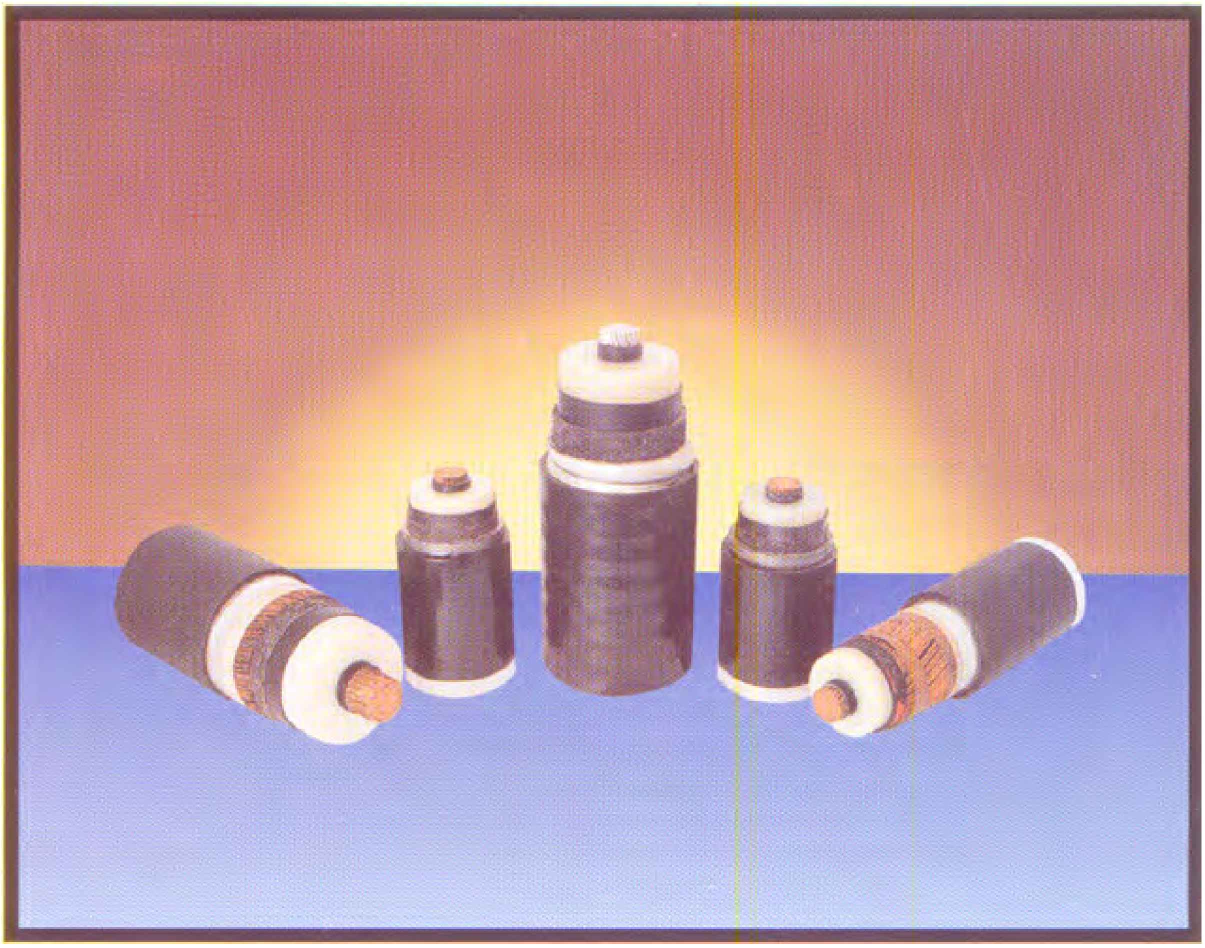
TROPOTHEN-S EHV CABLES



CABLE CORPORATION OF INDIA LTD.

INTRODUCTION

As India marches towards the 21st century, power becomes an essential ingredient for infrastructural development. With rapid urbanisation around the corner to sustain the industrial growth, the necessity of transmitting large blocks of power to load centres assumes significance. Over the years, there has been a marked increase in the voltage level for transmission of bulk power, due to the distinct advantages offered by the use of high voltage. This had ushered in the generation of Extra high voltage (EHV) power transmission systems with voltage grades of 66 kV and above. In this context, long-distance underground cable networks provide an ideal solution in many situations where the safety and logistic considerations preclude the use of cross-country overhead tower lines.

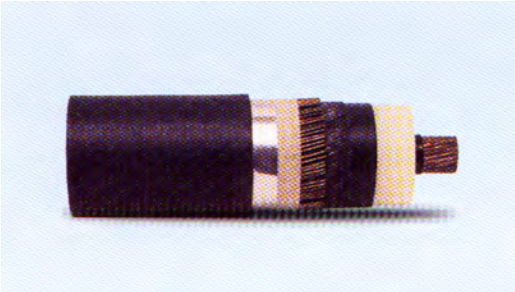
Underground EHV cables are also used for evacuating bulk power generated in pumped storage hydroelectric power generating stations, situated at a lower altitude, at outdoor switchyard located at a higher altitude. Similarly, underground cable systems are the appropriate means of power transmission over short distances where erection of overhead tower lines would be infeasible considering the space constraints.

The distinct advantages in achieving low transmission losses when such cable systems are operated at higher voltages for bulk power transfer are well-known.

