I-436-0

Leistungskraft für Lebensqualität SW//M Stadtwerke München

Elektrisches Prüfamt München, Franzstraße 9, 80 802 München

Elektrisches Prüfamt München

der Stadtwerke München
Werkbereich Versorgung
Abt. Elektrotechnisches
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Test Report
No. 97037E

Subject of Test: Inline-splice
3M QS 1000
Type 92-AG621-1

Manufacturer: 3M Deutschland GmbH
Hamburg

Applicant: 3M Laboratories (Europe) GmbH
Hamburg

Scope of Test: According to CENELEC HD 628 S1 and CENELEC HD 629.1 S1
Test requirements for accessories for extruded polymeric cables with rated voltage from 3.6/ 6 (7.2) kV to inclusive 20.8/ 36 (42) kV.

Test Result: **The requirements were fulfilled.**

Munich, 17th March 1998

Test Period

Start: 27.11.1997 **Completion:** 16.02.1998

Data of Test Specimen

Number: 4 test loops with one inline-splice each
3M QS 1000; Type 92-AG621-1

Cable: EAXCWB 1 × 150/ 25 mm^2; aluminium; round stranded; 8.7/ 15 kV

Cable data: Outer ∅ cable sheath= 35.5 mm Outer ∅ semi-cond. layer=27.0 mm
Outer ∅ primary insulation= 25.6 mm Outer ∅ conductor= 14.3 mm

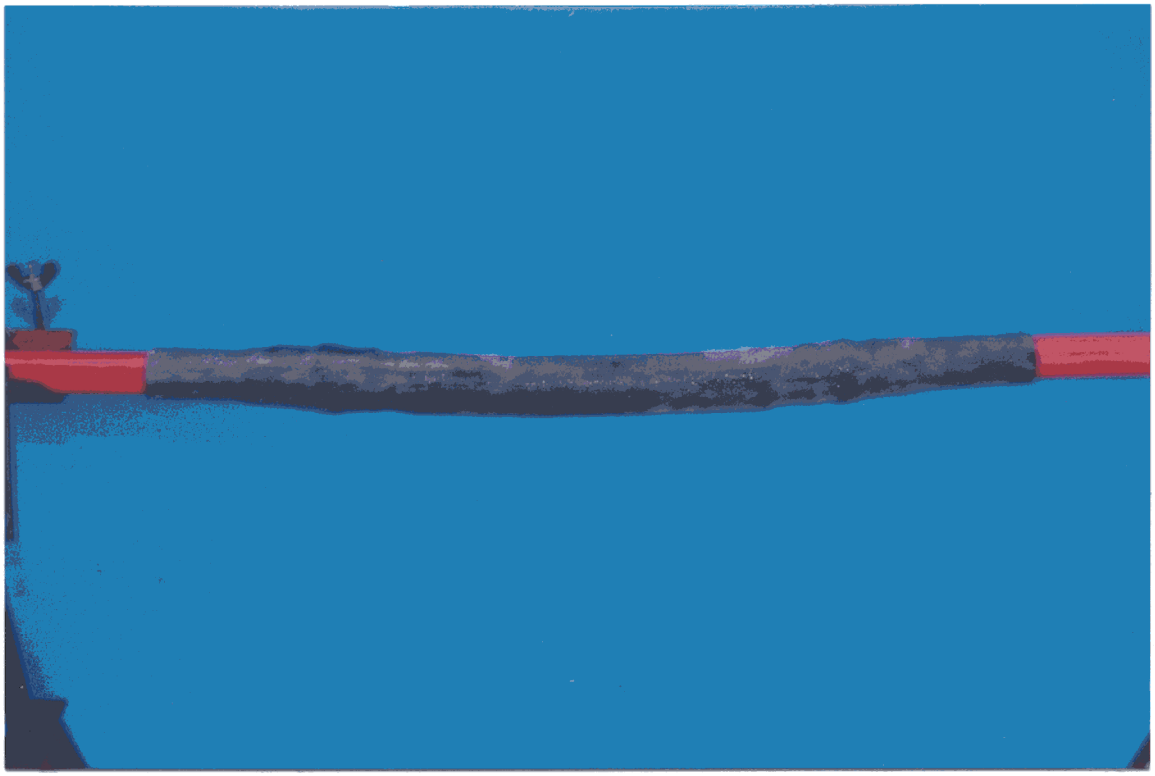
Cable lug: Hexagon lug Petri Al 150 mm^2 round stranded/sector stranded

Connector: Screw connector Petri M2-240-Alu-SV-T-V-TK

Termination: 3M Quick Term II; Type 93-EB63-2D

Cable length: approx. 6m

Test Specimen Figure 1



Installation

The test loops were installed by technicians of the manufacturer
at the Elektrisches Prüfamt München according to installation instructions
XE 0091- 2334- 2 of attached Appendix 2.

