VITA 66.1 Fiber-Optic Connector for Use with Multi-Mode MT Ferrules

1. INTRODUCTION

1.1. Purpose

Testing was performed on the TE Connectivity VITA 66.1 Fiber-Optic Connector for Use with Multi-Mode MT Ferrules to determine its conformance to the requirements of Product Specification 108-2467 Revision A.

1.2. Scope

This report covers the optical, mechanical, and environmental performance of the VITA 66.1 Fiber-Optic Connector for Use with Multi-Mode MT Ferrules. Testing was performed at the Harrisburg Fiber Optic Components Test Laboratory between 05Mar12 and 26Oct12. The test file number for this testing is B125424-006. This documentation is on file at and available from the Harrisburg Fiber Optic Components Test Laboratory.

1.3. Conclusion

The VITA 66.1 Fiber-Optic Connectors for Use with Multi-Mode MT Ferrules listed in paragraph 1.5. conformed to the optical, mechanical, and environmental performance requirements of Product Specification 108-2467 Revision A.

1.4. Product Description

The VITA 66.1 connector system provides a high-density, blind-mate optical interconnect in a backplane/card configuration. The fiber-optic ribbon cable interconnect is fed through the backplane to removable systems modules using standard-grade, Multi-Mode MT ferrules having up to 12 positions. The connectors consist of housings accepting two MT ferrules. The MT ferrules/cable assemblies are easily secured within the connector housings using the retainer plates provided with connector kits.

1.5. Test Specimens

Test specimens were representative of normal production lots. Specimens identified with the following part numbers were used for test:

Part Number	Description	Test Group 1 Quantity per Test Group
2000973-1	Connector Kit, Receptacle, Backplane, Fiber Optic, MT, VITA 66.1 Style	5
2000974-1	Connector Kit, Plug, Module, Fiber Optic, MT, VITA 66.1 Style	5
1938482-3	Cable Assembly, Fiber Optic, MT-to-MT, 12-Fiber Ribbon, 50/125 µm	10

Figure 1

1.6. Qualification Test Sequence

Test or Examination	Test Group (a)
	1
	Test Sequence (b)
Visual and mechanical inspection	1
Attenuation	2
Return loss	3
Thermal aging	4
Humidity, steady state	5
Temperature cycling	6
Vibration, sinusoidal	7
Vibration, random	8
Shock	9
Bench handling shock	10
Durability	11
End of service life	12, 14
Storage temperature endurance	13

NOTE

(a) See paragraph 1.5.
(b) Numbers indicate sequence in which tests are performed.

Figure 2

1.7. Environmental Conditions

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

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

2. SUMMARY OF TESTING

2.1. Visual and Mechanical Inspection

A Certificate of Conformance (C of C) was issued by Product Assurance 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. The samples were visually examined and no damage or defects were found that would prevent them from performing their intended function. Endface geometry of the cable assemblies was measured and confirmed within TE specification limits for production-grade, multimode, single-row MT ferrules.

2.2. Initial Attenuation of All Channels

All Initial Attenuation measurements met the requirements for maximum average attenuation of any channel, sample average attenuation, and group average attenuation. Summary data for Initial Attenuation performance at 850 nm and 1300 nm are presented in Table 2.2-1.

Table 2.2-1 Initial Attenuation Performance

Wavelength	850 nm	1300 nm
Attenuation Statistics		
Group Maximum	0.93	0.58
Sample Average, Maximum	0.52	0.30
Group Average	0.40	0.20
Group Standard Deviation	0.16	0.11
Channel Pass – Fail Count	120 - 0	120 - 0
Sample Pass – Fail Count	5 - 0	5 - 0
Attenuation Requirements		
Maximum, Any Channel	≤ 1.2	≤ 1.2
Sample Average	≤ 0.7	≤ 0.7
Group Average	≤ 0.65	≤ 0.65

NOTE All units in dB.

2.3. Return Loss

All Return Loss measurements were greater than 20 dB per channel. Summary data for Return Loss performance at 850 nm and 1300 nm are presented in Table 2.3-1.

