Medium Voltage Cables

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6/10 (12)kV 3-Core
XLPE Insulated, Unarmoured & Armoured, PVC Sheathed Cable

Description: CU/XLPE/CTS/PVC or CU/XLPE/CTS/PVC/SWA/PVC-AT or CU/XLPE/CTS/PVC/DSTA/PVC-AT



Application :	This is an electric power distribution network cable typically used as primary supply to commercial, industrial, and urban residential networks.
Voltage rating :	6/10 (12)kV, 6.35/11 (12)kV
Construction :	Plain annealed copper (IEC 60228 Class 2), cross-linked semi-conducting compound, XLPE compound insulated, cross-linked semi-conducting compound (bonded or strippable), plain annealed copper tape screen, unarmoured, or galvanized steel wires or double steel tape armoured, PVC or anti-termite PVC (for armoured cable only) compound sheathed cable
Insulation colour :	Natural Colour stripe: Brown, Black, Grey The individual cores shall be identified by the coloured stripe tapes applied under the copper tape screen
Sheath colour :	Black (Other colour upon request)
Specification :	IEC 60502-2, BS 6622
Operating temperature :	90˚C

Conductor		Insulation	Unarmoured			SWA Armoured			DSTA Armoured		
Nominal Area	Approx. Diam.	Thickness	**Part No.**	Approx. Overall Diam.	Approx. Weight	**Part No.**	Approx. Overall Diam.	Approx. Weight	**Part No.**	Approx. Overall Diam.	Approx. Weight
(mm^2)	(mm)	(mm)		(mm)	(kg/km)		(mm)	(kg/km)		(mm)	(kg/km)
25	6.0	3.4	**13039023**	41.6	2045	**13039009**	50.0	4415	**13039142**	47.0	3055
35	7.0	3.4	**14039023**	44.0	2435	**14039009**	52.4	4940	**14039142**	49.1	3480
50	8.4	3.4	**15039023**	47.3	2915	**15039009**	56.0	5640	**15039142**	52.8	4095
70	10.0	3.4	**16039023**	51.0	3670	**16039009**	60.0	6610	**16039142**	56.6	4965
95	11.6	3.4	**17039023**	54.8	4610	**17039009**	63.5	7730	**17039142**	60.3	5970
120	13.0	3.4	**18039023**	58.0	5445	**18039009**	67.0	8780	**18039142**	63.8	6915
150	14.6	3.4	**19039023**	61.7	6400	**19039009**	70.6	9975	**19039142**	67.6	7975
185	16.2	3.4	**20039023**	65.4	7620	**20039009**	74.7	11410	**20039142**	71.4	9315
240	18.4	3.4	**21039023**	70.5	9475	**21039009**	81.5	14540	**21039142**	76.8	11370
300	20.6	3.4	**22039023**	75.7	11475	**22039009**	86.7	16950	**22039142**	82.2	13545
400	23.8	3.4	**23039023**	83.0	14215	**23039009**	94.4	20265	**23039142**	91.1	17380

*MDPE, LSZH sheath is available if required.



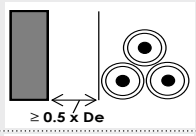
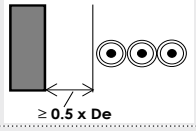
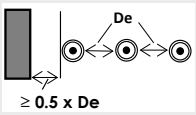
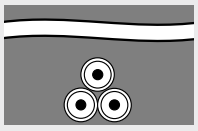
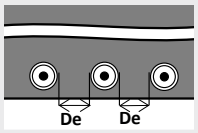
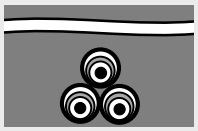
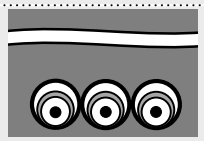
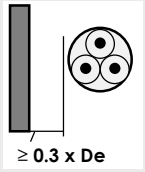




Technical Information

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Table 1 : Method of Installation

No.	Installation Method	Examples	Remarks
1	**Single-Core Cable (In Air)** Cables are assumed to be spaced at least 0.5 x D_e from any vertical surface and installed on brackets or ladder racks.		
a)	Three single-core cables in trefoil formation touching throughout their length		Where D_e is the external diameter of the cable
b)	Three single-core cables in horizontal flat formation touching throughout their length		
c)	Three single-core cables in horizontal flat formation with a spacing of one cable diameter, D_e		
2	**Single-Core Cable (Buried Direct)** Cables buried direct in the ground at a depth of 0.8m, soil thermal resistivity of 1.5 K·m/W, ground temperature 20°C.		
a)	Three single-core cables in trefoil formation touching throughout their length		
b)	Three single-core cables in horizontal flat formation with a spacing of one cable diameter, D_e		Where D_e is the external diameter of the cable
3	**Single-Core Cable (In Earthenware Ducts)** Cables in earthenware ducts buried at a depth of 0.8m with one cable per duct. The earthenware duct having an inside diameter of 1.5 x D_e and with a wall thickness equal to 6% of the duct inside diameter.		
a)	Three single-core cables in trefoil ducts touching throughout their length		
b)	Three single-core cables in horizontal flat formation, ducts touching throughout their length		
4	**3-Core Cables**		
a)	One 3-core cable in air spaced at least 0.3 x D_e from any vertical surface		Where D_e is the external diameter of the cable

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Table 1 (Continued)**:**

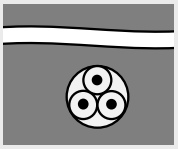
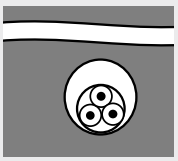
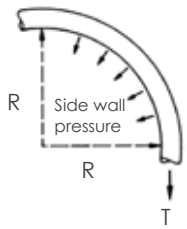
No.	Installation Method	Examples	Remarks
b)	One 3-core cable buried direct in the ground at a depth of 0.8m		Where D_e is the external diameter of the cable
c)	One 3-core cable in a buried earthenware duct having an inside diameter of 1.5 x D_e and with a wall thickness equal to 6% of the duct inside diameter. The depth of burial of duct is 0.8m		

Table 2 : Recommended Minimum Bending Radius

To install the cables safely without damaging the electrical and physical properties of the cables, the tabulated values (shown below) represent the permanent minimum bending radius the cables withstand in fixed installation and on dispatching reels. Other constraints may impose a greater bending radius.



