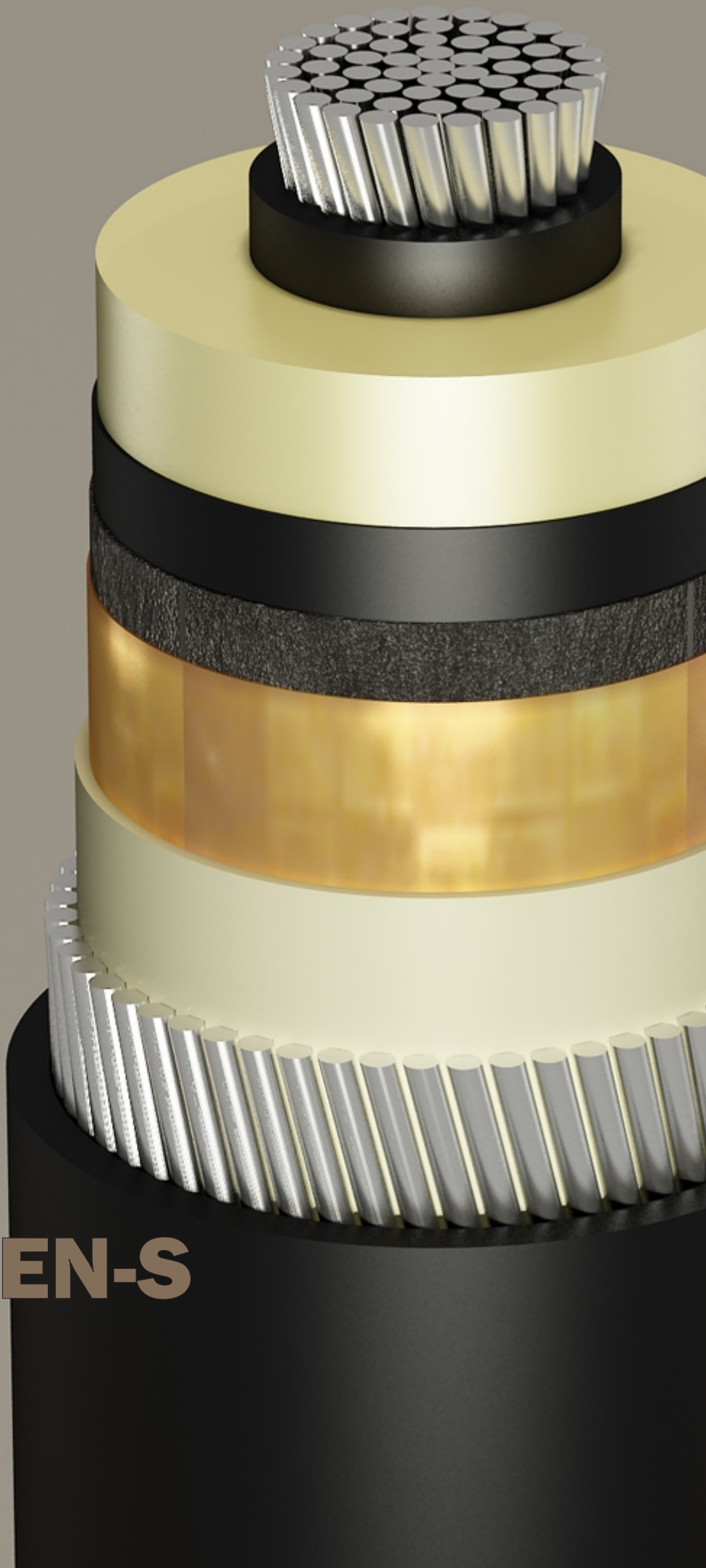
CABLE
CORPORTION
OF INDIA LIMITED

Bringing power to the people



TROPOTHEN-S

EHV XLPE CABLES

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INTRODUCTION

As India marches towards the 21st century,power becomes an essential ingredient for infrastructural development.With rapid urbanisation around the corner to sustain th e industrial growth,the necessity of transmitting large blocks o f power to load centres assumes significance.Over the years, t here ha s been 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 consideration s preclude the use of cross-country over head 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 locate data higher altitude. Similarly, underground cable systems are the appropriate me ans of power transmission over short distance s where erection of overhead tower lines would be infeasible considering the space constraints.

Th e distinct advantages in achieving low transmission losses when such cable system s 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 characteristic s of high dielectric strength , low relative permittivity and low loss factor . These advantages have rendered what XLPE cable s can achieve today – carrying large currents at voltages upto 220 k V 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.

