

**3M**

# 3838 PST/Gel Buried Service Wire Splice Kit

Technical Report

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## 1.0 Product Description

The 3M™ 3838 PST/Gel Buried Service Wire Splice (BSW) Kit is designed to be a protection device to guard splices on filled or unfilled PIC buried service wires. No encapsulant is needed. The PST/Gel is designed to maintain the integrity of the closure body against any water or moisture entering the closure and maintain the high insulation resistance between all wire pairs. The closure is resistant to saltwater (3.5% sodium chloride), acid (3% sulfuric acid), base (0.2N sodium hydroxide), and cable filling compounds. It is compatible with encapsulant possibly found in the field condition.

The 3M™ 3838 PST/Gel BSW splice kit will accommodate up to six pair buried service wire with a maximum diameter of 0.45 in. (11.4 mm) in either an in-line or butt splice configuration. Maximum diameter of a cable up to 0.65 in. (16.5 mm) can be used with the kit if a 3M™ Scotchlok™ 4460D shield bond connector is used. A 3M™ Scotchlok™ 4463 Service Wire Shield Connector and strain relief clamp are included for easy shield bonding, splice protection and strain relief to the buried service wires. The parts included in each kit and their dimensions are illustrated in the diagrams shown on the next page.

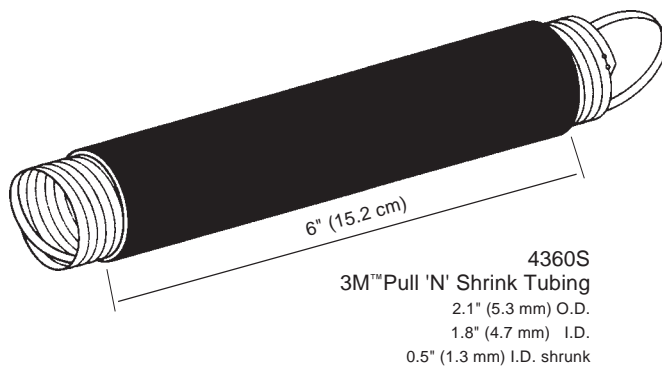
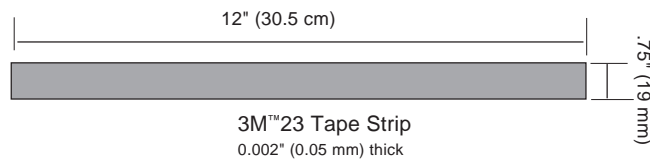
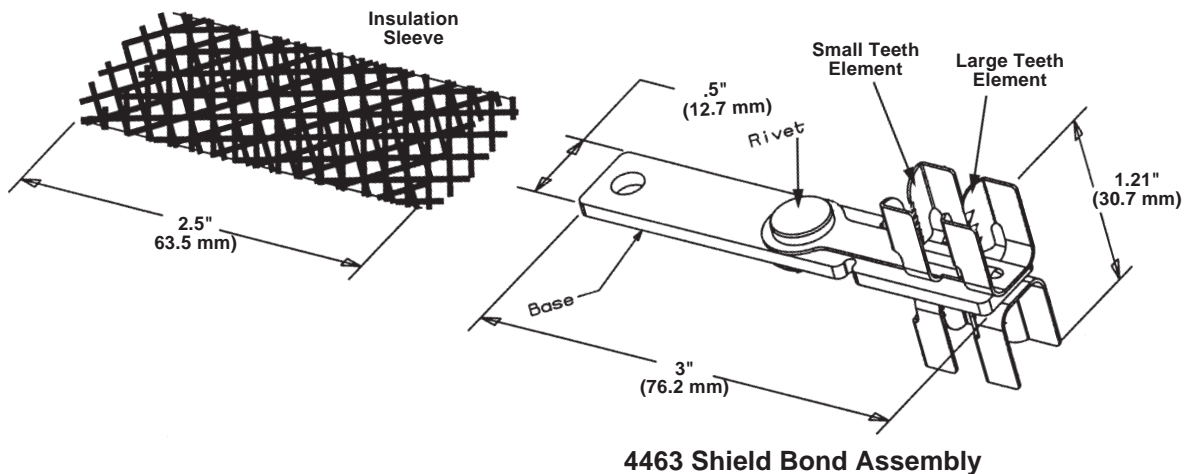
## 2.0 Test Program Overview

To assess the long term performance reliability of the 3M™ 3838 PST/Gel BSW splice kit, the kits were subjected to a number of tests which exposed them to conditions more severe than anticipated in actual field use.

