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Test Report for the Qualification Testing of the ORNL-SFC-W-1 Special Form Capsule

A. I. Adeniyi

O. A. Martinez, PhD

February 2020

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Reactor and Nuclear Systems Division

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Prepared by
OAK RIDGE NATIONAL LABORATORY
Oak Ridge, TN 37831-6285
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Prepared for
Oak Ridge National Laboratory
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A. I. Adeniyi
O. A. Martinez, PhD

Oak Ridge National Laboratory
Reactor and Nuclear Systems Division
Used Fuel Systems Group
at the
National Transportation Research Center

APPROVALS

Name	Position	Date
Abiodun Adeniyi A. I. Adeniyi	ORNL Package Testing Program	Digitally signed by Abiodun Adeniyi Date: 2020.11.18 14:44:34 -05'00'
O A. Martinez, PhD	ORNL Package Testing Program	Digitally signed by Oscar A. Martinez, Ph.D. Date: 2020.11.18 15:40:59 -05'00'
Michael B. Houston Michael Houston	ORNL Package Testing Quality Representative	Digitally signed by Michael B. Houston Date: 2020.11.23 11:12:11 -05'00'
Rose Montgomery Rose Montgomery	Used Fuel Systems Group Leader	Digitally signed by Rose Montgomery Date: 2020.11.23 11:32:49 -05'00'

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ACRONYMS AND ABBREVIATIONS

ANSI	American National Standards Institute
ASNT	American Society for Nondestructive Testing
ASTM	American Society for Testing and Materials
cDAQ	Compact Data Acquisition
CFR	US Code of Federal Regulations
IAEA	International Atomic Energy Agency
IBR	incorporated by reference
ISO	International Standards Organization
NDT	nondestructive testing
NSC	Y-12 National Security Complex
ORNL	Oak Ridge National Laboratory
PTP	Package Testing Program
QA	quality assurance
QAPD	quality assurance program description
REDC	Radiochemical Engineering Development Center
RHACS	Research Hazard Assessment and Control System
RSS	research safety summary
SBMS	Standards Based Management System
SFC	special form capsule
TC	thermocouple
TIG	tungsten inert gas
TU	test unit

ABSTRACT

Three prototypes the ORNL-SFC-W-1 special form capsules (SFCs) of the same design were evaluated to determine if the requirements of Title 49, Code of Federal Regulations (CFR), Part 173.469, *Tests for Special Form Class 7 (Radioactive) Materials*, were met. The results of the special form tests are documented in this test report.

This report describes the special form testing activities performed on the three ORNL-SFC-W-1 capsules. The test units were designated as TU-1, TU-2 and TU-3. TU-1 was subjected to leak testing, impact testing and percussion testing. TU-1 was leak tested using the leak rate test specified in 49 CFR 173.469(a)(4)(i). The impact test was conducted according to the requirements in 49 CFR 173.469 (b)(1). The percussion test that was carried out on TU-1 was conducted in accordance with 49 CFR 173.469 (b)(2). Both TU-2 and TU-3 were subjected to a leak rate test as specified in 173.469(a)(4)(i) and a heat test as specified in 49 CFR 173.469(b)(4). Each test unit was leak tested before and after these respective tests.

The leak rate tests performed were helium back-pressure tests and bubble tests as specified in American National Standards Institute (ANSI) N14.5-2014.The measured leak rates were converted to standard condition leak rates as specified in American Society for Testing and Measurement (ASTM) E 493. The determined standardized leak rates obtained from the test and the calculations for all the test units met the requirements for special form certification.

The testing was performed under the direction of the Oak Ridge National Laboratory (ORNL) Package Testing Program (PTP).

1. INTRODUCTION

This test report describes the special form testing activities for the ORNL-SFC-W-1 special form capsules (SFCs) tested to demonstrate compliance with the requirements of Title 49, Code of Federal Regulations (CFR), Part 173.469, *Tests for Special Form Class 7 (radioactive) materials*.

All testing was performed under the Oak Ridge National Laboratory (ORNL) Package Testing Program (PTP) quality assurance plan outlined in NTRC-PRF-QAP-001, Rev. 3, "Quality Assurance Plan for the Package Testing Program."

The empty weight of the sealed capsule is 0.42 kg. (0.92 lb), and the volume of the metal of the empty capsule is 51.6 cm^3 (3.15 in^3). The interior volume of the empty capsule is 102.0 cm^3 (6.20 in^3).

Figure 1-1 illustrates the ORNL-SFC-W-1 SFC. The test specimens, which are designated as TU-1, TU-2 and TU-3, were fabricated for testing purposes. One specimen (TU-1) had a stainless steel round bar 1-inch in diameter and 2 inches long as a surrogate inner container (content) for percussive testing. This bar is a conservative representation of the mass for the inner containers of all three specimens. The bar weighs 0.21 kg (0.46 lb). The total weight of TU-1, with surrogate inner container included, is 1.38 lb (0.63 kg). The volume of the TU-1 surrogate is 25.7 cm^3 (1.57 in^3). The internal void volume of TU-1, with surrogate, is 75.9 cm^3 (4.63 in^3). The other two specimens will each encapsulate an inner container having nonradioactive surrogate solid material within, which will be used to simulate Class 7 radioactive material. TU-2 has a nonradioactive surrogate ($ZrO(NO_3)_2$) for thorium oxide inside a stainless-steel inner container. TU-3 has a nonradioactive surrogate ($La(NO_3)_3$) for actinium nitrate inside a Zircalloy container. The internal void volume of TU-2 and TU-3, with the inner container, is 81.1 cm^3 (4.95 in^3).

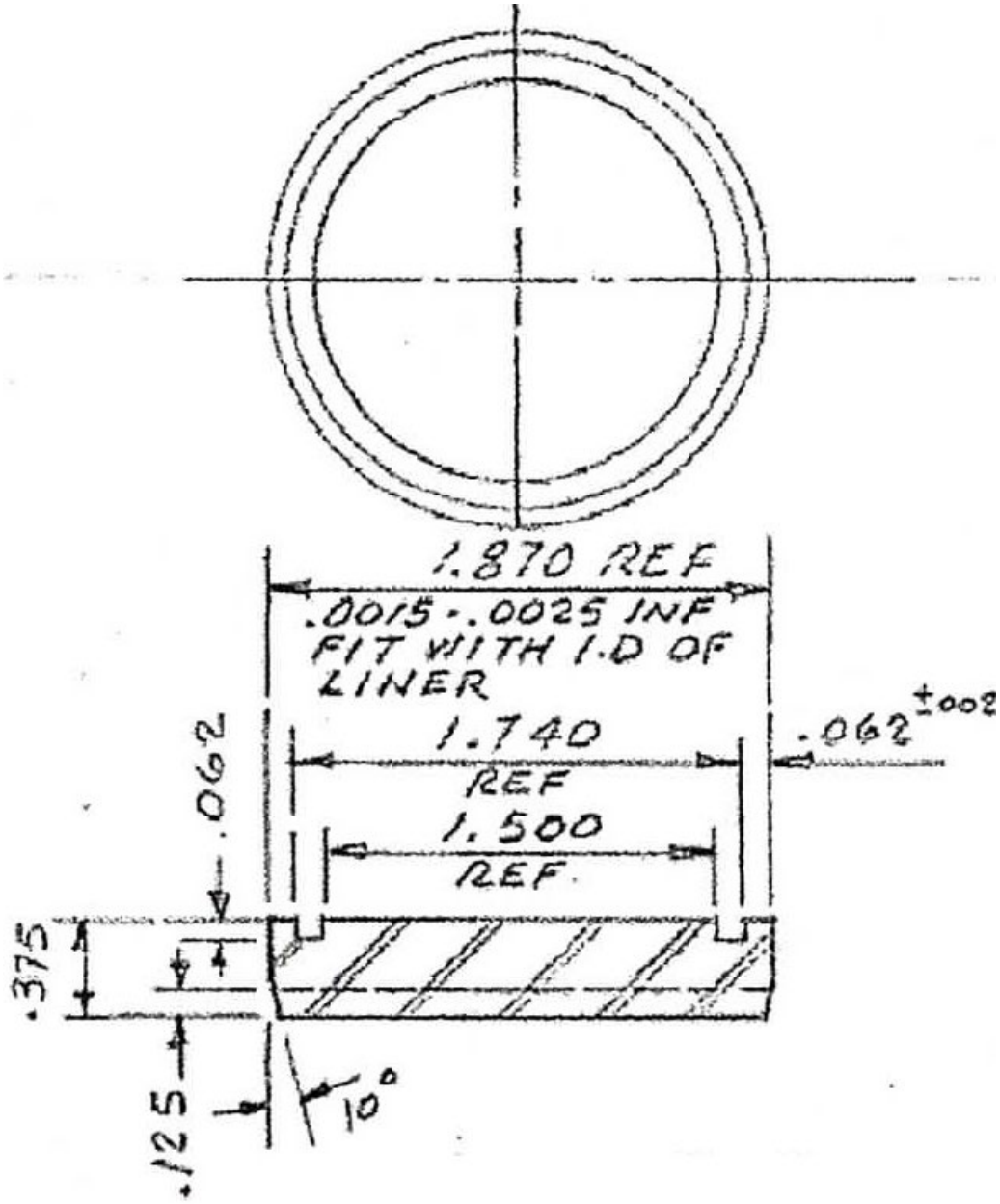


Figure 1-1. Top view of the ORNL-SFC-W-1 SFC.

All test units were tested for leak tightness (leak test) before and after each test outlined in the test plan, *"Test Plan for the Special Form Qualification Testing of the Mark 42 Pu Powder Special Form Capsule"* (ORNL/NTRC-084). The testing requirements for each test unit are described below.

Specimen TU-1 was subjected to leak testing, impact testing, and percussion testing. After each specified test, a leak test of the specimen was performed. See Table 1.1 for the TU-1 test sequence.

Leak Test - 49 CFR 173.469 (a)(4)(i): The leak test performed was to demonstrate a leak tightness of 10^{-4} $torr^{-1}/s$ (1.3×10^{-4} $atm\text{-}cm^3/s$) based on air at 25°C (77°F) and one atmosphere differential for solid radioactive content.

Impact Test - 49 CFR 173.469 (b)(1): The specimen was dropped onto a target from a height of 9 m (30 ft) or greater. This target met the requirement specified in Sec. 173.465(c)(5). According to 49 CFR 173.469 (a)(2), the specimen may not break or shatter when subjected to the impact test.

Percussion Test - 49 CFR 173.469 (b)(2)(i)*. The specimen was placed on a sheet of lead that was supported by a smooth solid surface and was struck by the flat face of a steel billet so as to produce an impact equivalent to that resulting from a free drop of 1.4 kg (3 lb) through 1 m (3.3 ft).*

(ii) The flat face of the billet was 2.5 cm (1 in.) in diameter, with the edges rounded off to a radius of 3 mm ±0.3 mm (0.12 in. ±0.012 in.).

(iii) The lead had a hardness number with values within the range of 3.5 to 4.5 on the Vickers scale and a thickness of 2.5 cm (1 in.) or greater, and it covered an area greater than that covered by the specimen.

(iv) The specimen was placed on a fresh surface of lead for the impact test.

(v) The billet struck the specimen so as to cause maximum damage.

49 CFR 173.469 (a)(2) specifies that the specimen may not break or shatter when subjected to the percussion test.

Specimens TU-2 and TU-3 were subjected to leak testing and heat testing. Leak tests of TU-2 and TU-3 were performed before and after the heat tests per the criteria described in 49 CFR 173.469 (b)(4). See Table 1.1 and Table 1.2 for the TU-2 and TU-3 test sequences.

The ORNL-SFC-W-1 SFC was fabricated from an ASTM A511/A269 stainless-steel liner (body) – a right cylinder with an outside diameter of 2 in. and wall thickness of 0.065 in. welded at the top and bottom to plugs made from 304L/304 stainless-steel bar. Details of the dimensions can be found in APPENDIX A, Figure 1-1, and Figure 1-2. The isometric view of the test unit is shown in Figure 1-3 with sample identification markings.

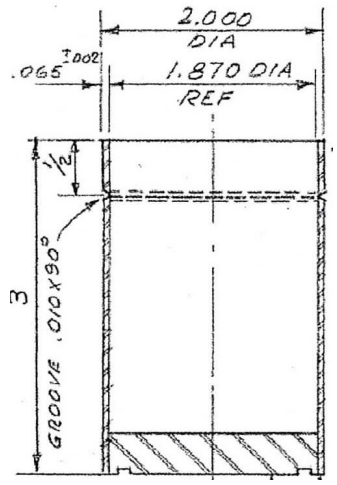


Figure 1-2. Side assembly view.

Figure 1-3. ORNL-SFC-W-1 SFC test unit.

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 830.122, *Quality Assurance Criteria*. Quality principles and methodologies are integrated and flowed down by management systems within the ORNL Standards Based Management System (SBMS).

ORNL's PTP Quality Assurance Program is under the direction of the Reactor and Nuclear Systems Division. All testing performed by the PTP is conducted under the PTP Quality Assurance Program Plan, PTP-QA-001/NTRC-PRF-QAP-001, Rev. 3., Integrated Document Management System ID 018050.

49 CFR 173.469, "Special Form Performance Testing," is documented by ORNL's test plan, *Test Plan for the Special Form Qualification Testing of the Mark 42 Pu Powder Special Form Capsule* (ORNL/NTRC-084, Rev.0, available upon request).

The safety aspects of the activities described in this test plan are controlled by ORNL's Research Hazard Assessment and Control (RHAC) Research Safety Summary (RSS), *General Use and Package Testing Activities Conducted in the NTRC Packaging Research Facility* (1082).

1.2 ORNL-SFC-W-1 SFC TEST MATRIX

All three specimens were tested following the sequence listed in Table 1.1 and Table 1.2.

Table 1.1. Sequence of tests and processes for the ORNL-SFC-W-1 SFC TU-1

Sequence	Test title	Reference / Acceptance	Procedures or test forms(s)	Comments
1	**Leak test**	49 CFR 173.469(a)(4)(i)	NDE-70 Rev.7	10^{-4} torr^{-1}/s (1.3×10^{-4} atm-cm^3/s) based on air at 25°C (77°F) and one atmosphere differential pressure for solid radioactive content.
2	**Impact test**	49 CFR 173.469 (b)(1)	PTP-PRF-10, Rev. 5 *Procedure Checklist* and PTP-PRF-10, Rev. 5 *Data Sheet*	Drop from a height of 9 m (30 ft) or greater. Vertical top down.
3	**Leak test**	49 CFR 173.469(a)(4)(i)	NDE-70 Rev.7	10^{-4} torr^{-1}/s (1.3×10^{-4} atm-cm^3/s) based on air at 25°C (77°F) and one atmosphere differential pressure for solid radioactive content.
4	**Percussion test**	49 CFR 173.469 (b)(2)	NTRC/ORNL-084 Rev. 0 Test Form 1	Free drop of 1.4 kg (3 pounds) through 1 m (3.3 ft). Vertical top up.
5	**Leak test**	49 CFR 173.469(a)(4)(i)	NDE-70 Rev.7	10^{-4} torr-1/s (1.3×10^{-4} atm-cm^3/s) based on air at 25°C (77°F) and one atmosphere differential pressure for solid radioactive content.

Table 1.2. Sequence of tests and processes for the ORNL-SFC-W-1 SFC TU-2 and TU-3

Sequence	Test title	Reference	Procedures or test forms(s)	Comments
1	**Leak test**	49 CFR 173.469(a)(4)(i)	NDE-70 Rev.7	10^{-4} torr-1/s (1.3×10^{-4} atm-cm^3/s) based on air at 25°C (77°F) and one atmosphere differential pressure for solid radioactive content.
2	**Heat test**	49 CFR 469(b)(4)	NTRC/ORNL-084 Rev. 0 Test Form 2 Test Form 3 Test Form 4	ORNL-SFC-W-1 SFC held above 825°C (1517 °F) for 10 min See Figure 3-6 See APPENDIX B
3	**Leak test**	49 CFR 173.469(a)(4)(i)	NDE-70 Rev.7	10^{-4} torr^{-1}/s (1.3×10^{-4} atm-cm^3/s) based on air at 25°C (77°F) and one atmosphere differential pressure for solid radioactive content.

1.3 TEST DATA RECORDS

This report documents the tests performed and measurements observed from the ORNL-SFC-W-1 SFC testing. The general data types for these tests are (1) manually derived measurements and observations, (2) digital still photography, and (3) video recording of the drop and percussion tests.

The primary recording media for each of the general types of data are (1) procedure checklists, data sheets and test forms for data, measurements, and observations; (2) computer files (JPG format) of the digital photography; and (3) computer files (MPG format) of the video recordings.

The completed data sheets and procedure checklists have been scanned into a digital format and are available upon request. Photographs are presented in the main body of this document as appropriate.

1.4 DEVIATIONS FROM THE TEST PLAN

Per the test plan (ORNL/NTRC-084), 3 test units were subjected to the pre-testing leak test. TU-1 was later tested as originally specified in the test plan (see Table 1.1). TU-2 and TU-3 were tested as specified in the original test plan (see **Table 1.2**). There was no deviation from the original test plan.

2. PRE-TEST ACTIVITIES

The test units were delivered in a ready-to-test condition, so there were no specific pretest activities.

3. SPECIAL FORM TESTS

Calibrated equipment was used when required. Calibration controls were per PTP-QA-13, Control of Measuring and Test Equipment. The test equipment calibration IDs and calibration due dates were recorded on the test data sheets as applicable.

Test Equipment:

Drop pad: The-outdoor drop pad facility located at the NTRC was used for the impact test. This drop pad facility consists of a massive steel plate set on top of rebar and concrete. The mass of the outdoor drop pad has a steel impact surface and mass in excess of 140 tons. The documentation of the pad construction and suitability for use is provided in *Design and Certification of Targets for Drop Testing at the NTRC Package Research Facility Rev. 0,* May 2003 (ORNL/NTRC-001).

Billet: The billet for the percussion test is made of 1-inch diameter steel according to the requirements stated in 49 CFR 173.469(b)(2). The diameter and weight of the billet were verified and recorded in the test record forms (see Appendix B) before testing using a calibrated caliper and scale. The billet has a threaded hole at one end into which a screw-eye is attached for rigging purposes.

Platform scale: A Mettler-Toledo scale (property number A000593, model number XP32001LDR, serial number 1129350702) was used to measure the mass of the percussion billet.

30 ft plumb bob: The 9 m (30 ft) measurement wire was used to establish the height of the test unit for the impact test. Its length was verified to be in excess of 30 ft before the tests using a calibrated tape measure.

1 m aluminum rod: The 1 m aluminum rod (property number A001146) was used to verify the minimum height of the test unit above the impact surface (lead sheet) prior to the percussion test. This rod's calibration is current until 6/30/2021.

Rigging: All standard rigging used includes a current inspection sticker.

Helium leak test: Helium leak test and pressure test equipment were provided by the ORNL Level III leak test and ORNL Facilities and Operations personnel. Calibrated leaks were used to calibrate leak test equipment as part of the leak test procedure.

Furnace: The furnace used for the heat test was located in the ORNL High Bay Core Facility, Room 131, Bldg. 4508. The furnace used was a RAD-O-GLOW Global Furnace (Model #RG-3010G-2, Serial No. R2-717, ORNL property number X183717), as shown in Figure 3-4. The furnace controller thermocouple was calibrated prior to testing. The calibration record was recorded in the test form.

Thermocouple data system: The thermal data system used was the PTP Compact Data Acquisition (cDAQ) system (property number M303131). Furnace temperature readings were automatically recorded every 5 seconds. The calibration records of the cDAQ thermal data system and thermocouples were recorded on the test forms, and copies are included in the APPENDIX F.

3.1 9 m (30 ft) IMPACT TEST

The impact test was performed using the outdoor drop pad at the NTRC north parking lot next to L110. This test was performed according to Procedure PTP-PRF-10, Rev. 6, dated 1-31-19.

