3M

Reenterable PST Dome Closure

Technical Report

September 1999
80-6111-6055-9-A

Contents:

1.0 Product Description

The 3M™ Reenterable PST Dome Closure System is designed to protect butt splices from water entry, insects, ultraviolet light, pic degradation and humidity while providing easy, no cost reentry. The closure system consists of an injection molded polypropylene dome and base which are clamped together with a stainless steel wire latch and sealed with a neoprene o-ring to protect the splice. A spiral wrap gel forms an end seal around the cables and a rubber Pre-Stretched Tube (PST) seals the transition between the dome and the gel.

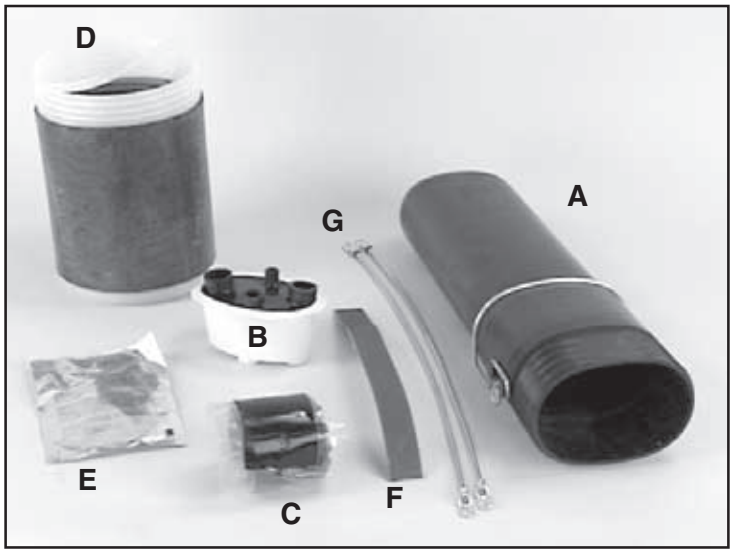
The Reenterable PST Dome Closure is easily installed without the use of heat or any special tools. The PST tube is slipped over the transition between the dome and the gel end seal. Pulling a rip cord on the PST allows it to shrink onto the closure body and gel end seal to form an airtight seal. The 3M™ Hand Hole Reenterable PST Dome Closure offers protection for splices contained in hand hole environments through the use of a second PST. This additional compression allows the closure to be placed in standing water or other harsh environments immediately after installation.

Reentry to the splice is accomplished by pulling out and down on the latch which lifts the dome from the base. The closure can be resealed by lining up the dome ears with the wire latch and pushing the clamp up until the latch rests on the dome.

1.1 Kit Contents:

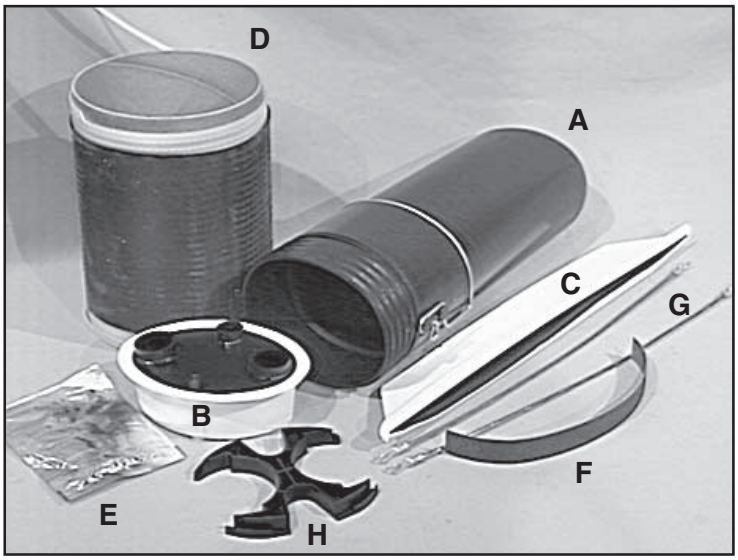
4604 and 4606 Closures

- Closure Assembly (A)
  - Dome
  - Base
  - O-ring
  - Latch
- Gel End Seal Core (B)
- Gel Sealing Strip (C)
- PST (D)
- Dessicant Bag (E)
- Sheath Scuff (F)
- Ground Wires (G)