The following sections describe the specific tests performed on this product and report the results obtained. All tests except the fungus test were performed by 3M Telecom Systems Division's Network Apparatus Test Laboratory in Austin, TX. The fungus test was performed by an independent lab. The tests were done using the Bellcore's TR-NWT-000251, "*Generic Requirements For Service Wire Splice For Buried Service Wire*," Issue 2, May 1991; U S West PGF#N600M07 "*U S West Communications Requirements for Buried Service Wire Splice Closures*," Issue 1, May 1992; and other appropriate specifications commonly used in the telecommunications industry as a guideline.

The report also points out if a deviation in testing condition from the Bellcore specification was used in the test. In most situations, the deviation means a more severe environmental testing condition than the Bellcore specification was adopted in the test, (i.e., such as more rapid transition and higher number of thermal shocks between the two extreme temperatures, higher water pressure, using aged samples instead of new samples for the test, etc.).

# 3M™ 3838 PST/Gel Buried Service Wire Splice Kit Components



### 3.0 Environmental Test Series (Bellcore 4.3 & 5.3)

Eighteen (instead of six) samples were prepared at normal room temperature as follows:

**Table of Sample Description of Eighteen Test Samples**

Sample Number*	Splice Configuration	Test Sample Description	
		# of Service Wire Pairs	Wire Connector
1,2,3	In-Line	2	UR2-D (Unfilled)
4,5,6	Butt	2	UR2-D (Unfilled)
7,8	In-Line	2	UR2 (Filled)
9,10,11	In-Line	5	UR2-D (Unfilled)
12,13,14	Butt	5	UR2-D (Unfilled)
15,16	In-Line	5	UR2 (Filled)
17,18	In-Line	2	UR2-D (Unfilled)

*\*Note: All samples use AT&T fully flooded, 22 AWG service wire cable and 3M™ Scotchlok™ connectors.*

### 3.1 Accelerated Aging/Insulation Resistance and Corrosion Resistance (Bellcore 4.3.1, 4.3.5, 5.3.1 & 5.3.5)

To test the seal against water or moisture entry to prevent corrosion and degradation of insulation resistance, each sample, except samples #17 & 18, went through all four environmental tests in the following order: Temperature Cycling with Humidity, Thermal Shock, Freeze/Thaw in Water and Water Head.

The above test procedure is different from the Bellcore specification. The Bellcore requires that new samples should be prepared for Freeze/Thaw test and Water Head test respectively. In addition, the Bellcore specification requires that the corrosion resistance samples do not need to go through Freeze/Thaw in Water test and Water Head test. This test is more severe than the Bellcore requirement.

Samples #17 & 18 were impact tested at 15° F (-9.5° C, see details in section 3.4.1 of this report) and then tested through Water Immersion (Bellcore 5.3.5.1) and Thermal Shock test (Bellcore 5.3.5.2) according to the test procedures of the Bellcore specification for Accelerated Aging test (Bellcore 5.3.5). An additional aging test, the Freeze/Thaw test, not required by the Bellcore specification, was performed on these two samples.

The insulation resistance of all samples was measured after each test and any reading under 1 x 10<sup>8</sup> ohms is considered a failure. The details of each test condition in the sequence and the test results are in the following sections 3.1.1 to 3.1.5.

**3.1.1 Temperature Cycling with High Humidity (Bellcore 5.2.2)**

The samples were tested in a 95% relative humidity environment for 30 days. During the testing, each sample was temperature cycled between 40° F (4.4° C) and 140° F (60° C) for 90 (instead of 45) cycles. The cycle time was reduced from 16 hours to eight hours. The dwell time at each extreme temperature was reduced from four hours to two hours and the transition time between the two extreme temperatures was shortened from four hours down to two hours.

