LC-UPC Build Out Attenuators

1. INTRODUCTION

1.1. Purpose

Testing was performed on Tyco Electronics LC-UPC, singlemode fiber optic Build Out Attenuators (BOA) to determine their conformance to the requirements of Tyco Electronics Product Specification 108-2221, Revision A.

1.2. Scope

This report covers the optical, environmental, and mechanical performance of the LC-UPC, singlemode fiber optic BOAs, provided by Tyco Electronics, Fiber Optics Business Unit. Qualification testing was completed by a third party in July 2004. Reliability testing was completed by a third party on 11Nov03. The test file number for all testing is Project B058280, Request Number 04.06.04. This documentation is on file at and available from the Fiber Optics Business Unit, FOBU EMEA Test Laboratory.

1.3. Conclusion

Tyco Electronics LC-UPC BOAs, listed in paragraphs 1.5 and 1.6, conform to the optical, environmental, and mechanical performance requirements of Tyco Electronics Product Specification 108-2221, Revision A.

1.4. Product Description

LC-UPC BOAs are singlemode, fiber optic, passive devices for reducing the amplitude of a signal without appreciably distorting the waveform. These attenuators are used for power equalization at the patch panel or at the receiver and also for attenuating the signal power level to bring it in line with the dynamic range of the receiver.

1.5. Qualification Test Specimens

Test specimens were taken from current production. A specimen is defined as one build out attenuator. Specimen part number and quantity are shown below.

Test Group	1
BOA Attenuation Value (dB)	10
BOA Part Number	1-1693560-0
Test specimens required	11

1.6. Reliability Test Specimens

The test specimens were taken from current production. Test Groups consisted of the build out attenuator quantities as shown below.

Test Group	1	2	3	4
BOA Attenuation Value (dB)	10	10	10	10
BOA Part Number	1-1693560-0			
Test specimens required	11	11	22	22

* Trademark
| Indicates change

1.7. Qualification Test Sequence

Numbers indicate sequence in which tests were performed.

Test or Examination	Test Group
	1
	10 dB
Initial optical performance:	1
Attenuation tolerance	
Return loss	
Polarization Dependent Loss (PDL)	
Controlled operating environment	2
Uncontrolled operating environment	3
Non-operating environment	4
Humidity/condensation cycling	5
Water Immersion	6
Vibration	7
Durability	8
Impact	9

1.8. Reliability Test Sequence

Numbers indicate sequence in which tests were performed.

Test or Examination	Test Group			
	1	2	3	4
	10 dB			
Mechanical shock (impact)	1			
Variable frequency vibration	2			
Water immersion	3			
Thermal shock	4			
Temperature cycling	5			
Temperature-humidity cycling (cyclic moisture resistance)	6			
Low temperature storage		1		
High temperature storage (damp heat)			1	
High temperature aging (dry heat)				1

2. SUMMARY OF QUALIFICATION TESTING

2.1 Initial Optical Performance - New Product

A. Attenuation Tolerance

All attenuation measurements for new product met the allowable tolerances. Attenuation was measured at 1310 and 1550 nm.

Attenuation Tolerance - Requirements

BOA Attenuation Value (dB)	Attenuation Tolerance (dB)
10	± (0.10 x attenuation value)

Attenuation Tolerance - Actual for New Product

BOA Attenuation Value (dB)	Allowable Attenuation Range (dB)	Wavelength (nm)	Actual Attenuation (dB)	
			Minimum	Maximum
10	9.0 - 11.0	1310	9.8	10.2
		1550	9.7	10.1

B. Return Loss

Return loss for new product met the minimum requirement. Return loss was measured at 1310 and 1550 nm.

Return Loss (New Product)

BOA Attenuation Value (dB)	Wavelength (nm)	Return Loss Requirement (dB)	Actual Minimum Return Loss (dB)
10	1310	≥ 55	56
	1550		

C. Polarization Dependent Loss (PDL)

The range of PDL measurements for all specimens met the specification requirement. Loss was measured at 1310 and 1550 nm.

