ELLEVIO

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Technical Specification of 123 kV XLPE Cables and Accessories

Revision History

Revision	Date	Author	Comment	Reviewed by
2.0	2024-06-24	Sebastian Bengtsson Nils Magnusson	Some clarifications and updated data sheet tables	
1.0	2019-06-13	Anders Lundvall	New template and revised content .	Nätkommittén

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1 Common

1.1 Abbreviations

The following abbreviations apply to this document:

Short	*Long*
PE	Polyethylene
XLPE	Cross Linked Polyethylene

Table 1 - Abbreviations

1.2 Scope of the Document

This specification covers a 123 kV XLPE cable system type that will be included in an electrical system.

All accessories shall have a rated voltage of 145 kV.

If not otherwise specified, parallel groups with three cable phases will be bundled in close trefoil formation and the copper wire screens solidly earthed in both ends, i.e. the cable screens will not be cross-bonded or insulated from earth.

The cable groups will be directly buried in soil and/or installed in tunnel.

1.3 Standards

The cables and accessories shall meet the latest version of the applicable standards and national regulations. Special requirements beyond the standard is specified for each cable.

1.4 Electrical main data

Maximum voltage U_m for cables	123 kV
Maximum voltage U_m for accessories	145 kV
Rated impulse withstand voltage	550 kV (SS-EN 60071-1)

1.5 Testing

Testing of the XLPE-cable system and components shall be performed in accordance with testing requirements in this specification.

Type testing may be excluded in the contract if the Contractor can present acceptable reports from previously performed type testing. Reports that cover the requested cable-type and accessories shall therefore be enclosed with the tender. Note that the cost for a renewed type test must be separately stated in the tender.

The number of sample tests shall follow IEC 60840 § 10.2, however the number shall never be less than two (performed on two delivery lengths taken from start and end of manufacturing). Repetition of tests shall be performed according to IEC 60840 § 10.3.

1.6 Marking

All cables shall be marked on the outside of the sheath with two text lines equally spaced around the circumference. The markings shall be embossed on the sheath. The following information shall be included:

a) Manufacturers name or logo.
b) Voltage level, i.e. “123 kV”.
c) Cable designation, i.e. “AXALJ” or similar.
d) Cross section of conductor and screen.
e) Year of manufacturing
f) Fire propagation class, i.e. “B2ca -s1, d0, a1”.
g) Meter marking of cable (may be printed with indelible ink)

The insulation screen shall contain information regarding batch number. This information shall be printed with indelible ink.

1.7 Delivery drums

Dimension of delivery drums for all cables shall be according to SS 84 28 01.

Marking of the delivery drums shall be made with relevant information for the installation and identification of cables. The markings on the drums shall be indelible and made by plastic laminated notes or tape. The minimum information shall be:

a) project name
b) project number
c) delivery length number
d) cable designation
e) voltage level
f) cross section of conductor
g) cross section of screen
h) length of cable on drum
i) drum type
j) dimensions
k) weight with and without cable

1.8 Cable System Documentation

The following information shall be included in Contractor’s tender:

Technical specifications shall be delivered and shall as minimum include:

a) all cable types
b) all joint types
c) all termination types
d) any link boxes

Data sheets for:

e) all cable types
f) all joint types

g) all termination types

shall be filled in (refer to the annexes) and submitted.

Detailed drawings shall be delivered and shall as minimum include:

h) the different joint types and associated components (connectors/lugs, joint body, complete joint, bonding lead connection etc.)
i) the terminations and associated components (stand, support isolators, main isolator, top bolt, earthing connection, box body, clamps etc.
j) electrical stress grading systems

The joint and termination types shall be of a standard type from which the Contractor has several years of service experience.

Detailed reference list together with type test report(s) shall be submitted for as minimum:

k) all cable types
l) all joint types
m) all termination types
n) any link boxes

2 Cable for Installation in Ground

The cables shall meet the requirements in IEC 60840, which shall be used as a general engineering standard.

2.1 Standard Conductor Cross-Sections

Conductor cross-sectional area	Max. DC-resistance for the conductor at 20 °C
1200 mm² (Al)	0.0247 Ohm/km

2.2 Conductor

Conductor, material / type	Aluminium (compacted, SS-EN 60228)
Type of water sealing system	Swelling powder/yarn/tapes or equivalent. The conductor shall have a completely water blocking construction longitudinally.
Conducting tape around the conductor	Manufacturer's standard (note the requirement of longitudinal water sealing)
Permissible conductor temperature at normal operation.	≥90 °C
Permissible conductor temperature at short circuit.	≥250 °C

2.3 Insulation system

Conductor screen, type / thickness	Cross-linked polyethylene / Manufacturer's standard
Insulation material	Cross-linked polyethylene (XLPE)
- maximum electric field within insulation (E_{max}) at phase voltage $U_m/\sqrt{3}$	8.0 kV/mm, calculated according to IEC 60840-2011 §6 m) with 71 kV phase voltage
- minimum insulation thickness	To be determined through calculation with basis in requirement of E_{max}. The requirement shall be fulfilled with the minimum thickness of the insulation at any point around the circumference.
- nominal insulation thickness	Manufacturer's standard
- insulation eccentricity	According to IEC 60840, § 10.6.2
Insulation screen, type / thickness	Cross-linked polyethylene / Manufacturer's standard
Extruding process / vulcanisation process	Triple-extrusion / Dry curing

2.4 Screen

Type of screen	Annealed circular Cu-wires with a thin Cu counter helix tape
Minimum screen area (excluding Al-foil/Cu-foil and Cu counter tape)	≥95 mm²
Max. DC-resistance for the screen at 20 °C (excluding Al-foil and Cu counter tape)	0.193 Ohm/km Stated resistance value refers to true screen length in the cable and not the length of the complete cable, i.e. with consideration taken to the screen lay/pitch.
Minimum dimensions of Cu counter tape (Width x Thickness)	10 x 0.1 mm

2.5 Longitudinal and radial water sealing system

Type of longitudinal water sealing system	Swelling tapes or equivalent (under and/or above wires)
Type of radial water sealing system	Al- or Cu-foil/laminate/tape bonded to the outer sheath.

2.6 Outer Sheath

Type / material	Extruded / HDPE or MDPE
Minimum thickness (excluding outer conductive layer)	3.5 mm (minimum thickness at any point around the circumference)
Nominal thickness	Manufacturer's standard
Colour	Naturally PE coloured, not black

2.7 Outer conductive layer

Type / material	Extruded and bonded to the outer sheath
Nominal thickness	Manufacturer's standard
Colour	Black

3 Cable for Installation in Tunnel

The cables shall meet the requirements in IEC 60840, which shall be used as a general engineering standard.

