INL/RPT-22-67393-Revision-0

Assembly and Functional Test of NRAD Heated Instrumentation Rig

October 2021

Joe Palmer

Changing the World's Energy Future

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Joe Palmer

October 2021

Idaho National Laboratory
Idaho Falls, Idaho 83415

http://www.inl.gov

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Contract DE-AC07-05ID14517

1. Effective Date	10/11/2021	**Professional Engineer's Stamp** **Not required per LWP-10010, Sec.4.1, para. cc**
2. Does this TEV involve a Safety SSC?	No	
3. Safety SSC Determination Document ID	NA	
4. SSC ID	NA	
5. Project No.	----	
6. Engineering Job (EJ) No.	NA	
7. Building	TRA-1626	
8. Site Area	ATR Complex	

9. Objective / Purpose

The purpose of this TEV is to document assembly and functional testing of a device which is designed to allow advanced sensors to be temporarily placed at the periphery of the NRAD reactor. While in this location, the operational characteristics of the sensors can be evaluated while they are exposed to a neutron flux. This device (or "rig") consists of a cartridge heater surrounded by six guide tubes, which are in turn surrounded by insulation and an aluminum dry tube. The heater allows for the sensors to be tested while at elevated temperature.

The assembly and functional testing was performed in building TRA-1626, the Test Train Assembly Facility (TTAF).

10. If revision, please state the reason and list sections and/or page being affected.

Rev. 1 a. Added missing sheets to Appendix B showing measured depths of guide tubes and corresponding locations of sensors (page B4 and B5). b. Added Appendix G, which shows the as-run location of the sensors (for irradiation conducted 8/25/2021).

11. Conclusion

The testing documented herein was to verify the test rig functions as intended, prior to transferring it to the NRAD reactor. The functional testing performed at TTAF confirmed the following attributes:

1. The dry tube does not leak.
2. The central heater in the test rig can raise the temperature in the sensor guide tubes to at least 800°C.
3. The sensors being tested have a sensitive region of 90 mm or less. The temperature variation along this 90 mm length was less than 25°C with the center of this region at 800°C.
4. The surface temperature of the dry tube at the elevation corresponding to core mid-plane was less than 10°C above the bulk water temperature during the test period.

CONTENTS

APPENDIXES

PROJECT ROLES AND RESPONSIBILITIES

Project Role	Name	Organization	Pages Covered (if applicable)
Performer	Joe Palmer	C660	-----
Checker[a]	Troy Unruh	C670	-----
Independent Reviewer[b]	NA	-----	-----
CUI Reviewer[c]	Nate Oldham	C660	-----
Manager[d]	Bryce Kelly	C660	-----
Requestor[e]	Pattrick Calderoni	C670	-----
Nuclear Safety[f]	NA	-----	-----
Document Owner	Pattrick Calderoni	C670	-----
Reviewer	NA	-----	-----

Responsibilities:

a. Confirmation of completeness, mathematical accuracy, and correctness of data and appropriateness of assumptions.
b. Concurrence of method or approach. See definition, LWP-10106.
c. Concurrence with the document's markings in accordance with LWP-11202.
d. Concurrence of procedure compliance. Concurrence with method/approach and conclusion.
e. Authorizes the commencement of work of the engineering deliverable. See Appendix A.
f. Concurrence with the document's assumptions and input information. See definition of Acceptance, LWP-10200.

NOTE: *Delete or mark "N/A" for project roles not engaged. Include ALL personnel and their roles listed above in the eCR system. The list of the roles above is not all inclusive. If needed, the list can be extended or reduced.*

SCOPE AND BRIEF DESCRIPTION

The instruments to be tested in NRAD are primarily Self Powered Neutron Detectors (SPNDs) and miniature fission chambers. While these sensors can be configured to detect both fast and thermal neutrons, the testing in NRAD is expected to focus on thermal neutron flux measurements. SPNDs and fission chambers have been used extensively in commercial power plants, but their application in Material Test Reactors (MTRs) has been much more limited. New SPNDs and fission chambers are being designed specifically for use in MTR tests and for use in advanced reactor designs. One challenge of these new applications for neutron sensors is much higher operating temperatures compared to commercial light water reactors. The vast majority of SPNDs and fission chamber designs are for operating temperatures of 400°C and less, while MTR tests and advanced reactor designs need sensors capable of working reliably at 800°C or higher.

The testing documented herein was to verify the test rig functions as intended, prior to transferring it to the NRAD reactor. The objectives of the functional testing were as follows:

1. Verify the dry tube does not leak.
2. Verify the central heater in the test rig can raise the temperature in the sensor guide tubes to at least 800°C.
3. The sensors being tested have a sensitive region of 90 mm or less. Verify that the temperature variation along this 90 mm length is no more than 25°C with the center of this region at 800°C.
4. Record the surface temperature of the dry tube at the elevation corresponding to core mid-plane and verify that it rises no more than 10°C above the water temperature during the test period. This is to ensure that there is no chance of boiling NRAD coolant during operation.

Appendices to this TEV document configuration and assembly details of the test rig.

TEST RESULTS AND OBSERVATIONS

The results of the test objectives are presented in Table 1 below.

Table 1. Test Results

No.	Objective	Result	Re.
1	Tube doesn't leak	This was listed as a specific step WR 21-128 (which fabricated the dry tube) with QA verification. And the step was signed as "Sat".	WR 21-128
2	Temperature of 800°C can be achieved	In final test run (Test #4), a temperature of 800°C was achieved and maintained for >30 minutes	App. A, Test #4
3	Temperature variation <25°C	While at 800°C the ΔT was 17°C	App. A, Test #4
4	ΔT between surface of dry tube and water	The ΔT was 0.9°C	App. A, Test #4

Other observations were as follows:

5. For the first run, a temperature of 900°C was achieved, however after about 10 minutes of operation the heater failed open.
6. A digital temperature control unit was integrated into the system and during runs 2 and 3 the GFI breaker tripped after heating the test above 500°C. It was determined that the abrupt on-off nature of the digital controller, coupled with reduced coil to sheath resistance due to elevated temperature, induced a brief leakage of current to ground, which tripped the GFI. When the heater was powered directly from a Variac (with manual voltage adjustments to achieve target temperature), a steady temperature of 800°C was achievable.
7. The coil resistance of the heater was measured as 14.9 ohm. The voltage required to maintain a temperature of 800°C was 53 V. Therefore the max heater output was (53V)^2/14.9 ohm = 189 W.

ASSUMPTIONS

None.

Appendix A

Test Logs

TEST PROCEDURE

Page 1 of 4

Performance Evaluation of Heated NRAD Instrumentation Test Rig Prior to Installation

ROLES AND RESPONSIBILITIES

Role	Name (Typed)	Organization	Signature
PR/PI	A. J. Palmer	C660	
Checker	T. C. Unruh	C670	
Doc Owner Approval	P. Calderoni	C670	Patrick Calderoni
Line Manger Approval	B. D. Kelly	C660	
Performer	R.N. Paulsen	C660/5442	RNP

TEST #4

Test #4 was the final test and the only test that wasn't terminated early.

TEST PROCEDURE

Performance Evaluation of Heated NRAD Instrumentation Test Rig Prior to Installation

Procedure for Assembly and Out of Pile Testing

Project	**NRAD Heated Instrumentation Tests**	**ID: Out of Pile-X (number tests sequentially)**		
Item	**Description**	**Comment**	**Sign-off**	**Date**
10	Assemble test rig in accordance with Fig. 1, Fig. 2, and directions of PI. Attach additional sheets as necessary to document details of construction.		RW PW	7-26-21
15	Record Cal ID of scale and record weight of test rig assembly (this weight will be used to verify rig won't float when installed in NRAD)		RW PW	7-26-21
20	Record Cal IDs of TCs-1, 2, 3, 4, 5, 6 as identified in Fig. 1 350°C RMF 7-29-21		RW PW	7-29-21
30	Gradually increase voltage applied to heater to achieve a temperature of ~~300°C~~ on TC-2. Record all TC readings, voltage and current		RW PW	7-29-21
40	Increase heater voltage to achieve temperatures of ~~400°C~~ to ~~1000°C~~ in ~~100°C~~ increments (note PI may elect to stop temperature increases at any point). Record all TC readings, voltage and current. Monitor water bath temperature during this process. If it exceeds 45°C, terminate test.	see changes Per PI	RW PW	7-29-21
50	After reaching peak temperature, turn heater power off, and allow test rig to cool 800°C max		RW PW	7-29-21
60	If test is satisfactory, remove test rig from water tank, disassemble and store all materials. If not, repeat test using next sequential test number.	Prep for Ship and Spent Testing.	RW PW	7-29-21

TEST PROCEDURE

Performance Evaluation of Heated NRAD Instrumentation Test Rig Prior to Installation

		Record Data from Steps 20, 30, and 40	350°C	500°C	650°C	800°C				
	Cal ID and Date	Description	(~~300C~~ on TC-2)	(~~400C~~)	(~~500C~~)	(~~600C~~)	(700C)	(800C)	(900C)	(1000C)
TC-1	737177 7-10-22	Bottom TC of multipoint in one of the guide tubes	346.5	493.4	644	792				
TC-2	737177 7-10-22	Middle TC of multipoint in one of the guide tubes	350.9	501.8	650	801				
TC-3	737177 7-10-22	Top TC of multipoint in one of the guide tubes	355.5	506.1	655	809				
TC-4	737176 6-29-22	Strapped to dry tube at heater mid-plane. To measure dry tube surface temperature	20.2	20.9	22.6	23.6			NA	
TC-5	737174 6-29-22	Strapped to bottom of dry tube. To measure surf. temp. at this location	19.4	19.8	20.9	21.5			RNP 7-29-21	
TC-6	737175 6-29-22	Temperature of water in tank	20.0	20.4	22.0	22.7				
TC-A	NA info only	Center line of heater temperature	370.4	528.6	686	848				
W	720096 1-23-22	Weight of test rig assembly 14.0 lbs	←			→				
V	NA info only	Heater voltage 57 VAC max	30v	42v	48v	57v				
A	NA info only	Heater current NA Single Wire not Available								

Comments: 10:17am → 11:51am for temp 1 to adjust and settle.
11:51am → 12:57pm for temp 2 to adjust and settle.
12:57pm → 3:48pm temp 3 adjust and settle. (got distracted) actual time may differ, lower.
3:50pm → 4:21pm temp 4 came right in.
Heater ran well without issue.

TEST PROCEDURE

Performance Evaluation of Heated NRAD Instrumentation Test Rig Prior to Installation

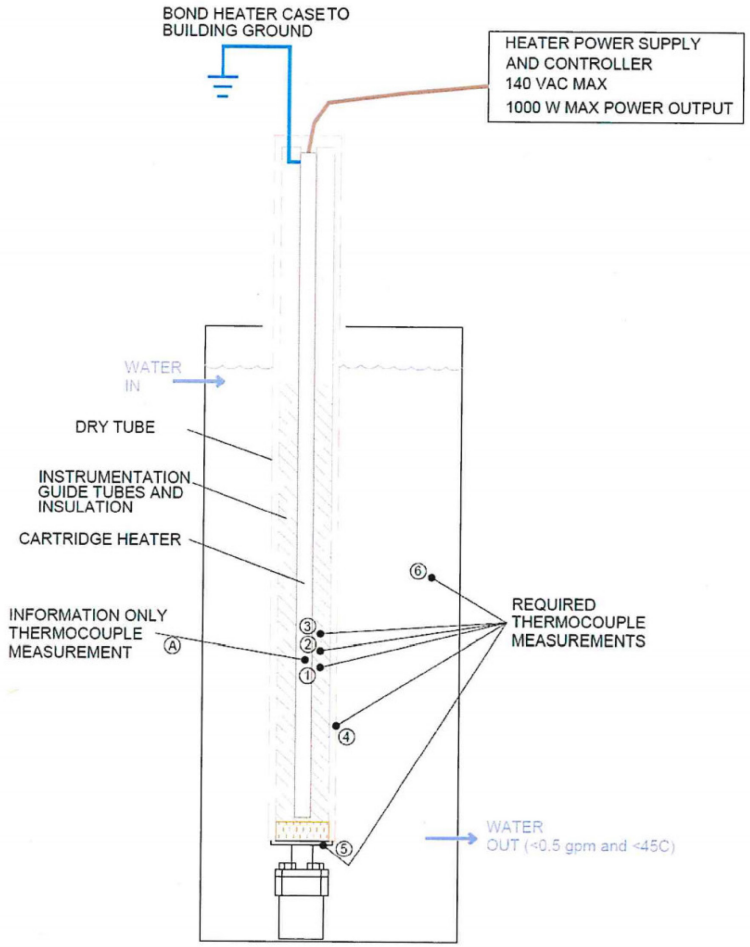

Figure 1. General Layout and Thermocouple Locations

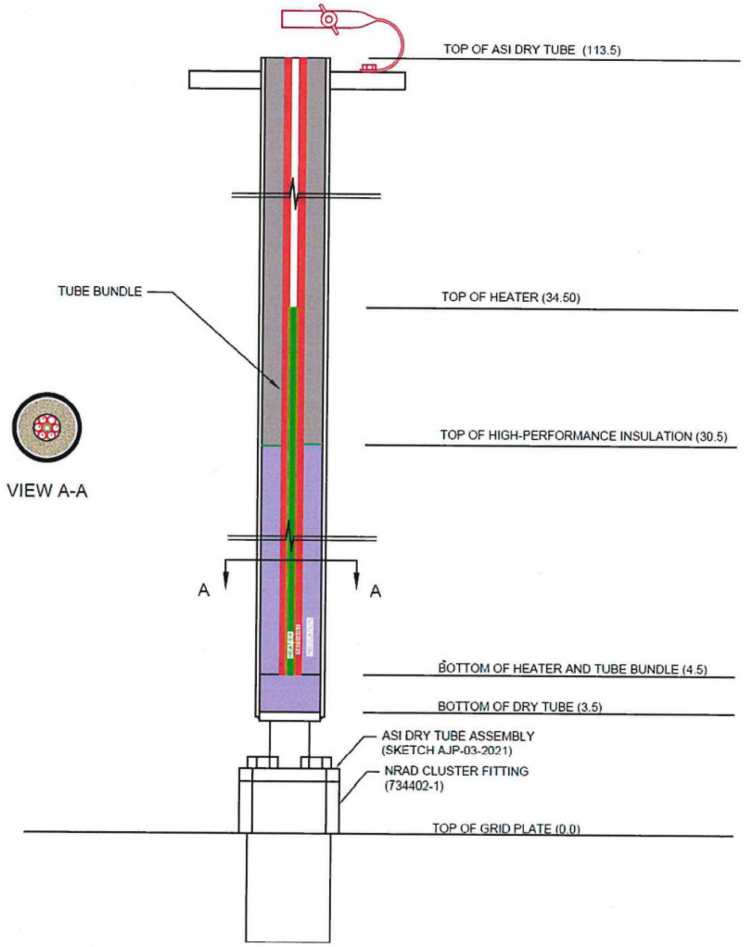

Figure 2. Test Rig Elevations and Details

TEST PROCEDURE

Page 1 of 4

Performance Evaluation of Heated NRAD Instrumentation Test Rig Prior to Installation

