LC Duplex Sealed Plug and Receptacle Singlemode and Multimode Connectors (ODVA Conforming)

1. INTRODUCTION

1.1. Purpose

Testing was performed on Tyco Electronics Fiber Optic LC Duplex Sealed Plug and Receptacle Singlemode and Multimode Connectors, Open DeviceNet Vendor Association, Inc. (ODVA conforming) to determine their conformance to the requirements of Product Specification 108-2227, Revision A, which is based on IEC 61753-1 Ed. 1.0 tests for Category E (Extreme Environment).

1.2. Scope

This report covers the optical, environmental, and mechanical performance of the LC Duplex Sealed Plug and Receptacle Connectors (ODVA Conforming), manufactured by Tyco Electronics, Fiber Optics Business Unit. Testing was performed between 02Oct06 and 12Feb09. The test file numbers for this testing are B069417-007, B069417-012, and B069417-014.

1.3. Conclusion

LC Duplex Sealed Plug and Receptacle Singlemode Connectors (ODVA Conforming), listed in paragraph 1.5, meet the optical, environmental, and mechanical performance requirements of Product Specification 108-2227, Revision A.

LC Duplex Sealed Plug and Receptacle Multimode Connectors (ODVA Conforming), listed in paragraph 1.5, meet the optical performance requirements of Product Specification 108-2227, Revision A. Environmental and mechanical performance are assumed qualified by similarity to LC Duplex Sealed Plug and Receptacle Singlemode Connectors (ODVA Conforming).

1.4. Product Description

Tyco Electronics LC Duplex Sealed Plug and Receptacle Connectors (ODVA Conforming) provide an environmentally sealed interface to mate a duplex LC connector to another duplex LC connector. These plug and receptacle connectors are IP67 rated to ensure protection from dust and water immersion and are ideal for fiber optic systems in harsh environments where chemicals, corrosive gases and liquids are commonplace.

1.5. Test Specimens

Test specimens were produced using normal manufacturing means. Mechanical test specimens consisted of an LC Duplex Sealed Plug pigtail mated to a standard LC duplex connector by use of an LC Duplex Sealed Receptacle. In addition to pigtail configuration, environmental test specimens also consisted of LC Duplex Sealed Plug-to-Plug jumpers mated between standard LC duplex connectors by use of LC Duplex Sealed Receptacles at each end.

Component Description	Test Group							
	1	2	3	4	5	6	7	8
Plug Connector Kit PN	1828618-2							1828618-1
Plug Termination Cable	1828719-4 Note (a)	1985529-4 Note (b)	1828719-4 Note (a)	1985529-4 Note (b)		6828719-1 Note (c)		1985529-2 Note (d)
Plug Cable Assembly PN	1828936-4 and 1828936-3	1985654-4 and 1985654-3	1828936-4	1985654-4		1918501-1		1918819-5
Plug Cable Test Length (m)	2 m pigtail 3 m jumper		2 m Note (e)			0.152 m		2.5 m Note (f)
Receptacle Kit PN	1828619-2							1828619-1
Test Lead Cable Assembly PN Note (g)	6374657-6					None required		1828899-1
Test Adapter PN Note (h)	1693648-2		NA					
Test Specimen Quantity	8 pigtails 4 jumpers		8 pigtails			4 each configuration Note (I)	4 each configuration Note (j)	10 pigtails
Control Cable Required	Yes		No					

