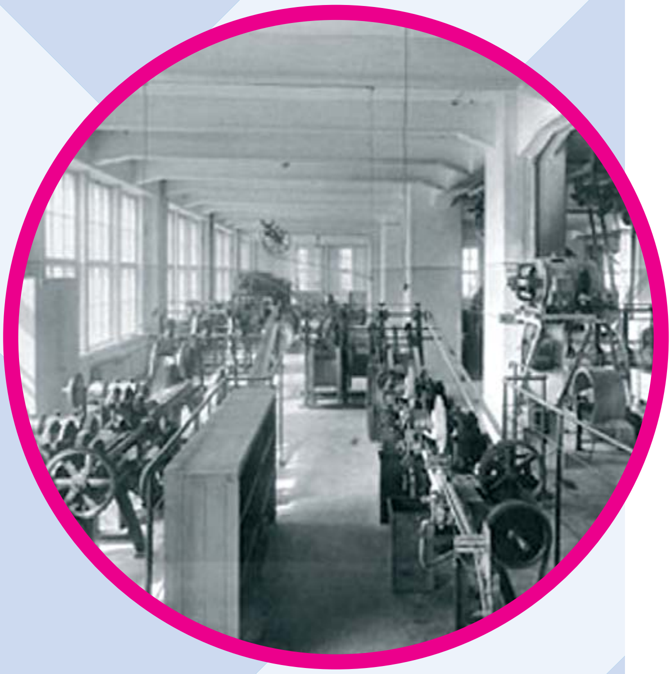
PRYSMIAN
CABLES & SYSTEMS

High Voltage Cables



The history of cables

With long experience since 1912 Prysmian Cables and Systems Oy is today one of the leading cable manufacturers in the world.

Today

The Prysmian Group has more than 50 production plants in several countries on all continents.
In addition to this the company has a worldwide network of sales and representative offices.

Prysmian Cables and Systems Oy, located in Pikkala, Finland, produces energy cables - from extra high (400 kV) to low voltage, for land, submarine and overhead applications - along with a wide range of accessories. All our products can be tailored to meet the customer's requirements.

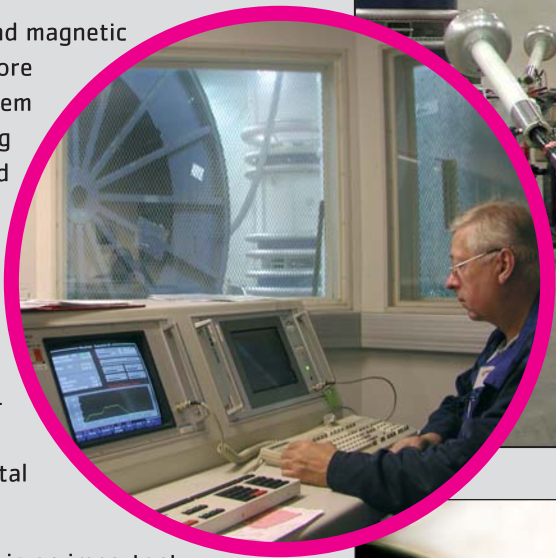
Our company has been the forerunner in high voltage cable technology for several decades. We have experience in supplying all types of high voltage cable systems throughout the world with full turn key capability.

Environmental and reliability aspects

When planning a new supply route, consideration of the environment is becoming more and more important due to regulation and public opinion.

The XLPE cables are environmentally friendly and safe.

The cable system is invisible. The required right of way is very small and normally after the installation the land can be used again for its original purpose. This can result in considerable savings.



Reducing the electrical and magnetic fields is also becoming more important. The cable system can be designed according to different magnetic field requirements, and the external electrical fields are zero.

Cable systems offer better safety to both workers and general public, with fewer dangerous situations due to accidental contacts or flashovers.

Reliability of the network is an important factor because the loss of supply has high cost consequences. Cable systems are less vulnerable for failures compared to overhead lines.

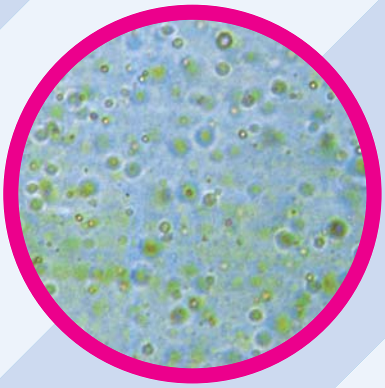
Prysmian sets High Standards

Partial discharges in the cable's insulation are regarded as one of the main reasons for electrical breakdown. Most recognized national and international standards permit discharges of 5 pC. However, our policy is not to allow deliveries of cables with any detectable discharges. Our new test set-up allows testing of up to 400 kV cables at a measuring sensitivity which is considerably better than the above requirement.

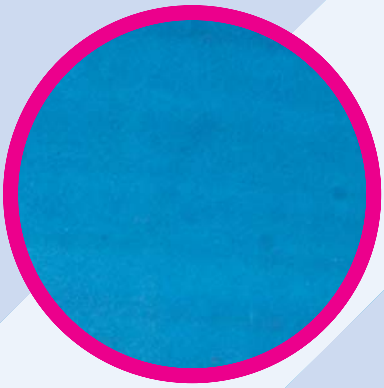
We are certified according to ISO 9001 Quality and ISO 14001 Environmental Management System standards for our activities.

High Voltage Cables

Cross-linked polyethylene insulation manu-factured using conventional process.



Cross-linked polyethylene insulation manu-factured using the CDCC process.



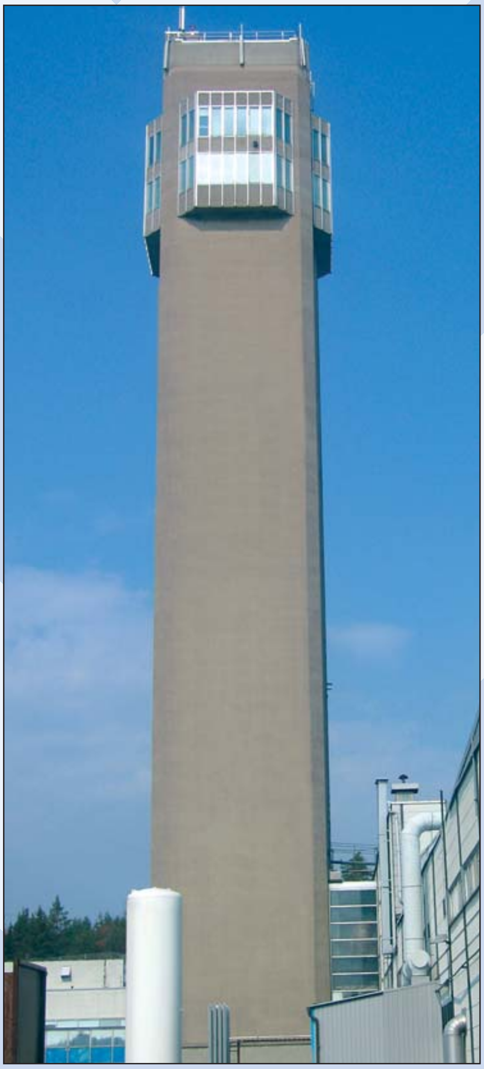
Completely Dry Curing and Cooling

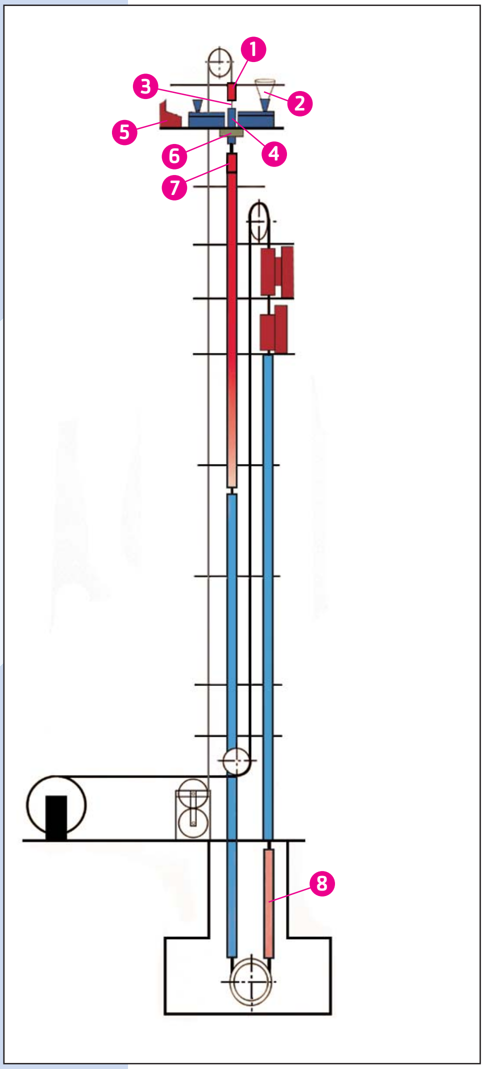
With Prysmian's Completely Dry Curing and Cooling method (developed under the name of Nokia Cables) the insulation is kept absolutely dry during the whole manufacturing process. This prevents the electrochemical treeing during the whole lifetime of the cable. Our high voltage cables are equipped with a metallic moisture barrier protecting the insulation from subsoil humidity.