Type of Cable	On Drum	During Installation	Placed into Position Adjacent to Joint or Termination with Former
Armoured Single-Core	8D	15D	12D
Unarmoured Single-Core	10D	20D	15D
Armoured Multi-Core	8D	12D	10D
Unarmoured Multi-Core	10D	15D	12D

Note : D means the overall diameter of cable (mm)

Table 3 : Permissible Maximum Pulling Tension of Medium Voltage Cable

With Pulling Eye on Conductor

Material	Maximum Safe Tensile Stress (S) (N/mm²)
Stranded Copper Conductor	70
Stranded Aluminium Conductor	50
Solid Aluminium Conductor	30

With Pulling Eye on Armour

Galvanized Steel Wire Armour	100
Hard Drawn Aluminium Wire Armour	60

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Table 4 : Technical Properties to IEC 60502-2

No.	Technical Properties		Rated Voltage (kV)					
			U_m	7.2	12	17.5	24	36
			U_0/U (IEC 60502-2)	3.6/6	6/10	8.7/15	12/20	18/30
1	Max. Conductor D.C. Resistance at 20°C (Ω/km)		See Table 5					
2	Routine Partial Discharge Test		The magnitude of discharge shall not exceed 10 pC at the test voltage, raised gradually to and held at 2 U_0 for 10 s and then slowly reduced to 1.73 U_0					
3	Routine A.C. High Voltage Test (kV/min)		No breakdown of the insulation shall occur	12.5/5	21/5	30.5/5	42/5	63/5
4	A.C. Voltage Test for 4h (kV) Note: Applicable for rated voltage above 3.6/6 (7.2)kV			-	24	35	48	72
5	Hot Set Test	Maximum Elongation under Load (%)	175					
6		Maximum Permanent Elongation after Cooling (%)	15					
7	Shrinkage Test	Maximum shrinkage (%)	4					
8	Impulse Test Followed by a Voltage Test (kV)		No breakdown of the insulation shall occur	60	75	95	125	170
9	Other Tests		Reference to IEC 60502-2, including raw materials and finished cables					

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Table 5 : Maximum Resistance and Short-Circuit Current of Cu and Al Conductor

Nominal Area	Copper Conductor			Aluminium Conductor		
	D.C. resistance at 20°C	A.C. resistance at 90°C	Short-circuit current for 1s	D.C. resistance at 20°C	A.C. resistance at 90°C	Short-circuit current for 1s
(mm²)	(Ω/km)	(Ω/km)	(kA)	(Ω/km)	(Ω/km)	(kA)
25	0.727	0.927	3.575	1.20	1.539	2.350
35	0.524	0.668	5.005	0.868	1.113	3.290
50	0.387	0.494	7.150	0.641	0.822	4.700
70	0.268	0.342	10.010	0.443	0.568	6.580
95	0.193	0.247	13.585	0.320	0.411	8.930
120	0.153	0.196	17.160	0.253	0.325	11.280
150	0.124	0.159	21.450	0.206	0.265	14.100
185	0.0991	0.128	26.455	0.164	0.211	17.390
240	0.0754	0.0977	34.320	0.125	0.161	22.560
300	0.0601	0.0787	42.900	0.100	0.130	28.200
400	0.0470	0.0627	57.200	0.0778	0.102	37.600
500	0.0366	0.0502	71.500	0.0605	0.080	47.000
630	0.0283	0.0407	90.090	0.0469	0.063	59.220
800	0.0221	0.0340	114.400	0.0367	0.051	75.200
1000	0.0176	0.0293	143.000	0.0291	0.042	94.000

Note : Short-circuit current in Kiloampere, are approximate values under non-adiabatic conditions.

Table 6 : Maximum Permissible Short-Circuit Current of Copper Tape Screen for Unarmoured Single-Core Cable

The following short-circuit current in kiloamperes, are approximate values, calculated with copper tape screen of 0.12mm thickness applied helically with about 15% overlapping under non-adiabatic conditions.

Nominal Area	Short-Circuit Current for 1 Second				
	3.6/6 (7.2)kV 3.8/6.6 (7.2)kV	6/10 (12)kV 6.35/11 (12)kV	8.7/15 (17.5)kV	12/20 (24)kV 12.7/22 (24)kV	18/30 (36)kV 19/33 (36)kV
(mm²)	(kA)	(kA)	(kA)	(kA)	(kA)
25	1.075	1.083	1.094	-	-
35	1.074	1.082	1.092	1.096	-
50	1.072	1.080	1.091	1.095	1.284
70	1.070	1.079	1.090	1.091	1.281
95	1.069	1.077	1.086	1.272	1.280
120	1.068	1.077	1.286	1.271	1.279
150	1.067	1.076	1.265	1.270	1.278
185	1.064	1.251	1.264	1.267	1.275
240	1.241	1.250	1.262	1.266	1.274
300	1.239	1.246	1.261	1.265	1.271
400	1.240	1.245	1.256	1.260	1.270
500	1.243	1.244	1.253	1.257	1.266
630	1.236	1.238	1.252	1.253	1.265
800	1.260	1.260	1.280	1.280	1.300
1000	1.260	1.260	1.270	1.280	1.290

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Table 7 : Reactance at 50 Hz for Single-Core XLPE Insulated Cable

Nominal Area	Reactance (Approximate)				
	3.6/6 (7.2)kV 3.8/6.6 (7.2)kV	6/10 (12)kV 6.35/11 (12)kV	8.7/15 (17.5)kV	12/20 (24)kV 12.7/22 (24)kV	18/30 (36)kV 19/33 (36)kV
(mm²)	(Ω/km)	(Ω/km)	(Ω/km)	(Ω/km)	(Ω/km)
25	0.142	0.147	0.153	-	-
35	0.135	0.140	0.146	0.150	-
50	0.122	0.133	0.139	0.143	0.154
70	0.111	0.124	0.129	0.135	0.144
95	0.109	0.117	0.122	0.128	0.137
120	0.105	0.113	0.118	0.123	0.131
150	0.103	0.110	0.114	0.119	0.127
185	0.100	0.106	0.110	0.116	0.124
240	0.097	0.101	0.105	0.111	0.118
300	0.095	0.099	0.102	0.106	0.114
400	0.093	0.095	0.098	0.102	0.109
500	0.091	0.093	0.096	0.099	0.106
630	0.088	0.089	0.092	0.096	0.102
800	0.095	0.087	0.090	0.091	0.097
1000	0.093	0.085	0.089	0.089	0.094

Table 8 : Capacitance

Nominal Area	Capacitance Per Phase (Approximate)				
	3.6/6 (7.2)kV 3.8/6.6 (7.2)kV	6/10 (12)kV 6.35/11 (12)kV	8.7/15 (17.5)kV	12/20 (24)kV 12.7/22 (24)kV	18/30 (36)kV 19/33 (36)kV
(mm²)	(μF/km)	(μF/km)	(μF/km)	(μF/km)	(μF/km)
25	0.2423	0.1922	0.1576	-	-
35	0.2684	0.2116	0.1725	0.1502	-
50	0.3022	0.2367	0.1917	0.1661	0.1363
70	0.3462	0.2693	0.2167	0.1868	0.1508
95	0.3875	0.2999	0.2400	0.2060	0.1643
120	0.4236	0.3266	0.2603	0.2228	0.1760
150	0.4647	0.3570	0.2834	0.2418	0.1893
185	0.5059	0.3873	0.3123	0.2656	0.2060
240	0.5430	0.4290	0.3439	0.2916	0.2207
300	0.5589	0.4706	0.3755	0.3175	0.2387
400	0.5940	0.5311	0.4213	0.3551	0.2648
500	0.6167	0.5839	0.4613	0.3880	0.2876
630	0.6848	0.6481	0.5099	0.4278	0.3151
800	0.7293	0.6908	0.5391	0.4528	0.3308
1000	0.7987	0.7562	0.5889	0.4937	0.3592

