Selected
BUSINESS
Superbrand
INDIA 2010/11
Industry Validated

KEI Industries Limited

THE POWER

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BRUGG CABLES
Well connected.

KEI is under Technical Collaboration Agreement with
BRUGG to manufacture EHV cables up to 220kV

KEI
Wires and Cables
The power behind the power™

BEHIND THE POWER

Nature abounds in power of every kind, for every purpose. The wind energy, the solar energy or the electrical energy, clasped in the air around us, all waiting to be harnessed. To be controlled. Only a few especially skilled humans can find specific means to tame these natural resources or replicate them with perfection, for specific and general good. These are the specialists, who with the sheer power of their minds lend brilliance to millions of lives.

Wires and Cables

The power behind the power™

THE SPECIALIST

KEI. The wires and cables specialist is ever finding new ways to brighten up the world around. Making electrical energy easily, economically and most importantly adequately available to people and organizations. Like a magician, KEI comes up with products that harness and transport electrical power smoothly in requisite amounts wherever and whenever needed. The specialist in turn empowers millions of households, thousands of industries and the nation on the whole. KEI is thus the specialist who is the power behind all the power we see around us.

THE GENESIS

1968
Established a partnership firm to manufacture switch board cables for DOT

1985
Started manufacturing Control, Instrumentation and Thermocouple Cables

1993
Added manufacturing of PVC/XLPE Power Cables

EVOLUTION

1995
Came up with first IPO and became a Public Ltd. Co.

2001
Started manufacturing Rubber Cables

2002
Setting up of manufacturing facilities at Silvassa (D&NH) for producing Power Cables

2005
New project for manufacturing HT/XLPE cables upto 33kV

2006
Came up with FCCB issue of USD 36mn

2008
Successfully commissioned 100% EOU at Chopanki

2009
Successfully completed the upgradation of HT Cable capacity at Bhiwadi up to 132kV and HT Power Cables at Chopanki

2010
Entered into a technical collaboration with M/S Brugg Kabel AG, Switzerland to manufacture EHV cables upto 220kV and diversified into EPC business

THE COMPANY

KEI has earned a formidable reputation by nurturing relationships, ensuring timely execution of orders and becoming a reliable partner in executing client projects. Our uncompromised cost-effective quality and reliable product range that meets rigorous technical requirements of our customers has made us an undisputed industry leader. KEI has invested in building an intelligent infrastructure which ensures that our clients receive products that conform to their stringent requirements.

KEI is perhaps one of the few companies in India to offer customers a unique range of EHV cables and specialty cables such as fire survival cables, zero halogen cables and braided cables. An ability to utilize more than 90% of its resources makes KEI one of the most efficient players in the industry. KEI enjoys a unique flexibility to switch production between HT and LT cables depending on prevailing market conditions and demands.

An ISO 9001:2000 certified company; KEI carries out stringent quality control measures under surveillance of a competent team of technocrats and quality enablers. Continuous product innovations and cutting-edge R&D at KEI's in-house labs are what contribute towards constant evolution in our offerings and services. All KEI cables and wires are of a superior quality, a reason why they have been accredited and certified by Testing Agencies across the globe.

BRUGG / CABLES
Well connected.

THE ALLIANCE

TWO CABLE GIANTS.
ONE POWER PACKED FUTURE.

KEI has joined hands with M/s Brugg Kabel AG, a 110 year old Swiss cable giant to upgrade its technology and to manufacture EHV Cables upto 220kV. With this powerful collaboration, the wires and cables specialist is all set to empower many more Indian lives.

It is a KEI initiative that will take the Indian power industry to the next level. So come connect with KEI, connect with success.

BRUGG / CABLES

CERTIFICATION

TO WHOM SOEVER IT MAY CONCERN

This is to advise that we, M/s Brugg Kabel AG, Switzerland have signed a technical collaboration agreement for design, manufacture, testing of XLPE insulated cables 66kV / 110kV / 132kV / 220KV with M/s KEI Industries Ltd. D-90, Okhla Industrial Area, Phase-I, New Delhi 110020 with manufacturing units located at Bhiwadi Unit, SP-919/920, RIICO Industrial Area, Phase-III, Bhiwadi, Dist. Alwar 301019, Rajasthan & Chopanki Unit, Plot-A 280/281/282, Chopanki, Dist. Alwar, Rajasthan 301019.

By virtue of this agreement, the complete manufacturing of High Voltage / Extra High Voltage cables covering voltage grades 66KV / 110 KV / 132KV / 154KV / 220KV shall be done as per Brugg's design and manufacturing systems and the product quality shall meet the required standards as per IEC 60840 / IS7098-III as relevant and applicable. M/s. KEI Industries Ltd shall manufacture the above voltage class of cables under Licence from M/s. Brugg Kabel AG, Switzerland.

For HV cable systems project in above voltage categories executed under this agreement Brugg Kabel AG is prepared to assure back up support for successful operation for offered cable and accessories.