Test Program

Sequence of tests according to HD 629.1 S1:1996, Table 5

No.	Tests	Tests acc. to Section	Page
1	D.C. withstand voltage test, dry 15 min. at 6 U_O **52 kV**	5	4
2	A.C. withstand voltage test, dry 5 min. at 4.5 U_O **39 kV**	4	5
3 *	Partial discharge test at ambient temperature **17.4 kV < 10 pC**	7	6+ 7
4 **	Impact test at ambient temperature	7	-
5	Impulse withstand voltage test at elevated temperature 10 pulses of each polarity **95 kV**	6+ 8	8+ 9
6	Thermal cycling test in air 3 cycles at 2.5 U_O **23 kV 479 A**	9+ 8	10
7 *	Partial discharge test at ambient temperature **17.4 kV < 10 pC**	7	10
7 *	Partial discharge test at elevated temperature **17.4 kV < 10 pC**	7+ 8	11
8	Thermal cycling test in air 60 cycles at 2.5 U_O **23 kV 475 A**	9	11
9	Thermal cycling test in water 63 cycles at 2.5 U_O **23 kV 475 A**	9	11
10 *	Partial discharge test at ambient temperature **17.4 kV < 10 pC**	7	12
10 *	Partial discharge test at elevated temperature **17.4 kV < 10 pC**	7+ 8	12
11	Thermal short circuit test (screen) 2 short circuits at 1 s **4.5 kA**	10	13
12	Thermal short circuit (conductor) 2 short circuits at 1 s **17.0 kA**	11	13
13 **	Dynamic short circuit (conductor) 1 short circuit at I_D	12	-
14	Impulse withstand voltage test at ambient temperature 10 pulses of each polarity **95 kV**	6	14
15	A.C. withstand voltage test at ambient temperature 15 min. at 2.5 U_O **23 kV**	4	15
16 **	Impact test at low temperature	15	-
17	Examination	-	16

* Test was conducted at elevated test voltage as requested by customer.
** Test was not conducted.

The following tests were conducted in compliance with the test sequence on page 3.

D.C. Withstand Voltage Test, Dry, according to Section 5

(Test No. 1)

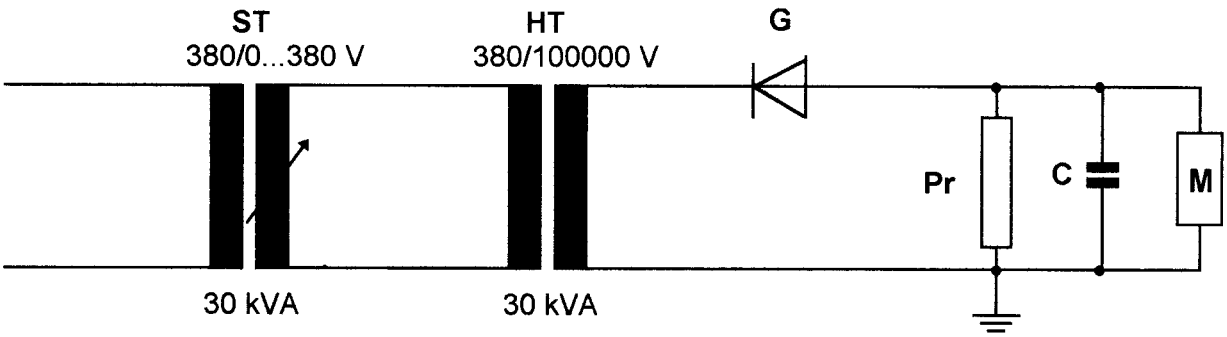
The test loops between conductor and screen were exposed to a negative D.C. voltage of 52 kV for 15 min.

The A.C. voltage share in the D.C. voltage was about 3%.

relative humidity of air	atmospheric pressure	temperature
42 %	955 mbar	21 °C

Result: No breakdown occurred on any of the test loops.

Figure 2



ST = Regulating transformer
HT = High-voltage transformer
Pr = Test specimen
M = D.C. voltage measuring instrument
G = Rectifier
C = Capacitor

Connection Diagram for D.C. Withstand Voltage Test

A.C. Withstand Voltage Test, Dry, according to Section 4

(Test No. 2)

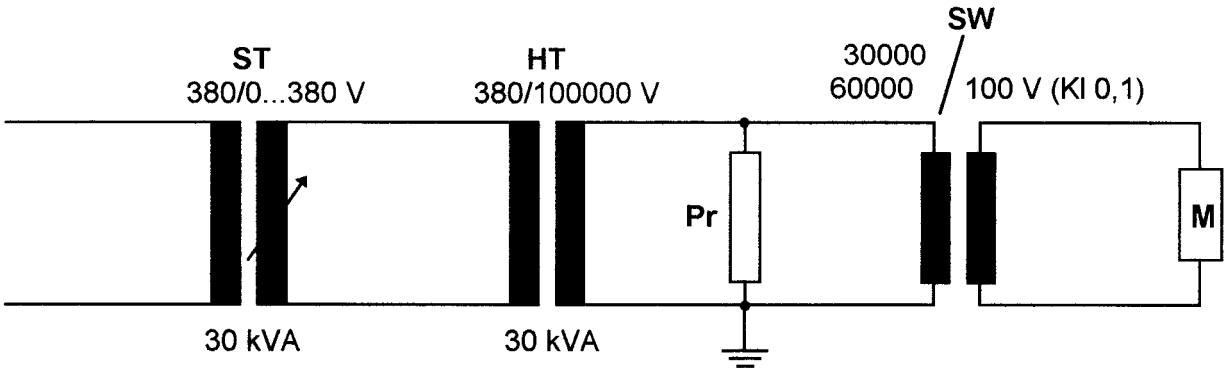
An effectively sinusoidal A.C. voltage of 39 kV rms, 50 Hz, was applied successively between the conductor and the screen for 5 min each time.