ROLES AND RESPONSIBILITIES

Role	Name (Typed)	Organization	Signature
PR/PI	A. J. Palmer	C660	
Checker	T. C. Unruh	C670	
Doc Owner Approval	P. Calderoni	C670	Patrick Calderoni
Line Manger Approval	B. D. Kelly	C660	

TEST #3

TEST PROCEDURE Page 2 of 4

Performance Evaluation of Heated NRAD Instrumentation Test Rig Prior to Installation

Procedure for Assembly and Out of Pile Testing

Project	NRAD Heated Instrumentation Tests	ID: Out of Pile-X (number tests sequentially) #3		
Item	**Description**	**Comment**	**Sign-off**	**Date**
10	Assemble test rig in accordance with Fig. 1, Fig. 2, and directions of PI. Attach additional sheets as necessary to document details of construction.		AJP	7.26.21
15	Record Cal ID of scale and record weight of test rig assembly (this weight will be used to verify rig won't float when installed in NRAD)		AJP	7.26.21
20	Record Cal IDs of TCs-1, 2, 3, 4, 5, 6 as identified in Fig. 1 350°C AJP 7.26.21		AJP	7.26.21
30	Gradually increase voltage applied to heater to achieve a temperature of ~~300~~°C on TC-2. Record all TC readings, voltage and current See new temperature schd p. 3. AJP 7.26.21			
40	Increase heater voltage to achieve temperatures of ~~400°C to 1000°C in 100°C~~ increments (note PI may elect to stop temperature increases at any point). Record all TC readings, voltage and current. Monitor water bath temperature during this process. If it exceeds 45°C, terminate test.		Terminated Test AJP 8.2.21	
50	After reaching peak temperature, turn heater power off, and allow test rig to cool			
60	If test is satisfactory, remove test rig from water tank, disassemble and store all materials. If not, repeat test using next sequential test number.			

250°C to 350°C took 8 minutes. Soaked @ 350°C for 12 minutes & recorded temp

TEST PROCEDURE

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Performance Evaluation of Heated NRAD Instrumentation Test Rig Prior to Installation

Record Data from Steps 20, 30, and 40

	Cal ID and Date	Description	350°C (300C on TC-2)	500°C (400C)	650°C (500C)	800°C (600C)	(700C)	(800C)	(900C)	(1000C)
TC-1	737177 7.10.22	Bottom TC of multipoint in one of the guide tubes	345.6	492.0						
TC-2	737177 7.10.22	Middle TC of multipoint in one of the guide tubes	350	500						
TC-3	737177 7.10.22	Top TC of multipoint in one of the guide tubes	354.4	507.3		Terminated ASP 8.2.21		NA		
TC-4	737176 6.29.22	Strapped to dry tube at heater mid-plane. To measure dry tube surface temperature	23.0	23.7					ASP 7.26.2021	
TC-5	737174 6.29.22	Strapped to bottom of dry tube. To measure surf. temp. at this location	22.2	22.5						
TC-6	737175 6.29.22	Temperature of water in tank	21.9	22.2						
TC-A	NA info only	Center line of heater temperature	~360	520.7						
W	~~720096~~ 1.23.22	Weight of test rig assembly 14.0 lbs								
V	NA info only	Heater voltage 65V	65V	65V						
A	NA info only	Heater current NA · Current is chopped								

Comments: 250°C to 350°C took 8 minutes. Soaked @ 350°C for 12 minutes & recorded temperature
350°C to 500°C took 10 minutes. Soaked @ 500°C for 10 minutes & recorded temps.
Tripped GFI Breaker @ 15:05pm during heatup to 650°C

Room temperature heater resistance was 14.9 Ω 727677 Exp 3.30.2022 Fluke Multimeter

TEST PROCEDURE Page 4 of 4

Performance Evaluation of Heated NRAD Instrumentation Test Rig Prior to Installation

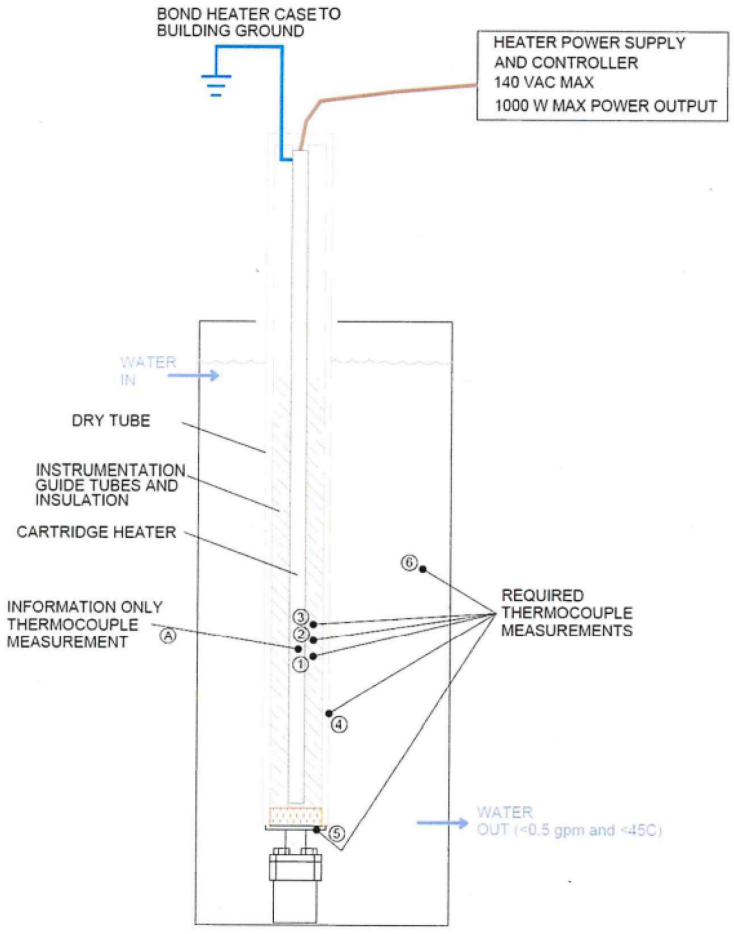

Figure 1. General Layout and Thermocouple Locations

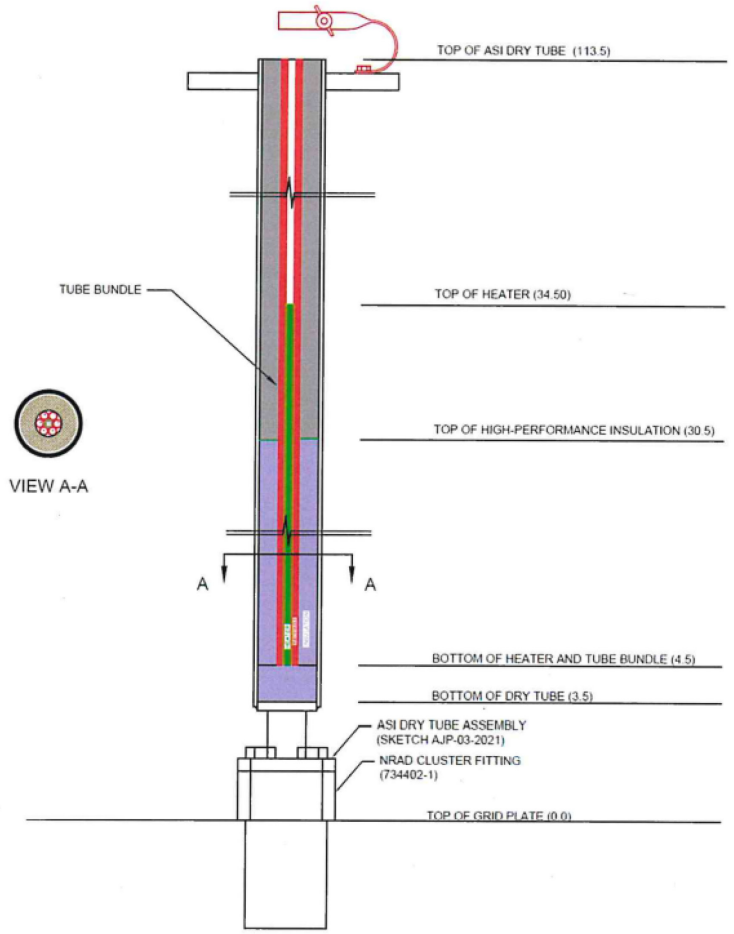

Figure 2. Test Rig Elevations and Details

TEST PROCEDURE

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Performance Evaluation of Heated NRAD Instrumentation Test Rig Prior to Installation

ROLES AND RESPONSIBILITIES

Role	Name (Typed)	Organization	Signature
PR/PI	A. J. Palmer	C660	
Checker	T. C. Unruh	C670	
Doc Owner Approval	P. Calderoni	C670	Patrick Calderoni
Line Manger Approval	B. D. Kelly	C660	

TEST #2

TEST PROCEDURE

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Performance Evaluation of Heated NRAD Instrumentation Test Rig Prior to Installation

Procedure for Assembly and Out of Pile Testing

Project	NRAD Heated Instrumentation Tests	ID: Out of Pile-X (number tests sequentially) #2		
Item	**Description**	**Comment**	**Sign-off**	**Date**
10	Assemble test rig in accordance with Fig. 1, Fig. 2, and directions of PI. Attach additional sheets as necessary to document details of construction.		AJP	7.22.21
15	Record Cal ID of scale and record weight of test rig assembly (this weight will be used to verify rig won't float when installed in NRAD)		AJP	7.22.21
20	Record Cal IDs of TCs-1, 2, 3, 4, 5, 6 as identified in Fig. 1		AJP	7.22.21
30	Gradually increase voltage applied to heater to achieve a temperature of ~~300~~ 350°C on TC-2. Record all TC readings, voltage and current 350°C AJP 7.22.21		AJP	7.22.21
40	Increase heater voltage to achieve temperatures of 400°C to 1000°C in 100°C increments (note PI may elect to stop temperature increases at any point). Record all TC readings, voltage and current. Monitor water bath temperature during this process. If it exceeds 45°C, terminate test.			
50	After reaching peak temperature, turn heater power off, and allow test rig to cool			
60	If test is satisfactory, remove test rig from water tank, disassemble and store all materials. If not, repeat test using next sequential test number.			

Test terminated
AJP 8/2/21

TEST PROCEDURE

Performance Evaluation of Heated NRAD Instrumentation Test Rig Prior to Installation

Record Data from Steps 20, 30, and 40

	Cal ID and Date	Description	~~350°C~~ (~~300C~~ on TC-2)	~~500°C~~ (~~400C~~)	~~650°C~~ (~~500C~~)	~~800°C~~ (~~600C~~)	(700C)	(800C)	(900C)	(1000C)
TC-1	737177 7.10.22	Bottom TC of multipoint in one of the guide tubes	346.1							
TC-2	737177 7.10.22	Middle TC of multipoint in one of the guide tubes	350.0							
TC-3	737177 7.10.22	Top TC of multipoint in one of the guide tubes	352.8							
TC-4	737176 6.29.22	Strapped to dry tube at heater mid-plane. To measure dry tube surface temperature	22.5							
TC-5	737174 6.29.22	Strapped to bottom of dry tube. To measure surf. temp. at this location	21.7							
TC-6	737175 6.29.22	Temperature of water in tank	21.3							
TC-A	NA info only	Center line of heater temperature	364.5							
W	720096 1.23.22	Weight of test rig assembly	14.016							
V	NA info only	Heater voltage	67V							
A	NA info only	Heater current	NA chopped							

NA AJS 7.22.21

NA AJS 9.2.21

Comments: 250°C to 350°C took 7minutes. Soaked @ 350°C for 10 min & recorded temps
Tripped GFI breaker during ramp to 500°C. Terminated test.

