2178-L/S Series Fiber Optic Splice Cases and Accessories

Technical Report

March 1998
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Contents

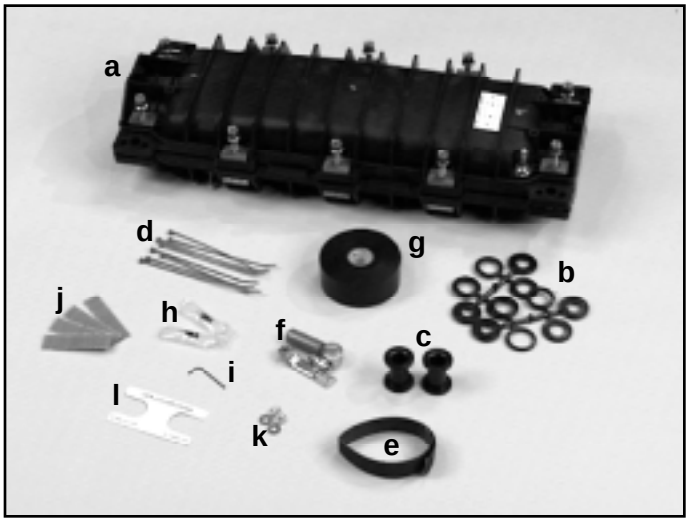
1.0 Product Description

3M™ 2178-L/S Series Fiber Optic Splice Cases are a series of molded plastic enclosures used for protecting splices in fiber optic cables. They are suitable for buried, underground, aerial, and pedestal applications.

The series consists of the 2178-S, 2178-L/S, 2178-SL, and 2178-LL Fiber Optic Splice cases, as well as the 2181-LS Cable Addition Kit and accessories. Splice case has two cable entrance ports on each end. The 2181-LS Cable Addition Kit expands each of the cases to allow extra cables and trays to be added. Port plugs allow the case to be used for butt or in-line splices. The rigid non-encapsulated cases provide physical and environmental protection. The splice cases are suitable for short term pressurization during flash testing.

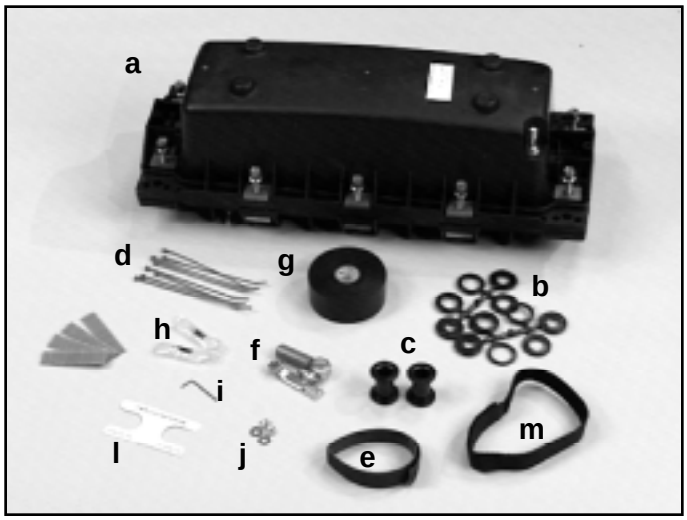
1.1 2178-S Splice Case Kit Contents:

a) Case assembly includes tray support, gasket, air valve, bolts, and cable strain relief
b) sealing washer trees.....6 ea
c) plugs .....2 ea
d) cable ties, blue and green.....4 ea
e) sheath scuff.....1 ea
f) 3M™ 2172 strength member clamps w/rubber boot and hose clamp .....3 ea
g) 3M™ 130C tape.....1 roll
h) silicone grease (5 cc tube).....2 ea
i) small allen wrench.....1 ea
j) dual lock (for tray support) .....4 ea
k) brass nut and washer .....2 ea
l) tape collar gauge.....1 ea



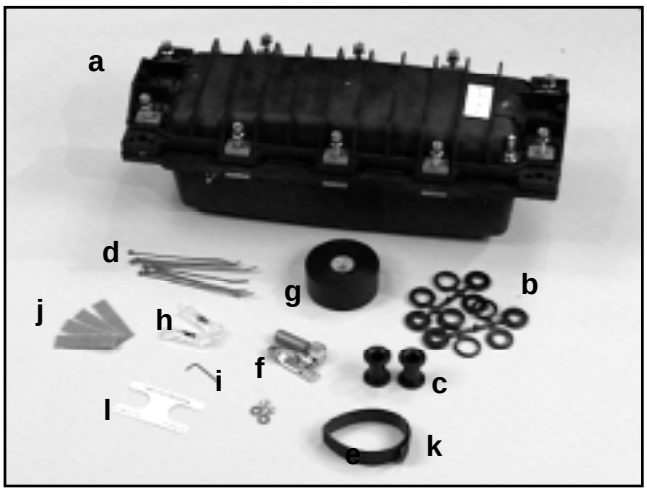
1.2 2178-L/S Splice Case Kit Contents:

a) Case assembly includes tray support, gasket, air valve, bolts, and cable strain relief
b) sealing washer trees..... 6 ea
c) plugs..... 2 ea
d) cable ties, blue and green..... 4 ea
e) sheath scuff..... 1 ea
f) 2172 strength member clamps w/rubber boot and hose clamp ..... 4 ea
g) 130C tape..... 1 roll
h) silicone grease (5 cc tube)..... 2 ea
i) small allen wrench..... 1 ea
j) dual lock (for tray support) ..... 4 ea
k) brass nut and washer ..... 2 ea
l) tape collar gauge..... 1 ea
m) tray strap ..... 1 ea



