UNISTAR®

EXTRA HIGH VOLTAGE XLPE CABLE

UNIVERSAL CABLES LIMITED
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In technical Collaboration with
THE FURUKAWA ELECTRIC CO., LTD., JAPAN
(In association with VISCAS Corporation, Japan)

CABLE CONSTRUCTION

EHV XLPE Cables

The XLPE cable has Aluminium or Copper conductor, insulated with super clean cross linked polyethylene and then metallic screened with lead alloy sheath (with or without additional copper wires) or corrugated aluminium sheath and covered by PVC or PE for anti corrosion.

a) Conductor

The conductor consists of annealed Copper or hard Aluminium stranded wires. The form of conductor is either stranded compacted circular or milliken (segmental compacted circular). Stranded compacted circular conductor consists of wires stranded together and then compacted. The milliken conductor normally consists of 4 / 5 segments and is normally applied for the conductor sizes above 1000 sqmm. Milliken conductors are used to prevent the increase of A.C. resistance caused by skin effect and proximity effect.

Lead Sheath Cable

1. Conductor
2. Conductor screen
3. XLPE insulation
4. Insulation screen
5. Semi conducting water swellable tape
6. Lead alloy sheath (copper wires can be additionally provided below or above the lead sheath)
7. PVC or PE outer sheath

Aluminium Sheath Cable

1. Conductor
2. Conductor screen
3. XLPE insulation
4. Insulation screen
5. Semi conducting water swellable tape
6. Corrugated Aluminium sheath with Asphalt coating
7. PVC or PE outer sheath

CABLE CONSTRUCTION

b) Core Extrusion (Triple Extrusion)

The conductor screen, insulation & insulation screen are extruded simultaneously in Triple Extrusion Process using single (common) cross-head employing Vertical Continuous Vulcanizing (VCV) line with Dry Cure Dry Cool Cross linking Technology. This assures perfect bonding of the semi conducting layers with insulation in order to eliminate chances of micro void formation.

b-1) Conductor Screen

The conductor screen consists of an extruded layer of semi conducting compound. The conductor screen not only eliminates the risk of electrical discharge at the interface between conductor and insulation but also presents a very smooth interface with the insulation to eliminate any localized stress concentration.

b-2) Insulation

The insulation material is extruded cross linked polyethylene and applied over the conductor screen in a strictly controlled atmospheric conditions. The cross linking process by dry (nitrogen gas) curing has enabled to protect the electrical characteristics from being deteriorated.

b-3) Insulation Screen

The insulation screen is provided over the insulation by extruding the semi conducting compound concentrically to minimize the possibility of ionization on the outer surface of the dielectric. Extruded semi conducting layer is followed by a semi conducting non-woven water swellable tape.

c) Metallic Screen

The metallic screen consists of corrugated aluminium sheath or lead alloy sheath. In case of lead sheath design additional copper wire may be provided if lead alloy sheath alone is not sufficient to meet the requirement of earth fault current.

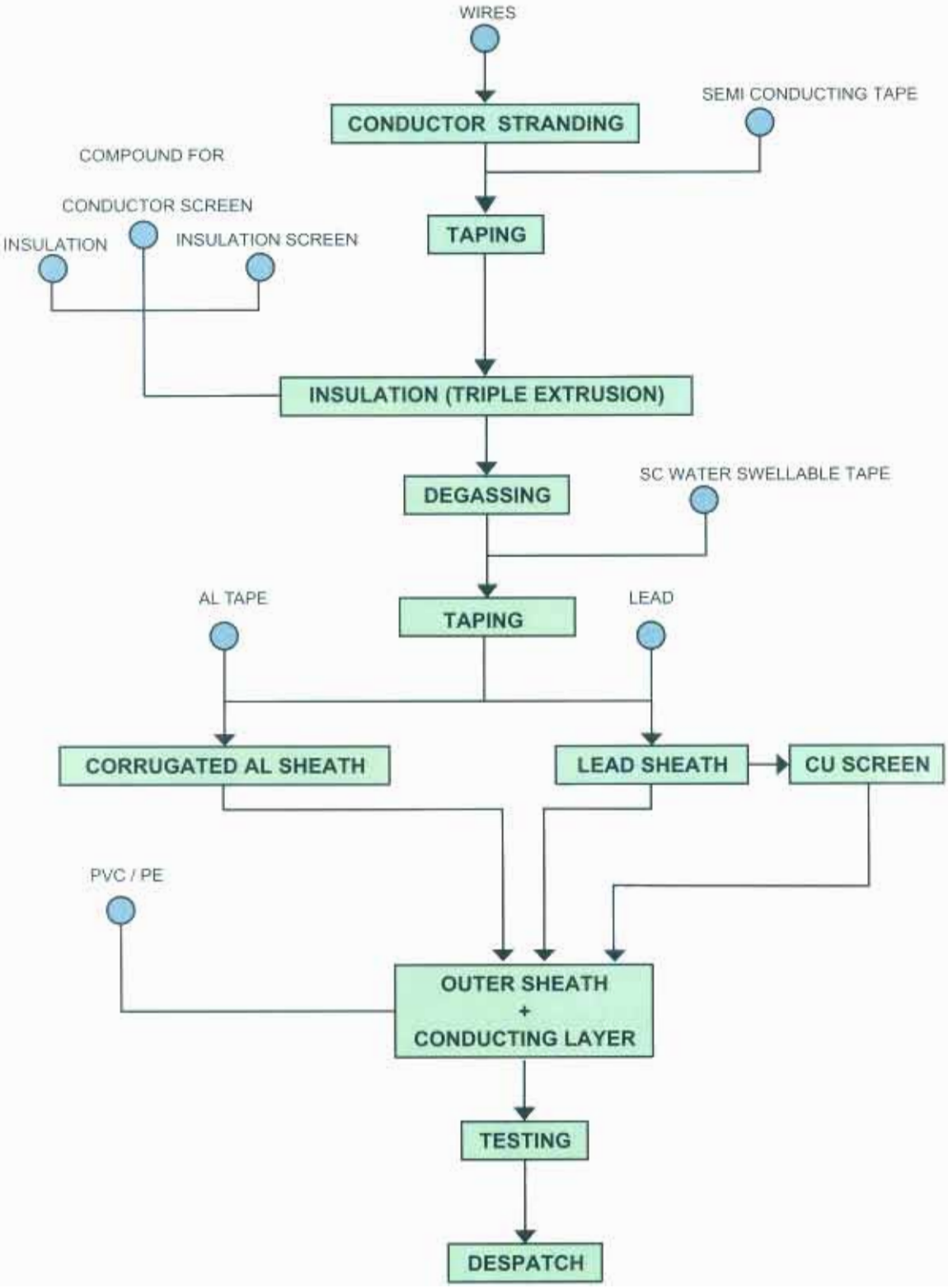
d) Outer Sheath

To protect the metallic sheath from electrochemical or galvanic corrosion, it is covered by PVC or PE.

e) Conductive outer layer

A conductive outer layer facilitates testing of the non metallic outer sheath. This test is important to ensure the physical integrity of the cable.