In other words, the test was performed in same test duration as the Bellcore requirement but the samples were subjected to twice the number of thermal shocks of the condition specified by the Bellcore. The insulation resistance measurement was performed immediately after the temperature cycling with high humidity test. The overall minimum insulation resistance value was  $4.7 \times 10^{10}$  ohms, well above the minimum requirement of  $1 \times 10^8$  ohms. All samples passed the test.

**The Insulation Resistance Data After Temperature Cycling with High Humidity Test**

Sample Number	Average (ohms)*	Minimum (ohms)	Pass/Fail
1	$5.7 \times 10^{10}$	$5.2 \times 10^{10}$	Pass
2	$5.5 \times 10^{10}$	$5.3 \times 10^{10}$	Pass
3	$5.6 \times 10^{10}$	$5.1 \times 10^{10}$	Pass
4	$5.0 \times 10^{10}$	$4.7 \times 10^{10}$	Pass
5	$5.8 \times 10^{10}$	$5.6 \times 10^{10}$	Pass
6	$5.4 \times 10^{10}$	$5.0 \times 10^{10}$	Pass
7	$5.8 \times 10^{10}$	$5.5 \times 10^{10}$	Pass
8	$5.5 \times 10^{10}$	$5.2 \times 10^{10}$	Pass
9	$5.7 \times 10^{10}$	$4.9 \times 10^{10}$	Pass
10	$5.4 \times 10^{10}$	$4.9 \times 10^{10}$	Pass
11	$5.4 \times 10^{10}$	$5.0 \times 10^{10}$	Pass
12	$5.4 \times 10^{10}$	$4.7 \times 10^{10}$	Pass
13	$5.4 \times 10^{10}$	$4.9 \times 10^{10}$	Pass
14	$5.1 \times 10^{10}$	$4.8 \times 10^{10}$	Pass
15	$5.7 \times 10^{10}$	$4.9 \times 10^{10}$	Pass
16	$5.4 \times 10^{10}$	$5.0 \times 10^{10}$	Pass

**Note:** *The insulation resistance (IR) measurement includes IR between Tip to two adjacent Rings, IR between Ring to two adjacent Tips, and IR between wire to shield for each service wire pair. Average data is the overall average of all data measured for each sample. Minimum data is the lowest IR data obtained for each sample.*

### 3.1.2 Water Immersion (Bellcore 5.3.5.1)

The cold impact tested samples #17 & 18 were submerged in tap water at a depth of 24 inches (61 cm) at a temperature  $76^{\circ}\text{F} \pm 2^{\circ}\text{F}$  ( $24^{\circ}\text{C} \pm 1^{\circ}\text{C}$ ) for 14 days. During testing, 48 V DC of power from a current limited short tester was applied to all service wire pairs to simulate working pairs and to detect a possibility of an electrical short in each working pair. The IR was measured at 100 V DC after one hour and every other day thereafter. At the end of the test, the IR between any two wire pairs and all pairs to shield should be at least  $1 \times 10^8$  ohms. Both samples passed the test and the lowest IR was at least two orders of magnitude above the requirement.

#### The Insulation Resistance Data After Water Immersion Test

Sample Number	Average (ohms)*	Minimum (ohms)	Pass/Fail
17	$7.3 \times 10^{10}$	$5.1 \times 10^{10}$	Pass
18	$6.7 \times 10^{10}$	$5.4 \times 10^{10}$	Pass

*Note: The insulation resistance (IR) measurement includes IR between Tip to two adjacent Rings, IR between Ring to two adjacent Tips, and IR between wire to shield for each service wire pair. Average data is the overall average of all data measured for each sample. Minimum data is the lowest IR data obtained for each sample*

**3.1.3 Thermal Shock (Bellcore 5.3.5.2)**

The samples #1-16 from the temperature cycling with high humidity test and samples #17 & 18 from the water immersion test, were subjected to fifteen 16 hour temperature cycles between -40° F (4.4° C) and 140° F (60° C). The dwell time at each extreme temperature and the transition time between the two extreme temperatures is four hours each. During aging, 48 volts of power from a current limited short tester was applied to all service wire pairs to simulate working pairs and to detect a possibility of an electrical short in each working pair. Applying 48 volts of power during the thermal shock test was not required by the Bellcore.