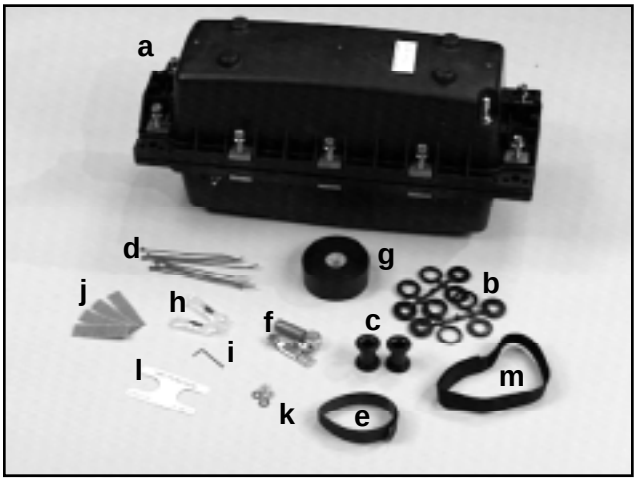
1.3 3M™ 2178-SL Splice Case Kit Contents:

a) Case assembly includes tray support, gasket, air valve, bolts, and cable strain relief
b) sealing washer trees.....6 ea
c) plugs.....2 ea
d) cable ties, blue and green.....4 ea
e) sheath scuff.....1 ea
f) 2172 strength member clamps w/ rubber boot and hose clamp.....4 ea
g) 130C tape.....1 roll
h) silicone grease (5 cc tube).....2 ea
i) small allen wrench.....1 ea
j) dual lock (for tray support) .....4 ea
k) brass nut and washer .....2 ea
l) tape collar gauge.....1 ea



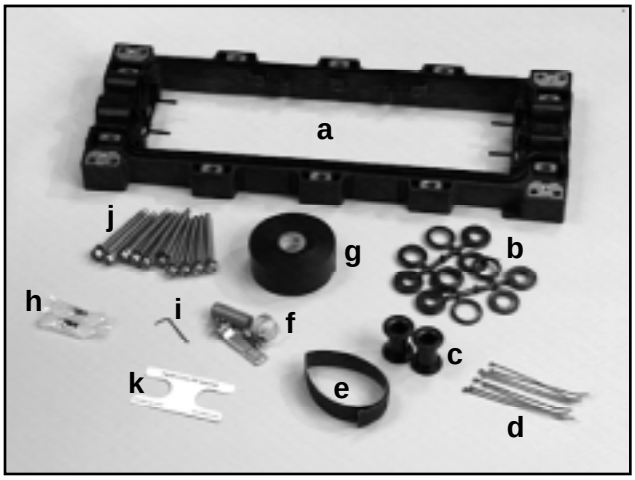
1.4 2178-LL Splice Case Kit Contents:

a) Case assembly includes tray support, gasket, air valve, bolts, and cable strain relief
b) sealing washer trees.....6 ea
c) plugs.....2 ea
d) cable ties, blue and green .....4 ea
e) sheath scuff .....1 ea
f) 3M™ 2172 strength member clamps w/ rubber boot and hose clamp .....4 ea
g) 3M™ 130C tape .....1 roll
h) silicone grease (5 cc tube) .....2 ea
i) small allen wrench.....1 ea
j) dual lock (for tray support) .....4 ea
k) brass nut and washer.....2 ea
l) tape collar gauge.....1 ea
m) tray strap .....1 ea



1.5 2181-LS Cable Addition Kit Contents:

a) adapter with gasket.....1 ea
b) sealing washer trees .....6 ea
c) plugs .....3 ea
d) cable ties, blue and green.....4 ea
e) sheath scuff.....1 ea
f) 2172 strength member clamps w/ rubber boot and hose clamp.....4 ea
g) 130C tape.....1 roll
h) silicone grease (5 cc tube).....2 ea
i) small allen wrench .....1 ea
j) bolts .....10 ea
k) tape collar gauge .....1 ea



1.6 Material Composition:

Injection molded case halves	Polypropylene
Case fasteners	Stainless steel
Air valve	Stainless steel
Gasket	Nitrile rubber
Sealing washer tree	Engineering-grade thermoplastic
Plugs	Engineering-grade thermoplastic

1.7 Closure Dimensions:

Maximum cable diameter:	1.0"	(25.0 mm)
Minimum cable diameter:	0.2"	(5.0 mm)
Closure length:	21.9"	(55.7 cm)
Closure width:	8.5"	(21.5 cm)
2178-S closure height:	4.7"	(11.9 cm)
2178-LS closure height:	8.0"	(20.3 cm)
2178-SL closure height:	8.0"	(20.3 cm)
2178-LL closure height:	11.3"	(28.7 cm)
Available splice chamber space:		
length:	16.4"	(41.6 cm)
width:	5.5"	(14.0 cm)
2178-S and 2178-SL height:	1.2"	(3.0 cm)
2178-LS and 2178-LL height:	3.7"	(9.4 cm)
2181-LS (1) height:	1.5"	(3.8 cm)
2181-LS (2) height:	3.0"	(7.6 cm)
2181-LS (3) height:	4.5"	(11.4 cm)

