OSFP-RHS Cage Assembly with Interleaved Plate Thermal Bridge

1. INTRODUCTION

1.1 Purpose

Testing was performed on the TE Connectivity 1x4 OSFP-RHS (Riding Heat Sink) Cage Assembly w/ Thermal Bridge to determine its conformance to the requirements of Product Specification 108-160953 Rev A.

1.2 Scope

This report covers the mechanical, environmental, and thermal performance of the 1x4 OSFP-RHS Cage Assembly w/ Thermal Bridge. Testing was performed at the Harrisburg Electrical Components Test Laboratory (HECTL) between December 6, 2022 and March 31, 2023. Detailed test data is on file and maintained at HECTL under EA20220203T.

1.3 Conclusion

The 1x4 OSFP-RHS Cage Assembly w/ Thermal Bridge specimens listed in paragraph 1.4 conformed to the requirements of Product Specification 108-160953 Rev A.

1.4 Product Description

The TE OSFP-RHS Cage Assemblies come in multiple port configurations and are utilized to interconnect OSFP fiber optic or copper transceiver modules to host printed circuit boards. TE's innovative thermal bridge technology provides up to 2x better thermal resistance over traditional thermal technologies such as gap pads or thermal pads. This solution was developed as customers seek ways to dissipate more heat associated with increasing system power requirements, specifically in fixed cooling applications with restricted airflow, liquid cooling or cold plates.

1.5 Test Specimens

The test specimens were representative of normal production lots, and specimens identified with the following part numbers were used for testing.

Table 1 – Test Specimens

Test Set	Quantity	Part Number	Description
1	5	2374033-2 Rev 2	1x4 OSFP-RHS Cage Assembly w/ Thermal Bridge
	5	60-1958495-1 Rev A	Host Test Board
	20	N/A	OSFP Dummy Module w/ Two 10 Ohm Resistors
2	5	2374033-2 Rev 2	1x4 OSFP-RHS Cage Assembly w/ Thermal Bridge
	5	60-1958495-1 Rev A	Host Test Board
	20	N/A	OSFP Dummy Module w/ Two 10 Ohm Resistors
3	5	2374033-2 Rev 2	1x4 OSFP-RHS Cage Assembly w/ Thermal Bridge
	5	60-1958495-1 Rev A	Host Test Board
	20	N/A	OSFP Dummy Module w/ Two 10 Ohm Resistors
	10	N/ A	OSFP Durability Module
4	5	2374033-2 Rev 2	1x4 OSFP-RHS Cage Assembly w/ Thermal Bridge
	5	60-1958495-1 Rev A	Host Test Board
	20	N/A	OSFP Dummy Module w/ Two 10 Ohm Resistors

Table 1 – Test Specimens, *Continued*

Test Set	Quantity	Part Number	Description
5	5	2374033-2 Rev 2	1x4 OSFP-RHS Cage Assembly w/ Thermal Bridge
	5	60-1958495-1 Rev A	Host Test Board
	20	N/A	OSFP Dummy Module w/ Two 10 Ohm Resistors
	10	N/A	OSFP Durability Module
6	5	2374033-2 Rev 2	1x4 OSFP-RHS Cage Assembly w/ Thermal Bridge
	5	60-1958495-1 Rev A	Host Test Board
	20	N/A	OSFP Dummy Module w/ Two 10 Ohm Resistors
7	2	2374033-2 Rev 2	1x4 OSFP-RHS Cage Assembly w/ Thermal Bridge
	8	2324869-2 Rev A	OSFP SMT Connector Assembly
	2	60-1958495-1 Rev A	Host Test Board
	8	N/A	OSFP Module w/ Paddlecard

1.6 Qualification Test Sequence

Specimens identified in Table 1 were subjected to the test sequences listed in Table 2.