4608 and 4608XL Closures

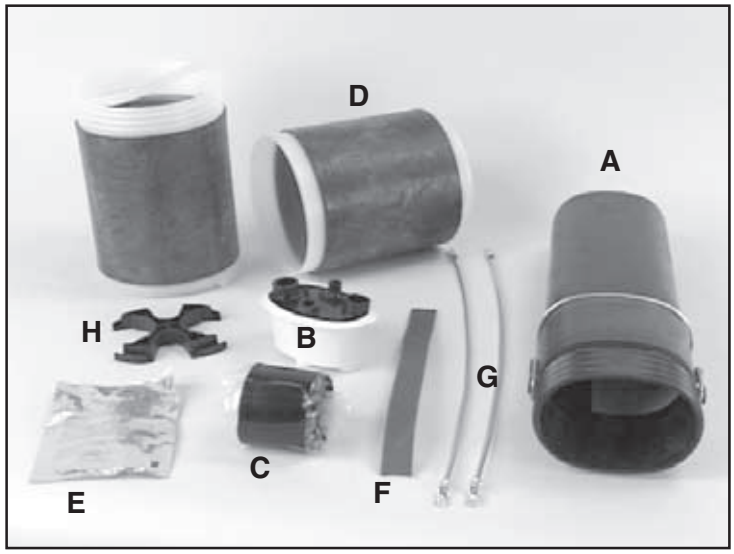
- Closure Assembly (A)
  - Dome
  - Base
  - O-ring
  - Latch
- Gel End Seal Core (B)
- Gel Sealing Strip (C)
- PST (D)
- Dessicant Bag (E)
- Sheath Scuff (F)
- Ground Wires (G)
- Base Plate (H)



1.1 Kit Contents:

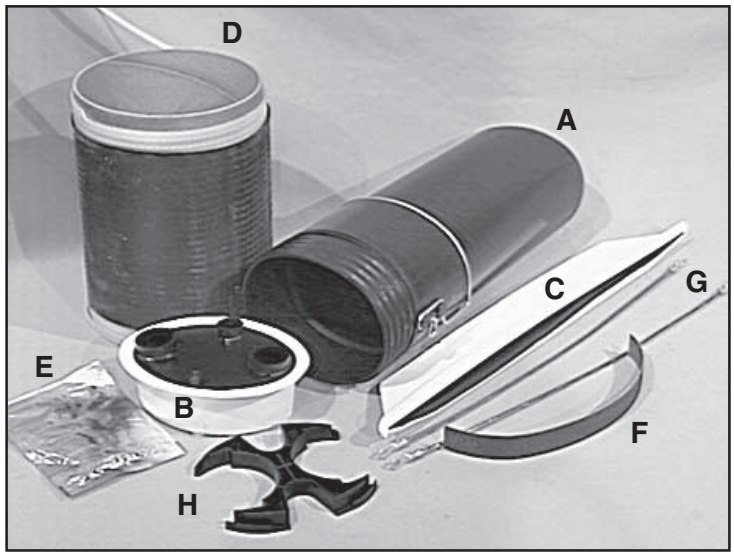
4604HH and 4606HH Closures

- Closure Assembly (A)
  - Dome
  - Base
  - O-ring
  - Latch
- Gel End Seal Core (B)
- Gel Sealing Strip (C)
- PSTs (D)
- Dessicant Bag (E)
- Sheath Scuff (F)
- Ground Wires (G)
- Base Plate (H) 4606HH only



4608HH Closure

- Closure Assembly (A)
  - Dome
  - Base
  - O-ring
  - Latch
- Gel End Seal Core (B)
- Gel Sealing Strip (C)
- PST (D)
- Dessicant Bag (E)
- Sheath Scuff (F)
- Ground Wires (G)
- Base Plate (H)



1.2 Material Composition

Injection molded dome and base	Polypropylene
O-ring	Neoprene
Wire form latch	Stainless Steel
Pull ‘n’ Shrink Tubing	Ethylene propylene rubber
Gel end seal	Modified polyurethane