Multi point was in guide tube #6. AJS 7.22.21

TEST PROCEDURE

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Performance Evaluation of Heated NRAD Instrumentation Test Rig Prior to Installation

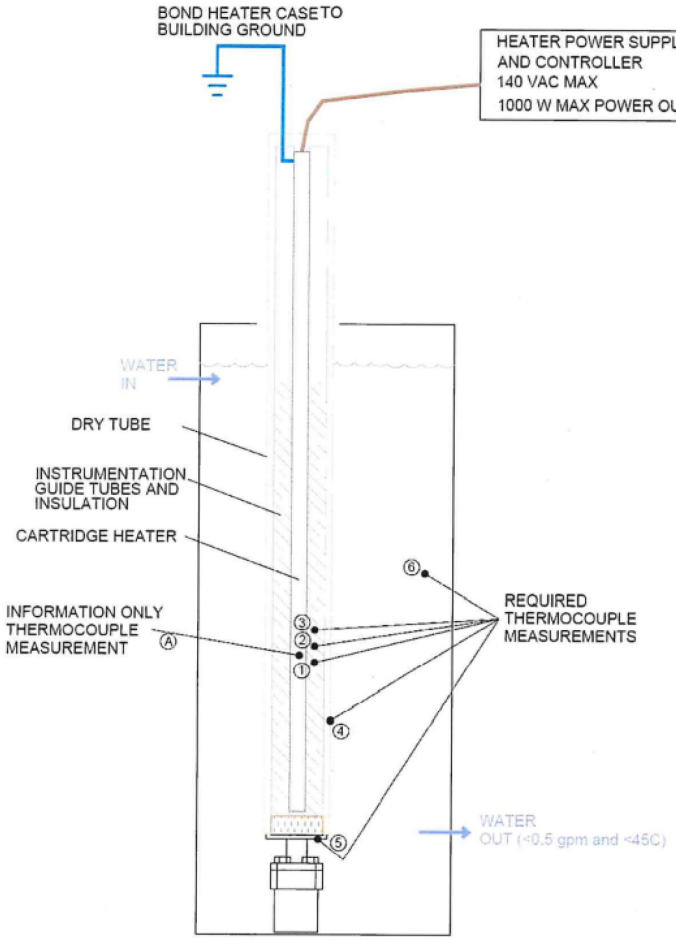

Figure 1. General Layout and Thermocouple Locations

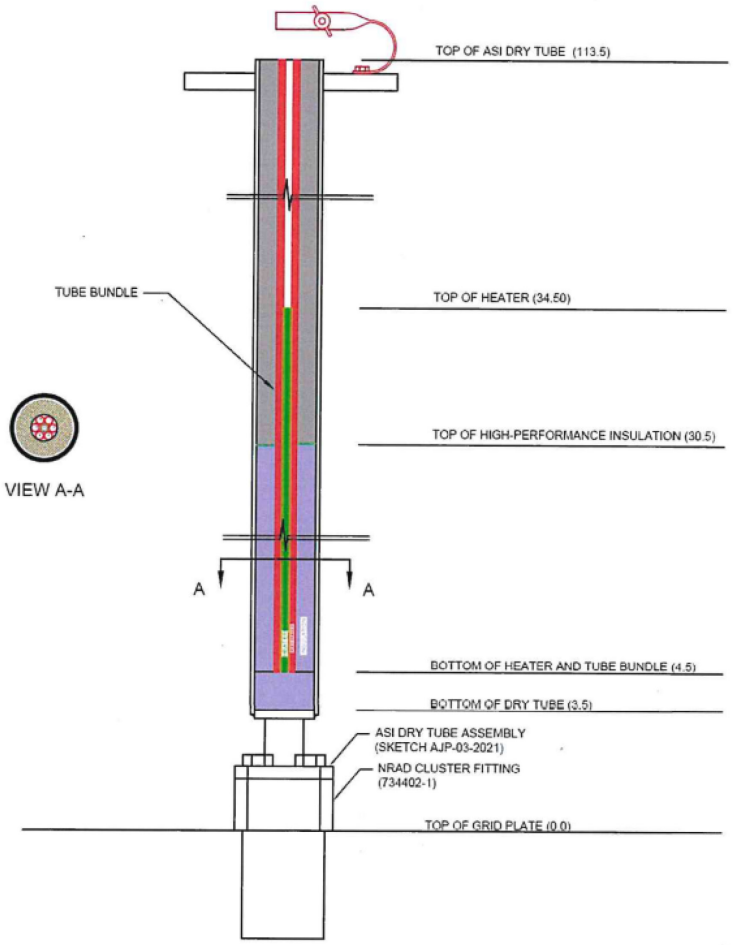

Figure 2. Test Rig Elevations and Details

TEST PROCEDURE

Page 1 of 4

Performance Evaluation of Heated NRAD Instrumentation Test Rig Prior to Installation

ROLES AND RESPONSIBILITIES

Role	Name (Typed)	Organization	Signature
PR/PI	A. J. Palmer	C660	
Checker	T. C. Unruh	C670	
Doc Owner Approval	P. Calderoni	C670	
Line Manger Approval	B. D. Kelly	C660	

TEST #1

TEST PROCEDURE

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Performance Evaluation of Heated NRAD Instrumentation Test Rig Prior to Installation

Procedure for Assembly and Out of Pile Testing

Project	NRAD Heated Instrumentation Tests	ID: Out of Pile-X (number tests sequentially)		
Item	**Description**	**Comment**	**Sign-off**	**Date**
10	Assemble test rig in accordance with Fig. 1, Fig. 2, and directions of PI. Attach additional sheets as necessary to document details of construction.		AQP	7/13/2021
15	Record Cal ID of scale and record weight of test rig assembly (this weight will be used to verify rig won't float when installed in NRAD)	See #1 Below	AQP	7/15/2021
20	Record Cal IDs of TCs-1, 2, 3, 4, 5, 6 as identified in Fig. 1		AQP	7/13/2021
30	Gradually increase voltage applied to heater to achieve a temperature of 300°C on TC-2. Record all TC readings, voltage and current		AQP	7/13/2021
40	Increase heater voltage to achieve temperatures of 400°C to 1000°C in 100°C increments (note PI may elect to stop temperature increases at any point). Record all TC readings, voltage and current. Monitor water bath temperature during this process. If it exceeds 45°C, terminate test.		AQP	7/13/2021
50	After reaching peak temperature, turn heater power off, and allow test rig to cool		AQP	7/13/2021
60	If test is satisfactory, remove test rig from water tank, disassemble and store all materials. If not, repeat test using next sequential test number.	Unsat *	AQP	7/13/2021

* Heater failed open

#1 Cal ID of scale is actually Cal ID of Certified weights used to ck scale prior to weighing test rig.

TEST PROCEDURE

Performance Evaluation of Heated NRAD Instrumentation Test Rig Prior to Installation

		Record Data from Steps 20, 30, and 40								
	Cal ID and Date	Description	(300C on TC-2)	(400C)	(500C)	(600C)	(700C)	(800C)	(900C)	(1000C)
TC-1	737177 7.10.22	Bottom TC of multipoint in one of the guide tubes	290.1	389.2	485.9	585.4	683	783	883	
TC-2	737177 7.10.22	Middle TC of multipoint in one of the guide tubes	300.0	400	500	600	700	800	900	
TC-3	737177 7.10.24	Top TC of multipoint in one of the guide tubes	299.9	398.6	498.7	597.5	695	793	891	
#1 TC-4	737176	Strapped to dry tube at heater mid-plane. To measure dry tube surface temperature	19.7	20.6	20.7	21.2	21.8	22.5	23.2	
#2 TC-5	737174	Strapped to bottom of dry tube. To measure surf. temp. at this location	19.0	19.3	19.7	20.1	20.4	20.9	21.2	
#3 TC-6	737175	Temperature of water in tank	19.0	19.2	19.3	19.7	19.9	20.2	20.6	
TC-A	NA info only	Center line of heater temperature	316.7	425.5	528.9	633	738	842	947	
W	720096 1.23.22	Weight of test rig assembly 140 lbs								
V	NA info only	Heater voltage 90V*								
A	NA info only	Heater current - Not available								

Not Done per PSB 7/13/21

Comments: ~10 min to achieve 300C, ~8 min ⇒400C, 7 min ⇒500C, 7 min ⇒600C, 7 min 30sec ⇒700C, ~9 min ⇒800C
Going from 700C to 800C heater peak temp of 870C (voltage still 90V)
*Reduced heater voltage to 80V for last step 800C ⇒900C. Max temp of heater = 955C. Elapsed time 800C-900C was 11 minutes. After about 5 min @ temperature the heater failed open.

TEST PROCEDURE Page 4 of 4

Performance Evaluation of Heated NRAD Instrumentation Test Rig Prior to Installation