It is in this context that Cross-linked Polyethylene (XLPE) insulated cables offer significant advantages. As an insulating material, XLPE combines the advantages of improved mechanical and thermal properties with excellent electrical characteristics of high dielectric strength, low relative permittivity and low loss factor. These advantages have rendered what XLPE cables can achieve today – carrying large currents at voltages upto 220 kV and above, with an inherent higher short circuit withstand capacity of 250^{o}C. Additional benefits that accrue are simple construction, easy installation and trouble free operation.

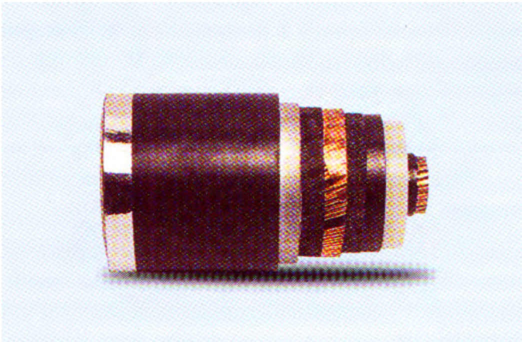
TYPICAL CONSTRUCTION

EHV XLPE cables are manufactured generally in accordance with IEC:502 and IS:7098 (Part 3) standards. The typical constructions and their salient features are as shown below.



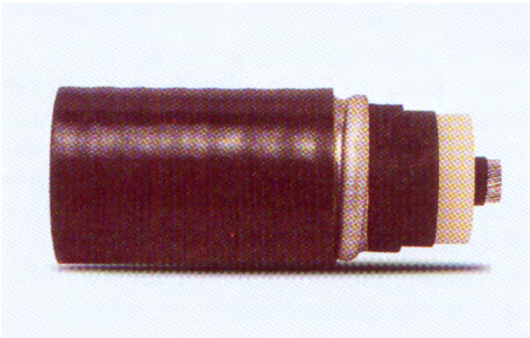
❑ Features of Metal Laminate Sheathed Cable

1. Impervious to ingress of water.
2. Layer is very thin, hence compact cable.
3. Lighter in weight.
4. Smaller diameter as compared at metallic sheathed cable.
5. Additional copper wires screen is necessary to carry earth fault current.
6. Larger delivery length and hence less number of joints.



❑ Features of Lead Sheathed Cable

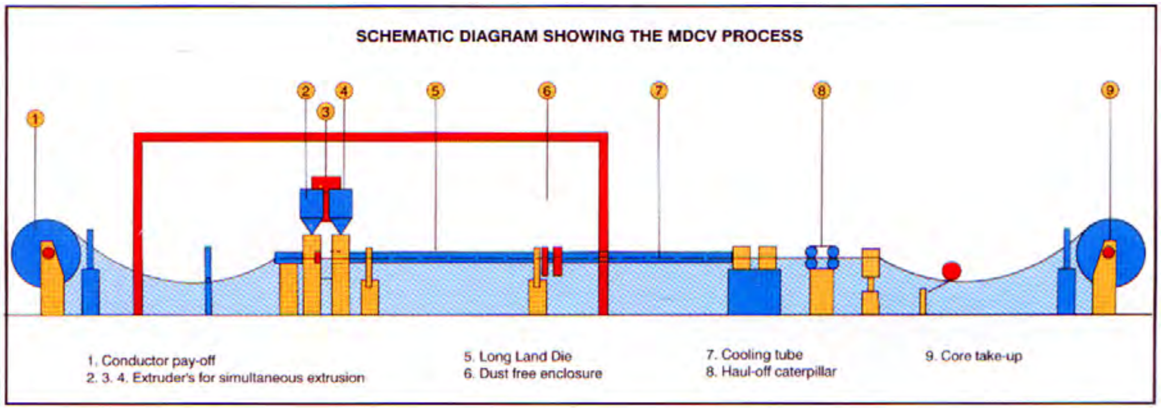
1. Continuous seamless sheathing, hence excellent protection against water penetration.
2. Cables is mechanically strong.
3. Lead sheath can act as metallic part of insulation screens.
4. Additional copper wires screen is not necessary to carry earth fault (short circuit) current except for the cases when earth fault current magnitude is very high.



❑ Features of Aluminium Sheathed Cable

1. Excellent protection against water penetration.
2. Cable is light in weight.
3. Cable is mechanically stronger.
4. Earth fault current carrying capacity of sheath is lighter.

THE MANUFACTURING PROCESS



For bulk power transmission, in addition to using higher voltages, higher ampacity is equally necessary. To meet this need, use of conductor with higher cross-sections is imminent. For conductor sizes below 1000 sq mm, compact circular stranded conductor construction is suitable. However, for conductor sizes above 1000 sq mm, use of segmental conductor construction (also called Milliken conductor) is recommended to overcome the skin effect. CCI has the technology to manufacture such segmental conductors.

Cable Corporation of India Ltd. Offers two distinct technologies, both employing dry curing systems for the production of XLPE insulated cables. The extruded core in the Continuous **Catenary Vulcanising (CCV)** line is subject to gravitational force which poses limitations in handling cores having a larger weight to length ratio. Difficulties, therefore, can be encountered with finished cores which many not have a fully concentric shape after cross-linking particularly for large cross-sections, thereby resulting in installation and jointing problems. In view of this, for very high electrical stress levels (as observed in EHV) and for large corss-sections, the conventional CCV line may not be adequate. It is for this reason that CCI has adopted a special patented MDCV process exclusively for manufacturing EHV cables.