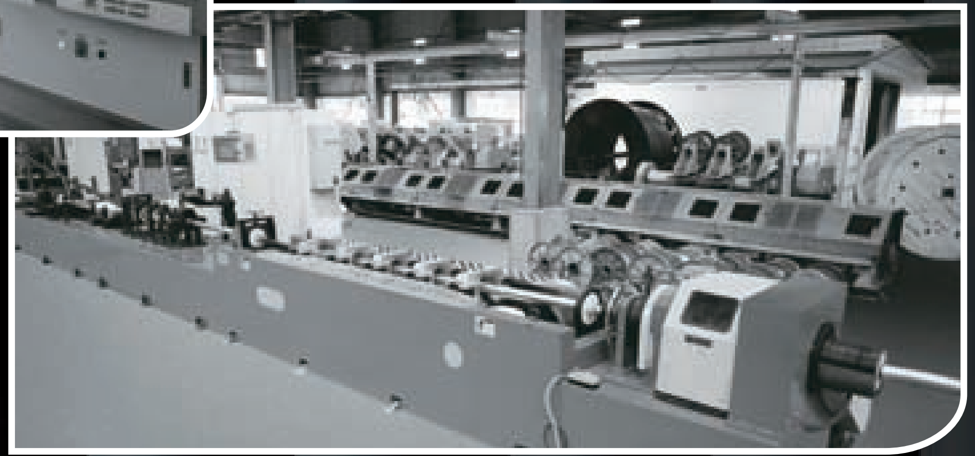
Markus Burger
CEO

Herbert Nyffenegger
Vice Director / Business Development

CH-5201 Brugg, Switzerland, December 29th, 2009

THE

OVERVIEW

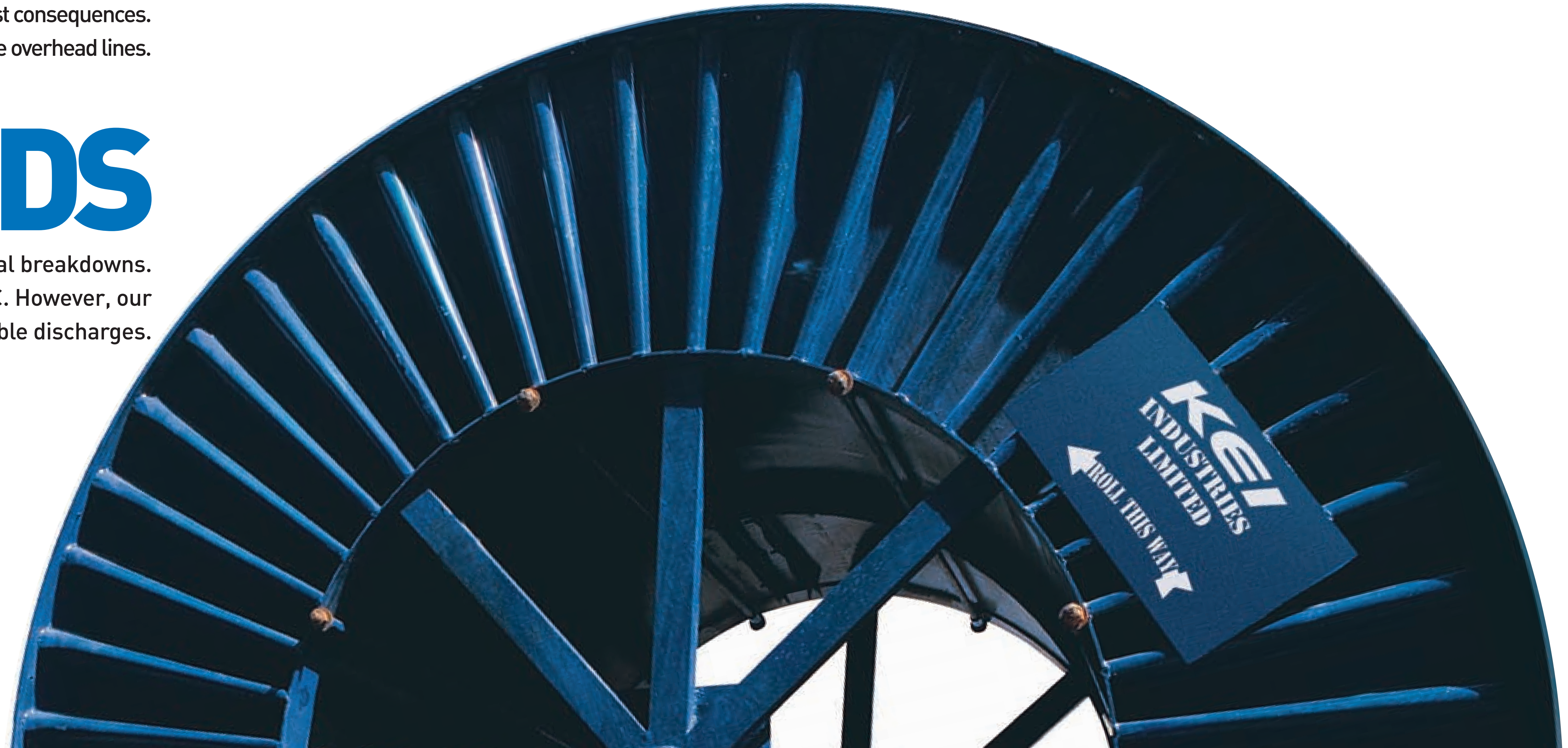


ENVIRONMENTAL AND RELIABILITY ASPECTS

KEI abides by the rules and regulations of the Government and stays in-sync with the public opinion. Similarly, it keeps the environment as its first consideration while planning a new supply route. For instance, it uses the impeccable XLPE system which is an invisible system. It requires a very small area for installation and normally the land can be reused for its original purpose after the installation, resulting in considerable savings. Moreover, reducing the electrical and magnetic fields is also becoming important now-a-days. The cable systems are designed according to different magnetic field requirements and the external electrical fields are zero. With fewer accidental contacts or flashovers, these systems ensure better standards of safety to both workers and general public. Reliability of the network is also an important factor because the loss of supply results in high cost consequences. The EHV cable systems are less vulnerable to failures compared to the overhead lines.

HIGH STANDARDS

Partial discharges in the cables insulation are regarded as one of the main reasons for electrical breakdowns. Most of the recognized national and international standards permit discharges of max. 5 pC. However, our policy is not to allow deliveries of cables with any detectable discharges.



EXTRA HIGH VOLTAGE (EHV) CABLES

The state-of-the-art EHV Cable plant with German technology manufactures cables up to 220kV. There are two CCV lines for the same:

1. Single-point-triple-extrusion and sophisticated control and monitoring systems from Machinenbau scholz GMBH & CO. KG.
2. Troester Germany

Both the above mentioned suppliers are well-known names in CCV lines technology and have supplied more than 250 lines world over. The triple extrusion and DCDC process ensure contamination-free cores. All three layers are well-bonded and the core has very less eccentricity and ovality. The insulation itself is free of micro voids and has negligible moisture content.

To control the manufacturing process, the line has been provided with computer-monitored instruments and servo controls. Some of the important systems are:

- X-ray non-touch sensors of SIKORA make for thickness and dimensional control. This system continuously measures the dimensions of insulated cores. The unit has the capability to measure multi-layer dimensions in all directions, record and analyze the data on line.
- CCV tube has a Touch Less Sag control system. This system ensures no marks / lines on core unlike the older lines. Facilities like conductor pre-heater, core twister (to control eccentricity / ovality) and DE-gasification have also been provided for EHV Cables.
- Computerized control system ensures optimum efficiency, fast start-up, synchronized operations of compound feeds, three extruders, CCV line heating temperature zones/ gas supply and pressure, pay off and take up.

INTEGRATED OPTICAL FIBRE UNIT

The optical fibres in power cables can be used for measuring the actual temperature along with the cable line or for data transmission. Fibre units are normally embedded under the lead sheath or between the screen wires.

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

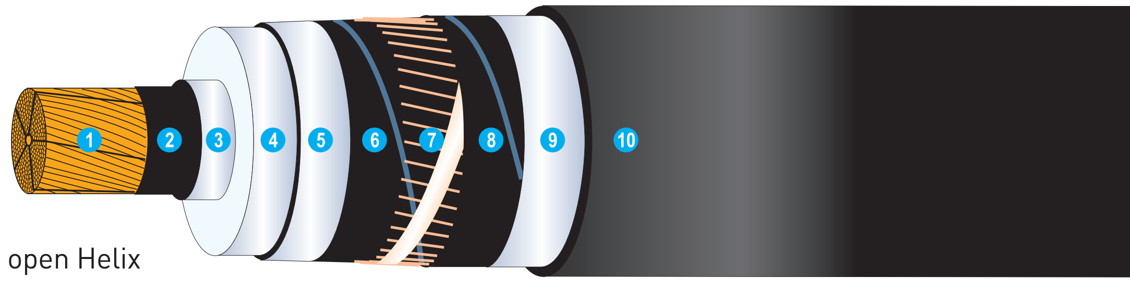
STANDARD SPECIFICATIONS

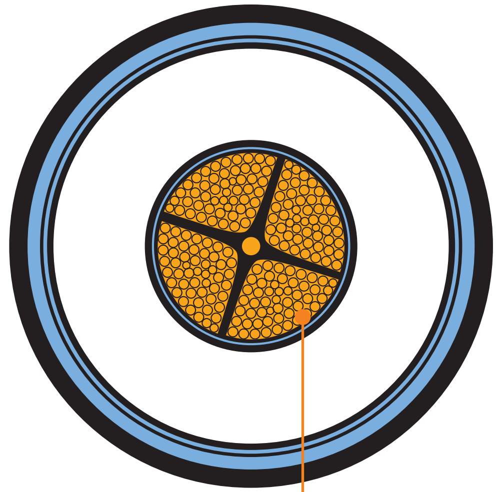
KEI manufactures Extra High Voltage cables according to various international or national standards. Such as, IEC: 60840, IEC: 62067, IS: 7098 (P-3)/93. Cable are also designed specially to the customer's requirement.

POPULAR CONSTRUCTIONS

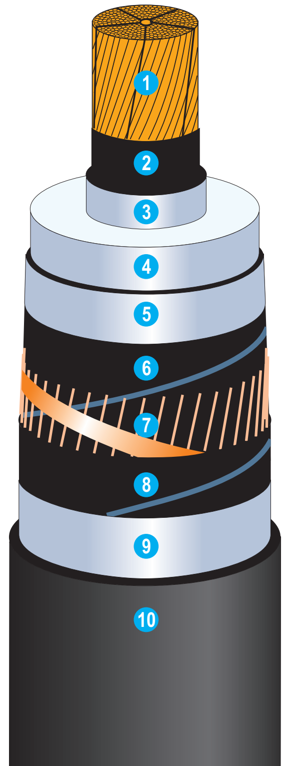
(A) Single core XLPE insulated power cable with copper wire screen and foil laminated sheath

1. Conductor: Longitudinally watertight segmental stranded and compacted Copper or Aluminum
2. Binder Tapes: Semiconducting water blocking tapes compound
3. Conductor Screen: Extruded semiconducting copolymer compound
4. Insulation: Extruded super clean XLPE compound
5. Insulation Screen: Extruded semiconducting copolymer compound
6. Bedding: Semiconducting water blocking tapes
7. Metallic Screen: A layer of Copper wire helix and a Copper contact tape in open Helix
8. Separation Tape: Semiconducting water blocking tapes and binder tapes
9. Radial Water Barrier: Aluminium or Copper foil laminate
10. Outer Sheath: Extruded PE of HFFR





Stranded Segmented Conductor



(B) Single core XLPE insulated power cable with Lead sheath/ corrugated Aluminium sheath

1. Conductor: Longitudinally watertight segmental stranded or compacted Circular Copper or Aluminum
2. Binder Tapes: Semiconducting water blocking tapes compound
3. Conductor Screen: Extruded semiconducting copolymer compound
4. Insulation: Extruded super clean XLPE compound
5. Insulation Screen: Extruded semiconducting copolymer compound
6. Bedding: Semiconducting water blocking tapes
7. Metallic Screen: A layer of copper wire helix and a copper contact tape in open helix (if required)
8. Water Blocking Tape
9. Metallic Sheath: Extruded Lead, alloy E/ Corrugated Alumunium
10. Outer Sheath: Extruded PE, PVC or HDFR

Constructions are given for unarmoured cables only. However, we manufacture the armoured cables also as per specifications and customer's requirements.