Table 2 – Qualification Test Sequence

Test or Examination	Test Group Per 108-160953						
	1	2	3	4	5	6	7
	Test Set						
	1	2	3	4	5	6	7
	Test Sequence (a)						
Initial Examination of Product	1	1	1	1	1	1	1
Random Vibration	3						
Mechanical Shock	4						
Durability Preconditioning			3,9				
Durability					4		3
Transceiver Mating Force (w/ Connector)							2
Transceiver Unmating Force (w/ Connector)							4
Transceiver Mating Force (w/o Connector)					2		
Transceiver Unmating Force (w/o Connector)					6		
Bridge Thermal Resistance	2,5	2,4,6	2,4,6,8,10	2,4	3,5	2,4	
Thermal Shock		3					
Humidity / Temperature Cycling		5					
Temperature Life				3			
Mixed Flowing Gas			5(b),7(b)				
Dust						3	
Final Examination of Product	6	7	11	5	7	5	5

NOTE
(a) The numbers indicate sequence in which tests were performed.
(b) MFG exposure interval of 10 days.

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 – All Test Groups

All specimens submitted for testing were representative of normal production lots. A Certificate of Conformance was issued by Product Assurance. Specimens were visually examined and no evidence of physical damage detrimental to product performance was observed.

2.2 Random Vibration – Test Group 1

No evidence of physical damage detrimental to product performance was visible due to random vibration.

2.3 Mechanical Shock – Test Group 1

No evidence of physical damage detrimental to product performance was visible due to mechanical shock.

2.4 Durability Preconditioning – Test Group 3

No evidence of physical damage detrimental to product performance was visible as a result of 50 cycles of durability preconditioning.

2.5 Durability – Test Groups 5 & 7

No evidence of physical damage detrimental to product performance was visible as a result of 100 cycles of durability.

2.6 Transceiver Mating Force (w/ Connector) – Test Group 7

All specimens met the maximum transceiver mating force requirement of 75 N. Refer to Table 3 for mating force data in Newtons.

Table 3 – Mating Force (w/ Connector) in Newtons

	Mating Force
	Newtons
Minimum	50.36
Maximum	70.65
Average	63.40

2.7 Transceiver Unmating Force (w/ Connector) – Test Group 7

All specimens met the maximum transceiver unmating force requirement of 45 N. Refer to Table 4 for unmating force data in Newtons.

Table 4 – Unmating Force (w/ Connector) in Newtons

	Unmating Force
	Newtons
Minimum	29.67
Maximum	37.10
Average	32.81

2.8 Transceiver Mating Force (w/o Connector) – Test Group 5

All specimens met the maximum transceiver mating force without connector requirement of 65 N. Refer to Table 5 for mating force data in Newtons.

Table 5 – Mating Force (w/o Connector) Data in Newtons

	Mating Force
	Newtons
Minimum	31.51
Maximum	62.96
Average	42.27

2.9 Transceiver Unmating Force (w/o Connector) – Test Group 5

All specimens met the maximum transceiver mating force without connector requirement of 35 N. Refer to Table 6 for unmating force data in Newtons.

Table 6 – Unmating Force (w/o Connector) Data in Newtons

	Unmating Force
	Newtons
Minimum	16.17
Maximum	29.66
Average	22.72

2.10 Bridge Thermal Resistance – Test Groups 1, 2, 3, 4, 5, 6

All specimens met the maximum bridge thermal resistance requirement of 0.8 °C/W. Refer to Tables 7 through 12 for bridge thermal resistance data.

Table 7 – Bridge Thermal Resistance Data in °C/W, Test Set 1

	Thermal Resistance, °C/W	
	Initial	After Vibe & Shock
Minimum	0.38	0.42
Maximum	0.74	0.76
Average	0.58	0.58

Table 8 – Bridge Thermal Resistance Data in °C/W, Test Set 2

	Thermal Resistance, °C/W		
	Initial	After Thermal Shock	After Temp/Humidity
Minimum	0.41	0.41	0.40
Maximum	0.67	0.68	0.70
Average	0.55	0.55	0.56

Table 9 – Bridge Thermal Resistance Data in °C/W, Test Set 3

	Thermal Resistance, °C/W				
	Initial	After Durability	After 10 Days MFG	After 20 Days MFG	After Durability
Minimum	0.44	0.41	0.41	0.40	0.40
Maximum	0.67	0.63	0.67	0.67	0.65
Average	0.56	0.52	0.53	0.54	0.53

