TYPE TEST REPORT

NO. 1213.1580.6.925

Tyco Electronics Raychem GmbH Finsinger Feld 1 85521 Ottobrunn GERMANY	**CLIENT**
Tyco Electronics Raychem GmbH	**MANUFACTURER**
Screened separable cable connector for single-core cables with extruded insulation	**TEST OBJECT**
RSTI 58xx	**TYPE**
14 test samples	**MANUFACTURING NO.**
Rated voltage U_0/U 12.7/22 kV Maximum value between two phase conductors U_m 24 kV Rated current 275…800 A Rated cross-section range 35…300 mm^2	**RATED CHARACTERISTICS GIVEN BY THE CLIENT**
CENELEC Harmonization Document HD 629.1 S2: 2006-02 DIN VDE 0278-629.1 (VDE 0278 Teil 629-1): 2002-06 EN 61442: 2005-04 DIN VDE 0278-442 (VDE 0278 Teil 442): 2006-01	**NORMATIVE DOCUMENT**
Test series D1 and D2 as well as special tests Nos. 17, 18, 19 and 21 as well as additional tests to Table 10	**RANGE OF TESTS PERFORMED**
20 December 2006 till 08 February 2007, 22. February 2007 till 19 April 2007 and 06. August 2007 till 15 August 2007	**DATE OF TEST**
The test series D1 and D2 as well as special tests Nos. 17, 18, 19 and 21 as well as the additional tests to Table 10 for smalles conductor cross-section have been PASSED.	**TEST RESULT**

PROF. DR. J. PANNICKE
Managing director

J. WITTWER
Test engineer in charge

Berlin, 11 February 2008

Independent test laboratory, accredited by Deutsche Akkreditierungsstelle Technik (DATech) e.V. in the fields of h.v. apparatus and switchgear, power cables and power cable accessories, l.v. apparatus and switchgear, installation equipment and switching and control equipment.

DAT - P - 019/92

Contents **Sheet**

This test document consists of 83 sheets.

Distribution Copy No. 2

Copy No. 1 in German: Tyco Electronics Raychem GmbH
Copy No. 2 in English: Tyco Electronics Raychem GmbH

1. Present at the test

Mr.	Wittwer	IPH test engineer in charge	
Mr.	Moritz	IPH test engineer	(Short-circuit tests and screen fault current initiation test)
Mr.	Schad	Tyco Electronics Raychem GmbH	(partially present)

2. Test performed

Test series D1 and D2 as well as special tests Nos. 17 to 19 and 53.34 cm the following order:

Sequence of tests	Test	Type of test
D1	1	DC voltage dry withstand test
	2	Dry power-frequency voltage test
	3	Partial discharge test at ambient temperature
	4	Impulse voltage test at elevated temperature
	5	Electrical heat cycling test[1)] in air
	6	Electrical heat cycling test[1)] in water
	7	Disconnection/connection
	8	Partial discharge test at elevated and ambient temperatures
	9	Impulse voltage test at ambient temperature
	10	Dry power-frequency voltage test

Sequence of tests	Test	Type of test
D2	1	DC voltage dry withstand test
	2	Dry power-frequency voltage test
	3	Thermal short-circuit test of the conductor
	4	Dynamic short-circuit test of the conductor
	5	Disconnection/connection
	6	Impulse voltage test at ambient temperature
	7	AC voltage dry withstand test

Test performed (continued)

Special tests	17	Screen resistance measurement
	18	Leakage current measurement[2)]
	19	Screen fault current initiation test[3)]
	21	Capacitive test point performance[3)]

Table 10 (Additional tests for smallest cross-	1	DC voltage dry withstand test
	2	Dry power-frequency voltage test
	3	Partial discharge test at ambient temperature
	4	Impulse voltage test at ambient temperature
	5	Electrical heat cycling test[1)] in air
	6	Partial discharge test at elevated and ambient temperatures
	7	AC voltage dry withstand test

These additional tests to Table 10 were necessary because the client extended the range of cross-sections of the connector type beyond the range from 95 to 300 mm^2 down to the minimum conductor cross-section of 35 mm^2.

The thermal short-circuit test of the screen does not apply because the test object is equipped neither with a connection to the metal screen nor with an adapter for the metal screen of the cable.

Test series D3 does not apply because the test object has no operating eye.
Special test No. 20 does not apply since it is a separable connector.

Special tests Nos. 17 to 19 and 21 have been carried out on separate test objects.

Note to the tests:
CENELEC Harmonization Document HD 629.1 S2: 2006-02 and EN 61442: 2005-04 use different terms for some of the tests. In the following, the terms of test standard are given:

1) AC voltage test with heating cycles
2) Screen leakage current measurement
3) Screen fault current test
4) Test of capacitive test point

3. Identity of the test object

3.1 Technical data and characteristics

The technical data and characteristics of the test object are defined by the following parameters and specified by the client.

Test object:	Screened separable cable connector for single-core cables with extruded insulation		
Type:	RSTI 58xx		
Manufacturer:	Tyco Electronics Raychem GmbH		
Serial No.:	12 test samples		
Year of manufacture:	2006		
Rated characteristics:	Rated voltage U_0/U	12.7/22	kV
	Maximum value between two phase conductors U_m	24	kV
	Rated current	275...800	A
	Rated cross-section range of the conductor	35...300	mm^2
Design:	Type of cable connection	Separable T-connector, screened (conductive layer on plastic housing) and with capacitive test point	
	Cable	Single-core cable with extruded insulation, screened	
	Cable marking	N2XSY 1x300 RM/25 mm^2 12/20	kV
	Designation of manufacturer	NEXANS	
	Material of conductor	Cu	
	Material of screen	Cu	

3.2 Identity documents

The manufacturer confirms that the test object has been manufactured in compliance with the drawings given in this document. IPH did not verify this compliance in detail. The identity of the test object is fixed by the following drawings and data submitted by the client:

Name of drawing	Drawing No.	Date of drawing	Author	Notes
Installations instruction Typ RSTI 58xx Sheet 1-6	EPP-0982-DE-	11/06	Tyco Electronics	Sheets 77 to 82

Entry of test objects at IPH: 20 December 2007

4. Results of test series D1

4.1 Test laboratory

High-voltage test laboratory, high-voltage hall 2

4.2 Normative document

CENELEC Harmonization Document HD 629.1 S2: 2006-02
DIN VDE 0278-629.1 (VDE 0278 Teil 629-1): 2002-06
EN 61442: 2005-04
DIN VDE 0278-442 (VDE 0278 Teil 442): 2006-01

4.3 Required test parameters

Test No.	Type of test	Required test parameters	
1	DC voltage dry withstand test	Test voltage 6 x U_0: Duration of test: Polarity:	76 kV 15 min Negative
2	AC voltage dry withstand test	Test voltage 4.5 x U_0: Test frequency: Duration of test:	57 kV 50 Hz 5 min
3	Partial discharge test at Ambient temperature	Prestress voltage 2.25 x U_0: Measuring voltage 2.00[1)] x U_0: Prestress duration: Measuring time:	29 kV 25 kV 1 min 1 min
4	Impulse voltage test at elevated temperature	Front time: Virtual time to half value: Test voltage: Number of impulses: Polarity: Conductor temperature:	1.2 µs 50 µs 125 kV 10 impulses pos./neg. 95 ... 100 °C[2)]
5	Electrical heat cycling test in air	• Continuous AC voltage Test voltage 2.5 x U_0: Test frequency: Duration of test: • Thermal cycles Number of thermal cycles: Cycle (8 h): Conductor temperature during the last 2 hours of heating cycle:	 32 kV 50 Hz 21 days 63 5 hours of heating + 3 hours of cooling 95 ... 100 °C[2)]
6	Electrical heat cycling test in water	See test No. 5, additionally Height of water head:	 1 m
7	Disconnection/connection	Number of complete operations:	5
8	Partial discharge test at ambient temperature and elevated temperature	See test No. 3, except Conductor temperature:	 ϑ_U and 95...100 °C[2)]
9	Impulse voltage test at Ambient temperature	See test No. 4, except Conductor temperature: Duration of test:	 ϑ_U 15 min

Required test parameters (continued)

Test No.	Type of test	Required test parameters	
10	AC voltage dry withstand test	Test voltage 2.5 x U_0: Test frequency: Duration of test:	32 kV 50 Hz 15 min

Notes to the table of required test parameters:

1) CENELEC Harmonization Document HD 629.1 S2: 2006-02, Table 7, requires the partial discharge to be measured at a measuring voltage of 1.73 x U_0 and 2.00 x U_0, .resp. The measurement was at the higher value of 2 x U_0 because the normative document specifies a test voltage of > 1.73, 73 x U_0 for the cable used.

2) Acc. to EN 61442: 2005-04, Clause 9, the heating current to be applied in this test depends on the set conductor temperature. HD 620 specifies that this shall be 5 K to 10 K above the maximum permissible cable conductor temperature of 90 °C for XLPE-insulated cables.

4.4 Test arrangement

Each of the four connectors under test was arranged on a test line by the client. They were connected with each other by a coupling unit of CP 440 type (made by Euromold). The test objects were mounted on cable lines of approx. 3-m length and of N2XSY 1x300 RM/25 mm^2 12/20 kV type. To apply the test voltage, each of the test lines had additionally been equipped with one auxiliary sealing end of EPKT type (made by Tyco Electronics Raychem). All test voltages were applied to the core against the cable screen, which was connected to the test earth.
The tests did not start earlier than 24 hours after the installation of the accessories on the cable lines.

4.4.1 DC voltage dry withstand test (test 1)

Test arrangement to IEC 61442: 2005-04, Clause 5

4.4.2 Power-frequency voltage test (test 2)

Test arrangement to IEC 61442: 2005-04, Clause 4

4.4.3 Partial discharge test at ambient temperature (test 3)

Test arrangement to IEC 61442: 2005-04, Clause 7, with the following simplifications:
Due to the short cable length, neither double impulse diagram nor terminating impedance or reflexion suppressor were used. The PD calibrator was connected in parallel to the test object only at the detector-remote end.

4.4.4 Impulse voltage test at elevated temperature (test 4)

Test arrangement to IEC 61442: 2005-04, Clause 6

The conductors of the four test objects were connected in series. To obtain the necessary elevated (conductor) temperature, the conductor of the single-core cable was heated with single-phase AC on the basis of the induction principle by leading the conductor loop through a heating transformer. The supply voltage of the heating circuit was automatically controlled. So, the elevated conductor temperature remained constant ± 2 K during the last 2 hours of the 5-hour heating cycle.

4.4.5 Electrical heat cycling test in air (test 5)

Test arrangement to IEC 61442: 2005-04, Clauses 4 and 9
For the test arrangement of the heating circuit see Sub-clause 4.40.4. The ambient temperature was kept to 20 °C ± 5 K. The thermal cycling was implemented by a test cycle control facility.

Test arrangement (continued)

4.4.6 Electrical heat cycling test in water (test 6)

In addition to the test arrangement to Sub-clause 4.4.5, the test objects were arranged in a water-filled tank (water bath). The water-level was 1 m above the upper edge of the test objects (see Figure 1).

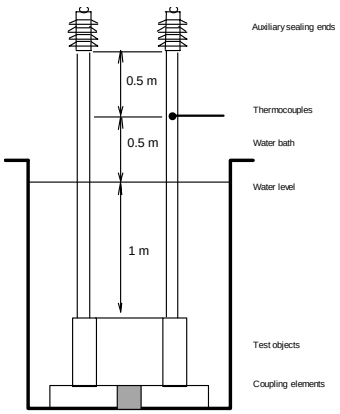


Figure 1: Test of the connectors in the water bath

4.4.7 Disconnection/connection (test 7)

None

4.4.8 Partial discharge test at elevated and ambient temperatures (test 8)

See Sub-clause 4.4.6
For the test at elevated temperature see Sub-clause 4.4.4.

4.4.9 Impulse withstand voltage test at ambient temperature (test 9)

See Sub-clause 4.4.4, but without additional conductor heating

4.4.10 Power-frequency voltage test (test 10)

See Sub-clause 4.4.2

4.5 Test and measuring circuits

4.5.1 DC voltage dry withstand test (test 1)

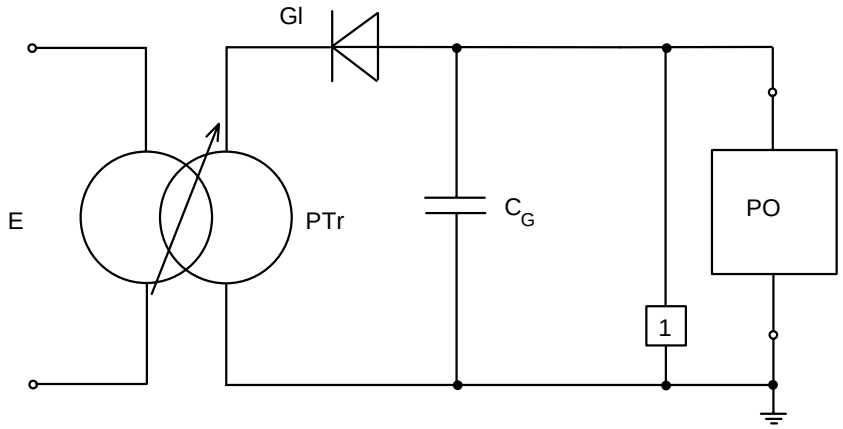
Technical data of test circuit

DC voltage source

Test transformer:	Rated voltage	100	kV
	Rated power	8	kVA
	Rated frequency	50	Hz
Rectifier:	Rated voltage	135	kV
	Rated current	15	mA
Smoothing capacitor:	Capacitance	10	nF

Technical data of measuring circuit

Measuring point	Measured quantity	Measuring sensor/device	Technical parameters
1	Test voltage	Ohmic divider with MU11 (made by TuRD) peak voltmeter	Ratio 560



E Supply
PTr Test transformer with variable transformer connected in series
Gl Rectifier
C_G Smoothing capacitor
1 Measuring point
P0 Test object

Figure 2: Test and measuring circuit for the DC voltage dry withstand test

4.5.2 AC voltage dry withstand test (tests 2 and 10)

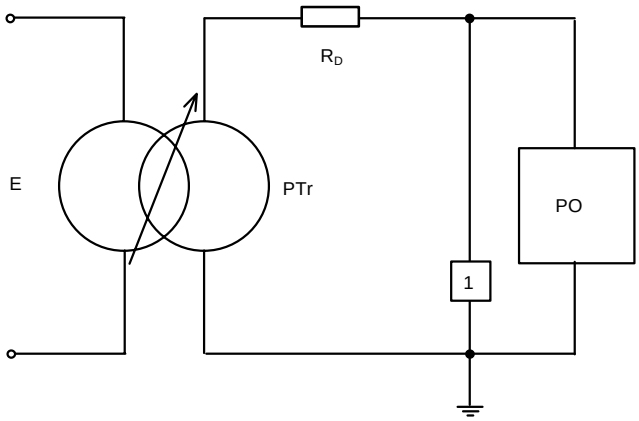
Technical data of test circuit

Single-phase AC voltage source

Test transformer:	Rated voltage	125	kV
	Rated power	100	kVA
	Rated frequency	50	Hz
	Damping resistance	0.67	kOhm

Technical data of measuring circuit

Measuring point	Measured quantity	Measuring sensor/device	Technical parameters
1	Test voltage	Capacitive divider with MU11 (made by TuRD) peak voltmeter	Ratio 864



E Supply
PTr Test transformer with variable transformer connected in series
R_D Damping resistance
1 Measuring point
PO Test object

Figure 3: Test and measuring circuit for the AC voltage dry withstand test

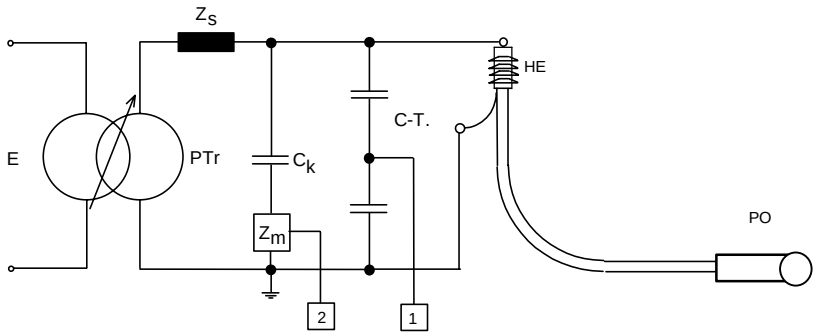
4.5.3 Partial discharge test at elevated and ambient temperatures (tests 3 and 8)

Technical data of test circuit

Test transformer:	Rated voltage	125	kV
	Rated power	100	kVA
	Rated frequency	50	Hz
	Damping resistance	0.67	kOhm