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Table 9 : Inductance for Single-Core XLPE Insulated Cable

Nominal Area	Inductance (Approximate)				
	3.6/6 (7.2)kV 3.8/6.6 (7.2)kV	6/10 (12)kV 6.35/11 (12)kV	8.7/15 (17.5)kV	12/20 (24)kV 12.7/22 (24)kV	18/30 (36)kV 19/33 (36)kV
(mm^2)	(mH/km)	(mH/km)	(mH/km)	(mH/km)	(mH/km)
25	0.5954	0.6143	0.6474	-	-
35	0.5753	0.5932	0.6248	0.6390	-
50	0.5543	0.5711	0.6011	0.6145	0.6501
70	0.5357	0.5486	0.5765	0.5919	0.6252
95	0.5172	0.5318	0.5608	0.5726	0.6043
120	0.5059	0.5197	0.5473	0.5586	0.5891
150	0.4949	0.5079	0.5341	0.5449	0.5740
185	0.4885	0.5006	0.5252	0.5351	0.5640
240	0.4790	0.4890	0.5143	0.5216	0.5487
300	0.4749	0.4818	0.5032	0.5102	0.5376
400	0.4660	0.4702	0.4927	0.4991	0.5219
500	0.4600	0.4619	0.4848	0.4907	0.5128
630	0.4547	0.4563	0.4748	0.4827	0.5012
800	0.4149	0.4156	0.4237	0.4315	0.4505
1000	0.4092	0.4099	0.4175	0.4247	0.4430

Table 10 : Inductance for 3-Core XLPE Insulated Cable

Nominal Area	Inductance (Approximate)				
	3.6/6 (7.2)kV 3.8/6.6 (7.2)kV	6/10 (12)kV 6.35/11(12)kV	8.7/15 (17.5)kV	12/20 (24)kV 12.7/22 (24)kV	18/30 (36)kV 19/33 (36)kV
(mm^2)	(mH/km)	(mH/km)	(mH/km)	(mH/km)	(mH/km)
25	0.3686	0.3932	0.4197	-	-
35	0.3518	0.3748	0.3998	0.4201	-
50	0.3358	0.3572	0.3805	0.3996	0.4432
70	0.3117	0.3313	0.3529	0.3708	0.4118
95	0.2980	0.3159	0.3359	0.3525	0.3910
120	0.2889	0.3057	0.3245	0.3401	0.3768
150	0.2808	0.2965	0.3142	0.3289	0.3638
185	0.2711	0.2858	0.3024	0.3163	0.3494
240	0.2635	0.2753	0.2905	0.3033	0.3440
300	0.2614	0.2695	0.2834	0.2953	0.3228
400	0.2556	0.2604	0.2733	0.2843	0.3100
500	0.2534	0.2556	0.2672	0.2772	0.3006

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Table 11 : Correction Factors for Ambient Air Temperature Other than 30°C

Maximum Conductor Temperature (°C)	Ambient Air Temperature (°C)								
	20	25	30	35	40	45	50	55	60
90	1.08	1.04	1.00	0.96	0.91	0.87	0.82	0.76	0.71

Table 12 : Correction Factors for Ambient Ground Temperature Other than 20°C

Maximum Conductor Temperature (°C)	Ambient Ground Temperature (°C)								
	10	15	20	25	30	35	40	45	50
90	1.07	1.04	1.00	0.96	0.93	0.89	0.85	0.80	0.76

Table 13 : Correction Factors for Depths of Laying Other than 0.8m for Direct Buried Cable

Depth of Laying (m)	Single-Core Cables		3-Core Cables
	Nominal Conductor Size		
	(≤ 185mm²)	(≥ 185mm²)	
0.5	1.04	1.06	1.04
0.6	1.02	1.04	1.03
0.8	1.00	1.00	1.00
1.0	0.98	0.97	0.98
1.25	0.96	0.96	0.96
1.5	0.95	0.93	0.95
1.75	0.94	0.91	0.94
2.0	0.93	0.90	0.93
2.5	0.91	0.88	0.91
3.0	0.90	0.86	0.90

Table 14 : Correction Factors for Depths of Laying Other than 0.8m for Cables in Ducts

Depth of Laying (m)	Single-Core Cables		3-Core Cables
	Nominal Conductor Size		
	(≤ 185mm²)	(≥ 185mm²)	
0.5	1.04	1.05	1.03
0.6	1.02	1.03	1.02
0.8	1.00	1.00	1.00
1.0	0.98	0.97	0.99
1.25	0.96	0.95	0.97
1.5	0.95	0.93	0.96
1.75	0.94	0.92	0.95
2.0	0.93	0.91	0.94
2.5	0.91	0.89	0.93
3.0	0.90	0.88	0.92

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Table 15 : Correction Factors for Soil Thermal Resistivities Other than 1.5 K · m/W for Direct Buried Single-Core Cables

Nominal Area (mm²)	Values of Soil Thermal Resistivity (K · m/W)							
	0.7	0.8	0.9	1.0	1.5	2.0	2.5	3.0
16	1.29	1.24	1.19	1.15	1.00	0.89	0.82	0.75
25	1.30	1.25	1.20	1.16	1.00	0.89	0.81	0.75
35	1.30	1.25	1.21	1.16	1.00	0.89	0.81	0.75
50	1.32	1.26	1.21	1.16	1.00	0.89	0.81	0.74
70	1.33	1.27	1.22	1.17	1.00	0.89	0.81	0.74
95	1.34	1.28	1.22	1.18	1.00	0.89	0.80	0.74
120	1.34	1.28	1.22	1.18	1.00	0.88	0.80	0.74
150	1.35	1.28	1.23	1.18	1.00	0.88	0.80	0.74
185	1.35	1.29	1.23	1.18	1.00	0.88	0.80	0.74
240	1.36	1.29	1.23	1.18	1.00	0.88	0.80	0.73
300	1.36	1.30	1.24	1.19	1.00	0.88	0.80	0.73
400	1.37	1.30	1.24	1.19	1.00	0.88	0.79	0.73

Table 16 : Correction Factors for Soil Thermal Resistivities Other than 1.5 K · m/W for Single-Core Cables in Buried Ducts