PDL (New Product)

BOA Attenuation Value (dB)	Wavelength (nm)	PDL Requirement (dB)	Actual Maximum PDL Range (dB)
10	1310	≤ 0.5	0.06
	1550		

2.2. Attenuation, Change in Attenuation, Return Loss and Polarization Dependent Loss - After Each Test

All optical performance measurements met the specification requirements. Measurements were recorded at 1310 and 1550 nm. Values shown in the table represent maximum and minimum attenuation, maximum change in attenuation, minimum return loss and maximum PDL, observed from any specimen within the test group. Optical performance before test is considered to be the same as attenuation after the prior test, and is therefore not shown twice. For the first test, the new product data in Section 2.1 represents the "before test" data.

Attenuation, Change in Attenuation, Return Loss and PDL After Each Test

Test Group	BOA Attenuation Value (dB)	Test or Examination	λ (nm)	Requirements (see Note)	Actual Optical Performance After Test (dB)				
					Attenuation		ΔA	RL	PDL
					Min A	Max A			
1	10	Controlled operating environment	1310	9.0 - 11.0 A ≤ 0.5 ΔA ≥ 55 RL ≤ 0.5 PDL	9.8	10.3	0.2	56	0.06
			1550		9.7	10.2	0.2	56	0.06
		Uncontrolled operating environment	1310		9.8	10.4	0.2	56	0.06
			1550		9.7	10.2	0.2	57	0.06
		Non-operating environment	1310		9.8	10.4	0.2	56	0.06
			1550		9.7	10.3	0.2	56	0.05
		Humidity/condensation cycling	1310		9.8	10.4	0.2	57	0.06
			1550		9.6	10.3	0.2	56	0.05
		Water immersion	1310		9.8	10.5	0.1	56	0.06
			1550		9.7	10.4	0.2	56	0.05
		Vibration	1310		9.7	10.4	0.2	56	0.06
			1550		9.6	10.1	0.3	56	0.05
		Durability	1310		9.8	10.5	0.2	57	0.06
			1550		9.6	10.2	0.2	56	0.05
		Impact	1310		9.9	10.5	0.2	56	0.06
			1550		9.7	10.1	0.2	56	0.05

NOTE

A: Attenuation Tolerance
Min A: Minimum Attenuation
Max A: Maximum Attenuation
ΔA: Change in Attenuation
RL: Return Loss
PDL: Polarization Dependent Loss

2.3. Controlled Operating Environment

There was no evidence of physical damage to the BOA due to the controlled operating environment exposure, and no change in attenuation beyond the specified limits after test. Optical performance was measured at 1310 and 1550 nm.

2.4. Uncontrolled Operating Environment

There was no evidence of physical damage to the BOA due to the uncontrolled operating environment test, and no change in attenuation beyond the specified limits after test. Optical performance was measured at 1310 and 1550 nm.

2.5. Non-operating Environment

There was no evidence of physical damage to the BOA due to the three part non-operating environment test. There was no change in attenuation beyond the specified limits after exposure to low temperature with thermal shock, high temperature with thermal shock, and high relative humidity tests. Optical performance was measured at 1310 and 1550 nm before and after the series of tests.

2.6. Humidity/condensation Cycling

There was no evidence of physical damage to the BOA and no change in attenuation beyond the specified limits after humidity/condensation cycling. Optical performance was measured at 1310 and 1550 nm.

2.7. Water Immersion

There was no change in attenuation beyond specified limits after specimens were subjected to the water immersion test. Optical performance was measured at 1310 and 1550 nm, before and after test.

2.8. Vibration

There was no evidence of physical damage to the BOA and no change in attenuation beyond the specified limits after vibration testing. Optical performance was measured at 1310 and 1550 nm.

2.9. Durability

There was no evidence of damage to the BOA and no change in attenuation beyond the specified limits after durability. Optical performance was measured at 1310 and 1550 nm.

2.10. Impact

There was no evidence of physical damage to the build out attenuator and no change in attenuation beyond the specified limits after impact testing. Optical performance was measured at 1310 and 1550 nm.

3. SUMMARY OF RELIABILITY TESTING

3.1. Reliability Test Status Summary Report

No failures occurred during any of the reliability tests. All specimens met optical requirements before, during (where applicable) and after each test. Refer to paragraph 3.3. for a data summary from each test.