Technical data of measuring circuit

Measuring point	Measured quantity	Measuring sensor/device	Technical parameters
1	Test voltage	Capacitive divider with MU11 peak voltmeter (made by TuRD)	Ratio 864
2	Partial discharges	- Koppelkondensator WMCF (Hersteller TuRD) - Koppelvierpol COPL542A - MPD540 measuring station - 502 USB interface - CAL542 PD calibrator (made by mtronix)	C_k = 1 nF Band width = 300 MHz Centre frequency = 400 kHz Output 10 pC



E Supply
PTr Test transformer with variable transformer connected in series
Z_s Blocking impedance
C_k Coupling capacitor
Z_m Coupling quatripole (measuring impedance)
C-T. Capacitive divider
HE Auxiliary sealing end
1, 2 Measuring points
PO Test object

Figure 4: Test and measuring circuit for the partial discharge test (schematic without heating circuit, for the heating circuit, see Figure 6)

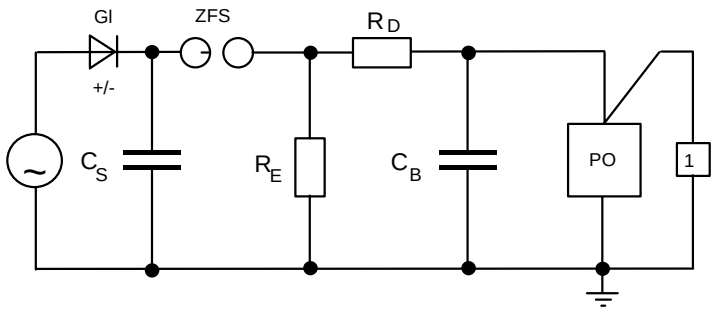
4.5.4 Impulse voltage test at elevated and ambient temperatures (tests 4 and 9)

Technical data of test circuit

Impulse circuit:	Number of stages	n	=	2	
	Impulse capacitance	C_S	=	70	nF
	Loading capacitance	C_B	=	1.5	nF
	Damping resistance	R_D	=	122	Ω
	Discharge resistance	R_E	=	1100	Ω

Technical data of measuring circuit

Measuring point	Measured quantity	Measuring sensor/device	Technical parameters
1	Test voltage	R divider of SMR 10/770 type (made by TuRD) with digital measuring instrument of DMI 551 type (made by Haefely) and TDS 220 digital oscilloscope (made by Tektronix)	Ratio 466.9



GI Rectifier
C_S Impulse capacitance
ZFS Spark gap
R_E Discharge resistance
R_D Damping resistance
C_B Loading capacitance
PO Test object
1 Measuring point

Figure 5: Test and measuring circuit for the impulse voltage test (without heating circuit; for this see Figure 6, but connection of impulse generator instead of single-phase AC voltage source)

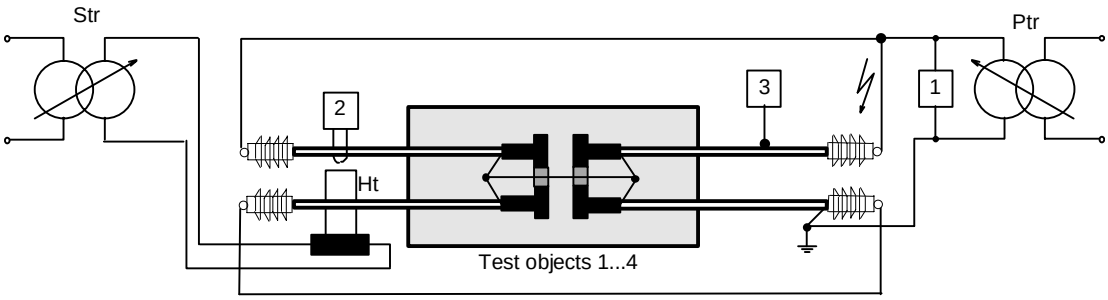
4.5.5 Electrical heat cycling in air and in water, resp. (tests 5 and 6)

Technical data of test circuit

Single-phase continuous AC voltage source			
Test transformer:	Rated voltage	125	kV
	Rated power	100	kVA
	Rated frequency	50	Hz
Heating circuit			
Heating transformers:	Rated primary voltage	380	V
	Rated power	57	kVA
	Max. secondary current	1000	A
	Rated frequency	50	Hz

Technical data of measuring circuit

Measuring point	Measured quantity	Measuring sensor/device	Technical parameters
1	Test voltage	Capacitive divider with MU11 peak voltmeter (made by TuRD)	Ratio 864
2	Heating current	LH 2040 prong-type ammeter	2000-A (AC) measuring range
3	Temperature	thermocouples of CoCo type in connections with Almemo temperature measuring system of 2290-3 type (made by Ahlborn)	



Str Variable transformer
Ht Heating transformer
1 - 3 Measuring points
Ptr Test transformer with variable transformer connected in series

Figure 6: Test and measuring circuit for the electrical heat cycling tests in air and in water, resp.

4.5.6 Disconnection/connection (test 8)

None

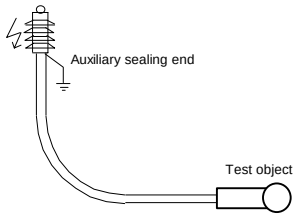
4.6 Test results

4.6.1 DC voltage dry withstand test (test 1)

Polarity: Negative

Duration of test after having reached full voltage: 15 min

Test temperature: Ambient temperature 20 °C
Conductor temperature 20 °C

Test set-up 			Test voltage	Result
No. of test object	Voltage applied to	Earthed	kV	
1	Conductor	Screen	-76	No disruptive discharge
2	Conductor	Screen		No disruptive discharge
3	Conductor	Screen	-76	No disruptive discharge
4	Conductor	Screen		No disruptive discharge

Notes:

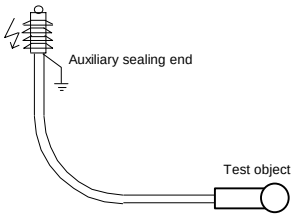
Connected by a coupling unit two test lines were tested together.

4.6.2 Power-frequency voltage test (test 2)

Duration of test after having reached full voltage: 5 min

Test frequency: 50 Hz

Test temperature: Ambient temperature 20 °C
Conductor temperature 20 °C

Test set-up 			Test voltage	Result
No. of test object	Voltage applied to	Earthed	kV	
1	Conductor	Screen	57	No disruptive discharge
2	Conductor	Screen		No disruptive discharge
3	Conductor	Screen	57	No disruptive discharge
4	Conductor	Screen		No disruptive discharge

Notes:

Connected by a coupling unit two test lines were tested together.

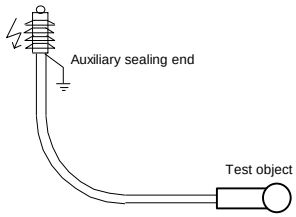
4.6.3 Partial discharge test at ambient temperature (test 3)

Test frequency: 50 Hz

Test temperature: Ambient temperature 20 °C
Conductor temperature 20 °C

Calibration of the test circuit by calibrator output 10 pC

Measured PD values

Test set-up 			Prestress voltage (1 min)	Measuring voltage (1 min)	Measured PD value
No. of test object	Voltage applied to	Earthed	kV	kV	pC
1	Conductor	Screen	29	25	1.1 [1)]
2	Conductor	Screen			
3	Conductor	Screen	29	25	1.1 [1)]
4	Conductor	Screen			

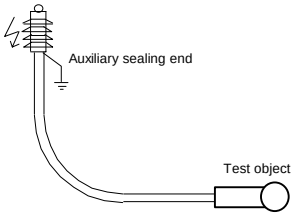
Notes:

Connected by a coupling unit two test lines were tested together.

[1)] Basic disturbance level at same value

4.6.4 Impulse voltage test at elevated temperature (test 4)

Full wave:	Front time	T_1 = 1.74 µs
	Virtual time to half value	T_2 = 52.0 µs
Test temperature:	Ambient temperature	20 °C
	Conductor temperature	95...100 °C

Test set-up 			Test voltage	Result
No. of test object	Voltage applied to	Earthed	kV	No. of impulses/disruptive discharges
1	Conductor	Screen		
2	Conductor	Screen	+125 [1), 2)]	10/0 [1), 2)]
3	Conductor	Screen	-125 [1), 2)]	10/0 [1), 2)]
4	Conductor	Screen		

Notes:

[1)] All four test lines were connected to form one closed conductor loop for heating the latter. Therefore, all test lines were simultaneously tested. Separate testing is not possible.

[2)] Test also passed at 150 kV.

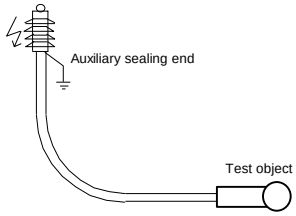
4.6.5 Electrical heat cycling test in air (test 5)

Duration of test: 21 days

Test frequency: 50 Hz

Test temperature: Ambient temperature 20 °C
Conductor temperature 95...100 °C

Number of load cycles:63

Test set-up 			Continuous AC withstand voltage	Heating current	Result
No. of test object	Voltage applied to	Earthed	kV	A	
1	Conductor	Screen	32 [1]	1010 [1), 2)]	No disruptive discharge
2	Conductor	Screen			No disruptive discharge
3	Conductor	Screen			No disruptive discharge
4	Conductor	Screen			No disruptive discharge

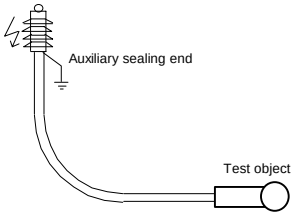
Notes:

[1] All four test lines were connected to form one closed conductor loop for heating the latter. Therefore, all test lines were simultaneously tested. Separate testing is not possible.

[2] The heating current was regulated and automatically controlled in such a way that a constant conductor temperature was obtained after approx. 3 hours of heating. This was kept constant ± 2 K for the remaining 2 hours of the 5-hour heating period.

4.6.6 Electrical heat cycling test in water (test 6)

Duration of test:		21 days
Test frequency:		50 Hz
Test temperature:	Ambient temperature	20 °C
	Water temperature	20...25 °C
	Conductor temperature	95...100 °C
Number of load cycles:		63

Test set-up 			Continuous AC withstand voltage	Heating current	Result
No. of test object	Voltage applied to	Earthed	kV	A	
1	Conductor	Screen	32 [1]	1010 [1), 2)]	No disruptive discharge
2	Conductor	Screen			No disruptive discharge
3	Conductor	Screen			No disruptive discharge
4	Conductor	Screen			No disruptive discharge

Notes:

[1] All four test lines were connected to form one closed conductor loop for heating the latter. Therefore, all test lines were simultaneously tested. Separate testing is not possible.

[2] The heating current was regulated and automatically controlled in such a way that a constant conductor temperature was obtained after approx. 3 hours of heating. This was kept constant ± 2 K for the remaining 2 hours of the 5-hour heating period.

4.6.7 Disconnection/connection (test 7)

Each of the four test objects was disconnected and connected altogether five times as specified by the manufacturer's assembly instructions. No visible damage was found on the contact.

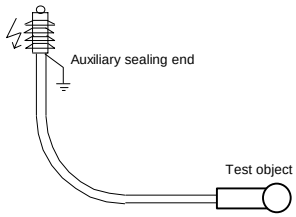
4.6.8 Partial discharge test at elevated and ambient temperatures (test 8)

Test frequency: 50 Hz

Test temperature: Ambient temperature 20 °C
Conductor temperature 20 °C and elevated, resp. 95...100 °C

Calibration of the test circuit by calibrator output 10 pC

Measured PD values

Test set-up 			Prestress voltage (1 min)	Measuring voltage (1 min)	Measured PD value
No. of test object	Voltage applied to	Earthed	kV	kV	pC
Measured PD values at elevated temperature					
1	Conductor	Screen	29	25	< 1.9 [1]
2	Conductor	Screen			
3	Conductor	Screen	29	25	< 1.9 [1]
4	Conductor	Screen			
Measured PD values at ambient temperature					
1	Conductor	Screen	29	25	< 1.0 [1] [2]
2	Conductor	Screen			
3	Conductor	Screen	29	25	< 1.0 [1] [2]
4	Conductor	Screen			

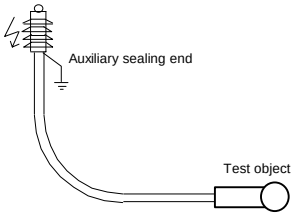
Notes:

[1] The two test lines were connected to form one closed conductor loop for heating the latter. Therefore, all test lines were simultaneously tested. Separate testing is not possible.

[2] Basic disturbance level at same value

4.6.9 Impulse withstand voltage test at ambient temperature (test 9)

Full wave:	Front time	T_1 = 1.64 µs
	Virtual time to half value	T_2 = 52.0 µs
Test temperature:	Ambient temperature	20 °C
	Conductor temperature	20 °C

Test set-up 			Test voltage	Result
No. of test object	Voltage applied to	Earthed	kV	No. of impulses/disruptive discharges
1	Conductor	Screen	+125 [1)]	10/0
			-125 [1)]	10/0
2	Conductor	Screen		
3	Conductor	Screen	+125 [1)]	10/0
			-125 [1)]	10/0
4	Conductor	Screen		

Notes:

Connected by a coupling unit two test lines were tested together.

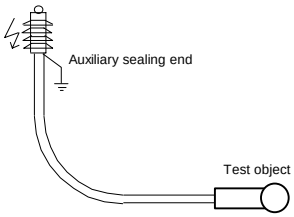
[1)] Test also passed at 150 kV.

4.6.10 Power-frequency voltage test (test 10)

Duration of test after having reached full voltage: 15 min

Test frequency: 50 Hz

Test temperature: Ambient temperature 20 °C
Conductor temperature 20 °C

Test set-up 			Test voltage	Result
No. of test object	Voltage applied to	Earthed	kV	
1	Conductor	Screen	32	No disruptive discharge
2	Conductor	Screen		
3	Conductor	Screen	32	No disruptive discharge
4	Conductor	Screen		

Notes:

Connected by a coupling unit two test lines were tested together.

4.7 Assessment of test series D1

• Test 1

In the DC withstand voltage test at -76 kV/15 min, no disruptive discharge occurred on any of the four test objects.

• Test 2

In the 50-Hz AC voltage dry withstand test at 57 kV/5 min, no disruptive discharge occurred on any of the four test objects.

• Test 3

In the partial discharge test at ambient temperature and at 50-Hz AC voltage of 25 kV, none of the four test objects exceeded the permissible maximum partial discharge value of 10 pC. The partial discharge value measured was not higher than 1.1 pC.

• Test 4

In the impulse voltage test at elevated temperature with 10 test impulses of 125 (150) kV lightning impulse voltage 1.2/50 of each polarity, no disruptive discharge occurred on any of the four test objects.

• Test 5

All of the four test objects were subjected to 63 electrical heat cycles in air. In the simultaneous 50-Hz continuous AC voltage test at 32 kV, no disruptive discharge occurred on any of the four test objects.

• Test 6

All of the four test objects were subjected to 63 electrical heat cycles in water. In the simultaneous test in water and in the 50-Hz continuous AC voltage test with 32 kV, no disruptive discharge occurred on any of the four test objects.

• Test 7

After 5 complete operations of disconnection and connection, no visible damage was found on the contact.

• Test 8

In the partial discharge test at elevated and ambient temperatures at 50-Hz AC voltage of 25 kV, none of the four test objects exceeded the permissible maximum partial discharge value of 10 pC. The partial discharge value measured was not higher than 1.9 pC.

• Test 9

In the impulse voltage test at ambient temperature with 10 test impulses of 125 (150) kV lightning impulse voltage 1.2/50 of each polarity, no disruptive discharge occurred on any of the four test objects.

• Test 10

In the 50-Hz AC voltage dry withstand test at 32 kV/15 min, no disruptive discharge occurred on any of the four test objects.

All four test objects meet the requirements defined by CENELEC Harmonisation Document HD 629.1 S2: 2006-02.

Test series D1 has been PASSED.

5. Test series D2

5.1 Test laboratory

High-voltage test laboratory, high-voltage hall 2 and
High-power test laboratory, high-current bay

5.2 Normative document

CENELEC Harmonization Document HD 629.1 S2: 2006-02
DIN VDE 0278-629.1 (VDE 0278 Teil 629-1): 2002-06
EN 61442: 2005-04
DIN VDE 0278-442 (VDE 0278 Teil 442): 2006-01

5.3 Required test parameters

Test No.	Type of test	Required test parameters	
1	DC voltage dry withstand test	Test voltage 6 x U_0: Duration of test: Polarity:	76 kV 15 min Negative
2	AC voltage dry withstand test	Test voltage 4.5 x U_0: Test frequency: Duration of test:	57 kV 50 Hz 5 min
3	Thermal short-circuit test of the conductor	Short-circuit-conductor final temperature: Number of short-circuits:	 250 °C 2
4	Dynamic short-circuit test of the conductor	Peak short-circuit current: Duration of short circuit: Number of short-circuits:	125 kA min. 10 ms 1
5	Disconnection/connection	Number of complete operations:	 5
6	Impulse voltage test at Ambient temperature	Front time: Virtual time to half value: Test voltage: Number of impulses: Polarity: Conductor temperature:	1.2 µs 50 µs 125 kV 10 impulses pos./neg. ϑ_u
7	AC voltage dry withstand test	Test voltage 2.5 x U_0: Test frequency: Duration of test:	32 kV 50 Hz 15 min

5.4 Test arrangement

Each of the three connectors under test was arranged on a test line by the client. The connectors were completed by bushings or sealing ends. The test objects were mounted on cable lines of approx. 3-m length and of N2XSY 1x300 RM/ 25 mm^2 12/20 kV type. To apply the test voltage, each of the test lines had additionally been equipped with one auxiliary sealing end of EPKT type (made by Tyco Electronics Raychem).
All test voltages were applied to the core against the cable screen, which was connected to the test earth. The tests did not start earlier than 24 hours after the installation of the accessories on the cable lines.