Table 10 – Bridge Thermal Resistance Data in °C/W, Test Set 4

	Thermal Resistance, °C/W	
	Initial	After Temperature Life
Minimum	0.46	0.46
Maximum	0.73	0.73
Average	0.59	0.59

Table 11 – Bridge Thermal Resistance Data in °C/W, Test Set 5

	Thermal Resistance, °C/W	
	Initial	After Durability
Minimum	0.41	0.41
Maximum	0.74	0.70
Average	0.56	0.54

Table 12 – Bridge Thermal Resistance Data in °C/W, Test Set 6

	Thermal Resistance, °C/W	
	Initial	After Dust
Minimum	0.43	0.44
Maximum	0.77	0.76
Average	0.58	0.59

2.11 Thermal Shock – Test Group 2

No evidence of physical damage detrimental to product performance was visible as a result of exposure to thermal shock.

2.12 Humidity / Temperature Cycling – Test Group 2

No evidence of physical damage detrimental to product performance was visible as a result of exposure to humidity-temperature cycling.

2.13 Temperature Life – Test Group 4

No evidence of physical damage detrimental to product performance was visible as a result of exposure to temperature life.

2.14 Mixed Flowing Gas – Test Group 3

No evidence of physical damage detrimental to product performance was visible as a result of exposure to the pollutants of mixed flowing gas. The average copper corrosion rate was 13.8 $\mu g/cm^2/day$.

2.15 Dust – Test Group 6

No evidence of physical damage detrimental to product performance was visible due to exposure to benign dust.

2.16 Final Examination of Product – All Test Groups

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 Certification of Conformance was issued stating that all specimens in this test package have been produced, inspected, and accepted as conforming to product drawing requirements, and made using the same core manufacturing processes and technologies as production parts. Where specified, specimens were visually examined with an unaided eye. Testing was performed in accordance with EIA-364-18B.

3.2 Random Vibration

The test specimens were subjected to a random vibration test in accordance with specification EIA-364-28F, test condition "VII", test condition letter "D". The parameters of this test condition are specified by a random vibration spectrum with excitation frequency bounds of 20 and 500 Hertz (Hz). The spectrum remains flat at 0.02 G^2/Hz from 20 Hz to the upper bound frequency of 500 Hz. The root-mean square amplitude of the excitation was 3.10 GRMS. The test specimens were subjected to this test for 15 minutes in each of the three mutually perpendicular axes, for a total test time of 45 minutes per test specimen. The specimens were not monitored for discontinuities. Refer to Figure 1 for images of the typical test setup.