1.8 Splice Tray Capacity:

Capacity of 2524 Splice Tray	24	3M™ Fibrlok™ Splices
	24	Fusion Splices
Capacity of 2523 Splice Tray	24	Fibrlok Splices
	12	3M™ Fibrlok™ Multi-Fiber Splices* (12 fibers each)
	48	Discrete Fusion Splices
	12	Fusion Splices (12 fibers each)
Capacity of 2522 Splice Tray	12	Fibrlok Splices
	8	Fibrlok Multi-Fiber Splices* (12 fibers each)
	24	Discrete Fusion Splices
	10	Fusion Splices (12 fibers each)

Note: *Varies with ribbon size

1.9 Closure Capacities

	2178-S, 2178-SL	2178-LS	2178-LL	2178-S*, 2178-SL	2178-LS*	2178-LL*	2178-S, 2178-SL	2178-LS	2178-LL
Number of 2181 Cable Addition Kits ADDED	0	0	0	1	1	1	1	1	1
Number of Cables INSTALLED	2-4	2-4	2-4	2-4	2-4	2-4	5-8	5-8	5-8
CAPACITY (Max Number of 2524 Splice Trays)	2	7	7	4	10	10	2	7	7
CAPACITY (Max Number of 2523 Splice Trays)	2	5	5	4	8	8	2	5	5
CAPACITY (Max Number of 2522 Splice Trays)	2	5	5	4	8	8	2	5	5
Number of 2181 Cable Addition Kits ADDED	2	2	2	2	2	2	2	2	2
Number of Cables INSTALLED	2-4	2-4	2-4	5-8	5-8	5-8	9-12	9-12	9-12
CAPACITY (Max Number of 2524 Splice Trays)	6	13	13	4	10	10	2	7	7
CAPACITY (Max Number of 2523 Splice Trays)	6	10	10	4	7	7	2	5	5
CAPACITY (Max Number of 2522 Splice Trays)	6	10	10	4	7	7	2	5	5
Number of 2181 Cable Addition Kits ADDED	3	3	3	3	3	3	3	3	3
Number of Cables INSTALLED	2-4	2-4	2-4	5-8	5-8	5-8	9-12	9-12	9-12
CAPACITY (Max Number of 2524 Splice Trays)	8	16	16	6	13	13	4	10	10
CAPACITY (Max Number of 2523 Splice Trays)	8	12	12	6	9	9	4	7	7
CAPACITY (Max Number of 2522 Splice Trays)	8	12	12	6	9	9	4	7	7

Note:** **The 3M™ 2181-LS Cable Addition is added for additional tray capacity.

Note:** **The 3M™ 2178-S and the 3M™ 2178-SL Splice Cases will accommodate up to four 1.0" (25 mm) diameter cables inline when using 3M™ 2522 trays. When using 3M™ 2523 or 3M™ 2524 trays it is limited to four .5" (12.5 mm) diameter cables inline. Butt applications will accommodate up to 1.0" (25 mm) diameter cables.

2.0 Test Program Overview

To predict the long-term performance reliability of the 3M™ 2178-L/S Series Fiber Optic Splice Cases, the cases have been subjected to a number of tests which expose them to conditions more severe than anticipated in actual field use. The tests are based upon telephone industry performance specifications and are believed to represent the most severe requirements of that industry.

The following list outlines the major areas which were examined in this test program:

- Environmental
- Mechanical Strength
- Material Integrity
- Bonding System Integrity

The following sections describe each of these test series and report the results obtained.

3.0 Environmental Tests

The 2178-L/S Series Fiber Optic Splice Cases were subjected to a series of environmental tests in order to determine the ability of the splice cases to withstand worst-case environmental conditions that may be experienced in outside plant. See tables below for configurations tested and results.

3.1 Thermal Aging

The thermal aging test simulates long-term exposure of the 2178-L/S Series Splice Cases sealing components to the environment. The sealing components for two splice cases (gasket, tape, and ground stud O-rings) were aged at 194° F (90° C) for 30 days.

Results: No deterioration of the aged sealing components.

3.2 Assembly

The assembly test verifies that the 2178-L/S Series Splice Case can be assembled at extreme temperatures. Thermal-aged components (ground stud O-rings assembled prior to conditioning) were conditioned at 32° F (0° C) and 104° F (40°C) prior to assembly.

Results: The splice cases performed as intended at both temperature extremes.

3.3 Temperature and Humidity Cycling

The temperature and humidity cycling test determines if rapid thermal expansion and contraction has any effect on the mechanical integrity of the 2178-L/S Series Splice Cases. The closures were exposed to 120 six-hour cycles from 150° F (65° C) to -40° F (-40° C). Relative humidity at the upper temperature limit is controlled at 95%. At all other times the chamber humidity was uncontrolled. The six hour cycle includes two hour transition periods and one hour dwell times at the two temperature extremes.

Closure configurations tested:

2178-S	2178-LS + one 2181-LS addition kit
2178-S + one 2181-LS addition kit	2178-LS + one 2181-LS SPLIT
2178-S + one 2181-LS SPLIT	2178-LS + three 2181-LS addition kits
2178-S + three 2181-LS addition kits	2178-LL + one 2181-LS SPLIT
2178-LS	2178-LL + two 2181-LS addition kits

Results: No splice case degradation and no water intrusion was apparent.