1.3 Closure Capacity

3M™ Reenterable PST Dome Closure Capacities

	4604/04HH	4606/06HH	4608/08HH	4608XL
Closure Outside Diameter	3.8" x 2.8" (97 x 71 mm)	5.6" x 3.9" (142 x 99 mm)	7.0" x 5.4" (178 x 137 mm)	7.0" x 5.4" (178 x 137 mm)
Closure Length	22.5" (572 mm)	22.5" (572 mm)	23.5" (597 mm)	33.5" (851 mm)
Approx. Bundle Diameter	2.5" (64 mm)	3.9" (99 mm)	5.30" (135 mm)	5.30" (135 mm)
Cable Capacity & Ranges				
- Main Cables	0.5" to 1.1" (13 to 28 mm)	0.9" to 1.6" (23 to 41 mm)	1.4" to 2.5" (36 to 64mm)	1.4" to 2.5" (36 to 64mm)
- Terminal Cable	0.4" to 0.6" (10 to 15mm)	0.4" to 0.6" (10 to 15mm)	0.4" to 0.8" (10 to 20mm)	0.4" to 0.8" (10 to 20mm)
- Branch Cable	- -	0.7" to 1.0" (18 to 25mm)	0.9" to 1.3" (23 to 33mm)	0.9" to 1.3" (23 to 33mm)
- Drop Cables	0" to 0.35" (0 to 9mm)	0" to 0.35" (0 to 9mm)	0" to 0.35" (0 to 9mm)	0" to 0.35" (0 to 9mm)
***Approx. Splice Range**	100 pr-MS[2] 50 pr-UR	300 pr-MS[2] 100 pr-UR	600 pr-MS[2] 300 pr-UR	900 pr-MS[2] 400 pr-UR

**** Note: Based on 2 bank 4000-DWP and Scotchlok™ connectors installed per 3M practices.***
**** Examples: 100 pair means 100 pair In and 100 pair Out or 100 pair straight splice.***

2.0 Test Program Overview

To predict the long-term performance reliability of the 3M™ Reenterable PST Dome closure system, the closures were subjected to a number of tests which exposed them to conditions more severe than anticipated in actual field use. The tests are based on telephone industry performance specifications. The following list outlines the test series performed in this program, as well as the major product capabilities which were examined in each series:

√ Environmental Testing - Seal Integrity
√ Mechanical Testing - Strength
√ Material Integrity Testing - Material Integrity
√ Material Compatibility Testing - Corrosion Resistance

The following sections describe each test series and report the results obtained for the Reenterable PST Dome Closure System.

3.0 Environmental Tests

The Reenterable Dome closure was subjected to a series of environmental tests in order to determine the ability of the closure to withstand worst-case environmental conditions that may be experienced in outside plant. Eighteen closures (3 ea. 4604, 4606, 4608, 4604HH, 4606HH, and 4608HH) were subjected to the test series.

3.1 Thermal Aging

The thermal aging test simulates long-term aging of the closure sealing components. The sealing components for eighteen 3M™ Reenterable PST Dome closures (O-rings, gel end seals, gel strips, PST's) were aged at 140°F (60°C) for seven days.

Results: No visible deterioration of the aged sealing components.

3.2 Assembly

The assembly test verifies that the Reenterable Dome closure can be assembled in extreme temperatures. Four sets of the above thermal-aged components were conditioned at 32°F (0°C) for two hours. The closures were assembled at this temperature using the cable configurations shown below. Watesmo paper (moisture indicating paper) was placed inside the domes to aid in moisture detection in the subsequent tests. The above procedure was repeated for the remaining nine sets of sealing components at 104°F (40°C). All samples contained the standard ground strap and hardware. For the Hand Hole Closures, a second PST was installed directly over the first on each closure.

Results: All eighteen closures performed as intended at both temperature extremes.