CCI under licence from Mitsubishi Petrochemical Company Ltd., Japan has set up the plant called the **Mitsubishi Dainichi Continuous Vulcanising (MDCV)** line for EHV cables, which is the first of its kind in Asia, outside Japan. The heart of the system is a unique Long Land Die (LLD), inside which cross-linking is carried out under specially controlled conditions. Because of its capacity to handle heavier and larger cores, the MDCV process is known worldwide for making high-quality XLPE cables even upto 400-500 kV range, with no limitations of conductor size upto 2000 sq.mm. With this technology, CCI has joined a select group of international manufacturers in the field of super tension XLPE cables.

❑ Unique features of the MDCV Process

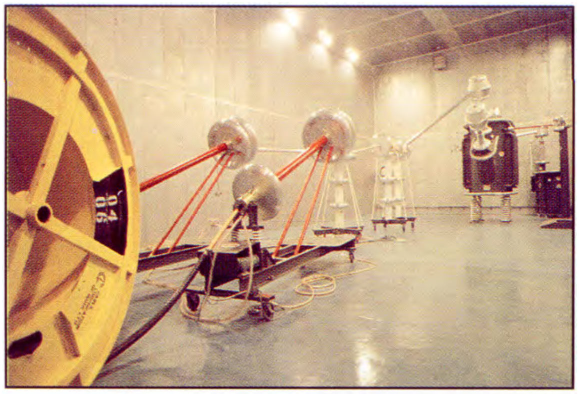
1) The plant has a horizontal layout, as a result of which the conductor as well as the extruded core can remain in a straight line without bending or sagging, thereby permitting stabilised manufacture of large-sized cables.
2) Cross-linking in Long Land Die under strict process control employing dry curing

at elevated temperatures, ensures void-free, homogeneous insulation.

3) Simultaneous extrusion of conductor screen, insulation and insulation screen in one single operation ensures perfect bonding without any surface irregularities.

4) Further perfection is achieved by the use of special techniques which constitute the hallmark of the process. The conductor and insulation (core) is fully supported in the LLD, and as such, the tendency of the core to sag is avoided inside the straight and horizontal LLD.

TESTING AND QUALITY CONTROL



PARTIAL DISCHARGE LABORATORY

Super Tension XLPE Cables from CCI are manufactured with stringent in-process quality control and ultimately tested to demanding performance requirements in accordance with the latest international specification like IEC:840/1988 and Swedish Standard SS:4242417/1988, and our own national specification IS:7098 (Part 3)/1993. Reference test voltages are indicated in table no.1.

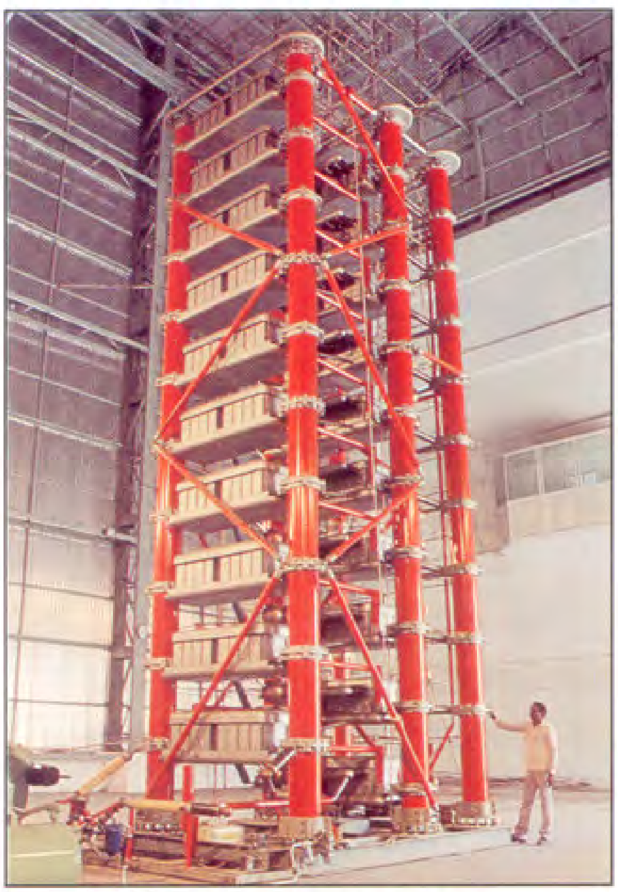
Our 220 kV cable, the first ever to be made in the country, has satisfactorily run through the tests conducted at **NV KEMA, Netherlands** (an independent testing laboratory and a research organisation of international repute), and has been successfully installed and commissioned at an Electricity Board in India.

CCI EHV cables have also passed rigorous tests conducted at the Central Power Research Institute (CPRI) with satisfactory results.

CCI has sophisticated laboratories to undertake basic material research and investigation to take care of continuous improvements in EHV cable construction. To sustain development work in the field, the Company has set up ultramodern test facilities which permit long term performance evaluation and reliability tests for EHV cables. The highlights of some of the equipment are listed below.

High Voltage and Partial Discharge Equipment

- Capacity : 400 kV
- System : Series Resonance Type
- Features : Double Shielded Room, Facilitates graphic recording of PD.