FLOW CHART


WIRES
CONDUCTOR STRANDING
SEMI CONDUCTING TAPE
COMPOUND FOR
CONDUCTOR SCREEN
INSULATION
INSULATION SCREEN
TAPING
INSULATION (TRIPLE EXTRUSION)
DEGASSING
SC WATER SWELLABLE TAPE
AL TAPE
TAPING
LEAD
CORRUGATED AL SHEATH
LEAD SHEATH
CU SCREEN
PVC / PE
OUTER SHEATH
+
CONDUCTING LAYER
TESTING
DESPATCH

PROCESS

Extrusion & Curing Process

The system adopted for insulation of EHV XLPE cable is Vertical Continuous Vulcanizing (VCV) and DCDC (Dry Curing and Dry Cooling) for cross-linking. The VCV line with triple extrusion ensures excellent concentricity of the cable coupled with a compact insulation with perfect contact between the layers and hence superior dielectric properties at very high voltages. On-line monitoring and controls in the production process ensures adherence to specified and strict dimensional standards. The DCDC process adopted for cross linking ensures that the insulation is kept absolutely dry during the curing process. This eliminates the chances of electrochemical treeing during the full life of the cable. The outstanding characteristics of XLPE cables manufactured by VCV line are:

- Fully concentric insulation,
- The dry cured and dry cooled cross linking by use of nitrogen gas guarantees excellent electrical characteristics of the insulation,
- The simultaneous extrusion of the inner and outer semi conducting layers and the insulation prevents void formation,
- Computerized controlled manufacturing processes maintain uniformity of quality.

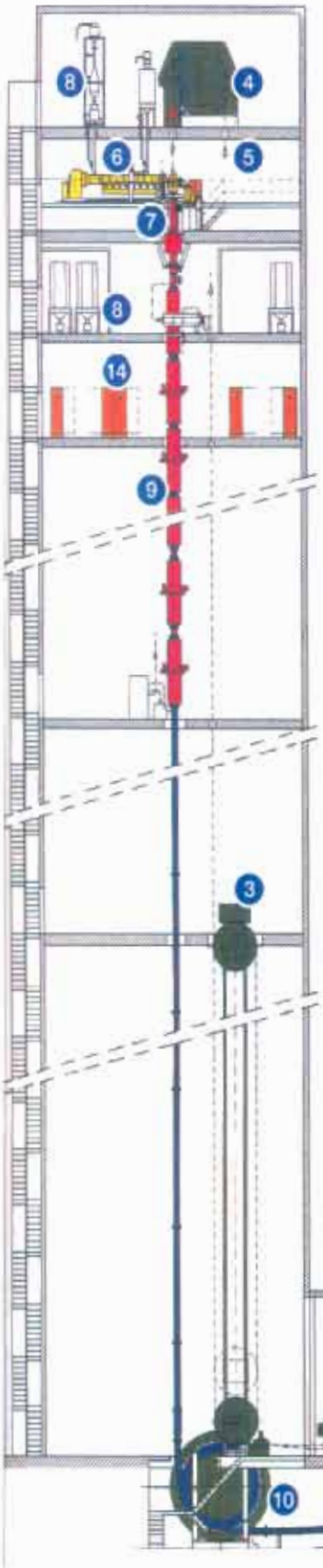
Internal View of VCV Plant

Stranding Machine

Triple Extrusion System of VCV Line

Dry Cure Dry Cool Vulcanizing System

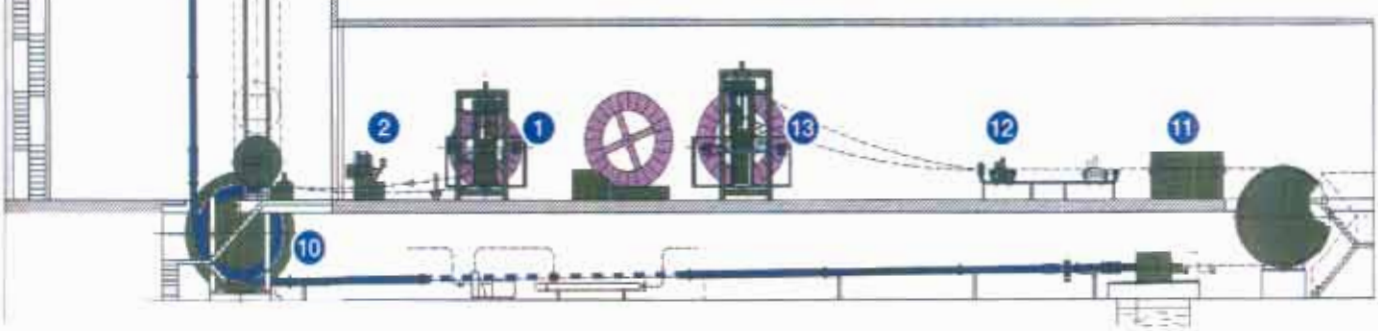
VCV LINE



1. Pay-off stand
2. Conductor butt welding machine
3. Accumulator
4. Braking unit
5. Conductor preheating
6. Extruder group with triple cross head
7. Diameter/wall thickness measuring device (X-Ray Monitoring Unit)
8. Granules conveying and drying system
9. CV tube
10. Reversing ring
11. Belt-type caterpillar
12. Cable Saw
13. Take-up stand
14. Line operating panel process computer

106 M Tower

EHV Manufacturing Bay



Material Handling System - VCV Line

- Material Handling Rooms : Class-1000 Clean Room Environment
- Working Platform : Class-1000 Clean Room Environment
- Material feeding System :
  Insulating Compound : Gravity Feed System

X-Ray Diameter Control

Gravitational XLPE Compound Feeding Class 1000 Clean Room

Line PC

QUALITY ASSURANCE

Process :

- Triple Extrusion System.
- Completely Dry Cured & Dry Cooled Vulcanization System.