Assembly Configuration - Reenterable Dome Closure

		Assembly		Cable Configuration			
Sample	Closure	Range	Temp	Qty	Pair	AWG	Dia.
1	4604	Min.	104°F	2	25	22 (.65 mm)	0.62 in.
2	4604	Mid.	32°F	1	100	22 (.65 mm)	1.1 in.
				1	25	22 (.65 mm)	0.62 in.
3	4604	Max.	104°F	2	100	22 (.65 mm)	1.1 in.
				1	25	22 (.65 mm)	0.62 in.
4	4606	Min.	104°F	2	100	22 (.65 mm)	1.1 in.
				1	25	22 (.65 mm)	0.62 in.
5	4606	Mid.	32°F	2	200	22 (.65 mm)	1.3 in.
				1	25	22 (.65 mm)	0.62 in.
6	4606	Max.	104°F	2	300	24 (.50 mm)	1.5 in.
				1	100	22 (.65 mm)	1.1 in.
				1	25	22 (.65 mm)	0.62 in.
7	4608	Min.	32°F	2	300	24 (.50 mm)	1.5 in.
				1	25	22 (.65 mm)	0.62 in.
8	4608	Mid.	104°F	2	300	24 (.50 mm)	1.5 in.
				1	100	22 (.65 mm)	1.1 in.
9	4608	Max.	32°F	2	600	22 (.65 mm)	2.4 in.
				1	100	22 (.65 mm)	1.1 in.
				1	25	22 (.65 mm)	0.62 in.
10	4604HH	Min.	32°F	2	25	22 (.65 mm)	0.62 in.
				1	2	22 (.65 mm)	0.31 in.
11	4604HH	Mid.	104°F	1	100	22 (.65 mm)	1.1 in.
				1	25	22 (.65 mm)	0.62 in.
				1	6	24 (.50 mm)	? in.
				1	2	22 (.65 mm)	0.31 in.
12	4604HH	Mid.	32°F	2	100	22 (.65 mm)	1.1 in.
				1	25	22 (.65 mm)	0.62 in.
				1	6	24 (.50 mm)	? in.
				1	2	22 (.65 mm)	0.31 in.
13	4606HH	Min.	32°F	2	100	22 (.65 mm)	1.1 in.
				1	6	22 (.65 mm)	0.62 in.
14	4606HH	Mid.	104°F	2	100	22 (.65 mm)	1.1 in.
				1	25	22 (.65 mm)	0.62 in.
				1	6	24 (.50 mm)	? in.
15	4606HH	Max.	32°F	2	300	24 (.50 mm)	1.5 in.
				1	100	22 (.65 mm)	1.1 in.
				1	6	24 (.50 mm)	? in.
				1	2	22 (.65 mm)	0.31 in.
16	4608HH	Min.	104°F	2	300	24 (.50 mm)	1.5 in.
				1	25	22 (.65 mm)	0.62 in.
				1	6	24 (.50 mm)	? in.
17	4608HH	Mid.	32°F	2	300	24 (.50 mm)	1.5 in.
				1	25	22 (.65 mm)	0.62 in.
				2	6	24 (.50 mm)	? in.
18	4608HH	Max.	104°F	2	600	22 (.65 mm)	2.4 in.
				1	100	22 (.65 mm)	1.1 in.
				2	6	24 (.50 mm)	? in.

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 Reenterable Dome closure. The eighteen closures from the previous test were exposed to 50 four-hour cycles from 140°F (60°C) and 95% relative humidity to -40°F (-40°C) with uncontrolled humidity. Each four hour cycle included one hour transition periods and one hour dwells at the temperature extremes. At the end of cycling, the closures were allowed to reach room temperature, then opened and inspected.

Results: No closure degradation or water intrusion.

3.4 Freeze / Thaw

The freeze / thaw test determines if an alternately freezing and thawing environment has any effect on the ability of the Reenterable Dome closure to maintain a watertight seal. The eighteen closures from the previous test were placed horizontally in a water tank to a depth which exceeds the top of the closure by a minimum of 1 in. (2.5 cm). The closures 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 four hour transition periods and ten hour dwell times at the two temperature extremes. At the end of cycling, the closures were opened and inspected.

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

3.5 Water Resistance

The water resistance test determines if the Reenterable Dome closure can withstand the rigors of the previous environmental test series without degradation of its seal. The eighteen closures from the previous test were subjected to a 4 ft. (1.2 m) water head in a horizontal position for a period of seven days and then checked for water intrusion. The closures were then immersed in 1 ft. (0.3 m) of water and a 2 psig (0.14 bar) internal pressure was applied for 5 minutes. Presence of air bubbles constitute a failure. The results of this test are as follows:

Sample	Closure	4 ft. (1.2 m) Water head	2 psig (0.14 bar) for 5 min.
1	4604	Pass	Pass
2	4604	Pass	Pass
3	4604	Pass	Pass
4	4606	Pass	Pass
5	4606	Pass	Pass
6	4606	Pass	Pass
7	4608	Pass	Pass
8	4608	Pass	Pass
9	4608	Pass	Pass
10	4604HH	Pass	Pass
11	4604HH	Pass	Pass
12	4604HH	Pass	Pass
13	4606HH	Pass	Pass
14	4606HH	Pass	Pass
15	4606HH	Pass	Pass
16	4608HH	Pass	Pass
17	4608HH	Pass	Pass
18	4608HH	Pass	Pass

3.6 Flood Resistance

The 3M™ Hand Hold Reenterable Dome closure is tested for water resistance at a depth of 10 ft. (3.0 m). The nine Hand Hold closures (3 ea. 4604HH, 4606HH and 4608HH) from the previous test were subjected to a 10 ft. (3.0 m) water head for seven days. The closures were then immersed in 1 ft. (0.3 m) of water and a 2 psig (0.14 bar) internal pressure was applied for 5 minutes. At the end of the testing, the closures were checked for water intrusion.

Results: All closures with a double layer PST passed the internal pressure test and no water intrusion was detected inside the closures.

3.7 Water Vapor Transmission

Three samples of the dome and base material were tested per ASTM F372-73 "Standard Test Method for Water Vapor Transmission Rate of Flexible Barrier Materials Using an Infrared Detection Technique" at 100°F (37.8°C) with 100% relative humidity on one side of the sample and 0% relative humidity on the other side for four days. This test is rated as comparable to ASTM E96, except shorter and more repeatable, by MOCON Testing Service, a water vapor transmission test specialist, located in Minneapolis, MN.

Results: All samples had less than the maximum of 0.001 grams ($3.5 \bullet 10^{-7}$ oz.) per hour transmission rate per 100 in^2 (645 cm^2) exposed area as specified.

4.0 Mechanical Tests

Twenty Reenterable PST Dome Closures were subjected to a series of mechanical stresses. After the samples were conditioned at test temperatures, they were pressurized with a minimum of 2 psig (0.14 bar). With the internal air pressure, each sample completed the Impact Stress, Flexure and Torsion tests. After the mechanical tests, the closures were allowed to equalize at 72°F (23°C) and checked for seal integrity with a minimum flash test of 2 psig (0.14 bar). While under pressure, the samples were submerged under 1.0 ft. (0.3 m) of water. During the five minute period, any indication of air bubbles would constitute a failure for that closure.

Assembly Configurations

4604

Min. 2 - 25 pair 22 AWG (0.65 mm) aircore cables ..... Dia. - 0.62 in. (15.7mm)

Max. 2 - 100 pair 22 AWG (0.65 mm) aircore cables ..... Dia. - 1.1 in. (27.9 mm);
1 - 25 pair 24 AWG (0.65 mm) aircore terminal cable .... Dia. - 0.62 in. (15.7mm);
2 - 2 pair 22 AWG (0.65 mm) buried service wires ..... Dia. - 0.31 in. (7.9 mm)

4606

Min. 2 - 100 pair 22 AWG (0.65 mm) aircore cable ..... Dia. - 1.1 in. (27.9 mm);
1 - 25 pair 22 AWG (0.65 mm) aircore terminal cable .... Dia. - 0.62 in. (15.7mm)

Max. 2 - 300 pair 24 AWG (0.50 mm) aircore cable ..... Dia - 1.5 in (41.1 mm);
1 - 100 pair 22 AWG (0.65 mm) aircore cable ..... Dia. - 1.1 in. (27.9 mm);
1 - 25 pair 22 AWG (0.65 mm) aircore terminal cable .... Dia. - 0.62 in. (15.7mm)

4608

Min. 2 - 300 pair 24 AWG (0.50 mm) aircore cable ..... Dia - 1.5 in (41.1 mm);
1 - 100 pair 22 AWG (0.65 mm) aircore cable ..... Dia. - 1.1 in. (27.9 mm);
1 - 25 pair 22 AWG (0.65 mm) aircore terminal cable .... Dia. - 0.62 in. (15.7mm)

Max. 2 - 900 pair 24 AWG (0.50 mm) aircore cable ..... Dia. - 2.4 in. (61 mm);
1 - 100 pair 22 AWG (0.65 mm) aircore cable ..... Dia. - 1.1 in. (27.9 mm);
1 - 25 pair 22 AWG (0.65 mm) aircore terminal cable .... Dia. - 0.62 in. (15.7mm)