5.4.1 DC voltage dry withstand test (test 1)

Test arrangement to IEC 61442: 2005-04, Clause 5

5.4.2 Power-frequency voltage test (test 2)

Test arrangement to IEC 61442: 2005-04, Clause 4

5.4.3 Thermal short-circuit test of the conductor (test 3)

Test arrangement to IEC 61442: 2005-04, Clause 11
The three test objects were arranged on an assembly plate on equal level with phase centres distances of 110 mm. Additionally the cables were fixed by cable clamps at a distance of 300 mm from the axis of the cable connector centre. For the test, a short-circuit bridge of 40 mm x 10 mm was connected at the three bushings and the auxiliary sealing end sides of the three test lines were connected three-pole to the short-circuit current source. For test arrangement see Figure Figure 14: Test objects subjected to test series D2 (mounted on bushing), Sheet 64.

5.4.4 Dynamic short-circuit test of the conductor (test 4)

Test arrangement to IEC 61442: 2005-04, Clause 12

See Sub-clause 5.4.3

5.4.5 Disconnection/connection (test 5)

None

5.4.6 Impulse withstand voltage test at ambient temperature (test 6)

Test arrangement to IEC 61442: 2005-04, Clause 6

5.4.7 Power-frequency voltage test (test 7)

See Sub-clause 5.4.2

5.5 Test and measuring circuits

5.5.1 DC voltage dry withstand test (test 1)

See Sub-clause 4.5.1

5.5.2 Power-frequency voltage test (test 2)

See Sub-clause 4.5.2

5.5.3 Thermal short-circuit test of the conductor (test 3)

See following sheet.

5.5.4 Dynamic short-circuit test of the conductor (test 4)

See following sheet.

5.5.5 Disconnection/connection (test 5)

None

5.5.6 Impulse withstand voltage test at ambient temperature (test 6)

See Sub-clause 4.5.4

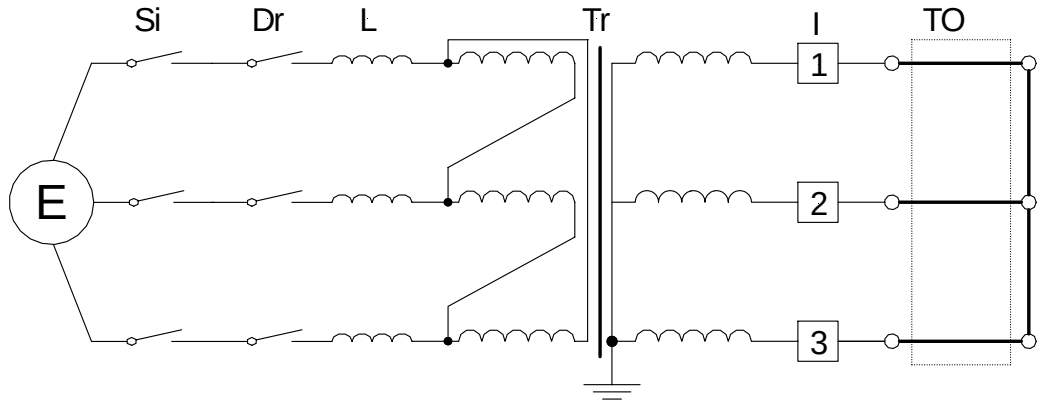
5.5.7 Power-frequency voltage test (test 7)

See Sub-clause 4.5.2

Thermal and dynamic short-circuit tests (tests 3 and 4)

Technical data of test circuits

Test requirement		Short-circuit tests
Test No.		107 1272 to 107 1275
Number of phases	(Test circuit)	3
Number of poles/phases	(Test object)	3
Power-frequency	Hz	50
Power factor cos φ		0.015
Earthing conditions	Generator / grid	Not earthed
	Short-circuit transformer	Earthed
	Short-circuit point	Not earthed



E	Power supply (grid)	TO	Test object
Si	Master breaker	I	Current measurement
Dr	Making switch	U	Voltage measurement
L	Current-limiting reactor	1 - 3	Measuring points
Tr	Short-circuit transformer		

Figure 7: Test and measuring arrangement for the thermal and dynamic short-circuit tests of the conductor

Technical data of measuring circuits

Measuring point	Symbol	Measured quantity	Measuring sensor/device
1	i L1	Current of conductor L1	Rogowski measuring device
2	i L2	Current of conductor L2	Rogowski measuring device
3	i L3	Current of conductor L3	Rogowski measuring device
Recording instrument: BE 256 transient recorder system			

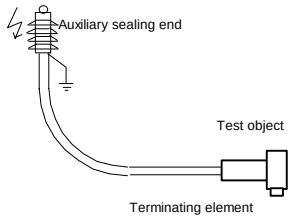
5.6 Test results

5.6.1 DC voltage dry withstand test (test 1)

Polarity: Negative

Duration of test after having reached full voltage: 15 min

Test temperature: Ambient temperature 20 °C
Conductor temperature 20 °C

Test set-up 			Test voltage	Result
No. of test object	Voltage applied to	Earthed	kV	
5	Conductor	Screen	-76	No disruptive discharge
6	Conductor	Screen	-76	No disruptive discharge
7	Conductor	Screen	-76	No disruptive discharge

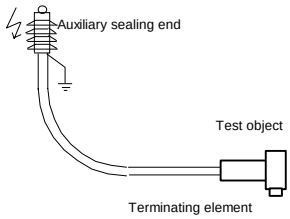
Notes: -

5.6.2 Power-frequency voltage test (test 2)

Duration of test after having reached full voltage: 5 min

Test frequency: 50 Hz

Test temperature: Ambient temperature 20 °C
Conductor temperature 20 °C

Test set-up 			Test voltage	Result
No. of test object	Voltage applied to	Earthed	kV	
5	Conductor	Screen	57	No disruptive discharge
6	Conductor	Screen	57	No disruptive discharge
7	Conductor	Screen	57	No disruptive discharge

Notes: -

5.6.3 Thermal short-circuit test of the conductor (test 3)

Condition of test object before test:	Prestressed by previous tests
Connection of test object:	By 300-mm^2 cable conductor
Short-circuit point:	At the bushings
Ambient temperature:	16 °C

Test No.			107 1273	107 1274
Peak short-circuit current	kA	L1	**46.3**	**46.5**
		L2	**46.6**	**44.5**
		L3	**44.9**	**45.9**
Symmetrical short-circuit current	kA	L1	**31.4**	**31.3**
		L2	**31.9**	**31.9**
		L3	**31.5**	**31.5**
	Average		**31.6**	**31.6**
Duration of short-circuit	ms		**3040**	**3040**
Joule integral 10^6	A^2s	L2	**3036**	**3036**
Symmetrical short-circuit current 3 s	kA		**31.8**	**31.8**
Symmetrical short-circuit current 1 s	kA		**55.1**	**55.1**
Notes			**1st thermal short-circuit test**	**2nd thermal short-circuit test**
Evaluation			**OK**	**OK**

Notes:

OK: The test object is able to carry the short-circuit current.

Condition of test object after test:

The test objects did not show any externally visible changes or damage.

5.6.4 Dynamic short-circuit test of the conductor (test 4)

Condition of test object before test:	Prestressed by previous tests
Connection of test object:	By 300-mm^2 cable conductor
Short-circuit point:	At the bushings
Ambient temperature:	16 °C

Test No.			**107 1275**
Peak short-circuit current	kA	L1	**128**
		L2	**105**
		L3	**97.9**
Symmetrical short-circuit current	kA	L1	**51.6**
		L2	**51.6**
		L3	**51.5**
	Average		**51.6**
Duration of short-circuit	ms		**105**
Joule integral 10^6	A^2s	L1	**128**
		L2	**105**
		L3	**97.9**
Symmetrical short-circuit current 1 s	kA		**-**
Notes			**Dynamic short-circuit test**
Evaluation			**OK**

Notes:

OK: The test object is able to carry a peak short-circuit current of 128 kA.

Condition of test object after test:

The test objects did not show any externally visible changes or damage.

5.6.5 Disconnection/connection (test 5)

Each of the three test objects was disconnected and connected altogether five times as specified by the manufacturer's assembly instructions. No visible damage was found on the contact.

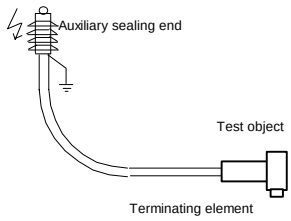
5.6.6 Impulse withstand voltage test at ambient temperature (test 6)

Full wave:

Front time T_1 = 1.34 µs
Virtual time to half value T_2 = 53.6 µs

Test temperature:

Ambient temperature 20 °C
Conductor temperature 20 °C

Test set-up 			Test voltage	Result
No. of test object	Voltage applied to	Earthed	kV	No. of impulses/disruptive discharges
5	Conductor	Screen	+125 -125	10/0 10/0
6	Conductor	Screen	+125 -125	10/0 10/0
7	Conductor	Screen	+125 -125	10/0 10/0

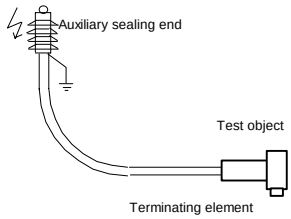
Notes: -

5.6.7 Power-frequency voltage test (test 7)

Duration of test after having reached full voltage: 15 min

Test frequency: 50 Hz

Test temperature: Ambient temperature 20 °C
Conductor temperature 20 °C

Test set-up 			Test voltage	Result
No. of test object	Voltage applied to	Earthed	kV	
5	Conductor	Screen	32	No disruptive discharge
6	Conductor	Screen	32	No disruptive discharge
7	Conductor	Screen	32	No disruptive discharge

Notes: -

5.7 Assessment of test series D2

• Test 1

In the DC withstand voltage test at -76 kV/15 min, no disruptive discharge occurred on any of the three test objects.

• Test 2

In the 50-Hz AC voltage dry withstand test at 57 kV/5 min, no disruptive discharge occurred on any of the three test objects.

• Test 3

In the thermal short-circuit test of the conductor with a thermally equivalent current of 31.9 kA/3 s, no visible damage was detected on any of the three test objects.

• Test 4

In the dynamic short-circuit test of the conductor with a peak current of 128 kA, no visible damage was detected on any of the three test objects.

• Test 5

After 5 complete operations of disconnection and connection, no visible damage was found on the contact.

• Test 6

In the impulse voltage test at ambient temperature with 10 test impulses of 125 kV lightning impulse voltage 1.2/50 of each polarity, no disruptive discharge occurred on any of the three test objects.

• Test 7

In the 50-Hz AC voltage dry withstand test at 32 kV/15 min, no disruptive discharge occurred on any of the three test objects.

All three test objects meet the requirements defined by CENELEC Harmonisation Document HD 629.1 S2: 2006-02.

Test series D2 has been PASSED.

6. Special tests (tests Nos. 17 to 19 and 21)

6.1 Test laboratory

Low-voltage test laboratory, test room 7 (test No. 17)
High-voltage test laboratory, high-voltage hall 2 (test No. 18)
Low-voltage test laboratory, test room 3 (test No. 19)
High-voltage test laboratory, high-voltage hall 2 (test No. 21)

6.2 Normative documents

CENELEC Harmonization Document HD 629.1 S2: 2006-02
DIN VDE 0278-629.1 (VDE 0278 Teil 629-1): 2002-06
EN 61442: 2005-04
DIN VDE 0278-442 (VDE 0278 Teil 442): 2006-01

6.3 Required test parameters

Test No.	Type of test	Required test parameters	
17	Screen resistance measurement	Temperature during exposure to heat: Duration of thermal ageing:	(120±2) °C 168 h
18	Leakage current measurement	Test voltage U_m:	24 kV
19	Screen fault current initiation test (in unearthed or impedance-earthed systems)	• Solidly earthed system Test voltage: Test current: Duration of current flow: Number of tests: • Unearthed or impedance-earthed system Test voltage: Test current: Test procedure:	 12.7 kV [1)] 10 kA 0.2 s 2 12.7 kV [1)] Minimum 10 A Start C-1 s O-2 min C-2 min O-2 min C 1 min O end
21	Capacitive test point performance	-	-

Note:
1) Test parameter complies with normative document. If lower values are applied the test will become more severe.

6.4 Test arrangement

6.4.1 Screen resistance measurement (test No. 17)

Test arrangement to IEC 61442: 2005-04, Clause 15

Only one single connector body was used for the measurement. For the definite and reproducible measurement of the resistance on the screen, two bare-copper rings of approx. 1-mm width were fixed to the screen. They served as fixed electrodes for the resistance measurement.

6.4.2 Leakage current measurement (test No. 18)

Test arrangement to IEC 61442: 2005-04, Clause 16

The client installed the test object on a short length of cable, which was equipped with an auxiliary sealing end on its other end, and completed it with a bushing. Subsequently, a square metal foil of 25 cm^2 was fitted to the outer screen of the test object in the region of the bushing. When the AC test voltage was applied to the test object, the leakage current from metal foil to earth was measured.

6.4.3 Screen fault current initiation test (test No. 19)

Test arrangement to IEC 61442: 2005-04, Clause 17

A bushing was centrally arranged in a metal plate of 600 mm x 600 mm x 5 mm, which was vertically fixed to a test rack. Each of the test objects, installed on a short length of cable by the client, was fixed to the bushing and the screen was earthed in accordance with the manufacturer's instructions. The other end of each length of cable was equipped with an auxiliary sealing end. For the test with solidly earthed system, a threaded rod of 10 mm ∅ was arranged in the region of the transition from the conductor to the cable lug in the body of the connector under test so that a connection was established from the cable lug through a drilled hole to the inner and outer screens of the connector body. For the test with unearthed or impedance earthed systems, a drilled hole was used instead of the rod. It had a copper wire of 0.2 mm ∅ bridging the insulation between the inner and outer screens and for initiating the arc. In both cases, neither the rod nor the wire protruded beyond the outer screen surface of the connector body.

6.4.4 Capacitive test point performance (test No. 21)

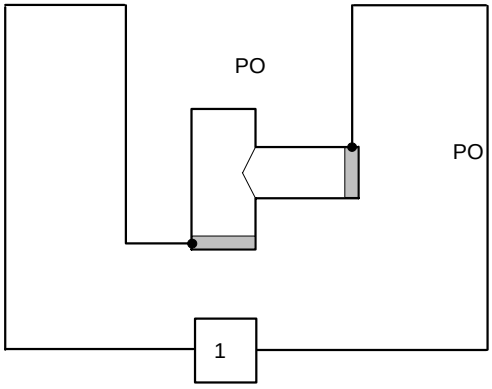
Test arrangement to IEC 61442: 2005-04, Clause 20
One connector was installed on a short length of cable by the client and the screen was earthed in accordance with the manufacturer's instructions. The test object was equipped with a mating bushing.