Contamination Control Measures :

- Material Handling and Processing under Class-1000 Clean Room Environment.
- Use of Super clean materials.

Process Control :

- Fully Automatic Computerized Process Control using SCADA (Supervisory Control And Data Acquisition) Software.

Dimensional Control :

Equipped with :-

- X-Ray Unit for Online Measurement & Control of Wall Thickness
- Laser Unit for Online Measurement & Control of Core diameter

High Voltage Testing Set →

PHYSICAL & ELECTRICAL PARAMETERS

66 kV (E) Lead Sheathed cables

Nom. Cross section of conductor	Nom. Thickness of insulation	Minimum lead sheath thickness	Nom. Area of copper screen	Nom. Outer sheath Thickness	Approx overall cable diameter	Approx wt. of cable (Cu-conductor)	Approx wt. of cable (Al-conductor)	Maximum Capacitance	Maximum charging current
(Sqmm)	(mm)	(mm)	(sqmm)	(mm)	(mm)	(kg/m)	(kg/m)	(µF/km)	(A/km)
240	9.0	1.8	187	2.7	56	8.5	-	0.22	2.6
300	9.0	1.8	186	2.7	58	9.2	-	0.24	2.9
400	9.0	1.9	183	2.8	61	10.5	8.1	0.26	3.1
500	9.0	2.0	180	2.9	64	11.9	8.9	0.28	3.3
630	9.0	2.1	176	3.0	68	13.7	9.9	0.31	3.7
800	9.0	2.2	171	3.2	75	16.3	11.4	0.36	4.3
1000	9.0	2.3	167	3.3	79	18.7	12.6	0.38	4.5
1200	9.0	2.4	162	3.4	84	21.7	14.0	0.42	5.0
1400	9.0	2.5	156	3.5	90	24.5	15.5	0.47	5.6
1600	9.0	2.6	152	3.6	93	27.0	16.6	0.48	5.7
2000	9.0	2.7	145	3.8	99	31.0	18.8	0.53	6.3

Note: Fault rating of Lead sheath in combination with copper screen is 31.5 kA for one second duration

110 kV (E) Lead Sheathed cables

Nom. Cross section of conductor	Nom. Thickness of insulation	Minimum lead sheath thickness	Nom. Area of copper screen	Nom. Outer sheath Thickness	Approx overall cable diameter	Approx wt. of cable (Cu-conductor)	Approx wt. of cable (Al-conductor)	Maximum Capacitance	Maximum charging current
(Sqmm)	(mm)	(mm)	(sqmm)	(mm)	(mm)	(kg/m)	(kg/m)	(µF/km)	(A/km)
240	17.0	2.2	172	3.2	73	11.7	-	0.14	2.8
300	15.5	2.2	172	3.2	72	12.0	-	0.16	3.2
400	15.5	2.3	169	3.3	76	13.4	11.1	0.17	3.4
500	15.5	2.4	165	3.4	79	15.0	12.0	0.19	3.8
630	15.0	2.4	163	3.5	82	16.6	12.8	0.21	4.2
800	15.0	2.5	157	3.6	88	19.3	14.4	0.24	4.8
1000	15.0	2.7	150	3.7	93	22.2	16.1	0.25	5.0
1200	15.0	2.8	144	3.8	98	25.3	17.6	0.28	5.6
1400	15.0	2.8	140	4.0	103	28.1	19.1	0.30	6.0
1600	15.0	2.8	138	4.1	106	30.4	20.0	0.32	6.4
2000	15.0	3.0	128	4.3	113	34.9	22.7	0.34	6.8

Note: Fault rating of Lead sheath in combination with copper screen is 31.5 kA for one second duration

PHYSICAL & ELECTRICAL PARAMETERS

132 kV (E) Lead Sheathed cables

Nom. Cross section of conductor	Nom. Thickness of insulation	Minimum lead sheath thickness	Nom. Area of copper screen	Nom. Outer sheath Thickness	Approx overall cable diameter	Approx wt. of cable (Cu-conductor)	Approx wt. of cable (Al-conductor)	Maximum Capacitance	Maximum charging current
(Sqmm)	(mm)	(mm)	(sqmm)	(mm)	(mm)	(kg/m)	(kg/m)	(µF/km)	(A/km)
240	21.5	2.5	160	3.6	84	14.1	-	0.12	2.9
300	20.5	2.5	160	3.6	84	14.6	-	0.13	3.1
400	19.0	2.5	160	3.6	84	15.2	12.9	0.15	3.6
500	18.0	2.5	160	3.6	85	16.2	13.3	0.17	4.1
630	18.0	2.6	155	3.7	89	18.3	14.5	0.18	4.3
800	17.5	2.7	149	3.8	94	20.9	16.0	0.21	5.0
1000	17.5	2.8	144	3.9	98	23.6	17.5	0.23	5.5
1200	17.5	2.8	141	4.0	103	26.6	18.8	0.25	6.0
1400	17.5	2.9	134	4.1	109	34.4	25.4	0.27	6.4
1600	17.5	3.0	129	4.2	111	32.3	21.9	0.28	6.7
2000	17.5	3.2	118	4.4	118	36.9	24.7	0.30	7.2

Note: Fault rating of Lead sheath in combination with copper screen is 31.5 kA for one second duration

