Scan QR Code Transformer

TRANSFORMER
Power Transformers

Transformers can be paralleled if they have the same Vector group, the same rated primary and secondary Voltage, the same phase relation, the same polarity, and approximately the same percentage impedance

If Buchholz Relay acts ?

If a transformer breaker trips with buchholz relay action, the transformer should not be charged before conducting detailed investigation. The H.V / LV sides of the transformer should be isolated. DC supply to and from Buchholz relay is also to be isolated.

The gas collected in the Buchholz relay has to be tested as detailed below.

1. Examine Buchholz relay.
2. Note and record the quality and colour of gas collected. A colourless accumulation usually indicates the presence of air.
3. Release a small quantity of gas and smell. Peculiar smell other than oil smell is not desirable.
4. Prepare silver nitrate solution of any concentration in an oil bottle (the solution must be clear).
5. Allow some quantity of gas to bubble through this clear solution of silver nitrate.
6. (a) If there is no change in the colour of the solution, it generally indicates that the gas is merely air.
   (b) Whitish precipitation-decomposition of paper.
   (c) Yellow precipitation-decomposition of wood.
   (d) Deep grey-gas of over heated oil due to burning of iron.
   (e) Black-gas of decomposed oil due to electric arc.
7. If a precipitate is obtained, thorough examination of the transformer should be made at the earliest opportunity

Get the dissolved analysis done before thorough inspection of the transformer to detect incipient-faults.

Collection of Transformer Oil sample and its analysis :- Oil sample shall be collected in a dry clean bottle through the cocks provided in the transformer after allowing small quantity of oil to drain out initially. Then cool the collected oil sample and remove any air bubbles present using a clean stirrer. Oil shall be clear, transparent and free from suspended matter or sediments. Oil sample shall be tested in a standard testing equipment and the interpretation of test shall be as per IS 1866.

Testing of Oil condition in Distribution Transformers - "Crackle Test" shall be done along with observation of colour and sludge in the oil.

Crackle Test - Close one end of a piece of steel tube of about half an inch in diameter and heat the closed end under dull red heat. Plunge the heated end in to the oil sample taken with the ear close to the open end of the tube. If a sharp crackle is heard, it indicates the presence of moisture, as dry oil will only sizzle and oil is considered unfit for use. If this test is positive, perform dielectric test with the same oil to know the dielectric strength.

INSULATION RESISTANCE MEASUREMENT

Recommended Minimum Insulation Resistances for Transformer Winding

Unless otherwise specified by the manufacturer the following IR values may be considered as the minimum satisfactory values at one minute measurement

Voltage Level System Voltage	Recommended Megger Voltage	Minimum lR Value at 30^{o} (meg. ohms)	
415	500 V	100	IR value of EHV Transformers shall preferably done with 5kV megger. *Temperature during test: As a rough guide, The megger values double itself for every 10^{0} C fall in temperature.
<6600	1000 V	200	
6600 - 22000	2500 V	300	
33000	2500 V	400	
66000	5000 V	500	

Polarisation Index	Insulation Condition	
Less than 1	Dangerous / Wet	The ratio of 60 seconds insulation resistance to 30 seconds insulation resistance value is called **Dielectric Absorption Coefficient** and the ratio of 600 seconds insulation resistance to 60 seconds insulation resistance value is called **Polarization Index**. (ie. Polarisation Index = IR Value at 10 minutes/ IR Value at 1 minute) Dielectric Absorption Coefficient above 1.5 is assumed to be good.
1.0 – 1.1	Poor	
1.1 – 1.25	Questionable	
1.25 – 2.0	Fair	
2.0 – 4.0	Good /Dry	
Above 4.0	Excellent / Dry	

CURRENT TRANSFORMER - Megger values

The minimum values of megger readings recommended

a. Primary winding 100 Meg.Ohms (Using a 1000 V Megger)

b. Secondary winding 2 Meg.ohms (Using a 500 V Megger)

Tan delta values for primary coil insulation of current transformers if a test tap is provided.