Test	Date Completed	Sample Size	Number of Failures	Test Passed
Mechanical shock (impact)	15Apr03	11	0	Yes
Variable frequency vibration	16Apr03	11	0	Yes
Water immersion	22Apr03	11	0	Yes
Thermal shock	24Apr03	11	0	Yes
Temperature cycling	30Jul03	11	0	Yes
Temperature-humidity cycling (cyclic moisture resistance)	08Aug03	11	0	Yes
Low temperature storage	28Jul03	11	0	Yes
High temperature storage (damp heat)	03Nov03	22	0	Yes
High temperature aging (dry heat)	11Nov03	22	0	Yes

3.2. New Product Optical Performance - All Groups

A. Initial Attenuation - All Groups

All initial attenuation measurements met the allowable tolerances. Attenuation was measured at 1310 and 1550 nm.

Attenuation Tolerance - Requirements

BOA Attenuation Value (dB)	Attenuation Tolerance (dB)
1 to 5	± 0.5
> 5	± (0.10 x attenuation value)

Attenuation - Actual for New Product

Test Group	BOA Attenuation Value (dB)	Allowable Attenuation Range (dB)	Actual Initial Attenuation (dB)			
			1310 nm		1550 nm	
			Min	Max	Min	Max
1	10	9.0 - 11.0	9.9	10.2	9.9	10.2
2			9.8	10.3	9.9	10.3
3			9.8	10.2	9.8	10.2
4			9.8	10.4	9.7	10.4

B. Initial Return Loss - All Groups

Return loss for each group met the specification requirement. Return loss was measured at 1310 and 1550 nm.

Initial Return Loss (New Product)

Test Group	BOA Attenuation Value (dB)	Return Loss Requirement (dB average)	Actual Minimum Return Loss (dB)	
			1310 nm	1550 nm
1	10	$\geq$ 55	56	56
2			56	56
3			56	56
4			57	56

C. Initial Polarization Dependent Loss (PDL) - All Groups

The range of PDL measurements for all specimens met the specification requirement. Loss was measured at 1310 and 1550 nm.

Initial PDL (New Product)

Test Group	BOA Attenuation Value (dB)	PDL Requirement (dB)	Actual Maximum PDL Range (dB)	
			1310 nm	1550 nm
1	10	≤ 0.5	0.05	0.05
2			0.05	0.05
3			0.05	0.05
4			0.05	0.05

3.3. Optical Performance After Test - All Groups

All attenuation measurements met the allowable tolerances. All change in attenuation, return loss and PDL measurements met the specification requirements. Measurements were recorded at 1310 and 1550 nm. Values shown in the table represent minimum attenuation, maximum attenuation, maximum change in attenuation, minimum return loss, and maximum PDL observed from any specimen within the test group. Optical performance before each test is the same as optical performance after the prior test, and is therefore not shown twice. For the first test, the new product data in paragraph 3.2. represents the "before test" data.

Test Group	Test or Examination	Test Hours	λ (nm)	Requirements (see Note)	Actual Optical Performance After Test (dB)				
					Attenuation		ΔA	RL	PDL
					Min A	Max A			
1	Mechanical shock (impact)	NA	1310	9.0 - 11.0 A ≤ 0.5 ΔA ≥ 55 RL ≤ 0.5 PDL	9.9	10.3	0.2	56	0.05
			1550		9.9	10.2	0.3	56	0.05
	Variable frequency vibration		1310		9.8	10.3	0.2	56	0.05
			1550		9.8	10.2	0.2	56	0.05
	Water immersion		1310		9.8	10.3	0.2	56	0.05
			1550		10.0	10.3	0.3	56	0.05
	Thermal shock		1310		9.9	10.2	0.2	56	0.05
			1550		9.9	10.3	0.3	56	0.05
	Thermal cycling		1310		9.9	10.3	0.2	56	0.05
			1550		9.9	10.3	0.2	56	0.06
	Temperature-humidity cycling (cyclic moisture resistance)		1310		9.8	10.3	0.1	56	0.05
			1550		10.0	10.3	0.2	56	0.06
2	Low temperature storage	0	1310	9.0 - 11.0 A ≤ 0.5 ΔA ≥ 55 RL ≤ 0.5 PDL	9.8	10.3	NA	56	0.05
			1550		9.9	10.3		56	0.05
		168	1310		9.8	10.3	0.2	56	0.06
			1550		9.9	10.3	0.3	56	0.06
		500	1310		9.8	10.2	0.2	56	0.05
			1550		9.9	10.3	0.3	56	0.06
		1000	1310		9.9	10.2	0.3	56	0.06
			1550		10.0	10.3	0.4	56	0.06
		2500	1310		9.9	10.2	0.4	56	0.06
			1550		9.9	10.3	0.4	56	0.06