220 kV (E) Lead Sheathed cables

Nom. Cross section of conductor	Nom. Thickness of insulation	Minimum lead sheath thickness	Nom. Area of copper screen	Nom. Outer sheath Thickness	Approx overall cable diameter	Approx wt. of cable (Cu-conductor)	Approx wt. of cable (Al-conductor)	Maximum Capacitance	Maximum charging current
(Sqmm)	(mm)	(mm)	(sqmm)	(mm)	(mm)	(kg/m)	(kg/m)	(µF/km)	(A/km)
500	26	2.9	195	4.2	103	22.3	19.4	0.13	5.2
630	25	2.9	193	4.2	105	23.8	20.0	0.15	6.0
800	25	3.0	186	4.4	111	26.9	22.0	0.17	6.8
1000	25	3.2	177	4.5	115	30.1	24.0	0.18	7.2
1200	25	3.3	170	4.6	120	33.7	25.9	0.19	7.6
1400	25	3.4	162	4.7	126	37.1	28.1	0.20	8.0
1600	25	3.4	160	4.8	129	39.5	29.2	0.21	8.0
2000	25	3.6	148	5.0	136	44.6	32.4	0.23	9.2

Note: Fault rating of Lead sheath in combination with copper screen is 40 kA for one second duration

PHYSICAL & ELECTRICAL PARAMETERS

66 kV (E) Aluminium Sheathed cables

Nom. Cross section of conductor	Nom. Thickness of insulation	Nom. Aluminium sheath thickness	Nom. Outer sheath Thickness	Approx overall cable diameter	Approx wt. of cable (Cu-Conductor)	Approx wt. of cable (Al-Conductor)	Maximum Capacitance	Maximum charging current
(Sqmm)	(mm)	(mm)	(mm)	(mm)	(kg/m)	(Kg/m)	(μF/km)	(A/km)
240	9	2.1	2.7	60	4.7	-	0.22	2.6
300	9	2.0	2.8	62	5.4	-	0.24	2.9
400	9	1.9	2.9	65	6.3	4.0	0.26	3.1
500	9	1.8	3.0	68	7.3	4.4	0.28	3.3
630	9	1.7	3.1	72	8.8	5.0	0.31	3.7
800	9	1.7	3.3	80	10.8	5.9	0.36	4.3
1000	9	1.7	3.4	84	12.9	6.8	0.38	4.5
1200	9	1.8	3.5	89	15.4	7.6	0.42	5.0
1400	9	1.9	3.7	97	17.7	8.7	0.47	5.6
1600	9	1.9	3.8	100	19.8	9.4	0.48	5.7
2000	9	2.0	4.0	107	23.2	11.0	0.53	6.3

Note: Fault rating of Aluminium sheath is 31.5 kA for one second duration

110 kV (E) Aluminium Sheathed cables

Nom. Cross section of conductor	Nom. Thickness of insulation	Nom. Aluminium sheath thickness	Nom. Outer sheath Thickness	Approx overall cable diameter	Approx wt. of cable (Cu-Conductor)	Approx wt. of cable (Al-Conductor)	Maximum Capacitance	Maximum charging current
(Sqmm)	(mm)	(mm)	(mm)	(mm)	(kg/m)	(Kg/m)	(μF/km)	(A/km)
240	17.0	1.7	3.3	79	6.3	-	0.14	2.8
300	15.5	1.7	3.3	78	6.7	-	0.16	3.2
400	15.5	1.7	3.4	81	7.7	5.4	0.17	3.4
500	15.5	1.8	3.5	85	9.0	6.0	0.19	3.8
630	15.0	1.8	3.6	87	10.4	6.6	0.21	4.2
800	15.0	1.9	3.7	94	12.6	7.7	0.24	4.8
1000	15.0	2.0	3.9	100	14.8	8.7	0.25	5.0
1200	15.0	2.0	4.0	105	17.4	9.6	0.28	5.6
1400	15.0	2.1	4.1	111	19.8	10.8	0.3	6.0
1600	15.0	2.2	4.2	114	22.0	11.6	0.32	6.4
2000	15.0	2.3	4.5	122	25.6	13.4	0.34	6.8

Note: Fault rating of Aluminium sheath is 31.5 kA for one second duration

PHYSICAL & ELECTRICAL PARAMETERS

132 kV (E) Aluminium sheathed cables

Nom. Cross section of conductor	Nom. Thickness of insulation	Nom. Aluminium sheath thickness	Nom. Outer sheath Thickness	Approx overall cable diameter	Approx wt. of cable (Cu-Conductor)	Approx wt. of cable (Al-Conductor)	Maximum Capacitance	Maximum charging current
(Sqmm)	(mm)	(mm)	(mm)	(mm)	(kg/m)	(Kg/m)	(μF/km)	(A/km)
240	21.5	1.9	3.6	89	7.7	-	0.12	2.9
300	20.5	1.9	3.6	89	8.1	-	0.13	3.1
400	19.0	1.9	3.6	89	8.8	6.4	0.15	3.6
500	18.0	1.9	3.7	90	9.7	6.8	0.17	4.1
630	18.0	1.9	3.8	94	11.4	7.5	0.18	4.3
800	17.5	2.0	3.9	101	13.4	8.6	0.21	5.0
1000	17.5	2.1	4.1	105	15.7	9.6	0.23	5.5
1200	17.5	2.1	4.2	111	18.3	10.6	0.25	6.0
1400	17.5	2.2	4.4	119	20.8	11.8	0.27	6.4
1600	17.5	2.3	4.5	121	23.1	12.7	0.28	6.7
2000	17.5	2.4	4.7	128	26.7	14.5	0.30	7.2

Note: Fault rating of Aluminium sheath is 31.5 kA for one second duration

220 kV (E) Aluminium sheathed cables

Nom. Cross section of conductor	Nom. Thickness of insulation	Nom. Aluminium sheath thickness	Nom. Outer sheath Thickness	Approx overall cable diameter	Approx wt. of cable (Cu-Conductor)	Approx wt. of cable (Al-Conductor)	Maximum Capacitance	Maximum charging current
(Sqmm)	(mm)	(mm)	(mm)	(mm)	(kg/m)	(Kg/m)	(μF/km)	(A/km)
500	26	2.2	4.3	110	12.5	9.6	0.13	5.2
630	25	2.2	4.3	112	13.9	10.0	0.15	6.0
800	25	2.3	4.6	120	16.3	11.5	0.17	6.8
1000	25	2.4	4.7	124	18.7	12.6	0.18	7.2
1200	25	2.4	4.8	129	21.4	13.7	0.19	7.6
1400	25	2.5	5.0	138	24.1	15.1	0.20	8.0
1600	25	2.6	5.1	140	26.4	16.1	0.21	8.4
2000	25	2.7	5.3	147	30.2	18.1	0.23	9.2