Nominal Area (mm²)	Values of Soil Thermal Resistivity (K · m/W)							
	0.7	0.8	0.9	1.0	1.5	2.0	2.5	3.0
16	1.20	1.17	1.14	1.11	1.00	0.92	0.85	0.79
25	1.21	1.17	1.14	1.12	1.00	0.91	0.85	0.79
35	1.21	1.18	1.15	1.12	1.00	0.91	0.84	0.79
50	1.21	1.18	1.15	1.12	1.00	0.91	0.84	0.78
70	1.22	1.19	1.15	1.12	1.00	0.91	0.84	0.78
95	1.23	1.19	1.16	1.13	1.00	0.91	0.84	0.78
120	1.23	1.20	1.16	1.13	1.00	0.91	0.84	0.78
150	1.24	1.20	1.16	1.13	1.00	0.91	0.83	0.78
185	1.24	1.20	1.17	1.13	1.00	0.91	0.83	0.78
240	1.25	1.21	1.17	1.14	1.00	0.90	0.83	0.77
300	1.25	1.21	1.17	1.14	1.00	0.90	0.83	0.77
400	1.25	1.21	1.17	1.14	1.00	0.90	0.83	0.77

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Table 17 : Correction Factors for Soil Thermal Resistivities other than 1.5 K · m/W for Direct Buried 3-Core Cables

Nominal Area (mm²)	Values of Soil Thermal Resistivity (K · m/W)							
	0.7	0.8	0.9	1.0	1.5	2.0	2.5	3.0
16	1.23	1.19	1.16	1.13	1.00	0.91	0.84	0.78
25	1.24	1.20	1.16	1.13	1.00	0.91	0.84	0.78
35	1.25	1.21	1.17	1.13	1.00	0.91	0.83	0.78
50	1.25	1.21	1.17	1.14	1.00	0.91	0.83	0.77
70	1.26	1.21	1.18	1.14	1.00	0.90	0.83	0.77
95	1.26	1.22	1.18	1.14	1.00	0.90	0.83	0.77
120	1.26	1.22	1.18	1.14	1.00	0.90	0.83	0.77
150	1.27	1.22	1.18	1.15	1.00	0.90	0.83	0.77
185	1.27	1.23	1.18	1.15	1.00	0.90	0.83	0.77
240	1.28	1.23	1.18	1.15	1.00	0.90	0.83	0.77
300	1.28	1.23	1.19	1.15	1.00	0.90	0.82	0.77
400	1.28	1.23	1.19	1.15	1.00	0.90	0.82	0.76

Table 18 : Correction Factors for Soil Thermal Resistivities Other than 1.5 K · m/W for 3-Core Cables in Ducts

Nominal Area (mm²)	Values of Soil Thermal Resistivity (K · m/W)							
	0.7	0.8	0.9	1.0	1.5	2.0	2.5	3.0
16	1.12	1.11	1.09	1.08	1.00	0.94	0.89	0.84
25	1.14	1.12	1.10	1.08	1.00	0.94	0.89	0.84
35	1.14	1.12	1.10	1.08	1.00	0.94	0.88	0.84
50	1.14	1.12	1.10	1.08	1.00	0.94	0.88	0.84
70	1.15	1.13	1.11	1.09	1.00	0.94	0.88	0.83
95	1.15	1.13	1.11	1.09	1.00	0.94	0.88	0.83
120	1.15	1.13	1.11	1.09	1.00	0.93	0.88	0.83
150	1.15	1.13	1.11	1.09	1.00	0.93	0.88	0.83
185	1.16	1.14	1.11	1.09	1.00	0.93	0.87	0.83
240	1.16	1.14	1.12	1.10	1.00	0.93	0.87	0.82
300	1.17	1.14	1.12	1.10	1.00	0.93	0.87	0.82
400	1.17	1.14	1.12	1.10	1.00	0.92	0.86	0.81

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Table 19 : Correction Factors for Groups of the 3-Core Cables in Horizontal Formation Laid Direct in the Ground

No. of Cables in Group	Spacing between Cable Centres (mm)				
	Touching	200	400	600	800
2	0.80	0.86	0.90	0.92	0.94
3	0.69	0.77	0.82	0.86	0.89
4	0.62	0.72	0.79	0.83	0.87
5	0.57	0.68	0.76	0.81	0.85
6	0.54	0.65	0.74	0.80	0.84
7	0.51	0.63	0.72	0.78	0.83
8	0.49	0.61	0.71	0.78	-
9	0.47	0.60	0.70	0.77	-
10	0.46	0.59	0.69	-	-
11	0.45	0.57	0.69	-	-
12	0.43	0.56	0.68	-	-

Table 20 : Correction Factors for Groups of the 3-Core Cables in Single Way Ducts in Horizontal Formation

No. of Cables in Group	Spacing between Cable Centres (mm)				
	Touching	200	400	600	800
2	0.85	0.88	0.92	0.94	0.95
3	0.75	0.80	0.85	0.88	0.91
4	0.69	0.75	0.82	0.86	0.89
5	0.65	0.72	0.79	0.84	0.87
6	0.62	0.69	0.77	0.83	0.87
7	0.59	0.69	0.76	0.82	0.86
8	0.57	0.65	0.75	0.81	-
9	0.55	0.64	0.74	0.80	-
10	0.54	0.63	0.73	-	-
11	0.52	0.62	0.73	-	-
12	0.51	0.61	0.72	-	-

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Table 21 : Correction Factors for Groups of the 3-Phase Circuits of Single-Core Cable Laid Direct in the Ground

No. of Cables in Group	Spacing between Cable Centres (mm)				
	Touching	200	400	600	800
2	0.73	0.83	0.88	0.90	0.92
3	0.60	0.73	0.79	0.83	0.86
4	0.54	0.68	0.75	0.80	0.84
5	0.49	0.63	0.72	0.78	0.82
6	0.46	0.61	0.70	0.76	0.81
7	0.43	0.58	0.68	0.75	0.80
8	0.41	0.57	0.67	0.74	-
9	0.39	0.55	0.66	0.73	-
10	0.37	0.54	0.65	-	-
11	0.36	0.53	0.64	-	-
12	0.36	0.52	0.64	-	-

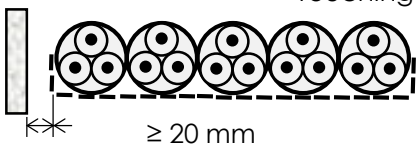
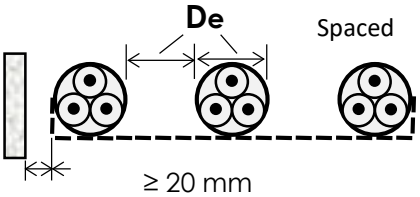
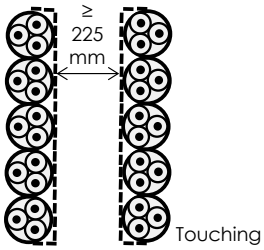
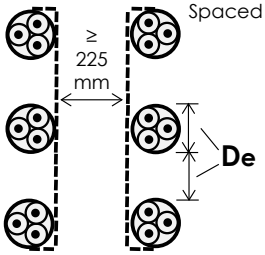
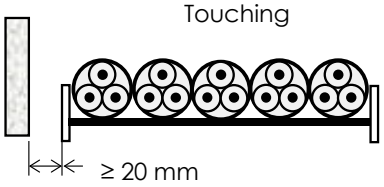
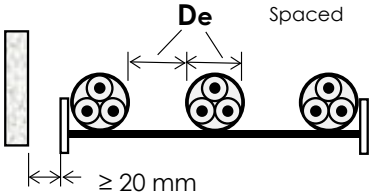
Table 22 : Correction Factors for Groups of the 3-Phase Circuits of Single-Core Cable in Single Way Ducts

