  
The CV assembly has been loaded into the drum with the 0° rotated and aligned with 0° line on the drum. Ensure temperature labels are not damaged.  
\_\_\_\_\_  
Place the CV flange wedge between the CV flange and the drum body.  
\_\_\_\_\_  
Place the silicone foam pads on top of the CV assembly lid.  
\_\_\_\_\_  
The drum lid has been loaded into the drum with the 0° rotated and aligned with the 0° location on the drum.  
\_\_\_\_\_  
If necessary, apply thread lubricant to the drum closure bolts.  
\_\_\_\_\_  
The drum lid has been closed using the same screws that were removed during disassembly. The screws shall be torqued in sequence following the numbers etched into the drum lid in two passes. First, the screws shall be torqued until the lid is in full contact with the drum. Second, the screws shall be torqued to 33-37 ft-lb. Record the assembled torque value on TEST FORM 11.  
Torque wrench #: \_\_\_\_\_ Calibration Expiration Date: \_\_\_\_\_  
\_\_\_\_\_  
Mount one (1) vibration (single axis) accelerometer on the drum lid center for NCT vibration monitoring on TU-6.  
Remove accelerometer after NCT Test.  
\_\_\_\_\_  
Mount one (1) impact (tri-axial) accelerometer on the drum lid center, and two (2) impact (tri-axial) accelerometers near the CG of the drum outside circumference at the 90° and 270° axial lines. The accelerometers need to be offset from each other by 180° (TU-5 & TU-6).  
\_\_\_\_\_  
Mount two (2) impact (tri-axial) accelerometers near the CG of the drum outside circumference at the 90° and 270° axial lines. The accelerometers need to be offset from each other by 180°. (TU-1 and TU-2)  
\_\_\_\_\_  
The accelerometers were checked to ensure they were installed and functioning as intended after each installation. **HOLD POINT:** Y-12 has approval: CNS STR \_\_\_\_\_, CNS QE \_\_\_\_\_  
\_\_\_\_\_  
The test package assembly has been weighed and the weight recorded on Test Form 1.  
\_\_\_\_\_  
Photographs of the assembly have been taken\*.  
\_\_\_\_\_  
The accelerometer mounting blocks have been spot welded to the drum outer shell as specified in Section 5.1.5  
\_\_\_\_\_  
HOLD POINT: Y-12 has approved final assembly of the test package.  
\_\_\_\_\_  
Before structural testing the accelerometers have been mounted to the TU.

*Comments:* \_\_\_\_\_

\_\_\_\_\_  
I certify that the above tasks have been performed and that the observations and comments are correct.

\_\_\_\_\_  
Testing Technician

\_\_\_\_\_  
Date

\_\_\_\_\_  
Witness

\_\_\_\_\_  
Date

\_\_\_\_\_  
CNS-Y-12 STR

\_\_\_\_\_  
Date

\_\_\_\_\_  
CNS-Y-12 QE

\_\_\_\_\_  
Date

\*All photographs/movies will be uniquely identified with test unit, date and time to ensure that the proper sequence can be reconstructed

**TEST FORM 4 - PACKAGE CHILLING RECORD**

TU \_\_\_\_\_

VERIFIED

TASK

_____	Record Environmental Chamber Manufacturer and Serial Number	
	Manufacturer: _____	Serial Number: _____
_____	Identify Temperature Calibration Unit and verify calibration due date	
	Temperature Calibration Unit: _____	Calibration Due Date: _____
_____	Place Test Unit into Environmental Chamber.	Date: _____ Time: _____
_____	Temperature Controller set to -70°F (-56.7°C).	
_____	Package in chamber for at least 72 hours and at -70°F for 24 hours.	
_____	Reset Temperature Controller set to -45°F (-42.7°C).	Date: _____ Time: _____
_____	Package in chamber at -45°F for at least 48 hours.	
_____	Package removed from Chamber.	Date: _____ Time: _____
_____	Package placed in insulated box for transport.	Yes / No
_____	Package packed in dry ice (optional):	Yes / No
_____	Package unpacked from insulated box.	Date: _____ Time: _____
_____	Photographs of the assembly have been taken*.	Yes / No

*Comments:*

I certify that the above tasks have been performed and that the observations and comments are correct.

\_\_\_\_\_  
Testing Technician\_\_\_\_\_  
Date\_\_\_\_\_  
Witness\_\_\_\_\_  
Date\_\_\_\_\_  
CNS-Y-12 STR\_\_\_\_\_  
Date\_\_\_\_\_  
CNS-Y-12 QE\_\_\_\_\_  
Date

\*All photographs/movies will be uniquely identified with test unit, date and time to ensure that the proper sequence can be reconstructed

# TEST FORM 5 - POST-THERMAL TESTING INSPECTION

Test Plan DPP-1.

TU \_\_\_\_\_

## VERIFIED

## TASK

Following the thermal test and after passive cooling, the test package was weighed, and recorded on TEST FORM 1 .

The drum, drum lid, bolts, and washers have been visually examined to determine the extent of the testing damage. Observations: \_\_\_\_\_

The camera(s) are set up to take photographs\* and/or videotape of the damage due to testing.

The drum lid has been removed and the condition of the exposed parts have been visually examined for damage and the condition has been recorded. Record the exposed temperature indicator blackout reading on TEST FORM 6. Record the torque values needed to loosen the drum lid weldment screws on TEST FORM 1 .

Observations: \_\_\_\_\_

The CV assembly and contents have been removed in the reverse assembly order and visually examined for damage. Record the exposed temperature indicator blackout readings on TEST FORM 6

Observations: \_\_\_\_\_

The CV assembly has been weighed and the weight recorded on TEST FORM 1 .

Use NDE 70 Rev. 7 for the CV post-test operational leak check and for the full containment boundary leak check and PTP-PEF-14 for the 0.9 m (3 ft). immersion test or PTP-PEF-15 for the 15 m immersion test. The leak test port plug shall be removed for these tests.

HOLD POINT: Y-12 has approved the CV drying process.

After immersion test the CV was dried using the CNS approved process (fans, plant air pressure, mild heat, vacuum suction, etc.) as shown in TEST FORM 12. The flange joint and space between the O-rings was dried by the approved process prior to opening the CV.

Disassemble the CV. Record torque value needed to loosen CV screws on TEST FORM 9.

If water is present inside the O-rings, stop work, inform CNS, and comment observations below.

Read the temperature labels from the CV. Record the temperature indicators' blackout readings on TEST FORM 6

The content test fixture weldment assembly was removed from the CV and the weight was recorded on TEST FORM 1 .

The content test fixture weldment assembly was disassembled in the reverse assembly order.

Loaded test fixture weldment content assembly: Remove the contents in the following order, loading test fixture weldment assembly using nylon springs, PCC silicone rubber pad, test weight weldment, lower PCC silicone rubber pad. CV silicone rubber pad.

All loose parts will be placed in separate plastic bags, marked with test unit identification, tape closed, and prepared for storage with the test package.

Mark and reassemble the test package to the extent possible for shipment.

\*Photographs and/or video of the damage resulting from the testing have been taken.

Comments: \_\_\_\_\_

I certify that the above tasks have been performed and that the observations and comments are correct.

Testing Technician

Date

Witness

Date

CNS-Y-12 STR

Date

CNS-Y-12 QE

Date

\*All photographs/movies will be uniquely identified with test unit, date and time to ensure that the proper sequence can be reconstructed.

# TEST FORM 6 - TEMPERATURE INDICATOR READINGS

Test Plan DPP-1

TU\_\_\_\_\_

A visual inspection of each temperature indicator on the package consisting of those indicators inside the CV, outside the CV, and on the drum-liner will be made. The values of the blackouts that occurred will be recorded below.

TEMPERATURE INDICATOR NUMBER LOCATION CHART				
TEST CONTENT ASSEMBLY (TL-10-105, TL-10-190)				
Location (outside)	0°	90°	180°	270°
Top end cap center	1 °F	2 °F	3 °F	4 °F
Top end cap under flange	5 °F	6 °F	7 °F	8 °F
Tube upper	9 °F	10 °F	11 °F	12 °F
Tube middle	13 °F	14 °F	15 °F	16 °F
Tube lower	17 °F	18 °F	19 °F	20 °F
Bottom end cap under flange	21 °F	22 °F	23 °F	24 °F
Bottom end cap center	25 °F	26 °F	27 °F	28 °F
Weight upper	29 °F	30 °F	31 °F	32 °F
Weight lower	33 °F	34 °F	35 °F	36 °F
INTERIOR OF THE CV (TL-10-105, TL-10-190)				
CV lid center	37 °F	38 °F	39 °F	40 °F
CV body flange	41 °F	42 °F	43 °F	44 °F
CV wall upper	45 °F	46 °F	47 °F	48 °F
CV wall middle	49 °F	50 °F	51 °F	52 °F
CV wall lower	53 °F	54 °F	55 °F	56 °F
CV base neck	57 °F	58 °F	59 °F	60 °F
CV base center	61 °F	62 °F	63 °F	64 °F
EXTERIOR OF THE CV (TL-10-105, TL-10-190)				
Lid center	65 °F	66 °F	67 °F	68 °F
Lid flange	69 °F	70 °F	71 °F	72 °F
Body flange	73 °F	74 °F	75 °F	76 °F
Base neck	77 °F	78 °F	79 °F	80 °F
Base toe	81 °F	82 °F	83 °F	84 °F
DRUM ASSEMBLY (TL-10-190, TL-10-290)				
Lid bottom	85 °F	86 °F	87 °F	88 °F
Cavity wall upper	89 °F	90 °F	91 °F	92 °F
Cavity wall middle	93 °F	94 °F	95 °F	96 °F
Cavity wall lower	97 °F	98 °F	99 °F	100 °F
Cavity wall lowest	101 °F	102 °F	103 °F	104 °F
Cavity bottom	105 °F	106 °F	107 °F	108 °F

Comments:

I certify that the above tasks have been performed and that the observations and comments are correct.

Testing Technician

Date

Witness

Date

CNS-Y-12 STR

Date

CNS-Y-12 QE

Date

\*All photographs/movies will be uniquely identified with test unit, date and time to ensure that the proper sequence can be reconstructed



# TEST FORM 7 –TEST UNIT DIMENSIONS

Test Plan – DPP-1

TU- \_\_\_\_\_

Initial Assembly \_\_\_\_\_  
 Post 1.2-m Drop \_\_\_\_\_  
 Post 9-m Drop \_\_\_\_\_  
 Post Crush Test \_\_\_\_\_  
 Post 1-m Puncture Test \_\_\_\_\_

## Drum outer shell

	0°	90°	180°	270°
Height				

DIAMETER	0° to 180°	90° to 270°
Top Surface		
Top Rolling hoop		
Center Rolling hoop		
Bottom Rolling hoop		
Bottom Surface		

Location	Flats width @ 0°	Flats width @ 180°
Top Surface		
Top Rolling hoop		
Center Rolling hoop		
Bottom Rolling hoop		
Bottom Surface		

Sketch Drop Setup Here

Sketch Package Damage Here

M&TE ID #: \_\_\_\_\_ Calibration Due Date: \_\_\_\_\_

M&TE ID #: \_\_\_\_\_ Calibration Due Date: \_\_\_\_\_

Comments:

I certify that the above tasks have been performed and that the observations and comments are correct.

\_\_\_\_\_  
 Testing Technician

\_\_\_\_\_  
 Date

\_\_\_\_\_  
 Witness

\_\_\_\_\_  
 Date

\_\_\_\_\_  
 CNS-Y-12 STR

\_\_\_\_\_  
 Date

\_\_\_\_\_  
 CNS-Y-12 QE

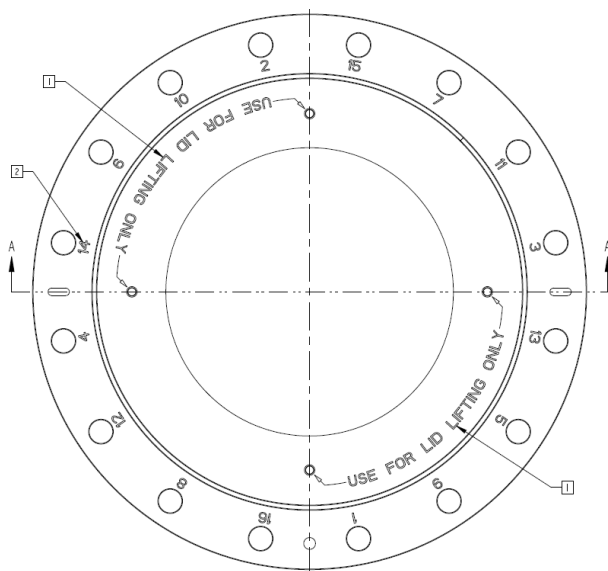
\_\_\_\_\_  
 Date

\*All photographs/movies will be uniquely identified with test unit, date and time to ensure that the proper sequence can be reconstructed

# TEST FORM 8 –DRUM LID DISASSEMBLY

Test Plan – DPP-1

TU- \_\_\_\_\_



DPP-1 Lid Disassembly	
Bolt #	Torque Removal (ft-lbs.)
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	
11	
12	
13	
14	
15	
16	

M&TE ID #: \_\_\_\_\_ Calibration Due Date: \_\_\_\_\_

M&TE ID #: \_\_\_\_\_ Calibration Due Date: \_\_\_\_\_

Comments:

I certify that the above tasks have been performed and that the observations and comments are correct.

Testing Technician

Date

Witness

Date

CNS-Y-12 STR

Date

CNS-Y-12 QE

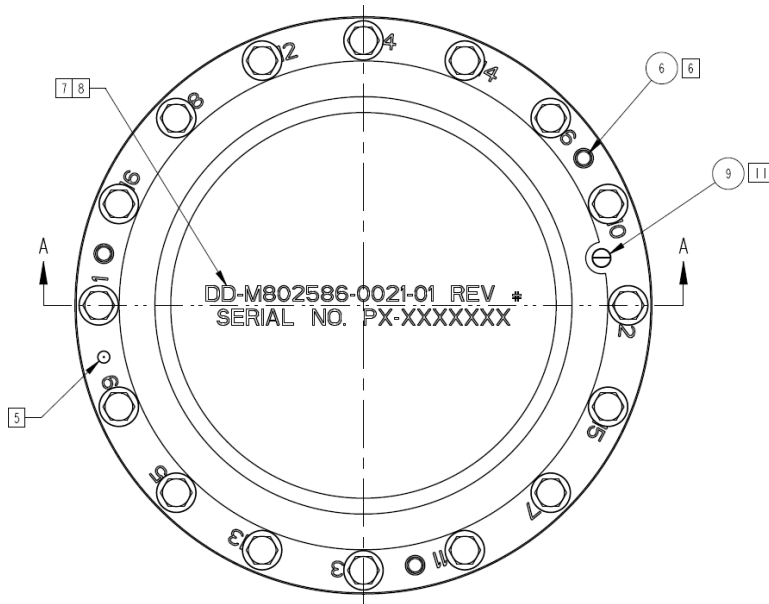
Date

\*All photographs/movies will be uniquely identified with test unit, date and time to ensure that the proper sequence can be reconstructed

# TEST FORM 9 –CV LID DISASSEMBLY

Test Plan – DPP-1

TU- \_\_\_\_\_



DPP-1 CV Lid Disassembly	
Bolt #	Torque Removal (ft-lbs.)
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	
11	
12	
13	
14	
15	
16	

M&TE ID #: \_\_\_\_\_ Calibration Due Date: \_\_\_\_\_

M&TE ID #: \_\_\_\_\_ Calibration Due Date: \_\_\_\_\_

*Comments:*

I certify that the above tasks have been performed and that the observations and comments are correct.

\_\_\_\_\_  
Testing Technician

\_\_\_\_\_  
Date

\_\_\_\_\_  
Witness

\_\_\_\_\_  
Date

\_\_\_\_\_  
CNS-Y-12 STR

\_\_\_\_\_  
Date

\_\_\_\_\_  
CNS-Y-12 QE

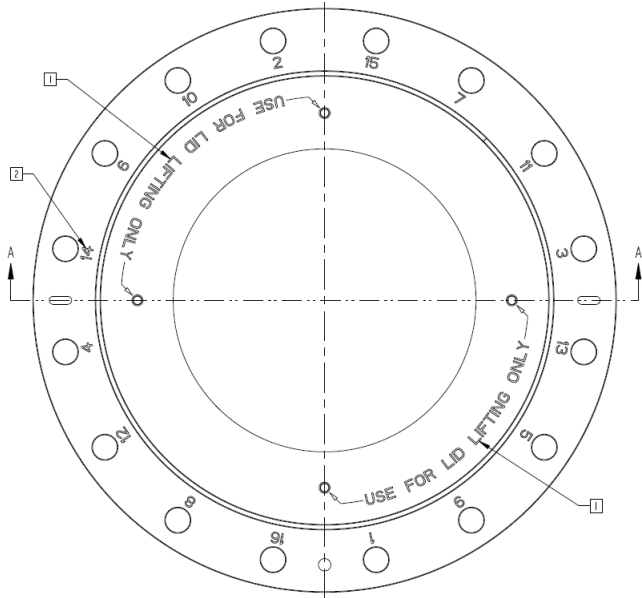
\_\_\_\_\_  
Date

\*All photographs/movies will be uniquely identified with test unit, date and time to ensure that the proper sequence can be reconstructed

# TEST FORM 10 –DRUM LID ASSEMBLY

Test Plan – DPP-1

TU- \_\_\_\_\_



DPP-1 Drum Lid Assembly	
Bolt #	Torque assembly (ft-lbs.)
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	
11	
12	
13	
14	
15	
16	

M&TE ID #: \_\_\_\_\_ Calibration Due Date: \_\_\_\_\_

M&TE ID #: \_\_\_\_\_ Calibration Due Date: \_\_\_\_\_

Comments:

I certify that the above tasks have been performed and that the observations and comments are correct.

\_\_\_\_\_  
Testing Technician

\_\_\_\_\_  
Date

\_\_\_\_\_  
Witness

\_\_\_\_\_  
Date

\_\_\_\_\_  
CNS-Y-12 STR

\_\_\_\_\_  
Date

\_\_\_\_\_  
CNS-Y-12 QE

\_\_\_\_\_  
Date

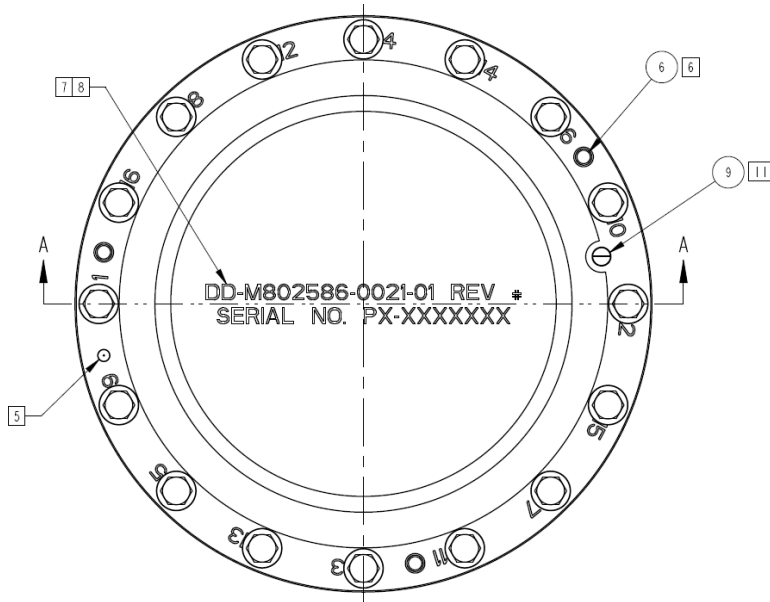
\*All photographs/movies will be uniquely identified with test unit, date and time to ensure that the proper sequence can be reconstructed



# TEST FORM 11 –CV LID ASSEMBLY

Test Plan – DPP-1

TU- \_\_\_\_\_



DPP-1 CV Lid Assembly	
Bolt #	Torque assembly (ft-lbs.)
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	
11	
12	
13	
14	
15	
16	

M&TE ID #: \_\_\_\_\_ Calibration Due Date: \_\_\_\_\_

M&TE ID #: \_\_\_\_\_ Calibration Due Date: \_\_\_\_\_

*Comments:*

I certify that the above tasks have been performed and that the observations and comments are correct.

\_\_\_\_\_  
Testing Technician

\_\_\_\_\_  
Date

\_\_\_\_\_  
Witness

\_\_\_\_\_  
Date

\_\_\_\_\_  
CNS-Y-12 STR

\_\_\_\_\_  
Date

\_\_\_\_\_  
CNS-Y-12 QE

\_\_\_\_\_  
Date

\*All photographs/movies will be uniquely identified with test unit, date and time to ensure that the proper sequence can be reconstructed

# TEST FORM 12 –CV DRYING PROCEDURE

Test Plan – DPP-1

TU- \_\_\_\_\_

VERIFIED

TASK

- \_\_\_\_\_ ORNL will remove the CV's from the immersion tank after a minimum of 8 hours.
- \_\_\_\_\_ The CV's will be placed on the worktable in a vertical position.
- \_\_\_\_\_ A shop vac will be used to blow out any water out of the CV flanges.
- \_\_\_\_\_ The external surface of the CV will be dried with cloth and paper towels.
- \_\_\_\_\_ ORNL will attach a vacuum to the CV flange O-ring port and supply a vacuum to remove most of the water between the inner and outer O-rings.
- \_\_\_\_\_ After about 1 hour of air drying under forced hot air convection, an air compressor or compressed air can, or shop air will be used to blow out any water left in between the CV O-rings.
- \_\_\_\_\_ The CV bolts will be loosened and removed, and the breakaway torque will be recorded on Test Form 9.
- \_\_\_\_\_ The CV top lid will be lifted about a 1/8<sup>th</sup> -in and cloth and paper towels will be used to wipe the surfaces of the internal CV flanges outboard of the outer O-ring.
- \_\_\_\_\_ A visual inspection of the internal surface of the CV flange will be done.
- \_\_\_\_\_ ORNL and CNS will verify that water droplets are not visible on the inside of the Inner O-ring.
- \_\_\_\_\_ After CNS approval, the CV lid will be completely removed from the CV base.

*Comments:*

I certify that the above tasks have been performed and that the observations and comments are correct.

\_\_\_\_\_  
Testing Technician

\_\_\_\_\_  
Date

\_\_\_\_\_  
Witness

\_\_\_\_\_  
Date

\_\_\_\_\_  
CNS-Y-12 STR

\_\_\_\_\_  
Date

\_\_\_\_\_  
CNS-Y-12 QE

\_\_\_\_\_  
Date

\*All photographs/movies will be uniquely identified with test unit, date and time to ensure that the proper sequence can be reconstructed

# TEST FORM 13 –SAMPLE LEAK TEST FORM

Test Plan – DPP-1

TU-\_\_\_\_\_



Report Number: \_\_\_\_\_

## LEAK TEST REPORT

Test Requested by:		Allowable Leak Rate:		Std-Atm-cc/s
Date Requested:		Date Required:		
Work Order Number:		Test Pressure Req. Across Boundary:		
Item Tested:		Customer:		
Specification:	NDE 70, Rev:	Technique Used:	Rev:	<input type="checkbox"/> Inside - Out <input type="checkbox"/> Outside - In

## EQUIPMENT

LEAK DETECTOR		STANDARD LEAK	
Make and Model:		Manufacturer:	Tracer Gas:
Serial Number:		Model:	Serial Number:
		Leak Rate:	Atm-cc/s @ atm @ °C
TEST GAUGES		Correlation Formula:	Temp Coefficient:
		$[1 - (T_{cat} - T_{avg}) C_T] LR$	% / °C
Temp Gauges:	Due:	Correlated LR:	Atm-cc/s @ atm @ °C
Pressure Gauges:	Due:	Calibration Due Date:	

## RESULTS

☐ Quantitative ☐ Semi - Quantitative

MACHINE CALIBRATION		SYSTEM TEST CONDITIONS	
System Pressure:		System Temperature: °C <input type="checkbox"/> Surface <input type="checkbox"/> Internal Gas	
Background:	Atm-cc/s	delta P Test Boundary:	
Leak Response:	Atm-cc/s	Tracer Gas:	% Concentration:
Minimum Detectable Leak:	Atm-cc/s	System Response Time:	
System Sensitivity:	Atm-cc/s	System Response: Atm-cc/s	
Response Time:		Duration of Test:	
Aux. Equipment:			
<input type="checkbox"/> ACCEPT <input type="checkbox"/> REJECT <input type="checkbox"/> SKETCH / DATA ATTACHED		System Leak Rate: <small>at rated tracer gas</small>	
		Atm-cc/s @ atm @ °C	

COMMENTS:

Test Conducted By:	Level:	Date:	Time:
--------------------	--------	-------	-------

Form NDE 70-MS, Rev. 1 CN01

IDMS 21077

Test Plan – DPP-1  
TU

## Calc. Version 12/6/17

### Calculations for Formula

dP Due to temperature change	
Delta Pressure T	0.06 WC

Allowable LR	1.00E-03	atm CC/Sec	Minimum Test Sensitivity	5.55E-07	atm CC/Sec
Measured LR	1.05E-04	atm CC/Sec	Uncertainty	5.78E-13	atm CC/Sec
Reported LR	1.05E-04	atm CC/Sec	Accept if Green, Reject if Red		
Procedure: NDE-70 Rev:	7	Technique: PCMT	Rev:	0	582402



## NRBK-41-1 Cask Cavity and Closure Assembly

Calc. Version 12/6/17

Variable	acc*FS rdg	Traceability	Resolution	Total Variable u	
P	9.06E-03	1.01E-04	0.010	5.37E-03	IWC
T	4.10E-02	7.60E-02	1.00E-03	4.92E-02	deg C
t	6.00E-02	1.00E-03	1.00E+00	2.90E-01	Sec
V	1.13E+00	2.07E-01	0.10	5.77E-01	CC

## Weighted Uncertainties

Initial Pressure	5.57E-15
Final Pressure	5.55E-15
Temp Final	4.13E-15
Temp Initial	2.80E-14
Volume	2.87E-13
Time	9.15E-18
Weighted U	5.78E-13

$$\sqrt{uP^2 + uV^2 + uT^2 + ut^2}$$

5.7771E-13



# TEST FORM 15 -WITNESS AND HOLD POINTS

Test Plan DPP-1

TU \_\_\_\_\_

The following applicable CNS hold points activities shall not start until written approval to proceed has been given from the CNS STR via e-mail. Additional hold points may be included when CNS reviews the approval data documents and as the work is being performed. The purpose of each hold point is to give the TA, STR, and QE an opportunity to (1) evaluate what has happened since the previous hold point, (2) evaluate previous lessons learned on the activities that follow, and (3) make an informed decision to proceed.

NO.	DESCRIPTION	TU NO.	TYPE	CNS INITIAL
1	<u>Initial package disassembly</u> Witness the disassembly, can be waived by a DA representative	1,2,3,4,5,6,7	Witness, Hold	
2	<u>pre-test operational leakage rate test</u> Witness the pre-test operational leakage rate test per ANSI N14.5, section 7.6, after final closure (and before commencing testing sequence)	1,2,3,4,5,6,7	Witness, Hold	
2.1	<u>pre-test operational leakage rate test acceptance</u> Inspection to verify the pre-test operational leakage rate test has met acceptance criteria <b>Subsequent reassembly sequence shall not commence until acceptable result is produced.</b>	1,2,3,4,5,6,7	Hold	
3	<u>Initial package reassembly</u> Witness the reassembly of the contents, CV, vibration pads, drum lid, instrumentation, and all associated fastening hardware	1,2,3,4,5,6,7	Witness	
3.1	<u>Initial Package Reassembly</u> Inspection and observation to verify the reassembly procedure has been followed according to supplied direction. <b>Subsequent testing sequence shall not commence until reassembly steps have been confirmed as acceptable.</b>	1,2,3,4,5,6,7	Hold	
4	<u>NCT vibration/shock test</u> Witness the NCT vibration/shock testing activities, including all preliminary setup, can be waived by a DA representative	6	Witness	
5	<u>NCT thermal pre-treatment</u> Witness the NCT thermal pre-treatment activities, including all preliminary setup, can be waived by a DA representative	1,2,3,4,5,6	Witness	
6	<u>NCT water spray test</u> Witness the NCT water spray test activities, including all preliminary setup, can be waived by a DA representative	2,3,4,6	Witness, Hold	
7	<u>NCT free drop (4 ft) test</u> Witness the NCT free drop (4 ft) test activities, including all preliminary setup, can be waived by a DA representative	1,2,3,4,5,6	Witness	
7.1	<u>NCT free drop (4 ft) test, critical parameters</u> Inspection to verify the critical parameters defining the NCT free drop (4 ft) test meet all requirements <b>Completion of NCT free drop (4 ft) test shall not commence until all critical parameters have been verified.</b>	1,2,3,4,5,6	Hold	

8	<u>NCT penetration test</u> Witness the NCT penetration test activities, including all preliminary setup, can be waived by a DA representative	6	Witness
8.1	<u>NCT penetration test, critical parameters</u> Inspection to verify the critical parameters defining the NCT penetration test meet all requirements  <b>Completion of NCT penetration test shall not commence until all critical parameters have been verified.</b>	6	Hold
9	<u>NCT compression test</u> Witness the NCT compression test activities, including all preliminary setup, can be waived by a DA representative	6	Witness
9.1	<u>NCT compression test, critical parameters</u> Inspection to verify the critical parameters defining the NCT compression test meet all requirements  <u>Completion of NCT compression test shall not commence until all critical parameters have been verified.</u>	6	Hold
10	<u>HAC thermal pre-treatment</u> Witness the HAC thermal pre-treatment activities, including all preliminary setup, can be waived by a DA representative	1,5	Witness
11	<u>HAC free drop (30 ft) test</u> Witness the HAC free drop (30 ft) test activities, including all preliminary setup, can be waived by a DA representative	1,2,3,4,5,6	Witness
11.1	<u>HAC free drop (30 ft) test, critical parameters</u> Inspection to verify the critical parameters defining the HAC free drop (30 ft) test meet all requirements  <b>Completion of HAC free drop (30 ft) test shall not commence until all critical parameters have been verified.</b>	1,2,3,4,5,6	Hold
11.2	<u>HAC free drop (30 ft) test, damage determination</u> Inspection to verify that the damage inflicted during the HAC free drop (30 ft) test is as expected, if unexpected damage is present, modifications to the subsequent HAC Crush (30 ft) test will be defined  <b>Testing shall not commence until new specification of HAC Crush (30 ft) test has been agreed-upon and adopted by the TA.</b>	1,2,3,4,5,6	Hold
12	<u>HAC crush (30 ft) test</u> Witness the HAC crush (30 ft) test activities, including all preliminary setup, can be waived by a DA representative	1,2,3,4,5,6	Witness
12.1	<u>HAC crush (30 ft) test, critical parameters</u> Inspection to verify the critical parameters defining the HAC crush (30 ft) test meet all requirements  <b>Completion of HAC crush (30 ft) test shall not commence until all critical parameters have been verified.</b>	1,2,3,4,5,6	Hold
12.2	<u>HAC crush (30 ft) test, damage determination</u> Inspection to verify that the damage inflicted during the HAC crush (30 ft) test is as expected, if unexpected damage is present, modifications to the subsequent HAC Puncture drop (40 in.) test will be defined <b>Testing shall not commence until new specification of HAC Puncture drop (40 in.) test has been agreed-upon and adopted by the TA.</b>	1,2,3,4,5,6	Hold

13	<u>HAC Puncture drop (40 in.) test</u> Witness the HAC Puncture drop (40 in.) test activities, including all preliminary setup, can be waived by a DA representative	1,2,3,4,5,6	Witness	
13.1	<u>HAC Puncture drop (40 in.) test, critical parameters</u> Inspection to verify the critical parameters defining the HAC Puncture drop (40 in.) test meet all requirements  <b>Completion of HAC Puncture drop (40 in.) test shall not commence until all critical parameters have been verified.</b>	1,2,3,4,5,6	Hold	
NO.	DESCRIPTION	TU NO.	TYPE	CNS INITIAL
14	<u>Thermal test, data collection hardware</u> Inspection to verify that all the thermocouple and hardware has been installed, or configured as specified and is operating correctly  <b>Completion of supplementary thermal test shall not commence until hardware installation has been verified.</b>	1,2,3,4,5,6	Hold	
15	<u>HAC thermal test</u> Witness the HAC thermal test activities, including all preliminary setup, can be waived by a DA representative	1,2,3,4,5,6	Witness	
15	<u>Overpack Inspection and Disassembly</u> Witness the overpack inspection and disassembly process. including all preliminary setup, can be waived by a DA representative	1,2,3,4,5,6	Witness	
16	<u>Overpack Inspection and Disassembly</u> Inspection to verify that sufficient data and measurements have been collected from overpack and CV prior to drilling and tapping the CV lid for post-test leakage rate measurements  <b>Post-test leakage rate activities, including all preliminary setup, shall not commence until hardware installation has been verified.</b>	1,2,3,4,5,6	Hold	
17	<u>post-test operational leakage rate test</u> Witness the post-test operational leakage rate test per ANSI N14.5, section 7.6, after completion of test activities (and before post-test full-boundary leakage rate test)	1,2,3,4,5,6	Witness	
18	<u>post-test full-boundary leakage rate test, drilling and tapping test port in CV lid</u> Witness the drilling and tapping of the leakage rate test port in the CV lid, after removal from the overpack assembly (and before completion of testing sequence)	1,2,3,4,5,6	Witness	
19	<u>post-test full-boundary leakage rate test</u> Witness the post-test full-boundary leakage rate test per ANSI N14.5, Section 7.5. This includes the sealing of the drilled and tapped hole in the CV lid after the leak rate measurements have completed	1,2,3,4,5,6	Witness	
19.1	<u>Final containment vessel leakage rate test acceptance</u> Inspection to verify the "post-test" leakage rate test has met acceptance criteria  <b>HAC immersion tests shall not commence until results are confirmed.</b>	1,2,3,4,5,6	Hold	

20	<u>HAC immersion test, fissile material packages</u> Witness the HAC immersion test, fissile material packages, activities, including preliminary setup, can be waived by a DA representative	1,2,3,4,5,6	Witness	
21	<u>HAC immersion test, all packages (undamaged)</u> Witness the HAC immersion test, all packages (undamaged), activities, including preliminary setup, can be waived by a DA representative	7	Witness	
22	<u>Opening containment vessel after HAC immersion test</u> Witness the opening of the containment vessel and inspection for 7 retained moisture within the containment vessel cavity, including preliminary setup and verification that the external surface is complete dry, can be waived by a DA representative	1,2,3,4,5,6, 7	Witness	
NO.	DESCRIPTION	TU NO.	TYPE	CNS INITIAL
23	<u>Final external inspection results</u> Inspection of all external inspection results, to verify all specified dimensional and photographic records have been obtained, these records cannot be confirmed after the overpack assembly has been cut-open and so must be confirmed at this point  <b>Disassembly and cross section examination shall not commence until all external inspections have been completed and all necessary records have been collected. (if required)</b>	1,2,3,4,5,6, 7	Hold	
24	<u>Disassembly and cross section inspection</u> Witness the cutting, disassembly, and dissection of the overpack assembly (if required)	1,2,3,4,5,6, 7	Witness	
25	<u>Final cross section inspection results (if required)</u> Inspection of all cross-section inspection results, to verify all specified dimensional and photographic records have been obtained  <b>Completion of final data report shall not commence until all cross-section inspections have been completed and all necessary records have been collected. (if required)</b>	1,2,3,4,5,6, 7	Hold	
26	<u>Preliminary data package</u> Inspection of all preliminary test results, including data collected, photos and videos captured, and dimensions measured  <b>Shipment or disposal (as defined by the DA) of TU shall not commence until the preliminary data package has been reviewed and determined to be complete.</b>	1,2,3,4,5,6, 7	Hold	

Comments:

I certify that the above tasks have been performed and that the observations and comments are correct.

Testing Technician

Date

Witness

Date

CNS-Y-12 STR

Date

CNS-Y-12 QE

Date

\*All photographs/movies will be uniquely identified with test unit, date and time to ensure that the proper sequence can be reconstructed



# TEST FORM 16 -**PHOTOGRAPHY/VIDEO CHECKLIST**

Test Plan DPP-1.

CTU \_\_\_\_\_

At a minimum, the following events shall be captured by photography. If necessary, photos shall be taken from multiple perspectives to provide a clear understanding of the event being captured. Date and time will be stamped on all photographs.

VERIFIED

TASK

	Overpack assembly, containment vessel, and vibration pads after taking delivery and during disassembly
	Overpack assembly, containment vessel, and vibration pads (where applicable) during reassembly
	Drop testing pad, including appropriate dimensional references
	Puncture bar installed onto drop pad, including appropriate dimensional reference
	Penetration bar, including appropriate dimensional references
	Equipment, instrumentation, and general arrangement used for vibration/shock tests
	Equipment, instrumentation, and general arrangement used for free and Puncture drop tests
	Equipment, instrumentation, and general arrangement used for water spray tests
	Pre-test leakage rate tests: <ul style="list-style-type: none"> <li>— Close-up views of CV before test, showing connection for CV lid leakage rate test port</li> <li>— Close-up views of CV during test, showing connections made to CV lid leakage rate test port</li> <li>— Test arrangement with CV during test, showing all connections made to CV</li> </ul>
	NCT vibration/shock tests: <ul style="list-style-type: none"> <li>— Test arrangement with the package installed onto the expander head or slip table</li> <li>— Attachment of tie-down chains or straps to top of package</li> <li>— Attachment of tie-down chains or straps to expander head or slip table</li> </ul>
	NCT water spray tests: <ul style="list-style-type: none"> <li>— Test arrangement with package before test, showing relative placement of water spray nozzles with respect to the package</li> <li>— Test arrangement with package during test, showing how the water is hitting the package</li> <li>— Test arrangement with package after test, showing evidence of water pooling or accumulation, if any</li> <li>— Rain gauge showing minimum allowable rainfall has been reached</li> </ul>
	NCT free drop (4 ft) tests: <ul style="list-style-type: none"> <li>— Test arrangement with package before test, showing the intended offset angle</li> <li>— Test arrangement with package before test, showing the intended drop height</li> <li>— Test arrangement with package after test, showing damaged package at final resting place</li> <li>— Close-up views of package after test, showing particular damage induced as a result of the NCT free drop (4 ft) test, including appropriate dimensional references</li> </ul>
	NCT penetration tests: <ul style="list-style-type: none"> <li>— Close-up views of package before test, showing intended point of impact</li> <li>— Test arrangement with package before test, showing supports and restraints that hold the package in place</li> <li>— Test arrangement with package before test, showing position and height of penetration bar, with respect to the package</li> <li>— Test arrangement with package after test, showing damaged package after penetration bar has made impact</li> <li>— Close-up views of package after test, showing particular damage induced as a result of the NCT penetration test, including appropriate dimensional references</li> </ul>
	NCT compression tests: <ul style="list-style-type: none"> <li>— If a compression tester machine is being used <ul style="list-style-type: none"> <li>• The relative arrangement of the package within the machine</li> <li>• The force read-out as indicated by the machine control system</li> </ul> </li> <li>— Test arrangement with package during test, showing weight having been applied to the package</li> <li>— Test arrangement with package after test, showing damaged package after weight has been removed (if any)</li> </ul>

	<ul style="list-style-type: none"> <li>—Close-up views of package after test, showing any particular damage induced as a result of the NCT compression test, including evidence of bulging/buckling of the drum, bending/buckling of the drum bolt guard, and crushing/buckling of the fork pockets</li> </ul>
	<p>HAC free drop (30 ft) tests: (check as performed)</p> <ul style="list-style-type: none"> <li>— Close-up views of package before test, showing intended point of initial impact</li> <li>— Test arrangement with package before test, showing the intended offset angle</li> <li>— Test arrangement with package before test, showing the intended drop height</li> <li>— Test arrangement with package after test, showing damaged package at final resting place</li> <li>— Close-up views of package after test, showing particular damage induced as a result of the HAC free drop (30 ft) test, including appropriate dimensional references</li> <li>— Close-up views of package after test, showing unexpected damage (if any), due to primary impact or any subsequent event</li> </ul>
	<p>HAC crush (30 ft) tests: (check as performed)</p> <ul style="list-style-type: none"> <li>— Close-up views of package before test, showing intended point of initial impact</li> <li>— Test arrangement with package before test, showing the intended offset angle</li> <li>— Test arrangement with package before test, showing the intended drop height</li> <li>— Test arrangement with package after test, showing damaged package at final resting place</li> <li>— Close-up views of package after test, showing particular damage induced as a result of the HAC crush (30 ft) test, including appropriate dimensional references</li> <li>— Close-up views of package after test, showing unexpected damage (if any), due to primary impact or any subsequent event</li> </ul>
	<p>HAC Puncture drop (40 in.) tests:</p> <ul style="list-style-type: none"> <li>—Close-up views of package before test, showing intended point of initial impact</li> <li>—Test arrangement with package before test, showing the intended offset angle</li> <li>—Test arrangement with package before test, showing the intended drop height</li> <li>—Test arrangement with package after test, showing damaged package at final resting place</li> <li>—Close-up views of package after test, showing particular damage induced as a result of the HAC puncture (1 m (40 in)) test, including appropriate dimensional references</li> <li>—Close-up views of package after test, showing unexpected damage (if any), due to primary impact or any subsequent event</li> </ul>
	<p>Supplementary and HAC thermal tests:</p> <ul style="list-style-type: none"> <li>—Views of relative spacing inside the furnace with door/trap open, with or without the package used as a dimensional point of reference, at hot or cold condition</li> <li>—Test arrangement with package before test, showing placement of thermocouple attachments on the package exterior surface</li> <li>—Test arrangement with package after test, showing damaged/burned package after initial removal from the furnace/fire</li> <li>—Close-up views of package after test, showing any excessively damaged/burned parts (if any)</li> </ul>
	<p>HAC immersion-fissile material tests:</p> <ul style="list-style-type: none"> <li>– Test arrangement with CV before test, showing placement of the CV within the tank</li> <li>– Test arrangement with CV during test, showing measurement of submerged depth of CV below water line</li> <li>– Close-up views of CV after test, after removal of the CV lid, showing evidence of water ingress (if any)</li> </ul>
	<p>HAC immersion- 10CFR71(c)(6) package tests</p> <ul style="list-style-type: none"> <li>– Test arrangement with CV before test, showing placement of the CV within the tank or hydraulic pressure chamber</li> <li>– Test arrangement with CV during test, showing measurement of submerged depth of CV below water line (or, if a hydraulic pressure chamber is being used, the internal pressure read-out as indicated by the hydraulic control system or in-line pressure gauge)</li> <li>– Close-up views of CV after test, after removal of the CV lid, showing evidence of water ingress (if any)</li> </ul>

	<p>Post-test leakage rate tests:</p> <ul style="list-style-type: none"> <li>– Close-up views of CV before test, showing drilled/tapped connection for CV lid leakage rate test port</li> <li>– Close-up views of CV during test, showing connections made to CV lid leakage rate test port</li> <li>– Test arrangement with CV during test, showing all connections made to CV</li> </ul>
	<p>Initial teardown and inspection:</p> <ul style="list-style-type: none"> <li>– Close-up views of CV after removal from overpack assembly, showing any superficial and structural damage due to interaction with overpack assembly during test sequence (if any), including appropriate dimensional references ( cursory examination only)</li> <li>– Close-up views of all thermal temperature indicators, showing temperatures indicated and evidence of stretching/tearing (if any), including appropriate dimensional references</li> <li>– Close-up views of overpack assembly after removal of CV, showing any superficial and structural damage due to interaction with CV or drum lid during test sequence (if any), including appropriate dimensional references</li> <li>– Close-up views of drum lid after removal from overpack assembly, showing any superficial and structural damage due to interaction with the CV or overpack assembly, including appropriate dimensional references</li> </ul>
	<p>Final teardown and inspection:</p> <ul style="list-style-type: none"> <li>– Close-up views of the CV, showing superficial and structural damage to ANY component, internal and external surfaces (if any), including appropriate dimensional references (detailed examination)</li> <li>– Close-up views of components within the CV, showing superficial and structural damage to ANY component, internal and external surfaces (if any), including appropriate dimensional references (detailed examination)</li> <li>– Markings on the surfaces of the overpack assembly and drum lid, showing the intended cross section cuts, including appropriate dimensional references (if requires)</li> <li>– Overall views of overpack assembly and drum lid after cross section cuts have been made (if required)</li> <li>– Close-up views of overpack assembly and drum lid after cross section cuts have been made, showing damage to internal components, including the following: (if required) <ul style="list-style-type: none"> <li>• Extent of burned/charred or disintegrated impact-limiting foam</li> <li>• Extent of disintegration, cracking, or separation of impact-limiting block</li> <li>• Extent of damage to thermal insulating blanket and indication of total radial thickness</li> <li>• Relative dimensional changes of structural components (including but not limited to drum liner assembly, perforated ring, drum lid inner section)</li> <li>• Any cracked welds</li> <li>• Any scratched, dented, or stretched sheet metal</li> </ul> </li> </ul>

Comments:

I certify that the above tasks have been performed and that the observations and comments are correct.

_____ Testing Technician	_____ Date	_____ Witness	_____ Date
_____ CNS-Y-12 STR	_____ Date	_____ CNS-Y-12 QE	_____ Date

\*All photographs/movies will be uniquely identified with test unit, date and time to ensure that the proper sequence can be reconstructed

## **7.0 Attachments**

**7.1 Request for Waiver of Deviation (RFWD) combined**

**7.2 Statement of Work (SOW)**

**7.2.1 DPP-1 Regulatory Compliance Testing**

**7.2.2 DPP-1 Thermal Testing at SwRI**

**7.3 DPP-1 Handling Procedures**

**7.4 Accelerometer Technical Specification Range**



## **7.2.1 DPP-1 Regulatory Compliance Testing SOW**

# Statement of Work

DPP-1 Regulatory Compliance Testing



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Y-12 National Security Complex

Packaging and Transportation Engineering

September 26, 2019

This document has been reviewed by a Y-12 DC/UCNI-RO and has been determined to be UNCLASSIFIED and contains no UCNI. This review does not constitute clearance for Public Release.

This document has been reviewed and confirmed to be UNCLASSIFIED and contains no UCNI.  
Name: Roger Aigner  
Date: 09/26/2019  
eDC/RO ID: 156406

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## DPP-1 Regulatory Compliance Testing

September 26, 2019

Prepared by  
Consolidated Nuclear Security, LLC  
Management & Operating Contractor  
for the  
Y-12 National Security Complex and Pantex Plant  
under Contract No. DE-NA0001942  
with the  
U.S. Department of Energy  
National Nuclear Security Administration



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**REVISION LOG**

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## 1. SCOPE

### 1.1 INTRODUCTION AND BACKGROUND

Consolidated Nuclear Security, LLC (CNS), the management and operating contractor for the Y-12 National Security Complex (Y-12) for the National Nuclear Security Administration (NNSA) is currently designing a new Type B shipping package called the DPP-1. The DPP-1 is a drum type packaging that has an inner liner and a removable lid. Both the drum body and lid are filled with an impact limiting and thermal insulating material called Packcrete that protect the inner containment vessel (CV) during normal conditions of transport (NCT) and hypothetical accident conditions (HAC) as defined by 10 CFR 71.

The purpose of this statement of work (SOW) is to test seven DPP-1 packages to demonstrate that the DPP-1 design complies with regulatory requirements under the tests specified in 10 CFR 71.71 (NCT) and 10 CFR 71.73 (HAC). A schematic of the DPP-1 package with a test content assembly that represents the heaviest normal payload during transportation is shown in Fig. 1. The test weight may be either light weight or heavy weight and may be placed in a low or high position. All seven of the test units will contain a test fixture weldment and a test weight.

#### DPP-1 Package

Weight shown: 885 lbs

Empty weight: 754 lbs

Drum OD: 27 in.

Drum height: 43 in.

#### CV

Empty weight: 258 lbs

ID: 19.7 in.

Internal height: 31.4 in.

External height: 32.4 in.

#### Payload

Light weight: 71 lbs

Heavy weight: 131 lbs

Fixture height: 29.3 in.

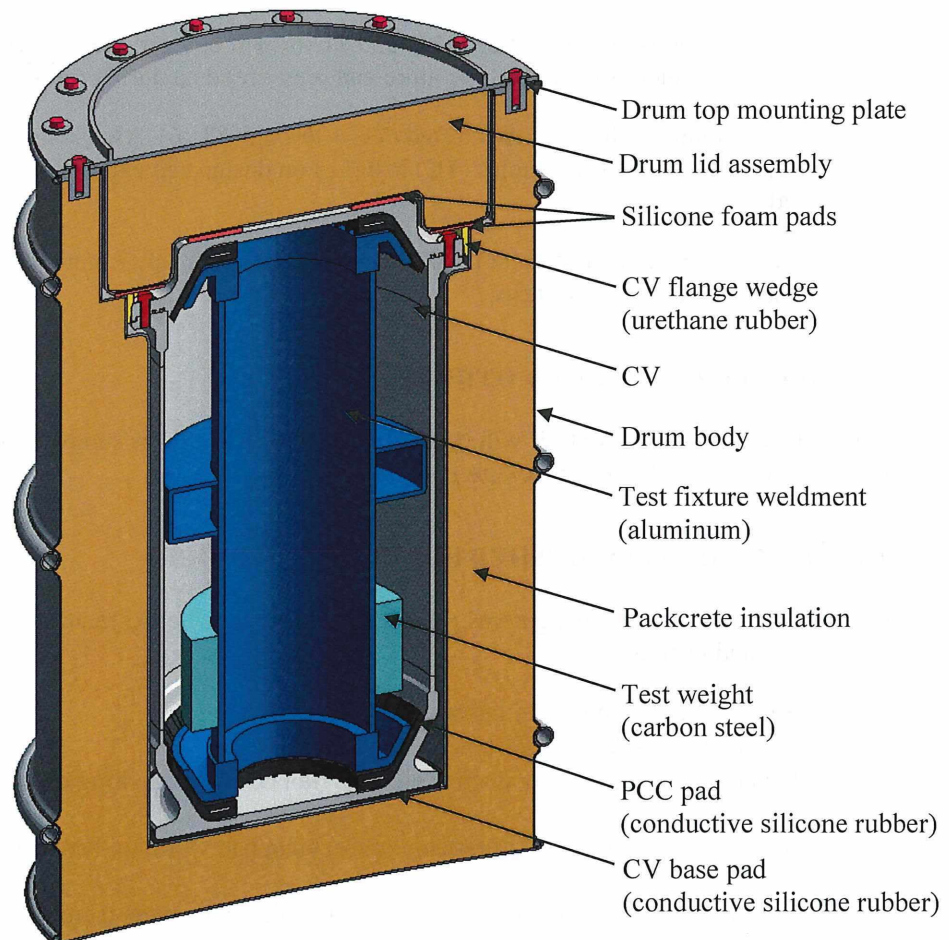


Fig. 1. DPP-1 package with a test content assembly.

## 1.2 GENERAL DESCRIPTION OF WORK

The testing agency (TA) conducting these tests for CNS will prepare a test plan, implement the test plan, and document the results in a test report. The TA will comply with all requirements in this document. A brief description of the seven test units (TU) is as follows.

- Each of the seven test units will be assigned a unique number of TU-1 through TU-7.
- All test units will contain a test fixture weldment with a test weight bolted to it. The weight and location of the center of gravity (CG) of the internal content will vary to bound the tested configurations.
- Four test units (TU-2, TU-3, TU-4, and TU-6) at various impact orientations will undergo a series of drop tests at ambient temperature.
- Two test units (TU-1 and TU-5) at different impact orientations will undergo a series of drop tests at -40°F cold temperature.
- One test unit (TU-6) will undergo both NCT and HAC testing. This includes a vibration and water spray test prior to the 4-ft drop test and a compression test and penetration test following the 4-ft drop test.
- Four test units (TU-1, TU-2, TU-5, and TU-6) will be instrumented with data loggers (DL) to collect acceleration (and temperature and pressure) data during the vibration and drop tests.
- Six test units will be furnace tested (TU-1 through TU-6). All test units subjected to the furnace test will have thermocouples (TC) installed on designated exterior surfaces of the drum body and lid.
- The CV from one test unit (TU-7) will undergo a 50-ft water immersion test only and will not be subjected to any other tests.

## 1.3 WORK PERFORMED BY OTHERS

All work described in this SOW will be performed by the TA, or its subtier suppliers, while operating under the TA's quality assurance (QA) program.

## 1.4 GOVERNMENT FURNISHED EQUIPMENT/SERVICES

CNS will provide the following items. The TA will provide all other materials associated with test unit preparation and testing.

- Seven DPP-1 drums with fastener parts
- Seven DPP-1 CVs with fastener parts
- Seven CV base pads (conductive silicone rubber) that pad vibration between the CV and drum liner
- Seven CV flange wedges (urethane rubber) that pad vibration between the CV flange and drum liner
- Seven test fixtures weldments and associated fastening parts (screws, nuts, washers, and bushings)
- Six sets of heavy test weights to be installed on seven test fixture weldments

- One set of light test weights to be installed on a single test fixture weldment
- Seven sets of PCC pads (reinforced, conductive silicone rubber) that brace the test content assemblies inside the CV
- One simulated DPP-1 (SDPP1) test article for furnace setup and qualification
- Spare parts and lifting components including but not limited to pads, O-rings, screws, washers, nuts, bushings, and swivel hoist rings

## 2. REFERENCES

### 2.1 DEFINITIONS

DPP-1 packaging	drum and CV assembly
DPP-1 package	drum and CV assembly plus the test content assembly and PCC pads
Test content assembly	light and heavy weight content mockups that bound the actual payload to be shipped

### 2.2 ACRONYMS AND INITIALISMS

ANSI	American National Standards Institute
ASNT	American Society for Nondestructive Testing
CG	center of gravity
CGoTC	center of gravity over top corner
CNS	Consolidated Nuclear Security, LLC
CoC	Certificate of Conformance
CV	containment vessel
FL	marked location on outside of the drum along weld seam aligned with CV flange
HAC	hypothetical accident conditions
ISO	International Organization for Standardization
IEC	International Electrotechnical Commission
NCT	normal conditions of transport
NDT	nondestructive testing
NNSA	National Nuclear Security Administration
QA	quality assurance
QASL	Quality Approved Supplier List
QE	Quality Engineer
RFWD	Request for Waiver or Deviation
SDPP1	simulated DPP-1
SOW	statement of work
STR	subcontract technical representative
TA	testing agency
TC	thermocouple
TL	temperature label
TPCR	test plan change request
TU	test unit
Y-12	Y-12 National Security Complex



## 2.3 CODES/STANDARDS/ORDERS/REGULATIONS

10 CFR 71, Packaging and Transportation of Radioactive Material, January 2018.

ANSI N14.5-2014, *Leakage Tests on Packages for Shipment*.

ASNT, *Recommended Practice No. SNT-TC-1A: Personnel Qualification and Certification in Nondestructive Testing*, 2016.

ASTM E2230-13, *Standard Practice for Thermal Qualification of Type B Packages for Radioactive Material*.

NNSA SG-600, Rev. 2, *Safety Guide: Regulatory Compliance Testing of NNSA Type B Packages*, September 2007.

## 2.4 APPLICABLE CNS AND STAND-ALONE DOCUMENTS

The following CNS and stand-alone documents will be provided to the TA along with this SOW.

1. DPP-1 drawings (DD-M802586-0001 to DD-M802586-0029)
2. Test content assembly drawings (DD-M802586-0030 to DD-M802586-0033)
3. NNSA SG-600, Rev. 2
4. Example test plan (ORNL/NTRC-023, Rev. 0, September 22, 2006)
5. Example test report (ORNL/NTRC-027/V1, V2, and V3, Rev. 0, March 7, 2008)
6. Y17-69-PE-345, *Regulatory Testing of Type B Packages*

## 3. TECHNICAL REQUIREMENTS

If requirements are unclear, or conflicts exist between the applicable documents on this work, the TA shall contact the CNS subcontract technical representative (STR) for resolution. If multiple interpretations are possible, the TA shall contact the STR for clarification based on CNS's intent. The STR will be identified in the TA's subcontract with CNS.

### 3.1 GENERAL

1. The TA's general responsibilities are described in Sect. 1.4 of SG-600, *NNSA Safety Guide for Regulatory Compliance Testing of NNSA Type B Packages*. A copy of SG-600 will be provided to the TA with this SOW. In general, the TA is directly responsible for writing the test plan, performing all tests or subcontracting for such tests to be performed, and documenting the testing process and test results in a test report.

**Note:** The Design Authority mentioned in SG-600 for this package is the CNS Packaging & Transportation organization. The STR identified in the TA's subcontract with CNS is the Design Authority representative on this procurement.

2. The TA shall comply with all applicable requirements in the following sections of SG-600.
  - a. Section 5, Packaging Test Plan Development
  - b. Section 6, Testing Procedures and Methodologies
  - c. Section 7, Test Reporting
3. The TA shall direct all technical communications to the STR, the day-to-day technical point of contact for this work, unless directed otherwise in writing by the STR.
4. If there is a need to deviate from the requirements in this SOW after the subcontract is awarded and before CNS approves the test plan, the TA shall request approval from the STR using a request for waiver or deviation (RFWD) form. An electronic version of this form will be provided by the STR upon request.
5. Test unit preparation and testing activities shall be conducted in accordance with the applicable requirements in 10 CFR 71.71; 10 CFR 71.73; 10 CFR 71, Subpart H; SG-600; and this SOW. As noted earlier, if requirements are unclear or conflicts exist between the applicable documents on this work, the TA shall contact the STR for resolution. If multiple interpretations are possible, the TA shall contact the STR for clarification based on CNS's intent.
6. Documents that are used by TA personnel during test unit preparation and testing activities (procedures, instructions, forms, guides, etc.) must be approved by CNS prior to performing the work. This includes documents from sub-tier suppliers. These documents shall be referred to as "approval data" documents. Examples are as follows. The test plan is the only approval data document that must be signed by CNS prior to execution.
  - QA program (TA's general QA plan for all testing campaigns)
  - QA plan (specific to this testing campaign)
  - Implementing procedures for QA program and QA plan
  - Test plan
  - Test procedures (leak test and others)
  - Equipment calibration procedures and records
  - Tooling calibration procedures and records
  - Training plan for this specific testing campaign
  - Work instructions (outside formal procedures)
  - Work guides (outside formal procedures)
  - Forms and/or routing sheets not included in the test plan or test procedures
  - Other documentation that is used by personnel during test unit preparation and testing that is not included in the above documents
  - Personnel qualification/certification records

7. The TA shall have an American Society for Nondestructive Testing (ASNT) Nondestructive Testing (NDT) Level III Leak Testing Specialist, or CNS approved equivalent, approve and sign off on the operational leak test and helium leak test procedures. The TA shall provide CNS a copy of the Level III Leak Testing Specialist's ASNT certification as an approval data document with the leak test procedures.

**Note:** The operational leak test is the same as the pre-shipment leak test described in Sect. 7.6 of American National Standards Institute (ANSI) N14.5-2014. The helium leak test is the same as the periodic leakage rate test described in Sect. 7.5 of ANSI N14.5-2014.

8. The TA shall provide documentation of qualification and certification of personnel in accordance with ANST "Recommended Practice No. SNT-TC-1A: Personnel Qualification and Certification in Nondestructive Testing". Leak testing personnel for each test shall be certified by the TA as an NDT Level II or III.
9. Personnel directly involved with performing test unit preparation and testing activities must be approved by CNS for use on this testing campaign. This includes direct personnel from subcontract suppliers. Documents that show these people to be qualified, trained, and/or certified to perform their work are approval data documents that require CNS review and approval prior to performing these activities. Indirect support personnel do not require CNS approval. The following documents are considered approval data documents for direct personnel.
  - Copy of the certifications for the level II leak test specialists that will conduct leak testing
  - Copy of qualification, training, experience, and/or certification records for personnel directly involved with test unit preparation and other testing activities
10. Documents that show that equipment and tooling used during test unit preparation and testing activities are calibrated and working properly are approval data documents. The TA shall not use equipment and tooling to perform test unit preparation and testing activities until CNS has approved their use via CNS's review and acceptance of these documents.
11. The TA shall not start test unit preparation and testing activities until the applicable approval data documents have been approved by CNS, and CNS has given the TA written authorization to proceed.
12. If there is a need to deviate from approval data documents after they have been approved by CNS, including a change in direct personnel, the TA shall request approval from the STR using a test plan change request (TPCR) form. An electronic version of this form will be provided by the STR upon request. The affected approval data documents do not require revision unless specifically noted on the TPCR form.
13. Requested changes shall be identified on the TPCR as non-intent, URGENT intent, or ROUTINE intent.

**Note 1:** Any change that affects or changes what was intended is an intent change. Any change that does not is a non-intent change. Most non-intent changes will be editorial in nature such as correcting errors or including clarifications where there is no intent to change or alter in any way what was intended. Changes that come up during execution of the drop tests are URGENT changes. Changes that come up during execution of the thermal tests are URGENT changes. Other changes are ROUTINE changes. On URGENT intent changes, the reason for the urgency as well as the concurrences/approvals obtained by the STR must be included on TPCR forms.



**Note 2:** Non-intent changes will be dispositioned by the STR, with no other approvals from CNS required. URGENT intent changes will be dispositioned by the STR after other CNS signees on the test plan have given their concurrence (in person, by phone, via email, or via another signee). ROUTINE intent changes will be authorized by the STR after other CNS signees on the test plan have signed the TPCR form.

14. The TA shall address URGENT and ROUTINE intent changes in the test report with the applicable test unit preparation or testing activity and shall refer to the applicable TPCR forms as authorization to deviate from the test plan.
15. If results from a test unit preparation activity or a testing activity are not as expected (i.e., cannot assemble parts correctly, cannot install a temperature label (TL) where required, cannot get a CV to pass the pre-test operations leak test on the first try, missed the target on a drop, visual damage to CV upon removal from drum, water drops inside the CV after the immersion test, etc.), the TA shall immediately stop work on that activity and notify the STR in person, via phone or e-mail. The TA shall address each situation in the test report and shall refer to the subject TPCR as authorization to proceed. The unexpected result shall be described by the TA in the reason for change section of the form. The resolution or path forward shall be described by CNS in the required change section of the form.

**Note:** The TPCR process is used on anomalies to engage the proper stakeholders, document the situation, and document the disposition or path forward decision. Anomalies fit the TPCR process in terms of tracking and documenting deviations during test unit preparation and testing activities because they are deviations from the expected results. The STR will assemble the appropriate people at CNS to resolve anomalies with the TA. CNS's basis for proceeding and approval will be documented on the TPCR form.

16. The TA shall keep a log and file of all approved TPCR forms and have them available for CNS review at the TA's site upon request. The TA shall include the full set of approved TPCR forms as an appendix or addendum to the test report.
17. For each regulatory test, including the pre-test and post-test leak tests, the TA shall use a test journal to document daily testing activities (who, what, when, how, etc.) that are not captured on the test forms. The TA shall include the full set of journals as an appendix or addendum to the test report. If there is any concern or uncertainty about the level of detail in these journals, the TA shall contact the STR for clarification and direction.

**Note:** The purpose of these journals is to capture details that are not on the test forms that may be helpful during investigations and evaluations of problems that are discovered during or after testing.

18. All test unit preparation activities and testing activities shall be documented with digital color photographs taken with a 16+ megapixel camera or Company approved equal. CNS will provide photography equipment and services, but the TA may further photograph activities to ensure adequate documentation.
19. All drops shall be documented with two high-speed digital color videos. Each video shall be at least 1920 x 1080 at 1000 frames per second. The two video cameras shall be positioned 90 degrees apart. Both videos shall be shot against a white backdrop with a 6-in. contrasting grid. The TA shall ensure these services are provided.



20. All photographs and videos shall be uniquely identified with subject matter, date, and time. All photographs and videos shall be provided on a USB drive with the test report. The photographs shall also appear in the test report where the subject matter is being discussed and/or in an appendix or separate volume of the test report where the photographs are to be referenced.
21. The TA shall provide a Certificate of Conformance (CoC) stating that all of the tests were conducted in accordance with the requirements in this SOW; the CNS approved test plan, 10 CFR 71.71 (NCT requirements); 10 CFR 71.73 (HAC requirements); 10 CFR 71, Subpart H (Quality requirements); SG-600 (NNSA Safety Guide requirements); and the approval data documents, except as approved otherwise via RFWDs and TPCRs. The CoC shall refer to the test report and shall state that the report accurately documents the test results. The CoC shall refer to the subject documents by document name, number, revision, and date. The CoC shall be transmitted to the STR with the FINAL test report. Unless otherwise approved by the STR, the CoC shall be signed by the TA manager responsible for the quality of the work on this subcontract.

### 3.2 TEST PLAN

1. The test plan shall be developed in accordance with the requirements in this SOW; 10 CFR 71.71 (NCT requirements); 10 CFR 71.73 (HAC requirements); 10 CFR 71, Subpart H (Quality requirements); and SG-600 Sect. 5.
2. From a format, presentation, content, and level of detail standpoint, the TA's test plan shall be similar to a previous test plan prepared for the MD-2 package (ORNL/NTRC-023), unless approved otherwise by CNS. This document will be provided to the TA with this SOW.
3. The test plan shall have a unique number that is assigned by the TA for its records.
4. The document title shall be "Test Plan for DPP-1 Regulatory Compliance Testing".
5. The signature page for the test plan shall include the following, in the following order:
  - TA lead technical person
  - TA lead quality person
  - DPP-1 Design Engineer
  - DPP-1 Test Engineer/Packaging Engineer
  - DPP-1 Quality Engineer (QE)
  - CNS Packaging & Transportation Manager
  - CNS DPP-1 Program Manager
6. The test plan shall be submitted to the STR for CNS review and approval.
7. After the test plan has been signed by all parties, the TA shall provide an electronic copy to the STR.
8. Deviations from the test plan shall be processed using the TPCR form.

9. Early in the preparation of the test plan, the CNS oversight team [Design Engineer, Test Engineer, QE] and the TA's team shall meet and discuss the requirements that have been included in this SOW as a result of the lessons learned from previous testing campaigns. The TA shall document the results of this meeting and send a copy to the STR via e-mail.
10. The test plan shall include the following applicable CNS hold points, as a minimum. These activities shall not start until written approval to proceed has been given from the STR via e-mail. Additional hold points may be included when CNS reviews the approval data documents and as the work is being performed. The purpose of each hold point is to give the TA, STR, and QE an opportunity to (1) evaluate what has happened since the previous hold point, (2) evaluate previous lessons learned on the activities that follow, and (3) make an informed decision to proceed.
  - a. Disassembly of empty shipping packages
  - b. Part marking
  - c. Installation of TLs
  - d. Part weighing
  - e. Assembly of test content assemblies
  - f. Assembly and closure of CV assemblies
  - g. CV operational leak testing
  - h. Assembly and closure of test units
  - i. Installation of data loggers
  - j. Vibration testing
  - k. Water spray testing
  - l. Test unit chilling
  - m. 4-ft drop testing
  - n. Compression testing
  - o. Penetration testing
  - p. 30-ft drop testing
  - q. Crush testing
  - r. Puncture testing
  - s. Thermal testing
  - t. Disassembly of test units
  - u. CV helium leak testing
  - v. CV water immersion testing
  - w. Opening CVs after water immersion testing
  - x. Measurement and documentation of damage
11. CNS shall witness the following applicable activities, as a minimum, all or in part as CNS deems appropriate. The TA shall not perform these activities without the STR or QE (or their designees) present, unless approved and documented otherwise in advance via a TPCR. The STR or QE shall sign and date applicable Test Forms to document their presence. The STR may include additional witness activities when CNS reviews the approval data documents and as the work is being performed. The purpose of witnessing these activities is to ensure that the work is being performed in accordance with the approval data documents and the work is being performed by CNS approved personnel.
  - a. Disassembly of shipping packages
  - b. Part marking on first test unit
  - c. Installation of TLs on first test unit
  - d. Part weighing on first test unit

- e. Assembly of test content assemblies
- f. Assembly of CV assemblies
- g. CV operational leak testing
- h. Assembly of test units
- i. Installation of data loggers
- j. Start of vibration testing
- k. Start of water spray testing
- l. Start of test unit chilling
- m. 4-ft drop testing
- n. Start of compression testing
- o. Penetration testing
- p. 30-ft drop testing
- q. Crush testing
- r. Puncture testing
- s. Thermal testing
- t. Disassembly of test units
- u. CV helium leak testing
- v. Start of CV water immersion testing
- w. Opening CVs after water immersion testing
- x. Measurement and documentation of damage

### 3.3 TEST UNIT PREPARATION

CNS will provide the following as separate deliverables (i.e., the items will not be fully assembled):

- Seven assembled DPP-1 drums with internal CV assemblies, CV bases pads, and CV flange wedges
- Seven test fixture weldments with associated fastener parts
- Six sets of heavy test weights
- One set of light test weights
- Seven sets of PCC pads
- Seven sets of new O-rings (inner and outer)

First, the assembled DPP-1 drums and CVs shall be disassembled, marked, and weighed. Second, the content related items shall be marked, weighed, temp-labeled, and re-assembled in accordance with the requirements in the following sections. Lastly, the test units with the content shall be fully re-assembled in accordance with the requirements in the following sections making sure to install TLs and data loggers in accordance with Attachment B when appropriate. Seven test units shall be assembled (TU-1 through TU-7). TU-1 through TU-6 will be subjected to vibration, drop, and thermal tests in accordance with Attachment A. TU-7 will be subjected to a 50-ft immersion test only. One fully assembled test unit with the test content fixture and heavy test weight installed inside the CV is shown in Fig. 1.

#### 3.3.1 General

1. Digital photographs shall be taken during test unit preparation to demonstrate compliance with this SOW and the test plan. These photographs shall be provided to CNS on a USB thumb drive prior to testing and shall be included in the test report as "Photographs taken during test unit preparation".



2. The TA shall have a process in place to ensure that parts remain with the test unit from which they came. Parts are not interchangeable between test units, without CNS approval.
3. As items are being disassembled and re-assembled, they shall be visually inspected for damage.
4. The TA and CNS (STR or QE) shall perform these inspections together at the TA's facility as items are being disassembled and assembled. Any signs of damage shall be photographed, documented, and dispositioned via TPCR. Damage shall be treated as an anomaly from a disposition and documentation standpoint.

### 3.3.2 Shipping Package Disassembly

1. Each of the fully assembled drums and CVs shall be visually inspected for external damage prior to disassembly. After deemed acceptable by CNS, each test unit shall be disassembled.
2. Before disassembly, the drum lids shall be marked TU-1 through TU-7.
3. During disassembly, the CV lids and CV bodies as well as the CV base pads and CV flange wedges shall be marked with their corresponding test unit number.
4. During disassembly, the drum and CV fastening components shall be marked with their corresponding test unit number. The CV bodies and lids shall be handled carefully and protected while disassembled so that the O-rings and O-ring sealing surfaces are not contaminated or damaged.

### 3.3.3 Markings

1. For TU-1 through TU-6, the drum bodies shall be marked with 4 axial lines equally spaced around the circumference of the drum wall, with one line located along the weld seam. The lines shall be marked near the open end of the drum body as follows: 0 at the weld seam line and then 90, 180, and 270 (degrees) going clockwise around the drum body (looking from the open end). The CVs and test content assemblies shall also be axially marked at 0°, 90°, 180°, and 270°.
2. For TU-1 through TU-6, the drum bodies shall also be marked with a circumferential line to indicate where the CG of the test unit is located. The intersection of this circumferential line and the 0-axial line shall be marked with a 3-in. target symbol and the letters CG shall be marked adjacent to the symbol. The CG location from the base of the drum (outside) to the center of the CG target symbols shall be as follows:

Test Unit	CG
TU-1	22.8
TU-2	23.2
TU-3	22.4
TU-4	22.8
TU-5	22.8
TU-6	22.4
TU-7	NA

3. For TU-1 through TU-6, the drum bodies shall also be marked with a circumferential line to indicate where the CV flange is located. The intersection of this circumferential line and the 0 and 180 lines shall be marked with a 3-in. target symbol and the letters FL marked adjacent to the



symbol. The flange location from the top edge of the drum lid to the center of the target symbol shall be 8.75 in.

4. A test content fixture with associated fastener parts and two PCC pads shall be set aside and marked for each test unit (TU-1 through TU-7).
5. A set of heavy test weights shall be set aside and marked for TU-1 and TU-3 through TU-7. A set of light test weights shall be set aside and marked for TU-2.

### 3.3.4 Temperature Labels and Data Loggers

1. TLs shall be installed on test weights, test fixture weldments, CV bodies, CV lids, drum body liners, and drum lid liners on TU-1 through TU-6 in accordance with Attachment B.  
  
**Note:** TLs are not to be installed on TU-7 because it is for the 50-ft immersion test only.
2. TLs located on the outside of CV bodies and inside of drum liner weldments shall be covered with high temperature Teflon® tape in accordance with Attachment B.
3. Data loggers shall be installed on the drum assembly exterior on TU-1, TU-2, TU-5, and TU-6 in accordance with Attachment B.

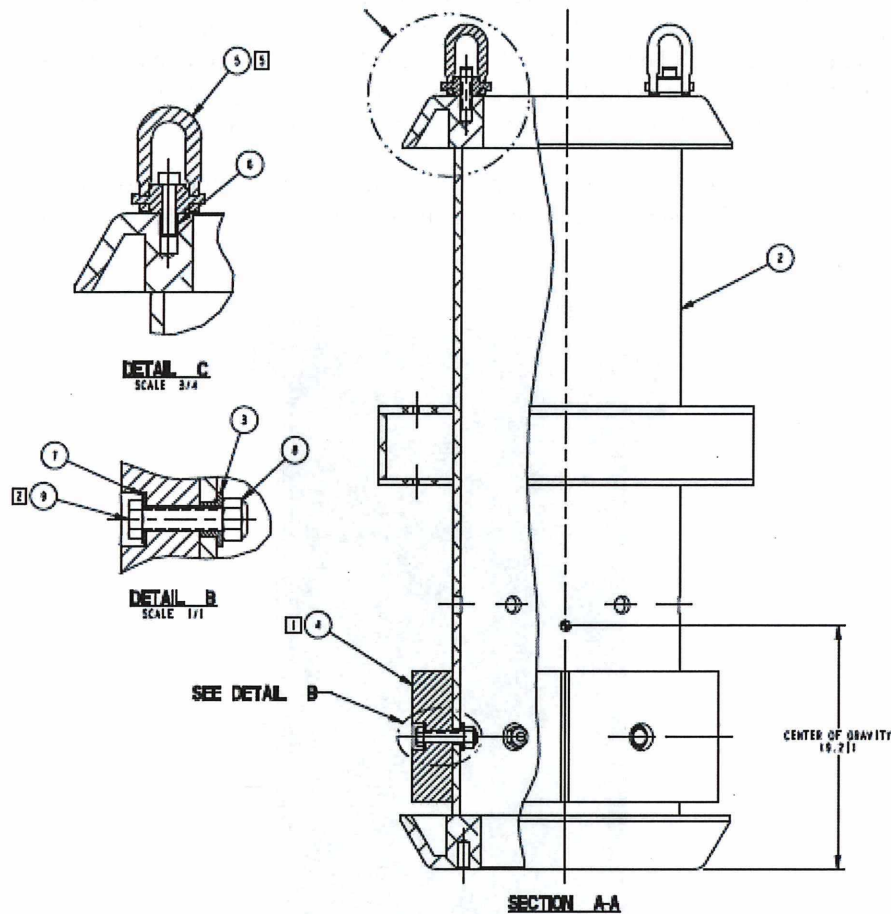
### 3.3.5 Part Weighing

1. Following marking and temp-labeling activities, the following items shall be weighed and the weights shall be recorded for each test unit.
  - CV body
  - CV lid, screws, washers, and O-rings (together)
  - Test fixture weldment, screws, washers, nuts, bushing (together)
  - Test weight sets
  - PCC pad sets
  - CV assembly with test content (weigh during reassembly)
  - Drum body
  - Drum lid assembly, screws, and washers (together)
  - CV base pad and CV flange wedge (together)
  - Test unit assembly (weigh during reassembly)
2. Following the weighing operations, the items shall receive a final inspection by CNS and the TA, digital pictures shall be taken, and then re-assembly shall proceed.  
  
**Note:** CNS shall inspect all markings and TLs, verify weights prior to re-assembly, and witness all re-assembly operations.

### 3.3.6 CV Assembly

1. Each test fixture weldment, fastener parts, and set of test weights shall be weighed, and the weights shall be recorded.

2. The test weight sets shall be installed on their respective test fixture weldments using the corresponding sets of hex head screws, washers, top hat bushings, and locknuts. The test weight and bolting locations that establish the low and high CG locations are documented in Attachment A. The hex head screws and locknuts shall be torqued to 33–37 ft-lb. The heavy test weight installed on the test fixture weldment is shown in Fig. 2.



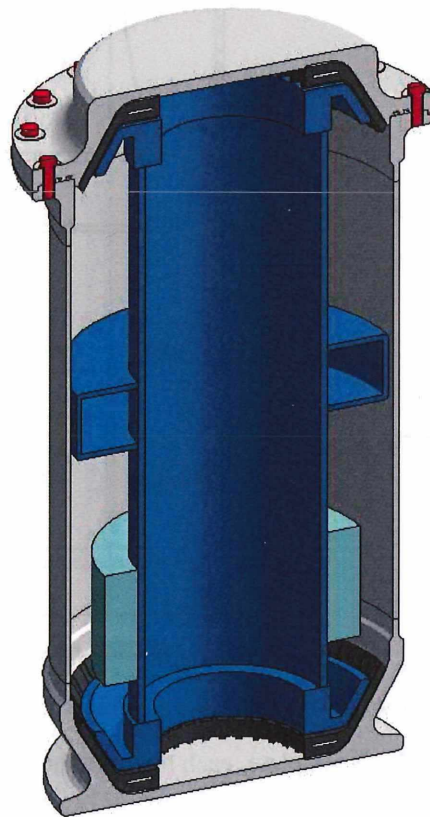
**Fig. 2. Heavy test weights installed on the test fixture weldment.**

3. After the test content assembly is complete, each test content assembly shall be weighed, and the weight shall be recorded.
4. Each set of corresponding PCC pads shall be weighed, and the weight shall be recorded.
5. For test content assemblies corresponding with TU-1 through TU-6, TLs shall be installed on each test content assembly in accordance with Attachment B.
6. For CVs corresponding with TU-1 through TU-6, TLs internal to the CV shall be installed in each CV in accordance with Attachment B.
7. One PCC pad from each set shall be placed in its respective CV base prior to loading the test content assemblies into the CVs. Each test content assembly shall be lifted and positioned using the swivel hoist rings and an adequately rated lifting device. The test content assemblies shall be loaded and clocked such that the 0° marking aligns with the 0° marking on the CVs. The

remaining PCC pad shall be placed on top of the respective test content assembly prior to lowering the CV lid into place. Care shall be taken to ensure the TLs on both the test content assembly or CV are not damaged.

8. The same screws that were removed during disassembly shall be used to close the CV. Additional compressive force may be needed to seat the CV lid to engage the screw threads. The screws shall be torqued in sequence following the numbers etched into the CV lid in three passes. During the first pass the screws shall be torqued to 19–21 ft-lb, during the second pass to 33–37 ft-lb, and during the third pass to 33–37 ft-lb. The final pass torque values shall be recorded. A model of the test fixture assembly and PCC pads loaded in the CV is shown in Fig. 3.

**Note:** Screws and O-rings shall not be replaced without CNS approval. If replacements are authorized, they shall be documented in the test report where the replacements occurred.