The voltage was continuously increased to the specified value and was then held constant during the required duration of the test.

relative humidity of air	atmospheric pressure	temperature
42 %	955 mbar	21 °C

Result: No breakdown occurred on any of the test loops.

Figure 3



ST = Regulating transformer
HT = High-voltage transformer
Pr = Test specimen
SW = Measuring transformer
M = Voltage measuring instrument

Connection Diagram for A.C. Withstand Voltage Test

Partial Discharge Test at Ambient Temperature according to Section 7

(Test No. 3)

a) Measuring instrument

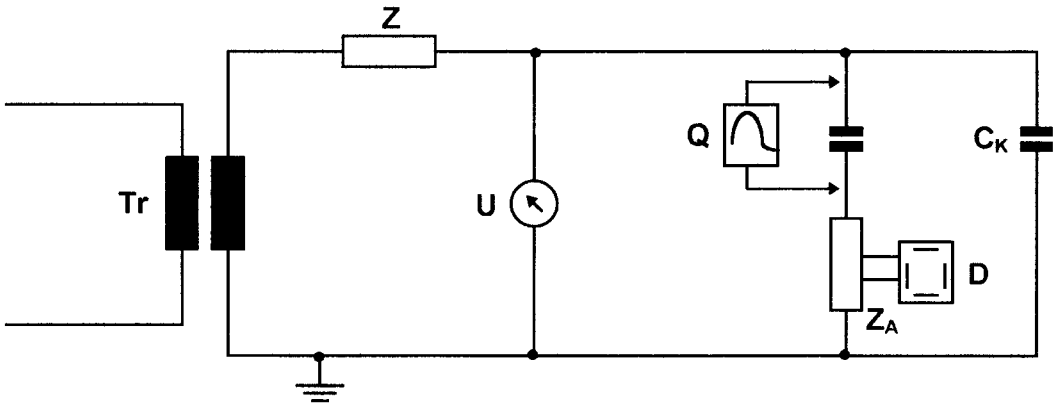
The partial discharge detector E.R.A. Model 3 - Type 652 - Series 652/412 of F.C. Robinson & Partners Ltd. was used to measure the partial discharge on the test loops, depending on the applied voltage.

Indicating sensitivity: 0.2 pC
Basic interference level: < 0.5 pC

b) Test circuit

Coupling quadripole was connected in series to test loop.

Figure 4



Tr = High-voltage source
U = High-voltage measuring instrument
Z = Impedance
$\mathbf{Z_A}$ = Coupling quadripole
$\mathbf{C_P}$ = Test loop
$\mathbf{C_K}$ = Coupling capacitor
D = Detector
Q = Calibrator

Connection Diagram for Partial Discharge Test

c) Test performance

The test loops were stored in a dry and clean condition for 3 hours before the test, at an ambient temperature of about 20°C.
Afterwards the connection elements were made discharge free by use of shielding electrodes, and a test A.C. voltage of 2.5 U_0 = 21.75 kV was applied for 1 min.

Subsequently, the voltage was decreased to a test A.C. voltage of U_{TE}= 2 U_0 = 17.4 kV and the maximum value of the partial discharge intensity was measured within 1 minute.

relative humidity of air	atmospheric pressure	temperature
42 %	955 mbar	21 °C

Results of the partial discharge test :

Test loop no.	partial discharge (pC) conductor
1	< 1
2	< 1
3	< 1
4	< 1

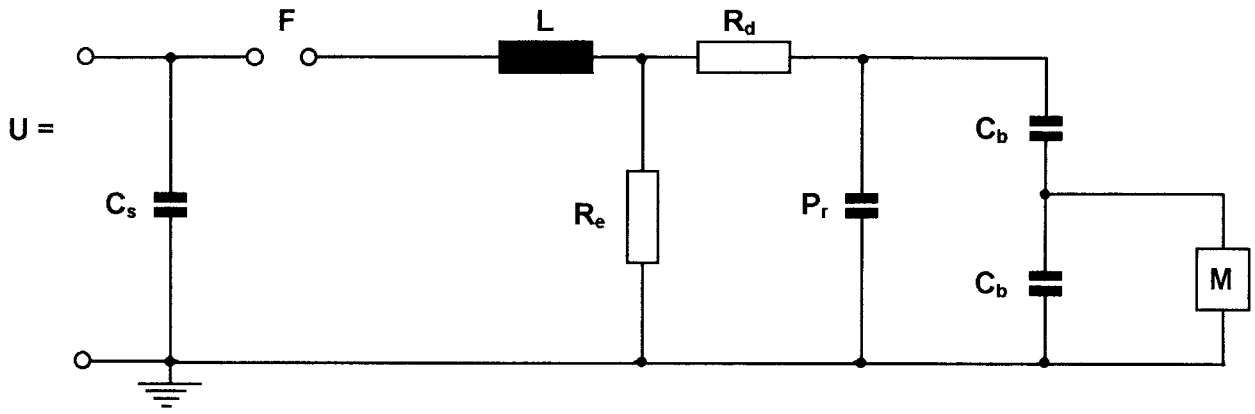
Admissible discharge level: ≤ 10 pC

Impulse Withstand Voltage Test according to Section 6
(Test No. 5)

The test specimens were arranged in compliance with the instruction, were heated with 479 A for about 3 hours, and the temperature was held constant during the test performance.
The test was performed with an impulse voltage of which the rise time was approx. 1.2 µs and the half-value decay was approx. 50 µs.
The test loops were exposed to 10 impulses each with an impulse voltage of 95 kV of positive and negative polarity between the conductor and the screen.