Test Group	Test or Examination	Test Hours	λ (nm)	Requirements (see Note)	Actual Optical Performance After Test (dB)				
					Attenuation		ΔA	RL	PDL
					Min A	Max A			
3	High temperature storage (damp heat)	0	1310	9.0 - 11.0 A ≤ 0.5 ΔA ≥ 55 RL ≤ 0.5 PDL	9.8	10.2	NA	56	0.05
			1550		9.8	10.2		56	0.06
		100	1310		9.8	10.2	0.2	56	0.05
			1550		9.7	10.2	0.2	56	0.07
		168	1310		9.7	10.3	0.2	56	0.05
			1550		9.7	10.2	0.2	56	0.06
		500	1310		9.8	10.3	0.2	56	0.05
			1550		9.7	10.4	0.2	56	0.06
		1000	1310		9.8	10.3	0.3	56	0.05
			1550		9.7	10.3	0.4	56	0.06
		2000	1310		9.9	10.3	0.2	56	0.05
			1550		9.7	10.4	0.2	56	0.06
4	High temperature aging (dry heat)	0	1310	9.0 - 11.0 A ≤ 0.5 ΔA ≥ 55 RL ≤ 0.5 PDL	9.8	10.4	NA	57	0.05
			1550		9.7	10.4		56	0.06
		168	1310		9.8	10.5	0.2	56	0.06
			1550		9.8	10.4	0.2	56	0.07
		500	1310		9.8	10.4	0.2	57	0.06
			1550		9.7	10.5	0.3	56	0.06
		1000	1310		9.9	10.4	0.2	56	0.06
			1550		9.8	10.4	0.2	56	0.06
		2000	1310		9.9	10.3	0.4	56	0.06
			1550		9.8	10.4	0.3	56	0.06
		5000	1310		9.9	10.3	0.3	56	0.05
			1550		9.8	10.4	0.2	56	0.06

NOTE *A: Attenuation*
ΔA: Change in Attenuation
RL: Return Loss
PDL: Polarization Dependent Loss

4. QUALIFICATION TEST METHODS

4.1. Initial Optical Performance - New Product

A. Attenuation Tolerance

All singlemode attenuation was measured in accordance with IEC 61300-3-4 or FOTP-171, Method D3, processes. The initial optical power through the test leads was measured. The attenuator specimen was inserted between the test leads and optical power was measured. The attenuation was calculated by taking the difference between the initial and the final measurements.

The measured attenuation was compared to the fixed attenuator value. The difference must meet the permissible tolerance for that attenuator value. Attenuation was measured at 1310 and 1550 nm.

After each sequential test, optical power readings were permitted to be compensated by changes in a source monitor cable. In cases where a control cable was also used and exceeded limits stated in the specification, the change in the control cable was also allowed to be factored into the loss.

B. Return Loss

Singlemode return loss was developed in accordance with IEC 61300-3-6 or FOTP-107 Method A, and similar Telcordia GR-326, continuous wave process. An optical source and PDL meter were used to measure return loss at 1310 and 1550 nm.

C. Polarization Dependent Loss (PDL)

Using an optical source and PDL meter, the PDL loss of an attenuator was measured between reference-quality test leads. PDL was recorded at 1310 and 1550 nm.

4.2. Change in Attenuation

The initial optical power (dBm) through the specimens was recorded before the test using an optical source and detector. Relative optical power (dB) through the fiber was measured after each test. Change in attenuation was calculated by taking the difference between the initial measurement and the final/after measurements. Optical power readings were compensated by changes in the source monitor cable.

In cases where a control cable was also used and exceeded limits stated in the specification, the change in the control cable could also be factored into the loss.

4.3. Controlled Operating Environment

Specimens were subjected to the test profile described in Section 5.1.2 of GR-63-CORE, which cycles between -5 and 50˚C with relative humidity varying between 5 and 95%. Exposure time was at least 182 hours. Optical performance was recorded before and after test with specimens at ambient conditions.

4.4. Uncontrolled Operating Environment

Specimens were subjected to 21 cycles of temperature extremes for a period of 168 hours, (7 days). Each cycle contained ramp and dwell times of 1.0 hour. The cycle started with a hot ramp/dwell to 75˚C then ramp/dwell back to ambient of 23˚C followed by a cold ramp/dwell of -40˚C. Optical performance was recorded before and after exposure with the specimens at ambient conditions.