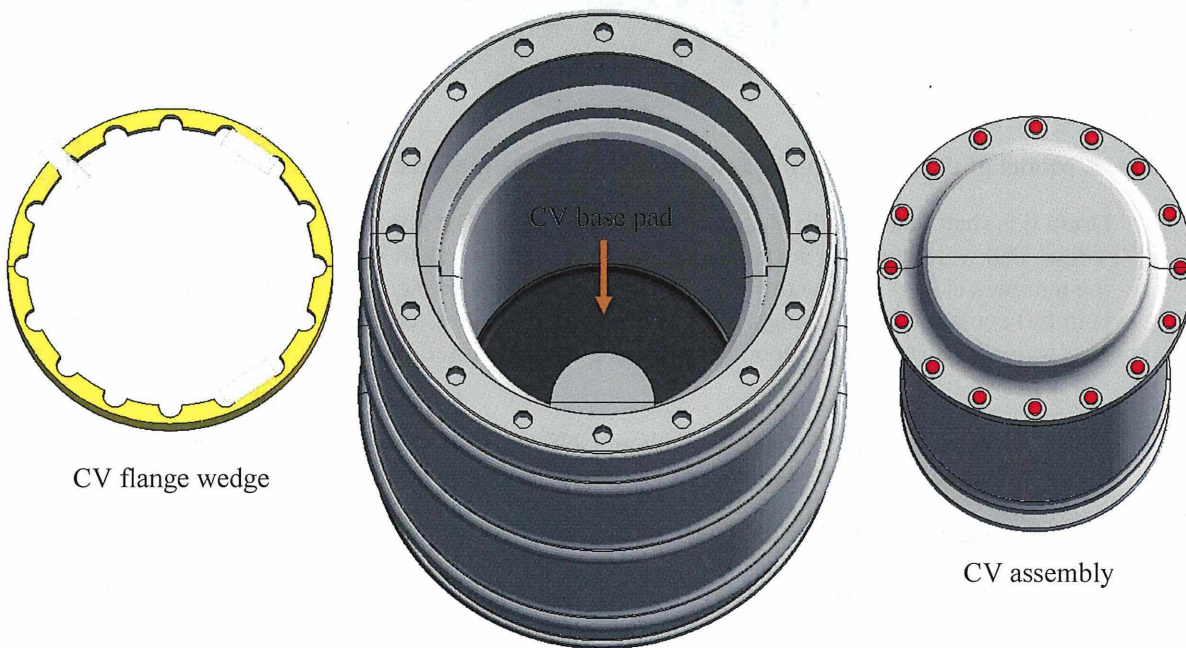
**Fig. 3. Model of test fixture assembly and PCC pads loaded in the CV.**

9. After assembly is complete, each CV assembly with the loaded content shall be weighed, and the weight shall be recorded.
10. The CV assemblies shall receive and pass an operational leak test in accordance with Sect. 7.6 of ANSI N14.5-2014 using the “A.5.2 gas pressure rise” method described in Table A-1.
11. For TU-1 through TU-6, TLs shall be installed on the outer surfaces of each CV assembly in accordance with Attachment B.



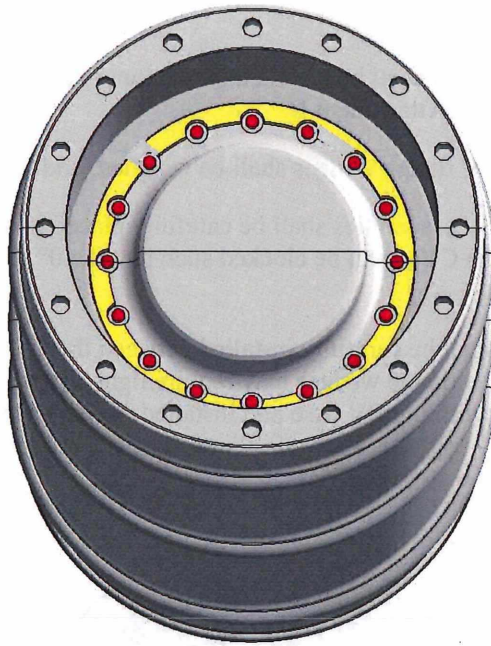
### 3.3.7 Drum Assembly

1. For TU-1 through TU-6, TLs shall be installed on the inner surfaces of each drum body and drum lid liner in accordance with Attachment B.
2. The CV base pads and CV flange wedges shall be weighed, and the weights shall be recorded.
3. The CV base pads and CV assemblies shall be carefully placed inside the drum bodies so that TLs are not damaged. The CVs shall be clocked such that the 0° marking aligns with the 0° marking on the drums.
4. The CV flange wedges shall be carefully installed between the CV flange and drum liner so that TLs are not damaged. The flange wedges may require light tapping to seat them into place. The inside of the drum body with the CV base pad installed, an adjacent (left) CV flange wedge, and an adjacent CV assembly (right) is shown in Fig. 4. The CV assembly and CV flange wedge installed in the drum is shown in Fig. 5.



**Fig. 4. Model of the inside of the drum body with the CV base pad installed including the CV flange wedge (left) and CV assembly (right).**



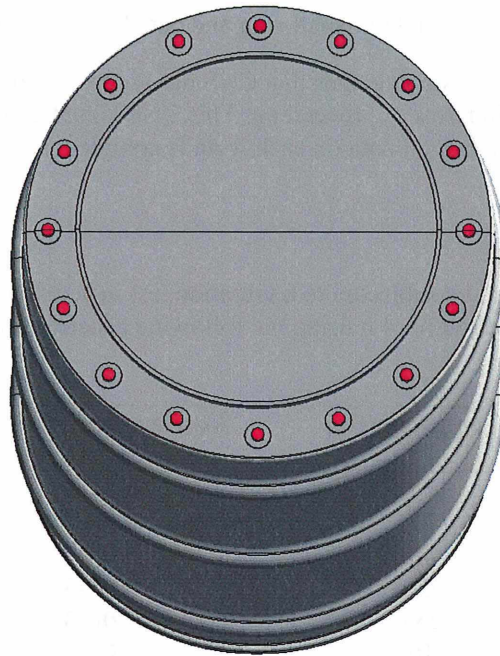


**Fig. 5. Model of the CV assembly and CV flange wedge installed with the drum lid removed.**

5. Drum lids shall be carefully placed on the drum bodies. The lids shall be closed using the same screws that were removed during disassembly. The screws shall be torqued in sequence following the numbers etched into the drum lid in two passes. First, the screws shall be torqued until the lid is in full contact with the flange. Second, the screws shall be torqued to 33–37 ft-lb. The final pass torque values shall be recorded. A model test unit closed with the screws installed is shown in Fig. 6.

**Note:** Screws shall not be replaced without CNS approval. If replacements are authorized, it shall be documented in the test report where the replacements occurred.

6. Assembled test units shall be weighed, and the weights shall be recorded.
7. Data loggers shall be installed on TU-1, TU-2, TU-5, and TU-6 in accordance with Attachment B.
8. At this point, the test units should be assembled, properly documented, and ready for regulatory testing. At this point, all records shall be carefully reviewed by CNS and the TA to ensure that the test units have been prepared and documented correctly.



**Fig. 6. Model of a closed test unit with screws installed.**

### **3.4 TESTING**

#### **3.4.1 General**

1. Regulatory testing requirements are specified in 10 CFR 71.71 (NCT) and 10 CFR 71.73 (HAC), with interpretations and guidelines in SG-600. The TA shall comply fully with these requirements, interpretations, and guidelines. If there is a conflict, potential or otherwise, between CFR requirements, SG-600 interpretations and guidelines, and the requirements stated herein, the TA shall resolve these conflicts with the STR during preparation of the test plan.
2. Digital photographs shall be taken during testing activities to demonstrate compliance with the test plan. These photographs shall be included in the test report as "Photographs taken during testing".
3. The attached testing matrix (Attachment A) identifies the regulatory tests that shall be performed on each test unit as well as their sequence.
4. All tests shall be conducted under ambient conditions except for the cold HAC drop tests for TU- 1 and TU-5 and the burn tests for TU-1 through TU-6.
5. TU-6 shall be subjected to the full series of NCT tests and full series of HAC tests.
6. TU-1 and TU-5 shall be chilled in a freezer for a minimum of 72 h, with the freezer set at  $-70^{\circ}\text{F}$  for 24 h and  $-45^{\circ}\text{F}$  for 48 h. The freezer setting shall remain on  $-45^{\circ}\text{F}$  until the test unit is removed for testing. The freezer shall be calibrated and there shall be evidence that the freezer has not lost power or failed to work properly during the freezing period.
7. The STR and QE shall review, sign, and date each test form after TA personnel have signed.

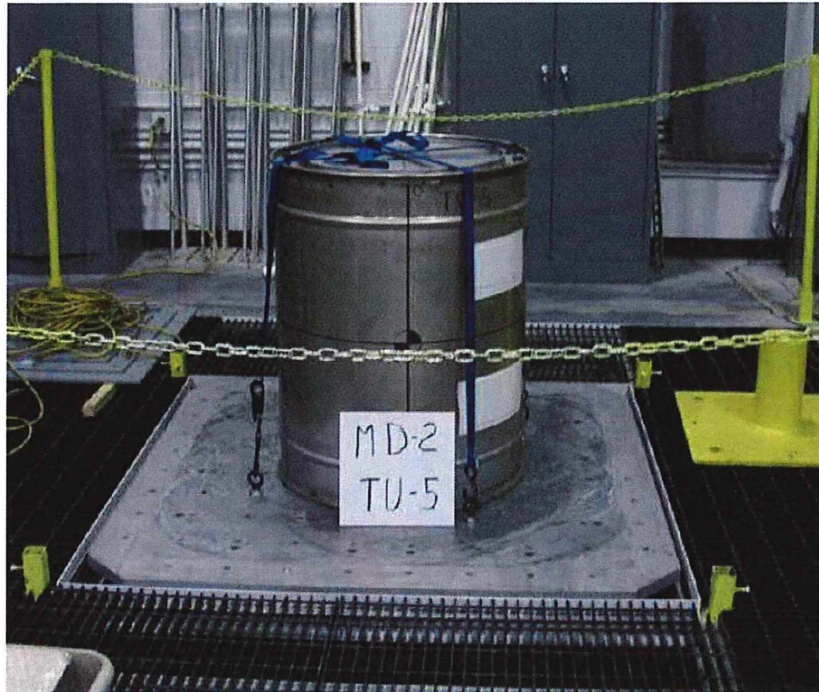
8. Both TA personnel, the STR and QE shall sign and date the forms on the day of their completion.
9. CNS's signature and date acknowledges that CNS has witnessed the activity and feels there are no issues with the data in terms of proceeding. This CNS signature does not relieve the TA of its responsibilities to ensure that all data on each form is complete and accurate.

### 3.4.2 NCT Vibration Test

TU-6 (ambient temperature) shall be subjected to a vibration test in accordance with 10 CFR 71.71(c) (5). The test unit shall be vibration tested for 4 h using the following acceleration spectral density in the vertical direction.

Frequency (Hz)	Acceleration Spectral Density ( $G^2/Hz$ )
1.0	4.0E-3
2.0	3.0E-2
4.0	3.0E-2
6.5	2.0E-3
75.0	2.0E-3
110.0	8.0E-5
380.0	8.0E-5
1000.0	5.0E-6

The test unit shall be secured to the test platform using a tie-down method similar to the one shown in Fig. 7 or an equivalent method approved by CNS. The vibration data logger installed on the drum lid of TU-6 shall be removed and the data captured prior to the water spray test.



**Fig. 7. Example vibration test tie-down method.**

### **3.4.3 NCT Water Spray Test**

TU-6 shall be subjected to a water spray test in accordance with 10 CFR 71.71(c)(6). The CFR requires that test units subjected to the water spray test see a water spray that simulates exposure to rainfall of ~2 in. per h for at least 1 h. The water spray test for TU-6 shall be performed within 1.5 to 2.5 h prior to the 4-ft drop test, as required in the CFR. The drum lid and body shall be fully exposed to the water spray. It is not necessary that the drum bottom be exposed to the water spray.

An example of an acceptable test setup is shown in Fig. 8.





**Fig. 8. Example water spray test setup.**

#### **3.4.4 NCT 4-ft Drop Test**

TU-1 through TU-6 shall be subjected to a 4-ft drop test in accordance with 10 CFR 71.71(c)(7). The CFR requires that test units subjected to the 4-ft drop test strike the impact surface in an orientation that will produce the maximum damage. Maximum damage is considered to be that damage that produces the most risk to the containment boundary. Based on CNS's modeling, several orientations shall be tested as follows.

- TU-1, cold side drop, 0° line marking down, heavy test weight
- TU-2, side drop, 0° line marking down, light test weight
- TU-3, end drop, lid down, lid down, heavy test weight
- TU-4, CG over corner drop, lid down, 0° line marking down, heavy test weight
- TU-5, cold slap down (12°) drop, 0° line marking down, heavy test weight
- TU-6, slap down (12°) drop, 0° line marking down, heavy test weight

The impact data loggers for TU-6 shall be installed prior to the 4-ft drop test. An example of a test setup for a 4-ft side drop test is shown in Fig. 9.

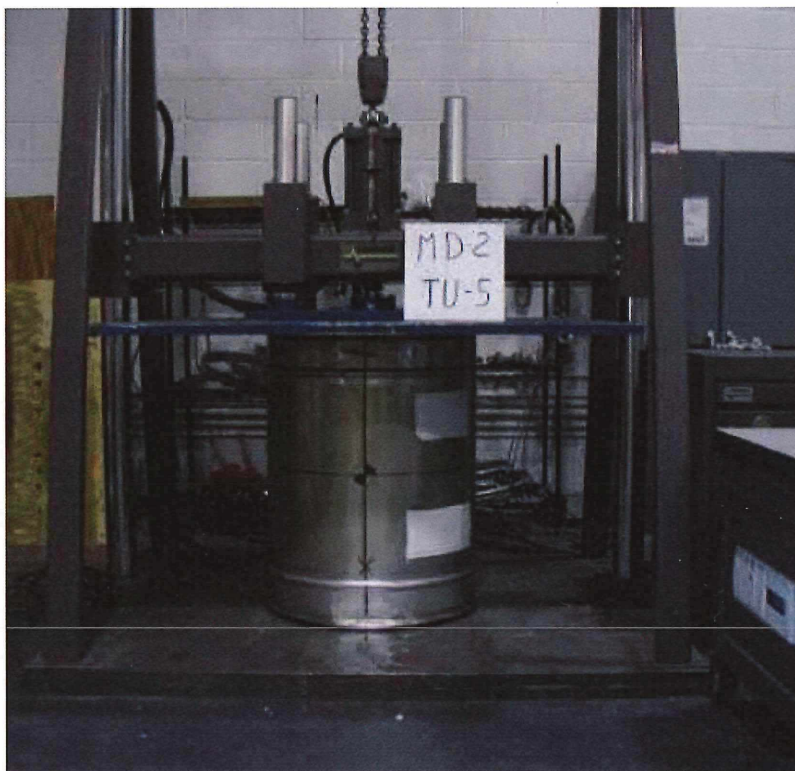


**Fig. 9. Example setup for 4-ft side drop test.**

#### **3.4.5 NCT Compression Test**

TU-6 shall be subjected to a compression test in accordance with 10 CFR 71.71(c) (9). The CFR requires a minimum axial compression force of 5 times the 905 lb maximum gross weight of the test unit (4525 lb) applied uniformly to the top and bottom of the test unit for at least 24 h. The overall drum height and drum diameter at the top, midsection, and bottom shall be measured and recorded before and after the test.

The impact data logger installed on the drum lid of TU-6 shall be removed prior to the compression test, and the data shall be extracted at this point if necessary. An example of an acceptable method is shown in Fig. 10.



**Fig. 10. Example setup for compression test.**

#### **3.4.6 NCT Penetration Test**

TU-6 shall be subjected to a penetration test in accordance with 10 CFR 71.71(c) (10). The CFR requires that test units subjected to the penetration test be impacted where they are most vulnerable to puncture. The most vulnerable area is considered to be on the drum weld seam near the CV flange. The impact area for this test shall be at the "FL" target where the 0 line marking intersects with the CV flange marking on the drum. The impact shall be at the "FL" target and the long axis of the penetration rod shall be perpendicular to the target at impact. An example of this test setup is shown in Fig. 11.





**Fig. 11. Example setup for penetration test.**

### **3.4.7 HAC 30-ft Drop Test**

TU-1 through TU-6 shall be subjected to a 30-ft drop test in accordance with 10 CFR 71.73(c) (1). The CFR requires that test units subjected to the 30-ft drop test strike the impact surface in an orientation that will produce the maximum damage. Maximum damage is considered to be that damage that produces the most risk to the containment boundary. Based on CNS's modeling, several orientations shall be tested as follows.

- TU-1, cold side drop, 0° line marking down
- TU-2, side drop, 0° line marking down
- TU-3, end drop, lid down
- TU-4, CG over corner drop, lid down, 0° line marking down
- TU-5, cold slap down (12°) drop, 0° line marking down



- TU-6, slap down (12°) drop, 0° line marking down

The impact data logger removed from the drum lid of TU-6 shall be reinstalled prior to the 30-ft drop test. An example of a test setup for a 30-ft side drop test is shown in Fig. 12.

Since TU-1 and TU-5 are cold units, all drop tests (4-ft drop, 30-ft drop, 30-ft crush test, and puncture test) shall be completed in less than 3 h after the test unit is removed from its environmental chamber, unless otherwise approved by CNS in advance of the tests.



**Fig. 12. Example setup for 30-ft side drop test.**

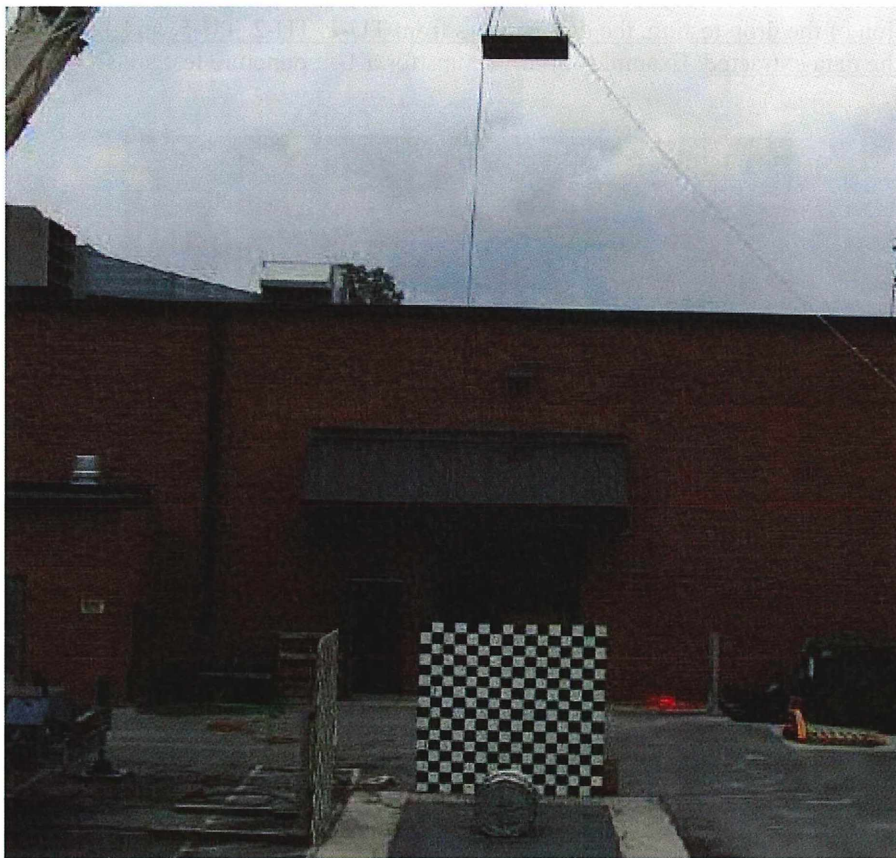
#### **3.4.8 HAC 30-ft Crush Test**

Following the 30-ft drop test, TU-1 through TU-6 shall be subjected to a 30-ft crush test in accordance with 10 CFR 71.73(c)(2). The CFR requires that test units subjected to the 30-ft crush test be positioned

so the plate while falling in a horizontal position strikes the test unit in an orientation that will produce the maximum damage. Since the cumulative effect of multiple impacts in the same damaged area is expected to produce the maximum overall damage, and as a result the most risk to the containment boundary, the test units shall be placed on the drop pad with the 0° line and damaged area facing the drop pad and the 180° line facing the crush plate. The crush plate shall be horizontally positioned and dropped so the CG of the crush plate is aligned with the target on the 180° line upon contact. Based on CNS's modeling, several test unit orientations shall be tested as follows.

- TU-1, cold side drop, 0° line facing pad, 180° line facing plate, plate CG over FL
- TU-2, side drop, 0° line facing pad, 180° line facing plate, plate CG over package CG
- TU-3, end drop, lid facing pad, bottom facing plate, plate CG over package CG
- TU-4, CG over corner drop, lid down, 0° line facing pad, 180° line facing plate, plate CG over package CG
- TU-5, cold side drop, 0° line facing pad, 180° line facing plate, plate CG over FL
- TU-6, side drop, 0° line facing pad, 180° line facing plate, plate CG over FL

An example of a test setup for a 30-ft side crush test is shown in Fig. 13.



**Fig. 13. Example setup for 30-ft side crush test.**



### 3.4.9 HAC Puncture Test

Following the 30-ft crush test, TU-1 through TU-6 shall be subjected to a 1-m puncture test in accordance with 10 CFR 71.73(c)(3). The CFR requires that test units subjected to the puncture test strike the punch in an orientation that will produce the maximum damage and the most risk to the containment boundary during thermal testing. Damage nearest to the CV flange will produce the highest risk to containment due to higher O-ring temperatures during thermal testing. Since the cumulative effect of multiple impacts in the same damaged area is expected to produce the maximum overall damage, the test units shall be positioned and dropped so the damaged area from the previous drop tests will contact the punch. Several test unit orientations shall be tested as follows.

- TU-1, cold side drop, 0° line facing punch, FL over punch
- TU-2, side drop, 0° line facing punch, CG over punch
- TU-3, end drop, lid facing punch, bottom facing up, CG over punch
- TU-4, CG over corner drop, lid down, 0° line facing punch, CG over punch
- TU-5, cold side drop, 0° line facing punch, FL over punch
- TU-6, side drop, 0° line facing punch, CG over punch

Upon completion of the drop testing, the data loggers from TU-1, TU-2, TU-5, and TU-6 shall be removed and the data extracted. Examples of test setups for a 1-m puncture test are shown below in Fig. 14 and Fig. 15.



**Fig. 14. Example setup for 1-m puncture test, CG over punch.**



**Fig. 15. Example setup for 1-m puncture test, FL over punch.**

#### **3.4.10 HAC Thermal (Burn) Test**

1. TU-1 through TU-6 shall be subjected to a furnace burn test in accordance with 10 CFR 71.73(c) (4). The test method shall be based on and shall closely follow Sect. 7.3 of American Society for Testing and Materials (ASTM) E2230-13.
2. Six TCs shall be installed on the exterior surface of the drum body and lid of TU-1 through TU-6 (four located around the mid-section at the 0° line, 90°, 180°, and 270°; one located in the center of the bottom; and one located in the center of the lid).
3. Each test unit shall be preheated at 150°F for 24 h and then soaked at 110°F for an additional 24 h. The test unit shall remain at the soaking temperature until the test unit is removed for TC installation and testing. An example of a pre-heat chamber setup is shown in Fig. 16.
4. Each test unit shall be placed on the support stand in a horizontal orientation, with the 0° line marking facing the furnace floor and the lid facing the right hand wall of the furnace. An example of this setup is shown in Fig. 17.
5. CNS will provide the TA a representative DPP-1 test unit, referred to as the SDPP1 unit, to setup and qualify its furnace. The TA shall install external TCs on the SDPP1 unit and connect the TCs to the data acquisition and monitoring system exactly as planned for the test units. When the TA feels its furnace is ready to burn test units, the TA shall contact CNS for a demonstration.

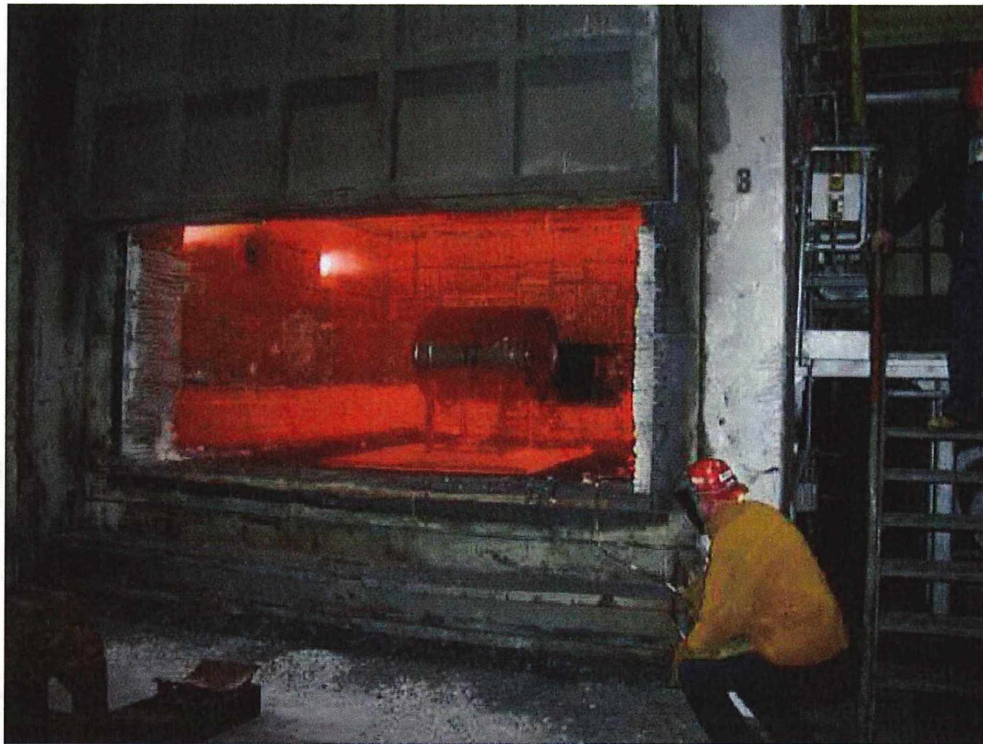
**Note:** CNS will consider the furnace qualified and ready for burning the test units when all TCs on the SDPP1 unit and the average temperature of the side wall TCs read between 1475 to 1600°F within 12 minutes of closing the furnace and all TCs read within this range for the duration of the burn test.



6. Other requirements for furnace hardware, setup, testing, and data recording are provided in Attachment C.



**Fig. 16. Example setup for pre-heating test units prior to furnace testing.**



**Fig. 17. Example setup for test unit in furnace.**

#### **3.4.11 Post-test Inspection**

1. Following the burn test, TU-1 through TU-6 shall be weighed and visually inspected. External anomalies that occurred during or after the burn test shall be documented with photographs and text.
2. Following the post-burn-test inspection, each test unit shall be disassembled down to the CV assembly. The inside surfaces of the drum bodies and lids and the external surfaces of the CV assemblies shall be visually inspected and all anomalies shall be documented with photographs and text.

**Note:** Removal of the CVs from most if not all of the drums will be a challenging effort. Most drums will be compressed inward around the CV, making it impossible to remove the CVs from the lid opening. In most cases, the drum bottom must be carefully removed and the CV must be pulled out from that end.

3. All visible TLs shall be read and the values shall be recorded.

#### **3.4.12 Post-test CV Operational Leak Test**

A post-test operational leak test shall be performed on the CVs in all test units in accordance with Sect. 7.6 of ANSI N14.5-2014 using the "A.5.2 gas pressure rise" method described in Table A-1. The test requirement is no detected leakage when tested to a sensitivity of at least  $1\text{E-}3 \text{ atm-cm}^3/\text{s}$ . This test shall be performed prior to the helium leak test. Each CV shall be at room temperature when conducting this test. A typical setup for this test is shown in Fig. 18.





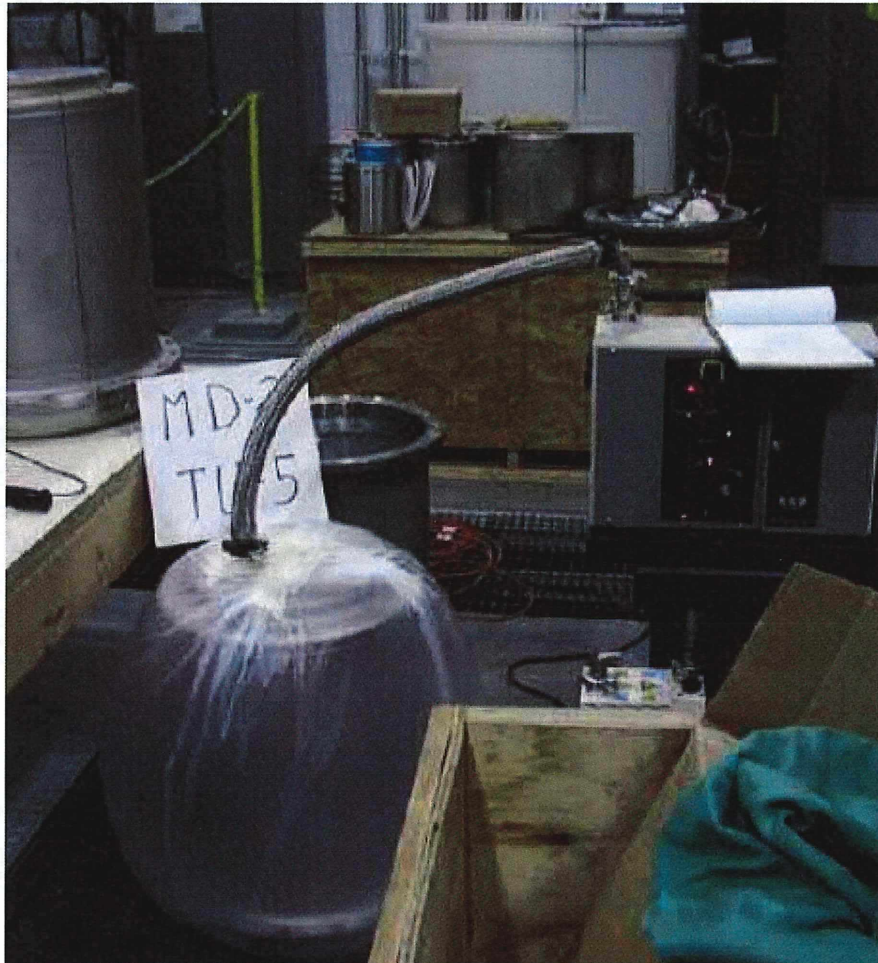
**Fig. 18. Example setup for operational leak test.**

### 3.4.13 Post-test CV Helium Leak Test

10 CFR 71.51 requires that there be no escape of radioactive materials following HAC testing that exceeds a total amount of  $A_2$  in one week. In order to demonstrate compliance with this requirement, a helium leak test shall be performed on the CVs in TU-1 through TU-6 following HAC thermal testing to demonstrate leak tight conditions in accordance with Sect. 7.5 of ANSI N14.5-2014 using the “A.5.3 gas filled envelope” method described in Table A-1. This test shall be performed after the post-test operational leak test and prior to the 3-ft water immersion test. The leak test port plug shall be removed for this test. Each CV shall be at room temperature when conducting this test.

**Note:** The CVs shall be leak checked to a sensitivity of  $< 5 \times 10^{-8} \text{ cm}^3 \text{ He/sec}$ . Each CV shall be prepared for the test by drilling a hole in the top of the CV body and tapping for a 1/4-in. NPT tapered pipe thread. Tapping lubricant in paste form shall be used rather than a tapping fluid to prevent the fluid from spreading to interior surfaces of the CV and inner O-ring. A K-flange adapter shall be screwed into this hole with a fast setting epoxy on the threads. After the epoxy hardens, the mass spectrometer helium leak tester shall be connected to the adapter and the vacuum pump shall evacuate the CV to  $< 100 \text{ mTorr}$ . The CV shall be enclosed in a plastic bag and evacuated to reduce the ambient air in the bag. A constant flow of helium gas shall be introduced into the bag to ensure that the CV

is fully surrounded in helium during the test. The helium atmosphere shall be maintained for at least 20 minutes. An example of this test setup is shown in Fig. 19.

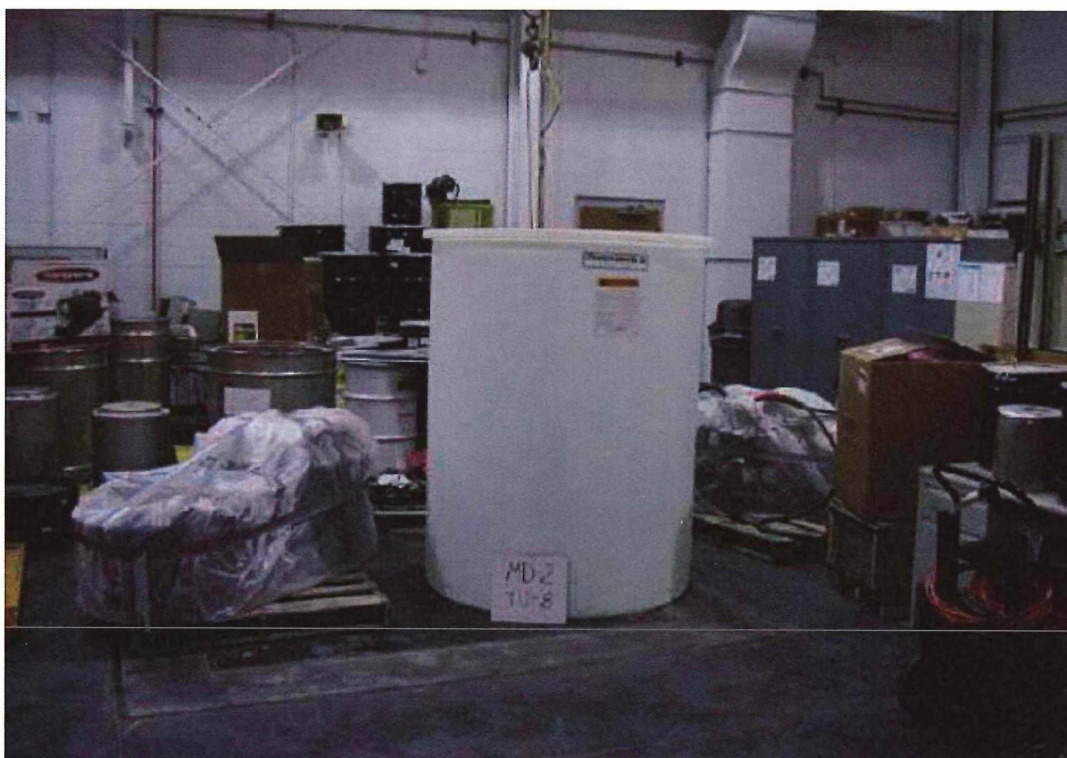


**Fig. 19. Example setup for helium leak test.**

#### **3.4.14 3-ft Water Immersion Test**

1. After the CVs from TU-1 through TU-6 have been subjected to the helium leak test and pass, the CVs shall be subjected to a 3-ft water immersion test in accordance with 10 CFR 71.73(c)(5). The CFR requires that CVs subjected to this test be in an orientation that will produce the maximum leakage. This orientation is considered to be in the horizontal position. Following the helium leak test, each CV shall be immersed in water with a head pressure equivalent to at least 3 ft for at least 8 h in the horizontal position. The leak test port plug shall be removed for this test. After immersion, each CV shall be dried, opened, and visually evaluated for signs of water ingress. A process approved by CNS in advance (utilizing fans, plant air pressure, mild heat, vacuum suction, etc.) shall be applied to the flange joint and space between the O-rings prior to opening each CV to ensure excess moisture has been removed. If water is present inside the inner O-ring upon opening, the TA shall stop work on this activity and contact the STR immediately for resolution. An example of this test setup is shown in Fig. 20 and Fig. 21.





**Fig. 20. Example tank for 3-ft water immersion test.**



**Fig. 21. Two example CVs being subjected to 3-ft water immersion test.**

2. After the CVs have been subjected to the water immersion test, they shall be opened and the test content assembly shall be removed.
3. The CVs shall be examined for any signs of water inside the inner O-ring, which constitutes a failure of the immersion test.
4. TLs internal to the CV shall be recorded, and any visible anomalies shall be documented with photographs and text.

#### **3.4.15 50-ft Water Immersion Test**

After the CV from TU-7 (undamaged) has been subjected to the operational leak test and passes, the CV shall be subjected to a head of water of at least 50-ft or an equivalent pressure of 21.7 psig in accordance with 10 CFR 71.73(c) (6) for at least 8 h in the lid down position. The leak test port plug shall be removed for this test. After immersion, each CV shall be dried, opened, and visually evaluated for signs of water. A process approved by CNS in advance (utilizing fans, plant air pressure, mild heat, vacuum suction, etc.) shall be applied to the flange joint and space between the O-rings prior to opening each CV to ensure excess moisture has been removed. If water is present inside the inner O-ring upon opening, the TA shall stop work on this activity and contact the STR immediately for resolution.

### **3.5 TEST REPORT**

1. The test report shall have a unique number that is assigned by the TA for its records.
2. The document title shall be "Test Report for DPP-1 Regulatory Compliance Testing".
3. From a format, presentation, content, and level of detail standpoint, the TA's test report shall be similar to the original NTRC test report prepared for the MD-2 package (ORNL/NTRC-027/V1, V2, and V3, Rev. 0, 3-7-2008), unless approved otherwise by CNS. This document will be provided to the TA with this SOW.
4. The test report shall be submitted to the STR for CNS review prior to issuance to ensure that the format, presentation, and content are acceptable

### **3.6 DEVIATIONS AND WAIVERS**

#### **3.6.1 RFWDs**

1. After award, if a waiver or deviation from the specified requirements is desired, then the Supplier shall submit to the Company a Request for Waiver or Deviation form: (UCN-13816B). The Company will provide this form upon request.
2. Use the UCN-13816B form to request permission to change or deviate from the specified requirements; obtain Company approval before proceeding with any changes.
3. Email the completed form to the STR.
4. Use the form to report any of the following conditions:
  - a. A request for deviation from the contract requirements.



- b. Anytime a requirement contained within the original specification or a contract modification approved by the Company is violated.
- c. There is nonconformance that cannot be corrected unless an item or process is modified, reworked, or repaired to an equivalent functional condition.
- d. A request for Company approved substitutions shall be submitted using the RFWD form for Company approval prior to implementation. Adequate information shall be provided with the request so that the Company can determine if the item is equivalent.

### 3.6.2 TPCRs

Requested exceptions, deviations, or proposed changes to the requirements in the approval data documents after the test plan has been approved by CNS, including changes in CNS approved personnel, shall be submitted to the STR using a TPCR form. An electronic version of this form will be provided by the STR upon request.

### 3.7 DELIVERABLES

1. The TA shall provide CNS a pdf copy of all approval data documents for CNS review and approval. These documents shall be submitted to the STR by a mutually agreed upon date that is consistent with CNS's needs and the TA's ability to provide the documentation. These documents shall be submitted to the STR via e-mail or USB thumb drive.
2. The TA shall provide the STR a detailed weekly schedule of activities and durations so CNS can finalize its surveillance activities. As a minimum, the schedule shall identify the activities between the hold points. The schedule shall be submitted to the STR with the test plan for CNS review and approval.
3. The TA shall provide the STR a weekly status report via e-mail on Monday of each week for the previous week's work. The report shall provide status against the schedule and the budget. If the schedule needs to change, the TA shall include an updated schedule with the report and a justification/explanation for the change.
4. After testing is complete, the TA shall issue a test report that addresses all activities in the test plan. The TA shall provide the STR a pdf copy via e-mail or USB thumb drive of the PRELIMINARY test report documents for CNS review prior to issuance. The purpose of this review is to ensure completeness and accuracy based on CNS's observations and records during testing. The TA shall provide the STR a pdf copy via e-mail or USB thumb drive of the FINAL test report documents.
5. After testing is complete and the test report has been issued, all CNS government furnished equipment items will be picked up by CNS and will be placed in CNS storage. The TA shall prepare all of these items for pickup.
6. All test materials and test equipment items purchased specifically for this work by the TA (TLs, fixtures, slings, tools, etc.), are considered to be property of CNS since they were purchased against this subcontract. All such items shall be delivered to CNS upon completion of this work, unless agreed otherwise in writing by both parties.

#### **4. QUALITY ASSURANCE REQUIREMENTS**

In order to do this work, the TA must be on CNS's Quality Approved Supplier List (QASL) as an approved provider of compliance testing services for Type B shipping packages. If the Offeror is not on the QASL, CNS will evaluate its QA program prior to subcontract award for compliance with 10 CFR 71, Subpart H. If the QA program is acceptable, the Offeror will be included on the QASL.

##### **4.1 PRICE ANDERSON AMENDMENTS ACT**

The Price-Anderson Amendments Act applies to this work because nuclear safety and/or public safety issues are involved with DPP-1 packages.

##### **4.2 QUALITY ASSURANCE REQUIREMENTS**

As a minimum, the TA's QA program shall comply with the following:

- Subpart H of 10 CFR 71 (Quality Assurance)
- Section 4 of SG-600 (Quality Assurance Requirements for Testing Programs)

The TA shall conduct all work in accordance with the QA program, QA plan, implementing procedures, and other approval data documents approved by CNS. As noted earlier, a copy of SG-600 will be provided to the TA with this SOW.

Inspection, Measuring and Test Equipment shall be calibrated and certified by an organization with ISO 17025 accreditation, or Y-12 approved equal, and traceable to the National Institute of Standards.

Where inspection or test equipment yields quantitative readings, actual measurements and deviation from nominal readings shall be recorded.

#### **5. DOCUMENT REQUIREMENTS**

##### **5.1 GENERAL REQUIREMENTS**

Documents shall be provided to CNS in accordance with the requirements of this SOW. A Submittal Checklist that corresponds with the following sections is provided in Attachment D.

##### **5.2 SUBMITTALS WITH THE PROPOSAL FOR CNS APPROVAL**

The following submittals are required with the offer for CNS approval.

- Basis for the offer, including a list of the primary activities and the estimated costs for each.
- List of planned subtiers (e.g., subtier testing agencies), including the work planned for each.
- Level 1 schedule showing major activities from date of award, durations, and dates when the test plan will be issued, when each test will be complete, and when the FINAL test report will be issued.



### **5.3 SUBMITTALS PRIOR TO COMMENCING WORK FOR CNS APPROVAL**

The following submittals are required prior to test unit preparation for CNS approval.

- Level 2 Microsoft Project schedule, or CNS approved equivalent, showing a level of detail sufficient to status the work on a weekly basis. A CNS hold point will need to be incorporated into the schedule prior to final approval.
- Approval data documents listed in Sect. 3.1
- RFWDS if applicable (prior to issuance of test plan)

### **5.4 SUBMITTALS PRIOR TO TESTING FOR CNS APPROVAL**

The following submittals are required during test unit preparation and physical testing.

- TPCRs as necessary (after test plan is issued)

### **5.5 SUBMITTALS PRIOR TO FINAL ACCEPTANCE**

The following submittals are required after physical testing is complete.

- PRELIMINARY test report for CNS review prior to issuance
- FINAL test report
- USB drive with photographs and high-speed videos

### **5.6 RFWDS**

Approved RFWDS shall be included as attachments to the test plan.

### **5.7 SCHEDULE**

The TA shall provide two schedules: One with the offer and one with the test plan.

1. A level 1 (milestone) schedule shall be provided with the offer that shows when the test plan will be issued, when each test will be complete, and when the FINAL test report will be issued.
2. A level 2 (detailed) schedule shall be provided with the test plan that shows a level of detail sufficient to status the work on a weekly basis. This schedule shall be a Microsoft Project schedule, or CNS approved equivalent. A CNS hold point will need to be incorporated in to the schedule prior to final approval.

## **6. SITE CONDITIONS**

Not applicable.

## **7. ACCEPTANCE CRITERIA**

CNS's acceptance of this work will be based on the results of CNS's quality surveillance and the quality of the test report in terms of format, presentation, completeness, and accuracy.

## **7.1 QUALITY CATEGORY AND QUALITY LEVEL**

**Note:** The information in this section is for CNS use only.

The Quality Category for this work is A. The Quality Level for this work is Q.

## **8. ATTACHMENTS**

Attachment A: Test Matrix for DPP-1 Test Units

Attachment B: DPP-1 Test Units—Instrumentation Requirements

Attachment C: DPP-1 Test Units—Thermal Testing Requirements

Attachment D: Submittal Checklist

## ATTACHMENT A: TEST MATRIX FOR DPP-1 TEST UNITS

The numbers in each column indicate the applicable activities and their sequence for each test unit.

**Table A.1 Test Matrix for DPP-1 Test Units**

	TU-1	TU-2	TU-3	TU-4	TU-5	TU-6	TU-7
Regulatory test	HAC <sup>a</sup>	HAC	HAC	HAC	HAC	NCT <sup>b</sup> /HAC	-
Temperature	Cold	Ambient	Ambient	Ambient	Cold	Ambient	Ambient
Test weight	Heavy	Light	Heavy	Heavy	Heavy	Heavy	None
Test weight CG <sup>c</sup>	High	Low	Low	High	High	Low	-
Drop orientation	Side	Side	Top	CGoTC <sup>d</sup>	Slapdown	Slapdown	-
<b>Preparation</b>							
Mark outside	1	1	1	1	1	1	1
Disassemble	2	2	2	2	2	2	2
Mark part & subassemblies	3	3	3	3	3	3	
Install TLs <sup>e</sup>	4	4	4	4	4	4	
Weigh parts & assemblies	5	5	5	5	5	5	3
Leak test CVs <sup>f</sup> (operational)	6	6	6	6	6	6	4
Assemble	7	7	7	7	7	7	
Install impact DLs <sup>g</sup>	8	8	8	8	8		
Install vibration DL						8	
Chill test unit (-40°F)	9				9		
<b>NCT tests</b>							
Vibration						9	
Remove DL & capture data						10	
Water spray						11	
Install impact DL						12	
4-ft drop	10	9	9	9	10	13	
Remove DL & capture data						14	
Compression						15	
Penetration						16	
Install impact DLs						17	
<b>HAC tests</b>							
30-ft drop	11	10	10	10	11	18	
Crush	12	11	11	11	12	19	
Puncture	13	12	12	12	13	20	
Measure deformations	14	13	13	13	14	21	
Remove DLs & capture data	15	14	14	14	15	22	
Install TCs <sup>h</sup> on drum & preheat	16	15	15	15	16	23	
Thermal test	17	16	16	16	17	24	
Capture TC data	18	17	17	17	18	25	
<b>Post-test inspection</b>							

	TU-1	TU-2	TU-3	TU-4	TU-5	TU-6	TU-7
Regulatory test	HAC <sup>a</sup>	HAC	HAC	HAC	HAC	NCT <sup>b</sup> /HAC	-
Temperature	Cold	Ambient	Ambient	Ambient	Cold	Ambient	Ambient
Test weight	Heavy	Light	Heavy	Heavy	Heavy	Heavy	None
Test weight CG <sup>c</sup>	High	Low	Low	High	High	Low	-
Drop orientation	Side	Side	Top	CGoTC <sup>d</sup>	Slapdown	Slapdown	-
Disassemble down to CV	19	18	18	18	19	26	5
Read TLs	20	19	19	19	20	27	
Leak test CV (operational)	21	20	20	20	21	28	6
Leak test CV (He)	22	21	21	21	22	29	
3-ft CV immersion	23	22	22	22	23	30	
50-ft CV immersion							7
Disassemble CV	24	23	23	23	24	31	8
Inspect for water	25	24	24	24	25	32	9
Remove test content assembly	26	25	25	25	26	33	10
Read TLs & inspect	27	26	26	26	27	34	

<sup>a</sup> HAC – hypothetical accident conditions

<sup>b</sup> NCT – normal conditions of transport

<sup>c</sup> CG – center of gravity

<sup>d</sup> CGoTC – center of gravity over top corner

<sup>e</sup> TL – temperature label

<sup>f</sup> CV – containment vessel

<sup>g</sup> DL – data logger

<sup>h</sup> TC – thermocouple



## ATTACHMENT B: DPP-1 TEST UNITS—INSTRUMENTATION REQUIREMENTS

### B.1 MATERIAL REQUIREMENTS

This attachment defines the requirements of the DPP-1 hardware modifications, temperature labels (TLs), data loggers (DLs), thermocouples (TCs), and supporting hardware for 10 CFR 71 certification drop testing. Each test unit (TU) defined in Attachment A shall be set up uniquely to survive the certification testing while minimizing damage to the instrumentation.

The following products are recommended for the instrumentation hardware. Any change from the recommended hardware items must be evaluated by Consolidated Nuclear Security, LLC (CNS) before being allowed.

#### 1. Temperature labels

Description: The total number for each test unit is provided in Table B.1. Different labels are used throughout the shipping package.

Model No.: TL-10-105, TL-10-190, and TL-10-290.

Supplier:  
One Omega Drive  
P.O. Box 4047  
Stamford, Connecticut 06907-0047  
Phone: (800) 848-4286  
Fax: (203) 359-7700

**TL-10 SERIES, 10-Temperature Range Labels**  
54 x 18 mm (2.1 x 0.7")

Model No.	Temperature Range										
TL-10-105(*)	°F	105	110	115	120	130	140	150	160	170	180
	°C	40	43	46	49	54	60	66	71	77	82
TL-10-190(*)	°F	190	200	210	220	230	240	250	260	270	280
	°C	88	93	99	104	110	116	121	127	132	138
TL-10-290(*)	°F	290	300	310	320	330	340	350	360	370	380
	°C	143	149	154	160	166	171	177	182	188	193
TL-10-390(*)	°F	390	400	410	420	435	450	465	480	490	500
	°C	199	204	210	216	224	232	241	249	254	260

\* Insert "-10" for package of 10 or "-30" for package of 30.

Ordering Example: TL-10-105-30, 10 temperature range labels (105, 110, 115, 120, 130, 140, 150, 160, 170, 180°F), package of 30.

#### 2. Teflon tape

Description: Used to cover TLs facing the foam 400°F optically clear high temperature FEP tape (Teflon®). The amount can be determined from the tables and figures that follow.

Part No.: 7562A15

Supplier:  
McMaster-Carr  
atl.sales@mcmaster.com

#### 3. Data loggers

Description: Used to collect acceleration, temperature, and pressure data. The total number for each test unit is provided in Table B.2.

Models: Slam Stick X – Metal (100g, 8GB) for vibration testing  
Slam Stick S (2000g, 8GB) for impact testing

Supplier:

Mide Technology  
 475 Wildwood Avenue  
 Woburn, MA 01801, USA  
 Phone: (781) 306-0609

#### 4. Adhesive

Description: May be used to attach the data loggers to the package. For removal apply nitromethane or acetone to the Loctite.

Model: Loctite® Instant-Bonding Adhesive #422,

Part No.: 74985A67

Supplier:  
 McMaster-Carr  
 atl.sales@mcmaster.com

#### 5. Thermocouples

Description: Described in Attachment C. The total number for each test unit is provided in Table B.3.

### B.2 LOCATIONS AND INSTALLATION

All TUs subjected to the HAC thermal test (TU-1 through TU-6) shall have the same TLs and locations shown in Table B.1.

1. Omega TLs shall be used. Labels and locations are defined in the figures and Table B.1 that follow. The counting starts on the lower section of the innermost content and rotates clockwise at 0°, 90°, 180°, and 270° looking from the top to the next outer assembly. Upon completion and disassembly of these test units, the blacked out numbers shall be recorded in the “°F” boxes in Table B.1.
2. Test content assembly shall have TL-10-105 and TL-10-190 installed at the locations shown on Fig. B.1.
3. The CV body and base shall have TL-10-105 and TL-10-190 installed at the locations shown on Fig. B.2 and Fig. B.3. TLs located on the outside of the CV shall be covered with high temperature Teflon® tape.
4. The drum lid and body shall have TL-10-190 and TL-10-290 TLs installed at the locations shown on Fig. B.4 and Fig. B.5. These TLs shall be covered with high temperature Teflon® tape.
5. The CV shall be installed into the drum body such that the angle line markings are aligned.

TU-1, TU-2, TU-5, and TU-6 subjected shall have the data loggers installed on the drum assembly exterior at the locations shown in Table B.2. In addition, the following rules apply.

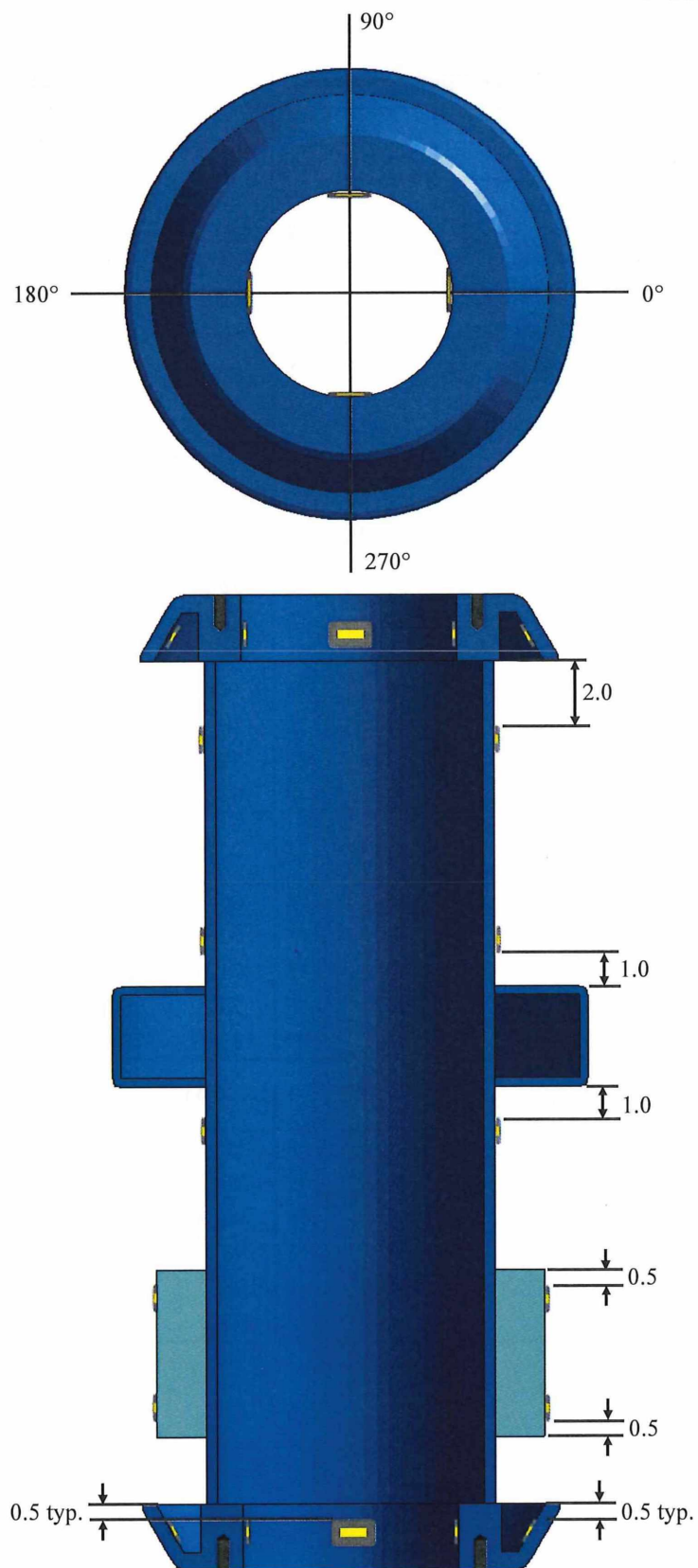
1. For TU-1, TU-2, and TU-5, impact data loggers (Slam Stick S) shall be installed prior to the 4-ft drop test and shall be removed following the puncture test. The measured data for all drops shall be captured.
2. For TU-6, a vibration data logger (Slam Stick X – Metal) shall be installed on the lid prior to the vibration test. The measured data for the vibration test shall be captured. Following the vibration test, the vibration data logger shall be removed to conduct the water spray test. Then, prior to the 4-ft drop, impact data loggers (Slam Stick S) shall be installed at the locations shown in Table B.2. The measured data for the 4-ft drop shall be captured. Following the 4-ft drop, the impact data logger located on the drum lid shall be removed to conduct the compression and penetration tests to prevent damage to the data logger. Then, the impact data logger previously removed from the drum lid shall be reinstalled prior to the remaining drop tests. The measured data for all remaining drops shall be captured.
3. Steps must be taken to ensure the data loggers are sampling at an appropriate rate and have sufficient battery to record the previously specified drop and vibration tests.

All TUs subjected to the HAC thermal test (TU-1 through TU-6) shall have the same TCs installed at the same locations on the drum assembly exterior as shown in Table B.3. The TCs shall be installed after the drop testing prior to performing the thermal test. See Attachment C for further detail.

**Table B.1 Temperature label (TL) number and location**

<b>Test content assembly [TL-10-105 and TL-10-190]</b>	<b>0°</b>		<b>90°</b>		<b>180°</b>		<b>270°</b>	
Top end cap center	1	°F	2	°F	3	°F	4	°F
Top end cap under flange	5	°F	6	°F	7	°F	8	°F
Tube upper	9	°F	10	°F	11	°F	12	°F
Tube middle	13	°F	14	°F	15	°F	16	°F
Tube lower	17	°F	18	°F	19	°F	20	°F
Bottom end cap under flange	21	°F	22	°F	23	°F	24	°F
Bottom end cap center	25	°F	26	°F	27	°F	28	°F
Weight upper	29	°F	30	°F	31	°F	32	°F
Weight lower	33	°F	34	°F	35	°F	36	°F
<b>CV (inside) [TL-10-105 and TL-10-190]</b>	<b>0°</b>		<b>90°</b>		<b>180°</b>		<b>270°</b>	
Lid center	37	°F	38	°F	39	°F	40	°F
Body flange	41	°F	42	°F	43	°F	44	°F
Wall upper	45	°F	46	°F	47	°F	48	°F
Wall middle	49	°F	50	°F	51	°F	52	°F
Wall lower	53	°F	54	°F	55	°F	56	°F
Base neck	57	°F	58	°F	59	°F	60	°F
Base center	61	°F	62	°F	63	°F	64	°F
<b>CV (outside) [TL-10-105 and TL-10-190]</b>	<b>0°</b>		<b>90°</b>		<b>180°</b>		<b>270°</b>	
Lid center	65	°F	66	°F	67	°F	68	°F
Lid flange	69	°F	70	°F	71	°F	72	°F
Body flange	73	°F	74	°F	75	°F	76	°F
Base neck	77	°F	78	°F	79	°F	80	°F
Base toe	81	°F	82	°F	83	°F	84	°F
<b>Drum assembly (inside) [TL-10-190 and TL-10-290]</b>	<b>0°</b>		<b>90°</b>		<b>180°</b>		<b>270°</b>	
Drum lid bottom	85	°F	86	°F	87	°F	88	°F
Cavity wall upper	89	°F	90	°F	91	°F	92	°F
Cavity wall middle	93	°F	94	°F	95	°F	96	°F
Cavity wall lower	97	°F	98	°F	99	°F	100	°F
Cavity wall lowest	101	°F	102	°F	103	°F	104	°F
Cavity bottom	105	°F	106	°F	107	°F	108	°F





**Fig. B.1. Temperature label locations for test content assemblies (36 total TCs).**

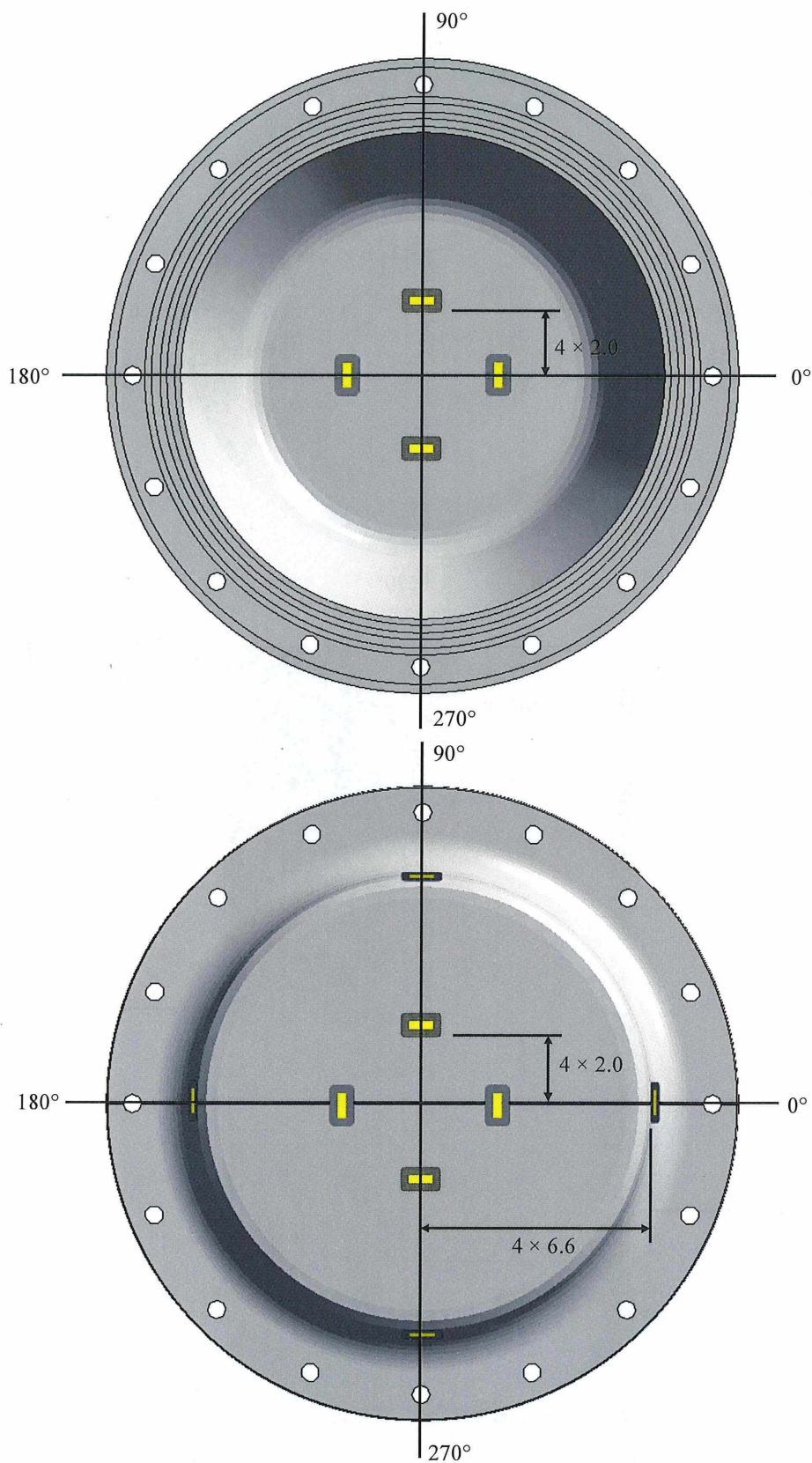


Fig. B.2. Temperature label locations for CV lids (12 total TCs).

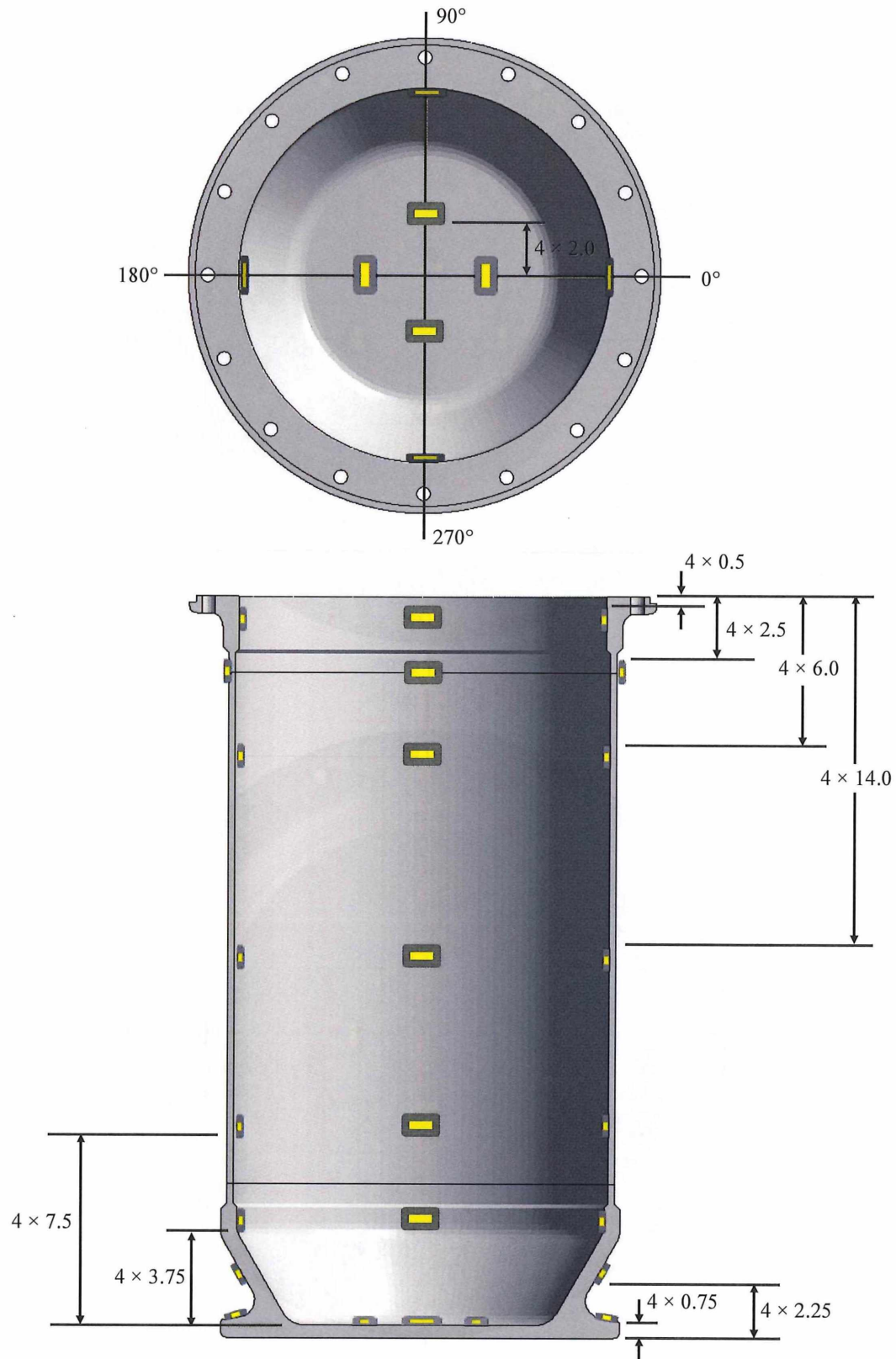
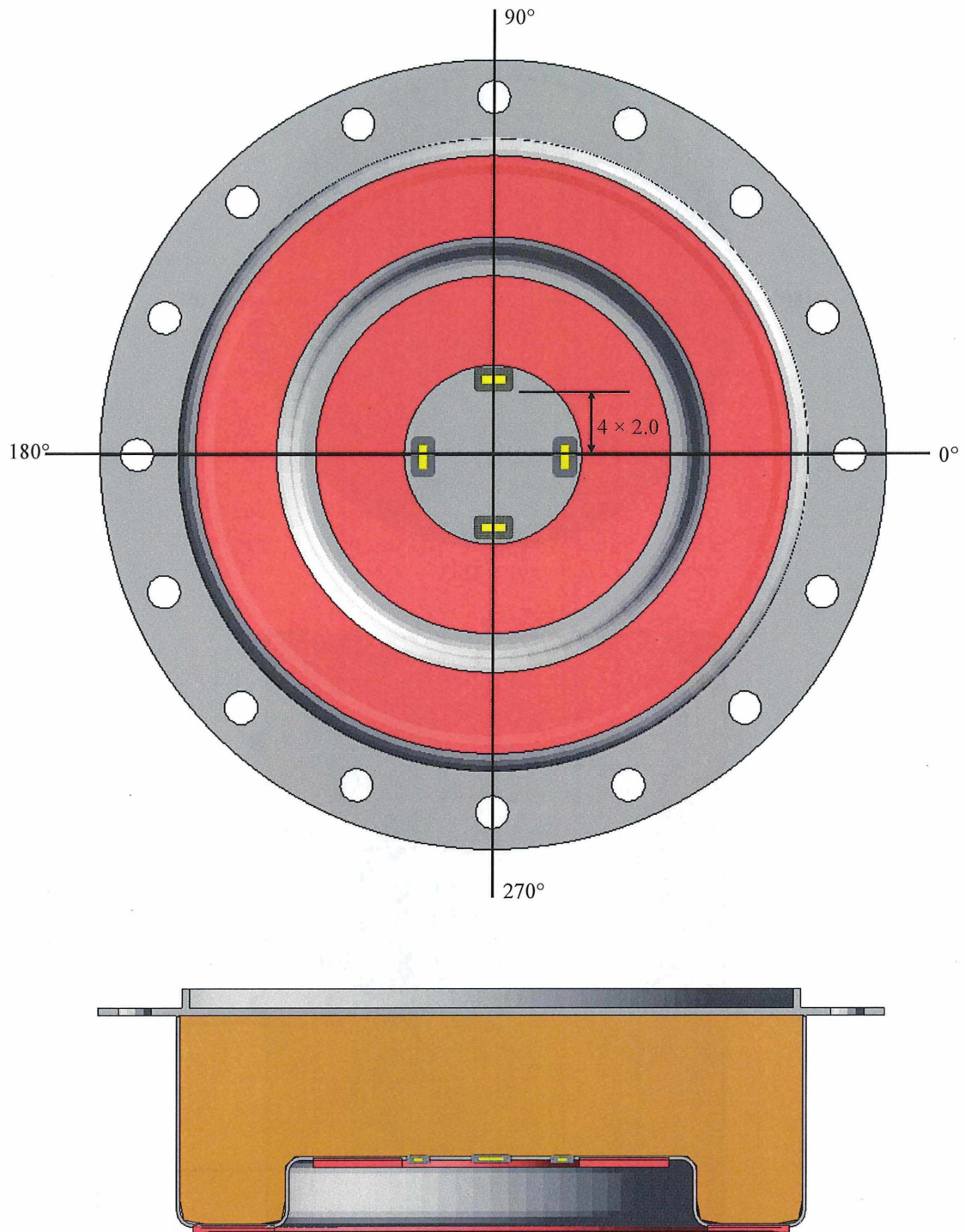


Fig. B.3. Temperature label locations CV bodies (36 total).





**Fig. B.4. Temperature label locations for drum lids (4 total).**



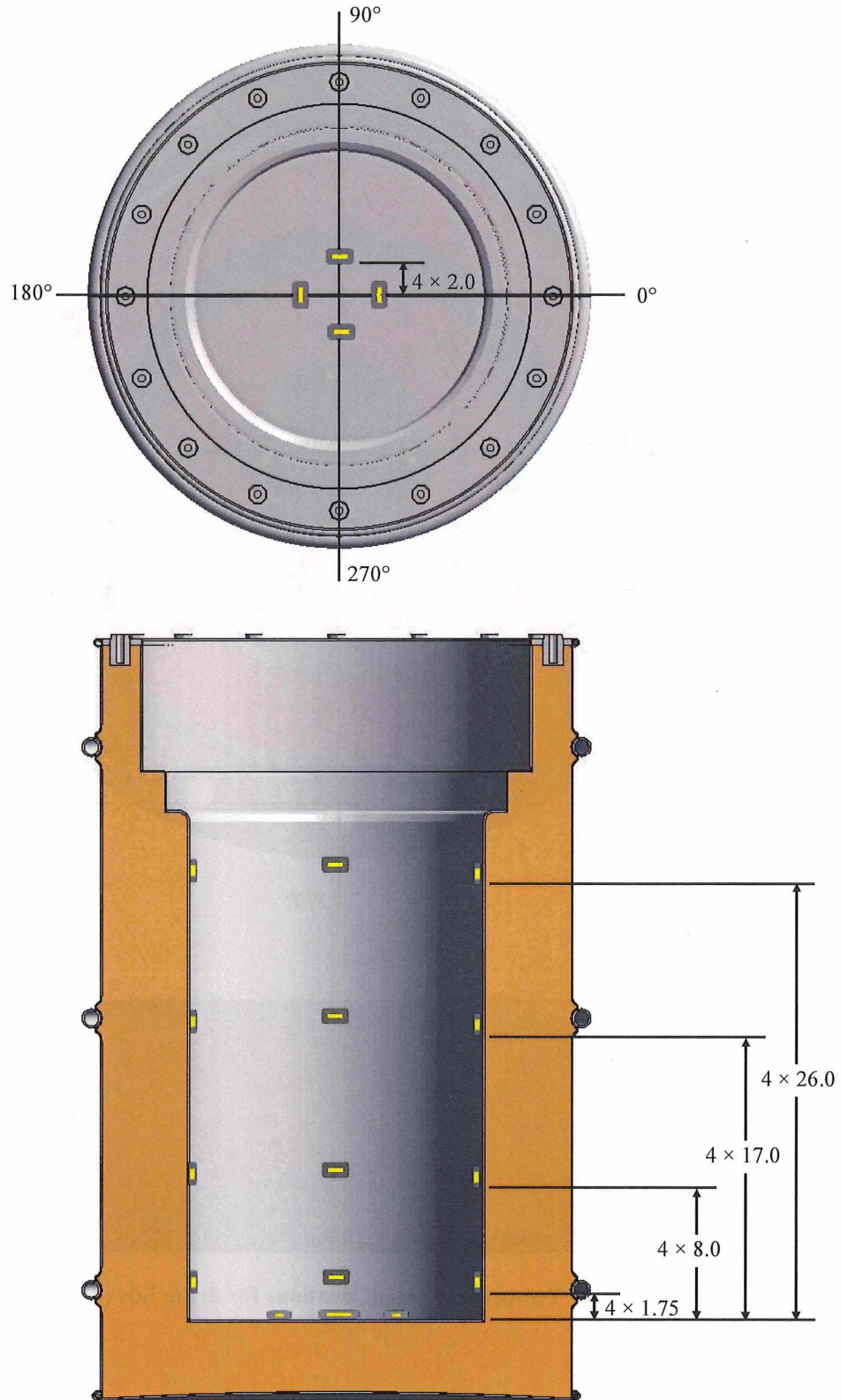


Fig. B.5. Temperature label locations for drum bodies (20 total).

**Table B.2 Data logger locations on drum assembly exterior**

<b>TU-1 and TU-2 (Slam Stick S)</b>	<b>0°</b>	<b>90°</b>	<b>180°</b>	<b>270°</b>
CG of drum	-	1	-	2
<b>TU-5 (Slam Stick S)</b>	<b>0°</b>	<b>90°</b>	<b>180°</b>	<b>270°</b>
Lid center	1	NA	NA	NA
CG of drum	-	2	-	3
<b>TU-6 (Slam Stick X &amp; S)</b>	<b>0°</b>	<b>90°</b>	<b>180°</b>	<b>270°</b>
Lid center <sup>a,b</sup>	1	NA	NA	NA
CG of drum <sup>c</sup>	-	2	-	3

<sup>a</sup> A single vibration data logger (Slam Stick X) shall be installed for the vibration test. The location may need offset from the lid center to accommodate tie-down system.

<sup>b</sup> The vibration data logger (Slam Stick X) shall be removed prior to the water spray test and shall be replaced with an impact data logger (Slam Stick S) following the water spray test.

<sup>c</sup> Impact data loggers (Slam Stick S) shall be installed following the water spray test.

**Table B.3 Thermocouple tip locations on drum assembly exterior**  
(See Attachment C, Section C.2 for details)

<b>TU-1 through TU-6</b>	<b>0°</b>	<b>90°</b>	<b>180°</b>	<b>270°</b>
Lid center (clip)	1	NA	NA	NA
Midsection of drum (clip)	2	3	4	5
Bottom center (clip)	6	NA	NA	NA

## ATTACHMENT C: DPP-1 TEST UNITS—THERMAL TESTING REQUIREMENTS

### C.1 HARDWARE REQUIREMENTS

1. Test stands: One required inside the furnace. The stand must locate the test units in the center of the furnace.
2. Cooling stands: Two required if all testing is conducted in one day for package preparation and cooling. If multiple days are used for testing, one cooling stand may be sufficient. The design of these stands must be identical to the test stand.
3. Steel plate for test stand: 4-ft x 8-ft x 1-in. thick. To be located in the center of the furnace floor. The plate provides a secure flat surface for the test stand.
4. Preheat chamber: Capable of holding two test units. Capable of maintaining temperatures at 150°F for 24 h and 110°F for a minimum of 24 h.
5. Fork truck: With modifications as necessary to load and unload test units. Test unit weighs ~900 lb.
6. Thermocouple (TC) metal clips: Used on the outside of the test units and on furnace walls and floor to hold TCs.

(LS45375-1) Linear Spring, 0.045 in. thick, .375 wide, 1 wave, 3in. long, Carbon Steel

Smalley Steel Ring Company  
 555 Oakwood Road  
 Lake Zurich, IL 60047  
 Phone: 847 719 5900  
 Fax: 847 719 5999  
 Email: [info@smalley.com](mailto:info@smalley.com)  
 Orders/POs: [sales@smalley.com](mailto:sales@smalley.com)

7. Lag bolts: 3/8-in. diam. Used to attach TCs to furnace walls. Length and number are as required.
8. TCs: Used outside the test units and inside the furnace

Calibrated type K, 0.062-in. diameter, stainless sleeve, 50-ft long. Length depends on the furnace and data recorder locations.

9. Soft steel wire: Used to bundle TC wires. At least 18-gauge (0.048-in.) diameter
10. Ceramic coating: Used to cover TC tips and metal clips outside the test units in order to eliminate any radiant viewing between the TCs and the furnace walls and floor. Two acceptable vendors and products are referenced below.

[http://www.cotronics.com/vo/cotr/rm\\_adhesive.htm](http://www.cotronics.com/vo/cotr/rm_adhesive.htm)  
 2300°F Resbond™ 907GF Adhesive & Sealant  
 Cotronics Corp.  
 131 47th Street, Brooklyn, NY 11232  
 Tel: 718-788-5533  
 Fax: 718-788-5538

Email: sales@cotronics.com

[http://www.aremco.com/ceramic-metallic-pastes/Pyro-Putty® 1500](http://www.aremco.com/ceramic-metallic-pastes/Pyro-Putty®1500)

Aremco Products Inc.

707 Executive Blvd.

Valley Cottage, NY 10989

Tel: 845-268-0039

Fax: 845-268-0041

11. Data recorder: Used to collect all TC readings.

To be selected by the testing agency.

**Note:** The data recorder must have enough data channels to cover the furnace and at least two shipping packages (one package during the thermal testing and one package during the cool down).

## C.2 TEST UNIT PREPARATION REQUIREMENTS

1. Prior to pre-heating, six metal TC clips shall be welded on the exterior surface of TU-1 through TU-6. Four metal clips shall be located around the mid-section at the 0° line, 90°, 180°, and 270°. One shall be located in the center of the bottom and one shall be located in the center of the lid. The metal clips are specified in Sect. C.1.
2. Each test unit shall be preheated at 150°F for 24 h and then soaked at 110°F for an additional 24 h. The test unit shall remain at the soaking temperature until the test unit is removed for TC installation and testing. There shall be evidence via TC readings that each test unit has been exposed to the pre-heat and soak requirements above. An example of a pre-heat chamber setup is shown in Fig. 16.
3. After pre-heating, the test unit shall be removed from the preheat chamber and six TCs shall be installed. Each TC tip shall be placed under the metal clip and then coated with a ceramic coating. TC and ceramic coating requirements are specified in Sect. C.1.
4. The six TCs on the external surfaces of TU-1 through TU-6 shall be checked with an appropriate heat source (e.g., butane or propane gas torch) before inserting the package into the furnace to ensure functionality.

## C.3 FURNACE REQUIREMENTS

1. The furnace shall be prepared, configured, and qualified in accordance with Sect. 7.3.2 of ASTM E2230-13.
2. The inside surface area of the furnace shall be at least 10 times greater than the exterior surface area of the test unit.
3. The furnace shall have a maximum operating temperature of at least 2,000°F.
4. The furnace shall be capable of recovering and achieving the testing temperatures in <12 min after the door has been open between tests for up to 90 s.