6.5 Test and measuring circuits

6.5.1 Screen resistance measurement (test No. 17)

Technical data of measuring circuit

Measuring point	Measured quantity	Measuring sensor/device	Technical parameters
1	Resistance	Digital manual multimeter of 137 (KEITHLEY) type	Measuring range R - 2 kOhm



1 Measuring point
PO Test object

Figure 8: Measuring circuit for resistance measurement on the screen

6.5.2 Leakage current measurement (test No. 18)

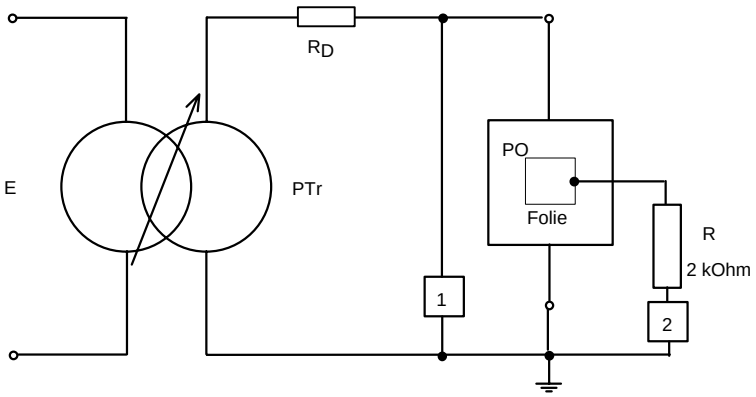
Technical data of test circuit

Single-phase AC voltage source

Test transformer:	Rated voltage	125	kV
	Rated power	100	kVA
	Rated frequency	50	Hz
	Damping resistance	0.67	kOhm

Technical data of measuring circuit

Measuring point	Measured quantity	Measuring sensor/device	Technical parameters
1	Test voltage	Capacitive divider with MU11 (made by TuRD) peak voltmeter	Ratio 864
1	Test current	Digital manual multimeter of 137 (made by KEITHLEY) type	MB 0.2 mA AC



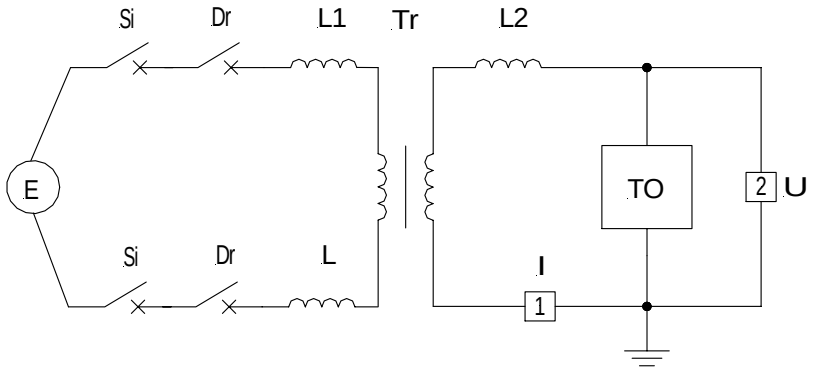
E Supply
PTr Test transformer with variable transformer connected in series
R_D Damping resistance
R Resistance
1, 2 Measuring points
PO Test object

Figure 9: Test and measuring circuit for the leakage current measurement

6.5.3 Screen fault current initiation test (test No. 19)

Technical data of test circuit

Test requirement		Screen fault current test
Test No.		107 1254 to 107 1263
Number of phases	(Test circuit)	2
Number of poles/phases	(Test object)	1
Power-frequency	Hz	50
Power factor cos φ		< 0.15
Connection of short-circuit transformers		I/i
Short-circuit power		120 MVA
Earthing conditions	Grid	Not earthed
	Short-circuit transformer	Earthed



E	Power supply (grid)	Tr	Short-circuit transformer
Si	Master breaker	1, 2	Measuring points
Dr	Making switch	I	Current measurement
L1,L2	Current limiting reactors	U	Voltage measurement
		TO	Test object

Figure 10: Test and measuring circuit for the screen fault current initiation test

Technical data of measuring circuits

Test No.	Measuring point	Symbol	Measured quantity	Measuring sensor/device
107 1254 bis 107 1263	1	i	Current	Current transformer
	2	u	Test voltage	RC divider
Recording instrument: BE 256 transient recorder				

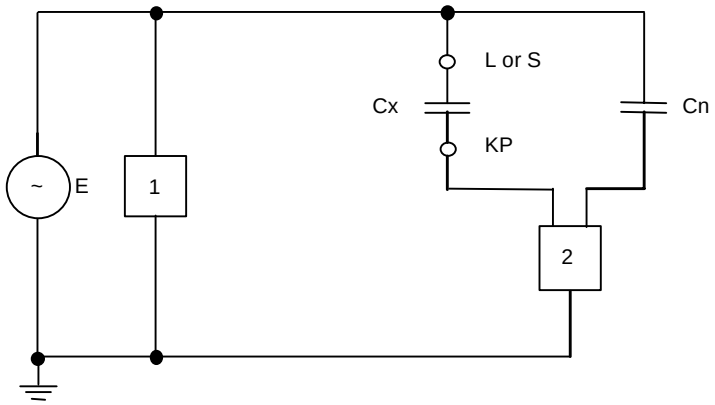
6.5.4 Capacitive test point performance (test No. 21)

Capacitance measurement by differential bridge

The capacitance Cx to be measured was connected to a capacitance measuring bridge together with the well-known capacitance Cn.

Technical data of measuring circuit

Measuring point	Measured quantity	Measuring sensor/device	Technical parameters
1	Capacitance	C-tan δ measuring bridge of VFM type (made by MWB)	Measuring range x 100 pF
2	Test voltage	Capacitive divider with MU11 (made by TuRD) peak voltmeter	Ratio 864



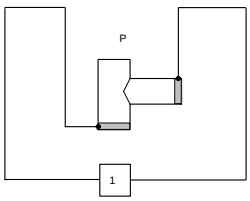
G Sine-wave generator
Cx Capacitance to be determined
L, S Cable conductor or cable screen
KP Capacitive test point
C Low-voltage partial capacitance
Ce Measuring device for incoming capacitance
Re Measuring device for incoming resistance
1...2 Measuring points

Figure 11: Test and measuring circuit for determining capacitive test point performance

6.6 Test results

6.6.1 Screen resistance measurement (test No. 17)

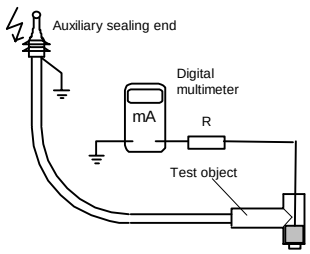
Test temperature: Ambient temperature 20 °C
Temperature during exposure to heat: 120 °C
Time of exposure to heat 168 h

Test set-up 		Resistance	Result
No. of test object	Condition of test object	Ω	
8	Before exposure to heat	2450	OK
8	After exposure to heat	2140	OK

OK: The resistance measured before and after the exposure to heat was below the maximum permissible value of 5000 Ω.

6.6.2 Leakage current measurement (test No. 18)

Test temperature: Ambient temperature 20 °C

Test set-up 			Test voltage	Leakage current	Result
No. of test object	Voltage applied to	Earthed	kV	µA	
9	conductor	Screen	24	< 183	OK

OK: The leakage current was below the maximum permissible value of 0.5 mA.

6.6.3 Screen fault current initiation test (test No. 19)

Test object No.:	10
Test requirement:	Test in solidly earthed systems
Connection of test object:	By 240-mm^2 cable
Ambient temperature:	11 °C

Test parameters for U_0 = 12.7 kV:

Test No.	107 ...	1255	1256	1257
Test object	No.	-	10	10
Test voltage	kV	12.8	12.8	12.8
Test current	kA	11.1	10.7	10.8
Time of test	s	210	200	200
Notes		1)	2)	2)
Evaluation		-	OK	OK

Notes:

1) Current setting

2) The fault current was properly carried.

OK In the case of a disruptive discharge, the screen of the cable connector is able to withstand a fault current which is sufficient to make respond the protective device.

Test parameters for U_0 = 6.35 kV:

Test No.	107 ...	1260	1261	1262
Test object	No.	-	10a	10a
Test voltage	kV	6.40	6.40	6.40
Test current	kA	10.3	10.1	10.2
Time of test	s	200	200	200
Notes		1)	2)	2)
Evaluation		-	OK	OK

Notes:

1) Current setting

2) The fault current was properly carried.

OK In the case of a disruptive discharge, the screen of the cable connector is able to withstand a fault current which is sufficient to make respond the protective device.

Test results (continued)

Test object No.:	11
Test requirement:	Test in unearthed or impedance-earthed systems
Connection of test object:	By 240-mm^2 cable
Ambient temperature:	11 °C

Prüfwerte für U_0 = 12.7 kV:

Test No.	107 ...	1254	1258		
Test object .	No.	-	11		
Cycle		-	C_{1s} - O_{2min} - C_{2min}- O_{2min}- C_{1min}- O		
Test voltage	KV	12.8	12.8	12.8	12.8
Test current	A	16.2	16.2	16.2	16.2
Time of test	s	0.2	1	120	60
Notes		1)	2)	2)	2)
Evaluation		-	2)	2)	2)

Notes:

1) Current setting

2) The fault current was properly carried.

OK During the making cycle the arc was ignited and re-ignited.
During the making time, the current flow was present. A fault in the insulation is reliably detectable.

Test parameters for U_0 = 6.35 kV:

Test No.	107 ...	1259	1263		
Test object .	No.	-	11a		
Cycle		-	C_{1s} - O_{2min} - C_{2min}- O_{2min}- C_{1min}- O		
Test voltage	KV	6.40	6.40	6.40	6.40
Test current	A	15.5	14.8	14.8	14.8
Time of test	s	0.2	1	120	60
Notes		1)	2)	2)	2)
Evaluation		-	2)	2)	2)

Notes:

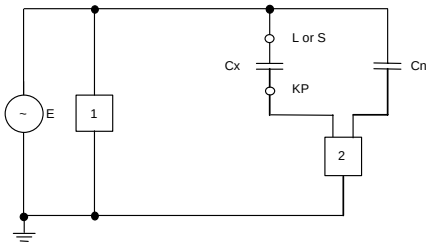
1) Current setting

2) The fault current was properly carried.

OK During the making cycle the arc was ignited and re-ignited.
During the making time, the current flow was present. A fault in the insulation is reliably etectable.

6.6.4 Capacitive test point performance (test No. 21)

Test temperature: Ambient temperature 23 °C

Test set-up			Capacitance of test point KP		Notes
					
No. of test object	Voltage applied to	Earthed	Towards cable screen C_{te}	Towards cable conductor C_{tc}	
			pF	pF	
12	L (conductor)	Screen connection of the connector body	-	12.6	OK
12	S (screen)	conductor	13.5	-	OK

Notes:

OK The capacitance ratio between measuring point and cable conductor, C_{tc}, was significantly exceeding 1 pF. The ratio C_{te} to C_{tc} was equal to 13.5 pF : 12.6 pF ≈ 1.07 and thus < than the value of 12 as specified by the normative document.

6.7 Assessment of special tests

• Test 17

The resistance measured before and after the exposure to heat at 120 °C / 168 h was 2450 and 2140 Ω, resp. This was below the maximum permissible value of 5000 Ω.

• Test 18

The leakage current measured at an applied AC test voltage of 24 kV fell below the maximum permissible value of 0.5 mA with a measured value of 183 µA.

• Test 19

- Solidly earthed systems

In the case of a disruptive discharge both at 6.4 kV and at 12.8 kV, the screen of the cable connector screen is able to initiate an earth fault with a fault current which is sufficient to make respond the protective device. The fault was reliably initiated within 3 s.

- Unearthed or impedance-earthed systems

In the case of a disruptive discharge both at 6.4 kV and at 12.8 kV, the screen of the cable connector screen is able to initiate and maintain an earth fault. The fault current continuously flew after reclosing.

• Test 21

The capacitance ratio between measuring point and cable conductor,C_{tc}, was significantly exceeding 1 pF. The ratio C_{te} to C_{tc} was equal to 13.5 pF : 12.6 pF ≈ 1.07 and thus < than the value of 12 as specified by the normative document.

The test objects meet the requirements defined by CENELEC Harmonisation Document HD 629.1 S2: 2006-02.

The special tests Nos. 17 to 19 and 21 have been PASSED.

7. Additional tests to Table 10 (for smallest cable cross-section)

7.1 Test laboratory

High-voltage test laboratory, high-voltage hall 2

7.2 Normative document

CENELEC Harmonization Document HD 629.1 S2: 2006-02
DIN VDE 0278-629.1 (VDE 0278 Teil 629-1): 2002-06
EN 61442: 2005-04
DIN VDE 0278-442 (VDE 0278 Teil 442): 2006-01

7.3 Required test parameters

Test No.	Type of test	Required test parameters	
1	DC voltage dry withstand test	Test voltage 6 x U_0: Duration of test: Polarity:	76 kV 15 min Negative
2	AC voltage dry withstand test	Test voltage 4.5 x U_0: Test frequency: Duration of test:	57 kV 50 Hz 5 min
3	Partial discharge test at Ambient temperature	Prestress voltage 1.2 x U_m: Measuring voltage 2.0 x U_0 [1]: Prestress duration: Measuring time:	29 kV 25 kV 1 min 1 min
4	Impulse voltage test at Ambient temperature	Front time: Virtual time to half value: Test voltage: Number of impulses: Polarity: Conductor temperature:	1.2 µs 50 µs 125 kV 10 impulses pos./neg. ϑ_u
5	Electrical heat cycling test in air	• Continuous AC voltage Test voltage 2.5 x U_0: Test frequency: Duration of test: • Thermal cycles Number of thermal cycles: Cycle (8 h): Conductor temperature during the last 2 hours of heating cycle:	 32 kV 50 Hz 3.3 days 10 5 hours of heating + 3 hours of cooling 95 ... 100 °C [2]
6	Partial discharge test at ambient temperature and elevated temperature	See test No. 3, except Conductor temperature:	 ϑ_u and 95...100 °C [2]
7	AC voltage dry withstand test	Test voltage 2.5 x U_0: Test frequency: Duration of test:	32 kV 50 Hz 15 min

7.4 Test arrangement

The client arranged each of the two connectors under test on a test line. The cable connections were dielectrically terminated by a filler plug. The client had mounted the test objects on cable lines of approx. 2.5-m length and of N2XSY 1x35 RM/25 mm^2 12/20 kV type. To apply the test voltage, each of the test lines had additionally been equipped with one auxiliary sealing end of EPKT type (made by Tyco Electronics Raychem).

All test voltages were applied to the core against the cable screen, which was connected to the test earth.

The tests did not start earlier than 24 hours after the installation of the accessories on the cable lines.

7.4.1 DC voltage dry withstand test (test 1)

Test arrangement to IEC 61442: 2005-04, Clause 5

7.4.2 Power-frequency voltage test (test 2)

Test arrangement to IEC 61442: 2005-04, Clause 4

7.4.3 Partial discharge test at ambient temperature (test 3)

Test arrangement to IEC 61442: 2005-04, Clause 7

7.4.4 Impulse withstand voltage test at ambient temperature (test 4)

Test arrangement to IEC 61442: 2005-04, Clause 6

7.4.5 Electrical heat cycling test in air (test 5)

Test arrangement to IEC 61442: 2005-04, Clauses 4 and 9

7.4.6 Partial discharge test at elevated and ambient temperatures (test 6)

See Sub-clause 7.4.3
For the test at elevated temperature see EN 61442: 2005-04, Clause 8

7.4.7 Power-frequency voltage test (test 7)

See Sub-clause 7.4.2

7.5 Test and measuring circuits

7.5.1 DC voltage dry withstand test (test 1)

See Sub-clause 4.5.1

7.5.2 Power-frequency voltage test (test 2)

See Sub-clause 4.5.2

7.5.3 Partial discharge test at ambient temperature (test 3)

See Sub-clause 4.5.3

7.5.4 Impulse withstand voltage test at ambient temperature (test 4)

See Sub-clause 4.5.4

7.5.5 Electrical heat cycling test in air (test 5)

See Sub-clause 4.5.5

7.5.6 Partial discharge test at elevated and ambient temperatures (test 6)

See Sub-clause 4.5.8

7.5.7 Power-frequency voltage test (test 7)

See Sub-clause 4.5.2

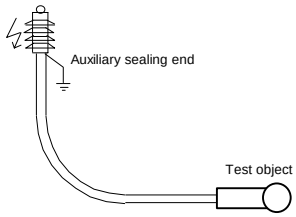
7.6 Test results

7.6.1 DC voltage dry withstand test (test 1)

Polarity: Negative

Duration of test after having reached full voltage: 15 min

Test temperature: Ambient temperature 20 °C
Conductor temperature 20 °C

Test set-up 			Test voltage	Result
No. of test object	Voltage applied to	Earthed	kV	
13	Conductor	Screen	-76	No disruptive discharge
14	Conductor	Screen	-76	No disruptive discharge

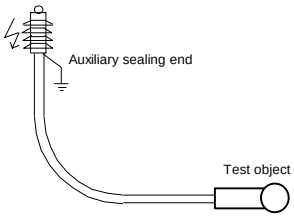
Notes: -

7.6.2 Power-frequency voltage test (test 2)

Duration of test after having reached full voltage: 5 min

Test frequency: 50 Hz

Test temperature: Ambient temperature 20 °C
Conductor temperature 20 °C

Test set-up 			Test voltage	Result
No. of test object	Voltage applied to	Earthed	kV	
13	Conductor	Screen	57	No disruptive discharge
14	Conductor	Screen	57	No disruptive discharge

Notes: -

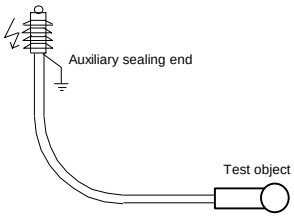
7.6.3 Partial discharge test at ambient temperature (test 3)

Test frequency: 50 Hz

Test temperature: Ambient temperature 20 °C
Conductor temperature 20 °C

Calibration of the test circuit by calibrator output 10 pC

Measured PD values

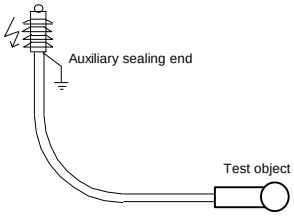
Test set-up 			Prestress voltage (1 min)	Measuring voltage (1 min)	Measured PD value
No. of test object	Voltage applied to	Earthed	kV	kV	pC
13	Conductor	Screen	29	25	< 1 [1)]
14	Conductor	Screen	29	25	< 1 [1)]

Notes:

[1)] Basic disturbance level at same value

7.6.4 Impulse withstand voltage test at ambient temperature (test 4)

Full wave:	Front time	T_1 = 1.20 µs
	Virtual time to half value	T_2 = 50.0 µs
Test temperature:	Ambient temperature	20 °C
	Conductor temperature	20 °C

Test set-up 			Test voltage	Result
No. of test object	Voltage applied to	Earthed	kV	No. of impulses/disruptive discharges
13	Conductor	Screen	+125[1)] -125[1)]	10/0 10/0
14	Conductor	Screen	+125[1)] -125[1)]	10/0 10/0

Notes: -

[1)] Test also passed at 150 kV

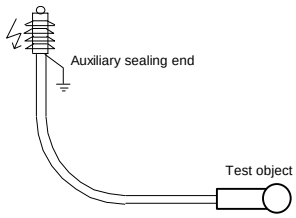
7.6.5 Electrical heat cycling test in air (test 5)

Duration of test: 3.3 days

Test frequency: 50 Hz

Test temperature: Ambient temperature 20 °C
Conductor temperature 95...100 °C

Number of load cycles:10

Test set-up 			Continuous AC withstand voltage	Heating current	Result
No. of test object	Voltage applied to	Earthed	kV	A	
13	Conductor	Screen			No disruptive discharge
14	Conductor	Screen	32 [1)]	341 [1), 2)]	No disruptive discharge

Notes:

[1)] Both test lines were connected to form one closed conductor loop for heating the latter. Therefore, both test lines were simultaneously tested. Separate testing is not possible.

