

Product Data

3M Quick Splice II

5411 and 5412

Inline Splicing Kit



With SJ-1 Splice Jacket Kit



1. Product Description

The 3M Brand 5411 and 5412 Quick Splice II Inline Splicing Kits are one-piece, factory made and factory tested 15 KV class molded rubber splices.

PST Cold Shrink Insulators are contained in the SJ-1 Splice Jacket Kit.

Splice Features:

- Low thermal profile
- Each splice fits both .175" and .220" insulation walls
- 5411 splice used to splice #2-#2/0 cable
- 5412 splice used to splice #2/0-#4/0 cable
- Easy to install one-piece splice
- Positive electric connection of splice outer conducting jacket to cable semi-conductive jacket
- Simple, positive visual location of splice with reasonable tolerance in cable semi-con jacket cutback
- Peroxide-cured EPDM rubbers guarantee splice life equal to the cable
- Computer generated stress plots give outstanding electrical properties of complete splice
- 100% factory tested

SJ-1 Rejacketing Features:

- Low profile
- Fits all cables from #2 to 4/0 spliced with the 5411 or 5412
- Easy to install
- Simple
- Peroxide-cured EPDM PST Cold Shrink tubes to equal cable life.

2. Applications

5411 kit used to splice 15 KV class concentric neutral (URD) cable from #2 to 2/0 whose primary insulation diameter is between .637" and .900". (16,2 mm-22,9 mm).

5412 kit is used to splice 15 KV class concentric neutral (URD) cable from 2/0 to 4/0 whose primary insulation diameter is between .840" and 1.050". (21,3 mm-26,7 mm). Splices can be used in direct burial or directly immersed in water.

The SJ-1 Kit is used to moisture seal and protect the jacketed concentric neutral cable splices with the 5411 or 5412 Quick Splice II which can be used on all #2 to 4/0 cables for direct burial, aerial, or immersed in water.

3. Data, Physical and Electrical Properties

5411 and 5412 Quick Splice II are used on cables with 90°C rated operating temperature and emergency overload rating of 130°C. Kit meets requirements of a 15 KV class splice in IEEE Standard 404-1986 for power cable joints. (See Section 5 — Performance Tests). Current rating of 5411 kit meets or exceeds current rating of a 2/0 cable. Current rating of 5412 kit meets or exceeds current rating of a 4/0 cable.

TABLE A
SPLICE SELECTION TABLE

Kit No.	Kit No. With Connector	Conductor Size (AWG)	Voltage Rating	Cable Insulation O.D. Range (in.)
5411	— 5411-CI-22 5411-CI-21 5411-CI-1/0 5411-20006	#2-2/0* #4 stranded, #2 solid #2 stranded, #1 stranded #1 solid, #1/0 solid #1/0 stranded #2/0 stranded*	15 KV Class (IEEE 404-1977)	.637-.900
5412	— 5412-CI-2/0 5412-CI-3/0 5412-CI-4/0	#2/0* - #4/0 #2/0 stranded** #3/0 stranded #4/0 stranded	15 KV Class (IEEE 404-1977)	.840-1.050

*.175" insulation thickness only.
**.220" insulation thickness only.

TABLE B
CABLE JACKETING SELECTION TABLE

Kit No.	Conductor Size (AWG)	Jacket O.D. Range (in.)
SJ-1	#2 stranded — 4/0 stranded	.900-1.500

TABLE C
SPLICE RATINGS (STATED IN IEEE STD. 404-1977)

Kit No.	Voltage Class	BIL	60 Hz 1 Min. Dry Withstand (min)	60 Hz 6 Hr. Dry Withstand (min)	Maximum Continuous Operation Temp.	Emergency Operating Temp. 500 Hrs. (max)
5411 5412	15 KV	150 KV	50 KV	35 KV	90°C	130°

4. Specification

Product

Power cable splice must be a 15 KV class device and meet all 15 KV class requirements of the IEEE Standard 404-1986 Standard for Power Cable Joints. Splice must be a one-piece molded rubber device. Rubber must be EPDM using a peroxide cure. Splice shield resistance center to end must be less than 5000 ohms. Conducting portion of splice shield must make positive electrical contact with the cable shield.