Table 2.3-1 Initial Return Loss Performance

Wavelength	850 nm	1300 nm
Return Loss Statistics		
Group Minimum	23.9	29.9
Group Average	30.1	34.0
Group Standard Deviation	1.3	1.3
Channel Pass – Fail Count	120 - 0	120 - 0
Sample Pass – Fail Count	5 - 0	5 - 0
Return Loss Requirements		
Minimum, Any Channel	≥ 20	≥ 20

NOTE All units in dB.

2.4. Thermal Aging

No evidence of physical damage was visible as a result of Thermal Aging. All samples met the Attenuation, Attenuation Increase, and Return Loss requirements at both 850 nm and 1300 nm after the Thermal Aging test. Summary data during Thermal Aging (collected for informational purposes) are presented in Table 2.4-1 and after Thermal Aging (as required) in Table 2.4-2.

Table 2.4-1 Optical Performance during Thermal Aging

Wavelength	850 nm			1300 nm		
Optical Test	Attenuation	Attenuation Increase	Return Loss	Attenuation	Attenuation Increase	Return Loss
Max*/Min*	0.58	0.35	29.7	0.52	0.28	33.5
Average	0.14	-0.01	34.0	0.11	-0.02	35.2
Std. Deviation	0.09	0.08	2.6	0.08	0.08	1.5

NOTE All units in dB.
* Worst case criteria - Maximum Attenuation, Maximum Attenuation Increase, or Minimum Return Loss

Table 2.4-2 Optical Performance after Thermal Aging

Wavelength	850 nm			1300 nm		
Optical Test	Attenuation	Attenuation Increase	Return Loss	Attenuation	Attenuation Increase	Return Loss
Max*/Min*	0.44	0.35	30.1	0.40	0.29	33.7
Average	0.18	0.03	33.9	0.13	0.00	34.7
Std. Deviation	0.11	0.14	2.3	0.10	0.13	0.9
Sample Pass – Fail Count	5 - 0	5 - 0	5 - 0	5 - 0	5 - 0	5 - 0
Requirements	≤ 1.2	≤ 0.5	≥ 20	≤ 1.2	≤ 0.5	≥ 20

NOTE All units in dB.
* Worst case criteria - Maximum Attenuation, Maximum Attenuation Increase, or Minimum Return Loss

2.5. Humidity, Steady State

No evidence of physical damage was visible as a result of Steady State Humidity testing. All samples met the Attenuation, Attenuation Increase, and Return Loss requirements at both 850 nm and 1300 nm during and after the Steady State Humidity test. Summary data during Humidity are presented in Table 2.5-1 and after Humidity in Table 2.5-2.

Table 2.5-1 Optical Performance during Humidity

Wavelength	850 nm			1300 nm		
Optical Test	Attenuation	Attenuation Increase	Return Loss	Attenuation	Attenuation Increase	Return Loss
Max*/Min*	0.47	0.25	29.9	0.40	0.24	33.6
Average	0.16	-0.01	34.0	0.11	-0.02	35.1
Std. Deviation	0.09	0.10	2.5	0.08	0.09	1.1
Sample Pass – Fail Count	5 - 0	5 - 0	5 - 0	5 - 0	5 - 0	5 - 0
Requirements	≤ 1.2	≤ 0.5	≥ 20	≤ 1.2	≤ 0.5	≥ 20

NOTE All units in dB.
* Worst case criteria - Maximum Attenuation, Maximum Attenuation Increase, or Minimum Return Loss

Table 2.5-2 Optical Performance after Humidity

Wavelength	850 nm			1300 nm		
Optical Test	Attenuation	Attenuation Increase	Return Loss	Attenuation	Attenuation Increase	Return Loss
Max*/Min*	0.45	0.27	30.7	0.37	0.23	34.0
Average	0.19	0.02	33.7	0.14	0.01	34.8
Std. Deviation	0.10	0.10	1.8	0.09	0.09	0.7
Sample Pass – Fail Count	5 - 0	5 - 0	5 - 0	5 - 0	5 - 0	5 - 0
Requirements	≤ 1.2	≤ 0.5	≥ 20	≤ 1.2	≤ 0.5	≥ 20

