COPALUM* Lite Sealed Terminals and Splices

1. INTRODUCTION

1.1 Purpose

Testing was performed on TE Connectivity (TE) COPALUM* Lite Sealed Terminals to determine their conformance to the requirements of Product Specification 108-32088, Revision A.

1.2 Scope

This report covers the electrical, mechanical, and environmental performance of the TE COPALUM Lite Sealed Terminal. Testing was completed at the TE Harrisburg Electrical Components Test Laboratory on April 16, 2014. The file numbers for the testing are EA20120299T and EA20120644T. This documentation is on file at and available from the TE Harrisburg Electrical Components Test Laboratory.

1.3 Conclusion

All part numbers listed in paragraph 1.5 conformed to the electrical, mechanical, and environmental performance of Product Specification 108-32088, Revision A.

1.4 Product Description

The COPALUM Lite Sealed Terminals and Splices were developed for the aerospace industry to meet the growing need for a reliable and stable electro-mechanical and light weight solution for terminating large gauge aluminum stranded conductor wires. The product is designed with the same dry crimp technology and utilizes the existing application tooling/crimp geometry as the legacy COPALUM copper terminal product, which has provided reliable service in the industry for over 30 years.

1.5 Test Specimens

The test specimens were representative of normal production lots, and the part numbers identified in Table 1 were used for testing.

Table 1 – Specimen Identification

Test Group	Quantity	Part Number	Description
1, 2, 3	8 Ea.	2102581-1	2/0 Dual Hole Lug Terminal on 2/0 600V PTFE Tape Insulated Aluminum Wire
	8 Ea.	2102581-1	2/0 Dual Hole Lug Terminal on 2/0 2000V ETFE Insulated Aluminum Wire
4	3	2102579-1	2 AWG Dual Hole Lug Terminal on 2 AWG 600V PTFE Tape Insulated Aluminum Wire
	3	2102579-1	2 AWG Dual Hole Lug Terminal on 2 AWG 2000V ETFE Insulated Aluminum Wire
	3	2102580-1	1/0 Dual Hole Lug Terminal on 1/0 600V PTFE Tape Insulated Aluminum Wire
	3	2102580-1	1/0 Dual Hole Lug Terminal on 1/0 2000V ETFE Insulated Aluminum Wire
	3	2102581-1	2/0 Dual Hole Lug Terminal on 2/0 600V PTFE Tape Insulated Aluminum Wire
	3	2102581-1	2/0 Dual Hole Lug Terminal on 2/0 2000V ETFE Insulated Aluminum Wire
	3	2102582-1	3/0 Dual Hole Lug Terminal on 3/0 600V PTFE Tape Insulated Aluminum Wire
	3	2102582-1	3/0 Dual Hole Lug Terminal on 3/0 2000V ETFE Insulated Aluminum Wire
	3	2102583-1	4/0 Dual Hole Lug Terminal on 4/0 600V PTFE Tape Insulated Aluminum Wire
	3	2102583-1	4/0 Dual Hole Lug Terminal on 4/0 2000V ETFE Insulated Aluminum Wire
5	6	2102579-1	2 AWG Dual Hole Lug Terminal on 2 AWG 600V PTFE Tape Insulated Aluminum Wire
	6	2102579-1	2 AWG Dual Hole Lug Terminal on 2 AWG 2000V ETFE Insulated Aluminum Wire
	6	2102580-1	1/0 Dual Hole Lug Terminal on 1/0 600V PTFE Tape Insulated Aluminum Wire
	6	2102580-1	1/0 Dual Hole Lug Terminal on 1/0 2000V ETFE Insulated Aluminum Wire
	6	2102581-1	2/0 Dual Hole Lug Terminal on 2/0 600V PTFE Tape Insulated Aluminum Wire
	6	2102581-1	2/0 Dual Hole Lug Terminal on 2/0 2000V ETFE Insulated Aluminum Wire
	6	2102582-1	3/0 Dual Hole Lug Terminal on 3/0 600V PTFE Tape Insulated Aluminum Wire
	6	2102582-1	3/0 Dual Hole Lug Terminal on 3/0 2000V ETFE Insulated Aluminum Wire
	6	2102583-1	4/0 Dual Hole Lug Terminal on 4/0 600V PTFE Tape Insulated Aluminum Wire
	6	2102583-1	4/0 Dual Hole Lug Terminal on 4/0 2000V ETFE Insulated Aluminum Wire

1.6 Qualification Test Sequence

The specimens identified in Table 1 were subjected to the tests outlined in Table 2.

Table 2 - Test Sequence

Test or Examination	Test Group				
	1	2	3	4	5
	Test Sequence (a)				
Initial Examination of Product	1	1	1	1	1
Crimp Millivolt Drop	2,4,6,9,11	2,4	2,5,7		
Salt Spray (500 hours)		3			
Humidity/Temperature Cycling	3				
Vibration	5				
Current Cycling, Rated Current (b)	7		3		
Current Cycling, 125% Rated Current (b)	8(c)		4(d)		
Energized Thermal Shock	10				
Hydrostatic Pressure Sealing				2	
Lightning Strike			6		
Crimp Tensile Strength	13	6	9		2
Final Examination of Product	12	5	8		

Notes: (a) Numbers indicate sequence which tests were performed.
(b) Terminal temperature rise and wire temperature recorded every 50th cycle.
(c) 100 cycles performed.
(d) 50 cycles performed.

1.7 Environmental Conditions

Unless otherwise stated, the following environmental conditions prevailed during testing:

Temperature: 15°C to 35°C
Relative Humidity 20% to 80%

2. SUMMARY OF TESTING

2.1 Initial Examination of Product

A Certificate of Conformance stating that all specimens submitted for testing were representative of normal production lots and met the requirements of the applicable product drawing was provided. Specimens were visually examined, and no evidence of physical damage detrimental to product performance was observed.

2.2 Crimp Millivolt Drop – Test Groups 1, 2, and 3

All calculated crimp millivolt drop measurements of the 2/0 dual hole lug terminals in Test Groups 1, 2, and 3 were less than 6.0 millivolts initially, and 6.6 millivolts following conditioning. Statistical summaries of the crimp millivolt drop results are contained in Tables 3 through 8.

Note: Negative crimp millivolt drop results indicate that the measured millivolt drop of the terminal crimp is less than the measured millivolt drop of an equivalent length of wire.