5. A minimum of 3 TCs shall be placed on each radiating surface within the furnace for a total of at least 18 TCs for a box-type furnace (3 minimum on each side wall, door, floor, and support stand). Additional TCs may be installed on the furnace ceiling at the TA's discretion. Each set of TCs shall be installed in a diagonal line, rather than a horizontal or vertical line, directly across from, below, and above the test unit.
6. Environmental temperatures also are needed to be recorded with TCs locally near the cooling shipping packages.
7. CNS will provide the testing agency a representative DPP-1 test unit (SDPP1) to qualify the furnace. The testing agency shall install external TCs on the representative unit and connect the TCs to the data acquisition and monitoring system exactly as planned for the test units. An additional TC lag bolt will be needed to attach the TC wire to the Packcrete casting surface. When the testing agency feels the furnace is ready to burn test units, the testing agency shall contact CNS for a demonstration.

**Note:** CNS will consider the furnace qualified and ready for burning the test units when all TCs on the representative unit and furnace radiating surfaces are reading between 1475°F and 1600°F range within 12 min of closing the furnace and all TCs read within this range for the duration of the burn test.

8. Test units shall be placed on a support stand in the center of the furnace and tested one at a time. The stand shall be welded to a plate of Company approved size (i.e. 4-ft × 8-ft × 1-in.), which shall also be located in the center of the furnace. The long side of the plate shall face the door and rear wall. The stand shall position the test unit at the center of the furnace. Three TCs shall be placed on the test stand, one at each end and one in the middle. The three TCs for the furnace floor shall be attached to the steel plate directly below the test unit and test stand.
9. The test stand shall be designed so the contact between the stand and the test unit is minimized and any view from the test unit to the furnace side walls and floor is maximized.
10. Each test unit shall be placed on the support stand in a horizontal orientation, with the 0° line marking facing the furnace floor and the lid facing the right hand wall of the furnace. The package may be rotated a minimal amount to prevent the lifting hardware from damaging the TCs. The approximate degree of rotation shall be recorded. An example of this setup is shown in Fig. 17.
11. The furnace loading process shall be capable of loading the representative unit and test units in <90 s, from the time the furnace door starts to open to the time the furnace door is closed.
12. The furnace shall be capable of heating the test unit and furnace side walls at or above 1475°F in <12 min after the door is closed.
13. The furnace unloading process shall be capable of unloading the test unit in <90 s, from the time the furnace door starts to open to the time the furnace door is closed.

#### C.4 TESTING REQUIREMENTS

1. The furnace shall be heated for at least 24 h before testing the first test unit. The furnace shall be heated for at least 2 h between tests.

2. The furnace door shall be opened, the test unit shall be placed in the middle of the furnace on the test stand, and the furnace door shall be closed as quickly as possible (<90 s is required), being careful to not damage the TC wires.
3. The burn test shall start when (1) at least 5 external TCs on the test unit are reading >1475°F, (2) at least 15 TCs on the furnace surfaces are reading >1475°F with at least 2 TCs on each furnace surface reading >1475°F, (3) at least 2 TCs on the test stand are reading >1475°F, and (4) CNS has agreed to proceed with the test.
4. The burn test shall be stopped after 31 min, the furnace door shall be opened as quickly as possible, and the test unit shall be removed from the furnace as quickly and as safely as possible.
5. Each test unit shall be allowed to cool naturally while indoors in an ambient environment (no fans).

**Note:** CNS thermal modeling indicates that each test unit should cool from 1475°F to 150°F in ~4 h and to 100°F in ~12 h.

#### C.5 DATA RECORDING REQUIREMENTS

1. The following items shall be recorded.
  - Ambient room temperature versus time (1 TC)
  - Preheat chamber temperature versus time (3 TCs, low, high, exhaust)
  - Furnace temperature versus time (minimum of 18 TCs)
  - Test stand temperature versus time (3 TCs)
  - Test unit external temperature versus time (6 TCs)

**Note:** During the progression of HAC thermal testing, 31 TCs for TU-1 through TU-6 will be monitored (at a minimum). The number of channels, sampling rates, and storage capacity required for the data recorder must support the data gathering requirements.

2. During the HAC thermal test hold period specified in Item 4 of Sect. C.4, temperature data from the test unit TCs shall be recorded at a minimum sampling rate of 4 times per minute (i.e., ≤15-s intervals).

**Note:** The temperature data sampling rates shall be specified in the CNS-approved test procedures for other test activities such as the preheat chamber hold periods (Sect. C.2, Item 2), furnace heat up (Sect. C.4, Item 1), and test unit cool down (Sect. C.5, Item 5).

3. Recording of temperature data from furnace sidewall TCs shall start at least 30 min prior to opening the door to load the test unit and continue until the test unit is unloaded from the furnace and the furnace door has been closed.
4. Recording of temperature data from test unit external TCs shall start before the oven door is opened to load the test unit and continue until the test unit is unloaded from the furnace and the furnace door has been closed.

All TC data shall be presented in graphical format in the test report, similar to the provided test report (ORNL/NTRC-027/V1, V2, and V3, Rev. 0, 3-7-2008) prepared by the Oak Ridge National Laboratory, National Transportation Research Center for the original MD-2 testing program.

**ATTACHMENT D: SUBMITTAL CHECKLIST**

SUBMITTAL SCHEDULE		FORMAT	SUBMITTAL PURPOSE
WP	With Proposal/Bid	DVD Digital Video Disk	FI For Information
PTC	Prior to Commencing Work	EM E-Mail	FA For Action
PTFA	Prior to Final Acceptance	EP Electronic (Pdf)	
Q	As Required	O Original	
		USB USB drive	

**DPP-1 Regulatory Compliance Testing Submittal Checklist**

Item No.	Reference	Requirement Description	Schedule	Format	No. of Copies	Submittal Purpose
1	Sect. 5.2	Basis for offer with list of primary activities and estimated costs for each	WP	EP	1	FA
2	Sect. 5.2	List of planned subtiers including work planned for each	WP	EP	1	FA
3	Sect. 5.2	Level 1 schedule	WP	EP	1	FA
4	Sect. 5.3	Level 2 schedule	PTC	EP	1	FA
5	Sect. 3.1, 5.3	Copy of QA program (for all testing campaigns)	PTC	EP	1	FA
6	Sect. 3.1, 5.3	Copy of QA plan (for this testing campaign)	PTC	EP	1	FA
7	Sect. 3.1, 5.3	Implementing procedures for QA program and plan	PTC	EP	1	FA
8	Sect. 3.1, 5.3	Test plan	PTC	EP	1	FA
9	Sect. 3.1, 5.3	Test procedures (leak test and others)	PTC	EP	1	FA
10	Sect. 3.1, 5.3	Equipment & tooling calibration procedures and records	PTC	EP	1	FA
11	Sect. 3.1, 5.3	Training plan for this testing campaign	PTC	EP	1	FA
12	Sect. 3.1, 5.3	Work instructions and guides (outside formal procedures)	PTC	EP	1	FA
13	Sect. 3.1, 5.3	Forms and/or routing sheets not included in test plan or test procedures	PTC	EP	1	FA
14	Sect. 3.1, 5.3	Other documents used by personnel during test unit preparation and testing not already included	PTC	EP	1	FA
15	Sect. 3.1, 5.3	Personnel qualification/certification records	PTC	EP	1	FA
16	Sect. 3.6, 5.3	RFWDs (prior to issuing test plan)	Q	EP	1	FA
17	Sect. 3.6, 5.4	TPCRs (after issuing test plan)	Q	EP	1	FA
18	Sect. 5.5	Preliminary test report for CNS review	PTFA	EP	1	FA
19	Sect. 5.5	Final test report	PTFA	O,EP	1	FA
20	Sect. 5.5	Photographs and videos	PTFA	USB	1	FI



# STATEMENT OF WORK FOR DPP-1 REGULATORY COMPLIANCE THERMAL TESTING

Prepared for the  
Southwest Research Institute  
Fire Technology Department  
Karen Carpenter, Assistant Director

by  
Oak Ridge National Laboratory  
Reactor and Nuclear Systems Division  
Used Fuel Systems Group  
managed by  
UT-Battelle  
for the  
U. S. DEPARTMENT OF ENERGY  
under contract  
DE-AC05-00OR22725

## APPROVALS

Name	Organization	Date
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Oscar Martinez, Ph.D.	ORNL Package Testing Program Manager
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Kaushik Banerjee	ORNL Package Systems and Logistics
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## **1 INTRODUCTION**

Oak Ridge National Laboratory is responsible for the regulatory testing of the Defense Program Package -1 (DPP-1) Type B package. The DPP-1 is a drum packaging that has an inner liner and a removable lid. Both the drum body and lid are filled with an impact limiting and thermal insulating material that protects the inner containment vessel (CV) during normal conditions of transport (NCT) and hypothetical accident conditions (HAC) as defined by 10 CFR 71.

The purpose of this statement of work (SOW) is to establish the scope of work of the thermal testing of six (6) DPP-1 packages. The conditions of the thermal test provided by the vendor must conform with the requirements of 10 CFR 71.73 (HAC). Six Test Units (TU) will be thermally tested and are designated as TU-1 through TU-6. One test unit (SDPP-1) will be used to qualify the performance of the furnace.

## **2 GENERAL DESCRIPTION OF WORK**

The thermal test facility at Southwest Research Institute (SwRI) conducting these tests for Oak Ridge National Laboratory will follow the outline procedures, requirements, and documents specified in this statement of work. The thermal test facility will comply with all requirements in this statement of work and its attachments.

## **3 WORK PERFORMED BY OTHERS**

All work described in this SOW will be performed by the SwRI, or its sub-tier suppliers, while operating under the SwRI's quality assurance (QA) program unless otherwise stated in this SOW.

## **4 TECHNICAL REQUIREMENTS**

If requirements are unclear, or conflicts exist between the applicable documents on this work, SwRI shall contact the ORNL technical representative (OTR) for resolution. If multiple interpretations are possible, SwRI shall contact the OTR for clarification based on ORNL's intent. The OTR will be identified in SwRI contract with ORNL.

## **5 GENERAL**

1. SwRI shall direct all technical communications to the OTR, the day-to-day technical point of contact for this work, unless directed otherwise in writing by the OTR.
2. Test unit preparation and thermal testing activities shall be conducted in accordance with the applicable requirements in 10 CFR 71.73, 10 CFR 71 Subpart H, ASTM E 2230-13 entitled Standard Practice for Thermal Qualification of Type B Packages for Radioactive Material, and this SOW.
3. Personnel directly involved with supporting the test and thermal test activities must be qualified, trained, and/or certified to perform their work.
4. Documents that show that the equipment, tooling, and furnace used during thermal test activities are calibrated and working properly are approval data documents. SwRI shall not use uncalibrated or uninspected equipment, tooling, and other hardware to perform testing.
5. SwRI shall not start the thermal test activities until the applicable approval documents have been provided and approved by ORNL and ORNL has given written authorization to proceed.

6. SwRI shall provide space for the ORNL package design staff and ORNL customer guests to witness the thermal testing.
7. All ORNL equipment and test units will remain the property of ORNL and ORNL will retain the tested units and associated equipment as ORNL deems necessary to meet ORNL customer needs.

## **6 DELIVERABLES**

1. Instrumentation (as required) to obtain necessary test data for each package tested.
2. Hardware (as required) to support the packages in the SwRI furnace during the thermal tests such that the requirements of 10 CFR 71.73 are met.
3. Staff and equipment support for package handling, storage, transportation, and other activities related pre- and post-test package movements and protection.
4. Thermal tests of 6 packages (provided by ORNL) to the requirements of 10 CFR 71.73.
5. Test data - SwRI shall provide ORNL with a pdf copy of all approval data documents. A list of approval data documents are shown below.
  - Calibration records for furnace thermocouples
  - Furnace survey, maintenance, and/or calibration records
  - Calibration records of all measuring and testing equipment that will be used during thermal testing activities.
  - Purchase receipt information for insulative material in the furnace
  - Dates of installation for insulative materials and thermocouples
  - Certifications for thermal testing (ASME, NQA-1, or others)
  - Names and qualifications of those who will be operating the furnace
  - Names and qualifications of those who will be operating handling/rigging equipment
  - Names and qualifications of those who will be operating other test/evaluation equipment.
  - Applicable qualifications of all sub-tier suppliers
  - Certifications for instrumentation applied by SwRI in support of the test.
6. After thermal testing is complete, SwRI shall provide the furnace temperature data, oxygen data and final thermal test report to ORNL for those thermocouples that were part of the SwRI furnace (i.e., not part of the ORNL data acquisition package).

## **7 QUALITY ASSURANCE REQUIREMENTS**

In order to do this work, SwRI must be on ORNL's Quality Approved Supplier List (QASL) as an approved provider of compliance testing services for Type B shipping packages. If the Offeror is not on the QASL, ORNL will evaluate its QA program prior to subcontract award for compliance with 10 CFR 71, Subpart H. If the QA program is acceptable, the Offeror will be included on the QASL.

## **8 DOCUMENT REQUIREMENTS**

The following submittals are required with the offer for ORNL approval.

- Basis for the offer (quote), including a list of the primary activities and the estimated costs for each.
- List of planned sub-tiers (e.g., subtier testing agencies), including the work planned for each.
- Level 1 schedule showing major activities from date of award, durations, and dates for thermal testing.

The following submittals are required prior to thermal testing for ORNL approval.

- Approval data documents

The following submittals are required after thermal testing.

- Furnace temperature data reported in absolute time
- Furnace oxygen sensor data reported in absolute time
- Video and photos.
- Final thermal test report.

## 9 TEST UNIT PREPARATION

The regulatory thermal testing set up, test unit instrumentation, preheat, furnace prep, regulatory testing, and test unit cool down shall be done/or directed by ORNL with the support of SwRI on preparing and operating the furnace, test unit material handling, loading and unloading of the test unit into the furnace.

## 10 THERMAL TEST PREP ACTIVITIES AND REGULATORY THERMAL TEST

Arrive and unload equipment required for performing the test including:

- Six (6) Certification Test Units, approximately ~ 900 lb each, 43-in high, 27-in diameter
  - Six (6) test units will be identified as TU-1 through TU-6
  - One (1) test unit will be identified as SDPP-1.
- Pre-heat chamber (insulated enclosure with associated heat source). The preheat chamber shall be large enough to preheat 6 test units at the same time in a horizontal orientation, Figure 9.
- Six (6) cooling stands for supporting test unit during preheating and cooling, Figure 8.
- Thermal monitoring and recording system, and
- Miscellaneous small equipment for test.

### **Setup equipment including pre-heat chamber and thermal monitoring system.**

ORNL will provide SwRI with the desired placement of the furnace thermocouples for the monitoring of the furnace temperatures, and ORNL will assist SwRI (as needed) to instrument the furnace with the thermocouples for the thermal monitoring system. The goal is to allow monitoring of all the furnace surfaces. During the testing ORNL will need to record the surface temperatures of the interior of the furnace every 15 seconds. The regulators do not view the air temperature close to the wall as a valid measurement of the “radiative environment” that is required for this test, thus the need to have thermocouples on the furnace inner surfaces. The thermocouples will be arranged with three thermocouples on each of the furnace walls, furnace roof, including the front door, and three thermocouples on the steel plate that covers the floor. The approximate arrangement for the left and right walls is shown in Figure 1 and Figure 2. The approximate arrangement for the back wall and door is shown in Figure 3 and Figure 4. The specific dimensions shown are approximate, assuming the test drum is located in the center of the furnace. Each thermocouple will be firmly mechanically attached to the surface or in a position agreed upon by SwRI and ORNL.

ORNL requests that SwRI conduct cold loading and unloading practice for moving packages from the pre-heat chamber to the prep stand, from the prep stand to the furnace, and from the furnace to the

cooling stand. The furnace must be turned off and allowed to cool for at least three days prior to ORNL arrival. The purposes of practicing loading are to:

- determine the path of fork truck or crane movements from the pre-heat chamber, or other staging location, to the furnace entry point,
- determine the best method to “tend” the thermocouple wires that will be attached to the package as it is lowered into the furnace, become confident loading the test package onto the support stand in the furnace, and minimize the loading and unloading time so that the temperature drop in the furnace is minimized during loading and unloading.

The furnace must undergo a preheat at approximately  $1580^{\circ} \pm 20^{\circ}\text{F}$  for at least 24 hours prior to beginning the first thermal test. At the end of that 24-hour period, ORNL will take time to observe the readings from the ORNL and SwRI thermal monitoring system to determine that all operational thermocouples on the furnace surfaces or package stand are between  $1475^{\circ}\text{F}$  and  $1600^{\circ}\text{F}$ . The furnace must remain in this range for the remainder of the thermal testing cycle.

During the thermal soaking and furnace characterization process the test units will have been placed in the pre-heat chamber and thermally “soaked” to  $150^{\circ}\text{F}$  for 24 hours and  $110^{\circ}\text{F}$  for 24 hours. This “soaking” or pre-heating will span at least 48 hours. During that time, staff shall monitor the conditions in the pre-heat chamber using a calibrated thermal monitoring system. SwRI shall provide the preheat chamber and operate the controls of the heat source. Additionally, SwRI shall record the preheat temperature at three locations in the preheat chamber during the entire pre-heat time.

SwRI will operate the furnace, crane, forklift, preheat chamber/room heat source and furnace instrumentation for the thermal tests on all thermal test units: 1 test unit for furnace qualification thermal test and 6 tests units for the regulatory test. After the furnace characterization run the test units will be subjected to the thermal test. A thermal test run will consist of:

- inserting a test unit into the furnace,
- operating the furnace to maintain it at or above  $1475^{\circ}\text{F}$ ,
- once 5 of 6 of the exterior thermocouples of the test unit and 15 of 18 of the furnace wall thermocouples reaches a temperature of  $1475^{\circ}\text{F}$  the test will start and run for 30 minutes,
- at the end of 30 minutes the test unit will be promptly removed from the furnace and set onto a cooling stand.

After each thermal test the units will be placed on cooling stands and allowed to passively cool. The typical cool-down time ranges from 4 to 12 hours. After each test the furnace door will be closed and the temperature in the furnace will be maintained at  $1580^{\circ} \pm 20^{\circ}\text{F}$ . The next thermal test shall not start until 45 minutes have passed from the previous thermal test.

SwRI personnel will assist ORNL in the loading of the equipment and the tested packages for return to ORNL.

## 11 TEST UNIT PREPARATIONS AND REQUIREMENTS

The preparation requirements detailed below are for TU-1 through TU-6 and the SDPP1. Unless otherwise specified all tasks outlined below shall be done by ORNL.



1. Prior to pre-heating, metal TC clips shall be welded on the exterior surface of TUs. Four metal clips shall be located around the mid-section at the 0° line, 90°, 180°, and 270°. One shall be located in the center of the bottom and one shall be located in the center of the lid. SwRI shall provide a welder to weld the TC metal clips to the external surface of the package.
2. Each test unit shall be preheated at 150°F for 24 h and then soaked at 110°F for an additional 24 h. The test unit shall remain at the soaking temperature until the test unit is removed for TC installation and testing. There shall be evidence via TC readings that each test unit has been exposed to the pre-heat and soak requirements above. SwRI shall supply the hardware and insulating material for the preheat. Additionally, SwRI shall assemble and disassembly the preheat chamber.
3. After pre-heating, the test unit shall be removed from the preheat chamber and TCs shall be installed. Each TC tip shall be placed under the metal clip and then coated with a ceramic coating. TC and ceramic coating requirements are specified in the SOW. SwRI shall support the material handling of the packages with appropriate forklift and rigging equipment.
4. The TCs on the external surface shall be checked with an appropriate heat source before inserting the package into the furnace to ensure functionality. SwRI shall provide a heat source (butane torch or heat gun).

## 12 TESTING REQUIREMENTS

SwRI shall be responsible for operating the furnace, package handling, collecting furnace data, recording video from the interior furnace camera, loading and unloading of the package from and to the furnace, and taking pictures of the thermal test activities. ORNL will gather package temperature data using the ORNL PTP thermal data acquisition and direct SwRI on package handling operations, loading and unloading into furnace, and thermal testing operations. SwRI will gather furnace wall temperature data, oxygen data, and video recording data during the thermal test.

1. The furnace shall be heated for at least 24 h before testing the first test unit. The furnace shall be heated for at least 45 min between tests.
2. The furnace opening shall be opened, the test unit shall be placed in the middle of the furnace on the test stand, and the furnace opening shall be closed as quickly as possible (<90 s is required), being careful to not damage the TC wires.
3. The burn test shall start when (1) at least 5 of 6 of the external TCs on the test unit are reading >1475°F, (2) at least 15 of the 18 TCs on the furnace surfaces are reading >1475°F with at least 2 TCs on each furnace surface reading >1475°F, (3) at least 2 TCs on the test stand are reading >1475°F, and (4) ORNL and CNS has agreed to proceed with the test.
4. The thermal test shall be stopped after 30 min, the furnace door shall be opened as quickly as possible, and the test unit shall be removed from the furnace as quickly and as safely as possible.
5. Each test unit shall be allowed to cool naturally while indoors in an ambient environment (no fans).

## 13 EQUIPMENT/SERVICES THAT WE REQUEST THE VENDOR SUPPLY:

- Access to and use of furnace at the subcontractor's facility,
- Fixture/supports required to attach thermocouples to walls, door, floor of high temperature furnace. Acceptable supports are lag bolts: 3/8 in diam, used to attach TCs to furnace walls and ceiling, length and number are as required.

- Fork truck capable of handling ~1,000 lbs and/or building handing equipment utilized for movement of the test units within the building
- Fixture(s) on fork truck, building handing equipment, or pallets that will allow moving the test units into and out of pre-heat chamber and onto a prep stand.
- Steel plate approximately 5 ft X 10 ft at least ½ in thick placed into furnace to provide an even floor for the test stand.
- Steel plate to create a baffle in the flue of the furnace to reduce draft (if determined to be needed).
- Lifting fixture attached to the crane to load and unload the test units into a hot furnace.
- Test Stand: One required inside the furnace. The stand must be located at the center of the furnace or at a location agreed upon by ORNL.
- Soft steel wire used to bundle the TC wires. At least 18-guage diameter.
- Data Acquisition used to collect TC readings of furnace and preheat chamber.
- Pre-heat chamber with reliable heat source to maintain the preheat profile.

#### 14 PERSONNEL/CAPABILITIES WE REQUEST THAT ARE SUPPLIED:

- Furnace operator(s),
- Equipment operator(s) to move test units and other heavy hardware (e.g., pre-heat chamber and thermal test dummy drums),
- Laborer(s) to assist with moving test units and other heavy hardware (e.g., pre-heat chamber and thermal test dummy drums),
- Electrician or other technical help required for instrument furnace and supplying electrical power of test monitoring equipment,
- Other technical help deemed necessary by the vendor to operate the facility for this testing.

#### 15 EQUIPMENT SUPPLIED BY ORNL

- Six (6) certification test units
- One (1) furnace qualification test unit.
- Package Testing Program thermal data acquisition
- Type K thermocouples, 0.062-in diameter, stainless steel, 50-ft length for the furnace, preheat chamber, ambient temperature, test units, and test stand.
- Omega Temperature indicating labels: TL-10-190, TL-10-290.

**TL-10 SERIES, 10-Temperature Range Labels**  
54 x 18 mm (2.1 x 0.7")

Temperature Range											
TL-10-105(*)	°F	105	110	115	120	130	140	150	160	170	180
	°C	40	43	46	49	54	60	66	71	77	82
TL-10-190(*)	°F	190	200	210	220	230	240	250	260	270	280
	°C	88	93	99	104	110	116	121	127	132	138
TL-10-290(*)	°F	290	300	310	320	330	340	350	360	370	380
	°C	143	149	154	160	166	171	177	182	188	193
TL-10-390(*)	°F	390	400	410	420	435	450	465	480	490	500
	°C	199	204	210	216	224	232	241	249	254	260

\* Insert "-10" for package of 10 or "-30" for package of 30.

Ordering Example: TL-10-105-30, 10 temperature range labels (105, 110, 115, 120, 130, 140, 150, 160, 170, 180°F), package of 30.

- 6 cooling stands

- Ceramic coating used to cover the TC tips and metal clips in order to eliminate any radiant viewing.
- Thermocouple (TC) metal clips.
- Camera and video recording devices

## 16 FURNACE REQUIREMENTS

1. The furnace shall be prepared, configured, and qualified in accordance with Sect. 7.3.2 of ASTM- E2230-13.
2. The inside surface area of the furnace shall be at least 10 times greater than the exterior surface area of the test unit.
3. The furnace shall have a maximum operating temperature of at least 2,000°F.
4. The furnace shall be capable of recovering and achieving the testing temperatures in <15 min after the opening has been open between tests for up to 90 s.
5. A minimum of 3 TCs shall be placed on each radiating surface within the furnace for a total of at least 18 TCs for a box-type furnace (3 minimum on each side wall, door, floor, and support stand). Additional TCs may be installed on the furnace ceiling at ORNLs discretion. Each set of TCs shall be installed in a diagonal line, rather than a horizontal or vertical line, directly across from, below, and above the test unit. All furnace TC's shall be checked with an appropriate heat source to ensure functionality.
6. Environmental temperatures also are needed to be recorded with TCs locally near the cooling shipping packages.
7. ORNL will consider the furnace qualified and ready for thermal testing the test units when all TCs on the representative unit and furnace radiating surfaces are reading between 1475°F and 1600°F range within 12 min of closing the furnace and all TCs read within this range for the duration of the burn test.
8. Test units shall be placed on a support stand in the center of the furnace and tested one at a time. The stand shall be welded to a plate (5x10 ft x .5 in) or company approved size, which shall also be located in the center of the furnace. The stand shall position the test unit at the center of the furnace. Three TCs shall be placed on the test stand, one at each end and one in the middle. The three TCs for the furnace floor shall be attached to the steel plate directly below the test unit and test stand.
9. The test stand shall be designed so the contact between the stand and the test unit is minimized and any view from the test unit to the furnace side walls and floor is maximized.
10. The furnace loading process shall be capable of loading the representative unit and test units in <90 s, from the time the furnace door/cover starts to open to the time the furnace door/cover is closed.
11. The furnace shall be capable of heating the test unit and furnace side walls at or above 1475°F in <12 min after the door/cover is closed.

## 17 DATA RECORDING REQUIREMENTS

ORNL will be responsible for recording temperature data of the test unit and ambient air temperature. SwRI shall be responsible for recording temperature data of the preheat chamber, furnace walls, and test stand. The following items shall be recorded

- Preheat chamber temperature versus time (3 TCs)
- Furnace temperature versus time (18 TCs)
- Ambient room temperature versus time (1 TC)
- Test stand temperature versus time (3 TCs)
- Test unit external temperature versus time (6 TCs each)
- All TC readings shall be recorded at a minimum sampling rate of 4 times per minute (i.e.,  $\leq 15$ -s intervals).
- Recording of temperature data from furnace sidewall TCs shall start at least 30 min prior to opening the door to load the test unit and continue until the test unit is unloaded from the furnace and the furnace door has been closed.
- Recording of temperature data from test unit external TCs shall start before the oven door is opened to load the test unit and continue until the test unit is unloaded from the furnace and the furnace door has been closed.
- All temperature data shall be reported in the local absolute time. Example, Month, day, year, 24-hour time.

### Left Interior Wall

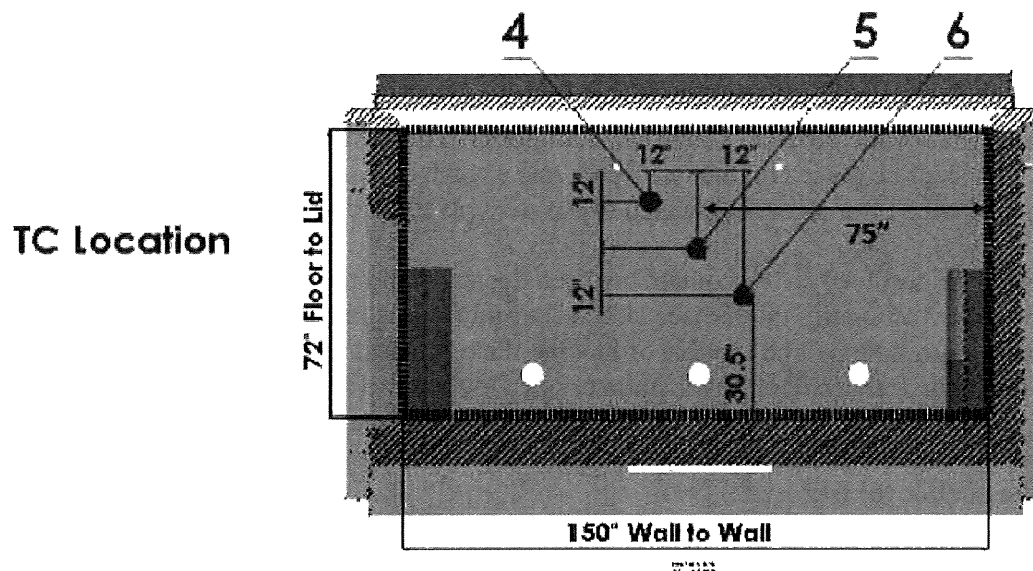


Figure 1 Thermocouple arrangement on left interior wall of furnace assuming furnace is 20 ft. deep. Example from previous thermal test.



## Right Interior Wall

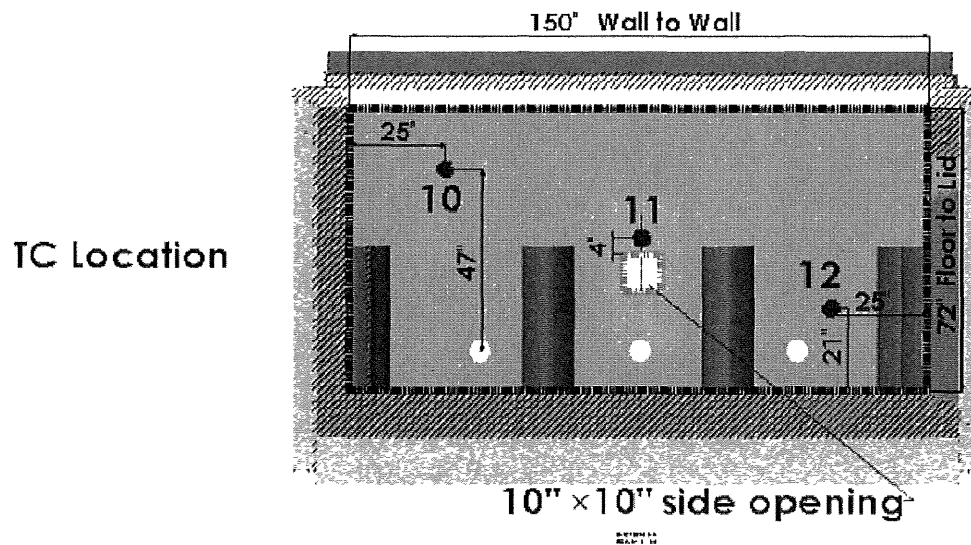


Figure 2 Thermocouple arrangement on right interior wall of furnace assuming furnace is 20 ft. deep. Example from previous thermal test.

## Rear Interior Wall

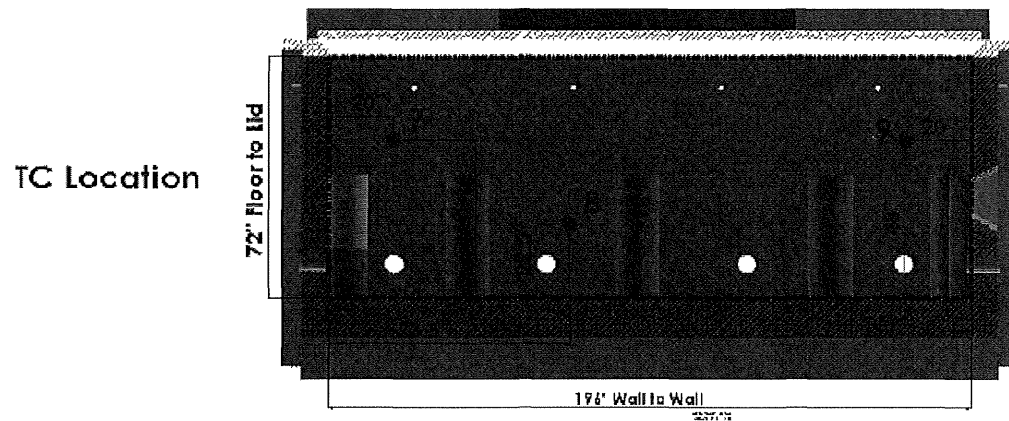


Figure 3 Thermocouple arrangement on back interior wall. Example from previous thermal test.

## Front Interior Wall

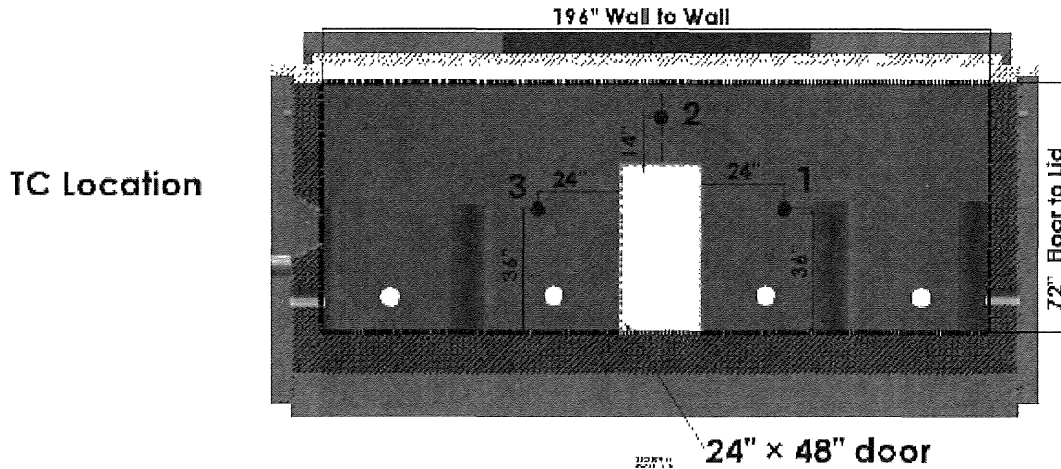


Figure 4 Thermocouple arrangement on the front interior wall. Example from previous thermal test.

## Furnace Layout

Top-Down View

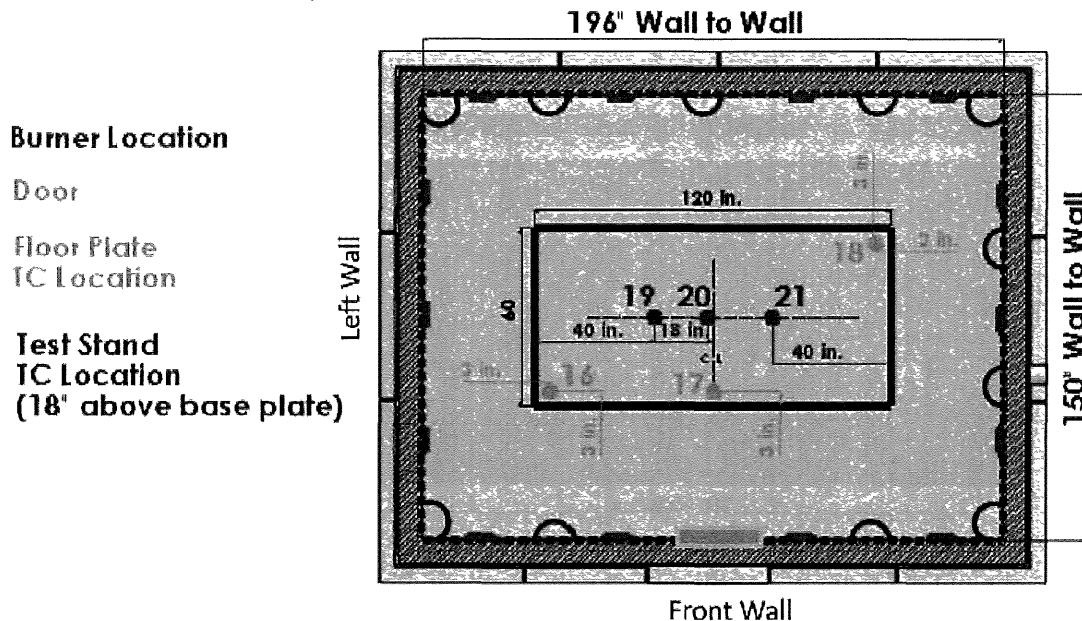


Figure 5 Thermocouple arrangement on the furnace interior floor. Example from previous thermal test.

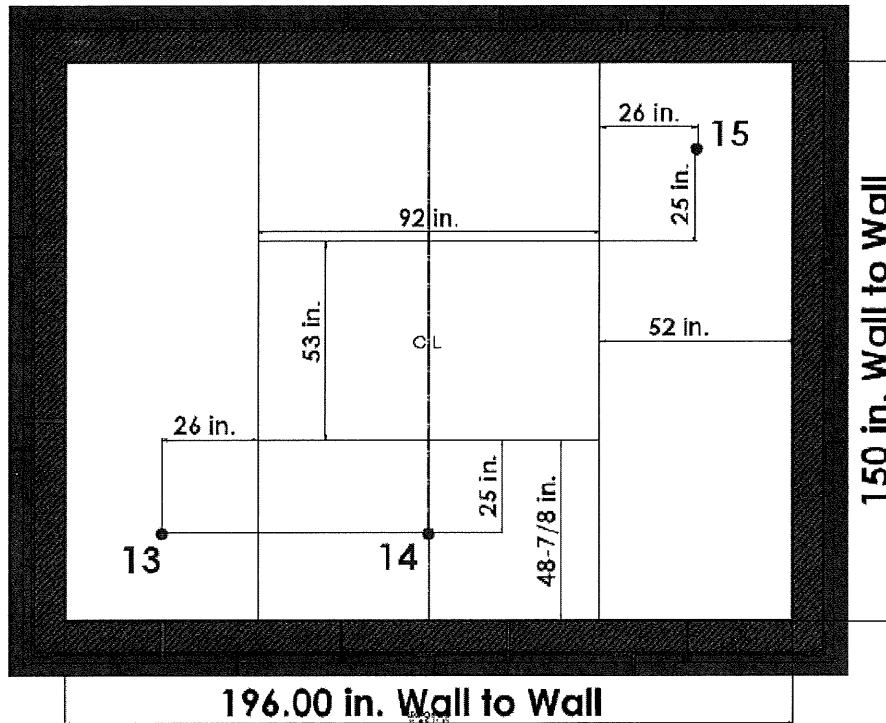
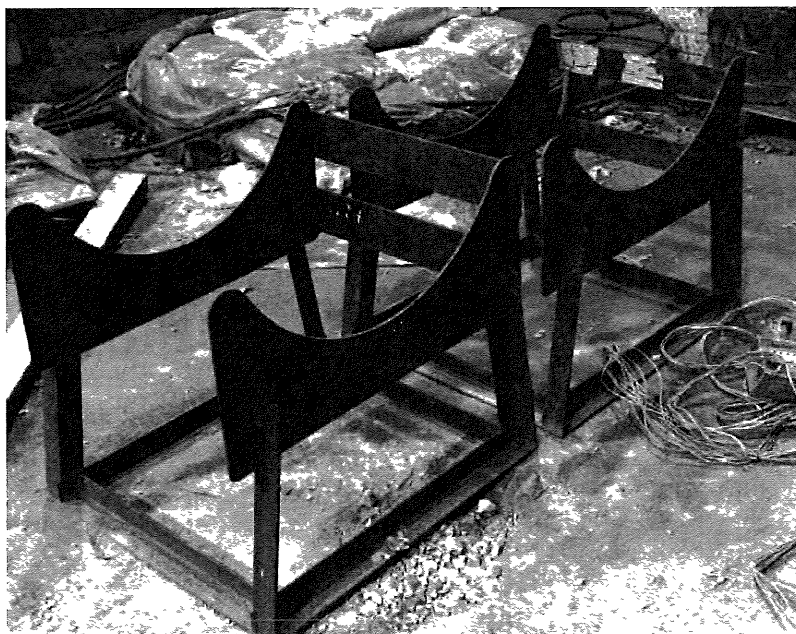


Figure 6 Thermocouple arrangement on the furnace interior ceiling. Example from previous thermal test.



Figure 7 Test stand in furnace. Example from previous test. Example from previous thermal test.



**Figure 8 Cooling stands.**



**Figure 9 Construction and set up of preheat chamber. Example from previous thermal test.**



## **7.3 DPP-1 Handling Procedures**

# DPP-1

## Handling, Assembly, and Disassembly Instructions for Test Units



---

Jonathan Weigand, Packaging and Transportation Engineering  
January 21, 2021

This document has been reviewed and confirmed to be  
UNCLASSIFIED and contains no UCNI.

Name: Christopher Smith

Date: 01/19/2021

CNS eDC/RO ID: 271836

## APPROVALS

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## REVISION LOG

Revision No.	Date	Description	Pages Affected
00	1/21/2021	Initial issue.	All



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## 1. Package Description for Handling, Assembly, and Disassembly

The guidelines and instructions outlined in Sections 2 through 4 shall be used for handling, assembly, and disassembly operations performed on DPP-1 test units during regulatory testing activities. The guidelines and instructions do not cover the application of temperature indicating labels, thermocouples, accelerometers, or any equipment specific to data acquisition during testing.

The main assembly drawing of the DPP-1 packaging is shown on DD-M802586-0001. The major components of the DPP-1 packaging consist of the following.

- Drum body weldment (DD-M802586-0012)
- Drum lid weldment assembly (DD-M802586-0018)
- Containment vessel (CV) assembly (DD-M802586-0021)
- CV base pad (DD-M802586-0028)
- CV flange wedge (DD-M802586-0029)

The DPP-1 package with the two loaded test contents are shown on DD-M802586-0003 and DD-M802586-0004. The major components of the test content consist of the following.

- Test content assembly (TCA) [DD-M802586-0030 (Heavy) and DD-M802586-0031 (Light)]
- (2) PCC pads (DD-M802586-0003/0004, F/N 4)

## 2. Lifting and Handling Instructions

For this set of instructions, *lifting* operations refer to vertical movements of components or assemblies, and *handling* operations refer to lateral movements of components or assemblies.

The following guidelines apply to lifting and handling operations of components or assemblies.

- Drum body weldments, empty DPP-1 packagings, and loaded DPP-1 packages may only be lifted or handled at locations such as the drum body waist where the structural integrity is not compromised. The lifting equipment must have capacity to lift the maximum gross weight of the DPP-1 package (900 lb). Pallets, pallet jacks, and forklifts may also be used during handling operations of the drum body, packaging, or package.
- Drum lid closure holes and CV lid closure holes SHALL NOT be used to lift or handle either assembly.
- The drum lid weldment assembly may be lifted or handled using the threaded lifting holes shown on DD-M802586-0018 and additional hardware such as swivel hoist rings. The lifting holes SHALL NOT be used to lift or handle the DPP-1 packaging or package once the drum lid is fastened to the drum.
- The CV lid and CV assembly may be lifted or handled using the threaded lifting holes shown on DD-M802586-0021 and additional hardware such as swivel hoist rings.
- The test fixture weldment and TCA may be lifted or handled using the threaded lifting holes shown on DD-M802586-0030 or DD-M802586-0031 and swivel hoist rings.

The testing authority may propose alternate lifting and handling methods to allow for safer and more efficient operations with Company approval. Additional lifting and handling measures may be required throughout testing activities, and these measures should adhere to the guidelines above.

### 3. DPP-1 Packaging Disassembly and Assembly

The following hardware and equipment shall be readily available for disassembly and assembly operations of the DPP-1 packaging. The hardware and equipment are in addition to the packaging components.

- (4) 3/8-16 UNC-2B, swivel hoist rings or eyebolts for drum lid lifting
- (3) 1/2-13 UNC-2B, swivel hoist rings or eyebolts for CV lifting
- 5/16 and 3/8 in. hex keys or hex bit sockets for swivel hoist rings, if necessary
- Calibrated torque wrench with 3/4 in. socket
- Pallet jack or fork lift
- Cleaning liquid (i.e. acetone, warm water and mild detergent) and lint free towels
- Jib or bridge-crane and crane-hook
- Lifting slings

The instructions outlined in Sections 3.1 and 3.2 apply to disassembly and assembly operations of the DPP-1 packaging. The testing authority may propose alternate disassembly or assembly steps to allow for safer and more efficient operations with Company approval.

#### 3.1 DPP-1 Packaging Disassembly Instructions

The DPP-1 packaging (DD-M802586-0001) shall be disassembled in accordance with the instructions below. Visual inspection of all components shall be performed during disassembly operations.

1. Visually inspect the exterior surfaces of the drum assembly.
2. Visually inspect and remove the tamper indicating devices (TID) that secure the drum lid if necessary.  
**Note:** Company oversight is required for TID removal.
3. Remove the drum lid closure bolts (DD-M802586-0011, F/N 4) and washers (DD-M802586-0011, F/N 5) and set aside.
4. Visually inspect the drum closure bolts and washers.
5. Remove the socket head cap screws (DD-M802586-0001, F/N 8) installed in the drum lid lifting holes and set aside.
6. Install (4) swivel hoist rings or eyebolts in the drum lid lifting holes.
7. Connect the swivel hoist rings or eyebolts to the lifting slings, crane hook, and crane (or lifting equipment).
8. Remove the drum lid (DD-M802586-0011, F/N 3) from the drum body and set aside.  
**Note:** Do not use the drum lid lifting features to lift the entire drum assembly.
9. Visually inspect the drum lid.
10. Remove the CV flange wedge (DD-M802586-0001, F/N 7) and set aside.
11. Visually inspect the CV flange wedge.
12. Install (3) swivel hoist rings or eyebolts in the CV lid lifting holes (DD-M802586-0021, F/N 6).
13. Connect the swivel hoist rings or eyebolts to the lifting slings, crane hook, and crane.
14. Remove the CV from the drum body and set aside.
15. Visually inspect the exterior surfaces of the CV assembly.
16. Remove the CV base pad (DD-M802586-0001, F/N 6) from the drum cavity and set aside.

17. Visually inspect the CV base pad.
18. Visually inspect the interior surfaces of the drum body.
19. Remove the leak test port plug (DD-M802586-0021, F/N 9) from the CV lid and set aside.
20. Visually inspect the leak test port plug and leak test port.
21. Remove the CV lid closure bolts (DD-M802586-0021, F/N 8) and washers (DD-M802586-0021, F/N 7) and set aside.  
**Note:** If the CV is loaded, the CV lid closure bolts shall be loosened following the sequence etched on the CV lid. Multiple passes may be required to evenly unseat the CV lid and prevent components from locking up.
22. Visually inspect the CV lid closure bolts and washers.
23. Connect the CV lid swivel hoist rings or eyebolts to the lifting slings, crane hook, and crane.
24. Remove the CV lid (DD-M802586-0021, F/N 5) from the CV body and set aside with the sealing surface facing in the upward direction.
25. Remove the CV lid swivel hoist rings or eyebolts and set aside.
26. Visually inspect the CV lid and sealing surfaces.
27. Remove the inner and outer O-rings (DD-M802586-0021, F/N 3 and 4) from the CV lid O-ring grooves.
28. Visually inspect the inner and outer O-rings as well as the O-ring grooves.
29. If the CV is loaded, unload the test content from the CV body as outlined in Section 4 and set aside.
30. Visually inspect the interior surfaces of the CV body and sealing surface of the CV body flange.

### 3.2 DPP-1 Packaging Assembly Instructions

The DPP-1 packaging (DD-M802586-0001) shall be assembled in accordance with the instructions below. Visual inspection and cleaning (if necessary) of all components shall be performed during assembly operations.

1. Visually inspect and clean the interior surfaces of the CV body.
2. Load the test content into the CV body as outlined in Section 4.
3. Visually inspect and clean the sealing surfaces of the CV body flange and lid.
4. Visually inspect and clean the inner and outer O-rings.  
**Note:** Replace the inner and outer O-rings as needed.
5. Install the inner and outer O-rings in the CV lid.  
**Note:** Apply lubrication (DD-M802586-0021, F/N 10) to the O-rings as needed.
6. Install (3) swivel hoist rings or eyebolts in the CV lid lifting holes.
7. Connect the CV lid swivel hoist rings or eyebolts to the lifting slings, crane hook, and crane.
8. Place the CV lid onto the test content in a centered orientation.  
**Note:** Be sure to align the CV lid pin hole with the CV flange alignment pin (DD-M802586-0022, F/N 5).
9. Visually inspect the CV closure bolts and washers.
10. Use one of the following methods to mate the CV lid and body sealing surfaces.
  - a. Place the CV closure bolts and washers into the CV lid holes. Hand tighten all CV bolts. Evenly work down the CV lid by tightening the CV bolts with a torque wrench following



- the sequence etched on the CV lid. Stop once all bolt heads and washers are mated. Several passes may be needed to mate the bolt heads and washers.
- b. Use a set of clamping tools or method approved by the Company to work the CV lid down to a seated or near-seated position. Place the CV closure bolts and washers into the CV lid holes. Hand tighten all CV bolts. Torque down the CV bolts, following the sequence etched on the CV lid, until all bolt heads are mated with the washers.
11. Once the CV lid is seated along the CV body flange, torque down the CV bolts per the following steps (DD-M802586-0021, Note 5).
    - a. Torque to  $20 \pm 1$  ft-lb following the sequence etched on the CV lid
    - b. Torque to  $35 \pm 2$  ft-lb following the sequence etched on the CV lid
    - c. Torque to  $35 \pm 2$  ft-lb following the sequence etched on the CV lid
  12. Perform pre-shipment leakage rate testing.
  13. Visually inspect and clean the leak test port plug.
  14. Install the leak test port plug in the CV lid leak test port.
  15. Visually inspect and clean the exterior surfaces of the CV assembly.
  16. Visually inspect and clean the interior surfaces of the drum body.
  17. Visually inspect and clean the CV base pad.
  18. Place the CV base pad in the bottom of the drum cavity in a centered position.
  19. Connect the CV lid swivel hoist rings or eyebolts to the lifting slings, crane hook, and crane.
  20. Place the CV assembly into the drum body.
  21. Remove the CV lid swivel hoist rings or eyebolts.
  22. Visually inspect and clean the CV flange wedge.
  23. Install the CV flange wedge along the rim of the CV lid with the etched arrow aligned with the leak test port.
  24. Visually inspect and clean the drum lid.
  25. Install (4) swivel hoist rings or eyebolts in the drum lid lifting holes.
  26. Connect the drum lid swivel hoist rings or eyebolts to the lifting slings, crane hook, and crane.
  27. Place the drum lid onto the drum body.
 

**Note:** Make sure to align the drum lid pin hole with the body locating pin (DD-M802586-0013, F/N 4) and drum lid TID holes with the body TID lugs (DD-M802586-0015, F/N 3).
  28. Remove the drum lid swivel hoist rings or eyebolts.
  29. Install (4) socket head cap screws in the drum lid lifting holes.
  30. Visually inspect the drum closure bolts and washers.
  31. Place the drum lid closure bolts and washers into the drum lid holes and thread into place.
  32. Torque down the drum lid closure bolts per the following steps (DD-M802586-0001, Note 4).
    - a. Torque until the drum lid is in full contact with the drum body flange following the sequence etched on the drum lid.
    - b. Torque to  $35 \pm 2$  ft-lb following the sequence etched on the drum lid.
  33. Visually inspect and clean the exterior surfaces of the drum assembly.

## 4. Test Content Unloading and Loading

The following hardware and equipment shall be readily available for unloading and loading operations of the DPP-1 test content. The hardware and equipment is in addition to the test content components.

- (2) 3/8-16 UNC-2B, swivel hoist rings for TCA lifting
- 5/16 in. hex key or hex bit socket for swivel hoist rings
- Calibrated torque wrench with 5/8 in. socket
- Pallet jack or fork lift
- Cleaning liquid (i.e. acetone, warm water and mild detergent) and lint free towels
- Jib or bridge-crane and crane-hook
- Lifting slings

The instructions outlined in Sections 4.1 and 4.2 apply to unloading and loading operations of the DPP-1 test content. Alternate methods or sequences may be proposed by the testing authority to allow for safer and more efficient operations with Company approval.

### 4.1 Test Content Unloading Instructions

The DPP-1 test content shall be unloaded in accordance with the instructions below. Visual inspection of all components shall be performed during unloading operations.

1. Remove the PCC pad located (DD-M802586-0003/0004, F/N 4) on top of the TCA and set aside.
2. Visually inspect the PCC pad.
3. Install (2) swivel hoist rings (DD-M802586-0030/0031, F/N 5) in the TCA lifting holes (DD-M802586-0030/0031, F/N 6).
4. Connect the CV lid swivel hoist rings to the lifting slings, crane hook, and crane.
5. Carefully remove the TCA from the CV body and set aside.
6. Visually inspect the TCA.
7. Remove the PCC pad from the bottom of the CV body.
8. Visually inspect the PCC pad.

### 4.2 Test Content Loading Instructions

1. Visually inspect and clean the test fixture weldment (DD-M802586-0032).
2. Visually inspect and clean the test weights (DD-M802586-0033).
3. Install the appropriate set of test weights (light or heavy) in the appropriate position (low or high) on the test fixture weldment using the fastening hardware shown on DD-M802586-0030/0031, Detail B (bolt, washer, top hat bushing, and locknut). Torque the bolts to  $25 \pm 2$  ft-lb.  
**Note:** Installation of the test weights may require incremental tightening of fasteners in order to work the test weights into place.
4. Visually inspect and clean a PCC pad.
5. Place the PCC pad in the bottom of the CV body.  
**Note:** Ensure the PCC pad is centered in the CV bottom to promote vertical orientation of the content components.
6. Install (2) swivel hoist rings in the TCA lifting holes.
7. Connect the CV lid swivel hoist rings to the lifting slings, crane hook, and crane.

8. Carefully place the TCA in the CV body.
9. Remove the TCA swivel hoist rings.
10. Center the TCA inside the CV body.
11. Visually inspect and clean a PCC pad.
12. Place the PCC pad on top of the TCA. (See Section 3.2 for closure instructions)

## 5. References

DD-M802586-0001, DPP-1 Main Assembly  
DD-M802586-0003, DPP-1/Heavy Test Content Assembly  
DD-M802586-0004, DPP-1/Light Test Content Assembly  
DD-M802586-0011, Drum Body Sub-Assembly  
DD-M802586-0012, Drum Body Weldment  
DD-M802586-0013, Drum Shell Welded Assembly  
DD-M802586-0015, Drum Top Mounting Plate Weldment Assembly  
DD-M802586-0018, Drum Lid Weldment Assembly  
DD-M802586-0021, Containment Vessel Assembly  
DD-M802586-0022, Containment Vessel Body Weldment  
DD-M802586-0028, CV Base Pad  
DD-M802586-0029, CV Flange Wedge  
DD-M802586-0030, Heavy Test Content Assembly  
DD-M802586-0031, Light Test Content Assembly  
DD-M802586-0032, Test Fixture Weldment  
DD-M802586-0033, Jacket Weight Details



## **7.4 Accelerometer Technical Specification Range**

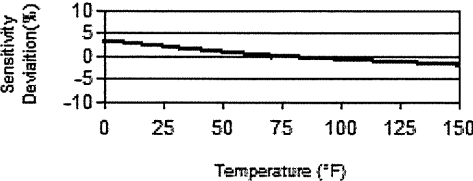

Model Number 352C68	ICP® ACCELEROMETER			Revision: N ECN #: 31827
Performance		ENGLISH	SI	OPTIONAL VERSIONS
Sensitivity(± 10 %)		100 mV/g	10.2 mV/(m/s²)	Optional versions have identical specifications and accessories as listed for the standard model except where noted below. More than one option may be used.
Measurement Range		± 50 g pk	± 491 m/s² pk	A - Adhesive Mount
Frequency Range(± 5 %)		0.5 to 10,000 Hz	0.5 to 10,000 Hz	Supplied Accessory : Model 080A90 Quick Bonding Gel (1) replaces Model 080A15
Frequency Range(± 10 %)		0.3 to 12,000 Hz	0.3 to 12,000 Hz	HT - High temperature, extends normal operation temperatures
Frequency Range(± 3 dB)		0.2 to 20,000 Hz	0.2 to 20,000 Hz	Frequency Range(5 %)
Resonant Frequency		≥ 35 kHz	≥ 35 kHz	Frequency Range(10 %)
Phase Response(± 5 °)(at 70°F [21°C])		2 to 6000 Hz	2 to 6000 Hz	Frequency Range(3 dB)
Broadband Resolution(1 to 10,000 Hz)		0.00016 g rms	0.0015 m/s² rms	Broadband Resolution(1 to 10,000 Hz)
Non-Linearity		≤ 1 %	≤ 1 %	Temperature Range(Operating)
Transverse Sensitivity		≤ 5 %	≤ 5 %	Discharge Time Constant
Environmental				Spectral Noise(1 Hz)
Overload Limit(Shock)		± 5000 g pk	± 49,050 m/s² pk	Spectral Noise(10 Hz)
Temperature Range(Operating)		-65 to +200 °F	-53 to +93 °C	J - Ground Isolated
Temperature Response		See Graph	See Graph	Frequency Range(5 %)
Base Strain Sensitivity		≤ 0.005 g/με	≤ 0.05 (m/s²)/με	Frequency Range(10 %)
Electrical				Frequency Range(3 dB)
Excitation Voltage		18 to 30 VDC	18 to 30 VDC	Resonant Frequency
Constant Current Excitation		2 to 20 mA	2 to 20 mA	Electrical Isolation(Base)
Output Impedance		≤ 300 ohm	≤ 300 ohm	Size - Hex x Height
Output Bias Voltage		8 to 12 VDC	8 to 12 VDC	Weight
Discharge Time Constant		0.8 to 2.4 sec	0.8 to 2.4 sec	M - Metric Mount
Settling Time(within 10% of bias)		<10 sec	<10 sec	Mounting Thread
Spectral Noise(1 Hz)		60 μg/√Hz	588 (μm/sec²)/√Hz	Supplied Accessory : Model M080A15 Adhesive Mounting Base (1) replaces Model 080A15
Spectral Noise(10 Hz)		16 μg/√Hz	157 (μm/sec²)/√Hz	W - Water Resistant Cable
Spectral Noise(100 Hz)		5 μg/√Hz	49 (μm/sec²)/√Hz	Electrical Connector
Spectral Noise(1 kHz)		1.5 μg/√Hz	14.7 (μm/sec²)/√Hz	Electrical Connection Position
Physical				Sealed Integral Cable
Sensing Element		Ceramic	Ceramic	Sealed Integral Cable
Sensing Geometry		Shear	Shear	
Housing Material		Titanium	Titanium	
Sealing		Welded Hermetic	Welded Hermetic	
Size (Hex x Height)		9/32 in x 0.73 in	9/32 in x 18.5 mm	
Weight		0.070 oz	2.0 gm	
Electrical Connector		10-32 Coaxial Jack	10-32 Coaxial Jack	
Electrical Connection Position		Top	Top	
Mounting Thread		5-40 Male	5-40 Male	
Mounting Torque		8 to 12 in-lb	90 to 135 N-cm	

CE

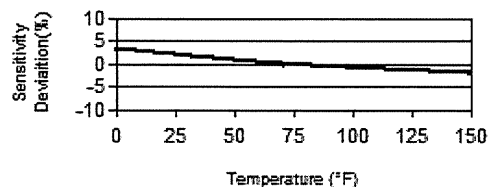
[5]

Typical Sensitivity Deviation vs Temperature

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Model Number 350B44	TRIAxIAL ICP® ACCELEROMETER			Revision B ECN # 51341
<b>Performance</b>		<b>ENGLISH</b>	<b>SI</b>	<b>OPTIONAL VERSIONS</b>
Sensitivity(± 30 %)		1 0 mV/g	1 mV/(m/s <sup>2</sup> )	Optional versions have identical specifications and accessories as listed for the standard model except where noted below. More than one option may be used.
Measurement Range		± 5,000 g pk	± 49,000 m/s <sup>2</sup> pk	
Frequency Range(± 1 dB)		0 4 to 10,000 Hz	0 4 to 10,000 Hz	
Frequency Range(- 3 dB)		0 2 to 25,000 Hz	0 2 to 25,000 Hz [1]	
Resonant Frequency		> 50 kHz	> 50 kHz	
Electrical Filter Corner Frequency(- 3 dB)		17 kHz	17 kHz [2][3]	
Mechanical Filter Resonant Frequency		35 kHz	35 kHz [2][4]	
Broadband Resolution(1 to 10,000 Hz)		0 04 g rms	0 39 m/s <sup>2</sup> rms [2]	
Non-Linearity(per 1000 g (9810 m/s <sup>2</sup> ))		≤ 2 0 %	≤ 2 0 %	
Transverse Sensitivity		≤ 7 %	≤ 7 %	
<b>Environmental</b>				
Overload Limit(Shock)		± 50,000 g pk	± 490,000 m/s <sup>2</sup> pk	
Temperature Range(Operating)		-10 to +150 °F	-23 to +66 °C	
Temperature Range(Storage)		-40 to +200 °F	-40 to +93 °C	
Temperature Response		See Graph	See Graph [2][5]	
Base Strain Sensitivity		0 002 g/με	0 02 (m/s <sup>2</sup> )/με [2]	
<b>Electrical</b>				
Excitation Voltage		20 to 30 VDC	20 to 30 VDC	
Constant Current Excitation		2 to 20 mA	2 to 20 mA	
Output Impedance		≤ 200 Ohm	≤ 200 Ohm	
Output Bias Voltage		8 to 14 VDC	8 to 14 VDC	
Discharge Time Constant		1 0 to 2 0 sec	1 0 to 2 0 sec [2]	
Settling Time(within 10% of bias)		< 10 sec	< 10 sec	
Electrical Isolation(Case)		> 10 <sup>8</sup> Ohm	> 10 <sup>8</sup> Ohm	
<b>Physical</b>				
Sensing Element		Ceramic	Ceramic	
Sensing Geometry		Shear	Shear	
Housing Material		Titanium	Titanium	
Sealing		Hermetic	Hermetic	
Size (Height x Length x Width)		1 02 in x 1 02 in x 1 02 in	26 0 mm x 26 0 mm x 26 0 mm	
Weight(without cable)		0 95 oz	27 g [2]	
Electrical Connector		Integral Cable	Integral Cable	
Electrical Connection Position		Side	Side	
Cable Termination		1/4-28 4-Pin Jack	1/4-28 4-Pin Jack	
Cable Length		5 0 ft	1 52 m	
Cable Type		034 4-cond Shielded	034 4-cond Shielded	
Mounting		Through Hole	Through Hole	
<div><div>CE</div><div>[6]</div></div> <div><div>Typical Sensitivity Deviation vs Temperature</div><div></div></div>				
<b>NOTES:</b> [1]Typical corner frequency for coupled electrical and mechanical filters [2]Typical [3]Electrical filter is a second order filter [4]Amplitude at resonance is +9 dB [5]Test performed on a shaker at 100Hz [6]See PCB Declaration of Conformance PS023 for details				
<b>SUPPLIED ACCESSORIES:</b> Model 034G05 4-cond shielded cable, 5 ft (1 5M), 4-pin plug to (3) BNC plugs (1) Model 100-16040-40 Metric mounting screws (M6x1 0 x 22mm long (1) Model 100-6774-10 STD mounting screw (1/4-28 x .87 long) (1) Model 100-8994-40 Coupling grease (1) Model ACS-14T High G shock triaxial accelerometer calibration using Hopkinson bar (1) Model ACS-22T NIST Traceable triaxial frequency response (100Hz to ±1 Db point (1)				
Entered LK	Engineer AJA	Sales RWM	Approved BAM	Spec Number
Date 12/17/2020	Date 12/17/2020	Date 12/17/2020	Date 12/17/2020	67765
<div><div><b>PCB PIEZOTRONICS</b></div><div>3425 Walden Avenue, Depew, NY 14043</div><div>Phone: 716-684-0001 Fax: 716-684-0987 E-Mail: info@pcb.com</div></div>				
All specifications are at room temperature unless otherwise specified In the interest of constant product improvement, we reserve the right to change specifications without notice ICP® is a registered trademark of PCB Piezotronics, Inc				

Typical Sensitivity Deviation vs Temperature



CE [6]

All specifications are at room temperature unless otherwise specified.  
In the interest of constant product improvement, we reserve the right to change specifications without notice.  
ICP® is a registered trademark of PCB Piezotronics, Inc.

## **P. APPENDIX TEST PLAN CHANGE REQUEST FORMS (TPCR)**



TPCR Number	Date	Description	Comments
ORNL/NTRC-092 TPCR-001 (Non-Intent Change)	09/07/2021	Correct typographical error in ORNL/NTRC-092 test plan Figure 5-4. Revise Temperature label number for <b>test content assemblies</b> Figure 5-4:  Change from TL-10-190 - Change to TL-10-105.	Revise Temperature label number for test content assemblies Figure 5-4:  Change from TL-10-190 - Change to TL-10-105.
TPCR Number	Date	Description	Comments
ORNL/NTRC-092 TPCR-002 (Non-Intent Change)	09/14/2021	ORNL/NTRC-092 Section 4.5 - Measuring and Test Equipment - Page 17.  Add the ESPEC Model EWSX499-30NW, Serial No. 3240761 to Section 4.5 - Measuring and Test Equipment - Page 17.	This gives ORNL 2 Environmental chambers for DPP-1 HAC testing.
TPCR Number	Date	Description	Comments
ORNL/NTRC-092 TPCR-003 (Non-Intent Change)	09/15/2021	Add Torque Wrench A001320 to ORNL/NTRC-092 Table 4.3 on Page 17.  Additional calibrated M&TE may be used if calibration data is approved by CNS prior to use.	This gives ORNL flexibility to use additional calibrated equipment not currently listed in the test plan for DPP-1 testing.
TPCR Number	Date	Description	Comments
ORNL/NTRC-092 TPCR-004 (Non-Intent Change)	09/15/2021	Correct Test Form 3 - Assembly of Test Package:  1. Correct typo: Change "Record the assembled torque value on Test Form 11 to Test Form 10.  2. Remove the following step on Test Form 3: "Place the silicone foam pads on top the CV assembly Lid".	1. Drum Lid torque value should be recorded on Test Form 10 not Test Form 11.  2. Delete the step to place the silicone pad on top of the CV assembly lid prior to closing the drum. The silicone pad is glued to the bottom of the drum lid.

TPCR Number	Date	Description	Comments
ORNL/NTRC-092 TPCR-005 (Non-Intent Change)	09/30/2021	<p>Relocate the TU-1, TU-2, TU-5 &amp; TU-6 data logger attachments on the drum assembly to prevent damage to the accelerometer during drop testing.</p> <p>1. Revise ORNL/NTRC-092 section 5.1.4 (Pages 28 &amp; 29 paragraphs 7a, b, &amp; c to incorporated the revised locations of the data logger attachments. Revised locations are submitted for approval on PTP-R-059: "DPP-1 Accelerometer Mounting Procedure" attached to this TPCR.</p> <p>2. Revise DPP-1 Test Form 3 - Assembly of Test Package to incorporate changes from TPCR-004 and TPCR-005. A new Test Form 3 is included with this TPCR.</p>	<p>PTP requests to relocate the data logger mounting attachments on the drum assembly for DPP-1 test units TU-1, TU-2, TU-5 &amp; TU-6 to prevent damage to the accelerometers during drop testing.</p> <p>NOTE: Refer to PTP submittal No. PTP-R-058 for DPP-1 Accelerometer Calibration Records. NOTE: Refer to PTP submittal No. PTP-R-059 for the DPP-1 Accelerometer Mounting Procedure attached to TPCR-005.</p> <p>CNS Criteria: CNS Y-12 SOW 802586-0007 000 00 Table B.2 Data logger locations for TU-1, TU-2, TU-5 &amp; TU-6. NOTE: RWFD 4300 165073-0002 – Section 13 Change 10 previously granted PTP the allowance to use PCB 350B44 or other accelerometers after approval by CNS.</p>
TPCR Number	Date	Description	Comments
ORNL/NTRC-092 TPCR-006 (Non-Intent Change)	10/06/2021	<p>Exchange TU-4 CV with TU-7 CV. Remove test content assembly (with temperature indicating labels) from TU-4 CV and set aside. Apply temperature indicating labels internally and externally to TU-7 CV per the test plan. Install the test content assembly into TU-7 CV along with upper and lower PCC pads per the test plan. Complete TU-7 CV assembly and perform pre-shipment leak testing per the test plan. Remark TU-7 CV as TU-4 CV and install back into the TU-4 drum per the test plan. Complete TU-4 drum assembly and weigh and record TU-4 final weight. Update the affected test forms with the new information.</p>	<p>Original TU-4 CV was removed from TU-4 drum assembly and inserted into the CV-7 drum assembly.</p> <p>The original CV-7 was remarked as CV-4 which will now be used for the immersion test.</p> <p>All affected test forms were updated to reflect the revised information.</p>

TPCR Number	Date	Description	Comments
ORNL/NTRC-092 TPCR-007 (Urgent - Intent Change)	10/20/2021	<p>Unexpected Result:</p> <p>Upon impact of the 1100 pound crush plate during the HAC crush test, the TU-5 Drum Lid Cover Plate fillet weld failed approximately 270 degrees around the Cover Plate allowing the release of Packcrete from the drum lid onto the outside drop pad at NTRC. TU-5 is the chilled, 22 degree slap-down unit with a heavy test weight located in the high position.</p>	<p>The CNS Y-12 STR and PTP staff halted work while the STR contacted the PTE manager via phone, along with the design engineer and the quality engineer (in person) relaying the results from the 30-foot crush test. A determination was made by the testing oversight team to proceed with the 1-meter puncture test before the three hour HAC test window expired for the chilled unit. The HAC puncture test, with impact located near the FL and the drum seam, completed as planned without any additional issues. This TPCR provides the details of the change and gives the authority for NTRC to proceed with testing. This is an URGENT intent change and must be documented in the body of the final test report.</p>
ORNL/NTRC-092 TPCR-008 (Urgent - Intent Change)	10/21/2021	<p>Request to change the 1-Meter Puncture Test CGoTC drop angle from 56.4 degrees to 52.3 degrees for TU-4.</p>	<p>The closest angle that could be achieved due to the previous drop test deformations was 52.3 degrees which was 2.1 degrees out of tolerance.</p> <p>The CNS STR gave approval to drop at this angle due to the previous drop deformation after agreement with the design engineer and quality engineer. This is an URGENT intent change and must be included in the body of the final test report</p>

TPCR Number	Date	Description	Comments
ORNL/NTRC-092 TPCR-009 (Non - Intent Change)	11/22/2021	<p>Test Form 5 typographical error on 4<sup>th</sup> verification Checkpoint:</p> <p>Incorrect sentence: "Record the torque values needed to loosen the rum lid weldment screws on <b>Test Form 1</b>"</p> <p>Correct sentence" "Record the torque values needed to loosen the rum lid weldment screws on <b>Test Form 8</b>".</p>	



# PACKAGING AND TRANSPORTATION ENGINEERING TEST PLAN CHANGE REQUEST

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1 of 1

Test Plan Change Request Number ORNL/NTRC-092 TPCR-001	Date 09/07/21
Test Plan Number ORNL,NTRC-092	Test Plan Revision 0
Test Plan Title TEST PLAN FOR DPP-1 REGULATORY TESTING	

Reason for Change:


Correct typographical error in ORNL/NTRC-092 test plan Figure 5-4. The correct numbers are shown in Table B.1 of SOW 802586-0007 000 00. PTP Figure 5-4 incorrectly lists the temperature indicating labels as TL-10-190 and TL-10-290 for the Test Content Assembly.

Change From TL-10-190 and TL-10-290 to "TL-10-105 and TL-10-190"

Required Change:

Table B.1 of SOW 802586-0007 000 00 lists the Test Content Assembly temperature indicating labels as TL-10-105 and TL-10-190.

The correct temperature indicating labels (TL-10-105 and TL-10-190) are adhered to the Test Content Assemblies. This is a non-intent change to correct the typo in the test plan. - Ross Whittenbarger 9/7/2021

Submitted by: (Test Engineer)	SIGNATURE  Digitally signed by Oscar Martinez Date: 2021.09.07 16:18:28 -04'00'	DATE
Concurrence: (Packaging Engineer)	SIGNATURE <b>Ross M (RWM) Whittenbarger</b> Digitally signed by Ross M (RWM) Whittenbarger Date: 2021.09.07 15:05:54 -04'00'	DATE 09/07/21
Approval: (Package Design Manager)	SIGNATURE <b>James C (J5A) Anderson</b> Digitally signed by James C (J5A) Anderson Date: 2021.09.08 09:19:04 -04'00'	DATE 09/08/21

This document has been reviewed by a Y-12 DC / UCNI RO and has been determined to be UNCLASSIFIED and contains no UCNI. This review does not constitute clearance for Public Release.

NAME <b>Ross M (RWM) Whittenbarger</b> Digitally signed by Ross M (RWM) Whittenbarger Date: 2021.09.07 15:06:28 -04'00'	DATE 09/07/21
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UCN-21627 (12-13)

# PACKAGING AND TRANSPORTATION ENGINEERING TEST PLAN CHANGE REQUEST

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1 of 1

Test Plan Change Request Number ORNL/NTRC-092 TPCR-002	Date 09/14/21
Test Plan Number ORNL/NTRC-092	Test Plan Revision 0
Test Plan Title TEST PLAN FOR DPP-1 REGULATORY TESTING	

Reason for Change


ORNL PTP wishes to add another Environmental chamber to ORNL/NTRC-092 Section 4.5 - Measuring and Test Equipment - Page 17. This will allow ORNL to utilize an additional Environmental Chamber if needed for the HAC Cold test.

Required Change

Add the following paragraph to ORNL/NTRC-092 Section 4.5 - Measuring and Test Equipment - Page 17.

"Environmental Chamber - The environmental chamber used to chill test units is manufactured by ESPEC Model EWSX499-30NW, Serial No. 3240761. The chamber has a temperature range from -65 ° to +150 °C. The chamber monitor is manufactured by Vaisala, model HMT335, S/N: L3450145 (ORNL ID X185666). The refrigeration chamber's calibration will be verified, documented, and approved by CNS before use."

This is acceptable to CNS as an alternate chamber pending the calibration is verified before use. This is considered a non-intent change. - Ross Whittenbarger, 9/15/21.

Submitted by: (Test Engineer)	SIGNATURE  Digitally signed by Oscar Martinez Date: 2021.09.15 08:41:27 -04'00'	DATE
Concurrence: (Packaging Engineer)	SIGNATURE <b>Ross M (RWM) Whittenbarger</b> Digitally signed by Ross M (RWM) Whittenbarger Date: 2021.09.15 09:29:24 -04'00'	DATE 09/15/21
Approval: (Package Design Manager)	SIGNATURE <b>James C (J5A) Anderson</b> Digitally signed by James C (J5A) Anderson Date: 2021.09.15 10:46:42 -04'00'	DATE 09/15/21

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NAME <b>Ross M (RWM) Whittenbarger</b> Digitally signed by Ross M (RWM) Whittenbarger Date: 2021.09.15 11:04:16 -04'00'	DATE 09/15/21
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UCN-21627 (12-13)

# PACKAGING AND TRANSPORTATION ENGINEERING TEST PLAN CHANGE REQUEST

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Test Plan Change Request Number 003 <i>JAM</i> ORNL/NTRC-092 TPCR-004 <i>1/13/2022</i>	Date 09/15/21
Test Plan Number ORNL/NTRC-092	Test Plan Revision 0
Test Plan Title TEST PLAN FOR DPP-1 REGULATORY TESTING	

## Reason for Change

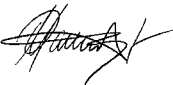
ORNL requests flexibility to use calibrated equipment that is not currently listed in the test plan. This will eliminate additional TPCR's to add equipment not listed in the test plan.

## Required Change

During final drum assembly, ORNL needed to use calibrated torque wrench A001320 which was not listed in the torque wrench table listed in ORNL/NTRC-092 test plan Section 4.5 Measuring and Test Equipment list - Page 17.

Revise 1st paragraph of ORNL/NTRC-092 test plan Section 4.5 to add this sentence: "Additional Measuring and Test Equipment (M&TE) not listed in the test plan may be used if calibration records are approved by CNS prior to use.

This is a non-intent change and is acceptable to CNS. - Ross Whittenbarger, STR, 9/21/21

Submitted by: (Test Engineer)	SIGNATURE 	Digitally signed by Oscar Martinez Date: 2021.09.21 14:16:11 -04'00'	DATE
Concurrence: (Packaging Engineer)	SIGNATURE Ross M (RWM) Whittenbarger	Digitally signed by Ross M (RWM) Whittenbarger Date: 2021.09.21 15:07:15 -04'00'	DATE 09/21/21
Approval: (Package Design Manager)	SIGNATURE Richard D (RT9) Turner	Digitally signed by Richard D (RT9) Turner Date: 2021.09.21 15:30:56 -04'00'	DATE 09/21/21

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NAME Ross M (RWM) Whittenbarger	Digitally signed by Ross M (RWM) Whittenbarger Date: 2021.09.21 15:33:15 -04'00'	DATE 09/21/21
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UCN-21627 (12-13)

# PACKAGING AND TRANSPORTATION ENGINEERING TEST PLAN CHANGE REQUEST

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Test Plan Change Request Number ORNL/NTRC-092 TPCR-004	Date 09/15/21
Test Plan Number ORNL/NTRC-092	Test Plan Revision 0
Test Plan Title TEST PLAN FOR DPP-1 REGULATORY TESTING	

Reason for Change:

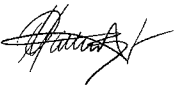
1. Typo on Test Form 3: Drum Lid torque value should be recorded on Test Form 10, not Test Form 11.
2. Incorrect Step on Test Form 3: The silicone pad(s) were thought to be laid on top of the CV. The silicone pad is actually glued to the bottom of the Drum Lid.

Required Change

Correct Test Form 3 - Assembly of Test Package:

1. Move "Record the assembled torque value" from Test Form 11 to Test Form 10.
2. Remove the following step on Test Form 3: - "Place the silicone foam pads on top the CV assembly Lid" due to the foam being adhered to the bottom of the drum lid.

This is a non-intent change and is acceptable to CNS. - Ross Whittenbarger, STR, 9/21/21

Submitted by: (Test Engineer)	SIGNATURE  Digitally signed by Oscar Martinez Date: 2021.09.21 14:16:36 -04'00'	DATE
Concurrence: (Packaging Engineer)	SIGNATURE <b>Ross M (RWM) Whittenbarger</b> Digitally signed by Ross M (RWM) Whittenbarger Date: 2021.09.21 15:19:29 -04'00'	DATE 09/21/21
Approval: (Package Design Manager)	SIGNATURE <b>Richard D (RT9) Turner</b> Digitally signed by Richard D (RT9) Turner Date: 2021.09.21 15:29:40 -04'00'	DATE 09/21/21

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NAME <b>Ross M (RWM) Whittenbarger</b> Digitally signed by Ross M (RWM) Whittenbarger Date: 2021.09.21 15:32:44 -04'00'	DATE 09/21/21
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Y17-69-PE-345

UCN-21627 (12-13)



# PACKAGING AND TRANSPORTATION ENGINEERING TEST PLAN CHANGE REQUEST

PAGE

1 of 1

Test Plan Change Request Number ORNL/NTRC-092 TPCR-005	Date 09/30/21
Test Plan Number ORNL/NTRC-092	Test Plan Revision 0
Test Plan Title TEST PLAN FOR DPP-1 REGULATORY TESTING	

Reason for Change


CNS Y-12 SOW 802586-0007 000 00 Table B.2 details Data logger locations for TU-1, TU-2, TU-5 & TU-6 at the drum CG. These locations must be changed to prevent damage to the accelerometers during drop testing and to provide potentially greater G-force measurements. CNS approved RWFD 4300165073-0002 - Section 13, Item 10 which grants PTP the allowance to use PCB 350B44 or other accelerometers after approval by CNS.

Refer to PTP Submittal No. PTP-R-058 - FY21 DPP-1 Accelerometer Calibration Records.

Refer to PTP Submittal No. PTP-R-059 - DPP-1 Accelerometer Mounting Procedure for locations of DPP-1 installed accelerometers.