NOTE All units in dB.
* Worst case criteria - Maximum Attenuation, Maximum Attenuation Increase, or Minimum Return Loss

2.6. Temperature Cycling

No evidence of physical damage was visible as a result of Temperature Cycling. All samples met the Attenuation, RL and Attenuation Increase requirements at both 850 nm and 1300 nm during and after the Temperature Cycling test. Summary data during Temperature Cycling are presented in Table 2.6-1 and after Temperature Cycling in Table 2.6-2.

Table 2.6-1 Optical Performance during Temperature Cycling

Wavelength	850 nm			1300 nm		
Optical Test	Attenuation	Attenuation Increase	Return Loss	Attenuation	Attenuation Increase	Return Loss
Max*/Min*	0.98	0.47	30.1	0.97	0.44	33.8
Average	0.31	0.08	34.2	0.28	0.07	35.6
Std. Deviation	0.26	0.11	2.7	0.24	0.10	1.6
Sample Pass – Fail Count	5 - 0	5 - 0	5 - 0	5 - 0	5 - 0	5 - 0
Requirements	≤ 1.2	≤ 0.5	≥ 20	≤ 1.2	≤ 0.5	≥ 20

NOTE All units in dB.
* Worst case criteria - Maximum Attenuation, Maximum Attenuation Increase, or Minimum Return Loss

Table 2.6-2 Optical Performance after Temperature Cycling

Wavelength	850 nm			1300 nm		
Optical Test	Attenuation	Attenuation Increase	Return Loss	Attenuation	Attenuation Increase	Return Loss
Max*/Min*	0.81	0.30	30.2	0.81	0.28	34.1
Average	0.32	0.09	34.1	0.29	0.08	35.5
Std. Deviation	0.26	0.09	2.4	0.24	0.09	1.3
Sample Pass – Fail Count	5 - 0	5 - 0	5 - 0	5 - 0	5 - 0	5 - 0
Requirements	≤ 1.2	≤ 0.5	≥ 20	≤ 1.2	≤ 0.5	≥ 20

NOTE All units in dB.
* Worst case criteria - Maximum Attenuation, Maximum Attenuation Increase, or Minimum Return Loss

2.7. Vibration, Sinusoidal

All samples met the 850 nm and 1300 nm requirements for Attenuation, Attenuation Increase, and Return Loss after testing Sinusoidal Vibration in each of three mutually perpendicular planes. Summary performance data are provided in Table 2.7-1, which include interim optical measurements (after exposure in each axis) and final measurements after Sinusoidal Vibration. Following Sinusoidal Vibration testing, no cracks, breaks, or loose parts were visible on the samples.

Table 2.7-1 Optical Performance after Sinusoidal Vibration

Wavelength	850 nm			1300 nm		
Optical Test	Attenuation	Attenuation Increase	Return Loss	Attenuation	Attenuation Increase	Return Loss
Max*/Min*	0.71	0.13	29.8	0.72	0.13	34.0
Average	0.33	-0.01	33.5	0.32	-0.02	35.1
Std. Deviation	0.20	0.05	1.5	0.20	0.05	0.7
Sample Pass – Fail Count	5 - 0	5 - 0	5 - 0	5 – 0	5 - 0	5 - 0
Requirements	≤ 1.2	≤ 0.5	≥ 20	≤ 1.2	≤ 0.5	≥ 20

NOTE All units in dB.
* Worst case criteria - Maximum Attenuation, Maximum Attenuation Increase, or Minimum Return Loss

2.8. Vibration, Random

All samples met the 850 nm and 1300 nm requirements for Attenuation, Attenuation Increase, and Return Loss after testing Random Vibration in each of three mutually perpendicular planes. Summary performance data are provided in Table 2.8-1, which include interim optical measurements (after exposure in each axis) and final measurements after Random Vibration. Following Random Vibration testing, no cracks, breaks, or loose parts were visible on the samples.