Table 3 – Test Group 1 Crimp Millivolt Drop Measurements (Millivolts)
2/0 Dual Hole Lug Terminals on 2/0 600V PTFE Tape Insulated Aluminum Wire

	Initial	Post Humidity/Temp	Post Vibration	Post Current Cycling	Post Thermal Shock
Minimum	-1.272	-1.289	-1.265	-1.105	-0.779
Maximum	-0.522	-0.584	-0.449	-0.526	-0.362
Average	-0.902	-0.885	-0.795	-0.801	-0.579
Std. Dev.	0.241	0.223	0.265	0.206	0.159
N	8	8	8	8	8

Table 4 – Test Group 1 Crimp Millivolt Drop Measurements (Millivolts)
2/0 Dual Hole Lug Terminals on 2/0 2000V ETFE Insulated Aluminum Wire

	Initial	Post Humidity/Temp	Post Vibration	Post Current Cycling	Post Thermal Shock
Minimum	-1.332	-1.382	-1.133	-1.125	-0.611
Maximum	-0.781	-0.662	-0.591	-0.580	-0.024
Average	-1.125	-0.991	-0.877	-0.869	-0.434
Std. Dev.	0.218	0.252	0.185	0.190	0.204
N	8	8	8	8	8

Table 5 – Test Group 2 Crimp Millivolt Drop Measurements (Millivolts)
2/0 Dual Hole Lug Terminals on 2/0 600V PTFE Tape Insulated Aluminum Wire

	Initial	Post Salt Spray
Minimum	-1.337	-1.289
Maximum	-0.781	-0.922
Average	-1.044	-1.085
Std. Dev.	0.220	0.146
N	8	8

Table 6 – Test Group 2 Crimp Millivolt Drop Measurements (Millivolts)
2/0 Dual Hole Lug Terminals on 2/0 2000V ETFE Insulated Aluminum Wire

	Initial	Post Salt Spray
Minimum	-1.581	-1.748
Maximum	-0.638	-0.615
Average	-1.001	-1.075
Std. Dev.	0.314	0.354
N	8	8

2.2 Crimp Millivolt Drop – Test Groups 1, 2, and 3 (cont.)

Table 7 – Test Group 3 Crimp Millivolt Drop Measurements (Millivolts)
2/0 Dual Hole Lug Terminals on 2/0 600V PTFE Tape Insulated Aluminum Wire

	Initial	Post Current Cycling	Post Lightning Strike
Minimum	-1.213	-1.204	-1.145
Maximum	-0.827	-0.798	-0.759
Average	-1.001	-0.982	-0.920
Std. Dev.	0.126	0.130	0.111
N	8	8	8

Table 8 – Test Group 3 Crimp Millivolt Drop Measurements (Millivolts)
2/0 Dual Hole Lug Terminals on 2/0 2000V ETFE Insulated Aluminum Wire

	Initial	Post Current Cycling	Post Lightning Strike
Minimum	-0.605	-0.621	-0.442
Maximum	0.188	0.218	0.531
Average	-0.268	-0.270	-0.026
Std. Dev.	0.240	0.264	0.288
N	8	8	8

2.3 Salt Spray (500 Hours) – Test Group 2

No evidence of physical damage was visible as a result of 500 hours of salt spray exposure.

2.4 Humidity/Temperature Cycling – Test Group 1

No evidence of physical damage was visible as a result of 400 cycles of humidity/temperature cycling exposure.

2.5 Vibration – Test Group 1

No evidence of physical damage was visible as a result of vibration testing.

2.6 Current Cycling, Rated Current – Test Groups 1 and 3

All temperature measurements of the 2/0 dual hole lug terminals in Test Groups 1 and 3 were less than the temperature of the wire. Statistical summaries of the temperature rise results are contained in Tables 9 through 12.

Note: Negative temperature rise results indicate that the measured temperature of the terminal is less than the measured temperature of the wire.

Table 9 – Test Group 1 Temperature Rise Above Wire Temperature (Degrees C)
2/0 Dual Hole Lug Terminals on 2/0 600V PTFE Tape Insulated Aluminum Wire

	Cycle 50	Cycle 100	Cycle 150	Cycle 200	Cycle 250	Cycle 300	Cycle 350	Cycle 400
Minimum	-8.7	-9.2	-9.9	-9.7	-8.6	-8.6	-9.2	-8.8
Maximum	-4.4	-4.5	-4.4	-4.3	-4.6	-4.8	-4.8	-5.0
Average	-6.5	-6.7	-6.9	-6.7	-6.5	-6.5	-6.7	-6.7
Std. Dev.	1.5	1.5	1.8	1.8	1.3	1.3	1.6	1.4
N	8	8	8	8	8	8	8	8

Table 10 – Test Group 1 Temperature Rise Above Wire Temperature (Degrees C)
2/0 Dual Hole Lug Terminals on 2/0 2000V ETFE Insulated Aluminum Wire

	Cycle 50	Cycle 100	Cycle 150	Cycle 200	Cycle 250	Cycle 300	Cycle 350	Cycle 400
Minimum	-9.6	-9.5	-9.4	-9.0	-10.0	-10.0	-9.7	-9.6
Maximum	-2.9	-3.1	-2.7	-2.9	-3.3	-3.4	-3.1	-3.3
Average	-6.8	-7.0	-6.9	-6.8	-7.0	-6.9	-6.9	-6.8
Std. Dev.	2.5	2.3	2.4	2.3	2.4	2.3	2.4	2.4
N	8	8	8	8	8	8	8	8

Table 11 – Test Group 3 Temperature Rise Above Wire Temperature (Degrees C)
2/0 Dual Hole Lug Terminals on 2/0 600V PTFE Tape Insulated Aluminum Wire

	Cycle 50	Cycle 100	Cycle 150	Cycle 200	Cycle 250	Cycle 300	Cycle 350	Cycle 400
Minimum	-7.8	-8.1	-8.4	-7.8	-7.7	-8.1	-9.2	-8.7
Maximum	-4.9	-5.3	-5.4	-5.0	-5.0	-5.3	-5.7	-5.4
Average	-6.3	-6.5	-6.8	-6.2	-6.2	-6.6	-7.2	-6.9
Std. Dev.	1.3	1.3	1.4	1.3	1.2	1.3	1.5	1.4
N	8	8	8	8	8	8	8	8

Table 12 – Test Group 3 Temperature Rise Above Wire Temperature (Degrees C)
2/0 Dual Hole Lug Terminals on 2/0 2000V ETFE Insulated Aluminum Wire

	Cycle 50	Cycle 100	Cycle 150	Cycle 200	Cycle 250	Cycle 300	Cycle 350	Cycle 400
Minimum	-10.3	-10.0	-11.2	-11.0	-11.5	-9.6	-10.7	-10.8
Maximum	-6.3	-6.1	-7.0	-6.7	-6.9	-5.8	-6.4	-6.9
Average	-8.1	-7.9	-8.8	-8.5	-8.8	-7.6	-8.2	-8.7
Std. Dev.	1.7	1.7	1.8	1.7	1.8	1.7	1.8	1.7
N	8	8	8	8	8	8	8	8

2.7 Current Cycling, 125% Rated Current – Test Groups 1 and 3

All temperature measurements of the 2/0 dual hole lug terminals in Test Groups 1 and 3 were less than the temperature of the wire. Statistical summaries of the temperature rise results are contained in Tables 13 through 16.

Note: Negative temperature rise results indicate that the measured temperature of the terminal is less than the measured temperature of the wire.