[2)] The heating current was regulated and automatically controlled in such a way that a constant conductor temperature was obtained after approx. 3 hours of heating. This was kept constant ± 2 K for the remaining 2 hours of the 5-hour heating period.

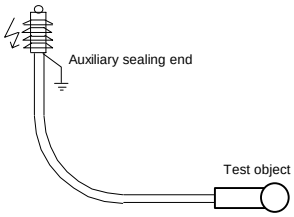
7.6.6 Partial discharge test at elevated and ambient temperatures (test 6)

Test frequency: 50 Hz

Test temperature: Ambient temperature 20 °C
Conductor temperature 20 °C and elevated, resp. 95...100 °C

Calibration of the test circuit by calibrator output 10 pC

Measured PD values

Test set-up 			Prestress voltage (1 min)	Measuring voltage (1 min)	Measured PD value
No. of test object	Voltage applied to	Earthed	kV	kV	pC
Measured PD values at elevated temperature					
13	Conductor	Screen	29	25	< 1 [1) 2)]
14	Conductor	Screen			
Measured PD values at ambient temperature					
13	Conductor	Screen	29	25	< 1 [1) 2)]
14	Conductor	Screen			

Notes:

[1)] The two test lines were connected to form one closed conductor loop for heating the latter. Therefore, two test lines were simultaneously tested. Separate testing is not possible.

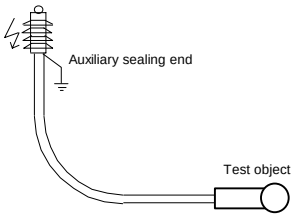
[2)] Basic disturbance level at same value

7.6.7 Power-frequency voltage test (test 7)

Duration of test after having reached full voltage: 15 min

Test frequency: 50 Hz

Test temperature: Ambient temperature 20 °C
Conductor temperature 20 °C

Test set-up 			Test voltage	Result
No. of test object	Voltage applied to	Earthed	kV	
13	Conductor	Screen	32	No disruptive discharge
14	Conductor	Screen	32	No disruptive discharge

Notes: -

7.7 Evaluation of the additional tests to Table 10 (for smallest cable cross-section)

- Test 1

In the DC withstand voltage test at -76 kV/15 min, no disruptive discharge occurred on both test objects.

- Test 2

In the 50-Hz AC voltage dry withstand test at 57 kV/5 min, no disruptive discharge occurred on both test objects.

- Test 3

In the partial discharge test at ambient temperature and at 50 Hz AC voltage of 25 kV, none of the two test objects exceeded the permissible maximum partial discharge value of 10 pC. The partial discharge value measured was not higher than 1.0 pC.

- Test 4

In the impulse withstand voltage test at ambient temperature with 10 test impulses of 125 (150) kV lightning impulse voltage 1.2/50 of each polarity, no disruptive discharge occurred on the two test objects.

- Test 5

The test objects were subjected to 10 electrical heating cycles in air. In the simultaneous test at 50-Hz continuous AC voltage of 32 kV, no disruptive discharge occurred on the test objects.

- Test 6

In the partial discharge test at elevated and ambient temperature at 50 Hz AC voltage of 25 kV, none of the test objects exceeded the permissible maximum partial discharge value of 10 pC. The partial discharge value measured was not higher than 1.0 pC.

- Test 7

In the 50-Hz AC voltage dry withstand test at 32 kV/15 min, no disruptive discharge occurred on both test objects.

Both test objects meet the requirements defined by CENELEC Harmonisation Document HD 629.1 S2: 2006-02.

The aditional tests to Table 10 (for smallest cable cross-section) have been PASSED.

8. Photos

Figure 12: View of one test object

Figure 13: Arrangement for electrical heat cycling test in air for test series D1

Figure 14: Test objects subjected to test series D2 (mounted on bushing)

Figure 15: Test object No. 10 before the screen fault current initiation test (solidly earthed systems)

Figure 16: Test object No. 10 before the screen fault current initiation test (solidly earthed systems), point of arc initiation

Figure 17: Test object No. 10 after the screen fault current initiation test at U_o = 12.7 kV (solidly earthed systems)

Figure 18: Test object No. 10a after the screen fault current initiation test at U_o = 6.35 kV (solidly earthed systems)

Figure 19: Test object No. 11 before the screen fault current initiation test (unearthed or impedance-earthed systems)

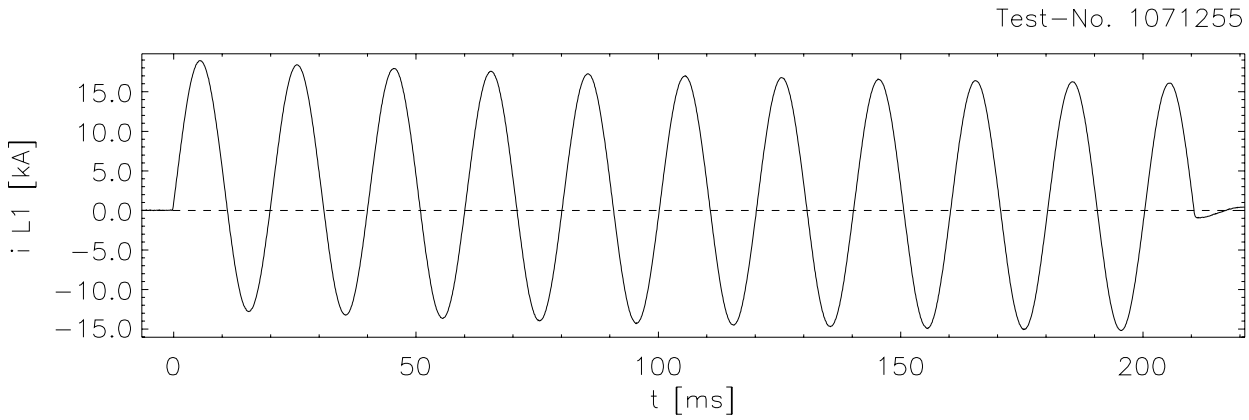
Figure 20: Test object No. 11 before the screen fault current initiation test (unearthed or impedance-earthed systems) point of arc initiation

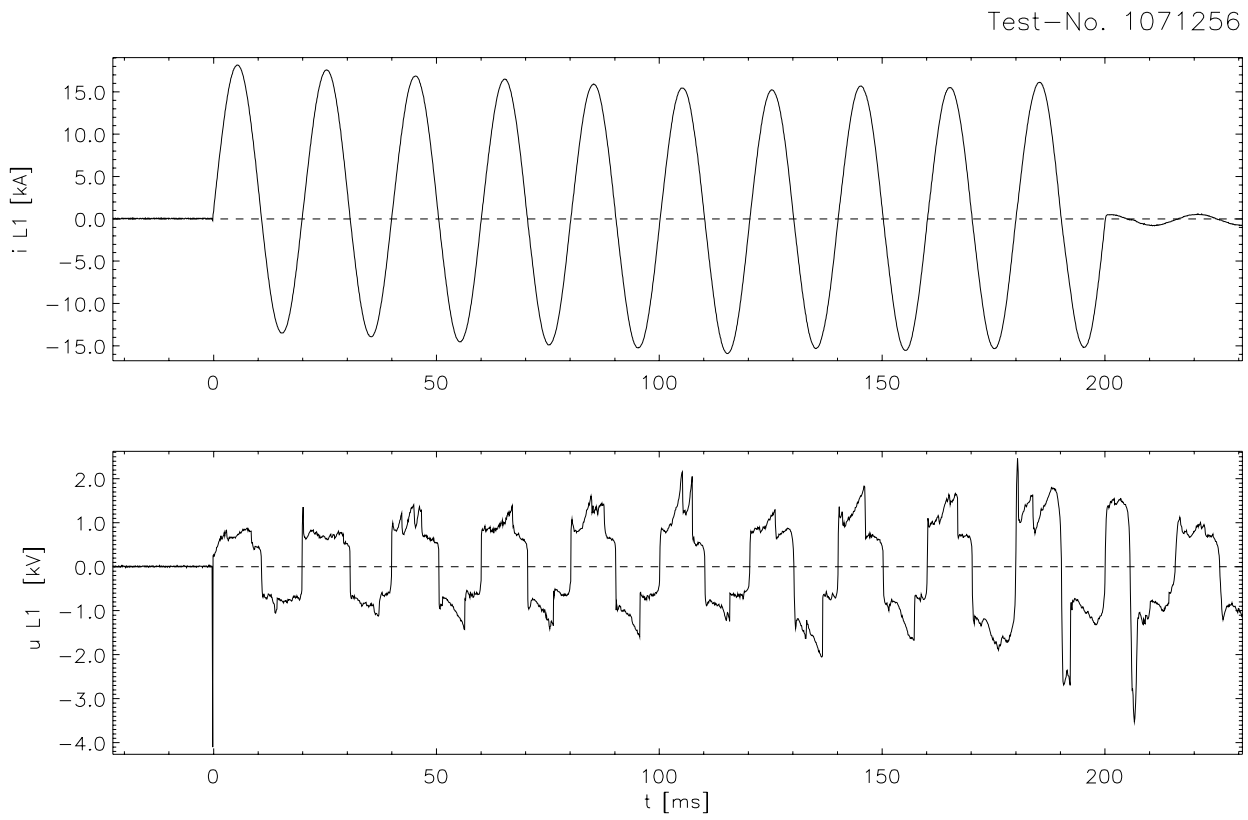
Figure 21: Test object No. 11 after the screen fault current initiation test at U_o = 12.7 kV (unearthed or impedance-earthed systems)

Figure 22: Test object No. 11a after the screen fault current initiation test at U_o = 6.35 kV

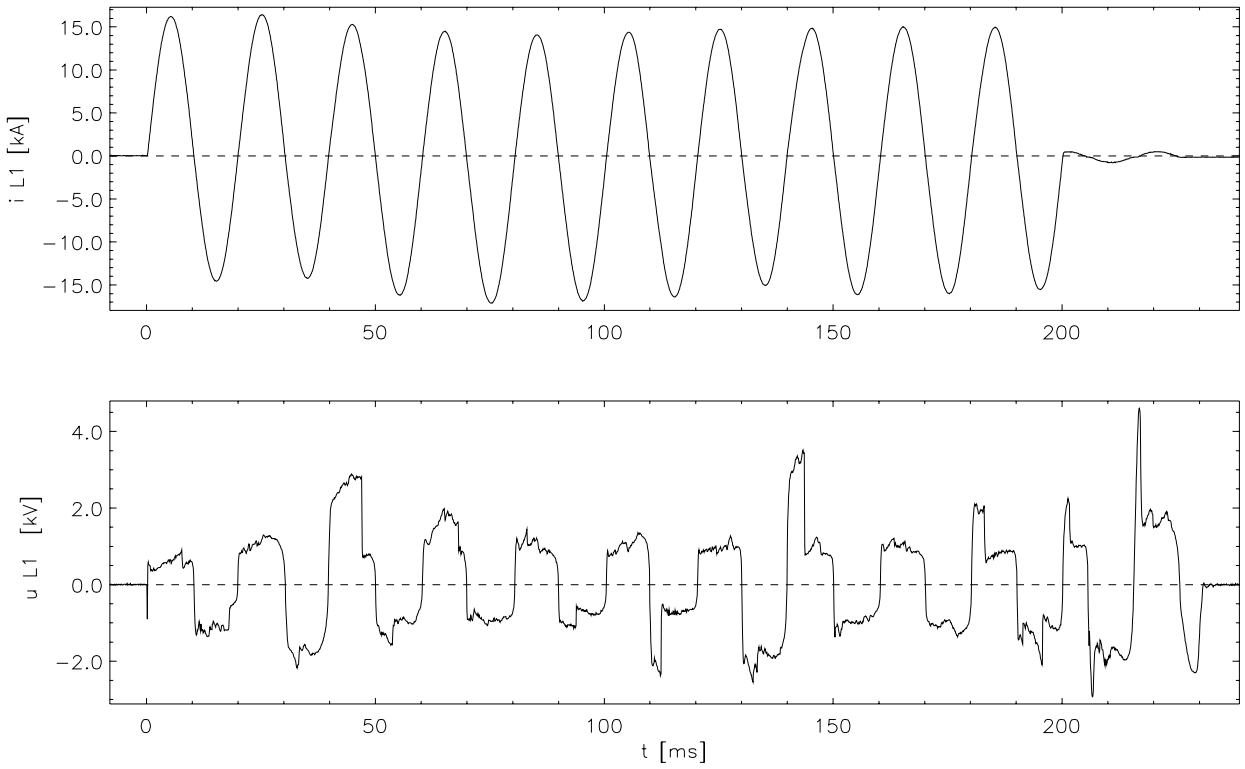
(unearthed or impedance-earthed systems)

