Instruktion

Ansvarig process/funktion Nätkommittén	**Informationsklass** Konfidentiell låg (K-L)
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Technical specification of 52-170 kV XLPE cables and accessories

Revision history

Version	Comments	Author	Reviewed by	Approved by	Valid from
1.0		Mats Bortas	Nätkommittén	Kjell Oberger	2024-03-27

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1 Common

1.1. General

This specification covers cable system in ground with highest system voltage (U_m) of 52 kV, 72,5 kV, 145 kV respectively 170 kV installed in Ellevios electrical network.

The cable and the accessories shall be designed for at least 50 years' lifetime and to withstand the electrical and mechanical stresses which will be experienced during the service life.

1.2. Standards

The cable and accessories shall meet the latest version of the applicable standards and national regulations. Special requirements beyond the standard are specified in this Technical Specification.

1.3. Testing

Testing of the XLPE-cable system and accessories shall be performed in accordance with standard IEC 60840:2020 - Power cables with extruded insulation and their accessories for rated voltages above 30 kV (Um = 36 kV) up to 150 kV (Um = 170 kV) – Test methods and requirements.

XLPE-cables and accessories shall have been type tested assessed by certification body.
Type testing may be excluded in the contract if the Contractor can present acceptable reports from previously performed type tests. Water penetration test of XLPE-cables according to annex E and annex F shall have been performed. Test of outer protection for joints according to Annex H shall have been performed. Reports covering requested cable and/or accessories shall be enclosed in the tender.

1.4. Cable design

1.4.1. General

The cable shall meet the requirements in IEC 60840:2020 which shall be used as a general engineering standard.

1.4.2. Conductor

The conductor shall be round, stranded and compacted according to SS-EN 60228, class 2. The conductor shall have a completely longitudinal water blocking construction and shall be blocked in all interstices. The conductor shall be longitudinal watertight by means of swelling powder, swelling yarn, or swelling tapes or equivalent. For larger conductor cross sections, a conducting tape can be used around the conductor if the longitudinal water blocking is maintained.

Conductor of cross section 1600 mm^2 can either be of round type, as described above, or of Milliken type. This will be stated by the client.

Conductor resistance shall be according to SS-EN 60228, class 2.

1.4.3. Insulation system

The insulation shall be made of a cross-linked polyethylene compound XLPE. XLPE-material shall be well proven and classified by material supplier to be used for specified voltage level (U_m) of cable. It shall comply with requirements specified in IEC 60840-2020.

Both conductor screen and insulation screen shall be of cross-linked semi-conductive material and firmly bonded to the XLPE-insulation.

The insulation system, conductor screen, XLPE-insulation, and insulation screen, shall be triple extruded in a vulcanized, dry curing process.

The insulated system shall after extrusion be degassed in heated chamber.

1.4.3.1. Conductor screen and insulation screen

Conductor screen and insulation screen shall be of cross-linked semi-conductive material.
Minimum thickness $t_{min} \geq 0{,}5$ mm.

1.4.3.2. XLPE-insulation

Thickness of XLPE-insulation in minimum thickness $t_{min.}$ (mm).

Conductor cross section mm²	Highest system voltage U_m			
	52 kV	72,5 kV	145 kV	170 kV
300	8,10	11,25	16,20	20,70
400	8,10	10,80	16,20	19,40
500	8,10	10,80	15,30	18,00
630	8,10	10,80	15,30	17,00
800	8,10	10,80	15,30	17,00
1000	8,10	10,80	15,30	17,00
1200	8,10	10,80	15,30	17,00
1600*	8,10	10,80	15,30	17,00

1.4.4. Metal screen

The metal screen is of SD-design. Radial water tightness is made by laminated foil and copper wires screen for carrying the full screen short circuit.

1.4.4.1. Screen of Cu-wires and counter helix of Cu

Screen shall be of annealed circular copper wires with a thin counter helix tape of copper (min dimension 10 x 0,1 mm). 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 and excluding counter helix of copper tape.

Screen of copper wires, excluding counter helix of copper, shall fulfil resistance requirement according to IEC 60228 class 2, annealed copper conductor:

Screen cross section of copper wires (excl. counter helix of copper tape) mm²	Maximum resistance at 20°C Ω/km
35	0,524
50	0,387
95	0,193
150	0,124

Screen cross section will be stated of client.

1.4.4.2. Longitudinal and radial water sealing system

Longitudinal water sealing system shall be of semi conductive swelling tapes, both above and under screen of copper wires.