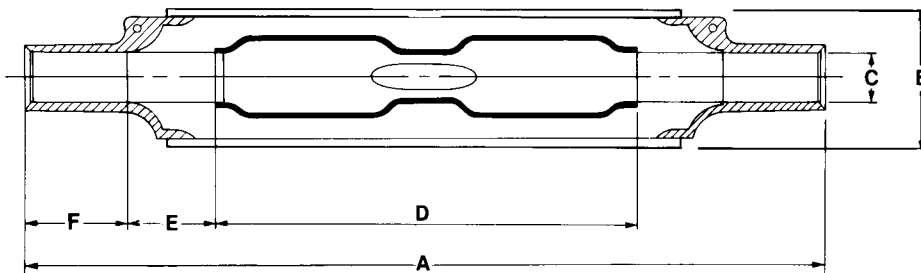
The splice on a jacketed concentric neutral power cable must meet 15 KV class requirements of the IEEE Standard 404-1986 Standard for Power Cable Joints. Splice must be a one-piece molded rubber device. Rubber must be EPDM using a peroxide cure. It shall be completely sealed with a moisture resistant peroxide cured EPDM Cold Shrink jacket.

Engineering/Architectural
Splice all #2-2/0 15 KV class concentric neutral (URD) cable

TABLE D
TYPICAL DIMENSIONS (INCHES)

Kit No.	A	B	C	D	E	F
5411	9.00	1.760	.600	4.40	1.05	1.25
5412	9.60	1.760	.780	5.00	1.05	1.25
SJ-1	23.00	2.000	—	—	—	—

SPLICE BODIES



SJ-1 KIT INSTALLED

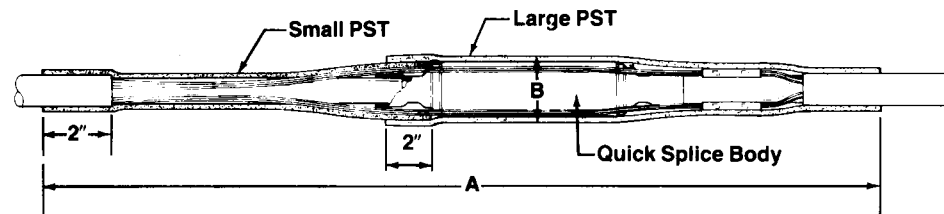


TABLE E
CONNECTOR DIMENSIONS

Kit No.	CI Connector No.	Connector Length (in.)	Connector O.D. (in.)
5411-CI-22	CI-22	2	5/8
5411-CI-21	CI-21	2	5/8
5411-CI-1/0	CI-1/0	2	5/8
5411-20006	20006	2	5/8
5412-CI-2/0	CI-2/0	3	.910
5412-CI-3/0	CI-3/0	3	.910
5412-CI-4/0	CI-4/0	3	.910

according to instructions in 3M Brand Quick Splice II 5411 Inline Splicing Kit. Splice all #2/0-4/0 15 KV class concentric neutral (URD) cable according to instructions in 3M Brand Quick Splice II 5412 Inline Splicing Kit.

Rejacketing shall be done with the 3M Brand SJ-1 Kit.

5. Characteristics and Test Data

Insulating Rubber

Electrical Properties

Dielectric Constant (SIC)

ASTM-D-150

@ 23°C	2.71
@ 90°C	2.58
@ 130°C	2.56

Dissipation Factor

ASTM-D-150

@ 23°C	.4%
@ 90°C	1.3%
@ 130°C	4.7%

Dielectric Strength

ASTM-D-149

@ 25 mil gap	1177 volts/mil
@ 100 mil gap	518 volts/mil
20 Days @ 96% R.H. @ 90°C	
@ 25 mil gap	1066 volts/mil
@ 100 mil gap	790 volts/mil

Physical Properties

Color	Black
Ultimate Elongation ASTM-D-412	570%
Ultimate Tensile Strength ASTM-D-412	900 psi
Shore A Hardness ASTM-D-2240	55
Permanent Set 70 hrs. @ 90°C	
100% Elongation 5 Minute Recovery (3M Test Method)	25%

PERMANENT SET is defined as:

That portion of the original stretched deformation not recovered in a given period of time after the deforming force has been removed. This is usually recorded as a percentage of the deformation.