No. of Cables in Group	Spacing between Cable Centres (mm)				
	Touching	200	400	600	800
2	0.78	0.85	0.89	0.91	0.93
3	0.66	0.75	0.81	0.85	0.88
4	0.59	0.70	0.77	0.82	0.86
5	0.55	0.66	0.74	0.80	0.84
6	0.51	0.64	0.72	0.78	0.83
7	0.48	0.61	0.71	0.77	0.82
8	0.46	0.60	0.70	0.76	-
9	0.44	0.58	0.69	0.76	-
10	0.43	0.57	0.68	-	-
11	0.42	0.56	0.67	-	-
12	0.40	0.55	0.67	-	-

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Table 23 : Reduction Factors for Groups of More than One 3-Core Cable in Air

To be Applied to the Current-Carrying Capacity for One 3-Core Cable in Free Air

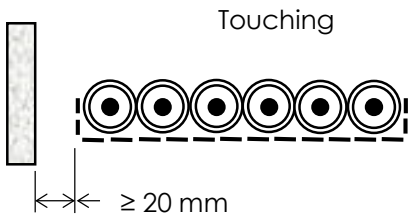
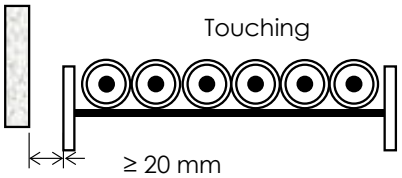
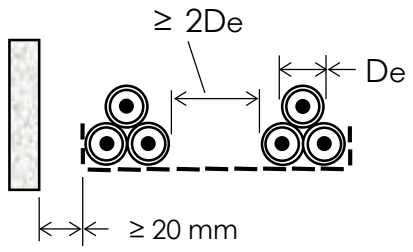
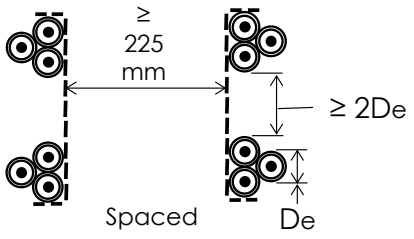
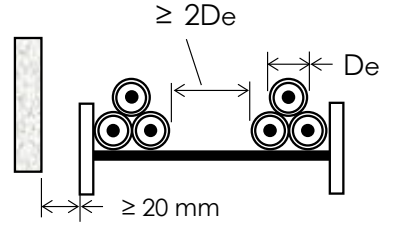
Method of Installation		No. of Tray	No. of Cables					
			1	2	3	4	6	9
Cables on Perforated Trays		1	1.00	0.88	0.82	0.79	0.76	0.73
		2	1.00	0.87	0.80	0.77	0.73	0.68
		3	1.00	0.86	0.79	0.76	0.71	0.66
		1	1.00	1.00	0.98	0.95	0.91	-
		2	1.00	0.99	0.96	0.92	0.87	-
		3	1.00	0.98	0.95	0.91	0.85	-
Cables on Vertical Perforated Trays		1	1.00	0.88	0.82	0.78	0.73	0.72
		2	1.00	0.88	0.81	0.76	0.71	0.7
		1	1.00	0.91	0.89	0.88	0.87	-
		2	1.00	0.91	0.88	0.87	0.85	-
Cables on Ladder Supports, Cleats etc.		1	1.00	0.87	0.82	0.80	0.79	0.78
		2	1.00	0.88	0.80	0.78	0.76	0.73
		3	1.00	0.85	0.79	0.76	0.73	0.70
		1	1.00	1.00	1.00	1.00	1.00	-
		2	1.00	0.99	0.98	0.97	0.96	-
		3	1.00	0.98	0.97	0.96	0.93	-

Note :
1. Values given are averages for the cable types and range of conductor sizes considered. The spread of values is generally less than 5%.
2. Factors apply to single layer groups of cables as shown above and do not apply when cables are installed in more than one layer touching each other, Values for such installation may be significantly lower and must be determined by an appropriate method.
3. Values are given for vertical spacings between trays of 300mm and at least 20mm between trays and wall. For closer spacing, the factors should be reduced.
4. Values are given for horizontal spacing between trays of 225mm with trays mounted back to back. For closer spacing, the factors should be reduced.

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Table 24 : Reduction Factors for Groups of More than One Circuit of Single-Core Cables (See Note 2)

To be Applied to the Current-Carrying Capacity for One Circuit of Single-Core Cables in Free Air

Method of Installation		No. of Tray	No. of 3-phase Circuits (See Note 5)			Use as a Multiplier to Rating for
			1	2	3	
Perforated Trays (Note 3)		1	0.98	0.91	0.87	3 Cables in Horizontal Formation
		2	0.96	0.87	0.81	
		3	0.95	0.85	0.78	
Ladder Supports Cleats etc. (Note 3)		1	1.00	0.97	0.96	3 Cables in Horizontal Formation
		2	0.98	0.93	0.89	
		3	0.97	0.90	0.86	
Perforated Trays (Note 3)		1	1.00	0.98	0.96	3 Cables in Trefoil Formation
		2	0.97	0.93	0.89	
		3	0.96	0.92	0.86	
Vertical Perforated Trays (Note 4)		1	1.00	0.91	0.89	
		2	1.00	0.90	0.86	
Ladder Supports Cleats etc. (Note 3)		1	1.00	1.00	1.00	
		2	0.97	0.95	0.93	
		3	0.96	0.94	0.90	

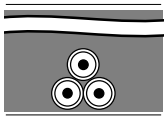
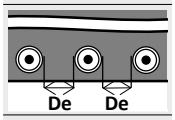
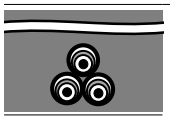
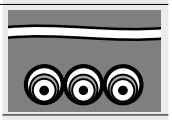
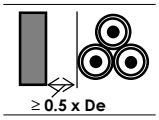
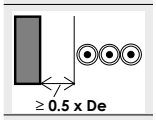
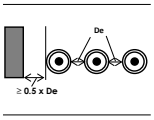
Note :
1. Values given are averages for the cable types and range of conductor sizes considered. The spread of values is generally less than 5%.
2. Factors are given for single layers of cables (or trefoil groups) as shown in the table and do not apply when cables are installed in more than one layer touching each other. Values for such installations may be significantly lower and should be determined by an appropriate method.
3. Values are given for vertical spacings between trays of 300mm. For closer spacing, the factors should be reduced.
4. Values are given for horizontal spacings between trays of 225mm with trays mounted back to back. For closer spacing, the factors should be reduced.
5. For circuits having more than one cable in parallel per phase, each 3-phase set of conductors should be considered as a circuit for the purpose of this table.