Required Change:

- ORNL/NTRC-092 Section 5.1.4 Drum Assembly (Page 28 & 29) paragraphs 7.a, b, and c as follows:  
Install the accelerometers on TU-1, TU-2, TU-5, and TU-6 in accordance with the "DPP-1 Accelerometer Mounting Procedure". The procedure shall be submitted and approved prior to any drop testing. NOTE: The TU-6 accelerometers will be removed before the water spray test if needed and reinstalled upon completion of the water spray test. PTP Submittal No. PTP-R-059 - DPP-1 Accelerometer Mounting Procedure is attached.
- ORNL/NTRC-092 Test Form 3 - Assembly of Test Package (Page 67): Revise checklist wording for TU-1, TU-2, TU-5 & TU-6 acceptance to read as follows: TU-1, TU-2, TU-5, and TU-6 accelerometer mounts have been installed and locations accepted in accordance with the DPP-1 Accelerometer Mounting Procedure prior to drop testing. Test Form 3 - Assembly of Test Package (Page 67) is attached to incorporate TPCR's 003 & 004. This is acceptable and is a non-intent change to protect the accelerometers and provide accurate data. - Ross Whittenbarger, STR 10/2/21.

Submitted by: (Test Engineer)	SIGNATURE  Digitally signed by Oscar Martinez Date: 2021.10.06 08:24:45 -04'00'	DATE
Concurrence: (Packaging Engineer)	SIGNATURE <b>Ross M (RWM) Whittenbarger</b> Digitally signed by Ross M (RWM) Whittenbarger Date: 2021.10.02 11:01:09 -04'00'	DATE  10/02/21
Approval: (Package Design Manager)	SIGNATURE <b>James C (J5A) Anderson</b> Digitally signed by James C (J5A) Anderson Date: 2021.10.06 15:11:30 -04'00'	DATE  10/06/21

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NAME <b>Ross M (RWM) Whittenbarger</b> Digitally signed by Ross M (RWM) Whittenbarger Date: 2021.10.02 11:01:14 -04'00'	DATE  10/02/21
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Y17-69-PE-345

UCN-21627 (12-13)

### TEST FORM 3 - ASSEMBLY OF TEST PACKAGE

Test Plan DPP-1  
TU- \_\_\_\_\_

VERIFIED

TASK

Verify operational leak test is complete and form completed and tighten the CV lid leak test port plug per the following sequence: 1<sup>st</sup> pass hand tight, 2<sup>nd</sup> pass torque to 6-7 ft-lb.

Torque wrench # \_\_\_\_\_ Calibration Expiration Date \_\_\_\_\_

The exterior of the drum has been clearly marked "TU- \_\_\_\_\_" and record the drum serial number if applicable:

Verify all exterior markings on the TU. If marks are not legible or inadequate, the TA will remark the TU. Mark the 0°, 90°, 180°, 270° locations on the Drum Lid, and the inner and outside walls of the drum with a permanent marker.

Install temperature labels on the inside of the drum body as shown in Figure 5-3.

Clean all surface of the drum body with isopropyl alcohol and let air dry.

The drum body, drum lid, bolts, washers, pads, were weighed and recorded on TEST FORM 1.

Place the lower CV base pad into the drum body.

Place the CV assembly into the drum body.

The CV assembly has been loaded into the drum with the 0° rotated and aligned with 0° line on the drum. Ensure temperature labels are not damaged.

Place the CV flange wedge between the CV flange and the drum body.

The drum lid has been loaded into the drum with the 0° rotated and aligned with the 0° location on the drum.

If necessary, apply thread lubricant to the drum closure bolts.

The drum lid has been closed using the same screws that were removed during disassembly. The screws shall be torqued in sequence following the numbers etched into the drum lid in two passes. First, the screws shall be torqued until the lid is in full contact with the flange. Second, the screws shall be torqued to 33–37 ft-lb. Record the assembled torque value on Test Form 10. **TPCR-04**

Torque wrench #: \_\_\_\_\_ Calibration Expiration Date: \_\_\_\_\_

The test package assembly has been weighed and the weight recorded on Test Form 1.

Mount one (1) vibration accelerometer on the TU-6 drum lid center for NCT vibration monitoring according to the DPP-1 Accelerometer Mounting Procedure. Remove accelerometer after NCT Test.

#### **TPCR-05**

The accelerometer mounting blocks and restraint rings have been welded to the drum outer shell as specified in the DPP-1 Accelerometer Mounting Procedure. **TPCR-05**

Install the accelerometers on TU-1, TU-2, TU-5, and TU-6 at the locations specified by the DPP-1 Accelerometer Mounting Procedure". **TPCR-05**

The accelerometers were checked to ensure they were installed and functioning as intended after each installation. **HOLD POINT:** Y-12 has approval: CNS STR \_\_\_\_\_, CNS QE \_\_\_\_\_

Photographs of the assembly have been taken\*.

Comments:

I certify that the above tasks have been performed and that the observations and comments are correct.

Testing Technician

Date

Witness

Date


CNS-Y-12 STR

Date

CNS-Y-12 QE

Date

\*All photographs/movies will be uniquely identified with test unit, date and time to ensure that the proper sequence can be reconstructed.

 <p>OAK RIDGE NATIONAL LABORATORY MANAGED BY UT-BATTELLE FOR THE DEPARTMENT OF ENERGY</p> <p>PTP QA Record</p>	<p>PTP QA Record Number : PTP- R-059 PTP Record Date: 10/05/2021</p> <p>Retention Period: Lifetime</p>
<p>Record Title : Mounting Procedure for External Accelerometers on DPP-1 Accelerometer Mounts</p>	
<p>Project Description or Project Number: Procedure for attaching accelerometer mounts and strain relief rings to the DPP-1 units.</p>	
<p>Location of record: <a href="#">\\ornl2\otsp\TTG PRF Files\Package Testing Program\PTP Records Management</a></p>	

## DPP-1 Accelerometer Mounting Procedure

Attachment A Drawings A-1 through A-15 detail the orientation of the mounts with relation to the drop points. All mounts have been designed by finite element analysis to meet a fundamental resonant frequency high enough to allow accurate collection of the acceleration data. Drawings A-1 through A-15 provide mounting locations for Accelerometer Model 350B44 sensor mounts and restraint rings that must be welded to the exterior of the TU-1, TU-2, TU-5, & TU-6 drum bodies. One Model 352C68 accelerometer sensor mount will be attached to the lid of TU-6 with double bubble epoxy glue at the location shown on drawing A-15. PTP personnel shall record the following information in the test logbook:

- a. the accelerometer serial numbers,
- b. the position of the accelerometer on the drum,
- c. the X,Y, Z axis for each sensor
- d. axis sensitivity for each sensor (MV/G)

Figures 1, 2 & 3 detail the DPP-1 container material, sensor mount material, and the restraint ring material. Welding filler metal shall be ER308/308L. The size of the welds shall be such that there is enough weld filler metal deposited to ensure that the mounts and rings cannot be removed easily by hand. Welding shall be performed by ORNL certified welders using ORNL approved welding procedures. The welds do not require inspection however, PTP Test Engineer shall verify the final installation of the mounts and restraint rings by visual inspection prior to testing.

The mounting of the sensors will follow best practices given by the manufacturers instructions shown in Attachment B. The links below contain PCB Piezotronics installation documents:

<https://www.pcb.com/products?m=350B44>

<https://www.pcb.com/products?model=352C68>

Through hole mounting guidelines are similar to stud mounting requirements and mounted per manufacturer's instructions. The surface finish should be 63 micro inch RMS or better and flat for a good mechanical connection to be achieved. The accelerometers are oriented per the drawing associated with each specific test unit and a small amount of epoxy glue (such as double bubble epoxy or approved equal) is applied to the mounting surface to assure good mechanical coupling. The through bolt is attached and torqued to 2-5-foot lbs. with a calibrated torque wrench. Allow the epoxy to cure for an hour prior to any further mechanical operation.

Tape electrical leads to the surface of the cask until it is time to run the umbilical cable and strain relief it and connect the umbilical cables to the three accelerometer connections. The installation manual discusses cable connection and wiring selection. The 350B44 transducers come with a permanently mounted cable hardwired by the factory based on the transducer characteristics.

Chilled unit drops (TU-1 and TU-5 respectively) will require application of strain relief methods for the OEM cable connections prior to going into their temperature baths. All accelerometer sensor connections will be made prior to refrigeration except for the final umbilical electrical connections which will be completed at the NTRC prior to HAC testing. This also aids in minimizing the exposure time prior to the actual drop test.

Prior to all drop orientations, the accelerometers, connections, and signals will be checked to ensure that signals are being received in the recording software.



## **Disassembly of Accelerometers**

After completion of each drop test, inspect the external accelerometers and cabling for damage. Perform all required photography to document the condition of the TU's and accelerometer hardware. Document observed damage per test plan requirements.

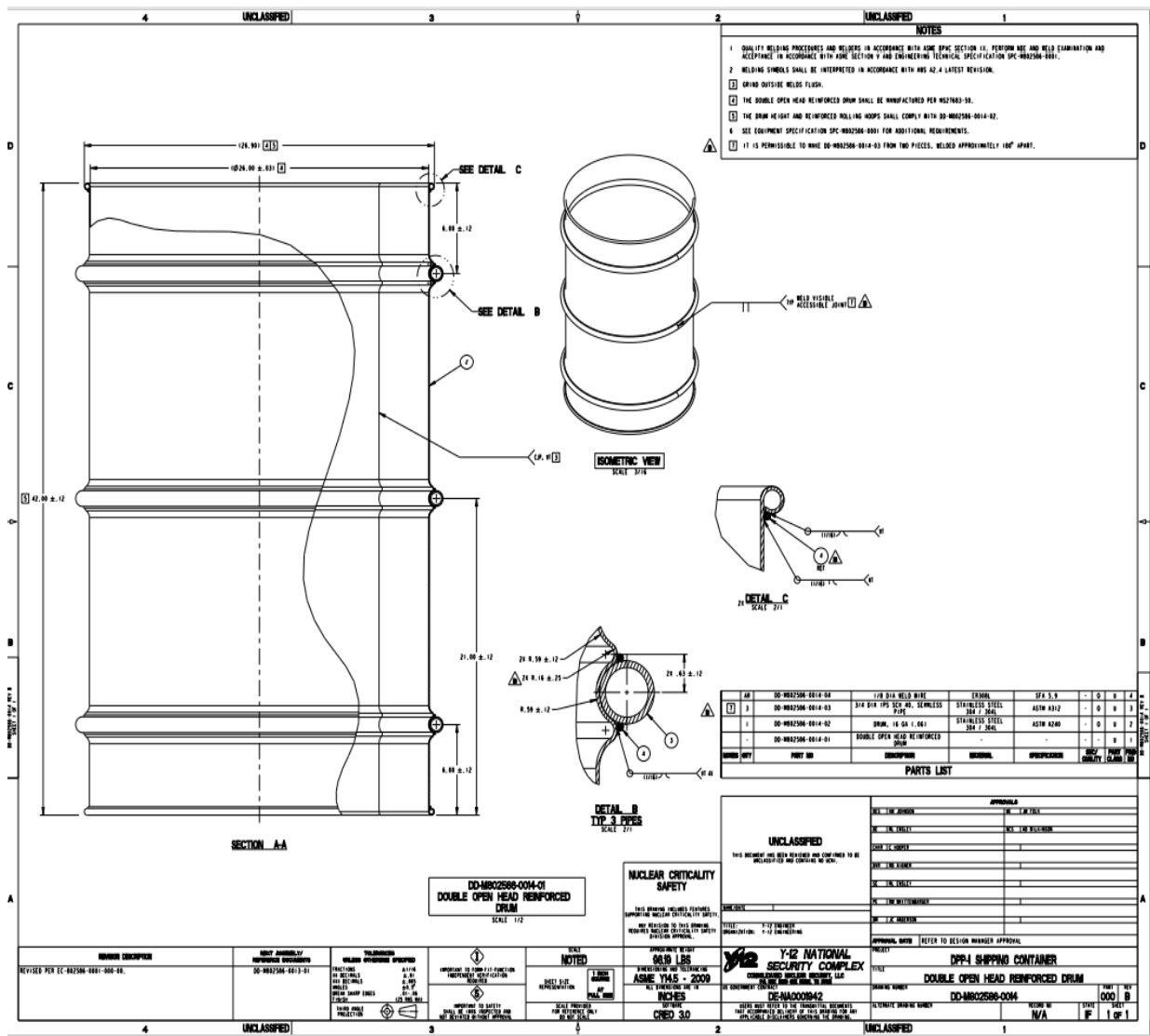
1. Remove the umbilical connections.
2. Remove all tape and strain relief on the original OEM cables.  
Note: Hold the cables away from the accelerometer and release the through bolt. If necessary, twist the sensor to shear any remaining adhesive and remove the sensor from the mount.
3. Inspect the mount for any weld failure or bending or material yielding. Take photographs of the removal area and document damage observed (if any).

Store the sensor back in its factory box. Check the serial number and position listing data of each sensor with the logbook to assure the records are correct.

### **Attachments:**

**Attachment A - Accelerometer mount and strain relief location drawings**

**Attachment B - PCB Piezotronics Manufactures Instructions**

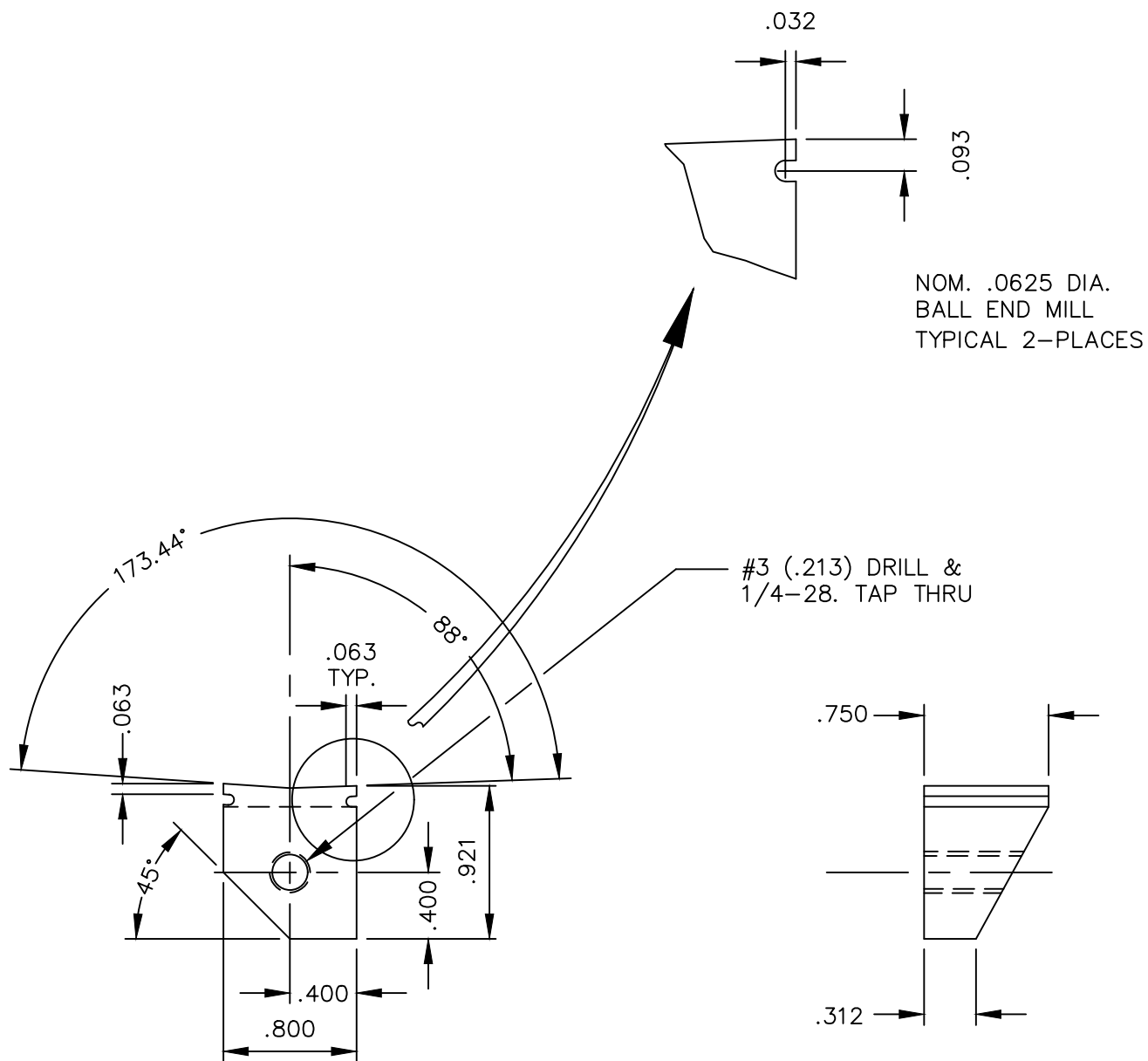


DPP-1 Shipping Container Double Open Head Reinforced Drum

AR	DD-M802586-0014-04	1/8 DIA WELD WIRE	ER308L	SFA 5.9	-	Q	U	4
7	3	DD-M802586-0014-03	3/4 DIA IPS SCH 40, SEAMLESS PIPE	STAINLESS STEEL 304 / 304L	ASTM A312	-	Q	3
1	DD-M802586-0014-02	DRUM, 16 GA (.06)	STAINLESS STEEL 304 / 304L	ASTM A240	-	Q	U	2
-	DD-M802586-0014-01	DOUBLE OPEN HEAD REINFORCED DRUM	-	-	-	-	U	1
NOTES	QTY	PART NO	DESCRIPTION	MATERIAL	SPECIFICATION	SSC/QUALITY	PART CLASS	FIND NO
PARTS LIST								

NOTE: The details above were derived from CNS Y-12 Drawing DD-M802586-0014 Rev. B. used as reference information only in support of the DPP-1 Accelerator Mounting Procedure for DPP-1 containers: TU-1, TU-2, TU-5 & TU-6.

Figure 1 - DPP-1 Shipping Container



## ACCEL. MOUNT

MAT'L: 304L STAINLESS STEEL

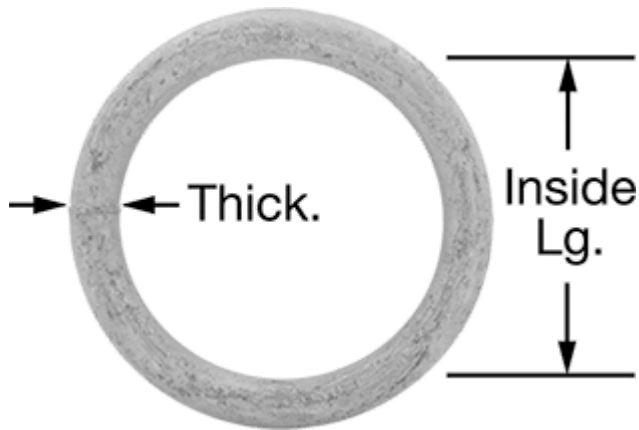
Figure 2 - Accelerometer Mounts for TU-1, TU-2, TU-5 & TU-6



## Ring - Not for Lifting

18-8 Stainless Steel, for 1/4 and 3/16 Chain Sizes, 2" Inside Length

P/N: 3769T77

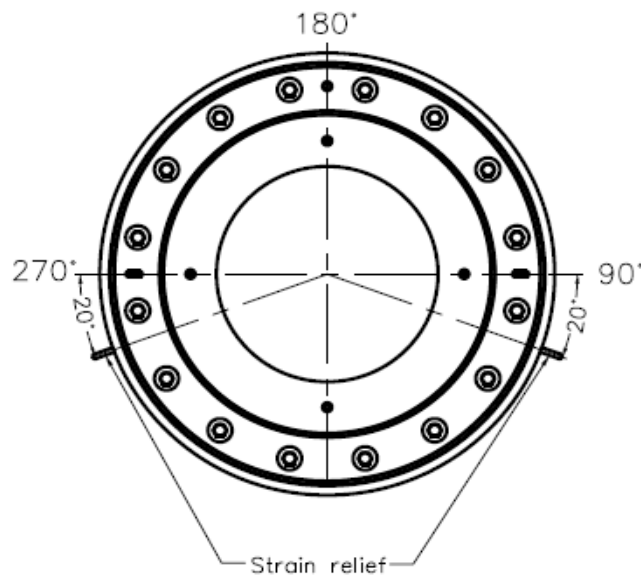


Material	18-8 Stainless Steel
For Chain Trade Size	3/16, 1/4
Thickness	5/16"
Inside Length	2"
Capacity	600 lbs.
Fabrication	Welded
Fitting Type	Link/Ring
Application	Not for Lifting
RoHS	RoHS 3 (2015/863/EU) Compliant
REACH	REACH (EC 1907/2006) (01/16/2020, 205 SVHC) Compliant
DFARS	Specialty Metals COTS-Exempt
Country of Origin	Taiwan
Schedule B	732690.8695
ECCN	EAR99

18-8 stainless steel rings have excellent corrosion resistance to chemicals.

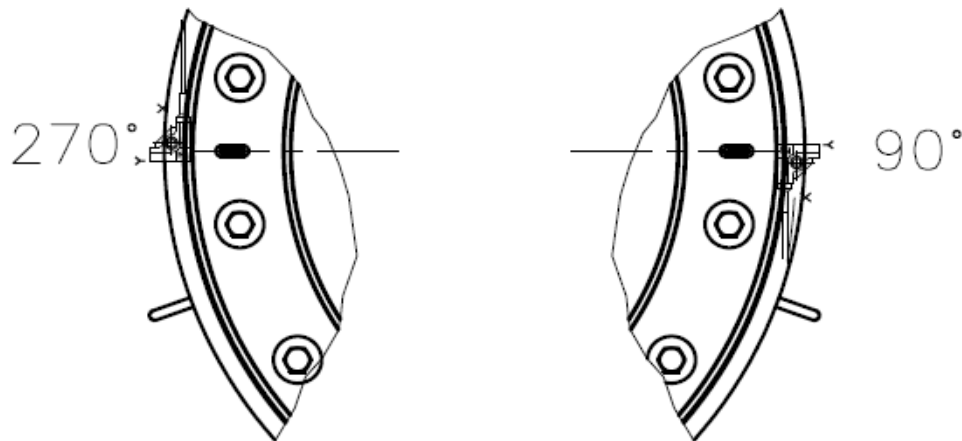
**Figure 3 - Strain Relief Ring**



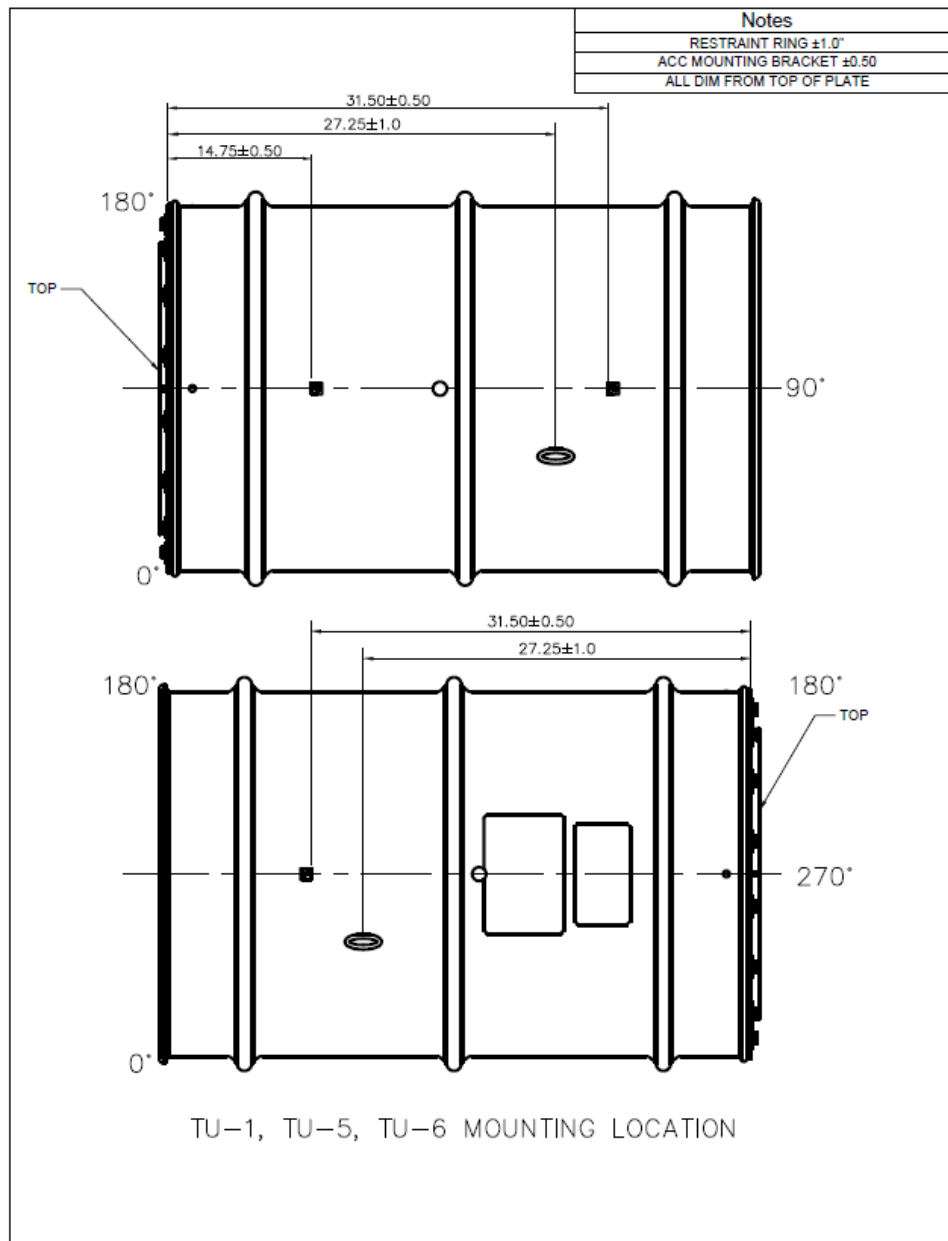


Accel. ORIENTATION  
 "Z" axis of the accel. is aligned with the vertical center line of the cask.  
 "Y" axis of the accel. is aligned with the 90°/270° designation of the cask.  
 "X" axis of the accel. is aligned with the 0°/180° designation of the cask, and tangential to the radius of the cask.

TU-1, TU-2, TU-5, TU-6 ACCEL/SR LOCATION



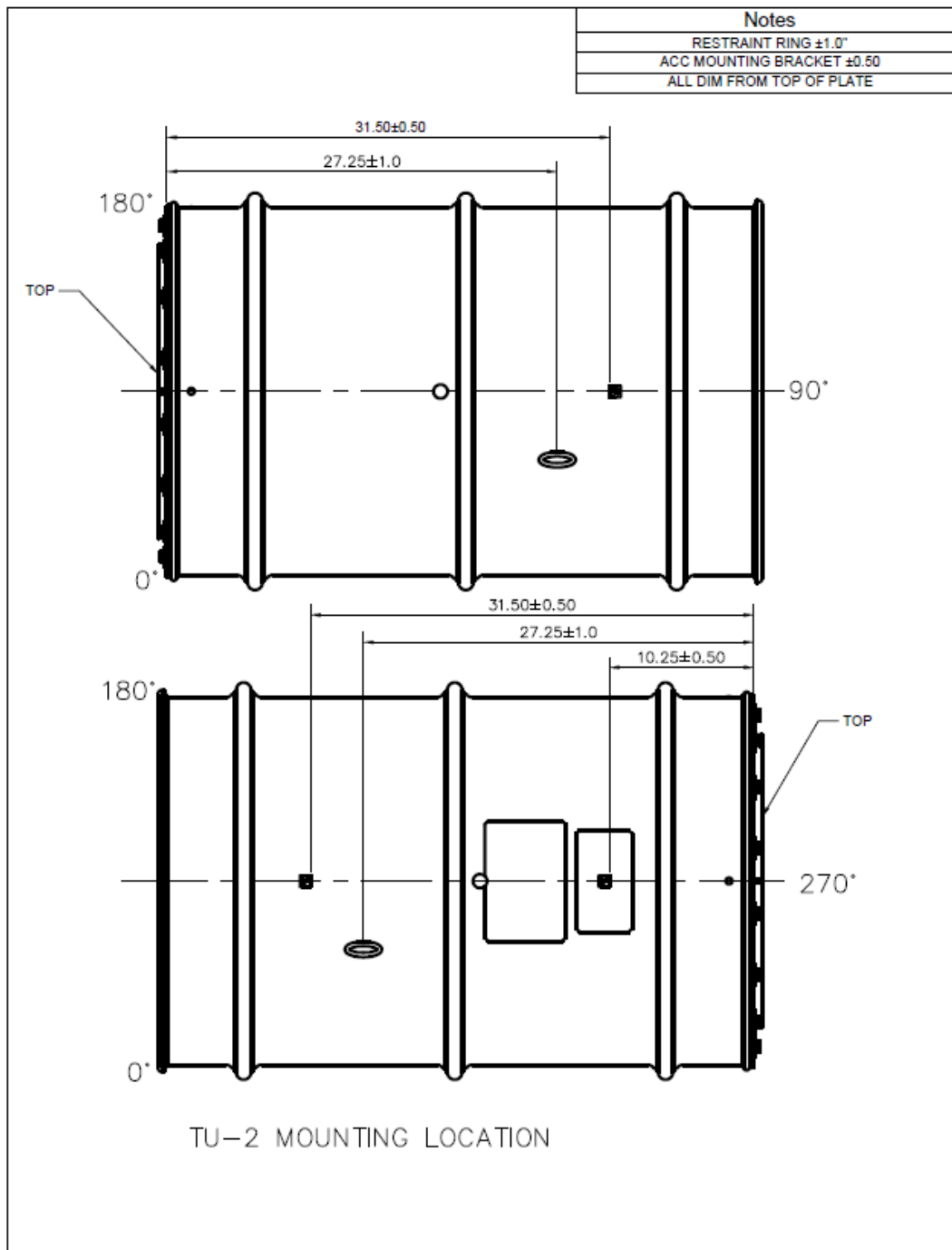
**Drawing A1 End Orientation**



**Drawing A-2 Accelerometer / Restraint Ring Mounting Locations**

**TU-1, TU-5, TU-6**

**For Accelerometer orientations reference Figure A1.**

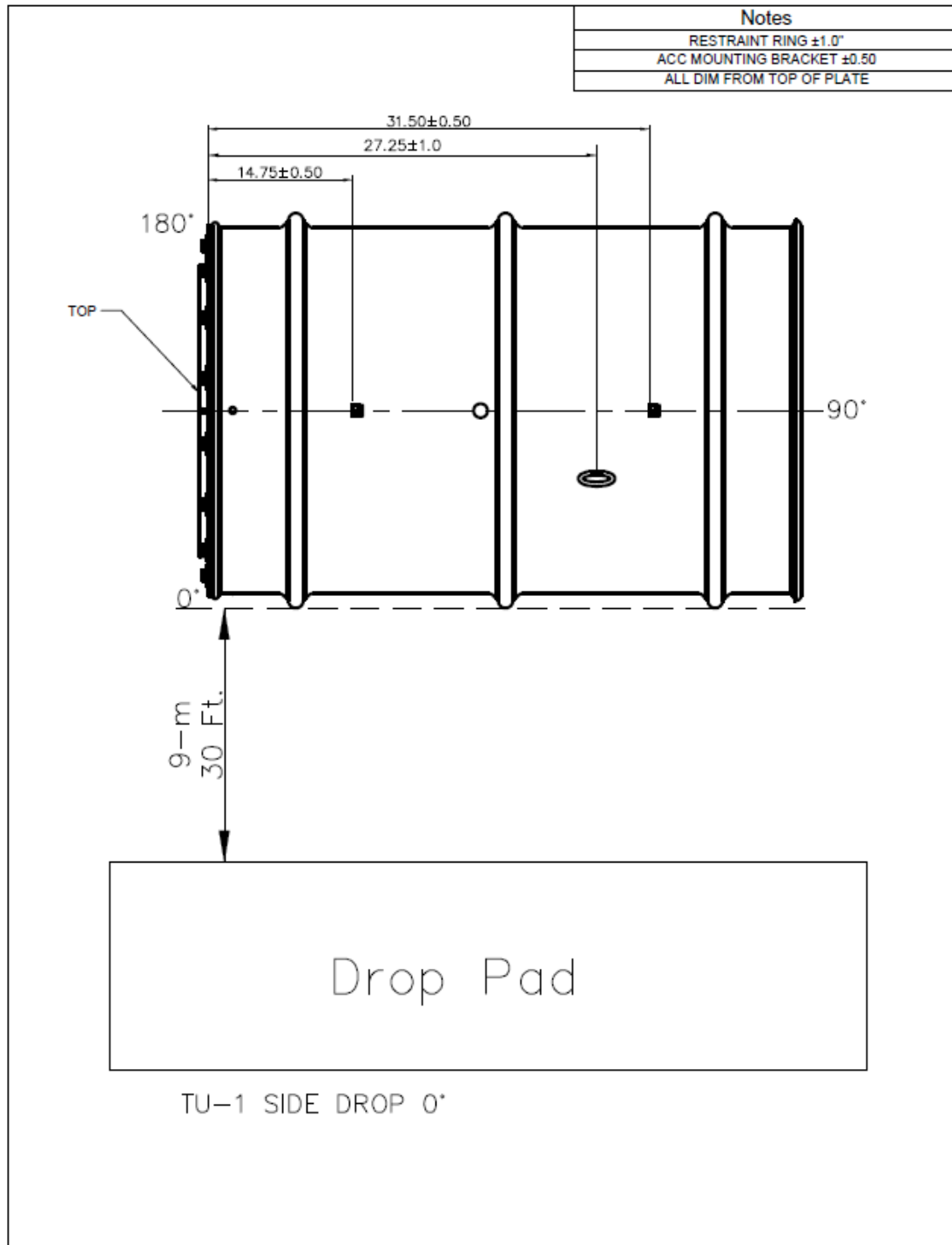


**Drawing A-3**

**Accelerometer / Restraint Ring Mounting Locations**

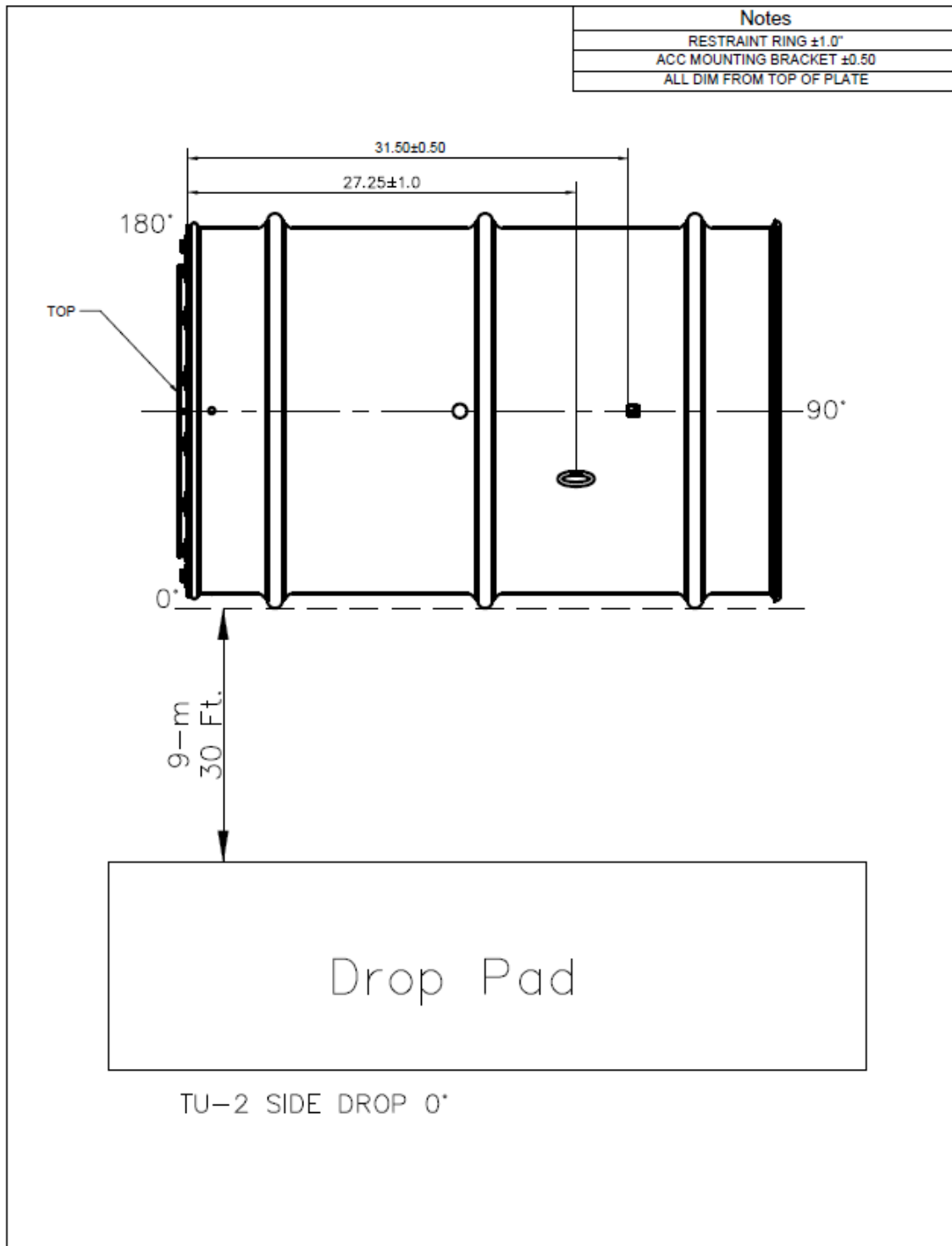
**TU-2**

**For Accelerometer orientations reference Figure A1.**

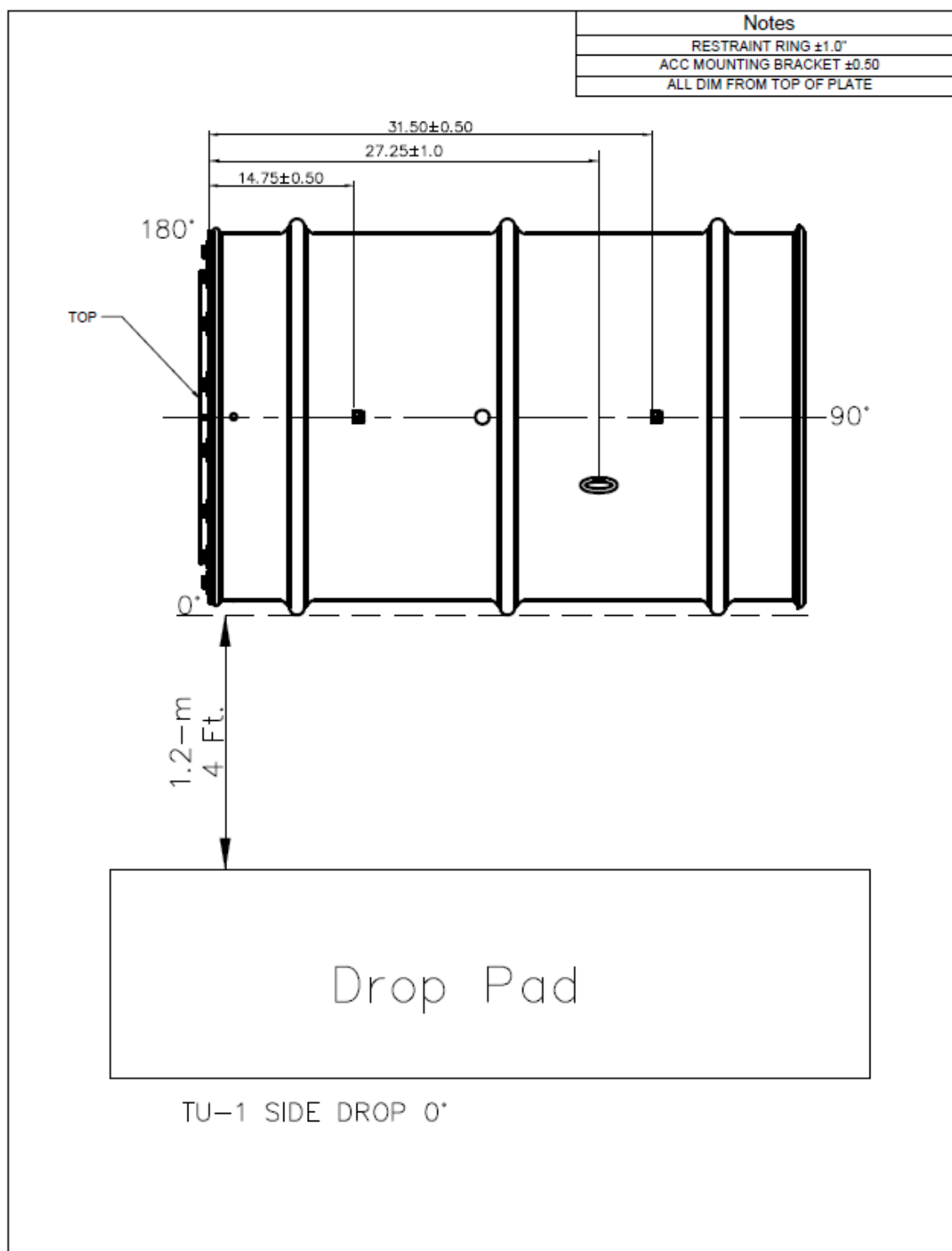


**Drawing A-4      Side Orientation      TU-1 Side Drop.**  
**For Accelerometer orientations reference Figure A1.**

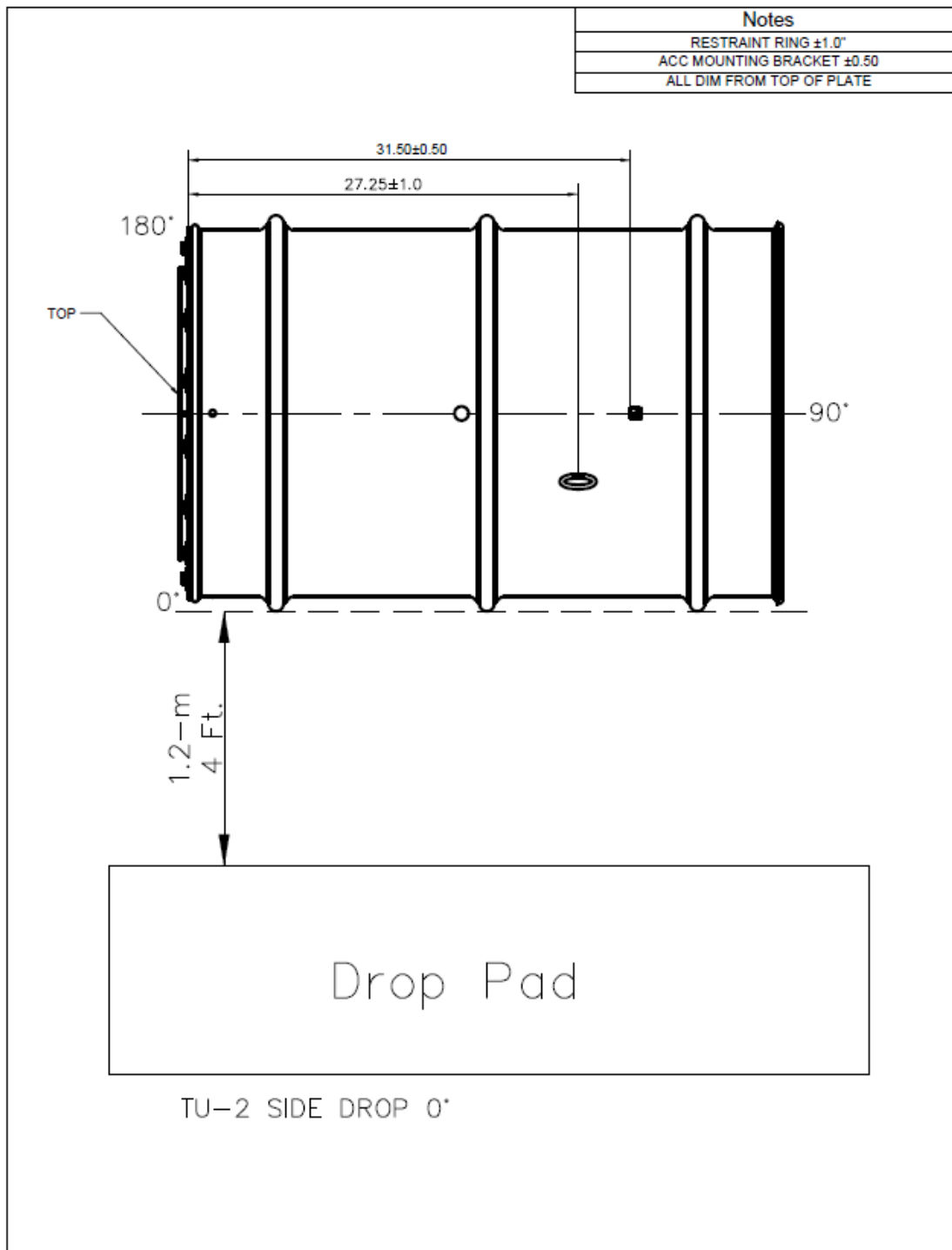




**Drawing A-5 TU-2 30 Ft. Side Drop**  
**For Accelerometer orientations reference Figure A1.**



**Drawing A-6      Side Orientation      TU-1      4 Ft Side Drop**  
**For Accelerometer orientations reference Figure A1.**



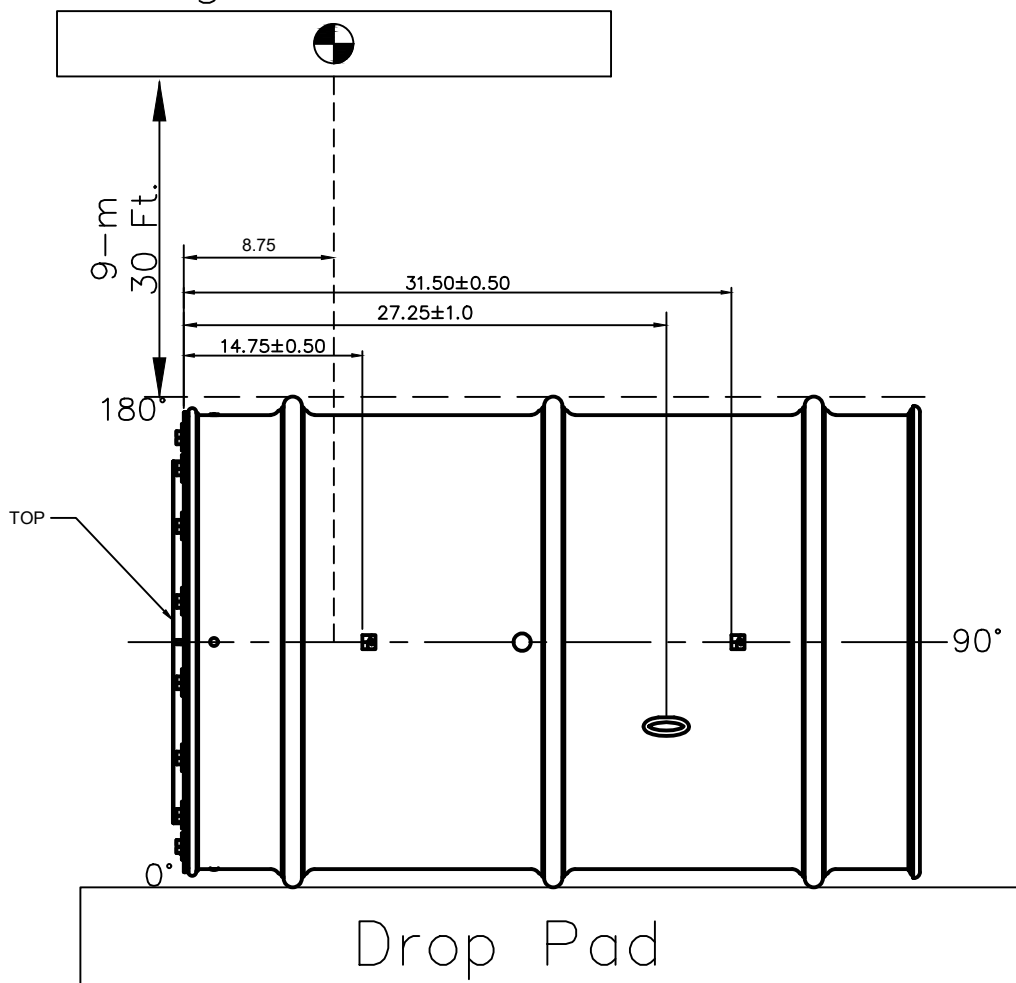
**Drawing A-7 TU-2 4 Ft Side Drop**  
**For Accelerometer orientations reference Figure A1.**

## Notes

RESTRAINT RING  $\pm 1.0^{\circ}$ ACC MOUNTING BRACKET  $\pm 0.50$ 

ALL DIM FROM TOP OF PLATE

## 500kg Crush Plate



TU-1, TU-5, TU-6 SIDE CRUSH

**Drawing A-8**      **TU-1, TU-5, & TU-6**      **Side Crush**  
**For Accelerometer orientations reference Figure A1.**



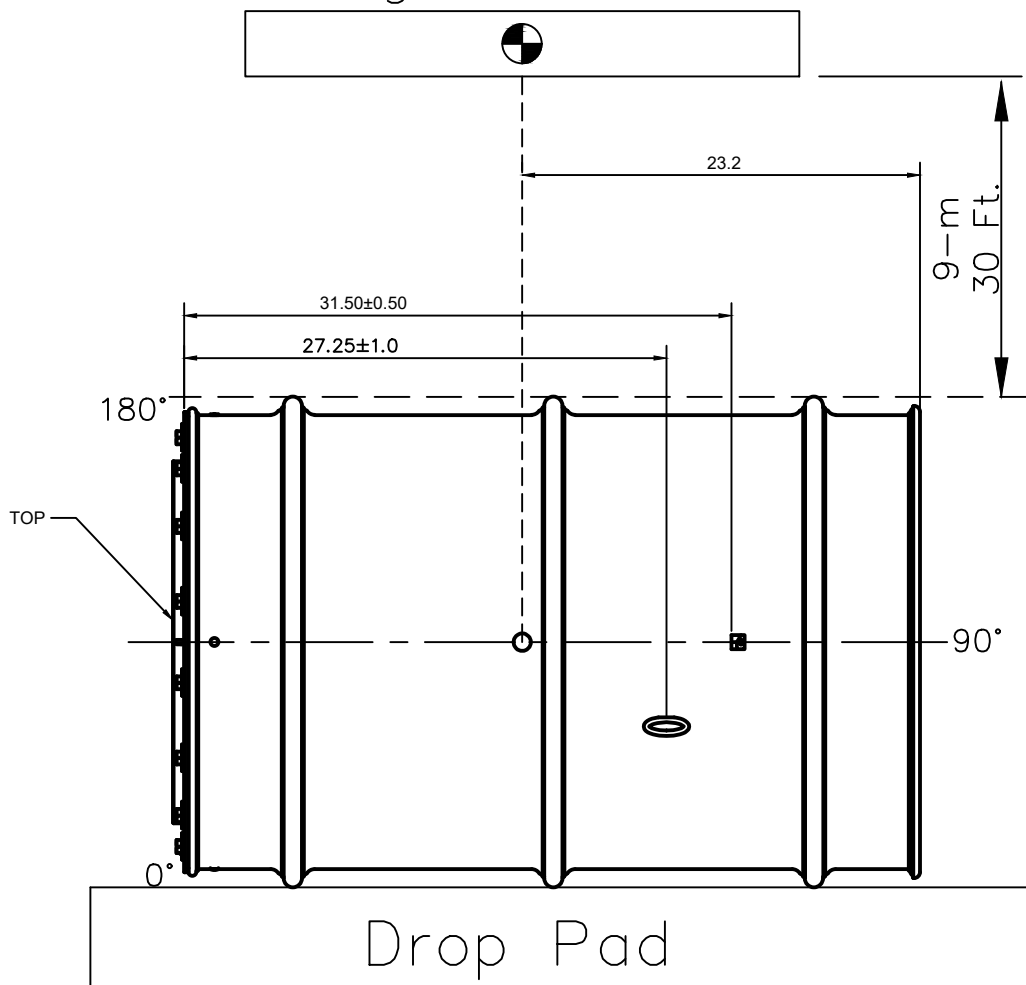
# Notes

RESTRAINT RING  $\pm 1.0^{\circ}$

ACC MOUNTING BRACKET  $\pm 0.50$

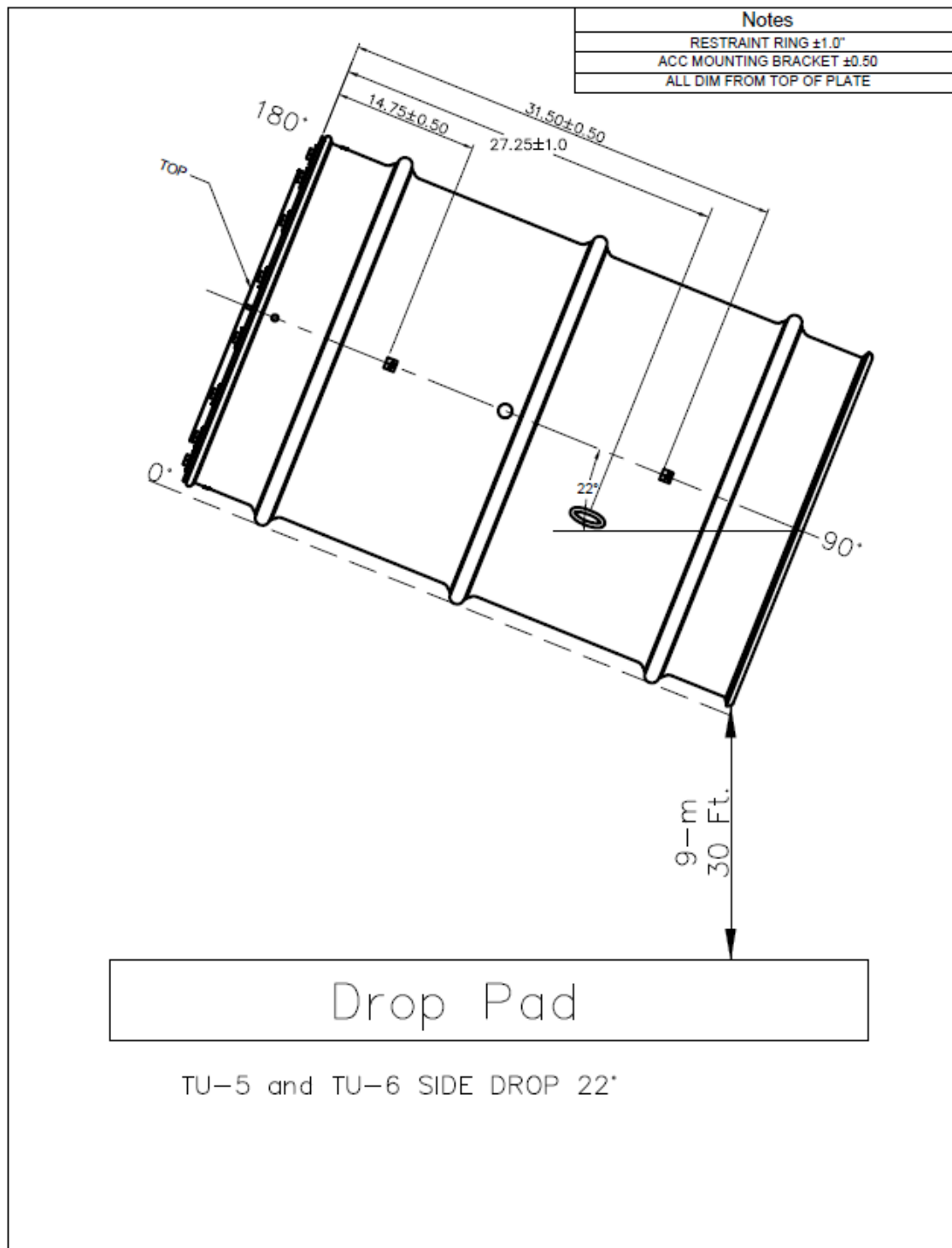
ALL DIM FROM TOP OF PLATE

## 500kg Crush Plate

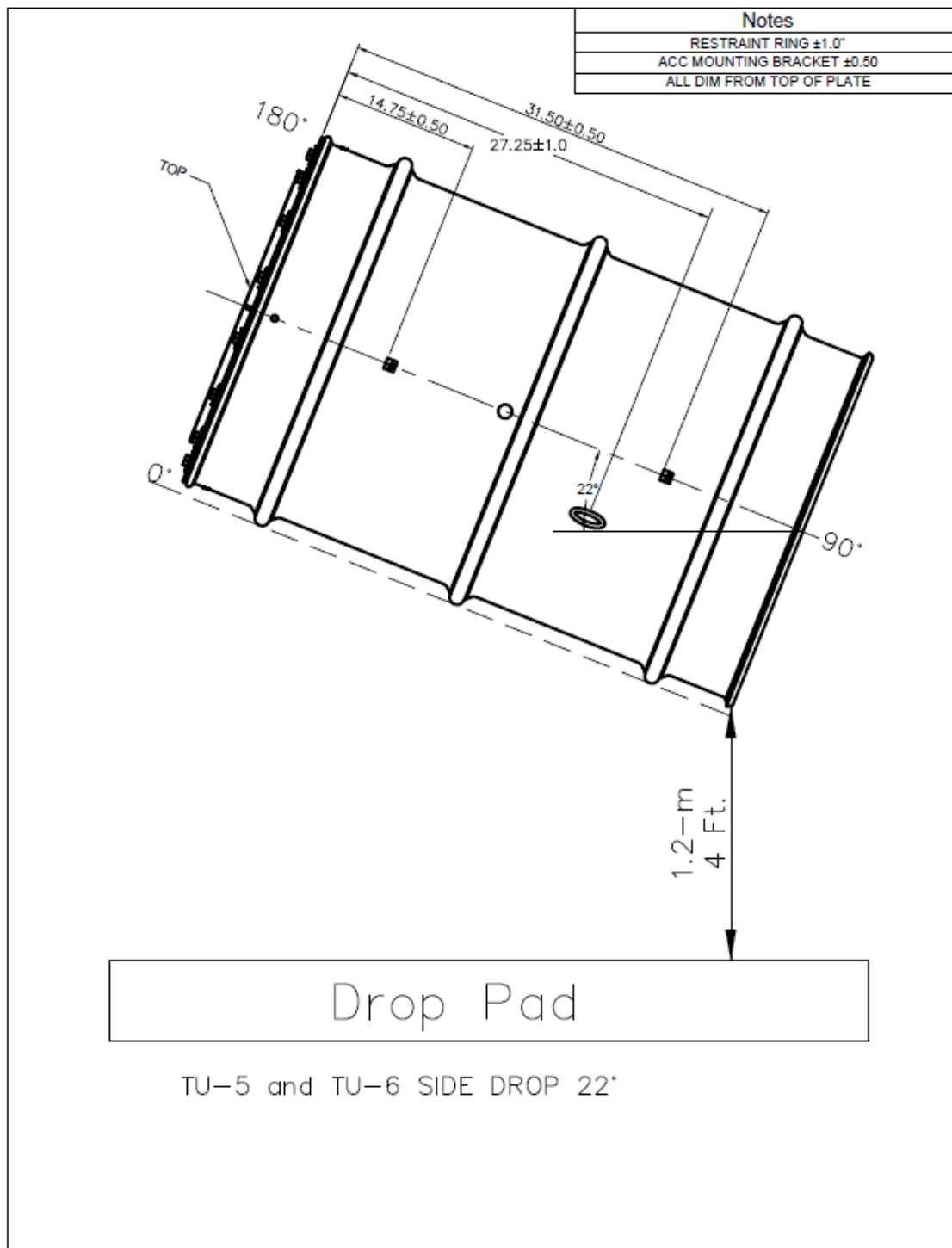


TU-2 SIDE CRUSH

**Drawing A-9 TU-2 Side Crush**  
**For Accelerometer orientations reference Figure A1.**



**Drawing A-10      T-5 & TU-6      30Ft Slap Down**  
**For Accelerometer orientations reference Figure A1.**



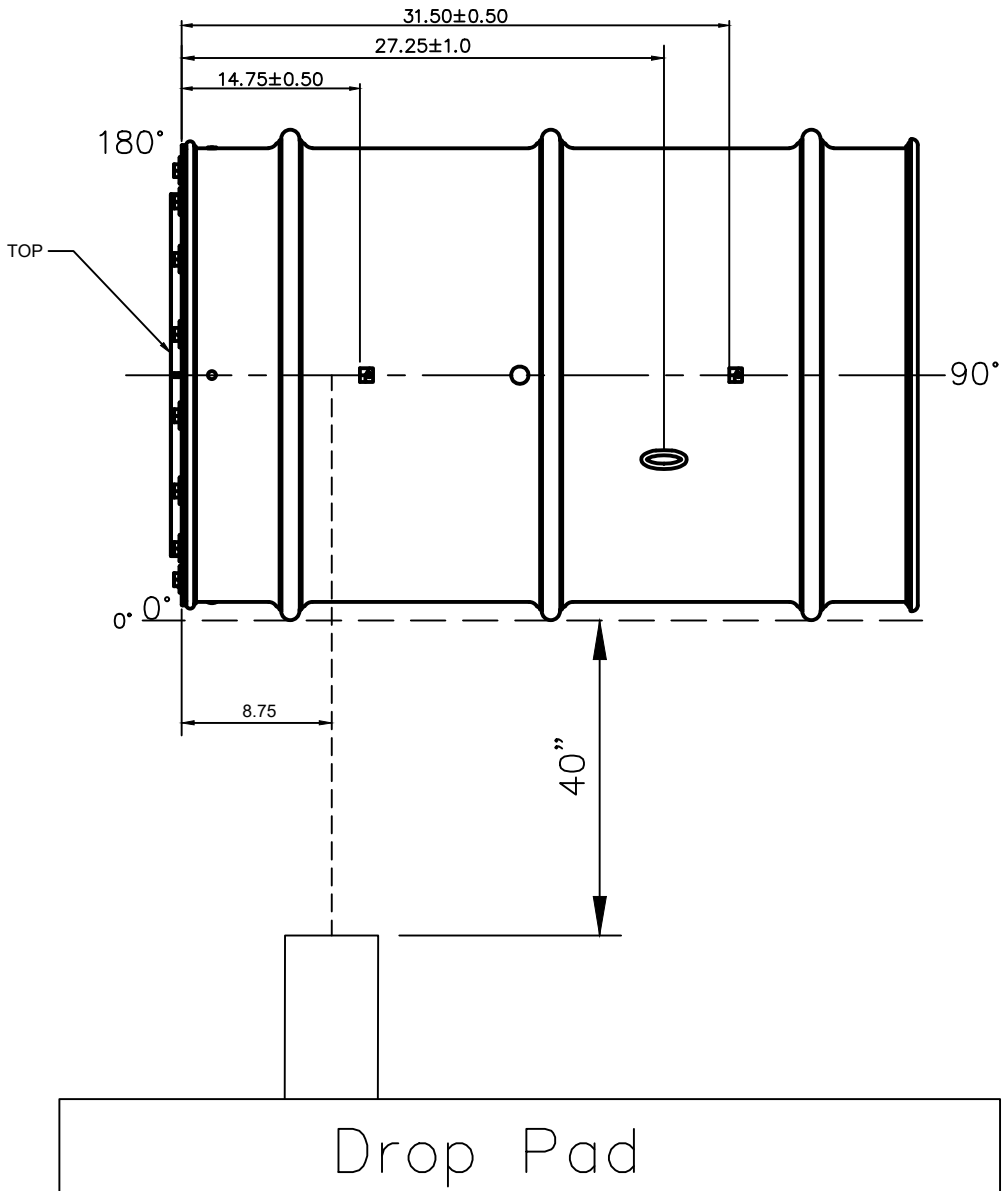
**Drawing A-11 TU 5 & TU6 4 Ft Slap Down  
For Accelerometer orientations reference Figure A1.**

# Notes

RESTRAINT RING  $\pm 1.0$ "

ACC MOUNTING BRACKET  $\pm 0.50$

ALL DIM FROM TOP OF PLATE



TU-1 AND TU-5 PUNCTURE DROP SIDE 0°

**Drawing A-12 TU-1 & TU-5 3.3 Ft. (1 Meter) Puncture Drop**

**For Accelerometer orientations reference Figure A1.**

ORNL/NTRC-095, Rev. 0 P-29

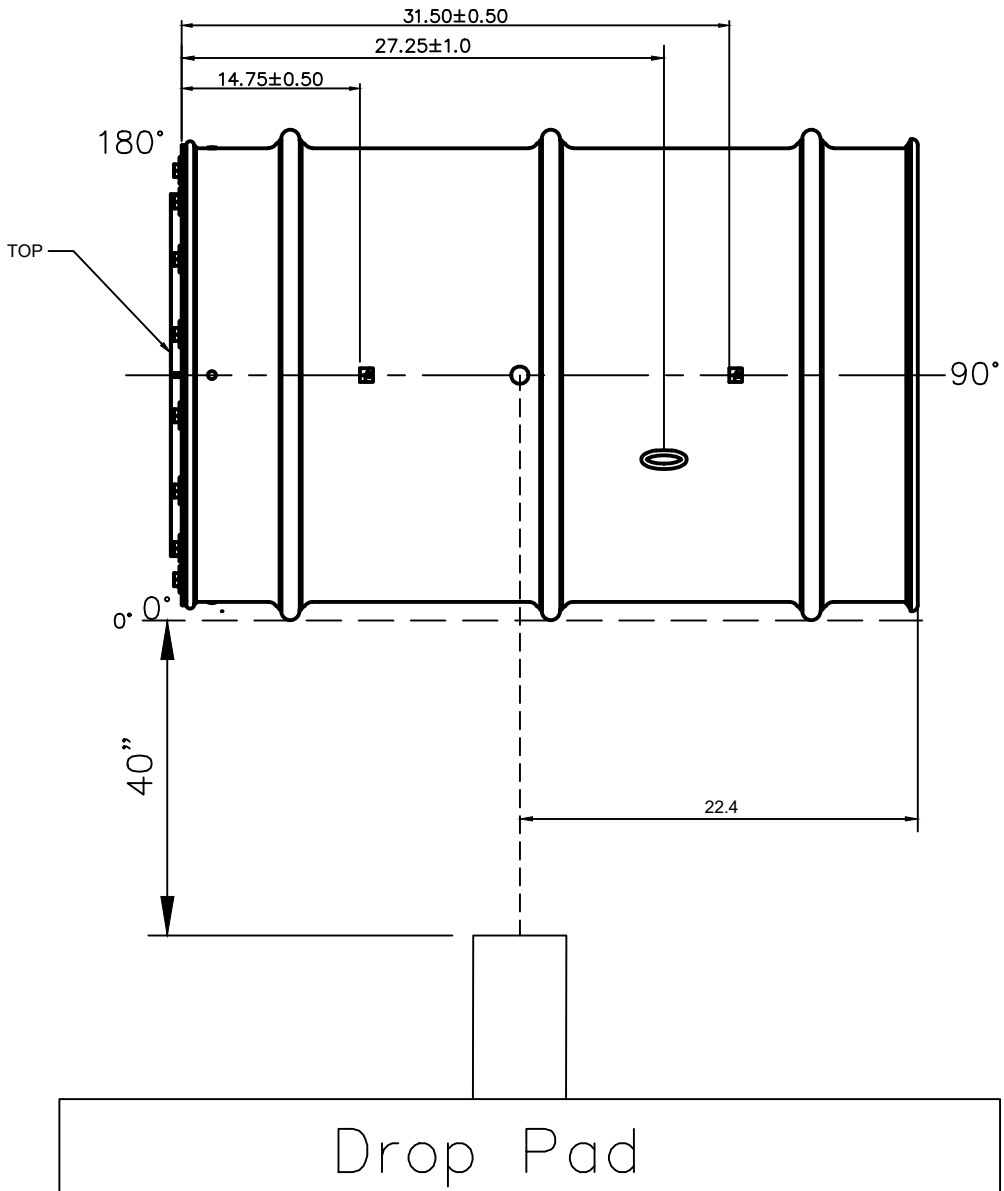


# Notes

RESTRAINT RING  $\pm 1.0^\circ$

ACC MOUNTING BRACKET  $\pm 0.50$

ALL DIM FROM TOP OF PLATE



TU-6 PUNCTURE DROP SIDE 0°

**Drawing A-13 TU-6 3.3 Ft. (1 Meter) Puncture Drop**  
**For Accelerometer orientations reference Figure A1.**

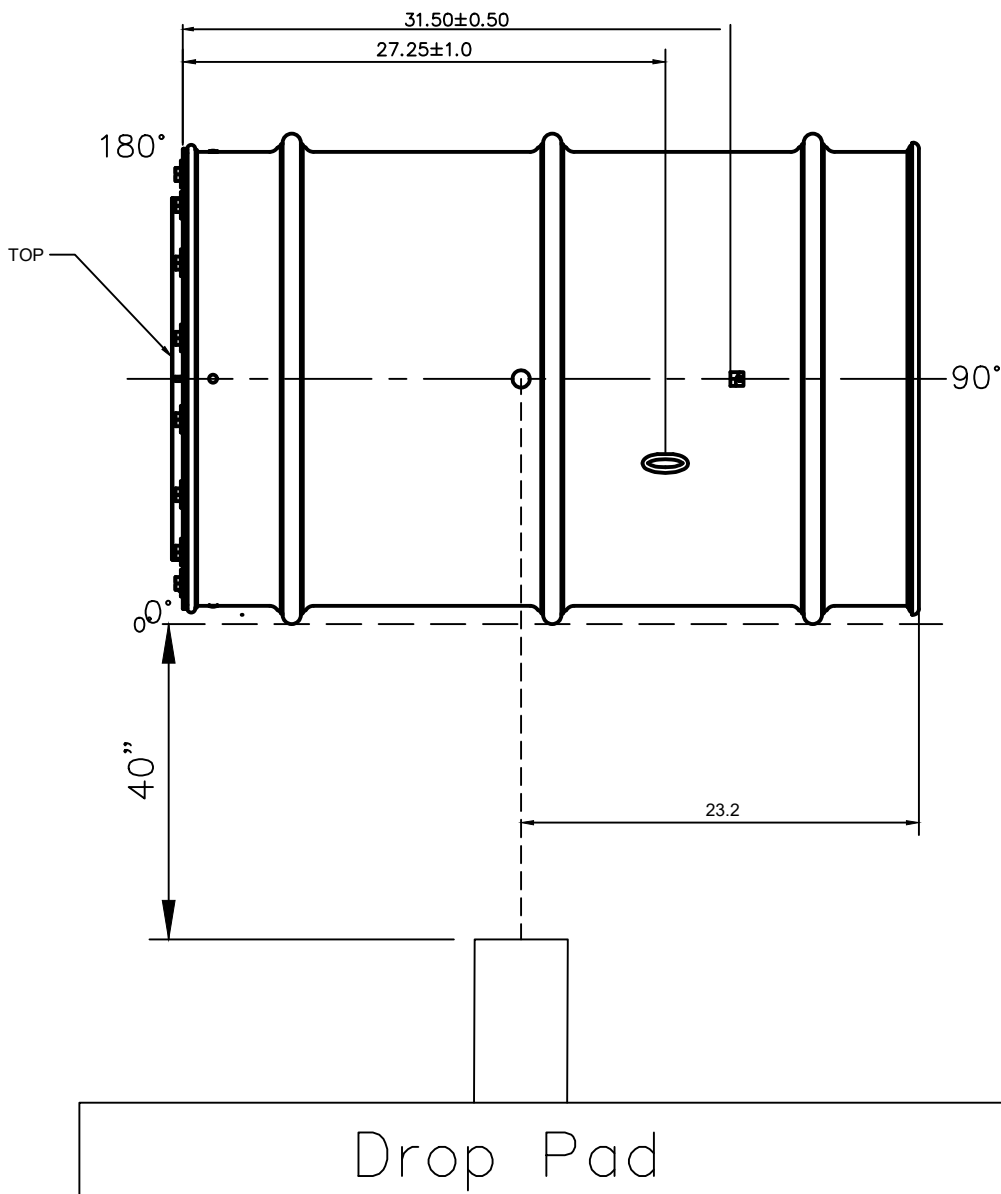
ORNL/NTRC-095, Rev. 0 P-30

# Notes

RESTRAINT RING  $\pm 1.0^\circ$

ACC MOUNTING BRACKET  $\pm 0.50$

ALL DIM FROM TOP OF PLATE



TU-2 PUNCTURE DROP SIDE 0°

Drawing A-14

TU-2

3.3 Ft. (1 Meter) Puncture Drop

For Accelerometer orientations reference Figure A1.

ORNL/NTRC-095, Rev. 0 P-31



# PACKAGING AND TRANSPORTATION ENGINEERING TEST PLAN CHANGE REQUEST

PAGE

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Test Plan Change Request Number ORNL/NTRC-092 TPCR-006	Date 10/06/21
Test Plan Number ORNL/NTRC-092	Test Plan Revision 0
Test Plan Title TEST PLAN FOR DPP-1 REGULATORY TESTING	

Reason for Change:

TU-4 CV exhibits potential damage to the CV flange sealing surface near the alignment pin which violates surface finish requirements and could potentially lead to a failed helium leak test result after HAC testing. The damage appears to have occurred at the fabricator (MTM) after CNS review and prior to shipment to the testing agency (NTRC). CNS Packaging and Transportation Engineering (PTE) have determined that this unit should not undergo helium leak testing but could be used for 50-ft water immersion testing.

Required Change:

Exchange TU-4 CV with TU-7 CV. Remove test content assembly (with temperature indicating labels) from TU-4 CV and set aside. Apply temperature indicating labels internally and externally to TU-7 CV per the test plan. Install the test content assembly into TU-7 CV along with upper and lower PCC pads per the test plan. Complete TU-7 CV assembly and perform pre-shipment leak testing per the test plan. Remark TU-7 CV as TU-4 CV and install back into the TU-4 drum per the test plan. Complete TU-4 drum assembly and weigh and record TU-4 final weight. Update the affected test forms with the new information. Remark damaged TU-4 CV as TU-7 CV. Complete TU-7 CV assembly and perform pre-shipment leak testing. This CV (with the flange damage) will be used for the 50-ft water immersion test. If this unit were to fail the immersion test, it would be exchanged with another test unit CV from CNS and the immersion test would be repeated. Update the affected test forms with the new information. This is a non-intent change. - Ross Whittenbarger, STR 10/06/21.

Submitted by: (Test Engineer)	SIGNATURE  Digitally signed by Oscar Martinez Date: 2021.10.07 10:07:03 -04'00'	DATE
Concurrence: (Packaging Engineer)	SIGNATURE <b>Ross M (RWM) Whittenbarger</b> Digitally signed by Ross M (RWM) Whittenbarger Date: 2021.10.06 21:57:03 -04'00'	DATE 10/06/21
Approval: (Package Design Manager)	SIGNATURE <b>James C (J5A) Anderson</b> Digitally signed by James C (J5A) Anderson Date: 2021.10.07 10:17:20 -04'00'	DATE 10/07/21

This document has been reviewed by a Y-12 DC / UCNI RO and has been determined to be UNCLASSIFIED and contains no UCNI. This review does not constitute clearance for Public Release.

NAME <b>Ross M (RWM) Whittenbarger</b> Digitally signed by Ross M (RWM) Whittenbarger Date: 2021.10.06 21:57:08 -04'00'	DATE 10/06/21
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Y17-69-PE-345

UCN-21627 (12-13)



# PACKAGING AND TRANSPORTATION ENGINEERING TEST PLAN CHANGE REQUEST

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Test Plan Change Request Number ORNL/NTRC-092 TPCR-007	Date 10/20/21
Test Plan Number ORNL/NTRC-092	Test Plan Revision 0
Test Plan Title: TEST PLAN FOR DPP-1 REGULATORY TESTING	

## Reason for Change


### Unexpected Result:

Upon impact of the 1100 pound crush plate during the HAC crush test, the TU-5 Drum Lid Cover Plate fillet weld failed approximately 270 degrees around the Cover Plate allowing the release of Packcrete from the drum lid onto the outside drop pad at NTRC. TU-5 is the chilled, 22 degree slap-down unit with a heavy test weight located in the high position.

## Required Change

### Path Forward:

The CNS Y-12 STR and PTP staff halted work while the STR contacted the PTE manager via phone, along with the design engineer and the quality engineer (in person) relaying the results from the 30-foot crush test. A determination was made by the testing oversight team to proceed with the 1-meter puncture test before the three hour HAC test window expired for the chilled unit. The HAC puncture test, with impact located near the FL and the drum seam, completed as planned without any additional issues. This TPCR provides the details of the change and gives the authority for NTRC to proceed with testing. This is an URGENT intent change and must be documented in the body of the final test report - Ross Whittenbarger, STR 10/20/21.

Submitted by: (Test Engineer)	SIGNATURE  Digitally signed by Oscar Martinez Date: 2021.10.21 15:22:05 -04'00'	DATE
Concurrence: (Packaging Engineer)	SIGNATURE <b>Ross M (RWM) Whittenbarger</b> Digitally signed by Ross M (RWM) Whittenbarger Date: 2021.10.20 19:14:29 -04'00'	DATE 10/20/21
Approval: (Package Design Manager)	SIGNATURE <b>James C (J5A) Anderson</b> Digitally signed by James C (J5A) Anderson Date: 2021.10.21 12:13:50 -04'00'	DATE 10/21/21

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NAME <b>Ross M (RWM) Whittenbarger</b> Digitally signed by Ross M (RWM) Whittenbarger Date: 2021.10.20 19:14:36 -04'00'	DATE 10/20/21
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Y17-69-PE-345  
UCN-21627 (12-13)

# PACKAGING AND TRANSPORTATION ENGINEERING TEST PLAN CHANGE REQUEST

PAGE

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Test Plan Change Request Number ORNL/NTRC-092 TPCR-008	Date 10/21/21
Test Plan Number ORNL/NTRC-092	Test Plan Revision 0
Test Plan Title TEST PLAN FOR DPP-1 REGULATORY TESTING	

## Reason for Change

Per the Test Plan section 5.4.3 and Figure 5-31, The TU-4 puncture test drop angle was to be 56.4 +/- 2 degrees. Due to deformations encountered on previous TU-4 HAC drop tests, the desired drop angle could not be achieved because the lifting strap could not be located at the correct height.

## Required Change

The closest angle that could be achieved due to the previous drop test deformations was 52.3 degrees which was 2.1 degrees out of tolerance. Request to change the 1-Meter Puncture Test CGoTC drop angle from 56.4 degrees to 52.3 degrees for TU-4. The CNS STR gave approval to drop at this angle due to the previous drop deformation after agreement with the design engineer and quality engineer. This is an URGENT intent change and must be included in the body of the final test report. - Ross Whittenbarger, STR 10/21/21.

Submitted by: (Test Engineer)	SIGNATURE  Digitally signed by Oscar Martinez Date: 2021.10.21 17:39:41 -04'00'	DATE
Concurrence: (Packaging Engineer)	SIGNATURE Ross M (RWM) Whittenbarger Digitally signed by Ross M (RWM) Whittenbarger Date: 2021.10.21 16:28:02 -04'00'	DATE 10/21/21
Approval: (Package Design Manager)	SIGNATURE James C (J5A) Anderson Digitally signed by James C (J5A) Anderson Date: 2021.10.21 16:37:43 -04'00'	DATE 10/21/21

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NAME Ross M (RWM) Whittenbarger Digitally signed by Ross M (RWM) Whittenbarger Date: 2021.10.21 16:27:35 -04'00'	DATE 10/21/21
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UCN-21627 (12-13)

# PACKAGING AND TRANSPORTATION ENGINEERING TEST PLAN CHANGE REQUEST

PAGE

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Test Plan Change Request Number ORNL/NTRC-092 TPCR-009	Date 11/22/21
Test Plan Number ORNL/NTRC-092	Test Plan Revision 0
Test Plan Title Test Plan for DPP-1 Regulatory Testing	


## Reason for Change.

Test Form 5 typographical error on 4th verification Checkpoint: Incorrect sentence: "Record the torque values needed to loosen the drum lid weldment screws on Test Form 1"

## Required Change

Correct Test Form 5 typographical error to read as shown: "Record the torque values needed to loosen the drum lid weldment screws on Test Form 8".