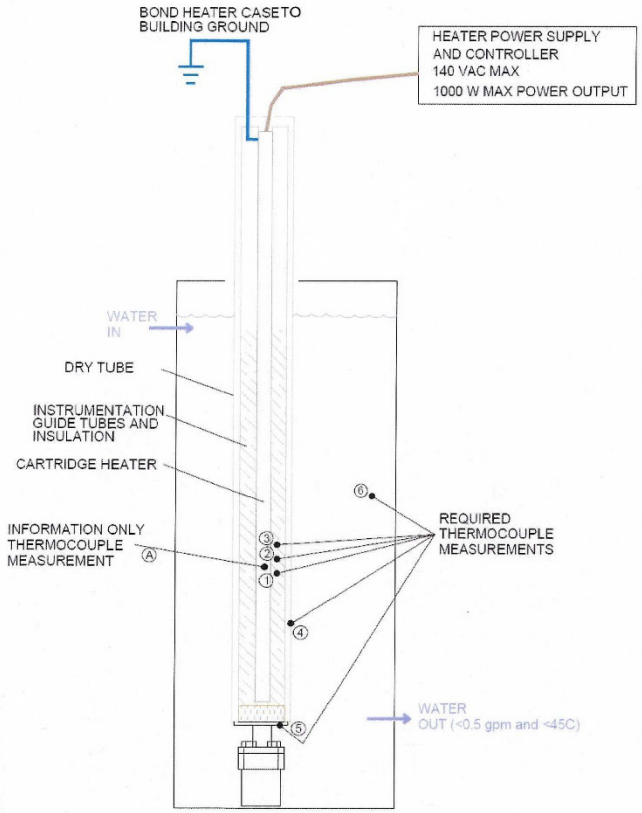


Figure 1. General Layout and Thermocouple Locations

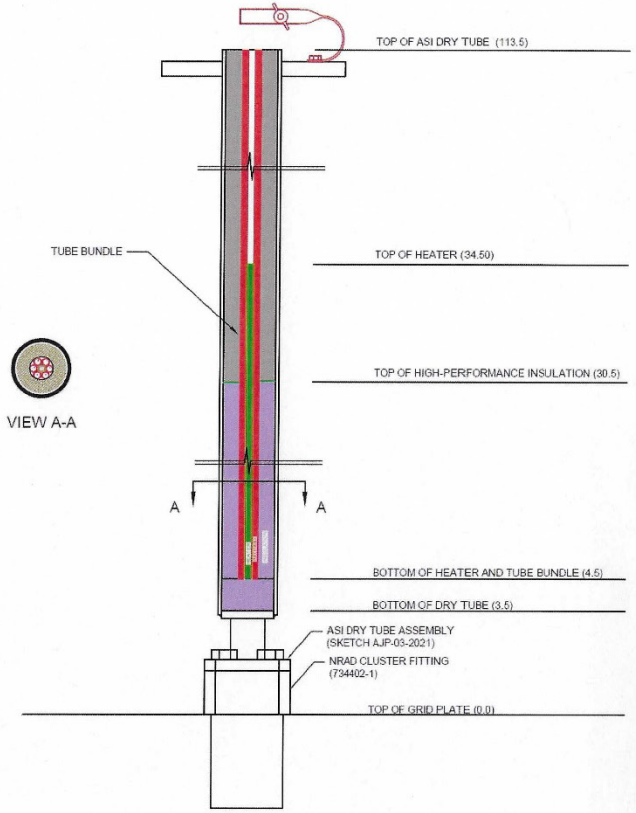


Figure 2. Test Rig Elevations and Details

Appendix B

Assembly Log

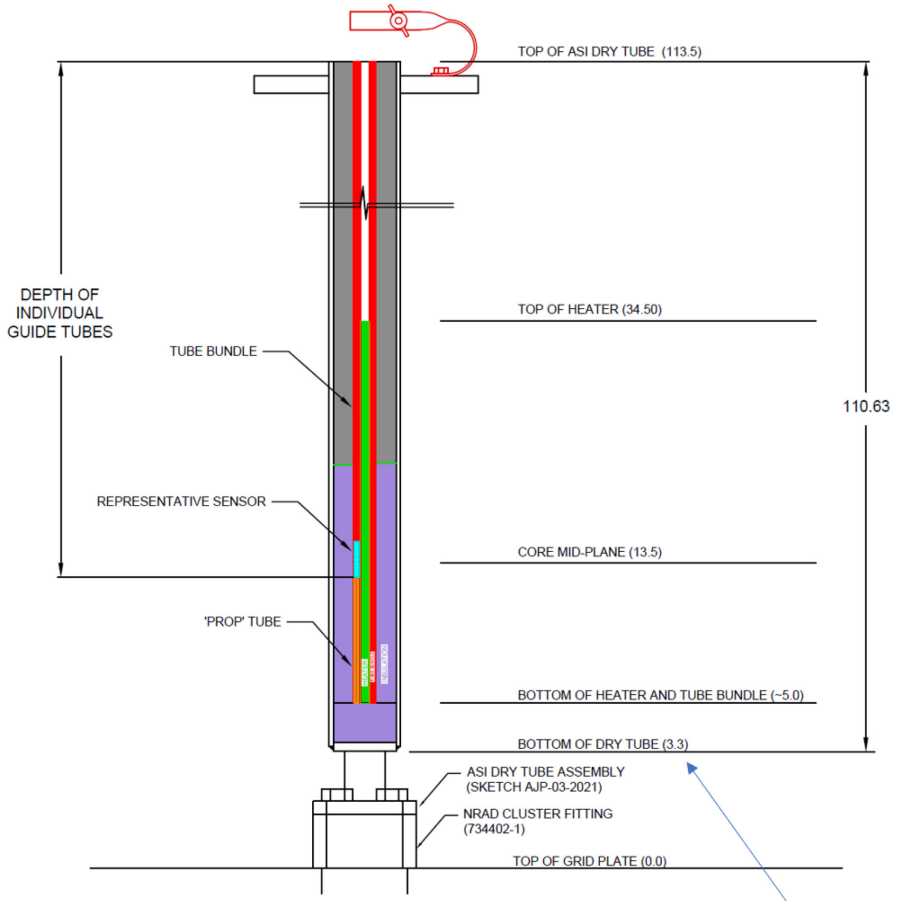
Assembly Log

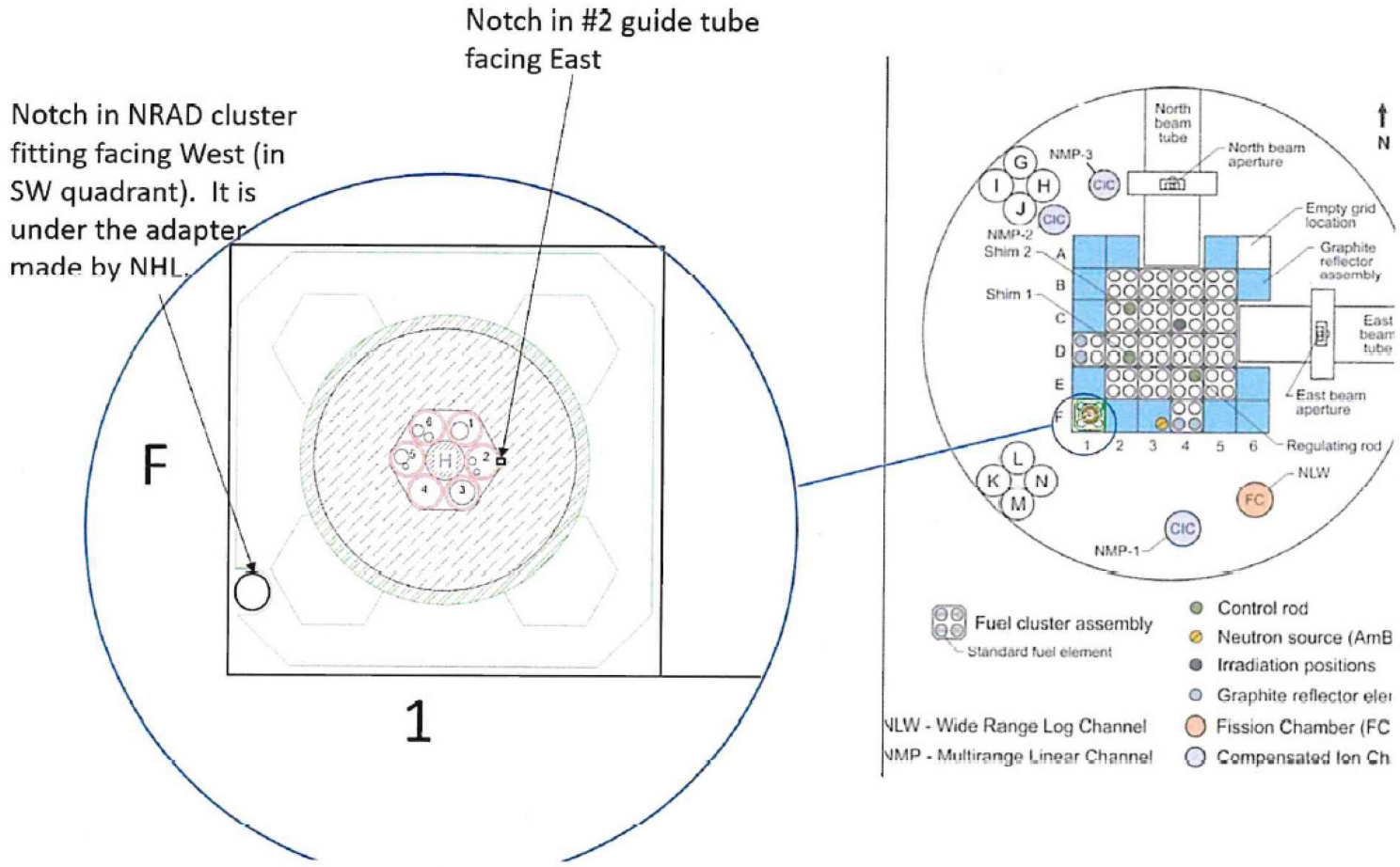
Date	Initial complete	Assembly Step	Comments
7-26-21	RNP	Cut four pieces of Microtherm insulation blanket (1/4" thk) to a diameter of 1 ¾"	These four disks of insulation will be stacked at the bottom of the dry tube and minimize axial heat transfer out the bottom.
7-26-21	RNP	Cut six ¼ x .016 sst tubes at 109 inches long	
7-26-21	RNP	Cut a seventh ¼ x .016 sst tube at 77.75 inches long	
7-26-21	RNP	Cut a .75 OD disk out of 1/16" thick stock to serve as the floor of the guide tube bundle	
7-26-21	RNP	Cut six "prop" tubes from 3/16 x .016" sst tube with the following lengths: #1 7.8 inch 7.68 #2 7.3 inch 7.18 #3 8.5 inch 8.38 #4 7.0 inch 6.88 #5 7.0 inch 6.88 #6 7.0 inch 6.88 AJP 8.2.21	These were later shortened ⅛" New lengths shown at left AJP 8.2.21
7-26-21	RNP	Slide the ¼" x 77.75" tube over the heater leads	
7-26-21	RNP	Arrange the six ¼" x 109" tubes around the heater and tie wire everything together into a solid entity (sst tie wire). In conjunction with this, apply T-99 compound between the heater and six tubes (lower 24" is sufficient)	**See Fig. 1**
7-26-21	RNP	After tie-wiring everything together, apply T-99 compound over the lower 24" of the completed assembly. The ¾"dia x 1/16"	

7-26-21	RNP	thick sst disk should be attached to the bottom of the bundle with tie-wire.	**See Fig. 2**
7-26-21	RNP	Cure the T-99 compound per manufacturer's directions	
7-26-21	RNP	Fabricate an aluminum cylinder 1.77 OD x .83 ID x 6 inch long	
7-26-21	RNP	Wrap insulation around the tube bundle. The top of the insulation should be roughly 83 inches from the top of the tube bundle (and about 27 inches from the bottom of the ceramic spacer at the bottom of the assembly). Tire wire insulation in place	**See Fig. 3**
7-26-21	RNP	Slide aluminum cylinder over the tube bundle down to the insulation.	**See Fig. 3**
7-26-21	RNP	Slide foam insulation over tube bundle to within 7" of the top end of the tube bundle. Cap off with the black silicone insulation, terminating it about ½" from the top of the tube bundle.	**See Fig. 4**
7-26-21	RNP	Mark guide tube #2 by cutting a slot at the top of the tube. This slot will face due East when the assembly is in the reactor. Insert prop tubes into their appropriate guide tubes.	**See Fig. 5**
7-26-21	RNP	Place the four 1 ¾" diameter microtherm disks at the bottom of the dry tube	
7-26-21	RNP	Slide the heater/tube assembly just finished into the dry tube noting the azimuthal orientation as shown in the figure below.	**"Figure below" refers to 'Assembly Orientation Figure'** **See Figs. 6 and 7 for completed assembly**
7-26-21	RNP	Weigh completed assembly and record calibration information	calibrated weights – 72 00 96 14 16s 1-23-2022

8.2.21	AJP	Measure overall length of dry tube. Measure depth of guide tubes (this confirms where the sensors will reside relative to core mid-plane).	
8.2.21	AJP	Overall length of dry tube	110 5/8"
8.2.21	AJP	Depth of guide tube #1 (see orientation figure in "Test Procedure" for guide tube numbering)	101 3/8"
8.2.21	AJP	Depth of guide tube #2	101 7/8"
8.2.21	AJP	Depth of guide tube #3	101 21/32"
8.2.21	AJP	Depth of guide tube #4	102 7/32"
8.2.21	AJP	Depth of guide tube #5	102 7/32"
8.2.21	AJP	Depth of guide tube #6	102 7/32"

	See prev page	Dry tube OAL - Guide tube depth + 3.3 inch	Elev of prop tube - 13.5
Guide Tube No.	**Guide Tube Depth (inch)**	**Elevation of Prop Tube (inch)**	**Elevation Relative to Core Mid-Plane (inch)**
1	101.38	12.55	-0.95
2	101.78	12.15	-1.35
3	101.66	12.27	-1.23
4	102.22	11.71	-1.79
5	102.22	11.71	-1.79
6	102.22	11.71	-1.79





Assembly orientation figure

Figure 1. Tubes wired together prior to application of T-99 cement

Figure 2. Guide tubes floor plate tie-wired to bottom of assembly

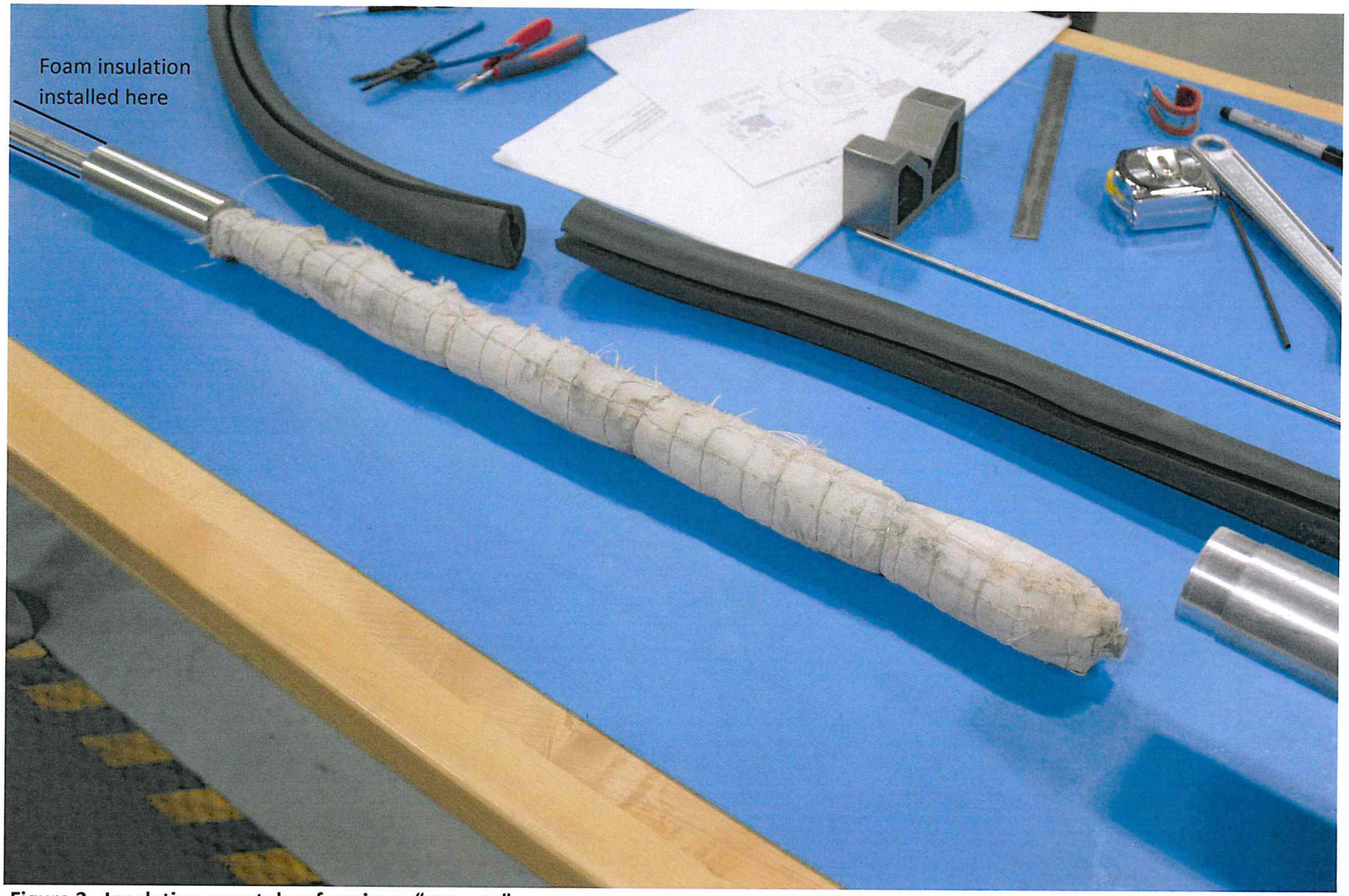


Figure 3. Insulation over tubes forming a "sausage"