NOTE

(a) 6.5 mm military tactical, singlemode, 2-fiber breakout cable.
(b) 7 mm singlemode, 2-fiber breakout cable.
(c) 6.5 mm military tactical, multimode 62.5/125 μm, 2-fiber indoor/outdoor breakout cable.
(d) 7.5 mm multimode 50/125 μm, OFNR, 2-fiber indoor/outdoor breakout cable.
(e) Four, 4-meter cable assemblies were cut in half to create 8 pigtail specimens, 2 m each.
(f) Five, 5-meter cable assemblies were cut in half to create 10 pigtail specimens, 2.5 m each.
(g) Singlemode: Standard LC duplex SM cable assembly, LDD, 2.0 mm zipcord, OFNR, 10 m length, cut in half and used as pigtails. Multimode: Standard LC duplex to dual FC MM 50/125 μm, 2.0 mm zipcord, OFNP, 6 m.
(h) Duplex LC Adapter, Singlemode, blue; used for reference reading of jumper specimens.
(I) Optically inactive specimens. Quantity consisted of 4 plug-to-receptacle and 4 capped receptacles.
(j) Optically inactive specimens. Quantity consisted of 4 plug-to-receptacle, 4 capped plugs and 4 capped receptacles.

1.6. Product Qualification Test Sequence

Test or Examination	Test Groups (a)							
	1	2	3	4	5	6	7	8
	Test Sequence (b)							
Visual and mechanical inspection	1	1	1	1	1	1	1	1
Attenuation	2	2	2	2	2			2
Return loss	3	3	3	3	5			3
Cold	4							
Change of temperature	5							
Dry heat (high temperature endurance)		4						
Composite temperature/humidity cyclic test		5						
Torsion (twist)			4					
Impact			5					
Cable retention, axial pull				4				
Cable retention, right angle pull					4			
Dust protection						2		
Temporary water immersion							2	

NOTE

(a) See paragraph 1.5.
(b) Numbers indicate sequence in which tests are performed.
(c) A specimen consists of a mated duplex connector pair, except where noted in paragraph 3 (such as capped specimens for sealing tests).

2. SUMMARY OF TESTING

2.1. Visual and Mechanical Inspection - All Groups

All specimens submitted for testing were manufactured by Tyco Electronics using normal production processes, and were inspected and accepted by the Product Assurance Department of the Fiber Optics Business Unit.

Specimens are assumed to be compliant with IEC 61754-20 dimensions per Tyco Electronics First Article approval, which includes verification of product drawings per the dimensions specified in IEC 61754-20.

Five dimensions from IEC 61754-20 (Fiber Optic Connector Interface Standard - Type LC Connector Family) were measured on specimens from Groups 1, 3 and 7. All were verified to meet dimensional requirements.

2.2. Initial Optical Performance - Groups 1, 2, 3, 4, 5 and 8

All attenuation and return loss measurements met the specification requirements. Singlemode attenuation and return loss were measured at 1310 and 1550 nm.

Attenuation and Return Loss - Requirements for New Product (dB)

Performance Criteria	Requirements for All Test Groups		
	Singlemode		Multimode
	Pigtail (1 mated connector pair)	Jumper (2 mated connector pairs)	Pigtail (1 mated connector pair)
Maximum allowed average attenuation among all groups	0.25	0.50	0.25
Maximum allowed attenuation for > 97% of all specimens	0.50	1.00	0.50
Maximum allowed attenuation for any individual specimen	0.75	1.50	0.75
Minimum allowed return loss for any individual specimen	40	37	20

Attenuation and Return Loss - Actual for New Product (dB)

Performance Criteria	Actual for Singlemode Test Groups 1, 2, 3, 4 and 5				Actual for Multimode Test Group 8	
	Pigtail		Jumper		Pigtail	
	1310 nm	1550 nm	1310 nm	1550 nm	850 nm	1300 nm
Group average attenuation	0.10	0.10	0.24	0.20	0.10	0.08
Maximum attenuation for > 97% of all specimens	0.27	0.32	0.58	0.54	0.31	0.28
Maximum attenuation for 100% of all specimens	0.43	0.51	0.58	0.54	0.33	0.43
Minimum return loss for 100% of all specimens	49	49	49	49	29	31

2.3. Attenuation, Change in Attenuation and Return Loss - All Groups (as applicable)

All attenuation, change in attenuation and return loss measurements met the specification requirements. Attenuation and return loss were measured at 1310 and 1550 nm for singlemode and at 850 and 1300 nm for multimode. Values shown in the table below represent maximum attenuation, maximum change in attenuation, and minimum return loss.