With the CDCC method, Prysmian has strengthened its position as one of the world's most prominent cable manufacturers and as a forerunner in the field of XLPE cables since 1975.

The conductor screen, insulation and insulation screen are extruded at the same time, i.e. triple extruded.

Curing takes place in a vulcanizing tube pressurized by nitrogen gas. Besides fully dry curing, cooling in dry conditions is another important feature. It is achieved by using nitrogen gas.





The insulation does not come into contact with water in any form during the whole manufacturing process. It is a well-known fact that high voltage insulation should be kept moisture-free and research shows that this also applies to XLPE insulation. Prysmian's CDCC cables represent high quality and high cable life expectancy.

Vertical CDCC-line up to 420 kV

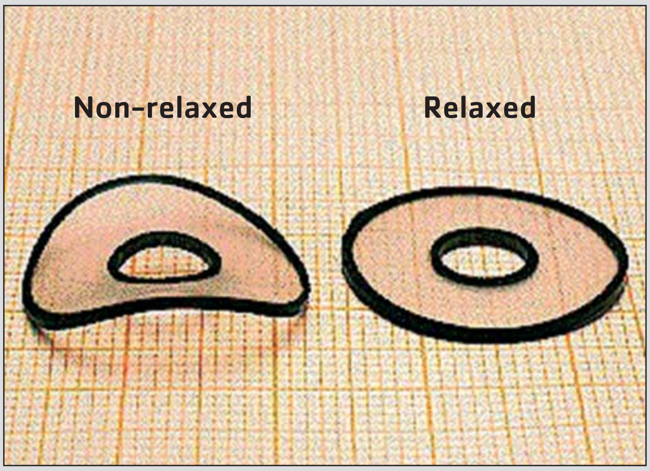
1. Conductor preheating
2. Clean room. Gravity feeding of insulation
3. On-line material purity control
4. Triple extrusion
5. Process control Autocure 3
6. X-ray wall thickness measurement
7. Post heater
8. On-line relaxation

On-line relaxation

First in the world, since 1994, our production line has been equipped with the unique on-line relaxation system, giving benefits as:

- increased impulse voltage withstand
- reduced internal mechanical stresses
- minimized shrinkback behaviour

The on-line relaxation unit consists of an additional heating zone located in the middle of the cooling section of the vulcanizing line. Insulation surface is heated up and cooled down again. This treatment reduces significantly both internal mechanical stresses and shrinkback of XLPE insulation.



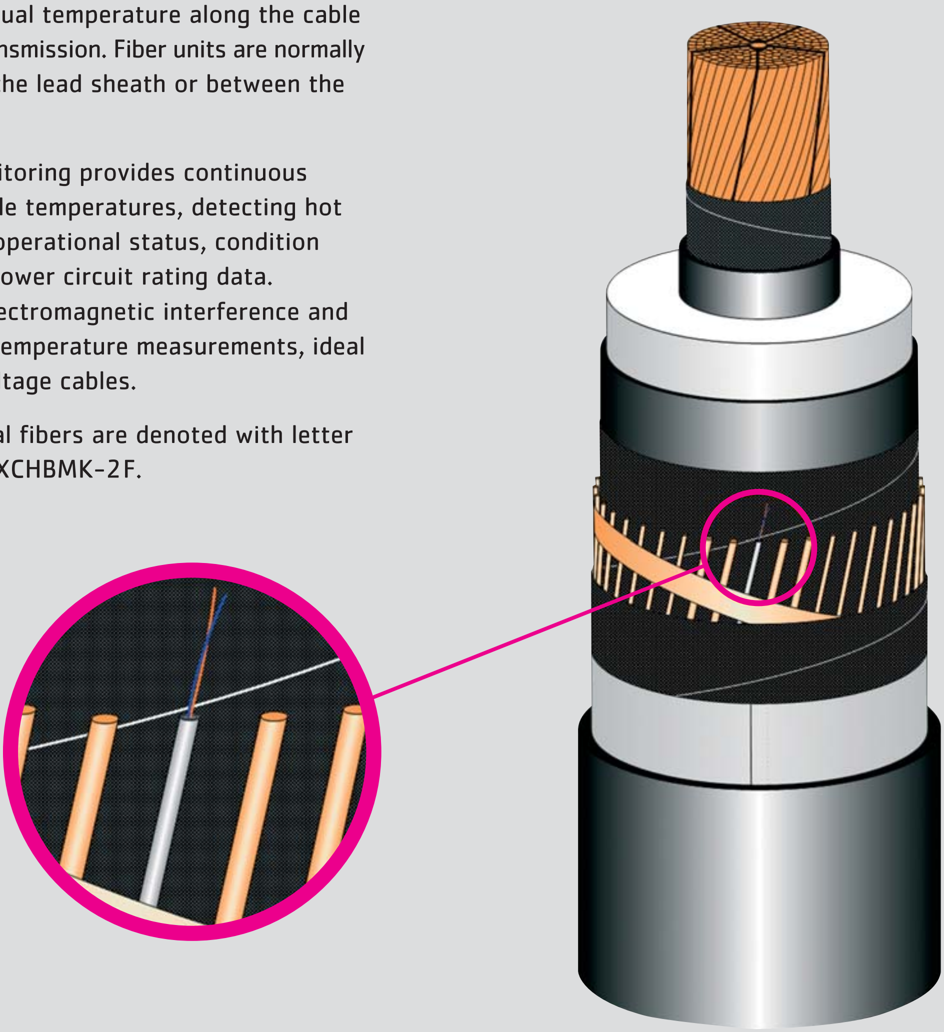
Two samples from the same cable and the same test run.
The only difference between these samples is the use of relaxation.

Integrated optical fiber unit

Optical fibers in power cables can be used for measuring the actual temperature along the cable line or for data transmission. Fiber units are normally embedded under the lead sheath or between the screen wires.

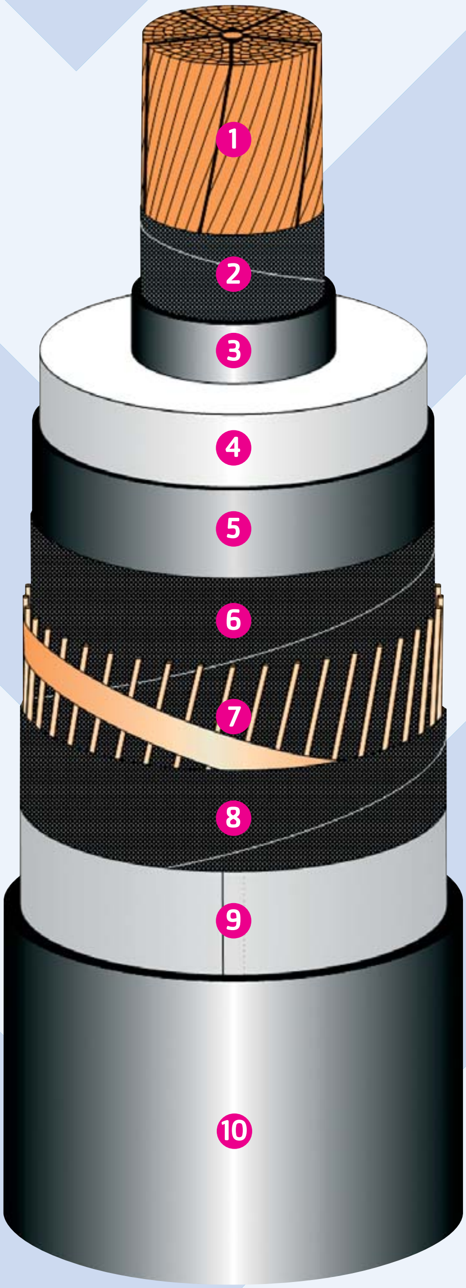
Temperature monitoring provides continuous monitoring of cable temperatures, detecting hot spots, delivering operational status, condition assessment and power circuit rating data.
It is immune to electromagnetic interference and provides reliable temperature measurements, ideal for use in high voltage cables.

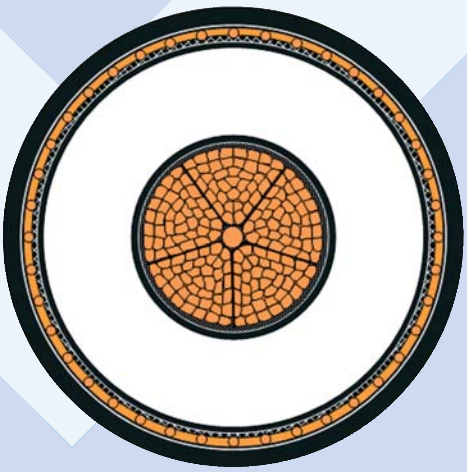
Cables with optical fibers are denoted with letter ´F´, for example HXCHBMK-2F.