Prior to the tests with positive and negative polarity, the test loops were exposed once to 50 %, 65 % and 80 % of the nominal impulse voltage.

Figure 5



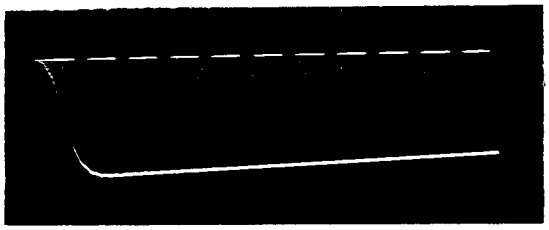
C_s = Impulse capacitor
F = Spark gap discharger
R_e = Discharge resistor
L = Impulse circuit inductive resistor
R_d = Damping resistor
C_b = Additional load capacitor
P_r = Test specimen
T = Impulse voltage divider
M = Impulse voltage measuring instrument

Simplified Connection Diagram

relative humidity of air	atmospheric pressure	temperature
41 %	953 mbar	20 °C

Result: No breakdown occurred on any of the test loops.

The following impulse oscillograms of test loop 1 do not show any discrepancy from the calibration oscillogram.
The oscillograms of the other test loops were identical to those of test loop 1.



10^{th} impulse of 95 kV of negative polarity

10^{th} impulse of 95 kV of positive polarity

Thermal Cycling Test in Air according to Section 9
(Test No. 6)

The test loops were connected in compliance with HD 628 S1:1996 Section 8, for one-phase heating to the source of current and were exposed to 3 heat cycles in air, with a continuous test voltage of 23 kV being applied.
Each heat cycle consisted of a five-hours heating period and a three-hours cooling period.
The current measured at a control cable was 479 A with a conductor temperature of 95°C.
At the end of the heating period of the first cycle, the current was adjusted and remained unchanged during the subsequent test run.
Ambient temperature during the heat cycling test was about 20°C.

Result: No breakdown occurred on any of the test loops.

Partial Discharge Test at Ambient Temperature according to Section 7
(Test No. 7)

After the 3rd heat cycling test the partial discharge test at ambient temperature was repeated as described in test no. 3.

relative humidity of air	atmospheric pressure	temperature
45 %	956 mbar	20 °C

Results of the partial discharge test:

Test loop no.	partial discharge (pC) conductor
1	< 1
2	< 1
3	< 1
4	< 1

Admissible discharge level: ≤ 10 pC

Partial Discharge Test at Elevated Temperature according to Section 7
(Test No. 7)

The test specimens were arranged in compliance with the instruction as described in test no. 3, were heated with 479 A for about 3 hours, and the temperature was held constant during test performance.

relative humidity of air	atmospheric pressure	temperature
45 %	956 mbar	20 °C

Results of the partial discharge test:

Test loop no.	partial discharge (pC) conductor
1	< 1
2	< 1
3	< 1
4	< 1

Admissible partial discharge level: ≤ 10 pC

Thermal Cycling Test in Air according to Section 9
(Test No. 8)

The same as test no. 5, however, with 60 heat cycles.

Result: No breakdown occurred on any of the test loops.

Thermal Cycling Test in Water according to Section 9
(Test No. 9)

The same as test no. 5, however, with 63 heat cycles in a water container with outer dimensions of 450× 100× 150 cm (l× w× h).
Height of water> 100 cm above the surface of all test specimens.
Water temperature = ambient temperature.

Result: No breakdown occurred on any of the test loops.

Partial Discharge Test at Ambient Temperature according to Section 7
(Test No. 10)

The partial discharge test at ambient temperature was repeated as described in test no. 3.

relative humidity of air	atmospheric pressure	temperature
36 %	960 mbar	20 °C

Results of the partial discharge test:

Test loop no.	partial discharge (pC) conductor
1	< 1
2	< 1
3	< 1
4	< 1

Admissible discharge level: ≤ 10 pC

Partial Discharge Test at Elevated Temperature according to Section 7
(Test No. 10)

The test specimens were arranged in compliance with the instruction as described in test no. 6, were heated with 479 A for about 3 hours, and the temperature was held constant during test performance.

Results of the partial discharge test:

Test loop no.	partial discharge (pC) conductor
1	< 1
2	< 1
3	< 1
4	< 1

Admissible discharge level: ≤ 10 pC

Thermal Short Circuit Test of Screen according to Section 11
(Test No. 11)

The short circuit current of the screen was 4.5 kA/ 1 s according to the manufacturer's information.

Test set-up: Both ends of the screen were connected to the source of current.

The conductors were set up in compliance with the instruction, heated with 479 A for about 3 hours, and the temperature was held constant during test performance.

Test current 4.5 kA
Test time 1.0 s

This short circuit loading was repeated once, following the cooling down of the cable screen to a temperature of 5 K to 10 K above the initial short circuit temperature Θ_i.
(Room temperature 21 °C).