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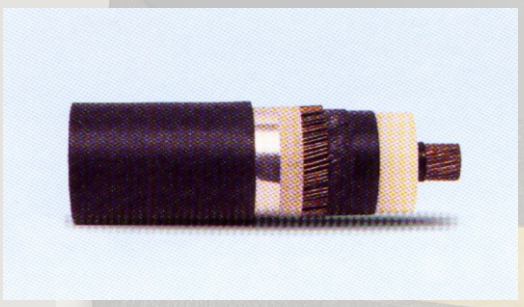
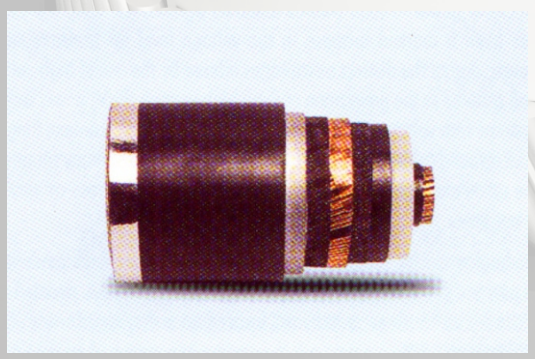
TYPICAL CONSTRUCTION

EH V XLP E cable s are manufactured generally in accordance with IEC: 502 and IS:7098 (Part-3) standards. The typical constructions and their salient features are as show n below.



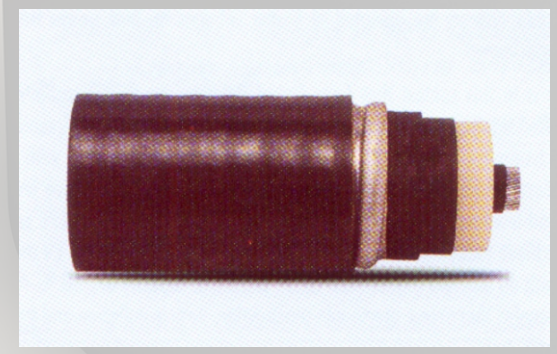
❑ Features of Metal Laminate Sheathed Cable

1. Impervious to ingress of water.
2. Layer is very thin,hence compact cable.
3. Lighter in weight.
4. Smaller diameter a s compar ed 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.

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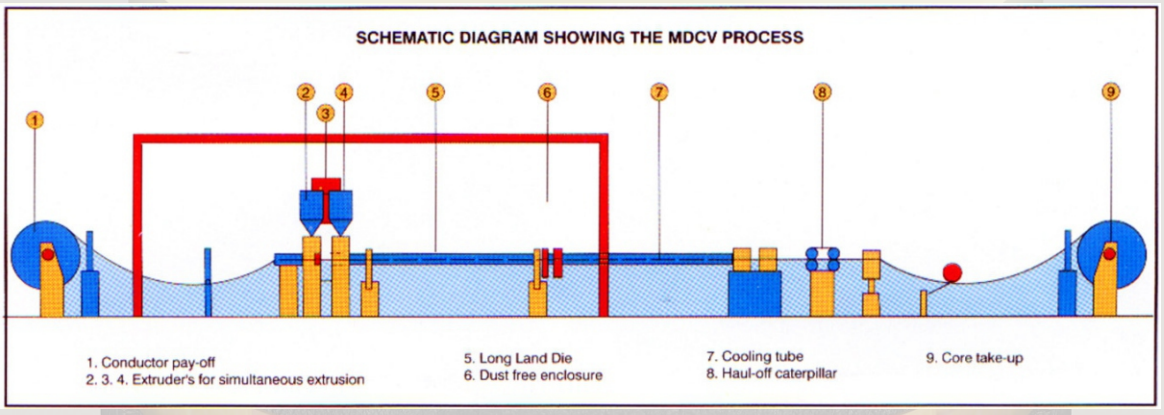
THE MANUFACTURING PROCESS



MDCV Process

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. Cross-linking in Long Land control employing dry curing at elevated temperatures,ensures void-free, homogeneous insulation. A very low eccentricity is achieved by this process as the process is horizontal.

The pressure is very high in LLD, resulting in void free extrusion.