Maximum Attenuation, Maximum Change in Attenuation, and Minimum Return Loss Results (dB)

Test Group	Condition	Specimen Configuration	Requirements (1310 and 1550 nm)			Actual (1310 nm)			Actual (1550 nm)		
			Before	During	After	Before	During	After	Before	During	After
			Atten (A) RL (R)	Atten (A) Change In Atten (ΔA) RL (R)		Atten (A) RL (R)	Atten (A) Change In Atten (ΔA) RL (R)		Atten (A) RL (R)	Atten (A) Change In Atten (ΔA) RL (R)	
1	Cold	Pigtail	0.50 (A) 40 (R)	0.50 (A) 0.2 (ΔA) 40 (R)	0.50 (A) 0.2 (ΔA) 40 (R)	0.34 (A) 53 (R)	0.34 (A) 0.1 (ΔA) 52 (R)	0.28 (A) 0.1 (ΔA) 53 (R)	0.29 (A) 54 (R)	0.41 (A) 0.2 (ΔA) 54 (R)	0.32(A) 0.1 (ΔA) 55 (R)
		Jumper	1.00 (A) 37 (R)	1.00 (A) 0.5 (ΔA) 37 (R)	1.00 (A) 0.4 (ΔA) 37 (R)	0.61 (A) 51 (R)	0.81 (A) 0.2 (ΔA) 50 (R)	0.57 (A) 0.1 (ΔA) 51 (R)	0.35 (A) 51 (R)	0.54 (A) 0.2 (ΔA) 51 (R)	0.37 (A) 0.2 (ΔA) 51 (R)
	Change of Temperature	Pigtail	0.50 (A) 40 (R)	0.50 (A) 0.2 (ΔA) 40 (R)	0.50 (A) 0.2 (ΔA) 40 (R)	0.28 (A) 53 (R)	0.40 (A) 0.2 (ΔA) 52 (R)	0.32 (A) 0.1 (ΔA) 53 (R)	0.32 (A) 55 (R)	0.47 (A) 0.2 (ΔA) 54 (R)	0.43 (A) 0.1 (ΔA) 55 (R)
		Jumper	1.00 (A) 37 (R)	1.00 (A) 0.5 (ΔA) 37 (R)	1.00 (A) 0.4 (ΔA) 37 (R)	0.57 (A) 51 (R)	0.82 (A) 0.4 (ΔA) 51 (R)	0.62 (A) 0.1 (ΔA) 51 (R)	0.37 (A) 5 (R)	0.65 (A) 0.5 (ΔA) 51 (R)	0.50 (A) 0.3 (ΔA) 51 (R)
2	Dry Heat (High Temperature Endurance)	Pigtail	0.50 (A) 40 (R)	0.50 (A) 0.2 (ΔA) 40 (R)	0.50 (A) 0.2 (ΔA) 40 (R)	0.24 (A) 53 (R)	0.24 (A) 0.1 (ΔA) 53 (R)	0.24 (A) 0.1 (ΔA) 55 (R)	0.25 (A) 52 (R)	0.25 (A) 0.2 (ΔA) 52 (R)	0.22 (A) -0.1 (ΔA) 55 (R)
		Jumper	1.00 (A) 37 (R)	1.00 (A) 0.5 (ΔA) 37 (R)	1.00 (A) 0.4 (ΔA) 37 (R)	0.62 (A) 48 (R)	0.70 (A) 0.1 (ΔA) 48 (R)	0.73 (A) 0.1 (ΔA) 52 (R)	0.56 (A) 47 (R)	0.56 (A) 0.1 (ΔA) 47 (R)	0.61 (A) 0.1 (ΔA) 51 (R)