Table 13 – Test Group 1 Temperature Rise Above Wire Temperature (Degrees C)
2/0 Dual Hole Lug Terminals on 2/0 600V PTFE Tape Insulated Aluminum Wire

	Cycle 50	Cycle 100
Minimum	-13.3	-13.0
Maximum	-7.4	-7.2
Average	-10.4	-10.2
Std. Dev.	2.1	2.1
N	8	8

Table 14 – Test Group 1 Temperature Rise Above Wire Temperature (Degrees C)
2/0 Dual Hole Lug Terminals on 2/0 2000V ETFE Insulated Aluminum Wire

	Cycle 50	Cycle 100
Minimum	-16.8	-17.5
Maximum	-6.7	-6.2
Average	-12.2	-12.3
Std. Dev.	3.8	3.9
N	8	8

Table 15 – Test Group 3 Temperature Rise Above Wire Temperature (Degrees C)
2/0 Dual Hole Lug Terminals on 2/0 600V PTFE Tape Insulated Aluminum Wire

	Cycle 50
Minimum	-14.0
Maximum	-10.0
Average	-11.7
Std. Dev.	1.7
N	8

Table 16 – Test Group 3 Temperature Rise Above Wire Temperature (Degrees C)
2/0 Dual Hole Lug Terminals on 2/0 2000V ETFE Insulated Aluminum Wire

	Cycle 50
Minimum	-20.0
Maximum	-14.0
Average	-16.5
Std. Dev.	2.3
N	8

2.8 Energized Thermal Shock – Test Group 1

No evidence of physical damage was visible as a result of 300 cycles of energized thermal shock exposure.

2.9 Hydrostatic Pressure Seal – Test Group 4

No evidence of water leakage was visible at the exposed wire end.

2.10 Lightning Strike – Test Group 3

No evidence of physical damage was visible as a result of lightning strike testing.

2.11 Crimp Tensile Strength – Test Groups 1, 2, 3, and 5

All crimp tensile strength measurements in Test Groups 1, 2, 3, and 5 were greater than the specified minimum requirement. Statistical summaries of the crimp millivolt drop results are contained in Tables 17 and 18.

Table 17 – Crimp Tensile Strength (Pounds)
600V PTFE Tape Insulated Aluminum Wire

Test Group	1	2	3	5				
Wire Size	2/0	2/0	2/0	2 AWG	1/0	2/0	3/0	4/0
Spec Minimum	825	825	825	500	900	1100	1300	1450
Minimum	1061.56	1167.32	1087.68	688.82	1094.23	1287.22	1352.01	1779.71
Maximum	1211.96	1341.03	1314.18	715.37	1128.45	1324.45	1429.72	1873.45
Average	1154.17	1251.54	1213.85	702.80	1111.87	1305.75	1381.84	1837.01
Std. Dev.	52.09	66.69	68.41	13.33	17.13	18.62	41.88	50.23
N	8	8	8	3	3	3	3	3

Table 18 – Crimp Tensile Strength (Pounds)
2000V ETFE Tape Insulated Aluminum Wire

Test Group	1	2	3	5				
Wire Size	2/0	2/0	2/0	2 AWG	1/0	2/0	3/0	4/0
Spec Minimum	825	825	825	500	900	1100	1300	1450
Minimum	1001.92	1113.79	1097.12	726.78	958.35	1300.84	1592.16	2011.56
Maximum	1158.41	1186.38	1168.23	734.90	987.52	1357.46	1635.97	2173.95
Average	1110.37	1151.00	1128.35	730.30	976.02	1330.18	1618.14	2109.57
Std. Dev.	48.48	23.53	24.47	4.17	15.53	28.37	23.02	86.26
N	8	8	8	3	3	3	3	3

2.12 Final Examination of Product

Specimens were visually examined, and no evidence of physical damage detrimental to product performance was observed.

3. TEST METHODS

3.1 Initial Examination of Product

A Certificate of Conformance was issued stating that all specimens in this test package were produced, inspected, and accepted as conforming to product drawing requirements, and were manufactured using the same core manufacturing processes and technologies as production parts.

3.2 Crimp Millivolt Drop

The Crimp Millivolt Drop measurements were conducted in accordance with EIA364-6, Revision C. Each test cable and Equal Wire Length (EWL) assembly was prepared for millivolt drop measurements by first attaching thermocouples as follows:

1. One thermocouple was attached to each terminal under test on the side of the terminal at the tongue / wire barrel transition using thermally conductive epoxy.
2. One thermocouple was attached to the wire (both terminal cable assemblies and EWL assemblies) by opening a window in the wire insulation, inserting the thermocouple between the wire strands, and closing and securing the window in the wire insulation using tape.

Terminal cable assemblies of the same wire size and type were series wired by means of 0.250” thick tin plated aluminum buss bars secured to the access terminal ends of the assemblies. The following buss bar part numbers were used.

1. 2.3” Buss Bar (Between Terminal Block Circuits) – 39-1824100-1 (See Figure 1).
2. 4.0” Buss Bar (Between Terminal Blocks) – 39-1824101-1 (See Figure 2).

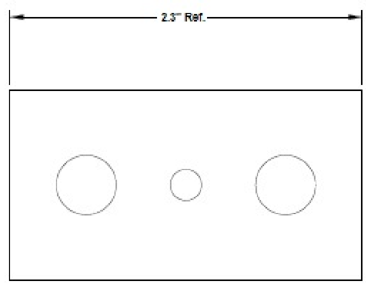

Figure 1: 2.3” Buss Bar p/n 39-1824100-1

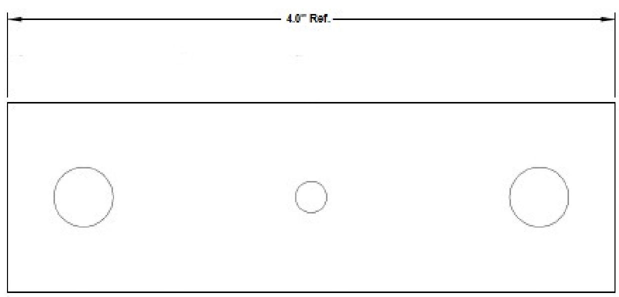

Figure 2: 4.0” Buss Bar p/n 39-1824101-1

3.2 Crimp Millivolt Drop (cont.)

Terminal assembly millivolt drop measurements were recorded in accordance with Figure 3 or 4, as applicable, by means of a hand probe measurement technique. The probe points for the terminal assembly millivolt drop measurements, mV_A and mV_B, were located at the transition between the component crimp and the terminal tongue, and at a point on the wire 8 inches from the probe point on the terminal. Probing of the wire was accomplished by creating a small opening in the wire insulation, and contacting the wire strands with a sharp tipped measurement probe. Care was taken when probing the wire to not damage the wire strands.