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TESTING AND QUALITY CONTROL

Super Tension XLPE Cable s from CCI are manufactured with stringent in-proces s quality control and u ltimatel y tested to demanding performance requirement s in accordance with the latest international specification like IEC:62840/2004 an d Swedish Standard SIS:442417/1988, and our own national specification IS:7098 (Part-.3). Reference test voltages are indicated in table no.1.Our 220 k V cable , the first ever to be made in the country, has satisfactorily run through the tests conducted a t **N V KEMA, Netherland** s (an independent testing laboratory a nd a research organisation of international repute), and has been successfully installed and commissioned at an Electricity board in india

CC I EH V cables 66kV,110kV,220kV grade have been type tested at Centra Power Research Institute (CPRI) with satisfactory results.
CCI has sophisticated laboratories to undertake basic material research and investigation to take care of continuous improvements i n EHV cable construction .To sustain development wor k in the field , the Company has se t up ultramodern test facilities which permit long term performance evaluation and reliability test s for EHV cables.

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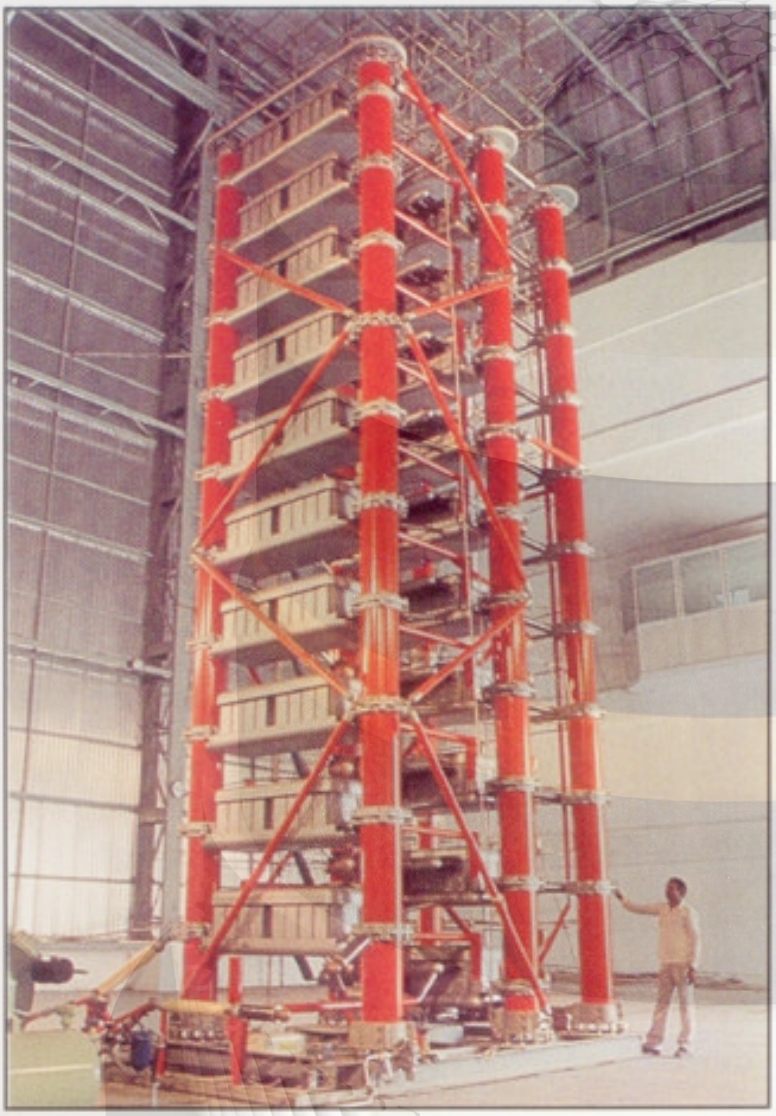

IMPULSE GENERATOR

High Voltage and Partial Discharge Equipment

·Capacity : 400 kV
·System : Series Resonance Type
·Features : Double Shielded Room , Facilitates graphic recording o f PD.

Impulse Equipment

Capacity : 2500 kV Impulse Generator
Features : Suitable for lightning impulse s 1 .2/5 0 microseconds.

Heat Cycle Equipment

Capacity : 30V, 4000 Amps ,1 0 kV A 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.

To top it all, it has been approved by **Bureau Veritas** that our Quality Management ISO:9001-2008.

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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 / I S: 7098 Part 3

Table No . 2 Conductor Resistance

Cross-Sectional area of conductor mm	Max D.C. resistance of conductor a t 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	Coppe r 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	0.047 0	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

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Table No.3 Conductor Short Circuit Rating

Cross Sectional area of conductor Sq.mm.	Short circuit 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	Nominal Thickness of Insulation
	sq mm	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)