	Composite Temperature/Humidity Cyclic Test	Pigtail	0.50 (A) 40 (R)	0.50 (A) 0.2 (ΔA) 40 (R)	0.50 (A) 0.2 (ΔA) 40 (R)	0.24 (A) 55 (R)	0.24 (A) 0.1 (ΔA) 53 (R)	0.23 (A) 0.1 (ΔA) 54 (R)	0.22 (A) 56 (R)	0.22 (A) 0.1 (ΔA) 52 (R)	0.22 (A) 0.0 (ΔA) 54 (R)
		Jumper	1.00 (A) 37 (R)	1.00 (A) 0.5 (ΔA) 37 (R)	1.00 (A) 0.4 (ΔA) 37 (R)	0.72 (A) 52 (R)	0.91 (A) 0.3 (ΔA) 49 (R)	0.82 (A) 0.1 (ΔA) 50 (R)	0.59 (A) 51 (R)	0.68 (A) 0.1 (ΔA) 48 (R)	0.56 (A) 0.0 (ΔA) 50 (R)
3	Torsion (Twist)	Pigtail	0.50 (A) 40 (R)	0.50 (A) 0.2 (ΔA) 40 (R)	0.50 (A) 0.2 (ΔA) 40 (R)	0.25 (A) 53 (R)	0.27 (A) 0.0 (ΔA) 53 (R)	0.27 (A) 0.0 (ΔA) 53 (R)	0.21 (A) 53 (R)	0.21 (A) 0.1 (ΔA) 54 (R)	0.21 (A) 0.1 (ΔA) 54 (R)
	Impact	Pigtail	0.50 (A) 40 (R)	NA	0.50 (A) 0.2 (ΔA) 40 (R)	0.27 (A) 53 (R)	NA	0.26 (A) 0.1 (ΔA) 53 (R)	0.21(A) 54 (R)	NA	0.30 (A) 0.2 (ΔA) 54 (R)
4	Cable Retention, Axial Pull	Pigtail	0.50 (A) 40 (R)	0.50 (A) 0.2 (ΔA) 40 (R)	0.50 (A) 0.2 (ΔA) 40 (R)	0.38 (A) 51 (R)	0.32 (A) 0.0 (ΔA) 51 (R)	0.35 (A) 0.0 (ΔA) 51 (R)	0.38 (A) 52 (R)	0.29 (A) 0.0 (ΔA) 52 (R)	0.32 (A) 0.0 (ΔA) 52 (R)
	Cable Retention, Right Angle Pull	Pigtail	0.50 (A) 40 (R)	0.50 (A) 0.2 (ΔA) 40 (R)	0.50 (A) 0.2 (ΔA) 40 (R)	0.35 (A) 53 (R)	0.36 (A) 0.0 (ΔA) 53 (R)	0.33 (A) 0.0 (ΔA) 53 (R)	0.24 (A) 53 (R)	0.38 (A) 0.2 (ΔA) 53 (R)	0.23 (A) 0.0 (ΔA) 54 (R)
5	Dust Protection	Pigtail	No optical requirements.			Results given in paragraph 2.12. See Note.					
6	Temporary Water Immersion	Pigtail	No optical requirements.			Results given in Paragraph 2.13. See Note.					
7	Attenuation and Return Loss	Pigtail	See paragraph 2.2.								