TU-1 was raised to a minimum height of 9m (30ft) using a man lift. A drop test fixture was used to set the drop orientation of the capsule (see Figure 3-1). The drop orientation of TU-1 was vertical top down, as stated in the test plan. Engineering judgement was used to choose the vertical top down orientation, which will cause direct damage to the threaded joint between the lid and body of the test unit. This joint is the most vulnerable feature of the design for the impact test. This orientation ensures that the impact causes maximum damage to the test unit. The test unit was released and allowed to free fall and impact onto the outdoor NTRC drop pad. The impact resulted in minor scuff marks on the impact area of the capsule. The capsule met the acceptance criteria of not shattering or breaking as a result of the impact.

After the 30-ft impact test, TU-1 was subjected to a leak test using 49 CFR 173.469 (a)(4)(i). Results of this leak test are documented in the leak rate test procedure in Section 3.3.

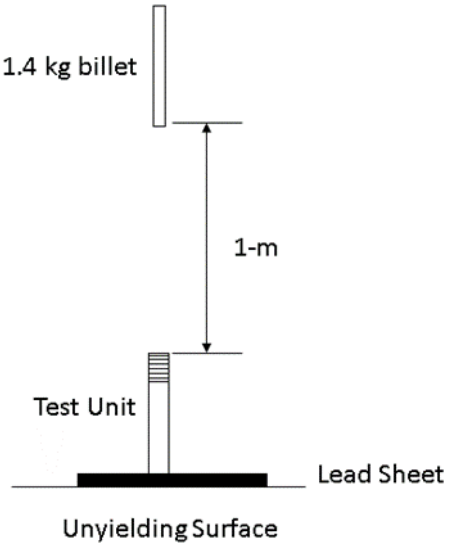
After a successful leak rate test, TU-1 was subjected to a percussion test per the test plan. This test was performed on the indoor drop pad at the NTRC, room L110. The procedure (ORNL/NTRC-084) for the percussion test can be found in the approved test plan. The setup was as shown in Figure 3-2.

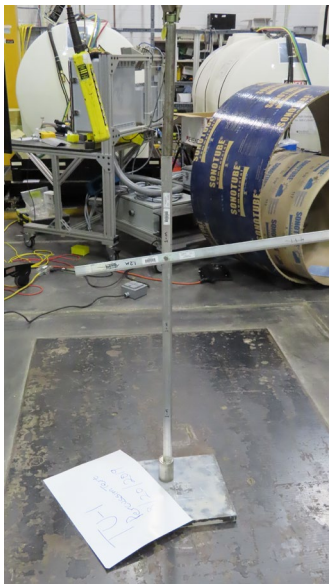
Man-lift at 30 ft height determined using the plum bob

Drop apparatus set up, horizontal level within 2°

TU-1 impact point and imprint on pad

Figure 3-1. TU-1 9 m (30 ft) impact test.





(a) (b)

Figure 3-2. Percussion test setup.

When released, the billet impacted TU-1 squarely on the top surface of the capsule. There was no discernible deformation or damage to the capsule as a result of the percussion test, though there was an impact scuff mark. Figure 3-3 photos show TU-1 before and after the percussion test.

Figure 3-3. Before and after percussion test of TU-1 (note billet impact point above letter "T").

After the percussion test, TU-1 was subjected to a leak test according to the test plan using 49 CFR 173.469 (a)(4)(i). Results of this leakage test are documented in the leak rate test procedure in Section 3.3.

3.2 HEAT TEST

The 49 CFR 173.469(b)(4) heat test was performed on TU-2 and TU-3. This heat test was performed in ORNL Bldg. 4508 in accordance with the test procedure detailed in the test plan (ORNL/NTRC-084 Rev. 0). The results are recorded on Test Forms 2, 3, and 4 in Appendix B of this test report.

The safety aspects of activities for this heat test are controlled by ORNL Research Hazard Analysis and Control System (RHACS) RSS 336.22, *Materials Processing/Refining at Bldg. 4508*. The furnace used was a RAD-O-GLOW Global Furnace (Model #RG-3010G-2, Serial No. R2-717, ORNL property number X183717), as shown in Figure 3-4.

The furnace has a temperature range of 648.89 – 1537.78 °C (1,200 - 2,800 °F). The furnace has two calibrated controllers: over-temp and temp control. Two calibrated (calibration date: 11-12-2018) Type K thermocouples (TCs) (ID: Delta M. Corp Type K) were inserted into the furnace—one at the top of the furnace to the center, and the other through the front of the furnace. These thermocouples were then connected to an ORNL-developed thermal data acquisition system (cDAQ model # M303131 calibration due date: 11-12-2019) shown in Figure 3-5.

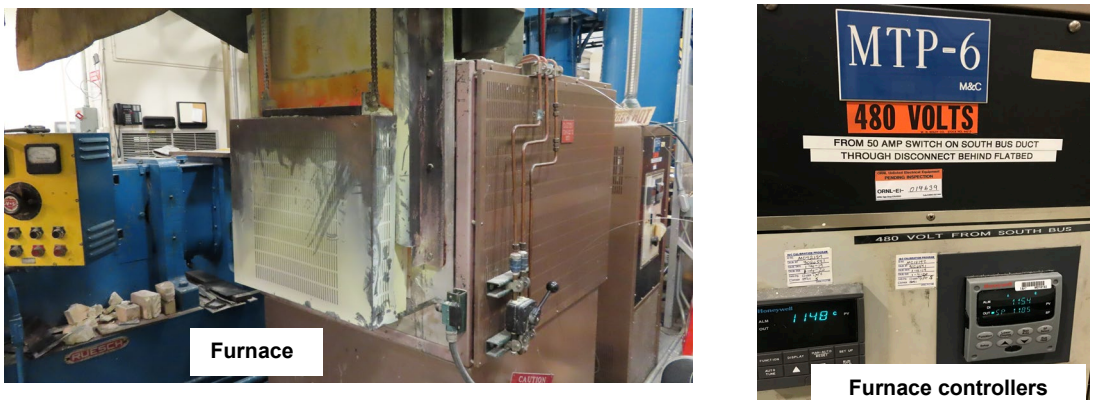


Figure 3-4. The RAD-O-GLOW furnace used for ORNL-SFC-W-1 capsules thermal test.

The PTP computer-based thermal monitoring system was used to monitor the furnace environment during the test. This system provides 48 data channels that can be continuously logged to a data file (Figure 3-5);

only two of these channels were used as specified in the test plan. The TCs were then connected to the PTP DAQ, which transferred temperature data to the laptop via an ethernet cable. During the test runs, the system was set to log data every 5 seconds from each data channel. The TCs used for TU-2 and TU-3 thermal testing were calibrated 0.062-inch diameter Type K TCs that were 50 ft in length. These lightweight TCs provided a very rapid response to changes in temperature, which in turn provided a very accurate picture of the furnace and test unit thermal behavior.

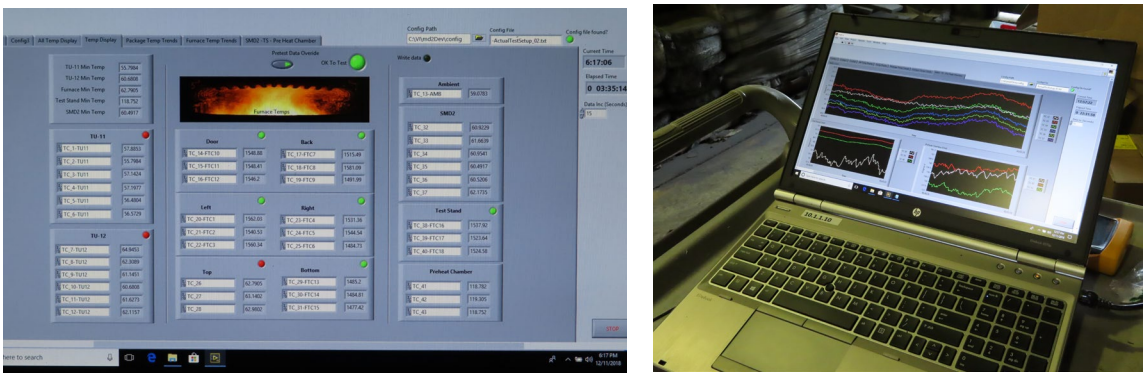


Figure 3-5. ORNL cDAQ system.

The furnace was preheated to a temperature above 850°C (1562 °F) for three hours. After a three-hour heat soaking period at a constant temperature above 850°C (1562 °F), the furnace door was opened, and TU-2 was inserted into the furnace cavity. The furnace door was closed, and when both TCs reached a furnace reading above 825°C (1517 °F), the 10-minute thermal test was started (Figure 3-6). TC1 was at the center of the furnace, and TC2 was near the front door. The DAQ system provided continuous monitoring of the temperature profile, as shown in Figure 3-6. The temperature profile represents four distinct activities: (1) the furnace pre-heat period, (2) the TU-2 heating period, (3) another pre-heat period between TU-2 extraction and TU-3 insertion, and (4) the TU-3 insertion period. After a 10-minute period, the door was opened, and TU-2 was removed from the furnace and allowed to cool naturally. TU-3 was inserted into the furnace after the furnace temperature had been allowed to reach a temperature greater 825°C (1517 °F). The furnace door was closed, and when both TCs reached a furnace reading above 825°C (1517 °F), the 10-minute thermal test for TU-3 was started. Figure 3-7 and Figure 3-8 show the units before and after the heat tests. After the thermal tests, the test units were subjected to the helium leak test and the bubble test.

Figure 3-6. TUs were carefully loaded into the furnace.

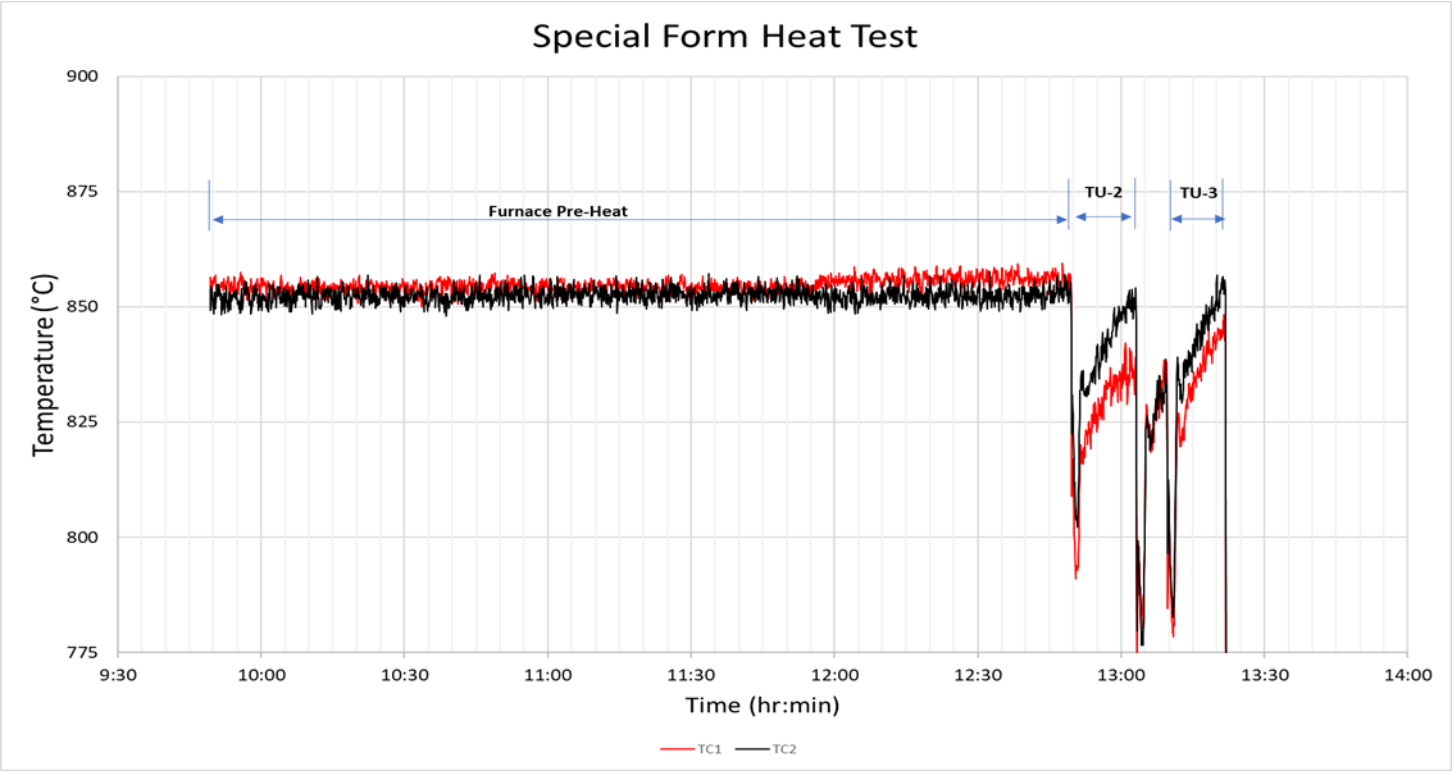


Figure 3-7. Pre-heat and heat test temperature profile.

Figure 3-8. TU-2 and TU-3 post-heat test results.

3.3 LEAK RATE TESTING

3.3.1 Evacuated Envelope (with Back Pressurization)

Leak rate tests that met the test requirements of 49 CFR 173.469 (a)(4)(i) were performed individually on each test unit before and after each special form test. The leak rate tests were performed according to ANSI N14.5-2014 *American National Standard for Radioactive Materials – Leakage Tests on Packages for Shipment*, Table A.1, Test Description A.5.5, "Evacuated Envelope (with back pressurization)" and Test Description A.5.6 "Gas bubble techniques." The ANSI document states that the back-pressure method
". . . is ideal for welded capsules from very small sizes up to the sizes limited by the dimensions of the pressurizing chamber," and that the "nominal test sensitivity = 10^{-3}- 10^{-8} ref-cm/s" and the bubble test method are used for hermetically sealed test specimens.

Section A.5.5 of ANSI N14.5-1997, *Evacuated Envelope with Helium Back Pressure* references ASTM E 493, *Standard Test Methods for Leaks Using the Mass Spectrometer Leak Detector in the Inside-Out Testing Mode*. This standard provides the method for converting a measured leak rate using the evacuated envelope with the helium back-pressure method into the standardized leak rate that must be compared to the pass/fail criteria specified in 49 CFR 173.469(a)(4)(i), which is 10^{-4} torr-l/s (1.3×10^{-4} atm-cm^3/s).

The equation provided in Section 11.1.9 of ASTM E493 is as follows:

$$S_l = (P_e/P_a) \times (1- e^{(-3600*a*T)}) * (e^{(-a*t)}) \times L \qquad (1)$$

where:

S_l = indicated (measured) leak rate (cc/s),
P_e = bombing pressure of helium (absolute),
P_a = atmospheric pressure (absolute),
T = bombing time (hours),
t = waiting time between bombing and testing (s),
L = actual (standardized) leak rate (atm-cc/s),
a = L/V (where V = internal volume), and
e = 2.71 (natural logarithm).

Since S_l is being measured and the objective is to solve for L, an iterative solver is required to find the solution. The equation was solved using Microsoft Excel. Note that the ASTM standard uses the term *bombing*, while the ANSI standard uses the term *back-pressure*. These terms are synonymous and are used interchangeably in this report.

TU-1, TU-2, and TU-3 were leak tested at ORNL by certified American Society for Nondestructive Testing (ASNT) Level II and Level III nondestructive testing (NDT) leak testing personnel using the NDE-70 R.7 procedure. See Appendixes D and E for documentation of leak tester certifications and the leak testing procedure. The test units were leak tested before and after each special form test. The test apparatuses used for these tests employed a spectrometer tuned to detect helium, a calibrated helium leak to calibrate the system, and two separate vessels—one vessel for helium back pressurization, and another vessel for the subsequent helium leakage rate testing under vacuum conditions. Figure 3-9 provides a schematic of the system used for helium back pressurization, and Figure 3-10 shows a schematic of the system used for the helium leakage rate test. Leak rate test variables and results for TU-1, TU-2 and TU-3 are shown in Table 3.1. A temperature correlation was performed to determine the measured leak rate at

25°C (77 °F), and per the requirement, the standardized leak test result was less than the 1.0×10^{-4} requirement for all the test units.

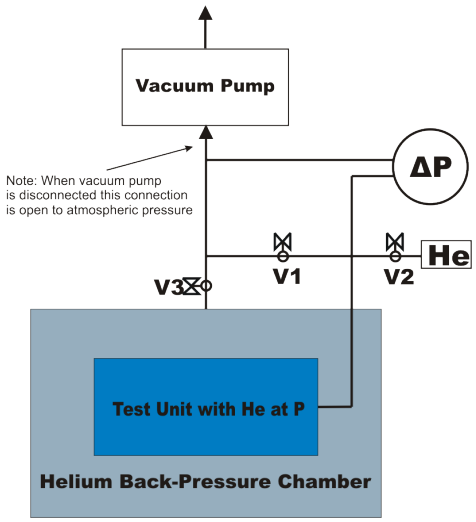


Figure 3-9. Diagram of helium back pressurization test.

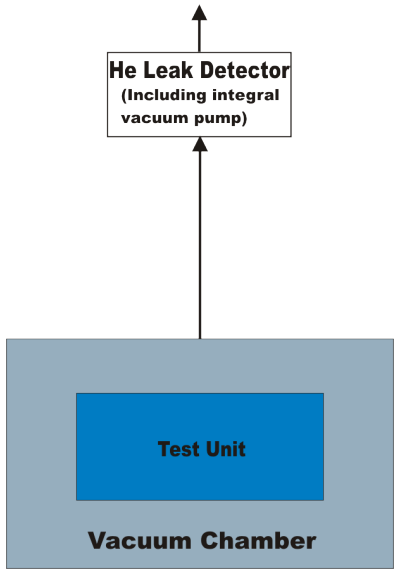


Figure 3-10. Diagram of helium leak testing system.

3.3.2 Gas Bubble Techniques

The gas bubble test was performed using the methods described in ANSI N14.5-2014, *American National Standard for Radioactive Materials – Leakage Tests on Packages for Shipment,* Table A.1, Test Description A.5.6 (b), "Vacuum Bubble." The method involves immersing the test unit in a liquid and then producing a vacuum above the liquid (e.g., water/glycol or isopropyl alcohol) in which the test item is submerged (see Figure 3-11). A leak is indicated by a stream of bubbles. This method applies to welded

capsules. The nominal test sensitivity is 10^{-3} ref-cm^3/s (10^{-4} Pa-m^3/s). Test units TU-1, TU-2 and TU-3 were bubble tested, and the results are presented in Table 3.2. See Appendixes D and E for documentation of leak tester certification and the leak testing procedure. While the sensitivity of the bubble test does not meet the minimum leak rate per 49 CFR 173.469 4(i), this test is needed because it is possible that a leak area is large enough that the helium inside the component may have evacuated out before the test unit is placed in the vacuum chamber for helium detection.

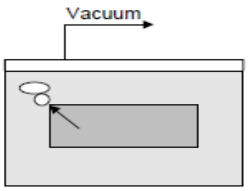


Figure 3-11. Vacuum bubble test.