Standard Specifications

We manufacture High Voltage Cables according to any international or national standard.
The two most common standard constructions are described on page 6-7.





HXCHBMK / AHXCHBMK

Single core XLPE insulated power cable with copper wire screen and foil laminate sheath

1. **Conductor**
   Longitudinally watertight segmental stranded and compacted copper or aluminium
2. **Binder tapes**
   Semiconducting waterblocking tapes and binder tapes
3. **Conductor screen**
   Extruded semiconducting copolymer compound
4. **Insulation**
   Extruded superclean XLPE compound
5. **Insulation screen**
   Extruded semiconducting copolymer compound
6. **Bedding**
   Semiconducting waterblocking tapes
7. **Metallic screen**
   A layer of copper wire helix and a copper contact tape counter helix
8. **Separation tape**
   Semiconducting waterblocking tapes and binder tapes
9. **Radial water barrier**
   Aluminium or copper foil laminate
10. **Outer sheath**
    Extruded PE or HFFR

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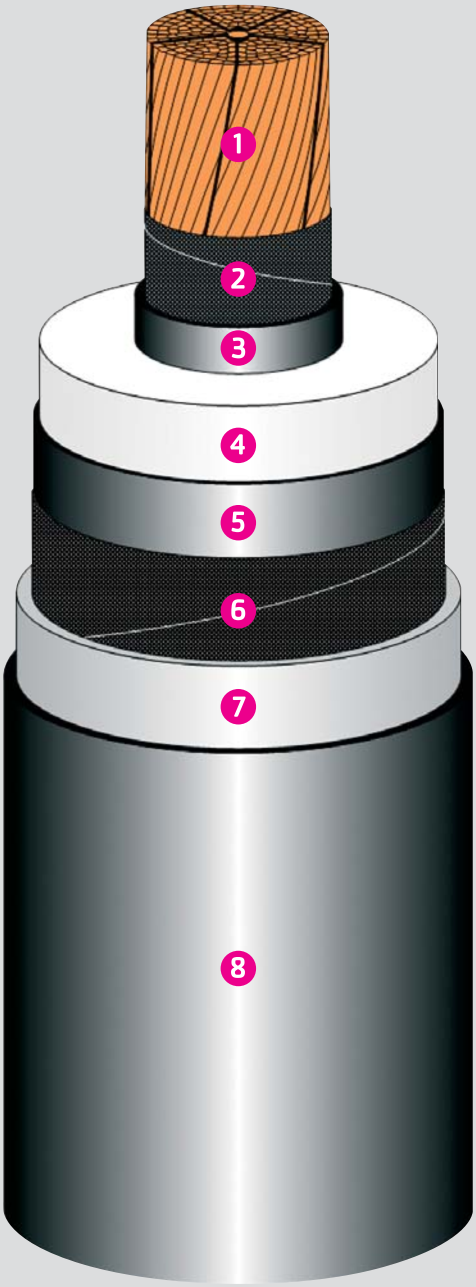
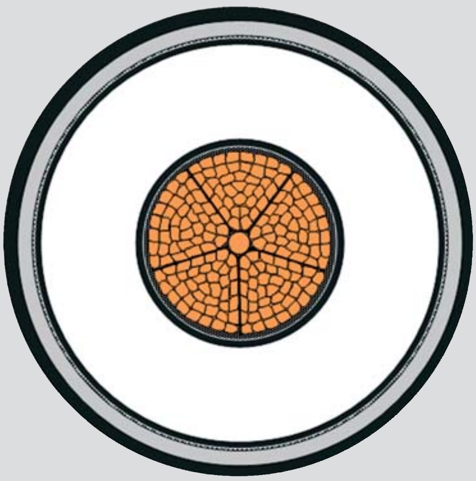




HXLMK / AHXLMK

Single core XLPE insulated power cable with lead sheath

1. **Conductor**
   Longitudinally watertight segmental stranded and compacted copper or aluminium
2. **Binder tapes**
   Semiconducting waterblocking tapes and binder tapes
3. **Conductor screen**
   Extruded semiconducting copolymer compound
4. **Insulation**
   Extruded superclean XLPE compound
5. **Insulation screen**
   Extruded semiconducting copolymer compound
6. **Bedding**
   Semiconducting waterblocking tapes
7. **Metallic sheath**
   Extruded lead, alloy E
8. **Outer sheath**
   Extruded PE, PVC or HFFR

Sample Constructions

Rated voltages
U_0/U = 38/66 kV
U_m = 72.5 kV
U_p = 325 kV
Rated temperatures
- Maximum permissible temp. of conductor in continuous use 90°C
- Maximum permissible temp. of conductor in short-circuit 250°C (for durations up to 5 sec.)

Standard IEC 60840

72 kV Cables 36/66 kV Single core, XLPE-insulated high voltage power cables

Nominal cross-sectional area of conductor		mm^2	300	500	800	1200	1600

Constructional data

Outer diameter	With aluminium conductor	mm	60	67	74	83	90
	With copper conductor	mm	60	67	74	85	93
Net weight with Pb sheath	With aluminium conductor	kg/km	6800	8400	11000	14000	16500
	With copper conductor	kg/km	8750	12000	16000	22000	27500
Recommended minimum bending radius during laying		m	1.1	1.2	1.3	1.5	1.7

Electrical properties at 66 kV and 50 Hz

Aluminium conductor	Maximum DC-resistance			at 20°C	Ω/km	0.1000	0.0605	0.0367	0.0247	0.0186
	Effective-resistance, screens bonded at both ends	Flat formation	Conductor temperature	20°C	Ω/km	0.120	0.084	0.065	0.059	0.056
				65°C	Ω/km	0.136	0.092	0.068	0.059	0.055
				90°C	Ω/km	0.145	0.097	0.070	0.060	0.055
		Trefoil formation	Conductor temperature	20°C	Ω/km	0.106	0.068	0.047	0.037	0.033
				65°C	Ω/km	0.123	0.078	0.052	0.040	0.035
				90°C	Ω/km	0.133	0.084	0.055	0.042	0.036
Copper conductor	Maximum DC-resistance			at 20°C	Ω/km	0.0601	0.0366	0.0221	0.0151	0.0113
	Effective-resistance, screens bonded at both ends	Flat formation	Conductor temperature	20°C	Ω/km	0.080	0.061	0.051	0.047	0.047
				65°C	Ω/km	0.089	0.064	0.052	0.046	0.045
				90°C	Ω/km	0.093	0.066	0.052	0.045	0.044
		Trefoil formation	Conductor temperature	20°C	Ω/km	0.067	0.045	0.033	0.024	0.022
				65°C	Ω/km	0.076	0.050	0.036	0.025	0.022
				90°C	Ω/km	0.082	0.054	0.038	0.026	0.023
DC-resistance of metallic screen at 20°C approx.					Ω/km	0.74	0.62	0.51	0.40	0.35
Inductance		Flat formation			mH/km	0.59	0.56	0.53	0.51	0.50
		Trefoil formation			mH/km	0.40	0.37	0.34	0.33	0.32
Operating capacitance					μF/km	0.20	0.25	0.30	0.35	0.40
Charging current					A/km	2.3	2.7	3.5	4.3	4.8

Continuous current-carrying capacities

Conductor	Cables laid	Conductor temperature	Laying formation	Screen circuit						
Aluminium	In ground of 15°C	65°C	Flat	Open	A	435	575	750	910	1040
				Closed	A	415	525	640	710	750
			Trefoil	Open	A	415	545	700	830	930
				Closed	A	410	535	680	790	870
		90°C	Flat	Open	A	515	680	890	1080	1235
				Closed	A	490	625	770	860	920
			Trefoil	Open	A	490	645	830	990	1110
				Closed	A	485	635	805	945	1045
	In air of 25°C	90°C	Flat	Open	A	685	930	1265	1555	1815
				Closed	A	660	865	1105	1270	1390
			Trefoil	Open	A	605	820	1095	1335	1535
				Closed	A	600	810	1085	1320	1515
Copper	In ground of 15°C	65°C	Flat	Open	A	560	730	940	1200	1390
				Closed	A	520	635	740	820	855
			Trefoil	Open	A	535	685	860	1095	1240
				Closed	A	525	670	820	1005	1105
		90°C	Flat	Open	A	660	865	1115	1415	1645
				Closed	A	620	765	900	1005	1055
			Trefoil	Open	A	630	815	1025	1305	1485
				Closed	A	620	795	980	1205	1335
	In air of 25°C	90°C	Flat	Open	A	880	1185	1585	2040	2420
				Closed	A	830	1065	1305	1505	1620
			Trefoil	Open	A	775	1035	1355	1765	2065
				Closed	A	770	1025	1340	1685	1940

Maximum permissible short-circuit currents for short-circuit duration of one second

Aluminium conductor	kA	28.3	47.2	75.6	113.4	151.2
Copper conductor	kA	42.8	71.4	114.2	171.4	228.5

Sample Constructions

123 kV Cables 64/110 kV Single core, XLPE-insulated high voltage power cables

Rated voltages
U_0/U = 64/110 kV
U_m = 123 kV
U_p = 550 kV
Rated temperatures
- Maximum permissible temp. of conductor in continuous use 90°C
- Maximum permissible temp. of conductor in short-circuit 250°C (for durations up to 5 sec.)