3.4 Freeze / Thaw

The freeze / thaw test determines if an alternately freezing and thawing environment has any effect on the ability of the 3M™ 2178-L/S Series Splice Cases to maintain a watertight seal. The splice cases were placed horizontally in a water tank to a depth which covers the top of the splice cases by a minimum of 1 in. (2.5 cm). The splice cases were subjected to 10 twenty-eight hour freeze / thaw cycles from -40° F (-40° C) to 158° F (70° C). The twenty-eight hour cycle includes 1/2 hour transition periods with 17 hours at -40° F (-40° C) and 10 hours at 158° F (70° C). Air circulation is maintained on all sides of the water trough such that there is complete freezing of the water surrounding the splice cases. At the end of cycling, the closures were opened and inspected.

Closure configurations tested:

2178-S
2178-S + one 2181-LS addition kit
2178-S + one 2181-LS SPLIT
2178-S + three 2181-LS addition kits
2178-LS
2178-LS + one 2181-LS addition kit
2178-LS + one 2181-LS SPLIT
2178-LL + one 2181-LS SPLIT
2178-LL + two 2181-LS addition kits

Results: No water intrusion or mechanical damage to the closure.

3.5 Water Resistance

The water resistance test determines if the 2178-L/S Series Splice Cases can withstand the rigors of water immersion without degradation of its seal. The splice cases were subjected to 20 ft (6m) water immersion for seven days.

Closure configurations tested:

2178-S
2178-S + one 2181-LS addition kit
2178-S + one 2181-LS SPLIT
2178-S + three 2181-LS addition kits
2178-LS
2178-LS + one 2181-LS addition kit
2178-LS + one 2181-LS SPLIT
2178-LL + one 2181-LS SPLIT

Results: No water intrusion or mechanical damage to the closure.

4.0 Mechanical Tests

The 2178-L/S Series Splice Cases were subjected to a series of mechanical tests in order to determine the ability of the closures to protect splices from external mechanical forces and stresses. This series of tests is intended to simulate the actual stresses that the splice case may be exposed to under normal installation and operating conditions.

4.1 Cable Clamping

The cable clamping test determines what effect the installation of the 2178-L/S Series Splice Cases and shield bond connectors has on the optical transmission qualities of the fibers and splices. The cables were spliced and initial attenuation readings were taken on three splices, later used in the sheath retention, cable flexing, and cable torsion testing. The splice cases were then fully assembled and light loss readings taken again. In all cases, light loss was much less than the .05 dB acceptance limit.

4.2 Sheath Retention

The sheath retention test determines the ability of the 3M™ 2178-L/S splice cases to isolate fibers and splices from tensile forces applied to the cable during installation. For large cables, an axial load of 100 lb. (44 kg) was applied for 30 minutes. An axial load of 50 lb. (22 kg.) was applied to small cables for the same amount of time.

Large Cable Sheath Retention / 2178-S Splice Case
Change in optical power (dB)

Fiber No.	1	2	3	4	5	6	7	8	9	10	11	12	Av. Change
During	.017	.001	.010	.019	.008	.008	.027	.000	.026	.006	.013	.000	.011
After	.011	.001	.007	.019	.008	.009	.030	.001	.012	.007	.009	.003	.010

Large Cable Sheath Retention / 2178-LS Splice Case + one 2181-LS Cable Addition Kit
Change in optical power (dB)

Fiber No.	1	2	3	4	5	6	7	8	9	10	11	12	Av. Change
During	.017	.007	.005	.004	.000	.012	.001	.006	.009	.018	.011	.005	.008
After	.013	.002	.014	.001	.015	.023	.002	.000	.001	.002	.000	.006	.006

Large Cable Sheath Retention / 2178-LS Splice Case
Change in optical power (dB)

Fiber No.	1	2	3	4	5	6	7	8	9	10	11	12	Av. Change
During	.019	.002	.010	.009	.002	.009	.003	.001	.008	.000	.002	.007	.006
After	.020	.001	.002	.007	.004	.002	.000	.010	.006	.006	.003	.003	.005

Small Cable Sheath Retention / 2178-S Splice Case
Change in optical power (dB)

Fiber No.	1	2	3	4	5	6	7	8	9	10	11	12	Av. Change
During	.005	.002	.001	.001	.000	.002	.006	.009	.005	.002	.003	.010	.004
After	.002	.005	.009	.019	.005	.012	.013	.010	.015	.001	.002	.028	.010

Small Cable Sheath Retention / 2178-LS Splice Case + one 2181-LS Cable Addition Kit
Change in optical power (dB)

Fiber No.	1	2	3	4	5	6	7	8	9	10	11	12	Av. Change
During	.003	.001	.001	.001	.001	.013	.006	.009	.005	.002	.003	.001	.003
After	.008	.003	.004	.002	.004	.024	.001	.005	.007	.013	.006	.007	.007

Small Cable Sheath Retention / 2178-LS Splice Case
Change in optical power (dB)

Fiber No.	1	2	3	4	5	6	7	8	9	10	11	12	Av. Change
During	.002	.001	.004	.008	.001	.001	.009	.002	.004	.004	.005	.008	.006
After	.017	.004	.002	.010	.000	.006	.007	.003	.009	.001	.004	.003	.005

4.3 Cable Flexing

The cable flexing test determines the ability of the 3M™ 2178-L/S Series Splice Cases to isolate fibers and splices from cable bending which may occur during installation. The splice case sample was conditioned at 0° F (-18° C) for two hours prior to initial readings. At a distance of 39 in. (1 m) from the closure/cable interface, the assembly was given a 90° bend in four directions with a return to the original position after each bend. The four bends were repeated and final readings taken. This procedure was then repeated at 104° F (40° C). The cable jacket and shield bond connector showed no signs of mechanical damage.