At the conclusion of the test, all samples were examined for any deterioration of the external closure material. No sign of deterioration was found. The insulation resistance was measured on each sample with samples having insulation resistance values above the minimum requirement of  $1 \times 10^8$  ohms.

**The Insulation Resistance Data After Thermal Shock Test**

<b>Sample Number</b>	<b>Average (ohms)*</b>	<b>Minimum (ohms)</b>	<b>Pass/Fail</b>
1	$6.7 \times 10^{10}$	$6.3 \times 10^{10}$	Pass
2	$6.5 \times 10^{10}$	$6.3 \times 10^{10}$	Pass
3	$6.7 \times 10^{10}$	$6.0 \times 10^{10}$	Pass
4	$5.6 \times 10^{10}$	$5.3 \times 10^{10}$	Pass
5	$6.3 \times 10^{10}$	$6.0 \times 10^{10}$	Pass
6	$6.6 \times 10^{10}$	$6.0 \times 10^{10}$	Pass
7	$6.3 \times 10^{10}$	$6.0 \times 10^{10}$	Pass
8	$6.3 \times 10^{10}$	$6.1 \times 10^{10}$	Pass
9	$6.1 \times 10^{10}$	$5.4 \times 10^{10}$	Pass
10	$6.1 \times 10^{10}$	$5.5 \times 10^{10}$	Pass
11	$5.8 \times 10^{10}$	$5.4 \times 10^{10}$	Pass
12	$6.1 \times 10^{10}$	$5.4 \times 10^{10}$	Pass
13	$6.0 \times 10^{10}$	$5.5 \times 10^{10}$	Pass
14	$5.9 \times 10^{10}$	$5.6 \times 10^{10}$	Pass
15	$6.1 \times 10^{10}$	$5.6 \times 10^{10}$	Pass
16	$6.0 \times 10^{10}$	$5.6 \times 10^{10}$	Pass
17	$4.8 \times 10^{10}$	$2.5 \times 10^{10}$	Pass
18	$4.7 \times 10^{10}$	$4.0 \times 10^{10}$	Pass

*\*Note: The insulation resistance (IR) measurement includes IR between Tip to two adjacent Rings, IR between Ring to two adjacent Tips, and IR between wire to shield for each service wire pair. Average data is the overall average of all data measured for each sample. Minimum data is the lowest IR data obtained for each sample*



### 3.1.4 Freeze/Thaw Cycling in Water (Bellcore 4.3.6 & 5.3.6)

In this test, aged samples were used rather than preparing new samples as specified by the Bellcore. The test samples included sixteen samples (samples #1-16) that had gone through a series of accelerated aging tests as described in sections 3.1.1 & 3.1.3, and two samples (samples #17 & 18) that had gone through cold impact (section 3.4.1) and several accelerated aging tests (sections 3.1.2 & 3.1.3). Samples #1-16 were immersed in water to a depth of 32 inches and samples 17 & 18 were under 12 inches of sand saturated with water. Weights were put on top of samples #1-16 to keep them submerged in the water tank throughout the test. The samples were cycled between -40° F (-40° C) and 158° F (70° C) for 50 cycles (59 days). The cycle time was 28 hours, 10 hours at each extreme temperature and four hour transition time between the hot and cold temperature extremes. During aging, 48 volts of power from a current limited short tester was applied to all service wire pairs to stimulate a working pair and to detect a possibility of an electrical short in each working pair. Applying 48 volts of power during the freeze/thaw cycling test was not required by the Bellcore. Again, there was no sign of deterioration of the closure material at the end of test and all samples had insulation resistance values greater than the minimum requirement of  $1 \times 10^8$  ohms.