Table 3.1. Leak rate test variables and results for TU-1, TU-2 and TU-3

Parameter	Test unit						
	TU-1			TU-2		TU-3	
	Test 1	Test 2	Test 3	Test 1	Test 2	Test 1	Test 2
Void space – V (cc)	75.9	75.9	75.9	81.2	81.1	81.2	81.1
Bombing pressure – P_e (psig)	30	30	30	30	30	30	30
Atmospheric pressure – P_a (psia)	14.69	14.69	14.69	14.69	14.69	14.69	14.69
Bombing time – T (hr)	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Time between bombing and testing – t (s)	<3,600	<3,600	<3,600	<3,600	<3,600	<3,600	<3,600
Measured leak rate (cc/s) – S_l (atm-cc He/s)	$<5.0\times10^{-7}$	$<5.0\times10^{-7}$	$<5.0\times10^{-7}$	$<5.0\times10^{-7}$	$<5.0\times10^{-7}$	$<5.0\times10^{-7}$	$<5.0\times10^{-7}$
a = L/V (s^{-1})	1.56×10^{-6}	1.56×10^{-6}	1.56×10^{-6}	1.50×10^{-6}	1.50×10^{-6}	1.50×10^{-6}	1.50×10^{-6}
Standardized leak rate – L (atm-cc He/s)	$<1.18\times10^{-4}$	$<1.18\times10^{-4}$	$<1.18\times10^{-4}$	$<1.22\times10^{-4}$	$<1.22\times10^{-4}$	$<1.22\times10^{-4}$	$<1.22\times10^{-4}$
Allowable leak rate – (atm-cc He/s)	$<1.3\times10^{-4}$	$<1.3\times10^{-4}$	$<1.3\times10^{-4}$	$<1.3\times10^{-4}$	$<1.3\times10^{-4}$	$<1.3\times10^{-4}$	$<1.3\times10^{-4}$

Table 3.2. Bubble test results for TU-1, TU-2 and TU-3

Parameter	Test unit						
	TU-1			TU-2		TU-3	
	Test 1	Test 2	Test 3	Test 1	Test 2	Test 1	Test 2
Bubble test pass/fail	pass	pass	pass	pass	pass	pass	pass

4. CONCLUSION

Three prototype ORNL-SFC-W-1 SFCs were subjected to the tests specified in 49 CFR 173.469. All the units were subjected to a pretest leak test. One unit was subjected to the impact test followed by a leak rate test and a percussion test, followed by another leak test. The other two units were subjected to the heat test followed by a leak rate test. Each unit met the leak rate criteria of 1.3×10^{-4} atm-cm^3/s following each test. None of the test specimens broke or were shattered when subjected to the impact and percussion tests, and the specimens did not melt or disperse when subjected to the heat test. This testing process has shown that the design of the ORNL-SFC-W-1 SFC meets special form criteria per 49 CFR 173.469 and International Atomic Energy Agency (IAEA) special form requirements.

The ORNL-SFC-W-1 capsules welds (see APPENDIX C) were also examined after the completion of series of tests described above.

APPENDIX A. ORNL-SFC-W-1 SPECIAL FORM CAPSULE DRAWINGS

Please note that the capsule named “Mark 42 Pu” in the test records was renamed “ORNL-SFC-W-1” at the time of report writing.

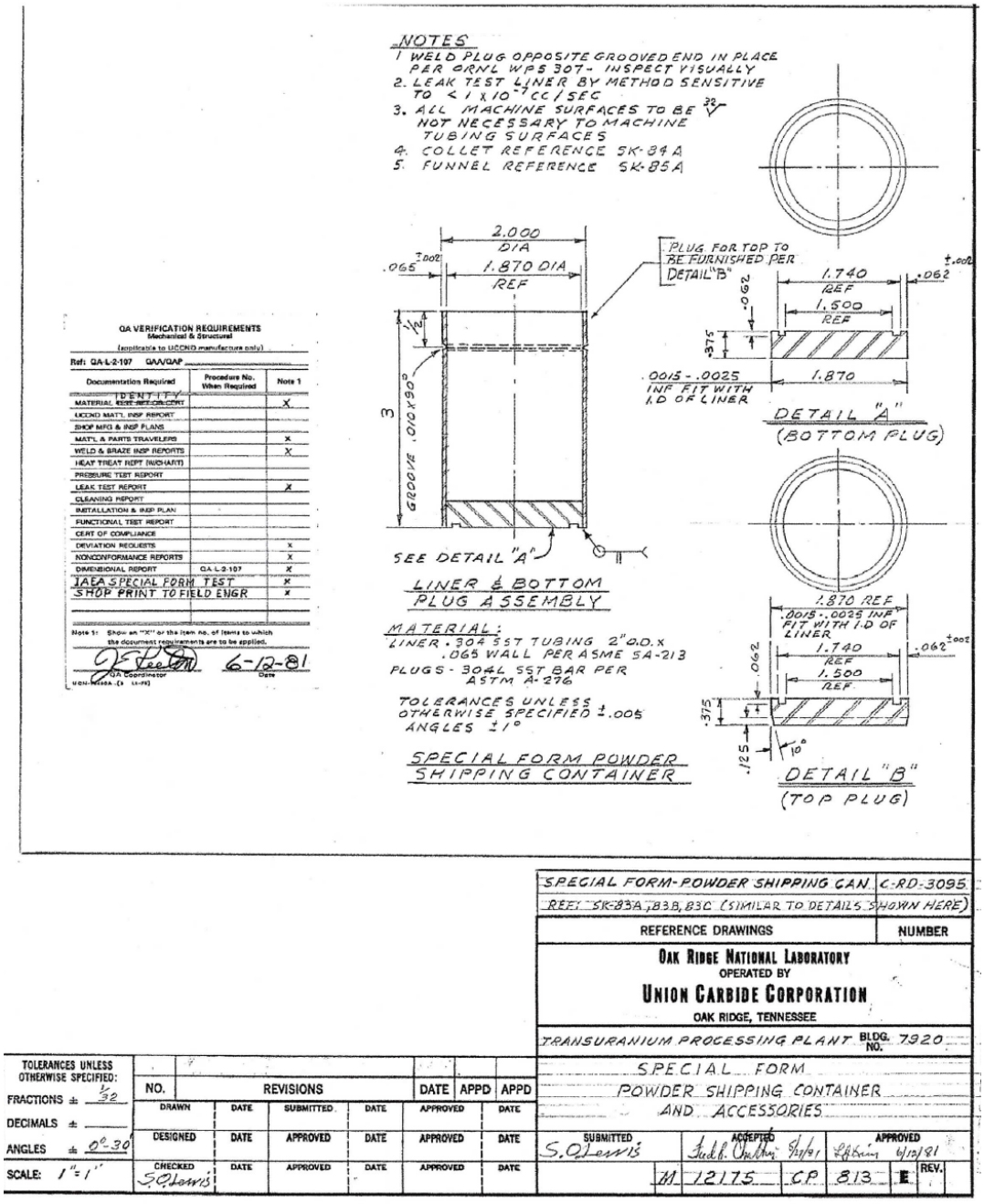


Figure A.4-1. ORNL-SFC-W-1 special form capsule engineering drawing.

APPENDIX B. TEST FORMS FOR ORNL-SFC-W-1 SPECIAL FORM CAPSULE

Please note that the capsule named “Mark 42 Pu” in the test records was renamed “ORNL-SFC-W-1” at the time of report writing.

ORNL Surveillance & Inspection Organization - Certificate #4121.01/Scope of Accreditation to ISO/IEC 17020:2012

Report Number: 7/19/19-1

LEAK TEST REPORT

Test Requested by: J. SHARPE	Allowable Leak Rate: < 1.3 E-4 Std-Atm-cc/s
Date Requested: 7/15/19	Date Required: –
Work Order Number: 3730855	Test Pressure Req. Across Boundary: - 1 ATM
Item Tested: 3EA. MK 42 SFC	Customer: NTRC
Specification: 49 CFR 173.469(a)(4)(i) NDE 70, Rev: 7	Technique Used: INSIDE-OUT Rev: 0 ☒ Inside - Out ☐ Outside - In

EQUIPMENT

LEAK DETECTOR

Make and Model: ADIXEN ASM 182 TD+	
Serial Number: HLD 0860905	

TEST GAUGES

Temp Gauges: A001952	Due: 9/6/19
Pressure Gauges: MTE 767	Date: CAL: 8/28/18

STANDARD LEAK

Manufacturer: VEECO	Tracer Gas: He	
Model: SC-4	Serial Number: 18091	
Leak Rate: 2.55E-8 Atm-cc/s @ - 1 atm @ 23.2 °C		
Correlation Formula: [1 - (T_{cal} - T_{surf}) C_T] LR	Temp Coefficient: 3.0 %/°C	
Correlated LR: 22BE-8 Atm-cc/s @ - 1 atm @ 19.7 °C		
Calibration Due Date: 9/25/19		

RESULTS ☒ Quantitative ☐ Semi - Quantitative

MACHINE CALIBRATION

System Pressure: 1.3E-3 mb	
Background: < 1.0 E-9 Atm-cc/s	
Leak Response: 2.3E-8 Atm-cc/s	
Minimum Detectable Leak: 1.0E-9 Atm-cc/s	
System Sensitivity: 2.0 E-9 Atm-cc/s	
Response Time: ~ 3 s	
Aux. Equipment:	

SYSTEM TEST CONDITIONS

System Temperature: 19.7 °C ☒ Surface ☐ Internal Gas	
delta P Test Boundary: - 1 ATM	
Tracer Gas: He	% Concentration: CALC
System Response Time: ~ 1 MIN	
System Response: < 2.0 E-7 Atm-cc/s	
Duration of Test: ~ 2 MIN EA.	

☒ ACCEPT ☐ REJECT ☒ SKETCH / DATA ATTACHED

System Leak Rate: w/ stated tracer gas < 1.3E-4 Atm-cc/s @ - 1 atm @ 25 °C

COMMENTS:

TU-1, TU-2, TU-3 LEAK TEST #1 PER ORNL/NTRC-084

FINE LT

Test Conducted By: E. VIOAL Level: III Date: 7/19/19 Time: 1:30

Form NDE 70-MS, Rev. 1 CN02

IDMS: 21077

ORNL Surveillance and Inspection Organization / Certification Number: 4121.01 / Scope of Accreditation to ISO/IEC 17020:2012

BOMBING TEST REPORT (*Supplement*)

Leak Test Report Number: 7/19/19-1	*Allowable Leak Rate:* < 1.3 E-4 Atm-cc/s

Item(s) Tested: MK-42 SFC TU-1, TU-2, TU-3

TRACER GAS BOMBING AND LEAK TEST

Bombing Pressure (psig): 30	*Tracer Gas:* He	*Bombing Time:* 15 MIN
Waiting Time (Sec): < 3600		*Internal Volume (cc):* 75.9 (TU-1) 81.1 (TU-2, TU-3)
Measured Leak Rate: < 5.0 E-7 *Atm cc/s*		*Calculated Leak Rate:* < 1.3 E-4 *Atm cc/s into vac. @* 25 °C

Test Results: ☒ *ACCEPT* ☐ *REJECT* ☒ *CALCULATIONS / DATA ATTACHED*

COMMENTS:

Test Conducted By: E. VIDAL Level: III Date: 7/19/19

Form NDE 70-Bomb Rev.1 CN02 IDMS: 21078

ASNT Formula

R	5.00E-07	scc/s	*Measured helium leak rate (Q)*
Pe	44.696	psia	*Bomb Chamber Pressure*
Po	14.696	psia	*Atmospheric pressure*
Ma	28.7	g/mol	*MW of air*
M	4	g/mol	*MW Helium*
T1	900	sec	*Time of exposure (bomb time)*
T2	3600	sec	*Dwell time (from bomb chamber to test start)*
V	75.9	cc	*Internal volume*
L	4.397E-05	scc/s	*Equivalent air leak rate (estimate value for calc to work)*
Part 1	3.582E-04		*Converts true air leak to helium leak rate*
Part 2	1.396E-03		*Calc amount of helium entering package during bomb*
Part 3	9.944E-01		*Amount of helium at the end of the dwell*
Lcf	2.9512E-05	scc/s	*Corrected for tracer concentration*

ASTM/CFR Formula

L	1.178E-04	scc/s	*Equivalent air leak rate*
Lcf	7.90516E-05	scc/s	*Corrected for tracer gas*

RESULTS

L (ASNT/MIL)	4.40E-05	scc/s air	1.18E-04	scc/s He
L(ASTM/CFR)	4.40E-05	scc/s air	1.18E-04	scc/s He

Calculator Version 3/2/18

ACCREDITED
Certificate Number 4121.0

Note: formula is modified for uniformity; a = L/V and 3600 converts hours to seconds

$$R = \left[\frac{LP_e}{P_o}\left(\frac{M_A}{M}\right)^{\frac{1}{2}}\right] \times \left\{1 - e^{-\left[\frac{LT_1}{VP_o}\left(\frac{M_A}{M}\right)^{\frac{1}{2}}\right]}\right\} \times e^{-\left[\frac{LT_2}{VP_o}\left(\frac{M_A}{M}\right)^{\frac{1}{2}}\right]}$$

$$R = \frac{LP_e}{P_o}\left[1 - e^{-\left(\frac{L}{V}\right)T_1}\right] \times \left[e^{-\left(\frac{L}{V}\right)T_2}\right]$$

WO 3730855 TU-1

E-VIDAL 7/19/19

ASNT Formula

R	5.00E-07	scc/s	*Measured helium leak rate (Q)*
Pe	44.696	psia	*Bomb Chamber Pressure*
Po	14.696	psia	*Atmospheric pressure*
Ma	28.7	g/mol	*MW of air*
M	4	g/mol	*MW Helium*
T1	900	sec	*Time of exposure (bomb time)*
T2	3600	sec	*Dwell time (from bomb chamber to test start)*
V	81.1	cc	*Internal volume*
L	4.548E-05	scc/s	*Equivalent air leak rate (estimate value for calc to work)*
Part 1	3.705E-04		*Converts true air leak to helium leak rate*
Part 2	1.351E-03		*Calc amount of helium entering package during bomb*
Part 3	9.946E-01		*Amount of helium at the end of the dwell*
Lcf	3.0526E-05	scc/s	*Corrected for tracer concentration*

ASTM/CFR Formula

L	1.218E-04	scc/s	*Equivalent air leak rate*
Lcf	8.17679E-05	scc/s	*Corrected for tracer gas*

RESULTS

L (ASNT/MIL)	4.55E-05 scc/s air	1.22E-04 scc/s He
L(ASTM/CFR)	4.55E-05 scc/s air	1.22E-04 scc/s He

Calculator Version 3/2/18

ACCREDITED
Certificate Number 4121.0

Note: formula is modified for uniformity; a = L/V and 3600 converts hours to seconds

$$R = \left[\frac{LP_e}{P_o}\left(\frac{M_A}{M}\right)^{\frac{1}{2}}\right] \times \left\{1 - e^{-\left[\frac{LT_1}{VP_o}\left(\frac{M_A}{M}\right)^{\frac{1}{2}}\right]}\right\} \times e^{-\left[\frac{LT_2}{VP_o}\left(\frac{M_A}{M}\right)^{\frac{1}{2}}\right]}$$

$$R = \frac{LP_e}{P_o}\left[1 - e^{-\left(\frac{L}{V}\right)T_1}\right] \times \left[e^{-\left(\frac{L}{V}\right)T_2}\right]$$

NO: 3730855 TU-2, TU-3

E. VIDAL 7/19/19

ORNL Surveillance and Inspection Organization / Certificate #4121.01 / Scope of Accreditation to ISO/IEC 17020:2012

ACCREDITED

Report Number: 7/19/19-2

LEAK TEST REPORT - BUBBLE TEST

Test Requested by: S. SHARPE	Customer: NTRC
Date Requested: 7/15/19	Date Required: –
Work Order Number: 3730855	NDE 70, Rev: 7 / Tech, NDE 70 - BT Rev: 0
Item Tested: 3 EA. MK-42 SFC	Test Pressure Required: 15 "Hg
Specification: 49 CFR 173.469(a)(4)(i)	Inspection Criteria: NO INDICATIONS @ 2 MIN
Technique Used: VAC BOX	Liquid Media Used: CIM 200 @ 20% SOLN.
Test Gas Used: VAC	Liquid Applicator Type: IMMERSION
Inspection Light Intensity: > 100 FC	Post Cleaning Method: DI H2O RINSE
Other Apparatus Used: FLASHLIGHT	

Direct Pressure Technique ☐ **Vacuum Pressure Technique** ☒

Component Limits of Test:

TU-1, TU-2, TU-3 LEAK TEST #1 PER ORNL/NTRC-084

Component Test Site	Component Installation Site
5500	—

Gauges				Test Pressure		Temperature	
Mfg	ID No	Calibration Date	Range	Beginning	End	Beginning	End
—	A002124	10/4/18	0-30 "Hg	15 "Hg	20 "Hg	19.7 °C	19.7 °C

Temperature Measuring Device

Mfg.	Model	Range	I.D. Number
OMEGA	HH804	K-TYPE	A001952

RESULTS ☒ ACCEPT ☐ REJECT POST CLENING PERFORMED: ☒ Y ☐ N

Comments:

GROSS LT

Test Conducted By: E. VIDAL Level: III Insp. Date: 7/19/19

Form NDE-70-Bubble Rev. 1 CN02 IDMS: 10960

767

PRESSURE GAGE CALIBRATION DATA SHEET

DUT M&TE # 767	Range 0-100 psig	Manufacturer WIKA
Calibration Frequency AFTER USE	Scale Subdivisions 0.1 psig	Accuracy (%Span ¼ - ½ - ¼) Grade B: 3 – 2 - 3
Calibrator Used BEAMEX MTE 564		Calibration Date 10-11-17
Calibrator Pressure Module N/A		Calibration Date N/A

Visual Inspection: ☒ Accept ☐ Reject

	DUT Scale	DUT Reading	Standard Gage	Allowed Error
UP	0%	0	0	3.0
	25%	25	24.7	2.0
	50%	50	49.7	2.0
	75%	75	75	2.0
	100%	100	99.5	3.0
Down	100%	100	100	3.0
	75%	75	74.7	2.0
	50%	50	49.7	2.0
	25%	25	24.7	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: 8-28-17

FORM NDE-80-2 Rev. 1

IDMS: 6438

Written By:	Reviewed By:	Approved By:
Richard Michelhaugh	Matt Feldman	John Scaglione

John M. Scaglione Digitally signed by John M. Scaglione Date: 2019.07.31 08:36:10 -04'00'

1. Scope

This procedure describes the process that the Package Testing Program (PTP) uses in the performance of Hypothetical Accident Conditions (HAC) drop tests, using a release mechanism, rigging, and a crane/hoist. Drop tests are performed during the package testing sequence to demonstrate compliance with the performance requirements embodied within the radioactive materials packaging requirements.

2. Safety Precautions

It is the responsibility of PTP personnel to remain alert to potential hazards and take the necessary precautions to ensure a safe working environment. Personnel Protective Equipment required for conducting drop tests: **safety glasses w/side shields, hardhat, gloves and safety shoes**. ***Observers*** of drop tests are required to wear **safety glasses w/side shields and hard hats**. All persons (workers and observers) should be familiar with the hazards associated with drop tests, which involve the release (drop) of heavy objects from specified heights, as well as manipulating heavy objects in preparation for such tests. All persons shall remain sufficiently clear of test specimens during any lifting operation to eliminate the possibility of injury from an accidental release. Release mechanisms are used to initiate the controlled release of the test specimen. Release mechanisms shall not be used for general hoisting operations - a release mechanism shall only be used to lift the test specimen in preparation for the actual drop test. Other test specimen lifts shall be accomplished with proper and approved rigging attached to the crane hook. Release mechanisms shall remain disconnected from actuating power sources until the test specimen is in final position and ready to be released.

3. Equipment

- Release Mechanisms:

  PTP Small Release Mechanism, IE 11631, (for test specimens with a gross mass less than 3000-lb). This is an electro-mechanical device in which an electrically actuated solenoid is used to open the release mechanism jaws, resulting in single-point release of the object suspended from the crane.

OR

PTP "Big Red" Release Mechanism, IE 12437, (for test specimens with a gross mass up to 20,000-lb). This is a larger version of the PTP Small Release Mechanism, enabling a drop capacity up to 20,000-lb. For these larger packages, it will be necessary to use the outside drop pad, a mobile crane, release mechanism, and appropriate rigging to conduct this drop test.

OR

Explosive Cable Cutters and Bolts. For some drop tests (especially those that exceed the capacity of the available release mechanisms, the use of alternative releasing methods (such as explosive cable cutters or explosive nut/bolts) is required. For these devices, an explosive charge is used to cause the release of the test specimen.

- Drop Pad:
  The drop pad that may be used for this test are documented in *Design and Certification 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 surface for impact (target) pads. The outside drop pad has a steel impact surface and mass in excess of 140 tons.

  NTRC Large Drop Pad. This drop pad is located adjacent to the NTRC PEF, and is embedded in the parking lot outside NTRC Room L110. The Large Drop Pad is certified as "essentially unyielding" for 9-m (30-ft) drops of test specimens weighing up to approximately 28,000-lb.

- Plumb bob cable. A commercial measuring tape or other suitable measuring device is to be used to verify the length of the plumb bob cable.

- Digital Camera, Video Camera and Photographer's Clapboard.

- Rigging suitable for lifting the package as required. Rigging includes items such as straps, wire rope chokers, shackles, etc.