Standard IEC 60840

Nominal cross-sectional area of conductor		mm^2	300	500	800	1200	1600

Constructional data

Outer diameter	With aluminium conductor	mm	67	74	82	92	99
	With copper conductor	mm	67	74	83	94	102
Net weight with Pb sheath	With aluminium conductor	kg/km	8100	10100	13000	16500	19000
	With copper conductor	kg/km	10050	13500	18500	24500	30000
Recommended minimum bending radius during laying		m	1.2	1.3	1.5	1.7	1.8

Electrical properties at 110 kV and 50 Hz

						300	500	800	1200	1600
Aluminium conductor	Maximum DC-resistance			at 20°C	Ω/km	0.1000	0.0605	0.0367	0.0247	0.0186
	Effective-resistance, screens bonded at both ends	Flat formation	Conductor temperature	20°C	Ω/km	0.123	0.088	0.070	0.064	0.061
				65°C	Ω/km	0.139	0.096	0.072	0.064	0.060
				90°C	Ω/km	0.148	0.101	0.074	0.064	0.060
		Trefoil formation	Conductor temperature	20°C	Ω/km	0.107	0.069	0.048	0.038	0.034
				65°C	Ω/km	0.125	0.079	0.053	0.041	0.036
				90°C	Ω/km	0.134	0.085	0.056	0.043	0.037
Copper conductor	Maximum DC-resistance			at 20°C	Ω/km	0.0601	0.0366	0.0221	0.0151	0.0113
	Effective-resistance, screens bonded at both ends	Flat formation	Conductor temperature	20°C	Ω/km	0.084	0.065	0.056	0.052	0.052
				65°C	Ω/km	0.092	0.068	0.056	0.050	0.049
				90°C	Ω/km	0.096	0.070	0.057	0.050	0.048
		Trefoil formation	Conductor temperature	20°C	Ω/km	0.068	0.046	0.034	0.025	0.023
				65°C	Ω/km	0.077	0.051	0.037	0.027	0.024
				90°C	Ω/km	0.083	0.054	0.038	0.028	0.024
DC-resistance of metallic screen at 20°C approx.					Ω/km	0.62	0.51	0.42	0.34	0.30
Inductance		Flat formation			mH/km	0.61	0.58	0.55	0.53	0.52
		Trefoil formation			mH/km	0.42	0.39	0.36	0.35	0.33
Operating capacitance					µF/km	0.15	0.20	0.25	0.30	0.30
Charging current					A/km	3.3	3.8	4.6	5.6	6.2

Continuous current-carrying capacities

Conductor	Cables laid	Conductor temperature	Laying formation	Screen circuit		300	500	800	1200	1600
Aluminium	In ground of 15°C	65°C	Flat	Open	A	435	575	750	905	1035
				Closed	A	410	515	625	690	730
			Trefoil	Open	A	415	545	700	830	930
				Closed	A	410	530	675	785	860
		90°C	Flat	Open	A	510	675	885	1075	1230
				Closed	A	490	615	750	840	895
			Trefoil	Open	A	490	640	830	990	1110
				Closed	A	485	630	800	940	1035
	In air of 25°C	90°C	Flat	Open	A	675	915	1235	1520	1775
				Closed	A	645	850	1075	1230	1350
			Trefoil	Open	A	605	815	1085	1325	1525
				Closed	A	600	805	1070	1300	1490
Copper	In ground of 15°C	65°C	Flat	Open	A	560	730	935	1190	1380
				Closed	A	510	625	720	790	825
			Trefoil	Open	A	530	685	860	1085	1230
				Closed	A	520	665	815	985	1080
		90°C	Flat	Open	A	660	860	1110	1410	1640
				Closed	A	610	750	875	970	1015
			Trefoil	Open	A	630	810	1025	1295	1475
				Closed	A	620	790	975	1190	1310
	In air of 25°C	90°C	Flat	Open	A	870	1165	1555	1995	2360
				Closed	A	815	1035	1270	1450	1565
			Trefoil	Open	A	775	1035	1350	1745	2040
				Closed	A	770	1020	1330	1655	1900

Maximum permissible short-circuit currents for short-circuit duration of one second

		300	500	800	1200	1600
Aluminium conductor	kA	28.3	47.2	75.6	113.4	151.2
Copper conductor	kA	42.8	71.4	114.2	171.4	228.5

Sample Constructions

Rated voltages
U_0/U = 76/132 kV
U_m = 145 kV
U_p = 650 kV
Rated temperatures
- Maximum permissible temp. of conductor in continuous use 90°C
- Maximum permissible temp. of conductor in short-circuit 250°C (for durations up to 5 sec.)

Standard IEC 60840

145 kV Cables 76/132 kV Single core, XLPE-insulated high voltage power cables

Nominal cross-sectional area of conductor		mm²	500	800	1200	1600	2000

Constructional data

		Unit	500	800	1200	1600	2000
Outer diameter	With aluminium conductor	mm	74	82	92	99	105
	With copper conductor	mm	74	83	94	102	109
Net weight with Pb sheath	With aluminium conductor	kg/km	10100	13000	16500	19000	22000
	With copper conductor	kg/km	13500	18500	24500	30000	35500
Recommended minimum bending radius during laying		m	1.3	1.5	1.7	1.8	1.9

Electrical properties at 132 kV and 50 Hz

Conductor	Property	Formation		Temp.	Unit	500	800	1200	1600	2000
Aluminium conductor	Maximum DC-resistance			at 20°C	Ω/km	0.0605	0.0367	0.0247	0.0186	0.0149
	Effective-resistance, screens bonded at both ends	Flat formation	Conductor temperature	20°C	Ω/km	0.089	0.070	0.064	0.061	0.062
				65°C	Ω/km	0.097	0.073	0.064	0.060	0.060
				90°C	Ω/km	0.101	0.074	0.064	0.060	0.059
		Trefoil formation	Conductor temperature	20°C	Ω/km	0.070	0.048	0.039	0.034	0.032
				65°C	Ω/km	0.080	0.053	0.042	0.036	0.034
				90°C	Ω/km	0.085	0.056	0.043	0.037	0.034
Copper conductor	Maximum DC-resistance			at 20°C	Ω/km	0.0366	0.0221	0.0151	0.0113	0.0090
	Effective-resistance, screens bonded at both ends	Flat formation	Conductor temperature	20°C	Ω/km	0.065	0.057	0.052	0.052	0.054
				65°C	Ω/km	0.068	0.057	0.051	0.050	0.051
				90°C	Ω/km	0.070	0.057	0.050	0.048	0.049
		Trefoil formation	Conductor temperature	20°C	Ω/km	0.046	0.035	0.025	0.023	0.022
				65°C	Ω/km	0.052	0.037	0.027	0.024	0.022
				90°C	Ω/km	0.055	0.039	0.028	0.024	0.022
DC-resistance of metallic screen at 20°C approx.					Ω/km	0.51	0.42	0.34	0.30	0.26
Inductance		Flat formation			mH/km	0.58	0.55	0.53	0.52	0.51
		Trefoil formation			mH/km	0.39	0.36	0.35	0.33	0.32
Operating capacitance					μF/km	0.20	0.25	0.30	0.30	0.35
Charging current					A/km	4.6	5.5	6.7	7.5	8.2

Continuous current-carrying capacities

Conductor	Cables laid	Conductor temperature	Laying formation	Screen circuit	Unit	500	800	1200	1600	2000
Aluminium	In ground of 15°C	65°C	Flat	Open	A	570	745	905	1030	1135
				Closed	A	515	620	685	725	745
			Trefoil	Open	A	540	695	830	925	1000
				Closed	A	530	670	780	855	905
		90°C	Flat	Open	A	675	885	1075	1230	1355
				Closed	A	615	750	840	895	920
			Trefoil	Open	A	640	825	990	1110	1200
				Closed	A	630	800	935	1035	1100
	In air of 25°C	90°C	Flat	Open	A	915	1235	1520	1770	1980
				Closed	A	845	1075	1230	1345	1415
			Trefoil	Open	A	815	1085	1325	1520	1680
				Closed	A	805	1070	1300	1490	1635
Copper	In ground of 15°C	65°C	Flat	Open	A	725	935	1190	1375	1530
				Closed	A	620	720	790	820	825
			Trefoil	Open	A	685	860	1085	1230	1330
				Closed	A	660	810	985	1075	1130
		90°C	Flat	Open	A	860	1110	1410	1635	1825
				Closed	A	750	875	970	1015	1030
			Trefoil	Open	A	810	1025	1290	1470	1600
				Closed	A	790	975	1185	1310	1380
	In air of 25°C	90°C	Flat	Open	A	1165	1555	1990	2360	2655
				Closed	A	1035	1265	1450	1565	1620
			Trefoil	Open	A	1030	1350	1745	2035	2260
				Closed	A	1020	1325	1650	1895	2075

Maximum permissible short-circuit currents for short-circuit duration of one second

	Unit	500	800	1200	1600	2000
Aluminium conductor	kA	47.2	75.6	113.4	151.2	189.1
Copper conductor	kA	71.4	114.2	171.4	228.5	285.7

Sample Constructions

170 kV Cables 89/154 kV Single core, XLPE-insulated high voltage power cables

Rated voltages
U_o/U = 89/154 kV
U_m = 170 kV
U_p = 750 kV
Rated temperatures
- Maximum permissible temp. of conductor in continuous use 90°C
- Maximum permissible temp. of conductor in short-circuit 250°C (for durations up to 5 sec.)