Note: Fault rating of Aluminium sheath is 40 kA for one second duration

CONTINUOUS CURRENT RATING

The continuous current carrying capacity is calculated in accordance with IEC 60287.
Standard conditions for current rating

a) Ground temperature : 30°C
b) Depth of laying : 1.0 m
c) Soil thermal resistivity : 150°C-cm/W
d) Ambient air temperature : 40°C
e) Max. conductor temperature : 90°C
f) Cable installation : Trefoil touching formation with single point or cross Bonding
OR
Flat formation with 70 mm clearance (surface to surface) single point or Cross Bonding
g) Frequency : 50 Hz
h) Load factor : 100%

Maximum permissible conductor temperature

Recommended conductor temperatures for various conditions are as under :
Normal operation 90°C
Emergency operation 130°C
Short circuit 250°C

SHORT CIRCUIT RATING OF CONDUCTOR

S. No.	Nom. Area of Cross Section (SQMM)	Short Circuit Rating of Conductor for a duration of one Second	
		CU	AL
1.	240	34.3	-
2.	300	42.9	-
3.	400	57.1	37.7
4.	500	71	47
5.	630	90	59
6.	800	114	75
7.	1000	142	94
8.	1200	171	113
9.	1400	200	132
10.	1600	228	150
11.	2000	285	188

CONTINUOUS CURRENT RATING

1. LEAD SHEATHED CABLE

1.1 - 66 kV (E) Lead sheathed cable

Area of conductor	Trefoil SPB/CB ⁂		Flat SPB/CB •••		Trefoil SPB/CB ⁂		Flat SPB/CB •••	
	Cu	Cu	Cu	Cu	Al	Al	Al	Al
	Ground	Air	Ground	Air	Ground	Air	Ground	Air
(Sqmm)	(Amps)	(Amps)	(Amps)	(Amps)	(Amps)	(Amps)	(Amps)	(Amps)
240	410	575	445	665	-	-	-	-
300	460	655	500	760	-	-	-	-
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
2000	1095	1920	1230	2390	935	1615	1025	1955

SPB = Single-Point bonding
CB = Cross-bonding

1.2 - 110 kV (E) Lead sheathed cable

Area of conductor	Trefoil SPB/CB ⁂		Flat SPB/CB •••		Trefoil SPB/CB ⁂		Flat SPB/CB •••	
	Cu	Cu	Cu	Cu	Al	Al	Al	Al
	Ground	Air	Ground	Air	Ground	Air	Ground	Air
(Sqmm)	(Amps)	(Amps)	(Amps)	(Amps)	(Amps)	(Amps)	(Amps)	(Amps)
240	420	590	445	660	-	-	-	-
300	470	675	500	760	-	-	-	-
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
2000	1105	1910	1215	2290	935	1595	1010	1870

SPB = Single-Point bonding
CB = Cross-bonding

CONTINUOUS CURRENT RATING

1.3 - 132 kV (E) Lead sheathed cable

Area of conductor	Trefoil SPB/CB ⁂		Flat SPB/CB •••		Trefoil SPB/CB ⁂		Flat SPB/CB •••	
	Cu	Cu	Cu	Cu	Al	Al	Al	Al
	Ground	Air	Ground	Air	Ground	Air	Ground	Air
(Sqmm)	(Amps)	(Amps)	(Amps)	(Amps)	(Amps)	(Amps)	(Amps)	(Amps)
240	420	590	440	650	-	-	-	-
300	470	670	495	745	-	-	-	-
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
2000	1105	1910	1210	2260	935	1590	1005	1845

SPB = Single-Point bonding
CB = Cross-bonding

1.4 - 220 kV (E) Lead sheathed cable

Area of conductor	Trefoil SPB/CB ⁂		Flat SPB/CB •••		Trefoil SPB/CB ⁂		Flat SPB/CB •••	
	Cu	Cu	Cu	Cu	Al	Al	Al	Al
	Ground	Air	Ground	Air	Ground	Air	Ground	Air
(Sqmm)	(Amps)	(Amps)	(Amps)	(Amps)	(Amps)	(Amps)	(Amps)	(Amps)
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
2000	1075	1855	1160	2145	915	1545	975	1755

SPB = Single-Point bonding
CB = Cross-bonding

CONTINUOUS CURRENT RATING

2. ALUMINIUM SHEATHED CABLE

2.1 - 66 kV (E) Aluminium sheathed cable

Area of conductor	Trefoil SPB/CB ⁂		Flat SPB/CB •••		Trefoil SPB/CB ⁂		Flat SPB/CB •••	
	Cu	Cu	Cu	Cu	Al	Al	Al	Al
	Ground	Air	Ground	Air	Ground	Air	Ground	Air
(Sqmm)	(Amps)	(Amps)	(Amps)	(Amps)	(Amps)	(Amps)	(Amps)	(Amps)
240	415	595	445	680	-	-	-	-
300	465	675	500	775	-	-	-	-
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
2000	1025	1795	1160	2210	890	1535	985	1845

SPB – Single-Point bonding
CB = Cross-bonding

2.2 - 110 kV (E) Aluminium sheathed cable

Area of conductor	Trefoil SPB/CB ⁂		Flat SPB/CB •••		Trefoil SPB/CB ⁂		Flat SPB/CB •••	
	Cu	Cu	Cu	Cu	Al	Al	Al	Al
	Ground	Air	Ground	Air	Ground	Air	Ground	Air
(Sqmm)	(Amps)	(Amps)	(Amps)	(Amps)	(Amps)	(Amps)	(Amps)	(Amps)
240	415	585	440	650	-	-	-	-
300	465	665	495	745	-	-	-	-
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
2000	1010	1760	1125	2100	875	1505	955	1755

SPB = Single-Point bonding
CB = Cross-bonding

2.3 - 132 kV (E) Aluminium sheathed cable

Area of conductor	Trefoil SPB/CB ⁂		Flat SPB/CB •••		Trefoil SPB/CB ⁂		Flat SPB/CB •••	
	Cu	Cu	Cu	Cu	Al	Al	Al	Al
	Ground	Air	Ground	Air	Ground	Air	Ground	Air
(Sqmm)	(Amps)	(Amps)	(Amps)	(Amps)	(Amps)	(Amps)	(Amps)	(Amps)
240	415	580	440	635	-	-	-	-
300	465	665	490	730	-	-	-	-
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
2000	1005	1760	1110	2065	870	1490	950	1730