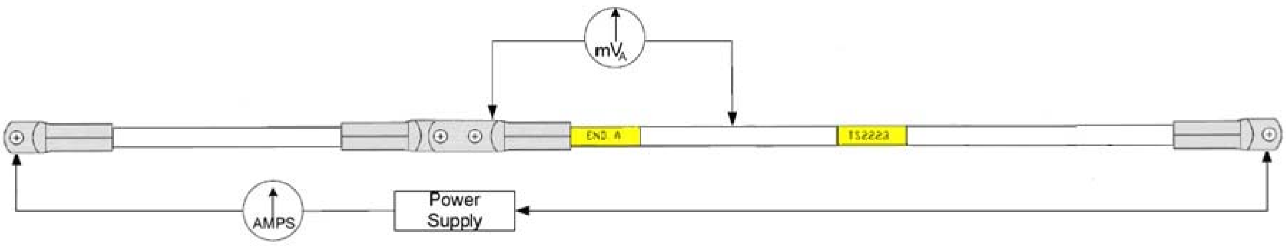

Figure 3: Terminal Assembly Millivolt Drop Test Configuration
Test Groups 1 and 2
Terminal Under Test on End A Only

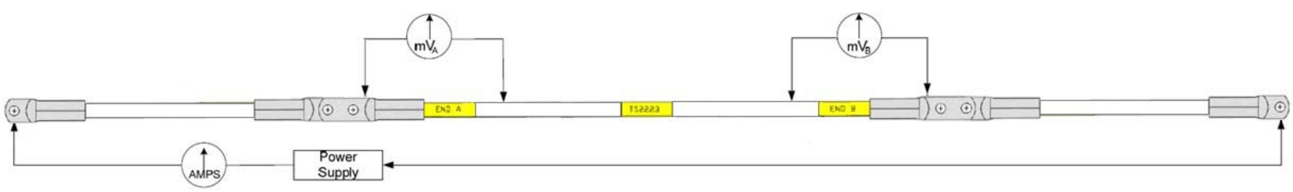

Figure 4: Terminal Assembly Millivolt Drop Test Configuration
Test Group 3
Terminals Under Test on Ends A and B

Series circuits having the same wire size, but different wire types, were combined by means of a 2/0 wire jumper between circuits. A photograph of the combined 2/0 600V PTFE Tape Insulated and 2/0 2000V ETFE Insulated Aluminum Wire series wired circuits is contained in Figure 5. The interface areas of the buss bars and the access terminals not under test were cleaned with a lint free cloth soaked in isopropyl alcohol prior to each series wiring assembly step. The thermocouples were wired into the millivolt drop data acquisition system, and the series circuit was energized at 235 Adc and allowed to reach thermal stability (temperature variation less than 2 degrees C per minute). Upon reaching thermal stability, the following measurements were recorded on each cable assembly:

1. The millivolt drop between the End “A” terminal and the wire (mV_A).
2. If applicable, the millivolt drop between the End “B” terminal and the wire (mV_B).
3. The terminal temperature, wire temperature, and ambient temperature.

3.2 Crimp Millivolt Drop (cont.)

Figure 5: Combined Series Circuit

EWL millivolt drop measurements were recorded in accordance with Figure 6 by means of a hand probe measurement technique. The probe points for the EWL millivolt drop measurements, mV_C, were located on the feed through splices, 8 inches apart across an uninterrupted length of wire.

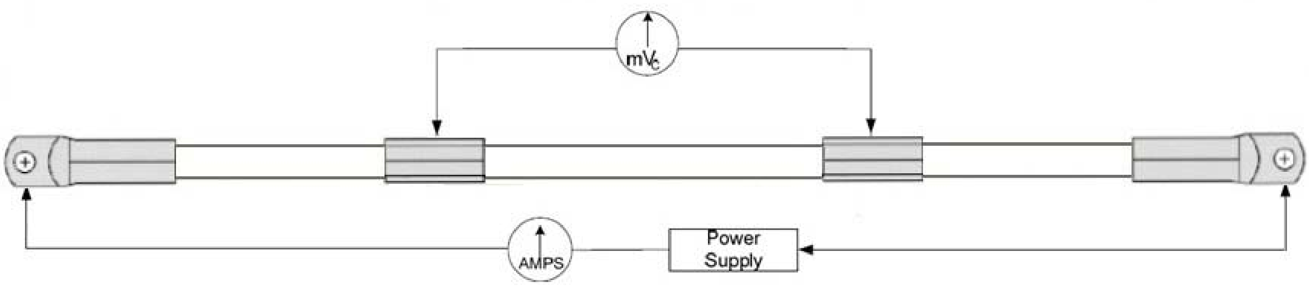

Figure 6: EWL Millivolt Drop Test Configuration

An EWL series circuit was created consisting of four 2/0 600V PTFE Tape Insulated Aluminum Wire EWL assemblies and four 2/0 2000V ETFE Insulated Aluminum Wire EWL assemblies, with all assemblies bolted end-to-end. The thermocouples were wired into the millivolt drop data acquisition system, and the series circuit was energized at 235 Adc and allowed to reach thermal stability (temperature variation less than 2 degrees C per minute). Upon reaching thermal stability, the following measurements were recorded on each cable assembly:

1. The millivolt drop between the feed through splices (mV_C).
2. The wire temperature and ambient temperature.

The average of the four EWL millivolt drop measurements (mV_C) for each wire type was calculated to establish a constant value for the EWL millivolt drop (mV_{EWL}). This constant (mV_{EWL}) was used for all crimp millivolt drop measurement calculations at all measurement intervals. The millivolt drop between the terminal lug and the wire end at the “A” end of the test cable was calculated as $mV_A – mV_{EWL}$. If applicable, the millivolt drop between the terminal lug and the wire end at the “B” end of the test cable was calculated as $mV_B – mV_{EWL}$.

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3.3 Salt Spray (500 Hours)

The Salt Spray exposure was conducted in accordance with EIA364-26, Revision B, Condition C (500 hours). The terminal assemblies were prepared for testing by first protecting the access terminals not under test with heat shrinkable sleeves. When loading the salt spray chamber, the terminal assemblies were placed horizontally on the chamber racks (see Figure 7).

Figure 7: Cable Assemblies Loaded Into Salt Spray Chamber

The procedures of ASTM B117 were used to prepare and maintain the 5% salt fog environment to which the terminal assemblies were exposed. Upon completion of the 500 hour exposure, the assemblies were rinsed in running tap water not warmer than 38°C for 5 minutes, and dried in an air circulating oven at 38°C for a maximum of 16 hours. The terminal assemblies were then visually examined for evidence of physical damage.

3.4 Humidity/Temperature Cycling

The Humidity/Temperature Cycling exposure was conducted in accordance with EIA364-31, Revision C, Method III, with exceptions as noted herein. The terminal assemblies were prepared for testing by first protecting the access terminals not under test with heat shrinkable sleeves. When loading the humidity/temperature cycling chamber, the terminal assemblies were placed horizontally on the chamber racks (see Figure 8).