Compression Set

70 hrs. @ 100°C ASTM-D-395, Method B	18.7%
100% Modulus ASTM-D-412	185 psi
300% Modulus ASTM-D-412	650 psi

Semi-Conductive Rubber

Electrical Properties

Volume Resistivity 3M Test Method TM 80	6 ohm-cm
Surface Resistivity 3M Test Method TM 83	125 ohm/cm ²

Physical Properties

Color	Black
Ultimate Elongation ASTM-D-412	450%
Ultimate Tensile Strength ASTM-D-412	1000 psi
Shore A Hardness ASTM-D-2240	75
Die C Tear ASTM-D-624	200 pounds/inch
Permanent Set 3M Test Method TM 86A	60%
Compression Kit ASTM-D-395-B	20%
100% Modulus ASTM-D-412	300 psi
300% Modulus ASTM-D-412	900 psi

PST Cold Shrink Jacket for Jacketed Concentric Neutral Cable

High-Stretch Ethylene Propylene Rubber

Typical Physical Properties

Color	Black
100% Modulus ASTM-D-412-75	.90 MPa (125 psi)
300% Modulus ASTM-D-412-75	3.50 MPa (500 psi)
Ultimate Tensile ASTM-D-412-75 Original	9.00 MPa (1300 psi)
Ultimate Elongation ASTM-D-412-75 Original	650%
Angle Tear ASTM-D-624C-73 Original	29.KN/m (160 ppl)
Shore A Hardness ASTM-D-2240-75	43
Ozone Resistance 70 hz @ 150 PPM ASTM-D-518-61	No cracking

Typical Electrical Properties

Dielectric Strength ASTM-D-149-75 Original @ 1.78 mm	12.8 MV/m (326 V/mil)
22 hr in H ₂ O at 90°C	8.5 MV/m (216 V/mil)

These are typical properties and are not to be used for specification purposes.

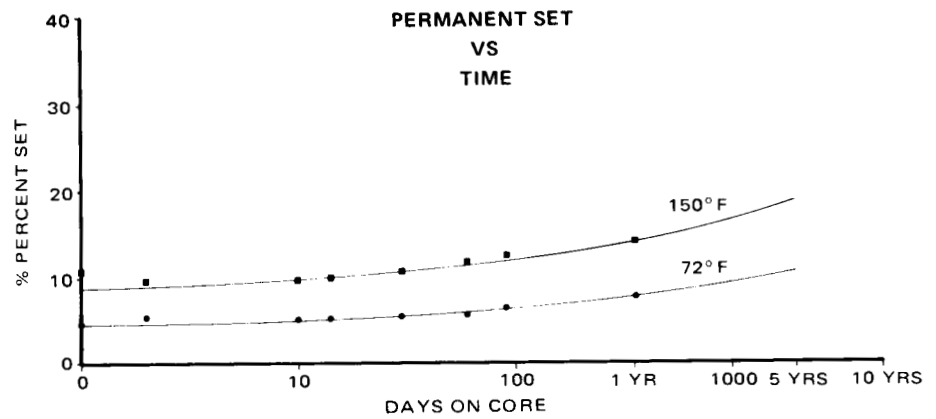


Figure 1

6. Performance Data

The characteristic which is vital to performance of the PST in the SJ-1 Kit is the permanent set. Permanent set is that percentage of the original stretched deformation not recovered in a given period of time after the deforming force has been removed. This is because a live rubber force must exist between the cable insulation and the rubber tube which has not been allowed to return to its original dimensions. Long-term permanent set is shown in Figure 1 at two temperatures.

Research has shown that it is conservative to use 22 hours at 100°C in order to simulate 2 years at storage temperatures. Q.C. values on these PST's have confirmed Figure 1. The Q.C. averages for permanent set per 3M Test Method #86 for these units are 11%.

Corona Tests

Corona tests are used to insure that properly installed splices operate corona free at a minimum of 150% of the operating voltage.

Installed splices were checked for corona levels. Voltage was gradually increased until high-frequency

discharges which occur were picked up capacitively and displayed on an oscilloscope. Voltage at which these discharges reach four picocoulombs was recorded as the corona starting voltage (CSV). Voltage was then lowered until discharges dropped below four picocoulombs and recorded as the corona extinction voltage (CEV).

All 5411 and 5412 splices conform with IPCEA recommended corona extinction level of 150% of operating voltage. All Quick Splice II's are production tested on an actual power cable for a 1-minute 35 KV AC withstand and must have a minimum corona extinction voltage of 13 KV.

Impulse Tests

Test voltage was a 1.2 x 50 microsecond wave having the crest values shown in Table F. Each specimen had three impulses at each polarity for each given voltage.

The 5411 and 5412 splices meet BIL requirement of 110 KV as given in the IEEE 404-1986.

AC Withstand Tests

All splices are factory tested for a 1-minute 35 KV withstand test.