This was a typo correction to an NTRC test form in the test plan. This is a non-intent change. - Ross Whittenbarger, STR 11/23/21.

Submitted by: (Test Engineer)	SIGNATURE  Digitally signed by Oscar Martinez Date: 2021.11.23 09:46:35 -05'00'	DATE
Concurrence: (Packaging Engineer)	SIGNATURE <b>Ross M (RWM) Whittenbarger</b> Digitally signed by Ross M (RWM) Whittenbarger Date: 2021.11.23 15:15:40 -05'00'	DATE 11/23/21
Approval: (Package Design Manager)	SIGNATURE <b>James C (J5A) Anderson</b> Digitally signed by James C (J5A) Anderson Date: 2021.11.24 07:07:16 -05'00'	DATE 11/24/21

This document has been reviewed by a Y-12 DC / UCNI RO and has been determined to be UNCLASSIFIED and contains no UCNI. This review does not constitute clearance for Public Release.

NAME <b>Ross M (RWM) Whittenbarger</b> Digitally signed by Ross M (RWM) Whittenbarger Date: 2021.11.23 13:52:32 -05'00'	DATE 11/23/21
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Y17-69-PE-345

UCN-21627 (12-13)

## **Q. APPENDIX TEST JOURNAL**



## DPP-1 CAMPAIGN START

08-26-2021.

Abi, Oscar, Mike, Paul.

→ 7 Test Units delivered to NTRC around noon.

→ Units were visually inspected for damages,  
no damage found. 8/26/2021

→ Pictures of units as delivered taken.

→ All TIDs verified to be intact, pictures taken

TU-1 - 2 TIDs verified to be intact, picture taken.

TU-1 TID: C0232293 & C0232294 were cut for lid removal.  
Approval received by Y-12 to remove TID's. 08-26-21→ TU-1: Mark exterior and interior of drum. Marked  
exterior of CV.

Added temp labels to TU-1 per test plan

8/27/2021 NTRC

Abi, Paul, Mike, Ross, Ryan &amp; Oscar ADA

- Temp labels to TU-1 per test plan

- Inspected and marked TU-6

08/30/2021 NTRC PEF Lab

Abi, Paul, Oscar, Mike

→ Temp labels added to TU-6 per test plan.

→ Inspected and marked TU-5

→ Temp labels added to TU-5 per test plan.

08/31/2021.

Abi, Paul, Oscar & Mike.

- Inspected and marked TU-7.
- Inspected and marked TU-3 per test plan.
- Temp labels added to TU-3 per test plan.
- \* → Inspected and marked TU-4.
- Temp. labels added to TU-4.

9/1/2021 Abi, Oscar, Paul, Mike

- Assembly of TU-4 with temp labels
- Removal of all test weights from crate
- Marking on all test weights.

9/2/2021 Abi, Oscar & Paul.

- Marking on all test weights Continued.
- Removed heavy test weight from TU-2.
- Installed light test weight on TU-2.
- Moved heavy test weight from low to high position TU-3.
- That bushing hole at high position not chamfered on TU-3.
- Need to remove chamfer, file used to remove it.

9/3/2021 Paul, Oscar, Ross & Ryan.

- finished applying temp. labels on all Test Units.
- Y-12 verified all temp. labels locations.
- Paul built horizontal drum roller.

09/07/2021 Abi, Paul, Oscar & Ross.

- Weighing test content assemblies, ~~CV~~<sup>AM</sup> CV,
- light test weight did not flush with test weldment at  $0^\circ$  and  $180^\circ$
- Placement of temp. labels on the interior of drum lid was limited by the foam. 1.5" from center mark used instead of 2" from the center.
- TU-1 CV, Drum & Test Content weldment temp. label value and location confirmed by Y-12.

09/08/2021 Abi, Paul, Oscar, Mike, Ross, Ryan & Mike Enshp

- CV: weighed and assembled TU-1, TU-2, TU-3 & TU-4.
- TU-4 CV body @ dowel pin on flange had scuff-indentation  
Abi 10/06
- All assembled CVs torqued as specified in the test plan.

09/09/2021.

Abi, Paul, Oscar, Ross, Ryan, Mike, Mike Enshp, Dustin

- CVs for TU-5 and TU-6 weighed and assembled.
- Both CVs (TU-5 & TU-6) were torqued as specified in the test plan.
- CV for TU-7 was assembled without test content weldment or pads (empty).
- CV for TU-7 was weighed and torqued as specified in the test plan.
- No label (temp. labels) attached/affixed to CV for TU-7.

~~09/13/17~~ 09/13/2021

Abi, Oscar, Eric, Paul, Ross, Ryan, Mike Enshp, Mike.

- Setup leak testing equipment on all CVs.

09/14/2021 Abi, Oscar, Paul, Mike, Eric, Ross, Ryan, Mike Enshp

- leak test operation continued.
- Y-12 confirmed temp label location and type on interior of TU-1 through TU-6 Drum

09/15/2021 Pre-shipment Leak Rate test.

Abi, Paul, Oscar, Mike, Erik, Ryan, Ross, Tim, Mike Ensley & Jon

- CV Leak test Completed.

- CV for TU-2 passed after a second test.

→ Eric Vidal level III & Jessica Osborne level II.

- Test Equipment:

Std Leak: ID# A001744, due 8/2022 50.72548cc

Omega Thermometer: ID# A005745, due 7/2022

Astcraft pressure gauge: duke ID# A001068, due 7/2022

gauge 1: ID# A002500, due 6/2022

gauge 2: ID# A001669, due 6/2022

Notes: All CVs were connected in series for this test.

Volume calculation performed for each test CV tested.

- Acceptance - No LR when tested to a sensitivity of at least  $1 \times 10^{-03}$  ref. cm<sup>3</sup>/sec (ANSI N14 Sect. 2.6.50W sect 3.4.12)

✓ TU-1 11:13 am (Zero LR) @ Sensitivity of  $9.94 \times 10^{-4}$   
LR  $3.25 \times 10^{-5}$  @ sensitivity of  $9.94 \times 10^{-6}$

failed  
due to  
fitting → TU-2 1:40 pm zero LR @ sensitivity of  $6.53 \times 10^{-4}$   
Retested  
& passed. LR  $3.25 \times 10^{-5}$  @ sensitivity  $6.53 \times 10^{-6}$ .

✓ TU-3 Zero LR @ sensitivity of  $9.84 \times 10^{-4}$   
11:40 am LR  $4.92 \times 10^{-5}$  @ sensitivity  $9.84 \times 10^{-6}$ .

✓ TU-4 10:56 am Zero LR @ sensitivity of  $9.99 \times 10^{-4}$   
LR  $5.50 \times 10^{-5}$  @ sensitivity of  $9.99 \times 10^{-6}$ .

TU-5 11:57 am zero LR @ sensitivity of  $9.84 \times 10^{-4}$   
LR  $5.17 \times 10^{-5}$  @ sensitivity of  $9.84 \times 10^{-6}$

TU-6 10:30 am zero LR @ sensitivity of  $9.94 \times 10^{-4}$   
LR  $5.21 \times 10^{-5}$  @ sensitivity of  $9.94 \times 10^{-6}$ .



✓ TU-1 10:08 am Zero LR @ Sensitivity of  $9.84 \times 10^{-04}$   
 LR  $4.92 \times 10^{-05}$  @ sensitivity of  $9.84 \times 10^{-06}$ .

- fully assembled TU-1, Pad, loaded CV, CV flange pad, & Drum lid. Torqued Drum bolts as specified in SDW & Test plan to b/w 33-37 ft-lbs; hand tight, and 2 passes.

09/16/2021

Asi, Paul, Oscar, Mike, Ross, Ryan. (Blake and Acell Team.)

- Fully assembled TU-2, TU-3 and TU-4.
- loaded pads CVs, flange Wedges, & Drum lids. All Components Weighted as required by Test plan.
- All bolts on drum lid torqued as specified in the test to b/w 33-37 ft-lbs (hand tight, and 2 passes)
- Blake and his team demo accel mounting positions.

09/17/2021.

- Paul, Oscar, Asi, Dustin,
- 3D Scanning of TU-1, TU-2

09/20/2021

Paul.

- 3D Scanning of TU-3, TU-4.
- Check or board frame designed in CAD.

09/21/2021

- fully assembled TU-5 and TU-6.
- loaded pads, CVs flange Wedge & Drum lid. All Components weighted as required by test plan.
- weight and torque recorded.

09/23/2021

Abi, Paul, Oscar, Mike, Ross, Ryan, Blake & Team, Mike Eastley.  
 - Welded accel mounts to TU-1, TU-2, TU-5 & TU-6.

10/06/2021

Abi, Paul, Oscar, Mike, Jon, Ryan, Ross, Blake

→ Conducted Vibration test on TU-6.

The Unit was setup as described in the Test plan, start time 8:50am, scheduled to run for 4hr/min.

→ Accel model # J352668 S/N 230190 was glued to top of on 10/05/2021 was connected to its data collector.

→ PSD information programmed into vibrator table

Controller: S/N: 10795658, model #10K-TTU2 due 03/30/2022

→ Vibration test started @ 8:50am. Stopped @ 12:51pm

→ no physical damage to the test unit observed.

→ TU-6 was setup for water spray test.

→ Water spray test started at 1:30pm Stopped @ 2:30pm

→ Water gauge read 5" (full), ambient temp: 78°F.

→ TU-6 wiped dry after water spray test.

→ Accel mounted on pre-installed accel mounts.

→ TU-6 was rigged and positioned for 4ft NCT drop.

→ Drop orientation, slap-down, 22°, bottom corner at 0° line lowest.

→ Obtained slap down angle: 21.9°

→ height above drop pad 1.2m (4ft) at the lowest point.

→ Damages (dents) to TU-6 (abi 10/06) were recorded on Testform 7 for TU-6.

10/07/2021

Abi, Paul, Oscar, Mike, Ross, Ryan, Tom and Mike Eastley

→ TU-6 3D Scanned.

→ TU-6 damages dimension taken and recorded.

→ TU-6 positioned in Compression tester.

→ Photograph taken and required data recorded.

→ Load information programmed into Comp. Tester Computer. Test started @ 11:23 am.

Programmed load is 4500 lb.

10/08/2021

Abi, Oscar, Paul, Mike, Ross, Ryan.

- CV-4 was swapped with CV-7, weldment content from old CV-4 used in the swapped CV-7.
- New CV-4 re-torqued according to test plan.
- Old CV-4 re-assembled as CV-7, new O-rings used. Temperature labels not removed from old CV-4.
- New CV-7 torqued according to test plan.
- All torque and weight recorded on new test forms.
- Inner O-Ring (CV) supplied by Y-12 material.  
P.O: 4300159191 - Mod 3 Abi  
Lot#: C1378-PC-032018-1
- Outer O-Ring (CV) supplied by Y-12 material.  
P.O: 4300159192 - Mod 3  
Lot#: C1378-PC-032018-1
- Compression test on TU-6 completed 10/08/2021 at 11:27am.
- Height measurement taken at 0, 90, 180 and 270 orientations.
- No physical damage observed.

10/11/2021

Abi, Paul, Oscar, Mike, Ross, Ryan, Blake &amp; Team.

- Setup TU-6 for penetration bar test. Check vertical alignment with square ruler, checked horizontal alignment with level (M212348).
- Positioned penetration bar (PB) above the target (@ FL on 0° orientation). Measured height of (PB) is 1m above the target.
- Dropped the PB and recorded dent position.
- Setup TU-2 for water spray test. Test started at 11:05am. Test ended @ 12:08pm, water gauge height 2.5".
- TU-2 was instrumented per test plan.
- TU-2 was rigged horizontally with 0° orientation facing the unyielding pad. Horizontal angle 1.4° and the drop height 4ft, above the pad.

-TU-2 drop time was 2:10 pm. Dents (flat) observed on the rolling hoops, top and bottom surface rings and a little foam on the lid ring.

CV-4 and CV-7 Setup for leak test @ 3 pm.

-TU-2 was 3D scanned.

10/12/2021

Ala, Paul, Oscar, Mike, Ross, Austin, Ryan

-TU-2 dimension (after drop) taken and recorded.

-TU-3 setup for water spray test.

-TU-3 Water Spray test started @ 9:25 am, ended @ 10:28 am.

-TU-3 wiped and cleaned and rigged for vertical top down 4ft drop after waiting for 1 hr.

-TU-3 dropped at 12:10 pm.

-TU-3 3D scanned. <sup>MAN 12-10-21</sup> TU-4 & TU-7 torqued CV bolting

-TU-4 S.I. performed Pre-Op Leak Test of CV - Passed

-TU-7 S.I. performed preop Leak Test of CV - Passed

-TU-4 Drum & Internals wipe clean prior to loading CV into drum

-TU-4 cleaned external surfaces, loaded CV into drum

-TU-4 Closed Drum and torqued Drum Bolting



Leak test on CV4(A) and CV7(A) @ 3:30 pm

Std leak: ID# A001909 (26.10385 cc) due 8/2022

Omega Thermometer: ID# A005495, due 7/2022

Ashcroft Pressure gauge: device ID# A001068, due 7/2022

gauge 1 ID# A002500 due 6/2022

gauge 2 ID# A001096 due 6/2022

(Acceptance - NO LR when tested to a sensitivity of at least  $1 \times 10^{-3}$  ref  $\text{cm}^3/\text{sec}$ ) ANSI N14.52014; Sec. 7.6, TP Sect 5.1.4.

TU-4A (new) 2:18 pm zero LR @ sensitivity of  $8.45 \times 10^{-4}$   
LR of  $4.44 \times 10^{-5}$  @ sensitivity of  $8.45 \times 10^{-6}$

TU-7A (new) 2:28 pm zero LR @ sensitivity of  $8.56 \times 10^{-4}$

(6 min test) LR of  $5.13 \times 10^{-5}$  @ sensitivity of  $8.56 \times 10^{-6}$ .



10/13/2021

Abi, Paul, Oscar, Mike, Ross, Austin, Ryan.

- TU-4 preped for water spray test with water spray nozzles position at 0, 90, 180 & 270 degree orientation.

- Water spray test on TU-4 started at 9:27am

- Water spray test ended at 10:32am.

- TU-4 cleaned, allowed to dry for 1+ hr.

- TU-4 rigged for 4ft drop.

- Lid facing down, obtained angle 55.1°.

- TU-4 raised 4ft above the pad at the lowest point, with 0° line facing the pad.

- TU-4 was dropped at 12:19pm.

- Bolt #4 at 0° orientation bent due to impact on the drop pad.

- TU-4 dimension taken and recorded.

- TU-3 dimension taken and recorded.

- TU-1 and TU-5 placed on pallet and strapped in preparation for transportation to chilling (6000) location on the main campus.

10/14/2021

Abi, Mike, Paul, Oscar, Blake &amp; Team, Ross, Ryan

TU-1 and TU-5: DOP-1 accelerometers installed on both units.

TU-1: Triaxial PCB accel:

S/N 66489 @ 270° bottom

S/N 66490 @ 90° Top.

S/N 66488 @ 90° Bottom

TU-5:

S/N 66495 @ 270° bottom

S/N 66667 @ 90° top

S/N 66493 @ 90° bottom.

TU-1 & TU-5 loaded around 1pm and transported to ORNL main campus at building. : the Environmental Chamber Lab.

Both units were loaded into the ESPEC chamber, the humidity sensor in the chamber was placed near the middle b/w the two units. The environmental chamber ESPEC used per TPCR-004 & PTP-R-CG3.

ESPEC chamber model # EWSX499-30WW S/N: 3240761

Temperature calibration unit: VAISSTA : model # HMT 335

S/N: P4150350 due date: 10/27/2021

Temperature data acquisition started @ 2:25 pm on 10/14/2021.

Programmed: chilled to  $-70^{\circ}\text{F}$  for 24 hrs, then  $-45^{\circ}\text{F}$  for 48 hrs until removed per SOW and test plan Sect 4.2.1 & Test form 4.

10/15/2021

Nathan provided screen grab of temperature profile.

10/18/2021

Nathan wood provided another update of the temp. profile.

10/19/2021

Nathan wood provided another update of the temp. profile.

Paul, Oscar & Abi set up crush orientation of TU-4 using TU-7 as practice.

10/19/2021

- Crush plate weighed on Intercomp scale

• Weight = 502.5 kg

## DPP-7 Thermal Test Activities.

11/04/2021

Abi, Paul, Oscar, Ross, Ryan, &amp; Mike Enslay.

- Arrived at SWRL @ 8:00am. Met with Karen, and inspected two test units.

- Conducted physical inspection of Pre-heat chamber and the furnace.

- Took physical inventory of shipped items from ORNL.

- TC clip locations determined: note that bottom of clip was aligned to the C.G. mark on the TUs.

- DAQ software configuration file created and tested.

- Initial functional test of DAQ and furnace wall thermocouples performed. DAQ and Configuration file performed as expected.

11/05/2021: Abi, Paul, Oscar, Ross, Ryan, Mike Enslay

- loaded all Test Units into Hot box.

- Used TU-7 for Setup & furnace Placement dry run.

- Hot box started @ 11:15am. Set point @ 250 °F

11:13 am (Texas time @ 12:13 am)

Oscar 11/5/2021

- all furnace TCs checked with heat-source. All OK.

- DAQ read temperatures correctly.

- 2:45pm (ET) 3:45pm (CT): all TCs in hot box > 150 °F

11/06/2021 Saturday. Abi (11/19/2021)

- Pre-heat (24hr) started @ 2:45pm (ET)

11/06/2021 (SAT)

- @ 2:45pm (ET) 3:45pm (CT) 24hr Pre-heat @ > 150 °F ended.

- Hotbox set to 110 °F.

11/07/2021 Sunday.

- Furnace pre-heat started @ 6pm local time,

- All furnace TCs were above 1475 °F @ 6:52pm local time.

11/08/2021 OSCAR, Paul, Mo'i, Lois, Ryan, Mike @ SWA.

- Verified furnace pre heat temp profile.
- Verified pre heat chamber temp. profile.

TC to be connected to TU, as specified in Tab. 5-1 of test plan.

Test	Check	Remove Burn Hot box.	Instrumented CFC connected.	TC function checked.	Furnace door open & close	On test stand	Test started	Test And	On cooling stand.	Safe to touch	Remove burner	Test date
TU-7		8:52	9:00	9:06	9:35	9:36	9:36	9:50	10:23	0° down on test stand	0° down on test stand	11/08/2021
TU-1		10:28	10:57	10:58	11:15	11:16	11:15	11:18	11:49	0° down on test stand	0° down on test stand	11/08/2021
TU-2		12:45 PM	1:19 PM	1:20 PM	1:25	1:26	1:26 PM	1:33 PM	2:03	0° down on test stand	0° down on test stand	11/08/2021 (afternoon)
TU-3		2:09 PM	2:29 PM	2:30 PM	2:52	2:52	2:52 PM	2:56	3:27 PM	0° down on test stand	0° down on test stand	11/08/2021 afternoon
TU-4		7:41 AM	8:12	8:14	8:18	8:18	8:18	8:21	8:52	350° down	350° down	11/09/2021
TU-6		9:00 AM	9:31	9:33	9:40	9:41	9:41	9:43	10:14	0° down on test stand	0° down on test stand	11/09/2021
TU-5		10:22 AM	10:51	10:53	11:02	11:02	11:02	11:04	11:35	~45° down on test stand	~45° down on test stand	11/09/2021
Hot box door opened 8:57 AM												



## Notes on TU-7

- All TCs required to meet min temp. specified in test plan.

- furnace door open & close ~ 1 min.

## TU-1 notes:

- Hot box opened @ 10:28am.

- Hot box door closed @ 10:29am.

Hot box temperature back @ 110°F @ 10:30am.

TU-1 5/6 TC on package met required temp.

- start started @ 11:18am.

- Test end @ 11:49am. Door closed @ 11:50am.

## TU-2 Notes:

- Hot box opened @ 12:45pm.

- furnace door closed @ 2:04pm after TU-2 pulled out.

## TU-3 Notes:

- Hot box opened @ 2:09pm.

- furnace door closed @ 3:27pm after pulling TU-3 out.

11/09/2021

TU-4 Notes: Hot box opened @ 7:41. <sup>furnace</sup> door closed @ 8:53am.

## TU-6 Notes:

- Removed from hot box @ 9:00am.

- Port 83 on DPA TC box not working. TC #3 moved to Port 84.

- furnace lid opened @ 10:14am and closed @ 10:15am.

TU-5: due to previous damage on the lid of TU-5 the unit was positioned @ ~45° on the test stand with the largest opening on the lid facing down.

11/10/2021

All TUs were allowed to cool below specified temperatures in test plan (ORNL/NTRC-092) Naturally.

All TUs loaded onto pallets and strapped. Thermal test campaign wrapped up.

11/15/2021 All TUs and other test-supporting items were shipped from SWRL on 11/12/2021, in a covered TRUCK.

- All TU and other test-supporting items were received at NTRC PEF on 11/15/2021 around 11:30 am.
- All TUs appeared not damaged/or no physical damage as a result of shipping observed.

11/22/2021 Paul, Oscar, Albi, Ross, Ryan, Mike

- Started Disassembly process.

- Straps removed from the test units.

TU-5: breakout torque recorded on the drum lid.  
- lid stucked, part of ~~the~~ drum body (above top rolling hoop) had to be cut all the way to drum liner.

- CV removed and weighed. Weight recorded.

- all temp. label readings recorded

- Drum body interior, lid, and CV exterior.

- lid and drum (empty) weight recorded.

TU-3: drum lid removed without cutting.

- All breakout torque on drum bolts recorded.

- Drum lid and bolts weighed and recorded.

- CV/drum bottom liner weighed and recorded.

- all temp. labels (drum interior, CV exterior and drum lid) recorded.

11/23/2021 TU-1, TU-2, TU-6 and TU-4 had to be cut @ in location similar to TU-5 to remove the drum lid.

- All component were weighed as required and specified in the test plan.

- All temp. label reading were recorded appropriately.

12/02/2021 Abi, Mike & Eric Vidal.

TU1, TU2, TU3, TU4, TU5 & TU6 CVs were prepped and set up for leak testing.

→ Holes were tapped on the CV's lid and all leak test fitting connected and checked for leaks.

→ CVs pump-down in preparation for <sup>Post</sup>~~Pre~~-operational leak test was started.

12/06/2021 Abi, Oscar, Mike, Ross, Ryan, Mikaela, Eric Vidal.

Leak test:

Equipment/Instrument.

Omega FFH804 : 48: A005945 due 7/28/2022

Ashcroft ATE-100: DA001068 due 7/01/2022

PFEIFFER Vacuum ORNL E1-014096.

Ashcroft Port: Model HQS-2 (0.025")

Range: 0-15 PSIA

S/N: HQS-59729.

ORNL ID: A002500 due: 6/28/2022

TU-1 Post-Operational Leak Test.

Started @ 11:19 am → 11:20 am

Zero LR @ sensitivity of  $8.94(10)^{-4}$  atm cc/sec

LR  $4.24(10)^{-5}$  @ sensitivity of  $8.94(10)^{-6}$  atm<sup>3</sup>/sec

TU-2

11:39a Zero LR @ sens.  $8.46(10)^{-4}$

11:49a LR  $3.62(10)^{-5}$  @ sens of  $8.46(10)^{-6}$

TU-3 11:54a Zero LR @ sens.  $8.42(10)^{-4}$

12:04p LR  $3.77(10)^{-5}$  @ sens.  $8.42(10)^{-6}$

TU-4 2:55p Zero LR @ sensitivity of  $8.44(10)^{-4}$   
 3:05p LR  $7.6(10)^{-5}$  @ sens.  $8.44(10)^{-6}$

replaced fitting w/ a new one due to leak in fitting

TU-5 2:00p 0 LR @ sens.  $8.44(10)^{-4}$   
 2:10p  $3.11(10)^{-3}$  @ sens.  $8.44(10)^{-6}$

TU-6 2:18p 0 @  $8.50(10)^{-4}$   
 2:28p  $3.49(10)^{-5}$  @  $8.5(10)^{-6}$

12/07/2021 He - leak test

Acceptance: 50W 802586-0007,  $\frac{1}{2}$  Test Plan: ORNL/NTRC-092  
 6 min, minimum test  $\leq 100$  mtorr.

Sensitivity of  $\leq 5 \times 10^{-8}$  cc/sec He

Acceptance value of:  $\leq 2.0 \times 10^{-7}$  cc/sec He using gas envelope

TU 1 see 12/08/2021 page

TU 2:  $-0.1$  mtorr start: 3:07pm stop: 3:13pm sensitivity:  $2.0 \times 10^{-9}$ .  
 $O_2 = 7\%$  LR:  $3.73 \times 10^{-8}$

TU 3 start: 1:56, stop: 2:02 sensitivity:  $2.0 \times 10^{-9}$ .  
 $-0.1$  mtorr  $O_2 = 4.6\%$  LR:  $1.67 \times 10^{-8}$

TU 4 see 12/08/2021 page.

TU 5 start 12:10pm, stop @ 12:16pm  $\Phi$  Sensitivity:  $2.0 \times 10^{-9}$   
 $O_2 = 4.1\%$  LR:  $1.36 \times 10^{-7}$   
 $-0.1$  mtorr

TU 6 see 12/08/2021 page



12/07/2021

Water immersion test started on TU5, TU3 & TU2. TUs wedged and placed in  $0^\circ$  orientation down in the tank.

12/08/2021

TU5, TU3, & TU2 <sup>CVs</sup> removed from immersion tank @ 9:15am  
Water temp was:  $70.5^\circ\text{F}$  and ambient temp was  $60.7^\circ\text{F}$

He-leak test procedure started on CVs for TU4, TU1 & TU6.

TU1: start: 4:23am end: 11:29am Sensitivity  $2.0 \times 10^{-09}$   
-0.0 Torr LR:  $5.52 \times 10^{-08}$  He/O<sub>2</sub> meter: 5.5%  
LR:  $5.52 \times 10^{-08}$

TU4: start: 2:08pm end: 2:14pm Sensitivity  $2.0 \times 10^{-09}$   
He/O<sub>2</sub> meter: 0.1 Torr LR:  $4.55 \times 10^{-08}$   
= 6%

TU6: start @ 9:38am stop: 8:45am, Sensitivity:  $2.0 \times 10^{-09}$   
-0.1 Torr, He/O<sub>2</sub> meter 8% LR:  $5.06 \times 10^{-08}$

12/08/2021 TU6, TU4 and TU1 placed @  $0^\circ$  orientation in the 3ft (0.9m) water immersion test tank @ 4:30pm.

12/09/2021, removed TU6, TU4 & TU1 from immersion tank @ 10:00am.

Water temperature:  $68.5^\circ\text{F}$  ambient:  $61.9^\circ\text{F}$

TU6 opened @ 11:32

TU1 opened @ 11:41am

TU4 opened @ 11:49am

12/13/2021

-started preparation for 15m immersion test on CV-071

-Thermometer: HHS04 ID: A005945 due 7/28/2022

-Pressure tank: 9T01585698

-Pressure gauge: CPQ 1500-5T-2-8-P 4369-WB52-13-W

13 TU  
6am

System Pressure for air flow LGRIMER QEF 1 MTE 689.

Tank Pressure at 1 hour interval.

start	8:20 am	21.7 Psig.
	8:30 am	24.5 ✓
① 1hr	9:30 am	24.8 Psig.
② 2hr	10:30 am	24.02 Psig.
③ 3hr	11:30 am	24.03 Psig.
④ 4hr	12:30 pm	23.25 Psig.
⑤ 5hr	1:30 pm	24.00 Psig.
⑥ 6hr	2:30 pm	23.30 Psig.
⑦ 7hr.	3:30 pm	23.05 Psig.
⑧ 8hr.	4:20 pm	23.53 Psig.

Removed TU-7 from Immersion Tank @ 4:38 pm  
CN of TU7 opened @ 5:50 pm on 12/13/2021

## **R. APPENDIX DPP-1 QAP PLAN**

**Nuclear Energy and Fuel Cycle Division**

**QUALITY ASSURANCE PLAN  
FOR  
DPP-1 REGULATORY  
COMPLIANCE TESTING**

**REVISION 0**

**Effective Date: January 05, 2021**

**National Transportation Research Center  
Packaging Evaluation Facility**

**Prepared by the  
Oak Ridge National Laboratory  
Oak Ridge, Tennessee 37831-6285  
Managed by  
UT-Battelle, LLC  
for the  
U.S. Department of Energy  
Under contract DE-AC05-00OR22725**





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Reviewed by:

**Michael B. Houston** Digitally signed by Michael B. Houston  
Date: 2021.01.05 11:50:35 -05'00'

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Michael B. Houston, PTP QA Representative

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Abiodun Adeniyi, PTP Test Director


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Oscar Martinez, PTP Program Manager

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Kaushik Banerjee, Package Systems and Logistics Group Leader

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**I. REVISION HISTORY**

<b>Revision</b>	<b>Issue Date</b>	<b>Summary of Changes</b>
Rev. 0	1/5/2021	Initial Release OF DPP-1 Regulatory Compliance Testing



## II. LIST OF ACRONYMS

ANSI	American National Standards Institute
ASME	American Society of Mechanical Engineers
CFR	Code of Federal Regulations
CNS	Consolidated Nuclear Security, LLC
DOE	Department of Energy
HAC	Hypothetical Accident Conditions
ISO	International Organization for Standardization
NEFCD	Nuclear Energy and Fuel Cycle Division
NTC	Normal Conditions of Transport
NTRC	National Transportation Research Center
ORNL	Oak Ridge National Laboratory
PEF	Package Evaluation Facility
PTP	Package Testing Program
QAP	Quality Assurance Program
QAPP	Quality Assurance Program Plan
QP	Quality Plan
SBMS	Standards-Based Management System
SOW	Statement of Work
STR	Subcontract Technical Representative
TPCR	Test Plan Change Request
UTB	UT-Battelle LLC
Y-12	Y-12 National Security Complex

## 1 INTRODUCTION/BACKGROUND

The U.S. government, in cooperation with other countries, regulates the development and use of hazardous materials packages. Special emphasis is placed on radioactive material packages, which are a subset of hazardous materials packages. The U.S. Code of Federal Regulations (CFR) Title 10 and Title 49 require that radioactive material packaging be able to maintain containment of its radioactive material content, provide shielding, and maintain nuclear subcriticality.

U.S. Department of Energy (DOE) Order 460.1D, Hazardous Materials Packaging and Transportation Safety subparagraph 4.a.(3) Quality Assurance (QA) directs that each Departmental element that participates in the use, design, purchase, fabrication, handling, shipping, storing, cleaning, assembly, inspection, testing, operation, maintenance, repair, and modification of Type B or fissile materials packaging must have and maintain a QA program that is approved by the Nuclear Regulatory Commission (NRC) or the DOE Certifying Official (CO).

ORNL maintains a Quality Assurance Program (QAP) in compliance with 10 CFR Part 71 Subpart H. DOE QAP Approval Certificate No. 12, Revision 3 (Docket Number 2011-005) was issued on 04/30/2019 and expires 04-30-2024. The approval satisfies the requirements of DOE 460.1D and complies with 49 CFR 173.7(d) for the DOE to maintain packaging standards equivalent to those specified in 10 Part CFR 71. UT-Battelle, LLC (UTB), is the management and operating contractor for the Oak Ridge National Laboratory (ORNL).

The ORNL Nuclear Energy and Fuel Cycle Division (NEFCD)/Packaging Systems and Logistics (PS&L) Organization performs and manages a Package Testing Program (PTP). PS&L PTP testing capabilities include testing of customer supplied Type B or Fissile package designs, Special Form Capsules and Type A DOT packages to support certification of those package designs by the regulator. Testing is performed at the National Transportation Research Center (NTRC) Package Evaluation Facility (PEF) near Knoxville, Tennessee or at other sites as needed.

This PTP Quality Assurance Program Plan (QAPP) is under the umbrella of the ORNL UTB Packaging Quality Assurance, Program Description (QAPD) as applicable to Type B or Fissile Packaging approved by DOE.

This “Quality Plan (QP) will describe the specific packaging performance testing requirements specified by Consolidated Nuclear Security, LLC (CNS) Memorandum Purchase Order 4300165073. This Scope of the work is to perform Regulatory Testing of DPP-1 Shipping Package test units in accordance with CNS Statement of Work (SOW) 802586-0007 000 00, DPP-1 Regulatory Compliance Testing dated September 26, 2019.

## 2 QUALITY ASSURANCE REQUIREMENTS

Quality Assurance Program Plan (QAPP) document, PTP-QA-001/NTRC-PEF-QAP-001 Rev. 5 implements requirements through a combination of ORNL Standards-Based Management System (SBMS) and specific PTP procedures, Test Plans, and supporting documents augmented with project instructions, checklists, forms, drawings, etc., as applicable to the scope of the work. PTP develops and executes test plans and associated support systems, performs supporting analyses, and writes test reports to demonstrate that the proposed package design meets regulatory requirements for ORNL and ORNL customers.

Source requirements include:

- 10 CFR 830.122 Quality Assurance Program;
- DOE Order O 414.1D Chg. 1 (2013), Quality Assurance;
- DOE Order O 460.1D, Hazardous Materials Packaging and Transportation Safety;
- 10 CFR 71 Subpart H – Quality Assurance;
- ASME NQA-1-2000, 2008, 1a 2009 Quality Assurance Requirements for Nuclear Facility Applications.
- ORNL Transportation Management System Program Description: Packaging Quality Assurance Program Description Applicable to Type B or Fissile Packaging (PQPD)
- ANSI/ISO/ASQ Q9001:2015 Quality Management Systems – Requirements;
- ORNL Standards-Based Management System (SBMS) Program Description: Quality Assurance Program
- ORNL Procedure: SBMS Manage Radioactive Packaging and Special Form Capsules
- SG-600 Safety Guide, Regulatory Compliance Testing of NNSA Type B Packages,
- CNS Y-12 National Security Complex SOW 802586-0007 000 00

The Package Testing QAP organizational structure, functions, roles, and responsibilities are implemented via the following documents:

- PTP-MGMNT-001 PTP Organizational Structure, Levels of Authority, Lines of Communication
- ORNL/NTRC-024 Package Testing Program Training Plan
- ORNL SBMS Subject Area: Roles, Responsibilities, Accountabilities, & Authorities (R2A2s)

### **3 PACKAGE DESIGN CONTROL**

PTP does not perform Package Design Control for the DPP-1 test units tested for Memorandum Purchase Order 4300165073 SOW.

### **4 PROCUREMENT CONTROL**

PTP does not procure parts or components for the DPP-1 test units. All container hardware material(s) are specified in Memorandum Purchase Order 4300165073 SOW and considered as Government-Furnished Equipment supplied by CNS.

### **5 DPP-1 SHIPPING PACKAGE TEST PLAN**

The ORNL PTP test plan ORNL/NTRC-092, Rev. 0, “Test Plan For DPP-1 Regulatory Compliance Testing” will be used for the testing activities associated with Memorandum Purchase Order 4300165073 SOW. Safety aspects of activities in this test plan are controlled by the ORNL Research Hazard Assessment and Control (RHAC) Research Safety Summaries (RSSs) 1082 and 2416.

The PTP will perform testing of seven (7) DPP-1 shipping packages provided by CNS to demonstrate that the DPP-1 design with regulatory requirements for the tests specified in Title 10 CFR 71.71 Normal Conditions of Transport (NTC) and 10 CFR 71.73 Hypothetical Accident Conditions (HAC).

Test packages with their surrogate payloads will be identified by sequential designation numbers TU-1 through TU-7. Test units will undergo pre- and post-test operational leak tests as well as post-test helium

leak tests. The TU's will be subjected to the prescribed NCT and HAC tests. All TU's will be disassembled and inspected following the conclusion of all NCT and HAC tests.

Test plan ORNL/NTRC-092, Rev.0 . See test plan ORNL/NTRC-092 for a summary for test sequence and testing procedures used by PTP. PTP shall request approval from the CNS-Y-12 subcontract technical representative (STR) for test plan/test procedure deviations using a test plan change request (TPCR) form.

## 6 DPP-1 SHIPPING PACKAGE TEST DOCUMENTATION

All appropriate test forms, procedure checklists and data sheets will be filled out during or immediately following each task or test. Photographs and video tapes of testing activities taken per the test plan requirements will be provided to CNS. A test report titled "Test Report for DPP-1 Regulatory Compliance Testing will document the test results following completion of testing. Test results derived from the test plan will be used the preparation of the DPP-1 Regulatory Compliance Testing Safety Analysis Report for Packaging (SARP).

### DPP-1 Package

Weight shown: 885 lbs

Empty weight: 754 lbs

Drum OD: 27 in.

Drum height: 43 in.

### CV

Empty weight: 258 lbs

ID: 19.7 in.

Internal height: 31.4 in.

External height: 32.4 in.

### Payload

Light weight: 71 lbs

Heavy weight: 131 lbs

Fixture height: 29.3 in.

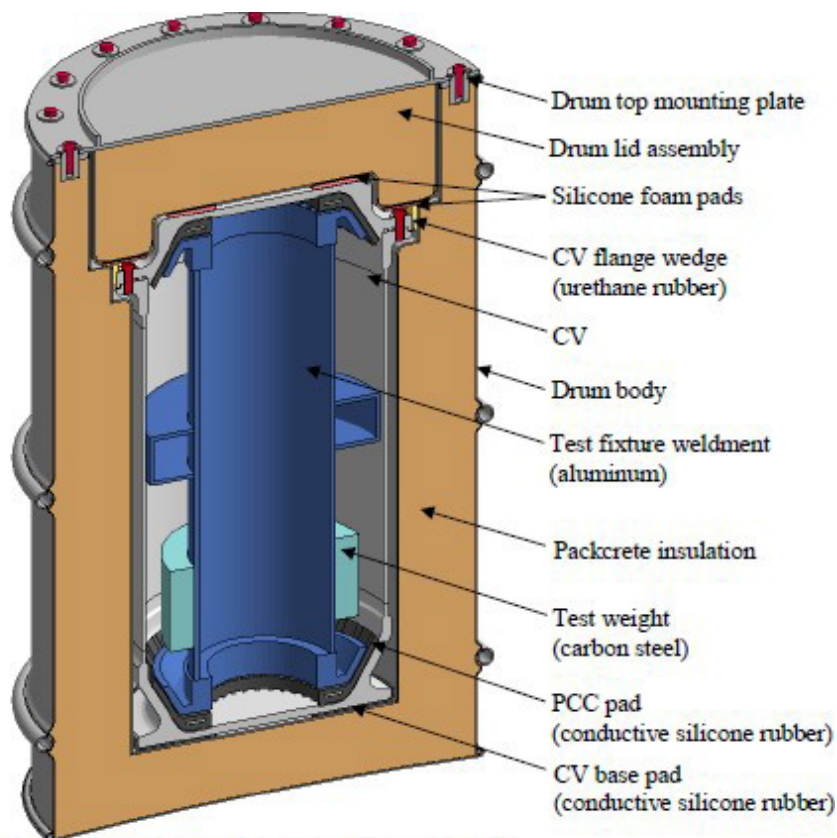


Fig. 1. DPP-1 package with a test content assembly.



## **S. APPENDIX REQUEST FOR WAIVER DEVIATION**

## REQUEST FOR WAIVER OR DEVIATION (RFWD)

	1. REQUEST TYPE		2. SHEET 1 of 3
	<input type="checkbox"/> DEVIATION (Supplier Initiated)	3a.	NUMBER 4300165073-0004
	<input type="checkbox"/> WAIVER (Supplier Initiated)	3b.	SAP DMS NUMBER
	<input checked="" type="checkbox"/> CHANGE (CNS Initiated)		

4. APPLICABLE RFWD NUMBER(S) [REVISED OR SUPERSEDED]:  
N/A

5. SUPPLIER NTRC	6. P.O. ITEM NO. #1	7. PROGRAM/PROJECT DPP-1 Regulatory Compliance Testing	8. DOCUMENT NO./REV. SOW 802586-0007 000 00
9. COMPONENT NAME Vibration Testing & TL Figure	10. PART OR IDENTIFYING NO. Section 3 4.2, Figure 7, & Figure B 3	11. <input checked="" type="checkbox"/> SERIAL or <input type="checkbox"/> LOT NO. TU-1 through TU-6	12. LOT SIZE N/A

13. SPEC. REF. NO.	14. SPECIFICATION REQUIREMENTS	15. DESCRIPTION OF WAIVER/DEVIATION/CHANGE	16. SUPPLIER PLAN FOR CORRECTIVE ACTION
1) SOW 802586-0007 000 00, Figure B.3, p 46	TL located inside the sectioned view of the CV body at the 2 5" location from the top of the CV	See corrected Figure below on page 3 that removes the TL that was shown incorrectly in Figure B.3 in the SOW. The four TLs at this location are external to the CV.	N/A, CNS internal change request after PO was awarded
2) SOW 802586-0007 000 00, Section 3 4.2 – NCT Vibration Testing of TU-6 and Figure 7, pp 18-19	Strapping of TU-6 to vibration table	Add the DPP-1 upper restraint ring, SNL Drawing J72340, for vibration testing. Toe clamps will need to be added to the vibration platform to secure the base of TU-6 and ratcheting straps will be used in conjunction with the upper restraint ring instead of chains. See figure below on page 3.	N/A, CNS internal change request after PO was awarded
3)			
4)			

17. INITIATING ENTITY REPRESENTATIVE (print/sign) Ross Whittenbarger	18. TITLE Packaging Engineer	19. COMPANY CNS Y12	20. DATE 3-8-2021
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**RESPONDING ENTITY EVALUATION (TO BE COMPLETED BY RESPONDING ENTITY EVALUATION)**

21. SPEC. REF. NO.	22. EVALUATION COMMENTS	23. EVALUATOR	24. RECOMMENDED DISPOSITION
		PRINT/SIGN	DATE
1) SOW 802586-0007 000 00, Figure B.3, p 46	This change was requested internally by CNS to clarify requirements	Ross Whittenbarger Ross M (RWM) Whittenbarger <small>Digitally signed by Ross M (RWM) Whittenbarger Date: 2021.03.08 18:08:09 -0500</small>	3/8/21 <input checked="" type="checkbox"/> ACCEPT <input type="checkbox"/> REJECT
2) SOW 802586-0007 000 00, Section 3 4.2 – NCT Vibration Testing of TU-6 and Figure 7, pp 18, 19	This change was requested internally by CNS once the upper restraint ring was made available by SNL	Ross Whittenbarger Ross M (RWM) Whittenbarger <small>Digitally signed by Ross M (RWM) Whittenbarger Date: 2021.03.08 18:08:09 -0500</small>	3/8/21 <input checked="" type="checkbox"/> ACCEPT <input type="checkbox"/> REJECT
3)			<input type="checkbox"/> ACCEPT <input type="checkbox"/> REJECT
4)			<input type="checkbox"/> ACCEPT <input type="checkbox"/> REJECT

25. ARE DESIGN DRAWING(S), SPECIFICATION(S), DATA SHEET(S), INSPECTION PLAN(S), OR SURVEILLANCE PLAN(S), ETC. CHANGES REQUIRED?  
IF YES, LIST DOCUMENTS REQUIRING CHANGES (TO BE COMPLETED BY CNS REPRESENTATIVE)

☐ YES ☒ NO

N/A

This document has been reviewed and confirmed to be UNCLASSIFIED and contains no UCNI.  
Name: Ross Whittenbarger  
Date: 03/08/2021  
CNS eDC/RO ID: 290357


[CLICK HERE FOR AN ADDITIONAL PAGE](#)

## REQUEST FOR WAIVER OR DEVIATION (RFWD)

SHEET 2 of 3

27. IS A CHANGE CONTROL PROCESS INVOKED? ☐ YES ☒ NO  
If yes and controls are needed to prevent use of the SSC prior to placing or returning the item/system to service, identify the controls put in place  
N/A

### APPROVALS (CNS Approvals Require Sam Affected Functions/Organizations Approval As Original Document)

28. ENTITY	29. NAME (print/sign)	30. DATE	31. APPROVE/REJECT RECOMMENDED DISPOSITIONS	
CNS CUSTOMER/PROGRAM MANAGER	Barak (B9Q) Tjader Barak Tjader	Digitally signed by Barak (B9Q) Tjader DN: c=US, o=U.S. Government, ou=Department of Energy, ou=Y-12 National Security Complex, ou=CAs, ou=people, cn=Barak (B9Q) Tjader Date: 2021.03.10 09:08:05 -05'00'	<input checked="" type="checkbox"/> APPROVED	<input type="checkbox"/> REJECTED
CNS TECHNICAL REPRESENTATIVE	Ross M (RWM) Whittenbarger Ross Whittenbarger	Digitally signed by Ross M (RWM) Whittenbarger Date: 2021.03.08 18:11:17 -05'00'	<input checked="" type="checkbox"/> APPROVED	<input type="checkbox"/> REJECTED
CNS DESIGN AUTHORITY REPRESENTATIVE	Richard D (RT9) Turner David Turner	Digitally signed by Richard D (RT9) Turner Date: 2021.03.10 09:23:58 -05'00'	<input checked="" type="checkbox"/> APPROVED	<input type="checkbox"/> REJECTED
CNS PROJECT REPRESENTATIVE	James C (J5A) Anderson Jim Anderson	Digitally signed by James C (J5A) Anderson Date: 2021.03.16 07:45:35 -04'00'	<input checked="" type="checkbox"/> APPROVED	<input type="checkbox"/> REJECTED
CNS QUALITY ENGINEER	Ryan J (RJF) Fisher Ryan Fisher	Digitally signed by Ryan J (RJF) Fisher Date: 2021.03.15 08:07:25 -04'00'	<input checked="" type="checkbox"/> APPROVED	<input type="checkbox"/> REJECTED
CNS DESIGN ENGINEERING	Michael L (MER) Ensley Michael Ensley	Digitally signed by Michael L (MER) Ensley Date: 2021.03.10 07:35:49 -05'00'	<input checked="" type="checkbox"/> APPROVED	<input type="checkbox"/> REJECTED
CNS PRODUCT/PACKAGING ENGINEERING	Ross M (RWM) Whittenbarger Ross Whittenbarger	Digitally signed by Ross M (RWM) Whittenbarger Date: 2021.03.08 18:12:58 -05'00'	<input checked="" type="checkbox"/> APPROVED	<input type="checkbox"/> REJECTED
NUCLEAR PROCUREMENT	Jeffrey E (2XK) Cook Jeff Cook	Digitally signed by Jeffrey E (2XK) Cook Date: 2021.03.15 16:56:19 -04'00'	<input checked="" type="checkbox"/> APPROVED	<input type="checkbox"/> REJECTED
CNS OTHER (List) Structural Analyst	Jonathan P (PJW) Weigand Jonathan Weigand	Digitally signed by Jonathan P (PJW) Weigand Date: 2021.03.08 18:44:22 -05'00'	<input checked="" type="checkbox"/> APPROVED	<input type="checkbox"/> REJECTED
SUPPLIER REPRESENTATIVE	Oscar Martinez 	Digitally signed by Oscar A. Martinez Date: 2021.03.16 11:36:12 -04'00'	<input checked="" type="checkbox"/> APPROVED	<input type="checkbox"/> REJECTED

**NOTE: Ensure Subcontract Administrator in Supply Chain Management receives a copy of the approved RFWD.**

## REQUEST FOR WAIVER OR DEVIATION (RFWD)

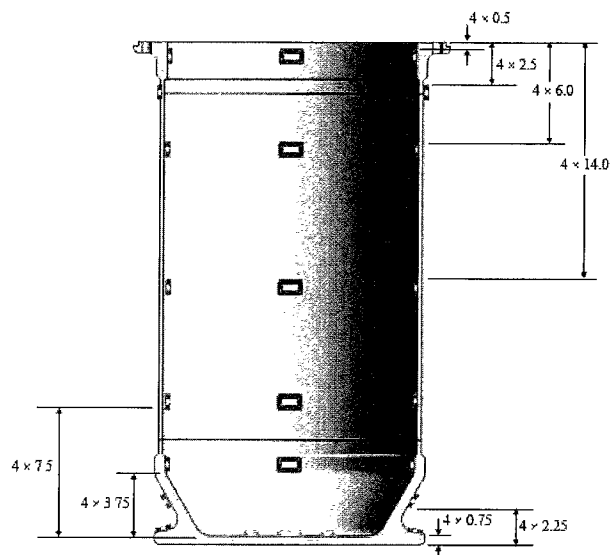
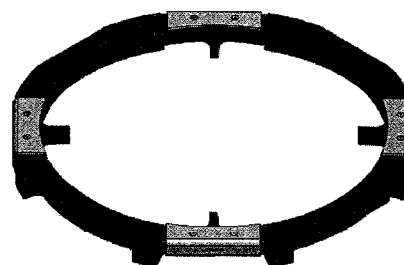
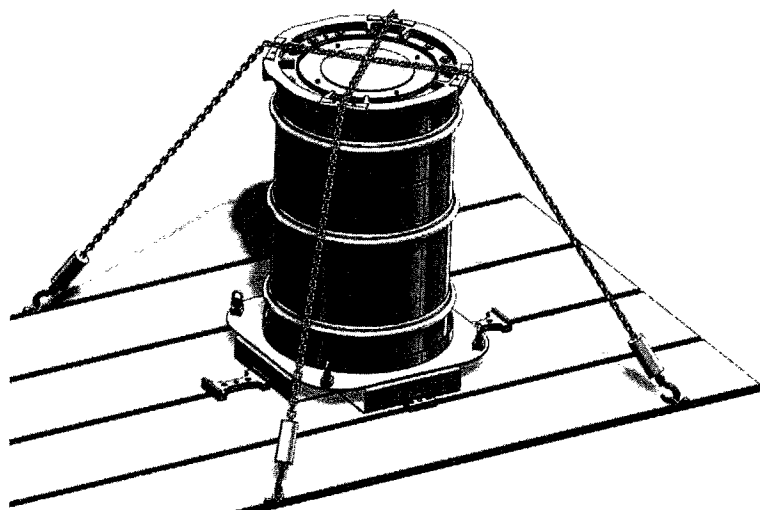
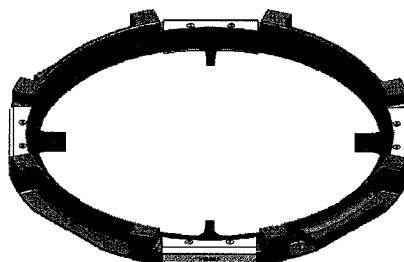


Figure B.3 – Correction



TOP VIEW



BOTTOM VIEW

Upper Restraint Ring Required for NCT Vibration Testing of TU-6, the lower tray will not be used but toe clamps similar to DPP-3 will be used and ratcheting straps will be used instead of chains.



## REQUEST FOR WAIVER OR DEVIATION (RFWD)

1.	REQUEST TYPE	2.	SHEET 1 of 2
<input type="checkbox"/>	DEVIATION (Supplier Initiated)	3a.	NUMBER 4300165073-0001
<input type="checkbox"/>	WAIVER (Supplier Initiated)	3b.	SAP DMS NUMBER
<input checked="" type="checkbox"/>	CHANGE (CNS Initiated)		

4. APPLICABLE RFWD NUMBER(S) [REVISED OR SUPERSEDED]:  
N/A

5. SUPPLIER NTRC	6. P.O. ITEM NO. #1	7. PROGRAM/PROJECT DPP-1 Regulatory Compliance Testing	8. DOCUMENT NO./REV. SOW 802586-0007 000 00
9. COMPONENT NAME Test Weight Assembly – Jacket Weight Locations	10. PART OR IDENTIFYING NO. Attachment A, Table A 1 and Section 3.3.3 CG table	11. <input checked="" type="checkbox"/> SERIAL or <input type="checkbox"/> LOT NO. TU-1, TU-3, TU-4	12. LOT SIZE N/A

13. SPEC. REF. NO.	14. SPECIFICATION REQUIREMENTS	15. DESCRIPTION OF WAIVER/DEVIATION/CHANGE	16. SUPPLIER PLAN FOR CORRECTIVE ACTION
1) SOW 802586-0007 000 00, Attachment A, Table A 1, Test Weight CG, pg. 38	TU-1 High, TU-3 Low, TU-4 High	Reverse the jacket weight locations by changing TU-1 to Low, TU-3 to High, and TU-4 to Low	N/A, CNS internal change request after PO was awarded
2) SOW 802586-0007 000 00, Section 3.3.3, Markings for CG locations, pg. 11	TU-1 (22.8), TU-3 (22.4), TU-4 (22.8)	The CG marking locations change to TU-1 (22.4), TU-3 (22.8), and TU-4 (22.4).	N/A, CNS internal change request after PO was awarded
3)			
4)			

17. INITIATING ENTITY REPRESENTATIVE (print/sign) Jonathan Weigand	18. TITLE Structural Analyst	19. COMPANY CNS Y12	20. DATE 11-11-2020
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**RESPONDING ENTITY EVALUATION (TO BE COMPLETED BY RESPONDING ENTITY EVALUATION)**

21. SPEC. REF. NO.	22. EVALUATION COMMENTS	23. EVALUATOR	24. RECOMMENDED DISPOSITION
		PRINT/SIGN	
1) SOW 802586-0007 000 00, Attachment A, Table A 1, Test Weight CG, pg. 38	This change was requested internally by CNS structural engineering and is acceptable to better match the structural modeling	ROSS Ross Whittenbarger WHITTENBARGER R (Affiliate) <small>Digitally signed by ROSS WHITTENBARGER (Affiliate) Date: 2020.11.18 11:10:35 -05'00'</small>	<input checked="" type="checkbox"/> ACCEPT <input type="checkbox"/> REJECT
2) SOW 802586-0007 000 00, Section 3.3.3, Markings for CG locations, pg. 11	This change was requested internally by CNS structural engineering and is acceptable to better match the structural modeling.	ROSS Ross Whittenbarger WHITTENBARGER (Affiliate) <small>Digitally signed by ROSS WHITTENBARGER (Affiliate) Date: 2020.11.18 11:11:13 -05'00'</small>	<input checked="" type="checkbox"/> ACCEPT <input type="checkbox"/> REJECT
3)			<input type="checkbox"/> ACCEPT <input type="checkbox"/> REJECT
4)			<input type="checkbox"/> ACCEPT <input type="checkbox"/> REJECT

25. ARE DESIGN DRAWING(S), SPECIFICATION(S), DATA SHEET(S), INSPECTION PLAN(S), OR SURVEILLANCE PLAN(S), ETC. CHANGES REQUIRED?  
IF YES, LIST DOCUMENTS REQUIRING CHANGES (TO BE COMPLETED BY CNS REPRESENTATIVE)

☐ YES    ☒ NO

N/A

This document has been reviewed and confirmed to be UNCLASSIFIED and contains no UCNI.  
 Name: Ross Whittenbarger  
 Date: 11/18/2020  
 CNS eDC/RO ID: 257585

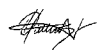
## REQUEST FOR WAIVER OR DEVIATION (RFWD)

[CLICK HERE FOR AN ADDITIONAL PAGE](#)

SHEET 2 of 2

27. IS A CHANGE CONTROL PROCESS INVOKED? ☐ YES ☒ NO  
If yes and controls are needed to prevent use of the SSC prior to placing or returning the item/system to service, identify the controls put in place  
N/A

### APPROVALS (CNS Approvals Require Sam Affected Functions/Organizations Approval As Original Document)

28. ENTITY	29. NAME (print/sign)	30. DATE	31. APPROVE/REJECT RECOMMENDED DISPOSITIONS	
CNS CUSTOMER/PROGRAM MANAGER	Barak (B9Q) Tjader Barak Tjader	Digitally signed by Barak (B9Q) Tjader DN c=US, o=U.S. Government, ou=Department of Energy, ou=Y-12 National Security Complex, ou=CAS, ou=people, cn=Barak (B9Q) Tjader Date: 2021.01.25 16:52:01 -05'00'	<input checked="" type="checkbox"/> APPROVED	<input type="checkbox"/> REJECTED
CNS TECHNICAL REPRESENTATIVE	ROSS WHITTENBARGER (Affiliate) Ross Whittenbarger	Digitally signed by ROSS WHITTENBARGER (Affiliate) Date: 2020.11.18 11:11:52 -05'00'	<input checked="" type="checkbox"/> APPROVED	<input type="checkbox"/> REJECTED
CNS DESIGN AUTHORITY REPRESENTATIVE	Richard D (RT9) Turner David Turner	Digitally signed by Richard D (RT9) Turner Date: 2021.01.21 10:42:37 -05'00'	<input checked="" type="checkbox"/> APPROVED	<input type="checkbox"/> REJECTED
CNS PROJECT REPRESENTATIVE	James C (J5A) Anderson Jim Anderson	Digitally signed by James C (J5A) Anderson Date: 2021.01.26 07:22:49 -05'00'	<input checked="" type="checkbox"/> APPROVED	<input type="checkbox"/> REJECTED
CNS QUALITY ENGINEER	Ryan J (RJF) Fisher Ryan Fisher	Digitally signed by Ryan J (RJF) Fisher Date: 2021.01.21 14:25:10 -05'00'	<input checked="" type="checkbox"/> APPROVED	<input type="checkbox"/> REJECTED
CNS DESIGN ENGINEERING	Michael L (MER) Ensley Michael Ensley	Digitally signed by Michael L (MER) Ensley Date: 2021.01.21 08:52:08 -05'00'	<input checked="" type="checkbox"/> APPROVED	<input type="checkbox"/> REJECTED
CNS PRODUCT/PACKAGING ENGINEERING	ROSS WHITTENBARGER (Affiliate) Ross Whittenbarger	Digitally signed by ROSS WHITTENBARGER (Affiliate) Date: 2020.11.18 11:12:32 -05'00'	<input checked="" type="checkbox"/> APPROVED	<input type="checkbox"/> REJECTED
NUCLEAR PROCUREMENT	Jeffrey E (2XK) Cook Jeff Cook	Digitally signed by Jeffrey E (2XK) Cook Date: 2021.01.26 06:57:44 -05'00'	<input checked="" type="checkbox"/> APPROVED	<input type="checkbox"/> REJECTED
CNS OTHER (List) Structural Analyst	Jonathan P (PJW) Weigand Jonathan Weigand	Digitally signed by Jonathan P (PJW) Weigand Date: 2021.01.21 09:50:40 -05'00'	<input checked="" type="checkbox"/> APPROVED	<input type="checkbox"/> REJECTED
SUPPLIER REPRESENTATIVE	 Oscar Martinez	Digitally signed by Oscar A. Martinez Date: 2021.01.26 15:17:37 -05'00'	<input checked="" type="checkbox"/> APPROVED	<input type="checkbox"/> REJECTED

**NOTE: Ensure Subcontract Administrator in Supply Chain Management receives a copy of the approved RFWD.**

## REQUEST FOR WAIVER OR DEVIATION (RFWD)

1.	REQUEST TYPE	2.	SHEET 1 of 4
<input type="checkbox"/>	DEVIATION (Supplier Initiated)	3a.	NUMBER 4300165073-0002
<input type="checkbox"/>	WAIVER (Supplier Initiated)	3b.	SAP DMS NUMBER
<input checked="" type="checkbox"/>	CHANGE (CNS Initiated)		

4. APPLICABLE RFWD NUMBER(S) [REVISED OR SUPERSEDED]:  
N/A

5. SUPPLIER NTRC	6. P.O. ITEM NO. #1	7. PROGRAM/PROJECT DPP-1 Regulatory Compliance Testing	8. DOCUMENT NO./REV. SOW 802586-0007 000 00
9. COMPONENT NAME See Below	10. PART OR IDENTIFYING NO. See Below	11. <input checked="" type="checkbox"/> SERIAL or <input type="checkbox"/> LOT NO. Vaness	12. LOT SIZE N/A

13. SPEC. REF. NO.	14. SPECIFICATION REQUIREMENTS	15. DESCRIPTION OF WAIVER/DEVIATION/CHANGE	16. SUPPLIER PLAN FOR CORRECTIVE ACTION
1) SOW 802586-0007 000 00, Section 3 1 18	CNS will provide photography equipment and services	NTRC will provide photography equipment and services.	N/A, CNS internal change request after PO was awarded
2) SOW 802586-0007 000 00, Section 3.1 20, 3.7, 3.4.8, 3.4.9, etc.	Photographs, videos, approval data, test plan, test report, and any other documents shall be provided on a USB drive	Any reference to a USB drive may be satisfied with emailed link options	N/A, CNS internal change request after PO was awarded
3) SOW 802586-0007 000 00, Section 3.3	TU-1 through TU-6 will be subjected to vibration	For clarification, only TU-6 will be subjected to vibration.	N/A, CNS internal change request after PO was awarded
4) SOW 802586-0007 000 00, Section 3.3 6.2	The hex head screws and locknuts shall be torqued to 33-37 ft-lb.	Torque to DD-M802586-0030 Rev A, note 2 requirements of 25 ± 2 ft-lb	N/A, CNS internal change request after PO was awarded
5) SOW 802586-0007 000 00, Section 3.4.4, 3.4.7, 3.4.8, 3.4.9, etc.	TU-5 & TU-6 slap down angles of 12°	All references to TU-5 & TU-6 slap down angles of 12° shall be 22°	N/A, CNS internal change request after PO was awarded
6) SOW 802586-0007 000 00, Section 3.4.4, 3.4.7, 3.4.8, 3.4.9, etc.	TU-4, CG over corner drop, lid down, 0° line facing pad	For clarification, the correct drop angle for TU-4 in each section is 56.4° from horizontal	N/A, CNS internal change request after PO was awarded
7) SOW 802586-0007 000 00, Section 3.4 13	The helium atmosphere shall be maintained for at least 20 minutes.	The helium atmosphere shall be 6 minutes minimum with He forced into the O-ring annulus and completed once the level III captures required data.	N/A, CNS internal change request after PO was awarded
8) SOW 802586-0007 000 00, Section 3.4 15	The lid down position	The lid position will be up for the 50 foot immersion test	N/A, CNS internal change request after PO was awarded
9) SOW 802586-0007 000 00, Attachment A, Table A.1	Water spray only TU-6	Water spray shall be performed on the ambient units of TU-2, -3, -4, & -6	N/A, CNS internal change request after PO was awarded
10) SOW 802586-0007 000 00, Attachment B, B.1.3, B.2, Table B.2	Data loggers - Slam Stick Models X and S	Allowance of PCB 350B44 or other accelerometers may be acceptable for use after approval by CNS	N/A, CNS internal change request after PO was awarded
11) SOW 802586-0007 000 00, Attachment B, B.1.4	Adhesive for data loggers	Allowance for tacked on accelerometer mounts with stainless wire in lieu of adhesive is acceptable with CNS approval of drawings/sketches	N/A, CNS internal change request after PO was awarded
12) SOW 802586-0007 000 00, Attachment C.1.2 & C.1.3	Number of cooling stands (2) and steel plate size (4 ft x 8 ft x 1 in)	Additional cooling stands will be required (6), alternate plate size is acceptable with CNS approval	N/A, CNS internal change request after PO was awarded
13) SOW 802586-0007 000 00, Attachment C.1.4	Preheat chamber capable of holding two test units	The preheat chamber will need to be able to accommodate all 6 test units	N/A, CNS internal change request after PO was awarded
14) SOW 802586-0007 000 00, Attachment C.11 Note	The data recorder must have enough data channels to cover the furnace and at least two shipping packages	The DAQ(s) must have enough channels to cover the furnace, preheat chamber, ambient, and packages during thermal testing and agreed upon cool down interval.	N/A, CNS internal change request after PO was awarded
15) SOW 802586-0007 000 00, Attachment C.3.7	An additional TC lag bolt will be needed to attach the TC wire to the Packcrete casting surface.	For clarification, this sentence is retracted and 6 external TCs will be attached to each TU in accordance with the SOW.	N/A, CNS internal change request after PO was awarded
16) SOW 802586-0007 000 00, Attachment C.4.1	The furnace shall be heated for at least 24h before testing the first test unit. The furnace shall be heated for at least 2h between tests.	Change 24h to 12h and change 2h to 45 minutes minimum and when section C.4.3 is met Furnace T/Cs will verify steady state	N/A, CNS internal change request after PO was awarded
17) SOW 802586-0007 000 00, Attachment C.5.1.Note	31 TCs will be required	The max number of channels will depend on the units that are being monitored during cool down as well	N/A, CNS internal change request after PO was awarded
18) SOW 802586-0007 000 00, Attachment C.5.4	Recording of TU external TCs shall continue until the test unit is unloaded from the furnace and the furnace door has been closed.	In addition, cool down data will need to be captured until each unit is below 100° F or for 6 hours	N/A, CNS internal change request after PO was awarded
19) SOW 802586-0007 000 00, Section 1.1, Fig. 1	Figure 1	Update Fig 1 per Sheet 4	N/A, CNS internal change request after PO was awarded

UCN-13816B (01-16)  
Y60-015, 4.2, 4.3, 4.7, 4.8 & 4.11

**UNCLASSIFIED**  
S-7

This document has been reviewed and confirmed to be UNCLASSIFIED and contains no UCNi.  
Name: Ross Whittenbarger  
Date: 01/20/2021  
CNS eDC/RO ID: 273395

## REQUEST FOR WAIVER OR DEVIATION (RFWD)

<b>17. INITIATING ENTITY REPRESENTATIVE (print/sign)</b> Ross Whittenbarger	<b>18. TITLE</b> Test Engineer	<b>19. COMPANY</b> CNS Y12	<b>20. DATE</b> 1-5-2021    Sheet   2   of   4
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### RESPONDING ENTITY EVALUATION (TO BE COMPLETED BY RESPONDING ENTITY EVALUATION)

21. SPEC. REF. NO.	22 EVALUATION COMMENTS	23. EVALUATOR			24. RECOMMENDED DISPOSITION
		PRINT/SIGN	DATE		
1) SOW 802586-0007 000 00, Section 3.1.18	This change was requested internally by CNS.	Ross Whittenbarger Ross M (RWM) Whittenbarger Digitally signed by Ross M (RWM) Whittenbarger Date: 2021.01.20 14:55:03 -05'00'	1/5/21	<input checked="" type="checkbox"/> ACCEPT <input type="checkbox"/> REJECT	
2) SOW 802586-0007 000 00, Section 3.1.20, 3.7, 5.5, etc.	This change was requested internally by CNS	Ross Whittenbarger Ross M (RWM) Whittenbarger Digitally signed by Ross M (RWM) Whittenbarger Date: 2021.01.20 15:14:04 -05'00'	1/5/21	<input checked="" type="checkbox"/> ACCEPT <input type="checkbox"/> REJECT	
3) SOW 802586-0007 000 00, Section 3.3	This change was requested internally by CNS.	Ross Whittenbarger Ross M (RWM) Whittenbarger Digitally signed by Ross M (RWM) Whittenbarger Date: 2021.01.20 14:58:06 -05'00'	1/5/21	<input checked="" type="checkbox"/> ACCEPT <input type="checkbox"/> REJECT	
4) SOW 802586-0007 000 00, Section 3.3.6.2	This change was requested internally by CNS.	Ross Whittenbarger Ross M (RWM) Whittenbarger Digitally signed by Ross M (RWM) Whittenbarger Date: 2021.01.20 14:58:39 -05'00'	1/5/21	<input checked="" type="checkbox"/> ACCEPT <input type="checkbox"/> REJECT	
5) SOW 802586-0007 000 00, Section 3.4.4, 3.4.7, 3.4.8, 3.4.9, etc.	This change was requested internally by CNS.	Ross Whittenbarger Ross M (RWM) Whittenbarger Digitally signed by Ross M (RWM) Whittenbarger Date: 2021.01.20 14:59:21 -05'00'	1/5/21	<input checked="" type="checkbox"/> ACCEPT <input type="checkbox"/> REJECT	
6) SOW 802586-0007 000 00, Section 3.4.4, 3.4.7, 3.4.8, 3.4.9, etc.	This change was requested internally by CNS	Ross Whittenbarger Ross M (RWM) Whittenbarger Digitally signed by Ross M (RWM) Whittenbarger Date: 2021.01.20 15:00:07 -05'00'	1/5/21	<input checked="" type="checkbox"/> ACCEPT <input type="checkbox"/> REJECT	
7) SOW 802586-0007 000 00, Section 3.4.13	This change was requested internally by CNS.	Ross Whittenbarger Ross M (RWM) Whittenbarger Digitally signed by Ross M (RWM) Whittenbarger Date: 2021.01.20 15:00:55 -05'00'	1/5/21	<input checked="" type="checkbox"/> ACCEPT <input type="checkbox"/> REJECT	
8) SOW 802586-0007 000 00, Section 3.4.15	This change was requested internally by CNS.	Ross Whittenbarger Ross M (RWM) Whittenbarger Digitally signed by Ross M (RWM) Whittenbarger Date: 2021.01.20 15:01:38 -05'00'	1/5/21	<input checked="" type="checkbox"/> ACCEPT <input type="checkbox"/> REJECT	
9) SOW 802586-0007 000 00, Attachment A, Table A.1	This change was requested internally by CNS.	Ross Whittenbarger Ross M (RWM) Whittenbarger Digitally signed by Ross M (RWM) Whittenbarger Date: 2021.01.20 15:02:47 -05'00'	1/5/21	<input checked="" type="checkbox"/> ACCEPT <input type="checkbox"/> REJECT	
10) SOW 802586-0007 000 00, Attachment B, B.1.3, B.2, Table B.2	This change was requested internally by CNS	Ross Whittenbarger Ross M (RWM) Whittenbarger Digitally signed by Ross M (RWM) Whittenbarger Date: 2021.01.20 15:03:29 -05'00'	1/5/21	<input checked="" type="checkbox"/> ACCEPT <input type="checkbox"/> REJECT	
11) SOW 802586-0007 000 00, Attachment B, B.1.4	This change was requested internally by CNS	Ross Whittenbarger Ross M (RWM) Whittenbarger Digitally signed by Ross M (RWM) Whittenbarger Date: 2021.01.20 15:04:04 -05'00'	1/5/21	<input checked="" type="checkbox"/> ACCEPT <input type="checkbox"/> REJECT	
12) SOW 802586-0007 000 00, Attachment C 1.2 & C 1.3	This change was requested internally by CNS	Ross Whittenbarger Ross M (RWM) Whittenbarger Digitally signed by Ross M (RWM) Whittenbarger Date: 2021.01.20 15:04:52 -05'00'	1/5/21	<input checked="" type="checkbox"/> ACCEPT <input type="checkbox"/> REJECT	
13) SOW 802586-0007 000 00, Attachment C 1.4	This change was requested internally by CNS.	Ross Whittenbarger Ross M (RWM) Whittenbarger Digitally signed by Ross M (RWM) Whittenbarger Date: 2021.01.20 15:05:29 -05'00'	1/5/21	<input checked="" type="checkbox"/> ACCEPT <input type="checkbox"/> REJECT	
14) SOW 802586-0007 000 00, Attachment C.11.Note	This change was requested internally by CNS.	Ross Whittenbarger Ross M (RWM) Whittenbarger Digitally signed by Ross M (RWM) Whittenbarger Date: 2021.01.20 15:07:33 -05'00'	1/5/21	<input checked="" type="checkbox"/> ACCEPT <input type="checkbox"/> REJECT	
15) SOW 802586-0007 000 00, Attachment C.3.7	This change was requested internally by CNS.	Ross Whittenbarger Ross M (RWM) Whittenbarger Digitally signed by Ross M (RWM) Whittenbarger Date: 2021.01.20 15:08:14 -05'00'	1/5/21	<input checked="" type="checkbox"/> ACCEPT <input type="checkbox"/> REJECT	
16) SOW 802586-0007 000 00, Attachment C 4.1	This change was requested by SwRI and data from DPP-3 testing supports this change. Furnace T/Cs will be verified to ensure readiness for testing.	Ross Whittenbarger Ross M (RWM) Whittenbarger Digitally signed by Ross M (RWM) Whittenbarger Date: 2021.01.20 15:10:51 -05'00'	1/20/21	<input checked="" type="checkbox"/> ACCEPT <input type="checkbox"/> REJECT	
17) SOW 802586-0007 000 00, Attachment C 5.1.Note	This change was requested internally by CNS	Ross Whittenbarger Ross M (RWM) Whittenbarger Digitally signed by Ross M (RWM) Whittenbarger Date: 2021.01.20 15:10:51 -05'00'	1/5/21	<input checked="" type="checkbox"/> ACCEPT <input type="checkbox"/> REJECT	
18) SOW 802586-0007 000 00, Attachment C 5.4	This change was requested internally by CNS.	Ross Whittenbarger Ross M (RWM) Whittenbarger Digitally signed by Ross M (RWM) Whittenbarger Date: 2021.01.20 15:12:24 -05'00'	1/5/21	<input checked="" type="checkbox"/> ACCEPT <input type="checkbox"/> REJECT	
19) SOW 802586-0007 000 00, Section 1.1, Fig. 1	This change was requested internally by CNS.	Ross Whittenbarger Ross M (RWM) Whittenbarger Digitally signed by Ross M (RWM) Whittenbarger Date: 2021.01.20 14:55:39 -05'00'	1/5/21	<input checked="" type="checkbox"/> ACCEPT <input type="checkbox"/> REJECT	

<b>25. ARE DESIGN DRAWING(S), SPECIFICATION(S), DATA SHEET(S), INSPECTION PLAN(S), OR SURVEILLANCE PLAN(S), ETC. CHANGES REQUIRED? IF YES, LIST DOCUMENTS REQUIRING CHANGES (TO BE COMPLETED BY CNS REPRESENTATIVE)</b>	<input type="checkbox"/> YES <input checked="" type="checkbox"/> NO
N/A, NTRC Test Plan to incorporate changes in accordance with this RFWD	



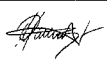
## REQUEST FOR WAIVER OR DEVIATION (RFWD)

[CLICK HERE FOR AN ADDITIONAL PAGE](#)

SHEET 3 of 4

27. **IS A CHANGE CONTROL PROCESS INVOKED?** ☐ YES ☒ NO  
If yes and controls are needed to prevent use of the SSC prior to placing or returning the item/system to service, identify the controls put in place  
N/A

### APPROVALS (CNS Approvals Require Sam Affected Functions/Organizations Approval As Original Document)

28. ENTITY	29. NAME (print/sign)	30. DATE	31. APPROVE/REJECT RECOMMENDED DISPOSITIONS
CNS CUSTOMER/PROGRAM MANAGER	Barak (B9Q) Tjader <small>Barak Tjader</small>	<small>Digitally signed by Barak (B9Q) Tjader DN c=US, o=U.S. Government, ou=Department of Energy, ou=Y-12 National Security Complex, ou=CAs, ou=people, cn=Barak (B9Q) Tjader Date: 2021.01.25 16:52:59 -05'00'</small>	<input checked="" type="checkbox"/> APPROVED <input type="checkbox"/> REJECTED
CNS TECHNICAL REPRESENTATIVE	Ross M (RWM) Whittenbarger <small>Ross Whittenbarger</small>	<small>Digitally signed by Ross M (RWM) Whittenbarger Date: 2021.01.20 14:56:14 -05'00'</small>	<input checked="" type="checkbox"/> APPROVED <input type="checkbox"/> REJECTED
CNS DESIGN AUTHORITY REPRESENTATIVE	Richard D (RT9) Turner <small>David Turner</small>	<small>Digitally signed by Richard D (RT9) Turner Date: 2021.01.21 10:48:19 -05'00'</small>	<input checked="" type="checkbox"/> APPROVED <input type="checkbox"/> REJECTED
CNS PROJECT REPRESENTATIVE	James C (J5A) Anderson <small>Jim Anderson</small>	<small>Digitally signed by James C (J5A) Anderson Date: 2021.01.26 07:24:54 -05'00'</small>	<input checked="" type="checkbox"/> APPROVED <input type="checkbox"/> REJECTED
CNS QUALITY ENGINEER	Ryan J (RJF) Fisher <small>Ryan Fisher</small>	<small>Digitally signed by Ryan J (RJF) Fisher Date: 2021.01.21 14:24:04 -05'00'</small>	<input checked="" type="checkbox"/> APPROVED <input type="checkbox"/> REJECTED
CNS DESIGN ENGINEERING	Michael L (MER) Ensley <small>Michael Ensley</small>	<small>Digitally signed by Michael L (MER) Ensley Date: 2021.01.21 08:55:20 -05'00'</small>	<input checked="" type="checkbox"/> APPROVED <input type="checkbox"/> REJECTED
CNS PRODUCT/PACKAGING ENGINEERING	Ross M (RWM) Whittenbarger <small>Ross Whittenbarger</small>	<small>Digitally signed by Ross M (RWM) Whittenbarger Date: 2021.01.20 14:56:40 -05'00'</small>	<input checked="" type="checkbox"/> APPROVED <input type="checkbox"/> REJECTED
NUCLEAR PROCUREMENT	Jeffrey E (2XK) Cook <small>Jeff Cook</small>	<small>Digitally signed by Jeffrey E (2XK) Cook Date: 2021.01.26 06:55:32 -05'00'</small>	<input checked="" type="checkbox"/> APPROVED <input type="checkbox"/> REJECTED
CNS OTHER (List) Structural Analyst	Jonathan P (PJW) Weigand <small>Jonathan Weigand</small>	<small>Digitally signed by Jonathan P (PJW) Weigand Date: 2021.01.21 10:25:41 -05'00'</small>	<input checked="" type="checkbox"/> APPROVED <input type="checkbox"/> REJECTED
SUPPLIER REPRESENTATIVE	 <small>Oscar Martinez</small>	<small>Digitally signed by Oscar A. Martinez Date: 2021.01.26 15:19:45 -05'00'</small>	<input checked="" type="checkbox"/> APPROVED <input type="checkbox"/> REJECTED

**NOTE: Ensure Subcontract Administrator in Supply Chain Management receives a copy of the approved RFWD.**

## REQUEST FOR WAIVER OR DEVIATION (RFWD)

SHEET 4 of 4

### DPP-1 Package

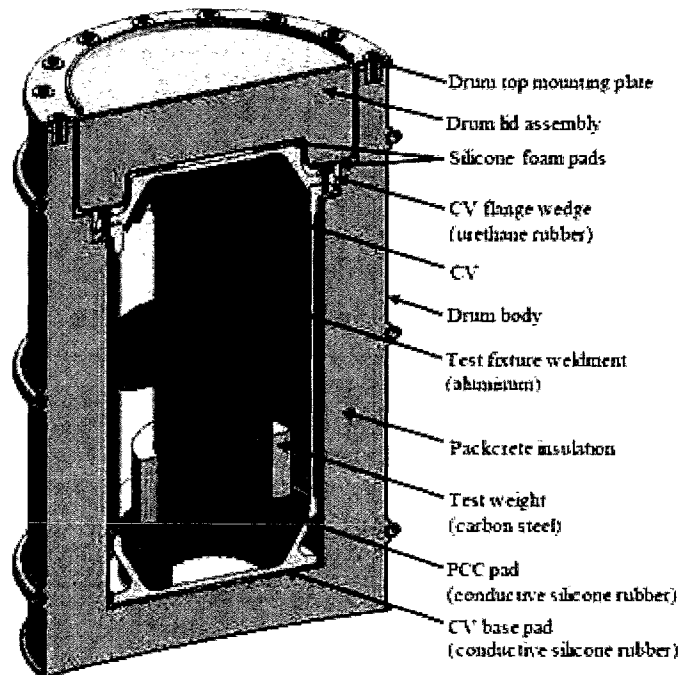
Weight shown: 882 lbs  
Empty weight: 753 lbs  
Drum OD: 27 in  
Drum height: 43 in

### CV

Empty weight: 257 lbs  
ID: 14.4 in  
Internal height: 31.4 in  
External height: 32.4 in

### Payload

Light weight: 73 lbs  
Heavy weight: 131 lbs  
Fixture height: 29.3 in



Updated Fig. 1

## REQUEST FOR WAIVER OR DEVIATION (RFWD)

<b>1. REQUEST TYPE</b> <input type="checkbox"/> DEVIATION (Supplier Initiated) <input type="checkbox"/> WAIVER (Supplier Initiated) <input checked="" type="checkbox"/> CHANGE (CNS Initiated)	<b>2. SHEET</b> 1 of 4 <b>3a. NUMBER</b> 4300165073-0003 <b>3b. SAP DMS NUMBER</b>
---	--