3.1 Standard Conductor Cross-Sections

Conductor cross-sectional area	Max. DC-resistance for the conductor at 20 °C
500 mm² (Al)	0.0605 Ohm/km

3.2 Conductor

Conductor, material / type	Aluminium (stranded, circular, compacted, SS-EN 60228)
Type of water sealing system	Swelling powder/yarn/tapes or equivalent. The conductor shall have a completely water blocking construction longitudinally.
Conducting tape around the conductor	Manufacturer's standard (note the requirement of longitudinal water sealing)
Permissible conductor temperature at normal operation.	≥90 °C
Permissible conductor temperature at short circuit.	≥250 °C

3.3 Insulation System

Conductor screen, type / thickness	Cross-linked polyethylene / Manufacturer's standard
Insulation material	Cross-linked polyethylene (XLPE), compound DIX 11
- maximum electric field within insulation (E_{max}) at phase voltage $U_m/\sqrt{3}$	8.0 kV/mm, calculated according to IEC 60840-2011 §6 m) with 71 kV phase voltage
- minimum insulation thickness	To be determined through calculation with basis in requirement of E_{max}. The requirement shall be fulfilled with the minimum thickness of the insulation at any point around the circumference.
- nominal insulation thickness	Manufacturer's standard
- insulation eccentricity	According to IEC 60840, § 10.6.2
Insulation screen, type / thickness	Cross-linked polyethylene / Manufacturer's standard
Extruding process / vulcanisation process	Triple-extrusion / Dry curing

3.4 Screen

Type of screen	Annealed circular Cu-wires with a thin Cu counter helix tape
Minimum screen area (excluding Al-foil/Cu-foil and Cu counter tape)	≥95 mm²
Max. DC-resistance for the screen at 20 °C (excluding Al-foil and Cu counter tape)	0.193 Ohm/km Stated resistance value refers to true screen length in the cable and not the length of the complete cable, i.e. with consideration taken to the screen lay/pitch.
Minimum dimensions of Cu counter tape (Width x Thickness)	10 x 0.1 mm

3.5 Longitudinal and Radial Water Sealing System

Type of longitudinal water sealing system	Swelling tapes or equivalent (under and/or above wires)
Type of radial water sealing system	Al- or Cu-foil/laminate/tape bonded to the outer sheath.

3.6 Outer Sheath

Type / material	Non-halogen polymer (HFFR)
Minimum thickness (excluding outer conductive layer)	3.5 mm (minimum thickness at any point around the circumference)
Nominal thickness	Manufacturer's standard
Colour	Naturally coloured, not black

3.7 Outer Conductive Layer

Type / material	Non-halogen polymer (HFFR)
Extruding process	Extruded and bonded to the outer sheath in the same operation as the outer sheath.
Nominal thickness	Manufacturer's standard
Colour	Black

3.8 Fire propagation classes

Cables for tunnel installations shall at least fulfil the following fire propagation class:

a) B2ca -s1, d0, a1.

The required fire propagation class shall include the complete cable construction including the outer protective layer. The fire propagation classes are defined in EN 13501-6.

4 Outdoor Termination Specification

4.1 General

This specification covers the outdoor termination of the cable system.

The termination shall be of composite type and shall meet the requirements in IEC 60840, IEC 60815 and IEC 60137, which all shall be used as engineering standards.

4.2 Electrical & climatic data

Maximum voltage U_m for accessories	145 kV
Current capacity (power rating)	Same as for the XLPE-cable
Short time overload capacity	Same as for the XLPE-cable
One phase short circuit current withstand	Same as for the XLPE-cable
DC-voltage test on outer sheath	According to chapter 10
Surrounding air temperature, outdoor	-40 to +40 °C, (-50 °C is required in the northern parts of the power networks, i.e. north of the river “Dalälven”)
Solar radiation	Max. 1000 W/m2
Design wind velocity	34 m/s

4.3 Termination construction

The termination shall electrically and thermally be dimensioned in accordance with above construction parameters and be fully adapted with the XLPE-cable.

The insulator shall be of composite type and shall have a leakage/creepage path of minimum 3075 mm, i.e. ≥ 25 mm/kV according to IEC 60815 “heavily polluted atmosphere”. The insulator shall be filled with an insulating liquid or equivalent that is harmless to the environment in case of leakage (note that a gas-filled insulator is not requested). A completely dry termination may be accepted if the supplier can present several years of service experience for the type.

The proposed termination shall have a system for insulated installation (support insulators etc.) so that regular voltage tests on the outer sheath of the cable phases can be performed.

Earth connections for screen wires, earthing bonds on the termination body/housing etc. shall be designed in such a way that a short circuit current in case of a fault will not damage the termination.

The metallic laminate layer (for radial water tightness) shall be properly connected directly to the screen or the screen connection point on the termination body.

The termination shall be able to withstand normal mechanical axial and radial forces that occur due to wind, normal forces on jumper lines etc.

5 Gas-Insulated Switchgear (GIS) Termination

5.1 General

This specification covers a dry-type cable-termination for connection to a GIS switchgear (see definition in IEC 62271-209 §3.1.2).

The termination shall have a separating insulating barrier (epoxy-resin insulator or similar) between the cable insulation and the gas insulation of the switchgear (i.e. shall not be of a "naked" design).

Note that a fluid-filled cable-termination type (see IEC 62271-209 §3.1.1) or a gas-pressurised termination type is not requested.

The termination shall meet the requirements in IEC 60840, IEC 62271-203 and IEC 62271-209, which all shall be used as engineering standards.

The gas-insulated cable connection enclosures for the terminations will be of one-phase type and connected to switchgears of following types:
- Cable circuit end A / Not yet contracted
- Cable circuit end B / Not yet contracted

5.2 Electrical Data

Maximum voltage U_m for accessories	145 kV
On-site short-duration AC-withstand voltage	Acc. to IEC 62271-203 table 107
Current capacity (power rating)	Same as for the XLPE-cable
Short time overload capacity	Same as for the XLPE-cable
Type of cable system earthing	Screens directly earthed at both ends (if not otherwise specified)
One phase short circuit current withstand	Same as for the XLPE-cable

5.3 GIS-Termination Construction

The termination shall electrically and thermally be dimensioned in accordance with above construction parameters and be fully adapted with the XLPE-cable, see separate cable specification.

The termination shall have a completely dry construction and be of "plug-in" type which makes it possible to remove and reassemble the cable end and internal parts of the cable termination (except the insulator) without any switchgear gas-leakage. A suitable cover/protection lid for the exposed insulator shall be included in each termination kit to enable energization of empty cable connection.

The termination shall be able to withstand the mechanical axial/radial forces and pressure that occur inside the gas-insulated metal-enclosed enclosure and the requirements in IEC 62271-203 and IEC-62271-209 shall be fulfilled. The termination shall also be capable to withstand the vacuum conditions when the enclosure is evacuated as part of the filling process.