Radial water sealing system shall be of laminated Al-foil firmly bonded to the oversheath.

1.4.5. Oversheath with outer conductive layer (CL)

Oversheath shall be of UV-stabilized MDPE or HDPE.

A black outer conductive layer (CL) shall be extruded and firmly bonded to the oversheath.
Thickness of outer conductive layer according manufacturers standard.

There shall be a clear visible difference of colors between oversheath and outer conductive layer.

Thickness of sheath is minimum thickness t_{min}, excluding thickness of outer conductive layer.

Conductor cross section mm²	**Minimum thickness of oversheath t_{min} (excluding thickness of outer conductive layer). mm**			
	52 kV	**72.5 kV**	**145 kV**	**170 kV**
300	2,11	2,28	2,62	2,88
400	2,20	2,37	2,71	2,88
500	2,28	2,45	2,71	2,88
630	2,37	2,54	2,88	2,96
800	2,45	2,62	2,96	3,05
1000	2,54	2,71	3,05	3,22
1200	2,62	2,79	3,13	3,30
1600	2,79	3,05	3,30	3,47

1.4.6. Marking

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

a) Manufacturer's name or logo
b) Rated voltage $U_o/U(U_m)$
c) Cable designation.

d) Cross section of conductor and screen.
e) Year of manufacturing
f) Meter marking (may be printed with indelible ink)
g) Batch number of individual lengths for traceability[1]

1.5. Delivery drums

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

Cable on delivery drum shall be prepared for DC-voltage test on oversheath according to 6.1, i.e. both ends of cable needs to be accessible for testing while being rolled up on drums.

Marking of the delivery drums shall be made with relevant information for the installation and identification of cable. Markings on the drums shall be indelible and made by weather resistant plastic laminated notes/documents on outside of both drum flanges. 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

1.6. Documentation

Documentation of cable and accessories shall as minimum include completed datasheets, drawings, type test reports, reference list etc according to item A, B and C in this document.

[1] If batch number is not presented on sheath, manufacturer shall present how individual length traceability is done.

2. Outdoor termination specification

2.1. General

The termination shall meet the requirements in IEC 60840:2020, IEC 60815 and IEC 60137, which all shall be used as engineering standards.

2.2. Termination construction

The design of the termination shall be of dry type[2]. The termination shall be
- Highest system voltage (U_m) of 52 kV and 72.5 kV: Self-supporting or non-self-supporting type.
- Highest system voltage (U_m) of 145 kV and 170 kV. Self-supporting type.

The termination shall have a composite insulator with a creepage distance according to IEC 60815-3.

Voltage **kV**	**Minimum creepage distance** **Class Medium (c)** **mm**	**Minimum creepage distance** **Class Heavy (d)** **mm**
52	1040	1300
72.5	1450	2060
145	2900	3620
170	3400	4250

Class of minimum creepage distance will be stated by client.

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

The termination shall have a system for insulated installation enabling DC-voltage tests of 10 kV DC on the oversheath.

Earth connections for screen wires, earthing bonds on the termination body/housing etc. shall be designed so 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.

[2] Note: For U_m = 170 kV, fluid filled termination can be accepted.

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

The termination shall withstand a surrounding air temperature outdoor of- 40°C to +40°C, solar radiation of 1000 W/m^2 and wind velocity ≤ 34 m/s.

3. Straight through joint

3.1. General

The straight through joint shall meet the requirements in IEC 60840:2020, which shall be used as a general engineering standard.

3.2. Joint construction

The joint shall be of
- Highest system voltage (U_m) of 52 kV and 72,5 kV. Heat-shrink type or prefabricated joint where prefabricated rubber bodies are installed over the prepared cable ends.
- Highest system voltage (U_m) of 145 kV and 170 kV. Prefabricated joint where prefabricated rubber bodies are installed over the prepared cable ends.

The joint will be directly buried in soil.
The joint shall electrically and thermally be dimensioned to be fully adapted with the XLPE-cable.
The metallic laminate layer (for radial water tightness) shall be properly (electrical) connected to the copper wire screen.
The recovering of the copper wire screen wires over the joint area shall be made so that a short circuit current, in case of a fault, will not damage the joint (current level determined by the XLPE-cable screen).
The XLPE-cable shall be supplied with an extruded conductive layer on the oversheath and the joint shall therefore be supplied with a system for electrical connection of these layers on both sides.
The joint shall meet the requirements in IEC 60840:2020, including § 12.4.2 g – test of outer protection for joints (Annex H).