Result: No damaging was detected in a visual inspection of all test loops.

Thermal Short Circuit Test of Conductor according to Section 11
(Test No. 12)

The maximum admissible short circuit temperature of the cable conductor Θ_{sc} was determined using a control cable identical to the cable to be tested.

Test set-up: One end of the cable was connected to the source of current and the other end was short circuited.

Owing to the test device, the test had to be carried out with a lower current, while the test time was prolonged accordingly.

Test current 10.0 kA
Test time 2.9 s

The short circuit loading was repeated once, following the cooling down of the conductors to a temperature of 5 K to 10 K above the initial circuit temperature Θ.
(Room temperature 21 °C).

Result: No damaging was detected in a visual inspection of all test loops.

Impulse Withstand Voltage Test at Ambient Temperature according to Section 6 as Test No. 3

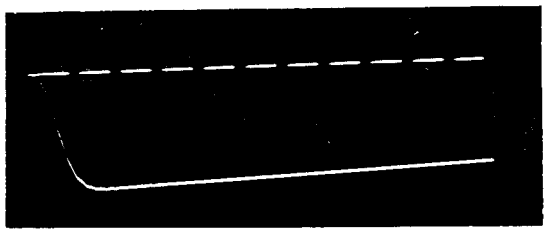
(Test No. 14)

relative humidity of air	atmospheric pressure	temperature
36 %	960 mbar	20 °C

Result: No breakdown occurred on any of the test loops.

The following impulse oscillograms of test loop 1 do not show any discrepancy from the calibration oscillogram.

The oscillograms of the other test loops were identical to those of test loop 1.



10th impulse of 95 kV of negative polarity

10th impulse of 95 kV of positive polarity

A.C. Withstand Voltage Test at Ambient Temperature according to Section 4

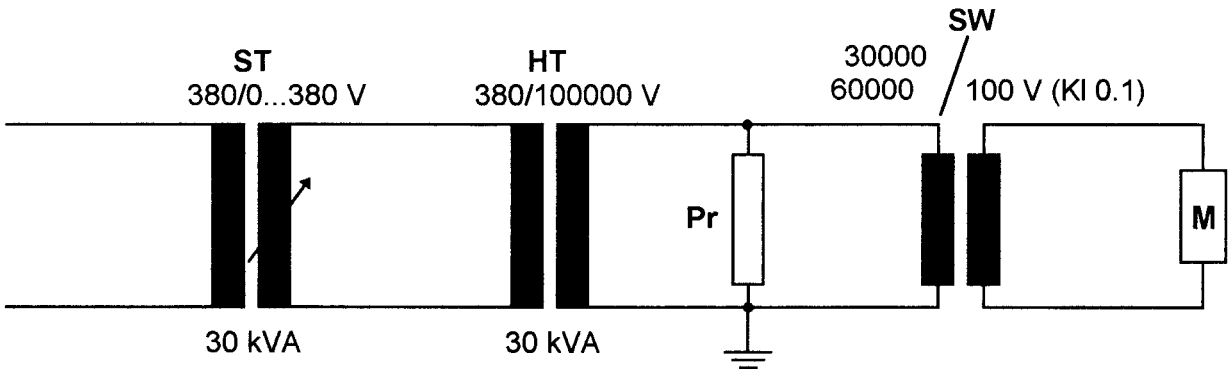
(Test No. 15)

An effectively sinusoidal A.C. voltage of 23 kV eff, 50 Hz, was applied to all test specimens between the conductor and the screen for 15 min. each time.
The voltage was continuously increased to the specified value and was then held constant during the required duration of the test.

relative humidity of air	atmospheric pressure	temperature
36 %	958 mbar	20 °C

Result: No breakdown occurred on any of the test loops.

Figure 7



ST = Regulating transformer
HT = High-voltage transformer
Pr = Test specimen
SW = Measuring transformer
M = Voltage measuring instrument

Connection Diagram for A.C. Withstand Voltage Test

Examination

(Test No. 17)

The inline-splices 3M QS 1000; type 92-AG621-1 passed the test according to CENELEC HD 628.1 S 1: 1996 and CENELEC HD 629.1 S 1: 1996, however, dynamic short circuit tests were not performed.