Standard IEC 60840

Nominal cross-sectional area of conductor	mm²	500	800	1200	1600	2000
Nominal cross-sectional area of screen	mm²	95	95	95	95	95

Constructional data

Outer diameter	With aluminium conductor	mm	80	88	97	104	110
	With copper conductor	mm	80	89	100	107	114
Net weight with Cu screen	With aluminium conductor	kg/km	6150	7700	9600	11500	13000
	With copper conductor	kg/km	9300	13500	18000	22000	26500
Recommended minimum bending radius during laying		m	1.6	1.8	2.0	2.1	2.3

Electrical properties at 154 kV and 50 Hz

Aluminium conductor	Maximum DC-resistance			at 20°C	Ω/km	0.0605	0.0367	0.0247	0.0186	0.0149
	Effective-resistance, screens bonded at both ends	Flat formation	Conductor temperature	20°C	Ω/km	0.118	0.095	0.084	0.079	0.079
				65°C	Ω/km	0.126	0.098	0.085	0.079	0.079
				90°C	Ω/km	0.131	0.101	0.086	0.079	0.079
		Trefoil formation	Conductor temperature	20°C	Ω/km	0.081	0.058	0.048	0.043	0.043
				65°C	Ω/km	0.090	0.062	0.049	0.043	0.043
				90°C	Ω/km	0.095	0.065	0.051	0.044	0.044
Copper conductor	Maximum DC-resistance			at 20°C	Ω/km	0.0366	0.0221	0.0151	0.0113	0.0090
	Effective-resistance, screens bonded at both ends	Flat formation	Conductor temperature	20°C	Ω/km	0.094	0.081	0.072	0.068	0.066
				65°C	Ω/km	0.097	0.082	0.072	0.068	0.065
				90°C	Ω/km	0.099	0.083	0.072	0.067	0.065
		Trefoil formation	Conductor temperature	20°C	Ω/km	0.057	0.045	0.035	0.031	0.029
				65°C	Ω/km	0.061	0.046	0.035	0.031	0.029
				90°C	Ω/km	0.064	0.047	0.036	0.031	0.029
DC-resistance of metallic screen at 20°C approx.					Ω/km	0.20	0.20	0.20	0.20	0.20
Inductance		Flat formation			mH/km	0.60	0.57	0.55	0.53	0.52
		Trefoil formation			mH/km	0.41	0.38	0.36	0.35	0.33
Operating capacitance					μF/km	0.17	0.20	0.24	0.27	0.29
Charging current					A/km	4.7	5.6	6.8	7.5	8.2

Continuous current-carrying capacities

Conductor	Cables laid	Conductor temperature	Laying formation	Screen circuit						
Aluminium	In ground of 15°C	65°C	Flat	Open	A	575	750	905	1035	1135
				Closed	A	465	550	610	650	675
			Trefoil	Open	A	540	690	815	910	985
				Closed	A	510	630	730	795	845
		90°C	Flat	Open	A	680	885	1075	1235	1360
				Closed	A	560	665	745	795	830
			Trefoil	Open	A	640	820	975	1095	1185
				Closed	A	605	760	880	970	1035
	In air of 25°C	90°C	Flat	Open	A	915	1235	1515	1765	1980
				Closed	A	790	980	1125	1235	1325
			Trefoil	Open	A	820	1085	1320	1515	1675
				Closed	A	790	1025	1225	1385	1510
Copper	In ground of 15°C	65°C	Flat	Open	A	725	935	1190	1375	1530
				Closed	A	535	610	680	715	740
			Trefoil	Open	A	670	845	1055	1185	1290
				Closed	A	620	745	885	960	1020
		90°C	Flat	Open	A	855	1115	1410	1635	1825
				Closed	A	650	750	830	880	915
			Trefoil	Open	A	800	1010	1265	1430	1555
				Closed	A	740	900	1075	1175	1250
	In air of 25°C	90°C	Flat	Open	A	1145	1550	1985	2340	2640
				Closed	A	925	1120	1295	1410	1495
			Trefoil	Open	A	1020	1345	1725	2005	2225
				Closed	A	965	1240	1535	1735	1890

Maximum permissible short-circuit currents for short-circuit duration of one second

Aluminium conductor	kA	47.2	75.6	113.4	151.2	189.1
Copper conductor	kA	71.4	114.2	171.4	228.5	285.7

PRYSMIAN CABLES & SYSTEMS

Sample Constructions

245 kV Cables 127/220 kV Single core, XLPE-insulated high voltage power cables

Rated voltages
U_o/U = 127/220 kV
U_m = 245 kV
U_p = 1050 kV
Rated temperatures
- Maximum permissible temp. of conductor in continuous use 90°C
- Maximum permissible temp. of conductor in short-circuit 250°C (for durations up to 5 sec.)

Standard IEC 62067

Nominal cross-sectional area of conductor	mm^2	500	800	1200	1600	2000
Nominal cross-sectional area of screen	mm^2	95	95	95	95	95

Constructional data

Outer diameter	With aluminium conductor	mm	91	98	106	113	119
	With copper conductor	mm	91	100	108	115	122
Net weight with Cu screen	With aluminium conductor	kg/km	7500	9000	11000	13000	14500
	With copper conductor	kg/km	11000	15000	19000	23500	28000
Recommended minimum bending radius during laying		m	1.8	2.0	2.2	2.3	2.4

Electrical properties at 220 kV and 50 Hz

Aluminium conductor	Maximum DC-resistance			at 20°C	Ω/km	0.0605	0.0367	0.0247	0.0186	0.0149
	Effective-resistance, screens bonded at both ends	Flat formation	Conductor temperature	20°C	Ω/km	0.120	0.097	0.085	0.080	0.077
				65°C	Ω/km	0.127	0.100	0.086	0.080	0.076
				90°C	Ω/km	0.132	0.102	0.087	0.080	0.076
		Trefoil formation	Conductor temperature	20°C	Ω/km	0.083	0.060	0.049	0.043	0.040
				65°C	Ω/km	0.091	0.063	0.050	0.044	0.040
				90°C	Ω/km	0.096	0.066	0.052	0.045	0.041
Copper conductor	Maximum DC-resistance			at 20°C	Ω/km	0.0366	0.0221	0.0151	0.0113	0.0090
	Effective-resistance, screens bonded at both ends	Flat formation	Conductor temperature	20°C	Ω/km	0.096	0.079	0.073	0.069	0.067
				65°C	Ω/km	0.099	0.080	0.073	0.068	0.066
				90°C	Ω/km	0.101	0.081	0.073	0.068	0.065
		Trefoil formation	Conductor temperature	20°C	Ω/km	0.059	0.042	0.035	0.032	0.030
				65°C	Ω/km	0.062	0.043	0.036	0.031	0.029
				90°C	Ω/km	0.065	0.045	0.036	0.031	0.029
DC-resistance of metallic screen at 20°C approx.					Ω/km	0.20	0.20	0.20	0.20	0.20
Inductance		Flat formation			mH/km	0.62	0.58	0.56	0.54	0.53
		Trefoil formation			mH/km	0.44	0.40	0.38	0.36	0.35
Operating capacitance					µF/km	0.14	0.18	0.21	0.23	0.25
Charging current					A/km	5.8	7.3	8.3	9.2	10.0