SPB = Single-Point bonding
CB = Cross-bonding

2.4 - 220 kV (E) Aluminium sheathed cable

Area of conductor	Trefoil SPB/CB ⁂		Flat SPB/CB •••		Trefoil SPB/CB ⁂		Flat SPB/CB •••	
	Cu	Cu	Cu	Cu	Al	Al	Al	Al
	Ground	Air	Ground	Air	Ground	Air	Ground	Air
(Sqmm)	(Amps)	(Amps)	(Amps)	(Amps)	(Amps)	(Amps)	(Amps)	(Amps)
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
2000	990	1720	1075	1980	860	1460	920	1655

SPB = Single-Point bonding
CB = Cross-bonding

RATING FACTORS

A. RATING FACTORS FOR VARIATION IN AMBIENT AIR TEMPERATURE -

Air temperature (°C)	30	35	40	45	50	55
Rating factor	1.11	1.05	1.0	0.94	0.88	0.81

B. RATING FACTORS FOR VARIATION IN GROUND TEMPERATURE -

Ground temperature (°C)	25	30	35	40	45	50
Rating factor	1.4	1.0	0.96	0.91	0.86	0.81

C. RATING FACTORS FOR VARIATION IN THERMAL RESISTIVITY OF SOIL -

Thermal resistivity (°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)	Rating factor
0.50	1.10
0.70	1.05
0.90	1.01
1.00	1.00
1.20	0.98
1.50	0.95

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

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

RATING FACTORS

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

No. of troughs	No. of Groups (circuits)		
	1	2	3
1	1.0	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 -

Axial 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

Note : All figures given in tables are indicative only.

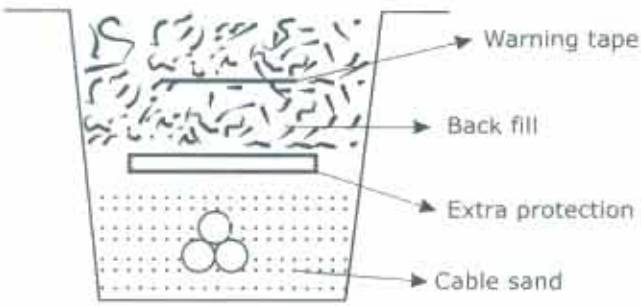
INSTALLATION

A) Underground Installation of EHV XLPE Cables

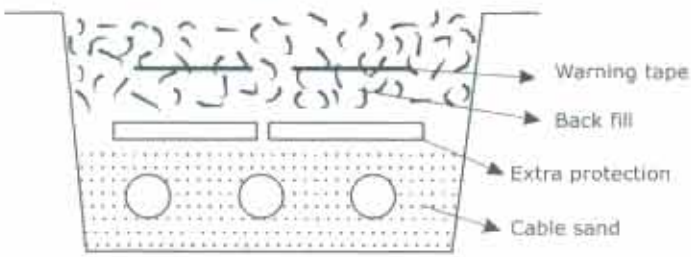
1.1) **Bending Radius** - The minimum bending radius for EHV XLPE cable is 20 x D, where D is the overall diameter of the cable.

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.



Three single core cables in trefoil formation



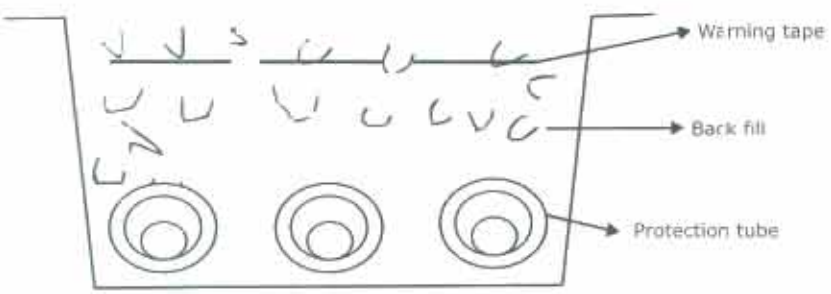
Three single core cables in flat formation

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 reasons for deeper laying, which then means 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 protected against damage. The thickness of the sand bedding should normally be a minimum of 10 cm in all directions from the cable surface. Sand with a 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.



Single core cables in protecting ducts, flat formation

In trenches normally extra protection is obtained by means of concrete slabs and its size to be chosen according to the expected damage. The slabs are placed directly on the cable sand.

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, e.g. of 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 flange.

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

- For aluminium 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 a sudden pulling stop, a brake should be arranged at the cable drum and a man placed there to operate this brake, which must be made rapidly at a stop.

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

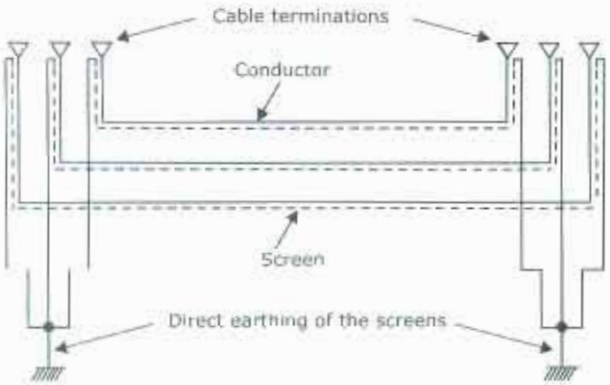
During the cable pulling telephones or walkie-talkie should be used to ensure the internal communication is established in order to prevent accidents and to enable a safe pulling operation.