ELEKTRISCHES PRÜFAMT EPM MÜNCHEN

(Nevihosteny)
Chief Test Engineer

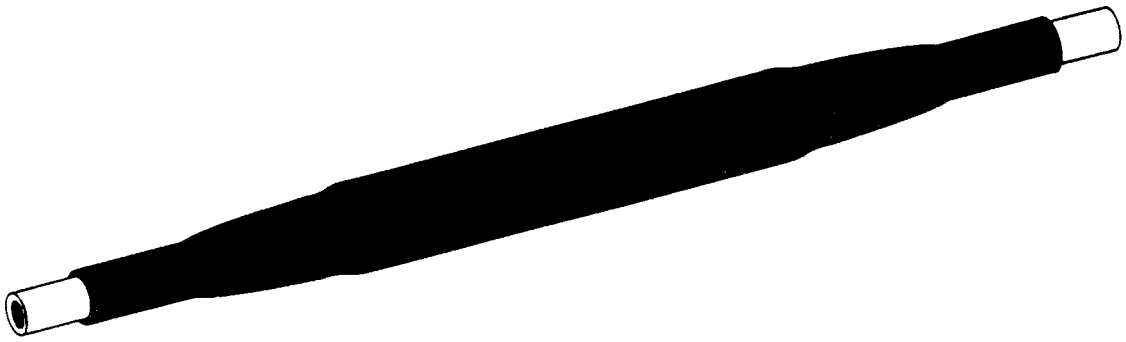
Measuring Instruments Used

No.	Type of Measuring Instrument	Manufacturer
102077	Precision voltmeter	Goerz
108013	Standard voltmeter POSE 45	Ritz
109106	Discharge magnitude meter type 666	ERA
109107	Discharge detector model 3 type 652	ERA
109108	Discharge detector input unit no. 3	ERA
102078	Impulse voltmeter StM 76	MWB
112093	HEME 1000 snap-on ammeter	HEME
102082	Analogue voltmeter 0.5	AEG
108021	Measuring transformer GSZ 30	Ritz
109066	High-voltage resistor	Haefely
109067	High-voltage resistor	Haefely
109068	D.C. voltage measuring instrument	Haefely
111085	Multimeter model 87	Fluke

Date: 02.03.1998

Tests performed by: Nevihosteny, Frackowiak

3M QUICK SPLICE 1000



Kit no.	Diameter over Cable Jacket max (mm)	Diameter over Insulation E (mm)	Cross Section (mm^2) 6/10 kV	Cross Section (mm^2) 8,7/15 kV	Diameter over Connector (mm)	Connector Length max (mm)
92-AG611-1	39	17.7 - 26.0	70 - 150	50 - 150	14.2 - 26.0	135
92-AG621-1	46	22.3 - 33.2	150 - 240	150 - 240	18.0 - 33.2	145
92-AG631-1	56	28.4 - 42.0	300 - 400	300 - 400	23.3 - 42.0	220

3M LABORATORIES (EUROPE) GMBH, HAMBURG

ISSUE: 2 | ISSUE DATE: 12.02.98

ID-0212-2334-5

DES. ENG.	W. Röhling	1. ISSUE DATE.	29.09.97
MOD. ENG.		1. CHANGE DATE.	12.02.98
DRAWN:	M. Hubrich	2. CHANGE DATE.	
CHECKED:	D. Hellbusch	3. CHANGE DATE.	
RELEASED:	V. Heyne	4. CHANGE DATE.	

3M QUICK SPLICE 1000

INLINE SPLICE

92-AG611-1 up to 92-AG631-1

WITH PST SHRINK TUBE

SUITABLE FOR POLYMERIC SINGLE CORE CABLES WITH COPPER WIRE SCREEN

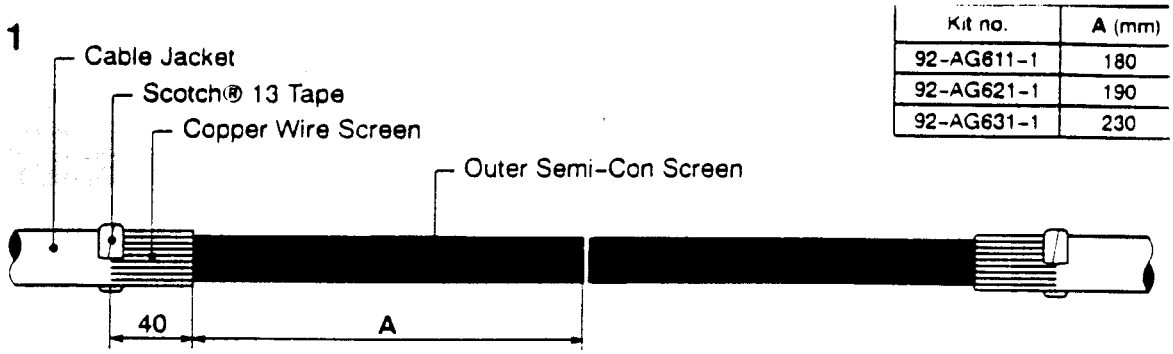
6/10 (12) kV and 8.7/15 (17.5) kV

acc to VDE 0273 (IEC 502-1)