Figure 8: Cable Assemblies Loaded Into Humidity/Temperature Cycling Chamber

3.4 Humidity/Temperature Cycling (cont.)

A total of 400 cycles of Humidity/Temperature Cycle testing was performed. Each cycle consisted of the following steps:

1. Dwell at 72°C ± 2°C at 95-100% RH for 15 minutes.
2. Ramp down to -54°C ± 2°C at an average temperature rate of change of approximately 5°C /min.
3. Dwell at -54°C ± 2°C for 15 minutes
4. Ramp back up to 72°C ± 2°C at an average temperature rate of change of approximately 5°C /min.

Dwell times began when the chamber conditions stabilized. A typical cycle is represented by the chamber profile in Figure 9.

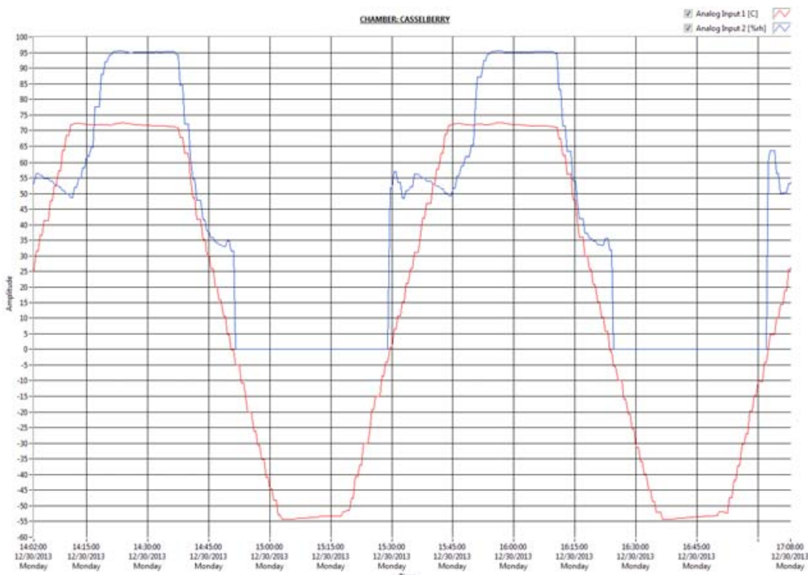

Figure 9: Typical Humidity/Temperature Cycle Chamber Profile

Upon completion of the 400 cycle exposure, the terminal assemblies were visually examined for evidence of physical damage.

3.5 Vibration

The Vibration test was conducted in accordance with EIA364-28, Revision F, Condition V, with exceptions as noted herein. The cable assemblies were secured to the vibration system using test fixtures designed to satisfy the requirements of Figures 10 and 11. The following vibration fixture part numbers were used:

1. Terminal Lug Cable Assembly – 39-1824136-1, 39-1824188-1, 39-1824189-1, 39-1824190-1, and wire support fixtures 39-1824409-1, 39-1824410-1, and 39-1824410-2.

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3.5 Vibration (cont.)

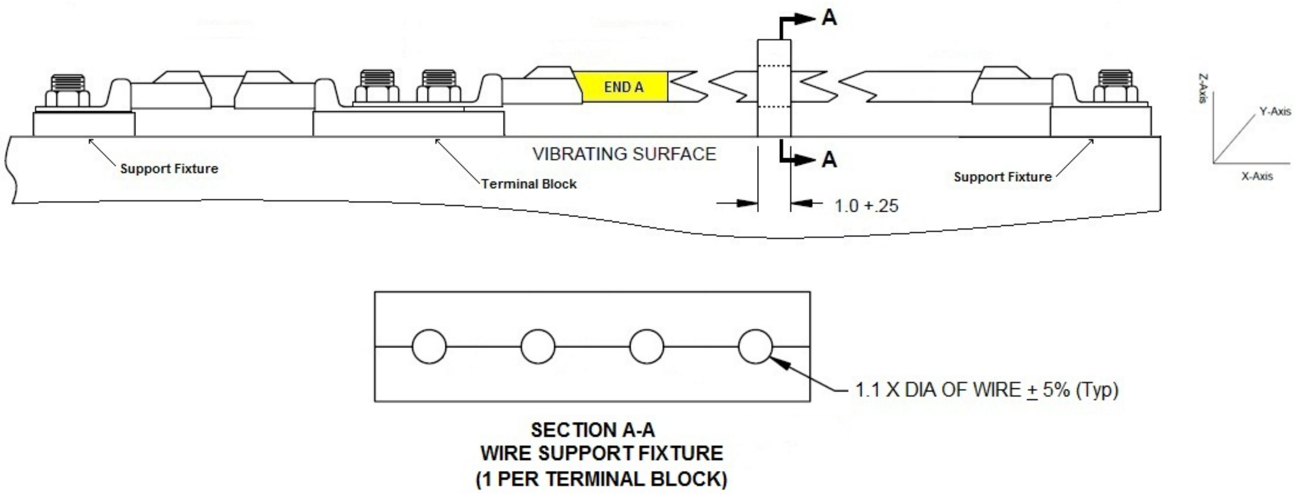

Figure 10: Vibration Test Setup, Straight Terminal Lug

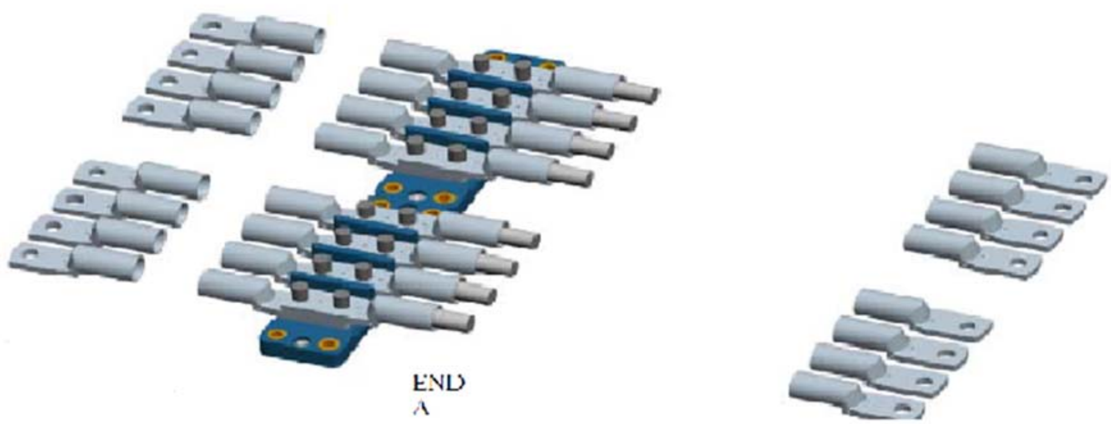

Figure 11: Vibration Test Setup, Straight Terminal Lug
4 Cable Assemblies x 2 Terminal Blocks

Control of the vibration system was established by averaging the response of two control accelerometers attached directly to the vibration fixture at an edge location and a center location, immediately adjacent to one of the two terminal blocks. Photographs of each setup in each axis are included in Figures 12 through 14.