9. Oscillograms

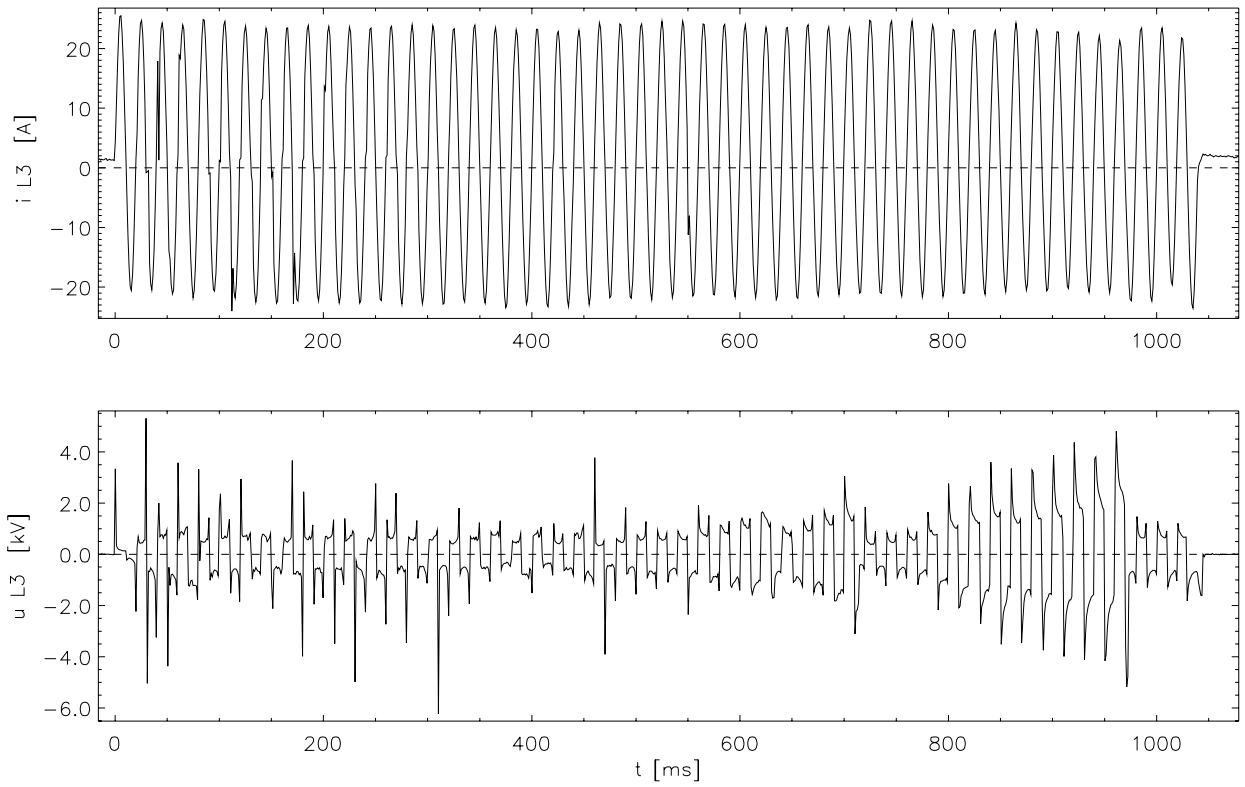




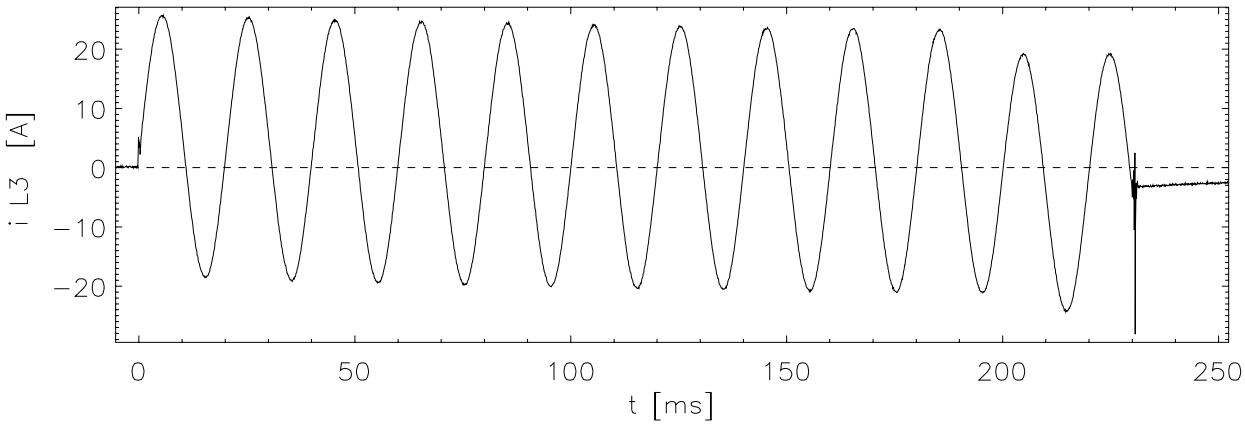
Test–No. 1071257



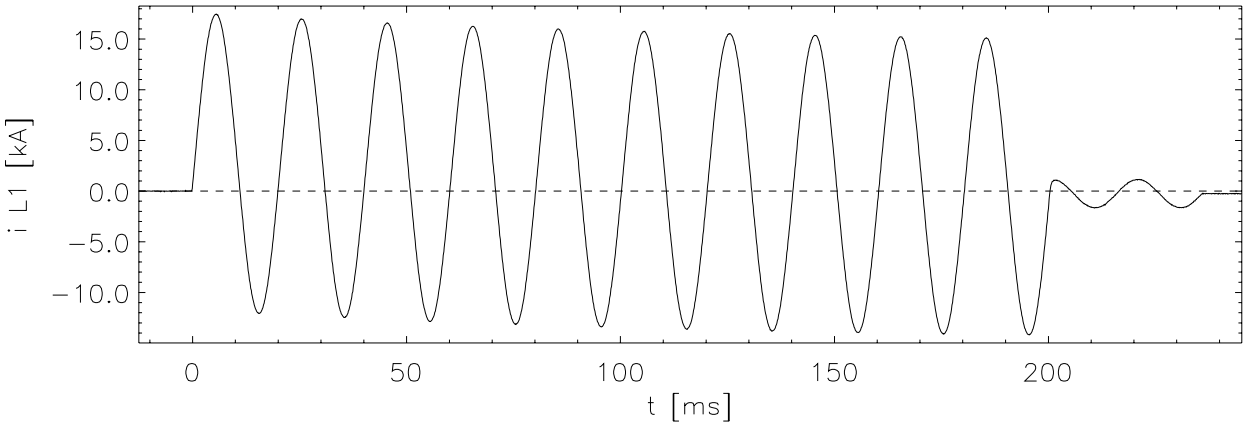
Test–No. 1071258



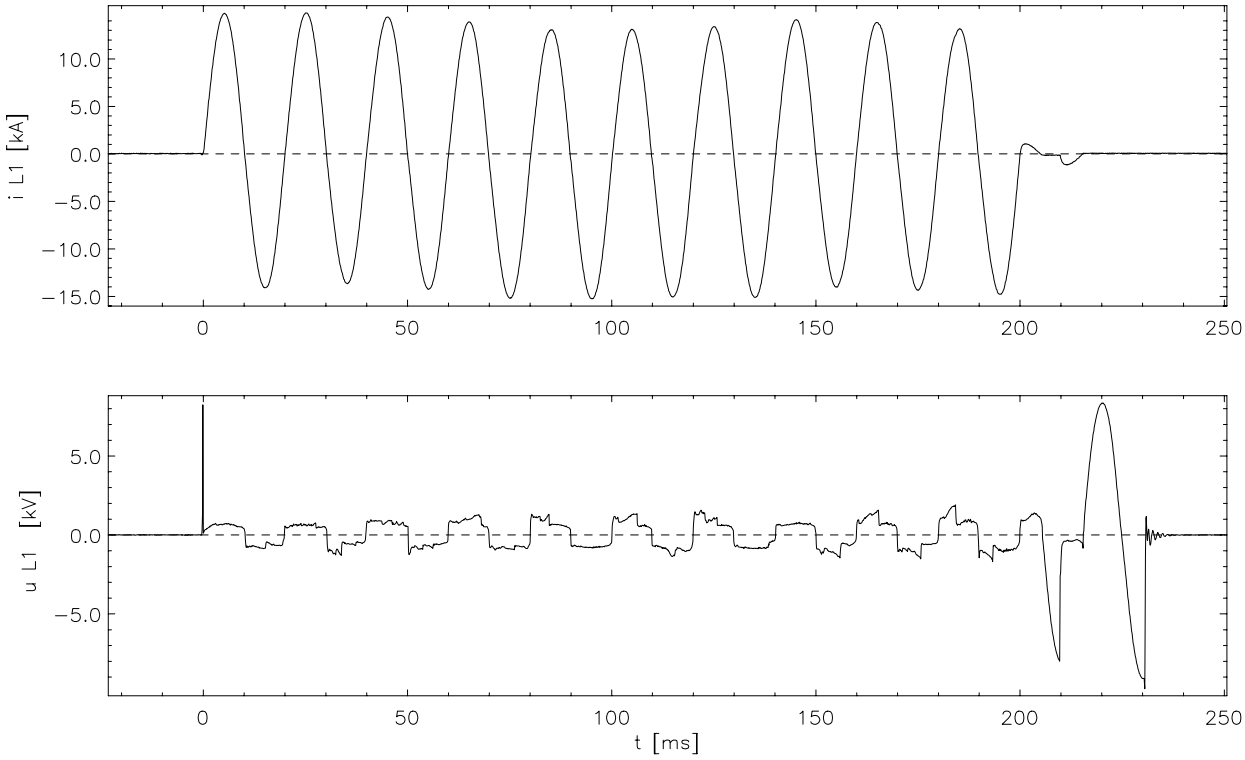
Test–No. 1071259



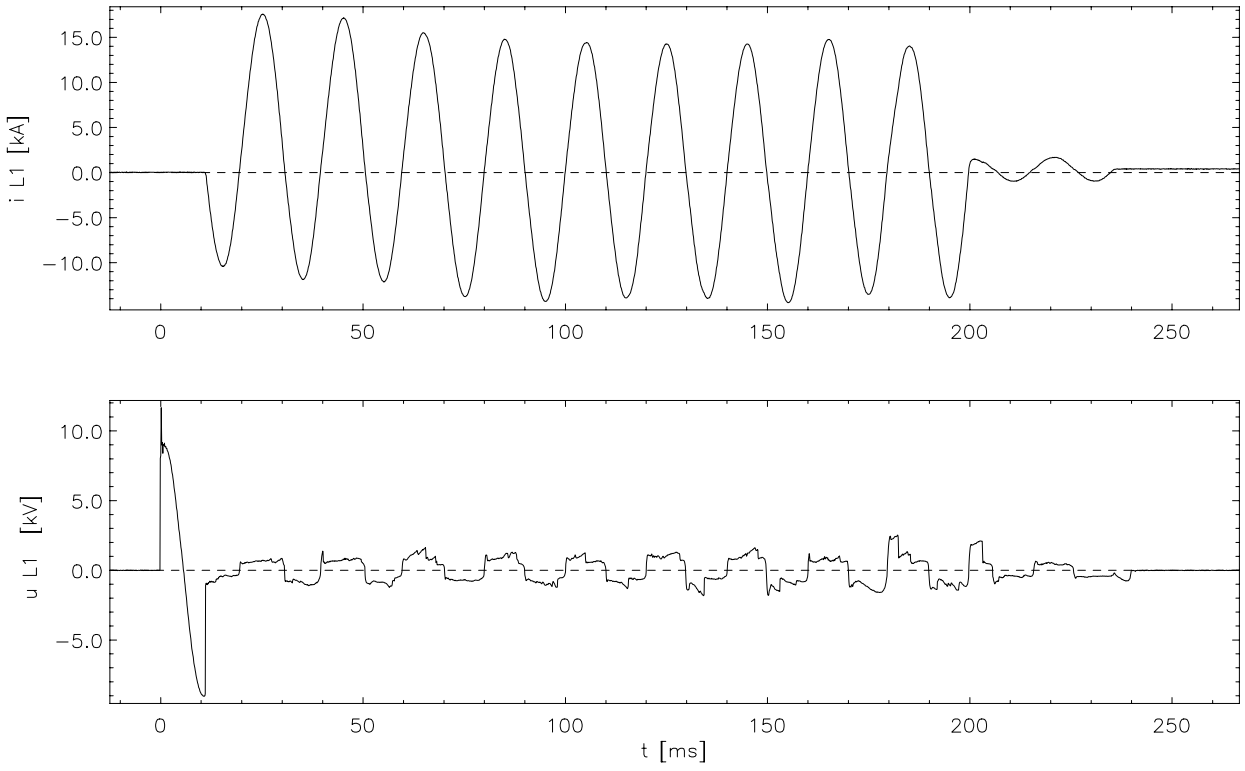
Test–No. 1071260



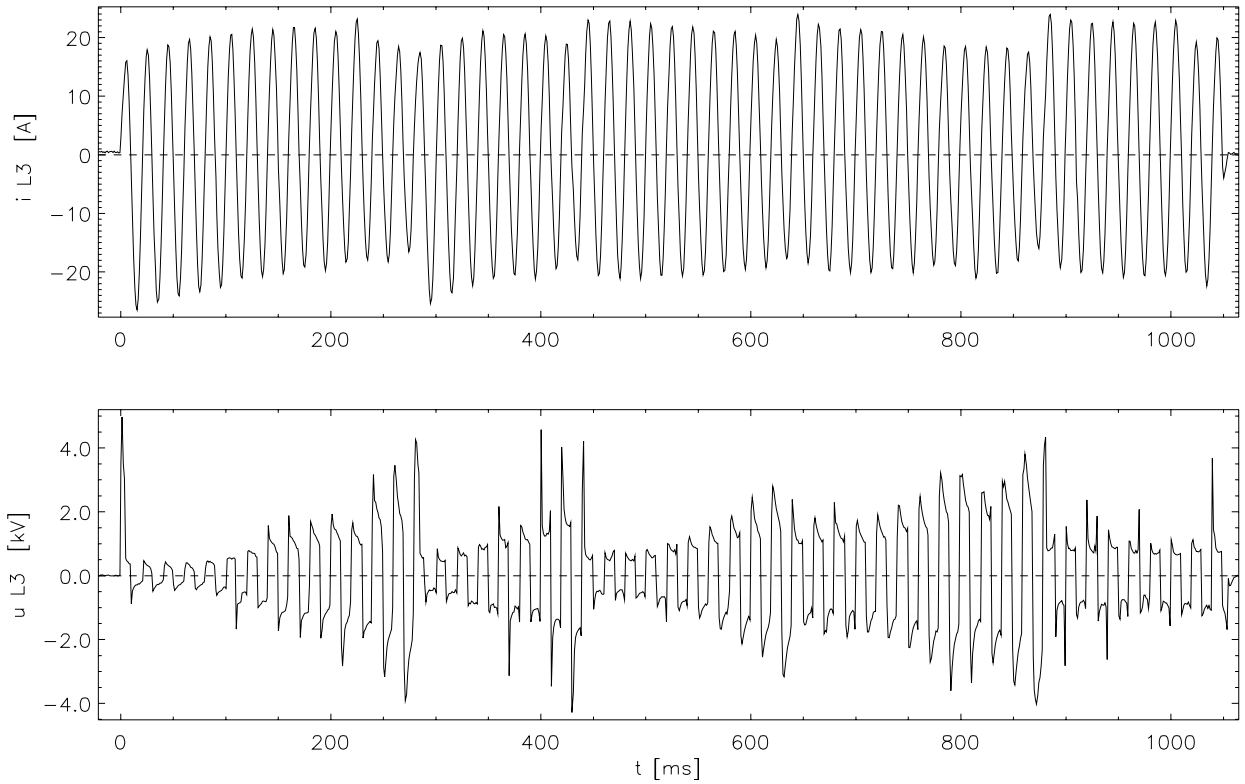
Test–No. 1071261



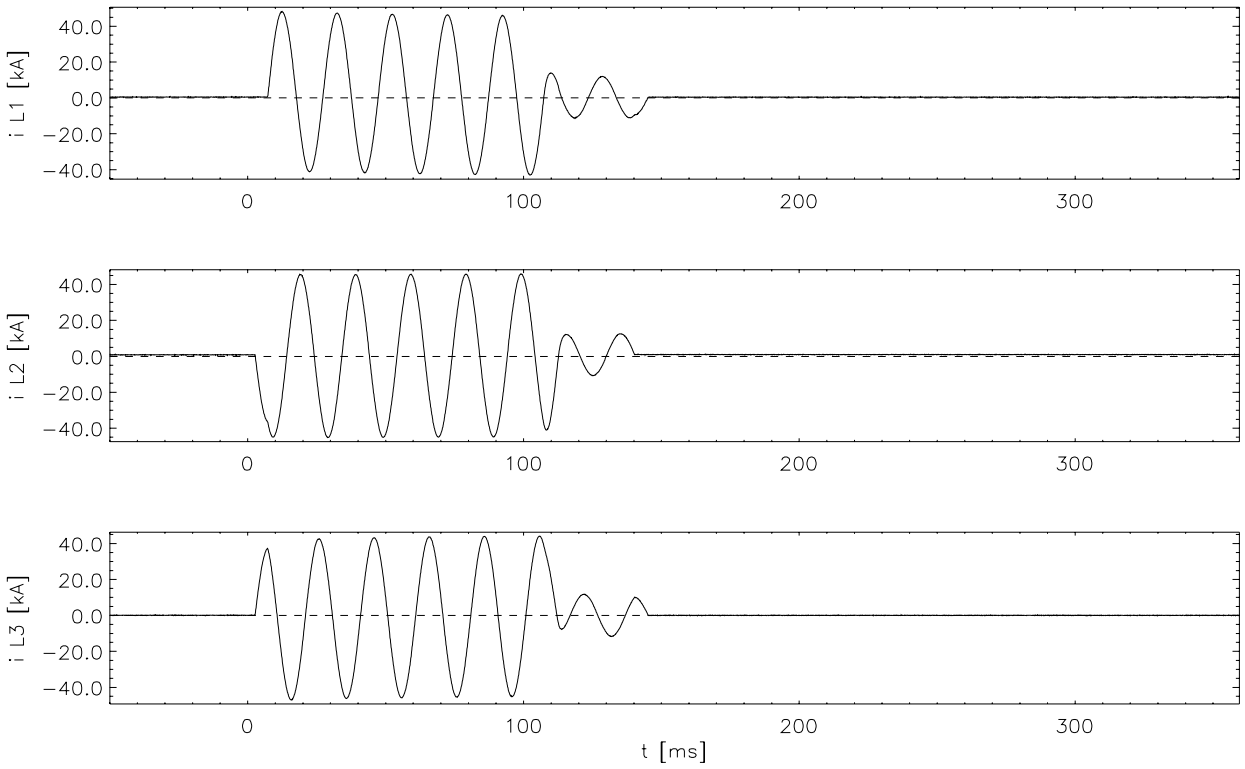
Test–No. 1071262



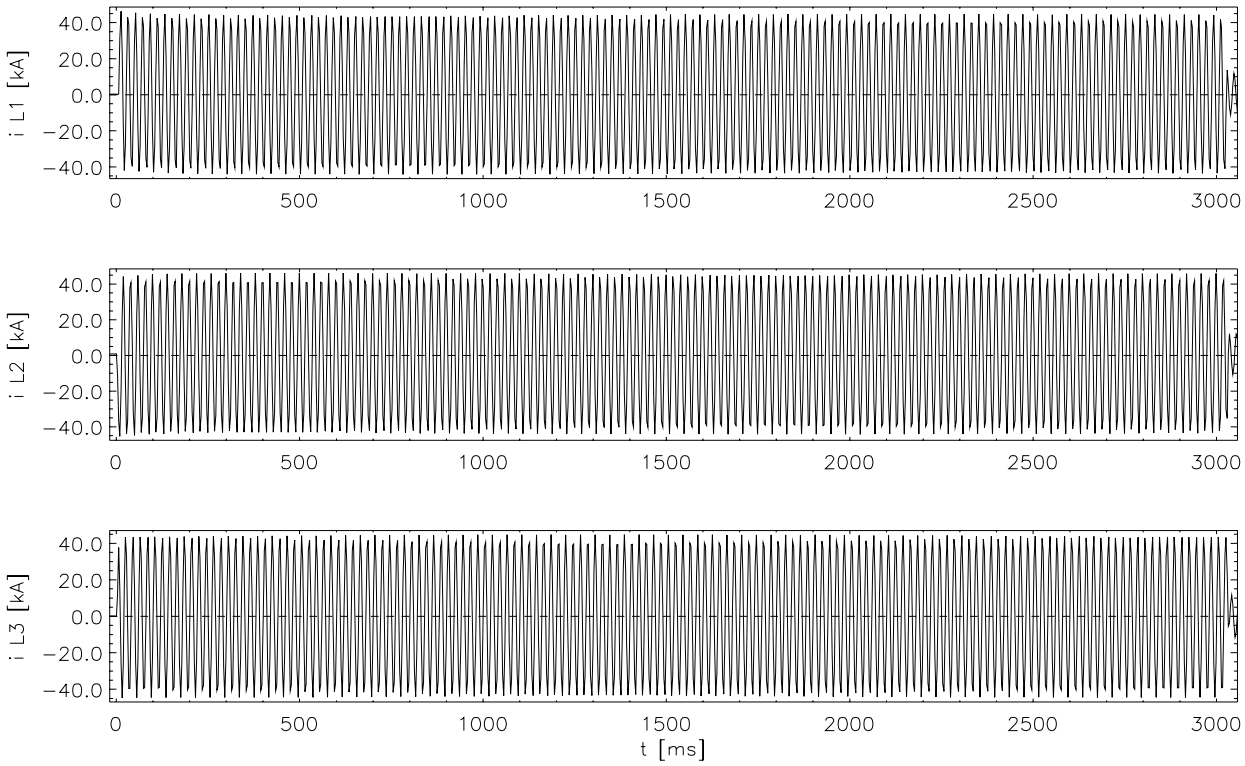
Test–No. 1071263



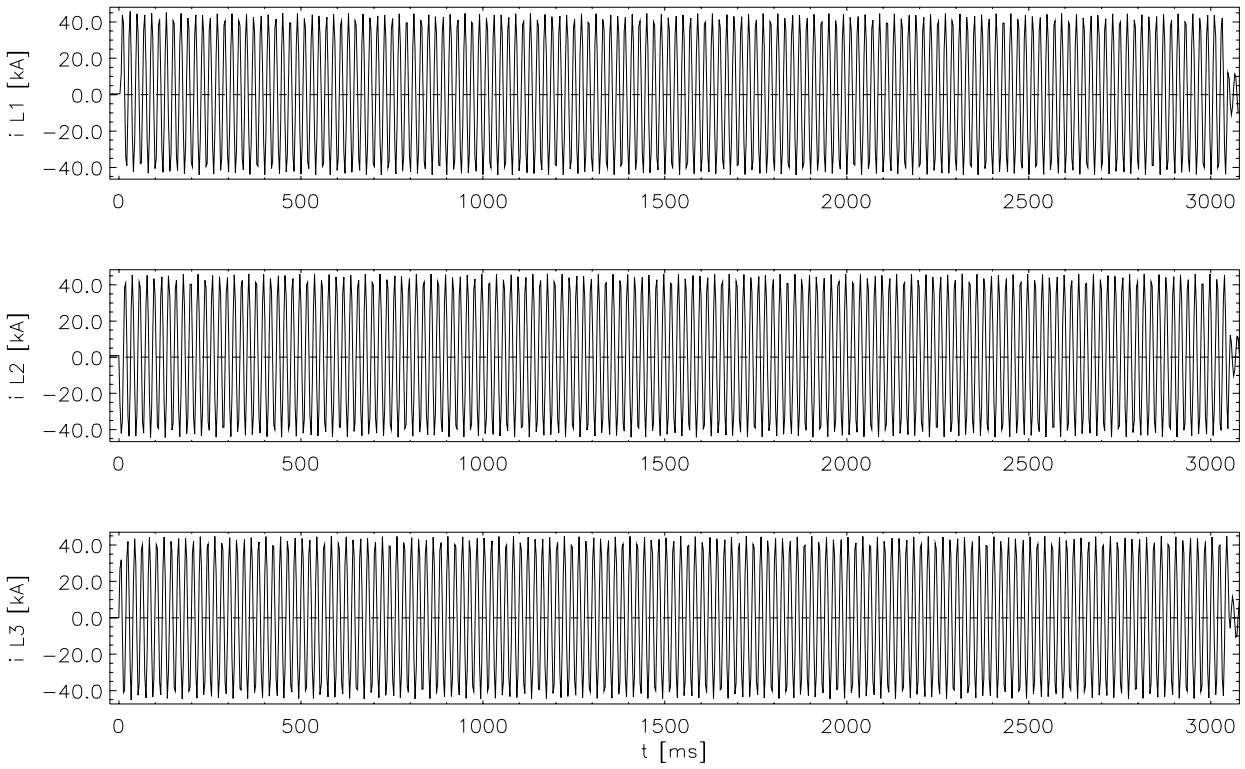
Test–No. 1071272



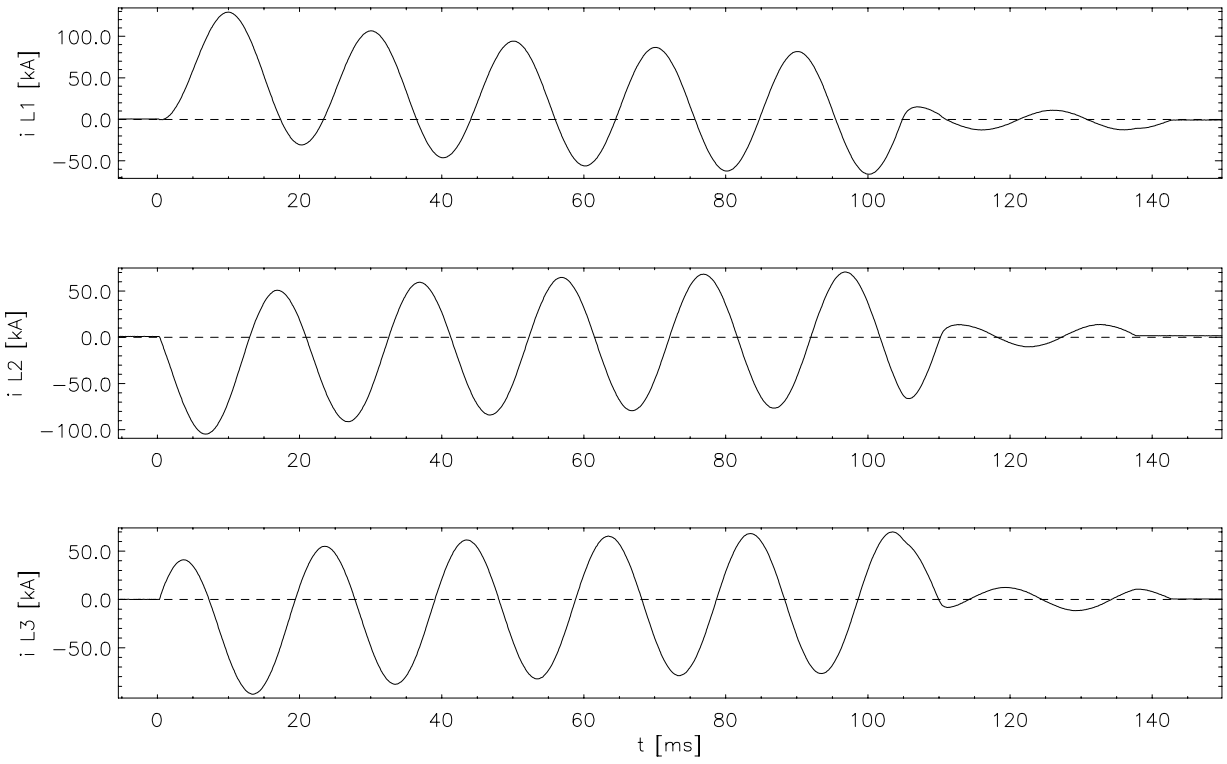
Test–No. 1071273



Test–No. 1071274



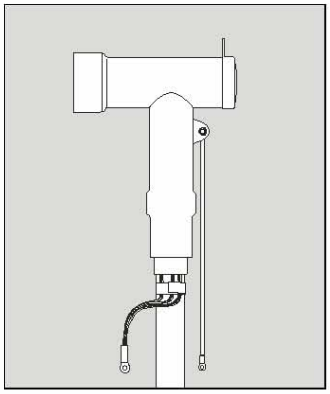
Test–No. 1071275



10. Drawings

Energy Division

Tyco Electronics



Installation Instruction
EPP-0982-11/06

Raychem
Screened Separable Connector
800 A for Bushing Profile “C”
in Accordance to EN 50181,
and Single Core Polymeric
Insulated Cable
12 to 24 kV

Typ: RSTI 58xx

Safety Warning
It is essential to observe the applicable safety regulations for working with high voltage equipment.
For precise safety information please contact the responsible authority.

Tyco Electronics Raychem GmbH
Energy Division
Finsinger Feld 1
85521 Ottobrunn
0049-89-6089-0 tel
0049-89-6089-345 fax
http://energy.tycoelectronics.com

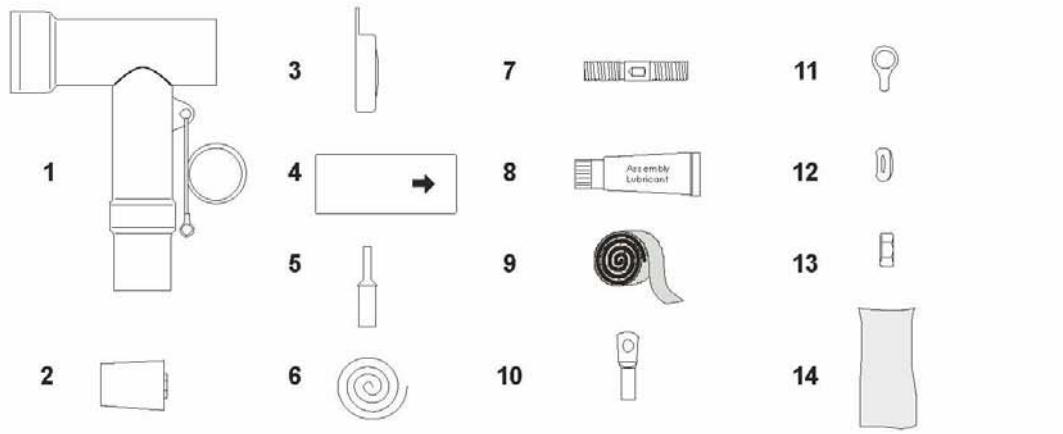
Before Starting

Check to ensure that the kit you are going to use fits the cable.

Refer to the kit label and the title of the installation instruction.

Components or work steps may have been improved since you last installed this product.

Carefully read and follow the steps in the installation instruction.

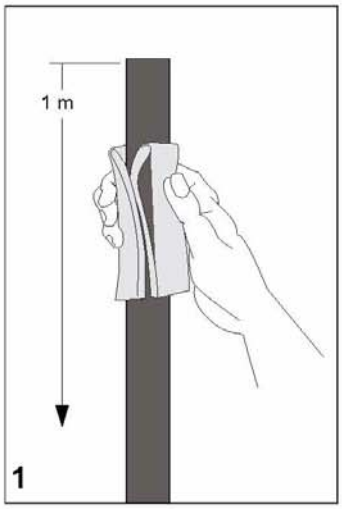


1	3 x Connector body	3	3 x Covering cap	7	3 x Threaded pin	11	3 x Screen cable lug
2	3 x Back plug	4	3 x Stress cone	8	1 x Assembly lubricant	12	3 x Wave type washer
		5	3 x main cable lug	9	1 x Sealing tape	13	3 x Nut M16
		6	1 x Binding wire	10	3 x cable lug (16 + 25)	14	3 x Protective bag

Table 1

Cross section	Ø Core insulation 12 kV		Reference No.		Cross section	Ø Core insulation 24 kV		Reference No.	