The electrical properties and continuous current rating apply for Lead sheathed cable with our normal sheath thickness. The thickness of sheath and especially the cross-section of Copper screen can be adjusted according to 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 esteemed as the sum of the resistances of conductor, 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 construction 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 transformer)
- Insulation level of equipment (bare conductor 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 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 hot water pipes and other factors liable to heat the cables
- Specifications and requirements to be met
  The 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

Impulse Generator

VOLTAGES RATED VOLTAGE

The voltage which forms the basis for certain operating characteristics and test conditions is called the rated voltage and test conditions is called the rated voltages and is denoted U_0/U where

U_0 = The voltage between the conductor and earth or earthed metallic cover (Concentric conductor, screen, armoring, metal sheath)

U = The voltage between the phase conductors

Aluminium Corrugation Sheathing Line

OPERATING VOLTAGE

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

The relationship between U_0/U and U_m in three phase systems according to IEC specification is as follows:

U_0/U kV	36/66	64/110	76/132	127/220
U_m kV	72.5	123	145	245

The relationship between U_0/U and U_m in three phase systems according to USA Standard C-84: 1-1995 is as follows:

U_0/U kV	40/69	66/115	80/138	132/230	200/345
U_m kV	72.5	123	145	245	362

CONTINUOUS CURRENT CARRYING CAPACITY

A separate group of three single core cables can be continuously loaded according to the tables on 1.1-1.4 and 2.1-2.4 if the presumptions below are fulfilled. Correction factors for other installations are given in table A to H.

The current-carrying capacities are calculated in accordance with the IEC publications 60287 and under the presumptions given below.

PRESUMPTIONS

- One three-phase group of single core cable

Standard conditions for current rating are given below:

- Maximum conductor temperature 90°C
- Ambient air temperature 40°C
- Ground temperature 30°C
- Depth of laying of cables 1.0 m
- Thermal resistivity of soil 150^{0}C - c_m/w

Distance between single core cables

- In case of flat formation-70mm (surface to surface)
- In case of trefoil formation-cable touching each other

- Thermal resistivity of soil 150^{0}CCm/W
- Cable in air-heat dissipation conditions same as 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 - screen 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

CONTINUOUS CURRENT RATINGS

LEAD SHEATHED CABLES

1.1 66 kV (E) Lead Sheathed Cables

Area of conductor	Trefoil SPB/CB		Flat SPB/CB		Trefoil SPB/CB		Flat SPB/CB	
	Cu Ground	Cu Air	Cu Ground	Cu Air	Al Ground	Al Air	Al Ground	Al Air
Sqmm	Amp.	Amp.	Amp.	Amp.	Amp.	Amp.	Amp.	Amp.
240	410	575	445	665	310	415	335	475
300	460	655	500	760	360	495	390	570
400	520	760	565	880	415	600	445	690
500	585	870	640	1020	470	695	505	805
630	660	1005	725	1195	535	810	575	950
800	730	1155	810	1395	605	945	655	1120
1000	790	1270	885	1555	665	1065	730	1275
1200	910	1505	1005	1825	750	1225	810	1460
1400	970	1645	1080	2010	805	1340	875	1600
1600	1015	1740	1135	2140	850	1440	930	1730

LEAD SHEATHED CABLES

1.2 110 kV Lead Sheathed Cables

Area of conductor	Trefoil SPB/CB		Flat SPB/CB		Trefoil SPB/CB		Flat SPB/CB	
	Cu Ground	Cu Air	Cu Ground	Cu Air	Al Ground	Al Air	Al Ground	Al Air
Sqmm	Amp.	Amp.	Amp.	Amp.	Amp.	Amp.	Amp.	Amp.
240	420	590	445	660	320	420	335	460
300	470	675	500	760	370	505	390	560
400	530	775	565	880	420	610	445	690
500	595	890	640	1020	475	710	505	805
630	665	1020	720	1180	540	820	575	935
800	740	1155	805	1350	605	945	650	1085
1000	800	1275	880	1505	670	1065	725	1230
1200	915	1495	995	1750	750	1210	805	1400
1400	975	1630	1065	1925	805	1325	865	1535
1600	1020	1730	1120	2050	850	1420	920	1655

1.3 132 kV Lead Sheathed Cables

Area of conductor	Trefoil SPB/CB		Flat SPB/CB		Trefoil SPB/CB		Flat SPB/CB	
	Cu Ground	Cu Air	Cu Ground	Cu Air	Al Ground	Al Air	Al Ground	Al Air
Sqmm	Amp.	Amp.	Amp.	Amp.	Amp.	Amp.	Amp.	Amp.
240	420	590	440	650	320	430	330	460
300	470	670	495	745	370	510	385	555
400	530	775	565	865	420	610	440	680
500	595	890	635	1005	475	705	505	795
630	670	1015	720	1160	540	815	575	920
800	740	1155	800	1330	605	940	650	1070
1000	800	1275	875	1485	670	1060	720	1215
1200	915	1485	990	1725	750	1205	800	1380
1400	975	1625	1060	1900	805	1315	860	1510
1600	1025	1725	1115	2025	855	1415	915	1630

1.4 220 kV Lead Sheathed Cables

Area of conductor	Trefoil SPB/CB		Flat SPB/CB		Trefoil SPB/CB		Flat SPB/CB	
	Cu Ground	Cu Air	Cu Ground	Cu Air	Al Ground	Al Air	Al Ground	Al Air
Sqmm	Amp.	Amp.	Amp.	Amp.	Amp.	Amp.	Amp.	Amp.
400	535	800	565	890	405	580	425	640
500	590	870	625	965	470	690	495	765
630	660	1000	705	1115	535	800	565	890
800	730	1130	780	1275	600	920	635	1025
1000	790	1250	855	1420	665	1035	705	1165
1200	895	1450	960	1645	735	1175	780	1315
1400	955	1585	1025	1810	790	1280	840	1445
1600	1000	1680	1075	1925	835	1375	890	1555

SPB= Single Point Bonding
CB= Cross-bonding

CONTINUOUS CURRENT RATINGS

ALUMINIUM SHEATHED CABLES

2.1 66 kV Aluminium Sheathed Cables

Area of conductor	Trefoil SPB/CB		Flat SPB/CB		Trefoil SPB/CB		Flat SPB/CB	
	Cu Ground	Cu Air	Cu Ground	Cu Air	Al Ground	Al Air	Al Ground	Al Air
Sqmm	Amp.	Amp.	Amp.	Amp.	Amp.	Amp.	Amp.	Amp.
240	415	595	445	680	315	435	335	490
300	465	675	500	775	365	515	390	585
400	525	775	570	900	415	610	445	705
500	590	885	645	1035	470	710	510	820
630	660	1010	725	1195	535	815	580	950
800	725	1140	805	1360	600	940	650	1095
1000	780	1255	875	1510	660	1050	720	1240
1200	885	1455	985	1745	735	1195	800	1405
1400	930	1570	1040	1895	780	1305	855	1545
1600	970	1655	1090	2010	825	1390	905	1650

2.2 110 kV Aluminium Sheathed Cables

Area of conductor	Trefoil SPB/CB		Flat SPB/CB		Trefoil SPB/CB		Flat SPB/CB	
	Cu Ground	Cu Air	Cu Ground	Cu Air	Al Ground	Al Air	Al Ground	Al Air
Sqmm	Amp.	Amp.	Amp.	Amp.	Amp.	Amp.	Amp.	Amp.
240	415	585	440	650	315	425	330	460
300	465	665	495	745	365	505	385	555
400	525	765	560	865	415	605	440	675
500	590	875	635	995	470	700	500	785
630	675	1030	730	1175	540	815	575	920
800	750	1180	820	1360	605	940	650	1070
1000	820	1315	900	1525	675	1065	725	1215
1200	870	1425	960	1665	725	1170	785	1345
1400	915	1540	1010	1810	770	1280	835	1480
1600	950	1615	1055	1915	810	1355	880	1575

ALUMINIUM SHEATHED CABLES

2.3 132 kV Aluminium Sheathed Cables

Area of conductor	Trefoil SPB/CB		Flat SPB/CB		Trefoil SPB/CB		Flat SPB/CB	
	Cu Ground	Cu Air	Cu Ground	Cu Air	Al Ground	Al Air	Al Ground	Al Air
Sqmm	Amp.	Amp.	Amp.	Amp.	Amp.	Amp.	Amp.	Amp.
240	415	580	440	635	315	410	340	445
300	465	665	490	730	365	495	390	540
400	520	765	560	850	415	600	440	665
500	585	875	630	980	470	695	500	775
630	670	1030	725	1155	535	810	570	905
800	750	1180	810	1335	605	935	645	1055
1000	815	1315	890	1500	670	1055	720	1200
1200	865	1425	945	1635	720	1160	775	1325
1400	910	1540	1000	1775	770	1265	830	1450
1600	945	1615	1040	1880	805	1345	875	1545

2.4 220 kV Aluminium Sheathed Cables

Area of conductor	Trefoil SPB/CB		Flat SPB/CB		Trefoil SPB/CB		Flat SPB/CB	
	Cu Ground	Cu Air	Cu Ground	Cu Air	Al Ground	Al Air	Al Ground	Al Air
Sqmm	Amp.	Amp.	Amp.	Amp.	Amp.	Amp.	Amp.	Amp.
400	525	785	555	865	405	575	425	625
500	580	855	615	940	465	680	490	745
630	645	975	690	1085	525	785	555	865
800	705	1095	760	1230	585	895	625	995
1000	760	1205	825	1360	645	1005	690	1120
1200	845	1380	915	1560	710	1130	755	1265
1400	895	1495	970	1695	755	1235	810	1385
1600	930	1575	1010	1795	795	1315	850	1480

SPB= Single Point Bonding
CB= Cross-bonding

The above current ratings are based on single-end bonding/ cross-end bonding. However, we also provide the rating for both end bonding as per customer's requirements.