3.5 Vibration (cont.)

Figure 12 – X-Axis Setup

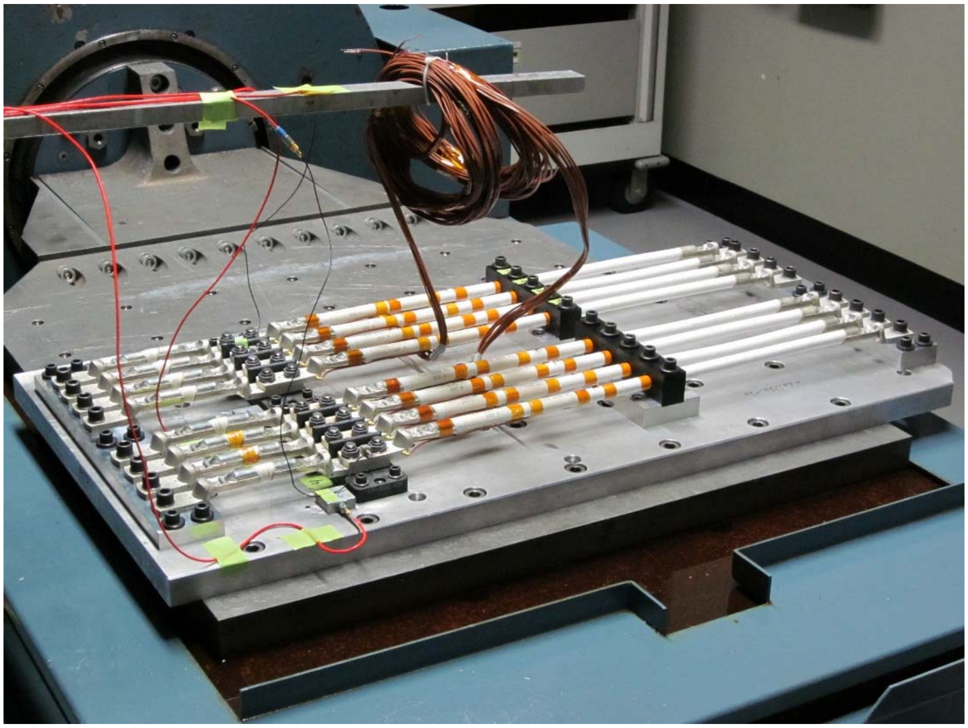

Figure 13 – Y-Axis Setup

3.5 Vibration (cont.)

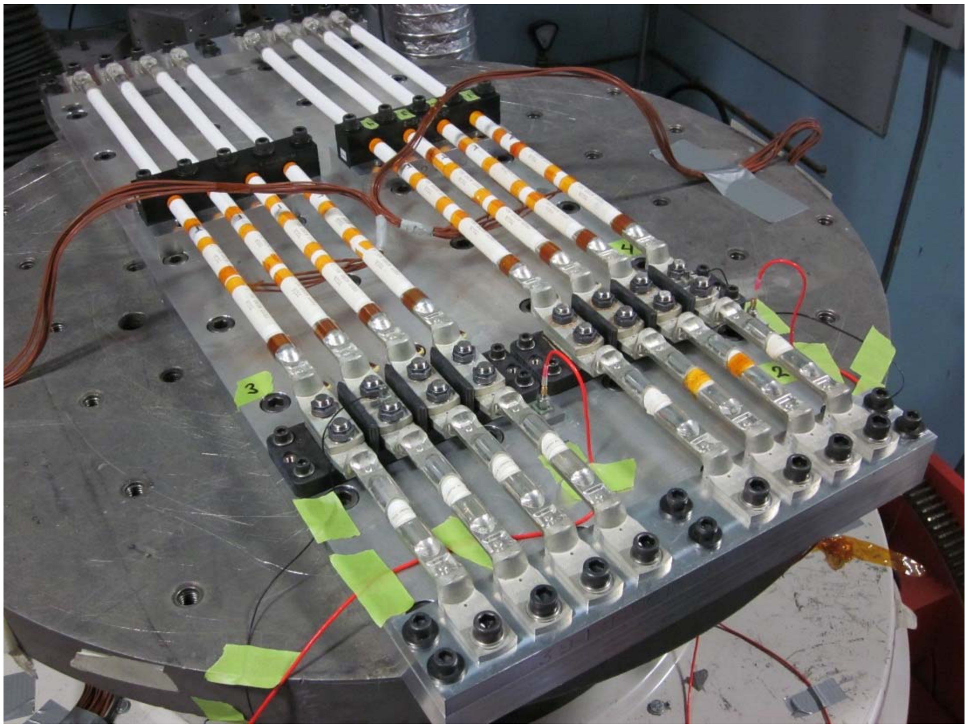

Figure 14 – Z-Axis Setup

Prior to, and at the completion of, each vibration run, a sinusoidal sweep survey was conducted as follows. Accelerometers were placed on a minimum of two randomly selected terminals under test. The cable assemblies were subjected to a 1G sinusoidal motion swept through a frequency range of 10 to 2000 Hz.

The cable assemblies were then subjected to the 19.24 Grms random vibration profile specified by the parameters of Table 19 for 5 hours in each of the three mutually perpendicular axes. The specimens were subjected to this motion in the X axis first, followed by the Y axis, then the Z axis.

Table 19 – Gaussian Random Vibration Test Level

Frequency (HERTZ)	Power Spectral Density (G^2/Hz)
10	.15
36	.15
60	.4
350	.4
2000	.08

Upon completion of the vibration test, the terminal assemblies were visually examined for evidence of physical damage.

3.6 Current Cycling, Rated Current

The Current Cycling test performed at rated current was conducted in accordance with EIA364-55, Revision A. The test was performed using the same test setup defined under Paragraph 3.2, Crimp Millivolt Drop, with the following exceptions. The series circuit was energized at the dc current level defined in Table 20 and maintained for a period of 60 minutes. The current was then removed for a period of 30 minutes. This process was repeated for a total of 400 cycles. Prior to the completion of the 60 minute “on” period of every 50th cycle, the terminal lug temperature, wire temperature, and ambient temperature was recorded.

Table 20 – Test Currents for Current Cycling

Wire Size (AWG)	Rated Current Test Current (AMPS)	125% Rated Current Test Current (AMPS)
2/0	235	294

3.7 Current Cycling, 125% Rated Current

The Current Cycling test performed at 125% rated current was conducted in accordance with EIA364-55, Revision A. The test was performed using the same test setup defined under Paragraph 3.2, Crimp Millivolt Drop, with the following exceptions. The series circuit was energized at the dc current level defined in Table 20 and maintained for a period of 60 minutes. The current was then removed for a period of 30 minutes. This process was repeated for a total of 100 cycles in Test Group 1, and 50 cycles in Test Group 3. Prior to the completion of the 60 minute “on” period of every 50th cycle, the terminal lug temperature, wire temperature, and ambient temperature was recorded.