Table 2.8-1 Optical Performance after Random Vibration

Wavelength	850 nm			1300 nm		
Optical Test	Attenuation	Attenuation Increase	Return Loss	Attenuation	Attenuation Increase	Return Loss
Max*/Min*	0.70	0.12	29.8	0.70	0.12	34.0
Average	0.26	0.00	33.0	0.25	0.00	35.3
Std. Deviation	0.22	0.04	1.5	0.20	0.05	0.6
Sample Pass – Fail Count	5 - 0	5 - 0	5 - 0	5 - 0	5 - 0	5 - 0
Requirements	≤ 1.2	≤ 0.5	≥ 20	≤ 1.2	≤ 0.5	≥ 20

NOTE All units in dB.
* Worst case criteria - Maximum Attenuation, Maximum Attenuation Increase, or Minimum Return Loss

2.9. Shock

All samples met the 850 nm and 1300 nm requirements for Attenuation, Attenuation Increase, and Return Loss after testing Shock in each of three mutually perpendicular planes. Summary performance data are provided in Table 2.9-1, which include interim optical measurements (after exposure in each axis) and final measurements after Shock. Following Shock testing, no cracks, breaks, or loose parts were visible on the samples.

Table 2.9-1 Optical Performance after Shock

Wavelength	850 nm			1300 nm		
Optical Test	Attenuation	Attenuation Increase	Return Loss	Attenuation	Attenuation Increase	Return Loss
Max*/Min*	0.72	0.11	29.7	0.74	0.12	33.9
Average	0.31	0.00	33.3	0.29	0.00	35.2
Std. Deviation	0.21	0.02	1.6	0.20	0.02	0.7
Sample Pass – Fail Count	5 - 0	5 - 0	5 - 0	5 - 0	5 - 0	5 - 0
Requirements	≤ 1.2	≤ 0.5	≥ 20	≤ 1.2	≤ 0.5	≥ 20

NOTE All units in dB.
* Worst case criteria - Maximum Attenuation, Maximum Attenuation Increase, or Minimum Return Loss

2.10. Bench Handling Shock

All samples met the requirements for Attenuation, Attenuation Increase, and Return Loss at both 850 nm and 1300 nm after the Bench Handling Shock test. Summary optical performance data after Bench Handling Shock are presented in Table 2.10-1. Following Bench Handling Shock testing, no cracks, breaks, or loose parts were visible on the samples.

Table 2.10-1 Optical Performance after Bench Handling Shock

Wavelength	850 nm			1300 nm		
Optical Test	Attenuation	Attenuation Increase	Return Loss	Attenuation	Attenuation Increase	Return Loss
Max*/Min*	0.51	0.07	28.5	0.52	0.06	33.8
Average	0.16	-0.03	32.6	0.16	-0.03	35.1
Std. Deviation	0.17	0.10	1.7	0.16	0.09	0.8
Sample Pass – Fail Count	5 - 0	5 - 0	5 - 0	5 - 0	5 – 0	5 - 0
Requirements	≤ 1.2	≤ 0.5	≥ 20	≤ 1.2	≤ 0.5	≥ 20

NOTE All units in dB.
* Worst case criteria - Maximum Attenuation, Maximum Attenuation Increase, or Minimum Return Loss

2.11. Durability

No physical damage occurred as a result of mating and unmating the samples 100 times. All samples met the Attenuation and RL requirements at both 850 nm and 1300 nm during the Durability test.

Additionally, all samples met the Attenuation, Attenuation Increase, and Return Loss requirements at both 850 nm and 1300 nm after the Durability test. Summary data during Durability, After Cleanings (collected for informational purposes), are presented in Table 2.11-1 and after Durability (as required) in Table 2.11-2.