- A thermometer for measuring the ambient temperature. Any commercial thermometer may be used, and calibration is not required. The PTP Fluke Thermocouple Thermometer is sufficient for this purpose.

- Test Specimen(s) (i.e., packaging test units)

4. Test Procedure

4.1. Ensure that Measuring & Test Equipment (M&TE) meets the requirements of PTP-QA-013, "Procedure on Control of Measuring and Test Equipment'. Record any M&TE on the Procedure Data Sheet.

4.2. Initiate a unique **Procedure Checklist** form and **Data Sheet** form for each Test Specimen. Record the **Test Plan** identifier and Test Unit identifier on each form. Record completion of each step and other required information at appropriate locations on **Procedure Checklist** and **Data Sheet**, as referenced by the following procedure steps.

4.3. The drop orientation is specified in the specific **Test Plan** for each package. Record the orientation.

4.4. Prepare photographer's clapboard with package name and test specimen identification information.

4.5. Rig the test specimen in the required orientation using the selected release mechanism and measure and record the attitude. The tolerance for rigging the angle of a test specimen's attitude is +/- 2.0° unless otherwise specified in the **Test Plan**. As a general rule, the testing team will rig the package to a tolerance of +/- 1.0°, if possible, given the attachment points and rigging available for a particular package. Take photograph of rigged and raised specimen. Take photograph of angle measurement.

4.6. Attach the PTP plumb bob cable to the lowest point of the test specimen with tape. The package will be properly blocked while attaching the cable to keep the operator safe in the event that the package is released prematurely.

4.7. Raise the test specimen to the specified drop height. Take photograph of height measurement. Pull the cable removal string and remove the 9-m plumb bob and cable from the drop pad.

4.8. Confirm that video cameras are rolling. Plug release mechanism into power. Countdown. Trigger release mechanism. Disconnect power from release mechanism.

4.9. Stop video cameras.

4.10. Record Date and time of test and record the ambient temperature at the test time.

4.11. Photograph damaged test specimen as it lies from drop. Turn test specimen to reveal any damage and photograph the damage. When inspection is complete, move the test unit from the drop pad.

4.12. The Test Engineer shall sign and date the completed **Procedure Checklist** and **Data Sheet**. A Quality Representative shall check each of these test forms for accuracy and completeness and sign and date each checked test form

5. Review and Revision History

- **1-30-04 - Original Issue**
- **5-27-04 - Expanded step 4.7 to explicitly require removal of the plumb bob before proceeding to next step. Added verification step to checklist.**
- **12-01-06 - Triennial Review. Editorial changes. Modified Signoff responsibilities for Checklist and Data Sheet.**
- **1-31-10 - Reviewed, no changes made**
- **1-31-13 - Reviewed, added ambient temperature recording to the end of the checklist. Also added attitude description in Section 7.**
- **1-19-16 - Triennial review, removed TTG reference. Approved by changed to current UFS group leader. – Oscar Martinez**
- **1-20-19 - Triennial review. Checked by must be performed by a QR if applicable. Included a step to ensure all equipment has been calibrated per the PTP-QA-013 procedure. Oscar Martinez**

7. Data Sheet

Test Plan: ORNL/NTRC-084	Test Unit: 1

VERIFIED TASK

✓ Intended attitude of the test unit 0°. Tolerance ± 2° (§4.2)

✓ Attitude Description: vertical top down (§4.2)

✓ Measured attitude of the test unit 1.7° degrees. (§4.4)

✓ Level number M212348 Calibration Exp. Date 7/30/~~2019~~ 2020 ohm 8/2/2019 (§4.4)

✓ Height above the drop pad 30ft. Measuring device A006327 (§4.6)

✓ Date and Time of Drop Test: 8/2/2019 (§4.9)

N/A Ambient temperature: _____°C (_____°F)

Measuring device _____(§4.9)

Testing Damage Observations: _____

Comments: _____

I certify that the above tasks have been performed and that the observations and comments are correct.

Test Engineer _____ Date 08/02/2019. Checked by Michael B. Hunter Date 08/02/2019

ORNL Surveillance & Inspection Organization - Certificate #4121.01/Scope of Accreditation to ISO/IEC 17020:2012

Report Number: 8/8/19-1

LEAK TEST REPORT

Test Requested by:	J. SHARPE	Allowable Leak Rate:	< 1.3 E-4 Std-Atm-cc/s
Date Requested:	7/15/19	Date Required:	-
Work Order Number:	3730855	Test Pressure Req. Across Boundary:	-1 ATM
Item Tested:	MK 42 SFC TU-1	Customer:	NTRC
Specification:	49 CFR 173.469(a)(4)(i) NDE 70, Rev: 7	Technique Used:	INSIDE-OUT Rev: 0 ☒ Inside - Out ☐ Outside - In

EQUIPMENT

LEAK DETECTOR

Make and Model:	ADIXEN ASM 340
Serial Number:	HLD-1601393

TEST GAUGES

Temp Gauges:	A001952	Due:	9/6/19
Pressure Gauges:	MTE-767	~~Due:~~ CAL:	8/28/18

STANDARD LEAK

Manufacturer:	~~VEECO~~ VTI	Tracer Gas:	He
Model:	GPPT-7-He-118T	Serial Number:	TP5150

Leak Rate: 3.97 E-7 Atm-cc/s @ -1 atm @ 23 °C

Correlation Formula: $[1 - (T_{cal} - T_{surf})\ C_T]\ LR$ — Temp Coefficient: 2.0 %/°C

Correlated LR: 3.72 E-7 Atm-cc/s @ -1 atm @ 19.9 °C

Calibration Due Date: 01/17/20

RESULTS ☒ Quantitative ☐ Semi - Quantitative

MACHINE CALIBRATION

System Pressure:	1.9 E-2 mb		
Background:	< 5.0 E-10	Atm-cc/s	
Leak Response:	3.7 E-7	Atm-cc/s	
Minimum Detectable Leak:	1.0 E-8	Atm-cc/s	
System Sensitivity:	2.0 E-8	Atm-cc/s	
Response Time:	~ 3s		
Aux. Equipment:			

SYSTEM TEST CONDITIONS

System Temperature:	19.9 °C	☒ Surface ☐ Internal Gas	
delta P Test Boundary:	~ 1 ATM		
Tracer Gas:	He	% Concentration:	CALC
System Response Time:	~ 1 MIN		
System Response:	< 1.0 E-7	Atm-cc/s	
Duration of Test:	~ 2 MIN		

☒ ACCEPT ☐ REJECT ☒ SKETCH / DATA ATTACHED

System Leak Rate: w/ stated tracer gas < 1.3 E-4 Atm-cc/s @ .1 atm @ 25 °C

COMMENTS:

TU-1 LEAK TEST #2 PER ORNL/NTRC-084 (TEST #3 - POST-IMPACT)

FINE LT

Test Conducted By: E. VIDAL — Level: II — Date: 8/8/19 — Time: 10:30

Form NDE 70-MS, Rev. 1 CN02 — IDMS: 21077

ORNL Surveillance and Inspection Organization / Certification Number: 4121.01 / Scope of Accreditation to ISO/IEC 17020:2012

BOMBING TEST REPORT (*Supplement*)

Leak Test Report Number: 8/8/19-1	*Allowable Leak Rate:* < 1.3 E-4 Atm·cc/s

Item(s) Tested: MK-42 SFC TU-1

TRACER GAS BOMBING AND LEAK TEST

Bombing Pressure (psig): 30	*Tracer Gas:* He	*Bombing Time:* 15 min
Waiting Time (Sec): < 3600	*Internal Volume (cc):* 75.9	
Measured Leak Rate: < 5.0 E-7 *Atm cc/s*	*Calculated Leak Rate:* < 1.3E-4 *Atm cc/s into vac. @* 25 *°C*	

Test Results: ☒ *ACCEPT* ☐ *REJECT* ☒ *CALCULATIONS / DATA ATTACHED*

COMMENTS:

Test Conducted By: E. Vidal Level: III Date: 8/8/19 8/8/19 EDV

Form NDE 70-Bomb Rev.1 CN02 IDMS: 21078

ASNT Formula

R	5.00E-07	scc/s	*Measured helium leak rate (Q)*
Pe	44.696	psia	*Bomb Chamber Pressure*
Po	14.696	psia	*Atmospheric pressure*
Ma	28.7	g/mol	*MW of air*
M	4	g/mol	*MW Helium*
T1	900	sec	*Time of exposure (bomb time)*
T2	3600	sec	*Dwell time (from bomb chamber to test start)*
V	75.9	cc	*Internal volume*
L	4.397E-05	scc/s	*Equivalent air leak rate (estimate value for calc to work)*
Part 1	3.582E-04		*Converts true air leak to helium leak rate*
Part 2	1.396E-03		*Calc amount of helium entering package during bomb*
Part 3	9.944E-01		*Amount of helium at the end of the dwell*
Lcf	2.9512E-05	scc/s	*Corrected for tracer concentration*

ASTM/CFR Formula

L	1.178E-04	scc/s	*Equivalent air leak rate*
Lcf	7.90516E-05	scc/s	*Corrected for tracer gas*

RESULTS

L (ASNT/MIL)	4.40E-05 scc/s air	1.18E-04 scc/s He
L(ASTM/CFR)	4.40E-05 scc/s air	1.18E-04 scc/s He

Calculator Version 3/2/18

ACCREDITED
Certificate Number 4121.0

Note: formula is modified for uniformity; a = L/V and 3600 converts hours to seconds

$$R = \left[\frac{LP_e}{P_o}\left(\frac{M_A}{M}\right)^{\frac{1}{2}}\right] \times \left\{1 - e^{-\left[\frac{LT_1}{VP_o}\left(\frac{M_A}{M}\right)^{\frac{1}{2}}\right]}\right\} \times e^{-\left[\frac{LT_2}{VP_o}\left(\frac{M_A}{M}\right)^{\frac{1}{2}}\right]}$$

$$R = \frac{LP_e}{P_o}\left[1 - e^{-\left(\frac{L}{V}\right)T_1}\right] \times \left[e^{-\left(\frac{L}{V}\right)T_2}\right]$$

WO 3730855 TU-1

E. VIOLA 7/19/19

767

PRESSURE GAGE CALIBRATION DATA SHEET

DUT M&TE # 767	Range 0-100 psig	Manufacturer WIKA
Calibration Frequency AFTER USE	Scale Subdivisions 0.1 psig	Accuracy (%Span ¼ - ½ - ¼) Grade B: 3 – 2 - 3
Calibrator Used BEAMEX MTE 564		Calibration Date 10-11-17
Calibrator Pressure Module N/A		Calibration Date N/A

Visual Inspection: ☒ Accept ☐ Reject

	DUT Scale	DUT Reading	Standard Gage	Allowed Error
UP	0%	0	0	3.0
	25%	25	24.7	2.0
	50%	50	49.7	2.0
	75%	75	75	2.0
	100%	100	99.5	3.0
Down	100%	100	100	3.0
	75%	75	74.7	2.0
	50%	50	49.7	2.0
	25%	25	24.7	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: 8-28-17

FORM NDE-80-2 Rev. 1

IDMS: 6438

ORNL Surveillance and Inspection Organization / Certificate #4121.01 / Scope of Accreditation to ISO/IEC 17020:2012

Report Number: 8/8/19-2

LEAK TEST REPORT - BUBBLE TEST

Test Requested by: J.SHARPE	Customer: RNSD		
Date Requested: 7/15/19	Date Required: -		
Work Order Number: 3730855	NDE 70, Rev: 7	Tech, NDE 70 - BT Rev: 0	
Item Tested: MK-42 SFC TU-1	Test Pressure Required: 15" Hg		
Specification: 49 CFR 173.469(a)(4)(i)	Inspection Criteria: NO INDICATIONS @ 2 MIN		
Technique Used: VAC BOX	Liquid Media Used: IMMERSIT CIM 200 @ 20% SOLN		
Test Gas Used: VAC	Liquid Applicator Type: IMMERSION		
Inspection Light Intensity: >100 FC	Post Cleaning Method: DI RINSE / WIPE DRY		
Other Apparatus Used: FLASHLIGHT			

Direct Pressure Technique ☐ **Vacuum Pressure Technique** ☒

Component Limits of Test:

TEST SEQUENCE #3, LEAK TEST #2 - POST-IMPACT

PER ORNL/NTRC-084

Component Test Site	Component Installation Site
5500	-

Gauges				Test Pressure		Temperature	
Mfg	ID No	Calibration Date	Range	Beginning	End	Beginning	End
	A002124	10/14/18	0-30" Hg	15" Hg	23" Hg	19.9°C	19.9°C

Temperature Measuring Device

Mfg.	Model	Range	I.D. Number
OMEGA	HH804	K-TYPE	A001952

RESULTS ☒ ACCEPT ☐ REJECT POST CLENING PERFORMED: ☒ Y ☐ N

Comments:

GROSS LT

Test Conducted By: E.VIOLA Level: III Insp. Date: 8/8/19

Form NDE-70-Bubble Rev. 1 CN02 IDMS: 10960

TEST FORM 1 – **Percussion Test Form**

Test Plan

ORNL/NTRC-084 Rev 0

Test Unit TU- 1

VERIFIED	TASK
✓	The weight of the percussion billet has been measured and verified to be 3lbs or greater:
	Measured weight of billet 1.4249 (lbs.)
✓	Scale used for measurement: A000593 Calibration due: 7/25/2020
	The calibration of the 1-m ruler has been verified:
✓	1-m Ruler Equipment # A000853 Calibration due: 6/30/2021
	The dimensions of the lead sheet have been measured by commercial tape measure: UAM 8/20/19
✓	Thickness 1" Length 12" Depth 12"
✓	The lead sheet has been placed on the unyielding surface and a picture has been taken.
✓	The test unit has been placed (centered) on the lead sheet and a picture has been taken.
✓	The drop test release mechanism has been attached to the crane.
✓	The percussion billet has been captured by the release mechanism.
✓	The billet has been centered over the test unit and a picture has been taken.
✓	The billet has been raised to height of 1 meter over the highest point of the test unit and a picture has been taken.
✓	The billet was released and impacted the test unit.
✓	All observable damage to the test unit caused by the percussion test has been recorded and pictures of the test unit after the percussion test have been taken.
✓	Form has been signed and dated by the Quality Assurance Representative (QAR).

Comments:

I certify that the above tasks have been performed and that the observations and comments are correct.

Testing Technician — Date: 8/20/2019

Checked by (QAR): Michael B. Houston — Date: 08/20/2019

All photographs will be uniquely identified with test unit, date and time to ensure that the proper sequence can be reconstructed

ORNL Surveillance & Inspection Organization - Certificate #4121.01/Scope of Accreditation to ISO/IEC 17020:2012

Report Number: 8/20/19-1

LEAK TEST REPORT

Test Requested by:	J. SHARPE	Allowable Leak Rate:	< 1.3E-4 Std-Atm-cc/s
Date Requested:	7/15/19	Date Required:	–
Work Order Number:	3730855	Test Pressure Req. Across Boundary:	-1 Atm
Item Tested:	Mk-42 SFC TU-1	Customer:	NTRC
Specification:	49 CFR 173.469(a)(4)(i) NDE 70, Rev: 7	Technique Used:	INSIDE-OUT Rev: 0 ☒ Inside - Out ☐ Outside - In

EQUIPMENT

LEAK DETECTOR

Make and Model:	ADIXEN ASM 340
Serial Number:	H20-1601393

TEST GAUGES

Temp Gauges:	A001952	Due: 9/6/19
Pressure Gauges:	MTE-767	~~Due:~~ CAL: 8/28/18

STANDARD LEAK

Manufacturer:	VTI	Tracer Gas:	He
Model:	GPPT-7-He-118T	Serial Number:	TP5150

Leak Rate: 3.97E-7 Atm-cc/s @ -1 atm @ 23 °C

Correlation Formula: $[1 - (T_{cal} - T_{surf})\ C_T]\ LR$ Temp Coefficient: 2.0 %/°C

Correlated LR: 3.72E-7 Atm-cc/s @ -1 atm @ 19.9 °C

Calibration Due Date: 01/17/20

RESULTS ☒ Quantitative ☐ Semi - Quantitative

MACHINE CALIBRATION

System Pressure:	1.9E-2 mb		
Background:	5.0E-10	Atm-cc/s	
Leak Response:	3.7E-7	Atm-cc/s	
Minimum Detectable Leak:	1.0E-8	Atm-cc/s	
System Sensitivity:	2.0E-8	Atm-cc/s	
Response Time:	~ 3 s		
Aux. Equipment:			

SYSTEM TEST CONDITIONS

System Temperature:	19.9 °C	☒ Surface ☐ Internal Gas	
delta P Test Boundary:	-1 Atm		
Tracer Gas:	He	% Concentration:	CALC
System Response Time:	~ 1 MIN		
System Response:	< 5.0E-8	Atm-cc/s	
Duration of Test:	~ 2 MIN		

☒ ACCEPT ☐ REJECT ☒ SKETCH / DATA ATTACHED

System Leak Rate: w/ stated tracer gas <1.3E-4 Atm-cc/s @ -1 atm @ 25 °C

COMMENTS:

TU-1 LEAK TEST #3 PER ORNL/NTRC-084 (TEST #5 POST-PERCUSSION)

FINE LT

Test Conducted By: E. VIDAL Level: III Date: 8/20/19 Time: 2:15

Form NDE 70-MS, Rev. 1 CN02 IDMS: 21077

ORNL Surveillance and Inspection Organization / Certification Number: 4121.01 / Scope of Accreditation to ISO/IEC 17020:2012

BOMBING TEST REPORT (*Supplement*)

Leak Test Report Number: 8/20/19-1	*Allowable Leak Rate:* < 1.3 E-4 Atm·cc/s

Item(s) Tested: MK-42 SFC TU-1 Post-Percussion

TRACER GAS BOMBING AND LEAK TEST

Bombing Pressure (psig): 30	*Tracer Gas:* He	*Bombing Time:* 15 min
Waiting Time (Sec): < 3600	*Internal Volume (cc):* 75.9	
Measured Leak Rate: < 5.0 E-7 *Atm cc/s*	*Calculated Leak Rate:* < 1.3E-4 *Atm cc/s into vac. @* 25 °C	

Test Results: ☒ *ACCEPT* ☐ *REJECT* ☒ *CALCULATIONS / DATA ATTACHED*

COMMENTS:

Test Conducted By: E-VIOR Level: III Date: 8/20/19

Form NDE 70-Bomb Rev.1 CN02 IDMS: 21078

ASNT Formula

R	5.00E-07	scc/s	*Measured helium leak rate (Q)*
Pe	44.696	psia	*Bomb Chamber Pressure*
Po	14.696	psia	*Atmospheric pressure*
Ma	28.7	g/mol	*MW of air*
M	4	g/mol	*MW Helium*
T1	900	sec	*Time of exposure (bomb time)*
T2	3600	sec	*Dwell time (from bomb chamber to test start)*
V	75.9	cc	*Internal volume*
L	4.397E-05	scc/s	*Equivalent air leak rate (estimate value for calc to work)*
Part 1	3.582E-04		*Converts true air leak to helium leak rate*
Part 2	1.396E-03		*Calc amount of helium entering package during bomb*
Part 3	9.944E-01		*Amount of helium at the end of the dwell*
Lcf	2.0512E-05	scc/s	*Corrected for tracer concentration*

ASTM/CFR Formula

L	1.178E-04	scc/s	*Equivalent air leak rate*
Lcf	7.90516E-05	scc/s	*Corrected for tracer gas*

RESULTS

L (ASNT/MIL)	4.40E-05	scc/s air	1.18E-04	scc/s He
L(ASTM/CFR)	4.40E-05	scc/s air	1.18E-04	scc/s He

Calculator Version 3/2/18

ACCREDITED
Certificate Number 4121.0

Note: formula is modified for uniformity; a = L/V and 3600 converts hours to seconds

$$R = \left[\frac{LP_e}{P_o}\left(\frac{M_A}{M}\right)^{\frac{1}{2}}\right] \times \left\{1 - e^{-\left[\frac{LT_1}{VP_o}\left(\frac{M_A}{M}\right)^{\frac{1}{2}}\right]}\right\} \times e^{-\left[\frac{LT_2}{VP_o}\left(\frac{M_A}{M}\right)^{\frac{1}{2}}\right]}$$

$$R = \frac{LP_e}{P_o}\left[1 - e^{-\left(\frac{L}{V}\right)T_1}\right] \times \left[e^{-\left(\frac{L}{V}\right)T_2}\right]$$