IMPULSE GENERATOR

Impulse Equipment

- Capacity : 2500 kV Impulse Generator
- Features : Suitable for lightning impulses 1.2/50 micro seconds.

Heat Cycle Equipment

- Capacity : 30 V, 4000 Amps, 120 kVA Current transformer
- Features : Can perform Heat Cycle test as per IEC:840 in combination with High Voltage Test.

DC High Voltage Equipment

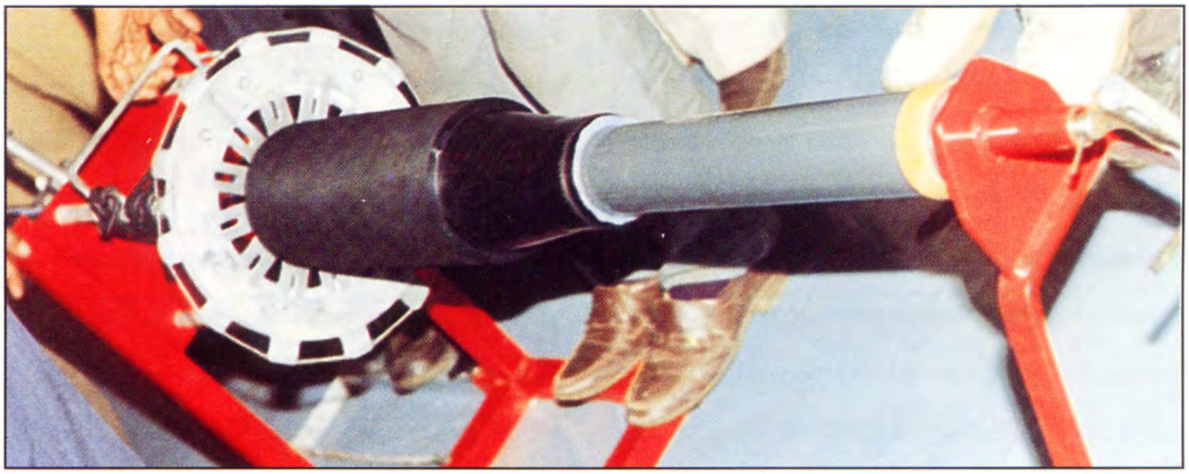
- Capacity : 400 kV DC Generator
- Features : Suitable for after installation tests on cables upto 220 kV.

The Company's electrical laboratory is accredited as a testing laboratory by NABL (National Accreditation Board for Testing & Calibration

Laboratories), Govt. of India. Our in-house R & D unit is recognized by the Department of Scientific & Industrial Research, Ministry of Science & Technology.

To top it all, it has been approved by BVQI that our Quality Management System Conforms to the quality standard ISO:9001-1994.

EHV CABLE ACCESSORIES



INSTALLATION OF EHV CABLE TERMINATION

Cable Accessories normally comprise of :

- Terminations : This could be for GIS/SF6 switchgear, transformer connections, outdoor power distribution.
- Straight Through Joints : This could be normal or insulated type depending on whether metallic sheath/screen is interrupted or not for bonding purposes.
- Link Boxes : These are used at terminations or joints for sheath interruptions or sheath integrity testing.

Joints and termination are available in the following types.

❑ **Taped type :**

Currently this techniques is applied upto 132 kV. Self amalgamating tapes are used for both insulation and shield; basically steps followed are to reconstruct the cable. Purity, cleanliness, homogeneity are important factors. Workmanship should ensure void-free and good interfacing to avoid internal stresses. The activity has to be carried out in a clean controlled environment.

From 170 kV to 245 kV however, to achieve proper homogeneity & pressure at interface, field moulding is employed under inert atmosphere to achieve vulcanisation of tapes.

Pre-fabricated

This type of accessories have rapidly come into use; precision, factory finished products, pretested quality and rapid, simple installation being distinct features. Termination have been developed and are in use upto 400 kV; joints are in use upto 245 kV. For 400 kV test is going on.

The accessories are designed for 3 main stresses – electrical, thermal and mechanical. Large field non-homogenates and high field strengths occur at interface of cable & accessories; by arrangement for stress control electrodes, the field strengths are kept below the working level. Pre-moulded stress cone for termination and sleeve for joints have embedded electrodes. These prefabricated parts are placed on cable insulation with an expansion. The expansion ensures pressure to match the irregularities of cable surface. Further, the prefabricated parts also take care of expansion of cable during load cycle and under short circuit – this is due to the elasticity of elastomeric prefabricated stress cone / joint body. For the stress cone / joint body either silicon or EPDM based elastomeric compounds are used with embedded electrodes for stress grading.

For outdoor cable terminations, a new type of insulator besides porcelain is now in use. The composite insulator is an epoxy tube reinforced with fibre glass and fitted with elastomeric sheds. The chief advantages are.

- Light Weight, not prone to damage, sabotage.
- Creepage distance can be increased as required.
- Does not blow apart even in case of inner flashover.

TECHNICAL PARTICULARS

The EHV cable system has to be considered in its totality, and viewed from both design and installation considerations so as to serve the end use effectively and in an optimum manner. More often than not, the installation parameters, suitably selected, provide the guiding principle for working out design solutions. Installation conditions such as depth of laying, laying formation, screen bonding systems and the environment, all play an important role in determining the current carrying capacity vis-à-vis economical selection of the conductor size. The EHV cable system is generally custom designed to suit the application. As a result, the cable construction is mutually agreed upon by the customer and the manufacturer. EHV cable design is not restricted to the design of the EHV cable as a product; a system perspective has to be adopted and as such EHV orders are invariably handled as turnkey assignments.