mm²	min	max	Al	Cu	mm²	min	max	Al	Cu
25	12.7-23.4 mm		RSTI-5810	RSTI-5830	25	12.7-23.4 mm		RSTI-5810	RSTI-5830
35			RSTI-5811	RSTI-5831	35			RSTI-5811	RSTI-5831
50			RSTI-5812	RSTI-5832	50			RSTI-5812	RSTI-5832
70			RSTI-5813	RSTI-5833	70			RSTI-5813	RSTI-5833
95			RSTI-5814	RSTI-5834	95	21.3-34.6 mm		RSTI-5824	RSTI-5844
120			RSTI-5815	RSTI-5835	120			RSTI-5825	RSTI-5845
150	21.3-34.6 mm		RSTI-5826	RSTI-5846	150			RSTI-5826	RSTI-5846
185			RSTI-5827	RSTI-5847	185			RSTI-5827	RSTI-5847
240			RSTI-5828	RSTI-5848	240			RSTI-5828	RSTI-5848
300			RSTI-5829	RSTI-5849	300			RSTI-5829	RSTI-5849
35-95	12.7-23.4 mm		RSTI-5851		35-70	12.7-23.4 mm		RSTI-5851	
95-120			RSTI-5852		–	–		–	
95-240	17.0-32.6 mm		RSTI-5853		95-185	17.0-32.6 mm		RSTI-5853	
150-240	21.3-34.6 mm		RSTI-5854		95-240	21.3-34.6 mm		RSTI-5854	
185 - 300			RSTI-5855		185 - 300			RSTI-5855	

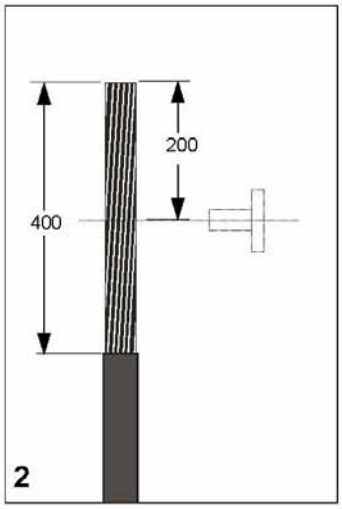
Cable Preparation



Clean and degrease the end of the oversheath for a length of 1 metre with solvent wipe.

Cut the core according to the dimension given in the drawing. Remove the core screen with appropriate screen cutting tool according to the drawing. The surface of the insulation should be free from all traces of conductive material. Compare the diameter over insulation with application range as shown in **Table 1** as well as with marking of supplied stress cone.

Application Check!



Cable with wire shield

Position the cable with 200 mm overlap to the bushing centre.
Mark the oversheath 200 mm below the bushing centre.
Cut the cable 400 mm above the mark and remove the oversheath over this distance. Cut off Cu-spiral screening tape flush with end of outer sheath.
Edges projecting beyond the outer sheath **must be avoided**, so that the stress cone can not be damaged during push on procedure.

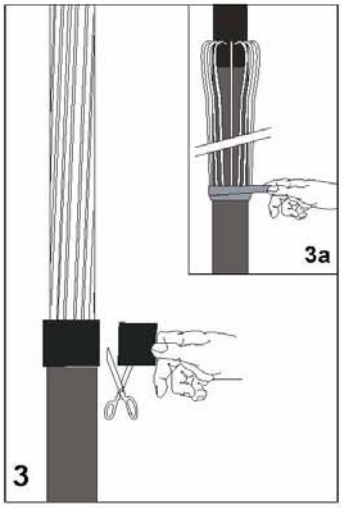
Cut back the insulation according to dimension **K given in drawing details.**

A. Hexagonal and deep indent compression lugs

Dimension K must not exceed 60 mm.