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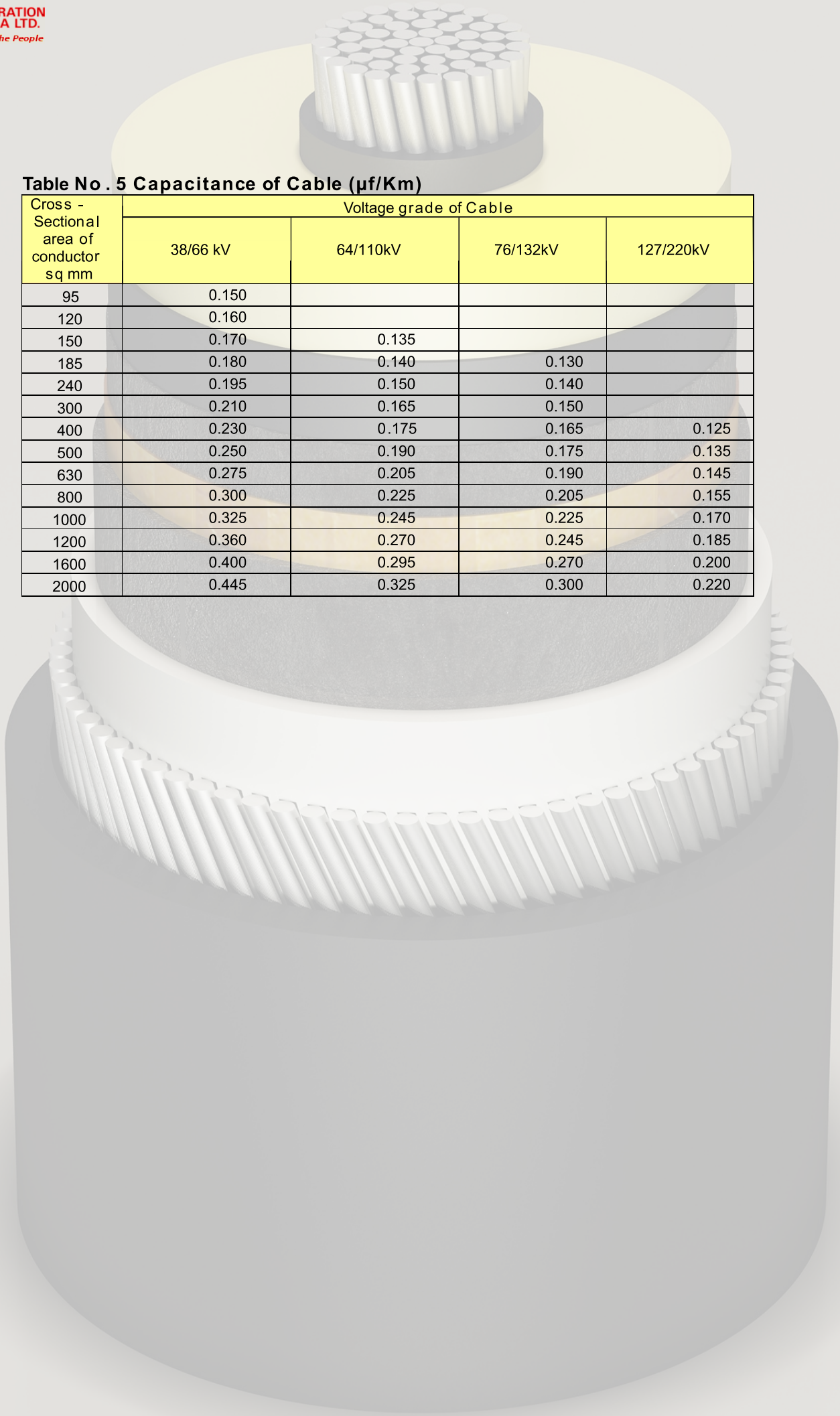

Table No . 5 Capacitance of Cable (µf/Km)

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

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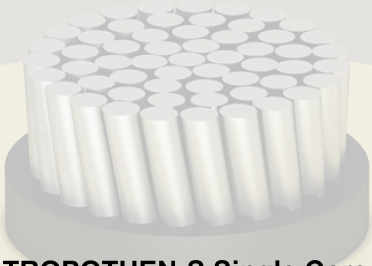

Table No. 6 Current Rating of TROPOTHEN-S Single Core 66 kV cable

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	17 63
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	45 3	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.

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

Cross - Sectional area of conductor sq mm	Single Point Bondin g / Cross Bonding							
	Trefoil Formation				Fl at 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
16 00	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							
	TrefoilFormation				Flat Formation			
	In Ground		In Air		In Ground		In Air	
	Aluminium Amp	Copper Amp	Aluminium Amp	Copper Amp	Aluminium Amp	Copper Amp	Aluminium Amp	CopperAmp
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.

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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	11 95	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	56 2	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.

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

Air temperatur e °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 the cable