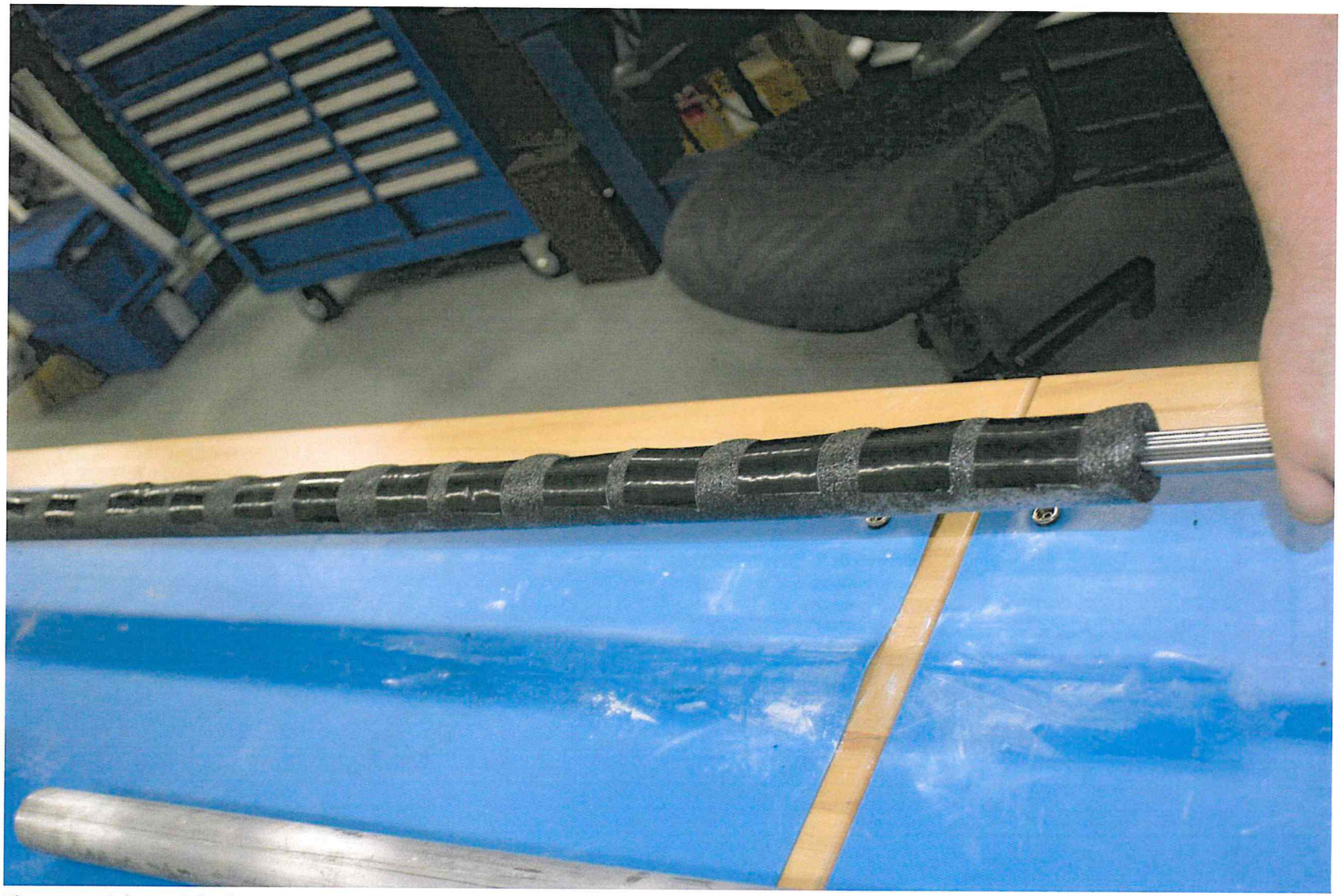


Figure 4. Light-weight foam insulation taped in place

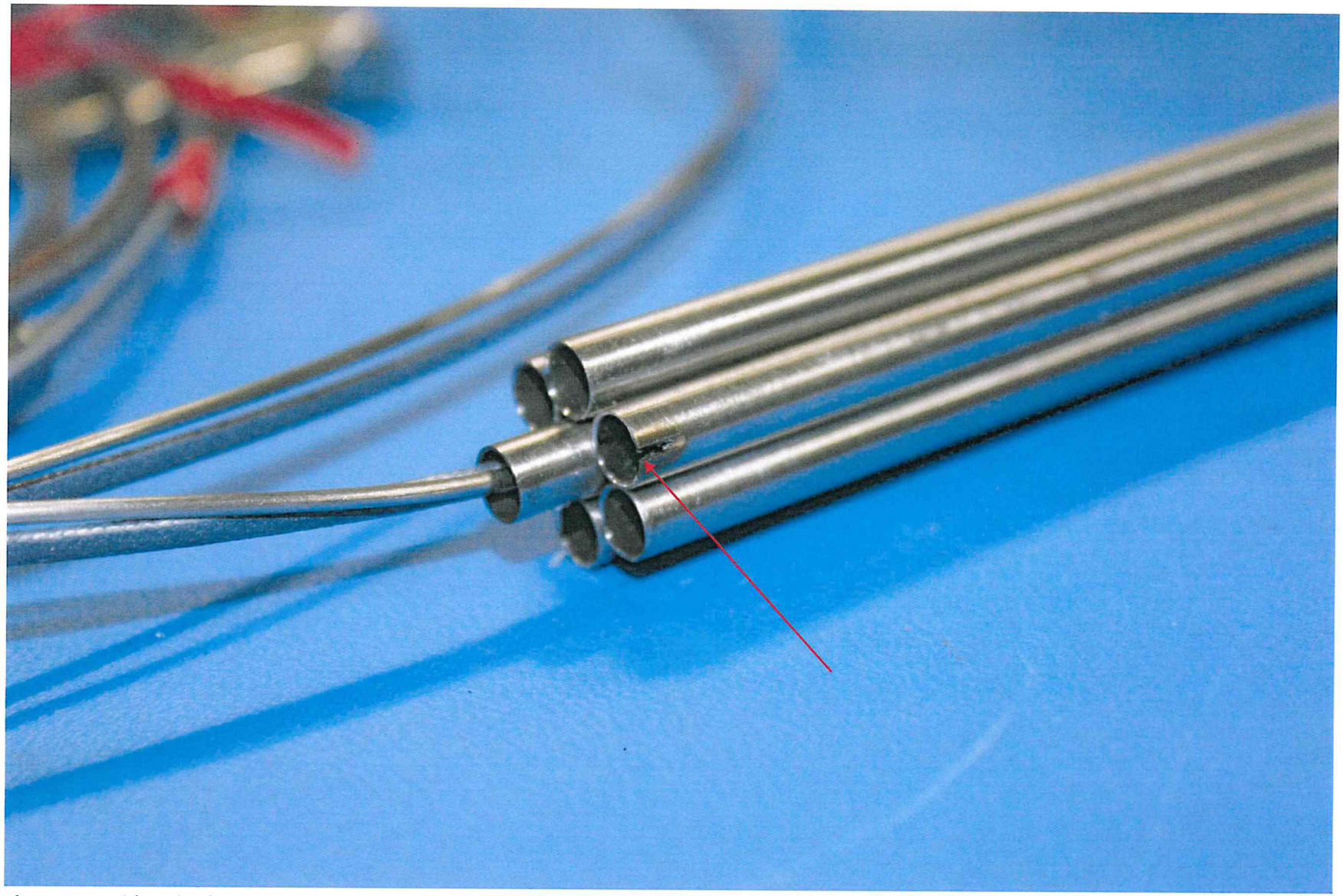


Figure 5. Guide tube facing east is marked with a cut at its top

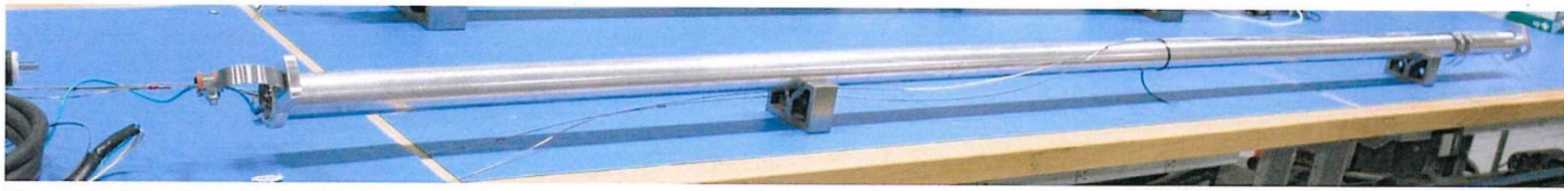


Figure 6. Completed assembly

Figure 7. Completed assembly in testing tank

Buoyancy Evaluation

					mass of water displaced (lbm)	
	OD	ID	Submerged Length	Density of water (lbm/in^3)		
	2.000	0.000	104.000	0.0359	**11.73**	
	OD (in)	ID (in)	Length (in)	Density (lbm/cu-in)	Mass (lbm)	
Mass of various objects making up assembly						
Aluminum tube	2	1.81	108	0.098	6.02	
Heater shell	0.27	0.234	30	0.29	0.12	
Heater insulation fill	0.234	0	30	0.085	0.11	
Guide tubes	0.25	0.218	624	0.28	2.06	
quilted insulation	1.75	0.85	26	0.07	3.34	conservatively took 66% of density of silica
Aluminum chill slug	1.75	0.83	6	0.098	1.10	
Upper insulation (foam)	1.75	0.77	70	0.005	0.68	
Total					**13.43**	
Since mass of assembly (13.43 lbm) is greater than mass of water displaced (11.72 lbs), the test rig will not float						

As discussed above, the test rig was also weighed and found to be 14.0 lbs +/-0.5 lbs.

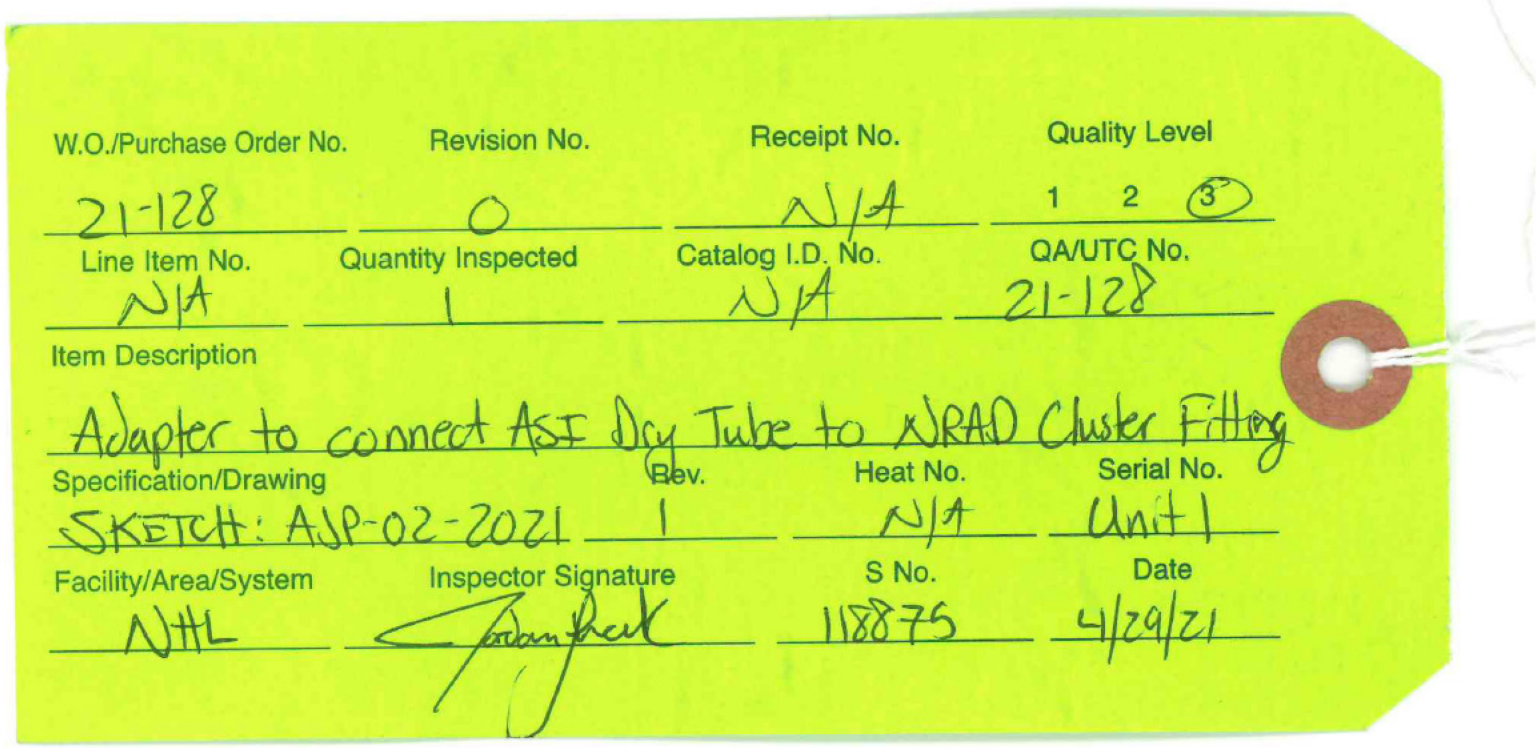
Appendix C

Quantities of Elements in Core Region

See supplementary information attached to this TEV on EDMS.

Appendix D

Documentation of Materials Used in Core Region



W.O./Purchase Order No.	Revision No.	Receipt No.	Quality Level
21-128	0	N/A	1 2 (3)
Line Item No.	**Quantity Inspected**	**Catalog I.D. No.**	**QA/UTC No.**
N/A	1	N/A	21-128

Item Description

Adapter to connect ASI Dry Tube to NRAD Cluster Fitting

Specification/Drawing	Rev.	Heat No.	Serial No.
SKETCH: AJP-02-2021	1	N/A	Unit 1
Facility/Area/System	**Inspector Signature**	**S No.**	**Date**
NTL	[signature]	118875	4/29/21

Note that this green-tag should have specified sketch AJP-03-2021 which was for the entire assembly.

ILC
Idaho Laboratories Corporation

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

CERTIFICATE OF CONFORMANCE

WE HEREBY CERTIFY THAT THE MATERIALS AND SERVICES SUPPLIED ARE IN CONFORMANCE WITH CUSTOMER PURCHASE ORDER REQUIREMENTS. THE REQUIRED TEST AND/OR INSPECTION RECORDS ARE ON FILE AND AVAILABLE FOR REVIEW BY THE CUSTOMER AT ANY TIME WITHIN THE RECORD RETENTION PERIOD.

CUSTOMER SUPPLIED TO: BATTELLE ENERGY ALLIANCE, LLC
SPECIFICATION/DWG#: N/A
CUSTOMER PURCHASE ORDER: 00248131
ILC PART NUMBER: 270-K/24/2NI-I600-H-GND-22"/8"
ILC SALES ORDER NUMBER: 243463
ILC HEAT NUMBER: 42049
ILC SPECIFICATION: S210226-01-GNH
DESCRIPTION OF MATERIAL: 3 PIECES
NOTES: AS PER CUSTOMER PURCHASE ORDER AGREEMENT.

RESISTANCE OF HEATER AT ROOM TEMPERATURE.
1- 14.50 OHMS/LOOP
2- 14.60 OHMS/LOOP
3- 14.48 OHMS/LOOP

Note that this page and the following six are for the heater used in the assembly.