4.5. Non-operating Environment

Specimens were exposed to a three part test. Part 1 consisted of 72 hours at -40˚C then thermal shock (less than 5 minute transition time) back to ambient. Part 2 consisted of 72 hours at 70˚C, then thermal shock back to ambient. Part 3 consisted of 96 hours at 40˚C with 90-95% relative humidity. Optical performance was recorded before Part 1 and after completion of Part 3.

4.6. Humidity/condensation Cycling

Specimens were subjected to 14 cycles of temperature/humidity cycling for a period of 168 hours (7 days). Each cycle consisted of -10 to 65˚C with $\geq$ 90% RH at 65˚C and 23˚C. Optical performance for each specimen was recorded at ambient conditions before and after humidity exposure.

4.7. Water Immersion

Specimens were immersed in water with pH of 5.5 ± 0.5 at 43 ± 2˚C for 168 hours (7 days). Optical performance was measured at ambient conditions before test and approximately 24 hours after test.

4.8. Vibration

Specimens were subjected to sinusoidal vibration, having a simple harmonic motion with amplitude of 1.52 mm [0.060 in] double amplitude. The vibration frequency was varied uniformly between the limits of 10 and 55 Hz and back to 10 Hz in approximately 4 minutes for one cycle. Exposure time was 2 hours per axis in each of the three mutually perpendicular planes, for a total vibration time of six hours per specimen. Optical performance was recorded before and after test with the specimens at ambient conditions.

4.9. Durability

Each build out attenuator was subjected to 200 cycles of durability. Specimens were mounted at 3, 4.5 and 6 feet heights per GR-326-CORE, and cycled at a rate not in excess of 300 cycles per hour. Optical performance was measured at ambient conditions before and after test.

4.10. Impact

The attenuator was dropped 8 times from a height of 1.8 m [6 ft]. The impact test was performed in all three axes for a total of 24 impacts per specimen. Initial optical performance was recorded before the specimen was unmated and subjected to testing. Final optical performance was recorded after all specimens were tested, inspected, cleaned and re-mated.

5. RELIABILITY TEST METHODS

5.1. Mechanical Shock (Impact)

The unmated and uncapped attenuator was dropped eight times from a height of 1.8m [6 ft]. The impact exposure was repeated 5 times in each of three mutually perpendicular axes. Initial optical performance was recorded before the specimen was unmated and exposed to testing. Final optical performance was recorded after all specimens were tested, inspected, cleaned and re-mated.

5.2. Variable Frequency Vibration

Specimens were subjected to 10-2000-10 Hz at 20 G. One cycle was traversed in 20 minutes. Perform 12 cycles in each of three mutually perpendicular planes. Optical performance was recorded before and after exposure.

5.3. Water Immersion

Specimens were submersed in water for 168 hours (7 days). Water was 43 ± 2˚C with pH of 5.5 ± 0.5. Optical performance was recorded at ambient before and after test.

5.4. Thermal Shock

Specimens were subjected to 20 cycles between 0 and 100˚C. Each cycle contained a 30 minute dwell at each temperature extreme with transfer time less than 2 minutes. Optical performance was recorded at ambient before and after the exposure.

5.5. Temperature Cycling

Specimens were subjected to 500 cycles between -40 and 75˚C. Optical performance was recorded at ambient before exposure and at the completion of testing.

5.6. Temperature-humidity Cycling

Specimens were subjected to 5 cycles between -40 and 75˚C with 90% relative humidity at 75˚C. Each cycle consisted of a 5 hour dwell at each temperature extreme. Optical performance was recorded at ambient before and after test.

5.7. Low Temperature Storage

Specimens were subjected to 2500 hours at -40˚C. Specimens were removed from the chamber and optical performance measured at 0, 168, 500, 1000 and 2500 hours.

5.8. High Temperature Storage (Damp Heat)

Specimens were subjected to 2000 hours at 85˚C with 85% relative humidity. Specimens were removed from the chamber and optical performance measured at 0, 100, 168, 500, 1000 and 2000 hours.

5.9. High Temperature Aging (Dry Heat)

Specimens were subjected to 5000 hours at 85˚C with relative humidity less than 40%. Specimens were removed from the chamber and optical performance measured at 0, 168, 500, 1000, 2000 and 5000 hours.