WO 3730855 TU-1

EVIDAL 7/19/19

ORNL Surveillance and Inspection Organization / Certificate #4121.01 / Scope of Accreditation to ISO/IEC 17020:2012

Report Number: 8/20/19-2

LEAK TEST REPORT - BUBBLE TEST

Test Requested by: J. SHARPE	Customer: NTRC
Date Requested: 7/15/19	Date Required: —
Work Order Number: 3730855	NDE 70, Rev: 7 / Tech, NDE 70 - BT Rev: 0
Item Tested: MK-42 SFC TU-1	Test Pressure Required: 15" Hg
Specification: 49 CFR 173.469(a)(4)(i)	Inspection Criteria: NO INDICATIONS @ 2 MIN
Technique Used: VAC BOX	Liquid Media Used: IMMERSIT CLM 200 @ 20% SOLN
Test Gas Used: VAC	Liquid Applicator Type: IMMERSION
Inspection Light Intensity: > 100 FC	Post Cleaning Method: DI RINSE / WIPE DRY
Other Apparatus Used: FLASHLIGHT	

Direct Pressure Technique ☐ **Vacuum Pressure Technique** ☒

Component Limits of Test:

TEST SEQUENCE #5, LT #3 - POST-PERCUSSION TEST PER ORNL/NTRC-084

Component Test Site	Component Installation Site
5500	—

Gauges				Test Pressure		Temperature	
Mfg	ID No	Calibration Date	Range	Beginning	End	Beginning	End
	A002124	10/14/18	0-30" Hg	-18" Hg	-18" Hg	19.9°C	19.9°C

Temperature Measuring Device

Mfg.	Model	Range	I.D. Number
OMEGA	HH804	K-TYPE	A003952

RESULTS ☒ ACCEPT ☐ REJECT POST CLENING PERFORMED: ☒ Y ☐ N

Comments:

GROSS LT

Test Conducted By: E. VIDAL Level: III Insp. Date: 8/20/19

Form NDE-70-Bubble Rev. 1 CN02 IDMS: 10960

TEST FORM 2 – **Heat Test Checklist**

Test Plan ORNL/NTRC-084 Rev. 0

Test Unit 2

VERIFIED	TASK
✓	The test unit tray has been placed in the furnace.
✓	Two calibrated Type K thermocouples have been installed in the working area of the furnace and attached to the Fluke thermocouple reader.
	Thermocouple calibration date: 11-12-18 Thermocouple ID: Delta M. Corp Type K Thermocouples
✓	The furnace doors have been closed and the furnace has been turned on with a set point of 850° C.
✓	Thermocouple readings have been made every 60 minutes for at least 3 hours with a calibrated thermocouple reader
	Thermocouple reader model number M303131 Calibration date: 11-12-18 → 11-12-19
✓	Any changes in the furnace set point during the three-hour preheat period have been recorded on TEST FORM 3.
✓	Just prior to test unit insertion, a final preheat temperature recording was made.
✓	Prior to opening the furnace ensure the operator has the proper PPE including gloves rated for work in 850 deg C atmosphere and a similarly rated face shield if required.
✓	The furnace door has been opened, the test unit inserted, the furnace door closed, and the furnace activated with a set point of 850° C (1560° F) (or as adjusted during the preheat process).
✓	When both thermocouple readings have reached 800° C (1475° F), the 10-minute thermal test was started.
✓	Thermocouple readings were taken and recorded on TEST FORM 4 every 30 seconds for the duration of the 10-minute thermal test.
✓	Adjustments were made to the furnace set point as directed by the test director.
✓	When the 10-minute test period was finished, the furnace was turned off and furnace door was opened to the maximum extent possible.
✓	As soon as conditions permitted, the test unit was removed from the furnace and allowed to cool naturally.
✓	Any deformation or other unusual circumstances regarding the test or the test unit was recorded.
	Form has been signed and dated by the Quality Assurance Representative (QAR).

Comments: Pictures were taken, no deformation observed. Furnace was allowed to heat-back up after TU-2 removal.

I certify that the above tasks have been performed and that the observations and comments are correct.

Testing Technician	Date	Checked by (QAR)	Date
	09/27/2019	Michael B. Houston	09/27/2019

*All photographs will be uniquely identified with test unit, date and time to ensure that the proper sequence can be reconstructed

TEST FORM 3 – **Heat Test Preheat Data Sheet**

Test Plan ORNL/NTRC-084 Rev. 0

Test Unit 2

VERIFIED	TASK
✓	Record the temperature in the furnace every thirty (30) minutes for the duration of the preheat (at least 3 hours):
✓	Form has been signed and dated by the Quality Assurance Representative (QAR).

Time (min)	°C Thermocouple 1 (°F)	°C Thermocouple 2 (°F)
0	853.9 (1569.04)	853.7 (1568.7)
30	856.2 (1573.2)	854.1 (1569.3)
60	854.8 (1570.7)	853.9 (1569.2)
90	853.7 (1568.6)	850.7 (1563.4)
120	855.1 (1571.1)	850.4 (1562.7)
150	856.3 (1573.2)	852.8 (1567.2)
180	857.2 (1574.9)	852.6 (1566.8).

Comments:

I certify that the above tasks have been performed and that the observations and comments are correct.

Testing Technician	Date	Checked by (QAR)	Date
	09/27/2019	Michael B. Howton	09/27/2019

*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 – **Heat Test Data Sheet**

Test Plan ORNL/NTRC-084, Rev. 0

Test Unit 2

VERIFIED	TASK
✓	Record the temperature in the furnace every 30 seconds for the duration of the test:
✓	Form has been signed and dated by the Quality Assurance Representative (QAR).

Time (min:sec)	Thermocouple 1 (Celsius)	Thermocouple 2 (Celsius)
00:00	822.2	831.8
00:30	820.9	833.9
01:00	825.4	833.7
01:30	825.8	836.2
02:00	824.2	841.7
02:30	826.4	837.9
03:00	828.2	844.5
03:30	829.9	843.3
04:00	833.6	843.2
04:30	833.4	841.8
05:00	832.3	844.4
05:30	831.9	848.6
06:00	832.3	845.1
06:30	835.6	848.9
07:00	832.3	847.2
07:30	834.3	850.0
08:00	832.9	849.9
08:30	832.9	852.9
09:00	840.4	850.6
09:30	835.1	850.3
10:00	829.1	849.8

Comments:

I certify that the above tasks have been performed and that the observations and comments are correct.

Testing Technician — Date: 09/27/2019 — Checked by (QAR): Michael B. Hunter — Date: 09/27/2019

*All photographs/movies will be uniquely identified with test unit, date and time to ensure that the proper sequence can be reconstructed

TEST FORM 2 – **Heat Test Checklist**

Test Plan ORNL/NTRC-084 Rev. 0

Test Unit 3

VERIFIED	TASK
✓	The test unit tray has been placed in the furnace.
✓	Two calibrated Type K thermocouples have been installed in the working area of the furnace and attached to the Fluke thermocouple reader. Delta M. Corp TYPE K Thermocouple calibration date: 11-12-18 Thermocouple ID: Thermocouples
✓	The furnace doors have been closed and the furnace has been turned on with a set point of 850° C.
✓	Thermocouple readings have been made every 60 minutes for at least 3 hours with a calibrated thermocouple reader Thermocouple reader model number M303131 Calibration date: 11-12-18 → 11-12-19
✓	Any changes in the furnace set point during the three-hour preheat period have been recorded on TEST FORM 3.
✓	Just prior to test unit insertion, a final preheat temperature recording was made.
✓	Prior to opening the furnace ensure the operator has the proper PPE including gloves rated for work in 850 deg C atmosphere and a similarly rated face shield if required.
✓	The furnace door has been opened, the test unit inserted, the furnace door closed, and the furnace activated with a set point of 850° C (1560° F) (or as adjusted during the preheat process).
✓	When both thermocouple readings have reached 800° C (1475° F), the 10-minute thermal test was started.
✓	Thermocouple readings were taken and recorded on TEST FORM 4 every 30 seconds for the duration of the 10-minute thermal test.
✓	Adjustments were made to the furnace set point as directed by the test director.
✓	When the 10-minute test period was finished, the furnace was turned off and furnace door was opened to the maximum extent possible.
✓	As soon as conditions permitted, the test unit was removed from the furnace and allowed to cool naturally.
✓	Any deformation or other unusual circumstances regarding the test or the test unit was recorded.
	Form has been signed and dated by the Quality Assurance Representative (QAR).

Comments:

No unsual deformation observed, pictures were taken. After TU-2 removal, the furnace was allowed to heat-back-up above test temp. range before TU-3 was inserted.

I certify that the above tasks have been performed and that the observations and comments are correct.

Testing Technician — Date: 09/27/2019 — Checked by (QAR): Michael B Houston — Date: 09/27/2019

*All photographs will be uniquely identified with test unit, date and time to ensure that the proper sequence can be reconstructed

TEST FORM 3 – **Heat Test Preheat Data Sheet**

Test Plan ORNL/NTRC-084 Rev. 0

Test Unit 3

VERIFIED	TASK
✓	Record the temperature in the furnace every thirty (30) minutes for the duration of the preheat (at least 3 hours): Form has been signed and dated by the Quality Assurance Representative (QAR).

Time (min)	°C Thermocouple 1 (°F)	°C Thermocouple 2 (°F)
0	853.9 (1569.04)	853.7 (1568.7)
30	856.2 (1573.2)	854.1 (1569.3)
60	854.8 (1570.7)	853.9 (1569.2)
90	853.7 (1568.6)	850.7 (1563.4)
120	855.1 (1571.1)	850.4 (1562.7)
150	856.3 (1573.2)	852.8 (1567.2)
180	857.2 (1574.9)	852.6 (1566.8)

Comments:

I certify that the above tasks have been performed and that the observations and comments are correct.

Testing Technician	Date	Checked by (QAR)	Date
	09/27/2019	Michael B. Houston	09/27/2019

*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 – **Heat Test Data Sheet**

Test Plan ORNL/NTRC-084, Rev. 0

Test Unit 3

VERIFIED	TASK
✓	Record the temperature in the furnace every 30 seconds for the duration of the test:
✓	Form has been signed and dated by the Quality Assurance Representative (QAR).

Time (min:sec)	Thermocouple 1 (Celsius)	Thermocouple 2 (Celsius)
00:00	822.5	834.9
00:30	822.6	832.9
01:00	823.0	829.2
01:30	821.0	838.3
02:00	830.0	837.1
02:30	833.5	836.9
03:00	832.3	836.0
03:30	835.9	840.0
04:00	834.3	843.4
04:30	834.7	844.4
05:00	AA ~~836~~ 836.3	846.9
05:30	841.4	847.9
06:00	839.7	850.5
06:30	843.3	844.7
07:00	839.8	848.1
07:30	843.6	849.7
08:00	840.6	857.2
08:30	845.4	850.3
09:00	845.1	853.8
09:30	844.3	856.6
10:00	847.3	853.5

Comments:

I certify that the above tasks have been performed and that the observations and comments are correct.

Testing Technician — Date 09/27/2019 — Checked by (QAR) Michael B. Howton — Date 09/27/2019

*All photographs/movies will be uniquely identified with test unit, date and time to ensure that the proper sequence can be reconstructed

ORNL Surveillance & Inspection Organization - Certificate #4121.01/Scope of Accreditation to ISO/IEC 17020:2012

ACCREDITED

Report Number: 10/3/19-1

LEAK TEST REPORT

Test Requested by: J. SHARPE	Allowable Leak Rate: $< 1.3 E^{-4}$ Std-Atm-cc/s
Date Requested: 7/15/19	Date Required: –
Work Order Number: 3730855	Test Pressure Req. Across Boundary: -1 Atm
Item Tested: 20in. MK 42 SFC	Customer: NTRC
Specification: 49 CFR 173.469(a)(4)(i) NDE 70, Rev: 7	Technique Used: INSIDE-OUT Rev: 0 ☒ Inside - Out ☐ 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: TPS154
		Leak Rate: $5.24 E^{-8}$ Atm-cc/s @ -1 atm @ 22.2 °C	
TEST GAUGES		Correlation Formula: $[1 - (T_{cal} - T_{surf}) C_T] LR$	Temp Coefficient: 2.0 %/°C
Temp Gauges: A005947	Due: 9/12/20	Correlated LR: $5.4 E^{-8}$ Atm-cc/s @ -1 atm @ 23.8 °C	
Pressure Gauges: A002110	Due: 8/13/20	Calibration Due Date: 01/18/20	

RESULTS ☒ Quantitative ☐ Semi - Quantitative

MACHINE CALIBRATION		SYSTEM TEST CONDITIONS	
System Pressure: $1.8 E^{-2}$ mb		System Temperature: 24 °C ☒ Surface ☐ Internal Gas	
Background: $< 5.0 E^{-10}$	Atm-cc/s	delta P Test Boundary: -1 Atm	
Leak Response: $5.4 E^{-8}$	Atm-cc/s	Tracer Gas: He	% Concentration: CALC
Minimum Detectable Leak: $1.0 E^{-9}$	Atm-cc/s	System Response Time: ~ 2 MIN	
System Sensitivity: $2.0 E^{-9}$	Atm-cc/s	System Response: $1.4 E^{-8}$	Atm-cc/s
Response Time: ~3s		Duration of Test: ~ 3 MIN	
Aux. Equipment:			

☒ ACCEPT ☐ REJECT ☒ SKETCH / DATA ATTACHED

System Leak Rate: w/ Stated tracer gas $< 1.3 E^{-4}$ Atm-cc/s @ -1 atm @ 25 °C

COMMENTS:

TU-2, TU-3 POST-HEAT LEAK TEST

FINE-LT

Test Conducted By: E. VICAR Level: III Date: 10/3/19 Time: 9:40

Form NDE 70-MS, Rev. 1 CN02

IDMS: 21077

ORNL Surveillance and Inspection Organization / Certification Number: 4121.01 / Scope of Accreditation to ISO/IEC 17020:2012

BOMBING TEST REPORT (*Supplement*)

Leak Test Report Number: 10/3/19-1	*Allowable Leak Rate:* ≤ 1.3 E-4

Item(s) Tested: TU-2, TU-3 MK 42 SFC

TRACER GAS BOMBING AND LEAK TEST

Bombing Pressure (psig): 30	*Tracer Gas:* He	*Bombing Time:* 15 MIN
Waiting Time (Sec): < 3600		*Internal Volume (cc):* 81.1
Measured Leak Rate: < 5.0 E-7 *Atm cc/s*		*Calculated Leak Rate:* < 1.3E-4 *Atm cc/s into vac. @* 25 *°C*

Test Results: ☒ *ACCEPT* ☐ *REJECT* ☒ *CALCULATIONS / DATA ATTACHED*

COMMENTS:

POST-HEAT LEAK TEST

Test Conducted By: E. VIDAL Level: III Date: 10/3/19

Form NDE 70-Bomb Rev.1 CN02 IDMS: 21078

ASNT Formula

R	5.00E-07	scc/s	*Measured helium leak rate (Q)*
Pe	44.696	psia	*Bomb Chamber Pressure*
Po	14.696	psia	*Atmospheric pressure*
Ma	28.7	g/mol	*MW of air*
M	4	g/mol	*MW Helium*
T1	900	sec	*Time of exposure (bomb time)*
T2	3600	sec	*Dwell time (from bomb chamber to test start)*
V	81.1	cc	*Internal volume*
L	4.548E-05	scc/s	*Equivalent air leak rate (estimate value for calc to work)*
Part 1	3.705E-04		*Converts true air leak to helium leak rate*
Part 2	1.351E-03		*Calc amount of helium entering package during bomb*
Part 3	9.946E-01		*Amount of helium at the end of the dwell*
Lcf	3.0526E-05	scc/s	*Corrected for tracer concentration*

ASTM/CFR Formula

L	1.218E-04	scc/s	*Equivalent air leak rate*
Lcf	8.17679E-05	scc/s	*Corrected for tracer gas*

RESULTS

L (ASNT/MIL)	4.55E-05 scc/s air	1.22E-04 scc/s He
L(ASTM/CFR)	4.55E-05 scc/s air	1.22E-04 scc/s He

Calculator Version 3/2/18

ACCREDITED
Certificate Number 4121.0

Note: formula is modified for uniformity; a = L/V and 3600 converts hours to seconds

$$R = \left[\frac{LP_e}{P_o}\left(\frac{M_A}{M}\right)^{\frac{1}{2}}\right] \times \left\{1 - e^{-\left[\frac{LT_1}{VP_o}\left(\frac{M_A}{M}\right)^{\frac{1}{2}}\right]}\right\} \times e^{-\left[\frac{LT_2}{VP_o}\left(\frac{M_A}{M}\right)^{\frac{1}{2}}\right]}$$

$$R = \frac{LP_e}{P_o}\left[1 - e^{-\left(\frac{L}{V}\right)T_1}\right] \times \left[e^{-\left(\frac{L}{V}\right)T_2}\right]$$

NO: 3730855 TU-2, TU-3

E-VIOAR 7/19/19

ORNL Surveillance and Inspection Organization / Certificate #4121.01 / Scope of Accreditation to ISO/IEC 17020:2012

Report Number: 10/3/19-2

LEAK TEST REPORT - BUBBLE TEST

Test Requested by: J. SHARPE	Customer: NTRC
Date Requested: 7/15/19	Date Required: —
Work Order Number: 3730855	NDE 70, Rev: 7 / Tech, NDE 70 - BT Rev: 0
Item Tested: TU-2, TU-3 MK42 SFC	Test Pressure Required: -15" Hg
Specification: 49 CFR 173.469(a)(4)(i)	Inspection Criteria: NO BUBBLES @ 2 MIN
Technique Used: VAC BOX	Liquid Media Used: IMMERSIT CIM200 @ 20%
Test Gas Used: VAC	Liquid Applicator Type: IMMERSION
Inspection Light Intensity: >100 FC	Post Cleaning Method: RINSE
Other Apparatus Used: FLASHLIGHT	

Direct Pressure Technique ☐ **Vacuum Pressure Technique** ☒

Component Limits of Test:

TEST SEQUENCE #3 PER ORNL/NTRC-084

POST-HEAT LT

Component Test Site	Component Installation Site
5300	

Gauges				Test Pressure		Temperature	
Mfg	ID No	Calibration Date	Range	Beginning	End	Beginning	End
	A002124	10/4/18	0-30" Hg	15" Hg	18" Hg	23.8°C	23.18°C

Temperature Measuring Device

Mfg.	Model	Range	I.D. Number
OMEGA	HH804	K-TYPE	A005947

RESULTS ☒ ACCEPT ☐ REJECT POST CLEANING PERFORMED: ☒ Y ☐ N

Comments:

GROSS LT

Test Conducted By: R. VIDAL Level: II Insp. Date: 10/3/19

Form NDE-70-Bubble Rev. 1 CN02 IDMS: 10960

APPENDIX C. WELD INSPECTION REPORT

ORNL – Oak Ridge Sites

Weld Examination Report

Job Title: SPECIAL FORM POWDER SHIPPING CONTAINER		**Work Order:** 3665AC63	
Specification: SEE NDE-21-REV-3		**Examination Procedures (Rev.):** NDE-21-REV-3	
Drawing No: M 12175 CP 813 E	**Line No:** N/A	**Auxiliary Light Equipment:** FLASHLIGHT	
Sketch or Weld Map No./Other: SEE DRAWING			

Weld No.	Materials			WPS	Welder Stencil	Exams	Inspector/ Level	Time & Date of Inspection	Results	Comments
	Base A *Size and Heat	Base B *Size and Heat	Filler *Size and Heat							
W-1	bottom plug 304L HT-E181838	liner /tube 304L304L HT-11R648	ER308/308L .030" HT-DAFS	GT88-1[PP]	3V	1,6	Mark A Denton Digitally signed by Mark A Denton Date: 2019.06.16 06:40:55 -04'00'	6-16-19	8 SAT	CAPSULE # 1
W-2	top plug 304L HT-E181838	liner /tube 304L304L HT-11R648	ER308/308L .030" HT-DAFS	GT88-1[PP]	3V	1,6	Mark A Denton Digitally signed by Mark A Denton Date: 2019.06.16 06:41:01 -04'00'	6-16-19	8 SAT	CAPSULE # 1
-------	----------	[SURROGATE #	TH228TST]	----------	--------	--------		----------	--------	----------
W-1	bottom plug 304L HT-E181838	iner /tube 304L304L HT-11R648	ER308/308L .030" HT-DAFS	GT88-1[PP]	3V	1,6	Mark A Denton Digitally signed by Mark A Denton Date: 2019.06.16 06:41:08 -04'00'	6-16-19	8 SAT	CAPSULE # 2
W-2	top plug 304L HT-E181838	iner /tube 304L304L HT-11R648	ER308/308L .030" HT-DAFS	GT88-1[PP]	3V	1,6	Mark A Denton Digitally signed by Mark A Denton Date: 2019.06.16 06:41:14 -04'00'	6-16-19	8 SAT	CAPSULE # 2
--------	----------	[SURROGATE #	AcB-014]	----------	---------	----------		----------	--------	----------
W-1	bottom plug 304L HT-E181838	iner /tube 304L304L HT-11R648	ER308/308L .030" HT-DAFS	GT88-1[PP]	3V	1,6	Mark A Denton Digitally signed by Mark A Denton Date: 2019.06.16 06:41:21 -04'00'	6-16-19	8 SAT	CAPSULE # 3
W-2	top plug 304L HT-E181838	iner /tube 304L304L HT-11R648	ER308/308L .030" HT-DAFS	GT88-1[PP]	3V	1,6	Mark A Denton Digitally signed by Mark A Denton Date: 2019.06.16 06:41:28 -04'00'	6-16-19	8 SAT	CAPSULE # 3
-------	----------	[SURROGATE #	D1SFC]	----------	----------	----------		----------	----------	----------

***Pipe Size or Plate Thickness**

1. Joint Preparation and Fit-Up
2. Visual Root Pass
3. P.T. Root Pass
4. Intermediate Visual
5. P.T. Final Pass
6. Final Pass Visual
7. Final R.T.
8. A.W.S. QC1 Final Acceptance
9. In Process per B31.3, paras. 341.4.1(b)(1) and 344.7, requires engineers' approval
10. Other: _____

Penetrant Materials Batch No:

SKL-SP2 N/A
SKC-S N/A
SKD-S2 N/A

Note: This form is for use with Type II Visible, Solvent Removeable only. PT reject indications must record type, location and extent.