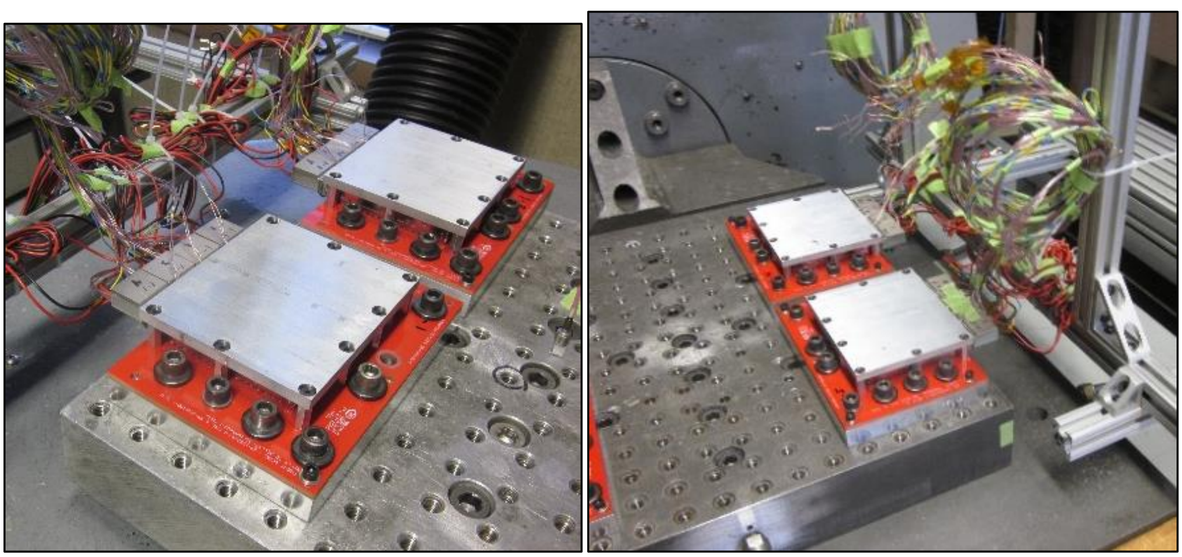

Figure 1 – Typical Random Vibration Test Setup

3.3 Mechanical Shock

The test specimens were subjected to a mechanical shock test in accordance with specification EIA-364-27D, test condition “H”. The parameters of this test condition are a half-sine waveform with an acceleration amplitude of 30 gravity units (g's peak) and a duration of 11 milliseconds. Three shocks in each direction were applied along the three mutually perpendicular axes of the test specimens, for a total of eighteen shocks. The specimens were not monitored for discontinuity. Refer to Figure 2 for images of the typical test setup.