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Table 25 : Single-Core Cables with Copper Conductor, XLPE Insulation, 3.6/6kV to 18/30kV

Conductor Operating Temperature : 90°C
Ambient Temperature : 30°C
Ground Temperature : 20°C
Depth of Laying : 0.8m

IEC 60502-2
Thermal Resistivity of Soil : 1.5 K · m/W
Thermal Resistivity of Earthenware Ducts : 1.2 K · m/W
Screens Bonded at Both Ends

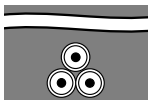
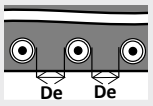
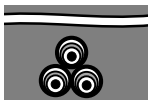
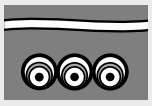
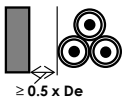
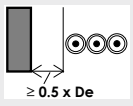
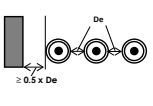
Conductor Cross-sectional Area	Buried Direct in the Ground		In Single-way Ducts		In Air		
	Trefoil	Flat Spaced	Trefoil Ducts	Flat Touching Ducts	Trefoil	Flat Touching	Flat Spaced
							
(mm²)	(A)	(A)	(A)	(A)	(A)	(A)	(A)
16	109	113	103	104	125	128	150
25	140	144	132	133	163	167	196
35	166	172	157	159	198	203	238
50	196	203	186	188	238	243	286
70	239	246	227	229	296	303	356
95	285	293	271	274	361	369	434
120	323	332	308	311	417	426	500
150	361	366	343	347	473	481	559
185	406	410	387	391	543	550	637
240	469	470	447	453	641	647	745
300	526	524	504	510	735	739	846
400	590	572	564	571	845	837	938
500	640	635	608	603	942	944	1003
630	712	703	676	668	1071	1070	1117
800	781	770	742	732	1210	1207	1240
1000	841	827	799	786	1332	1328	1344

Note : Current ratings table (calculated for cables having a rated voltage of 6/10kV) as per IEC 60502-2:2014.

Table 26 : Single-Core Cables with Aluminium Conductor, XLPE Insulation, 3.6/6kV to 18/30kV

Conductor Operating Temperature : 90°C
Ambient Temperature : 30°C
Ground Temperature : 20°C
Depth of Laying : 0.8m

IEC 60502-2
Thermal Resistivity of Soil : 1.5 K · m/W
Thermal Resistivity of Earthenware Ducts : 1.2 K · m/W
Screens Bonded at Both Ends

Conductor Cross-sectional Area	Buried Direct in the Ground		In Single-way Ducts		In Air		
	Trefoil	Flat Spaced	Trefoil Ducts	Flat Touching Ducts	Trefoil	Flat Touching	Flat Spaced
							
(mm²)	(A)	(A)	(A)	(A)	(A)	(A)	(A)
16	84	88	80	81	97	99	116
25	108	112	102	103	127	130	153
35	129	134	122	123	154	157	185
50	152	157	144	146	184	189	222
70	186	192	176	178	230	236	278
95	221	229	210	213	280	287	338
120	252	260	240	242	324	332	391
150	281	288	267	271	368	376	440
185	317	324	303	307	424	432	504
240	367	373	351	356	502	511	593
300	414	419	397	402	577	586	677
400	470	466	451	457	673	676	769
500	550	560	485	494	779	764	837
630	622	640	534	555	893	882	950
800	704	720	582	618	1017	1009	1070
1000	776	800	621	679	1150	1140	1193

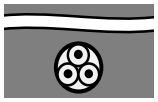
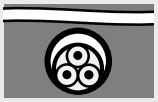
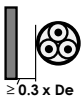
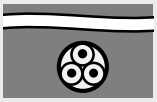
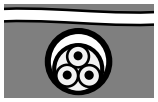
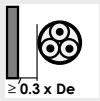
Note : Current ratings table (calculated for cables having a rated voltage of 6/10kV) as per IEC 60502-2:2014.

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Table 27 : 3-Core Cables with Copper Conductor, XLPE Insulation, Unarmoured and Armoured, 3.6/6kV to 18/30kV

Conductor Operating Temperature : 90°C
Ambient Temperature : 30°C
Ground Temperature : 20°C
Depth of Laying : 0.8m

IEC 60502-2
Thermal Resistivity of Soil : 1.5 K · m/W
Thermal Resistivity of Earthenware Ducts : 1.2 K · m/W
Screens Bonded at Both Ends

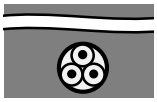
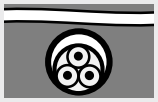
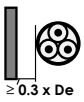
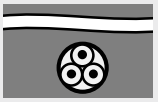
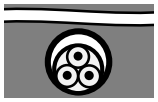
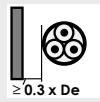
Conductor Cross-sectional Area	Unarmoured			Armoured		
	Buried Direct in Ground	Buried in a Duct	In Air	Buried Direct in Ground	Buried in a Duct	In Air
						
(mm²)	(A)	(A)	(A)	(A)	(A)	(A)
16	101	87	109	101	88	110
25	129	112	142	129	112	143
35	153	133	170	154	134	172
50	181	158	204	181	158	205
70	221	193	253	220	198	253
95	262	231	304	263	232	307
120	298	264	351	298	264	352
150	334	297	398	332	296	397
185	377	336	455	374	335	453
240	434	390	531	431	387	529
300	489	441	606	482	435	599
400	553	501	696	541	492	683

Note : Current ratings table (calculated for cables having a rated voltage of 6/10kV) as per IEC 60502-2:2014.

Table 28 : 3-Core Cables with Aluminium Conductor, XLPE Insulation, Unarmoured and Armoured, 3.6/6kV to 18/30kV

Conductor Operating Temperature : 90°C
Ambient Temperature : 30°C
Ground Temperature : 20°C
Depth of Laying : 0.8m

IEC 60502-2
Thermal Resistivity of Soil : 1.5 K · m/W
Thermal Resistivity of Earthenware Ducts : 1.2 K · m/W
Screens Bonded at Both Ends

Conductor Cross-sectional Area	Unarmoured			Armoured		
	Buried Direct in Ground	Buried in a Duct	In Air	Buried Direct in Ground	Buried in a Duct	In Air
						
(mm²)	(A)	(A)	(A)	(A)	(A)	(A)
16	78	67	84	78	68	85
25	100	87	110	100	87	111
35	119	103	132	119	104	133
50	140	122	158	140	123	159
70	171	150	196	171	150	196
95	203	179	236	204	180	238
120	232	205	273	232	206	274
150	260	231	309	259	231	309
185	294	262	355	293	262	354
240	340	305	415	338	304	415
300	384	346	475	380	343	472
400	438	398	552	432	393	545

Note : Current ratings table (calculated for cables having a rated voltage of 6/10kV) as per IEC 60502-2:2014.