#### The Insulation Resistance Data After After Freeze/Thaw Cycling in Water Test

Sample Number	Average (ohms)*	Minimum (ohms)	Pass/Fail
1	$5.6 \times 10^{10}$	$5.3 \times 10^{10}$	Pass
2	$5.6 \times 10^{10}$	$5.3 \times 10^{10}$	Pass
3	$5.1 \times 10^{10}$	$4.6 \times 10^{10}$	Pass
4	$5.2 \times 10^{10}$	$4.9 \times 10^{10}$	Pass
5	$5.7 \times 10^{10}$	$5.5 \times 10^{10}$	Pass
6	$5.8 \times 10^{10}$	$5.4 \times 10^{10}$	Pass
7	$5.5 \times 10^{10}$	$5.3 \times 10^{10}$	Pass
8	$5.7 \times 10^{10}$	$5.4 \times 10^{10}$	Pass
9	$5.6 \times 10^{10}$	$5.0 \times 10^{10}$	Pass
10	$5.2 \times 10^{10}$	$4.9 \times 10^{10}$	Pass
11	$5.3 \times 10^{10}$	$5.0 \times 10^{10}$	Pass
12	$5.2 \times 10^{10}$	$4.7 \times 10^{10}$	Pass
13	$5.0 \times 10^{10}$	$4.8 \times 10^{10}$	Pass
14	$5.3 \times 10^{10}$	$5.1 \times 10^{10}$	Pass
15	$5.6 \times 10^{10}$	$5.1 \times 10^{10}$	Pass
16	$5.3 \times 10^{10}$	$5.0 \times 10^{10}$	Pass
17	$7.7 \times 10^{10}$	$2.6 \times 10^{10}$	Pass
18	$7.6 \times 10^{10}$	$3.6 \times 10^{10}$	Pass

**Note:** *The insulation resistance (IR) measurement includes IR between Tip to two adjacent Rings, IR between Ring to two adjacent Tips, and IR between wire to shield for each service wire pair. Average data is the overall average of all data measured for each sample. Minimum data is the lowest IR data obtained for each sample.*

**3.1.5 Water Head Test (Bellcore 4.3.7 & 5.3.7)**

Again, all sixteen samples (samples 1-16) that had gone through a series of accelerated aging tests as described in sections 3.1.1, 3.1.3, and 3.1.4 instead of using six new samples as specified by the Bellcore were used for this test. One end of the service cable was cut one foot from the closure sample and a three foot water head instead of the two feet requirement was connected to the cut end of the service cable. The test was conducted at room temperature, approximately 76° F (24° C), for 14 days. After the test, the water head was removed from the samples and insulation resistance measured. All of the samples meet the minimum requirement of  $1 \times 10^8$  ohms. All samples were then opened for examination with no rust or other degradation observed as described in section 3.1.6.

**The Insulation Resistance Data After Water Head Test**

<b>Sample Number</b>	<b>Average (ohms)*</b>	<b>Minimum (ohms)</b>	<b>Pass/Fail</b>
1	$6.1 \times 10^{10}$	$5.7 \times 10^{10}$	Pass
2	$6.0 \times 10^{10}$	$5.8 \times 10^{10}$	Pass
3	$5.5 \times 10^{10}$	$4.8 \times 10^{10}$	Pass
4	$5.8 \times 10^{10}$	$5.4 \times 10^{10}$	Pass
5	$6.1 \times 10^{10}$	$5.8 \times 10^{10}$	Pass
6	$5.8 \times 10^{10}$	$4.8 \times 10^{10}$	Pass
7	$6.0 \times 10^{10}$	$5.7 \times 10^{10}$	Pass
8	$6.1 \times 10^{10}$	$5.9 \times 10^{10}$	Pass
9	$6.1 \times 10^{10}$	$5.3 \times 10^{10}$	Pass
10	$5.9 \times 10^{10}$	$5.4 \times 10^{10}$	Pass
11	$5.9 \times 10^{10}$	$5.4 \times 10^{10}$	Pass
12	$6.3 \times 10^{10}$	$5.4 \times 10^{10}$	Pass
13	$6.0 \times 10^{10}$	$5.4 \times 10^{10}$	Pass
14	$5.9 \times 10^{10}$	$5.5 \times 10^{10}$	Pass
15	$6.3 \times 10^{10}$	$5.4 \times 10^{10}$	Pass
16	$5.8 \times 10^{10}$	$5.4 \times 10^{10}$	Pass