The termination will be installed in gas insulated switchgears of one-phase type with standardized dimensions according to IEC 62271-209 Figure 5.

The proposed termination shall have a system for insulated erection against the metallic switchgear parts so that regular voltage-tests on the outer sheath of the cable can be performed.

Earth connections for screen wires, earthing bonds on the termination body/housing etc. shall be constructed to withstand the actual short circuit current.

The metallic laminate layer on the XLPE-cable (for radial water tightness) shall be properly connected to the screen wires, i.e. shall be included in the termination assembly.

6 Straight Through Joint and Repair Joint for Underground Cable System

6.1 General

This specification covers a "Prefabricated Joint" where prefabricated rubber bodies are installed over the prepared cable ends.

The joint will be directly buried in soil. Splicing may be performed both between new cables and between new and existing cables.
The joint shall meet the requirements in IEC 60840, including § 12.4.2 g – test of outer protection for joints (Annex G). The IEC 60840 shall be used as a general engineering standard.

6.2 Electrical data

Maximum voltage U_m for accessories	145 kV
Current capacity (power rating)	Same as for the XLPE-cable
Short time overload capacity	Same as for the XLPE-cable
One phase short circuit current withstand	Same as for the XLPE-cable
DC-voltage test on outer sheath	Same as for the XLPE-cable

6.3 Joint Construction

The joint shall electrically and thermally be dimensioned in accordance with above construction parameters and be fully adapted with the XLPE-cable. The recovering of the screen wires over the joint area shall be made in such a way that a short circuit current in case of a fault will not damage the joint (current level determined by the XLPE-cable screen).

If not otherwise specified, the screen wires on both sides of the cable shall be recovered straight through the joint, i.e. the joint shall not be of cross-bonded or insulated screen end type.

If required by Client, an earth bonding cable (connected to the wire-screen) shall be brought out from the joint. The bonding cable shall be a PE-insulated flexible bonding cable with a copper conductor of at least 95 mm^2 cross sectional area. The bonding cable shall be connected to the screen wires and brought out from the joint to a grounding point.
Special attention shall be taken to stop water penetration along the bonding cable connected to the screen wires. The insulation of the bonding cable shall also be able to withstand regular voltage tests.
The metallic laminate layer (for radial water tightness) shall be properly connected to the screen.

The proposed joint shall have a construction which makes it possible to perform regular voltage-tests on the outer sheath of the cable. This means that the recovered screen wires and the bonding cable must be sufficiently insulated from surrounding ground with a mechanical stable suitable outer cover that also fully prevents moisture penetration.

The XLPE-cable shall be supplied with an extruded conductive layer on the outer sheath and the joint shall therefore be supplied with a system for electrical connection of these layers on both sides.

7 Straight Through and Repair Joint for Tunnel Cable System

7.1 General

This specification covers a "Prefabricated Joint" where prefabricated rubber bodies are installed over the prepared cable ends.

The joint will be installed in tunnel. Splicing may be performed both between new cables and between new and existing cables.
The joint shall meet the requirements in IEC 60840, which shall be used as a general engineering standard.

7.2 Electrical data

Maximum voltage U_m for accessories	145 kV
Current capacity (power rating)	Same as for the XLPE-cable
Short time overload capacity	Same as for the XLPE-cable
One phase short circuit current withstand	Same as for the XLPE-cable
DC-voltage test on outer sheath	Same as for the XLPE-cable

7.3 Joint construction

The joint shall electrically and thermally be dimensioned in accordance with above construction parameters and be fully adapted with the XLPE-cable. The recovering of the screen wires over the joint area shall be made in such a way that a short circuit current in case of a fault will not damage the joint (current level determined by the XLPE-cable screen).

If not otherwise specified, the screen wires on both sides of the cable shall be recovered straight through the joint, i.e. the joint shall not be of cross-bonded or insulated screen end type.

If required by Client, an earth bonding cable (connected to the wire-screen) shall be brought out from the joint. The bonding cable shall be a PVC/HFFR-insulated flexible bonding cable with a copper conductor of at least 95 mm^2 cross sectional area. The bonding cable shall be connected to the screen wires and brought out from the joint to a grounding point.
Special attention shall be taken to stop water penetration along the bonding cable connected to the screen wires. The insulation of the bonding cable shall also be able to withstand regular voltage tests.
The metallic laminate layer (for radial water tightness) shall be properly connected to the screen.

The proposed joint shall have a construction which makes it possible to perform regular voltage-tests on the outer sheath of the cable. This means that the recovered screen wires and the bonding cable must be sufficiently insulated from surrounding ground with a mechanical stable suitable outer cover that also fully prevents moisture penetration.

The XLPE-cable shall be supplied with an extruded conductive layer on the outer sheath and the joint shall therefore be supplied with a system for electrical connection of these layers on both sides.

The joint shall be installed with a cable with the required fire propagation class in chapter 3. The fire propagation properties of the joint shall match that of the cable and shall be proved with test reports. If this

cannot be proven the proposal of fire propagation actions for the joint will be subject to Client's acceptance.

8 Transition Joint

8.1 General

This specification covers a "Prefabricated Joint", where prefabricated rubber bodies are installed over the prepared cable ends. The joint shall be used for jointing cables where one cable is an underground cable, the other one is a tunnel cable, both with a construction according to this specification. Conductor cross-section of the cables to be specified separately.

The transition joints will be installed in a tunnel (i.e. in air) and the screen wires on both sides of the cable joint shall be connected to two bonding cables that are brought out from the joint and directly earthed, see principle in Figure. The joint shall not be of straight through type.

The joint shall be supplied with an integrated screen separation.

The joint shall meet the requirements in IEC 60840, which shall be used as a general engineering standard.

8.2 Electrical data

Maximum voltage U_m for accessories	145 kV
Current capacity (power rating)	Same as for the XLPE-cable
Short time overload capacity	Same as for the XLPE-cable
One phase short circuit current withstand	Same as for the XLPE-cable
DC-voltage test on outer sheath	Same as for the XLPE-cable

8.3 Joint construction

The joints shall electrically and thermally be dimensioned in accordance with above construction parameters and be fully adapted with the XLPE-cable types.

From each joint two PVC/HFFR-insulated 95 mm^2 copper bonding leads shall be brought out, one connected to the screen wires of the underground cable and one connected to the screen wires of the existing tunnel cable. After approved voltage test of each group of underground cable sheaths the six (2x3) bonding leads shall, in pairs, be electrically connected together by a permanent method. The length of the leads shall be chosen in such a way that they in case of a fault can be split apart (insulated) for fault location on the underground cable section and then connected together again.

The bundle shall via a 95 mm^2 insulated copper bonding lead be connected to an earthing link-box or similar, see Figure 1.