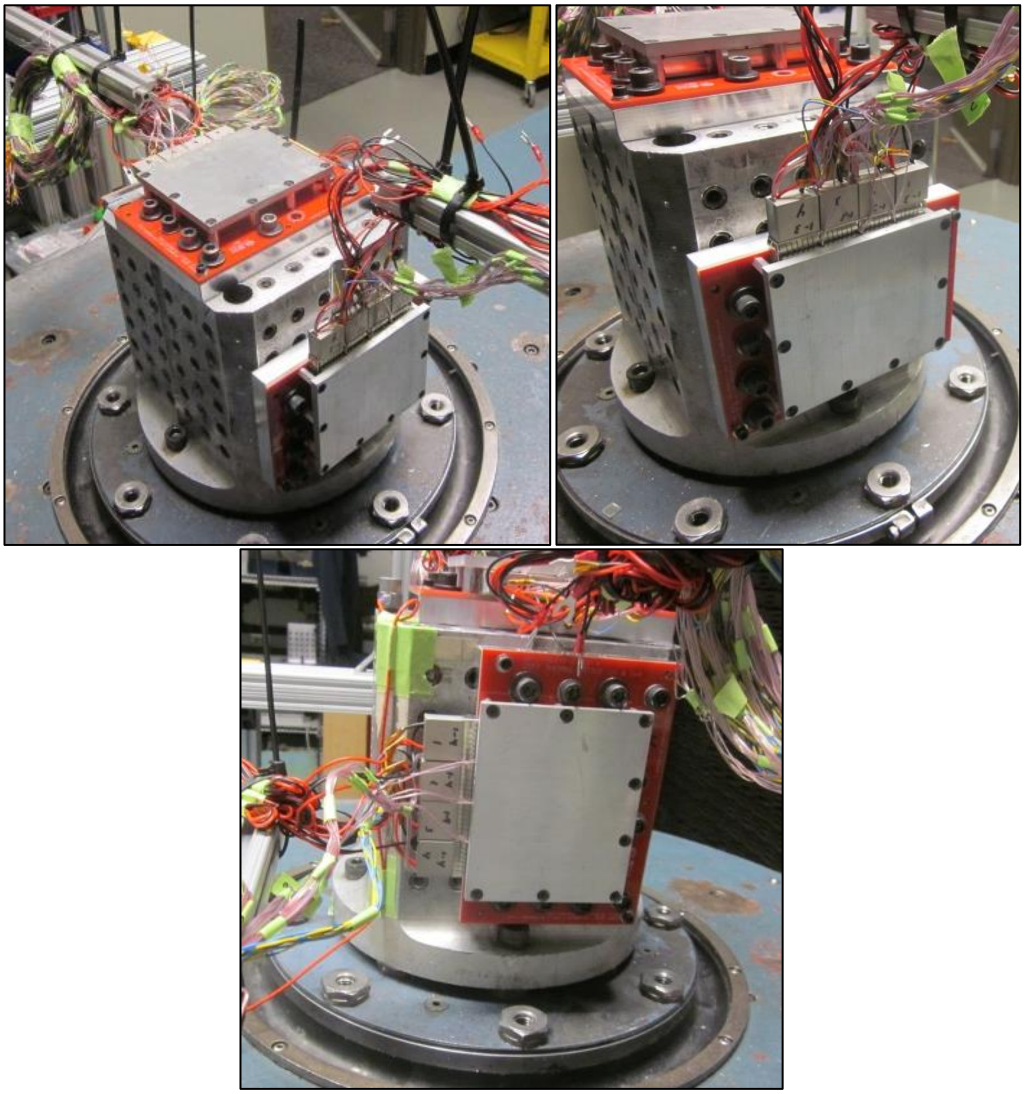

Figure 2 – Typical Mechanical Shock Test Setup

3.4 Durability Preconditioning

Specimens were mated and unmated by hand 50 times at a rate no more than 300 cycles per hour. Testing was performed in accordance with EIA-364-09D.

3.5 Durability

Specimens were mated and unmated by hand 100 times at a rate no more than 300 cycles per hour. Testing was performed in accordance with EIA-364-09D.

3.6 Transceiver Mating Force (w/ Connector)

The PCB of the thermal bridge specimen was clamped in a vise on a mill table at the base of the tensile/compression machine. A probe was attached to the moveable crosshead of the tensile/compression machine. The transceiver was started into the cage to the point immediately before engaging with the thermal bridge. The probe was aligned with the rear of the transceiver and force was applied in a downward direction at a rate of 25.4 mm/min until the specimen was fully mated. Refer to Figure 3 for an image of the typical test setup. Testing was performed in accordance with EIA-364-13E.

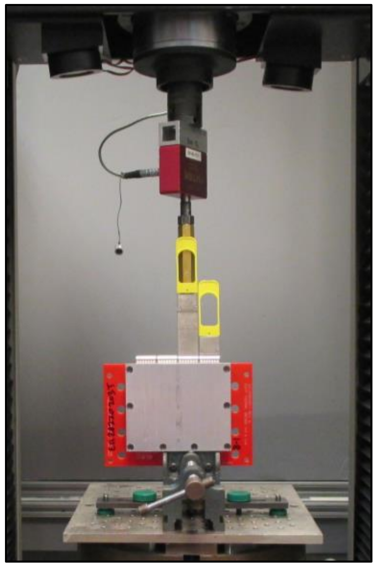

Figure 3 – Typical Mating Force Test Setup

3.7 Transceiver Unmating Force (w/ Connector)

The PCB of the thermal bridge specimen was clamped in a vise on a free floating x/y and rotational table at the base of the tensile/compression machine. The transceiver pull tab was clamped in a parallel vise attached to the moveable crosshead of the tensile/compression machine. Force was applied in an upward direction at a rate of 25.4 mm/min until the transceiver was removed from the cage. Refer to Figure 4 for images of the typical test setup. Testing was performed in accordance with EIA-364-13E.

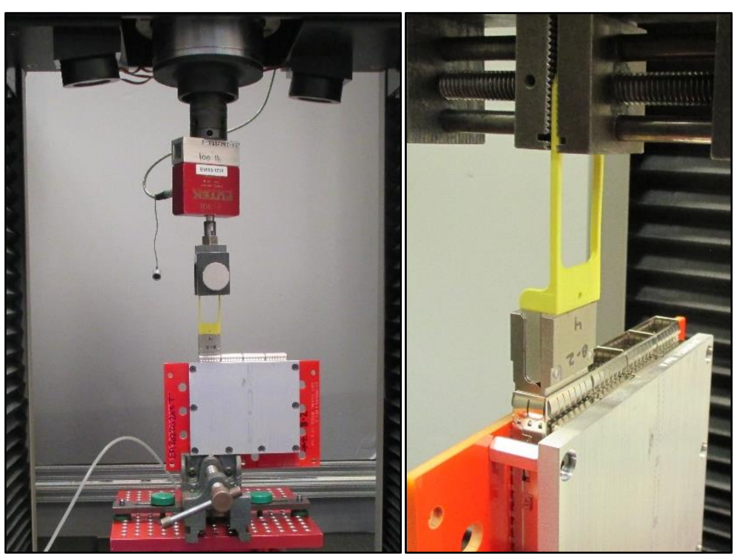

Figure 4 – Typical Unmating Force Test Setup

3.8 Transceiver Mating Force w/o Connector

Refer to Paragraph 3.6 for test procedure information. The same test setup/procedure was used with the exception that no OSFP connector was soldered to the test PCB.

