## LightCrimp* Plus Singlemode SC Connector (Field Installable)

### 1. INTRODUCTION

#### 1.1. Purpose

Testing was performed on CS Connectivity (CS) LightCrimp* Plus singlemode SC fiber optic connectors terminated to 900 μm tight buffer fiber or 3 mm jacketed cable to determine their conformance to the requirements of Product Specification 108-2138, Revision D, which meets the Optical Fiber Cabling Components Standard ANSI/TIA-568-C.3.

#### 1.2. Scope

This report covers the optical, environmental, and mechanical performance of LightCrimp Plus singlemode SC fiber optic connectors, manufactured by CS. Testing was performed on standard product between 16May03 and 21Oct03 for 900 micron fiber termination, and between 26Sep05 and 14Aug07 for 3 mm jacketed cable termination. Testing was performed on APC digital product between 24Nov08 and 01Dec08, and on APC analog product between 28June11 and 29June11. Both APC digital and analog products were 900 micron fiber terminations. The test file numbers for this testing are B034073 003, B034073 011, K160 017, K160 025, B108822 002 and B085500 009.

#### 1.3. Conclusion

LightCrimp Plus singlemode SC standard fiber optic connectors terminated to 900-micron tight buffer fiber and 3 mm jacketed cable meet or exceed the optical, environmental, and mechanical performance requirements of Product Specification 108-2138, Revision C, and the Optical Fiber Cabling Components Standard ANSI/TIA-568-C.3.

LightCrimp Plus singlemode SC APC digital and analog connectors terminated to 900 micron tight buffered fiber meet the optical performance requirements of Product Specification 108 2138, Revision C, and the Optical Fiber Cabling Components Standard ANSI/TIA 568 C.3. Environmental and mechanical performance are assumed to be qualified by similarity to the standard LightCrimp Plus singlemode SC connector.

#### 1.4. Product Description

The LightCrimp Plus singlemode SC fiber optic connectors are field installable connectors that are used in data communication and telecommunications networks and equipment.

LightCrimp Plus SC APC connectors can be used in digital applications where return loss requirements are less than 55 dB and in analog applications where return loss requirements are less than 60 dB.

1.5. Test Specimens

Test specimens were manufactured using normal production means. Specimens consisted of a mated connector pair and the following supplies outlined below.

| Component Description | Test Group | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| Fiber size (microns/microns) | 9/125 | | | | | | |
| Termination cable type (launch) | 900 µm Buffered Fiber | | 3 mm Jacketed Fiber | | | 900 µm Buffered Fiber | |
| Termination cable PN | 599208-6 | | 5599734-6 | | | 6828209-6 | |
| Connector kit PN | 1693276-1 | | | | | 2064184-1 | 1985155-1 |
| Coupling receptacle PN | 1278348-7 | | 6278348-3 | | | 1695150-1 | |
| Mating connector PN (receive) | 504646-2 (connector kit) | | 5492015-4 (cable assembly) | | | 1457108-1 (cable assembly) | |
| Test specimen quantity (see Note) | 8 | 10 | 16 | 30 | 8 | 30 | 16 |
| Control cable required | 1 | 0 | 1 | 0 | 0 | 0 | 0 |

**NOTE** *Refer to Product Specification 108-2138 for minimum specimen quantities required. The table above shows the actual quantity tested. For Test Group 4, a quantity of 30 connectors were terminated and measured for initial attenuation and return loss, after which 8 were randomly selected for mechanical tests, and are shown as Group 5.*

1.6. Qualification Test Sequence

| Test or Examination | Test Groups | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4(a) | 5(b) | 6 | 7 |
| Visual and mechanical inspection | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Attenuation (insertion loss) | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| Return loss | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| Low temperature | 4 | | 5 | | | | |
| Temperature life | 5 | | 4 | | | | |
| Humidity, steady state | | | 6 | | | | |
| Durability | | | 7 | | | | |
| Strength of coupling mechanism | 6 | | | | 4 | | |
| Cable retention, 0 degree | | 6 | | | 5 | | |
| Cable retention, 90 degree | | 7 | | | 6 | | |
| Flex | | 4 | | | 7 | | |
| Twist | | 5 | | | 8 | | |
| Impact | | | | | 9 | | |