**Note:** *The insulation resistance (IR) measurement includes IR between Tip to two adjacent Rings, IR between Ring to two adjacent Tips, and IR between wire to shield for each service wire pair. Average data is the overall average of all data measured for each sample. Minimum data is the lowest IR data obtained for each sample.*

### 3.1.6 Corrosion Resistance (Bellcore 4.3.1 & 5.3.1)

The inspection for any possibility of corrosion inside the samples was not done until after the conclusion of the water head test since the same samples had to go through a series of different aging tests (see sections 3.1.3 - 3.1.5). The Bellcore does not require samples to go through Freeze/Thaw in Water test and Water Head test. The samples were examined after the water head test for any possibility of corrosion. An analysis was made of the tested samples for the degree of rust in accordance with ASTM D610. A rust grade of "9 " or better is required. All samples passed the test.

#### The Rust Grade Data After Water Head Test

Sample Number	Rust Grade	Pass/Fail
1	Better Than 9	Pass
2	Better Than 9	Pass
3	Better Than 9	Pass
4	Better Than 9	Pass
5	Better Than 9	Pass
6	Better Than 9	Pass
7	Better Than 9	Pass
8	Better Than 9	Pass
9	Better Than 9	Pass
10	Better Than 9	Pass
11	Better Than 9	Pass
12	Better Than 9	Pass
13	Better Than 9	Pass
14	Better Than 9	Pass
15	Better Than 9	Pass
16	Better Than 9	Pass

### 3.2 Sealant (Bellcore 4.3.8 & 5.3.8)

Since encapsulant is not used in this product, the test results for the gel material used is included.

#### 3.2.1 Sealant Compatibility and Consistency (Bellcore 4.3.8.1, 5.3.8.1, 4.3.8. 3, & 5.3.8.3)

The test of the sealant compatibility and its consistency was done on samples that went through the accelerated aging test (see sections 3.1.1 to 3.1.5). All closure samples were opened after the accelerated aging test. The gel was found to be compatible with the wire and connector materials and retained its sealing properties over the installed connector based on visual inspection and insulation resistance measurement. Therefore, the gel should maintain its compatibility and sealing consistency over the expected product's service life.

#### 3.2.2 Sealant Material (Bellcore 4.3.8.2 & 5.3.8.2)

The material contains no toluene diisocyanate(TDI).

#### 3.2.3 Odor (Bellcore 4.3.8.4 & 5.3.8.4)

The 3M™ Pull ' N' Shrink tubing (PST) smells like rubber. The gel is odorless.

**3.2.4 Corrosion of Copper (Bellcore 4.3.8.5 & 5.3.8.5)**

This test was performed per Bellcore TA-TSY-000361, Issue 1, 2/86, section 4.2. Current flow greater than one microampere or any visual evidence of copper corrosion is considered a failure. The boards were washed initially with pumice soap and a nylon brush. Each board was suspended above potassium sulfate covered with a saturated solution of saltwater. Each board was connected individually to a 50.9 V instead of a 45 V power source. Current readings were taken for each board at the beginning and the end of the 14 day test. All samples showed a current reading less than 100 nanoamperes ( $1 \times 10^{-7}$  ampere), which is one order of magnitude less than the maximum allowed current of  $1 \times 10^{-6}$  ampere. No evidence of copper corrosion was found.

**The Current Reading of 14 Day Corrosion of Copper Test**

Sample Number	Initial Current (nA)*	Final (Day 14) Current (nA)*	Pass/Fail
1	56.0	94.6	Pass
2	77.0	68.8	Pass
3	94.0	71.3	Pass
4	49.8	89.3	Pass
5	51.0	91.8	Pass
6	70.9	96.5	Pass

\* Note: one nanoampere (nA) =  $1 \times 10^{-3}$  microampere ( $\mu A$ ) =  $1 \times 10^{-9}$  ampere (A)

**3.3 Fungus Growth (Bellcore 4.3.2 & 5.3.2)**

The splice closure material samples were tested in accordance with ASTM G-21-70 for 28 days. A control sample, agar, was tested along with the subject test samples to verify the inoculation.