**** All samples contained the standard bond strap and hardware.***

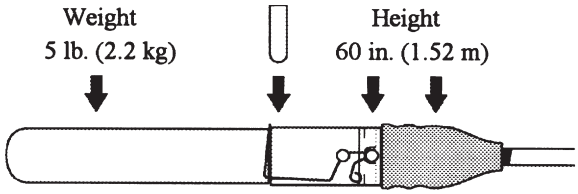
Mechanical Test Sample Matrix

Sample Number	Closure Size	Assembly Configuration	Re-Entry Capable	Test Temperature
1	4604	Min.	Yes	0°F (-18°C)
2	4604	Max.	Yes	0°F (-18°C)
3	4604	Min.	Yes	0°F (-18°C)
4	4604	Max.	Yes	0°F (-18°C)
5	4604	Min.	Yes	100°F (38°C)
6	4604	Max.	Yes	100°F (38°C)
7	4604	Min.	Yes	100°F (38°C)
8	4604	Max.	Yes	100°F (38°C)
9	4606	Min.	Yes	0°F (-18°C)
10	4606	Max.	Yes	0°F (-18°C)
11	4606	Min.	Yes	0°F (-18°C)
12	4606	Max.	Yes	0°F (-18°C)
13	4606	Min.	Yes	100°F (38°C)
14	4606	Max.	Yes	100°F (38°C)
15	4606	Min.	Yes	100°F (38°C)
16	4606	Max.	Yes	100°F (38°C)
17	4608	Min.	Yes	0°F (-18°C)
18	4608	Max.	Yes	0°F (-18°C)
19	4608	Min.	Yes	100°F (38°C)
20	4608	Max.	Yes	100°F (38°C)

4.1 Impact Stress

All closures were conditioned for 24 hours at either 0°F (-18°C) or 100°F (38°C). Each closure was subjected to two impact drops onto the dome, one impact drop on the dome-base interface and one impact drop onto the PST over the base.

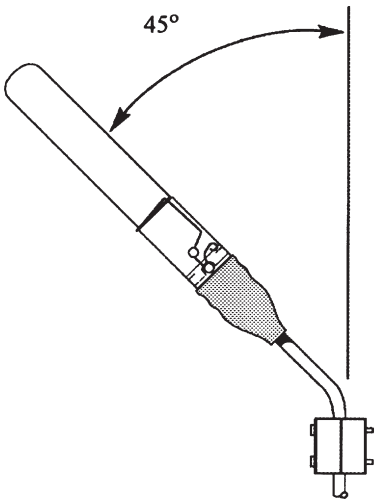
The impact force of 300 in-lb. (33.8 Joules) was delivered by a 5 lb. (2.26 kg) weight dropped 60 in. (1.52 m). The weight was a 2.0 in. (50.8 mm) diameter cylinder with a 1.0 in. (25.4 mm) spherical radius at the striking end.



4.2 Flexure

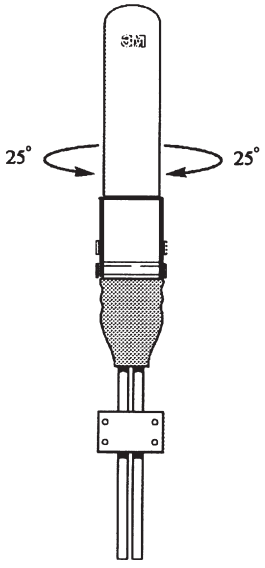
Each sample was clamped parallel to the plane of the cables, at a point 6 in. (15.2 cm) below the lowest portion of the PST tube. The face of the closure was moved through a 45° angle in less than 10 seconds.

Each sample received two flexures separated by 2 minutes. The 4608 closures that were assembled with 600 pair cable were moved through a 30° angle only because of the cable stiffness.



4.3 Torsion

All samples were clamped parallel to the plane of the cable, at a point 6 in. (15.2 cm) below the lowest portion of the PST tube. The closures were rotated through an arc of ± 25° for a total of two complete rotations. After the Torsion, Flexure, and Impact tests, the closures were examined for physical damage and then subjected to the Flash test.