**NOTE**

*(a) Key FOCIS dimensions were verified on a quantity of 8 specimens.*

*(b) Samples from Group 5 were sourced from Group 4.*

## 2. SUMMARY OF TESTING

2.1. Visual and Mechanical Inspection - All Groups

All specimens submitted for testing were manufactured by CS, and were inspected and accepted by the Product Assurance Department. On Group 5 specimens, 7 dimensions were verified and met criteria per FOCIS-3, Fiber Optic Connector Intermateability Standard, TIA-604-3B. Dimensions not measured on actual test specimens are assumed to be compliant with FOCIS-3 from CS First Article approval, which includes verification of product drawings per dimensions specified in TIA-604-3B.

2.2. Initial Optical Performance - All Groups

All attenuation and return loss measurements met the specification requirements. Attenuation and return loss were measured at 1310 and 1550 nm for all test groups.

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

| Performance Requirements | Singlemode Groups (1-7) | |
|---|---|---|
| | 1310 nm | 1550 nm |
| Maximum allowed attenuation for any individual specimen | 0.75 | 0.75 |
| Minimum allowed return loss for any individual specimen | 26 | 26 |

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

| Test Groups | Maximum and Median Attenuation Values | | Minimum and Median Return Loss | |
|---|---|---|---|---|
| | 1310 nm | 1550 nm | 1310 nm | 1550 nm |
| 1,2 (900 µm tight buffer) | 0.37 maximum<br>0.15 median | 0.29 maximum<br>0.10 median | 49 minimum<br>56 median | 55 minimum<br>57 median |
| 3,4,5 (3 mm jacketed) | 0.65 maximum<br>0.29 median | 0.46 maximum<br>0.22 median | 51 minimum<br>56 median | 51 minimum<br>58 median |
| 6 (900 µm tight buffer, APC digital) | 0.56 maximum<br>0.24 median | 0.51 maximum<br>0.24 median | 48 minimum<br>56 median | 52 minimum<br>62 median |
| 7 (900 µm tight buffer, APC analog) | 0.45 maximum<br>0.26 median | 0.43 maximum<br>0.26 median | 60 minimum<br>63 median | 63 minimum<br>65 median |

2.3. Attenuation, Attenuation Increase, Return Loss and Change in Optical Transmittance - All Groups

All attenuation, attenuation increase, return loss and change in optical transmittance measurements met the specification requirements. All measurements were recorded at 1310 and 1550 nm for 9/125 µm fiber size.

Attenuation, Attenuation Increase and Return Loss Results (dB)