The key technical features are shown in Tables 2 to 5. The current ratings for various conductor sizes and voltage grades are shown in Tables 6 to 8. These are based on standard conditions of installation as mentioned below.

1) Maximum continuous operating conductor temperature : 90^{o}C
2) Standard ground temperature : 30^{o}C
3) Ambient air temperature : 40^{o}C
4) Thermal resistivity of soil : 150^{o}C cm/Watt
5) Depth of laying : 150 cm
6) Trefoil formation : For Cables in ‘close touching’, Transposition not applicable

Flat formation : Cables laid with gap, centre to centre spacing being 2D, where D = overall diameter of cable without transposition in case of both end bonding. Transposition not applicable in case of single end bonding.

In selecting the starting conductor size of different voltage grades of super tension cables, Bureau of Indian Standards (BIS) guidelines which specify the corresponding minimum conductor cross sections have been followed.

All current ratings have been computed considering screen cross-sections suitable for short circuit current of 31.5 kA for one second duration. The assumptions is in accordance with the general engineering practice employed in the country for electrical systems which are solidly earthed. For any other short circuit rating of screen, corresponding values of current rating can be furnished on request.

Rating Factors

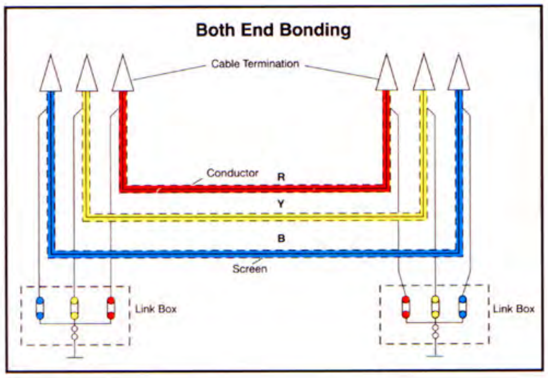
For installation conditions other than standard, rating factors will apply as given in Tables 9 to 14.

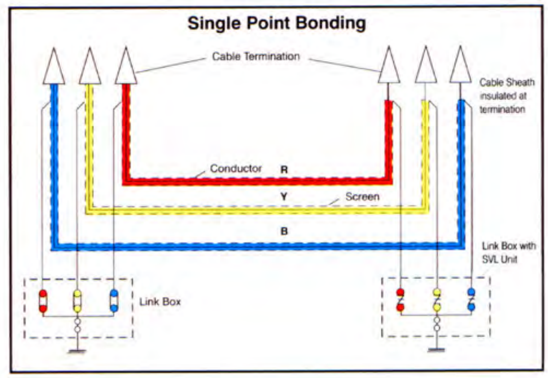
Short Circuit Rating

Thermally admissible short circuit current ratings for TROPOTHEN-S Cables are given in Table 3.

The computations are based on full load conductor temperatures of 90^{o}C at the inception of short circuit, and build up to maximum temperature of 250^{o}C at the end of short circuit. For any other duration "t" second/s divide the value given in respective table by $\sqrt{t}$.

CONSIDERATIONS FOR EHV CABLE INSTALLATION





SCREEN BONDING METHODS

1. Both End Bonding

The system depicted involves bonding and earthing of cable screens at both ends to form part of a closed loop which is electromagnetically linked with the loop formed by the conductors. In such a system, ciruclating currents are set up in the cable screen, resulting in heat loss and consequent derating of current carrying capacity. Such losses are minimized when cables are laid in trefoil “close-touching” formation, but increase with the spacing between cables.

2. Special Bonding Systems

Special bondign systems have been developed to keep circulating current losses to the minimum. Advantages which follow are :

a) Economical conductor size for optimum current ratings

b) Laying of cables with spacing, for example, in flat formation, to reduce the mutual heating effect due to proximity.

Special bonding is generally advantageous for high–amperage cable circuits. In such a system, standing voltages will appear in the cable screen which needs to be adequately insulated. Further, from the safety angle, a limiting value of such voltages becomes important. For the purpose, specially designed Sheath Voltage Limiters (SVL) which serve to restrict the voltage rise, particularly under transient conditions, are to be employed.

Two types of special bonding systems are in use:

a) Single Point Bonding

In such a system the screens are connected and earthed at one end of the route. At all other points, the screen being insulated from earth will have a standing voltage which will be proportional to the circuit length, conductor current and cable spacing, and be maximum at the furthest point from the earth bond. Since there is no closed circuit, screen circulating current is eliminated. Single point bonding is normally used for limited route lengths to keep the standing voltage to the minimum and render the cable installation safe against "touch–voltage".

b) Cross Bonding

Cross bonding essentially consists of sectionalising the cable screen into elementary sections called minor sections and cross connecting them so as to neutralise the total induced voltage in three consecutive sections. Three minor sections together make a major section.

In cross bonding system, the route is split up into groups of three drum lengths with the screens bounded and earthed together at both ends of a major section, but interrupted and connected in series at all other points. The purpose is to allow a standing voltage between screen and earth in each major section but eliminate circulating currents. With such an arrangement, the current carrying capacity can be considerably enhanced particularly for large conductor sizes and further, application is possible for longer route lengths.