2178-S Splice Case
Change in optical power (dB) at -18°C

Fiber No.	1	2	3	4	5	6	7	8	9	10	11	12	Av. Change
During	-.002	-.003	-.004	-.004	-.007	-.008	.006	.001	-.008	-.005	.002	.011	- .004
After	.010	-.001	-.001	-.001	-.003	-.004	.005	.007	.007	.004	.000	-.013	.001

2178-S Splice Case
Change in optical power (dB) at 40°C

Fiber No.	1	2	3	4	5	6	7	8	9	10	11	12	Av. Change
During	-.001	.001	.005	-.011	-.007	.009	.027	.000	.004	.001	-.008	-.003	.000
After	-.004	.002	.005	-.016	-.014	.016	.042	.001	.006	.001	-.011	-.014	-.004

2178-LS Splice Case with one 2181-LS Cable Addition Kit
Change in optical power (dB) at -18°C

Fiber No.	1	2	3	4	5	6	7	8	9	10	11	12	Av. Change
During	.000	-.009	-.007	-.005	-.015	-.009	-.007	-.003	-.007	-.005	-.011	-.010	-.007
After	.001	-.009	-.002	-.003	-.009	-.012	-.001	-.002	-.001	-.004	-.011	-.004	-.005

2178-LS Splice Case with one 2181-LS Cable Addition Kit
Change in optical power (dB) at 40°C

Fiber No.	1	2	3	4	5	6	7	8	9	10	11	12	Av. Change
During	.002	-.001	.009	.009	.004	-.002	.011	.001	.011	.010	-.001	.012	.006
After	.008	.002	.012	.021	.009	.000	.019	.001	.011	.012	.002	.003	.008

2178-LS Splice Case
Change in optical power (dB) at -18°C

Fiber No.	1	2	3	4	5	6	7	8	9	10	11	12	Av. Change
During	-.020	.003	-.003	-.001	-.001	-.021	.000	-.014	-.006	-.025	.037	-.001	-.004
After	-.021	.007	.000	-.010	-.004	-.005	.015	-.018	-.003	-.021	-.005	.002	-.005

2178-LS Splice Case
Change in optical power (dB) at 40°C

Fiber No.	1	2	3	4	5	6	7	8	9	10	11	12	Av. Change
During	.020	-.002	.008	.004	.013	-.001	-.016	.012	.016	.004	.018	-.012	.005
After	.014	-.004	.010	.003	.016	.000	-.024	.020	.029	.007	.021	-.013	.007

4.4 Cable Torsion

The cable torsion test determines the ability of the 3M™ 2178-L/S Series Splice Cases to isolate fibers and splices from torsion which may occur during installation. The samples were conditioned at 0° F (-18° C) for two hours prior to initial readings. At a distance of 39 in. (1 m) from the closure/cable interface, the cable was twisted for ten cycles. A cycle consists of a 90° clockwise twist followed by a 180° counter-clockwise twist followed by a 90° clockwise twist back to the original position. Final readings were taken. This procedure was repeated at 104° F (40° C). The cable jacket and shield bond connector showed no signs of mechanical damage.

2178-S Splice Case
Change in optical power (dB) at -18°C

Fiber No.	1	2	3	4	5	6	7	8	9	10	11	12	Av. Change
During	.006	.003	-.001	-.004	-.004	-.003	.012	.021	-.008	-.005	.002	.011	.002
After	-.007	-.001	.000	.005	.006	.001	-.018	-.025	.007	.004	.000	-.013	-.003

2178-S Splice Case
Change in optical power (dB) at 40°C

Fiber No.	1	2	3	4	5	6	7	8	9	10	11	12	Av. Change
During	-.001	.006	.007	-.013	-.010	.012	.035	.000	-.008	-.007	-.014	-.009	.000
After	-.005	.004	.005	-.013	-.007	.010	.029	-.005	-.020	-.020	-.016	-.006	-.004

2178-LS Splice Case with one 2181-LSCable Addition Kit
Change in optical power (dB) at -18°C

Fiber No.	1	2	3	4	5	6	7	8	9	10	11	12	Av. Change
During	.003	-.001	-.001	-.001	-.007	-.004	.000	-.004	-.002	.000	.004	.002	-.001
After	-.003	-.004	.000	-.004	.000	.001	-.008	.001	.002	-.003	-.007	-.001	-.002

2178-LS Splice Case with one 2181-LS Cable Addition Kit
Change in optical power (dB) at 40°C

Fiber No.	1	2	3	4	5	6	7	8	9	10	11	12	Av. Change
During	.015	.006	.015	.017	.007	.005	.019	-.002	.009	.011	.003	.006	.009
After	.014	.007	.010	.015	.002	.004	.007	-.004	.005	.010	.000	.005	.006

2178-LS Splice Case
Change in optical power (dB) at -18°C

Fiber No.	1	2	3	4	5	6	7	8	9	10	11	12	Av. Change
During	.005	.001	.000	.006	-.001	.001	-.020	.044	-.012	.032	.012	.031	.008
After	.016	-.001	-.001	-.007	.001	-.008	.032	-.060	.013	-.047	.003	-.044	-.009