RATING FACTORS

A. Rating factors for variation in ambient air temperature

Air Temperature (Deg C)	30	35	40	45	50	55
Rating Factor	1.11	1.05	1.00	0.94	0.88	0.81

B. Rating factors for variation in ground temperature

Ground Temperature (Deg C)	25	30	35	40	45	50
Rating Factor	1.04	1.00	0.96	0.91	0.86	0.81

C. Rating factors for variation in Thermal Resistivity of soil

Thermal Resistivity (^{0}C cm/w)	100	120	150	200	250	300
Rating Factor	1.19	1.10	1.00	0.88	0.80	0.72

D. Rating factors for variation in Depth of laying

Depth of laying (m)	0.5	0.7	0.9	1.0	1.2	1.5
Rating Factor	1.10	1.05	1.05	1.00	0.98	0.95

E. Group Rating factors : Group rating factors for cables laid in formed concrete trenches with removable covers on cable troughs where air circulation in stricted . The cables spaced by one cable diameter and trays in tiers by 300 mm. The clearance of the cable from the wall is 20mm.

No. of troughs	No. of groups (Circuits)		
	1	2	3
1	0.92	0.89	0.88
2	0.87	0.84	0.83
3	0.84	0.82	0.81
6	0.82	0.80	0.79

F. Group Rating factors : Group rating factors for cables laid on racks. The cables spaced by one cable diameter and racks in tiers by 300mm. The clearance between the wall and the cable is 20mm.

No. of troughs	No. of groups (Circuits)		
	1	2	3
1	1.00	0.97	0.96
2	0.97	0.94	0.93
3	0.96	0.93	0.92
6	0.94	0.91	0.90

G. Group rating factors for cables laid in ground in horizontal formation

Axis distance between groups	No. of groups (Circuits)	
	2	3
200 mm	0.81	0.71
400 mm	0.85	0.77
600 mm	0.88	0.81
800 mm	0.90	0.84
1000 mm	0.96	0.93

H. Rating factors for phase spacing in flat formation

Phase spacing (S) cm	D	D+70	D+200	D+250	D+300	D+350	D+400
Rating Factor	0.93	1.00	1.03	1.05	1.07	1.08	1.10

REFERENCE TEST VOLTAGES (Table 1)

Rated Voltages of cables	Highest voltage for equipment between conductors	30 min voltage test	Partial discharge test	Tan delta measurement	Heating cycle test	Impulse withstand test	15 min power frequency voltage test after Impulse test
U_o/U kV	U_m kV	2.5 U_o kV	1.5 U_o kV	U_o kV	2 U_o kV	kV	2.5 U_o kV
38/66	72.5	90	57	38	76	325	90
64/110	123	160	96	64	128	550	160
76/132	145	190	114	76	152	650	190
127/220	245	318	190	127	254	1050	315

* Test voltages are generally in line with IEC 60840/ IS :7098 Part 3/IEC:62067

CONDUCTOR RESISTANCE (Table 2)

Cross-sectional area of conductor	Max D.C. Resistance of conductor at 20^{0}C		App. A. C. resistance of conductor at 90^{0}C	
	Aluminium conductor	Copper conductor	Aluminium conductor	Copper conductor
sq.mm.	ohm/ km	ohm/ km	ohm/ km	ohm/ km
240	0.1250	0.0754	0.1610	0.0972
300	0.1000	0.0601	0.1290	0.0780
400	0.0778	0.0470	0.1010	0.0618
500	0.0605	0.0366	0.0791	0.0491
630	0.0469	0.0283	0.0622	0.0393
800	0.0367	0.0221	0.0497	0.0322
1000	0.0291	0.0176	0.0380	0.0236
1200	0.0247	0.0151	0.0326	0.0207
1600	0.0186	0.0113	0.0251	0.0163

MAX. PERMISSIBLE SHORT-CIRCUIT CURRENTS FOR ONE SECOND

CONDUCTOR SHORT CIRCUIT RATING (Table 3)

Cross-sectional area of conductor sq.mm.	Short Circuit rating For 1 Sec. Aluminium	Copper
Sqmm	Kamp. (rms)	Kamp. (rms)
240	22.6	34.32
300	28.2	42.90
400	37.6	57.20
500	47.0	71.50
630	59.2	90.10
800	75.2	114.40
1000	94.0	143.00
1200	112.8	171.6
1600	150.4	228.8

MINIMUM CONDUCTOR CROSS-SECTIONS AND INSULATION THICKNESS (Table 4)

Voltage grade	Smallest nominal conductor cross-section	Nominal thickness of insulation
kV	sq. mm.	mm
38/66	240	11.0
64/110	240	16.0
76/132	240	18.0
127/220	400	27.0

* Thickness given in the above table are as per IS:7098(P-3)/1993. However we also provide the thickness as per IEC

CAPACITANCE OF THE CABLE (μf/ Km) (Table 5)

Cross- sectional area of conductor Sq. mm	Voltage grade of the cable			
	38/66 kV	64/110 kV	76/132 kV	127/220 kV
240	0.195	0.150	0.140	-
300	0.210	0.165	0.150	-
400	0.230	0.175	0.165	0.125
500	0.250	0.190	0.175	0.135
630	0.275	0.205	0.190	0.145
800	0.300	0.225	0.205	0.155
1000	0.325	0.245	0.225	0.170
1200	0.360	0.270	0.245	0.185
1600	0.400	0.295	0.270	0.200

CABLE LAYOUT AND SYSTEM DESIGN

The dimensioning of a high voltage cable system is always based on the specifications and demands of the project at hand. The following details are required for calculation:

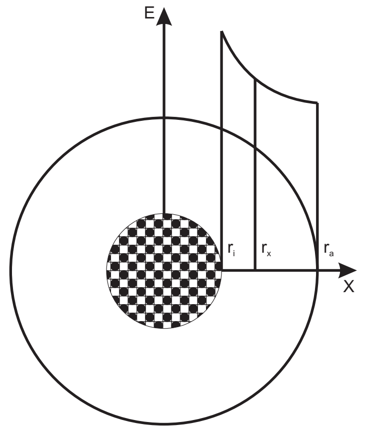
- The type of cable insulation
- Nominal and maximum operating voltage
- Short- circuit capacity or short- circuit current with statement of the effect time
- Transmission capacity or nominal current
- Operating mode: permanent operation or partial load operation (load factors)
- Ambient conditions:
  - -Type of installation
  - -Ambient temperature
  - -Special thermal resistance of the ground

The calculation of the admissible load currents (ampacity) and the cable temperature is performed in accordance with the IEC publication 60287. **At KEI, professional computer programs are in use for the calculation of the various cable data.**

1.1 ELECTRICAL FIELD

In initial approximation, the main insulation of a high voltage XLPE cable can be regarded as a homogeneous cylinder. Its field distribution or voltage gradient is therefore represented by a homogeneous radial field. The value of the voltage gradient at a point x within the insulation can be calculated as:

$Ex = U_o / r_x \,.\, \ln(r_a/r_i)$ (kV/ mm)
U_o= Operating voltage (kV)
r_x= Radius at position x (mm)
r_a= External radius above the insulation (mm)
r_i= Radius of the internal field diameter (mm)



The electrical field strength is highest at the inner semiconductor and lowest above the insulation.
(below the external semiconductor, $r_x = r_a$)

1.2 CAPACITY, CHARGING CURRENT

The operating capacity depends on the type of insulation and its geometry. The following formula applies for all radial field cables :

$C = E_r / 18 * \ln(D/d)$ (μF/km)

With E_r= Relative permitivity (XLPE: 2.4)

D= Diameter over main insulation excluding screen (mm)
d= Diameter over conductor including screen (mm)