NOTE

For Dust Protection and Temporary Water Immersion tests, pigtail specimens were optically inactive
(A) - Maximum Attenuation
(ΔA) - Maximum Change in Attenuation
(R) - Minimum Return Loss

2.4. Cold - Group 1

There was no evidence of physical damage to the plug, receptacle or mating cable assemblies during or after cold temperature test, and no change in optical performance beyond the specified limits. Optical performance was measured at 1310 and 1550 nm for singlemode specimens.

2.5. Change of Temperature - Group 1

There was no evidence of physical damage to the plug, receptacle or mating cable assemblies during or after change of temperature test, and no change in optical performance beyond the specified limits. Optical performance was measured at 1310 and 1550 nm for singlemode specimens.

2.6. Dry Heat (High Temperature Endurance) - Group 2

There was no evidence of physical damage to the plug, receptacle or mating cable assemblies during or after dry heat test, and no change in optical performance beyond the specified limits. Optical performance was measured at 1310 and 1550 nm for singlemode specimens.

2.7. Composite Temperature/Humidity Cyclic Test - Group 2

There was no evidence of physical damage to the plug, receptacle or mating cable assemblies during or after temperature humidity cycling, and no change in optical performance beyond the specified limits. Optical performance was measured at 1310 and 1550 nm for singlemode specimens.

2.8. Torsion (Twist) - Group 3

There was no evidence of physical damage to the connector or attached cable during or after torsion, and no change in optical performance beyond the specified limits. Optical performance was measured at 1310 and 1550 nm for singlemode specimens.

2.9. Impact - Group 3

There was no evidence of physical damage to the connector or attached cable after impact, and no change in optical performance beyond the specified limits. Optical performance was measured at 1310 and 1550 nm for singlemode specimens.

2.10. Cable Retention, Axial Pull - Group 4

There was no evidence of fiber pullout, or other damage to the connector or attached cable during or after cable retention, and no change in optical performance beyond the specified limits. Optical performance was measured at 1310 and 1550 nm for singlemode specimens.

2.11. Cable Retention, Right Angle Pull - Group 5

There was no evidence of fiber pullout, or other damage to the connector or attached cable during or after cable retention, and no change in optical performance beyond the specified limits. Optical performance was measured at 1310 and 1550 nm for singlemode specimens.

2.12. Dust Protection - Group 6

There was no evidence of talcum powder dust past the cap seal, within the receptacle, past the plug connector or past the interface seal after completion of dust exposure. Specimens met criteria for International Protection Code rating IP6X.

2.13. Temporary Water Immersion - Group 7

There was no evidence of water ingress past the cap seal or within the plug, receptacle, or enclosure after completion of temporary water immersion test. Specimens met criteria for International Protection Code rating IPX7

3. TEST METHODS

The singlemode environmental measurement facility is an automated, TIA-455-20B compliant test system. A build-up method of specimen installation onto the test facility was used in determining insertion loss. Following installation of the specimens and test leads, initial optical performance was recorded, then the sequential testing was performed.

The multimode measurement facility consisted of a TIA-455-20B compliant test system which includes a Category 1 source and optical power meter. Launch leads were mandrel wrapped to maintain Category 1 conditions according to TIA/EIA-526-14A requirements. Initial optical measurements were obtained according to TIA/EIA-455-171A procedures.

3.1. Visual and Mechanical Inspection

Product drawings and inspection plans were used to examine the specimens. They were examined visually and functionally.

In addition, dimensions D, H1, H2, K, and O, as defined in the Fiber Optic Connector Interfaces Standard (FOCIS), IEC 61754-20, were measured on specimens from Test Groups 1, 3 and 7. For specimens in all other groups, fiber optic connector interface dimensions are assumed to be comparable to those specimens that were measured. Parts are also assumed to be compliant with IEC 61754-20 dimensions based on Tyco Electronics First Article approval, which included verification of product drawings per the dimensions specified in IEC 61754-20.

3.2. Attenuation

All attenuation was measured in accordance with IEC 61300-3-4 processes, except the launch and receive are both part of the pair under test and are not reference quality.

For singlemode pigtail specimens, the initial optical power through each of the selected launch connector fibers was measured. The connector assembly was then mated and final optical power measured from the receive side cable assembly. The attenuation was calculated by taking the difference between the initial measurement and the final measurement.

For singlemode jumper specimens, LC connectors from the launch and receive leads were mated with an LC adapter and initial power through each fiber was measured. The jumper was then inserted between launch and receive leads, and final optical power was measured. The attenuation was calculated by taking the difference between the initial measurement and the final measurement.

For multimode specimens (Test Group 8), 10 plug pigtails, 10 LC ODVA receptacles and 10 LC duplex launch leads were used. Each plug pigtail was mated to 5 different launch leads, each with a different receptacle, producing a total of 100 random mate attenuation data. Launch condition was Category 1, overfilled.