The recovering of the screen wires shall be made in such a way that a short circuit current in case of a fault will not damage the joint (current level determined by the XLPE-cable screen).

The metallic laminate layer on the underground XLPE-cable (for radial water tightness) shall be properly connected to the screen.

The proposed joint shall have a construction which makes it possible to perform voltage-tests on the outer sheath of the cable. This means that the recovered screen wires and the bonding cable must be sufficiently insulated from surrounding ground with a mechanically stable suitable outer cover that also fully prevents moisture penetration.

The proposed joint shall be used with a cable with fire propagation class B2ca -s1, do, a1. Fire propagation properties of joint and/or proposal of fire propagation actions shall be submitted for approval by Ellevio.

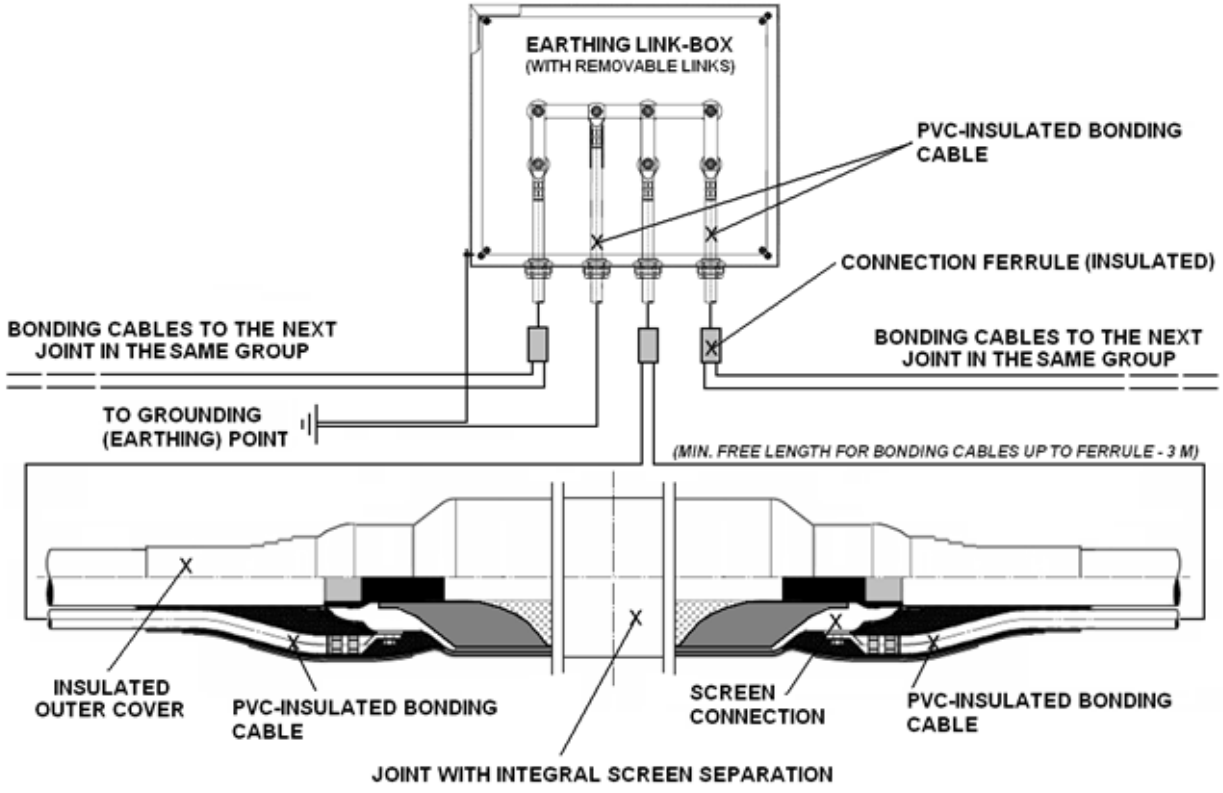

Figure 1 - Principle connection scheme for bonding cables at the transition joints.

9 Type, Sample and Routine Testing

9.1 General

This specification covers testing of a 123 kV cable system with one or several of the items in this specification:

a) Underground XLPE-cable
b) XLPE-cable for installation in tunnel
c) Outdoor termination
d) GIS termination
e) Straight through joint/ repair joint for underground cable
f) Straight through joint for tunnel cable
g) Transition joint for tunnel installation

All measurements for partial discharges shall be made with instruments with measurement sensitivity for ≤ 5 pC or better for both cables and accessories. The noise level shall be below 2.5 pC.

9.2 Electrical main data

Maximum voltage U_m	123 kV
Rated impulse withstand voltage	550 kV (SS-EN 60071-1)
DC-voltage test on outer sheath	25 kV in factory and 10 kV after installation

9.3 Type Test

9.3.1 Electrical tests

Tests shall be performed on a cable length including outdoor termination and joints, according to IEC 60840 § 12.4.2 which includes the following:

a) § 12.4.3 – Bending test and § 12.4.4 – Partial Discharge-test 96 kV
b) § 12.4.5 – Tan δ measurement
c) § 12.4.6 – Heating cycle voltage test 128 kV
d) § 12.4.4 – Partial Discharge-test 96 kV
e) § 12.4.7 – Lightning impulse voltage test 550 kV incl. AC-test 160 kV during 15 min.
f) § 12.4.4 – Partial Discharge-test 96 kV
g) Annex G – Test for outer protection for joints
h) § 12.4.8 – Examination
i) § 12.4.9 – Resistivity of semi-conducting screens

9.3.2 Non electrical tests

Tests shall be performed on a cable length according to IEC 60840 § 12.5, which includes the following:

a) § 12.5.1 – Check of cable construction
b) § 12.5.2 – Mechanical properties of insulation
c) § 12.5.3 – Mechanical properties of oversheath
d) § 12.5.4 – Ageing tests

e) § 12.5.5 – Loss of mass test on PVC oversheath (if applicable)
f) § 12.5.6 – Pressure test at high temperature on oversheath
g) § 12.5.7 – Tests on PVC oversheaths at low temperature (if applicable)
h) § 12.5.8 – Heat shock tests for PVC oversheaths (if applicable)
i) § 12.5.10 – Hot set test for XLPE insulation
j) § 12.5.11 – Measurement of density of HDPE insulation
k) § 12.5.12 – Measurement of carbon black for PE oversheaths
l) § 12.5.14 & Annex E– Water penetration test
m) § 12.5.15 & Annex F– Test on components of cables with a longitudinally applied metal tape/foil
n) 12.5.16 – Shrinkage test for PE, HDPE and XLPE insulations
o) 12.5.17 – Shrinkage test for PE oversheaths (ST3 and ST7) (if applicable)

9.3.3 Test under fire condition (for installation in tunnels)

Tests shall be performed according to EN 130501-6.