3.9 Transceiver Unmating Force w/o Connector

Refer to Paragraph 3.7 for test procedure information. The same test setup/procedure was used with the exception that no OSFP connector was soldered to the test PCB.

3.10 Bridge Thermal Resistance

Thermal transceivers were supplied by the requester. Each transceiver had four 30 AWG “Type T” thermocouples epoxied to the upper shell of the transceiver as shown in top photo of Figure 9. The four measured temperatures were averaged to obtain one value used for calculations. Two 10 Ω resistors were mounted inside each transceiver. The resistors were wired in series for a total of 20 Ω per transceiver. A current value of 0.89 Amps DC was applied to each transceiver to create approximately 16 Watts per port. Refer to Figure 5 for images of a typical transceiver with covers removed to show the internals.

Six 30 AWG “Type T” thermocouples were epoxied to the underside of the cold plate mounted to the top of the cage. For port 1, thermocouples 1 and 2 were averaged for calculations. For port 2, thermocouples 1, 2, 3, and 4 were averaged. For port 3, thermocouples 3, 4, 5, and 6 were averaged. For port 4, thermocouples 5 and 6 were averaged. The temperatures were recorded when all thermocouples reached stability, defined as three consecutive readings taken over a minimum duration of 10 minutes differing not more than ±1°C.
Refer to Figure 6 for images of a typical cold plate setup.

Test enclosures/fixtures were designed to ensure the proper thermal bridge compression at nominal working height during testing. Specimens were tested “Dry” with no thermal grease applied. Fans were designed into the setup to provide air flow over the heatsink. Refer to Figure 7 for an image of the overall setup and a detailed illustration of the test enclosure.

Thermal resistance is measured by passing a known amount of heat across the thermal bridge and measuring the temperature difference across it. The temperature of the cold plate was subtracted from the transceiver temperature to obtain the temperature differential. This temperature differential was divided by 16 (known wattage) to obtain the thermal resistance in °C/W.