2178-LS Splice Case
Change in optical power (dB) at 40°C

Fiber No.	1	2	3	4	5	6	7	8	9	10	11	12	Av. Change
During	.011	-.001	.017	.003	.007	.004	-.015	.023	.015	.003	.023	-.016	.006
After	.004	-.002	.016	.000	.004	.004	-.007	.022	.015	-.001	.020	-.018	.005

4.5 Vertical Drop

The vertical drop test simulates an impact that could occur if the splice case is dropped during installation. The 3M™ 2178-S and 2178-LS splice cases were conditioned at 0° F (-18° C) for two hours. The splice cases were dropped from a height of 30 in. (75 cm) onto a 1/2" (13 mm) thick steel plate. The above procedure was repeated at 104° F (40° C). Since this test does not affect the splice case/cable interface, optical measurements are not necessary.

Results: The splice cases experienced no cracks in the splice case housings or breaks in the splice case seals.

4.6 Compression

The compression test determines if the 2178-L/S Series Splice Cases can withstand heavy loads that may be applied during installation or maintenance. Two splice cases were conditioned at 0° F (-18° C) for two hours. Each closure was placed horizontally in a compression fixture device and a height measurement of the closure was taken. A uniformly distributed 300 lb. (136 kg) compressive load was applied for 15 minutes and the measurement was repeated. The load was removed, the closure allowed to return to room temperature, and the measurement was repeated again. The above procedure was repeated with two new cases at 104° F (40° C).

Results: The cases experienced no visible physical damage at both extreme temperatures under 300 lb. compression load. There was a 1% change in dimension height during and after a 300 lb. compression load at 0° F (-18°C) and a 2% change in dimension height during and after a 300 lb. compression load at 104° F (40°C). This is well within the 20% deformation during load and well within the 10% permanent deformation limit.

4.7 Impact

The impact test determines if the 2178-L/S Series Splice Cases can withstand a sudden impact from a foreign object. Two 2178-S splice cases were conditioned at 0° F (-18° C) for two hours. Each splice case was subjected to a 100 ft-lb. (68 J) vertical impact in the center of the splice case using a 2 in. (5.1 cm) spherical radius impact head. The above procedure was repeated at 104° F (40° C).

Results: The splice cases experienced no external mechanical damage at either temperature.

5.0 Material Integrity Tests

The materials used in the 3M™ 2178-L/S splice cases were tested to determine their ability to withstand the severe conditions that could exist in the outside plant environment.

5.1 Chemical Resistance - Material Degradation

The first of four chemical resistance tests, this test evaluates the resistance of the 2178-L/S Series Splice Case material to chemicals that may be used during installation and maintenance. The splice case material was fabricated into samples having the dimension 2.5 in. x 0.5 in. x 0.125 in. (63.5 mm x 12.7 mm x 3.2 mm). Each sample bar was placed into a three-point test fixture and loaded to a deflection of 0.04 in. (1 mm). Five samples each were coated with the following chemicals for a period of 24 hours at room temperature.

- WD-40™ Water Displacing Lubricant
- 10% IGEPAL™
- Cable Filling Compound (Flexgel™ and PEPJ)
- Splice Encapsulating Compound (3M™ 4442 High Gel Encapsulant and Caschem™ 126)
- Isopropyl Alcohol
- Wasp and Hornet Spray

Results: No evidence of stress cracking of the material was observed.

5.2 Chemical Resistance - Weight, Hardness, and Tensile Strength

This chemical resistance test determines if the splice cases can withstand immersion in three different chemicals for 7 days without a reduction in their physical properties. "Dog-bone" samples of the material were fabricated. The average weight, hardness, and tensile strength of the samples were measured and recorded as the baseline values. For tensile strength measurements, a crosshead speed of 2 in/min. (50 mm/min.) was used. Five samples each were immersed in the following chemicals for a period of 7 days.

- Sulfuric Acid (3% H_2SO_4 by weight)
- Sodium Hydroxide (0.2 N NaOH)
- 10% IGEPAL™

The weight, hardness, and tensile strength of each sample were measured again. It was desired that each sample exhibit no more than a 10% change in weight or hardness and no more than a 20% reduction in tensile strength when compared to the baseline values.

Results: All samples met the above requirements. The average changes are as follows:

Chemical	Material	% Weight Change	% Hardness Change	% Tensile Reduction
Sulfuric Acid	Splice Case	0.0	-0.4	-0.4
Sodium Hydroxide	Splice Case	0.0	0.0	-0.5
IGEPAL™	Splice Case	0.0	-1.0	-0.2

5.3 Chemical Resistance -Splice Cases

This chemical resistance test determines if the 3M™ 2178-L/S Series Splice Cases can withstand immersion in four different chemicals for 7 days without loss of mechanical strength properties. Four splice cases were prepared, one splice case was immersed in each of the following four chemicals for a period of 7 days.