Continuous current-carrying capacities

Conductor	Cables laid	Conductor temperature	Laying formation	Screen circuit						
Aluminium	In ground of 15°C	65°C	Flat	Open	A	565	730	890	1015	1115
				Closed	A	460	540	600	640	665
			Trefoil	Open	A	525	670	800	895	965
				Closed	A	500	615	715	780	830
		90°C	Flat	Open	A	665	865	1060	1215	1340
				Closed	A	555	655	735	785	820
			Trefoil	Open	A	625	800	960	1080	1170
				Closed	A	595	740	865	950	1015
	In air of 25°C	90°C	Flat	Open	A	875	1160	1450	1690	1890
				Closed	A	760	935	1085	1190	1270
			Trefoil	Open	A	795	1040	1285	1475	1625
				Closed	A	770	985	1195	1350	1470
Copper	In ground of 15°C	65°C	Flat	Open	A	715	955	1170	1350	1500
				Closed	A	535	620	670	705	730
			Trefoil	Open	A	660	865	1030	1160	1255
				Closed	A	610	760	865	945	1000
		90°C	Flat	Open	A	850	1135	1390	1610	1795
				Closed	A	645	755	825	870	905
			Trefoil	Open	A	790	1035	1235	1400	1525
				Closed	A	730	920	1055	1160	1230
	In air of 25°C	90°C	Flat	Open	A	1115	1520	1895	2235	2510
				Closed	A	905	1105	1250	1355	1430
			Trefoil	Open	A	1005	1355	1670	1940	2150
				Closed	A	955	1250	1495	1690	1835

Maximum permissible short-circuit currents for short-circuit duration of one second

Aluminium conductor	kA	47.2	75.6	113.4	151.2	189.1
Copper conductor	kA	71.4	114.2	171.4	228.5	285.7

Sample Constructions

Rated voltages
U_o/U = 200/345 kV
U_m = 362 kV
U_p = 1175 kV
Rated temperatures
- Maximum permissible temp. of conductor in continuous use 90°C
- Maximum permissible temp. of conductor in short-circuit 250°C (for durations up to 5 sec.)

Standard IEC 62067

362 kV Cables 200/345 kV Single core, XLPE-insulated high voltage power cables

		630	800	1200	1600	2000
Nominal cross-sectional area of conductor	mm^2	630	800	1200	1600	2000
Nominal cross-sectional area of screen	mm^2	95	95	95	95	95

Constructional data

			630	800	1200	1600	2000
Outer diameter	With aluminium conductor	mm	111	112	115	122	128
	With copper conductor	mm	111	112	117	124	131
Net weight with Cu screen	With aluminium conductor	kg/km	11000	11500	12500	14500	16000
	With copper conductor	kg/km	15000	16500	20500	25000	29500
Recommended minimum bending radius during laying		m	2.2	2.2	2.3	2.5	2.6

Electrical properties at 345 kV and 50 Hz

						630	800	1200	1600	2000
Aluminium conductor	Maximum DC-resistance			at 20°C	Ω/km	0.0469	0.0367	0.0247	0.0186	0.0149
	Effective-resistance, screens bonded at both ends	Flat formation	Conductor temperature	20°C	Ω/km	0.110	0.100	0.089	0.083	0.080
				65°C	Ω/km	0.114	0.102	0.089	0.082	0.079
				90°C	Ω/km	0.118	0.105	0.090	0.083	0.079
		Trefoil formation	Conductor temperature	20°C	Ω/km	0.072	0.062	0.051	0.046	0.042
				65°C	Ω/km	0.077	0.065	0.052	0.045	0.042
				90°C	Ω/km	0.081	0.068	0.053	0.046	0.042
Copper conductor	Maximum DC-resistance			at 20°C	Ω/km	0.0283	0.0221	0.0151	0.0113	0.0090
	Effective-resistance, screens bonded at both ends	Flat formation	Conductor temperature	20°C	Ω/km	0.091	0.083	0.076	0.072	0.070
				65°C	Ω/km	0.092	0.083	0.075	0.070	0.068
				90°C	Ω/km	0.093	0.084	0.075	0.070	0.068
		Trefoil formation	Conductor temperature	20°C	Ω/km	0.053	0.044	0.037	0.034	0.032
				65°C	Ω/km	0.055	0.045	0.037	0.032	0.030
				90°C	Ω/km	0.057	0.046	0.037	0.033	0.030
DC-resistance of metallic screen at 20°C approx.					Ω/km	0.20	0.20	0.20	0.20	0.21
Inductance		Flat formation			mH/km	0.64	0.61	0.58	0.56	0.55
		Trefoil formation			mH/km	0.45	0.42	0.39	0.38	0.36
Operating capacitance					μF/km	0.13	0.16	0.18	0.20	0.22
Charging current					A/km	8.2	9.9	11.6	12.7	13.9

Continuous current-carrying capacities

Conductor	Cables laid	Conductor temperature	Laying formation	Screen circuit		630	800	1200	1600	2000
Aluminium	In ground of 15°C	65°C	Flat	Open	A	635	715	870	995	1090
				Closed	A	500	535	595	630	655
			Trefoil	Open	A	590	660	785	875	945
				Closed	A	550	605	700	765	815
		90°C	Flat	Open	A	760	855	1045	1195	1320
				Closed	A	605	655	730	780	815
			Trefoil	Open	A	705	790	945	1065	1155
				Closed	A	665	735	855	940	1005
	In air of 25°C	90°C	Flat	Open	A	990	1125	1420	1650	1845
				Closed	A	845	925	1080	1185	1265
			Trefoil	Open	A	905	1020	1265	1455	1605
				Closed	A	870	975	1180	1335	1460
Copper	In ground of 15°C	65°C	Flat	Open	A	805	935	1140	1320	1460
				Closed	A	570	610	665	695	720
			Trefoil	Open	A	735	845	1005	1130	1225
				Closed	A	665	745	850	925	975
		90°C	Flat	Open	A	960	1120	1370	1585	1765
				Closed	A	695	750	820	865	895
			Trefoil	Open	A	880	1020	1215	1375	1495
				Closed	A	805	905	1045	1145	1215
	In air of 25°C	90°C	Flat	Open	A	1250	1480	1855	2185	2455
				Closed	A	995	1100	1250	1360	1435
			Trefoil	Open	A	1135	1335	1645	1910	2120
				Closed	A	1070	1235	1480	1675	1825

Maximum permissible short-circuit currents for short-circuit duration of one second

		630	800	1200	1600	2000
Aluminium conductor	kA	59.5	75.6	113.4	151.2	189.1
Copper conductor	kA	90.0	114.2	171.4	228.5	285.7

Sample Constructions

420 kV Cables 220/400 kV Single core, XLPE-insulated high voltage power cables

Rated voltages
U_0/U = 220/400 kV
U_m = 420 kV
U_p = 1425 kV
Rated temperatures
- Maximum permissible temp. of conductor in continuous use 90°C
- Maximum permissible temp. of conductor in short-circuit 250°C (for durations up to 5 sec.)

Standard IEC 62067

Nominal cross-sectional area of conductor	mm²	800	1000	1200	1600
Nominal cross-sectional area of screen	mm²	95	95	95	95

Constructional data

Outer diameter	With aluminium conductor	mm	123	124	124	127
	With copper conductor	mm	122	123	125	128
Net weight with Cu screen	With aluminium conductor	kg/km	13000	13500	14000	15500
	With copper conductor	kg/km	18500	20500	22000	26000
Recommended minimum bending radius during laying		m	2.4	2.5	2.5	2.6

Electrical properties at 400 kV and 50 Hz

Aluminium conductor	Maximum DC-resistance			at 20°C	Ω/km	0.0367	0.0291	0.0247	0.0186
	Effective-resistance, screens bonded at both ends	Flat formation	Conductor temperature	20°C	Ω/km	0.101	0.094	0.090	0.085
				65°C	Ω/km	0.103	0.095	0.090	0.083
				90°C	Ω/km	0.106	0.096	0.091	0.084
		Trefoil formation	Conductor temperature	20°C	Ω/km	0.063	0.056	0.052	0.047
				65°C	Ω/km	0.066	0.057	0.052	0.046
				90°C	Ω/km	0.069	0.059	0.054	0.047
Copper conductor	Maximum DC-resistance			at 20°C	Ω/km	0.0221	0.0176	0.0151	0.0113
	Effective-resistance, screens bonded at both ends	Flat formation	Conductor temperature	20°C	Ω/km	0.084	0.079	0.077	0.074
				65°C	Ω/km	0.084	0.078	0.076	0.071
				90°C	Ω/km	0.084	0.079	0.076	0.071
		Trefoil formation	Conductor temperature	20°C	Ω/km	0.045	0.040	0.038	0.035
				65°C	Ω/km	0.046	0.040	0.038	0.033
				90°C	Ω/km	0.047	0.041	0.038	0.033
DC-resistance of metallic screen at 20°C approx.					Ω/km	0.20	0.20	0.20	0.21
Inductance		Flat formation			mH/km	0.62	0.60	0.59	0.57
		Trefoil formation			mH/km	0.44	0.42	0.41	0.38
Operating capacitance					μF/km	0.14	0.16	0.17	0.19
Charging current					A/km	10.3	11.5	12.3	14.0