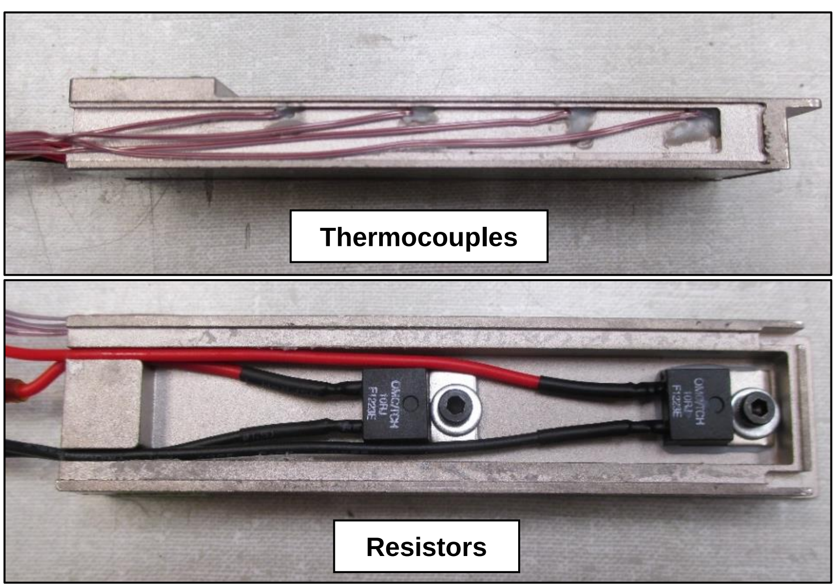

Figure 5 – Typical Thermal Transceiver

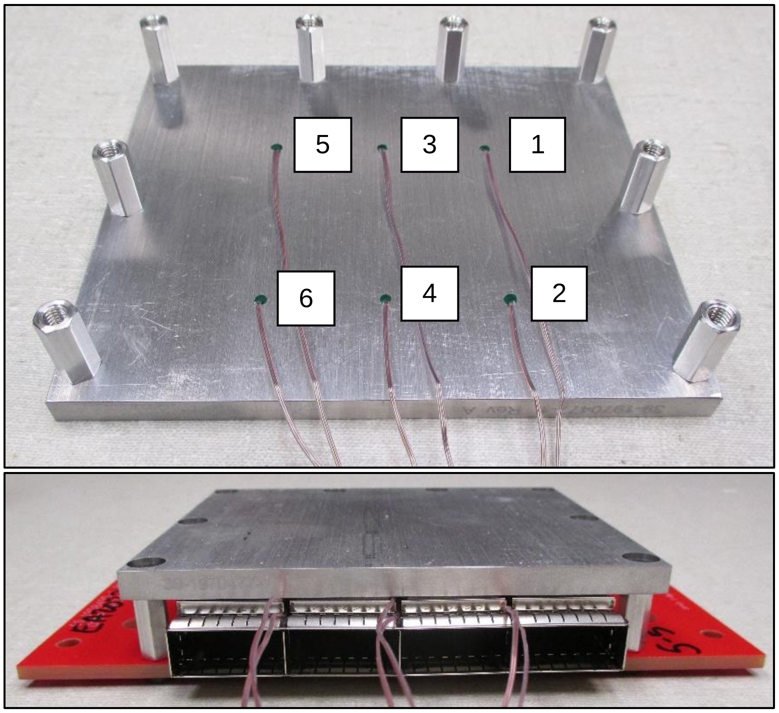

Figure 6 – Typical Cold Plate Setup

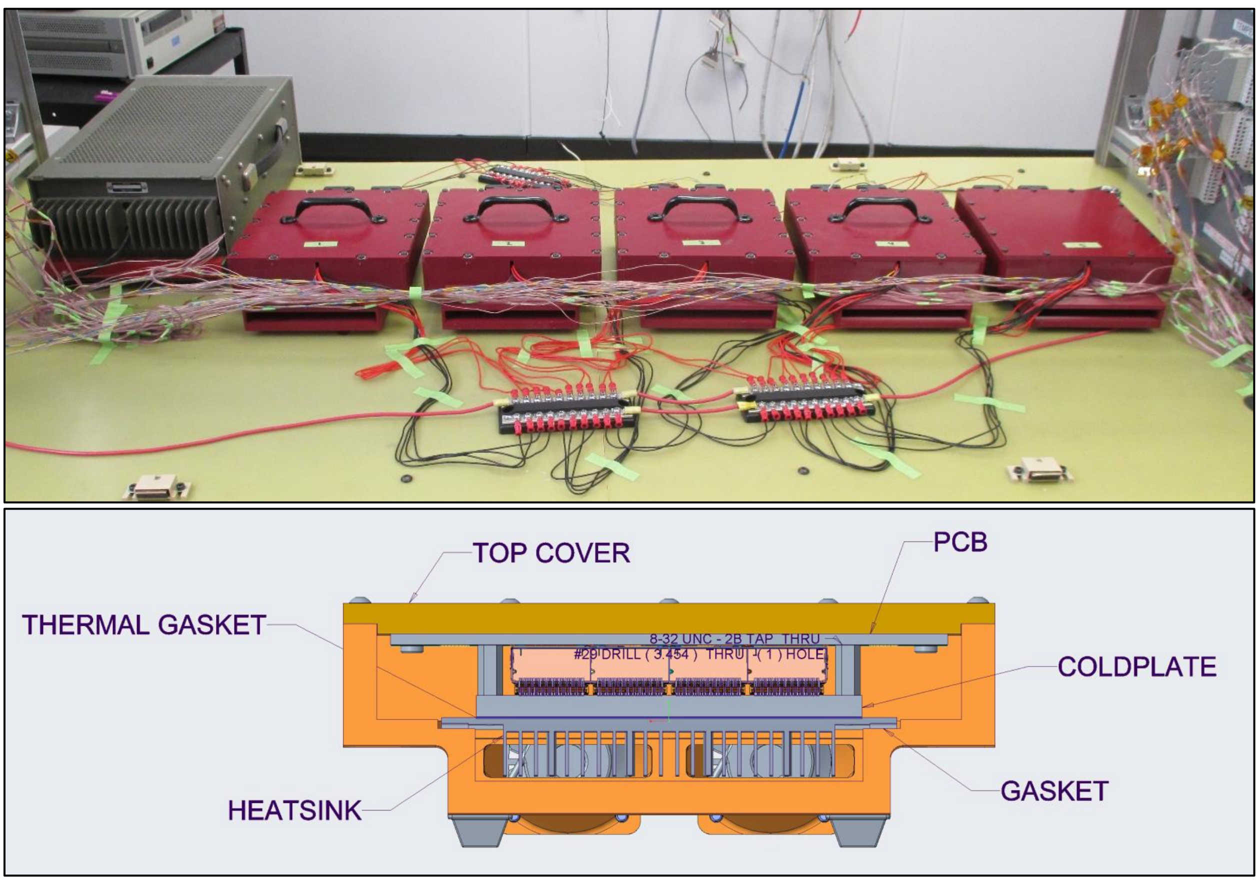

Figure 7 – Typical Thermal Bridge Test Setup

3.11 Thermal Shock

Mated specimens were subjected to 10 cycles of thermal shock with each cycle consisting of 60 minute dwells at -55°C and 85°C. The transition between temperatures was less than one minute. Testing was performed in accordance with EIA-364-32G.

3.12 Humidity / Temperature Cycling

Mated specimens were exposed to 10 cycles of humidity-temperature cycling. Each cycle lasted 24 hours and consisted of cycling the temperature between 25°C and 65°C twice while maintaining high humidity. Testing was performed in accordance with EIA-364-31F.

3.13 Temperature Life

Mated specimens were exposed to a temperature of 115°C for 411 hours. Testing was performed in accordance with EIA-364-17C.

3.14 Mixed Flowing Gas

Specimens were subjected to a mixed flowing gas environment for 20 days. One-half of the specimens (301,302,303) were unmated for 10 days (receptacle only) followed by 10 days mated. The remaining one-half of the specimens (304,305) were mated for all 20 days. Specimens were removed from the chamber for Thermal Resistance measurements at 10 days. Refer to Table 13 for MFG Class IIA test parameters. Testing was performed in accordance with EIA-364-65B, Class IIA.

Table 13 – MFG Test Parameters

Environment	Class IIA