- Sulfuric Acid (3% H_2SO_4 by weight)
- Sodium Hydroxide (0.2 N NaOH)
- 10% IGEPAL™
- Kerosene

The samples were flash tested after each test at 8 psi to detect for leaks. The splice cases were checked for chemical intrusion and then subjected to the 300 lb. compression test and the impact test . The samples were then subjected to 20 ft water immersion test for 7 days. The results of this testing are as follows:

Chemical	Compression at 0°F (-18°C)	Compression at 104°F (40°C)	Impact at 0°F (-18°C)	Impact at 104°F (40°C)	20 ft (6.1m) water immersion
Sulfuric Acid	Passed	Passed	Passed 100 ft lbs	Passed 100 ft lbs	Passed
Sodium Hydroxide	Passed	Passed	Passed 100 ft lbs	Passed 100 ft lbs	Passed
10% IGEPAL™	Passed	Passed	Passed 100 ft lbs	Passed 100 ft lbs	Passed
Kerosene	Passed	Passed	Passed 80 ft lbs	Passed 100 ft lbs	Passed

5.4 UV Resistance

The UV resistance test determines the effect that extreme UV exposure has on the plastic materials of the 2178-L/S Series Splice Cases. Ten "dog-bone" samples of each material were fabricated. The tensile strength of half the samples was measured per ASTM D638 using a crosshead speed of 2 in/min. (50 mm/min.). The average of these measurements constituted the baseline values for the two materials. The remaining samples were exposed to ultraviolet radiation per ASTM G53 using UVB-313 type fluorescent lamps. The cycle consisted of 8 hours of UV exposure at 150°F (65°C) followed by 4 hours of condensation at 122°F (50°C) with no UV exposure. After the end of 90 days of cycling, the tensile strength of the samples was measured. It was desired that the UV radiation cause no more than a 20% reduction in tensile strength when compared to the unexposed baseline values.

Results: The molded material exhibited an average tensile strength change of -0.9 %.

5.5 Fungus Resistance

The fungus resistance test ensures that the external closure materials of the 2178-L/S Series Splice Cases do not support fungus growth. Three samples of the molded material were tested per ASTM G21.

Results: A rating of 0 (no visible growth) was obtained.

6.0 Shield Bond Connector Tests

6.1 AC Fault

The AC Fault test verifies that the shield bond connector provides a sufficient electrically conductive path for grounding of the metallic components of the cable. Two 3M™ Scotchlok™ 4460-D / FO Shield Bond Connectors were installed on the ends of two 3 in. (7.5 cm) pieces of AT&T 216 ribbon fiber, dielectric cable. The two shield bond clamps were connected using a #6 AWG copper lead. The circuit was completed by connecting an AC power source to the shields on the opposite ends of the two fiber cables. A 350 amp current was applied to the circuit until the cable failed.

Results: No damage occurred to the shield bond connector.

6.2 Strength Member Protrusion of Scotchlok™ 4460-D / FO Shield Bond Connectors

The strength member protrusion test verifies that the strength member clamp will prevent bowing, pistoning, or breaking of the cable strength member when the member exerts a 100 lb. (445 N) force on the clamp. This verification was accomplished with two separate tests. The first test determined the amount of force that can be applied to the strength member before it moved more than 0.05 in. (1.3 mm) inside the clamp. The second test determined the amount of force that can be applied to the clamp before it was pulled from the cable shield. It was desired that both force levels exceed 100 lb. (445 N). Six samples were prepared using the 4460-D / FO shield bond connector on three different types of fiber cable (see table below).

For the first test, the amount of force required to move the strength member within each cable was measured. The strength member was then terminated in the clamp and the amount of force required to move each strength member more than 0.05 in. (1.3 mm) within the clamp was measured. The difference in these two measurements is the amount of force required to move the strength member in the strength member clamp (see table below).

For the second test, the same samples were used but the strength member was first disconnected from the clamp. The amount of force required to pull the strength member clamp from the cable shield was then measured (see table below).

Results: All samples met the 100 lb. (445 N) requirement for both tests. The results were as follows:

Sample	Cable	Force to Move SM (lb.)	Force to Move SM Clamp (lb.)
1	AT&T 12 fiber, dielectric (0.49" OD)	197 (877 N)	106 (472 N)
2	AT&T 12 fiber, dielectric (0.49" OD)	188 (837 N)	102 (454 N)
3	AT&T 216 fiber, metallic (0.69" OD)	167 (743 N)	180 (801 N)
4	AT&T 216 fiber, metallic (0.69" OD)	169 (752 N)	166 (739 N)
5	Siecor 24 fiber, dielectric (0.45" OD)	187 (832 N)	142 (632 N)
6	Siecor 24 fiber, dielectric (0.45" OD)	192 (854 N)	152 (676 N)

6.3 Strength Member Clamp Deflection

The 3M™ Strength Member 2172 clamp was tested under tension to check for clamp deflection. Nine samples were pulled to determine how far the central strength member lock position would move when 100 lb. (445 N) was applied to this area.

Results: The average deflection of the nine samples was 0.01 in. (0.25 mm). This position is allowed to move 0.05 in. (1.3 mm) per the Bellcore specification. The 2172 clamp meets this requirement.

6.4 Thermal Cycle / Light Loss Scotchlok™ 4460-D / FO Shield Bond Connector and 2172 Clamp

The thermal cycle / light loss test examines the ability of the shield bond connector to constrain strength member / sheath movement and prevent light loss over a wide range of operating temperatures. The two following cable types were used for testing the 4460-D / FO Shield Bond Connector and 2172 strength member clamp.