A rating of 0, no visible fungus growth on the specimen, was required. Six samples of PST and two samples of Gel Sample ID 102-90 were submitted to an independent outside laboratory for testing. A rating of "0" was obtained for all test samples except the control sample.

**The Rating of Fungus Growth Test**

Test Subject	All Closure Material Samples	Control Sample-Agar
PST	0*	4*
Gel Sample I.D.102-90	0	4

\*Note: 0 = no visible fungus growth on the specimen, 4 = heavy growth (>60%).

### **3.4 Shock Resistance (Bellcore 4.3.3 & 5.3.3)**

Two physical tests were used to test the 3838 PST/Gel BSW splice kit's ability to withstand physical handling and abuse anticipated with normal field application. The tests include the impact resistance test and the drop test.

#### **3.4.1 Impact Resistance (Bellcore 4.3.3.1 & 5.3.3.1)**

All six samples were prepared with AT&T fully flooded BSW (#22 AWG) cable. Both two-pair and five-pair service cables were spliced with 3M™ Scotchlok™ UR2-D unfilled connectors. The tested samples include three in-line and three butt types. All samples were preconditioned at 15° F (-9.4° C) overnight before subjected to 40 ft.lb. (5.6 m-kg) impact to both the top and bottom of the closure body. The impact was positioned at the approximate midpoint of the closure body. The impact consists of a 10 lb. (4.5 kg) weight with a 6 in. (15.2 cm) spherical radius head, dropped from a height of 4 ft. (1.22 m). All samples then went through another impact test with an impact head of 2 in. (5.1 cm) spherical radius. There should be no cracking or breaking of any of the samples. All samples passed with no visible damages on the closure body. In addition, no discontinuity in shield bond connection was observed for all samples tested.

#### **3.4.2 Drop Test (Bellcore 4.3.3.2 & 5.3.3.2)**

Six closure kits were individually packaged as they will be received from the manufacturer. The sample packages were preconditioned at 15° F (-9.4° C) overnight before being dropped from a six ft. (1.83 m) height onto a hard brick surface. Each package was dropped with a different part of the package making contact with a hard brick surface. There should be no cracking or breaking of any of the components or parts in the sample package. All samples passed with no visible damages on all components or parts in all sample packages.

## **4.0 Performance Verification/Test Procedures (Bellcore 4. & 5.)**

### **4.1 Design and Fabrication Testing (Bellcore 4.1 & 5.1)**

#### **4.1.1 Metallic Corrosion and Chemical Resistance Test (Test Done beyond Bellcore's Requirement)**

In addition to corrosion test described in section 3.1.5, four sets of the electrical shield bond connector, strain relief clamps and aluminum plate were tested in eight different chemicals for six hours in each chemical (a total of 48 hours) in consecutive order. The chemicals included two cable filling compounds (Flexgel 65° C and PE/PJ), three encapsulants (D Encapsulant, Caschem 126, and 3M™ 4442 High Gel), and household ammonia, Black Flag Wasp and Hornet Spray, and Rainbow™ herbicide. All samples showed no sign of degradation.

#### **4.1.2 Non-Metallic — Chemical Resistance Test (Bellcore 4.1.2 & 5.1.2)**

The requirements are that all materials should be spray and solvent resistant and should resist chemical pollutants and not develop any stress cracks, stripping, molting, texture or color change when exposed to the chemicals such as 3% sulfuric acid, .2N sodium hydroxide, Kerosene, and 10% Igepal CO-630. Four assembled closure samples were immersed in the above mentioned four chemicals (one in each chemical) for a period of 72 hours. The PST showed no sign of degradation except it showed expansion and gained weight in Kerosene. Additional five samples were added to the Kerosene test. All samples maintained their insulation resistance above the minimum requirement of  $1 \times 10^8$  ohms after submerging in Kerosene for 10 days.

#### **4.1.3 Tools (Bellcore 4.1.3 & 5.1.3)**

The use of specialized tools or equipment not normally at the craftspersons' disposal should be avoided. This was confirmed by a review of installation instructions that this requirement was met, no special tools are required to install these closures.