Continuous current-carrying capacities

Conductor	Cables laid	Conductor temperature	Laying formation	Screen circuit					
Aluminium	In ground of 15°C	65°C	Flat	Open	A	715	800	865	980
				Closed	A	540	570	595	625
			Trefoil	Open	A	660	725	775	865
				Closed	A	605	660	700	760
		90°C	Flat	Open	A	855	960	1040	1185
				Closed	A	655	700	730	775
			Trefoil	Open	A	790	875	940	1055
				Closed	A	735	805	855	935
	In air of 25°C	90°C	Flat	Open	A	1125	1265	1390	1630
				Closed	A	935	1015	1080	1185
			Trefoil	Open	A	1025	1150	1250	1440
				Closed	A	980	1090	1175	1330
Copper	In ground of 15°C	65°C	Flat	Open	A	930	1045	1130	1300
				Closed	A	615	645	660	690
			Trefoil	Open	A	840	930	995	1115
				Closed	A	740	805	840	910
		90°C	Flat	Open	A	1110	1255	1360	1570
				Closed	A	755	795	820	860
			Trefoil	Open	A	1010	1130	1210	1365
				Closed	A	905	985	1035	1135
	In air of 25°C	90°C	Flat	Open	A	1450	1670	1825	2160
				Closed	A	1100	1195	1250	1355
			Trefoil	Open	A	1320	1500	1630	1895
				Closed	A	1230	1375	1470	1665

Maximum permissible short-circuit currents for short-circuit duration of one second

Aluminium conductor	kA	75.6	94.5	113.4	151.2
Copper conductor	kA	114.2	142.8	171.4	228.5

High Voltage Cables

Using the tables

The electrical properties and continuous current ratings apply for lead sheathed cables with our normal sheath thickness. The thickness of sheath and especially the cross-section of copper screen can be adjusted according to the required short circuit rating of sheath or screen.

Where loading is cyclic, appreciable increase in current capacities may be justified. Refer to IEC Publication 60853 for calculation of the cyclic ratings.

In cable circuits having no magnetic saturating materials the positive and negative sequence impedances are equal and can be deduced from the tabulated effective resistance and inductance values corrected as required for frequencies other than 50 Hz.

Zero sequence impedance for solidly bonded systems can be roughly estimated as the sum of the resistances of conductor and sheath and a reactance of 0.05 to 0.1 ohms/km depending on the proportion of diameters of sheath and conductor at 50 to 60 Hz. For single point bonded systems the zero sequence impedance depends on the ground wires and any other grounded metallic objects along the cable route.

Selecting a power cable

Different kinds of power cable constructions are required to transport electrical energy from the power station to the consumer.
The following factors are important when selecting a suitable cable construction:

- Maximum operating voltage
- Insulation level
- Frequency
- Load to be carried
- Daily load curve
- Magnitude and duration of possible overloads currents phase-to-phase and phase-to-earth
- Connection between overhead and cable line (whether directly or via a transformator)
- Insulation level of equipment (bareconductor insulators, arresters, etc.)
- Voltage drop
- Length of line
- Profile of line
- Mode of installation:
  - underground (whether directly or in ducts)
  - in air (if in a tunnel, the dimensions and mode of ventilation of the tunnel)
- Chemical and physical properties of the soil:
  - whether rocky, sandy, clay or boggy; moist or dry
  - chemical agents liable to cause corrosion etc.
  - the maximum thermal resistivity of the soil
- Maximum and minimum ambient air and soil temperatures, bearing in mind nearby hotwater pipes and other factors liable to heat the cables
- Specifications and requirements to be met
- The cable should be economical to use; an optimum cross-sectional area can be calculated based on the capital costs of the cable and its running costs incurred by the power losses in the cable

High Voltage Cables

Voltages

Rated voltage
The voltage which forms the basis for certain operating characteristics and test conditions is called the rated voltage and is denoted U_o/U where
U_o = the voltage between the conductor and earth or earthed metallic cover (concentric conductor, screen, armouring, metal sheath)
U = the voltage between the phase conductors

Operating voltage
U_m = the maximum continuously permissible operating voltage of the network at any time or in any part of the network, excluding temporary fluctuations such as those occuring during switching or faults.

Relationship between U_o/U and U_m in three phase systems are as follows according to IEC specifications:

U_o/U kV	36/66	64/110	76/132	127/220	190/345	220/400
U_m kV	72.5	123	145	245	362	420

and according to USA Standard C-84: 1-1995

U_o/U kV	40/69	66/115	80/138	132/230	200/345
U_m kV	72.5	121	145	242	362

Complete System Supply

It is essential that the accessories and cables are type-tested together forming a complete system. We supply a full range of accessories and fittings for the splicing and terminating as well as tools and equipment, complete with instructions for installation. We also provide planning and supervision of the complete system packages.

Standards

The cables described in this catalogue are our standard types, and their performance has been proven in operation. Construction and tests are in accordance with IEC publications where applicable.

Custom designed cables

Power cables ranging from 72.5 kV to 420 kV can be manufactured also according to other standards (eg. AEIC, VDE, BS, SEN), regulations or specifications in-line with the customers' requirements.

Circular Mils

In American standards the cross section area is expressed in Circular Mils Ac.

$$A = \frac{Ac}{1973.5} \text{ mm}^2$$

Cross-Sections in mm^2 converted into Circular Mils

mm^2	185	300	500	800	1200	1600	2000
kcmil	365	590	990	1580	2370	3160	3950

Weights and dimensions

Weights, dimensions and characteristic data are approximate. Deviations due to different constructions are reserved.

Sheath marking

Our standard embossed or surface printed outer sheath marking on round cables consists of:

- name of manufacturer
- type designation, cross-sectional area of conductor, rated voltage and year of manufacture
- continuous length marking every meter or every few feet.

Example:
AHXLMK 1 x 300 mm² 132 kV 2006 1234 m

Laying information

Minimum permissible bending radii during laying:

- during pulling of power cables, the bending radii should not be smaller than the values given on pages 8-14
- in the case of single bends, the above values may be reduced to a min. of 70 % if the cables are carefully and evenly bent only once before a termination (around a prefabricated bow, if necessary).

Max. permissible pulling tension during laying:

- during laying of power cables particular attention must be paid to the permissible tensile forces
- permissible tensile forces when pulling by cable pulling grip:
  F = A x 15 N/mm²
  (cable with Al-conductor)
  F = A x 20 N/mm²
  (cable with Cu-conductor)
  maximum value in both cases is 8500 N
- maximum recommended tensile forces when pulling eye is attached to the conductor:

  Al-conductors; ≤ 800 mm², F = A x 70 N/mm²
  > 800 mm², F = A x 50 N/mm²
  Cu-conductors; ≤ 800 mm², F = A x 90 N/mm²
  > 800 mm², F = A x 70 N/mm²

  A = cross-sectional area of conductor in mm² (without screen and conc. conductor)

Minimum permissible cable temperature during laying:

- XLPE insulated cables U > 30 kV; -5°C for HFFR and PVC-sheath, -15°C for PE-sheath. At lower temperature the cables must be adequately warmed up beforehand. This can be done by storing the cables in a heated room for several days or by means of special equipment.

Resistances

Direct Current resistance

The maximum DC resistance values of conductors at 20°C are shown in cable standards.

The DC resistance at other conductor temperatures may be calculated using the equation:

$$R = R_{20}\left[1+\alpha_{20}(t-20°C)\right]$$

R = DC resistance at temperature t, Ω/km
R_{20} = DC resistance of cond. at 20°C, Ω/km
t = temperature of conductor, °C
α_{20} = temperature coefficient of the resistance at 20°C, 1/°C

for copper conductors $\alpha_{20} = 0.00393$
for Al. cond. and sheath $\alpha_{20} = 0.00403$
for lead alloy sheath $\alpha_{20} = 0.00400$

On pages 8-14 are given:

- maximum DC resistance of conductors at 20°C (in accordance with IEC 60228)
- calculated DC resistance of metallic sheaths and metallic screens at 20°C

Effective resistance

The effective resistance (= alternating current resistance) is made up of the DC resistance and the extra resistance, which takes into account additional losses caused by the current displacement in the conductor (skin effect, proximity effect), dielectrical losses in insulation circulating currents in the metal sheath or screen and eddy currents as well as magnetic reversal in the armour.

On pages 8-14 are given effective resistance of conductors at 20°C and at maximum conductor temperature. They are based on the following presumptions:

- frequency 50 Hz
- closed screen circuit
- distance between single core cables
  - in case of flat formation = one cable diam.
  - in case of trefoil formation = cables touching each other.

Inductance

The values for the inductance of single core cables have been calculated based on the following presumptions:

- open screen circuit
- distance between single core cables
  - in case of flat formation = one cable diam.
  - in case of trefoil formation = cables touching each other.

Operating capacitance, charging current and earth fault current

The values for the operating capacitance of the cables are average values based on measurements and calculations.

The values for the charging current are valid at a temperature of 20°C, at a frequency of 50 Hz and at a rated voltage of the cable.