When cable are lain in flat formation, transposition is resorted to, so that each phase cable is arranged to occupy over equal lengths of the route, each of the three geometrical positions in the laying formation. This results in balancing of induced voltages in the screen because of equal relative proximity of each single core cable with respect to the other.

Laying Methods

As dicussed in the preceding paragraphs, cables can be laid in trefoil or flat formation, depending upon design requirements and end use suitability. Installation conditions play a major role in optimising the performance of an EHV cable circuit, as also rendering it safe for long term reliability and usage. For the purpose, utmost care is to be exercised in handling an EHV cable installation so that it can serve its useful life to the fullest extent.

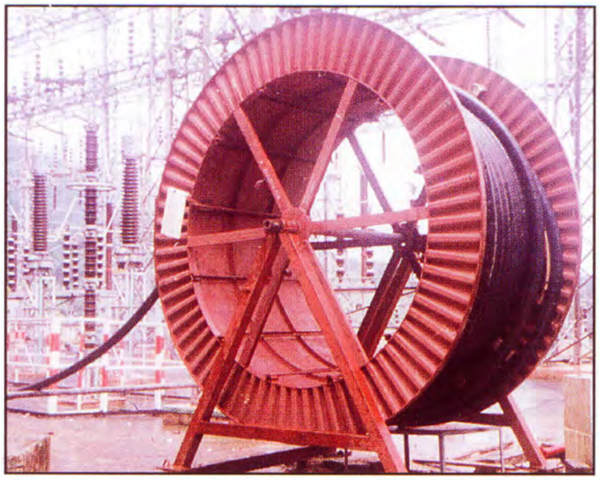
Standard methods of laying employed for power cable circuits apply to EHV cables as well, guidelines for which are available from Codes of Practice formulated by the BIS. Attention in particular needs to be paid to the consolidation of the surrounding soil environment in direct burial conditions for improvement of heat dissipation properties.

Bending Radius

While installing TROPOTHEN-S cables, the following minimum bending radius should be observed for single core cables, so that the cable and especially the insulation are not unduly stressed.

20 x D where D is the overall diameter of the cable.

TOTAL CABLE SERVICE



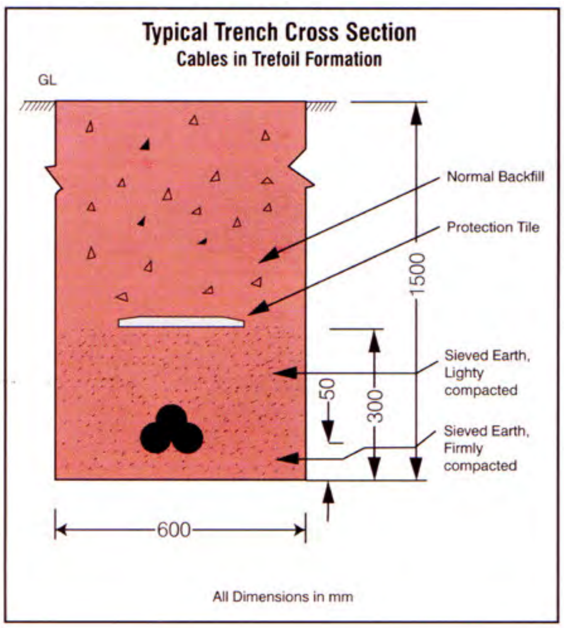
CABLE LAYING AT SITE

CCI'S responsibility does not end with supply of cables and jointing accessories only, but extends to assisting customers in installing maintenance-free cable network.

The Company is committed to providing its customers with “Total Cable Service” which embraces apart from design, selection and supply of cables, installation of the cable system as a whole, including pre-commissioning tests. In its simplest from, this may mean the presence of CCI's Service Engineer at site, to oversee the entire cable installation work. CCI is also positioned to take up the total responsibility for turnkey execution of a cable installation project starting with route survey, subsequent cable laying and jointing and final testing and commissioning of the installed system. CCI has a team of jointers who are trained abroad for installation of Joints and Terminations upto 230 kV grade.

The importance of achieving a synergy between design and installation parameters for an EHV cable system involves the application of integrated Project Engineering for finding total solutions from concept to commissioning. CCI has a Special Cell looking into this aspect to render all necessary assistance in designing and offering a complete EHV cable system.

CCI's Total Cable Service concept means total responsibility for a project so as to offer a comprehensive package, inclusive of all aspects of supply and installation. A few typical installation with EHV cables alongwith protection measures when laid in critical locations are furnished in the accompanying sketches to serve as guidance.