The limiting values specified for tan delta is 3% (Max.)

CONDITION MONITORING OF CVT

Drift in Secondary Voltage	Condition of CVT	Measurement frequency	Remarks
Upto± 0.5 volts	Healthy	Six Monthly	* Before replacement of CVT, voltage drift to be reconfirmed by simultaneous measurement of voltage w.r.t other CVT of same phase. There may be difference in secondary voltage due to unbalance in Primary voltage also.
± 0.5 to ± 0.8 volts	Needs Monitoring	Three Monthly	
+ 0.8 to + 1.2 volts	Needs close Monitoring	Monthly	
+ 1.2 to +2.0 volts	Needs close Monitoring	15 Days	
Above + 2.0 volts	Alarming / Critical	Needs Replacement *	
- 0.8 to – 4.0 volts	Needs close Monitoring	15 Days	
Less than – 4.0 volts	Alarming / Critical	Needs Replacement *	

INSULATING MATERIAL CLASSIFICATION

Class of Insulation	MAX TEMP (Hottest Spot)	Material
Y	90^0c	Cotton, Silk, Paper, Wood without Impregnation.
A	105^0c	Cotton, Silk and Paper when suitably impregnated.
E	120^0c	Materials possessing a degree of thermal stability allowing them to be operated at a temperature 10^0C higher than class A, e.g. wire enamel etc.
B	130^0c	Mica, Glass, Fiber, Asbestos etc. with suitable binding, impregnating or coating substances.
F	155^0c	Mica, Glass, Fiber, Asbestos etc. with suitable binding, impregnating or coating substances capable of withstanding 25^0C higher than class B.
H	180^0c	Combinations of materials such as Mica, Glass, Fiber and Asbestos suitably bonded.
C	Above 180^0c	Mica, Porcelain, Glass, Quartz and Asbestos with or without inorganic binder.

CABLE CODE AS PER IS 7096-PART 2 -2011

Constituent	Code Letter	Remarks
Aluminium Conductor	A	Note: For copper conductor no code letter. First letter – Conductor, Second Letter-Insulation for Conductor, Third Letter-Type of armour, Fourth Letter-Material for outer sheath/ Insulation. Eg: AYFY – Aluminium conductor, PVC insulated, Steel strip armoured, PVC outer sheathed cable.
XLPE Insulation	2X	
PVC Insulation	Y	
Steel round wire armoured	W	
Non-Magnetic round wire armoured	Wa	
Steel strip armoured	F	
Non-Magnetic Steel strip armoured	Fa	
Double Steel strip armoured	FF	
Double Steel wire armoured	WW	
PVC Outer sheath	Y	

DEVICE NUMBERS AND THEIR NOMENCLATURE

2	Time Delay Starting or closing relay
3	Checking or interlocking relay
21	Distance relay
25	Check synchronizing relay
27	Undervoltage relay
29	Isolating Contactor
30	Annunicator relay
32	Directional power relay
32 R	Directional Reverse power relay
37	Under current or Under power relay
40	Field failure (loss of excitation) relay
46	Negative phase sequence relay
47	Phase-sequence Voltage relay
49	Machine or Transformer Thermal relay
50	Instantaneous Overcurrent relay
50 N	Instantaneous Earth Fault relay
50BF	Breaker Failure
50NS	Sensitive earth-fault protection
51	A.C. Time delay Over current relay
51N	A/c Time delay Earth Fault relay
52	A/c Circuit breaker
52a	Circuit breaker Auxiliary Switch "Normally open" ('a' contact) contact open when CB open
52b	Circuit breaker Auxiliary Switch "Normally close" ('b' contact) contact close when CB open
55	Power Factor relay
56	Field Application relay
59	Over voltage relay