B. Mechanical lugs

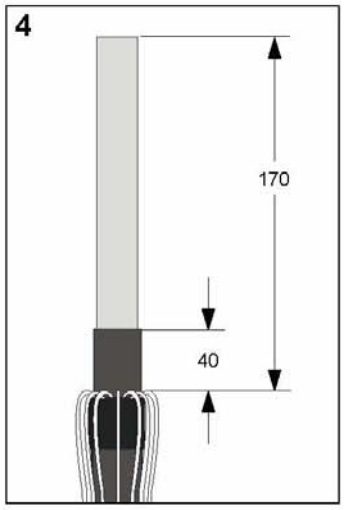
Dimension **K** is identical to depth of bore. Barrel butts against insulation!

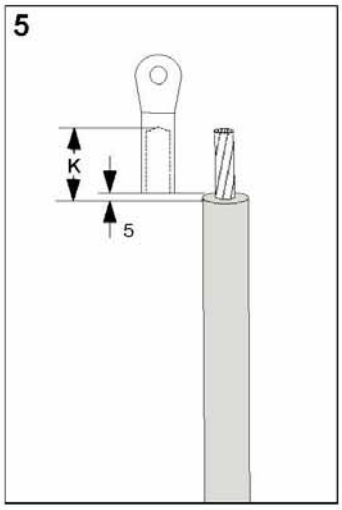


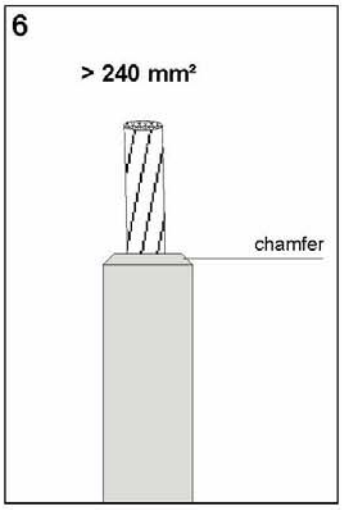
Wrap one turn of sealant tape (grey) with no overlap and slight tension around the end of the oversheath.
Cut the tape and push ends together.
Bend the shielding wires back onto the oversheath.
Avoid crossing the individual wires.
Temporarily secure the wires with a tape or wire binder.

Recommendation for large cross sections

Convenient push on process of the stress cone requires chamfering of the insulation for cross section 240 mm² and above. See drawing!





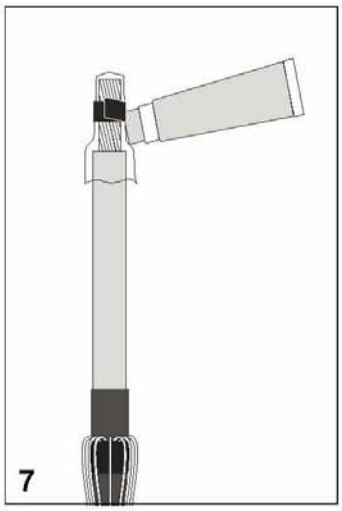


Core Preparation

Table 2
Use of Insert

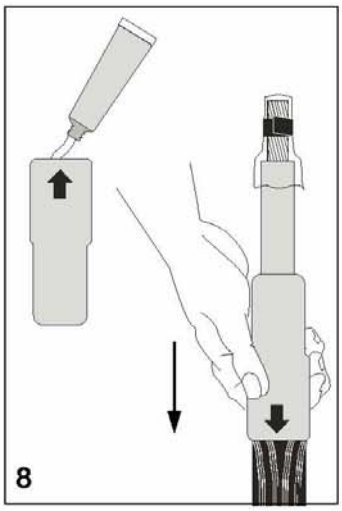
Lug Type / mm² (RM)	BLMC-25/95-16-800A	BLMC-95/240-16-800A	BLMC-185/300-16-800A
35	Yes	-	-
50	Yes	-	-
70	No	-	-
95	No	Yes	-
120	-	Yes	-
150	-	Yes	-
185	-	No	Yes
240	-	No	Yes
300	-	-	No

A. Compression lugs
Install the cable lug with the appropriate die and compression tool.
Note:
Remove any sharp edges.
Clean and degrease the lug and insulation from any excessive compression grease.



Slide the small protective bag (assembly aid) over the exposed conductor and tie it down with a PVC tape as shown in the drawing.
Gently lubricate the outer surface of the protective bag and the core insulation with a thin layer of assembly lubricant Apply the lubricant layer with the sponge top as shown.

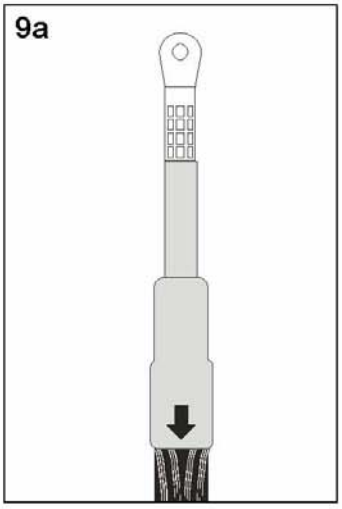
B. Mechanical lugs with inserts
The insert has to be used as noted in **Table 2**.
Ensure that the retention of the insert is locked into the appropriate slot in the barrel.
Install the cable lug using a lug fixture. Tighten the bolt set alternately in several equal steps until the heads shear off.
Remove any sharp edges.

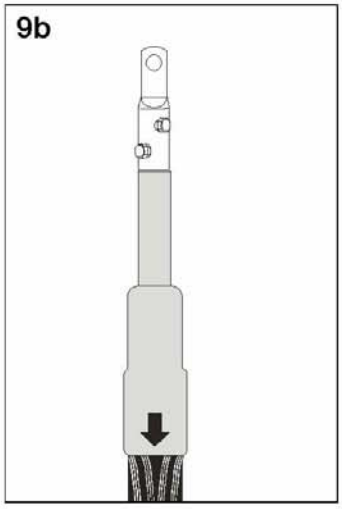


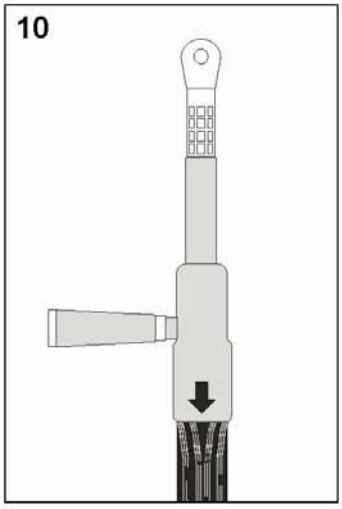
Apply onto the inner surface of the stress cone at the bottom end a 3 cm long sausage of assembly lubricant and spread it evenly over the inner surface. Use assembly lubricant without sponge top. Push the stress cone in one sequence with a twisting movement over the assembly aid completely onto the insulation until the inner collar of the stress cone stops at the oversheath cut back of the cable.
Note: The arrow on the stress cone should point onto the cable sheath.

Remove the assembly aid from the conductor.

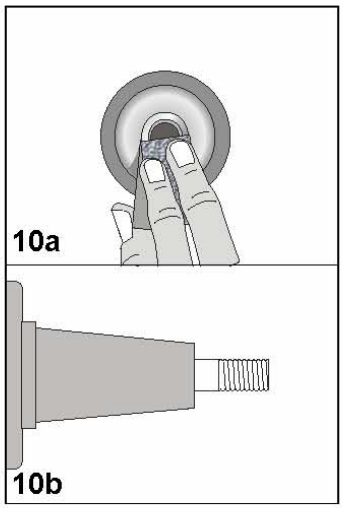
Apply a thin layer of lubricant onto the outer surface of the stress cone with the sponge top.





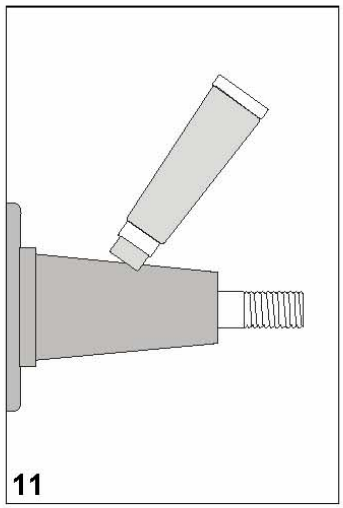


Installation of connector body



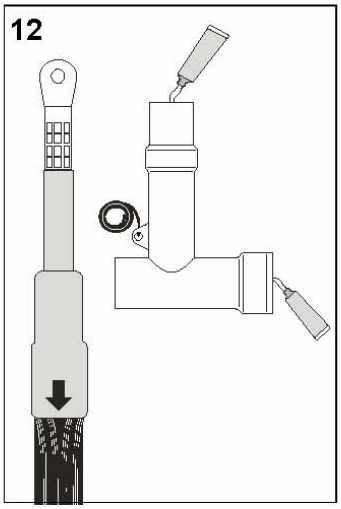
a. Abrade and clean the contact ring of the bushing thread from residuals such as resin or varnish if any.

b. Insert the threaded stud into the bushing and tighten it up with an Allen key (8 mm). Maximum torque: **35 Nm**.

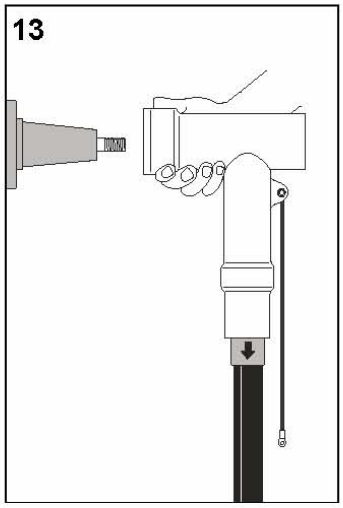


Clean the conical surface of the bushing and lubricate it with the assembly lubricant as shown.

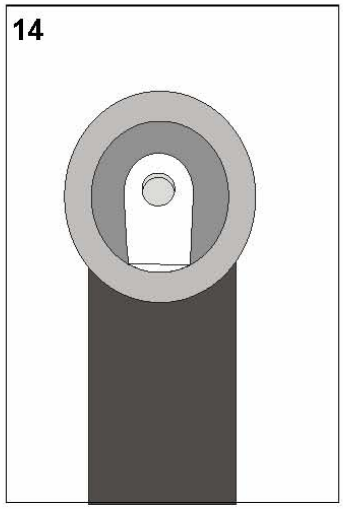
Clean and degrease the bottom and front end of the screened connector body and apply a thin layer of lubricant onto the inner surface without the sponge top as shown.
Note: Use one way glove to evenly lubricate the inner surface at a length of approximately 50 mm.

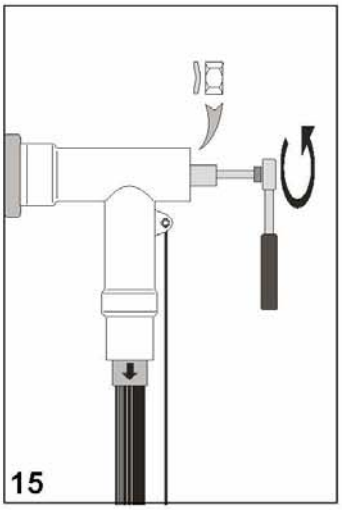


Push screened connector body with no interruption onto the stress cone and hold it. Continue **immediately** with the next step.

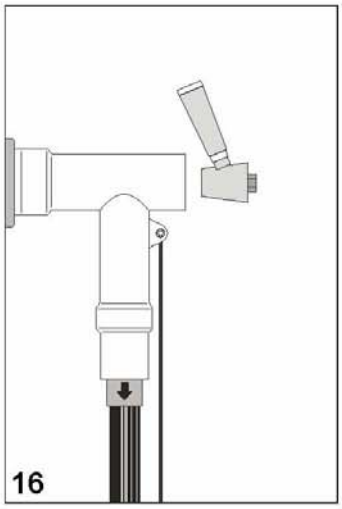


Align the eye of the cable lug with the threaded pin and push the screened connector onto the bushing.

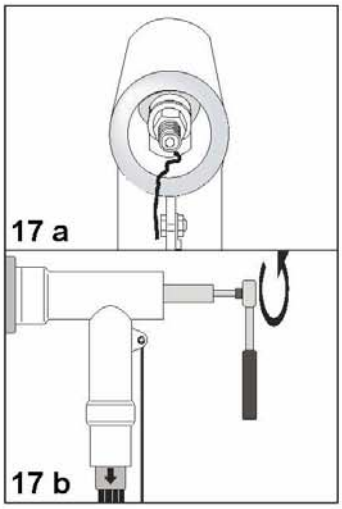




Insert the spring washer and hex nut. Tighten the hex nut onto the stud with a spanner (24 mm) at a torque of **30 Nm**.

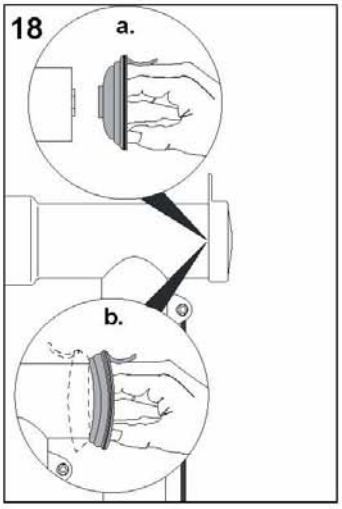


Clean the inner surface of connector back end and apply a thin layer of assembly lubricant. Do the same with the conical interface of the back plug as shown.

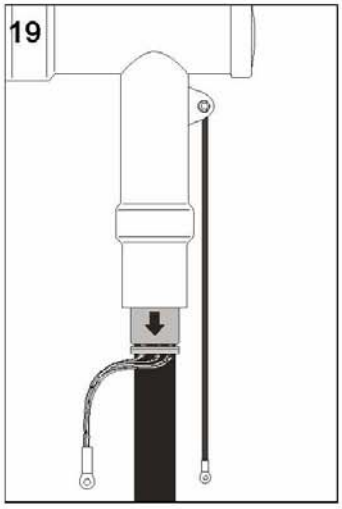


a) Place a string into the rear entry of the connector as shown.
b) Insert the back plug and screw it into place using a spanner (19 mm) at a torque of **30 Nm**.
Remove the string prior to the last two turns.

a Flip-back the endcap as shown in detail **a**. Position the protruding ring onto test point
b Flip the endcap into final position with your finger as shown in detail **b**.

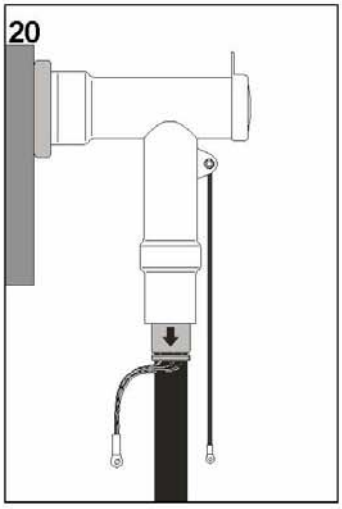


Ensure that the grounding lead is fastened tightly.
Fix the shielding wires with a wire binder (four layers) at the end of the stress cone. Gather the wires together to form an earth lead. Install at the end of the shielding wires the connection lugs supplied in the kit.
Perform connection to ground.



Screened separable connector completed.

Please dispose of all waste according to environmental regulations.



11. Identification of test cable

To CENELEC Harmonization Document 629.1 S1: 1996 Annex A
for cable with plastic insulation

Rated voltage U_0/U (U_m) 12/20 (24) kV

Cable construction	☒	1-core	☒	screened	
	☐	3-core	☐	individually screened	
	☐	4-core	☐	not individually screened	
Conductors	☐	Al	☒	Cu	
	☒	stranded	☐	solid	
	☒	round	☐	shaped	
	☐	120 mm²	☐	150 mm² ☐ 185 mm²	
	☒	other cross-section	300 mm²		
	☐	cross-section branch	mm²		
Cable insulation	☐	PVC	☒	XLPE	
	☐	EPR	☐	HEPR	
Insulation screen	☒	bonded	☐	strippable	
	☒	wires	☐	tapes	☐ None
oversheath	☐	PVC	☒	PE (state type)	☐ other material
Water blocking (if any, where?)	☐	in conductor	☐	under oversheath	☐ other place

Diameter	●	conductor	16.4 mm
	●	Insulation	33.1 mm
	●	insulation screen	34.5 mm
	●	oversheath	43.2 mm

Cable marking N2XSY 1x300 RM/25 mm² 12/20 kV
NEXANS 2003