3.8 Energized Thermal Shock

The Energized Thermal Shock test was conducted in accordance with EIA364-32, Revision F, Condition V, with exceptions as noted herein. Prior to the test, the specimens were prepared for testing by first shortening the length of the test cable assembly to 14 inches. This was required in order to fit the assemblies into the thermal shock chamber without bending of the wire. This was accomplished by cutting off the access terminal (not under test), and reterminating with a new access terminal crimped to the assembly at the location required to establish the 14 inch length (see Figure 15). The process of cutting and reterminating the access terminals was performed while the End “A” terminal under test and its associated mating terminal remained bolted to the terminal block.

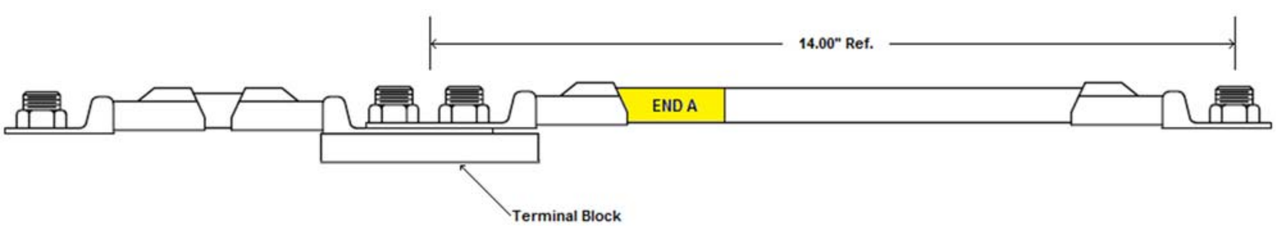

Figure 15: Thermal Shock Assembly Configuration w/ Reduced Overall Length

The assemblies were then series wired and prepared for temperature measurements using the same test setup defined under Paragraph 3.2, Crimp Millivolt Drop. The ends of the overall assemblies were secured to insulating base fixtures to ensure that the series circuits did not short to the thermal shock chamber. The following insulating base fixture part numbers were used.

1. Insulating Base, Test Assembly Side – 39-1824102-1.
2. Insulating Base, Jumper Side – 39-1824103-1.

3.8 Energized Thermal Shock (cont.)

Thermal Shock testing was performed using a dual capacity thermal shock chamber. One dual terminal block assembly (reference the configuration of Figure 11) of a single wire type was loaded into each zone of the thermal shock chamber (see Figures 16 and 17). Power lead-in wires and thermocouple leads attached to the series wired assembly exited the thermal shock chamber via the top side port, and were connected to a current cycling data acquisition system. Both hot zones of the thermal shock chamber were set to the specified temperature of 175°C, and the cold zone was set to the specified temperature of -65°C. The series wired assembly in the hot zone was energized at 235 Adc, and the temperature of that zone was adjusted as necessary to achieve, on average, a terminal temperature of 175°C. The chamber was then manually transferred, and the second series wired assembly, now in the second hot zone, was energized at 235 Adc, and the temperature of that zone was adjusted as necessary to achieve, on average, a terminal temperature of 175°C. These established hot zone temperature set points were used throughout the thermal shock test. The chamber was now considered ready to begin testing.

Figure 16: Dual Zone Chamber Loading

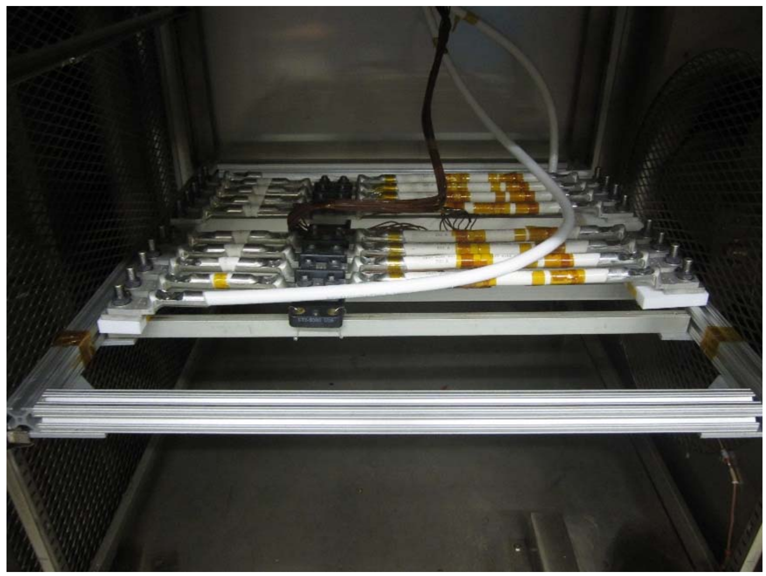

Figure 17: Energized Thermal Shock Series Wired Assembly

When the test was ready to begin, and the thermal shock temperature zones had stabilized at the predetermined set points, the thermal shock chamber was manually transferred, and both the thermal shock chamber program and the current cycling program were simultaneously initiated. The thermal shock chamber dwell times were 61 minutes at each temperature extreme. The current cycling program was set to alternately energize the two series wired assemblies (each assembly energized only while in its respective hot zone) for a period of 60 minutes, with one minute segments of no current flow to either series wired assembly between the alternating power segments. This ensured that the temperature data collected at the end of the 60 minute energized hot zone exposure did not occur while the thermal shock chamber was in transition. A total of 301 cycles were performed. (The additional cycle ensured that the series wired assembly that began the test in the cold zone was subjected to 300 complete cycles that began with the energized hot zone segment.) An external trigger signal initiated by the thermal shock chamber resynchronized the chamber and the current cycling system at the start of each cycle. The component temperatures, wire temperatures, and ambient temperatures were recorded at the end of the current on portion of every 50th cycle. Upon completion of the exposure, the terminal assemblies were visually examined for evidence of physical damage.

3.9 Hydrostatic Pressure Seal

The Hydrostatic Pressure Seal test was conducted in accordance with EIA364-39, Revision B, with exceptions as noted herein. The test cable assemblies were set up in accordance with Figure 18 using the purpose built Hydrostatic Seal test system illustrated in Figure 19.