4.4 Flash Test

Following the three mechanical tests, each sample was flash tested for five minutes with a minimum of 2 psig (.14 bar) air pressure at 72°F (23°C). While under pressure, the samples were submerged under 1.0 ft. (0.3 m) of water in a horizontal position. During the five minute period, any indication of air bubbles would constitute a failure for that closure.

Mechanical Sequence

Sample	Closure	Visually Detectable Damage			Flash Test
		Impact	*Bending*	*Torsion*	2 psig (.14 bar)
1	4604	None	None	None	Pass
2	4604	None	None	None	Pass
3	4604	None	None	None	Pass
4	4604	None	None	None	Pass
5	4604	None	None	None	Pass
6	4604	None	None	None	Pass
7	4604	None	None	None	Pass
8	4604	None	None	None	Pass
9	4606	None	None	None	Pass
10	4606	None	None	None	Pass
11	4606	None	None	None	Pass
12	4606	None	None	None	Pass
13	4606	None	None	None	Pass
14	4606	None	None	None	Pass
15	4606	None	None	None	Pass
16	4606	None	None	None	Pass
17	4608	None	None	None	Pass
18	4608	None	None	None	Pass
19	4608	None	None	None	Pass
20	4608	None	None	None	Pass

5.0 Material Integrity Tests

The materials used in the 3M™ Reenterable PST Dome closure were tested to determine their ability to withstand the severe conditions that could exist in an outside plant environment.

5.1 Chemical Resistance - Material Degradation

The first of four chemical resistance tests evaluates the resistance of the Reenterable PST Dome closure material to chemicals that may be used during installation and maintenance. The closure material was fabricated into samples having the dimension 2.5in. x 0.5 in. x 0.125 in. (6.4 cm x 1.3 cm x 0.32 cm).

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 HighGel 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 external closure materials (both molded material and PST) can withstand immersion in three different chemicals for seven days without a reduction in their physical properties. "Dog-bone" samples of each material were fabricated. The average weight, hardness, and tensile strength of the samples was measured and recorded as the baseline values. For tensile strength measurements, a crosshead speed of 2in/min. (50 mm/min.) was used. Five samples each were immersed in the following chemicals for a period of seven days.

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

The weight, hardness, and tensile strength of each sample was 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.

Chemical	Material	% Weight Change	% Hardness Change	% Tensile Reduction
Sulfuric Acid	Closure	0.0	-0.4	-0.4
	PST	0.0	-0.4	No reduction
Sodium Hydroxide	Closure	0.0	0.0	-0.5
	PST	-0.1	-2.6	No reduction
IGEPAL	Closure	0.0	-1.0	-0.2
	PST	-1.6	1.2	No reduction

5.3 UV Resistance

The UV resistance test determines the effect that extreme UV exposure has on the external materials (the molded material and the PST) of the Reenterable PST Dome closure. 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 eight hours of UV exposure at 150°F (65°C) followed by four hours of condensation at 122°F (50°C) with no UV exposure.

At 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%. The PST material exhibited an average tensile strength change of 1.6%.

5.4 Fungus Resistance

The fungus resistance test ensures that the external closure materials of the 3M‘ Reenterable PST Dome closure do not support fungus growth. Samples of the molded material, PST, gel seal material, O-ring and O-ring grease were tested per ASTM G21.

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

6.0 Material Compatibility - Corrosion of Copper

Six samples of the gel seal material and six samples of the O-ring grease were tested for possible chemical corrosion of copper. The gel was applied in strips to one side of a specially designed printed circuit board, perpendicular to the printed comb pattern. The grease was applied all across the circuit board. All samples were sealed in glass jars and were aged for 14 days at 140°F (60°C). Throughout the aging period, 45 volts was applied to the boards. After completing the 14 days, the samples were examined for discoloration of the copper and current flow across the printed circuit pattern.

Results: No discoloration or erratic current readings were observed.

7.0 Conclusions

The 3M™ Reenterable PST Dome closures were examined through a variety of tests which cover the product's ability to protect copper butt splices. Throughout these tests, the Reenterable PST closure met or exceeded the severe requirements and performed with excellent results.

Important Notice
Before using this product, you must evaluate it and determine if it is suitable for your intended application. You assume all risks and liability associated with such use.

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