9.4 Sample test

Client shall have the right to witness the sample test of the cable length(s). Notifications of the time and date of the test shall be sent at least 14 days ahead of testing.

9.4.1 Tests on cable lengths from manufacturing

The tests shall be performed according to IEC 60840 § 10, which includes the following:

a) § 10.4 – Conductor examination
b) § 10.5 – Measurement of electrical resistance of conductor and of metal screen/sheath
c) § 10.6 – Measurement of thickness of insulation and oversheath
d) § 10.7 – Measurement of thickness of metal sheath
e) § 10.8 – Measurement of diameters
f) § 10.9 – Hot set test for XLPE insulations
g) § 10.10 – Measurement of capacitance
h) § 10.11 – Measurement of density of HDPE insulation (if applicable)
i) Not Applicable, if $E_{max} \leq 8.0$ kV/mm at $U_m/\sqrt{3}$ (§ 10.12 Lightning impulse voltage test)
j) § 10.13 – Water penetration test
k) § 10.14 – Tests on components of cables with longitudinally applied metal tape or foil, bonded to the oversheath)

9.4.2 Tests on one cable length from manufacturing including termination and joint

If a type test is not performed in direct connection with the order (i.e. in the case Client accept already performed type tests) the following tests may be performed according to the relevant clauses in IEC 60840:

a) § 12.4.7.2 – Lightning impulse voltage test 550 kV including AC-test 160 kV during 15 min.
b) § 12.4.4 – PD-test 96 kV
c) § 12.4.8 – Examination

9.5 Routine test

Client shall have the right to witness the routine test of the sample tested length(s) in connection with the witnessing of the sample test.

9.5.1 Tests on each manufactured cable length

Electrical tests shall be performed according to IEC 60840 § 9.

p) PD-test 96 kV
q) Voltage test 160 kV during 30 min.
r) Electrical test on oversheath of the cable, 25 kV DC during 1 min.

9.5.2 Tests on main insulation of termination and prefabricated joints

Electrical tests shall be performed according to IEC 60840 § 9.

s) PD-test 96 kV
t) Voltage test 160 kV during 30 min.

10 Test during and after installation

10.1 Tests on each cable length performed by Contractor

10.1.1 DC-voltage test on outer sheath

Voltage shall be applied between the conductive layer (on the outer sheath) and the screen wire connection at the termination housings on each installed underground cable phase. The tests shall be performed before filling the trench.

The test shall be performed according to the levels in IEC 60840 § 16.2.

a) DC voltage test of the oversheath, 10 kV DC during 1 min

10.2 Tests on complete cable system performed by Contractor

10.2.1 DC-voltage test on outer sheath

Voltage shall be applied between the conductive layer (on the outer sheath) and the screen wire connection at the termination housings on each completed underground cable phase. The tests shall be performed before the bonding leads from screens have been grounded. Separate additional tests may also be performed on each individual installed cable length before jointing.

The test shall be performed according to the levels in IEC 60840 § 16.2.

a) DC voltage test of the oversheath, 10 kV DC during 1 min

10.2.2 Phase sequence test

Shall be performed according to an established standard method. The method for performing the test shall be described by Contractor and accepted by Client. The description shall include how the test can be performed practically, needed necessary electric equipment, prevailing conditions and requirements etc.

10.2.3 Sequence Impedance test

The following tests shall be performed on the complete cable system:

a) Positive and negative sequence impedance measurement
a) Zero sequence impedance measurement

The method for performing these tests shall be described by Contractor and accepted by Client. The description shall include how the above impedance tests can be performed practically, needed necessary electric equipment, prevailing conditions and requirements etc.

10.3 Test on complete cable system performed by Client

10.3.1 AC voltage test of the insulation

AC voltage test on the complete cable installation shall be performed at normal operating voltage or at least U_0 during 48 h. The test will be performed at no-load conditions.

A.Data Sheet - Underground Cable

1. CONSTRUCTION DATA

1.1	**Conductor**		
1.1.1	Type (segmented, compacted etc.)		
1.1.2	Material		
1.1.3	Cross sectional area		mm^2
1.1.4	Nominal diameter		mm
1.1.5	Allowable tensile strength		N/mm2
1.1.6	Number of segments in the conductor		pcs.
1.1.7	Number of wires in each segment		pcs.
1.1.8	Longitudinal water sealing system: - type description (swelling powder/yarn etc.) - test report enclosed with bid (Y/N)		

1.2	**Insulation System**		
1.2.1	**Conductor screen**		
1.2.1.1	Material		
1.2.1.2	Nominal thickness		mm
1.2.1.3	Min. thickness		mm
1.2.2	**XLPE-Insulation**		
1.2.2.1	Material (type of quality etc.)		
1.2.2.2	Nominal insulation thickness		mm
1.2.2.3	Min. insulation thickness at any point around circumference		mm
1.2.2.4	Diameter over insulation		mm
1.2.3	**Insulation screen**		
1.2.3.1	Material		
1.2.3.2	Nominal thickness		mm
1.2.3.3	Min. thickness		mm

1.2.3.4	Type of extruding and vulcanisation process (cond. screen + insulation + insul. screen)		

1.3	**Screen, longitudinal and radial water sealing system**		
1.3.1	Longitudinal water sealing system underneath screen wires: - type description (swelling tapes etc.) - test report enclosed with bid (Y/N)		
1.3.2	Nominal thickness		mm
1.3.3	Screen, material and type		
1.3.4	Screen, nominal wire diameter		mm
1.3.5	Screen, number of wires		pcs.
1.3.6	Pitch angle		deg
1.3.7	Screen, cross-sectional area		mm^2
1.3.8	Type and dimensions of copper counter helix tape(-s)		
1.3.9	Copper counter helix tape(-s) cross-sectional area		mm^2
1.3.10	Longitudinal water sealing layers above screen wires: - type description (swelling tapes etc.) - test report enclosed with bid (Y/N)		
1.3.11	Nominal thickness of longitudinal water sealing layer		mm
1.3.12	Radial water sealing layer: - type description (Al-foil/Cu-foil/laminate/tape) - layer bonded to the outer sheath (Y/N)		
1.3.13	Radial water sealing layer: - nominal thickness of Al/Cu - nominal thickness of entire foil		mm mm
1.3.14	AL-foil/Cu-foil cross-sectional area		mm^2
1.3.15	Diameter (centre of screen and water sealing systems)		mm

1.4	**Outer PE-sheath**		
1.4.1	Material (extruded MDPE or HDPE)		
1.4.2	Material density		kg/dm^3
1.4.3	Nominal thickness		mm

1.4.4	Min. thickness (at any point around circumference)		mm
1.4.5	Colour		

1.5	**Outer conductive layer (for DC-voltage testing of outer sheath)**		
1.5.1	Material		
1.5.2	Nominal thickness		mm
1.5.3	Colour		
1.5.4	Application process	Extruded and bonded to the outer sheath	

1.6	**Reaction to fire Properties**		
1.6.1	Class of reaction to fire		
1.6.2	Smoke production classification		
1.6.3	Flaming droplets/particles classification		
1.6.4	Acidity classification		

1.7	**Cable dimensions and weight**		
1.7.1	Nominal overall cable diameter		mm
1.7.2	Nominal weight of complete cable		kg/m

2. ELECTRICAL AND THERMAL DATA

Impedance and inductance calculations shall be based on the following:

Phases in trefoil formation, screens solidly earthed in both ends.