Single-core high voltage XLPE cables represent an extended capacitance with a homogeneous radial field distribution. Thus a capacitive charging current to earth results in the following formula:

$Ic = U_o.\omega.C$ (A/ km)

With U_o= Operating voltage (kV)
ω = Angular frequency (1/s)
C = Operating capacity (μF/km)

1.3 INDUCTANCE, INDUCTIVE REACTANCE

The operating inductance in general depends on the relation between the conductor axis spacing and the external conductor diameter. Practically, two cases have to be considered:

LAYING FORMATION: TREFOIL

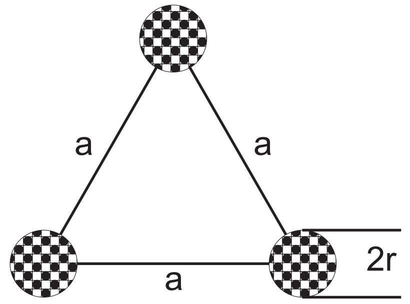
The operating inductance for all three phases calculated as:

$L = 2.10^{-4} \ln(a/0.779.\, r_L)$ (H/Km)

with

a= Phase Axis distance (mm)

r_L = Diameter of conductor over inner semiconducting layer (mm)



LAYING FORMATION: FLAT

The mean operating inductance for the three phases calculates for both cases as:

L m= 2. 10-4 . ln (a'/0.779.r_L) (H/km)

With

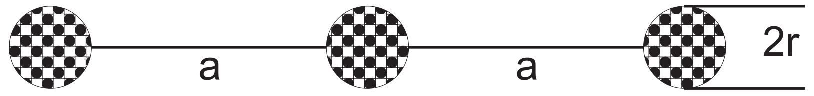
á= $\sqrt[3]{2}$.a Mean geometric distance (mm)

a= Phase axis distance (mm)

r_L= Diameter of conductor over inner semiconducting layer (mm)

The inductive reactance of the cable system calculates for both cases as:
X = ω. L (Ω/ km)

With ω= Angular frequency (1/s)



Partial Discharge Test Chamber

1.4 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 given below:

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

R_t = DC resistance at temperature t, Ω/km
R_{20} = DC resistance of conductor at 20°C, Ω/km
T = temperature of conductor, °C
α_{20} = temperature coefficient of resistance at 20°C, 1/°C

For Copper conductors α_{20}=0.0393
For Aluminium conductor and sheath α20=0.0403
For Lead alloy sheath α_{20}=0.0400

Maximum DC resistance of conductors at 20°C (in accordance with IEC 60228/IS: 8130). Calculated DC resistance of metallic sheaths and metallic screens at 20°C

1.5 LOSSES IN CABLES

Voltage– dependent and current- dependent power losses occur in cables.

I) Voltage – dependent losses.

Voltage- dependent power losses are caused by polarization effects within the main insulation.

They calculate to:

$P_d = U_o^2 \omega \; C \tan\delta$ (ω/km)

with U_o= Operating Voltage (kV)

ω= Angular Frequency

Dielectric power loss factors tan δ for typical cable insulations are:
XLPE (1.5 to 3.5) 10^{-4}

C= Operating Capacity (μF/km)

II) Current – dependent losses

The current dependent losses consist of the following components:

- Ohmic conductor losses
- Losses through skin effect
- Losses through proximity effect
- Losses in the metal sheath

OHMIC CONDUCTOR LOSSES

The ohmic losses depend on material and temperature. For the calculation of the ohmic losses I^2R, The conductor resistance stated for 20^{o} C (R_o) must be converted to the operating temperature of the cable.

$R_t = R_o (1 + \alpha(\theta - 20^{o} C))$ (Ω/km)
With
α= 0.0393 for Copper
α= 0.0403 for Aluminium
The conductor cross- section and admissible DC resistances at 20^{o}C (R_o) correspond to the standard series pursuant to IEC 60228/IS:8130.

LOSSES THROUGH SKIN EFFECTS

The losses caused by the skin effect, meaning the displacement of the current against the conductor surface, rise approximately quadratic with the frequency. This effect can be reduced with suitable conductor constructions, e.g. segmented conductors

LOSSES THROUGH PROXIMITY EFFECT

The proximity effect detects the additional losses caused by magnet fields of parallel conductors through eddy currents and current displacement effects in the conductor and cable sheath. In practice , their influence is of less importance, because three conductor cables are only installed up to medium cross sections and single conductor cables with large cross sections with sufficient axis space. The resistance increase through proximity effects relating to the conductor resistance is therefore mainly below 10%

Lead Extruder

LOSSES IN THE METAL SHEATH

High voltage cables are equipped with metal sheaths or screens that must be earthed adequately.

Sheath losses occur through:

- Circulating currents in the system
- Eddy currents in the cable sheath (Only applicable for tubular types)
- Resulting sheath currents caused by induced sheath voltage (in unbalanced earthing systems)

The sheath losses, especially high circulating currents, may substantially reduce the current load capacity under certain circumstances. They can be lowered significantly through special earthing methods

LAYING INFORMATION

Minimum permissible bending radii during laying:

- During pulling of power cables, the bending radii should not be smaller than the recommended values
- In the case of single bends, the values may be reduced to a minimum of 70% if the cables are carefully and evenly bent only once before a termination (around a pre-fabricated bow, if necessary)

Maximum Permissible pulling tensions during laying:

- During laying of power cables attention must be paid to permissible tensile forces

Permissible tensile forces when pulling by cable pulling grip:

F = A x 15 N/mm^2
(Cable with Al-Conductor)

F = A x 20 N/mm^2
(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-conductor <800 mm^2, F = A X 70 N/mm^2
>800 mm^2, F = A X 50 N/mm^2

Cu-conductor <800 mm^2, F = A X 90 N/mm^2
>800 mm^2, F = A X 70 N/mm^2

A = Cross Sectional area of conductor in mm^2 (without screen and conc. Conductor)

Minimum permissible cable temperature during laying:

XLPE insulated cable 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 heated room for several days or by means of special equipment.

XLPE - INSULATED CABLES 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 a considerable increase in the 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 considerations the dynamic short-circuit current capacity and to pay attention to the technique of installation.

THERMAL STRESSES

On page No. 10, the maximum permissible short-circuit currents for short-circuit duration of one second are given. These values are based on the following presumptions:

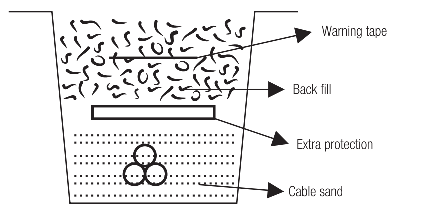
- Before short-circuit, the temperature of conductors - maximum permissible temperature of conductor in continuous use
- Maximum permissible temperature of conductor in short-circuit is 250 Deg C for XLPE Insulated cables
- The permissible short-circuit currents for short-circuit duration of 0.2 upto 5 seconds may be calculated by multiplying the value of maximum 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

A) Underground installation of EHV XLPE Cables

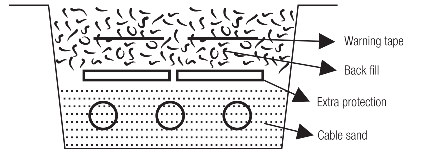
1.1) Bending Radius - The minimum bending radius for EHV XLPE cables is 20 X D, where D is the overall diameter of cable.

1.2) Installation in ground - Underground XLPE cables are usually buried directly in the ground.

Single core cables can be laid in flat or trefoil formation as shown in figures.



(1.2a) Three single core cables in trefoil formation

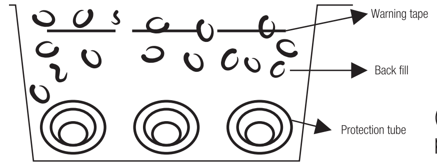


(1.2b) Three single core cables in flat formation

1.3) Depth of laying – As a general rule, EHV cables are laid at a depth of 1 to 1.5 m. the laying depth is chosen depending on obstacles in the ground e.g. telephone cables or water pipes. There may be more reasons for deeper laying, which then mean a reduction of current carrying capacity.

1.4) Sand bedding - The cable shall be completely surrounded by well-compacted sand to such a thickness and of such a grain size that the cable is completely protected against damage. The thickness of sand bedding should normally be a minimum of 10 cm in directions from the cable surface. Sand with grain size less than 8 mm is considered to give the cable a good protection.

1.5) Extra protection - Important feeders and cables at places where extended digging activity is expected can be further protected against damage by means of tubes, slabs, troughs or warning tapes. Ducts of non-magnetic material for single core cables can be mainly used at road crossing etc., the duct diameter should not be less than 1.5 times the cable diameter. In trenches, normally extra protection is obtained by means of concrete slabs and its size is chosen according to the expected damage. The slabs are placed directly on the cable sand.