#### **4.1.4 Cable Pull-Out Test (Bellcore 4.1.4 & 5.1.4)**

Four closure samples were tested for cable pull-out with a 35 lb. (15.9 kg) weight hanging from each cable for 15 seconds. The pass/fail criteria are no damage to the shield bond connector or discontinuity in shield bond connection. The load time and pass/fail criteria were verified with Bellcore. In addition, the load duration was extended to 20 minutes and the shield bond connection was still maintained.

#### **4.1.5 Torsion Resistance Test (Bellcore 4.1.5 & 5.1.5)**

Five closure samples (three in-line and two butt type) were tested for torsion resistance. Each sample was clamped four inches (10.2 cm) from the closure end. All wire pairs were connected in series and connected to a discontinuity monitor that could detect momentary circuitry opens of 10 microseconds or longer. Each sample was then rotated 90° to each side until a wire is dislodged within the contacts or up to a maximum of ten rotations to each side. For the in-line sample, the above test procedures were repeated at the other end of the closure sample. The pass/fail criterion is that the sample should resist ten rotations to each side of the service wire. All samples passed the torsion test with no electrical discontinuity observed during and after the test.

#### **4.1.6 Bend Resistance Test (Bellcore 4.1.6 & 5.1.6)**

The same five samples tested for torsion resistance were used for bend resistance test. Each sample was held in a fixed orientation. Each service wire was then bent 45° from the axis of the wire to both sides, in a plane of the service wire pair, and in a plane perpendicular to the service wire pair. Again, all wire pairs were connected in series and connected to a discontinuity monitor that could detect momentary circuitry opens of 10 microseconds or longer. The pass/fail criterion is that the sample should resist ten wire bends to each side of the service wire in each of the two planes. All samples passed the bend resistance test with no electrical discontinuity observed during and after the test.

## 4.2 Electrical Tests (Bellcore 4.2 & 5.2)

There are two tests under this category. The first one is the shield bond continuity test to test the durability of the shield bond connector to maintain its functionality under a surge of high current. The second one is the temperature cycling with high humidity test to test the shield bond connector's connection stability against the possible increase of shield bond connection resistance.

### 4.2.1 Shield Bond Continuity Test (Bellcore 4.2.1. & 5.2.1)

The test was performed with a current of 500 amps AC instead of 1000 amps. This was done due to the limitation imposed by the current carrying capacity of the six-pair double insulated #22 AWG buried service wire cable. The test duration was extended to 35 seconds to compensate the lower current applied in the test. There should be no damage to the shield bond connector in the closure. In all tests, the cable failed first when the outer jacket burned and the shield broke due to heat generated by the applied high current in the test. All samples passed the test with no damage to the closure and the shield bond connector.

### 4.2.2. Electrical Resistance — Temperature Cycling with High Humidity Test (Bellcore 4.2.2 & 5.2.2)

See details in section 3.1.1.

## 5.0 Conclusions

The 3M™ 3838 PST/Gel Buried Service Wire Splice Kits were subjected to a variety of environmental, mechanical, electrical, corrosion resistance, and chemical resistance tests. The tests were based upon Bellcore TR-NWT-000251 and other appropriate specifications commonly used in the telecommunications industry. In some tests, the tests were performed in a much more harsh testing condition than the Bellcore requirement to test the product to its limit. This was done by using the same samples that had gone through a series of the accelerated aging tests before, rather than preparing new samples.

In all insulation resistance measurements carried out at different stages of the accelerated aging test, the test results indicate the minimum value is two orders of magnitude higher than the minimum requirement of  $1 \times 10^8$  ohms. The tests showed that the kit provides an excellent seal against water or moisture entry to the closure protecting the splice of the buried service wire cable. In addition, the closure was shown to be corrosion and chemical resistive. Based on these results, the long term durability of the splice protection can be expected.

For further information regarding specific agency approvals please contact your 3M Telecom Systems Division representative.

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**3M****Telecom Systems Division**

6801 River Place Blvd.  
Austin, TX 78726-9000  
800/426-8688



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