Form: Weld Insp Short Rev 0

outokumpu
high performance stainless steel

Certificate of Test

PRODEC QUALITY Page: 1

HEAT E181838 ORDER 684829/ 04 BOL 0245602 * CERTIFICATION * 12/17/18

SHIP TO:
ROLLED ALLOYS BAR CENTER
711 PHOENIX LAKE AVENUE

STREAMWOOD 601070000

Job#57122-02

---------- YOUR ORDER & DATE ----------
0168505-STR 11/01/18 CUST# 0773001 CUST TAG#0009151

---------- ITEM DESCRIPTION ----------
GRADE 304L/304 PRODEC QUALITY Ship Condition CONDA
Size304L RND CFA CONDA 2.2500 x 144.000 RL
Country of Melt: UNITED KINGDOM Country of Mfg.: UNITED STATES
No weld repair
Free of mercury contamination, Free of radiation contamination
No WEEE relevant substances; Meets RoHS-2011/65/EU and 2015/863

Total Bundles 1 Total Weight 2498 Approx. Hot Red. Ratio 8:1

WO 2091731 Bundles: 1A

---------- SPECIFICATIONS ----------

MFG TO FINISHED BAR IN THE USA FROM BILLETS IMPORTED UNITED KINGDOM

AMS 5639J, 5647K	SAE AMS-QQ-S-763D
ASME BPVC.II.A-2017 SA-182	ASME SA-479 2017 Ed.
ASME SA-484 2017 Ed.	ASME SA-320 B8 CL1, 2017 Ed.
ASME SA-193 B8 2017 Edition	ASTM A182/A182M 18a
ASTM A262 15 Practice A/E	ASTM A276/A276M 17
ASTM A314 15	ASTM A479/A479M 18
ASTM A484/A484M 18a	ASTM A320 17a B8 Class 1
ASTM A193 16 B8	Solution Annealed Condition
NACE MR0175-09, ISO 15156:09	DFARS 252.225.7009 10/4/11
Federal Spec QQ-S-763F	UNS S30400, AISI 304
UNS S30403, AISI 304L	Free of Cont.carbide network
EN 10204 Type 3.1 Document	RA-53 RAM 304L
Prodec Quality	ASTM F899 12b
NACE MR0103-10	DFARS 225.7002-3(B)(1)
QTC is a prolongation of bar	1.4301 X2CrNi18-9 304
No WEEE relevant substances	Sol Ann 1900F min/WQ
Bars are Eddy Current tested	
Sol Anneal at 1900F min/ Water Quench	

---------- MECHANICAL & OTHER TESTS ----------

Hardness as shipped	174 HB		
Hardness as shipped	(86 HRB)		
Grain size	7.5	Tensile strength,KSI (MPa)	88.7 (612)
Micro	OK	0.2% Yield Strngth,KSI(MPa)	38.3 (264)
Intergranular corrosion	OK		
		Elongation % in 4D	54.4
		Reduction of area %	76.0

-- Continued --

Outokumpu Stainless Bar, LLC
3043 Crenshaw Pkwy.
Richburg, SC 29729

HEAT # E181838
TRACER # 0556947US

M.E. Marcinis

LA81122 M118459

WLPSSW089020

MILL INSPECTION CERTIFICATE

EN 10204 3.1

CHANGSHU WALSIN SPECIALTY STEEL CO.,LTD.

CUSTOMER:	TA CHEN STAINLESS PIPE CO. LTD.	HEAT NO.:	11R648
DATE:	2018/11/07	SPECIFICATION:	ASTM A511-16/AMS 5639H(Chemistry Only)/ASTM A269-15a
COMMODITY:	STAINLESS STEEL SEAMLESS TUBE	CERTIFICATE NO.:	20181107250083331
DELIVERY CONDITION:	COLD FINISHED,SOLUTION ANNEALED AND PICKLED	GRADE:	TP304/304L

CHEMICAL COMPOSITION (WT%)

ELEMENTS		C	Si	Mn	P	S	Ni	Cr	Mo	N	Cu	Ti	Nb	Nb+Ta	Co	V	B	Al	Sb	Pb	As	Sn	Fe	Bi	Zr	Al+Ti	PREN	Ferrite content
SPECIFICATION	min	0.000	0.000	0.000	0.000	0.0000	8.000	18.000	0.000		0.000																	
	max	0.030	1.000	2.000	0.040	0.0300	10.500	20.000	1.000		1.000																	
RESULTS		0.018	0.370	1.680	0.036	0.0245	8.090	18.290	0.100		0.598																	

SIZE OD(") >WT(")<LG(mm)	BUNDLE NO.	PIECES	WEIGHT lt	WEIGHT kg	TS MPa	YS 0.2% MPa	YS 1% MPa	EL(50mm) %	HARDNESS HRB	FLATTENING TEST	FLARING TEST	I.C. TEST	REDUCTION OF AREA %	GRAIN SIZE	Lot No.	HYDROSTATIC TEST MPa	EDDY CURRENT TEST	ULTRASONIC TEST
2 1/2"0.250"5182-7315	TA32-33	1	22.74	63	591	335	/	55.5	82.5/82.5	/	GOOD	GOOD	58	/	201805-TL-A28	/	GOOD	/
2 1/4"0.250"5182-7315	TA32-44	8	182.61	483	601	372	/	59	86/86	/	GOOD	GOOD	60	/	201807-GR-A66	/	GOOD	/
2 3/4"0.500"5182-7315	TA32-48	2	45.73	256	556	263	/	65	75.5/75.5	/	GOOD	GOOD	65	/	201807-TG-B93	/	GOOD	/
2"0.188"5182-7315	TA32-51	23	469.36	831	617	338	/	58.5	83/83	/	GOOD	GOOD	56	/	201808-TG-B18	/	GOOD	/
2 3/8"0.188"5182-7315	TA32-55	4	89.42	144	590	289	/	58	78/78	/	GOOD	GOOD	59	/	201808-GR-A60	/	GOOD	/
TOTAL:		38	789.68	1757														

Remarks:
AS PER PROFORMA INVOICE NO.:172442-I
NO REPAIR BY WELDING
MATERIAL FREE FROM MERCURY CONTAMINATION
MATERIAL COMPLAINT WITH ROHS DIRECTIVE 2002/95/EC
COUNTRY OF MELT:CHINA, COUNTRY OF MANUFACTURE: CHINA
ET STANDARD PRACTICE: ASTM E426
THE UNTESTED ENDS ARE CROPPED AFTER NDE
ANNEALING TEMPERATURE:1050℃ WATER QUENCHED
CONFORMS TO CHEMICAL AND MECHANICAL REQUIREMENTS OF ASTM A479/ASME SA 479
The untested ends are cropped after NDE
I.C.TEST PER ASTM A262-02a E MIL-P24691/3 MIL-P1144D

1.EACH LENGTH OF TUBEING RECEIVED FROM THE MANUFACTURER MAY BE INSPECTED BY THE PURCHASER AND,IF IT DOES NOT MEET THE REQUIREMENT OF THE SPECIFICATION BASED ON THE INSPECTION AND TEST METHOD AS OUTLINED IN THE SPECIFICATION ,THE LENGTH MAY BE REJECTED AND THE MANUFACTURER SHALL BE NOTIFIED .

2. WE HEREBY CERTIFY THAT THE MATERIAL HAS BEEN MADE BY AN APPROVED PROCESS AND HAS BEEN SATISFACTORILY TESTED IN ACCORDANCE WITH THE SOCIETY'S RULES AND STANDARDS FOR CLASSIFICATION.

3. NO REPAIR BY WELDING.MATERIAL FREE FROM MERCURY CONTAMINATION AND RADIOACTIVE CONTAMINATION.

4. THE CERTIFICATE SHALL NOT BE REPRODUCED EXCEPT IN FULL WITHOUT THE WRITTEN APPROVAL OF THE COMPANY.

Sun Bin

QUALITY MANAGER

ADDRESS: 2# HAIYANG ROAD, HAIYU TOWN, CHANGSHU CITY, JIANGSU PROVINCE, CHINA 215519 TEL: +86-512-52566260 FAX: +86-512-52588027

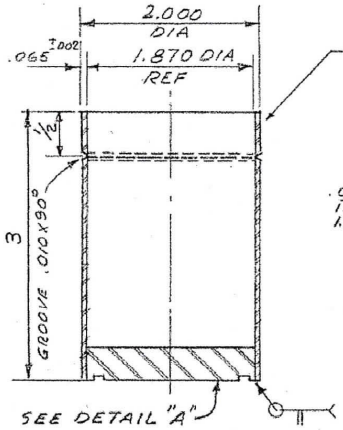
Form No.: WLCS-QP-017-001 Rev 0

Job # 57122-02

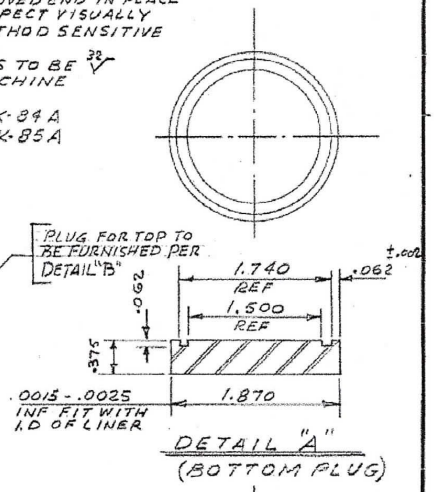
MILL TEST REPORT TA CHEN INTERNATIONAL, INC. This MTR contains 1 page (Page# 1)
Customer: PENQUA PO#:P031503 SO#:LXFX76 MTR#:WLPSSW089020.GIF
Item:SP4L0020.188 Bundle:SW089TA32-51 Heat#:11R648
Item:SP4L002B.250 Bundle:SW089TA32-44 Heat#:11R648
Item:SP4L002C.188 Bundle:SW089TA32-55 Heat#:11R648
Item:SP4L002D.250 Bundle:SW089TA32-33 Heat#:11R648
Item:SP4L002E.500 Bundle:SW089TA32-48 Heat#:11R648

NOTES

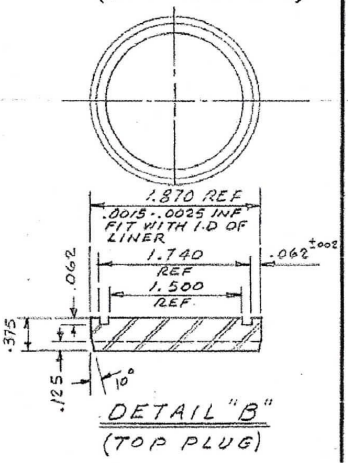
1. WELD PLUG OPPOSITE GROOVED END IN PLACE PER ORNL WPS 307 - INSPECT VISUALLY
2. LEAK TEST LINER BY METHOD SENSITIVE TO $< 1 \times 10^{-7}$ CC/SEC
3. ALL MACHINE SURFACES TO BE 32 NOT NECESSARY TO MACHINE TUBING SURFACES
4. COLLET REFERENCE SK-84A
5. FUNNEL REFERENCE SK-85A



LINER & BOTTOM PLUG ASSEMBLY



DETAIL "A" (BOTTOM PLUG)



DETAIL "B" (TOP PLUG)

MATERIAL:
LINER - 304 SST TUBING 2" O.D. x .065 WALL PER ASME SA-213
PLUGS - 304L SST BAR PER ASTM A-276

TOLERANCES UNLESS OTHERWISE SPECIFIED ±.005
ANGLES ±1°

SPECIAL FORM POWDER SHIPPING CONTAINER

QA VERIFICATION REQUIREMENTS
Mechanical & Structural
(applicable to UCCND manufacture only)

Ref: QA-L-2-107 QAA/QAP

Documentation Required	Procedure No. When Required	Note 1
IDENTITY		
MATERIAL TEST RPT OR CERT		X
UCCND MAT'L INSP REPORT		
SHOP MFG & INSP PLANS		
MAT'L & PARTS TRAVELERS		X
WELD & BRAZE INSP REPORTS		X
HEAT TREAT REPT (W/CHART)		
PRESSURE TEST REPORT		
LEAK TEST REPORT		X
CLEANING REPORT		
INSTALLATION & INSP PLAN		
FUNCTIONAL TEST REPORT		
CERT OF COMPLIANCE		
DEVIATION REQUESTS		X
NONCONFORMANCE REPORTS		X
DIMENSIONAL REPORT	QA-L-2-107	X
IAEA SPECIAL FORM TEST		X
SHOP PRINT TO FIELD ENGR		X

Note 1: Show an "X" or the item no. of items to which the document requirements are to be applied.

J E Lee QA Coordinator 6-12-81 Date

UCN-7430A-(3 11-79)

SPECIAL FORM-POWDER SHIPPING CAN C-RD-3095
REF: SK-83A, 83B, 83C (SIMILAR TO DETAILS SHOWN HERE)

REFERENCE DRAWINGS | NUMBER

OAK RIDGE NATIONAL LABORATORY
OPERATED BY
UNION CARBIDE CORPORATION
OAK RIDGE, TENNESSEE

TRANSURANIUM PROCESSING PLANT BLDG. NO. 7920

SPECIAL FORM POWDER SHIPPING CONTAINER AND ACCESSORIES

TOLERANCES UNLESS OTHERWISE SPECIFIED:	NO.	REVISIONS	DATE	APPD	APPD
FRACTIONS ± 1/32					
DECIMALS ±					
ANGLES ± 0°-30'					
SCALE: 1"=1'					

DRAWN	DATE	SUBMITTED	DATE	APPROVED	DATE
DESIGNED	DATE	APPROVED	DATE	APPROVED	DATE
CHECKED S.O.Lewis	DATE	APPROVED	DATE	APPROVED	DATE

SUBMITTED S.O.Lewis ACCEPTED Fadl. Owaiss 5/21/81 APPROVED L.A.Bain 6/10/81

M 12175 C.P. 813 E REV.

Fab File # or MWP #	Part Name	Drawing #	Rev.	Part #	Page
N/A	SPECIAL FORM POWDER SHIPPING CONTAINER AND ACCESSORIES	M12175CP813	1	N/A	1 of 2

Job Description: SPECIAL FORM POWDER SHIPPING CONTAINER AND ACCESSORIES **Inspection # A007367**

P.O. Or Req. #	Material Type	Heat Number	Serial Number(s)
N/A	N/A	N/A	AS LISTED
Temperature	**Relative Humidity**	**Initial Inspection or Re-inspection?**	
20° C	45%	Initial inspection ☐ Re-inspection No. __3___	

QC #*	Inspection Result	Drawing Requirement	Inspection Method
		LINER 1	
1	SEE	Ø 2.000	OUTSIDE MICROMETER
2	PAGE	.065 ± .002	POLY MICROMETER
3	TWO	3 ± 1/32	TRIMOS HEIGHT GAGE
4		1/2 ± 1/32	OPTICAL COMPARATOR
5		GROOVE .010 x 90°	OPTICAL COMPARATOR
REF.		TOP ID	INSIDE MICROMETER
REF.		BOTTOM ID	INSIDE MICROMETER
		BOTTOM PLUG 1	
6		.062	TRIMOS HEIGHT GAGE
7		.062 ± .002	POLY MICROMETER
8		.375	TRIMOS HEIGHT GAGE
9		.0015 - .0025 INFERENCE FIT	CALCULATIONS
10		1.870	OUTSIDE MICROMETER
		TOP PLUG 1	
REF.		OD	OUTSIDE MICROMETER
11		.0015 - .0025 INFERENCE FIT	CALCULATIONS
12		10°	OPTICAL COMPARATOR
13		.062 ± .002	POLY MICROMETER
14		.062	TRIMOS HEIGHT GAGE
15		.375	TRIMOS HEIGHT GAGE
16		.125	OPTICAL COMPARATOR

Inspection Results			
All inspection tools were verified for accuracy prior to and after their use	☑Yes	Inspector: [signature]	Date: 5/30/2019
Meets Drawing Requirements	☑Yes ☐No	Inspector Supervisor: [signature]	Date: 5/30/2019

Fab File # or MWP #	Part Name	Drawing #	Rev.	Part #	Page
N/A	SPECIAL FORM POWDER SHIPPING CONTAINER AND ACCESSORIES	M12175CP813	1	N/A	2 of 2

	Serial Number						
QC #*	1	2	3				
1	2.001	2.001	2.001				
2	.066	.066	.066				
3	3	3	3				
4	1/2	1/2	1/2				
5	OK	OK	OK				
REF	1.8692	1.8690	1.8689				
REF	1.8693	1.8689	1.8691				
6	.062	.062	.062				
7	.062	.062	.062				
8	.376	.376	.376				
9	.0025	.0025	.0023				
10	1.8718	1.8714	1.8712				
REF	1.8714	1.8712	1.8712				
11	.0022	.0022	.0023				
12	10	10	10				
13	.062	.062	.062				
14	.062	.062	.062				
15	.377	.376	.376				
16	.129	.130	.127				

**Supplemental inspections should be listed starting a new sequential series and adding the initials "SI" next to each entry*

APPENDIX D. LEAK TEST NDT EXAMINER TECHNICIAN CERTIFICATION

ANSI ACCREDITED
ISO/IEC 17024
Personnel Certification Program
#0644

The American Society for Nondestructive Testing, Inc.

Be it known that

Eric Steven Vidal

has met the established and published Requirements for Certification by ASNT as

NDT Level III

in the following Nondestructive Testing Methods:

Method	Issue Date	Expiration Date
Leak Testing	7/17	7/22
Liquid Penetrant Testing	5/17	5/22

THE AMERICAN SOCIETY FOR NONDESTRUCTIVE TESTING, INC. ASNT

208178
Certificate Number

ASNT President

Certification Management Council Chair

This certificate is the property of ASNT, is not official without ASNT's raised gold seal and is subject to revocation prior to the listed expiration date.
This certificate should be verified on the ASNT website or by contacting the ASNT Technical Services Department.