Optical power readings were 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 factored into the loss.

3.3. Average Attenuation

After attenuation was recorded for each individual specimen, the average attenuation was calculated for all specimens from all groups.

3.4. 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 during and after each test as applicable. Change in attenuation was calculated by taking the difference between the initial measurement and the during/after measurements, and recording the maximum range of all values for a specimen. 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 was also factored into the loss.

3.5. Return Loss

Return loss was measured in accordance with IEC 61300-3-6. A single return loss reading was recorded for each singlemode specimen at each measurement interval. Return loss was measured initially and during/after each test evaluation, as applicable.

For multimode specimens (Test Group 8), 10 plug pigtails, 10 LC ODVA receptacles and 10 LC duplex launch leads were used. Each plug pigtail was mated to 5 different launch leads, each with a different receptacle, producing a total of 100 random mate return loss data.

3.6. Cold

In accordance with IEC 61300-2-17 Test Ab, initial optical performance was measured after specimens remained undisturbed in the chamber for 2 hours at ambient conditions. Mated specimens were subjected to -40˚C for a period of 96 hours. Optical performance was recorded before and after exposure with the specimens in place in the test chamber and at 15 minute intervals throughout the exposure. Final optical performance was recorded after the specimens remained undisturbed at ambient conditions for 2 hours.

3.7. Change of Temperature

In accordance with IEC 61300-2-22 Test Nb, initial optical performance was measured after specimens remained undisturbed in the chamber for at least 2 hours at ambient conditions. Mated specimens were subjected to 12 cycles of temperature extremes. Each cycle contained a 1 hour dwell at 85˚C and a 1 hour dwell at -40˚C. All cycles used a ramp rate of 1˚C per minute. Optical performance was recorded before and after exposure with the specimens in place in the test chamber and at 10 minute intervals throughout the exposure. Final optical performance was recorded after the specimens remained undisturbed at ambient conditions for at least 2 hours.

3.8. Dry Heat (High Temperature Endurance)

In accordance with IEC 61300-2-18 Test Bb, initial optical performance was measured after specimens remained undisturbed in the chamber for 2 hours at ambient conditions. Mated specimens were subjected to 85˚C for a period of 96 hours. Optical performance was recorded before and after exposure with the specimens in place in the test chamber and at 15 minute intervals throughout the exposure. Final optical performance was recorded after the specimens remained undisturbed at ambient conditions for 2 hours.

3.9. Composite Temperature/Humidity Cyclic Test

Specimens were tested in accordance with IEC 61300-2-21 Test Z/AD with exposure to cold. Mated specimens were pre-conditioned for 24 hours at 55˚C and 20% relative humidity. Initial optical measurements were recorded after specimens stabilized at ambient conditions (25˚C and 50% RH) for 2 hours. Specimens were subjected to Test Z/AD from IEC 68-2-38. This profile contained 3-hour dwells at -10˚C and 65˚C with 95% relative humidity at the maximum temperature. A total of 10 cycles were performed. The cold temperature sub-cycle was run during the first 5 cycles only. Optical performance for each specimen was recorded before and after exposure with the specimens in place in the test chamber and at 10-minute intervals throughout the exposure. Final optical performance was recorded after the specimens remained undisturbed at ambient conditions for 24 hours.

3.10. Torsion (Twist)

Testing was performed in accordance with IEC 61300-2-5. Specimens were manually subjected to 25 cycles of cable twisting. The plug was mounted to a fixture and a mandrel was used to attach a 15 N [3.4 lbf] tensile load to the breakout cable at a point 25 cm [9.8 in] from the plug. The loaded side of the cable was twisted +/- 180 degrees per cycle. Optical performance was measured before and after test with the load removed. During the test, attenuation and return loss were measured once at the +/- 180 degree extreme positions.