(1.5) Three single core cables in protecting ducts, flat formation

1.6) Back filling - Normally, the back fill consists of the material earlier excavated. However, bigger stones or pieces of rock should be removed.

1.7) Warning Tape - A pre-warning tape (yellow PVC tape) should be laid in the ground.

1.8) Transportation - In order to avoid damage to the cable, the cable drum must be handled carefully during transportation. It is very important that the cable drum stands on the flanges during transportation, well fixed to the transport vehicle. Loading and unloading should be made by crane or fork truck, not by rolling. Rolling of the drum should be done slowly and carefully in the direction of the arrow on the drum.

1.9) Cable pulling - During the pulling, the cable drum is normally placed on jacks at the starting point and wire winch at the other end of the trench. The pulling wire can be connected to cable either by a cable stocking or pulling eye to the conductors in such a manner that water or soil cannot enter into the cable.

The maximum pulling force for Aluminium and Copper conductor shall be as follows:

For Aluminum conductor 30 N/ sqmm

For Copper Conductor 50 N/ sqmm

The cable should preferably be pulled from the top of the drum. To prevent crossing of turns on the drum at sudden pulling stop, a brake should be arranged at the cable drum and a man placed there to operate this brake, which must be pulled rapidly to stop.

To protect the cable from damage during the pulling out, cable rollers should be used and placed at suitable intervals. At bends, angle rollers and guide rollers as required must be used in order to maintain the desired bending radius of the cable.

During the cable pulling, telephones or walkie-talkie should be used to ensure the internal communication. Once established, it helps in preventing accidents and enables a safe pulling operation.

B) Installation of XLPE cable in air

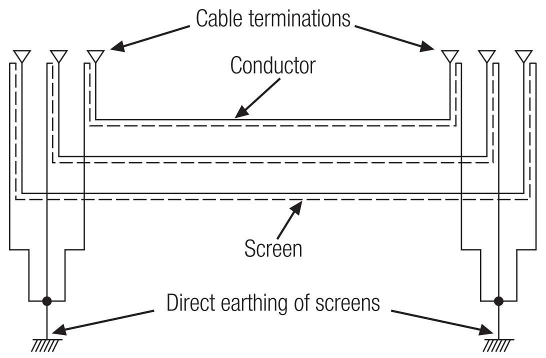
The requirement for bending radii, transportation and pulling of the cables are the same as for underground installation. For fixing of the cable, the following requirements have to be taken into consideration:

Cable fixing	After laying of three Nos. cable, the cable shall be tied up with non-magnetic metals trefoil/ single clamp depend up on the laying configuration i.e., Trefoil/flat
Horizontal distance between cleats	At 1 to 1.2 meter interval or as per customer's choice
Vertical distance between cleats	If the cable circuits are laid in tiers then the vertical spacing between the tiers should not be less than 300 mm

SCREEN BONDING METHODS

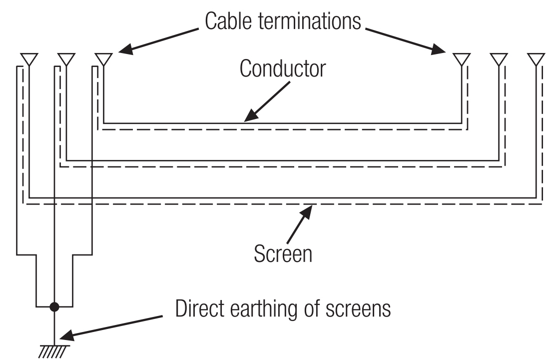
BOTH-ENDS BONDING OF SCREENS

Both ends of the cable sheath are connected to the system earth. With this method no standing voltages occur at the cable ends, which make it the most secure regarding safety aspects. On the other hand, circulating currents may flow in the sheath as the loop between the two earthing points is closed through the ground. These circulating currents are proportional to the conductor currents and therefore reduce the cable ampacity significantly making it the most disadvantageous method regarding economic aspects.



SINGLE-POINT BONDING OF SCREENS

One end of the cable sheath is connected to the system earth, so that at the other end ("open end") the standing voltage appears, which is induced linearly along the cable length. In order to ensure the relevant safety requirements, the "open end" of the cable sheath has to be protected with a surge arrester. In order to avoid potential lifting in case of a failure, both earth points have to be connected additionally with an earth continuity wire. The surge arrester (sheath voltage limiter) is designed to deflect switching and atmospheric surges but must not trigger in case of a short- circuit.



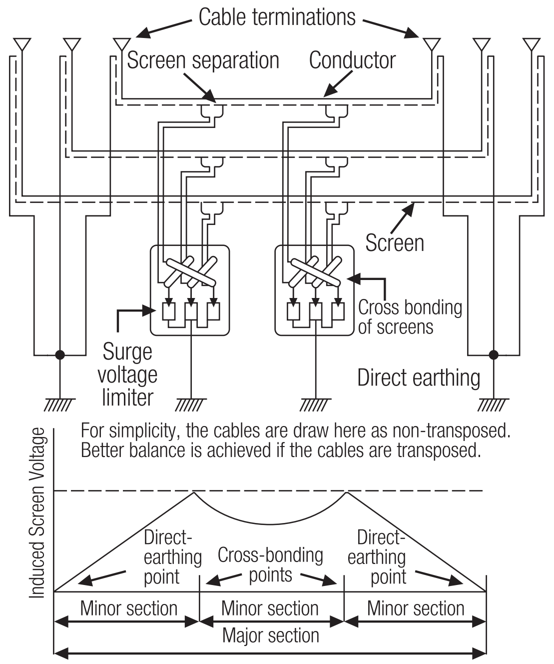
CROSS BONDING OF SCREENS

This earthing method shall be applied for longer route lengths where joints are required due to the limited cable delivery length. A cross-bonding system consists of three equal sections with cyclic sheath crossing after each section. The termination points shall be solidly bonded to earth.

Along each section, a standing voltage is induced. In ideal cross- bonding systems the three section lengths are equal, so that no residual voltage occurs and thus no sheath current flows. The sheath losses can be kept very low with this method impairing the safety as in the two- sided sheath earthing.

Very long route lengths can consist of several cross-bonding systems in a row. In this case, it is recommended to maintain solid bonding of the system ends in order to prevent travelling surges in case of a fault.

In addition to cross- linking the sheaths, the conductor phases can be transposed cyclicity. This solution is especially suited for very long cable lengths or parallel circuits.



TESTING PROCEDURE AFTER INSTALLATION

(UPTO 220 kV XLPE CABLE)

Tests will be performed according to IEC: 60840, IEC: 62067 and SCECO-E-Specification.

DESCRIPTION OF TEST	REQUIREMENT
1. PHASE CHECKING: Correct phasing is verified by successively grounding individual phases and checking the corresponding phase at the opposite end using a Megger set at 5kV. The correct phase should be grounded with all other phases showing open circuit.	**POSITIVE CONFIRMATION**
2. INSULATION RESISTANCE MEASUREMENT: The Insulation Resistance is measured between the conductor at 5kV DC, and its grounded shield. This test is to be performed both before and after the DC High Voltage Test.	**SUITABLE RESISTANCE FOR CABLE AGE.**
3. DC SHEATH TEST: A DC voltage of 10 kV is applied to the metallic shield wires for 1 minute. This test should be performed after initial cable installation with the cable backfilled in the trench (where applicable) and finally when the cable installation is complete. No breakdown should occur.	**10kV DC 1 MIN.**
4. DC HIGH VOLTAGE TEST: This is performed on each of the phases with all remaining phases solidly grounded. A negative polarity DC Voltage equal to 3μ0 for 15 minutes is applied to the conductor with its corresponding shield grounded. The leakage current is recorded each minute after full voltage is applied and presented in a graph for review.	**3μ0 (398kV) FOR 15 MIN. NO BREAKDOWN.**
5. POSITIVE AND ZERO SEQUENCE IMPEDANCE: **a.** All conductors are shorted with substantial connectors at the far end. A current of around 30 Amps is injected into the loop. Voltage, Current and Phase Angle are recorded and the circuit Impedance is calculated. Note all SVL's and Shield Links should be in their "In Service" position. **b.** Zero Sequence Impedance All conductors are shorted and grounded at the far end, and shorted together at the near end using substantial connectors. A current of around 30 amps is injected into all three conductors and returns via ground. Current, Voltage, and Phase Angle are recorded and Zero Sequence Impedance is calculated.	**MATCHING CABLE DESIGN PARAMETERS**

6. CAPACITANCE:
Using a digital LCR Meter capacitance is measured between conductor and shield.

MATCHING CABLE DESIGN PARAMETERS

7. CONDUCTOR CONTINUITY AND CONDUCTOR DC RESISTANCE TEST:
With the conductors looped at the remote end, a loop resistance is measured successively between all phases. By simultaneous equations DC resistance for each conductor can be calculated.