APPENDIX E. LEAK TESTING PROCEDURE

ORNL Leak Test Procedure (NDE-70 R.7) IS not available for public release.

APPENDIX F. CALIBRATION RECORDS

FO-IC-157

ORNL Work Order: 3548806

COMPLETED

v2.11

3548806 *DATACQ-M303131* *M3548806*

Equipment: DATACQ-M303131 / Data acqusition-SCXI **Location/Add'l Loc:** 5700~3~I309 /

Work Description: CB-V-IC-4004-X Frequency: 1-Y **Service Org:** IC-RESCH/INST

CB-V-IC-Calibration-G4-XF-1P-4H Variable Type

Act	Trade	Task	Comment	Est. Hrs	Start Date	End Date	Comp.
10	INSTTECH	Calibration		4	11/13/18	12/12/18	

Sched Start/End: 11/13/2018 / 12/12/2018 **Status:** Ready To Work **Cost Code:** 35304D81 **Grade:** 4
Req. Start/End: **Cycle Time:** N **Surv Req:** **Priority:** 7
Importance: **Custodian:** 00984677: Adeniyi, Abiodun Idowu **Type:** CAL
Configuration ID: **Alternate ID:** **Filepoint:** IC-A4
WO Additional Information/Documents

Equipment: **Equipment Location:** 5700~3~I309 **Addl. Location:**
Parent ID: **Description:**
Manufacturer: International Instruments Company **Model:** NI cDAQ-9184
Serial Number: 01B68499 **Fammis FLD:**

Equipment Customs:

MTEW : Not Applicable

Input : Type K TC **Range** : 0-2400F

Contact	Name	Building	Room	Phone	Pager
Requested by:	Adeniyi, Abiodun Idowu	5700	I309	865-576-2750	
Assigned To:	Walker, Drew P	4500S	B048	865-574-5589	
Assigned by:	Mcbee, Anthony	2033	139	865-574-6293	
Fac Ops Manager:	Blackburn, Donald Lee	3500	004A	865-576-0502	

Safety Review: (Grade 4 only) Answer the following for this job & work location. Any Yes answer - contact the Task Leader for further instructions before starting work.

1. Yes ☐ No ☑ Will I be exposed to hazards at the work location that are not associated with the job?
2. Yes ☐ No ☑ Will I use chemicals or materials for which I do not understand the hazards?
3. Yes ☐ No ☑ Will the job require Personal Protective Equipment (PPE) that I do not normally use or have not been trained to use?
4. Yes ☐ No ☑ Will bystanders or passersby be exposed to job hazards?
5. Yes ☐ No ☑ Will any permits be required?
6. Yes ☐ No ☑ Is there any aspect of the work that I do not feel safe performing?

HPI Pre-Check Questions: Each worker should confirm readiness to begin the work (regardless of the Work Grade) by asking these or similar questions.

- What am I (are we) doing?
- What are the hazards? What PPE is required?
- Are there lessons learned that should be considered?
- How are we going to respond in the event of a local, area or equipment alarm?
- What is the worst thing that can happen? How can I/we prevent it? What will I/we do if it does occur?
- What communication is needed during the task? How will we communicate?

Calibration:

Seq	LABEL	INPUT	OUTPUT	TOLERANCE	ASFOUND	Pass / Fail / N/A	As Left	Pass / Fail / N/A
1	This captures diagnosis of calibration only. Refer to equipment documentation to see actual calibration data. 0-Pass 1-Pass w/Adj	0 *		0 to +1	* 0	P	* 0	P

Nov 21, 2018 8:57:11 AM

M303131-M3548806

ORNL Work Order: 3548806

v2.11

3548806 *DATACQ-M303131* *M3548806*

Seq	LABEL	INPUT	OUTPUT	TOLERANCE	ASFOUND	Pass / Fail / N/A	As Left	Pass / Fail / N/A
	2-Fail							

Set Name: Calibration Effective: 11-12-18 Calibration Status: Incomplete

Standards Used: A004172, A001277, A001278

PMT: As Found Reading:_____ As Left Reading_____ N/A: ✓

Last Calibration
No Data Available

Signatures:

Person Notified :_____ Date/Time:_____ N/A [T]

Accepted By:_____ Date:_____ N/A [T]

Reviewed by: [signature] Date: 11/28/18 N/A [ ]

Closing: Completed: ☑ Yes ☐ No Date Completed: 11-21-18

Comments: Performed calibrations of DAQ and TC Batch. TC certificate from manufacturer is ~~reclosed~~ attached. DW 11-21-18

Delay:_____ Est. Hours:_____ Date:_____

Time Sheet

Act. #	Badge - Name	Date	Hours	Act. #	Badge - Name	Date	Hours

Booked Hours

Note: Only 10 time records will be displayed; See Total WO Booked Hours field for total hours.

Act. #	Badge - Name	Date	Hours
10	03026591 - Walker, Drew P	Nov 12, 2018	0.5
	03026591 - Walker, Drew P		3
		Total Hours for Activity 10	**3.5**

Total Estimated Hours	Total Booked Hours
4	3.5

INSTRUMENTATION AND CONTROLS SERVICES

DATA SHEET

Procedure: CALIBRATION OF ELECTRONIC RECORDERS **IDMS: # 20566**

TECHNICIAN(s)/BADGE(s): 3026591 DATE: 11-12-18

WORK ORDER #: 3548806 ID#: M303131

REVIEWED BY: _____ DATE: _____

GENERIC DATA SHEET FOR ELECTRONIC RECORDERS

UUT Make/Model/Range:

Input Unit:	Expected Response	Channel # 1		Channel # 2		Channel # 3		Channel # 4	
F°	From To	As-Found	As-Left	As-Found	As-Left	As-Found	As-Left	As-Found	As-Left
0		-0.074		-0.087		0.420		1.057	
400		399.88		399.84		400.40		400.955	
800		799.92		799.87		800.38		800.88	
1200		1200		1200		1200		1200.79	
1600		1600		1600		1600		1601	
2000		2000		2000		2000		2001	
2400		2400		2400		2400		2401	

STANDARDS:

ID Number: A004172	Due Date:
ID Number:	Due Date:
ID Number:	Due Date:
ID Number:	Due Date:

COMMENTS: Page 1 - 11

INSTRUMENTATION AND CONTROLS SERVICES

DATA SHEET

ICS/CREA1022–DS Rev. 04 (03/08/2017)

Procedure: CALIBRATION OF ELECTRONIC RECORDERS **IDMS: # 20566**

TECHNICIAN(s)/BADGE(s): _____ **DATE:** _____

WORK ORDER #: _____ **ID#:** _____

REVIEWED BY: _____ **DATE:** _____

GENERIC DATA SHEET FOR ELECTRONIC RECORDERS

UUT Make/Model/Range:

Input Unit:	Expected Response		Channel # 5		Channel # 6		Channel # 7		Channel # 8	
F°	From	To	As-Found	As-Left	As-Found	As-Left	As-Found	As-Left	As-Found	As-Left
0			0.633	-	-0.054		-0.046		0.301	
400			400.628		399.96		400.008		400.369	
800			800.595		799.933		799.948		799.969	
1200			1200.57		1200		1200		1200	
1600			1601		1600		1600		1600	
2000			2001		2000		2000		2000	
2400			2401		2400		2400		2400	

STANDARDS:

ID Number:	Due Date:
ID Number:	Due Date:
ID Number:	Due Date:
ID Number:	Due Date:

COMMENTS: Continuation 2-11

Procedure: CALIBRATION OF ELECTRONIC RECORDERS **IDMS: # 20566**

TECHNICIAN(s)/BADGE(s): _____ **DATE:** _____

WORK ORDER #: _____ **ID#:** _____

REVIEWED BY: _____ **DATE:** _____

GENERIC DATA SHEET FOR ELECTRONIC RECORDERS

UUT Make/Model/Range:									
Input Unit:	Expected Response	Channel # 9		Channel # 10		Channel # 11		Channel # 12	
°F	From To	As-Found	As-Left	As-Found	As-Left	As-Found	As-Left	As-Found	As-Left
0		0.228		0.217		0.185		0.167	
400		400.276		400.276		400.23		400.244	
800		800.253		800.236		800.206		800.212	
1200		1200		1200		1200		1200	
1600		1600		1600		1600		1600	
2000		2000		2000		2000		2000	
2400		2400		2400		2400		2400	

STANDARDS:

ID Number:	Due Date:
ID Number:	Due Date:
ID Number:	Due Date:
ID Number:	Due Date:

COMMENTS: Continuation 3-11

Procedure: CALIBRATION OF ELECTRONIC RECORDERS **IDMS: # 20566**

TECHNICIAN(s)/BADGE(s): _____ **DATE:** _____

WORK ORDER #: _____ **ID#:** _____

REVIEWED BY: _____ **DATE:** _____

GENERIC DATA SHEET FOR ELECTRONIC RECORDERS

UUT Make/Model/Range:									
Input Unit:	Expected Response	Channel # 13		Channel # 14		Channel # 15		Channel # 16	
°F	From To	As-Found	As-Left	As-Found	As-Left	As-Found	As-Left	As-Found	As-Left
0		0.066		0.173		0.182		0.141	
400		400.144		400.266		400.177		400.173	
800		800.166		800.228		800.175		800.125	
1200		1200		1200		1200		1200	
1600		1600		1600		1600		1600	
2000		2000		2000		2000		2000	
2400		2400		2400		2400		2400	

STANDARDS:

ID Number:	Due Date:
ID Number:	Due Date:
ID Number:	Due Date:
ID Number:	Due Date:

COMMENTS: Continuation 4-11

Procedure: CALIBRATION OF ELECTRONIC RECORDERS **IDMS: # 20566**

TECHNICIAN(s)/BADGE(s): _____ **DATE:** _____

WORK ORDER #: _____ **ID#:** _____

REVIEWED BY: _____ **DATE:** _____

GENERIC DATA SHEET FOR ELECTRONIC RECORDERS

UUT Make/Model/Range:									
Input Unit:	Expected Response	Channel # 17		Channel # 18		Channel # 19		Channel # 20	
°F	From To	As-Found	As-Left	As-Found	As-Left	As-Found	As-Left	As-Found	As-Left
0		-0.164		-0.252		-0.050		-0.110	
400		399.89		399.85		399.959		399.929	
800		799.871		799.918		799.941		799.892	
1200		1200		1200		1200		1200	
1600		1600		1600		1600		1600	
2000		2000		2000		2000		2000	
2400		2400		2400		2400		2400	

STANDARDS:

ID Number:	Due Date:
ID Number:	Due Date:
ID Number:	Due Date:
ID Number:	Due Date:

COMMENTS: Continuation 5-11

Procedure: CALIBRATION OF ELECTRONIC RECORDERS **IDMS: # 20566**

TECHNICIAN(s)/BADGE(s): _____ **DATE:** _____

WORK ORDER #: _____ **ID#:** _____

REVIEWED BY: _____ **DATE:** _____

GENERIC DATA SHEET FOR ELECTRONIC RECORDERS

UUT Make/Model/Range:									
Input Unit:	Expected Response	Channel #21		Channel #22		Channel #23		Channel #24	
°F	From To	As-Found	As-Left	As-Found	As-Left	As-Found	As-Left	As-Found	As-Left
0		-0.308		-0.167		-0.205		-0.184	
400		399.755		399.859		399.836		399.807	
800		799.785		799.801		799.864		799.893	
1200		1200		1200		1200		1200	
1600		1600		1600		1600		1600	
2000		2000		2000		2000		2000	
2400		2400		2400		2400		2400	

STANDARDS:

ID Number:	Due Date:
ID Number:	Due Date:
ID Number:	Due Date:
ID Number:	Due Date:

COMMENTS: Continuation 6-11

Procedure: CALIBRATION OF ELECTRONIC RECORDERS **IDMS: # 20566**

TECHNICIAN(s)/BADGE(s): _____ **DATE:** _____

WORK ORDER #: _____ **ID#:** _____

REVIEWED BY: _____ **DATE:** _____

GENERIC DATA SHEET FOR ELECTRONIC RECORDERS

UUT Make/Model/Range:									
Input Unit:	Expected Response	Channel #25		Channel # 26		Channel #27		Channel #28	
°F	From To	As-Found	As-Left	As-Found	As-Left	As-Found	As-Left	As-Found	As-Left
0		-0.158		-0.131		-0.128		-0.148	
400		399.889		399.919		399.826		399.827	
800		799.868		799.911		799.842		799.903	
1200		1200		1200		1200		1200	
1600		1600		1600		1600		1600	
2000		2000		2000		2000		2000	
2400		2400		2400		2400		2400	

STANDARDS:

ID Number:	Due Date:
ID Number:	Due Date:
ID Number:	Due Date:
ID Number:	Due Date:

COMMENTS: Continuation 7-11

Procedure: CALIBRATION OF ELECTRONIC RECORDERS **IDMS: # 20566**

TECHNICIAN(s)/BADGE(s): _____ **DATE:** _____

WORK ORDER #: _____ **ID#:** _____

REVIEWED BY: _____ **DATE:** _____

GENERIC DATA SHEET FOR ELECTRONIC RECORDERS

UUT Make/Model/Range:									
Input Unit:	Expected Response	Channel # 29		Channel # 30		Channel # 31		Channel # 32	
°F	From To	As-Found	As-Left	As-Found	As-Left	As-Found	As-Left	As-Found	As-Left
0		-0.338		-0.317		-0.340		-0.348	
400		399.702		399.661		399.651		399.648	
800		799.733		799.717		799.736		799.722	
1200		1200		1200		1200		1200	
1600		1600		1600		1600		1600	
2000		2000		2000		2000		2000	
2400		2400		2400		2400		2400	

STANDARDS:

ID Number:	Due Date:
ID Number:	Due Date:
ID Number:	Due Date:
ID Number:	Due Date:

COMMENTS: Continuation 8-11

Procedure: CALIBRATION OF ELECTRONIC RECORDERS **IDMS: # 20566**

TECHNICIAN(s)/BADGE(s): _____ DATE: _____

WORK ORDER #: _____ ID#: _____

REVIEWED BY: _____ DATE: _____

GENERIC DATA SHEET FOR ELECTRONIC RECORDERS

UUT Make/Model/Range:									
Input Unit:	Expected Response	Channel # 33		Channel # 34		Channel # 35		Channel # 36	
°F	From To	As-Found	As-Left	As-Found	As-Left	As-Found	As-Left	As-Found	As-Left
0		0.100		0.045		0.251		0.199	
400		400.152		400.123		400.263		400.231	
800		800.167		800.106		800.279		800.247	
1200		1200		1200		1200		1200	
1600		1600		1600		1600		1600	
2000		2000		2000		2000		2000	
2400		2400		2400		2400		2400	

STANDARDS:

ID Number:	Due Date:
ID Number:	Due Date:
ID Number:	Due Date:
ID Number:	Due Date:

COMMENTS: Continuation 9-11

Procedure: CALIBRATION OF ELECTRONIC RECORDERS IDMS: # 20566

TECHNICIAN(s)/BADGE(s): _____ DATE: _____

WORK ORDER #: _____ ID#: _____

REVIEWED BY: _____ DATE: _____

GENERIC DATA SHEET FOR ELECTRONIC RECORDERS

UUT Make/Model/Range:

Input Unit:	Expected Response		Channel # 37		Channel # 38		Channel # 39		Channel # 40	
°F	From	To	As-Found	As-Left	As-Found	As-Left	As-Found	As-Left	As-Found	As-Left
0			0.167		0.189		0.174		0.180	
400			400.178		400.203		400.183		400.221	
800			800.185		800.255		800.164		800.212	
1200			1200		1200		1200		1200	
1600			1600		1600		1600		1600	
2000			2000		2000		2000		2000	
2400			2400		2400		2400		2400	

STANDARDS:

ID Number:	Due Date:
ID Number:	Due Date:
ID Number:	Due Date:
ID Number:	Due Date:

COMMENTS: Continuation 10-11

Procedure: CALIBRATION OF ELECTRONIC RECORDERS **IDMS: # 20566**

TECHNICIAN(s)/BADGE(s): _____ **DATE:** _____

WORK ORDER #: _____ **ID#:** _____

REVIEWED BY: _____ **DATE:** _____

GENERIC DATA SHEET FOR ELECTRONIC RECORDERS

UUT Make/Model/Range:									
Input Unit:	Expected Response	Channel #41		Channel # 42		Channel #43		Channel #	
°F	From To	As-Found	As-Left	As-Found	As-Left	As-Found	As-Left	As-Found	As-Left
0		0.170		-0.044		-0.148			
400		400.194		400.136		399.903			
800		800.184		800.148		799.927			
1200		1800		1200		1200			
1600		1600		1600		1600			
2000		2000		2000		2000			
2400		2400		2400					

STANDARDS:

ID Number:	Due Date:
ID Number:	Due Date:
ID Number:	Due Date:
ID Number:	Due Date:

COMMENTS: Continuation 11-11

DELTA m CORPORATION

Delta M Corporation
1003 Larsen Drive
Oak Ridge, TN 37830
T – (865)483-1569
F – (865)483-1142

ISO 9001:2008
10000442QM08

Material Certification Documentation

The following documents are to certify that the material and test data as described below conforms in accordance with the requirements and specifications stated within the Purchase Order.

Customer :	UT-Battelle, LLC for the Dept. of Energy 1 Bethel Valley Road, c/o ORNL Oak Ridge, TN 37830
P.O. No. :	4000150155
D.M. Job No. :	TC-160365
Mat'l Desc. :	T5-U-062-304-K-M-600 Thermocouple
Mat'l Trace :	.062-K-304-MgO – PN: 100472 PO# 160339
Quantity :	100 pc (95pc-160339.1 / 5pc-160339.2)

Certificate Of Compliance

This certifies that the articles and/or services supplied to **UT-Battelle, LLC** by Delta M Corporation on **October 12th, 2016** are in Compliance with the requirements of your Purchase Order **4000150155**. This Certification also applies to any documented amendments and/or clarifications pertaining to this stated Purchase Order.

DELTA M CORPORATION
Rob Belcher

DMF171 Material Certification Documentation 1/16/08

100472
#160339.1

Idaho Laboratories Corporation
2101 Hemmert Ave.
Idaho Falls, ID 83401
Phone (208) 522-0055
Fax (800) 524-4522

MATERIAL CERTIFICATE

Material Heat #: 39700
ILC Sales Order #: 216492
Customer P.O. #: 160339

Material Description: 062-KS-304
Customer: DELTA M

The materials and services supplied are in conformance with ASTM E585/585M-12 and/or customer purchase order requirements. Thermocouple material has been calibrated as covered by ASTM E-220 07a, ASTM E-230/E230M, AMS 2750, ANSI/NCSL Z540.1 and ITP 0017 and is traceable to the National Institute of Standards and Technology.

CALIBRATION REPORT

Actual Temperature (°F)	Measured Temperature (°F)	Deviation (°F)
1000.515	1004.0	3.486
1001.952	1005.309	3.357
1504.813	1508.371	3.559
1504.484	1508.327	3.844
1996.717	2002.973	6.256
1996.412	2002.783	6.371

RAW MATERIALS REPORT

Tube	
Material	304SST
Heat #	954673
Spec.	ASTMA269
C	0.021%
Cr	18.2%
Cu	0.52%
Fe	BAL.
Mn	1.69%
Mo	0.50%
N	0.07%
Ni	8.1%
P	0.038%
S	0.0005%
Si	0.45%

Thermoelement	
FUR-KP	
2353	
Al	<0.01
C	<0.001
Co	<0.01
Cr	9.05%
Cu	<0.005
Fe	0.48%
Mn	<0.01
Ni	bal.
Si	0.40%

Thermoelement	
FUR-KN	
740	
Co	1.11%
Cu	1.96%
Fe	0.15%
Ni	bal.
Si	2.46%

Insulator	
MgO	
16919.700	
E1652-14A	
Al2o3	0.03%
B	< 26 PPM
C	< 50 PPM
CaO	0.35%
Cd	< 3 PPM
Fe2o3	0.04%
MgO	99.47%
S	< 5 PPM
SiO2	0.10%

ILC Q.A. #8 A FINAL

ILC Quality Assurance

Sep 30, 2016
Date

Q.A. int.