XLPE Insulation Thickness (UL 1072) & Wire Gauge Conversion

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Table 29 : XLPE Insulation Thickness for Shielded Single and Multiple Conductor Cable

Voltage Rating	Conductor Size	Conductor Size	Insulation Thickness (mm)					
			100% Level		133% Level		173% Level	
(V)	(AWG or kcmil)	(mm²)	Min. at Any Point	Max. at Any Point	Min. at Any Point	Max. at Any Point	Min. at Any Point	Max. at Any Point
5000	8~1000	8.37~506.7	2.16	3.05	2.16	3.05	3.43	4.32
	1001~2000	506.8~1013.4	3.43	4.32	3.43	4.32	3.43	4.32
5001~8000	6~1000	13.3~506.7	2.79	3.68	3.43	4.32	4.19	5.21
	1001~2000	506.8~1013.4	4.19	5.21	4.19	5.21	5.33	6.35
8001~15000	2~1000	33.6~506.7	4.19	5.21	5.33	6.35	6.22	7.37
	1001~2000	506.8~1013.4	5.33	6.35	5.33	6.35	6.22	7.37
15001~25000	1~2000	42.4~1013.4	6.22	7.37	7.75	8.89	10.2	11.4
25001~28000	1~2000	42.4~1013.4	6.73	7.87	8.38	9.53	10.8	12.1
28001~35000	1/0~2000	53.5~1013.4	8.38	9.53	10.2	11.4	14.1	15.5

Table 30 : Wire Gauge Conversion

U.S. Standard	Equivalent IEC Cross-section Area	Nearest available IEC Cross-section Area	U.S. Standard	Equivalent IEC Cross-section Area	Nearest available IEC Cross-section Area
(AWG/kcmil)	(mm²)	(mm²)	(AWG/kcmil)	(mm²)	(mm²)
20 AWG	0.519	0.5 or 0.75	350 kcmil	177.3	185
18 AWG	0.823	1	400 kcmil	202.7	185
16 AWG	1.31	1.5	450 kcmil	228.0	240
14 AWG	2.08	2.5	500 kcmil	253.4	240
12 AWG	3.31	4	550 kcmil	278.7	300
10 AWG	5.26	6	600 kcmil	304.0	300
8 AWG	8.37	10	650 kcmil	329.4	300
6 AWG	13.3	16	700 kcmil	354.7	400
4 AWG	21.2	25	750 kcmil	380.0	400
2 AWG	33.6	35	800 kcmil	405.4	400
1 AWG	42.4	50	850 kcmil	430.7	400
1/0 kcmil	53.5	70	900 kcmil	456.0	400
2/0 kcmil	67.2	70	950 kcmil	481.4	500
3/0 kcmil	85.0	95	1000 kcmil	506.7	500
4/0 kcmil	107.2	120	1250 kcmil	633.4	630
250 kcmil	126.7	120	1500 kcmil	760.0	800
300 kcmil	152.0	150	1750 kcmil	886.7	800 or 1000
			2000 kcmil	1013.4	1000

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Table 31 : Recommended Ordering Parameters

In order to respond to your requirement promptly, please provide the following information in your request for quotation:

No.	Information
1	International or Special Standard (Alternatively, please provide the precise use of the cable for our technical team to make the recommendation.)
2	Rated Voltage
3	Copper or Aluminium Conductors
4	Size of Each Conductor
5	Insulation Material: XLPE or Others
6	Number and Identification of Conductors
7	Armour Type
8	Packing
9	Required Delivery Time
10	Required Validity

Table 32 : Identification of Pairs for Pilot Cable

Pair	A - wire	B - wire	Pair	A - wire	B - wire
1	White	Blue	11	Black	Blue/black stripe
2	White/orange stripe	Orange	12	Black/orange stripe	Orange/black stripe
3	White/green stripe	Green	13	Black/green stripe	Green/black stripe
4	White/brown stripe	Brown	14	Black/brown stripe	Brown/black stripe
5	White/grey stripe	Grey	15	Black/grey stripe	Grey/black stripe
6	Red	Blue/red stripe	16	Yellow	Blue/yellow stripe
7	Red/orange stripe	Orange/red stripe	17	Yellow/orange stripe	Orange/yellow stripe
8	Red/green stripe	Green/red stripe	18	Yellow/green stripe	Green/yellow stripe
9	Red/brown stripe	Brown/red stripe	19	Yellow/brown stripe	Brown/yellow stripe
10	Red/grey stripe	Grey/red stripe	20	Yellow/grey stripe	Grey/yellow stripe

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Copper Rod / Aluminium Rod

Copper rod of diameter of 8.0mm, made from electrolytic copper, with copper purity higher than 99.95%. Aluminium rod of diameter of 9.5mm, drawn from aluminium ingots with minimum aluminium purity requirement of 99.70%.

Drawing (Annealing for Copper Wire; Hard Drawn for Aluminium Wire)

A variety of required copper wire sizes are drawn from the copper rod, and treated at specified temperatures to restore ductility to the copper, making it soft and flexible. The heat treatment process is known as annealing and the resulting metal is known as soft annealed copper.

Hard drawn: A variety of required aluminium wire sizes are hard drawn from aluminium rod. As a result, the strength of the wire is increased, and it has a better surface finish.

Stranding

The conductor consists of annealed copper or aluminium wires. Usually conductors up to 1000mm^2 will be circular compacted stranded and shall comply with the requirement of IEC 60228 Class 2.

Triple Extrusion Process: Conductor Screen / Insulation / Insulation Screen

The three layers are extruded in one step using state-of-the-art Catenary Continuous Vulcanization (CCV) technology with advanced automatic concentricity control system which guarantees the highest quality of the insulated conductor.

- **Conductor Screen (Stress Control Layer)**

A cross-linked semi-conducting compound is extruded over the metallic conductor. This semi-conductive layer acts as a stress control layer as it smooths out any irregularities that could cause protrusions into the insulation. Such protrusions into the insulation increases the localized stress that may weaken the long-term breakdown strength of the insulation.

- **Insulation**

Each core conductor is insulated by extruding cross-linked low density polyethylene. This insulating compound is specially developed for the CCV technology.

- **Insulation Screen (Stress Relief Layer)**

A cross-linked semi-conducting compound is extruded over the insulation. This layer, which has a very smooth surface, serves as a transition material between the insulation where electric field exists and the conductive metallic screen and where the electric field is zero. This helps to reduce the stress at the insulation layer. This insulation screen layer could be bonded to the insulation or is a strippable type for easy removal to facilitate splicing and terminating works.

Metallic Screen

The metallic screen usually consists of a layer of copper tape, applied helically with an overlap, over the insulation screen. The metallic screens in a 3-core cable are in contact with each other.