ILC Q.A. #5 A FINAL
SIGNATURE — QA Manager (TITLE) — 04/22/2021 (DATE)

ILC Q.A. #6 A Final
Ryan Philips
SIGNATURE — Document Control (TITLE)

ILC
Idaho Laboratories Corporation

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

Customer: BATTELLE ENERGY ALLIANCE, LLC.
Customer PO: 00248131
ILC Sales Order Number: 243463
Date: 04/22/2021

The following pieces were PMI tested by Idaho Laboratories Corporation. The results of the tests are as follows:

NICHROME WIRE	NICKEL WIRE
Test #8558 08:43, 4/22/2021 Ni_NichromeV 99 X200-00506 Cr 18.85% ±0.49% Fe 0.23% ±0.06% Ni 80.92% ±0.92%	Test #8559 08:43, 4/22/2021 Ni_Ni 200 100 X200-00506 Mn 0.10% ±0.05% Ni 99.90% ±2.55%

ILC QA #5 A FINAL
SIGNATURE — TITLE: QA Manager — DATE: 04/22/2021

ILC QA #6 A Final
Ryan Phillips
SIGNATURE — TITLE: Document Control

540.04
11/01/2006
Rev. 05

CERTIFICATE OF CONFORMANCE

Page 1 of 3

NOTE: Prior to completing this certification, the Supplier shall review and comply with the attached **form instructions**.

A. A. Purchase Order/Contract Data

1. PO No.: 00248131	2. PO Rev No.: N/A	3. PO Line Item: 1
4. Contract No.: N/A	5. Contract Amendment No.: N/A	

B. Supplier/Source Information

6. Supplier: IDAHO LABORATORIES CORPORATION	7. Supplier Address (Street/City/State): 2101 HEMMERT AVENUE IDAHO FALLS, IDAHO 83401
8. Source of Origin: Street: 2101 HEMMERT AVENUE City: IDAHO FALLS State: IDAHO Country: USA	**CAUTION:** The suppliers shall take all necessary actions and precautions to assure that this Certificate of Conformance(C of C) is accurate, complete, and true, regardless of the actual source of origin.

C. Applicable Requirements

9. Code/Standard No.:	3 PCS 270-K/24/2NI-I600-H-GND-22"/8"	Revisions/Editions/Addendum:	N/A
10. Specification No.:	N/A	Revision/Editions:	N/A
11. Technical Drawings/Diagrams:	N/A	Revision:	N/A
12. Other:	N/A	Revisions/Editions/Addendum:	N/A

D. Approved Changes/Deviations/Waivers/Substitutions/Nonconformances:

E. Nonconformance(s): Unless otherwise directed in writing by the Procurement Agent, Do NOT deliver/ship materials/items/equipment if there are any changes, deviations, substitutions, or nonconforming conditions that have not been previously submitted and approved utilizing Form 540.33, Information/Change Request.

F. Certification Statement

Idaho Laboratories Corp. (Supplier), hereby certifies that the materials/items/equipment identified in **Section A** above, and all required documentation, conforms in all respects to the stated Purchase Order/Contract requirements and that all exceptions, waivers, deviations, and/or nonconforming conditions are identified in **Section D**. Furthermore, information provided is accurate, complete, and true pursuant to 10 CFR 820.11 (see definition).

Authorized Certifying Official (See Definitions/Instructions):

RYAN PHILIPS	Ryan Philips (ILC Q.A. #6 A Final)	DOCUMENT CONTROL	04/22/2021
Printed Name	**Signature**	**Title**	**Date**

See Instructions

C of C is Limited To One Page. Attached Additional Pages On Supplier Letter Head If Required.

DEUTSCHE NICKEL GMBH

Certified Material Test Report

EN 10204 - 3.1

Messrs.
Deutsche Nickel America
70 Industrial Road
Cumberland, RI 02864
USA

No.: R 65052
Order-No.:
401644
Confirmation-No.:
220/80129089/002

Material:	Ni 205	**Specification:**	GE 0024-2843 Rev. 6, dt. 19 11.2003 33-MN-15A GE Part CA 3725663
Mat.-No.:	UNS No2205		
Form of delivery:	wire		
Dimension:	dia. 0.0588" dia. 1,494 mm	**Condition:**	cold drawn, 1/4-hard

Net weight:	**No. of pieces:**	**Heat-No.:**
230,50 kg 508,16 lbs:	8 coils	81085

MEASURED VALUES

Composition (mass-%:) **(melting composition of heat)**

Ni	Cu	Fe	Mn	S	Si	C
99,6	0,014	0,036	0,20	0,0010	0,02	0,011

Ti	Mg
0,034	0,038

Tensile strength (PSI).	85900 - 89600
Yield strength at 0,2 % offset (PSI)	84500 - 87300
Elongation at 10" (%)	1,0 - 1,5

Our QM-system is certified by Lloyd's Quality Assurance in accordance to DINENISO9001, certificate-no.: KLN 4000313.10
Our QM-system is certified by Lloyd's Quality Assurance in accordance to DINENISOTS16949, certificate no: KLN 4000313.14
Our EM-system is certified by Lloyd's Quality Assurance in accordance to DINENISO14001, certificate-no: KLN 4001020

Schwerte, 29.11.2010

QC Manager
Bernd Jacobs

Page 1

PELICAN WIRE COMPANY, INC.

WHITE LAKE CORPORATE PARK
3650 SHAW BOULEVARD
NAPLES, FLORIDA 34117-8408

(239) 597-8555 PH
(239) 597-9783 FX

Sold to:

Idaho Labs
2101 Hemmert Avenue

IDAHO FALLS, ID 83401

Ship to:

2101 Hemmert Avenue

IDAHO FALLS ID 83401

Date: 7/25/13

CERTIFICATE OF COMPLIANCE

Pelican Wire Part No: 2120N80
Customer Part No: N/A

Quantity: 43.220 LB
P.O. 25189
Folder # 64024

We hereby certify that the material supplied on the above Purchase Order is 20 AWG NICHROME 80 bare wire, composed of 80% Nickel, 20% Chromium/conforming to all requirements of ASTM B344. The 20 AWG (.032) NICHROME wire has a nominal resistance of .6293 +/- 3%. The nominal strength for annealed Nichrome 80 is 120 kpsi. This bare wire is supplied on spools in one continuous length per spool .

Very truly yours,
PELICAN WIRE CO., INC.

Edward Valykeo

Edward Valykeo
Quality Manager

R:\Reports\CR_CertificateofCompliance\CR_CertificateofCompliance.RPT

SECTION 2A - ALLOY NAME AND NOMINAL COMPOSITIONS

WEIGHT % - 1% OR GREATER

Alloy	Alloy Name	Cr	Fe	Mn	Ni*	Si	Other	Spec. Grav.	Approx. Melting Point °C
007	NiCr 60 Alloy C	16	24		59	1		8.2	1350
241	NiCr 80 - Alloy A	20			79	1		8.4	1400

*Includes element plus other trace elements

GTC Greenville Tube Company

GREENVILLE TUBE COMPANY LLC **Material Test Report per EN 10204 3.1**

501 S Montgomery St
Clarksville, AR 72830

PHONE 1-479-754-6500 FAX 1-479-754-8426

CUSTOMER: IDAHO LABORATORIES CORP
2101 HEMMERT AVE
IDAHO FALLS, ID 83401

SHIPPED TO: IDAHO LABORATORIES CORP
2101 HEMMERT AVE
IDAHO FALLS, ID 83401 UNITED ST

ORDER NUMBER GV423584/1 **PO Number** 26633

DFARS

PART ID CS0375016N06600JAS01 **DESCRIPTION** .375 OD X .016 AW 600 SMLS Tube

SPEC ASTM-B-163-19/B-167-18

FINISH Cold Drawn, Bright Annealed & Passiv **CONDITION** Bright Solution Annealed

DATE CERTIFIED 5/20/2020 **EACH TUBE ON THIS ORDER HAS BEEN SPECTOGRAPHICALLY CHECKED FOR 600**

TESTS PREFORMED

TENSILE STRENGTH	YIELD STRENGTH	ELONGATION	EDDY CURRENT	Pass
97366 PSI	56918 PSI	50%	FLARE	Pass
98199 PSI	57366 PSI	50%		

CHEMICAL ANALYSIS

HEAT NUMBER 306128 **TYPE** 600 SMLS

	C	Mn	P	S	Si	Ni	Cr	Mo	Ti	N	Fe	Ta	Nb(Cb)+Ta	Cu	Nb(Cb)	Al	Co		
L	.02	.24		.001	.20	73.49	16.26	.05			8.81			.09			.06		
P	.03	.23		.001	.22	73.30	16.49	.05			8.77			.09			.05		

"I HEREBY CERTIFY THAT THE HEAT NUMBERS, ANALYSIS AND TESTS DETAILED HEREON, ARE CORRECT AS CONTAINED IN THE RECORDS OF THIS CORPORATION"

Country of Manufacture: United States of America *Country of Melt:* Japan

Pieces: **Footage:**

TOTC TATEHO OZARK Technical Ceramics, Inc.

CSM-4

CRUSHABLE MGO INSULATORS
99.4% TATEHO OZARK GRADE CSM

CERTIFICATE OF COMPLIANCE

CUSTOMER NAME: **Idaho Labs**
CONTRACT NO: **26459**
CUSTOMER P/N: **R6H 232x037+**
OUR JOB NO: **24044** *(Please refer to this number for all correspondence)*

Tateho Ozark Technical Ceramics, Inc. certifies that this shipment complies with the specifications of the above referenced contract with the exceptions listed below. Also listed is any additional information for reference as required.

Tateho Ozark Technical Ceramics, Inc. certifies that this product complies with the requirements of Type 1 of the current ASTM specification. Reference Chemical analysis results follow:

Chemical Analysis: *Values in wt% unless specified. MgO value is by difference of emission spec impurities*

*Raw Material Analysis Only

MgO	99.78%
CaO	0.19%
SIO2	0.03%
AI2O3	0.03%
Fe2O3	0.04%
C	<50 ppm
S	<5 ppm
B+Cd	<30 ppm

BATCH NO:	MOR:
5966.100	4500 psi

All products manufactured and sold by Tateho Ozark Technical Ceramics Inc. are in conformance with ROHS standards. No material supplied by Tateho Ozark Technical Ceramics are environmentally hazardous or represent health hazards from routine exposure. No banned substances are used in the manufacture of our products.

REACH compliant as of 1/17/2019

By: Brandi Maggard
Brandi Maggard

Date: 2/18/2019

Please note condition of packaging materials and Shipper abuse when you observe breakage. For Quality/Quantity issues, please have your inspection information available for review and comparison. Please refer to the TOTC job number above and the Batch number in all correspondence. All Returns must be pre-approved by TOTC. Please contact this office for a Return Authorization.

Tateho Ozark Technical Ceramics Inc.
402 Ware Street Webb City, Missouri 64870 USA
(417) 673-2463 FAX: (417) 673-2464 sales@TatehoOzark.com

rev 1

End certs for heater

EAGLE STAINLESS

Tube and Fabrication, Inc

Franklin Industrial Park 10 Discovery Way Franklin, MA 02038

Telephone: (508) 528-8650 or (800) 528-8650 Fax: (508) 520-1954 or (800) 520-1954 Website: www.eagletube.com Email: info@eagletube.com

MATERIAL TEST REPORT
CERTIFICATE OF CONFORMANCE

SOLD TO:	Eagle Rock Specialties LLC	**DATE:**	3/1/2021
ADDRESS:	PO Box 51436	**PURCHASE ORDER:**	247960
		OUR ORDER#:	160459
	Idaho Falls ID 83405	**PART #**	N/A
		REVISION:	N/A

HEAT #:	707880
SOURCE:	51-64688-01-21
ITEM:	.250 OD X .016 WALL T316/316L SMLS
Spec:	ASTM A213-19A EAW/A269-15A
Temper:	BRIGHT ANNEALED
Quantity:	120 **Units:** FT

C:	.018	**Ti:**	-	**Yield (PSI):**	50,100/50,300
Si:	.33	**Cb:**	-	**Tensile (PSI):**	91,800/91,800
Mn:	1.16	**Ta:**	-	**Elong. (% IN 2"):**	50/51%
P:	.036	**Fe:**	balance	**Hardness (Rockwell):**	B 66/67
S:	.007	**Cu:**	-	**Flattening:**	PASS
Ni:	12.22	**Al:**	-	**Flaring:**	PASS
Cr:	16.80	**N:**	-	**Rev F/B:**	-
Mo:	2.06	**Co:**	-	**Flange:**	-
Misc Chem 1:	-			**Int C/E:**	-
Misc Chem 2:	-			**Eddy Current:**	PASS
Misc Chem 3:	-			**Hydrostatic:**	-
				Grain Size:	-

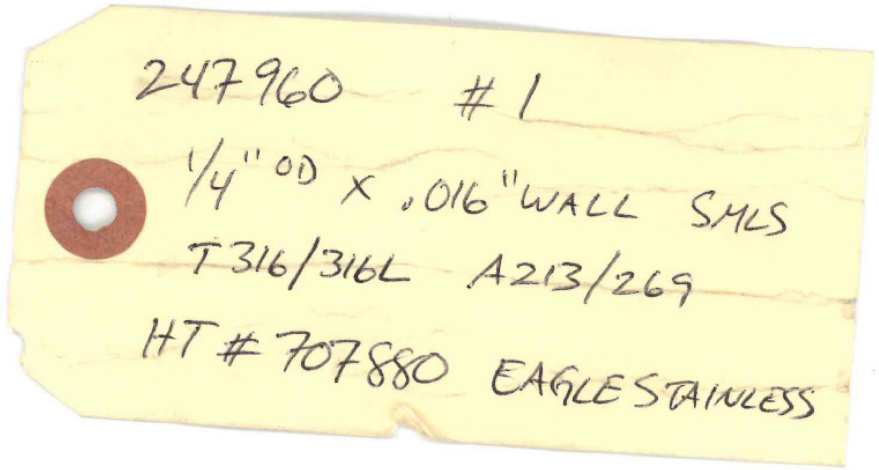
Note 1: ORIGIN & MELT: JAPAN
Note 2: MFG: USA DFARS COMPLIANT
Note 3: MERCURY FREE
Comments:

Conforms to all drawing and/or specifications requirements. To the best of our knowledge the material is mercury free and compliant with Directive 2011/65/EC and 2006/122/ECOF regarding the Restriction of Hazardous Substances (RoHS),and is conflict free per Dodd-Frank section 1502. By the definitions provided in Article 3 (3) of the REACH regulation, the material(s) are considered "articles," and do not contain substances "intended to release" under normal circumstances and as such, the registration requirements of Article 7(1) do not apply. Reports governing this material are on file.