| Test Group | Condition | Requirements (1310 and 1550 nm) | | | Actual (1310 nm) | | | Actual (1550 nm) | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Before | During | After | Before | During | After | Before | During | After |
| | | Atten(A) | Incr(I) | Atten(A)<br>Incr(I)<br>RL(R) | Atten(A) | Incr(I) | Atten(A)<br>Incr(I)<br>RL(R) | Atten(A) | Incr(I) | Atten(A)<br>Incr(I)<br>RL(R) |
| | Low Temperature | 0.75 | 0.3 | 0.75(A)<br>26(R) | 0.37 | 0.1 | 0.36(A)<br>51(R) | 0.29 | 0.0 | 0.28(A)<br>54(R) |
| | Temperature Life | 0.75 | NA | 0.75(A)<br>26(R) | 0.36 | NA | 0.34(A)<br>49(R) | 0.28 | NA | 0.30(A)<br>55(R) |
| 1 | Strength of Coupling Mechanism* | 0.75 | NA | 0.75(A)<br>26(R) | 0.39 | NA | 0.41(A)<br>51(R) | 0.31 | NA | 0.32(A)<br>54(R) |
| | Flex | | | 0.75(A)<br>26(R) | 0.27 | | 0.20(A)<br>54(R) | 0.18 | | 0.15(A)<br>54(R) |
| | Twist | | | 0.75(A)<br>26(R) | 0.20 | | 0.20(A)<br>53(R) | 0.15 | | 0.17(A)<br>53(R) |
| | Cable Retention, 0 Degrees* | | | 0.75(A)<br>0.5(I)<br>26(R) | 0.19 | | 0.28(A)<br>0.1(I)<br>54(R) | 0.15 | | 0.21(A)<br>0.1(I)<br>51(R) |
| 2 | Cable Retention, 90 Degrees | 0.75 | NA | 0.75(A)<br>0.5(I)<br>26(R) | 0.28 | NA | 0.27(A)<br>0.1(I)<br>53(R) | 0.20 | NA | 0.19(A)<br>0.0(I)<br>55(R) |
| | Temperature Life | | NA | 0.75(A)<br>26(R) | 0.53 | NA | 0.54 (A)<br>51(R) | 0.46 | NA | 0.49(A)<br>50(R) |
| | Low Temperature | | 0.3 | 0.75(A)<br>26(R) | 0.54 | 0.2 | 0.58 (A)<br>51(R) | 0.49 | 0.2 | 0.47(A)<br>50(R) |
| | Humidity, Steady State | | 0.4 | 0.75(A)<br>26(R) | 0.53 | 0.0 | 0.56 (A)<br>51(R) | 0.45 | 0.1 | 0.47(A)<br>50(R) |
| 3 | Durability | 0.75 | NA | 0.75(A)<br>26(R) | 0.48 | NA | 0.45 (A)<br>50(R) | 0.37 | NA | 0.39(A)<br>50(R) |
| | Strength of Coupling Mechanism | | | 0.75(A)<br>26(R) | 0.60 | | 0.61 (A)<br>53(R) | 0.31 | | 0.33(A)<br>54(R) |
| | Cable Retention, 0 Degrees | | | 0.75(A)<br>0.5(I)<br>26(R) | 0.59 | | 0.54 (A)<br>0.0(I)<br>53(R) | 0.33 | | 0.33 (A)<br>0.0(I)<br>54(R) |
| | Cable Retention, 90 Degrees | | | 0.75(A)<br>0.5(I)<br>26(R) | 0.54 | | 0.58 (A)<br>0.0(I)<br>54(R) | 0.33 | | 0.34 (A)<br>0.1(I)<br>54(R) |
| | Flex | | | 0.75(A)<br>26(R) | 0.53 | | 0.51 (A)<br>54(R) | 0.30 | | 0.31(A)<br>53(R) |
| | Twist | | | 0.75(A)<br>26(R) | 0.51 | | 0.45 (A)<br>53(R) | 0.31 | | 0.30(A)<br>53(R) |
| 5 | Impact* | 0.75 | NA | 0.75(A)<br>26(R) | 0.50 | NA | 0.45 (A)<br>53(R) | 0.30 | NA | 0.31(A)<br>54(R) |
| 6 | Attenuation and Return Loss | See paragraph 2.2. | | | | | | | | |
| 7 | Attenuation and Return Loss | See paragraph 2.2. | | | | | | | | |

**NOTE** *Asterisk denotes that product was tested to harsher criteria than ANSI/TIA-568-C.3 requirements. Refer to Section 3, Test Methods, for full details.*
*(A) - Attenuation, (I) - Attenuation Increase, (R) - Return Loss.*

2.4. Low Temperature - Groups 1 and 3

There was no evidence of physical damage to the connector or terminated fiber and no increase in attenuation beyond the specified limit during low temperature exposure. All attenuation and return loss measurements met requirements before and after test.

2.5. Temperature Life - Groups 1 and 3

There was no evidence of physical damage to the connector or terminated fiber after temperature life. All attenuation and return loss measurements met specified limits before and after test.

2.6. Humidity, Steady State - Group 3

There was no evidence of physical damage to the connector or terminated fiber and no increase in attenuation beyond the specified limits during steady state humidity. All attenuation and return loss measurements met requirements before and after test.

2.7. Impact - Group 5

There was no evidence of physical damage to the connector due to impact testing. Attenuation and return loss measurements met the specified limits before and after test.

2.8. Durability - Group 3

There was no evidence of physical damage to the connector or attached cable. Attenuation and return loss measurements met the specified limits before and after durability.

2.9. Flex - Groups 2 and 5

There was no evidence of physical damage to the connector or attached fiber. Attenuation and return loss measurements met the specified limits before and after flex testing.

2.10. Twist - Groups 2 and 5

There was no evidence of physical damage to the connector or attached fiber. Attenuation and return loss measurements met the specified limits before and after the twist test.