TABLE F
IMPULSE TEST RESULTS FOR 5411

Voltage (KV)	Specimen 1		Specimen 2		Specimen 3		Specimen 4	
	+	-	+	-	+	-	+	-
147	ok	ok	ok	ok	ok	ok	ok	ok
159	ok	ok	ok	ok	ok	ok	ok	ok
175	ok	ok	ok	ok	ok	ok	ok	fail*
187	ok	ok	ok	ok	ok	ok	—	—
204	ok	fail	fail	ok	fail	ok	—	—
220	—	—	—	—	—	—	ok	—

*This specimen was tested at 220 KV positive prior to testing 175 KV negative.

— Four specimens were tested in an AC 500 V/sec. rate of rise to failure with the following results:

Sample	KV at Breakdown
1	81
2	95
3	98
4	94

All splices meet 6-hour 35 KV withstand specified in the IEEE 404-1986.

Long Term Over-Voltage Current Cycle Test

The 5411 Quick Splice II's were installed on #2 solid, #2 stranded and 1/0 stranded cable. The 5412 Quick Splice II's were installed on #3/0 stranded cable. Specimens operated at 25 KV. Specimens were current cycled at 90°C (4 hours on — 4 hours off) for 30 days in air and 30 days in water. This was followed by 30 days in both air and water at a conductor temperature of 130°C. All specimens were tested for corona extinction and a 35 KV 1-minute withstand. Corona values either increased or remained the same and all samples passed the 35 KV withstand.

Long Term Tests — Outdoor Aging

Nine splices were made on concentric neutral cable using the 5411 Kit. They were energized and buried in November of 1979 in the outdoor test area in St. Paul, MN. The following data was obtained on April 23, 1981.

No. of Specimens	Voltage Phase to Ground	Energized Time Hours	No. of Failures
3	17 KV	10,963	0
3	25 KV	11,175	0
3	40 KV	10,481	0

TABLE G
THERMAL PROFILE READINGS (°C)

Kit No.	1 Cable Conductor	2 Cable Surface	3 Conn. Ends	4 Conn. Center	5 Exp. Cond.	6 Splice Jacket Center	7 Splice Jacket End	8 Insul. Interface	Current Amps
5411	61	48	56	53	48	34	35	45	198
	82	53	76	72	63	41	43	59	239
	98	76	93	89	80	53	49	72	270
	118	89	112	107	94	59	52	82	303
	135	99	130	122	106	69	60	93	312
5412	130	95	121	117	103	74	69	93	485

	% Retention		
	100% Modulus	Breaking Strength	Breaking Elongation
10% Sulfuric Acid (H ₂ SO ₄)	100	90	95
10% Sodium Hydroxide (NaOH)	81	78	104

Figure 2

URD Jacket Resistance

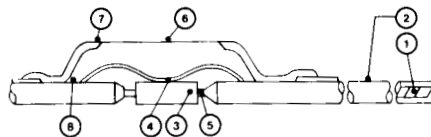
The 5411 splices were installed on 1/0 cable and operated at 25 KV. Samples (one immersed in water, another in air) were current cycled for 5 months at 90°C (4 hours on — 4 hours off) and one month at 130°C. Splice jacket resistance from center to end was recorded as follows:

	Resistance Center to End	
	Splice in Air	Splice in Water
At start of test	1630 ohms	1260 ohms
After 6 months in water and air	1000 ohms	1450 ohms

This data shows the stability of the splice conducting jacket after accelerated operation.

Thermal Profile

A thermal profile at various conductor temperatures was run on a 5411 Quick Splice II (1/0 15 KV cable) and a 5412 Quick Splice II (4/0 15 KV aluminum cable). Splices were in air. All readings taken after splices operated 7-20 hours at indicated current. Location of thermocouples and readings are detailed in the figure below and in Table G.



Jacket Stability Test

A 5411 was assembled on a very flexible cable and flexed over 10" diameter wheels for 5000 cycles. Jacketed splice thus flexed 5000 times to a 5" radius. The end to center resistance was measured to obtain the following data which also applies to the 5412 because of design similarity:

Cycles	Resistance
0	2200 ohms
50	2500 ohms
500	2300 ohms
5000	2000 ohms

Resistance to UV

Samples are mounted 20 inches from two UA-3 type G.E. Brand bulbs. The samples are examined after 70 hours. No cracks were observed.

Chemical Resistance

Samples of rubber were immersed in solutions for 30 days at room temperature and the physical characteristics were measured. (Figure 2)

Water Seal Pressure Test

(Designed to detect moisture seeping into the splice area)

A 5411 Quick Splice II covered with the SJ-1 Kit was placed in a pressure bomb filled with water and pressurized to 30 psi. After two months of testing the samples were removed and the jacket was stripped off. No moisture was detected.