100472
#160339.2

Idaho Laboratories Corporation
2101 Hemmert Ave.
Idaho Falls, ID 83401
Phone (208) 522-0055
Fax (800) 524-4522

MATERIAL CERTIFICATE

Material Heat #: 39288
ILC Sales Order #: 216492
Customer P.O. #: 160339

Material Description: 062-KS-304
Customer: DELTA M

The materials and services supplied are in conformance with ASTM E585/585M-12 and/or customer purchase order requirements. Thermocouple material has been calibrated as covered by ASTM E-220 07a, ASTM E-230/E230M, AMS 2750, ANSI/NCSL Z540.1 and ITP 0017 and is traceable to the National Institute of Standards and Technology.

CALIBRATION REPORT

Actual Temperature (°F)	Measured Temperature (°F)	Deviation (°F)
1000.0	1000.57	0.57
1000.0	1000.77	0.77
1500.0	1502.48	2.48
1500.0	1503.08	3.08
2000.0	2004.39	4.39
2000.0	2005.4	5.4

RAW MATERIALS REPORT

Tube	
Material	304SST
Heat #	954673
Spec.	ASTMA269
C	0.021%
Cr	18.2%
Cu	0.52%
Fe	BAL.
Mn	1.69%
Mo	0.50%
N	0.07%
Ni	8.1%
P	0.038%
S	0.0005%
Si	0.45%

Thermoelement	
FUR-KP	
2353	
Al	<0.01
C	<0.001
Co	<0.01
Cr	9.05%
Cu	<0.005
Fe	0.48%
Mn	<0.01
Ni	bal.
Si	0.40%

Thermoelement	
FUR-KN	
740	
Co	1.11%
Cu	1.96%
Fe	0.15%
Ni	bal.
Si	2.46%

Insulator	
MgO	
5-H-11	
Al2o3	0.02%
B	11.0 PPM
C	0.004%
CaO	0.14%
Fe2o3	0.03%
MgO	99.760%
S	<0.002%
SiO2	0.03%

ILC Q.A. #8 A FINAL

ILC Quality Assurance

Oct 5, 2016
Date

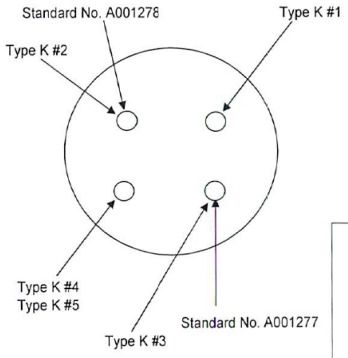
Q.A. int.

11/5/2018
Calibration Check Of Type K Thermocouples
Standard T.C.s A001277 and A001278
Work Order: 3548806

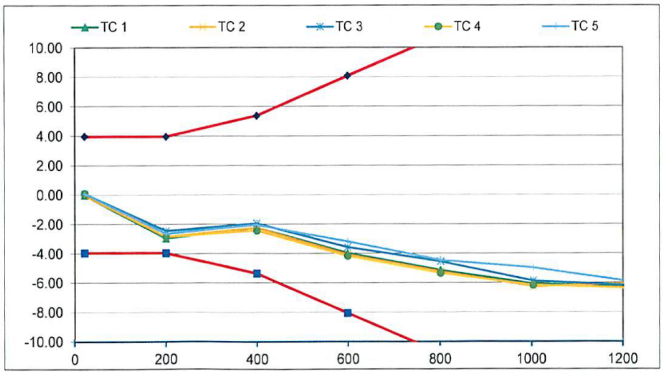
Per ASTM E230 the allowable error applies only to new standard Type K wire. If calibrating used wire the purpose of the allowable error column is only for comparability, and does not imply a pass or fail condition for the used thermocouples.

Standard Type S A001278-A	Standard Type S A001278-B
21.4	21.4
200.0	200.1
399.1	399.0
598.0	598.1
800.0	800.0
1003.2	1003.4
1201.6	1201.4

Type K Under Test Number One	Type K Under Test Number Two	Type K Under Test Number Three	Type K Under Test Number Four	Type K Under Test Number Five	Standard Type S A001277-A	Standard Type S A001277-B
21.5	21.5	21.4	21.4	21.4	21.6	21.5
202.8	202.7	202.3	202.7	202.5	199.7	199.6
401.1	401.1	400.8	401.3	400.9	398.6	398.7
602.0	602.1	601.6	602.2	601.2	597.9	598.1
805.1	805.2	804.5	805.3	804.4	799.8	800.0
1009.3	1009.5	1009.1	1009.4	1008.2	1003.0	1003.3
1207.7	1207.5	1207.6	1207.8	1207.3	1201.2	1201.5



Average Standard Reading	Standard Type K Allowable Error Deg F Plus	Minus	T.C. One Calculated Error	T.C. Two Calculated Error	T.C. Three Calculated Error	T.C. Four Calculated Error	T.C. Five Calculated Error
21.5	**3.96**	**-3.96**	-0.02	-0.02	0.08	0.08	0.08
199.9	**3.96**	**-3.96**	-2.95	-2.85	-2.45	-2.85	-2.65
398.9	**5.38**	**-5.38**	-2.25	-2.25	-1.95	-2.45	-2.05
598.0	**8.07**	**-8.07**	-3.98	-4.08	-3.58	-4.18	-3.18
800.0	**10.80**	**-10.80**	-5.15	-5.25	-4.55	-5.35	-4.45
1003.2	**13.54**	**-13.54**	-6.08	-6.28	-5.88	-6.18	-4.98
1201.4	**16.22**	**-16.22**	-6.28	-6.08	-6.17	-6.38	-5.88



UT-BATTELLE
Management Contractor for DOE's Oak Ridge National Laboratory

Calibration Results

Oak Ridge National Laboratory

ORNL Metrology Laboratory
Bethel Valley Rd. Bldg. 5510A
Oak Ridge, TN 37831-6366

Unit Under Test Information	Customer Information	Test Information
Manufacturer: Stanley	Oscar A Martinez	Certificate Number: **2018000749**
Description: 40 Foot Tape Measure	Building 5700	Overall Result: Pass
Model Number: 33-740	Room H320	Performed on: 3/20/2018
Serial Number: None	Mail Stop 6170	Next Cal Due: 3/20/2023
Asset / ID Number: A006327		Performed by: Jerry Freeman
Custodian: Oscar A Martinez		Environment: 20°C 46%Rh
Work Order Number: 2018000749		Received: In Tolerance

Notes:

Asset No.

Work Order No.

ORNL Metrology Laboratory (ORNL ML) certifies that the above listed instrument meets or exceeds all specifications as stated in the referenced procedure unless otherwise noted. This Report of Calibration applies only to the item being calibrated, identified above.

This calibration report documents the traceability to national standards, which realize the units of measurement according to the International System of Units (SI). Calibration data and conformity assessment (Pass/Fail decision) is limited to the performance of the instrument at the time of test. The "Next Cal Due" date is based on manufacturer's recommendations or best calibration practices and with customer agreement (in the case of external ORNL customers); the instrument should not be used past this date without recalibration. This report shall not be reproduced, except in full, unless written permission for an approved abstract is obtained from ORNL ML. Any report containing accredited data shall not be used to claim product certification, approval, or endorsement by NVLAP, NIST, or any agency of the Federal Government. Calibration reports without authorizing signature(s) are not valid.

For accredited data, measurement uncertainties at the time of test, expressed in base units, are given on the following pages, where applicable. They are calculated in accordance with the methods described in EA-4/02, NIST TN1297, DKD-3, or other applicable documents that comply with the Guide to the Uncertainty in Measurement (GUM), using a coverage factor of k=2, corresponding to a confidence level of approximately 95%. Unless otherwise indicated, any conformity determination in this report is based on a Test Uncertainty Ratio (TUR) of 4:1 or greater. Any TUR less than 4:1 will be identified in the test data. It is the responsibility of the instrument custodian, with the assistance of his/her Quality Representative, to determine whether this level of confidence for the determination of conformance is adequate for the intended use of this instrument.

This calibration was performed using measurement standards traceable to the appropriate standard(s), maintained by the National Institute of Standards and Technology (NIST), to accepted intrinsic standards of measurement, or is derived by ratio type self-calibration techniques. The calibration system used to derive accredited data complies with the requirements of NIST Handbook 150, ANSI/NCSL Z540.1-1999 (R2002), ISO/IEC 17025.

Standards Used

ID	Description	Service Date	Due Date
0084705	Agilent 5519A Laser Head (5530A System)	4/20/2017	4/20/2018

Found/Left

Procedure used: STANLEY 0 to 30 ft TAPE RULES /LASER, Rev. 1.0

Test Data

UUT Range / Comment	Standard Reading	Standard Modifier	UUT Reading	UUT Tolerance	UUT Error	% Tol	Measurement Uncertainty	Accred	Test Status
INITIAL INSPECTION No Calibration Seals found on the UUT. Instrument was received in good, functional condition. UUT Full Length = 39 ft. UUT Resolution = 0.0625 in.									
	95.995 in		96.00 in	0.032 in	0.005 in	16	3.6e-002 in	No	*Pass
	191.996 in		192.00 in	0.039 in	0.004 in	10	3.6e-002 in	No	*Pass
	276.006 in		276.00 in	0.045 in	-0.006 in	13	3.6e-002 in	No	*Pass
	372.016 in		372.00 in	0.053 in	-0.016 in	30	3.6e-002 in	No	*Pass
	468.024 in		468.00 in	0.060 in	-0.024 in	40	3.6e-002 in	No	*Pass

Test Status Notes

* Test Uncertainty Ratio is less than 4:1!
Test Uncertainty Ratio is the ratio between the Unit Under Test specification and the Test Measurement Uncertainty (UUT Spec / Measurement Uncertainty).

-- End of measurement results--

Approved By: Brian Sizemore 3/20/2018 2:39:39PM
Mass/Dimensional Task Leader

Calibration Results

Oak Ridge National Laboratory

Mass Standard Laboratory
Bethel Valley Rd. Bldg. 2547 Rm. 4
Oak Ridge, TN 37831
Phone: 865.574.8978

Unit Under Test Information		Customer Information
Manufacturer:	Mettler Toledo	Oscar A Martinez
Description:	Balance 32 Kg	Building 5700
Model Number:	XP32001	Room H320
Serial Number:	Unknown	Mail Stop 6170
Asset / ID Number:	A000593	
Custodian:	Oscar A Martinez	
Work Order Number:	2019002157	

Notes:

Asset No.

Work Order No.

ORNL Metrology Laboratory (ORNL ML) certifies that the above listed instrument meets or exceeds all specifications as stated in the referenced procedure unless otherwise noted. This Report of Calibration applies only to the item being calibrated, identified above.

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This calibration was performed using measurement standards traceable to the appropriate standard(s), maintained by the National Institute of Standards and Technology (NIST), to accepted intrinsic standards of measurement, or is derived by ratio type self-calibration techniques. The calibration system used to derive accredited data complies with the requirements of NIST Handbook 150, ANSI/NCSL Z540.1-1999 (R2002), ISO/IEC 17025.

Magnetic screening was not performed and any errors due to magnetic properties of the items were not considered in the uncertainty calculation.

Approved by: Brian Sizemore 7/26/2019
Mass/Dimensional Task Leader

Oak Ridge National Laboratory

Mass Metrology

Building 2547 Room 4
Oak Ridge, TN 37831

CALIBRATION REPORT

Delta Range Balance

ID#	A000593	Procedure	XP32001L
Cal Date	7/25/19	Make	Mettler

Standards Used

ID #	Cal Due Date
M212203	9/18/19

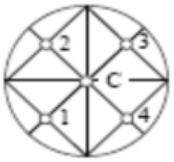
Next Due Date	7/25/20
Work Order Number	2019002157
Metrologist	954800
Location	NTRC , L110

Corner load (Eccentricity) Test

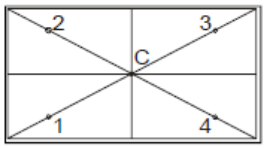
Eccentricity Weight	10000 g
MFG Eccentricity Tolerance +/-	1 g

Instructions

Place the eccentricity weight in the center position zero the balance. Add a 1 g weight and record the reading. Then move weights to each remaining position and record the reading. Weights should be placed 3/4 distance from the center at each position as shown below. Place an "X" in the box that indicates the appropriate pan style of the balance under test.



[ ]



[X]

As Found		
Position	UUT Reading (g)	Absolute Error g
Center	0.9	~
1	0.9	0.0
2	0.8	0.1
3	0.9	0.0
4	1.0	0.1
Center	0.9	0.0
	PASS	0.1

As Left		
Position	UUT Reading (g)	Absolute Error g
Center	1.0	~
1	0.9	0.1
2	0.8	0.2
3	1.0	0.0
4	1.0	0.0
Center	1.0	0.0
	PASS	0.2

Standard Deviation (Repeatability) Test

Repeatability Weight	10000 g
Tare Weight	5000
Number of Measurements	6
MFG Repeatability Tolerance	0.6 g

Instructions

Place the tare weight on the pan and tare the balance. Remove the tare weight (reading will be negative) and record Empty Reading. Do not zero or tare the balance for the rest of this test. Place the repeatability weight in the center and record the reading. Continue removing and placing the repeatability weight until the required measurements are taken.

Standard Deviation (Repeatability) (Cont)

As Found

Reading #	Empty Reading (g)	Loaded Reading (g)	Difference Reading (g)
1	-5000.6	5001.5	10002.1
2	-5000.6	5001.5	10002.1
3	-5000.6	5001.5	10002.1
4	-5000.6	5001.5	10002.1
5	-5000.6	5001.5	10002.1
6	-5000.6	5001.5	10002.1

Standard Deviation	0.00	PASS

As Left

Reading #	Empty Reading (g)	Loaded Reading (g)	Difference Reading (g)
1	-5000.0	5000.1	10000.1
2	-5000.0	5000.1	10000.1
3	-5000.0	5000.1	10000.1
4	-5000.0	5000.1	10000.1
5	-5000.0	5000.1	10000.1
6	-5000.0	5000.1	10000.1

Standard Deviation	0.00	PASS

Linearity Test

Reference Weight	500 g
MFG Linearity Tolerance +/-	0.3 g

Instructions

Place preload weight on pan, tare, and record Preload Tared reading. Next place Reference Weight on pan and record Reading. Repeat process for each point listed below. (If As Found readings fail, and the balance has two internal weights, perform an internal calibration.)

As Found

Preload Weight (g)	Preload Tared (g)	Reading (g)
0	0.0	500.5
10000	0.0	500.7
20000	0.0	500.7
30000	0.0	501.4
Max-Min/2	0.45	*FAIL*

As Left

Preload Weight (g)	Preload Tared (g)	Reading (g)
0	0.0	500.0
10000	0.0	500.0
20000	0.0	500.0
30000	0.0	500.0
Max-Min/2	0.00	PASS

Span Test

Span Weight	32000 g
MFG Span Tolerance +/-	1 g

Instructions

Zero the balance with no weight applied. Place the span weight in the center of the pan and record the reading.

As Found

Weight Value (g)	Reading (g)	
32000	32009	*FAIL*

As Left

Weight Value (g)	Reading (g)	
32000	32000	PASS

This calibration was performed using measurement standards traceable to the appropriate standard(s), maintained by the National Institute of Standards and Technology (NIST) or other approved National Measurement Institutes, to accepted intrinsic standards of measurement, or is derived by ratio type self-calibration techniques.

Notes

UT-BATTELLE
Management Contractor for DOE's Oak Ridge National Laboratory

Oak Ridge National Laboratory

ORNL Metrology Laboratory
Bethel Valley Rd. Bldg. 5510A
Oak Ridge, TN 37831-6366

Unit Under Test Information	Customer Information	Test Information
Manufacturer: Wedge Innovations	Oscar A Martinez	Certificate Number: **2019002173**
Description: Digital Level		Overall Result: Pass
Model Number: SmartTool	Building 5700	Performed on: 7/30/2019
Serial Number: N/A	Room H320	Next Cal Due: 7/30/2020
Asset / ID Number: M212348	Mail Stop 6170	Performed by: Jerry Freeman
Custodian: Oscar A Martinez		Environment: 20°C 45%Rh
Work Order Number: 2019002173		Received: In Tolerance

Notes:

Asset No.

Work Order No.

ORNL Metrology Laboratory (ORNL ML) certifies that the above listed instrument meets or exceeds all specifications as stated in the referenced procedure unless otherwise noted. This Report of Calibration applies only to the item being calibrated, identified above.

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Standards Used

ID	Description	Service Date	Due Date
M212335	Mitutoyo America CRTA920H Coordinate Measuring Machine	2/7/2019	2/7/2020

– End of measurement results–

Approved By: Brian Sizemore 7/30/2019 9:49:17AM
Mass/Dimensional Task Leader

OAK RIDGE NATIONAL LABORATORY

QUALITY DEPARTMENT

TEST REPORT

PRECISION LEVEL

ITEM: LEVEL, PRECISION 6" Serial Number: M212348

MANUFACTURER: SMARTTOOL REF Number: 311-006-501

CUSTODIAN: O. A. Martinez

This is to certify that this level has a sensitivity of 0.1/per degree and a calibrated accuracy of 0.1/per degree division.

This tool calibrated by reversal technique on granite surface plate.

Temperature: 68 ° F

Date 7/30/2019 Calibrated By 701194

Due Date 7/30/2020 Approved By 38642 7/30/19

NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY TRACEABILITY
ESTABLISHED THROUGH ORNL PRIMARY STANDARDS

Item Number	Calibration Date	Due Date
M212335	2/7/19	2/7/20

Oak Ridge National Laboratory
Metrology Laboratory

Instrument Out of Tolerance Notification

The following instrument(s) was(were) found Out of Tolerance (OOT) in the As Found Calibration process. In accordance with SBMS Calibration Subject Area procedure "*Verifying the Quality of Calibration*", this notification requires the recipient to take the following actions:

1. compare the OOT condition against the requirements for each application of the instrument,
2. determine if there were any impacts,
3. document the OOT evaluation, and
4. implement appropriate actions.

Equipment Custodian: Oscar A Martinez

Instrument ID Number:	A000593	Model Name/Number:	XP32001
Instrument Description:	Balance 32 Kg	Work Order Number:	2019002157
Manufacturer:	Mettler Toledo		
Disposition of Instrument:	After adjustment and or repair, the instrument passed the As Left calibration process.		

Notes:
See the Calibration Data attached to the instrument for a full description of the As Found As Left condition.

UT-BATTELLE
Management Contractor for DOE's Oak Ridge National Laboratory

Oak Ridge National Laboratory

ORNL Metrology Laboratory
Bethel Valley Rd. Bldg. 5510A
Oak Ridge, TN 37831-6366

Unit Under Test Information	Customer Information	Test Information
Manufacturer: Oak Ridge National Laboratory Description: 1 Meter Length Standard Model Number: None Serial Number: N/A Asset / ID Number: A001146 Custodian: Matthew R Feldman Work Order Number: 2016002294	Matthew R Feldman Bldg 5700 Room N323 Mail Stop 6170 865-241-8801	Certificate Number: **2016002294** Overall Result: Pass Performed on: 6/30/2016 Next Cal Due: 6/30/2021 Performed by: Jerry Freeman Environment: 20°C 47%Rh Received: In Tolerance

Notes:

Asset No.

Work Order No.

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Standards Used

ID	Description	Service Date	Due Date
M212335	Mitutoyo America CRTA920H Coordinate Measuring Machine	2/11/2016	2/11/2017

-- End of measurement results--

Approved By: Brian Sizemore 7/7/2016
Mass/Dimensional Task Leader

OAK RIDGE NATIONAL LABORATORY

METROLOGY DEPARTMENT

TEST REPORT

ITEM: 39.38" LENGTH STANDARD Serial Number: A001146

CUSTODIAN: M. FELDMAN

	AS FOUND	REQUIREMENT	INSPECTION METHOD
LENGTH	39.4000/39.4010	39.38	CMM

Temperature: 68 ° F

Date 6/30/16

Inspector '701194

Reviewed by 25642 7/7/16

Date Due 6/30/2021

NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY TRACEABILITY
ESTABLISHED THROUGH ORNL PRIMARY STANDARDS

Standards used:

ID#	Calibration Due Date
M212335	2/11/17