Paulette Cartier
EAGLE STAINLESS TUBE AND FABRICATION INC.
Paulette Cartier
Quality Assurance Manager

AA
Int.

3/1/2021
Date



Cert for sensor guide tubes

INL RECEIVING REPORT

PO/RELEASE:	00246855 /	**STATUS:**	COMPLETE	**RECEIPT DATE:**	20210219
RECEIPT #:	00079984 : REC	**FACILITY:**	TRA	**CARRIER:**	SELF
PACKING SLIP #:	74505	**MR #:**	03227740	**FREIGHT BILL #:**	
VENDOR CODE:	0304612			**BOXES:**	0
VENDOR NAME:	EAGLE ROCK SPECIALTIES				
RECEIPT LINE ITEM:	1	**QUALITY LEVEL:**		**RECEIPT USER ID:**	MATHKA2
CHEMICAL ITEM:				**CONFORM TO PO:**	Y
CATALOG ID:	0000233976			**DOCK NOTES:**	
WHSE:	A			**SHELF LIFE IND:**	N
WHSE PUTAWAY:				**OSDD #:**	
HOT IND:	N			**FINAL SHIPMENT:**	Y
MANUFACTURE CODE:	EAGLE STAINL			**TRACE TYPE CODE:**	N
MODEL NUMBER:				**UNIT OF ISSUE:**	EA
PART NUMBER:	S0188016T316SAO			**QUANTITY:**	7
DESCRIPTION:	TUBING, 3/16" OD X .016" WALL, 20 FT LONG, 316 SS, SEAMLESS, ANNEALED TEMPER			**UNIT PRICE:**	55.760000

Receiving report for “prop tubes” above, material cert below.

EAGLE STAINLESS

Tube and Fabrication, Inc Franklin Industrial Park 10 Discovery Way Franklin, MA 02038

Telephone: (508) 528-8650 or (800) 528-8650 Fax: (508) 520-1954 or (800) 520-1954 Website: www.eagletube.com Email: info@eagletube.com

MATERIAL TEST REPORT
CERTIFICATE OF CONFORMANCE

SOLD TO:	Eagle Rock Specialties LLC	**DATE:**	2/10/2021
ADDRESS:	PO Box 51436	**PURCHASE ORDER:**	246855
		OUR ORDER#:	160094
	Idaho Falls ID 83405	**PART #**	N/A
		REVISION:	N/A

HEAT #:	YX1510-802
SOURCE:	47-64843-02-21
ITEM:	.188 OD X .016 WALL T316/316L SMLS
Spec:	ASTM A213-17/A269-15a EAW
Temper:	BRIGHT ANNEALED
Quantity:	140 **Units:** FT

C:	.021	**Ti:**	-	**Yield (PSI):**	47,000/48,000
Si:	.37	**Cb:**	-	**Tensile (PSI):**	89,000/90,000
Mn:	.59	**Ta:**	-	**Elong. (% IN 2"):**	61/62%
P:	.038	**Fe:**	balance	**Hardness (Rockwell):**	B 75/77
S:	.004	**Cu:**	-	**Flattening:**	PASS
Ni:	10.41	**Al:**	-	**Flaring:**	PASS
Cr:	17.00	**N:**	-	**Rev F/B:**	-
Mo:	2.04	**Co:**	-	**Flange:**	-
Misc Chem 1:	-			**Int C/E:**	PASS
Misc Chem 2:	-			**Eddy Current:**	PASS
Misc Chem 3:	-			**Hydrostatic:**	-
				Grain Size:	-

Note 1:	MELT & MFG: CHINA
Note 2:	MERCURY FREE
Note 3:	NO WELD REPAIR
Comments:	

Conforms to all drawing and/or specifications requirements. To the best of our knowledge the material is mercury free and compliant with Directive 2011/65/EC and 2006/122/ECOF regarding the Restriction of Hazardous Substances (RoHS),and is conflict free per Dodd-Frank section 1502. By the definitions provided in Article 3 (3) of the REACH regulation, the material(s) are considered "articles," and do not contain substances "intended to release" under normal circumstances and as such, the registration requirements of Article 7(1) do not apply. Reports governing this material are on file.

Paulette Cartier — Int. — 2/10/2021

EAGLE STAINLESS TUBE AND FABRICATION INC.
Paulette Cartier
Quality Assurance Manager

Date

INL RECEIVING REPORT

PO/RELEASE:	00252289 /	**STATUS:**	COMPLETE	**RECEIPT DATE:**	20210611
RECEIPT #:	00081537 : REC	**FACILITY:**	TRA	**CARRIER:**	SELF
PACKING SLIP #:	77843	**MR #:**	03291642	**FREIGHT BILL #:**	
VENDOR CODE:	0304612			**BOXES:**	0
VENDOR NAME:	EAGLE ROCK SPECIALTIES				
RECEIPT LINE ITEM:	1	**QUALITY LEVEL:**		**RECEIPT USER ID:**	USHEJW
CHEMICAL ITEM:				**CONFORM TO PO:**	Y
CATALOG ID:	0000237525			**DOCK NOTES:**	
WHSE:	A	4		**SHELF LIFE IND:**	N
WHSE PUTAWAY:				**OSDD #:**	
HOT IND:	N			**FINAL SHIPMENT:**	Y
MANUFACTURE CODE:	EAGLE STAINL			**TRACE TYPE CODE:**	N
MODEL NUMBER:	NA			**UNIT OF ISSUE:**	EA
PART NUMBER:	H0083008T316WHO			**QUANTITY:**	5
DESCRIPTION:	TUBING, STAINLESS STEEL, HYPODERMIC, GAUGE: 14SP, .083 OD X .008 WALL, 316 SS, 10 FT LENGTH,			**UNIT PRICE:**	42.860000

Receiving report for flux wire holder tubes above, material cert below.

EAGLE STAINLESS

Tube and Fabrication, Inc Franklin Industrial Park 10 Discovery Way Franklin, MA 02038

Telephone: (508) 528-8650 or (800) 528-8650 Fax: (508) 520-1954 or (800) 520-1954 Website: www.eagletube.com Email: info@eagletube.com

MATERIAL TEST REPORT
CERTIFICATE OF CONFORMANCE

SOLD TO:	Eagle Rock Specialties LLC	**DATE:**	6/2/2021
ADDRESS:	PO Box 51436	**PURCHASE ORDER:**	252289
		OUR ORDER#:	161840
	Idaho Falls ID 83405	**PART #**	N/A
		REVISION:	N/A

HEAT #:	SE54994
SOURCE:	57-50802-01-15
ITEM:	.0820/.0840 OD X .0650/.0690 T316/316L WLD/DRN
Spec:	ASTM A249 CHEMISTRY ONLY
Temper:	FULL HARD
Quantity:	60 **Units:** FT

C:	.02	**Ti:**	-	**Yield (PSI):**	152,582
Si:	.54	**Cb:**	-	**Tensile (PSI):**	170,000
Mn:	1.03	**Ta:**	-	**Elong. (% IN 2"):**	13
P:	.027	**Fe:**	balance	**Hardness (Rockwell):**	-
S:	.003	**Cu:**	-	**Flattening:**	-
Ni:	10.23	**Al:**	-	**Flaring:**	-
Cr:	16.42	**N:**	-	**Rev F/B:**	-
Mo:	2.03	**Co:**	-	**Flange:**	-
				Int C/E:	-
Misc Chem 1:	-			**Eddy Current:**	-
Misc Chem 2:	-			**Hydrostatic:**	-
Misc Chem 3:	-			**Grain Size:**	-

Note 1:	MELT SOURCE & MFG: SOUTH KOREA
Note 2:	MERCURY FREE

INL RECEIVING REPORT

Microtherm 1000X

PO/RELEASE:	00247852 /	**STATUS:**	COMPLETE	**RECEIPT DATE:**	20210511
RECEIPT #:	00081142 : REC	**FACILITY:**	TRA	**CARRIER:**	SELF
PACKING SLIP #:	77133	**MR #:**	03244392	**FREIGHT BILL #:**	
VENDOR CODE:	0304612			**BOXES:**	0
VENDOR NAME:	EAGLE ROCK SPECIALTIES				
RECEIPT LINE ITEM:	1	**QUALITY LEVEL:**		**RECEIPT USER ID:**	USHEJW
CHEMICAL ITEM:				**CONFORM TO PO:**	Y
CATALOG ID:	0000234581			**DOCK NOTES:**	
WHSE:	A			**SHELF LIFE IND:**	N
WHSE PUTAWAY:				**OSDD #:**	
HOT IND:	N			**FINAL SHIPMENT:**	Y
MANUFACTURE CODE:	PROMAT			**TRACE TYPE CODE:**	N
MODEL NUMBER:	1000X			**UNIT OF ISSUE:**	PC
PART NUMBER:	257392			**QUANTITY:**	5
DESCRIPTION:	INSULATION, 1220MM X 610MM X 6MM, HIGH TEMP, MICROTHERM (SEMI) QUILTED,			**UNIT PRICE:**	72.140000

3

Promat

Safety Data Sheet (SDS)

OSHA HazCom Standard 29 CFR 1910.1200(g), Rev. 2012 and GHS Rev 03.

Issued on 11-Oct-2017

Trade name: MICROTHERM® 1000X and related products

3 Composition/information on ingredients

10034-76-1	Calcium sulphate	0-25%
1343-98-2	Silica Fiber	0-12%

· ***Chemical characterization: Mixtures***

· ***Description:*** Mixture of the substances listed below with nonhazardous additions.

· ***Hazardous Components:***

112945-52-5	Amorphous Silica	50-90%
409-21-2	silicon carbide	10-50%
1344-28-1	aluminium oxide	0-25%
	⚠ STOT SE 3, H335	
1344-95-2	Silica fiber	0-12%
65997-17-3	Fibrous Glass	0-12%
	⚠ Skin Irrit. 2, H315; Eye Irrit. 2A, H319; STOT SE 3, H335	