2.1	**Electrical and thermal data**		
2.1.1	Max. AC system voltage		kV
2.1.2	Lightning impulse level		kV
2.1.3	Max. conductor DC resistance at 20 °C		Ω/km
2.1.4	Permissible conductor temperature: - at max. continuous current (≥ 90 °C) - at short circuit		 °C °C
2.1.5	Max. conductor AC resistance at: - 90 °C - 65 °C		 Ω/km Ω/km

2.1.6	Screen earthing system		
2.1.7	Nominal capacitance of cable		µF/km
2.1.8	Inductance of cable		mH/km
2.1.9	Positive and negative sequence impedance (R+jX) at 50 Hz and continuous conductor temperature 65 °C		Ω/km
2.1.10	Zero sequence impedance (R+jX) at 50 Hz and continuous conductor temperature 65 °C		Ω/km
2.1.11	Positive and negative sequence impedance (R+jX) at 50 Hz and continuous conductor temperature 90 °C		Ω/km
2.1.12	Zero sequence impedance (R+jX) at 50 Hz and continuous conductor temperature 90 °C		Ω/km
2.1.13	Nominal electric field strength at Um - at insulation screen - at conductor screen		 kV/mm kV/mm
2.1.14	Permissible short circuit current in copper wire screen at continuous current capacity (90 °C initial conductor temperature): - during 0.5 s - during 1.0 s		 kA kA

3. DOCUMENTATION, SERVICE EXPERIENCE ETC.

3.1	**Drawings and documents <u>to be enclosed</u>**	
3.1.1	Sectional drawing No.	
3.1.2	Type test reports No. (incl. documentation covering longitudinal water sealing systems)	
3.1.3	Reference list No.	

4. CABLE HANDLING AND DRUM DATA

4.1	**Cable handling data**		
4.1.1	Minimum cable bending radius: - at laying - when installed (single bending)		 m m
4.1.2	Maximum pulling force in conductor		kN
	Maximum pulling force with pulling stock applied on the outside of cable		kN

4.2	**Drum data (delivery lengths see separate documentation !)**		
4.2.1	Cable length on drum		m
4.2.2	Type of drums (wood/steel)		
4.2.3	Drum width		mm
4.2.4	Outer drum diameter		mm
4.2.5	Barrel diameter		mm
4.2.6	Spindle hole diameter		mm
4.2.7	Total weight (cable and drum)		kg

B.Data Sheet - Tunnel Cable

1. CONSTRUCTION DATA

1.1	**Conductor**		
1.1.1	Type (round, compacted etc.)		
1.1.2	Material		
1.1.3	Cross sectional area		mm^2
1.1.4	Nominal diameter		mm
1.1.5	Allowable tensile strength		N/mm2
1.1.6	Number of segments in the conductor		pcs.
1.1.7	Number of wires in the conductor		pcs.
1.1.8	Longitudinal water sealing system: - type description (swelling powder/yarn etc.) - test report enclosed with bid (Y/N)		

1.2	**Insulation System**		
1.2.1	**Conductor screen**		
1.2.1.1	Material		
1.2.1.2	Nominal thickness		mm
1.2.1.3	Min. thickness		mm
1.2.2	**XLPE-Insulation**		
1.2.2.1	Material (type of quality etc.)		
1.2.2.2	Nominal insulation thickness		mm
1.2.2.3	Min. insulation thickness at any point around circumference		mm
1.2.2.4	Diameter over insulation		mm
1.2.3	**Insulation screen**		
1.2.3.1	Material		
1.2.3.2	Nominal thickness		mm
1.2.3.3	Min. thickness		mm

1.2.3.4	Type of extruding and vulcanisation process (cond. screen + insulation + insul. screen)		

1.3	**Screen, longitudinal and radial water sealing system**		
1.3.1	Longitudinal water sealing system underneath screen wires: - type description (swelling tapes etc.) - test report enclosed with bid (Y/N)		
1.3.2	Nominal thickness		mm
1.3.3	Screen, material and type		
1.3.4	Screen, nominal wire diameter		mm
1.3.5	Screen, number of wires		pcs.
1.3.6	Pitch angle		deg
1.3.7	Screen, cross-sectional area		mm^2
1.3.8	Type and dimensions of copper counter helix tape(-s)		
1.3.9	Copper counter helix tape(-s) cross-sectional area		mm^2
1.3.10	Longitudinal water sealing layers above screen wires: - type description (swelling tapes etc.) - test report enclosed with bid (Y/N)		
1.3.11	Nominal thickness of longitudinal water sealing layer		mm
1.3.12	Radial water sealing layer: - type description (Al-foil/Cu-foil/laminate/tape) - layer bonded to the outer sheath (Y/N)		
1.3.13	Radial water sealing layer: - nominal thickness of Al/Cu - nominal thickness of entire foil		mm mm
1.3.14	AL-foil/Cu-foil cross-sectional area		mm^2
1.3.15	Diameter (centre of screen and water sealing systems)		mm

1.4	**Outer PE-sheath**		
1.4.1	Material (extruded HFFR)		
1.4.2	Material density		kg/dm^3
1.4.3	Nominal thickness		mm

1.4.4	Min. thickness (at any point around circumference)		mm
1.4.5	Colour		

1.5	**Outer conductive layer (for DC-voltage testing of outer sheath)**		
1.5.1	Material		
1.5.2	Nominal thickness		mm
1.5.3	Colour		
1.5.4	Application process	Extruded and bonded to the outer sheath	

1.6	**Reaction to fire Properties**		
1.6.1	Class of reaction to fire		
1.6.2	Smoke production classification		
1.6.3	Flaming droplets/particles classification		
1.6.4	Acidity classification		

1.7	**Cable dimensions and weight**		
1.7.1	Nominal overall cable diameter		mm
1.7.2	Nominal weight of complete cable		kg/m

2. ELECTRICAL AND THERMAL DATA

Impedance and inductance calculations shall be based on the following:

Phases in trefoil formation, screens solidly earthed in both ends.