Compatibility Test

A splice jacket should not interact with the cable semi-conducting jacket so as to change the conductivity of this material. Figure 3 shows the data obtained on a cable semi-conducting jacket when covered with the SJ-1 Cold Shrink tubes and the same semi-conducting jacket used as a control.

7. Installation Techniques

Exact instructions for installing the Quick Splice II are packed in each kit and summarized below.

For Concentric Neutral Cable:

- Prepare cable according to standard procedure.
- Lubricate insulation of both cables and semi-con of one cable with silicone grease furnished.

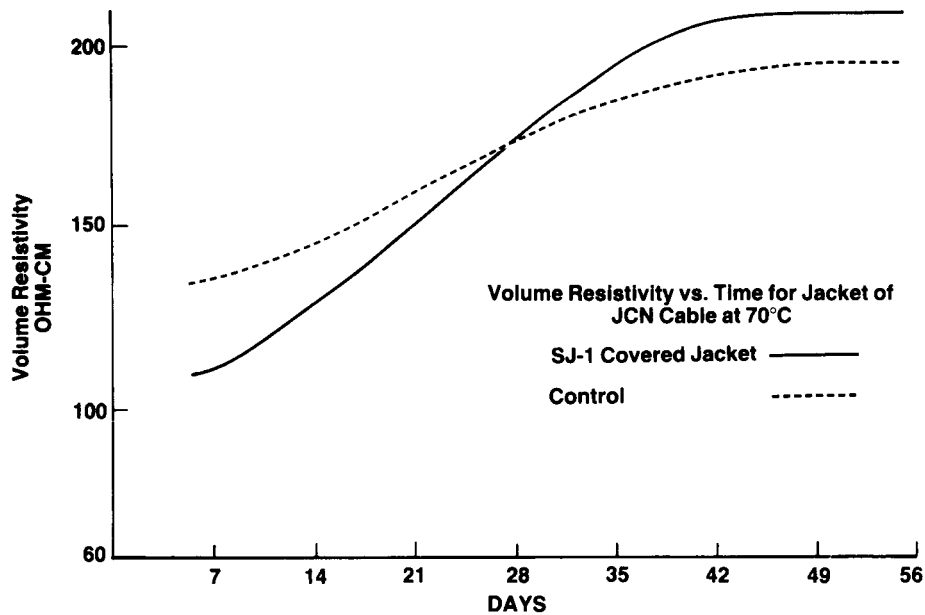


Figure 3

- c. Install splice onto one cable leaving just the conductor exposed for connector.
- d. Install connector.
- e. Slide splice into final position over connector using bumps formed on splice end as guides for centering.
- f. Ground splice by connecting concentric neutral wires. Attach one concentric strand from each cable to its splice grounding eye.

For Jacketed Concentric Neutral Cable:

- a. Slide both PST Cold Shrink tubes on the cable.
- b. Prepare cable and splice with 5411 and 5412 as above.
- c. Slide small PST Cold Shrink tube next to the mold body and remove core.
- d. Slide large PST over splice body and two inches onto the small PST. Remove core to seal splice.

8. Maintenance

Components within this kit are stable under normal storage conditions. Normal storage and stock rotation are recommended.

The rubber splice is not impaired by freezing nor by overheated storage up to the point of flow. After installation the 5411 and 5412 splices can be checked periodically by visual inspection or by normal hypotting procedures.

Components of 3M Brand PST Connector Insulators are not impaired by freezing or overheating due to the ambient temperatures found in storage or shipping. Normal storage and stock rotation are recommended.

9. Availability

3M Brand Quick Splice II 5411 and 5412 Inline Splicing Kits and SJ-1 Kits (PST Cold Shrink) are available through your electrical distributor.

IMPORTANT NOTICE:

All statements, technical information and recommendations contained herein are based on tests we believe to be reliable, but the accuracy or completeness thereof is not guaranteed, and the following is made in lieu of all warranties, express or implied: Seller's and manufacturer's only obligation shall be to replace such quantity of the product proved to be defective. Neither seller nor manufacturer shall be liable for any injury, loss or damage, direct or consequential, arising out of the use of or the inability to use the product. Before using, user shall determine the suitability of the product for his intended use, and user assumes all risk and liability whatsoever in connection therewith. No statement or recommendation not contained herein shall have any force or effect unless in an agreement signed by officers of seller and manufacturer.

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