3M ELECTRICAL PRODUCTS

XE 0091-2334-2

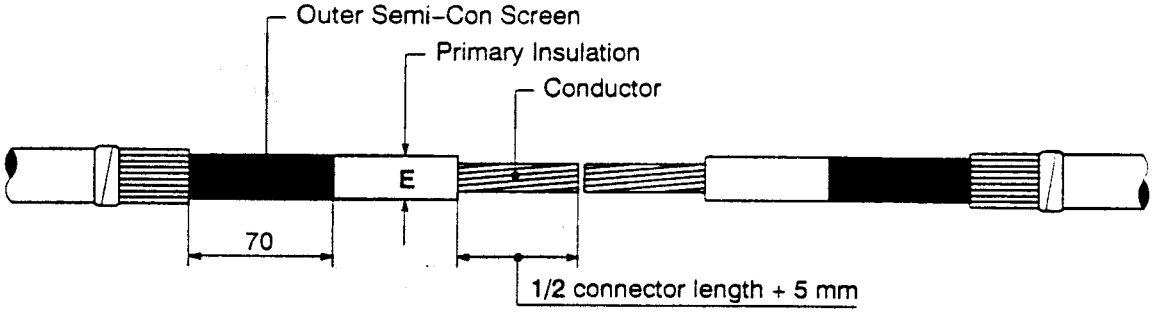
1



Kit no.	A (mm)
92-AG611-1	180
92-AG621-1	190
92-AG631-1	230

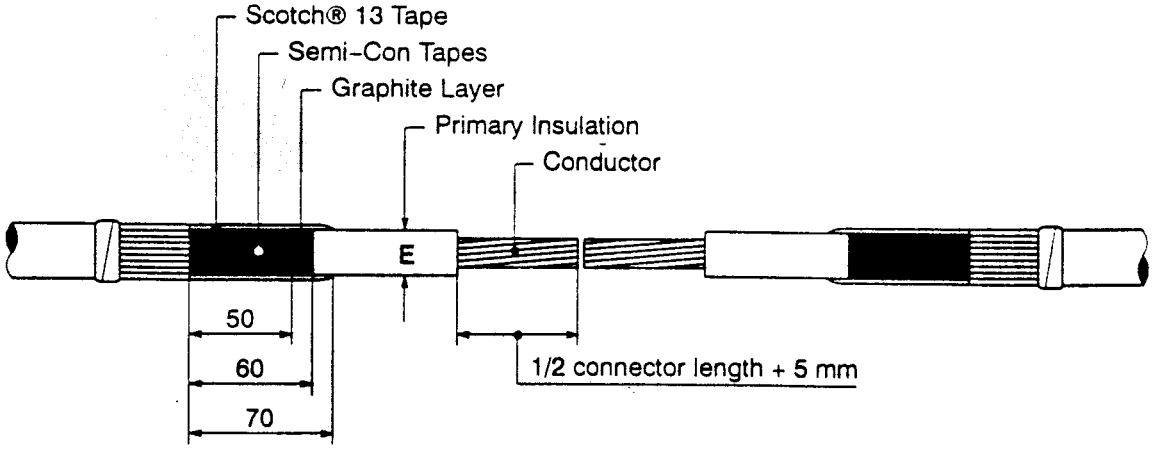
1.1 Remove the cable jacket acc to dimension **A**.
1.2 Bend the copper wire screen back onto the cable jacket, cut the wires for 40 mm and fix them with two layers of Scotch® 13 tape.

2 Cable with Extruded Semi-Conductive Screen



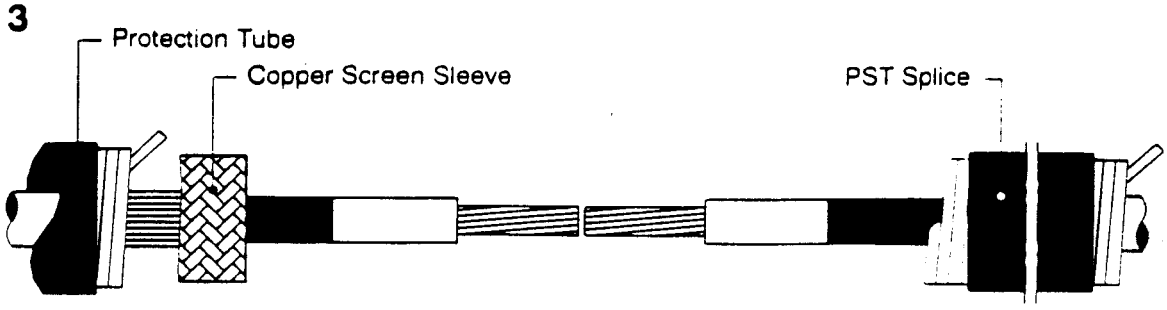
2.1 Remove cotton tapes.
2.2 Remove outer semi-conductive screen leaving 70 mm exposed.
2.3 Remove primary insulation for 1/2 connector length + 5 mm.

Cable with Semi-Conductive Tapes and Graphite Layer



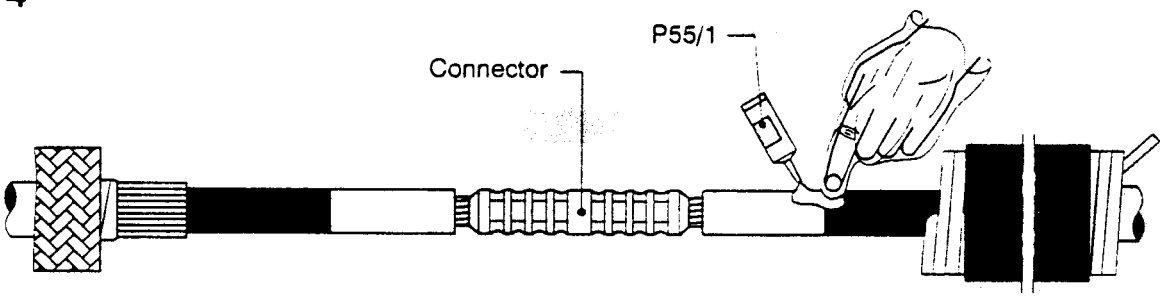
2.1 Remove semi-conductive tapes leaving 50 mm in front of the cable jacket.
2.2 Remove graphite layer leaving 60 mm in front of the cable jacket.
2.3 Apply one half-lapped layer of Scotch® 13 tape from the semi-conductive tapes onto the primary insulation and back again.
2.4 Remove primary insulation for 1/2 connector length + 5 mm.