MATCHING CABLE DESIGN PARAMETERS

8. CABLE SHIELD CONTINUITY AND CABLE SHIELD DC RESISTANCE TEST:
With the cable shields looped at the remote end, a loop resistance is measured successively between all phases. By simultaneous equations DC resistance for each cable shield can be calculated.

MATCHING CABLE DESIGN PARAMETERS

9. LINKBOX/ JOINTBAY EARTH RESISTANCE TEST:
Using specialized contact resistance test equipment and the 3 point method, the Linkbox Ground Rod network earth resistance is measured.

LESS THAN 20µΩ

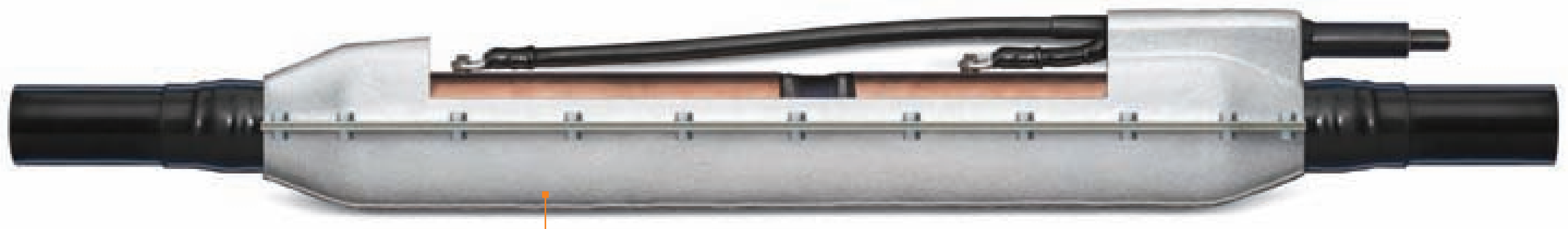
10. LINKBOX LINK CONTACT RESISTANCE TEST:
Using specialized contact resistance test equipment (Digital Micro Ohmmeter) the Linkbox Link Contact Resistance is directly measured.

LESS THAN 20µΩ AT EACH CONNECTION

11. SHEATH VOLTAGE LIMITER (SVL) CHARACTERISTIC CHECK:
SVL DC Voltage withstand test- application of DC voltage to verify SVL design parameters.
SVL design parameters.
SVL Insulation Resistance Check.

MATCHING SVL DESIGN PARAMETERS

JOINT, TERMINATION AND OTHER ACCESSORIES



We will be using accessories and jointing kits with our collaboration M/s Brugg Kabel for 132 kV and above.

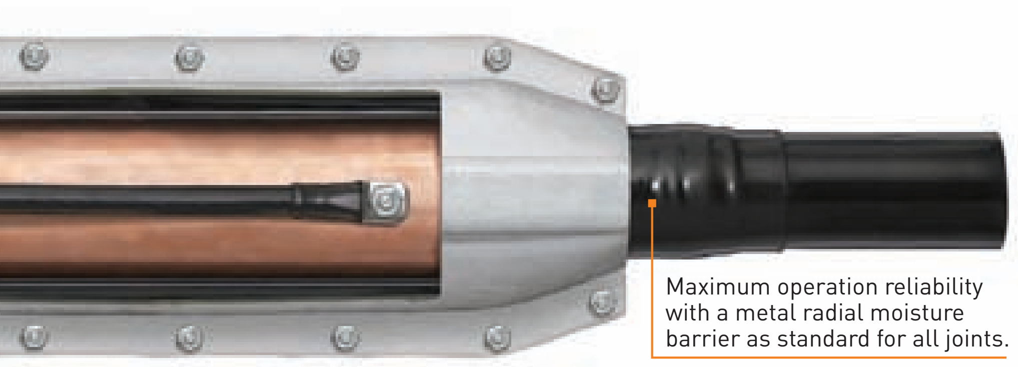
High voltage cable systems are as reliable as their accessories. Brugg Cables never forgets this and leaves nothing to chance. To underline our dedication, research and improvements are made all the time. Based on our well-known MP family we came up with a new joint for voltages up to 145 kV. It fully considers the needs of our customers and demonstrates Brugg Cables' commitment to quality and reliability.

Maximum operation reliability: Cables are standardised with a radial moisture barrier of a metallic shield. In Brugg Cables' efforts to make the accessories as reliable as the cable, a metallic radial moisture barrier became a standard part of all joints. Depending on the type of the joint, the barrier is a metal foil (Al or Cu) or a copper tube. Both versions extend the lifetime and reliability of your cable system.

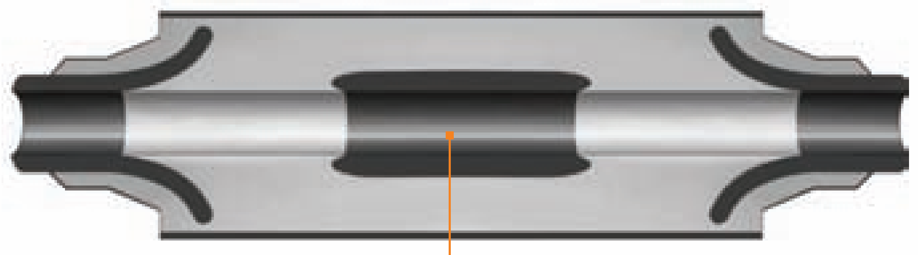
Wide range of usage: For greater flexibility in the application on your cables, the insulation diameter of XLPE for the joints has been extended from 57 to 102 mm.

High flexibility in application. To provide more flexibility in application, four different protection designs where developed. A heat shrink cover provides basic protection. If greater protection is required, a copper tube or a box of polyester filled with an insulation compound, or even both, can be selected. With these features, it is easy to choose the appropriate design for the application without incurring great expense.

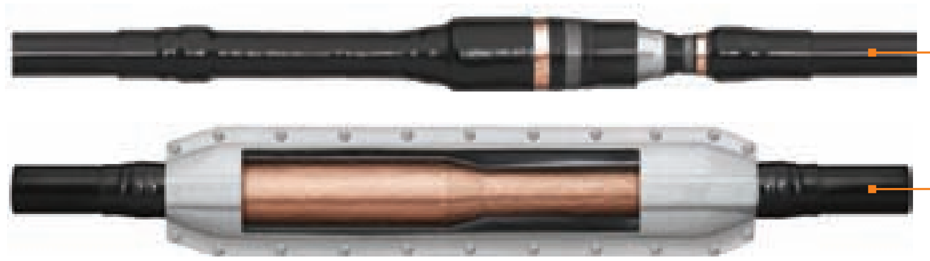
Easier installation. The reduced dimensions of the joint make laying and installation much easier.



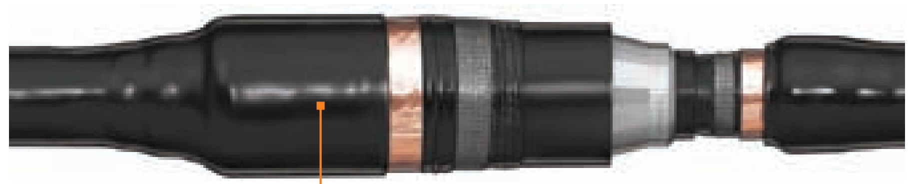
Maximum operation reliability with a metal radial moisture barrier as standard for all joints.



Wide range of application with insulation diameters from 57 to 102 mm.



High flexibility in usage without incurring great expense with our 4 different protection designs.



Easier installation thanks to smaller dimensions.

Based on excellent experience with joints of our MP family, all main advantages of the pre-tested one-piece SiR slip-on bodies have been kept. As the most crucial element of the joint, design, material selection and production of the insulation body undergoes extensive research at Brugg Cables. As a result, the outstanding properties and long-time stability of the SiR were maintained and the electrical design was optimized.