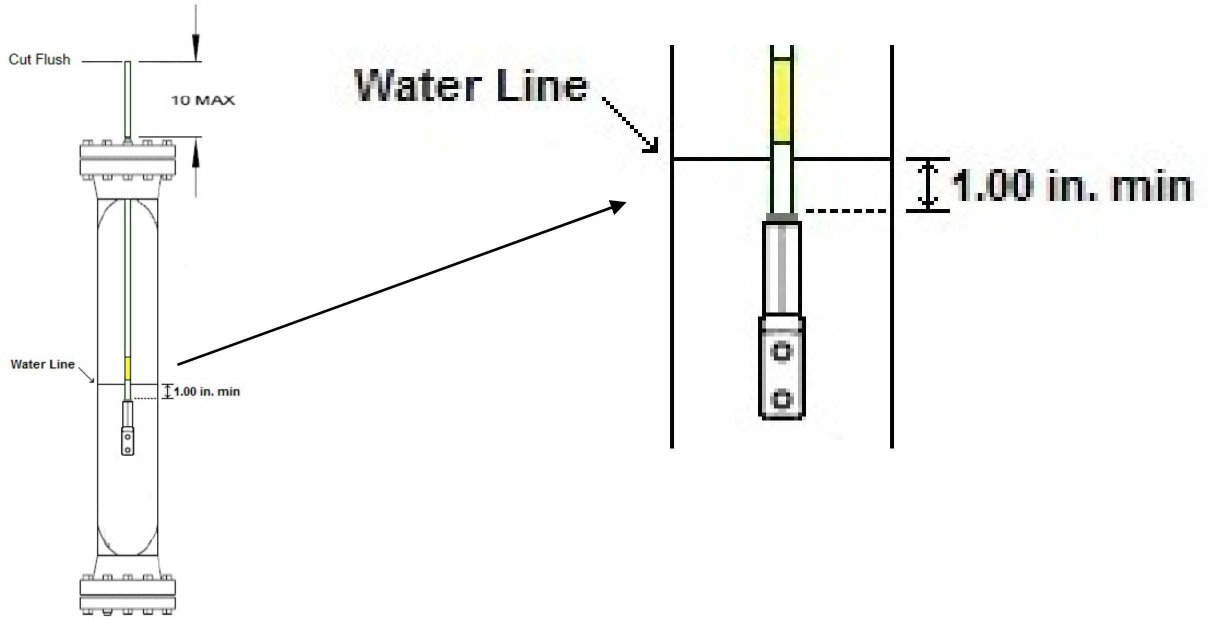

Figure 18: Installation of the Test Cable in the Pressure Vessel Water Level at 1.00 Inch Minimum Above Inner Moisture Seal Sleeve

Figure 19: Hydrostatic Pressure Test system

3.9 Hydrostatic Pressure Seal (cont.)

A minimum 6 inch length of appropriately sized heat shrink tubing with integrated adhesive was slid over the free end of the wire. The free end of the wire was then inserted into an appropriately sized fitting secured into one of the six test ports in the pressure vessel lid, and temporarily held in place, ensuring that no more than 10 inches of wire extended beyond the point where the wire will be sealed to the fitting. The heat shrink tubing was positioned over the seam between the fitting and the wire, and using a heat gun, was applied to the wire and fitting (see Figure 20). This process was repeated until all six test ports in the pressure vessel lid were filled.

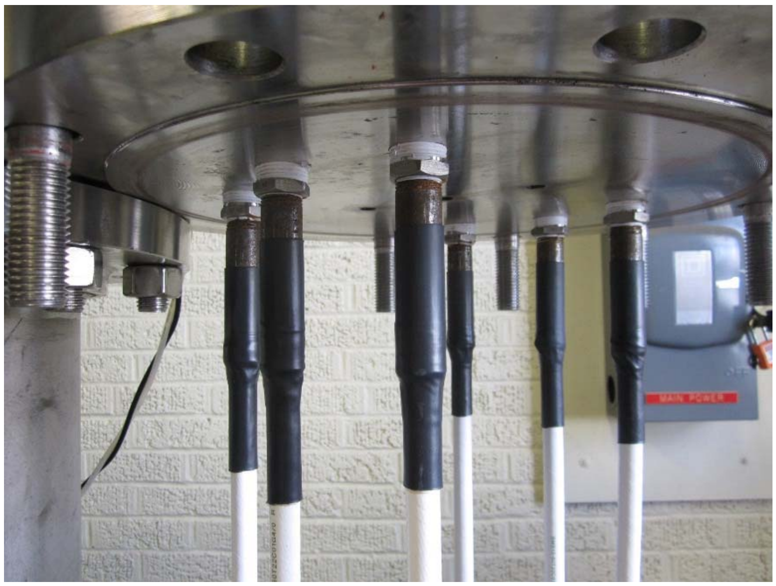

Figure 20 – Test Specimen Sealing in Hydrostatic Pressure Vessel Lid

The pressure vessel was filled with water to a level that completely covered the terminals under test and 1 inch minimum of wire above the inner moisture seal sleeve. The lid was lowered into place and secured to the pressure vessel (see Figures 21 and 22).

Figure 21 – Cable Assemblies Secured to Pressure Vessel Lid

Figure 22 – Cable Assemblies Being Lowered Into Pressure Vessel

3.9 Hydrostatic Pressure Seal (cont.)

The input pressure to the vessel was pre-set to 80 psi. The PLC controller was pre-programmed to apply and release pressure from the vessel at 5 minute intervals. The system controller was reset to 25 cycles to initiate the test, and the pressure and time intervals were verified via the system chart recorder.

Fifteen minutes following the completion of the last cycle, the free ends of the cable assemblies extending out of the vessel lid were inspected for evidence of fluid leakage.

3.10 Lightning Strike

Lightning Strike testing was conducted in accordance with SAE ARP5412, Revision A. Testing of the assemblies was accomplished in a light-tight chamber as described in industry standard SAE ARP5416 (See Figure 23).

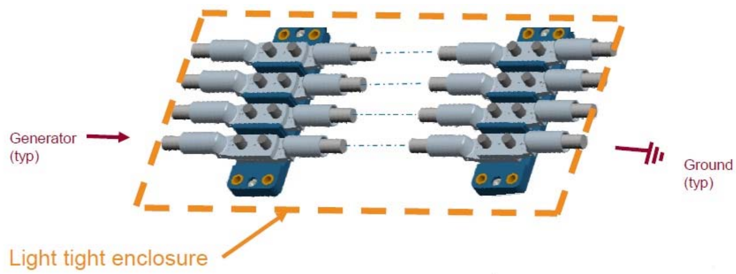

Figure 23: Lightning Test Setup

Each test cable was subjected to a minimum of twelve (12) lightning strikes:

Six consecutive strikes at a peak current of 60 KA using waveform 5A wave shape per ARP5412, Revision A, plus a 275 Coulomb follow-on charge transfer, were followed by six consecutive strikes at a peak current of 50KA using waveform component D lightning current per ARP5412, Revision A. The current was injected through the lead in cable assembly attached to the terminal at the “A” End of the test cable. Upon completion of the lightning strike test, the terminal assemblies were visually examined for evidence of physical damage.

3.11 Crimp Tensile Strength

The Crimp Tensile Strength test was conducted in accordance with EIA364-8, Revision B. The test cable assemblies were individually mounted in the tensile test system by securing the terminal lug of one end of the assembly into clamping jaws fixed to the base of the system, and securing the terminal lug of the opposing end of the assembly into clamping jaws fixed to the movable crosshead of the system (see Figure 24). The assembly was pulled along the conductor longitudinal axis at a rate of approximately 1 inch per minute until a failure occurred. The force at which the failure occurred, and the failure mode, was recorded.

3.11 Tensile Strength (cont.)

Figure 24: Straight Terminal Tensile Setup

3.12 Final Examination of Product

Specimens were visually examined for evidence of physical damage detrimental to product performance.