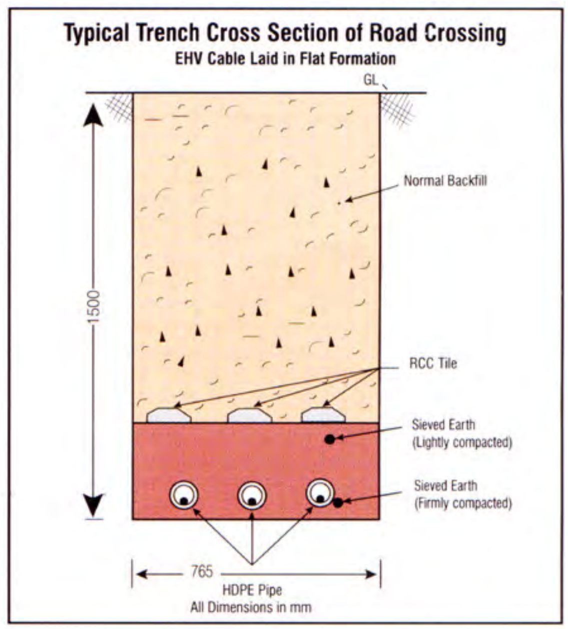


Table No. 1 Reference Test voltages for TROPOTHEN-S Cables

Rated voltage of cables Uo/U	Highest voltage for equipment between conductors Um	30 min voltage test 2.5Uo	Partial discharge test 1.5Uo	Tan delta measurement Uo	Heating cycle test 2 Uo	Impulse withstand test	15 min power frequency voltage test after impulse test 2.5 Uo
kV	kV	kV	kV	kV	kV	kV	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	315	190	122	254	1050	315

* Test voltages are generally in line with IEC 840 / IS : 7098 Part 3

Table No. 2 Conductor Resistance

Cross-Sectional area of conductor sq mm	Max D.C. resistance of conductor at 20 Deg. Centigrade		App. A.C. resistance of conductor at 90 Deg. Centigrade	
	Aluminium conductor ohm/km	Copper conductor ohm/km	Aluminium conductor ohm/km	Copper conductor ohm/km
95	0.3200	0.1930	0.4110	0.2460
120	0.2530	0.1530	0.3250	0.1960
150	0.2060	0.1240	0.2640	0.1590
185	0.1640	0.0991	0.2110	0.1270
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
2000	0.0149	0.0090	0.0207	0.0138

Table No. 3 Conductor Short Circuit Rating

Cross Sectional area of conductor Sq.mm.	Short Circuit Rating for 1 Sec.	
	Al kA(rms)	Cu kA(rms)
95	8.93	13.58
120	11.30	17.16
150	14.10	21.45
185	17.40	26.45
240	22.60	34.32
300	28.20	42.90
400	37.60	57.20
500	47.00	71.50
630	59.20	90.10
800	75.20	114.40
1000	94.00	143.00
1200	112.80	171.60
1600	150.40	228.80
2000	188.00	286.00

Table No. 4 Minimum conductor cross-sections and insulation thickness

Voltage grade kV	Smallest Nominal conductor cross-section sq mm	Nominal Thickness of Insulation mm
38/66	95	11.0
64/110	150	16.0
76/132	185	18.0
127/220	400	27.0

Note: Above values are as per IS:7098 (part 3)

Table No. 5 Capacitance of Cable (µf/Km)

Cross-Sectional area of conductor sq mm	Voltage grade of Cable			
	38/66 kV	64/110kV	76/132kV	127/220kV
95	0.150			
120	0.160			
150	0.170	0.135		
185	0.180	0.140	0.130	
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
2000	0.445	0.325	0.300	0.220

Table No. 6 Current Rating of TROPOTHEN-S Single Core 66 kV cable

Cross-Sectional area of conductor sq mm	Single Point Bonding / Cross Bonding							
	Trefoil Formation				Flat Formation			
	In Ground		In Air		In Ground		In Air	
	Aluminium Amp	Copper Amp	Aluminium Amp	Copper Amp	Aluminium Amp	Copper Amp	Aluminium Amp	Copper Amp
95	194	250	271	349	202	261	295	380
120	221	383	312	401	230	296	341	438
150	246	316	352	452	257	331	385	496
185	277	354	402	515	290	372	440	566
240	319	407	471	602	335	429	519	666
300	358	455	537	685	377	483	594	762
400	408	513	624	789	431	548	692	882
500	462	576	722	904	491	620	806	1021
630	523	644	835	1033	560	701	938	1179
800	585	708	953	1161	632	781	1080	1341
1000	686	816	1111	1372	723	905	1264	1592
1200	722	871	1235	1503	790	977	1416	1763
1600	815	965	1434	1716	907	1108	1669	2055
2000	892	1038	1613	1897	1008	1216	1904	2317

Cross-Sectional area of conductor sq mm	Both End Bonding							
	Trefoil Formation				Flat Formation			
	In Ground		In Air		In Ground		In Air	
	Aluminium Amp	Copper Amp	Aluminium Amp	Copper Amp	Aluminium Amp	Copper Amp	Aluminium Amp	Copper Amp
95	191	242	267	341	189	234	284	357
120	215	272	307	390	211	258	324	404
150	239	301	345	437	231	281	362	449
185	267	334	391	494	255	305	408	501
240	305	378	456	571	284	335	469	570
300	339	417	516	642	309	359	524	629
400	380	461	593	728	337	384	591	697
500	424	507	678	821	365	407	662	767
630	471	554	772	920	391	429	737	837
800	516	595	866	1013	415	447	806	900
1000	554	631	961	1115	437	465	884	976
1200	587	660	1048	1198	453	477	946	1032
1600	639	704	1176	1317	474	493	1030	1105
2000	678	736	1285	1415	490	505	1101	1166

Note : The above current ratingscorrespond to a metallic sheath/screen short circuit current capability of 31.5 kA For one second duration. For any variation from this value of short circuit current and duration, kindly refer to us.