3.11. Impact

Specimens were tested in accordance with IEC 61300-2-12 Method A. An unmated connector plug was manually dropped from a height of 1.5 m [5 ft] onto a steel plate. The impact exposure was performed 8 times. Because the sample alone was not at the appropriate length, Panduit braiding was added to create a length of 2.45 m [6.0 ft]. 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. After completion of the test, specimens were visually inspected for damage.

3.12. Cable Retention, Axial Pull

Specimens were tested in accordance with IEC 61300-2-4. A fixture plate was placed behind the coupling nut of a plug connector so that the load was applied to the fiber/cable retention mechanism and not the coupling mechanism. A 7.6 cm [3 in] mandrel was used to apply a 100 N [22.5 lbf] load to the cable at a point 25.4 cm [10 in] from the strain relief. The first 5 N was applied at a rate of 2.54 cm per minute [1 in/min] and then the remainder of the 100 N [22.5 lbf] load was applied at a rate of 5 N per second [1 lbf/s]. The load was held for 120 seconds. Thirty seconds after the full load was reached, optical measurements were recorded. Attenuation and return loss were also measured before and after test with the load removed.

3.13. Cable Retention, Right Angle Pull

Specimens were tested in accordance with IEC 61300-2-7. The receptacle was mounted to a plate that was secured to the tensile tester. The plug was mated to the receptacle. A 40 N [9.0 lbf] load was applied at a 90 degree pull angle by wrapping the cable around a 7.6 cm [3 in] mandrel at a point approximately 25.4 cm [10 in] from the strain relief. The load was applied at a rate of approximately 5 N per second [1 lbf/s]. Only a 30 second duration was required, but more time was needed to record optical measurements which resulted in a hold time of at least 66 seconds. The full load was held for a minimum of 10 seconds before recording optical performance. Attenuation and return loss were also measured before and after test with the load removed. Each specimen was tested once in one of the following directions: LC connector latches up, latches down, or latches to the side. At least 2 specimens were tested in each position.

3.14. Dust Protection

Testing was performed in accordance with IEC 60529, International Protection Code rating IP6X. Four specimens were tested as follows. An unmated receptacle was mounted to a panel and tightened to a torque of 2.26 Nom [20 lbf-in]. The protective cap was mated to the receptacle. The specimen was placed inside the dust chamber with the panel secured to the face of the chamber. A vacuum attachment was placed over the exposed half of the receptacle and the panel. With the vacuum, an atmospheric depression of between 0.26 and 0.28 psi was created which attempted to draw dust into the receptacle and to the other side of the mounting panel. The specimens were exposed to a circulation of 2 kg/m3 [0.125 lbf/ft3] of talcum powder for a 2 hour duration. After test, a microscope was used to inspect specimens at a minimum of 10X magnification.

A plug cable assembly was mated and locked to a receptacle to create a mated condition. The test was repeated for four specimens in mated configuration.

3.15. Temporary Water Immersion

Testing was performed in accordance with IEC 60529, International Protection Code rating IPX7. Specimens were immersed in water to a depth of 1000 mm [39.37 in] for 30 minutes. Four specimens were subjected to each of the following three tests:

Part 1: Unmated receptacle with cap. An unmated receptacle was mounted to a water-tight enclosure by tightening the receptacle fitting to a torque of 2.26 N•m [20 lbf-in]. A protective cap was placed over the exposed end of the receptacle.

Part 2: Mated receptacle. A receptacle was mounted to a water-tight enclosure by tightening the receptacle fitting to a torque of 2.26 N•m [20 lbf-in]. A plug cable assembly was mated and locked to the receptacle.

Part 3: Unmated plug with cap. A protective cap was placed on the plug and the plug cable assembly was immersed.

Specimens were subjected to a water depth at which the bottom of the enclosure was 1000 mm [39.4 in] below the water surface and the highest point of the enclosure was more than 150 mm [5.9 in] below the water surface. Following the test, specimens were visually inspected for any sign of water ingress.