**4. APPLICABLE RFWD NUMBER(S) [REVISED OR SUPERSEDED]:**  
N/A

<b>5. SUPPLIER</b> NTRC	<b>6. P.O. ITEM NO. #1</b>	<b>7. PROGRAM/PROJECT</b> DPP-1 Regulatory Compliance Testing	<b>8. DOCUMENT NO./REV.</b> SOW 802586-0007 000 00
<b>9. COMPONENT NAME</b> Table A 1	<b>10. PART OR IDENTIFYING NO.</b> Attachment A, Table A 1 and Section 1.4 GFE	<b>11. <input checked="" type="checkbox"/> SERIAL or <input type="checkbox"/> LOT NO.</b> TU-1 through TU-6	<b>12. LOT SIZE</b> N/A

13. SPEC. REF. NO.	14. SPECIFICATION REQUIREMENTS	15. DESCRIPTION OF WAIVER/DEVIATION/CHANGE	16. SUPPLIER PLAN FOR CORRECTIVE ACTION
1) SOW 802586-0007 000 00, Attachment A, Table A.1	TU-3 and TU-4 Installation and Removal of Data Loggers under Preparation and HAC Testing sections	Remove the Installation of Data Loggers from TU-3 and TU-4 from Table A.1. For clarity there are no impact data loggers (accels) on TU-3 and TU-4. Please see new Table A 1 attached. Also Attachment B, section B 2 and Table B 2 in the SOW are correct which identifies TU-1, TU-2, TU-5, and TU-6 are the only TUs that require the installation of accels.	N/A, CNS internal change request after PO was awarded
2) SOW 802586-0007 000 00, Section 1.4 - Government Furnished Equipment	Seven Test Fixture Weldments	To clarify seven test fixture weldments will be shipped to NTRC. One is a spare and only six will be used in TU-1 through TU-6. One set of light test weights will be installed on TU-2 and the heavy test weights will be installed on the other TUs	N/A, CNS internal change request after PO was awarded
3)			
4)			

<b>17. INITIATING ENTITY REPRESENTATIVE (print/sign)</b> Ross Whittenbarger	<b>18. TITLE</b> Packaging Engineer	<b>19. COMPANY</b> CNS Y12	<b>20. DATE</b> 2-2-2021
--	--	-------------------------------	-----------------------------

**RESPONDING ENTITY EVALUATION (TO BE COMPLETED BY RESPONDING ENTITY EVALUATION)**

21. SPEC. REF. NO.	22 EVALUATION COMMENTS	23. EVALUATOR	24. RECOMMENDED DISPOSITION
		PRINT/SIGN	DATE
1) SOW 802586-0007 000 00, Attachment A, Table A 1	This change was requested internally by CNS to clarify requirements	Ross Whittenbarger Ross M (RWM) Whittenbarger <small>Digitally signed by Ross M (RWM) Whittenbarger Date: 2021 02 03 16:16:33 -05 00</small>	2/2/21 <input checked="" type="checkbox"/> ACCEPT <input type="checkbox"/> REJECT
2) SOW 802586-0007 000 00, Section 1.4 - Government Furnished Equipment	This change was requested internally by CNS to clarify requirements	Ross Whittenbarger Ross M (RWM) Whittenbarger <small>Digitally signed by Ross M (RWM) Whittenbarger Date: 2021 02 03 16:17:43 -05 00</small>	2/2/21 <input checked="" type="checkbox"/> ACCEPT <input type="checkbox"/> REJECT
3)			<input type="checkbox"/> ACCEPT <input type="checkbox"/> REJECT
4)			<input type="checkbox"/> ACCEPT <input type="checkbox"/> REJECT

**25. ARE DESIGN DRAWING(S), SPECIFICATION(S), DATA SHEET(S), INSPECTION PLAN(S), OR SURVEILLANCE PLAN(S), ETC. CHANGES REQUIRED?** ☐ YES ☒ NO  
 IF YES, LIST DOCUMENTS REQUIRING CHANGES (TO BE COMPLETED BY CNS REPRESENTATIVE)  
 N/A

This document has been reviewed and confirmed to be UNCLASSIFIED and contains no UCNl.  
 Name: Ross Whittenbarger  
 Date: 02/03/2021  
 CNS eDC/RO ID: 278295

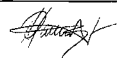
## REQUEST FOR WAIVER OR DEVIATION (RFWD)

[CLICK HERE FOR AN ADDITIONAL PAGE](#)

SHEET 2 of 4

27. **IS A CHANGE CONTROL PROCESS INVOKED?** ☐ YES ☒ NO  
If yes and controls are needed to prevent use of the SSC prior to placing or returning the item/system to service, identify the controls put in place  
N/A

### APPROVALS (CNS Approvals Require Sam Affected Functions/Organizations Approval As Original Document)

28. ENTITY	29. NAME (print/sign)	30. DATE	31. APPROVE/REJECT RECOMMENDED DISPOSITIONS	
CNS CUSTOMER/PROGRAM MANAGER	Barak Tjader <small>Barak Tjader</small>	Digitally signed by Barak (B9Q) Tjader DN: c=US, o=U.S. Government, ou=Department of Energy, ou=Y-12 National Security Complex, ou=CAs, ou=people, cn=Barak (B9Q) Tjader Date: 2021.02.04 07:33:40 -05'00'	<input checked="" type="checkbox"/> APPROVED	<input type="checkbox"/> REJECTED
CNS TECHNICAL REPRESENTATIVE	Ross M (RWM) Whittenbarger <small>Ross Whittenbarger</small>	Digitally signed by Ross M (RWM) Whittenbarger Date: 2021.02.03 16:18:22 -05'00'	<input checked="" type="checkbox"/> APPROVED	<input type="checkbox"/> REJECTED
CNS DESIGN AUTHORITY REPRESENTATIVE	Richard D (RT9) Turner <small>David Turner</small>	Digitally signed by Richard D (RT9) Turner Date: 2021.02.04 07:43:49 -05'00'	<input checked="" type="checkbox"/> APPROVED	<input type="checkbox"/> REJECTED
CNS PROJECT REPRESENTATIVE	James C (J5A) Anderson <small>Jim Anderson</small>	Digitally signed by James C (J5A) Anderson Date: 2021.02.04 09:55:24 -05'00'	<input checked="" type="checkbox"/> APPROVED	<input type="checkbox"/> REJECTED
CNS QUALITY ENGINEER	Ryan J (RJF) Fisher <small>Ryan Fisher</small>	Digitally signed by Ryan J (RJF) Fisher Date: 2021.02.03 17:08:37 -05'00'	<input checked="" type="checkbox"/> APPROVED	<input type="checkbox"/> REJECTED
CNS DESIGN ENGINEERING	Michael L (MER) Ensley <small>Michael Ensley</small>	Digitally signed by Michael L (MER) Ensley Date: 2021.02.03 16:34:18 -05'00'	<input checked="" type="checkbox"/> APPROVED	<input type="checkbox"/> REJECTED
CNS PRODUCT/PACKAGING ENGINEERING	Ross M (RWM) Whittenbarger <small>Ross Whittenbarger</small>	Digitally signed by Ross M (RWM) Whittenbarger Date: 2021.02.03 16:18:52 -05'00'	<input checked="" type="checkbox"/> APPROVED	<input type="checkbox"/> REJECTED
NUCLEAR PROCUREMENT	Jeffrey E (2XK) Cook <small>Jeff Cook</small>	Digitally signed by Jeffrey E (2XK) Cook Date: 2021.02.04 08:19:34 -05'00'	<input checked="" type="checkbox"/> APPROVED	<input type="checkbox"/> REJECTED
CNS OTHER (List) Structural Analyst	Jonathan P (PJW) Weigand <small>Jonathan Weigand</small>	Digitally signed by Jonathan P (PJW) Weigand Date: 2021.02.03 16:40:31 -05'00'	<input checked="" type="checkbox"/> APPROVED	<input type="checkbox"/> REJECTED
SUPPLIER REPRESENTATIVE	Oscar Martinez 	Digitally signed by Oscar A. Martinez Date: 2021.02.04 15:44:40 -05'00'	<input checked="" type="checkbox"/> APPROVED	<input type="checkbox"/> REJECTED

**NOTE: Ensure Subcontract Administrator in Supply Chain Management receives a copy of the approved RFWD.**



## REQUEST FOR WAIVER OR DEVIATION (RFWD)

**Table A.1 Test Matrix for DPP-1 Test Units**

	TU-1	TU-2	TU-3	TU-4	TU-5	TU-6	TU-7
Regulatory test	HAC <sup>a</sup>	HAC	HAC	HAC	HAC	NCT <sup>b</sup> /HAC	-
Temperature	Cold	Ambient	Ambient	Ambient	Cold	Ambient	Ambient
Test weight	Heavy	Light	Heavy	Heavy	Heavy	Heavy	None
Test weight CG <sup>c</sup>	Low	Low	High	Low	High	Low	-
Drop orientation	Side	Side	Top	CGoTC <sup>d</sup> (56.4°)	Slapdown (22°)	Slapdown (22°)	-
<b>Preparation</b>							
Mark outside	1	1	1	1	1	1	1
Disassemble	2	2	2	2	2	2	2
Mark part & subassemblies	3	3	3	3	3	3	
Install TLs <sup>e</sup>	4	4	4	4	4	4	
Weigh parts & assemblies	5	5	5	5	5	5	3
Leak test CVs <sup>f</sup> (operational)	6	6	6	6	6	6	4
Assemble	7	7	7	7	7	7	
Chill test unit (-40°F)	8				8		
<b>NCT tests</b>							
Install vibration DL <sup>g</sup>						8	
Vibration						9	
Remove DL & capture data						10	
Water spray		8	8	8		11	
Install impact DLs	9	9			9	12	
4-ft drop	10	10	9	9	10	13	
Compression						14	
Penetration						15	
<b>HAC tests</b>							
30-ft drop	11	11	10	10	11	16	
Crush	12	12	11	11	12	17	
Puncture	13	13	12	12	13	18	
Measure deformations	14	14	13	13	14	19	
Remove DLs & capture data	15	15			15	20	
Install TCs <sup>h</sup> on drum & preheat	16	16	14	14	16	21	
Thermal test	17	17	15	15	17	22	
Capture TC data	18	18	16	16	18	23	
<b>Post-test inspection</b>							
Disassemble down to CV	19	19	17	17	19	24	
Read TLs	20	20	18	18	20	25	
Leak test CV (operational)	21	21	19	19	21	26	
Leak test CV (He)	22	22	20	20	22	27	
3-ft CV immersion	23	23	21	21	23	28	
50-ft CV immersion							5
Disassemble CV	24	24	22	22	24	29	6
Inspect for water	25	25	23	23	25	30	7
Remove test content assembly	26	26	24	24	26	31	

## REQUEST FOR WAIVER OR DEVIATION (RFWD)

	TU-1	TU-2	TU-3	TU-4	TU-5	TU-6	TU-7
Regulatory test	HAC <sup>a</sup>	HAC	HAC	HAC	HAC	NCT <sup>b</sup> /HAC	-
Temperature	Cold	Ambient	Ambient	Ambient	Cold	Ambient	Ambient
Test weight	Heavy	Light	Heavy	Heavy	Heavy	Heavy	None
Test weight CG <sup>c</sup>	Low	Low	High	Low	High	Low	-
Drop orientation	Side	Side	Top	CGoTC <sup>d</sup> (56.4°)	Slapdown (22°)	Slapdown (22°)	-
Read TLs & inspect	27	27	25	25	27	32	

<sup>a</sup> HAC – hypothetical accident condition

<sup>b</sup> NCT – normal conditions of transport

<sup>c</sup> CG – center of gravity

<sup>d</sup> CGoTC – center of gravity over top corner

<sup>e</sup> TL – temperature label

<sup>f</sup> CV – containment vessel

<sup>g</sup> DL – data logger

<sup>h</sup> TC – thermocouple

## **T. APPENDIX LEAK TEST REPORT**

# PCMT Leak Test Calculator - Absolute P Gauge-Pchange (LR=SCC/S)

## DPP-1 TU-4 Operational Leak Test

Calc. Version 8/8/18

Input Required in Yellow Cells

Barometric Pressure	WC
Initial	394.90
Final	394.90

Start Gauge Pressure	WC abs
	8.52

End Gauge Pressure	WC abs
	8.74

Start Temperature	Deg C	Deg K
	20.100	293.250

End Temperature	Deg C	Deg K
	20.100	293.250

Test Volume	61.16	CC
(calculated minimum)	61.01	CC

### Calculations for Formula

Allowable LR	1.00E-04	atm CC/Sec
Test P Differential	350	WC diff
Test Time	600	Seconds
Standard Atm	407	WC

Initial Pressure	8.52	WC - ABS
Initial Pressure	-386.38	WC - Gauge

Final Pressure	8.74	WC - ABS
Final Pressure	-386.16	WC - Gauge

dP Due to Pressure Gauge change	
Delta Pressure G	0.22 WC

dP Due to Barometer change	
Delta Pressure T	0.00 WC

dP Due to temperature change	
Delta Pressure T	0.00 WC

	Pressure	B	Temp C	Temp comp P	Delta Time	Rej Pressure	LR
Start Time	10:56:00 AM	9/15/2021	8.52	394.90	20.100		
	10:58:00 AM	9/15/2021	8.57	394.90	20.100	8.57	120
	11:00:00 AM	9/15/2021	8.61	394.91	20.100	8.61	240
	11:03:00 AM	9/15/2021	8.68	394.92	20.100	8.68	420
End Time	11:06:00 AM	9/15/2021	8.74	394.90	20.100	8.74	600
					Delta Time	600	Sec
						10	Min

Allowable LR	1.00E-04	atm CC/Sec	Minimum Test Sensitivity	9.99E-06	atm CC/Sec
Measured LR	5.50E-05	atm CC/Sec	Uncertainty	8.19E-12	atm CC/Sec

Reported LR	5.50E-05	atm CC/Sec	Accept if Green, Reject if Red
Procedure: NDE-70 Rev:	7	Technique: PCMT	Rev: 0

Accepted 9/15/21  
<1.0E-4 atm\*cc/s air at test sensitivity of <5.0E-5 atm\*cc/s

Work Request 4293615



Certificate Number: 4121/01

Digitally signed by  
**Eric Vidal**  
Date: 2021.09.17  
09:14:21 -04'00'



# PCMT Leak Test Calculator - Uncertainties Calculation Worksheet

DPP-1 TU-4 Operational Leak Test

Calc. Version 8/8/18

Gauge	Identification	MTE #	FS Accuracy	FS/Act Rdg	Subdivisions	Units	
Pressure Gauge	Ashcroft HQS-2	A002500	0.025%	8.62	0.01	WC	
Temperature Gauge	Omega HH804	A005945	0.40%	20.1	0.1	deg C	
Time Gauge	Computer Time	none	0.100%	60	1	Sec	
Reference Volume	50.72548	A001744	1.000%	61.16	0.1	CC	

Variable	acc*FS rdg	Traceability	Resolution	Total Variable u	
P	2.16E-03	2.27E-05	0.010	3.08E-03	IWC
T	8.04E-02	5.80E-02	1.00E-01	5.74E-02	deg C
t	6.00E-02	1.00E-03	1.00E+00	2.90E-01	Sec
V	6.12E-01	2.04E-01	0.10	3.24E-01	CC

## PCMT Gauge Resolution

	Formula	Calc
Pressure Resolution	$(Gres \times V) / (StdAtm \times t)$	2.49830E-06
Temperature Resolution	$\{(Pi \times V) / (StdAtm \times t)\} \times (Tres/Ti)$	7.25848E-07
Time Resolution	$\{[(Pi \times (Tf/Ti) - Pf) \times V] / (StdAtm \times Dtime)\} \times (t \text{ res} / (Dtime + t \text{ res}))$	9.14518E-08

2.4983E-06 Maximum PCMT Test Resolution

## Weighted Uncertainties

Initial Pressure	5.93E-13
Final Pressure	5.93E-13
Temp Final	1.73E-13
Temp Initial	4.01E-12
Volume	8.50E-14
Time	8.79E-16

Weighted U 8.19E-12

## PCMT Test Uncertainty

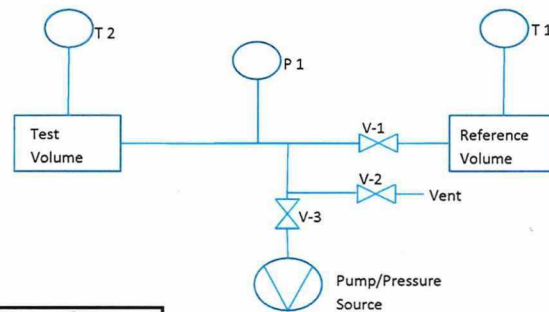
$\sqrt{(uP^2 + uV^2 + uT^2 + ut^2)}$

8.1932E-12

## System Under Test Volume Calc

DPP-1 TU-4 Operational Leak Test

Calc. Version 8/8/18



### Steps for Determination of Test + System Volume

- Step 1 Vent test system  
Close V-3; Open Valves V-1 & V-2  
Wait for pressure to equalize
- Step 2 Record P-1 and T-1 as Ref P&T
- Step 3 Close V-2 (vent) and then close V-1, Isolating Reference volume
- Step 4 Open V-3; Pressurize/evacuate as needed to bring system to Start Pressure,
- Step 5 Close V-3; Wait for pressure to equalize
- Step 6 Record P-1 and T-2 as Start P&T
- Step 7 Open V-1; Exposing Reference Volume to the system  
Wait for pressure to equalize
- Step 8 As soon as pressure is equalized, record P-1, T-1 and T-2 as Equalized P&T  
  
Note: pressure may continue to drop if Test Volume has leaks, so record quickly
- Step 9 Repeat steps 1 through 8 a total of 6 times

Input Data in orange and yellow cells only!

Reference Volume	
Calibration Due Date:	8/14/2022
MTE Number	A001744
Volume	50.7255 CC

Gauge	P-1	T-1	P-1	T-2	P-1	T-1	T-2	
	Ref P&T		Start; Ref Vol Isolated		Equalized Pressure			
Run	P ref (PSIA)	T ref (deg C)	Pstart (PSIA)	Tvstart (deg C)	P eq (PSIA)	T eq (deg C)	Tveq (deg C)	Test Sys Vol (CC)
1	14.250	20.800	4.221	20.800	8.779	20.800	20.800	60.8862
2	14.250	20.800	4.286	20.800	8.802	20.800	20.800	61.1941
3	14.250	20.800	4.554	20.800	8.950	20.800	20.800	61.1567
4	14.250	20.800	4.022	20.800	8.659	20.800	20.800	61.1616
5	14.250	20.800	5.026	20.800	9.201	20.800	20.800	61.3444
6	14.250	20.800	4.466	20.800	8.905	20.800	20.800	61.0786

Test VoLume	61.1592	CC	median
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0.1507	Std Dev
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Min Calculated Volume	61.0084	CC
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# PCMT Leak Test Calculator - Absolute P Gauge-Pchange (LR=SCC/S)

## DPP-1 TU-3 Operational Leak Test

Calc. Version 8/8/18

Input Required in Yellow Cells

Calculations for Formula

Barometric Pressure	WC
Initial	394.88
Final	394.84

Allowable LR	1.00E-04	atm CC/Sec
Test P Differential	350	WC diff
Test Time	600	Seconds
Standard Atm	407	WC

Start Gauge Pressure	WC abs
	15.52

Initial Pressure	15.52	WC - ABS
Initial Pressure	-379.36	WC - Gauge

End Gauge Pressure	WC abs
	15.72

Final Pressure	15.72	WC - ABS
Final Pressure	-379.12	WC - Gauge

Start Temperature	Deg C	Deg K
	20.200	293.350

dP Due to Pressure Gauge change	
Delta Pressure G	0.20 WC

End Temperature	Deg C	Deg K
	20.200	293.350

dP Due to Barometer change	
Delta Pressure T	0.04 WC

Test Volume	60.24	CC
(calculated minimum)	60.09	CC

dP Due to temperature change	
Delta Pressure T	0.00 WC

			Pressure	B	Temp C	Temp comp P	Delta Time	Rej Pressure	LR
Start Time	11:40:00 AM	9/15/2021	15.52	394.88	20.200				
	11:42:00 AM	9/15/2021	15.56	394.87	20.200	15.56	120	15.44	4.92E-05
	11:44:00 AM	9/15/2021	15.60	394.84	20.200	15.60	240	16.15	4.92E-05
	11:47:00 AM	9/15/2021	15.66	394.83	20.200	15.66	420	16.62	4.92E-05
End Time	11:50:00 AM	9/15/2021	15.72	394.84	20.200	15.72	600	17.09	4.92E-05
						Delta Time	600	Sec	
							10	Min	

Allowable LR	1.00E-04	atm CC/Sec	Minimum Test Sensitivity	9.84E-06	atm CC/Sec
Measured LR	4.92E-05	atm CC/Sec	Uncertainty	2.68E-11	atm CC/Sec

Reported LR	4.92E-05	atm CC/Sec	Accept if Green, Reject if Red
Procedure: NDE-70 Rev:	7	Technique: PCMT	Rev: 0



Certificate Number: 4121/01

Accepted 9/15/21

<1.0E-4 atm\*cc/s air at test sensitivity of <5.0E-5 atm\*cc/s

Work Request 4293615

Digitally signed  
by Eric Vidal  
Date: 2021.09.17  
09:12:34 -04'00'

# PCMT Leak Test Calculator - Uncertainties Calculation Worksheet

DPP-1 TU-3 Operational Leak Test

Calc. Version 8/8/18

Gauge	Identification	MTE #	FS Accuracy	FS/Act Rdg	Subdivisions	Units	
Pressure Gauge	Ashcroft HQS-2	A002500	0.025%	15.61	0.01	WC	
Temperature Gauge	Omega HH804	A005945	0.40%	20.2	0.1	deg C	
Time Gauge	Computer Time	none	0.100%	60	1	Sec	
Reference Volume	50.72548	A001744	1.000%	60.24	0.1	CC	

Variable	acc*FS rdg	Traceability	Resolution	Total Variable u	
P	3.90E-03	2.27E-05	0.010	3.48E-03	IWC
T	8.08E-02	5.80E-02	1.00E-01	5.75E-02	deg C
t	6.00E-02	1.00E-03	1.00E+00	2.90E-01	Sec
V	6.02E-01	2.04E-01	0.10	3.19E-01	CC

## PCMT Gauge Resolution

	Formula	Calc
Pressure Resolution	$(Gres \times V) / (StdAtm \times t)$	2.46083E-06
Temperature Resolution	$\{(Pi \times V) / (StdAtm \times t)\} \times (Tres / Ti)$	1.30193E-06
Time Resolution	$\{[(Pi \times (Tf / Ti) - Pf) \times V] / (StdAtm \times Dtime)\} \times (t \text{ res} / (Dtime + t \text{ res}))$	8.18912E-08

2.4608E-06 Maximum PCMT Test Resolution

## Weighted Uncertainties

Initial Pressure	7.35E-13
Final Pressure	7.35E-13
Temp Final	5.60E-13
Temp Initial	1.34E-11
Volume	6.84E-14
Time	6.86E-16

Weighted U 2.68E-11

## PCMT Test Uncertainty

$$\sqrt{uP^2 + uV^2 + uT^2 + ut^2}$$

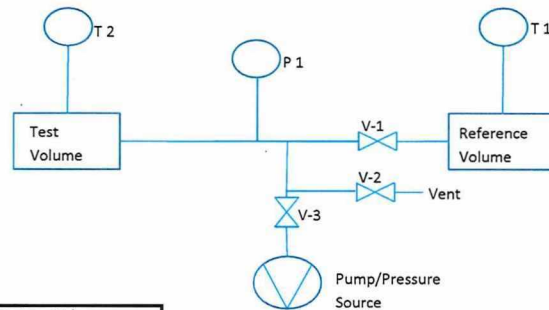
2.6816E-11



## System Under Test Volume Calc

DPP-1 TU-3 Operational Leak Test

Calc. Version 8/8/18



### Steps for Determination of Test + System Volume

- Step 1 Vent test system  
Close V-3; Open Valves V-1 & V-2  
Wait for pressure to equalize
- Step 2 Record P-1 and T-1 as Ref P&T
- Step 3 Close V-2 (vent) and then close V-1, Isolating Reference volume
- Step 4 Open V-3; Pressurize/evacuate as needed to bring system to Start Pressure,
- Step 5 Close V-3; Wait for pressure to equalize
- Step 6 Record P-1 and T-2 as Start P&T
- Step 7 Open V-1; Exposing Reference Volume to the system  
Wait for pressure to equalize
- Step 8 As soon as pressure is equalized, record P-1, T-1 and T-2 as Equalized P&T  
  
Note: pressure may continue to drop if Test Volume has leaks, so record quickly
- Step 9 Repeat steps 1 through 8 a total of 6 times

Input Data in orange and yellow cells only!

Reference Volume	
Calibration Due Date:	8/14/2022
MTE Number	A001744
Volume	50.7255 CC

Gauge	P-1	T-1	P-1	T-2	P-1	T-1	T-2	
	Ref P&T		Start; Ref Vol Isolated		Equalized Pressure			
Run	P ref (PSIA)	T ref (deg C)	Pstart (PSIA)	Tvstart (deg C)	Peq (PSIA)	Teq (deg C)	Tveq (deg C)	Test Sys Vol (CC)
1	14.250	20.800	4.849	20.800	9.151	20.800	20.800	60.1230
2	14.250	20.800	4.884	20.800	9.169	20.800	20.800	60.1485
3	14.250	20.800	4.140	20.800	8.762	20.800	20.800	60.2296
4	14.250	20.800	4.390	20.800	8.897	20.800	20.800	60.2471
5	14.250	20.800	4.797	20.800	9.107	20.800	20.800	60.5293
6	14.250	20.800	4.902	20.800	9.174	20.800	20.800	60.2721

Test Volume	60.2384	CC	median
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0.1449	Std Dev
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Min Calculated Volume	60.0935	CC
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# PCMT Leak Test Calculator - Absolute P Gauge-Pchange (LR=SCC/S)

## DPP-1 TU-5 Operational Leak Test Supplement

Calc. Version 8/8/18

Input Required in Yellow Cells

### Calculations for Formula

Barometric Pressure	WC
Initial	395.00
Final	395.00

Allowable LR	1.00E-03	atm CC/Sec
Test P Differential	350	WC diff
Test Time	600	Seconds
Standard Atm	407	WC

Start Gauge Pressure	WC abs
	16.00

Initial Pressure	16.00	WC - ABS
Initial Pressure	-379.00	WC - Gauge

End Gauge Pressure	WC abs
	16.00

Final Pressure	16.00	WC - ABS
Final Pressure	-379.00	WC - Gauge

Start Temperature	Deg C	Deg K
	20.000	293.150

dP Due to Pressure Gauge change	
Delta Pressure G	0.00 WC

End Temperature	Deg C	Deg K
	20.000	293.150

dP Due to Barometer change	
Delta Pressure T	0.00 WC

Test Volume	60.46	CC
(calculated minimum)	60.08	CC

dP Due to temperature change	
Delta Pressure T	0.00 WC

	Pressure	B	Temp C	Temp comp P	Delta Time	Rej Pressure	LR
Start Time	11:57:00 AM	9/15/2021	16.00	395.00	20.000		
End Time	12:07:00 PM	9/15/2021	16.00	395.00	20.000		
				16.00	600	31.26	0.00E+00
				Delta Time	600 Sec		
					10 Min		

Allowable LR	1.00E-03	atm CC/Sec	Minimum Test Sensitivity	9.84E-04	atm CC/Sec
Measured LR	0.00E+00	atm CC/Sec	Uncertainty	1.43E-08	atm CC/Sec

Reported LR	1.43E-08	atm CC/Sec	Accept if Green, Reject if Red
Procedure: NDE-70 Rev:	7	Technique: PCMT	Rev: 0



Certificate Number: 4121/01

Accepted 9/15/21  
No leak detected at test sensitivity of <1.0E-3 atm\*cc/s  
Work Request 4293615

Eric  
Vidal

Digitally signed  
by Eric Vidal  
Date: 2021.09.17  
09:17:20 -04'00'

# PCMT Leak Test Calculator - Uncertainties Calculation Worksheet

DPP-1 TU-5 Operational Leak Test Supplement

Calc. Version 8/8/18

Gauge	Identification	MTE #	FS Accuracy	FS/Act Rdg	Subdivisions	Units	
Pressure Gauge	Ashcroft HQS-2	A002500	0.025%	8.50	1	WC	
Temperature Gauge	Omega HH804	A005945	0.40%	20	1	deg C	
Time Gauge	Computer Time	none	0.100%	60	1	Sec	
Reference Volume	50.7255	A001744	1.000%	60.46	0.1	CC	

Variable	acc*FS rdg	Traceability	Resolution	Total Variable u	
P	2.13E-03	2.27E-05	1.000	2.89E-01	IWC
T	8.00E-02	5.80E-02	1.00E+00	2.93E-01	deg C
t	6.00E-02	1.00E-03	1.00E+00	2.90E-01	Sec
V	6.05E-01	2.04E-01	0.10	3.20E-01	CC

## PCMT Gauge Resolution

	Formula	Calc
Pressure Resolution	$(Gres \times V) / (StdAtm \times t)$	2.46022E-04
Temperature Resolution	$\{ (Pi \times V) / (StdAtm \times t) \} \times (Tres / Ti)$	1.34278E-05
Time Resolution	$\{ [ (Pi \times (Tf / Ti) - Pf) \times V ] / (StdAtm \times Dtime) \} \times (t \text{ res} / (Dtime + t \text{ res}))$	0.00000E+00

2.4602E-04 Maximum PCMT Test Resolution

## Weighted Uncertainties

Initial Pressure	5.04E-09
Final Pressure	5.04E-09
Temp Final	1.55E-11
Temp Initial	3.68E-10
Volume	0.00E+00
Time	0.00E+00

Weighted U 1.43E-08

## PCMT Test Uncertainty

$\sqrt{uP^2 + uV^2 + uT^2 + ut^2}$

1.4285E-08

# PCMT Leak Test Calculator - Absolute P Gauge-Pchange (LR=SCC/S)

## DPP-1 TU-4 Operational Leak Test Supplement

Calc. Version 8/8/18

Input Required in Yellow Cells

Barometric Pressure	WC
Initial	395.00
Final	395.00

Start Gauge Pressure	WC abs
	9.00

End Gauge Pressure	WC abs
	9.00

Start Temperature	Deg C	Deg K
	20.000	293.150

End Temperature	Deg C	Deg K
	20.000	293.150

Test Volume	61.16	CC
(calculated minimum)	61.01	CC

### Calculations for Formula

Allowable LR	1.00E-03	atm CC/Sec
Test P Differential	350	WC diff
Test Time	600	Seconds
Standard Atm	407	WC

Initial Pressure	9.00	WC - ABS
Initial Pressure	-386.00	WC - Gauge

Final Pressure	9.00	WC - ABS
Final Pressure	-386.00	WC - Gauge

dP Due to Pressure Gauge change	
Delta Pressure G	0.00 WC

dP Due to Barometer change	
Delta Pressure T	0.00 WC

dP Due to temperature change	
Delta Pressure T	0.00 WC

	Pressure	B	Temp C	Temp comp P	Delta Time	Rej Pressure	LR
Start Time	10:56:00 AM	9/15/2021	9.00	395.00	20.000		
End Time	11:06:00 AM	9/15/2021	9.00	395.00	20.000		
				9.00	600	36.13	0.00E+00
				Delta Time	600 Sec		
					10 Min		

Allowable LR	1.00E-03	atm CC/Sec	Minimum Test Sensitivity	9.99E-04	atm CC/Sec
Measured LR	0.00E+00	atm CC/Sec	Uncertainty	1.47E-08	atm CC/Sec

Reported LR	1.47E-08	atm CC/Sec	Accept if Green, Reject if Red
Procedure: NDE-70 Rev:	7	Technique: PCMT	Rev: 0



Certificate Number: 4121/01

Accepted 9/15/21

No leak detected at test sensitivity of <1.0E-3 atm\*cc/s

Work Request 4293615

Eric  
Vidal

Digitally signed  
by Eric Vidal  
Date:  
2021.09.17  
09:15:15 -04'00'



# PCMT Leak Test Calculator - Uncertainties Calculation Worksheet

DPP-1 TU-4 Operational Leak Test Supplement

Calc. Version 8/8/18

Gauge	Identification	MTE #	FS Accuracy	FS/Act Rdg	Subdivisions	Units	
Pressure Gauge	Ashcroft HQS-2	A002500	0.025%	9.00	1	WC	
Temperature Gauge	Omega HH804	A005945	0.40%	20	1	deg C	
Time Gauge	Computer Time	none	0.100%	60	1	Sec	
Reference Volume	50.72548	A001744	1.000%	61.16	0.1	CC	

Variable	acc*FS rdg	Traceability	Resolution	Total Variable u	
P	2.25E-03	2.27E-05	1.000	2.89E-01	IWC
T	8.00E-02	5.80E-02	1.00E+00	2.93E-01	deg C
t	6.00E-02	1.00E-03	1.00E+00	2.90E-01	Sec
V	6.12E-01	2.04E-01	0.10	3.24E-01	CC

## PCMT Gauge Resolution

	Formula	Calc
Pressure Resolution	$(Gres \times V) / (StdAtm \times t)$	2.49830E-04
Temperature Resolution	$((Pi \times V) / (StdAtm \times t)) \times (Tres/Ti)$	7.67002E-06
Time Resolution	$((Pi \times (Tf/Ti) - Pf) \times V) / (StdAtm \times Dtime) \times (t \text{ res} / (Dtime + t \text{ res}))$	0.00000E+00

2.4983E-04 Maximum PCMT Test Resolution

## Weighted Uncertainties

Initial Pressure	5.20E-09
Final Pressure	5.20E-09
Temp Final	5.05E-12
Temp Initial	1.17E-10
Volume	0.00E+00
Time	0.00E+00

Weighted U 1.47E-08

## PCMT Test Uncertainty

$\sqrt{uP^2 + uV^2 + uT^2 + ut^2}$

1.4713E-08

# PCMT Leak Test Calculator - Absolute P Gauge-Pchange (LR=SCC/S)

## DPP-1 TU-6 Operational Leak Test

Calc. Version 8/8/18

Input Required in Yellow Cells

Barometric Pressure	WC
Initial	394.73
Final	394.78

Start Gauge Pressure	WC abs
	7.79

End Gauge Pressure	WC abs
	8.02

Start Temperature	Deg C	Deg K
	20.050	293.200

End Temperature	Deg C	Deg K
	20.050	293.200

Test Volume	60.95	CC
(calculated minimum)	60.66	CC

### Calculations for Formula

Allowable LR	1.00E-04	atm CC/Sec
Test P Differential	350	WC diff
Test Time	600	Seconds
Standard Atm	407	WC

Initial Pressure	7.79	WC - ABS
Initial Pressure	-386.94	WC - Gauge

Final Pressure	8.02	WC - ABS
Final Pressure	-386.76	WC - Gauge

dP Due to Pressure Gauge change	
Delta Pressure G	0.23 WC

dP Due to Barometer change	
Delta Pressure T	-0.05 WC

dP Due to temperature change	
Delta Pressure T	0.00 WC

	Pressure	B	Temp C	Temp comp P	Delta Time	Rej Pressure	LR
Start Time	10:30:00 AM	9/15/2021	7.79	394.73	20.050		
	10:32:00 AM	9/15/2021	7.83	394.73	20.050	7.71	4.97E-05
	10:34:00 AM	9/15/2021	7.89	394.76	20.100	9.04	6.13E-05
	10:38:00 AM	9/15/2021	7.97	394.76	20.100	10.30	5.55E-05
End Time	10:40:00 AM	9/15/2021	8.02	394.78	20.050	10.92	5.71E-05
					Delta Time	600 Sec	
						10 Min	

Allowable LR	1.00E-04	atm CC/Sec	Minimum Test Sensitivity	9.94E-06	atm CC/Sec
Measured LR	5.71E-05	atm CC/Sec	Uncertainty	6.88E-12	atm CC/Sec

Reported LR	5.71E-05	atm CC/Sec	Accept if Green, Reject if Red
Procedure: NDE-70 Rev:	7	Technique: PCMT	Rev: 0



Certificate Number: 4121/01

Accepted 9/15/21

<1.0E-4 atm\*cc/s air at test sensitivity of <5.0E-5 atm\*cc/s

Work Request 4293615

Eric Vidal

Digitally signed by Eric

Vidal

Date: 2021.09.17 09:18:16

-04'00'

# PCMT Leak Test Calculator - Uncertainties Calculation Worksheet

DPP-1 TU-6 Operational Leak Test

Calc. Version 8/8/18

Gauge	Identification	MTE #	FS Accuracy	FS/Act Rdg	Subdivisions	Units	
Pressure Gauge	Ashcroft HQS-2	A002500	0.025%	7.90	0.01	W/C	
Temperature Gauge	Omega HH804	A005945	0.40%	20.05	0.1	deg C	
Time Gauge	Computer Time	none	0.100%	60	1	Sec	
Reference Volume	50.72548	A001744	1.000%	60.95	0.1	CC	

Variable	acc*FS rdg	Traceability	Resolution	Total Variable u	
P	1.98E-03	2.27E-05	0.010	3.05E-03	IWC
T	8.02E-02	5.80E-02	1.00E-01	5.73E-02	deg C
t	6.00E-02	1.00E-03	1.00E+00	2.90E-01	Sec
V	6.09E-01	2.04E-01	0.10	3.23E-01	CC

## PCMT Gauge Resolution

	Formula	Calc
Pressure Resolution	$(Gres \times V) / (StdAtm \times t)$	2.48387E-06
Temperature Resolution	$((Pi \times V) / (StdAtm \times t)) \times (Tres / Ti)$	6.59937E-07
Time Resolution	$(([Pi \times (Tf / Ti) - Pf] \times V) / (StdAtm \times Dtime)) \times (t \text{ res} / (Dtime + t \text{ res}))$	9.50565E-08

2.4839E-06 Maximum PCMT Test Resolution

## Weighted Uncertainties

Initial Pressure	5.74E-13
Final Pressure	5.74E-13
Temp Final	1.43E-13
Temp Initial	3.34E-12
Volume	9.23E-14
Time	9.44E-16

Weighted U 6.88E-12

## PCMT Test Uncertainty

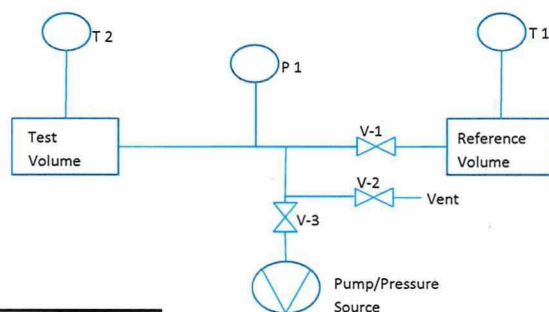
$\sqrt{uP^2 + uV^2 + uT^2 + ut^2}$

6.8834E-12

## System Under Test Volume Calc

DPP-1 TU-6 Operational Leak Test

Calc. Version 8/8/18



### Steps for Determination of Test + System Volume

- Step 1 Vent test system  
Close V-3; Open Valves V-1 & V-2  
Wait for pressure to equalize
- Step 2 Record P-1 and T-1 as Ref P&T
- Step 3 Close V-2 (vent) and then close V-1, Isolating Reference volume
- Step 4 Open V-3; Pressurize/evacuate as needed to bring system to Start Pressure,
- Step 5 Close V-3; Wait for pressure to equalize
- Step 6 Record P-1 and T-2 as Start P&T
- Step 7 Open V-1; Exposing Reference Volume to the system  
Wait for pressure to equalize
- Step 8 As soon as pressure is equalized, record P-1, T-1 and T-2 as Equalized P&T  
  
Note: pressure may continue to drop if Test Volume has leaks, so record quickly
- Step 9 Repeat steps 1 through 8 a total of 6 times

Input Data in orange and yellow cells only!

Gauge	Ref P&T		Start; Ref Vol Isolated		Equalized Pressure			Test Sys Vol (CC)
	P ref (PSIA)	T ref (deg C)	Pstart (PSIA)	Tvstart (deg C)	P eq (PSIA)	T eq (deg C)	Tveq (deg C)	
Run								
1	14.254	20.800	4.738	20.800	9.072	20.800	20.800	60.6505
2	14.254	20.800	4.367	20.800	8.862	20.800	20.800	60.8480
3	14.254	20.800	4.533	20.800	8.955	20.800	20.800	60.7857
4	14.254	20.800	4.823	20.800	9.103	20.800	20.800	61.0484
5	14.254	20.800	4.394	20.800	8.852	20.800	20.800	61.4668
6	14.254	20.800	4.393	20.800	8.865	20.800	20.800	61.1269

Test Volume 60.9482 CC median

0.2921 Std Dev

Min Calculated Volume 60.6561 CC



## PCMT Leak Test Calculator - Absolute P Gauge-Pchange (LR=SCC/S)

DPP-1 TU-5 Operational Leak Test Calc. Version 8/8/18

Calc. Version 8/8/18

### Input Required in Yellow Cells

Barometric Pressure	WC
Initial	394.84
Final	394.79

Start Gauge Pressure	WC abs
	15.73

End Gauge Pressure	WC abs
	15.94

Start Temperature	Deg C	Deg K
	20.300	293.450

End Temperature	Deg C	Deg K
	20.300	293.450

Test Volume	60.46	CC
(calculated minimum)	60.08	CC

### Calculations for Formula

Allowable LR	1.00E-04	atm CC/Sec
Test P Differential	350	WC diff
Test Time	600	Seconds
Standard Atm	407	WC

Initial Pressure	15.73	WC - ABS
Initial Pressure	-379.11	WC - Gauge

Final Pressure	15.94	WC - ABS
Final Pressure	-378.85	WC - Gauge

dP Due to Pressure Gauge change		
Delta Pressure G	0.21	WC

dP Due to Barometer change		
Delta Pressure T	0.05	WC

dP Due to temperature change		
Delta Pressure T	0.00	WC

			Pressure	B	Temp C	Temp comp P	Delta Time	Rej Pressure	LR
Start Time	11:57:00 AM	9/15/2021	15.73	394.84	20.300				
	11:59:00 AM	9/15/2021	15.76	394.84	20.250	15.76	120	15.65	4.02E-05
	12:01:00 PM	9/15/2021	15.81	394.83	20.250	15.81	240	16.35	5.09E-05
	12:04:00 PM	9/15/2021	15.87	394.81	20.300	15.87	420	16.82	4.92E-05
End Time	12:07:00 PM	9/15/2021	15.94	394.79	20.300	15.94	600	17.28	5.17E-05

Delta Time	600	Sec
	10	Min

Allowable LR	1.00E-04	atm CC/Sec	Minimum Test Sensitivity	9.84E-06	atm CC/Sec
Measured LR	5.17E-05	atm CC/Sec	Uncertainty	2.77E-11	atm CC/Sec

Reported LR	5.17E-05	atm CC/Sec	Accept if Green, Reject if Red		
Procedure: NDE-70 Rev:	7	Technique:	PCMT	Rev:	0

Accepted 9/15/21

<1.0E-4 atm\*cc/s air at test sensitivity of <5.0E-5 atm\*cc/s

Work Request 4293615



Certificate Number: 4121/01

**Eric Vidal** Digitally signed by  
Eric Vidal  
Date: 2021.09.17  
09:16:12 -04'00'

# PCMT Leak Test Calculator - Uncertainties Calculation Worksheet

DPP-1 TU-5 Operational Leak Test

Calc. Version 8/8/18

Gauge	Identification	MTE #	FS Accuracy	FS/Act Rdg	Subdivisions	Units	
Pressure Gauge	Ashcroft HQS-2	A002500	0.025%	15.82	0.01	WC	
Temperature Gauge	Omega HH804	A005945	0.40%	20.3	0.1	deg C	
Time Gauge	Computer Time	none	0.100%	60	1	Sec	
Reference Volume	50.72548	A001744	1.000%	60.46	0.1	CC	

Variable	acc*FS rdg	Traceability	Resolution	Total Variable u	
P	3.96E-03	2.27E-05	0.010	3.50E-03	IWC
T	8.12E-02	5.80E-02	1.00E-01	5.76E-02	deg C
t	6.00E-02	1.00E-03	1.00E+00	2.90E-01	Sec
V	6.05E-01	2.04E-01	0.10	3.20E-01	CC

## PCMT Gauge Resolution

	Formula	Calc
Pressure Resolution	$(Gres \times V) / (StdAtm \times t)$	2.46022E-06
Temperature Resolution	$\{((Pi \times V) / (StdAtm \times t)) \times (Tres / Ti)\}$	1.31877E-06
Time Resolution	$\{((Pi \times (Tf / Ti) - Pf) \times V) / (StdAtm \times Dtime)\} \times (t \text{ res} / (Dtime + t \text{ res}))$	8.59643E-08

2.4602E-06 Maximum PCMT Test Resolution

## Weighted Uncertainties

Initial Pressure	7.41E-13
Final Pressure	7.41E-13
Temp Final	5.78E-13
Temp Initial	1.38E-11
Volume	7.59E-14
Time	7.61E-16

Weighted U 2.77E-11

## PCMT Test Uncertainty

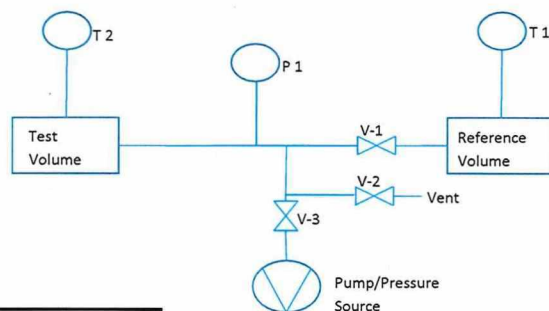
$\sqrt{uP^2 + uV^2 + uT^2 + ut^2}$

2.7677E-11

## System Under Test Volume Calc

DPP-1 TU-5 Operational Leak Test

Calc. Version 8/8/18



### Steps for Determination of Test + System Volume

- Step 1 Vent test system  
Close V-3; Open Valves V-1 & V-2  
Wait for pressure to equalize
- Step 2 Record P-1 and T-1 as Ref P&T
- Step 3 Close V-2 (vent) and then close V-1, Isolating Reference volume
- Step 4 Open V-3; Pressurize/evacuate as needed to bring system to Start Pressure,
- Step 5 Close V-3; Wait for pressure to equalize
- Step 6 Record P-1 and T-2 as Start P&T
- Step 7 Open V-1; Exposing Reference Volume to the system  
Wait for pressure to equalize
- Step 8 As soon as pressure is equalized, record P-1, T-1 and T-2 as Equalized P&T  
  
Note: pressure may continue to drop if Test Volume has leaks, so record quickly
- Step 9 Repeat steps 1 through 8 a total of 6 times

Input Data in orange and yellow cells only!

Reference Volume	
Calibration Due Date:	8/14/2022
MTE Number	A001744
Volume	50.7255 CC

Gauge	P-1	T-1	P-1	T-2	P-1	T-1	T-2	
	Ref P&T		Start; Ref Vol Isolated		Equalized Pressure			
Run	P ref (PSIA)	T ref (deg C)	Pstart (PSIA)	Tvstart (deg C)	P eq (PSIA)	T eq (deg C)	Tveq (deg C)	Test Sys Vol (CC)
1	14.254	20.800	4.760	20.800	9.099	20.800	20.800	60.2650
2	14.254	20.800	4.458	20.800	8.925	20.800	20.800	60.5140
3	14.254	20.800	4.626	20.800	8.984	20.800	20.800	61.3408
4	14.254	20.800	4.203	20.800	8.783	20.800	20.800	60.5937
5	14.254	20.800	4.537	20.800	8.972	20.800	20.800	60.4131
6	14.254	20.800	4.608	20.800	9.011	20.800	20.800	60.4028

Test Volume	60.4635 CC	median
	0.3851	Std Dev
Min Calculated Volume	60.0785 CC	

# PCMT Leak Test Calculator - Absolute P Gauge-Pchange (LR=SCC/S)

## DPP-1 TU-7 Operational Leak Test Supplement

Calc. Version 8/8/18

Input Required in Yellow Cells

Barometric Pressure	WC
Initial	395.00
Final	395.00

Start Gauge Pressure	WC abs
	7.00

End Gauge Pressure	WC abs
	7.00

Start Temperature	Deg C	Deg K
	20.000	293.150

End Temperature	Deg C	Deg K
	20.000	293.150

Test Volume	60.10	CC
(calculated minimum)	60.05	CC

### Calculations for Formula

Allowable LR	1.00E-03	atm CC/Sec
Test P Differential	350	WC diff
Test Time	600	Seconds
Standard Atm	407	WC

Initial Pressure	7.00	WC - ABS
Initial Pressure	-388.00	WC - Gauge

Final Pressure	7.00	WC - ABS
Final Pressure	-388.00	WC - Gauge

dP Due to Pressure Gauge change	
Delta Pressure G	0.00 WC

dP Due to Barometer change	
Delta Pressure T	0.00 WC

dP Due to temperature change	
Delta Pressure T	0.00 WC

	Pressure	B	Temp C	Temp comp P	Delta Time	Rej Pressure	LR
Start Time	10:08:00 AM	9/15/2021	7.00	395.00	20.000		
End Time	10:18:00 AM	9/15/2021	7.00	395.00	20.000		
				7.00	600	41.89	0.00E+00
				Delta Time	600 Sec		
					10 Min		

Allowable LR	1.00E-03	atm CC/Sec	Minimum Test Sensitivity	9.84E-04	atm CC/Sec
Measured LR	0.00E+00	atm CC/Sec	Uncertainty	1.43E-08	atm CC/Sec

Reported LR	1.43E-08	atm CC/Sec	Accept if Green, Reject if Red
Procedure: NDE-70 Rev:	7	Technique: PCMT	Rev: 0



Certificate Number: 4121/01

Accepted 9/15/21

No leak detected at test sensitivity of <1.0E-3 atm\*cc/s

Work Request 4293615

Eric Vidal

Digitally signed by Eric

Vidal

Date: 2021.09.17 09:20:47

-04'00'



# PCMT Leak Test Calculator - Uncertainties Calculation Worksheet

DPP-1 TU-7 Operational Leak Test Supplement

Calc. Version 8/8/18

Gauge	Identification	MTE #	FS Accuracy	FS/Act Rdg	Subdivisions	Units	
Pressure Gauge	Ashcroft HQS-2	A002500	0.025%	4.00	1	WC	
Temperature Gauge	Omega HH804	A005945	0.40%	20	1	deg C	
Time Gauge	Computer Time	none	0.100%	60	1	Sec	
Reference Volume	50.72548	A001744	1.000%	60.10	0.1	CC	

Variable	acc*FS rdg	Traceability	Resolution	Total Variable u	
P	1.00E-03	2.27E-05	1.000	2.89E-01	IWC
T	8.00E-02	5.80E-02	1.00E+00	2.93E-01	deg C
t	6.00E-02	1.00E-03	1.00E+00	2.90E-01	Sec
V	6.01E-01	2.04E-01	0.10	3.19E-01	CC

## PCMT Gauge Resolution

	Formula	Calc
Pressure Resolution	$(Gres \times V) / (StdAtm \times t)$	2.45916E-04
Temperature Resolution	$\{(Pi \times V) / (StdAtm \times t)\} \times (Tres/Ti)$	5.87211E-06
Time Resolution	$\{[(Pi \times (Tf/Ti) - Pf) \times V] / (StdAtm \times Dtime)\} \times (t \text{ res} / (Dtime + t \text{ res}))$	0.00000E+00

2.4592E-04 Maximum PCMT Test Resolution

## Weighted Uncertainties

Initial Pressure	5.04E-09
Final Pressure	5.04E-09
Temp Final	2.96E-12
Temp Initial	7.05E-11
Volume	0.00E+00
Time	0.00E+00

Weighted U 1.43E-08

## PCMT Test Uncertainty

$\sqrt{uP^2 + uV^2 + uT^2 + ut^2}$

1.4255E-08

# PCMT Leak Test Calculator - Absolute P Gauge-Pchange (LR=SCC/S)

## DPP-1 TU-6 Operational Leak Test Supplement

Calc. Version 8/8/18

Input Required in Yellow Cells

Barometric Pressure	WC
Initial	395.00
Final	395.00

Start Gauge Pressure	WC abs
	8.00

End Gauge Pressure	WC abs
	8.00

Start Temperature	Deg C	Deg K
	20.000	293.150

End Temperature	Deg C	Deg K
	20.000	293.150

Test Volume	60.95	CC
(calculated minimum)	60.66	CC

### Calculations for Formula

Allowable LR	1.00E-03	atm CC/Sec
Test P Differential	350	WC diff
Test Time	3600	Seconds
Standard Atm	407	WC

Initial Pressure	8.00	WC - ABS
Initial Pressure	-387.00	WC - Gauge

Final Pressure	8.00	WC - ABS
Final Pressure	-387.00	WC - Gauge

dP Due to Pressure Gauge change	
Delta Pressure G	0.00 WC

dP Due to Barometer change	
Delta Pressure T	0.00 WC

dP Due to temperature change	
Delta Pressure T	0.00 WC

	Pressure	B	Temp C	Temp comp P	Delta Time	Rej Pressure	LR
Start Time	10:30:00 AM	9/15/2021	8.00	395.00	20.000		
End Time	10:40:00 AM	9/15/2021	8.00	395.00	20.000		
				8.00	600	38.52	0.00E+00
				Delta Time	600	Sec	
					10	Min	

Allowable LR	1.00E-03	atm CC/Sec	Minimum Test Sensitivity	9.94E-04	atm CC/Sec
Measured LR	0.00E+00	atm CC/Sec	Uncertainty	1.45E-08	atm CC/Sec

Reported LR	1.45E-08	atm CC/Sec	Accept if Green, Reject if Red
Procedure: NDE-70 Rev:	7	Technique: PCMT	Rev: 0



Certificate Number: 4121/01

Accepted 9/15/21

No leak detected at test sensitivity of <1.0E-3 atm\*cc/s

Work Request 4293615

Eric Vidal

Digitally signed  
by Eric Vidal  
Date: 2021.09.17  
09:19:01 -04'00'

# PCMT Leak Test Calculator - Uncertainties Calculation Worksheet

DPP-1 TU-6 Operational Leak Test Supplement

Calc. Version 8/8/18

Gauge	Identification	MTE #	FS Accuracy	FS/Act Rdg	Subdivisions	Units	
Pressure Gauge	Ashcroft HQS-2	A002500	0.025%	8.00	1	WC	
Temperature Gauge	Omega HH804	A005945	0.40%	20	1	deg C	
Time Gauge	Computer Time	none	0.100%	60	1	Sec	
Reference Volume	50.72548	A001744	1.000%	60.95	0.1	CC	

Variable	acc*FS rdg	Traceability	Resolution	Total Variable u	
P	2.00E-03	2.27E-05	1.000	2.89E-01	IWC
T	8.00E-02	5.80E-02	1.00E+00	2.93E-01	deg C
t	6.00E-02	1.00E-03	1.00E+00	2.90E-01	Sec
V	6.09E-01	2.04E-01	0.10	3.23E-01	CC

## PCMT Gauge Resolution

	Formula	Calc
Pressure Resolution	$(Gres \times V) / (StdAtm \times t)$	2.48387E-04
Temperature Resolution	$\{(Pi \times V) / (StdAtm \times t)\} \times (Tres/Ti)$	6.77842E-06
Time Resolution	$\{[(Pi \times (Tf/Ti) - Pf) \times V] / (StdAtm \times Dtime)\} \times (t \text{ res} / (Dtime + t \text{ res}))$	0.00000E+00

2.4839E-04 Maximum PCMT Test Resolution

## Weighted Uncertainties

Initial Pressure	5.14E-09
Final Pressure	5.14E-09
Temp Final	3.94E-12
Temp Initial	9.21E-11
Volume	0.00E+00
Time	0.00E+00

Weighted U 1.45E-08

## PCMT Test Uncertainty

$\sqrt{uP^2 + uV^2 + uT^2 + ut^2}$

1.4543E-08

# PCMT Leak Test Calculator - Absolute P Gauge-Pchange (LR=SCC/S)

## DPP-1 TU-1 Operational Leak Test Supplement

Calc. Version 8/8/18

Input Required in Yellow Cells

Calculations for Formula

Barometric Pressure	WC
Initial	395.00
Final	395.00

Allowable LR	1.00E-03	atm CC/Sec
Test P Differential	350	WC diff
Test Time	600	Seconds
Standard Atm	407	WC

Start Gauge Pressure	WC abs
	9.00

Initial Pressure	9.00	WC - ABS
Initial Pressure	-386.00	WC - Gauge

End Gauge Pressure	WC abs
	9.00

Final Pressure	9.00	WC - ABS
Final Pressure	-386.00	WC - Gauge

Start Temperature	Deg C	Deg K
	20.000	293.150

dP Due to Pressure Gauge change	
Delta Pressure G	0.00 WC

End Temperature	Deg C	Deg K
	20.000	293.150

dP Due to Barometer change	
Delta Pressure T	0.00 WC

Test Volume	60.78	CC
(calculated minimum)	60.71	CC

dP Due to temperature change	
Delta Pressure T	0.00 WC

	Pressure	B	Temp C	Temp comp P	Delta Time	Rej Pressure	LR
Start Time	11:13:00 AM	9/15/2021	9.00	395.00	20.000		
End Time	11:23:00 AM	9/15/2021	9.00	395.00	20.000		
				9.00	600	36.13	0.00E+00
				Delta Time	600	Sec	
					10	Min	

Allowable LR	1.00E-03	atm CC/Sec	Minimum Test Sensitivity	9.94E-04	atm CC/Sec
Measured LR	0.00E+00	atm CC/Sec	Uncertainty	1.46E-08	atm CC/Sec

Reported LR	1.46E-08	atm CC/Sec	Accept if Green, Reject if Red
Procedure: NDE-70 Rev:	7	Technique: PCMT	Rev: 0



Certificate Number: 4121/01

Accepted 9/15/21

No leak detected at test sensitivity of <1.0E-3 atm\*cc/s

Work Request 4293615

Eric  
Vidal

Digitally signed  
by Eric Vidal  
Date: 2021.09.17  
09:07:23 -04'00'



# PCMT Leak Test Calculator - Uncertainties Calculation Worksheet

DPP-1 TU-1 Operational Leak Test

Calc. Version 8/8/18

Gauge	Identification	MTE #	FS Accuracy	FS/Act Rdg	Subdivisions	Units	
Pressure Gauge	Ashcroft HQS-2	A002500	0.025%	5.00	1	WC	
Temperature Gauge	Omega HH804	A005945	0.40%	20	1	deg C	
Time Gauge	Computer Time	none	0.100%	60	1	Sec	
Reference Volume	50.72548	A001744	1.000%	60.78	0.1	CC	

Variable	acc*FS rdg	Traceability	Resolution	Total Variable u	
P	1.25E-03	2.27E-05	1.000	2.89E-01	IWC
T	8.00E-02	5.80E-02	1.00E+00	2.93E-01	deg C
t	6.00E-02	1.00E-03	1.00E+00	2.90E-01	Sec
V	6.08E-01	2.04E-01	0.10	3.22E-01	CC

## PCMT Gauge Resolution

	Formula	Calc
Pressure Resolution	$(Gres \times V) / (StdAtm \times t)$	2.48625E-04
Temperature Resolution	$\{(Pi \times V) / (StdAtm \times t)\} \times (Tres/Ti)$	7.63303E-06
Time Resolution	$\{[(Pi \times (Tf/Ti) - Pf) \times V] / (StdAtm \times Dtime)\} \times (t \text{ res} / (Dtime + t \text{ res}))$	0.00000E+00

2.4862E-04 Maximum PCMT Test Resolution

## Weighted Uncertainties

Initial Pressure	5.15E-09
Final Pressure	5.15E-09
Temp Final	5.00E-12
Temp Initial	1.17E-10
Volume	0.00E+00
Time	0.00E+00

Weighted U 1.46E-08

## PCMT Test Uncertainty

$\sqrt{uP^2 + uV^2 + uT^2 + ut^2}$

1.4572E-08

# PCMT Leak Test Calculator - Absolute P Gauge-Pchange (LR=SCC/S)

## DPP-1 TU-7 Operational Leak Test

Calc. Version 8/8/18

Input Required in Yellow Cells

Barometric Pressure	WC
Initial	394.68
Final	394.72

Start Gauge Pressure	WC abs
	7.24

End Gauge Pressure	WC abs
	7.44

Start Temperature	Deg C	Deg K
	20.000	293.150

End Temperature	Deg C	Deg K
	20.000	293.150

Test Volume	60.10	CC
(calculated minimum)	60.05	CC

## Calculations for Formula

Allowable LR	1.00E-04	atm CC/Sec
Test P Differential	350	WC diff
Test Time	600	Seconds
Standard Atm	407	WC

Initial Pressure	7.24	WC - ABS
Initial Pressure	-387.44	WC - Gauge

Final Pressure	7.44	WC - ABS
Final Pressure	-387.28	WC - Gauge

dP Due to Pressure Gauge change	
Delta Pressure G	0.20 WC

dP Due to Barometer change	
Delta Pressure T	-0.04 WC

dP Due to temperature change	
Delta Pressure T	0.00 WC

	Pressure	B	Temp C	Temp comp P	Delta Time	Rej Pressure	LR
Start Time	10:08:00 AM	9/15/2021	7.24	394.68	20.000		
	10:10:00 AM	9/15/2021	7.29	394.69	20.000	7.16	6.15E-05
	10:12:00 AM	9/15/2021	7.33	394.71	20.000	8.59	5.53E-05
	10:16:00 AM	9/15/2021	7.41	394.73	20.000	9.94	5.23E-05
End Time	10:18:00 AM	9/15/2021	7.44	394.72	20.000	10.61	4.92E-05
					Delta Time	600 Sec	
						10 Min	

Allowable LR	1.00E-04	atm CC/Sec	Minimum Test Sensitivity	9.84E-06	atm CC/Sec
Measured LR	4.92E-05	atm CC/Sec	Uncertainty	5.97E-12	atm CC/Sec

Reported LR	4.92E-05	atm CC/Sec	Accept if Green, Reject if Red
Procedure: NDE-70 Rev:	7	Technique: PCMT	Rev: 0



Certificate Number: 4121/01

Accepted 9/15/21

<1.0E-4 atm\*cc/s air at test sensitivity of <5.0E-5 atm\*cc/s

Work Request 4293615

Eric Vidal

Digitally signed by Eric Vidal

Date: 2021.09.17 09:20:00

-04'00'

# PCMT Leak Test Calculator - Uncertainties Calculation Worksheet

DPP-1 TU-7 Operational Leak Test

Calc. Version 8/8/18

Gauge	Identification	MTE #	FS Accuracy	FS/Act Rdg	Subdivisions	Units
Pressure Gauge	Ashcroft HQS-2	A002500	0.025%	7.34	0.01	WC
Temperature Gauge	Omega HH804	A005945	0.40%	20	0.1	deg C
Time Gauge	Computer Time	none	0.100%	60	1	Sec
Reference Volume	50.72548	A001744	1.000%	60.10	0.1	CC

Variable	acc*FS rdg	Traceability	Resolution	Total Variable u	
P	1.84E-03	2.27E-05	0.010	3.03E-03	IWC
T	8.00E-02	5.80E-02	1.00E-01	5.72E-02	deg C
t	6.00E-02	1.00E-03	1.00E+00	2.90E-01	Sec
V	6.01E-01	2.04E-01	0.10	3.19E-01	CC

## PCMT Gauge Resolution

	Formula	Calc
Pressure Resolution	$(Gres \times V) / (StdAtm \times t)$	2.45916E-06
Temperature Resolution	$\{(Pi \times V) / (StdAtm \times t)\} \times (Tres / Ti)$	6.07344E-07
Time Resolution	$\{[(Pi \times (Tf / Ti) - Pf) \times V] / (StdAtm \times Dtime)\} \times (t \text{ res} / (Dtime + t \text{ res}))$	8.18355E-08

2.4592E-06 Maximum PCMT Test Resolution

## Weighted Uncertainties

Initial Pressure	5.55E-13
Final Pressure	5.55E-13
Temp Final	1.21E-13
Temp Initial	2.88E-12
Volume	6.81E-14
Time	6.82E-16

Weighted U 5.97E-12

## PCMT Test Uncertainty

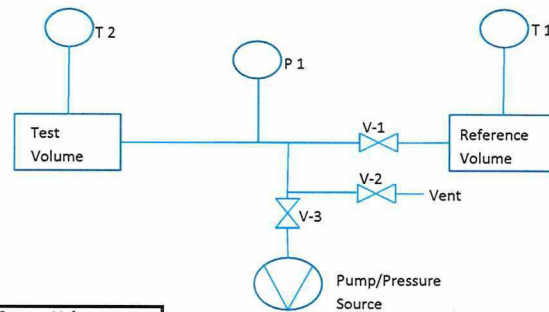
$\sqrt{uP^2 + uV^2 + uT^2 + ut^2}$

5.9728E-12

## System Under Test Volume Calc

DPP-1 TU-7 Operational Leak Test

Calc. Version 8/8/18



### Steps for Determination of Test + System Volume

- Step 1 Vent test system  
Close V-3; Open Valves V-1 & V-2  
Wait for pressure to equalize
- Step 2 Record P-1 and T-1 as Ref P&T
- Step 3 Close V-2 (vent) and then close V-1, Isolating Reference volume
- Step 4 Open V-3; Pressurize/evacuate as needed to bring system to Start Pressure,
- Step 5 Close V-3; Wait for pressure to equalize
- Step 6 Record P-1 and T-2 as Start P&T
- Step 7 Open V-1; Exposing Reference Volume to the system  
Wait for pressure to equalize
- Step 8 As soon as pressure is equalized, record P-1, T-1 and T-2 as Equalized P&T  
  
Note: pressure may continue to drop if Test Volume has leaks, so record quickly
- Step 9 Repeat steps 1 through 8 a total of 6 times

Input Data in orange and yellow cells only!

Reference Volume	
Calibration Due Date:	8/14/2022
MTE Number	A001744
Volume	50.7255 CC

Gauge	P-1	T-1	P-1	T-2	P-1	T-1	T-2	
	Ref P&T		Start; Ref Vol Isolated		Equalized Pressure			
Run	P ref (PSIA)	T ref (deg C)	Pstart (PSIA)	Tvstart (deg C)	P eq (PSIA)	T eq (deg C)	Tveq (deg C)	Test Sys Vol (CC)
1	14.254	20.800	5.007	20.800	9.240	20.800	20.800	60.0845
2	14.254	20.800	4.560	20.800	8.996	20.800	20.800	60.1250
3	14.254	20.800	4.563	20.800	8.997	20.800	20.800	60.1407
4	14.254	20.800	4.875	20.800	9.170	20.800	20.800	60.0439
5	14.254	20.800	4.492	20.800	8.962	20.800	20.800	60.0535
6	14.254	20.800	4.796	20.800	9.122	20.800	20.800	60.1764

Test Volume	60.1047	CC	median
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0.0521	Std Dev
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Min Calculated Volume	60.0526	CC
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# PCMT Leak Test Calculator - Absolute P Gauge-Pchange (LR=SCC/S)

## DPP-1 TU-1 Operational Leak Test

Calc. Version 8/8/18

Input Required in Yellow Cells

Barometric Pressure	WC
Initial	394.92
Final	394.93

Start Gauge Pressure	WC abs
	9.16

End Gauge Pressure	WC abs
	9.39

Start Temperature	Deg C	Deg K
	20.100	293.250

End Temperature	Deg C	Deg K
	20.150	293.300

Test Volume	60.78	CC
(calculated minimum)	60.71	CC

### Calculations for Formula

Allowable LR	1.00E-04	atm CC/Sec
Test P Differential	350	WC diff
Test Time	600	Seconds
Standard Atm	407	WC

Initial Pressure	9.16	WC - ABS
Initial Pressure	-385.76	WC - Gauge

Final Pressure	9.39	WC - ABS
Final Pressure	-385.54	WC - Gauge

dP Due to Pressure Gauge change	
Delta Pressure G	0.23 WC

dP Due to Barometer change	
Delta Pressure T	-0.01 WC

dP Due to temperature change	
Delta Pressure T	0.00 WC

	Pressure	B	Temp C	Temp comp P	Delta Time	Rej Pressure	LR
Start Time	11:13:00 AM	9/15/2021	9.16	394.92	20.100		
	11:15:00 AM	9/15/2021	9.20	394.91	20.100	9.08	4.97E-05
	11:17:00 AM	9/15/2021	9.25	394.93	20.100	10.23	5.59E-05
	11:20:00 AM	9/15/2021	9.32	394.94	20.150	11.03	5.63E-05
End Time	11:23:00 AM	9/15/2021	9.39	394.93	20.150	11.83	5.68E-05
					Delta Time	600	Sec
						10	Min

Allowable LR	1.00E-04	atm CC/Sec	Minimum Test Sensitivity	9.94E-06	atm CC/Sec
Measured LR	5.68E-05	atm CC/Sec	Uncertainty	9.43E-12	atm CC/Sec

Reported LR	5.68E-05	atm CC/Sec	Accept if Green, Reject if Red
Procedure: NDE-70 Rev:	7	Technique: PCMT	Rev: 0



Certificate Number: 4121/01

Accepted 9/15/21  
<1.0E-4 atm\*cc/s air at test sensitivity of <5.0E-5 atm\*cc/s

Work Request 4293615

Eric  
Vidal

Digitally signed  
by Eric Vidal  
Date: 2021.09.17  
09:06:18 -04'00'

# PCMT Leak Test Calculator - Uncertainties Calculation Worksheet

DPP-1 TU-1 Operational Leak Test

Calc. Version 8/8/18

Gauge	Identification	MTE #	FS Accuracy	FS/Act Rdg	Subdivisions	Units	
Pressure Gauge	Ashcroft HQS-2	A002500	0.025%	9.26	0.01	WC	
Temperature Gauge	Omega HH804	A005945	0.40%	20.1	0.1	deg C	
Time Gauge	Computer Time	none	0.100%	60	1	Sec	
Reference Volume	50.72548	A001744	1.000%	60.78	0.1	CC	

Variable	acc*FS rdg	Traceability	Resolution	Total Variable u	
P	2.32E-03	2.27E-05	0.010	3.11E-03	IWC
T	8.04E-02	5.80E-02	1.00E-01	5.74E-02	deg C
t	6.00E-02	1.00E-03	1.00E+00	2.90E-01	Sec
V	6.08E-01	2.04E-01	0.10	3.22E-01	CC

## PCMT Gauge Resolution

	Formula	Calc
Pressure Resolution	$(Gres \times V) / (StdAtm \times t)$	2.48625E-06
Temperature Resolution	$\{(Pi \times V) / (StdAtm \times t)\} \times (Tres / Ti)$	7.76608E-07
Time Resolution	$\{[(Pi \times (Tf / Ti) - Pf) \times V] / (StdAtm \times Dtime)\} \times (t \text{ res} / (Dtime + t \text{ res}))$	9.45015E-08

2.4862E-06 Maximum PCMT Test Resolution

## Weighted Uncertainties

Initial Pressure	5.98E-13
Final Pressure	5.98E-13
Temp Final	1.98E-13
Temp Initial	4.63E-12
Volume	9.06E-14
Time	9.28E-16

Weighted U 9.43E-12

## PCMT Test Uncertainty

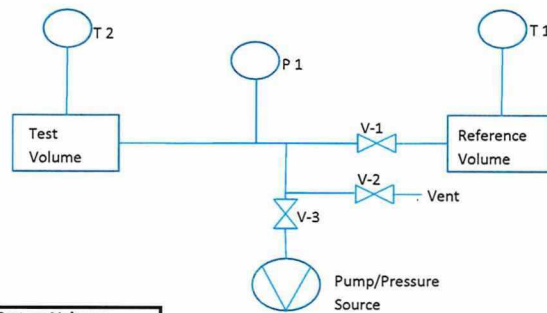
$\sqrt{uP^2 + uV^2 + uT^2 + ut^2}$

9.4257E-12

## System Under Test Volume Calc

DPP-1 TU-1 Operational Leak Test

Calc. Version 8/8/18



### Steps for Determination of Test + System Volume

- Step 1 Vent test system  
Close V-3; Open Valves V-1 & V-2  
Wait for pressure to equalize
- Step 2 Record P-1 and T-1 as Ref P&T
- Step 3 Close V-2 (vent) and then close V-1, Isolating Reference volume
- Step 4 Open V-3; Pressurize/evacuate as needed to bring system to Start Pressure,
- Step 5 Close V-3; Wait for pressure to equalize
- Step 6 Record P-1 and T-2 as Start P&T
- Step 7 Open V-1; Exposing Reference Volume to the system  
Wait for pressure to equalize
- Step 8 As soon as pressure is equalized, record P-1, T-1 and T-2 as Equalized P&T  
  
Note: pressure may continue to drop if Test Volume has leaks, so record quickly
- Step 9 Repeat steps 1 through 8 a total of 6 times

Input Data in orange and yellow cells only!

Gauge	Ref P&T		Start; Ref Vol Isolated		Equalized Pressure			Test Sys Vol (CC)
	P ref (PSIA)	T ref (deg C)	Pstart (PSIA)	Tvstart (deg C)	P eq (PSIA)	T eq (deg C)	Tveq (deg C)	
Run								
1	14.250	20.800	4.660	20.800	9.024	20.800	20.800	60.7450
2	14.250	20.800	4.903	20.800	9.156	20.800	20.800	60.7561
3	14.250	20.800	5.207	20.800	9.321	20.800	20.800	60.7744
4	14.250	20.800	5.224	20.800	9.325	20.800	20.800	60.9176
5	14.250	20.800	4.672	20.800	9.027	20.800	20.800	60.8356
6	14.250	20.800	4.527	20.800	8.950	20.800	20.800	60.7834

Reference Volume	
Calibration Due Date:	8/14/2022
MTE Number	A001744
Volume	50.7255 CC

Test Volume	60.7789 CC	median
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0.0647	Std Dev
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Min Calculated Volume	60.7142 CC
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# PCMT Leak Test Calculator - Absolute P Gauge-Pchange (LR=SCC/S)

## DPP-1 TU-2 Operational Leak Test Supplement

Calc. Version 8/8/18

Input Required in Yellow Cells

### Calculations for Formula

Barometric Pressure	WC
Initial	394.00
Final	394.00

Allowable LR	1.00E-03	atm CC/Sec
Test P Differential	350	WC diff
Test Time	240	Seconds
Standard Atm	407	WC

Start Gauge Pressure	WC abs
	11.00

Initial Pressure	11.00	WC - ABS
Initial Pressure	-383.00	WC - Gauge

End Gauge Pressure	WC abs
	11.00

Final Pressure	11.00	WC - ABS
Final Pressure	-383.00	WC - Gauge

Start Temperature	Deg C	Deg K
	20.000	293.150

dP Due to Pressure Gauge change	
Delta Pressure G	0.00 WC

End Temperature	Deg C	Deg K
	20.000	293.150

dP Due to Barometer change	
Delta Pressure T	0.00 WC

Test Volume	15.97	CC
(calculated minimum)	15.94	CC

dP Due to temperature change	
Delta Pressure T	0.00 WC

	Pressure	B	Temp C	Temp comp P	Delta Time	Rej Pressure	LR
Start Time	1:40:00 PM	9/15/2021	11.00	394.00	20.000		
End Time	1:44:00 PM	9/15/2021	11.00	394.00	20.000		
				11.00	240	19.88	0.00E+00
				Delta Time	240	Sec	
					4	Min	

Allowable LR	1.00E-03	atm CC/Sec	Minimum Test Sensitivity	6.53E-04	atm CC/Sec
Measured LR	0.00E+00	atm CC/Sec	Uncertainty	6.64E-09	atm CC/Sec

Reported LR	6.64E-09	atm CC/Sec	Accept if Green, Reject if Red
Procedure: NDE-70 Rev:	7	Technique: PCMT	Rev: 0



Certificate Number: 4121/01

Accepted 9/15/21

No leak detected at test sensitivity of <1.0E-3 atm\*cc/s

Work Request 4293615

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Date: 2021.09.17  
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# PCMT Leak Test Calculator - Uncertainties Calculation Worksheet

DPP-1 TU-2 Operational Leak Test Supplement

Calc. Version 8/8/18

Gauge	Identification	MTE #	FS Accuracy	FS/Act Rdg	Subdivisions	Units	
Pressure Gauge	Ashcroft HGS-2	A002500	0.025%	11.00	1	W/C	
Temperature Gauge	Omega HH804	A005945	0.40%	20	1	deg C	
Time Gauge	Computer Time	none	0.100%	60	1	Sec	
Reference Volume	50.72548	A001744	1.000%	15.97	0.1	CC	

Variable	acc*FS rdg	Traceability	Resolution	Total Variable u	
P	2.75E-03	2.27E-05	1.000	2.89E-01	IWC
T	8.00E-02	5.80E-02	1.00E+00	2.93E-01	deg C
t	6.00E-02	1.00E-03	1.00E+00	2.90E-01	Sec
V	1.60E-01	2.04E-01	0.10	1.33E-01	CC

## PCMT Gauge Resolution

	Formula	Calc
Pressure Resolution	$(Gres \times V) / (StdAtm \times t)$	1.63193E-04
Temperature Resolution	$\{(Pi \times V) / (StdAtm \times t)\} \times (Tres / Ti)$	6.12355E-06
Time Resolution	$\{[(Pi \times (Tf / Ti) - Pf) \times V] / (StdAtm \times Dtime)\} \times (t \text{ res} / (Dtime + t \text{ res}))$	0.00000E+00

1.6319E-04 Maximum PCMT Test Resolution

## Weighted Uncertainties

Initial Pressure	2.22E-09
Final Pressure	2.22E-09
Temp Final	3.22E-12
Temp Initial	1.09E-09
Volume	0.00E+00
Time	0.00E+00

Weighted U 6.64E-09

## PCMT Test Uncertainty

$\sqrt{uP^2 + uV^2 + uT^2 + ut^2}$

6.6436E-09

# PCMT Leak Test Calculator - Absolute P Gauge-Pchange (LR=SCC/S)

## DPP-1 TU-2 Operational Leak Test

Calc. Version 8/8/18

Input Required in Yellow Cells

Barometric Pressure	WC
Initial	394.40
Final	394.40

Start Gauge Pressure	WC abs
	11.06

End Gauge Pressure	WC abs
	11.29

Start Temperature	Deg C	Deg K
	20.500	293.650

End Temperature	Deg C	Deg K
	20.500	293.650

Test Volume	15.97	CC
(calculated minimum)	15.94	CC

### Calculations for Formula

Allowable LR	1.00E-04	atm CC/Sec
Test P Differential	350	WC diff
Test Time	240	Seconds
Standard Atm	407	WC

Initial Pressure	11.06	WC - ABS
Initial Pressure	-383.34	WC - Gauge

Final Pressure	11.29	WC - ABS
Final Pressure	-383.11	WC - Gauge

dP Due to Pressure Gauge change	
Delta Pressure G	0.23 WC

dP Due to Barometer change	
Delta Pressure T	0.00 WC

dP Due to temperature change	
Delta Pressure T	0.00 WC

	Pressure	B	Temp C	Temp comp P	Delta Time	Rej Pressure	LR
Start Time	1:40:00 PM	9/15/2021	11.06	394.40	20.500		
	1:42:00 PM	9/15/2021	11.18	394.40	20.500	11.18	120
	1:44:00 PM	9/15/2021	11.29	394.40	20.500	11.29	240
End Time	1:44:00 PM	9/15/2021	11.29	394.40	20.500	11.29	240
					Delta Time	240	Sec
						4	Min

Allowable LR	1.00E-04	atm CC/Sec	Minimum Test Sensitivity	6.53E-06	atm CC/Sec
Measured LR	3.75E-05	atm CC/Sec	Uncertainty	8.60E-11	atm CC/Sec

Reported LR	3.75E-05	atm CC/Sec	Accept if Green, Reject if Red
Procedure: NDE-70 Rev:	7	Technique: PCMT	Rev: 0



Certificate Number: 4121/01

Accepted 9/15/21  
<1.0E-4 atm\*cc/s air at test sensitivity of <5.0E-5 atm\*cc/s

Work Request 4293615

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# PCMT Leak Test Calculator - Uncertainties Calculation Worksheet

DPP-1 TU-2 Operational Leak Test

Calc. Version 8/8/18

Gauge	Identification	MTE #	FS Accuracy	FS/Act Rdg	Subdivisions	Units	
Pressure Gauge	Ashcroft HQS-2	A002500	0.025%	11.21	0.01	WC	
Temperature Gauge	Omega HH804	A005945	0.40%	20.5	0.1	deg C	
Time Gauge	Computer Time	none	0.100%	60	1	Sec	
Reference Volume	50.72548	A001744	1.000%	15.97	0.1	CC	

Variable	acc*FS rdg	Traceability	Resolution	Total Variable u	
P	2.80E-03	2.27E-05	0.010	3.21E-03	IWC
T	8.20E-02	5.80E-02	1.00E-01	5.79E-02	deg C
t	6.00E-02	1.00E-03	1.00E+00	2.90E-01	Sec
V	1.60E-01	2.04E-01	0.10	1.33E-01	CC

## PCMT Gauge Resolution

	Formula	Calc
Pressure Resolution	$(Gres \times V) / (StdAtm \times t)$	1.63193E-06
Temperature Resolution	$\{(Pi \times V) / (StdAtm \times t)\} \times (Tres / Ti)$	6.14647E-07
Time Resolution	$\{[(Pi \times (Tf / Ti) - Pf) \times V] / (StdAtm \times Dtime)\} \times (t \text{ res} / (Dtime + t \text{ res}))$	1.55744E-07

1.6319E-06 Maximum PCMT Test Resolution

## Weighted Uncertainties

Initial Pressure	2.74E-13
Final Pressure	2.74E-13
Temp Final	1.27E-13
Temp Initial	4.30E-11
Volume	9.76E-14
Time	4.31E-16

Weighted U 8.60E-11

## PCMT Test Uncertainty

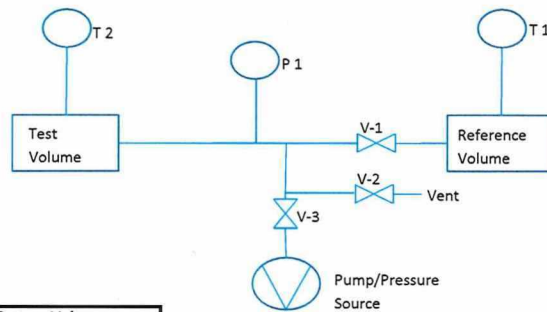
$\sqrt{uP^2 + uV^2 + uT^2 + ut^2}$

8.6037E-11

## System Under Test Volume Calc

DPP-1 TU-2 Operational Leak Test

Calc. Version 8/8/18



### Steps for Determination of Test + System Volume

- Step 1 Vent test system  
Close V-3; Open Valves V-1 & V-2  
Wait for pressure to equalize
- Step 2 Record P-1 and T-1 as Ref P&T
- Step 3 Close V-2 (vent) and then close V-1, Isolating Reference volume
- Step 4 Open V-3; Pressurize/evacuate as needed to bring system to Start Pressure,
- Step 5 Close V-3; Wait for pressure to equalize
- Step 6 Record P-1 and T-2 as Start P&T
- Step 7 Open V-1; Exposing Reference Volume to the system  
Wait for pressure to equalize
- Step 8 As soon as pressure is equalized, record P-1, T-1 and T-2 as Equalized P&T  
  
Note: pressure may continue to drop if Test Volume has leaks, so record quickly
- Step 9 Repeat steps 1 through 8 a total of 6 times

Input Data in orange and yellow cells only!