3



3.1 Position the protection tube, copper screen sleeve and the PST splice onto the cable ends.

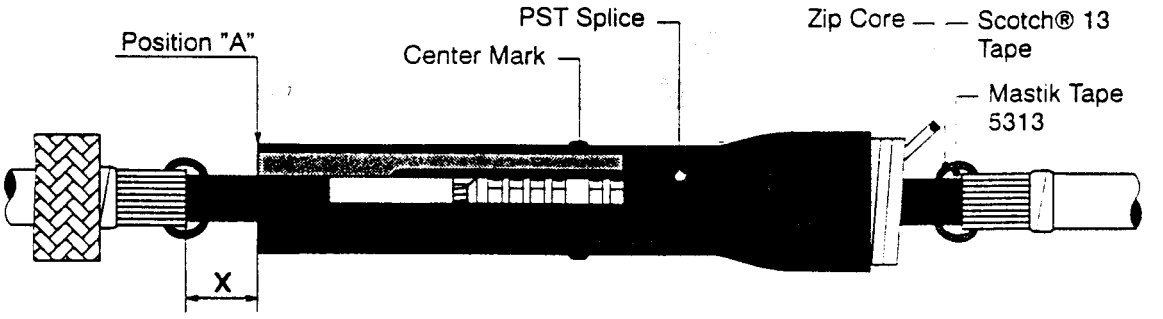
4



4.1 Crimp the connector, remove the excess grease, smooth and clean the connector.
4.2 Apply a liberal amount of P55/1 over the end of the semi-conductive layer, onto the exposed cable insulation and connector using the plastic glove provided.

5

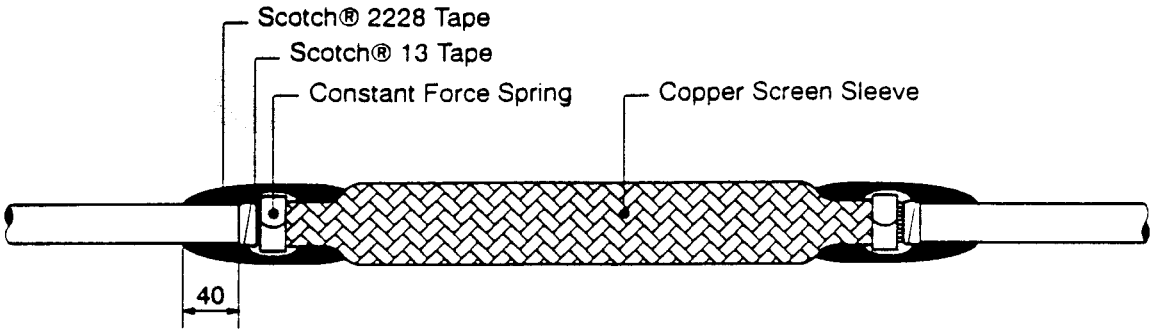
mm^2	50	70	95	120	150	185	240	300	400
X (mm)	25	25	25	30	30	35	40	20	25



5.1 Slide the PST splice over the connection up to position "A".
5.2 Shrink the PST splice into position by pulling out and unwinding the core in clockwise direction.
5.3 After shrinking, check the position of the PST splice, otherwise make correction by displacement.
5.4 Apply in front of each cable jacket one layer of Mastic tape 5313. Cover the mastic with two layers of Scotch® 13 tape.

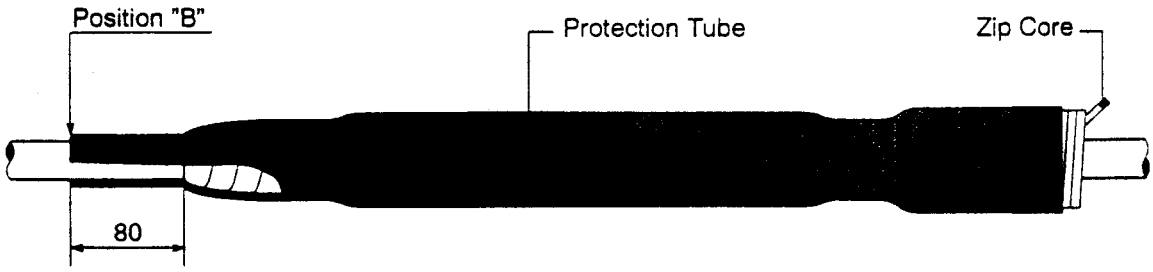
6

Kit no.	Min Diameter over Scotch® 2228 Tape (mm)
92-AG611-1	32
92-AG621-1	34
92-AG631-1	36



6.1 Slide the copper screen sleeve over the splice and fix it by means of a constant force spring on the metallic screen. Cut off the remaining wires of the sleeve.
6.2 Overwrap the constant force springs with two half-lapped layers of Scotch® 13 tape as shown.
6.3 Wrap the Scotch® 2228 tape over the Scotch® 13 tape, cable jacket and copper screen sleeve acc illustration. Ensure min diameter over Scotch® 2228 tape.

7



7.1 Slide the protection tube over the connection up to position "B" and pull out the plastic spiral. The tube then begins to shrink from that point over the splice body.