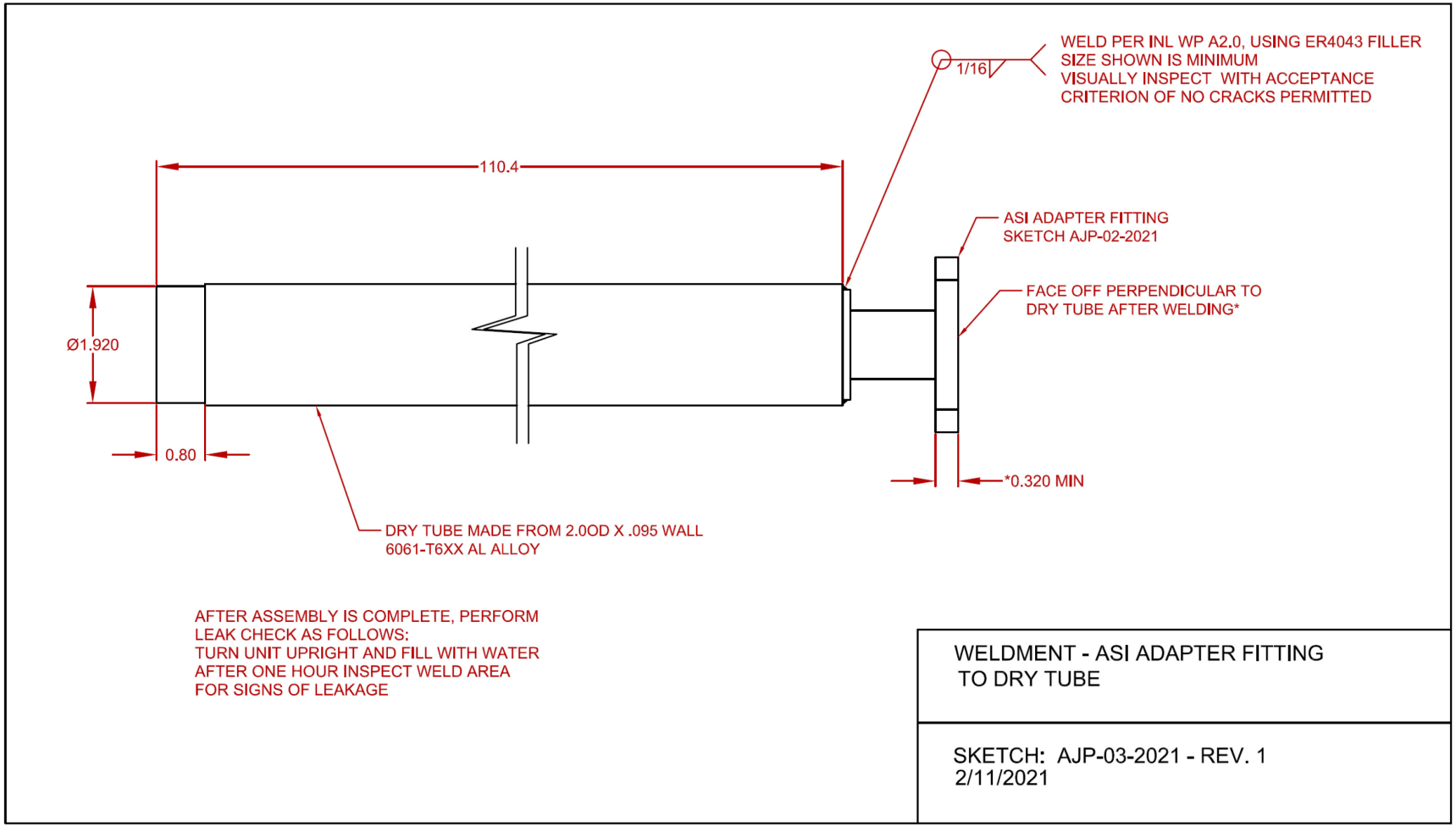
· ***Additional information:***

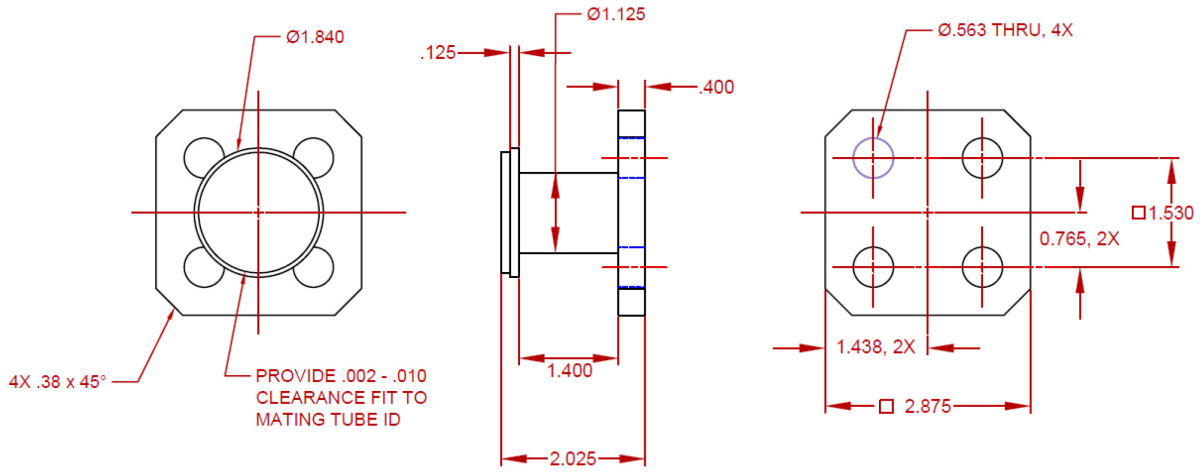
MICROTHERM 1000X insulation products contain no respirable fibers (see Section 11) and therefore fall outside the scope of European Community Directive Amendment 97/69/EC.

MICROTHERM 1000X insulation products may be supplied encapsulated in covering materials such as woven glass cloth, non-woven polyester cloth, PE foil, aluminum foil and mica sheet.

Appendix E

Dry Tube Assembly Sketches

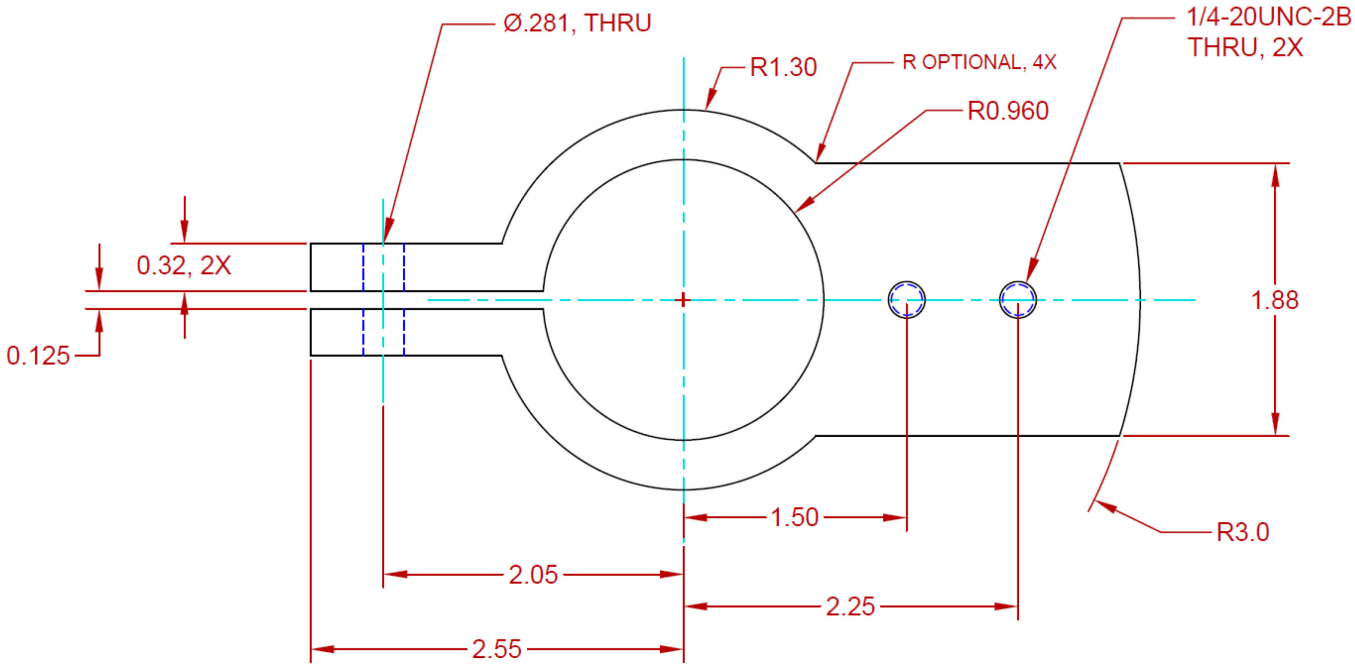




MATERIAL: ALUMINUM ALLOY PLATE OR BAR
ASTM B221 OR B209, 6061-T6XX

ADAPTER TO CONNECT ASI DRY TUBE TO
NRAD CLUSTER FITTING (734402)

SKETCH: AJP-02-2021 - REV. 1
2/13/2021



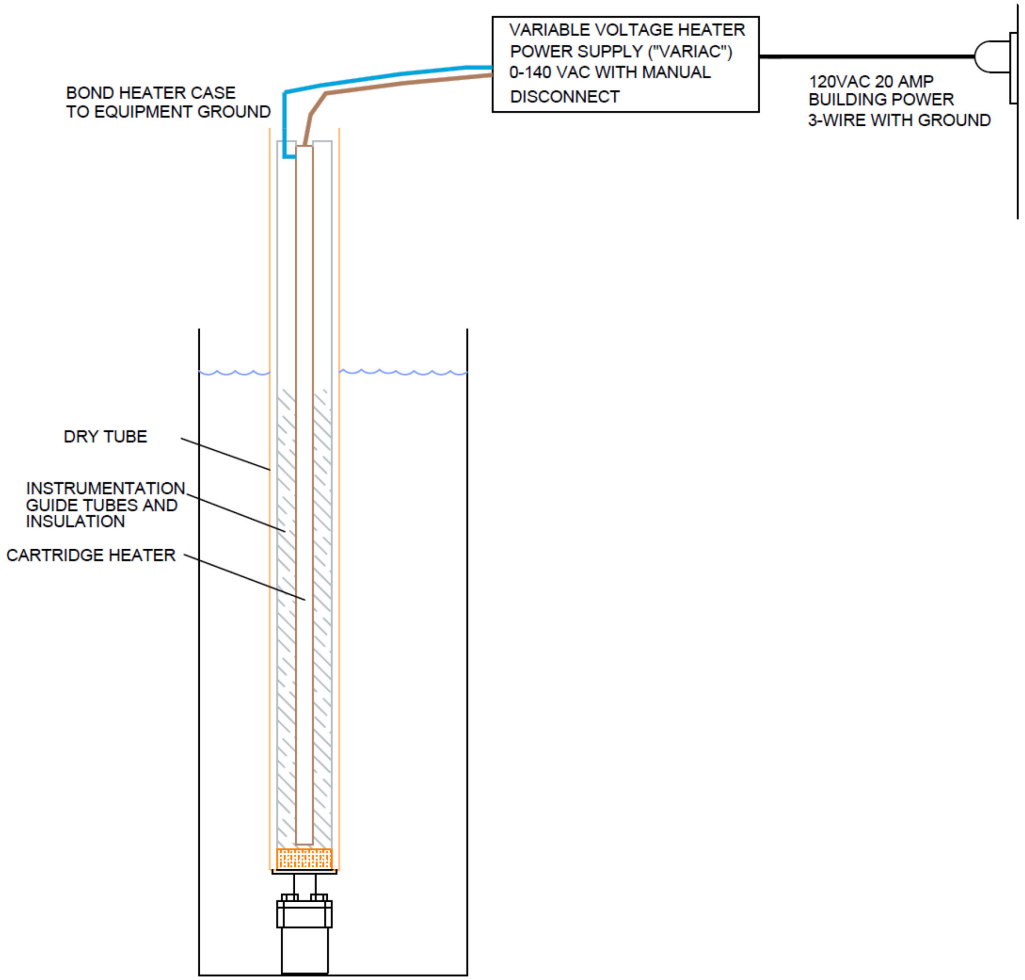
MATERIAL: 6061-T6 AL, 0.50 INCH THICK

NRAD DRY TUBE CABLE SUPPORT PLATE

SKETCH AJP-04-2021
4/30/2021

Appendix F

Heater Power Supply



VARIAC Power Supply

RE: TTAF Immersion heater

JJ

John J. Whipple
To Mark A. Redden
Cc Joe J. Palmer; Randel N. Paulsen

You replied to this message on 7/1/2021 4:41 PM.

Mark,

Thank you for looking at the heater and taking the time to document your observations.

Joe & Randal,

Based on Mark's evaluation the heater is approved for use. You can file this e-mail in your project file for documentation.

Thank You,

John

From: Mark A. Redden <Mark.Redden@inl.gov>
Sent: Thursday, July 1, 2021 2:55 PM
To: John J. Whipple <john.whipple@inl.gov>
Cc: Joe J. Palmer <joe.palmer@inl.gov>; Randel N. Paulsen <randel.paulsen@inl.gov>
Subject: TTAF Immersion heater

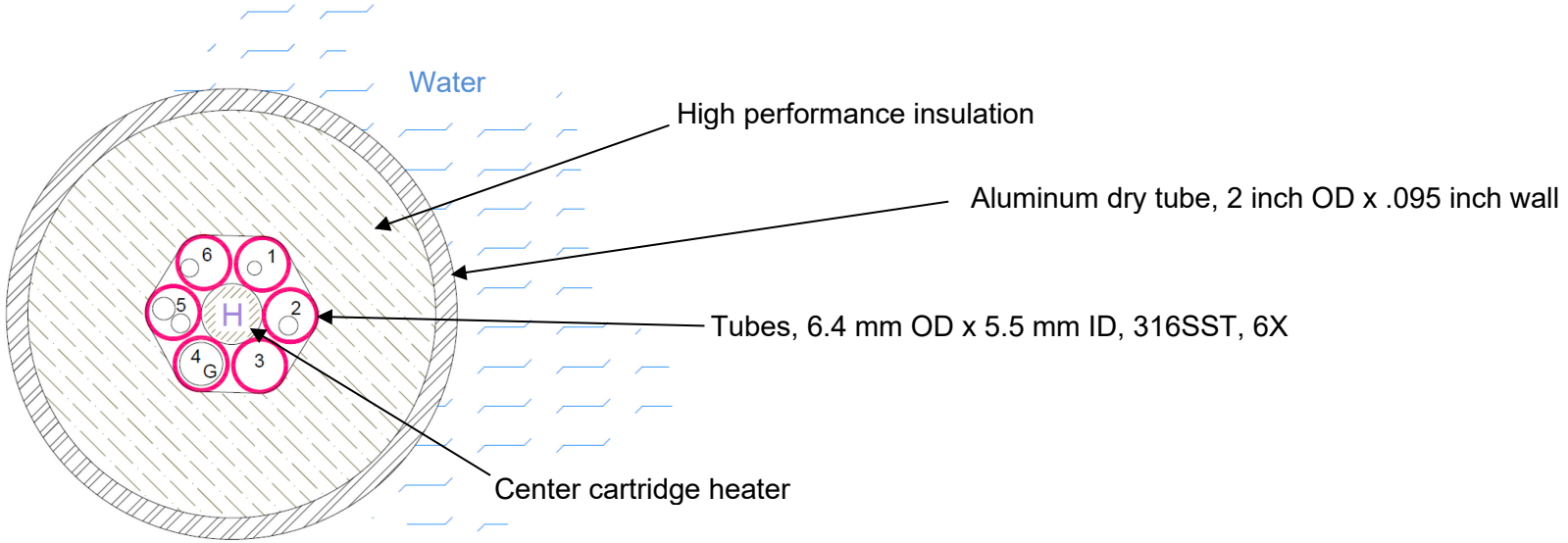
John, at the request of Randal, I walked over to TTAF and looked at the immersion heater. These are the observations I made:

1. Connection at the heater is a threaded bolt threaded into one of the tubes.
2. #12 AWG stranded THHN/THWN green copper conductor with a crimped stakon ring tongue lug connector.
3. #12 AWG ground with the heater line and neutral conductors connected to a 3c. #12 SEOOW cord with crimped connections and insulated with heat shrink tubing.
4. The other end of the cord has a 15 amp three prong (ground, line and neutral) 120v. male connector.
5. The circuit feeding the heater is GFCI protected.

Appendix G

NRAD Heated Test – Sensors and Cabling Summary (As-Run 8/25/2021)

Instr. No.	Sensor Description	Probe diameter (mm)	Probe length (mm)	Cable diameter (mm)	Mating connector(s) at end of soft cable	Bundle hole position
1	Thermocouple, Type K (3 points)	1.6	90	1.6	TC plugs (3 ea)	1
2	RML Dosimetry (NRAD-1)	1.0	~30	NA	NA	2
3	INL (Rh) SPND	2.5	95	2.5	2 ea BNC male	5
4	RML Dosimetry (NRAD-2)	1.0	~30	NA	NA	5
5	INL (Rh) SPND	2	95	2.0	2 ea BNC male	6



Notes:

1. Position 3 was open
2. Position 4 contained a grounding lug (no room for sensors)