4. Type, sample, and routine testing

4.1. General

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

a) Underground XLPE-cable
b) Outdoor termination
c) Straight through joint

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.

4.2. Type test

4.2.1. General

Tests shall be performed on a cable length including outdoor termination and joints, according to IEC 60840:2020 § 12.4.2.

Type testing may be excluded in the contract if the bidder 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.

Type test report shall not be older than 10 years.

4.2.2. Electrical tests

Tests shall be performed on a cable length including outdoor termination and joints, according to IEC 60840:2020 § 12.4.2

4.2.3. Non-electrical tests

Tests shall be performed on a cable length according to IEC 60840:2020 § 12.5.

4.3. Routine tests on cables and accessories

Shall be performed according to IEC 60840:2020 § 9.

4.4. Sample test

4.4.1. Tests on cables

The number of sample tests shall follow IEC 60840:2020 § 10.2, however the number shall never be less than two, performed on two delivery lengths taken from start respectively end of XLPE manufacturing.

The sample tests shall be performed according to IEC 60840:2020 § 10 with an addition:
- measurement of diameters, over core respectively over sheath, according to §10.8.
- clearing (transparency) test.
- measurement of copper screen cross section (number of copper wires, diameter, total cross section) and measurement of copper counter helix.

4.4.2. Tests on accessories

Shall be performed according to IEC 60840:2020 § 11.

4.5. Witness of routine and sample testing

Ellevio shall have the right to witness the routine and sample test of the cable length(s). Notification shall be sent latest two weeks before start of testing. An ITP related to routine tests and sample tests, but not limited to these tests only, shall be enclosed to the notification.

5. Tests after installation

5.1. Tests on the complete installed cable system

a) Phase sequence test. Shall be performed according to an established standard method.

b) DC voltage test of the oversheath, IEC 60840:2020 § 16.2.

c) Cable (system) impedance test. Positive, negative and zero sequence impedance.

d) AC-test with normal operation voltage for 24 h, IEC 60840:2020 § 16.3[3].

[3] Generally performed by Ellevio.

A. Data Sheet - Underground Cable

1. CONSTRUCTION DATA

1.1	**Conductor**		
1.1.1	Type (round, stranded, compacted etc.)		
1.1.2	Material	Aluminum	
1.1.3	Cross sectional area		mm^2
1.1.4	Nominal diameter		mm
1.1.5	Allowable tensile strength		N/mm^2
1.1.6	Number of wires in the conductor		pcs.
1.1.7	Milliken conductor. Number of segments in the conductor Number of wires in each segment		 pcs 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		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 vulcanization 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 angel of wires		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	Longitudinal water sealing layers above screen wires: - type description (swelling tapes etc.) - test report enclosed with bid (Y/N)		
1.3.10	Nominal thickness of longitudinal water sealing layer		mm
1.3.11	Radial water sealing layer: - type description (Al-foil/laminate/tape) - layer bonded to the oversheath (Y/N)		
1.3.12	Radial water sealing layer: - nominal thickness of Al - nominal thickness of entire foil - cross sectional area Al-foil		 mm mm mm^2
1.3.13	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		mm
1.4.5	Nominal thickness		mm
1.4.6	Colour		

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

1.6	**Cable dimensions and weight**		
1.6.1	Nominal overall cable diameter		mm
1.6.2	Nominal weight of complete cable		kg/m

2. ELECTRICAL AND THERMAL DATA

Ampacity, impedance, and inductance calculations shall be based on the following:

a) One group of three cables in trefoil formation in ground or in duct in ground
b) Screens solidly earthed in ground
c) Thermal resistivity of protective fill and refill 1,0 K*m/W
d) Laying depth 0,9 m (counted from ground to upper edge of the top-phase).
e) Duct of PE with dimension 148 mm/160 mm (ø inner/ ø outer). One cable per duct.

Calculations according to IEC 60287.