Table 2.5-1 Optical Performance during Durability, After Cleanings

Wavelength	850 nm			1300 nm		
Optical Test	Attenuation	Attenuation Increase	Return Loss	Attenuation	Attenuation Increase	Return Loss
Max*/Min*	0.69	0.20	14.7**	0.66	0.32	18.9
Average	0.23	-0.02	32.7	0.21	0.03	35.0
Std. Deviation	0.21	0.09	2.5	0.19	0.11	2.0

NOTE All units in dB.
* Worst case criteria - Maximum Attenuation, Maximum Attenuation Increase, or Minimum Return Loss
** One data point only was less than 20 dB. This was noted following 75 cycles after just one cleaning and inspection.

Table 2.5-2 Optical Performance after Durability, After Final Cleaning

Wavelength	850 nm			1300 nm		
Optical Test	Attenuation	Attenuation Increase	Return Loss	Attenuation	Attenuation Increase	Return Loss
Max*/Min*	0.58	0.20	30.0	0.57	0.18	33.3
Average	0.21	-0.03	32.9	0.19	0.02	34.9
Std. Deviation	0.19	0.10	1.9	0.17	0.07	1.0
Sample Pass – Fail Count	5 - 0	5 - 0	5 - 0	5 – 0	5 - 0	5 - 0
Requirements	≤ 1.2	≤ 0.5	≥ 20	≤ 1.2	≤ 0.5	≥ 20

NOTE All units in dB.
* Worst case criteria - Maximum Attenuation, Maximum Attenuation Increase, or Minimum Return Loss

2.12. End of Service Life

End of Service Life optical performance was measured at 850 nm and 1300 nm. All paths still intact and not damaged from mishandling met the End of Service Life requirements for maximum average attenuation of any channel, sample average attenuation, group average attenuation, maximum attenuation increase, and return loss. Attenuation summary data are presented in Table 2.12-1; Attenuation Increase summary data are presented in Table 2.12-2; Return Loss summary data are presented in Table 2.12-3.

Table 2.12-1 End of Service Life, Attenuation Performance

Wavelength	850 nm	1300 nm
Attenuation Statistics		
Group Maximum	0.56	0.34
Sample Average, Maximum	0.24	0.16
Group Average	0.15	0.10
Group Standard Deviation	0.10	0.07
Channel Pass – Fail Count	117* – 0	117* – 0
Sample Pass – Fail Count	5 - 0	5 - 0
Attenuation Requirements		
Maximum, Any Channel	≤ 1.2	≤ 1.2
Sample Average	≤ 0.7	≤ 0.7
Group Average	≤ 0.65	≤ 0.65

NOTE All units in dB.
* 3 Channels were damaged due to handling and excluded from these statistics.

Table 2.13-2 End of Service Life, Attenuation Increase Performance

Wavelength	850 nm	1300 nm
Attenuation Increase Statistics		
Group Maximum	0.22	0.27
Group Average	-0.28	-0.11
Group Standard Deviation	0.15	0.11
Channel Pass – Fail Count	117* - 0	117* - 0
Sample Pass – Fail Count	5 - 0	5 - 0
Attenuation increase Requirements		
Maximum, Any Channel	≤ 0.5	≤ 0.5

NOTE All units in dB.
* 3 Channels were damaged due to handling and excluded from these statistics.

Table 2.13-3 End of Service Life, Return Loss Performance

Wavelength	850 nm	1300 nm
Return Loss Statistics		
Group Minimum	26.2	32.3
Group Average	28.4	35.3
Group Standard Deviation	1.1	0.9
Channel Pass – Fail Count	117* - 0	117* - 0
Sample Pass – Fail Count	5 - 0	5 - 0
Return Loss Requirements		
Minimum, Any Channel	≥ 20	≥ 20

NOTE All units in dB.
* 3 Channels were damaged due to handling and excluded from these statistics.

2.13. Storage Temperature Endurance

No evidence of physical damage was visible as a result of Storage Temperature Endurance testing. All samples met the Attenuation, Attenuation Increase, and Return Loss requirements at both 850 nm and 1300 nm after the Storage Temperature Endurance test. Summary data after cleaning following Storage Temperature Endurance are presented in Table 2.13-1.