Table No. 7 Current Rating of TROPOTHEN-S Single Core 110/132 kV Cable

Cross-Sectional area of conductor sq mm	Single Point Bonding / Cross Bonding							
	Trefoil Formation				Flat Formation			
	In Ground		In Air		In Ground		In Air	
	Aluminium Amp	Copper Amp	Aluminium Amp	Copper Amp	Aluminium Amp	Copper Amp	Aluminium Amp	Copper Amp
185	277	354	398	510	289	371	429	551
240	319	407	467	598	335	429	505	649
300	358	456	533	680	377	483	578	742
400	408	514	618	783	431	548	673	859
500	463	577	715	898	491	620	783	992
630	523	646	826	1027	560	701	910	1145
800	586	712	943	1155	632	782	1046	1302
1000	666	817	1098	1362	723	905	1223	1544
1200	721	873	1219	1492	789	977	1368	1708
1600	816	969	1417	1707	906	1108	1612	1992
2000	893	1043	1595	1890	1007	1217	1838	2247

Cross-Sectional area of conductor sq mm	Both End Bonding							
	Trefoil Formation				Flat Formation			
	In Ground		In Air		In Ground		In Air	
	Aluminium Amp	Copper Amp	Aluminium Amp	Copper Amp	Aluminium Amp	Copper Amp	Aluminium Amp	Copper Amp
185	268	336	390	494	256	308	403	499
240	306	381	455	574	286	338	465	570
300	341	421	516	646	312	363	521	632
400	383	466	593	735	341	389	591	705
500	428	513	679	830	369	414	664	778
630	475	561	775	933	396	436	741	853
800	522	605	871	1030	420	454	815	920
1000	559	639	970	1138	443	473	897	1003
1200	593	668	1057	1222	459	485	961	1060
1600	645	713	1190	1347	480	500	1050	1137
2000	685	746	1303	1449	496	512	1123	1200

Note : The above current ratingscorrespond to a metallic sheath/screen short circuit current capability of 31.5 kA
For one second duration. For any variation from this value of short circuit current and duration, kindly refer to us.

Table No. 8 Current Rating of TROPOTHEN-S Single Core 220 kV Cable

Cross-Sectional area of conductor sq mm	Single Point Bonding / Cross Bonding							
	Trefoil Formation				Flat Formation			
	In Ground		In Air		In Ground		In Air	
	Aluminium Amp	Copper Amp	Aluminium Amp	Copper Amp	Aluminium Amp	Copper Amp	Aluminium Amp	Copper Amp
400	406	513	608	771	430	546	651	831
500	461	576	703	885	490	619	756	960
630	522	645	811	1212	558	699	878	1106
800	585	712	927	1141	630	780	1009	1258
1000	664	815	1077	1342	720	902	1178	1490
1200	718	870	1195	1470	785	973	1316	1647
1600	809	961	1386	1678	899	1101	1546	1916
2000	869	1010	1544	1833	990	1191	1756	2147

Cross-Sectional area of conductor sq mm	Both End Bonding							
	Trefoil Formation				Flat Formation			
	In Ground		In Air		In Ground		In Air	
	Aluminium Amp	Copper Amp	Aluminium Amp	Copper Amp	Aluminium Amp	Copper Amp	Aluminium Amp	Copper Amp
400	384	469	589	734	344	394	585	706
500	429	518	674	831	373	419	660	784
630	478	566	770	935	400	442	740	862
800	525	612	869	1038	425	461	818	935
1000	562	646	971	1152	448	480	904	1024
1200	595	674	1059	1237	465	493	971	1085
1600	643	713	1188	1358	493	516	1071	1174
2000	670	728	1286	1440	537	561	1186	1288

Note : The above current ratingscorrespond to a metallic sheath/screen short circuit current capability of 31.5 kA For one second duration. For any variation from this value of short circuit current and duration, kindly refer to us.

Table No. 9 Rating factors for variation in ambient air temperature :

Air temperature °C	15	20	25	30	35	40	45	50	55	60
Conductor Temp 90 ° C / Rating Factors	1.25	1.20	1.16	1.11	1.05	1.00	0.94	0.88	0.82	0.76

Table No. 10 Rating factors for variation in ground temperature :

Air temperature °C	15	20	25	30	35	40	45	50
Conductor Temp 90 ° C / Rating Factors	1.12	1.08	1.04	1.00	0.96	0.91	0.87	0.82

Table No. 11 Rating factors for grouping of single core cable laid direct in ground in horizontal formation

Distance between centres of circuits	Number of circuits in group								
mm	1	2	3	4	5	6	7	8	9
100	1	0.76	0.67	0.59	0.55	0.51	0.49	0.47	0.46
200	1	0.81	0.71	0.65	0.61	0.58	0.56	0.53	0.52
400	1	0.85	0.77	0.72	0.69	0.66	0.64	0.63	0.62
600	1	0.88	0.81	0.77	0.74	0.72	0.71	0.70	0.69
800	1	0.90	0.84	0.81	0.79	0.77	0.76	0.75	0.75
2000	1	0.96	0.93	0.92	0.91	0.91	0.91	0.90	0.90

Table No. 12 Rating factor for thermal resistivity of soil

Soil thermal resistivity Deg. C cm/Watt	70	100	120	150	200	250	300
Rating factor	1.36	1.19	1.11	1.00	0.88	0.78	0.73

Table No. 13 Rating factor for depth of laying

Depth of laying cm	90	100	120	150	160	170	180	190	200
Rating factor	1.06	1.05	1.03	1.00	0.99	0.99	0.98	0.98	0.97

Table No. 14 Rating factor 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

Note : D is the overall diameter of cable.

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