Cable Assembly (Optional)

For a 3-core cable, the screened cores will have identification tapes (Brown, Black, Grey) under the metallic screen, before the cores are laid up. A non-hygroscopic polypropylene filler is applied between the laid up cores to provide a circular shape to the overall cable. Polypropylene tape(s) or PETP (Polyester) tape(s) is used as a barrier tape over the laid up cores.

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Separation Sheath (Optional)

All armoured cables have an extruded layer of Black PVC, MDPE or LSZH separation sheath, applied over the core or laid-up cores to separate the different metals to prevent the corrosion of metal due to galvanic effect.

Armour (Optional)

In the case of armoured cables, the armour is applied over a separation sheath which is used to provide additional mechanical protection. For single-core cables, the armour consists of layer of aluminium wires, double aluminium tape or other non-magnetic armour, and for multi-core cables, the armour consists of a layer of galvanized steel wires, or double galvanized tape.

Outer Sheath Extrusion

All cables have an extruded layer of PVC, MDPE or LSZH outersheath over the core, laid-up cores or the armour. This outersheath has anti-termite properties and also protects the cable from sunlight and other atmospheric conditions. The outer sheath is normally black but another colour may be provided upon agreement between the manufacturer and the purchaser.

Inspection

Packing

Characteristics of XLPE-Insulated Cables

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XLPE-Insulated Cables

Cross-linked polyethylene (XLPE) insulated power cable offers various advantages compared with conventional paper insulated oil-filled cable. XLPE cable is lighter in weight, has more flexibility, and does not require an oil supplying system, hence requires less maintenance. In addition it boasts smaller charging current and dielectric loss. XLPE cable also has excellent thermal properties which improves performance in continuous and short circuit current carrying capacity. Based on these features, XLPE cable is used in up to 500kV extra-high voltage line.

Characteristics of XLPE Insulated Cable

Polyethylene (PE) is superior in electrical characteristics and chemical resistance, however it faces a thermal instability issue and starts to melt when it reaches a temperature of 110°C.

Cross-linked polyethylene (XLPE), which is the result of a molecular bonding chemical process called 'cross-linking', solves this melting issue.

The molecular structure of cross-linked polyethylene allows excellent ozone resistance as well as outstanding stability and resistance to heat. The mainstream process of 'cross-linking' is to blend peroxide (e.g. dicumyl peroxide) into polyethylene and extrude it around the conductor, and heat it up to a high temperature sufficient to achieve the peroxidation.

Comparison of Characteristics between 'Cross-linked Polyethylene' and 'Pure Polyethylene'

Item		Material	
		Cross-linked Polyethylene	Pure Polyethylene
Specific Gravity		0.92	0.92
Dielectric Strength	(kV/mm)	35~50	35~50
Volume Resistivity	(Ω•cm)	10^{18}	10^{18}
Dielectric Constant		2.3	2.3
Power Factor	(%)	0.03	0.03
Tensile Strength	(kg/mm^2)	1.2~1.5	1.2~1.5
Elongation	(%)	500~600	500~700
Max. Operating Temperature	(°C)	90	75
Max. Short Circuit Temperature	(°C)	250	150
Heat Deformation		G	F
Ozone Resistivity		G	G
Water Resistance		F	F
Oil Resistivity		E	E

Note: E - Excellent, G - Good, F - Fair

Rated Voltage of Medium Voltage Cables

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The rated voltage of the cable for a given application shall be suitable for the operating conditions in the system in which the cable is used.

- U_0/U (U_m) - Cable rated voltage which applies to system voltage and operating condition of the cable
- U_0- the rated power frequency voltage between conductor and earth or metallic screen
- U- the rated power frequency voltage between conductors
- U_m- the maximum value of the 'highest system voltage' for which the equipment may be used

To facilitate the selection of the cable, systems are divided into three categories:

- Category A: Systems in which any phase conductor that comes in contact with earth or an earth conductor is disconnected from the system within 1 min.
- Category B: Systems which, under fault conditions, will operate for a short period with one phase earthed. This period, according to IEC 60183, should not exceed 1 h. For cables that are covered by IEC 60502-2, this period should not exceed 8 h.
- Category C: Systems that do not fall into Category A or B.

The following table provides the maximum permissible operating voltage relative to each rated voltage (U_0/U).

Highest System Voltage (U_m)	Rated Voltage (U_0/U)	
(kV)	IEC 60502-2	BS 6622, BS 7835
	(kV)	
7.2	3.6/6	3.8/6.6
12	6/10	6.35/11
17.5	8.7/15	8.7/15
24	12/20	12.7/22
36	18/30	19/33

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Cable Testing

All cables will go through the relevant tests in accordance with IEC 60502-2 before delivery.

Routine Tests

Routine tests are carried out on each finished length of cable to verify overall cable quality. They consist of:

1. Measurement of conductor resistance
2. Partial discharge test
3. High voltage test

Sample Tests

1. Conductor examination
2. Check of dimensions
3. Voltage test for cables of rated voltage above 3.6/6 (7.2)kV
4. Hot set test for XLPE insulation

Type Tests

1. Electrical type test
2. Non-electrical type test

Main Applicable Standards

Standards	Description
IEC 60502-2	Power cables with extruded insulation and their accessories for rated voltages from 1 kV (U_m = 1.2 kV) up to 30 kV (U_m = 36 kV) – Part 2: Cables for rated voltages from 6 kV (U_m = 7.2 kV) up to 30 kV (U_m = 36 kV)
IEC 60228	Conductors of insulated cables
IEC 60840	Power cables with extruded insulation and their accessories for rated voltages above 30 kV (U_m = 36 kV) up to 150 kV (U_m = 170 kV)
BS 6622	Electric cables – Armoured cables with thermosetting insulation for rated voltages from 3.8/6.6 kV to 19/33 kV
BS 7835	Electric cables – Armoured cables with thermosetting insulation for rated voltages from 3.8/6.6 kV to 19/33 kV having low emission of smoke and corrosive gases when affected by fire
ICEA S-66-524	Cross-linked polyethylene wire and cable for the transmission and distribution of electricalenergy
ICEA S-93-639	5-46kV shielded power cable for use in the transmission and distribution of electrical energy
UL 1072	Medium voltage power cables
IEC 60811	Electric and optical fibre cables – Test methods for non-metallic materials
IEC 60332	Tests on electric and optical fibre cables under fire conditions
IEC 60331-4	Tests for electric cables under fire conditions – Circuit integrity – Part 4: Test method for fire with shock at a temperature at least 830°C for cables of rated voltage higher than 1kV up to and including 30kV
IEC 61034	Measurement of smoke density of cables burning under defined conditions
IEC 60754	Test on gases evolved during combustion of materials from cables

Note: Low Smoke Zero Halogen (LSZH) cables comply with IEC 61034 and IEC 60754
Fire resistant cables comply with IEC 60331-4
Flame retardant cables comply with IEC 60332