Table 2.13-1 Optical Performance after Storage Temperature Endurance, after Final Cleaning

Wavelength	850 nm			1300 nm		
Optical Test	Attenuation	Attenuation Increase	Return Loss	Attenuation	Attenuation Increase	Return Loss
Max*/Min*	0.49	0.30	28.6	0.49	0.27	37.9
Average	0.16	0.03	33.2	0.15	0.02	34.7
Std. Deviation	0.13	0.11	2.2	0.13	0.11	1.3
Sample Pass – Fail Count	5 - 0	5 - 0	5 - 0	5 - 0	5 - 0	5 - 0
Requirements	≤ 1.2	≤ 0.5	≥ 20	≤ 1.2	≤ 0.5	≥ 20

NOTE All units in dB.
* Worst case criteria - Maximum Attenuation, Maximum Attenuation Increase, or Minimum Return Loss

2.14. Second End of Service Life

End of Service Life optical performance was measured again at 850 nm and 1300 nm. All paths still intact and not damaged from mishandling met the End of Service Life requirements for maximum average attenuation of any channel, sample average attenuation, group average attenuation, maximum attenuation increase, and return loss. Attenuation summary data are presented in Table 2.14-1;

Attenuation Increase summary data are presented in Table 2.14-2; Return Loss summary data are presented in Table 2.14-3.

Table 2.14-1 Second End of Service Life, Attenuation Performance

Wavelength	850 nm	1300 nm
Attenuation Statistics		
Group Maximum	0.43	0.31
Sample Average, Maximum	0.19	0.15
Group Average	0.14	0.11
Group Standard Deviation	0.08	0.07
Channel Pass – Fail Count	117* – 0	117* – 0
Sample Pass – Fail Count	5 - 0	5 - 0
Attenuation Requirements		
Maximum, Any Channel	≤ 1.2	≤ 1.2
Sample Average	≤ 0.7	≤ 0.7
Group Average	≤ 0.65	≤ 0.65

NOTE All units in dB.
* 3 Channels were damaged due to handling and excluded from these statistics.

Table 2.14-2 Second End of Service Life, Attenuation Increase Performance

Wavelength	850 nm	1300 nm
Attenuation Increase Statistics		
Group Maximum	0.00	0.11
Group Average	-0.28	-0.10
Group Standard Deviation	0.15	0.11
Channel Pass – Fail Count	117* - 0	117* - 0
Sample Pass – Fail Count	5 - 0	5 - 0
Attenuation increase Requirements		
Maximum, Any Channel	≤ 0.5	≤ 0.5

NOTE All units in dB.
* 3 Channels were damaged due to handling and excluded from these statistics.

Table 2.14-3 Second End of Service Life, Return Loss Performance

Wavelength	850 nm	1300 nm
Return Loss Statistics		
Group Minimum	27.5	26.5
Group Average	31.0	34.3
Group Standard Deviation	1.9	1.7
Channel Pass – Fail Count	117* - 0	117* - 0
Sample Pass – Fail Count	5 - 0	5 - 0
Return Loss Requirements		
Minimum, Any Channel	≥ 20	≥ 20

NOTE All units in dB.
* 3 Channels were damaged due to handling and excluded from these statistics.

3. TEST METHODS

3.1. Visual and Mechanical Inspection

The specimens were examined visually, dimensionally and functionally per the product drawings and inspection plans per FOTP-13. A C of C 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. Initial Attenuation of All Channels

Attenuation (multi-mode) was measured in accordance with FOTP-171, Method D1, processes. All fiber paths were measured initially and at the end of the test sequence at both 850 nm and 1300 nm. Attenuation was measured at the minimum connector mating engagement distance as defined per VITA 66.0. This distance was maintained using a test fixture used for environmental testing.