Sample	Cable Type
#1 .....4460-D/FO	Siecor 24 fiber, loose tube buffer, dielectric
#2 .....4460-D/FO	AT&T 216 ribbon fiber, single tube, dielectric
#3 2172	Siecor 24 fiber, loose tube buffer, dielectric
#4 2172	AT&T 216 ribbon fiber, single tube, dielectric

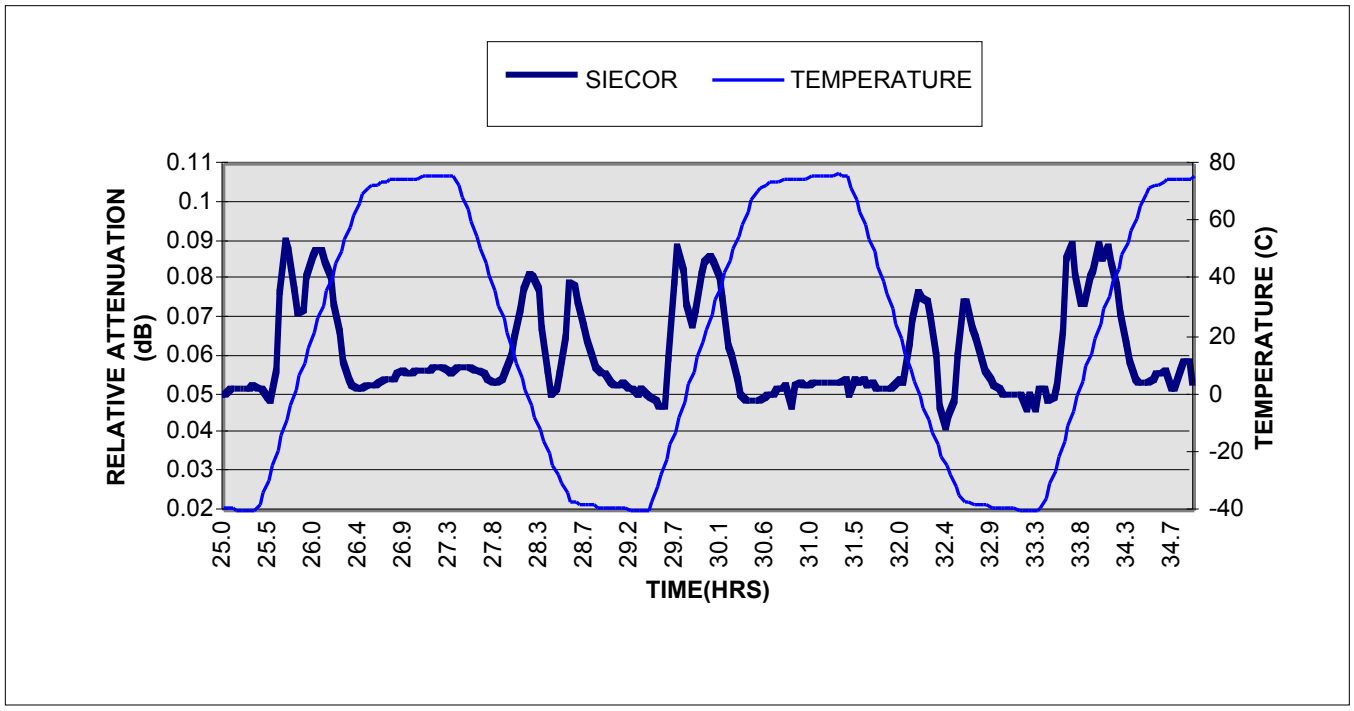
For each sample, approximately 70 ft. (21.3 m) of cable was coiled in a 5 ft. (1.5 m). diameter loop on the floor of an environmental chamber. One end of the cable was terminated inside the chamber and the other end spliced to jumpers outside of the chamber to allow for optical measurements. Inside the chamber, a minimum of 10 fibers from each cable were fusion spliced to each other (accounting for a minimum of five splices / data points) to simulate splicing in a splice case. At least one fiber from every buffer tube was used. The strength member of each cable was clamped using either a 4460-D / FO Shield Bond Connector or a 2172 strength member clamp. The samples were subjected to 10 four hour cycles from -40° F (-40° C) to 176° F (80° C). The four hour cycle includes one hour transition periods and one hour dwells at temperature extremes. Attenuation (light loss) was monitored continuously during this cycling using an optical source operating at a wavelength of 1550 ± 20 nm.

Results: The attenuation data (in dB's) was compiled and is recorded in the table and chart below. The table shows the maximum light power increase and decrease of the readings that occurred over all monitored fibers during the 40 hour cycling period. The table also shows the maximum power change in light loss after cycling.

Power Variations in dB's

Sample	Max Light Power Increase	Max Light Power Decrease	Max Power Change Before/After Cycling
#1 .....4460-D/FO	0.050	- 0.120	0.040
#2 .....4460-D/FO	0.090	- 0.110	0.030
#3 2172	0.110	- 0.070	0.050
#4 2172	0.110	- 0.130	0.090

The following chart shows a typical fiber response in one of the cables (Siecor 24 fiber) from sample #1 during the seventh and eight cycles of the test. This chart exhibits the relationship between temperature and attenuation and also demonstrates the repeatability of the data.



7.0 Conclusions

The 3M™ 2178-L/S Series Splice Cases were examined through a variety of tests which cover the product's ability to protect a fiber cable splice. Throughout these tests, the 2178-L/S Series Splice Cases met the requirements and performed with excellent results.

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