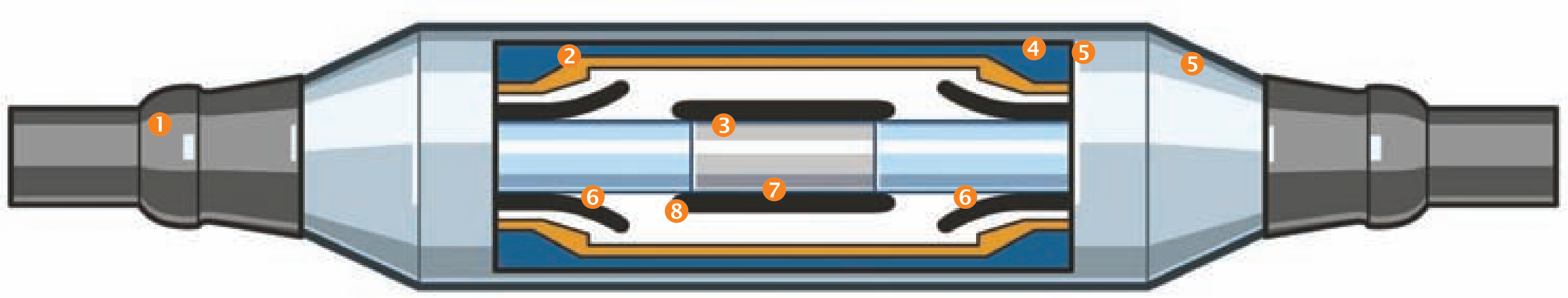
The insulation body comprises the semiconductive deflectors & middle electrode and the insulation compound. Thanks to a perfect combination of outstanding electrical and mechanical properties and excellent interface behaviour, silicone rubber (SiR) is used for the deflectors, the middle electrode and the insulation. To ensure proper functioning at all voltage loads and to guarantee a long and reliable life, the semiconductive parts are made of solid material. For optimal electrical stress distribution, the insulation body was designed based on computer FEM simulations. The extreme flexibility of the SiR ensures easy and fast assembling. The excellent elasticity of the SiR has an optimised level of surface pressure and ensures void-free contact between the insulation body and the cable. These advantages will remain constant over an extremely long service period.

All these features result in a joint that is highly reliable and will last a lifetime. For added quality, the insulation bodies are produced as a single piece, are prefabricated in-house and are pretested in our Swiss production plant.

ADVANTAGES OF THE PRE-FABRICATED AND PRE-TESTED ONE-PIECE SiR INSULATION BODY:

- Very high breakdown strength of →23 kV/mm at 50/60 Hz
- Excellent temperature stability of– 50 to +180 °C
- Very high life exponent of n →→40
- Excellent field grading performance at high frequency load due to semiconductive parts of solid material
- Optimal electrical stress distribution due to computer-assisted FEM-design
- Void-free contact pressure on the cable surface at normal and elevated load conditions with the excellent elasticity of the SiR
- Long lifetime due to excellent mechanical properties of the SiR
- Connection of different types of polymer cables with different insulation diameters possible due to a high elasticity of the SiR slip-on body

EFFECTIVE RESISTANCE



1 High voltage polymer cable 2 Radial metallic moisture barrier 3 Conductor clamp 4 Filling material 5 Mechanical protection 6 Deflector 7 SiR slip-on insulation body 8 Middle electrode

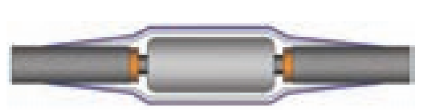
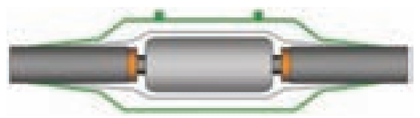
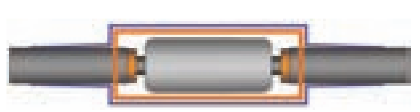
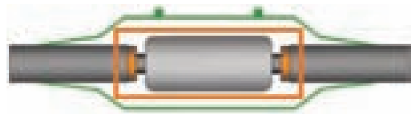
By incorporating a radial metallic moisture barrier as standard, the reliability of the joint is even greater. Four different mechanical designs ensure added flexibility in usage and application. Smaller dimensions and a larger diameter range for applications round off the new features. Together with the proven advantages of the SiR slip-on body, you are always well connected with our new joints.

That you can benefit from the advantages of the new slip-on joints, we offer the products for polymer cables with insulation diameters of 57 to 102 mm and a conductor cross-section of up to 2500 mm^2. The joints are tested to a service voltage of 145 kV and a BIL level of 650 kV.

AT A GLANCE, THE MAIN ADVANTAGES OF OUR PRE-TESTED SLIP-ON JOINTS ARE:

- Very compact dimensions
- 100 % failure free pre-tested one-piece SiR slip-on bodies
- Total moisture barrier provided by a radial metallic shield as a standard
- No preload during transport or storage
- Possibility to use different types of outer mechanical protection designs
- Easy to handle and install thanks to a longer middle electrode and exceptional elasticity, no high mechanical forces needed for installation
- Possible to apply coaxial cross-bonding cables up to a cross-section of 500/500 mm^2
- Many uses in all environments, laying conditions and climates

APPLICATION TABLE OF THE SLIP-ON JOINTS.

Type	MPAH	MPAP	MPCC	MPCP
				
Radial Moisture Barrier	Metal foil of Al or Cu	Metal foil of Al or Cu	Cu-tube	Cu-tube
Mechanical Protection	Heat shrink Cover	Protection box	Cu-tube with HDPE-coating	Cu-tube and protection box
Advantages	• Extremely compact dimensions • Total sealing against moisture • Cost effective solution	• Good mechanical protection in different environments • Total sealing against moisture	• Compact dimensions • High degree of mechanical Protection • Total sealing against moisture	• High degree of mechanical Protection • Total sealing against moisture
Application	• For limited dimensions, such as small manholes • In tunnels or concrete manholes without permanent water ingress	• All types of laying, such as in tunnels, concrete pits or buried installations • In buried installations with humid soil	• All types of laying, such as in tunnels, concrete pits or buried installations • In installations with permanent humidity or shallow water	• All types of laying, such as in tunnels, concrete pits or buried installations • In installations with permanent humidity or shallow water

TECHNICAL DATA SLIP-ON JOINTS.

Operating Voltage	Max. Conductor cross- section (Cu/Al)	0 over polymer insulation	Max. 0 of outer sheath	Type
Umax/kV	mm^2	mm	mm	
145	2500	57-102	155	Heat Shrink cover
145	2500	57-102	155	Protection box
145	2500	57-102	155	Cu-tube with HDPE-coating
145	2500	57-102	155	Cu-tube and protection

Brugg Cables is devoted to the quality, performance and reliability of its products. High standards in production and testing are the order of the day at our factory in Switzerland. Computerised machines and skilled personnel are the guarantee for our high quality. To ensure this, each insulation body is tested individually. Of course, all our joints are suitable for any type of polymer cable or cable manufacturer.

Earthing. Earthing can be made according to customer specifications. All joints are designed in a way that are either direct earthing, straight through connection or through where cross-bonding is possible. Cross-bonding cables can be applied up to 500/500 mm^2.

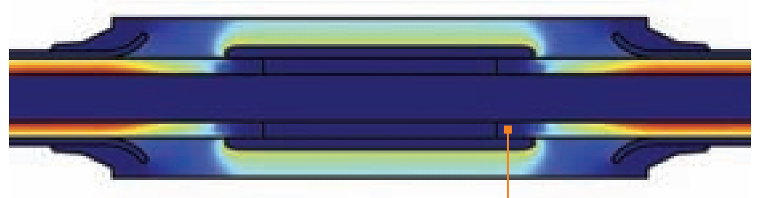
High quality in production. Consistent, high quality standards in manufacturing are guaranteed by using computerised machines. To ensure 0-failure during production, each part is tested several times in the manufacturing process. Every device is certified individually.

Standards. All joints are designed according to international standards, such as IEC 60840 or IEEE 404-2000. As a matter of course, we are certified according to ISO 9001 and ISO 14001.

Testing. To guarantee the quality of our products, testing is essential. All equipment is tested extensively in R&D. Our products are type-tested according to IEC 60840 and IEEE 404-2000. To ensure that all slip-on bodies are 100 % working, they all have to pass a routine test in accordance with IEC 60840.

Installation. To ensure highest quality in the field, we have an own installation department. Brugg engineers operate around the world, erecting and commissioning our various products. In order that you benefit as much as possible, we offer a complete installation service, training for your teams or the supervision of the installation by our experts, all at a reasonable price.

MPAH:
Joint with metal foil and heat shrink cover.

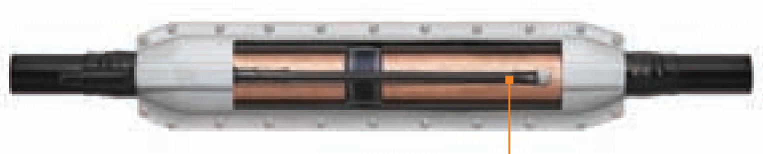


Simulations:
Design based on computer FEM-simulations for optimal electrical stress.

Laying in a tunnel:
Joints with Cu-tube and HDPE-coating in a tunnel.

Laying in a pit:
Joints with protection box in a concrete pit.

Final testing:
Every joint is tested individually to ensure 100 % performance.



MPCP:
Joint with Cu-tube and protectionbox.

Other type of Joints and Termination kits are also available as per customer requirement.