2.11. Cable Retention, 0 Degrees - Groups 2 and 5

There was no evidence of fiber pullout, or other damage to the connector or attached fiber and no increase in attenuation beyond the specified limits after cable retention. Attenuation and return loss measurements met the specified limits before and after the 0 degree cable retention test.

2.12. Cable Retention, 90 Degrees - Groups 2 and 5

There was no evidence of fiber pullout, or other damage to the connector or attached fiber and no increase in attenuation beyond the specified limits after 90 degree cable retention. Attenuation and return loss measurements met the specified limits before and after the 90 degree cable retention test.

2.13. Strength of Coupling Mechanism - Groups 1 and 5

There was no evidence of physical damage to the connector or attached fiber. Attenuation and return loss measurements met the specified limits before and after strength of coupling mechanism test.

## 3. TEST METHODS

The singlemode environmental facility is an automated, TIA-455-20B compliant test system. Following the installation of the specimens, the sequential testing was performed.

### 3.1. Visual and Mechanical Inspection

Product drawings and inspection plans were used to examine the specimens. They were examined visually and functionally. A sampling of 8 specimens were measured to verify conformance to Dimensions B, E, H, J, N, P and R in the FOCIS-3, Fiber Optic Connector Intermateability Standard, TIA-604-3B. Ferrule extension and contact force per FOCIS-3 Figure 3.2.2 were also verified.

### 3.2. Attenuation (Insertion Loss)

All singlemode attenuation was measured in accordance with TIA/EIA-455-171A, Method D3 processes. The initial optical power through each launch fiber was measured. The LightCrimp Plus SC connector was terminated to the fiber and optical power was measured from the connector end. The LightCrimp Plus connector was then mated to an epoxy-style SC connector and optical power was measured from the receive fiber. Attenuation was calculated by taking the difference between the first and third fiber measurements. The receive fiber was then spliced to a test lead attached to the optical measurement equipment. 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.

For Test Groups 1 through 5, each LightCrimp Plus SC connector was mated to a unique epoxy style SC connector. In Test Groups 6 and 7, all LightCrimp Plus SC APC connectors were mated to a single epoxy style SC APC connector.

### 3.3. Return Loss

Return loss was measured in accordance with TIA/EIA-455-107A. A single measurement was recorded for return loss. Return loss was measured initially and after each test evaluation.

For Test Groups 1 through 5, each LightCrimp Plus SC connector was mated to a unique epoxy style SC connector. In Test Groups 6 and 7, all LightCrimp Plus SC APC connectors were mated to a single epoxy style SC APC connector.

### 3.4. 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).

### 3.5. Low Temperature

Mated specimens were subjected to -10°C for a period of 96 hours (4 days). Optical performance for each specimen 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 specimens returned to ambient conditions.

### 3.6. Temperature Life

Mated specimens were subjected to 60°C for a period of 96 hours (4 days). Optical performance for each specimen was recorded before and after exposure with the specimens in place in the test chamber. Final optical performance was recorded after specimens returned to ambient conditions.

3.7. Humidity, Steady State

Specimens were preconditioned at 50°C and low humidity for 24 hours per TIA/EIA-455-5C Method A prior to starting the Humidity test. Mated specimens were subjected to 40 ± 2°C at 90 to 95% RH for a period of 96 hours (4 days). Optical performance for each specimen 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 specimens returned to ambient conditions.

3.8. Impact

An unmated connector was dropped from a height of 1.8 m [70.9 in] onto a concrete floor (exception to ANSI/TIA-568-C.3) while the fixed end was mounted at a height of 0.60 m [2 ft] with cable length of 2 m [79 in]. Dust caps were used to protect the fiber endface. The impact exposure was performed 8 times. Initial optical performance was recorded before the specimen was unmated and exposed to testing. After completion of the 8 impacts, each connector was inspected, cleaned and re-mated before recording final optical measurements. Test drop height and duration were harsher criteria than ANSI/TIA-568-C.3 requirements.

3.9. Durability

The launch connector of each mated specimen was subjected to 500 cycles of durability. Specimens were manually cycled at a rate not in excess of 300 cycles per hour. The connector and adapter were cleaned as necessary, during the course of the test. Attenuation and return loss were measured before and after test. Specimens were unmated, cleaned, inspected, and re-mated before final optical measurements.