2.1	**Electrical and thermal data**		
2.1.1	Max. AC system voltage		kV
2.1.2	Lightning impulse level		kV
2.1.3	Max. conductor DC resistance at 20 °C		Ω/km
2.1.4	Permissible conductor temperature: - at max. continuous current (≥ 90 °C) - at short circuit		 °C °C
2.1.5	Max. conductor AC resistance at: - 90 °C - 65 °C		 Ω/km Ω/km

2.1.6	Screen earthing system		
2.1.7	Nominal capacitance of cable		µF/km
2.1.8	Inductance of cable		mH/km
2.1.9	Positive and negative sequence impedance (R+jX) at 50 Hz and continuous conductor temperature 65 °C		Ω/km
2.1.10	Zero sequence impedance (R+jX) at 50 Hz and continuous conductor temperature 65 °C		Ω/km
2.1.11	Positive and negative sequence impedance (R+jX) at 50 Hz and continuous conductor temperature 90 °C		Ω/km
2.1.12	Zero sequence impedance (R+jX) at 50 Hz and continuous conductor temperature 90 °C		Ω/km
2.1.13	Nominal electric field strength at Um - at insulation screen - at conductor screen		 kV/mm kV/mm
2.1.14	Permissible short circuit current in copper wire screen at continuous current capacity (90 °C initial conductor temperature): - during 0.5 s - during 1.0 s		 kA kA

3. DOCUMENTATION, SERVICE EXPERIENCE ETC.

3.1	**Drawings and documents <u>to be enclosed</u>**	
3.1.1	Sectional drawing No.	
3.1.2	Type test reports No. (incl. documentation covering longitudinal water sealing systems)	
3.1.3	Reference list No.	

4. CABLE HANDLING AND DRUM DATA

4.1	**Cable handling data**		
4.1.1	Minimum cable bending radius: - at laying - when installed (single bending)		 m m
4.1.2	Maximum pulling force in conductor		kN
4.1.3	Maximum pulling force with pulling stock applied on the outside of cable		kN

4.2	**Drum data (delivery lengths see separate documentation !)**		
4.2.1	Cable length on drum		m
4.2.2	Type of drums (wood/steel)		
4.2.3	Drum width		mm
4.2.4	Outer drum diameter		mm
4.2.5	Barrel diameter		mm
4.2.6	Spindle hole diameter		mm
4.2.7	Total weight (cable and drum)		kg

C.Data Sheet - Outdoor Termination

1. CONSTRUCTION DATA

1.1	Type of termination (fluid filled, dry type etc.)	
1.2	Type designation and manufacturer	
1.3	Type of system for insulation of cable screen from earth at the termination	
1.4	Type of insulator	
1.5	Type of connection on termination for the screen wire bundle	
1.6	Description of connection of the metallic Al-laminate to the screen wires	
1.7	Colour of insulator body	

2. ELECTRICAL & CLIMATIC MAIN DATA

2.1	Maximum operating AC voltage		kV
2.2	Lightning impulse withstand voltage		kV
2.3	Continuous and overload current capacity		A
2.4	Creepage distance: - total - protected		 mm mm
2.5	Mechanical loads on the top bolt: - in 90° angle to the termination - axially		 N N
2.6	Top bolt: - material - surface treatment		
2.7	Top bolt dimensions: - ∅ (diameter) - length (for jumper-wire clamp)		 mm mm
2.8	Short circuit withstand for the bonding cable to screen connection at the termination		 kA
2.9	Max. installation inclination		Degrees
2.10	Weight of complete termination (including filling compound)		 kg
2.11	Rated ambient temperature conditions -min -max		 °C °C

2.12	Rated wind conditions -max		m/s

3. DOCUMENTATION, SERVICE EXPERIENCE ETC.

3.1	Enclosed reference list No./Nos.	
3.2	Enclosed sectional drawing No./Nos.	
3.3	Enclosed type test report No./Nos.	
3.4	Approximately number of 123 kV outdoor terminations of actual type: - sold - in commercial operation - first year of commercial operation	

D.Data Sheet - GIS Termination

1. CONSTRUCTION DATA

1.1	Type of GIS-termination		
1.2	Type designation and manufacturer of GIS-termination		
1.3	Type and description of main-insulator body (epoxy etc.)		
1.4	Method for connection conductor-top bolt (welding, press sleeve, shear-off bolt connection etc.)		
1.5	Method for electric contact between top bolt and top terminal (silver plated electric contacts etc.)		
1.6	Material of stress cone (EPDM-rubber, silicone-rubber etc.)		
1.7	Minimum SF6 gas-pressure withstand (within the metallic enclosure, ≥ 0,85 MPa)		MPa (abs.)
1.8	Type of system for insulation of cable screen from earth at the termination.		
1.9	Type of connection on termination of the screen wire bundle and a 150 mm^2 bonding cable to be brought to an earthing point		
1.10	Description of connection of the metallic laminate (radial water sealing) to the screen wires within termination		
1.11	Method for removal of the outer conductive layer on the XLPE-cable at the termination		
1.12	Description and requirement for fastening/clamping of XLPE-cable beneath the termination body (number of clamps, distance between clamps etc.)		
1.13	Weight of complete termination		Kg
1.14	Dimensions of GIS-termination complies with IEC 62271-209/2007 (Y/N)		
1.15	Termination capable to withstand vacuum conditions occurring during the gas filling of metallic switchgear enclosure (Y/N)		
1.16	Description of considerations (assembly, handling, test voltage limits etc.) to be taken in case of a pre-installation of the main-insulator (epoxy etc.) during GIS-manufacturing, see IEC 62271-209 § 8.1		

2. ELECTRICAL MAIN DATA

2.1	Maximum operating AC voltage		kV
2.2	Lightning impulse withstand voltage		kV
2.3	Continuous and overload current capacity		A
2.8	Short circuit withstand for the bonding cable to screen connection at the termination		kA
2.10	Weight of complete termination (including filling compound)		kg

3. DOCUMENTATION, SERVICE EXPERIENCE ETC.

3.1	Enclosed reference list No./Nos.	
3.2	Enclosed sectional drawing No./Nos.	
3.3	Enclosed type test report No./Nos.	
3.4	Approximately number of 123 kV outdoor terminations of actual type: - sold - in commercial operation - first year of commercial operation	