Reference Volume	
Calibration Due Date:	8/14/2022
MTE Number	A001744
Volume	50.7255 CC

Gauge	P-1	T-1	P-1	T-2	P-1	T-1	T-2	
Ref P&T		Start; Ref Vol Isolated		Equalized Pressure				
Run	P ref (PSIA)	T ref (deg C)	Pstart (PSIA)	Tvstart (deg C)	P eq (PSIA)	T eq (deg C)	Tveq (deg C)	Test Sys Vol (CC)
1	14.227	20.400	2.664	20.400	11.458	20.400	20.400	15.9721
2	14.226	20.400	1.055	20.400	11.074	20.400	20.400	15.9584
3	14.226	20.400	3.229	20.400	11.592	20.400	20.400	15.9764
4	14.226	20.400	3.918	20.400	11.760	20.400	20.400	15.9512
5	14.226	20.400	1.224	20.400	11.106	20.400	20.400	16.0153
6	14.226	20.400	2.132	20.400	11.333	20.400	20.400	15.9492

Test Volume	15.9652	CC	median
	0.0246	Std Dev	
Min Calculated Volume	15.9407	CC	



# PCMT Leak Test Calculator - Absolute P Gauge-Pchange (LR=SCC/S)

## DPP-1 TU-3 Operational Leak Test Supplement

Calc. Version 8/8/18

Input Required in Yellow Cells

Calculations for Formula

Barometric Pressure	WC
Initial	395.00
Final	395.00

Allowable LR	1.00E-03	atm CC/Sec
Test P Differential	350	WC diff
Test Time	600	Seconds
Standard Atm	407	WC

Start Gauge Pressure	WC abs
	16.00

Initial Pressure	16.00	WC - ABS
Initial Pressure	-379.00	WC - Gauge

End Gauge Pressure	WC abs
	16.00

Final Pressure	16.00	WC - ABS
Final Pressure	-379.00	WC - Gauge

Start Temperature	Deg C	Deg K
	20.000	293.150

dP Due to Pressure Gauge change	
Delta Pressure G	0.00 WC

End Temperature	Deg C	Deg K
	20.000	293.150

dP Due to Barometer change	
Delta Pressure T	0.00 WC

Test Volume	60.24	CC
(calculated minimum)	60.09	CC

dP Due to temperature change	
Delta Pressure T	0.00 WC

	Pressure	B	Temp C	Temp comp P	Delta Time	Rej Pressure	LR
Start Time	11:40:00 AM	9/15/2021	16.00	395.00	20.000		
End Time	11:50:00 AM	9/15/2021	16.00	395.00	20.000		
				16.00	600	31.26	0.00E+00
				Delta Time	600 Sec		
					10 Min		

Allowable LR	1.00E-03	atm CC/Sec	Minimum Test Sensitivity	9.84E-04	atm CC/Sec
Measured LR	0.00E+00	atm CC/Sec	Uncertainty	1.43E-08	atm CC/Sec

Reported LR	1.43E-08	atm CC/Sec	Accept if Green, Reject if Red	
Procedure: NDE-70 Rev:	7	Technique: PCMT	Rev:	0



Certificate Number: 4121/01

Accepted 9/15/21  
No leak detected at test sensitivity of <1.0E-3 atm\*cc/s  
Work Request 4293615

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Date:  
2021.09.17  
09:13:32 -04'00'

# PCMT Leak Test Calculator - Uncertainties Calculation Worksheet

DPP-1 TU-3 Operational Leak Test Supplement

Calc. Version 8/8/18

Gauge	Identification	MTE #	FS Accuracy	FS/Act Rdg	Subdivisions	Units	
Pressure Gauge	Ashcroft HQS-2	A002500	0.025%	8.50	1	WC	
Temperature Gauge	Omega HH804	A005945	0.40%	20	1	deg C	
Time Gauge	Computer Time	none	0.100%	60	1	Sec	
Reference Volume	50.72548	A001744	1.000%	60.24	0.1	CC	

Variable	acc*FS rdg	Traceability	Resolution	Total Variable u	
P	2.13E-03	2.27E-05	1.000	2.89E-01	IWC
T	8.00E-02	5.80E-02	1.00E+00	2.93E-01	deg C
t	6.00E-02	1.00E-03	1.00E+00	2.90E-01	Sec
V	6.02E-01	2.04E-01	0.10	3.19E-01	CC

## PCMT Gauge Resolution

	Formula	Calc
Pressure Resolution	$(Gres \times V) / (StdAtm \times t)$	2.46083E-04
Temperature Resolution	$\{(Pi \times V) / (StdAtm \times t)\} \times (Tres / Ti)$	1.34311E-05
Time Resolution	$\{[(Pi \times (Tf / Ti) - Pf) \times V] / (StdAtm \times Dtime)\} \times (t \text{ res} / (Dtime + t \text{ res}))$	0.00000E+00

2.4608E-04 Maximum PCMT Test Resolution

## Weighted Uncertainties

Initial Pressure	5.05E-09
Final Pressure	5.05E-09
Temp Final	1.55E-11
Temp Initial	3.68E-10
Volume	0.00E+00
Time	0.00E+00

Weighted U 1.43E-08

## PCMT Test Uncertainty

$$\sqrt{uP^2 + uV^2 + uT^2 + ut^2}$$

1.4293E-08

# PCMT Leak Test Calculator - Absolute P Gauge-Pchange (LR=SCC/S)

## DPP-1 TU-1 Operational Leak Test II

Calc. Version 8/8/18

Input Required in Yellow Cells

Barometric Pressure	WC
Initial	394.00
Final	394.00

Start Gauge Pressure	WC abs
	5.00

End Gauge Pressure	WC abs
	5.00

Start Temperature	Deg C	Deg K
	20.000	293.150

End Temperature	Deg C	Deg K
	20.000	293.150

Test Volume	51.86	CC
(calculated minimum)	51.82	CC

### Calculations for Formula

Allowable LR	1.00E-03	atm CC/Sec
Test P Differential	350	WC diff
Test Time	600	Seconds
Standard Atm	407	WC

Initial Pressure	5.00	WC - ABS
Initial Pressure	-389.00	WC - Gauge

Final Pressure	5.00	WC - ABS
Final Pressure	-389.00	WC - Gauge

dP Due to Pressure Gauge change	
Delta Pressure G	0.00 WC

dP Due to Barometer change	
Delta Pressure T	0.00 WC

dP Due to temperature change	
Delta Pressure T	0.00 WC

	Pressure	B	Temp C	Temp comp P	Delta Time	Rej Pressure	LR
Start Time	11:19:00 AM	12/6/2021	5.00	394.00	20.000		
End Time	11:29:00 AM	12/6/2021	5.00	394.00	20.000		
				5.00	600	53.84	0.00E+00
				Delta Time	600 Sec		
					10 Min		

Allowable LR	1.00E-03	atm CC/Sec	Minimum Test Sensitivity	8.49E-04	atm CC/Sec
Measured LR	0.00E+00	atm CC/Sec	Uncertainty	1.06E-08	atm CC/Sec

Reported LR	1.06E-08	atm CC/Sec	Accept if Green, Reject if Red
Procedure: NDE-70 Rev:	7	Technique: PCMT	Rev: 0



Certificate Number: 4121/01

Accepted 12/6/21  
No leak detected at test sensitivity of <1.0E-3 atm\*cc/s  
Work Request 4360792

Eric  
Vidal

Digitally signed  
by Eric Vidal  
Date:  
2021.12.14  
11:31:23 -05'00'

# PCMT Leak Test Calculator - Uncertainties Calculation Worksheet

DPP-1 TU-1 Operational Leak Test II

Calc. Version 8/8/18

Gauge	Identification	MTE #	FS Accuracy	FS/Act Rdg	Subdivisions	Units	
Pressure Gauge	Ashcroft HQS-2	A002500	0.025%	5.00	1	WC	
Temperature Gauge	Omega HH804	A005945	0.40%	20	1	deg C	
Time Gauge	Computer Time	none	0.100%	60	1	Sec	
Reference Volume	50.72543	A001744	1.000%	51.86	0.1	CC	

Variable	acc*FS rdg	Traceability	Resolution	Total Variable u	
P	1.25E-03	2.27E-05	1.000	2.89E-01	IWC
T	8.00E-02	5.80E-02	1.00E+00	2.93E-01	deg C
t	6.00E-02	1.00E-03	1.00E+00	2.90E-01	Sec
V	5.19E-01	2.04E-01	0.10	2.80E-01	CC

## PCMT Gauge Resolution

	Formula	Calc
Pressure Resolution	$(Gres \times V) / (StdAtm \times t)$	2.12185E-04
Temperature Resolution	$\{ (Pi \times V) / (StdAtm \times t) \} \times (Tres / Ti)$	3.61906E-06
Time Resolution	$\{ [ (Pi \times (Tf / Ti) - Pf) \times V ] / (StdAtm \times Dtime) \} \times (t \text{ res} / (Dtime + t \text{ res}))$	0.00000E+00

2.1219E-04 Maximum PCMT Test Resolution

## Weighted Uncertainties

Initial Pressure	3.75E-09
Final Pressure	3.75E-09
Temp Final	1.12E-12
Temp Initial	3.60E-11
Volume	0.00E+00
Time	0.00E+00

Weighted U 1.06E-08

## PCMT Test Uncertainty

$$\sqrt{uP^2 + uV^2 + uT^2 + ut^2}$$

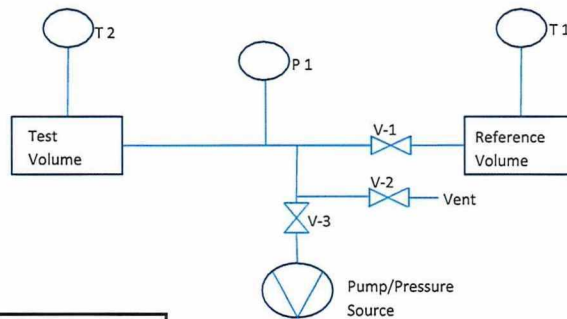
1.0612E-08



## System Under Test Volume Calc

DPP-1 TU-1 Operational Leak Test II

Calc. Version 8/8/18



### Steps for Determination of Test + System Volume

- Step 1 Vent test system  
Close V-3; Open Valves V-1 & V-2  
Wait for pressure to equalize
- Step 2 Record P-1 and T-1 as Ref P&T
- Step 3 Close V-2 (vent) and then close V-1, Isolating Reference volume
- Step 4 Open V-3; Pressurize/evacuate as needed to bring system to Start Pressure,
- Step 5 Close V-3; Wait for pressure to equalize
- Step 6 Record P-1 and T-2 as Start P&T
- Step 7 Open V-1; Exposing Reference Volume to the system  
Wait for pressure to equalize
- Step 8 As soon as pressure is equalized, record P-1, T-1 and T-2 as Equalized P&T  
  
Note: pressure may continue to drop if Test Volume has leaks, so record quickly
- Step 9 Repeat steps 1 through 8 a total of 6 times

Input Data in orange and yellow cells only!

Gauge	P-1	T-1	P-1	T-2	P-1	T-1	T-2	
	Ref P&T		Start; Ref Vol Isolated		Equalized Pressure			
Run	P ref (PSIA)	T ref (deg C)	Pstart (PSIA)	Tvstart (deg C)	P eq (PSIA)	T eq (deg C)	Tveq (deg C)	Test Sys Vol (CC)
1	14.262	19.300	5.721	19.300	9.945	19.300	19.300	51.8423
2	14.262	19.300	3.696	19.300	8.921	19.300	19.300	51.8516
3	14.262	19.300	5.567	19.300	9.866	19.300	19.300	51.8700
4	14.262	19.300	0.900	19.300	7.509	19.300	19.300	51.8307
5	14.262	19.300	5.842	19.300	10.005	19.300	19.300	51.8709
6	14.262	19.300	5.507	19.300	9.832	19.300	19.300	51.9570

### Reference Volume

Calibration Due Date:	8/14/2022
MTE Number	A001744
Volume	50.7255 CC

Test Volume 51.8603 CC median

0.0452 Std Dev

Min Calculated Volume 51.8156 CC



PCMT Leak Test Calculator - Uncertainties Calculation Worksheet

DPP-1 TU-1 Operational Leak Test II

Calc. Version 8/8/18

Gauge	Identification	MTE #	FS Accuracy	FS/Act Rdg	Subdivisions	Units	
Pressure Gauge	Ashcroft HQS-2	A002500	0.025%	4.96	0.01	WC	
Temperature Gauge	Omega HH804	A005945	0.40%	20.2	0.1	deg C	
Time Gauge	Computer Time	none	0.100%	60	1	Sec	
Reference Volume	50.72548	A001744	1.000%	51.86	0.1	CC	

Variable	acc*FS rdg	Traceability	Resolution	Total Variable u	
P	1.24E-03	2.27E-05	0.010	2.95E-03	IWC
T	8.08E-02	5.80E-02	1.00E-01	5.75E-02	deg C
t	6.00E-02	1.00E-03	1.00E+00	2.90E-01	Sec
V	5.19E-01	2.04E-01	0.10	2.80E-01	CC

PCMT Gauge Resolution

	Formula	Calc
Pressure Resolution	$(Gres \times V) / (StdAtm \times t)$	2.12185E-06
Temperature Resolution	$\{ (Pi \times V) / (StdAtm \times t) \} \times (Tres / Ti)$	3.51532E-07
Time Resolution	$\{ [ (Pi \times (Tf / Ti) - Pf) \times V ] / (StdAtm \times Dtime) \} \times (t \text{ res} / (Dtime + t \text{ res}))$	7.06107E-08

2.1219E-06 Maximum PCMT Test Resolution

Weighted Uncertainties

Initial Pressure	3.93E-13
Final Pressure	3.93E-13
Temp Final	4.09E-14
Temp Initial	1.31E-12
Volume	5.26E-14
Time	3.93E-16

Weighted U 2.85E-12

PCMT Test Uncertainty

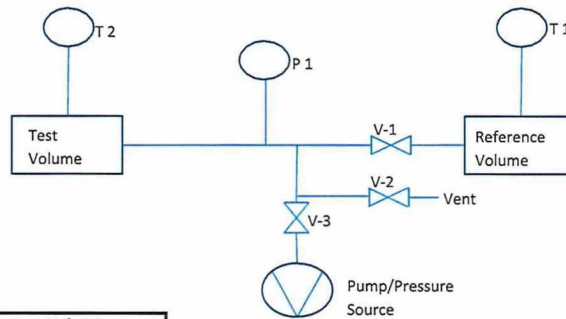
$\sqrt{uP^2 + uV^2 + uT^2 + ut^2}$

2.8480E-12

# System Under Test Volume Calc

DPP-1 TU-1 Operational Leak Test II

Calc. Version 8/8/18



## Steps for Determination of Test + System Volume

- Step 1 Vent test system  
Close V-3; Open Valves V-1 & V-2  
Wait for pressure to equalize
- Step 2 Record P-1 and T-1 as Ref P&T
- Step 3 Close V-2 (vent) and then close  
V-1, Isolating Reference volume
- Step 4 Open V-3; Pressurize/evacuate as needed to  
bring system to Start Pressure,
- Step 5 Close V-3; Wait for pressure to equalize
- Step 6 Record P-1 and T-2 as Start P&T
- Step 7 Open V-1; Exposing Reference Volume  
to the system  
Wait for pressure to equalize
- Step 8 As soon as pressure is equalized, record  
P-1, T-1 and T-2 as Equalized P&T  
  
Note: pressure may continue to drop if  
Test Volume has leaks, so record quickly
- Step 9 Repeat steps 1 through 8 a total of 6 times

Input Data in orange and yellow cells only!

Reference Volume	
Calibration Due Date:	8/14/2022
MTE Number	A001744
Volume	50.7255 CC

Gauge	P-1	T-1	P-1	T-2	P-1	T-1	T-2	
	Ref P&T		Start; Ref Vol Isolated		Equalized Pressure			
Run	P ref (PSIA)	T ref (deg C)	Pstart (PSIA)	Tvstart (deg C)	P eq (PSIA)	T eq (deg C)	Tveq (deg C)	Test Sys Vol (CC)
1	14.262	19.300	5.721	19.300	9.945	19.300	19.300	51.8423
2	14.262	19.300	3.696	19.300	8.921	19.300	19.300	51.8516
3	14.262	19.300	5.567	19.300	9.866	19.300	19.300	51.8700
4	14.262	19.300	0.900	19.300	7.509	19.300	19.300	51.8307
5	14.262	19.300	5.842	19.300	10.005	19.300	19.300	51.8709
6	14.262	19.300	5.507	19.300	9.832	19.300	19.300	51.9570

Test Volume	51.8608 CC	median
-------------	------------	--------

0.0452	Std Dev
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Min Calculated Volume	51.8156 CC
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# PCMT Leak Test Calculator - Absolute P Gauge-Pchange (LR=SCC/S)

## DPP-1 TU-2 Operational Leak Test Supplement II

Calc. Version 8/8/18

Input Required in Yellow Cells

Barometric Pressure	WC
Initial	393.00
Final	393.00

Start Gauge Pressure	WC abs
	5.00

End Gauge Pressure	WC abs
	5.00

Start Temperature	Deg C	Deg K
	20.000	293.150

End Temperature	Deg C	Deg K
	20.000	293.150

Test Volume	51.69	CC
(calculated minimum)	51.66	CC

Calculations for Formula

Allowable LR	1.00E-03	atm CC/Sec
Test P Differential	350	WC diff
Test Time	240	Seconds
Standard Atm	407	WC

Initial Pressure	5.00	WC - ABS
Initial Pressure	-388.00	WC - Gauge

Final Pressure	5.00	WC - ABS
Final Pressure	-388.00	WC - Gauge

dP Due to Pressure Gauge change	
Delta Pressure G	0.00 WC

dP Due to Barometer change	
Delta Pressure T	0.00 WC

dP Due to temperature change	
Delta Pressure T	0.00 WC

	Pressure	B	Temp C	Temp comp P	Delta Time	Rej Pressure	LR
Start Time	11:37:00 AM	12/6/2021	5.00	393.00	20.000		
End Time	11:47:00 AM	12/6/2021	5.00	393.00	20.000		
				5.00	600	53.84	0.00E+00
				Delta Time	600	Sec	
					10	Min	

Allowable LR	1.00E-03	atm CC/Sec	Minimum Test Sensitivity	8.46E-04	atm CC/Sec
Measured LR	0.00E+00	atm CC/Sec	Uncertainty	1.05E-08	atm CC/Sec

Reported LR	1.05E-08	atm CC/Sec	Accept if Green, Reject if Red
Procedure: NDE-70 Rev:	7	Technique: PCMT	Rev: 0



Certificate Number: 4121/01

Accepted 12/6/21  
No leak detected at test sensitivity of <1.0E-3 atm\*cc/s  
Work Request 4360792

Eric  
Vidal

Digitally signed  
by Eric Vidal  
Date:  
2021.12.14  
11:32:37 -05'00'

# PCMT Leak Test Calculator - Uncertainties Calculation Worksheet

DPP-1 TU-2 Operational Leak Test Supplement II

Calc. Version 8/8/18

Gauge	Identification	MTE #	FS Accuracy	FS/Act Rdg	Subdivisions	Units	
Pressure Gauge	Ashcroft HQS-2	A002500	0.025%	5.00	1	WC	
Temperature Gauge	Omega HH804	A005945	0.40%	20	1	deg C	
Time Gauge	Computer Time	none	0.100%	60	1	Sec	
Reference Volume	50.72548	A001744	1.000%	51.69	0.1	CC	

Variable	acc*FS rdg	Traceability	Resolution	Total Variable u	
P	1.25E-03	2.27E-05	1.000	2.89E-01	IWC
T	8.00E-02	5.80E-02	1.00E+00	2.93E-01	deg C
t	6.00E-02	1.00E-03	1.00E+00	2.90E-01	Sec
V	5.17E-01	2.04E-01	0.10	2.79E-01	CC

## PCMT Gauge Resolution

	Formula	Calc
Pressure Resolution	$(Gres \times V) / (StdAtm \times t)$	2.11559E-04
Temperature Resolution	$((Pi \times V) / (StdAtm \times t)) \times (Tres/Ti)$	3.60837E-06
Time Resolution	$((Pi \times (Tf/Ti) - Pf) \times V) / (StdAtm \times Dtime) \times (t \text{ res} / (Dtime + t \text{ res}))$	0.00000E+00

2.1156E-04 Maximum PCMT Test Resolution

## Weighted Uncertainties

Initial Pressure	3.73E-09
Final Pressure	3.73E-09
Temp Final	1.12E-12
Temp Initial	3.60E-11
Volume	0.00E+00
Time	0.00E+00

Weighted U 1.05E-08

## PCMT Test Uncertainty

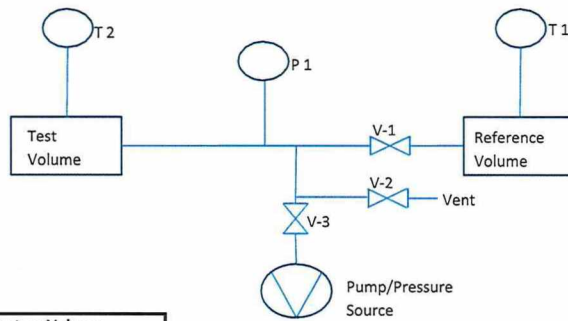
$$\sqrt{uP^2 + uV^2 + uT^2 + ut^2}$$

1.0550E-08

## System Under Test Volume Calc

DPP-1 TU-2 Operational Leak Test Supplement II

Calc. Version 8/8/18



### Steps for Determination of Test + System Volume

- Step 1 Vent test system  
Close V-3; Open Valves V-1 & V-2  
Wait for pressure to equalize
- Step 2 Record P-1 and T-1 as Ref P&T
- Step 3 Close V-2 (vent) and then close V-1, Isolating Reference volume
- Step 4 Open V-3; Pressurize/evacuate as needed to bring system to Start Pressure,
- Step 5 Close V-3; Wait for pressure to equalize
- Step 6 Record P-1 and T-2 as Start P&T
- Step 7 Open V-1; Exposing Reference Volume to the system  
Wait for pressure to equalize
- Step 8 As soon as pressure is equalized, record P-1, T-1 and T-2 as Equalized P&T  
  
Note: pressure may continue to drop if Test Volume has leaks, so record quickly
- Step 9 Repeat steps 1 through 8 a total of 6 times

Input Data in orange and yellow cells only!

Reference Volume	
Calibration Due Date:	8/14/2022
MTE Number	A001744
Volume	50.7255 CC

Gauge	P-1	T-1	P-1	T-2	P-1	T-1	T-2	
	Ref P&T		Start; Ref Vol Isolated		Equalized Pressure			
Run	P ref (PSIA)	T ref (deg C)	Pstart (PSIA)	Tvstart (deg C)	Peq (PSIA)	Teq (deg C)	Tveq (deg C)	Test Sys Vol (CC)
1	14.262	19.350	2.086	19.350	8.117	19.350	19.350	51.6843
2	14.262	19.350	4.308	19.350	9.238	19.350	19.350	51.6927
3	14.262	19.350	5.169	19.350	9.671	19.350	19.350	51.7283
4	14.261	19.350	2.834	19.350	8.494	19.350	19.350	51.6844
5	14.261	19.350	6.210	19.350	10.196	19.350	19.350	51.7308
6	14.261	19.350	2.842	19.350	8.499	19.350	19.350	51.6670

Test Volume	51.6885 CC	median
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0.0259 Std Dev

Min Calculated Volume	51.6626 CC
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# PCMT Leak Test Calculator - Absolute P Gauge-Pchange (LR=SCC/S)

## DPP-1 TU-2 Operational Leak Test II

Calc. Version 8/8/18

Input Required in Yellow Cells

Barometric Pressure	WC
Initial	393.54
Final	393.39

Start Gauge Pressure	WC abs
	5.22

End Gauge Pressure	WC abs
	5.39

Start Temperature	Deg C	Deg K
	20.250	293.400

End Temperature	Deg C	Deg K
	20.200	293.350

Test Volume	51.69	CC
(calculated minimum)	51.66	CC

### Calculations for Formula

Allowable LR	1.00E-04	atm CC/Sec
Test P Differential	350	WC diff
Test Time	240	Seconds
Standard Atm	407	WC

Initial Pressure	5.22	WC - ABS
Initial Pressure	-388.32	WC - Gauge

Final Pressure	5.39	WC - ABS
Final Pressure	-388.00	WC - Gauge

dP Due to Pressure Gauge change	
Delta Pressure G	0.17 WC

dP Due to Barometer change	
Delta Pressure T	0.15 WC

dP Due to temperature change	
Delta Pressure T	0.00 WC

	Pressure	B	Temp C	Temp comp P	Delta Time	Rej Pressure	LR
Start Time	11:39:00 AM	12/6/2021	5.22	393.54	20.250		
	11:42:00 AM	12/6/2021	5.27	393.47	20.200	5.27	180
	11:45:00 AM	12/6/2021	5.33	393.38	20.250	5.33	360
End Time	11:49:00 AM	12/6/2021	5.39	393.39	20.200	5.39	600
					Delta Time	600	Sec
						10	Min

Allowable LR	1.00E-04	atm CC/Sec	Minimum Test Sensitivity	8.46E-06	atm CC/Sec
Measured LR	3.62E-05	atm CC/Sec	Uncertainty	3.23E-12	atm CC/Sec

Reported LR	3.62E-05	atm CC/Sec	Accept if Green, Reject if Red
Procedure: NDE-70 Rev:	7	Technique: PCMT	Rev: 0



Certificate Number: 4121/01

Accepted 12/6/21  
<1.0E-4 atm\*cc/s air at test sensitivity of <5.0E-5 atm\*cc/s  
Work Request 4360792

Eric  
Vidal

Digitally signed  
by Eric Vidal  
Date:  
2021.12.14  
11:21:15 -05'00'



# PCMT Leak Test Calculator - Uncertainties Calculation Worksheet

DPP-1 TU-2 Operational Leak Test II

Calc. Version 8/8/18

Gauge	Identification	MTE #	FS Accuracy	FS/Act Rdg	Subdivisions	Units	
Pressure Gauge	Ashcroft HQS-2	A002500	0.025%	5.30	0.01	WC	
Temperature Gauge	Omega HH804	A005945	0.40%	20.25	0.1	deg C	
Time Gauge	Computer Time	none	0.100%	60	1	Sec	
Reference Volume	50.72548	A001744	1.000%	51.69	0.1	CC	

Variable	acc*FS rdg	Traceability	Resolution	Total Variable u	
P	1.33E-03	2.27E-05	0.010	2.96E-03	IWC
T	8.10E-02	5.80E-02	1.00E-01	5.76E-02	deg C
t	6.00E-02	1.00E-03	1.00E+00	2.90E-01	Sec
V	5.17E-01	2.04E-01	0.10	2.79E-01	CC

## PCMT Gauge Resolution

	Formula	Calc
Pressure Resolution	$(Gres \times V) / (StdAtm \times t)$	2.11559E-06
Temperature Resolution	$\{(Pi \times V) / (StdAtm \times t)\} \times (Tres / Ti)$	3.76393E-07
Time Resolution	$\{[(Pi \times (Tf / Ti) - Pf) \times V] / (StdAtm \times Dtime)\} \times (t \text{ res} / (Dtime + t \text{ res}))$	6.01550E-08

2.1156E-06 Maximum PCMT Test Resolution

## Weighted Uncertainties

Initial Pressure	3.93E-13
Final Pressure	3.93E-13
Temp Final	4.70E-14
Temp Initial	1.51E-12
Volume	3.82E-14
Time	2.83E-16

Weighted U 3.23E-12

## PCMT Test Uncertainty

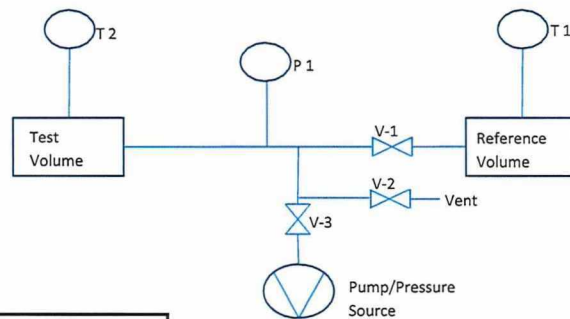
$$\sqrt{\{uP^2 + uV^2 + uT^2 + ut^2\}}$$

3.2275E-12

## System Under Test Volume Calc

DPP-1 TU-2 Operational Leak Test II

Calc. Version 8/8/18



Input Data in orange and yellow cells only!

Reference Volume	
Calibration Due Date:	8/14/2022
MTE Number	A001744
Volume	50.7255 CC

Steps for Determination of Test + System Volume	
Step 1	Vent test system Close V-3; Open Valves V-1 & V-2 Wait for pressure to equalize
Step 2	Record P-1 and T-1 as Ref P&T
Step 3	Close V-2 (vent) and then close V-1, Isolating Reference volume
Step 4	Open V-3; Pressurize/evacuate as needed to bring system to Start Pressure,
Step 5	Close V-3; Wait for pressure to equalize
Step 6	Record P-1 and T-2 as Start P&T
Step 7	Open V-1; Exposing Reference Volume to the system Wait for pressure to equalize
Step 8	As soon as pressure is equalized, record P-1, T-1 and T-2 as Equalized P&T  Note: pressure may continue to drop if Test Volume has leaks, so record quickly
Step 9	Repeat steps 1 through 8 a total of 6 times

Gauge	P-1	T-1	P-1	T-2	P-1	T-1	T-2	
	Ref P&T		Start; Ref Vol Isolated		Equalized Pressure			
Run	P ref (PSIA)	T ref (deg C)	Pstart (PSIA)	Tvstart (deg C)	P eq (PSIA)	T eq (deg C)	Tveq (deg C)	Test Sys Vol (CC)
1	14.262	19.350	2.086	19.350	8.117	19.350	19.350	51.6843
2	14.262	19.350	4.308	19.350	9.238	19.350	19.350	51.6927
3	14.262	19.350	5.169	19.350	9.671	19.350	19.350	51.7283
4	14.261	19.350	2.834	19.350	8.494	19.350	19.350	51.6844
5	14.261	19.350	6.210	19.350	10.196	19.350	19.350	51.7308
6	14.261	19.350	2.842	19.350	8.499	19.350	19.350	51.6670

Test Volume	51.6885 CC	median
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0.0259 Std Dev
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Min Calculated Volume	51.6626 CC
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# PCMT Leak Test Calculator - Absolute P Gauge-Pchange (LR=SCC/S)

## DPP-1 TU-3 Operational Leak Test Supplement II

Calc. Version 8/8/18

### Input Required in Yellow Cells

Barometric Pressure	WC
Initial	393.00
Final	393.00

Start Gauge Pressure	WC abs
	6.00

End Gauge Pressure	WC abs
	6.00

Start Temperature	Deg C	Deg K
	20.000	293.150

End Temperature	Deg C	Deg K
	20.000	293.150

Test Volume	51.45	CC
(calculated minimum)	51.43	CC

### Calculations for Formula

Allowable LR	1.00E-03	atm CC/Sec
Test P Differential	350	WC diff
Test Time	600	Seconds
Standard Atm	407	WC

Initial Pressure	6.00	WC - ABS
Initial Pressure	-387.00	WC - Gauge

Final Pressure	6.00	WC - ABS
Final Pressure	-387.00	WC - Gauge

dP Due to Pressure Gauge change	
Delta Pressure G	0.00 WC

dP Due to Barometer change	
Delta Pressure T	0.00 WC

dP Due to temperature change	
Delta Pressure T	0.00 WC

	Pressure	B	Temp C	Temp comp P	Delta Time	Rej Pressure	LR
Start Time	11:54:00 AM	12/6/2021	6.00	393.00	20.000		
End Time	12:04:00 PM	12/6/2021	6.00	393.00	20.000	6.00	600
					600	46.70	0.00E+00
					10	Sec	
					10	Min	

Allowable LR	1.00E-03	atm CC/Sec	Minimum Test Sensitivity	8.42E-04	atm CC/Sec
Measured LR	0.00E+00	atm CC/Sec	Uncertainty	1.05E-08	atm CC/Sec

Reported LR	1.05E-08	atm CC/Sec	Accept if Green, Reject if Red
Procedure: NDE-70 Rev:	7	Technique: PCMT	Rev: 0



Certificate Number: 4121/01

Accepted 12/6/21  
No leak detected at test sensitivity of <1.0E-3 atm\*cc/s  
Work Request 4360792

Eric  
Vidal

Digitally signed  
by Eric Vidal  
Date: 2021.12.14  
11:34:05 -05'00'

# PCMT Leak Test Calculator - Uncertainties Calculation Worksheet

DPP-1 TU-3 Operational Leak Test Supplement II

Calc. Version 8/8/18

Gauge	Identification	MTE #	FS Accuracy	FS/Act Rdg	Subdivisions	Units	
Pressure Gauge	Ashcroft HQS-2	A002500	0.025%	6.00	1	WC	
Temperature Gauge	Omega HH804	A005945	0.40%	20	1	deg C	
Time Gauge	Computer Time	none	0.100%	60	1	Sec	
Reference Volume	50.72548	A001744	1.000%	51.45	0.1	CC	

Variable	acc*FS rdg	Traceability	Resolution	Total Variable u	
P	1.50E-03	2.27E-05	1.000	2.89E-01	IWC
T	8.00E-02	5.80E-02	1.00E+00	2.93E-01	deg C
t	6.00E-02	1.00E-03	1.00E+00	2.90E-01	Sec
V	5.15E-01	2.04E-01	0.10	2.78E-01	CC

## PCMT Gauge Resolution

	Formula	Calc
Pressure Resolution	$(Gres \times V) / (StdAtm \times t)$	2.10608E-04
Temperature Resolution	$\{ (Pi \times V) / (StdAtm \times t) \} \times (Tres / Ti)$	4.31058E-06
Time Resolution	$\{ [ (Pi \times (Ti / Tt) - Pf) \times V ] / (StdAtm \times Dtime) \} \times (t \text{ res} / (Dtime + t \text{ res}))$	0.00000E+00

2.1061E-04 Maximum PCMT Test Resolution

## Weighted Uncertainties

Initial Pressure	3.70E-09
Final Pressure	3.70E-09
Temp Final	1.59E-12
Temp Initial	5.18E-11
Volume	0.00E+00
Time	0.00E+00

Weighted U 1.05E-08

## PCMT Test Uncertainty

$\sqrt{uP^2 + uV^2 + uT^2 + ut^2}$

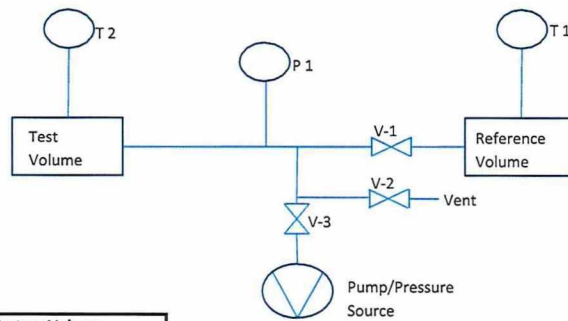
1.0455E-08



## System Under Test Volume Calc

DPP-1 TU-3 Operational Leak Test Supplement II

Calc. Version 8/8/18



### Steps for Determination of Test + System Volume

- Step 1 Vent test system  
Close V-3; Open Valves V-1 & V-2  
Wait for pressure to equalize
- Step 2 Record P-1 and T-1 as Ref P&T
- Step 3 Close V-2 (vent) and then close  
V-1, Isolating Reference volume
- Step 4 Open V-3; Pressurize/evacuate as needed to  
bring system to Start Pressure,
- Step 5 Close V-3; Wait for pressure to equalize
- Step 6 Record P-1 and T-2 as Start P&T
- Step 7 Open V-1; Exposing Reference Volume  
to the system  
Wait for pressure to equalize
- Step 8 As soon as pressure is equalized, record  
P-1, T-1 and T-2 as Equalized P&T  
  
Note: pressure may continue to drop if  
Test Volume has leaks, so record quickly
- Step 9 Repeat steps 1 through 8 a total of 6 times

Input Data in orange and yellow cells only!

Gauge	P-1	T-1	P-1	T-2	P-1	T-1	T-2	
	Ref P&T		Start; Ref Vol Isolated		Equalized Pressure			
Run	P ref (PSIA)	T ref (deg C)	Pstart (PSIA)	Tvstart (deg C)	P eq (PSIA)	T eq (deg C)	Tveq (deg C)	Test Sys Vol (CC)
1	14.259	19.400	6.299	19.400	10.251	19.400	19.400	51.4443
2	14.256	19.400	5.045	19.400	9.618	19.400	19.400	51.4465
3	14.256	19.400	1.745	19.400	7.956	19.400	19.400	51.4523
4	14.256	19.400	3.330	19.400	8.754	19.400	19.400	51.4549
5	14.255	19.400	7.032	19.400	10.616	19.400	19.400	51.5039
6	14.255	19.400	4.886	19.400	9.536	19.400	19.400	51.4782

### Reference Volume

Calibration Due Date:	8/14/2022
MTE Number	A001744
Volume	50.7255 CC

Test Volume 51.4536 CC median

0.0233 Std Dev

Min Calculated Volume 51.4304 CC

## PCMT Leak Test Calculator - Absolute P Gauge-Pchange (LR=SCC/S)

DPP-1 TU-3 Operational Leak Test II Calc. Version 8/8/18

Calc. Version 8/8/18

### Input Required in Yellow Cells

Barometric Pressure	WC
Initial	393.35
Final	393.38

Start Gauge Pressure	WC abs
	5.45

End Gauge Pressure	WC abs
	5.63

Start Temperature	Deg C	Deg K
	20.200	293.350

End Temperatur	Deg C	Deg K
	20.250	293.400

Test Volume	51.45	CC
(calculated minimum)	51.43	CC

### Calculations for Formula

Allowable LR	1.00E-04	atm CC/Sec
Test P Differential	350	WC diff
Test Time	600	Seconds
Standard Atm	407	WC

Initial Pressure	5.45	WC - ABS
Initial Pressure	-387.90	WC - Gauge

Final Pressure	5.63	WC - ABS
Final Pressure	-387.75	WC - Gauge

dP Due to Pressure Gauge change		
Delta Pressure G	0.18	WC

dP Due to Barometer change		
Delta Pressure T	-0.03	WC

dP Due to temperature change		
Delta Pressure T	0.00	WC

			Pressure	B	Temp C	Temp comp P	Delta Time	Rej Pressure	LR
Start Time	11:54:00 AM	12/6/2021	5.45	393.35	20.200				
	11:57:00 AM	12/6/2021	5.51	393.29	20.250	5.51	180	5.31	4.15E-05
	11:59:00 AM	12/6/2021	5.54	393.29	20.250	5.54	300	7.69	3.75E-05
	12:02:00 PM	12/6/2021	5.59	393.38	20.250	5.59	480	9.03	3.66E-05
End Time	12:04:00 PM	12/6/2021	5.63	393.38	20.250	5.63	600	9.93	3.77E-05
						Delta Time	600	Sec	
							10	Min	

Allowable LR	1.00E-04	atm CC/Sec	Minimum Test Sensitivity	8.42E-06	atm CC/Sec
Measured LR	3.77E-05	atm CC/Sec	Uncertainty	3.48E-12	atm CC/Sec

Reported LR	3.77E-05	atm CC/Sec	Accept if Green, Reject if Red		
Procedure: NDE-70 Rev:	7	Technique:	PCMT	Rev:	0



Certificate Number: 4121/01

Accepted 12/6/21

<1.0E-4 atm\*cc/s air at test sensitivity of <5.0E-5 atm\*cc/s

Work Request 4360792

# Eric Vidal

Digitally signed  
by Eric Vidal

Date: 2021.12.14

11:22:45 -05'00'

# PCMT Leak Test Calculator - Uncertainties Calculation Worksheet

DPP-1 TU-3 Operational Leak Test II

Calc. Version 8/8/18

Gauge	Identification	MTE #	FS Accuracy	FS/Act Rdg	Subdivisions	Units	
Pressure Gauge	Ashcroft HQS-2	A002500	0.025%	5.54	0.01	WC	
Temperature Gauge	Omega HH804	A005945	0.40%	20.2	0.1	deg C	
Time Gauge	Computer Time	none	0.100%	60	1	Sec	
Reference Volume	50.72548	A001744	1.000%	51.45	0.1	CC	

Variable	acc*FS rdg	Traceability	Resolution	Total Variable u	
P	1.39E-03	2.27E-05	0.010	2.97E-03	IWC
T	8.08E-02	5.80E-02	1.00E-01	5.75E-02	deg C
t	6.00E-02	1.00E-03	1.00E+00	2.90E-01	Sec
V	5.15E-01	2.04E-01	0.10	2.78E-01	CC

## PCMT Gauge Resolution

	Formula	Calc
Pressure Resolution	$(G_{res} \times V) / (StdAtm \times t)$	2.10608E-06
Temperature Resolution	$\{[(P_i \times V) / (StdAtm \times t)] \times (T_{res}/T_i)\}$	3.91277E-07
Time Resolution	$\{[(P_i \times (T_f/T_i) - P_f \times V) / (StdAtm \times Dtime)] \times (t_{res}/(Dtime + t_{res}))\}$	6.27516E-08

2.1061E-06 Maximum PCMT Test Resolution

## Weighted Uncertainties

Initial Pressure	3.91E-13
Final Pressure	3.91E-13
Temp Final	5.06E-14
Temp Initial	1.65E-12
Volume	4.16E-14
Time	3.06E-16

Weighted U 3.48E-12

## PCMT Test Uncertainty

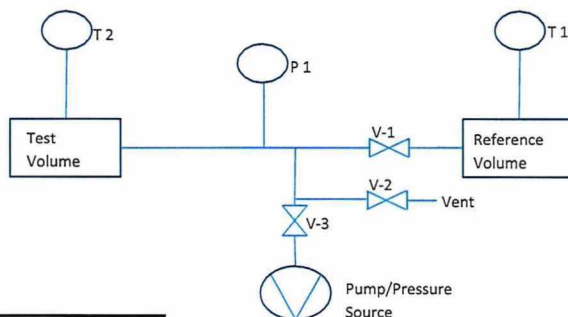
$\sqrt{u_P^2 + u_V^2 + u_T^2 + u_t^2}$

3.4781E-12

## System Under Test Volume Calc

DPP-1 TU-3 Operational Leak Test II

Calc. Version 8/8/18



### Steps for Determination of Test + System Volume

- Step 1 Vent test system  
Close V-3; Open Valves V-1 & V-2  
Wait for pressure to equalize
- Step 2 Record P-1 and T-1 as Ref P&T
- Step 3 Close V-2 (vent) and then close V-1, Isolating Reference volume
- Step 4 Open V-3; Pressurize/evacuate as needed to bring system to Start Pressure,
- Step 5 Close V-3; Wait for pressure to equalize
- Step 6 Record P-1 and T-2 as Start P&T
- Step 7 Open V-1; Exposing Reference Volume to the system  
Wait for pressure to equalize
- Step 8 As soon as pressure is equalized, record P-1, T-1 and T-2 as Equalized P&T  
  
Note: pressure may continue to drop if Test Volume has leaks, so record quickly
- Step 9 Repeat steps 1 through 8 a total of 6 times

Input Data in orange and yellow cells only!

Reference Volume	
Calibration Due Date:	8/14/2022
MTE Number	A001744
Volume	50.7255 CC

Gauge	P-1	T-1	P-1	T-2	P-1	T-1	T-2	
	Ref P&T		Start; Ref Vol Isolated		Equalized Pressure			
Run	P ref (PSIA)	T ref (deg C)	Pstart (PSIA)	Tvstart (deg C)	P eq (PSIA)	T eq (deg C)	Tveq (deg C)	Test Sys Vol (CC)
1	14.259	19.400	6.299	19.400	10.251	19.400	19.400	51.4443
2	14.256	19.400	5.045	19.400	9.618	19.400	19.400	51.4465
3	14.256	19.400	1.745	19.400	7.956	19.400	19.400	51.4523
4	14.256	19.400	3.330	19.400	8.754	19.400	19.400	51.4549
5	14.255	19.400	7.032	19.400	10.616	19.400	19.400	51.5039
6	14.255	19.400	4.886	19.400	9.536	19.400	19.400	51.4782

Test Volume	51.4536 CC	median
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0.0233	Std Dev
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Min Calculated Volume	51.4304 CC
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# PCMT Leak Test Calculator - Absolute P Gauge-Pchange (LR=SCC/S)

## DPP-1 TU-4 Operational Leak Test Supplement II

Calc. Version 8/8/18

### Input Required in Yellow Cells

Barometric Pressure	WC
Initial	394.00
Final	394.00

Start Gauge Pressure	WC abs
	1.00

End Gauge Pressure	WC abs
	1.00

Start Temperature	Deg C	Deg K
	20.000	293.150

End Temperature	Deg C	Deg K
	20.000	293.150

Test Volume	51.61	CC
(calculated minimum)	51.53	CC

### Calculations for Formula

Allowable LR	1.00E-03	atm CC/Sec
Test P Differential	350	WC diff
Test Time	600	Seconds
Standard Atm	407	WC

Initial Pressure	1.00	WC - ABS
Initial Pressure	-393.00	WC - Gauge

Final Pressure	1.00	WC - ABS
Final Pressure	-393.00	WC - Gauge

dP Due to Pressure Gauge change	
Delta Pressure G	0.00 WC

dP Due to Barometer change	
Delta Pressure T	0.00 WC

dP Due to temperature change	
Delta Pressure T	0.00 WC

	Pressure	B	Temp C	Temp comp P	Delta Time	Rej Pressure	LR
Start Time	2:55:00 PM	12/6/2021	1.00	394.00	20.000		
End Time	3:05:00 PM	12/6/2021	1.00	394.00	20.000		
				1.00	600	245.20	0.00E+00
				Delta Time	600 Sec		
					10 Min		

Allowable LR	1.00E-03	atm CC/Sec	Minimum Test Sensitivity	8.44E-04	atm CC/Sec
Measured LR	0.00E+00	atm CC/Sec	Uncertainty	1.05E-08	atm CC/Sec

Reported LR	1.05E-08	atm CC/Sec	Accept if Green, Reject if Red
Procedure: NDE-70 Rev:	7	Technique: PCMT	Rev: 0



Certificate Number: 4121/01

Accepted 12/6/21  
No leak detected at test sensitivity of <1.0E-3 atm\*cc/s  
Work Request 4360792

Eric  
Vidal

Digitally signed  
by Eric Vidal  
Date: 2021.12.14  
11:35:17 -05'00'

# PCMT Leak Test Calculator - Uncertainties Calculation Worksheet

DPP-1 TU-4 Operational Leak Test Supplement II

Calc. Version 8/8/18

Gauge	Identification	MTE #	FS Accuracy	FS/Act Rdg	Subdivisions	Units	
Pressure Gauge	Ashcroft HQS-2	A002500	0.025%	1.00	1	WC	
Temperature Gauge	Omega HH804	A005945	0.40%	20	1	deg C	
Time Gauge	Computer Time	none	0.100%	60	1	Sec	
Reference Volume	50.72548	A001744	1.000%	51.61	0.1	CC	

Variable	acc*FS rdg	Traceability	Resolution	Total Variable u	
P	2.50E-04	2.27E-05	1.000	2.89E-01	IWC
T	8.00E-02	5.80E-02	1.00E+00	2.93E-01	deg C
t	6.00E-02	1.00E-03	1.00E+00	2.90E-01	Sec
V	5.16E-01	2.04E-01	0.10	2.79E-01	CC

## PCMT Gauge Resolution

	Formula	Calc
Pressure Resolution	$(Gres \times V) / (StdAtm \times t)$	2.11034E-04
Temperature Resolution	$\{(Pi \times V) / (StdAtm \times t)\} \times (Tres/Ti)$	7.19884E-07
Time Resolution	$\{[(Pi \times (Tf/Ti) - Pf) \times V] / (StdAtm \times Dtime)\} \times (t \text{ res} / (Dtime + t \text{ res}))$	0.00000E+00

2.1103E-04 Maximum PCMT Test Resolution

## Weighted Uncertainties

Initial Pressure	3.71E-09
Final Pressure	3.71E-09
Temp Final	4.45E-14
Temp Initial	1.44E-12
Volume	0.00E+00
Time	0.00E+00
Weighted U	1.05E-08

## PCMT Test Uncertainty

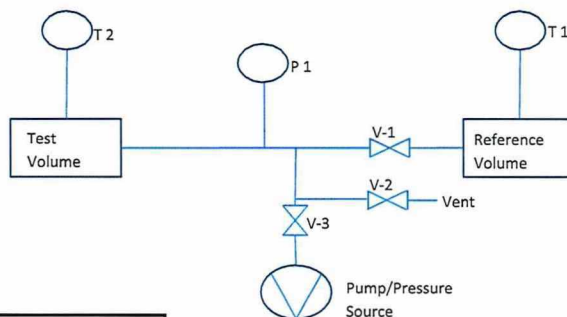
$\sqrt{uP^2 + uV^2 + uT^2 + ut^2}$

1.0497E-08

## System Under Test Volume Calc

DPP-1 TU-4 Operational Leak Test Supplement II

Calc. Version 8/8/18



### Steps for Determination of Test + System Volume

- Step 1 Vent test system  
Close V-3; Open Valves V-1 & V-2  
Wait for pressure to equalize
- Step 2 Record P-1 and T-1 as Ref P&T
- Step 3 Close V-2 (vent) and then close V-1, Isolating Reference volume
- Step 4 Open V-3; Pressurize/evacuate as needed to bring system to Start Pressure,
- Step 5 Close V-3; Wait for pressure to equalize
- Step 6 Record P-1 and T-2 as Start P&T
- Step 7 Open V-1; Exposing Reference Volume to the system  
Wait for pressure to equalize
- Step 8 As soon as pressure is equalized, record P-1, T-1 and T-2 as Equalized P&T  
  
Note: pressure may continue to drop if Test Volume has leaks, so record quickly
- Step 9 Repeat steps 1 through 8 a total of 6 times

Input Data in orange and yellow cells only!

Reference Volume	
Calibration Due Date:	8/14/2022
MTE Number	A001744
Volume	50.7255 CC

Gauge	P-1	T-1	P-1	T-2	P-1	T-1	T-2	
	Ref P&T		Start; Ref Vol Isolated		Equalized Pressure			
Run	P ref (PSIA)	T ref (deg C)	Pstart (PSIA)	Tvstart (deg C)	P eq (PSIA)	T eq (deg C)	Tveq (deg C)	Test Sys Vol (CC)
1	14.254	19.300	6.609	19.300	10.401	19.300	19.300	51.5415
2	14.253	19.300	4.980	19.300	9.578	19.300	19.300	51.5749
3	14.253	19.300	5.483	19.300	9.832	19.300	19.300	51.5653
4	14.252	19.300	4.670	19.300	9.418	19.300	19.300	51.6443
5	14.252	19.300	2.775	19.300	8.462	19.300	19.300	51.6442
6	14.252	19.300	2.703	19.300	8.420	19.300	19.300	51.7458

Test Volume	51.6096 CC	median
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0.0751 Std Dev
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Min Calculated Volume	51.5345 CC
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# PCMT Leak Test Calculator - Uncertainties Calculation Worksheet

DPP-1 TU-4 Operational Leak Test II

Calc. Version 8/8/18

Gauge	Identification	MTE #	FS Accuracy	FS/Act Rdg	Subdivisions	Units	
Pressure Gauge	Ashcroft HQS-2	A002500	0.025%	0.98	0.01	WC	
Temperature Gauge	Omega HH804	A005945	0.40%	19.9	0.1	deg C	
Time Gauge	Computer Time	none	0.100%	60	1	Sec	
Reference Volume	50.72548	A001744	1.000%	51.61	0.1	CC	

Variable	acc*FS rdg	Traceability	Resolution	Total Variable u	
P	2.46E-04	2.27E-05	0.010	2.89E-03	IWC
T	7.96E-02	5.80E-02	1.00E-01	5.71E-02	deg C
t	6.00E-02	1.00E-03	1.00E+00	2.90E-01	Sec
V	5.16E-01	2.04E-01	0.10	2.79E-01	CC

## PCMT Gauge Resolution

	Formula	Calc
Pressure Resolution	$(Gres \times V) / (StdAtm \times t)$	2.11034E-06
Temperature Resolution	$\{[(Pi \times V) / (StdAtm \times t)] \times (Tres / Ti)\}$	5.54500E-08
Time Resolution	$\{[(Pi \times (Tf / Ti) - Pf) \times V] / (StdAtm \times Dtime)\} \times (t \text{ res} / (Dtime + t \text{ res}))\}$	1.26410E-07

2.1103E-06 Maximum PCMT Test Resolution

## Weighted Uncertainties

Initial Pressure	3.72E-13
Final Pressure	3.72E-13
Temp Final	1.00E-15
Temp Initial	3.24E-14
Volume	1.69E-13
Time	1.25E-15

Weighted U 1.11E-12

## PCMT Test Uncertainty

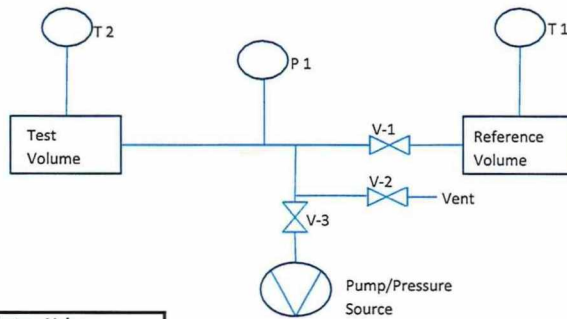
$$\sqrt{uP^2 + uV^2 + uT^2 + ut^2}$$

1.1066E-12

# System Under Test Volume Calc

DPP-1 TU-4 Operational Leak Test II

Calc. Version 8/8/18



## Steps for Determination of Test + System Volume

- Step 1 Vent test system  
Close V-3; Open Valves V-1 & V-2  
Wait for pressure to equalize
- Step 2 Record P-1 and T-1 as Ref P&T
- Step 3 Close V-2 (vent) and then close V-1, Isolating Reference volume
- Step 4 Open V-3; Pressurize/evacuate as needed to bring system to Start Pressure,
- Step 5 Close V-3; Wait for pressure to equalize
- Step 6 Record P-1 and T-2 as Start P&T
- Step 7 Open V-1; Exposing Reference Volume to the system  
Wait for pressure to equalize
- Step 8 As soon as pressure is equalized, record P-1, T-1 and T-2 as Equalized P&T  
  
Note: pressure may continue to drop if Test Volume has leaks, so record quickly
- Step 9 Repeat steps 1 through 8 a total of 6 times

Input Data in orange and yellow cells only!

Gauge	P-1	T-1	P-1	T-2	P-1	T-1	T-2	
	Ref P&T		Start; Ref Vol Isolated		Equalized Pressure			
Run	P ref (PSIA)	T ref (deg C)	Pstart (PSIA)	Tvstart (deg C)	P eq (PSIA)	T eq (deg C)	Tveq (deg C)	Test Sys Vol (CC)
1	14.254	19.300	6.609	19.300	10.401	19.300	19.300	51.5415
2	14.253	19.300	4.980	19.300	9.578	19.300	19.300	51.5749
3	14.253	19.300	5.483	19.300	9.832	19.300	19.300	51.5653
4	14.252	19.300	4.670	19.300	9.418	19.300	19.300	51.6443
5	14.252	19.300	2.775	19.300	8.462	19.300	19.300	51.6442
6	14.252	19.300	2.703	19.300	8.420	19.300	19.300	51.7458

## Reference Volume

Calibration Due Date:	8/14/2022
MTE Number	A001744
Volume	50.7255 CC

Test Volume 51.6096 CC median

0.0751 Std Dev

Min Calculated Volume 51.5345 CC

# PCMT Leak Test Calculator - Absolute P Gauge-Pchange (LR=SCC/S)

## DPP-1 TU-5 Operational Leak Test Supplement II

Calc. Version 8/8/18

### Input Required in Yellow Cells

Barometric Pressure	WC
Initial	394.00
Final	394.00

Start Gauge Pressure	WC abs
	17.00

End Gauge Pressure	WC abs
	17.00

Start Temperature	Deg C	Deg K
	20.000	293.150

End Temperature	Deg C	Deg K
	20.000	293.150

Test Volume	51.56	CC
(calculated minimum)	51.54	CC

### Calculations for Formula

Allowable LR	1.00E-03	atm CC/Sec
Test P Differential	350	WC diff
Test Time	600	Seconds
Standard Atm	407	WC

Initial Pressure	17.00	WC - ABS
Initial Pressure	-377.00	WC - Gauge

Final Pressure	17.00	WC - ABS
Final Pressure	-377.00	WC - Gauge

dP Due to Pressure Gauge change	
Delta Pressure G	0.00 WC

dP Due to Barometer change	
Delta Pressure T	0.00 WC

dP Due to temperature change	
Delta Pressure T	0.00 WC

	Pressure	B	Temp C	Temp comp P	Delta Time	Rej Pressure	LR
Start Time	2:00:00 PM	12/6/2021	17.00	394.00	20.000		
End Time	2:10:00 PM	12/6/2021	17.00	394.00	20.000	17.00	600
					600	31.36	0.00E+00
					10	Min	

Allowable LR	1.00E-03	atm CC/Sec	Minimum Test Sensitivity	8.44E-04	atm CC/Sec
Measured LR	0.00E+00	atm CC/Sec	Uncertainty	1.05E-08	atm CC/Sec

Reported LR	1.05E-08	atm CC/Sec	Accept if Green, Reject if Red
Procedure: NDE-70 Rev:	7	Technique: PCMT	Rev: 0



Certificate Number: 4121/01

Accepted 12/6/21  
No leak detected at test sensitivity of <1.0E-3 atm\*cc/s  
Work Request 4360792

Eric  
Vidal

Digitally signed  
by Eric Vidal  
Date: 2021.12.14  
11:36:59 -05'00'

# PCMT Leak Test Calculator - Uncertainties Calculation Worksheet

DPP-1 TU-5 Operational Leak Test Supplement II

Calc. Version 8/8/18

Gauge	Identification	MTE #	FS Accuracy	FS/Act Rdg	Subdivisions	Units	
Pressure Gauge	Ashcroft HQS-2	A002500	0.025%	17.00	1	WC	
Temperature Gauge	Omega HH804	A005945	0.40%	20	1	deg C	
Time Gauge	Computer Time	none	0.100%	60	1	Sec	
Reference Volume	50.7255	A001744	1.000%	51.56	0.1	CC	

Variable	acc*FS rdg	Traceability	Resolution	Total Variable u	
P	4.25E-03	2.27E-05	1.000	2.89E-01	IWC
T	8.00E-02	5.80E-02	1.00E+00	2.93E-01	deg C
t	6.00E-02	1.00E-03	1.00E+00	2.90E-01	Sec
V	5.16E-01	2.04E-01	0.10	2.79E-01	CC

## PCMT Gauge Resolution

	Formula	Calc
Pressure Resolution	$(Gres \times V) / (StdAtm \times t)$	2.11036E-04
Temperature Resolution	$\{ (Pi \times V) / (StdAtm \times t) \} \times (Tres / Ti)$	1.22382E-05
Time Resolution	$\{ [(Pi \times (Tf / Ti) - Pf) \times V] / (StdAtm \times Dtime) \} \times (t \text{ res} / (Dtime + t \text{ res}))$	0.00000E+00

2.1104E-04 Maximum PCMT Test Resolution

## Weighted Uncertainties

Initial Pressure	3.71E-09
Final Pressure	3.71E-09
Temp Final	1.28E-11
Temp Initial	4.16E-10
Volume	0.00E+00
Time	0.00E+00

Weighted U 1.05E-08

## PCMT Test Uncertainty

$$\sqrt{uP^2 + uV^2 + uT^2 + ut^2}$$

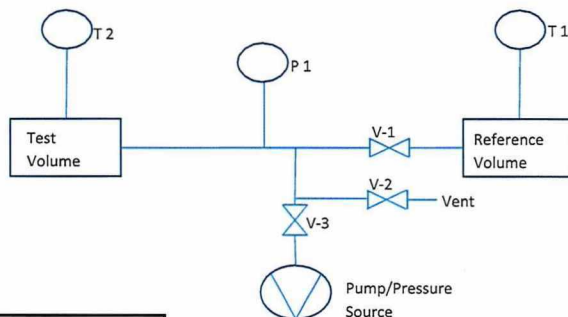
1.0531E-08



## System Under Test Volume Calc

DPP-1 TU-5 Operational Leak Test Supplement II

Calc. Version 8/8/18



### Steps for Determination of Test + System Volume

- Step 1 Vent test system  
Close V-3; Open Valves V-1 & V-2  
Wait for pressure to equalize
- Step 2 Record P-1 and T-1 as Ref P&T
- Step 3 Close V-2 (vent) and then close V-1, Isolating Reference volume
- Step 4 Open V-3; Pressurize/evacuate as needed to bring system to Start Pressure,
- Step 5 Close V-3; Wait for pressure to equalize
- Step 6 Record P-1 and T-2 as Start P&T
- Step 7 Open V-1; Exposing Reference Volume to the system  
Wait for pressure to equalize
- Step 8 As soon as pressure is equalized, record P-1, T-1 and T-2 as Equalized P&T  
  
Note: pressure may continue to drop if Test Volume has leaks, so record quickly
- Step 9 Repeat steps 1 through 8 a total of 6 times

Input Data in orange and yellow cells only!

Gauge	P-1	T-1	P-1	T-2	P-1	T-1	T-2
	Ref P&T		Start; Ref Vol Isolated		Equalized Pressure		
Run	P ref (PSIA)	T ref (deg C)	Pstart (PSIA)	Tvstart (deg C)	P eq (PSIA)	T eq (deg C)	Tveq (deg C)
1	14.252	19.200	8.072	19.200	11.137	19.200	19.200
2	14.251	19.200	2.735	19.200	8.448	19.200	19.200
3	14.251	19.200	6.154	19.200	10.171	19.200	19.200
4	14.251	19.200	4.555	19.200	9.363	19.200	19.200
5	14.250	19.200	3.574	19.200	8.868	19.200	19.200
6	14.250	19.200	2.576	19.200	8.364	19.200	19.200

### Reference Volume

Calibration Due Date:	8/14/2022
MTE Number	A001744
Volume	50.7255 CC

Test Volume 51.5608 CC median

0.0258 Std Dev

Min Calculated Volume 51.5350 CC

# PCMT Leak Test Calculator - Absolute P Gauge-Pchange (LR=SCC/S)

## DPP-1 TU-5 Operational Leak Test II

Calc. Version 8/8/18

### Input Required in Yellow Cells

Barometric Pressure	WC
Initial	393.72
Final	393.72

Start Gauge Pressure	WC abs
	16.63

End Gauge Pressure	WC abs
	16.78

Start Temperature	Deg C	Deg K
	19.800	292.950

End Temperature	Deg C	Deg K
	19.850	293.000

Test Volume	51.56	CC
(calculated minimum)	51.54	CC

### Calculations for Formula

Allowable LR	1.00E-04	atm CC/Sec
Test P Differential	350	WC diff
Test Time	600	Seconds
Standard Atm	407	WC

Initial Pressure	16.63	WC - ABS
Initial Pressure	-377.09	WC - Gauge

Final Pressure	16.78	WC - ABS
Final Pressure	-376.94	WC - Gauge

dP Due to Pressure Gauge change	
Delta Pressure G	0.15 WC

dP Due to Barometer change	
Delta Pressure T	0.00 WC

dP Due to temperature change	
Delta Pressure T	0.00 WC

	Pressure	B	Temp C	Temp comp P	Delta Time	Rej Pressure	LR
Start Time	2:00:00 PM	12/6/2021	16.63	393.72	19.800		
	2:02:00 PM	12/6/2021	16.66	393.73	19.800	16.54	3.17E-05
	2:05:00 PM	12/6/2021	16.70	393.74	19.800	17.36	2.95E-05
	2:08:00 PM	12/6/2021	16.74	393.71	19.850	17.80	2.83E-05
End Time	2:10:00 PM	12/6/2021	16.78	393.72	19.850	18.10	3.11E-05
	Delta Time		600	Sec			
			10	Min			

Allowable LR	1.00E-04	atm CC/Sec	Minimum Test Sensitivity	8.44E-06	atm CC/Sec
Measured LR	3.11E-05	atm CC/Sec	Uncertainty	3.01E-11	atm CC/Sec

Reported LR	3.11E-05	atm CC/Sec	Accept if Green, Reject if Red
Procedure: NDE-70 Rev:	7	Technique: PCMT	Rev: 0



Certificate Number: 4121/01

Accepted 12/6/21  
 <1.0E-4 atm\*cc/s air at test sensitivity of <5.0E-5 atm\*cc/s  
 Work Request 4360792

Eric  
Vidal

Digitally signed  
 by Eric Vidal  
 Date: 2021.12.14  
 11:27:22 -05'00'

# PCMT Leak Test Calculator - Uncertainties Calculation Worksheet

DPP-1 TU-5 Operational Leak Test II

Calc. Version 8/8/18

Gauge	Identification	MTE #	FS Accuracy	FS/Act Rdg	Subdivisions	Units	
Pressure Gauge	Ashcroft HQS-2	A002500	0.025%	16.70	0.01	WC	
Temperature Gauge	Omega HH804	A005945	0.40%	19.8	0.1	deg C	
Time Gauge	Computer Time	none	0.100%	60	1	Sec	
Reference Volume	50.72548	A001744	1.000%	51.56	0.1	CC	

Variable	acc*FS rdg	Traceability	Resolution	Total Variable u	
P	4.18E-03	2.27E-05	0.010	3.56E-03	IWC
T	7.92E-02	5.80E-02	1.00E-01	5.69E-02	deg C
t	6.00E-02	1.00E-03	1.00E+00	2.90E-01	Sec
V	5.16E-01	2.04E-01	0.10	2.79E-01	CC

## PCMT Gauge Resolution

	Formula	Calc
Pressure Resolution	$(G_{res} \times V) / (StdAtm \times t)$	2.11036E-06
Temperature Resolution	$\{(Pi \times V) / (StdAtm \times t)\} \times (T_{res} / Ti)$	1.19800E-06
Time Resolution	$\{[(Pi \times (Tf / Ti) - Pf) \times V] / (StdAtm \times Dtime)\} \times (t_{res} / (Dtime + t_{res}))$	5.16746E-08

2.1104E-06 Maximum PCMT Test Resolution

## Weighted Uncertainties

Initial Pressure	5.65E-13
Final Pressure	5.65E-13
Temp Final	4.65E-13
Temp Initial	1.50E-11
Volume	2.82E-14
Time	2.08E-16

Weighted U 3.01E-11

## PCMT Test Uncertainty

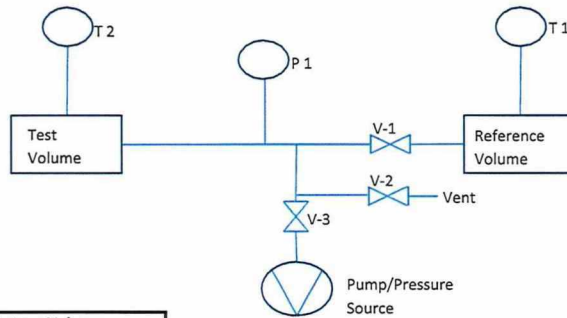
$$\sqrt{(u_P^2 + u_V^2 + u_T^2 + u_t^2)}$$

3.0142E-11

## System Under Test Volume Calc

DPP-1 TU-5 Operational Leak Test II

Calc. Version 8/8/18



### Steps for Determination of Test + System Volume

- Step 1 Vent test system  
Close V-3; Open Valves V-1 & V-2  
Wait for pressure to equalize
- Step 2 Record P-1 and T-1 as Ref P&T
- Step 3 Close V-2 (vent) and then close V-1, Isolating Reference volume
- Step 4 Open V-3; Pressurize/evacuate as needed to bring system to Start Pressure,
- Step 5 Close V-3; Wait for pressure to equalize
- Step 6 Record P-1 and T-2 as Start P&T
- Step 7 Open V-1; Exposing Reference Volume to the system  
Wait for pressure to equalize
- Step 8 As soon as pressure is equalized, record P-1, T-1 and T-2 as Equalized P&T  
  
Note: pressure may continue to drop if Test Volume has leaks, so record quickly
- Step 9 Repeat steps 1 through 8 a total of 6 times

Input Data in orange and yellow cells only!

Reference Volume	
Calibration Due Date:	8/14/2022
MTE Number	A001744
Volume	50.7255 CC

Gauge	P-1	T-1	P-1	T-2	P-1	T-1	T-2	
	Ref P&T		Start; Ref Vol Isolated		Equalized Pressure			
Run	P ref (PSIA)	T ref (deg C)	Pstart (PSIA)	Tvstart (deg C)	Peq (PSIA)	Teq (deg C)	Tveq (deg C)	Test Sys Vol (CC)
1	14.252	19.200	8.072	19.200	11.137	19.200	19.200	51.5530
2	14.251	19.200	2.735	19.200	8.448	19.200	19.200	51.5246
3	14.251	19.200	6.154	19.200	10.171	19.200	19.200	51.5210
4	14.251	19.200	4.555	19.200	9.363	19.200	19.200	51.5695
5	14.250	19.200	3.574	19.200	8.868	19.200	19.200	51.5687
6	14.250	19.200	2.576	19.200	8.364	19.200	19.200	51.5843

Test Volume	51.5603 CC	median
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0.0258	Std Dev
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Min Calculated Volume	51.5350 CC
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# PCMT Leak Test Calculator - Absolute P Gauge-Pchange (LR=SCC/S)

## DPP-1 TU-6 Operational Leak Test Supplement II

Calc. Version 8/8/18

Input Required in Yellow Cells

Barometric Pressure	WC
Initial	394.00
Final	394.00

Start Gauge Pressure	WC abs
	16.00

End Gauge Pressure	WC abs
	16.00

Start Temperature	Deg C	Deg K
	20.000	293.150

End Temperature	Deg C	Deg K
	20.000	293.150

Test Volume	51.97	CC
(calculated minimum)	51.87	CC

### Calculations for Formula

Allowable LR	1.00E-03	atm CC/Sec
Test P Differential	350	WC diff
Test Time	3600	Seconds
Standard Atm	407	WC

Initial Pressure	16.00	WC - ABS
Initial Pressure	-378.00	WC - Gauge

Final Pressure	16.00	WC - ABS
Final Pressure	-378.00	WC - Gauge

dP Due to Pressure Gauge change	
Delta Pressure G	0.00 WC

dP Due to Barometer change	
Delta Pressure T	0.00 WC

dP Due to temperature change	
Delta Pressure T	0.00 WC

	Pressure	B	Temp C	Temp comp P	Delta Time	Rej Pressure	LR
Start Time	2:18:00 PM	12/6/2021	16.00	394.00	20.000		
End Time	2:28:00 PM	12/6/2021	16.00	394.00	20.000	16.00	600
					600	31.26	0.00E+00
					10	Min	

Allowable LR	1.00E-03	atm CC/Sec	Minimum Test Sensitivity	8.50E-04	atm CC/Sec
Measured LR	0.00E+00	atm CC/Sec	Uncertainty	1.07E-08	atm CC/Sec

Reported LR	1.07E-08	atm CC/Sec	Accept if Green, Reject if Red	
Procedure: NDE-70 Rev:	7	Technique: PCMT	Rev:	0



Certificate Number: 4121/01

Accepted 12/6/21  
No leak detected at test sensitivity of <1.0E-3 atm\*cc/s  
Work Request 4360792

Digitally signed  
by Eric Vidal  
Date: 2021.12.14  
11:38:10 -05'00'

# PCMT Leak Test Calculator - Uncertainties Calculation Worksheet

DPP-1 TU-6 Operational Leak Test Supplement II

Calc. Version 8/8/18

Gauge	Identification	MTE #	FS Accuracy	FS/Act Rdg	Subdivisions	Units	
Pressure Gauge	Ashcroft HQS-2	A002500	0.025%	16.00	1	W/C	
Temperature Gauge	Omega HH804	A005945	0.40%	20	1	deg C	
Time Gauge	Computer Time	none	0.100%	60	1	Sec	
Reference Volume	50.72548	A001744	1.000%	51.97	0.1	CC	

Variable	acc*FS rdg	Traceability	Resolution	Total Variable u	
P	4.00E-03	2.27E-05	1.000	2.89E-01	IWC
T	8.00E-02	5.80E-02	1.00E+00	2.93E-01	deg C
t	6.00E-02	1.00E-03	1.00E+00	2.90E-01	Sec
V	5.20E-01	2.04E-01	0.10	2.81E-01	CC

## PCMT Gauge Resolution

	Formula	Calc
Pressure Resolution	$(Gres \times V) / (StdAtm \times t)$	2.12395E-04
Temperature Resolution	$\{ (Pi \times V) / (StdAtm \times t) \} \times (Tres / Ti)$	1.15924E-05
Time Resolution	$\{ [ (Pi \times (Tf / Ti) - Pf) \times V ] / (StdAtm \times Dtime) \} \times (t \text{ res} / (Dtime + t \text{ res}))$	0.00000E+00

2.1240E-04 Maximum PCMT Test Resolution

## Weighted Uncertainties

Initial Pressure	3.76E-09
Final Pressure	3.76E-09
Temp Final	1.15E-11
Temp Initial	3.68E-10
Volume	0.00E+00
Time	0.00E+00

Weighted U 1.07E-08

## PCMT Test Uncertainty

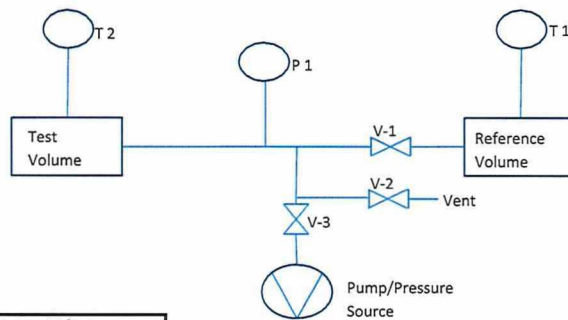
$$\sqrt{uP^2 + uV^2 + uT^2 + ut^2}$$

1.0659E-08

## System Under Test Volume Calc

DPP-1 TU-6 Operational Leak Test Supplement II

Calc. Version 8/8/18



### Steps for Determination of Test + System Volume

- Step 1 Vent test system  
Close V-3; Open Valves V-1 & V-2  
Wait for pressure to equalize
- Step 2 Record P-1 and T-1 as Ref P&T
- Step 3 Close V-2 (vent) and then close V-1, Isolating Reference volume
- Step 4 Open V-3; Pressurize/evacuate as needed to bring system to Start Pressure,
- Step 5 Close V-3; Wait for pressure to equalize
- Step 6 Record P-1 and T-2 as Start P&T
- Step 7 Open V-1; Exposing Reference Volume to the system  
Wait for pressure to equalize
- Step 8 As soon as pressure is equalized, record P-1, T-1 and T-2 as Equalized P&T  
  
Note: pressure may continue to drop if Test Volume has leaks, so record quickly
- Step 9 Repeat steps 1 through 8 a total of 6 times

Input Data in orange and yellow cells only!