3.10. Flex

Specimens were subjected to 100 cycles of fiber flexing. Specimens were tested at a rate of approximately 25 cycles per minute. A mandrel was used to apply a tensile load of 2.2 N [0.5 lbf] to buffered fiber (load is slightly greater than ANSI/TIA-568-C.3 requirements) at a point approximately 25 cm [10 in] from the rear of a mated connector. The flex arc was ± 90 degrees from a vertical position. Optical performance was measured before and after test with the load removed.

Specimens terminated to 3 mm [.12 in] jacketed cable (Test Group 5) were subjected to 100 cycles of cable flexing with a load of 4.9 N [1.1 lbf] applied (meets ANSI/TIA-568-C.3 requirements). A 38.1 mm [1.5 in] piece of the cable jacket was removed and the load was clamped directly to the strength members and buffer simultaneously (exception to TIA/EIA-455-1 procedure).

3.11. Twist

Specimens were subjected to 10 cycles of twist. Specimens were tested at a rate of approximately 3 cycles per minute. A mandrel was used to apply a tensile load of 2.2 N [0.5 lbf] to buffered fiber (load is slightly greater than ANSI/TIA-568-C.3 requirements) at a point approximately 25 cm [10 in] from the ferrule endface of a mated specimen. The twist motion for each cycle was ± 2.5 revolutions about the axis of the fiber. Optical performance was measured before and after test with the load removed.

Specimens terminated to 3 mm [.12 in] jacketed cable (Test Group 5) were subjected to 10 cycles of twist with a load of 15 N [3.4 lbf] applied to jacketed cable (meets ANSI/TIA-568-C.3 requirements). A 38.1 mm [1.5 in] piece of the cable jacket was removed and the load was clamped directly to the strength members and buffer simultaneously (exception to TIA/EIA-455-36 procedure).

3.12. Cable Retention, 0 Degrees

Specimens terminated to 900 μm tight buffer fiber (Test Group 2) were subjected to a sustained load of 5 N [1.1 lbf] for 60 seconds (exceeds ANSI/TIA-568-C.3 requirements, due to longer duration). An adapter was secured to the test fixture. The tensile load was manually applied by wrapping the buffered fiber around a mandrel at a point 25 cm [10 in] from the endface of the connector. Optical performance was measured before and after test with the load removed.

Specimens terminated to 3 mm [.12 in] jacketed cable (Test Group 5) were subjected to a sustained load of 50 N [11.24 lbf] for a minimum of 5 seconds (meets ANSI/TIA-568-C.3 requirements). Load was applied at a rate of 5 N [1.12 lbf] per second. A 38.1 mm [1.5 in] piece of the cable jacket was removed and the load was clamped directly to the strength members and buffer simultaneously.

3.13. Cable Retention, 90 Degrees

For buffered fiber, specimens were subjected to a sustained load of 2.2 N [0.5 lbf] for 5 seconds (load is slightly greater than ANSI/TIA-568-C.3 requirements). An adapter was secured to the test fixture. The load was applied at a 90 degree pull angle by wrapping the buffered fiber around a mandrel at a point approximately 25 cm [10 in] from behind the end of the strain relief of a mated specimen. Optical performance was measured before and after test with the load removed.

For 3 mm [.12 in] jacketed cable (Test Group 5), specimens were subjected to a sustained load of 19.4 N [4.4 lbf] for a minimum of 5 seconds. Load was applied at a rate of 5 N [1.12 lbf] per second. A 38.1 mm [1.5 in] piece of cable jacket was removed and the load was clamped directly to the strength members and buffer simultaneously. Quantity of samples were split in order to test samples while mounted in three different positions.

3.14. Strength of Coupling Mechanism

A 40 N [9.0 lbf] tensile load was applied between the connector plug and adapter. The load was applied at a rate of approximately 50 N [11.24 lbf] per minute for Test Group 1 and a rate of 2 N [0.45 lbf] per second for Test Group 5. The load was sustained for a minimum of 5 seconds (Group 1 specimens were held for 60 seconds. Optical performance was measured before and after test with the load removed. Test duration was greater than ANSI/TIA-568-C.3 requirements for Group 1.