Temperature (°C)	30 ± 1
Relative Humidity (%)	70 ± 2
Chlorine (Cl_2) Concentration (ppb)	10 ± 3
Hydrogen Sulfide (H_2S) Concentration (ppb)	10 ± 5
Nitrogen Dioxide (NO_2) Concentration (ppb)	200 ± 50
Sulfur Dioxide (SO_2) Concentration (ppb)	100 ± 20
Exposure Period	20 Days
Chamber Volume Exchange Rate [Minimum of 6/hr.]	8.8/hr.*

**Volume exchange rate for 105-liter test chamber [Total flow rate of 15.4 L/Min]*

3.15 Dust

Specimens were subjected to dust exposure in accordance with EIA-364-91B. Specimens 601, 602, and 603 were exposed in the unmated condition and specimens 604 and 605 were exposed mated to transceivers. The dust composition was #1 benign. Nine grams of dust per cubic food of chamber space was utilized. The chamber space has been estimated at 13.9 cubic feet, resulting in the use of approximately 125 grams of dust. The dust was dried for an hour at 50°C prior to being spread inside the chamber. The specimens were hung in the chamber and the blower system was turned on for an hour with a flow rate of 300 meters/minute. The blower system was then turned off and the specimens remained in the closed chamber for an additional hour. The specimens were then removed and gently tapped 5 times to remove any excess accumulation of dust. Refer to Figure 8 for images of the typical test setup.

Figure 8 – Typical Dust Test Setup

3.16 Final Examination of Product

Specimens were visually examined with an unaided eye. Testing was performed in accordance with EIA-364-18B.