The instrument was set up with two MPO to FC breakout cables used as launch leads, providing a low Category 1 fill condition per OFSTP-14. Reference optical measurements (P_0) were recorded with two uncut sample cable assemblies mated to the launch lead MT ferrules (MPO ends). Then, the two sample cable assemblies (along with two additional uncut sample cable assemblies) were mounted in the VITA 66.1 connectors, and optical measurements (P_1) were recorded. The Attenuation values were calculated by subtracting P_1 from P_0 and compensating for any changes in the source monitor. The test cable assemblies were then flipped in order to test the opposite ends, and Attenuation measurements were repeated in the same manner.

3.3. Initial Return Loss of All Channels

Return Loss (multi-mode) was measured in accordance with FOTP-107. The test system RL modules were frequently referenced and zeroed using a reference cable having a length similar to the breakout launch leads. A single measurement was recorded for Return Loss. Optical RL was measured initially, after each test evaluation, and during test as applicable. RL was likewise measured at the minimum connector engagement distance as defined per VITA 66.0.

3.4. Build-up Attenuation and Return Loss Verification of Limited Channels

Six channels, the 1st (end, upper row), 6th (center, upper row), 12th (end, upper row), 13th (end, lower row), 19th (center, lower row), and 24th (end, lower row), of each sample were selected for optical monitoring before and after environmental and mechanical testing. Certain tests required optical measurements of these channels during the exposure.

A sample build-up process required in order to monitor these channels. The sample test cable assemblies were cut in half and spliced to 50/125 µm FC pigtails mated to the test system optical switch. Reference Attenuation and RL measurements (P_0) were recorded for each channel. The cleaved sample cable assemblies were populated into the VITA 66.1 connectors, which were then mounted into the test fixture, mated at minimum connector engagement per VITA 66.0. Optical measurements (P_1) of the six channels were made at the cleaved end using a bare fiber adapter. Attenuation values were calculated by subtracting P_1 from P_0 and compensating for any changes in the source monitor.

3.5. Attenuation Increase

Increase in Attenuation was calculated by taking the difference between the initial measurement before test and the during/after measurements for each test as applicable. Attenuation Increase represents a change in attenuation that results from a decrease in optical power (degraded performance).

3.6. Thermal Aging

Thermal Aging was performed per FOTP-4. The test chamber was ramped from ambient to 85° in one hour, followed by a 168-hr (7-day) dwell at 85°C, followed by a one-hour ramp back to ambient. The specimens were tested mounted in the test fixture, mated at the minimum connector engagement distance as defined per VITA 66.0. Optical measurements were made with the specimens in the test chamber before the exposure and every six hours during test for information purposes. Final optical performance was recorded at least two hours after returning to lab ambient conditions.

3.7. Humidity, Steady State

Samples were subjected to Steady State Humidity per FOTP-5, Method A, at 60°C, 95%RH for 168 hours (7 days).This was followed by a two-hour dry out period at 60°C, 20%RH, and then returned to ambient conditions. The samples were tested mounted in the test fixture, mated at the minimum connector engagement distance as defined per VITA 66.0. Optical performance was measured before testing and at least every 12 hours during the humidity exposure. Final optical measurements were recorded after samples stabilized at least two hours after returning to lab ambient conditions.

3.8. Temperature Cycling

Mated samples were subjected to Temperature Cycling per FOTP-3, Test Condition C, except hot extreme first. The chamber was ramped from 23°C to 85°C in 1 hour, 45 minutes. The exposure continued with a 1-hour dwell at 85°C. This was followed by 1-hour, 45-minute ramp to 23°C, with a 1-hour dwell at 23°C. This was followed by a 1-hour, 15-minute ramp to -20°C, with a 1-hour dwell at -20°C. The cycle was completed with a 1-hour, 15-minute ramp to 23°C. The samples were exposed to a total of 21 cycles. For this test they remained mounted in the test fixture, mated at the minimum connector engagement distance as defined per VITA 66.0. Optical measurements were recorded initially and every 15 minutes. Final optical performance was recorded after the samples remained undisturbed at ambient conditions for 2 hours.