2.1	**Electrical and thermal data**		
2.1.1	Rated voltage Uo/U (Um) kV		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	Cables buried in ground. Continuous current capacity (A/phase) at 90°C conductor temp. and 15°C soil temp.		A
2.1.7	Cables buried in ground. Continuous current capacity (A/phase) at 90°C conductor temp and 5°C soil temp.		A
2.1.8	Cables buried in ground. Continuous current capacity (A/phase) at 65°C conductor temp. and 15°C soil temp.		A
2.1.9	Cables buried in ground. Continuous current capacity (A/phase) at 65°C conductor temp. and 5°C soil temp		A
2.1.10	Cables in ducts in ground. Continuous current capacity (A/phase) at 90°C conductor temp. and 15°C soil temp.		A
2.1.11	Cables in ducts in ground. Continuous current capacity (A/phase) at 90°C conductor temp. and 5°C soil temp.		A
2.1.12	Cables in ducts in ground. Continuous current capacity (A/phase) at 65°C conductor temp. and 15°C soil temp.		A
2.1.13	Cables in ducts in ground. Continuous current capacity (A/phase) at 65°C conductor temp. and 5°C soil temp.		A
2.1.14	Screen earthing system		
2.1.15	Nominal capacitance of cable		µF/km
2.1.15	Inductance of cable		mH/km
2.1.13	Positive and negative sequence impedance (R+jX) at 50 Hz and continuous conductor temperature 65°C		Ω/km
2.1.14	Zero sequence impedance (R+jX) at 50 Hz and continuous conductor temperature 65°C		Ω/km
2.1.15	Positive and negative sequence impedance (R+jX) at 50 Hz and continuous conductor temperature 90°C		Ω/km

2.1.16	Zero sequence impedance (R+jX) at 50Hz and continuous conductor temperature 90°C		Ω/km
2.1.17	Nominal electric field strength at U_m - at insulation screen - at conductor screen		 kV/mm kV/mm
2.1.18	Max. copper screen DC-resistance at 20 °C (for true screen length in the cable with consideration taken to the screen lay/pitch)		Ω/km
2.1.19	Max. metallic screen resistance (Cu-screen and Al-foil) DC-resistance at 20°C.		Ω/km
2.1.20	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

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

Cable on delivery drum shall be prepared for DC-voltage test on oversheath according to 6.1, i.e., both ends of cable needs to be accessible for testing while being rolled up on drums.

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 please 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

5. Complementary cable information

5.1	**Complementary information**	
5.1.1	Description how cable ends will be prepared for sheath testing on delivery drum	
5.1.2	Description how individual length traceability is made when this information is not marked on sheath.	

A.Data Sheet - Outdoor Termination

1. CONSTRUCTION DATA

1.1	Type of termination (dry type)	
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	Color of insulator body	

2. ELECTRICAL & CLIMATIC MAIN DATA

	Rated voltage Uo/U (Um) kV		kV
	Lightning impulse withstand voltage		kV
	Continuous and overload current capacity		A
	Creepage distance: - total - protected		 mm mm
	Mechanical loads on the top bolt: - in 90° angle to the termination - axially		 N N
	Top bolt: - material - surface treatment		
	Top bolt dimensions: - ∅ (diameter) - length (for jumper-wire clamp)		 mm mm
	Short circuit withstand for the bonding cable t connection at the termination		 kA
	Max. installation inclination		degrees
	Weight of complete termination (including filling compound)		 kg

	Rated ambient temperature conditions -min -max		 °C °C
	Rated wind conditions -max		 m/s

3. DOCUMENTATION, SERVICE EXPERIENCE ETC.

	Enclosed reference list No./Nos.	
	Enclosed sectional drawing No./Nos.	
	Enclosed type test report No./Nos.	
	Approximately number of outdoor termination actual type: - sold - in commercial operation - first year of commercial operation	

B.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		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	Methods for radial and longitudinal water sealing at the joint (both into cables and the joint) i.e., design and description of the water barrier		
1.12	Method and material for connection of bonding cable to the screen wires		
	One-phase short circuit current withstand for screen and bonding cable connection	Same or higher as for the cable screen !	kA
	Description of protective outer cover (method, material etc.)		
	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	Rated voltage Uo/U (Um) kV		kV
2.2	Lightning impulse withstand voltage		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	Sectional drawing No.	
3.2	Type test reports including Water Immersion test according to Annex H Nos.	
3.4	Reference list No.	
3.5	Approximately number of 145 kV joints of actual type: - sold - in commercial operation - first year of commercial operation	

6. Omfattning (Ellevio internal)

Denna instruktion är en teknisk specifikation som omfattar kabelsystem för spänningsnivåerna 52 – 170 kV exklusive 110 kV (som har en egen specifikation).

7. Giltighet och revision (Ellevio internal)

Instruktionen är godkänd av ordföranden för Nätkommittén, och granskas och revideras vid behov.

8. Syfte (Ellevio internal)

Syftet med instruktionen är att vara materialspecifikation för FFU vid upphandling av kabelsystem.