B) Installation of XLPE cable in air

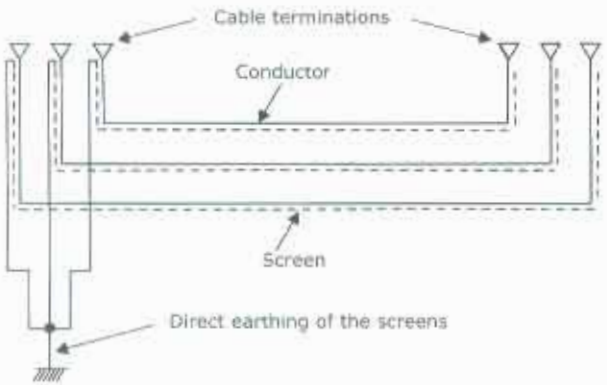
The requirement for bending radii, transportation and pulling of the cables are the same as for underground installation. For fixing of the cables, the following has to be taken into consideration.

Cable fixing	After laying of three Nos cables, the cable shall be tied up with non-magnetic metals trefoil/single clamp depend up on the laying configurations ie. 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 than the vertical spacing between the tiers shall not be less then 300mm.

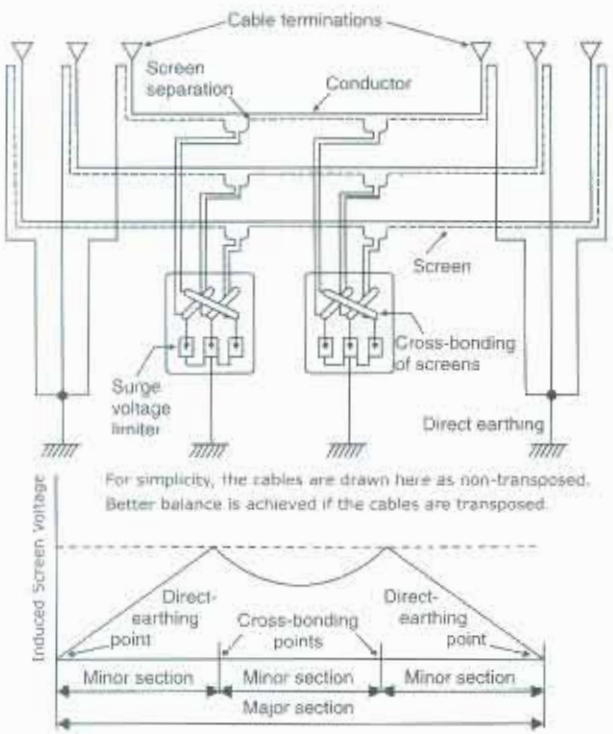
Screen Bonding Method



Both-ends bonding of screens, means that the screens are connected and earthed at both ends of the cable route. In this case a current will appear in the screen. This will cause losses in the screen, which reduces the cable current-carrying capacity. These losses are smaller for cables in trefoil formation than in flat formation.



Single-point bonding of screens, means that the screens are connected and earthed at one end of the cable route. In this case, a voltage will be induced between screen and earth, but no current will appear. This induced voltage is proportional to the cable length and current. Single-point bonding can only be used for limited route lengths.

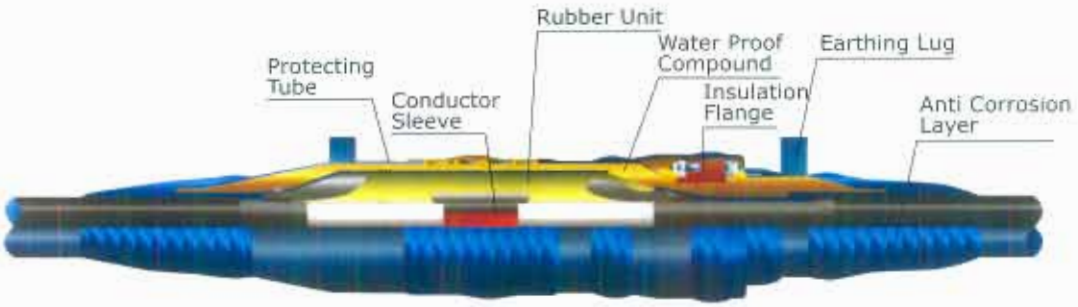


Cross-bonding of screens, means that the screens belonging to adjoining cables are connected as in the figure. In this case, a voltage will be induced between screen and earth, but no current will appear. The maximum induced voltage will appear at the link boxes for cross-bonding, see figure. This method permits a cable current-carrying capacity as high as with single-point bonding but longer route lengths than the latter. It requires screen separation and additional link boxes.

JOINT & ACCESSORIES

Accessories for indoor and outdoor termination and also for straight through joint, are being supplied by VISCAS Corporation, Japan. Details of accessories and their installation instructions are available on request.

Cold Shrinkable Joint (CSJ) :- With the one piece pre-molded type, the joint is compact and low cost. Assembling is extremely easy due to the innovative pull-fit system. Special tools and special skills are not required.



Body of Cold-Shrinkable-Joint consists of a silicone rubber one-piece-sleeve molded in a factory. The Cold-Shrinkable-Joint has a built-in electrical control system in one unit, composed of stress-relief high voltage electrode, insulation layer, stress-relief cone, and outer semi-conductive layer. It is expanded in the factory to bigger diameter than outer diameter of cable jacket by carrier-pipes to minimize whole joint length.

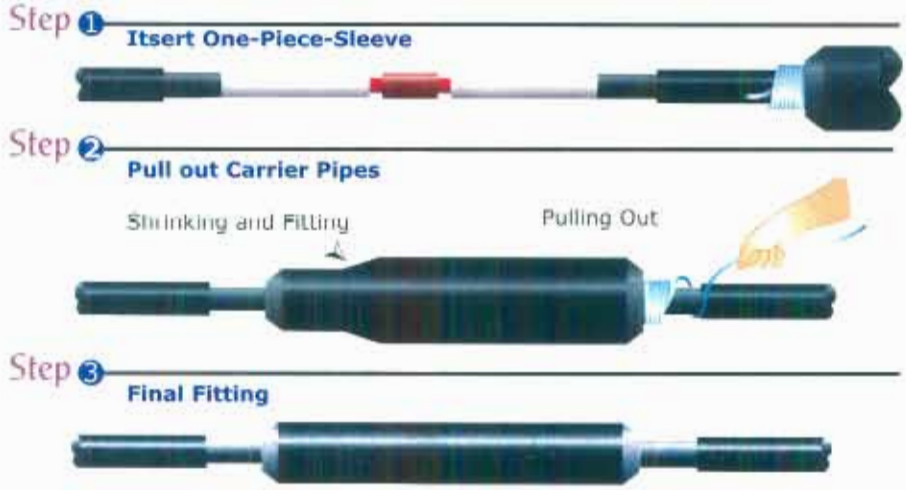
The assembling of the one-piece-sleeve can be completed only by pulling out carrier-pipes mounted inside of the sleeve. Special tools and skills are not required because it can be shrunk and fitted without any tool under room temperature.