3.9. Vibration, Sinusoidal

Sinusoidal Vibration was performed per FOTP-11, Test Condition 1. The samples were mounted in the mechanical test fixtures, with the connectors likewise mated at the minimum connector engagement distance as defined per VITA 66.0. The fixtures were then mounted to the vibration table and baseline optical measurements were recorded. Each mated sample pair was subjected to 10 to 55 Hz sinusoidal vibration two hours in each of three mutually perpendicular directions. Optical performance was recorded before the test and after exposure in each plane, with the test fixtures secured to vibration table.

3.10. Vibration, Random

Random Vibration was performed per FOTP-11, Test Condition VI, Test Condition Letter D. After Sinusoidal Vibration the samples remained secured to the vibration table, mounted in the mechanical test fixtures at the minimum connector engagement distance. The final measurements of Sinusoidal Vibration served as the baseline measurements for Random Vibration. Each mated sample pair was subjected to 11.95 G_{RMS} between 50 and 2000 Hz of random vibration for 15 minutes in each of three mutually perpendicular directions. Optical performance was recorded after exposure in each plane, with the test fixtures remaining secured to vibration table.

3.11. Shock

Shock testing was performed per FOTP-14, Condition E. After Random Vibration the samples remained secured to the vibration table, mounted in the mechanical test fixtures at the minimum connector engagement distance. The final measurements of Random Vibration served as the baseline measurements for Shock. Each mated sample pair was subjected to three sawtooth shock pulses in each of three mutually perpendicular directions, each pulse having a 50 G amplitude and an 11 millisecond duration. Optical performance was recorded after exposure in each plane, with the test fixtures remaining secured to vibration table.

3.12. Bench Handling Shock

Bench Handling Shock testing was performed per MIL-STD-810, Method 516.6, Procedure VI. The samples were re-installed in their respective environmental test fixtures, mated at the minimum connector engagement distance as defined per VITA 66.0, and baseline optical measurements were recorded. The test fixtures were unmated, manually raised, and positioned at a 45° angle. Each fixture half was dropped a total of eight times. The samples were cleaned, inspected and reconnected, then final optical measurements were recorded.

3.13. Durability

Samples were subjected to Durability testing per FOTP-21. A connector mating pair was installed in a durability apparatus by manually aligning the receptacle (backplane) and plug (module) halves and clamping the fixture plates in the correct positions. The connector was mated through the maximum connector engagement distance as defined per VITA 66.0, and baseline optical measurements were recorded. Optical measurements were repeated every 5 cycles through a total of 100 cycles. The samples were cleaned and visually inspected after 24, 49, 74, and 99 durability cycles.

3.14. End of Service Life of All Channels

Final Attenuation and Return Loss were recorded per FOTP-20 for all fiber paths following the durability test. Attenuation increase data were calculated by subtracting the Initial Attenuation data from the End of Service Life Attenuation data.

3.15. Storage Temperature Endurance

Samples were placed unmated in the environmental chamber and subjected to Storage Temperature Endurance per FOTP-3. The chamber was ramped from 23°C to 85°C in 1 hour, 45 minutes. The exposure continued with a 48-hour dwell at 85°C. This was followed by 1-hour, 45-minute ramp to 23°C, with a 1-hour dwell at 23°C. This was followed by a 2-hour ramp to -55°C, with a 48-hour dwell at -55°C. This was followed by a 2-hour ramp to 23°C, with a 1-hour dwell at 23°C. Humidity was left uncontrolled throughout the entire exposure. Upon removal from the chamber, the samples were cleaned, visually inspected, and re-mated. Final optical measurements were recorded, and Attenuation Increase data was calculated.

3.16. Second End of Service Life of All Channels

Final Attenuation and Return Loss were again recorded per FOTP-20 for all fiber paths following the Storage Temperature Endurance test. Attenuation Increase data were calculated by subtracting the Initial Attenuation data from the Second End of Service Life Attenuation data.