E. Data Sheet - Underground Cable Joint

1. CONSTRUCTION DATA

1.1	Type of straight through/repair joint (e.g. prefabricated rubber type etc)		
1.2	Type designation and manufacturer of joint		
1.3	Continuous current capacity	Same as for the cable !	A
1.4	Maximum permissible conductor temperature in the joint: - at max. permissible continuous current - at short circuit		 °C °C
1.5	Method and material for conductor jointing (welding, press sleeve, bolt connection, sleeve with electric contacts etc.)		
1.6	Tensile load strength of the conductor joint		kN
1.7	Type and description of main insulation body (one-piece, multi piece, specific technical characteristics etc.)		
1.8	Material of main insulation body (EPDM-rubber, silicone-rubber, XLPE etc.)		
1.9	Method and material for recovering and connection of the copper wire screen at both ends of the joint		
1.10	Description of electric connection of the metallic laminate/tape (radial water sealing layer) to the screen wires within joint		
1.11	Method and material for connection of bonding cable to the screen wires		
1.12	One-phase short circuit current withstand for screen and bonding cable connection	Same or higher as for the cable screen !	kA
1.13	Description of protective outer cover (method, material etc.)		
1.14	Method and material for connection of the conductive layers (on cable outer covering) on both sides of the joint		

2. ELECTRICAL AND THERMAL DATA

2.1	Maximum operating/system AC voltage		kV
2.2	Lightning impulse withstand voltage		kV
2.3	Lightning impulse levels for the integrated screen separation (IEC 60840) - Between parts - Each part to earth		 kV kV
2.3	Continuous and overload current capacity		A

2.4	Maximum permissible conductor temperature in the joint: - at max. permissible continuous current - at short circuit		 °C °C
2.5	One-phase short circuit current withstand for the straight through screen connection - during 0.5 s - during 1.0 s		 kA kA

3. DOCUMENTATION, SERVICE EXPERIENCE ETC.

3.1	Tests of outer protection of joint performed according to “IEC 60840” (Y/N)	
3.2	Sectional drawing Nos.	
3.3	Type test reports Nos.	
3.4	Reference list No.	
3.5	Approximately number of 123 kV joints of actual type: - sold - in commercial operation - first year of commercial operation	

F. Data Sheet - Tunnel Cable Joint

1. CONSTRUCTION DATA

1.1	Type of straight through/repair joint (e.g. prefabricated rubber type etc)		
1.2	Type designation and manufacturer of joint		
1.3	Continuous current capacity	Same as for the cable !	A
1.4	Maximum permissible conductor temperature in the joint: - at max. permissible continuous current - at short circuit		°C °C
1.5	Method and material for conductor jointing (welding, press sleeve, bolt connection, sleeve with electric contacts etc.)		
1.6	Tensile load strength of the conductor joint		kN
1.7	Type and description of main insulation body (one-piece, multi piece, specific technical characteristics etc.)		
1.8	Material of main insulation body (EPDM-rubber, silicone-rubber, XLPE etc.)		
1.9	Method and material for recovering and connection of the copper wire screen at both ends of the joint		
1.10	Insulated flexible bonding cable connected to the screen wires - Cross-sectional area - PVC/HFFR-insulation (Y/N)		mm²
1.11	Description of electric connection of the metallic laminate/tape (radial water sealing layer) to the screen wires within joint		
1.12	Method and material for connection of bonding cable to the screen wires		
1.13	One-phase short circuit current withstand for screen and bonding cable connection	Same or higher as for the cable screen !	kA
1.14	Description of and material used for the protective outer cover (heat-shrinkable tubes, adhesive tapes, metallic casing, glass-fibre shells etc.)		
1.15	Method and material for the connection of the conductive layers (on the cable outer covering) on both sides of the joint		
1.16	Method and material for matching the fire propagation class of the cable.		

2. ELECTRICAL AND THERMAL DATA

2.1	Maximum operating/system AC voltage		kV
2.2	Lightning impulse withstand voltage		kV
2.3	Lightning impulse levels for the integrated screen separation, if applicable (IEC 60840) - Between parts - Each part to earth		 kV kV
2.3	Continuous and overload current capacity		A
2.4	Maximum permissible conductor temperature in the joint: - at max. permissible continuous current - at short circuit		 °C °C
2.5	One-phase short circuit current withstand for the straight through screen connection - during 0.5 s - during 1.0 s		 kA kA

3. DOCUMENTATION, SERVICE EXPERIENCE ETC.

3.1	Tests of outer protection of joint performed according to “IEC 60840” (Y/N)	
3.2	Sectional drawing Nos.	
3.3	Type test reports Nos.	
3.4	Reference list No.	
3.5	Approximately number of 123 kV joints of actual type: - sold - in commercial operation - first year of commercial operation	

G. Data Sheet - Transition Joint

1. CONSTRUCTION DATA

1.1	Type of transition joint (“Prefabricated rubber type”)		
1.2	Type designation and manufacturer of repair joint		
1.3	Continuous current capacity	Same as for the cable !	A
1.4	Maximum permissible conductor temperature in the joint: - at max. permissible continuous current - at short circuit		 °C °C
1.6	Method and material for conductor jointing (welding, press sleeve, bolt connection, sleeve with electric contacts etc.)		
1.6	Tensile load strength of the conductor joint		kN
1.7	Type and description of main insulation body (one-piece, multi piece, specific technical characteristics etc.)		
1.8	Material of main insulation body (EPDM-rubber, silicone-rubber etc.)		
1.9	Method and material for the sectionalizing parts of the joint		
1.10	Insulated flexible bonding cable connected to the screen wires - Cross-sectional area - PVC/HFFR-insulation (Y/N)		 mm²
1.11	Description of electric connection of the metallic Al-laminate/tape (radial water sealing layer) to the screen wires within joint		
1.12	Method and material for connection of bonding cable to the screen wires		
1.13	One-phase short circuit current withstand for screen and bonding cable connection	Same or higher as for the cable screen !	kA
1.14	Description of and material used for the protective outer cover (heat-shrinkable tubes, adhesive tapes, metallic casing, glass-fibre shells etc.)		
1.15	Method and material for the connection of the conductive layers (on the cable outer covering) on both sides of the joint.		
1.16	Construction makes it possible to perform regular voltage-tests on the outer sheath of the cable (Y/N)		

2. ELECTRICAL AND THERMAL DATA

2.1	Maximum operating/system AC voltage		kV
2.2	Lightning impulse withstand voltage		kV
2.3	Lightning impulse levels for the integrated screen separation, if applicable (IEC 60840) - Between parts - Each part to earth		 kV kV
2.3	Continuous and overload current capacity		A
2.4	Maximum permissible conductor temperature in the joint: - at max. permissible continuous current - at short circuit		 °C °C
2.5	One-phase short circuit current withstand for the straight through screen connection - during 0.5 s - during 1.0 s		 kA kA

3. DOCUMENTATION, SERVICE EXPERIENCE ETC.

3.1	Tests of outer protection of joint performed according to “IEC 60840” (Y/N)	
3.2	Sectional drawing Nos.	
3.3	Type test reports Nos.	
3.4	Reference list No.	
3.5	Approximately number of 123 kV joints of actual type: - sold - in commercial operation - first year of commercial operation	