Reference Volume	
Calibration Due Date:	8/14/2022
MTE Number	A001744
Volume	50.7255 CC

Gauge	P-1	T-1	P-1	T-2	P-1	T-1	T-2	
	Ref P&T		Start; Ref Vol Isolated		Equalized Pressure			
Run	P ref (PSIA)	T ref (deg C)	Pstart (PSIA)	Tvstart (deg C)	Peq (PSIA)	Teq (deg C)	Tveq (deg C)	Test Sys Vol (CC)
1	14.250	19.300	4.185	19.300	9.159	19.300	19.300	51.9187
2	14.250	19.300	5.913	19.300	10.033	19.300	19.300	51.9197
3	14.250	19.300	3.480	19.300	8.800	19.300	19.300	51.9650
4	14.250	19.300	3.974	19.300	9.049	19.300	19.300	51.9849
5	14.250	19.300	4.252	19.300	9.179	19.300	19.300	52.2080
6	14.250	19.300	5.635	19.300	9.888	19.300	19.300	52.0255

Test Volume	51.9749 CC	median
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0.1080 Std Dev
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Min Calculated Volume	51.8669 CC
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# PCMT Leak Test Calculator - Absolute P Gauge-Pchange (LR=SCC/S)

## DPP-1 TU-6 Operational Leak Test II

Calc. Version 8/8/18

Input Required in Yellow Cells

Barometric Pressure	WC
Initial	393.78
Final	393.79

Start Gauge Pressure	WC abs
	16.27

End Gauge Pressure	WC abs
	16.44

Start Temperature	Deg C	Deg K
	19.700	292.850

End Temperature	Deg C	Deg K
	19.800	292.950

Test Volume	51.97	CC
(calculated minimum)	51.87	CC

### Calculations for Formula

Allowable LR	1.00E-04	atm CC/Sec
Test P Differential	350	WC diff
Test Time	600	Seconds
Standard Atm	407	WC

Initial Pressure	16.27	WC - ABS
Initial Pressure	-377.51	WC - Gauge

Final Pressure	16.44	WC - ABS
Final Pressure	-377.35	WC - Gauge

dP Due to Pressure Gauge change	
Delta Pressure G	0.17 WC

dP Due to Barometer change	
Delta Pressure T	-0.01 WC

dP Due to temperature change	
Delta Pressure T	0.01 WC

	Pressure	B	Temp C	Temp comp P	Delta Time	Rej Pressure	LR
Start Time	2:18:00 PM	12/6/2021	16.27	393.78	19.700		
	2:21:00 PM	12/6/2021	16.33	393.79	19.700	16.13	4.25E-05
	2:23:00 PM	12/6/2021	16.36	393.79	19.800	17.02	3.59E-05
	2:25:00 PM	12/6/2021	16.39	393.79	19.800	17.32	3.47E-05
End Time	2:28:00 PM	12/6/2021	16.44	393.79	19.800	17.77	3.49E-05
					Delta Time	600 Sec	
						10 Min	

Allowable LR	1.00E-04	atm CC/Sec	Minimum Test Sensitivity	8.50E-06	atm CC/Sec
Measured LR	3.49E-05	atm CC/Sec	Uncertainty	2.87E-11	atm CC/Sec

Reported LR	3.49E-05	atm CC/Sec	Accept if Green, Reject if Red
Procedure: NDE-70 Rev:	7	Technique: PCMT	Rev: 0



Certificate Number: 4121/01

Accepted 12/6/21  
 <1.0E-4 atm\*cc/s air at test sensitivity of <5.0E-5 atm\*cc/s  
 Work Request 4360792

Eric  
Vidal

Digitally signed  
by Eric Vidal  
Date: 2021.12.14  
11:28:40 -05'00'



# PCMT Leak Test Calculator - Uncertainties Calculation Worksheet

DPP-1 TU-6 Operational Leak Test II

Calc. Version 8/8/18

Gauge	Identification	MTE #	FS Accuracy	FS/Act Rdg	Subdivisions	Units	
Pressure Gauge	Ashcroft HQS-2	A002500	0.025%	16.36	0.01	WC	
Temperature Gauge	Omega HH804	A005945	0.40%	19.7	0.1	deg C	
Time Gauge	Computer Time	none	0.100%	60	1	Sec	
Reference Volume	50.72548	A001744	1.000%	51.97	0.1	CC	

Variable	acc*FS rdg	Traceability	Resolution	Total Variable u	
P	4.09E-03	2.27E-05	0.010	3.54E-03	IWC
T	7.88E-02	5.80E-02	1.00E-01	5.68E-02	deg C
t	6.00E-02	1.00E-03	1.00E+00	2.90E-01	Sec
V	5.20E-01	2.04E-01	0.10	2.81E-01	CC

## PCMT Gauge Resolution

	Formula	Calc
Pressure Resolution	$(Gres \times V) / (StdAtm \times t)$	2.12395E-06
Temperature Resolution	$\{ (Pi \times V) / (StdAtm \times t) \} \times (Tres / Ti)$	1.18001E-06
Time Resolution	$\{ [ (Pi \times (Tf / Ti) - Pf) \times V ] / (StdAtm \times Dtime) \} \times (t \text{ res} / (Dtime + t \text{ res}))$	5.81151E-08

2.1240E-06 Maximum PCMT Test Resolution

## Weighted Uncertainties

Initial Pressure	5.65E-13
Final Pressure	5.65E-13
Temp Final	4.49E-13
Temp Initial	1.43E-11
Volume	3.57E-14
Time	2.67E-16

Weighted U 2.87E-11

## PCMT Test Uncertainty

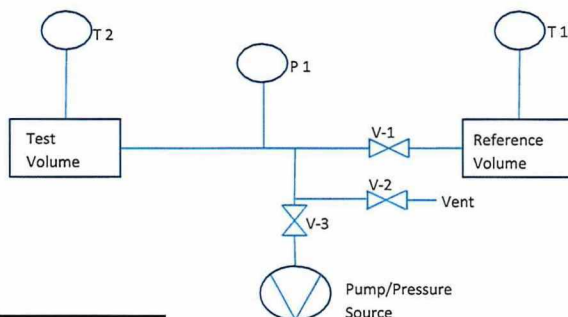
$$\sqrt{u_P^2 + u_V^2 + u_T^2 + u_t^2}$$

2.8725E-11

## System Under Test Volume Calc

DPP-1 TU-6 Operational Leak Test II

Calc. Version 8/8/18



### Steps for Determination of Test + System Volume

- Step 1 Vent test system  
Close V-3; Open Valves V-1 & V-2  
Wait for pressure to equalize
- Step 2 Record P-1 and T-1 as Ref P&T
- Step 3 Close V-2 (vent) and then close V-1, Isolating Reference volume
- Step 4 Open V-3; Pressurize/evacuate as needed to bring system to Start Pressure,
- Step 5 Close V-3; Wait for pressure to equalize
- Step 6 Record P-1 and T-2 as Start P&T
- Step 7 Open V-1; Exposing Reference Volume to the system  
Wait for pressure to equalize
- Step 8 As soon as pressure is equalized, record P-1, T-1 and T-2 as Equalized P&T  
  
Note: pressure may continue to drop if Test Volume has leaks, so record quickly
- Step 9 Repeat steps 1 through 8 a total of 6 times

Input Data in orange and yellow cells only!

Reference Volume	
Calibration Due Date:	8/14/2022
MTE Number	A001744
Volume	50.7255 CC

Gauge	P-1	T-1	P-1	T-2	P-1	T-1	T-2	
	Ref P&T		Start; Ref Vol Isolated		Equalized Pressure			
Run	P ref (PSIA)	T ref (deg C)	Pstart (PSIA)	Tvstart (deg C)	Peq (PSIA)	Teq (deg C)	Tveq (deg C)	Test Sys Vol (CC)
1	14.250	19.300	4.185	19.300	9.159	19.300	19.300	51.9187
2	14.250	19.300	5.913	19.300	10.033	19.300	19.300	51.9197
3	14.250	19.300	3.480	19.300	8.800	19.300	19.300	51.9650
4	14.250	19.300	3.974	19.300	9.049	19.300	19.300	51.9849
5	14.250	19.300	4.252	19.300	9.179	19.300	19.300	52.2080
6	14.250	19.300	5.635	19.300	9.888	19.300	19.300	52.0255

Test Volume	51.9749 CC	median
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0.1080 Std Dev
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Min Calculated Volume	51.8669 CC
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## LEAK TEST REPORT

Test Requested by: A. ADENIYI		Allowable Leak Rate: $< 2.0E-7$		Std-Atm-cc/s
Date Requested: 12/14/21		Date Required: -		
WO / Report Number: 4360792-1		Test Pressure Req. Across Boundary: -1 ATM ( $< 100$ MT)		
Item Tested: DPP-1, TU-5		Customer: NTRC		
Specification: ANSI N14.5	NDE 70, Rev: 7	Technique Used: Hood	Rev: 0	<input type="checkbox"/> Inside - Out <input checked="" type="checkbox"/> Outside - In

## EQUIPMENT

LEAK DETECTOR		STANDARD LEAK	
Make and Model: ADIXEN ASM 340	Manufacturer: VTI	Tracer Gas: He	
Serial Number: HLD 1601393	Model: GPPT-8-He-118T	Serial Number: TP5154	
		Leak Rate: $5.94E-8$ Atm-cc/s @ -1 atm @ 22.6 °C	
TEST GAUGES		Correlation Formula: [1 - (T <sub>cal</sub> - T <sub>surf</sub> ) C <sub>T</sub> ] LR	Temp Coefficient: $2.0\% / ^\circ C$
Temp Gauges: A005945	Due: 7/28/22	Correlated LR: $5.38E-8$ Atm-cc/s @ -1 atm @ 17.9 °C	
Pressure Gauges: A002500	Due: 6/28/22	Calibration Due Date: 02/10/22	

## RESULTS

☒ Quantitative ☐ Semi - Quantitative

MACHINE CALIBRATION		SYSTEM TEST CONDITIONS	
System Pressure: $1.3E-2$ mb		System Temperature: 16.9 °C	<input checked="" type="checkbox"/> Surface <input type="checkbox"/> Internal Gas
Background: $2.2E-10$	Atm-cc/s	delta P Test Boundary: -1 ATM	
Leak Response: $5.4E-8$	Atm-cc/s	Tracer Gas: He	% Concentration: 95
Minimum Detectable Leak: $1.0E-9$	Atm-cc/s	System Response Time: ~ 5 MIN	
System Sensitivity: $2.0E-9$	Atm-cc/s	System Response: $1.2E-7$	Atm-cc/s
Response Time: ~ 3s		Duration of Test: ~ 6 MIN	

Aux. Equipment:

☒ ACCEPT ☐ REJECT ☐ SKETCH / DATA ATTACHEDSystem Leak Rate:  $1.36E-7$  Atm-cc/s @ -1 atm @ 17 °C  
w/ stated tracer gas

COMMENTS:

$$PSCF = 5.4E-8 / (5.7E-8 - 3.8E-10) = 0.95$$

$$FSCF = 5.4E-8 / (1.7E-7 - 1.2E-7) = 1.08$$

$$F_{105} 1.1\% O_2 = 95\% He$$

$$\frac{1.2E-7 (1.08)}{0.95} = 1.36E-7$$

Test Conducted By:

E-VIOAZ

Level:

III

Date:

12/7/21

Time:

12/6





## LEAK TEST REPORT

Test Requested by: <u>A. ADENIYI</u>		Allowable Leak Rate: <u>&lt; 2.0E-7</u>		Std-Atm-cc/s
Date Requested: <u>12/14/21</u>		Date Required: <u>-</u>		
WO / Report Number: <u>4360792-2</u>		Test Pressure Req. Across Boundary: <u>-1 ATM (&lt;100MT)</u>		
Item Tested: <u>DPP-1, TU-3</u>		Customer: <u>NTRC</u>		
Specification: <u>ANSI N14.5</u>	NDE 70, Rev: <u>7</u>	Technique Used: <u>Hood</u>	Rev: <u>0</u>	<input type="checkbox"/> Inside - Out <input checked="" type="checkbox"/> Outside - In

## EQUIPMENT

LEAK DETECTOR		STANDARD LEAK	
Make and Model: <u>ADIXEN ASM 340</u>	Manufacturer: <u>VTI</u>	Tracer Gas: <u>He</u>	
Serial Number: <u>HLO 1601393</u>	Model: <u>GPPT-8-He-118T</u>	Serial Number: <u>TP5154</u>	
		Leak Rate: <u>5.94E-8</u> Atm-cc/s @ <u>-1 atm @ 22.6 °C</u>	
TEST GAUGES		Correlation Formula: [1 - (T <sub>cal</sub> - T <sub>sur</sub> ) C <sub>T</sub> ] LR	
Temp Gauges: <u>A005945</u>	Due: <u>7/28/22</u>	Temp Coefficient: <u>2.0</u> %/°C	
Pressure Gauges: <u>A002500</u>	Due: <u>6/28/22</u>	Correlated LR: <u>5.38E-8</u> Atm-cc/s @ <u>-1 atm @ 17.9 °C</u>	
		Calibration Due Date: <u>02/10/22</u>	

## RESULTS

☒ Quantitative ☐ Semi - Quantitative

MACHINE CALIBRATION		SYSTEM TEST CONDITIONS	
System Pressure: <u>1.3E-2 mb</u>		System Temperature: <u>16.9 °C</u>	<input checked="" type="checkbox"/> Surface <input type="checkbox"/> Internal Gas
Background: <u>2.2E-10</u>	Atm-cc/s	delta P Test Boundary: <u>-1 ATM</u>	
Leak Response: <u>5.4E-8</u>	Atm-cc/s	Tracer Gas: <u>He</u>	% Concentration: <u>78%</u>
Minimum Detectable Leak: <u>1.0E-9</u>	Atm-cc/s	System Response Time: <u>~ 5 MIN</u>	
System Sensitivity: <u>2.0E-9</u>	Atm-cc/s	System Response: <u>1.3E-8</u> Atm-cc/s	
Response Time: <u>~ 3s</u>		Duration of Test: <u>~ 6 MIN</u>	

Aux. Equipment:

☒ ACCEPT ☐ REJECT ☐ SKETCH / DATA ATTACHEDSystem Leak Rate: 1.67E-8 Atm-cc/s @ -1 atm @ 17 °C  
w/ stated tracer gas

COMMENTS:

$$PSCF = 5.4E-8 / (6.0E-8 - 4.5E-9) = 0.97$$

$$FSCF = 5.4E-8 / (6.7E-8 - 1.3E-8) = 1.0$$

$$4.6\% O_2 = 78\% He$$

$$\frac{1.3E-8 (1.0)}{.78} = 1.67E-8$$

Test Conducted By:

E. VIOAZLevel: IIIDate: 12/7/21Time: 1402





## LEAK TEST REPORT

Test Requested by: A. ADENIYI	Allowable Leak Rate: $< 2.0E-7$	Std-Atm-cc/s
Date Requested: 12/14/21	Date Required: -	
WO / Report Number: 4360792-3	Test Pressure Req. Across Boundary: -1 ATM ( $< 100$ MT)	
Item Tested: DPP-1, TU-2	Customer: NTRC	
Specification: ANSI N14.5	NDE 70, Rev: 7	Technique Used: Hood
	Rev: 0	<input type="checkbox"/> Inside - Out <input checked="" type="checkbox"/> Outside - In

## EQUIPMENT

LEAK DETECTOR	STANDARD LEAK
Make and Model: ADIXEN ASM 340	Manufacturer: VTI
Serial Number: H20 1601393	Tracer Gas: He
	Model: GPPT-8-He-118T
	Serial Number: TP5154
	Leak Rate: $5.94E-8$ Atm-cc/s @ -1 atm @ 22.6 °C
	Correlation Formula: $[1 - (T_{cal} - T_{surf}) C_T] LR$
	Temp Coefficient: $2.0\% / ^\circ C$
TEST GAUGES	
Temp Gauges: A005945	Due: 7/28/22
Pressure Gauges: A002500	Due: 6/28/22
	Correlated LR: $5.38E-8$ Atm-cc/s @ -1 atm @ 17.9 °C
	Calibration Due Date: 02/10/22

## RESULTS

☒ Quantitative ☐ Semi - Quantitative

MACHINE CALIBRATION	SYSTEM TEST CONDITIONS
System Pressure: $1.3E-2$ mb	System Temperature: 16.9 °C <input checked="" type="checkbox"/> Surface <input type="checkbox"/> Internal Gas
Background: $2.2E-10$ Atm-cc/s	delta P Test Boundary: -1 ATM
Leak Response: $5.4E-8$ Atm-cc/s	Tracer Gas: He
Minimum Detectable Leak: $1.0E-9$ Atm-cc/s	% Concentration: 67%
System Sensitivity: $2.0E-9$ Atm-cc/s	System Response Time: ~ 5 MIN
Response Time: ~ 3s	System Response: $2.5E-8$ Atm-cc/s
Aux. Equipment:	Duration of Test: ~ 6 MIN
<input checked="" type="checkbox"/> ACCEPT <input type="checkbox"/> REJECT <input type="checkbox"/> SKETCH / DATA ATTACHED	System Leak Rate: $3.73E-8$ Atm-cc/s @ -1 atm @ 17 °C

## COMMENTS:

$$P_{SLCF} = 5.4E-8 / (6.0E-8 - 5.6E-9) = 0.99$$

$$F_{SLCF} = 5.4E-8 / (7.9E-8 - 2.5E-8) = 1.0$$

$$7\% O_2 = 67\% He$$

$$\frac{2.5E-8(1.0)}{.67} = 3.73E-8$$

Test Conducted By:

E. VIOAR

Level: III

Date: 12/7/21

Time: 1513



## LEAK TEST REPORT

Test Requested by: A. ADENIYI		Allowable Leak Rate: $< 2.0E-7$ Std-Atm-cc/s	
Date Requested: 12/14/21		Date Required: -	
WO / Report Number: 4360792-4		Test Pressure Req. Across Boundary: -1 Atm (< 100 MT)	
Item Tested: DPP-1, TU-6		Customer: NTRC	
Specification: ANSI N14.5	NDE 70, Rev: 7	Technique Used: Hood	Rev: 0 <input type="checkbox"/> Inside - Out <input checked="" type="checkbox"/> Outside - In

## EQUIPMENT

LEAK DETECTOR		STANDARD LEAK	
Make and Model: ADIXEN ASM 340	Manufacturer: UTI	Tracer Gas: He	
Serial Number: HLD 1601393	Model: GPPT-8-He-118T	Serial Number: TP5154	
		Leak Rate: $5.44E-8$ Atm-cc/s @ -1 atm @ 22.6 °C	
TEST GAUGES		Correlation Formula: $[1 - (T_{cal} - T_{surf}) C_T] LR$	
		Temp Coefficient: $2.0 \% / ^\circ C$	
Temp Gauges: A005945	Due: 7/28/22	Correlated LR: $5.36E-8$ Atm-cc/s @ -1 atm @ 17.7 °C	
Pressure Gauges: A002500	Due: 6/28/22	Calibration Due Date: 02/10/22	

## RESULTS

☒ Quantitative ☐ Semi - Quantitative

MACHINE CALIBRATION		SYSTEM TEST CONDITIONS	
System Pressure: $1.5E-2$ mb		System Temperature: 18.7 °C	<input checked="" type="checkbox"/> Surface <input type="checkbox"/> Internal Gas
Background: $< 1.0E-10$ Atm-cc/s		delta P Test Boundary: -1 Atm	
Leak Response: $5.4E-8$ Atm-cc/s		Tracer Gas: He	% Concentration: 62%
Minimum Detectable Leak: $1.0E-9$ Atm-cc/s		System Response Time: ~ 5 MIN	
System Sensitivity: $2.0E-9$ Atm-cc/s		System Response: $3.3E-8$ Atm-cc/s	
Response Time: ~ 3s		Duration of Test: ~ 6 MIN	
Aux. Equipment:			

☒ ACCEPT ☐ REJECT ☐ SKETCH / DATA ATTACHEDSystem Leak Rate:  $5.06E-8$  Atm-cc/s @ -1 atm @ 19 °C  
w/ stated tracer gas

## COMMENTS:

$$PSCF = 5.4E-8 / (6.4E-8 - 6.3E-9) = 0.94$$

$$FSCF = 5.4E-8 / (9.0E-8 - 3.3E-8) = 0.95$$

$$8\% O_2 = 62\% He$$

$$\frac{3.3E-8 (0.95)}{0.62} = 5.06E-8$$

Test Conducted By:

E. VIOAL

Level:

TIP

Date:

12/8/21

Time:

0945





## LEAK TEST REPORT

Test Requested by: <u>A. ADENIYI</u>		Allowable Leak Rate: <u>&lt; 2.0E-7</u>		Std-Atm-cc/s
Date Requested: <u>12/14/21</u>		Date Required: <u>-</u>		
WO / Report Number: <u>4360792-5</u>		Test Pressure Req. Across Boundary: <u>-1 Atm (&lt; 100 mT)</u>		
Item Tested: <u>DPQ-1, TU-1</u>		Customer: <u>NTRC</u>		
Specification: <u>ANSI N14.5</u>	NDE 70, Rev: <u>7</u>	Technique Used: <u>Hood</u>	Rev: <u>0</u>	<input type="checkbox"/> Inside - Out <input checked="" type="checkbox"/> Outside - In

## EQUIPMENT

LEAK DETECTOR		STANDARD LEAK	
Make and Model: <u>ADIXEN ASM 340</u>	Manufacturer: <u>VTI</u>	Tracer Gas: <u>He</u>	
Serial Number: <u>H20 1601393</u>	Model: <u>GPPT-8-He-118T</u>	Serial Number: <u>TPS154</u>	
		Leak Rate: <u>5.94E-8</u> Atm-cc/s @ <u>-1 atm @ 22.6 °C</u>	
TEST GAUGES		Correlation Formula: [1 - (T <sub>cal</sub> - T <sub>surf</sub> ) C <sub>T</sub> ] LR	Temp Coefficient: <u>2.0</u> %/°C
Temp Gauges: <u>A005945</u>	Due: <u>7/28/22</u>	Correlated LR: <u>5.36E-8</u> Atm-cc/s @ <u>-1 atm @ 17.7 °C</u>	
Pressure Gauges: <u>A002500</u>	Due: <u>6/28/22</u>	Calibration Due Date: <u>02/10/22</u>	

## RESULTS

☒ Quantitative ☐ Semi - Quantitative

MACHINE CALIBRATION		SYSTEM TEST CONDITIONS	
System Pressure: <u>1.5E-2 mb</u>		System Temperature: <u>18.7 °C</u>	<input checked="" type="checkbox"/> Surface <input type="checkbox"/> Internal Gas
Background: <u>&lt; 1.0E-10</u>	Atm-cc/s	delta P Test Boundary: <u>-1 Atm</u>	
Leak Response: <u>5.4E-8</u>	Atm-cc/s	Tracer Gas: <u>He</u>	% Concentration: <u>74</u>
Minimum Detectable Leak: <u>1.0E-9</u>	Atm-cc/s	System Response Time: <u>~ 5 MIN</u>	
System Sensitivity: <u>2.0E-9</u>	Atm-cc/s	System Response: <u>4.3E-8</u> Atm-cc/s	
Response Time: <u>~ 3s</u>		Duration of Test: <u>~ 6 MIN</u>	

Aux. Equipment:

☒ ACCEPT ☐ REJECT ☐ SKETCH / DATA ATTACHEDSystem Leak Rate: 5.5E-8 Atm-cc/s @ -1 atm @ 19 °C  
w/ stated tracer gas

COMMENTS:

$$P_{SLCF} = 5.4E-8 / (6.4E-8 - 2.7E-9) = .90$$

$$F_{SLCF} = 5.4E-8 / (1.0E-7 - 4.3E-8) = .95$$

$$5.5\% O_2 = 74\% He$$

$$\frac{4.3E-8 (.95)}{.74} = 5.5E-8$$

Test Conducted By:

E-VIOMLevel: IIIDate: 12/8/21Time: 1130



## LEAK TEST REPORT

Test Requested by: A. ADENIYI	Allowable Leak Rate: $< 2.0E-7$ Std-Atm-cc/s
Date Requested: 12/14/21	Date Required: -
WO / Report Number: 4360792 -6	Test Pressure Req. Across Boundary: -1 Atm ( $< 100$ mT)
Item Tested: DPP-1, TU-4	Customer: NTRC
Specification: ANSI N14.5	NDE 70, Rev: 7
Technique Used: Hood	Rev: 0
	<input type="checkbox"/> Inside - Out <input checked="" type="checkbox"/> Outside - In

## EQUIPMENT

LEAK DETECTOR	STANDARD LEAK	
Make and Model: AOXEN ASM 340	Manufacturer: VTI	Tracer Gas: He
Serial Number: HLD 1601393	Model: GPPT-8-He-118T	Serial Number: TPS154
	Leak Rate: $5.94E-8$ Atm-cc/s @ -1 atm @ 22.6 °C	
TEST GAUGES	Correlation Formula: [1 - (T <sub>cal</sub> - T <sub>sur</sub> ) C <sub>T</sub> ] LR	Temp Coefficient: $\pm 2.0$ %/°C
Temp Gauges: A005945	Due: 7/28/22	Correlated LR: $5.36E-8$ Atm-cc/s @ -1 atm @ 17.7 °C
Pressure Gauges: A002500	Due: 6/28/22	Calibration Due Date: 02/10/22

## RESULTS

☒ Quantitative ☐ Semi - Quantitative

MACHINE CALIBRATION	SYSTEM TEST CONDITIONS	
System Pressure: $1.5E-2$ mb	System Temperature: 18.7 °C	<input checked="" type="checkbox"/> Surface <input type="checkbox"/> Internal Gas
Background: $< 1.0E-10$ Atm-cc/s	delta P Test Boundary: -1 Atm	
Leak Response: $5.4E-8$ Atm-cc/s	Tracer Gas: He	% Concentration: 71%
Minimum Detectable Leak: $1.0E-9$ Atm-cc/s	System Response Time: ~ 5 MIN	
System Sensitivity: $2.0E-9$ Atm-cc/s	System Response: $3.4E-8$ Atm-cc/s	
Response Time: ~ 3s	Duration of Test: ~ 6 MIN	

Aux. Equipment:

☒ ACCEPT ☐ REJECT ☐ SKETCH / DATA ATTACHEDSystem Leak Rate:  $4.5E-8$  Atm-cc/s @ -1 atm @ 19 °C  
w/ stated tracer gas

COMMENTS:

$$PSCF = 5.4E-8 / (5.9E-8 - 2.1E-9) = .95$$
$$FSCF = 5.4E-8 / (8.5E-8 - 3.4E-8) = .95$$

6% OL = 71% He

$$\frac{3.4E-8 (.95)}{.71} = 4.5E-8$$

Test Conducted By:

EVIDAL

Level: III

Date: 12/8/21

Time: ~ 1415



# PRESSURE TEST REPORT

ITEM TESTED: <u>DPP-1, TU-7</u>		MJR NUMBER: <u>4360792</u>		LOCATION: (if installed) <u>NTRC-II</u>			
TEST PRESSURE REQUIRED: <u>21.7 PSIG</u>		SAFETY WORK PERMIT NO. (if required): <u>—</u>		DRAWING NUMBER: <u>—</u>			
TEST PRESSURE REQUIRED: <u>21.7 PSIG</u>		SAFETY WORK PERMIT NO. (if required): <u>—</u>		CHARGE NUMBER: <u>—</u>			
TEST PRESSURE REQUIRED: <u>21.7 PSIG</u>		SAFETY WORK PERMIT NO. (if required): <u>—</u>		PRESSURE SOURCE USED: <u>PNEU-PUMP MTE-689</u>			
TEST PRESSURE REQUIRED: <u>21.7 PSIG</u>		SAFETY WORK PERMIT NO. (if required): <u>—</u>		TEST REQUESTED BY: <u>A. ADENIYI</u>			
TEST MEDIUM: <input checked="" type="checkbox"/> WATER <input type="checkbox"/> NITROGEN <input type="checkbox"/> AIR <input type="checkbox"/> OTHER _____							
LEAK TEST METHOD USED: <input type="checkbox"/> VISUAL <input type="checkbox"/> ULTRASONIC <input type="checkbox"/> BUBBLE <input type="checkbox"/> PRESSURE DECAY <u>N/A</u>							
<b>PRE-TEST CHECKLIST</b>							
OVER-PRESSURE PROTECTION REQUIRED: <input checked="" type="checkbox"/> YES <input type="checkbox"/> NO							
WELDED JOINTS PAINTED OR INSULATED: <input type="checkbox"/> YES <input checked="" type="checkbox"/> NO							
HAS AIR BEEN BLED FROM VESSEL (HYDROSTATIC TEST ONLY): <input checked="" type="checkbox"/> YES <input type="checkbox"/> NO							
<b>TEST GAUGE DATA</b>							
		SERIAL NUMBER	MANUFACTURER	CAL. DATE	RANGE	SUBDIVISIONS	
PRESSURE GAUGE #1		<u>MTE-767</u>	<u>WIKA</u>	<u>7/20/20</u>	<u>0-100</u> psig	<u>0.01</u> psig	
PRESSURE GAUGE #2					psig	psig	
TEMPERATURE GAUGE		<u>A005945</u>	<u>OMEGA</u>	<u>DUE 8/28/22</u> <u>EZ</u>	<u>K-TYPE</u> °F	<u>0.1</u> °F	
<b>TEST RESULTS</b>							
TIME	PRESSURE	TEMPERATURE	INITIALS	TIME	PRESSURE	TEMPERATURE	INITIALS
	GAUGE #1 GAUGE #2				GAUGE #1 GAUGE #2		
<u>0820</u>	<u>22.35</u> psig	<u>63.7</u> °F	<u>EZ</u>		psig	°F	
<u>1620</u>	<u>23.60</u> psig	<u>64.8</u> °F	<u>EZ</u>		psig	°F	
	psig	°F			psig	°F	
	psig	°F			psig	°F	
INITIAL METAL TEMPERATURE _____ °F + 460 = _____ °R				FINAL METAL TEMPERATURE _____ °F + 460 = _____ °R			
Final Pressure (psig) $\left[ \frac{\text{Initial Temperature (Degrees R)}}{\text{Final Temperature (Degrees R)}} \right]$ - Adjusted Pressure (psig)				_____ psig $\left[ \frac{\text{Degrees R INITIAL}}{\text{Degrees R FINAL}} \right]$ = _____ psig			
FINAL ADJUSTED PRESSURE = _____ (psig)*				FOR PNEUMATIC TEST ONLY POST TEST CALIBRATION ACCEPTABLE: <input type="checkbox"/> YES <input type="checkbox"/> NO <input type="checkbox"/> N/A (Require for single gauge tests)			
TEST RESULTS: <input checked="" type="checkbox"/> ACCEPTABLE <input type="checkbox"/> UNACCEPTABLE							
REMARKS: <u>50 FT IMMERSION TEST</u>							
INSPECTOR (Print & Sign Name, Level) <u>E. VIOAL</u> <u>[Signature]</u> <u>LT LIII</u>						Date: <u>12/13/21</u>	

\* For Pneumatic Test Only.

## PRESSURE GAGE CALIBRATION DATA SHEET

DUT M&TE # <b>767</b>	Range 0-100 psig	Manufacturer <b>WIKI</b>
Calibration Frequency <b>AFTER USE</b>	Scale Subdivisions <b>101 PSI</b>	Accuracy (%Span 1/4 - 1/2 - 1/4) <b>Grade B: 3 - 2 - 3</b>
Calibrator Used <b>BEAMEX</b>	<b>M301752</b>	Calibration Date <b>11-12-19</b>
Calibrator Pressure Module <b>BEAMEX</b>	<b>A006778</b>	Calibration Date <b>10-17-19</b>

Visual Inspection:

☒ Accept☐ Reject

	DUT		Standard Gage	Allowed Error
	Scale	Reading		
UP	0%	0	0	3.0
	25%	25	25.1	2.0
	50%	50	50.4	2.0
	75%	75	75.5	2.0
	100%	100	100.8	3.0
Down	100%	100	100.8	3.0
	75%	75	75.2	2.0
	50%	50	49.23	2.0
	25%	25	25.06	2.0
	0%	0	0	3.0

Circle any non-conforming readings

Note: all readings in PSIG

Disposition:

☒ Accept☐ Reject☐ If Rejected was tag applied

Adjustment Necessary:

☐ Yes☒ No

Decal Applied:

☒ Yes☐ No

Inspector:

**B. Brown**

Date:

**7-20-20**

## CERTIFICATE OF CALIBRATION

Calibration Report Number: TP5154-AC3-132567542737166613

Customer: OAK RIDGE NATIONAL LABORATORY

One Bethel Valley Road  
Bldg 5510A, RM 208, MS6366  
Oak Ridge, TN USA 37830-6366

Customer Purchase Order Number: CC - Keck

Order Number: 17731BR03

### MODEL NUMBER AND/OR DESCRIPTION

GPPT-8-HE-118T

### SERIAL NUMBER

TP5154

### CALIBRATION RESULTS

The unit specified was calibrated using the calibration procedure defined below and was within the manufacturer's specifications in the 'As Found' condition. The "As Left" flow rate is the same as the "As Found" flow rate. No repairs or adjustments were required.

### ISO/IEC17025:2017 DECISION RULE DEFINITION

The Unit Under Test (UUT) is considered IN SPECIFICATION if the As Found Leak Rate is within the customer-specified Acceptable Leak Rate Range. The UUT is considered IN TOLERANCE if the As Found Leak Rate measurement uncertainty banding overlaps the previous calibration measurement uncertainty banding with an additional 15% non-metrology use allowance. A UUT is deemed acceptable if it is both IN SPECIFICATION and IN TOLERANCE.

### METHODS AND EQUIPMENT

The unit was calibrated by a traceable comparison against a primary transfer standard on an Automated AERO VAC Mass Spectrometer System (AutoCal) using Calibration Procedure VTI-QAP-11-001, Rev G.


*Procedures used are in accordance with and accredited to ISO/IEC 17025:2017. Additionally, the procedures used are in compliance with ANSI/NCSL Z540-1-1994.*

### MEASUREMENT TRACEABILITY

All measurement and test equipment (M&TE) as well as all primary transfer standards are calibrated traceable to National Metrology Institutes with Mutual Recognition Arrangements (NMI/MRA). The Calibrated Leak Laboratory maintains all relevant calibration records for the M&TE and primary transfer standards used. Spinning rotor gauges, capacitance manometers, temperature measurement devices, and reference volumes are NMI/MRA traceable. Time measurements are traceable through the U.S. Naval Observatory Master Clock.

### MEASUREMENT UNCERTAINTY

The total estimated measurement uncertainty for this calibration, as reported on Page 2 of this Certificate of Calibration, reflects a coverage factor of 2 ( $k=2$ ) which reflects a 95% confidence interval. The reported estimated measurement uncertainty is calculated in accordance with NIST Technical Note 1297, 1994 Edition, *Guidelines for Evaluating and Expressing the Uncertainty of NIST Measurement Results*.

  
Calibration Lab Technician

 2-10-2021  
Calibration Lab Approver  
Date: 10-Feb-2021



**Vacuum Technology**  
INCORPORATED

## CERTIFICATE OF CALIBRATION

### Vacuum Technology Inc.

1003 Alvin Weinberg Drive  
Oak Ridge, TN 37830  
Phone: (865) 481-3342



#### Accu-Flow Calibrated Leak

Model #: GPPT-8-HE-118T

Element : FEP Teflon

Fill Gas: Helium

Serial #: TP5154

Fill Pressure: 2163 Torr

Volume: 110cc

#### Calibration Data

LR =  $5.94 \times 10^{-8}$  atm-cc/s into vac. at 22.6C

n =  $2.40 \times 10^{-12}$  mol/s ( $\pm 7.4\%$ ) (k=2)

Depletion Rate: 0.6% Per Year

Calibration Date: Feb 10, 2021 Due: 2/10/2022

Temp Coeff: 2.0% per C

#### Warning!!

Do not bake!

#### VTI Recalibration Service

Phone: (865) 481-3342

Email: sales@vacuumtechnology.com

For permeation leaks, the isolation valve  
should be left open when not in use  
to prevent saturation of the teflon element.

#### Calibration Report Number

TP5154-AC3-132567542737166613

#### Customer

OAK RIDGE NATIONAL LABORATORY

#### Order ID

17731BR03

#### Purchase Order

CC - Keck

#### Recalibration ID

#### Pressure Measurement Equip.

Manufacturer	-
Model#	-
Serial#	-
Report # :	-
Cal Date :	-
Cal Due :	-

#### Volume Standard

Manufacturer	-
Model#	-
Serial#	-
Report # :	-
Cal Date :	-
Cal Due :	-

#### Primary Transfer Flow Standard

Manufacturer	VTI
Leak Model#	CLP-8-1P-HE-4MVCR-110CC-NV-IHS
Leak Serial#	903
Report # :	903-MSL-ROR-1-20201222163324
Cal Date:	December 22, 2020
Cal Due :	December 22, 2021
Cal Temp (°C):	20.8
Coeff (%/°C) :	4.0%
Gas Type	He
Q (atm-cc/s)	2.01E-08

#### Temperature Measurement Equip.

Manufacturer	Athena
Model#	16C-B-B-30-00
Serial#	0743000336
Report # :	1000459644
Cal Date :	September 18, 2020
Cal Due :	September 17, 2021

\*\* This Certificate shall not be reproduced, except in full, without prior written approval of Vacuum Technology Incorporated, 1003 Alvin Weinberg Drive, Oak Ridge, Tennessee 37830. \*\*



## **U. APPENDIX MEASURING AND TEST EQUIPMENT**

DPP-1 Calibrated Equipment List									
PTP Calibrated Equipment Description	Mfg. Serial Number	ORNL Tag Number	Calibration Date	Calibration Due Date	Old Status	2020 Calibration Status	Calibration Location	Storage Area	Comments
Fluke 52 II Thermometer	40010294WS	A006681	5/12/2021	5/12/2022	Current	Current	ORNL I&C Lab	NTRC PEF 2360HVC Room L-110	Cal. record on hand. Reference PTP-R-056.
Thermal DAQ System TC Box M303131 Model No. NI cDAQ 9184	01868499	M303131	4/12/2021	4/12/2022	Current	Current	ORNL I&C Lab	NTRC PEF 2360HVC Room L-110	Cal. record on hand - Calibrated per Work Orders 3965466 & 4207229. See PTP Record Number: PTP-R-053.
Thermal DAQ System TC Box M305811 Model No: NI cDAQ 9179	01EC3ABB	M305811	5/18/2021	5/18/2022	Current	Current	ORNL I&C Lab	NTRC PEF 2360HVC Room L-110	Cal. record on hand - Calibrated per Work Order 4207229. See PTP Record Number: PTP-R-057.
Digital Level (6") Wedge Innovations Model: Smart Tool	N/A	M212348	2/23/2021	2/23/2022	Current	Current	Metrology Lab	NTRC PEF 2360HVC Room L-110	Cal. record on hand Reference PTP-R-056.
Torque Wrench (Snap-On Model Tech2R100 - 5 lbf-ft - 100lbf-ft)	0810601588	A001096	2/10/2021	2/10/2022	Current	Current	Metrology Lab	NTRC PEF 2360HVC Room L-110	Cal. record on hand. Reference PTP-R-056.
Torque Wrench (Snap-On Tech1FRM240 - 24 lbf-in 240 lbf-in)	0212800465	A001320	2/11/2021	2/11/2022	Current	Current	Metrology Lab	NTRC PEF 2360HVC Room L-110	Cal. record on hand. Reference PTP-R-056.
Intercomp platform Scale Model CW250 (2000 lbs)	23192515	X-502322	2/17/2021	2/17/2022	Current	Current	On-site @ NTRC	NTRC PEF 2360HVC Room L-110	Cal. record on hand. Reference PTP-R-056.
Rod 1 m (36") Length Standard	N/A	A001146	2/24/2021	2/24/2026	Current	Current	Metrology Lab	NTRC PEF 2360HVC Room L-110	Cal. record on hand. Reference PTP-R-056.
Rod 1.2 m (48") Length Standard	N/A	A000885	2/24/2021	2/24/2026	Current	Current	Metrology Lab	NTRC PEF 2360HVC Room L-110	Cal. record on hand. Reference PTP-R-056.
Mitutoyo 18" Digital Caliper	0021988	A001319	2/23/2021	2/23/2022	Current	Current	Metrology Lab	NTRC PEF 2360HVC Room L-110	Cal. record on hand. Reference PTP-R-056.
Puncture Bar - 6.077/6.051 OD. X 0.25 Corner Radius	N/A	A000883	3/15/2018	3/15/2023	Current	Current	On-site @ NTRC	NTRC PEF 2360HVC Room L-110	Cal. record on hand. Change custodium to Oscar. Some of the radius has damaged areas. Reference PTP-R-056.
Penetration Bar/Puncture Bar - 1.25" OD. X 0.625 Radius	N/A	A000884	2/25/2021	2/25/2026	Current	Current	On-site @ NTRC	NTRC PEF 2360HVC Room L-110	Cal. record on hand. Reference PTP-R-056.
40' tape measure Stanley 33-740	N/A	A006327	3/20/2018	3/20/2023	Current	Current	Metrology Lab	NTRC PEF 2360HVC Room L-110	Cal. record on hand. Reference PTP-R-056.
Compression Tester (Lansmont Compression Test System Model 152-30K SN 1999)	1999	N/A	3/30/2021	3/30/2022	Current	Current	On-site @ NTRC	NTRC PEF 2360HVC Room L-110	Cal. record on hand. Machine SN. 1999 - System Calibrated 152-30K Compression Test System - Lansmont Dactron Calibration Certificate Cert No. 03102020-1999 - Force 3000 lbf - 30,000 lbf Compression. Reference PTP-R-056.
Vibration Table (Lansmont Shaker Controller Model 10000 TTV2 Unit No. 11000 SN 10795658)	10795658	N/A	3/30/2021	3/30/2022	Current	Current	On-site @ NTRC	NTRC PEF 2360HVC Room L-110	Cal. record on hand. SN 10795658 - System Calibrated LDS Dactron Laser USB Shaker Controller - Unit No. 11000 - Lansmont Dactron Calibration Certificate No. 03102020 -10795658. Reference PTP-R-056.
Nathan Wood - TTAC Lab - HAC Cold Test									

ESPEC Environmental Chamber Vaisala Humidity & Temperature Transmitter - Model No. HMT335 - Calibration Certificate No.'s: 201027-HMT335-P4150350 & 201102-HMT335-P4150350	P4150350	N/A	10/27/2020	10/27/2021	Current	Current	Off-site Vendor	Bldg. 6000 Room T109	Cal. Record on hand. Reference Vaisala Accreditation Certificate of Calibration - Calibration Certificate No.ABOS204540001 See PTP Record Id. No: PTP-R-063
<b>Immersion Test - 3 Ft.</b>									
Fluke 52 II Thermometer	40010294W5	A006681	5/12/2021	5/12/2022	Current	Current	Metrology Lab	NTRC PEF 2360HVC Room L-110	PTP Equipment. Cal. record on hand. Reference PTP-R-056.
40' tape measure Stanley 33-740	N/A	A006327	3/20/2018	3/20/2023	Current	Current	Metrology Lab	NTRC PEF 2360HVC Room L-110	PTP Equipment. Cal. record on hand. Reference PTP-R-056.
Tank 1	N/A	N/A	N/A	N/A	N/A	N/A	N/A	NTRC PEF 2360HVC Room L-110	PTP Equipment. No Calibration Required.
Tank 2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	NTRC PEF 2360HVC Room L-110	PTP Equipment. No Calibration Required.
<b>Immersion Test - 50 Ft.</b>									
Deep Water Submersion Test Vessel	N/A	N/A	N/A	N/A	N/A	N/A	N/A	NTRC PEF 2360HVC Room L-110	PTP Equipment. Refer to Deep Water Submersion Vessel Design Summary Report - Dr. Mark Lower May, 21, 2020 PTP-R-052
40' tape measure Stanley 33-740	N/A	A006327	3/20/2018	3/20/2023	Current	Current	Metrology Lab	NTRC PEF 2360HVC Room L-110	Cal. record on hand. PTP equipment. Reference PTP-R-056.
Pressure Gage - Wika 0-100 PSIG	MTE767	MTE767	Pre Cal. Date 07-20-20	Post Cal. Date 01-27-2022	Current	Current	F&O S&I Group	F&O S&I Group	Cal. Record on hand. F&O S&I equipment. Reference PTP-R-071.
Temperature Gauge Omega	170203	A005945	7/28/2021	7/28/2022	Current	Current	Metrology Lab	F&O S&I Group	Cal. Record on hand. F&O S&I equipment. Reference PTP-R-071.
<b>ORNL IOSD S&amp;I NDT Leak Test Equipment Operational Pressure Change</b>									
Calibrator - Ashcroft Model ATE-100	13549	A001068	7/21/2021	7/21/2022	Current	Current	Metrology Lab	F&O S&I Group	Cal. record on hand. Reference PTP-R-060.
Pressure Module - Ashcroft AQS-2	39666	A001069	6/24/2021	6/24/2022	Current	Current	Metrology Lab	F&O S&I Group	Cal. record on hand. Reference PTP-R-060.
Sample Cylinder Model SS-4CS-TW-50 Calibrated Reference Volume	952946001	A001744	8/14/2020	8/14/2022	Current	Current	Metrology Lab	F&O S&I Group	Cal. record on hand. Reference PTP-R-060.
Pressure Gauge - Ashcroft HQS-2 SN HQS-59729	HQS-59729	A002500	6/28/2021	6/28/2022	Current	Current	Metrology Lab	F&O S&I Group	Cal. Record on hand. Reference PTP-R-060.
Temperature Gauge - Omega Thermometer Model HH804	170203	A005945	7/28/2021	7/28/2022	Current	Current	Metrology Lab	F&O S&I Group	Cal. record on hand. Reference PTP-R-060.
<b>ORNL IOSD S&amp;I NDT Leak Test Equipment He Leak Test</b>									
Pressure Gauge - Ashcroft HQS-2 SN HQS-59729	HQS-59729	A002500	6/28/2021	6/28/2022	Current	Current	Metrology Lab	F&O S&I Group	Cal. Record on hand. Reference PTP-R-071.
Temperature Gauge - Omega Thermometer Model HH804	170203	A005945	7/28/2021	7/28/2022	Current	Current	Metrology Lab	F&O S&I Group	Cal. record on hand. Reference PTP-R-060.
Leak Detector - Adixen Model ASM 340	HLD-1601393	N/A	N/A	N/A	Current	Current	N/A	F&O S&I Group	Machine is calibrated by the NDE examiner prior to use with a calibrated leak. Equipment was in working order with no issues or complications.
VTI Model GPPT-8-He-118T	TP5154	N/A	2/10/2021	1/28/2021	Current	Current	Off Site Vendor	F&O S&I Group	Cal. Record on hand. Reference PTP-R-071. See VTI Cal. Report No. TP5154-Ac3-132567542737166613. Equipment was in working order with no issues or complications.
<b>Accelerometers - TU-1, TU-2, TU-5 &amp; TU-6</b>									
Blake VanHoy									
ICP Triaxial Accelerometer - PCB Piezotronics Model No. 350B44 Used on DPP-1 CTU-6 Position 270.1 X,Y,Z	66351	N/A	5/19/2021	5/19/2022	Used on DPP-1	Off Site Vendor	5800 I&C Lab D203	5800 I&C Lab D203	CTU-6: 04' Slap Down Drop - 10/11/2021 6: 30' Drop - 10/11/2021 No Data due to Power Failure 30' Crush - 10/11/2021 Meter Puncture - 10/11/2021 PTP-R-058. CTU-6: 1 Reference

ICP Triaxial Accelerometer - PCB Piezotronics Model No. 350B44 Used on DPP-1 CTU-2 Position 270.1 X,Y,Z	66491	N/A	5/19/2021	5/19/2022	Used on DPP-1	Off Site Vendor	5800 I&C Lab D203	5800 I&C Lab D203	CTU-2: 04' Drop - 10/11/2021 2: 30' Drop - 10/22/2021 2: 30' Crush - 10/22/2021 1 Meter Puncture - 10/22/2021 PTP-R-058.	CTU- CTU-2: Reference
ICP Triaxial Accelerometer - PCB Piezotronics Model No. 350B44 Used on DPP-1 CTU-5 Position 90.1 X,Y,Z	66493	N/A	5/19/2021	5/19/2022	Used on DPP-1	Off Site Vendor	5800 I&C Lab D203	5800 I&C Lab D203	CTU- 5 Chilled Drops CTU-5: 04' Drop - 10/20/2021 5: 30' Drop - 10/20/2021 - No Data due to Power Failure CTU-5: 30' Crush - 10/20/2021 CTU-5: 1 Meter Puncture - 10/20/2021 PTP-R-058.	CTU- Reference
ICP Triaxial Accelerometer - PCB Piezotronics Model No. 350B44 Used on DPP-1 CTU-6 Position 90.2 X,Y,Z	66494	N/A	5/19/2021	5/19/2022	Used on DPP-1	Off Site Vendor	5800 I&C Lab D203	5800 I&C Lab D203	CTU-6: 04' Slap Down Drop - 10/11/2021 6: 30' Drop - 10/11/2021 No Data due to Power Failure CTU-6: 30' Crush - 10/11/2021 CTU-6: 1 Meter Puncture - 10/11/2021 PTP-R-058.	CTU- Reference
ICP Triaxial Accelerometer - PCB Piezotronics Model No. 350B44 Used on DPP-1 CTU-5 Position 270.1 X,Y,X	66495	N/A	5/18/2021	5/18/2022	Used on DPP-1	Off Site Vendor	5800 I&C Lab D203	5800 I&C Lab D203	CTU-5 Chilled Drops CTU-5: 04' Drop - 10/20/2021 5: 30' Drop - 10/20/2021 - No Data due to Power Failure CTU-5: 30' Crush - 10/20/2021 CTU-5: 1 Meter Puncture - 10/20/2021 Reference PTP-R-058.	CTU- Reference
ICP Triaxial Accelerometer - PCB Piezotronics Model No. 350B44 Used on DPP-1 CTU-2 Position 90.1 X,Y,Z	66350	N/A	6/4/2021	6/4/2022	Used on DPP-1	Off Site Vendor	5800 I&C Lab D203	5800 I&C Lab D203	CTU-2: 04' Drop - 10/11/2021 2: 30' Drop - 10/22/2021 30' Crush - 10/22/2021 Meter Puncture - 10/22/2021 056.	CTU- CTU-2: CTU-2: 1 Reference PTP-R-
ICP Triaxial Accelerometer - PCB Piezotronics Model No. 350B44 Used on DPP-1 CTU-1 Position 90.1 X,Y,Z	66488	N/A	5/18/2021	5/18/2022	Used on DPP-1	Off Site Vendor	5800 I&C Lab D203	5800 I&C Lab D203	CTU-1 Chilled Drops CTU-1: 04' Drop - 10/20/2021 CTU-1: 30' Drop - 10/20/2021 CTU-1: 30' Crush - 10/20/2021 CTU-1: 1 Meter Puncture - 10/20/2021 PTP-R-056.	Reference
ICP Triaxial Accelerometer - PCB Piezotronics Model No. 350B44 Used on DPP-1 CTU-1 Position 270.1 X,Y,Z	66489	N/A	5/18/2021	5/18/2022	Used on DPP-1	Off Site Vendor	5800 I&C Lab D203	5800 I&C Lab D203	CTU-1 Chilled Drops CTU-1: 04' Drop - 10/20/2021 CTU-1: 30' Drop - 10/20/2021 CTU-1: 30' Crush - 10/20/2021 CTU-1: 1 Meter Puncture - 10/20/2021 PTP-R-056.	Reference
ICP Triaxial Accelerometer - PCB Piezotronics Model No. 350B44 Used on DPP-1 CTU-1 Position 90.1 X,Y,Z & 90.2 X,Y,Z	66490	N/A	5/18/2021	5/18/2022	Used on DPP-1	Off Site Vendor	5800 I&C Lab D203	5800 I&C Lab D203	CTU-1 Chilled Drops CTU-1: 04' Drop - 10/20/2021 1: 30' Drop - 10/20/2021 30' Crush - 10/20/2021 Meter Puncture - 10/20/2021 058.	CTU- CTU-1: CTU-1: 1 Reference PTP-R-
ICP Triaxial Accelerometer - PCB Piezotronics Model No. 350B44 Used on DPP-1 CTU-2 Position 270.2 X,Y,Z	66565	N/A	5/18/2021	5/18/2022	Used on DPP-1	Off Site Vendor	5800 I&C Lab D203	5800 I&C Lab D203	CTU-2: 04' Drop - 10/11/2021 2: 30' Drop - 10/22/2021 30' Crush - 10/22/2021 Meter Puncture - 10/22/2021 058.	CTU- CTU-2: CTU-2: 1 Reference PTP-R-
ICP Triaxial Accelerometer - PCB Piezotronics Model No. 350B44 Used on DPP-1 CTU-6 Position 90.1 X,Y,Z	66567	N/A	5/18/2021	5/18/2022	Used on DPP-1	Off Site Vendor	5800 I&C Lab D203	5800 I&C Lab D203	CTU-6: 04' Slap Down Drop - 10/11/2021 6: 30' Drop - 10/11/2021 No Data due to Power Failure CTU-6: 30' Crush - 10/11/2021 1 Meter Puncture - 10/11/2021 058.	CTU- CTU- CTU-6: Reference PTP-R-
ICP Triaxial Accelerometer - PCB Piezotronics Model No. 350B44 Used on DPP-1 CTU-5 Position 90.2 X,Y,Z	66667	N/A	5/18/2021	5/18/2022	Used on DPP-1	Off Site Vendor	5800 I&C Lab D203	5800 I&C Lab D203	CTU-5 Chilled Drops CTU-5: 04' Drop - 10/20/2021 5: 30' Drop - 10/20/2021 - No Data due to Power Failure CTU-5: 30' Crush - 10/20/2021 CTU-5: 1 Meter Puncture - 10/20/2021 PTP-R-058.	CTU- Reference



ICP Accelerometer - PCB Piezotronics No. J352C68 Used on DPP-1 CTU-6 Position Lid	Model	230190	N/A	5/5/2021	5/5/2022	Used on DPP-1	Off Site Vendor	5800 I&C Lab D203	5800 I&C Lab D203	CTU-6 Viration Table Accelerometer attached to CTU-6 Lid. Reference PTP-R-058.
ICP Accelerometer - Kistler Uni-Axel 8704B100 Used on DPP-1 Lansmont Vibration Table	Model	2083324	N/A	5/10/2021	5/10/2022	Used on DPP-1	Off Site Vendor	5800 I&C Lab D203	5800 I&C Lab D203	CTU-6 Vibration Table Accelerometer on Vibration Table. Reference PTP-R-056.

## **V. APPENDIX ACCELERATION DATA**

## Accelerometer Plots and Referenced Data Files for DPP-1 Testing

### V.1 INTRODUCTION

The following figures and data plots are from the DPP-1 drop tests that were completed on October 2021. The orientation and direction of the sensors are discussed in the main body of the report and will not be duplicated in this appendix. Each selected container was instrumented with three Triaxial accelerometers making a total of nine channels of data. The resulting X, Y, and Z axes at the three measurement points were recorded in the time domain at either 102.4 kHz sample rates. The sample rate was well above the frequency response of 10 kHz of the sensors and that frequency response was above the measured frequency of the structural responses of the container impacts.

The procedure for recording the Impact event was to start the recording while the container was being hoisted into position prior to the initiation of the drop in case a lifting component failed, and the drop was premature. These time files were very long with lots of recording that had no data since we had no premature drops. These files were trimmed down to the last few seconds that contained the release and impact event and the resulting data is shown in the following graphs.

Using the formula  $D=1/2 A*T^2$ , where D is distance in feet, A is the acceleration of Gravity, and T is time, when you solve for time you can check your location of release event and impact initiation to verify you have chosen the main impact point. This is necessary because the rigging hardware such as clevis and pins, large cables and other rigging hardware impact the container and even the sensors and create large shocks that show in the measurement data but actually result in no container damage or very slight dents that have no effect on the actual test results. However, due to the high frequency content of these impacts they appear as high G peaks on the plots. Below are the Time calculations for the three drop heights used from release event to impact.

**Table V-1 Impact time for each drop test.**

Time Seconds	Drop Distance
0.495	4 feet
1.365	30 feet
0.451416	1 meter

These data are for the drops specified in the Statement of Work for TU-1, TU-2, TU-5 and TU-6. Each Test Unit has data for four drop tests. One trace is plotted here and labeled for each drop. The time axis is in units of seconds and will be typical of the time window into the data trace necessary to display the actual values for the impacts of the unit onto the drop test pad of choice for that test. When using the M+P viewer on the data files the time value should be within this range. After converting the entire data file to MATLAB format, you will have to select the time shown on the X Axis to display the same information. These data plots can be utilized for each drop test to compare with the same raw data furnished to assure the viewer or MATLAB software are configured correctly to display the data.

## V.2 TEST UNIT-1 COLD TEST

### V.2.1 TU-1, 4 Foot Drop Test Data

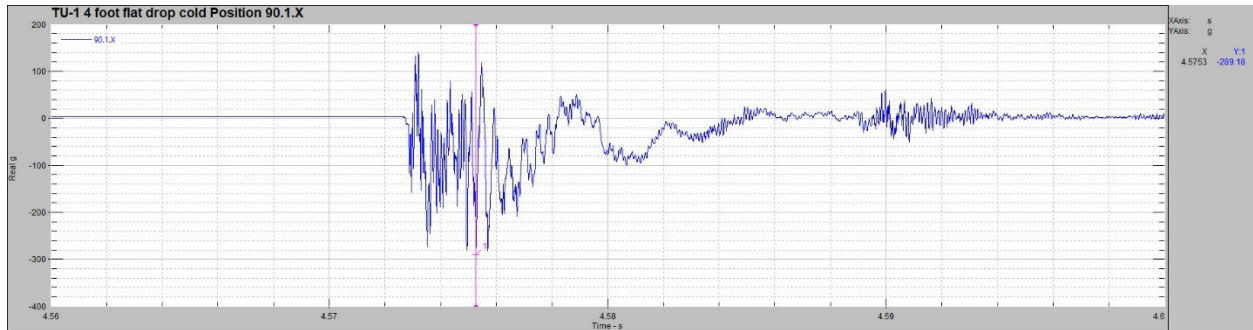


Figure V-1 4 Foot Test, Measurement Point 90.1.X Time Plot.

### V.2.2 TU-1, 1 Meter Puncture Impact Test

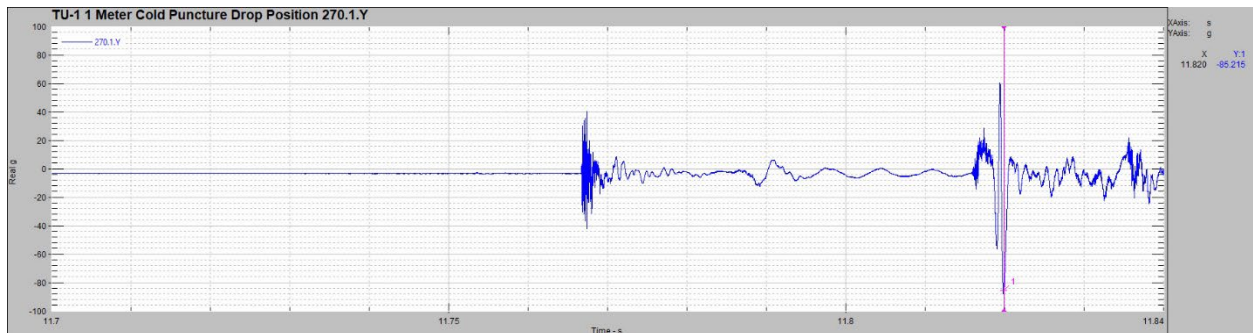


Figure V-2 1 Meter Puncture Test, Measurement Point 270.1.Y, Time Plot

### V.2.3 TU-1, 30 Foot Cold Drop Test Data

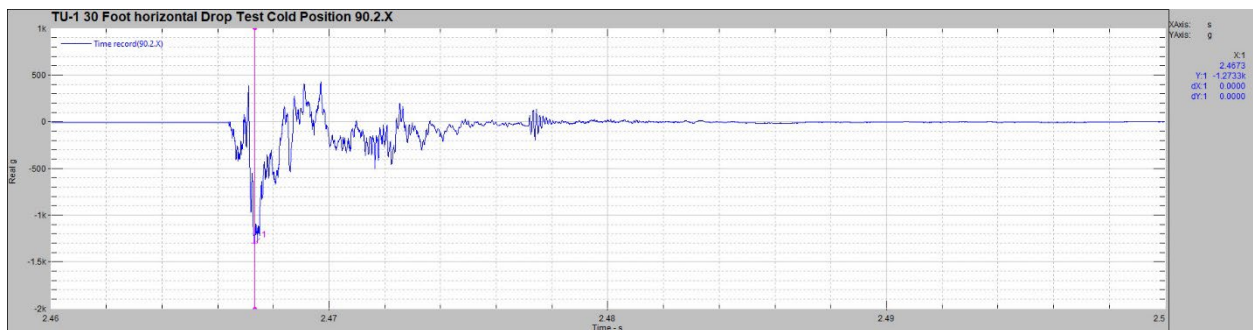


Figure V-3 30 Foot Cold Drop Test, Measurement Point 90.2.X, Time Plot



## V.2.4 TU-1, 30 Foot Crush Test Data

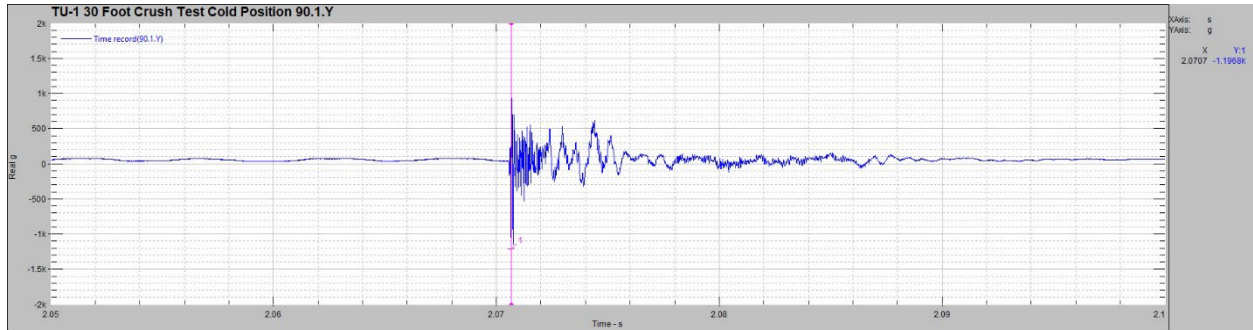


Figure V-4 30 Foot Cold Crush Test, Measurement Point 90.1.Y, Time Plot

## V.3 TEST UNIT – 2

### V.3.1 TU-2, 4 Foot Slap Down Drop Test Data

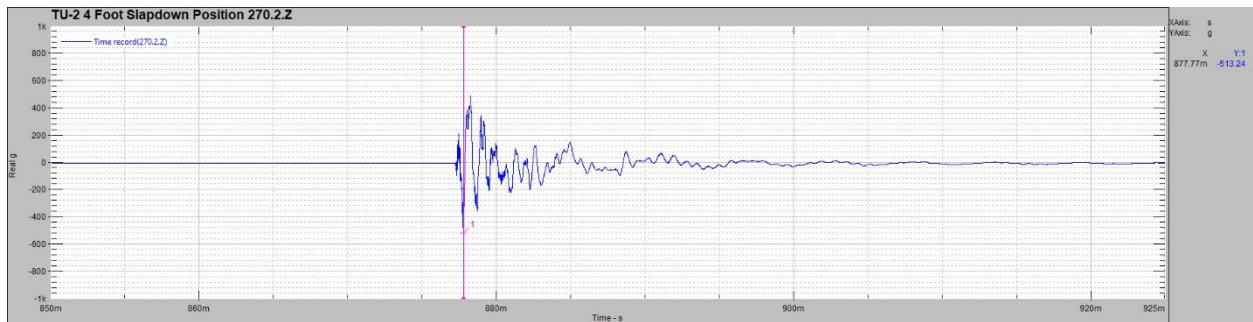


Figure V-5 4 Foot Slap Down Drop Test, Measurement Point 270.2.Z, Time Plot

### V.3.2 TU-2, 1 Meter Puncture Impact Test

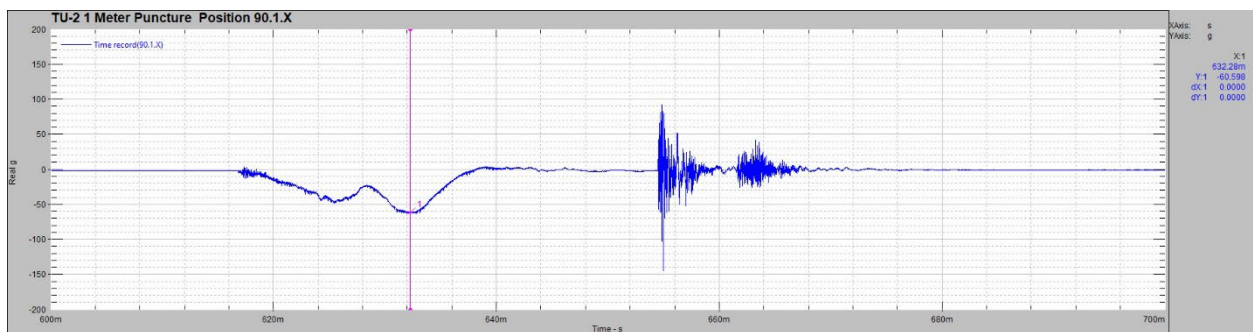


Figure V-6 1 Meter Puncture Test, Measurement Point 90.1.X, Time Plot

### V.3.3 TU-2, 30 Foot Drop Test Data

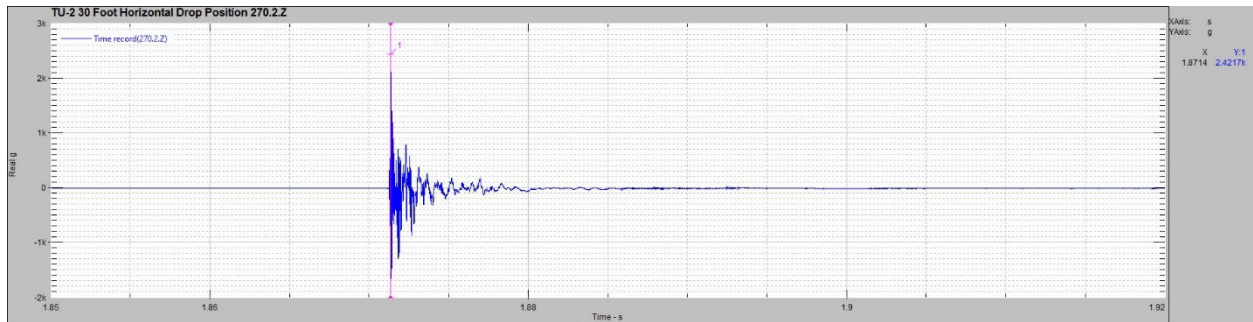


Figure V-7 30 Foot Drop Test, Measurement Point 270.2.Z, Time Plot

### V.3.4 TU-2, 30 Foot Crush Drop Test Data

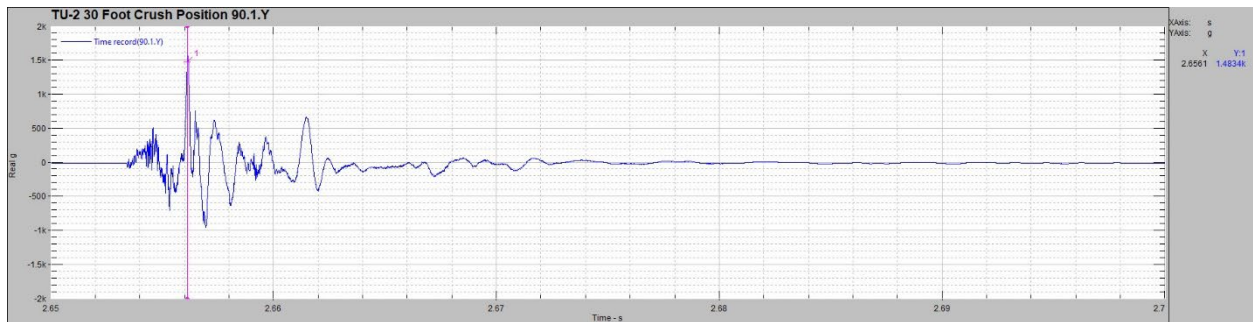


Figure V-8 30 Foot Crush Drop Test, Measurement Point 90.1.Y, Time Plot

## V.4 TEST UNIT-5 COLD TEST

### V.4.1 TU-5, 4 Foot Slap Down Cold Test Data

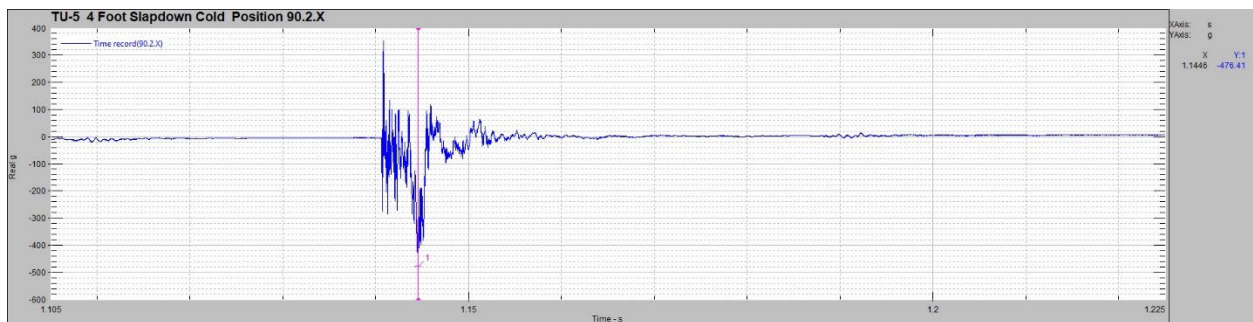


Figure V-9 4 Foot Slap Down Cold Test, Measurement Point 90.2.X, Time Plot

#### V.4.2 TU-5, 1 Meter Cold Puncture Impact Test

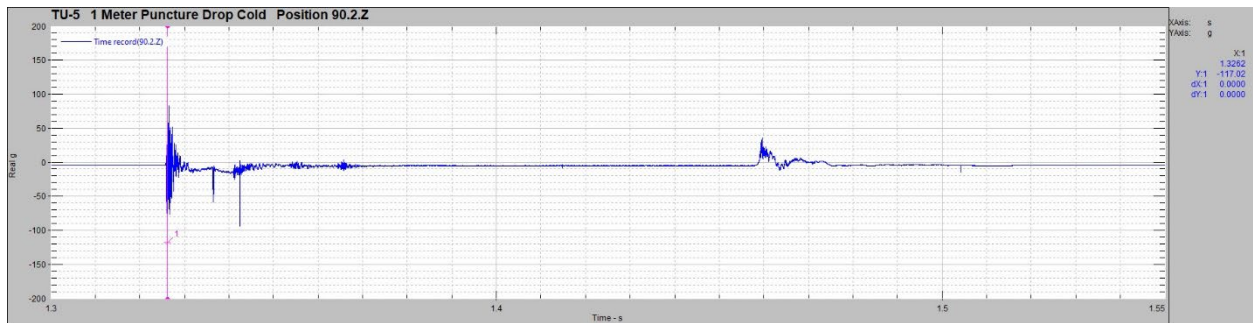


Figure V-10, 1 Meter Cold Puncture Test, Measurement Point 90.2.Z, Time Plot

#### V.4.3 TU-5, 30 Foot Cold Drop Test Data - Failed Measurement No data

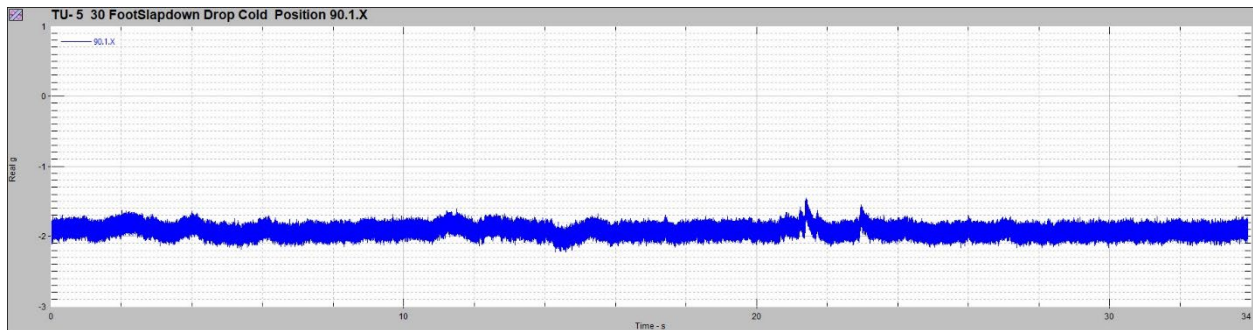


Figure V-11 30 Foot Cold Drop Test, Measurement Point 90.1.X, Time Plot

#### V.4.4 TU-5, 30 Foot Cold Crush Drop Test Data

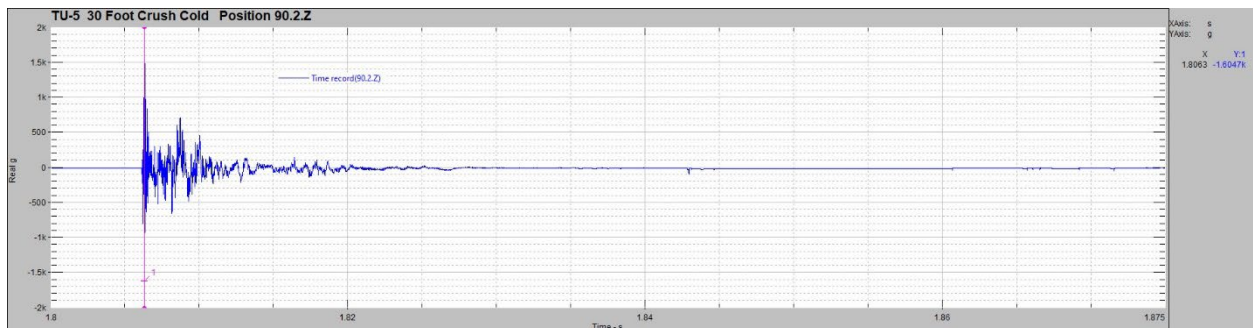


Figure V-12 30 Foot Cold Crush Drop Test, Measurement Point 90.2.Z, Time Plot



## V.5 TEST UNIT - 6

### V.5.1 TU-6, 4 Foot Slap Down Drop Test Data

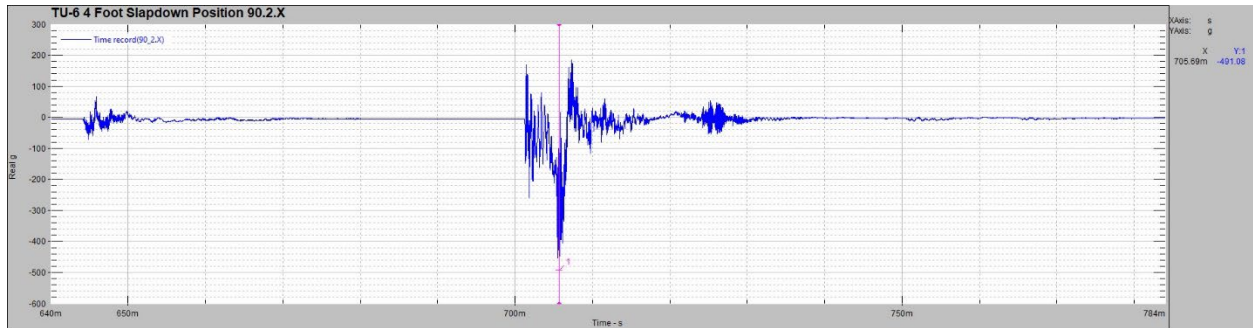


Figure V-13 4 Foot Slap Down Drop Test, Measurement Point 90.2.X, Time Plot

### V.5.2 TU-6, 1 Meter Puncture Impact Test

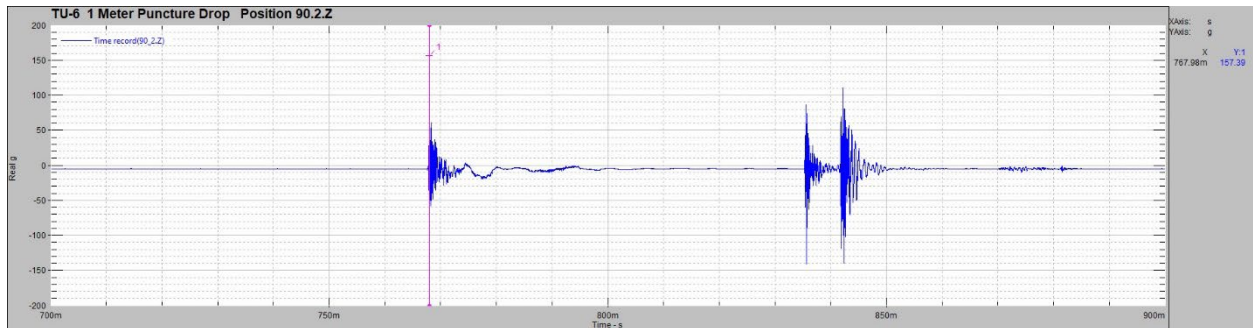


Figure V-14 1 Meter Puncture Test, Measurement Point 90.2.Z, Time Plot

### V.5.3 TU-6, 30 Foot Slap Down Drop Test Data – Measurement Failed after release no data

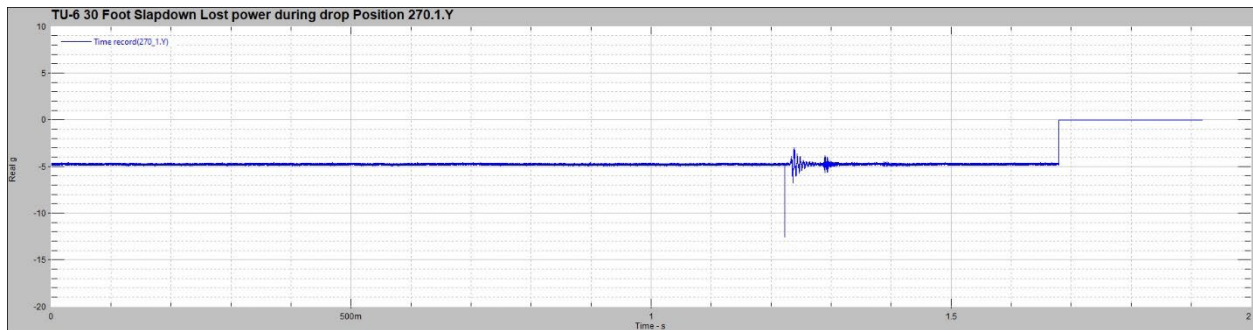


Figure V-15 30 Foot Drop Test, Measurement Point 270.1.Y, Time Plot



## V.5.4 TU-6, 30 Foot Crush Drop Test Data

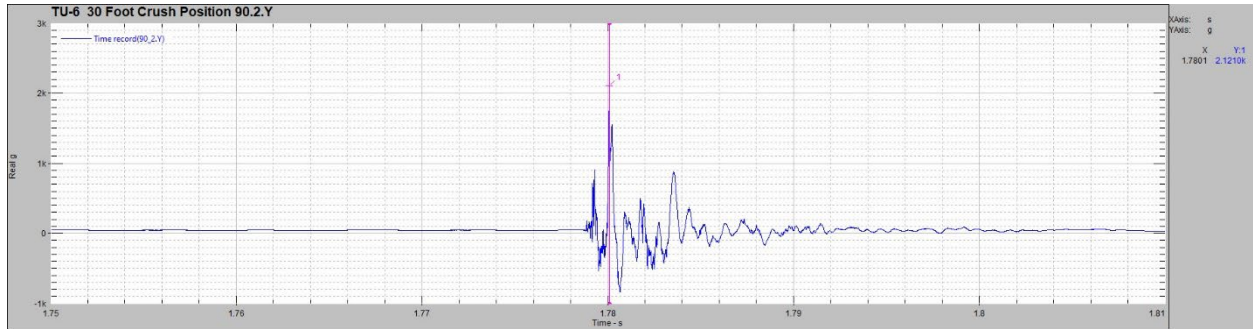


Figure V-16 30 Foot Crush Drop Test, Measurement Point 90.2.Y, Time Plot

## V.6 ACCELEROMETER PLOT FOR THE SHAKE TABLE TESTING

The associated plot showing the time domain data for a 4-hour testing sequence is shown below. The vertical axis is in units of G for acceleration and the horizontal axis is time in seconds. 14,458 Seconds is 4.0161 hours of time data.

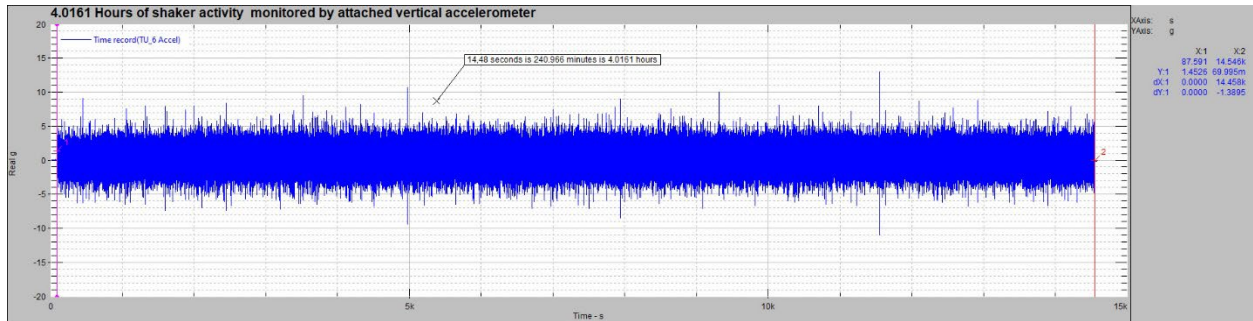


Figure V-17 4.0161 Hour Shaker Table Test, Measurement Point, Time Plot