Advantage on CSJ

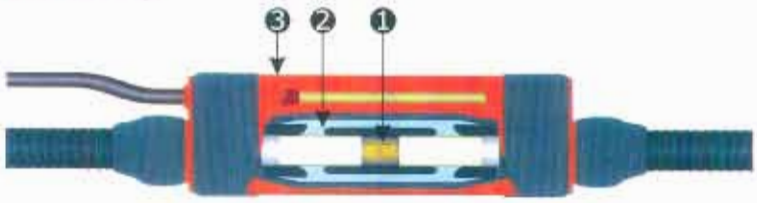
- Factory-Expanded and cold-Shrinkable-Joint from Silicone Rubber one-Piece-Sleeve
- Easier Assembling by Pull Fit System
- Only-ten-minutes Assembling for One-Piece-Sleeve
- Gurantee for High Quality of One-Piece-Sleeve by Manufacturing in the Factory under perfect and Clean Environment and Testing before Shipping.

JOINT & ACCESSORIES

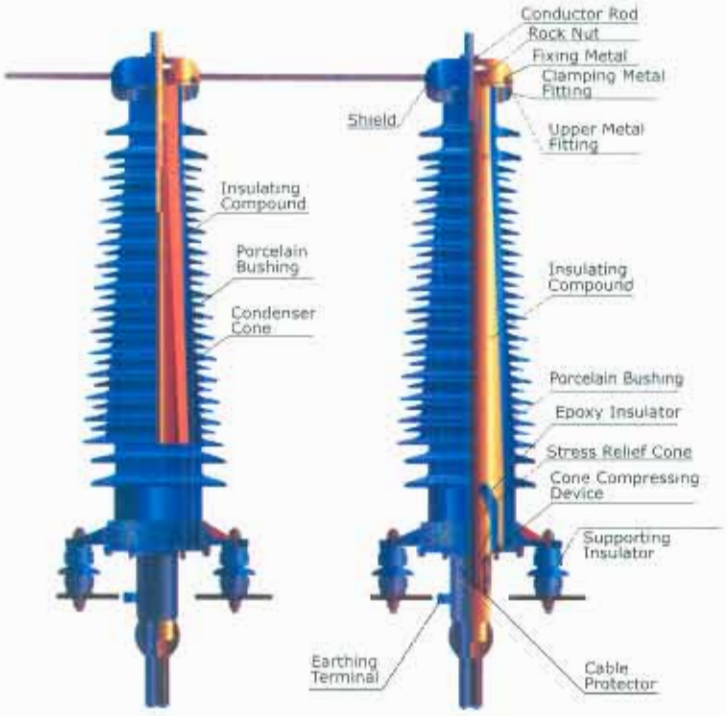
Pull-Fit System in CSJ



Construction of CSJ



Outdoor / Indoor (Aerial) Cable Termination



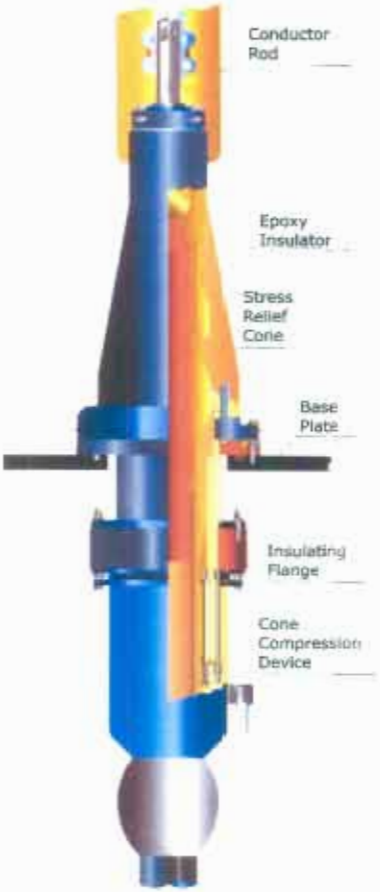
Oil-Immersed type **Prefabricated type**

Conventional type - Two types of terminations of the low cost prefabricated type which is easily installed onsite and the oil-immersed type which is effective for electric field distribution. Can be proposed considering customer's requirement. A condenser cone, very similar to oil-filled cable technology is applied to the oil-immersed type.

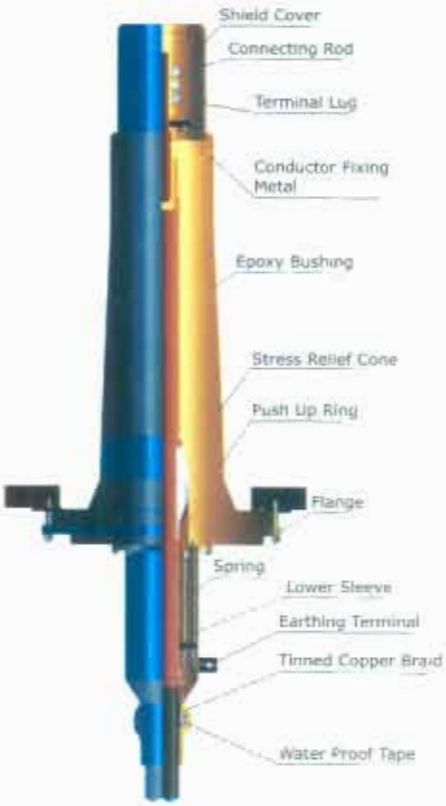
New type - New type of termination with further reductions in numbers of components and simplified assembling was developed and completed PQ test up to 230 KV. Application of one piece pre-molded technology results in high reliability.

SF6 Gas Immersed Type / Oil Immersed Type Termination

The gas termination and oil termination types are available in the low cost prefabricated type and the oil-immersed type. The prefabricated type has excellent work-ability, with a good record for reliability. In addition, it can be installed reversed or horizontally.



JCS type



IEC type