The values of capacitance, charging current and earth fault current will not change when using XLPE insulated cables when the temperature increases from 20°C to the maximum permissible continuous conductor temperature.

Continuous current-carrying capacity

A separate group of three single core cables can be continuously loaded according to the tables on pages 8 to 14 if the presumptions below are fulfilled. Correction factors for other installations are given in tables 1-7.
The current-carrying capacities are calculated in accordance with the IEC Publication 60287 and under the presumptions given below.

Presumptions
- One three-phase group of single core cables
- Maximum permissible temperature of inner conductor in continuous use:
- XLPE insulated cables 90°C
- Ambient air temperature 25°C
- Ground temperature 15°C
- Depth of laying of cables 1.0 m
- Distance between single core cables:
  - in case of flat formation = one cable diam.
  - in case of trefoil formation = cables touching each other
- Thermal resistivity of soil 1.0 K m/W
- Cable in air = heat dissipation conditions same as if cables in free air.
- Open screen circuit in single core cable group = circuit of metal sheaths, concentric conductors or metallic screens connected to each other and earthed at one point only = screens bonded at a single point. In addition, screen circuit is considered open when cross-bonded at equal interval.
- Closed screen circuit in single core cable group = circuit of metal sheaths, concentric conductors or metallic screens connected to each other at both ends of the group and earthed at least at one end = screens bonded at both ends.

XLPE-insulated cables buried directly in ground
XLPE-insulated cables can continuously be loaded to a conductor temperature of 90°C.
In underground installations, if a cable in the ground is continuously operated at this highest rated conductor temperature, the thermal resistivity of the soil surrounding the cable may in the course of time increase from its original value as a result of the drying-out processes. As a consequence, the conductor temperature may greatly exceed the highest rated value.

Using single-point bonding or cross-bonding instead of both-end bonding results in considerable increase in current carrying capacity.

Short-circuit current capacity

When planning cable installations, care has to be taken that the cables and fittings chosen are capable of withstanding the expected dynamic and thermal short-circuit stresses.

The dynamic stresses depend on the max. asymmetric short-circuit current and the thermal stresses on the mean short-circuit current.

Dynamic stresses
Generally cables and their standard accessories will withstand the dynamic stresses under short-circuit conditions, but near the power stations it is important to take into consideration the dynamic short-circuit current capacity and to pay attention to the technique of installation.

Thermal stresses
On pages 8 to 14 are given the max. permissible short-circuit currents for short-circuit duration of one second and the values are based on the following presumptions:
- before short-circuit the temperature of conductors = max. permissible temperature of conductor in continuous use
- max. permissible temperature of conductor in short-circuit is 250°C for XLPE-insulated cables
- the permissible short-circuit currents for short-circuit duration of 0.2 up to 5 seconds may be calculated by multiplying the value of max. permissible short-circuit current for short-circuit duration of one second by the figure $1/\sqrt{t}$, where t is the duration of short-circuit in seconds.

Correction factors for the current-carrying capacity

The following tables of correction factors are to be applied to the current-carrying capacity when installation conditions vary from the presumptions above.

The rating for most conditions can be quickly estimated by multiplying the continuous current-carrying capacity value by the correction factors given in the appropriate tables 1-7.

Table 1. Correction factors for groups of cables buried directly in ground

Spacing between groups of cables, mm	Numbers of groups of single core cables beside each other: 2	3	4	5	6	8	10
0 (touching)	0.79	0.69	0.63	0.58	0.55	0.50	0.46
70	0.85	0.75	0.68	0.64	0.60	0.56	0.53
250	0.87	0.79	0.75	0.72	0.69	0.66	0.64

The values apply to groups of three single core cables (in trefoil or flat formation) without or with spacing between the cable groups horizontally placed.

Table 2. Correction factors for different thermal resistivities of soil

Thermal resistivity of soil Km/W	0.7	1.0	1.2	1.5	2.0	2.5	3.0
Correction factor	1.10	1.00	0.92	0.85	0.75	0.69	0.63

Examples of thermal resistivities of soil:
- dry sand (moisture content 0%) 3.0 K m/W
- dry gravel and clay 1.5 K m/W
- semi-dry gravel and sand (moisture content 10%) 1.2 K m/W
- semi-dry and moist gravel 1.0 K m/W
- moist clay and sand (moisture content 25%) 0.7 K m/W

Table 3. Correction factors for different installation depths in ground

Depth of laying, m	0.50-0.70	0.71-0.90	0.91-1.10	1.11-1.30	1.31-1.50
Rating factor	1.05	1.02	1.00	0.97	0.95

Table 4. Correction factors for different ground temperatures

Conductor temperature	Ground temperature, C°										
C°	-5	0	5	10	15	20	25	30	35	40	45
90	1.13	1.10	1.06	1.03	1.00	0.96	0.93	0.89	0.86	0.82	0.77
80	1.14	1.11	1.07	1.04	1.00	0.96	0.92	0.88	0.83	0.78	0.73
70	1.17	1.13	1.09	1.04	1.00	0.95	0.90	0.85	0.80	0.73	0.67
65	1.18	1.14	1.10	1.05	1.00	0.95	0.89	0.84	0.77	0.71	0.63

Table 5. Correction factors for different cables in unfilled plastic pipes

Spacing between the tubes, mm	Numbers of tubes beside each other							
	1	2	3	4	5	6	8	10
0 (touching)	0.80	0.75	0.65	0.60	0.60	0.55	0.55	0.50
70		0.75	0.70	0.65	0.60	0.60	0.55	0.55
250		0.75	0.70	0.70	0.70	0.65	0.65	0.65

For parallel ducts with a group of three single core cables in each and with the cables equally loaded the current-carrying capacity indicated on pages 8 to 14 for cables buried directly in ground shall be reduced by correction factors given above.

The reduction in current carrying capacity can be avoided if the pipes after cable pulling are filled with material thermally equal to the ambient ground.

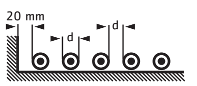
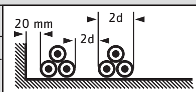
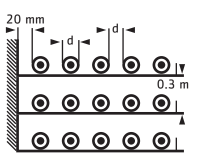
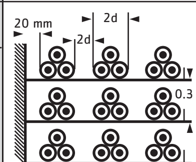
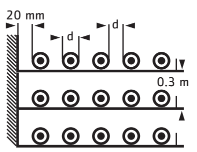
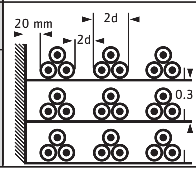
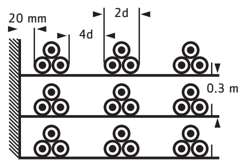
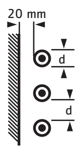
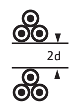
If factors in table 5 are used, factors in table 1 are not applicable.

Table 6. Correction factors for different ambient air temperatures

Conductor temperature	Ambient air temperature, C°									
C°	10	15	20	25	30	35	40	45	50	55
90	1.12	1.08	1.04	1.00	0.95	0.90	0.85	0.80	0.74	0.68
80	1.14	1.09	1.05	1.00	0.95	0.89	0.84	0.77	0.69	0.61
70	1.18	1.12	1.06	1.00	0.93	0.86	0.79	0.71	0.62	0.52
65	1.20	1.14	1.07	1.00	0.93	0.85	0.77	0.68	0.57	0.45

Table 7. Correction factors for different groups of three single core cables laid in the air

This applies only when the cable temperature does not affect the ambient air temperature.

Type of laying		Cables laid in flat formation Spacing = One cable diameter (d). Distance from the wall not less than 20 mm.				Cables laid in trefoil formation Spacing = Two cable diameters (2d). Distance from the wall not less than 20 mm.			
Number of groups		1	2	3		1	2	3	
		Correction factor				Correction factor			
On floor		0.92	0.89	0.88		0.95	0.90	0.88	
On metal trays (restricted air circulation)	Number of trays								
	1	0.92	0.89	0.88		0.95	0.90	0.88	
	2	0.87	0.84	0.83		0.90	0.85	0.83	
	3	0.84	0.82	0.81		0.88	0.83	0.81	
	6	0.82	0.80	0.79		0.86	0.81	0.79	
On metal ladders	Number of ladders								
	1	1.00	0.97	0.96		1.00	0.98	0.96	
	2	0.97	0.94	0.93		1.00	0.95	0.93	
	3	0.96	0.93	0.92		1.00	0.94	0.92	
	6	0.94	0.91	0.90		1.00	0.93	0.90	
Arrangements where reduction of current is not necessary		The cooling of cables in flat formation by increased spacing will get better while the losses in metallic screens and sheaths will increase reducing the current-carrying capacity. Each case must be calculated separately.							
Systems placed on top of each other		1	2	3		1	2	3	
		Correction factor				Correction factor			
On structures or on wall		0.94	0.91	0.89		0.89	0.86	0.84	

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