60	Voltage balance relay
61	Current balance relay
62	Time-delay stopping or opening relay
63	Liquid or Gas pressure, Level or Flow relay
64	Ground Protection relay
64REF	Restricted earth fault differential
67 N	AC Directional over current relay
67	AC Directional Earth Fault relay
68	Blocking relay
74	Alarm relay
76	D.C. Over current relay
78	Phase angle measuring or our of step relay
79	AC Auto reclose relay
80	Monitoring loss of DC supply
81	Frequency relay
81U	Under frequency
81O	Over frequency relay
83	Automatic selective control or transfer relay
85	Carrier or pilot wire receive relay
86	Locking out relay (Tripping relay)
87	Differential relay
87G	Generator differential relay
87GT	Overall differential relay
87U	UAT differential relay
87NT	Restricted earth fault relay
95	Trip circuit supervision relay
99	Overflux relay
186A	Auto reclose lockout relay
186B	Auto reclose lockout relay

CODE OF PRACTICE – LEAD IDENTIFICATION
(CONTROL WIRING - PROTECTION & METERING CIRCUITS)

A series	C.T secondaries for special protection; A1, A2, A3 etc. (Distance /Differential / REF Protection)	**H series**	LT AC supply; H1, H2, H3 etc
B series	C.T secondary for Bus bar protection; B1, B2, B3 etc.	**J series**	Main DC incoming; J1 (+ve) J2 (-ve) etc.
C series	C.T Secondary for protection circuits; C1, C2, C3 etc. (Back up Protection Over Current & Earth Fault)	**K series**	Controls, closing, tripping; K1, K2, K3 etc.
D series	C.T secondaries for metering circuits; D1, D2, D3 etc.	**L series**	Alarm indication and annunciation; L1, L2, L3 etc
E series	Potential Transformer secondaries; E1, E2, E3 etc. (For protection and metering)	**P series**	DC Supply for Bus Bar Protection and LBB protection Circuit.

TRANSMISSION LINE - DESIGN SPAN

VOLTAGE	NORMAL DESIGN SPAN	VOLTAGE	NORMAL DESIGN SPAN
1200 kV	400 m	132 kV	315,325,335 m
765 kV	400, 450 m	66 kV	240, 250, 275 m
400 kV	400 m	± 800 kV HVDC	400 m
220 kV	335, 350, 375 m	± 500 kV HVDC	400 m

WIND SPAN: Sum of the two half spans adjacent to the support under consideration.

PERMISSIBLE WEIGHT SPAN (m)

VOLTAGE LEVEL	TERRAIN	PLAIN TERRAIN				HILLY TERRAIN			
	TOWER TYPE	NORMAL CONDITION		BROKEN WIRE CONDITION		NORMAL CONDITION		BROKEN WIRE CONDITION	
		MAX	MIN	MAX	MIN	MAX	MIN	MAX	MIN
1200 kV	Suspension	550	200	330	100	--	--	--	--
	Small/ Medium Angle	1000	- 200	600	- 200	--	--	--	--
	Large Angle	1000	- 300	600	- 300	--	--	--	--
765 kV	Suspension	600	200	360	100	600	200	360	100
	Small/ Medium Angle	600	0	360	- 200	1000	- 1000	600	-600
	Large Angle	600	0	360	- 300	--	--	--	--
400 kV	Suspension	600	200	360	100	600	200	360	100
	Small/ Medium Angle	600	0	360	- 200	1000	- 1000	600	- 600
	Large Angle	600	0	360	- 300	--	--	--	--
220 kV	Suspension	525	200	315	100	525	200	315	100
	Small/ Medium Angle	525	0	315	- 200	1000	- 1000	600	- 600
	Large Angle	525	0	315	- 300	--	--	--	--
132 Kv / 110 kV	Suspension	488	195	195	104	488	208	192	104
	Small/ Medium Angle	488	0	195	- 200	960	- 960	576	- 576
	Large Angle	488	0	195	- 300	--	--	--	--
66 kV	Suspension	375	163	150	75	375	163	150	75
	Small/ Medium Angle	375	0	150	- 150	750	- 750	450	- 450
	Large Angle	375	0	150	- 150	750	- 750	450	- 450
± 800kV HVDC	Suspension	550	200	330	100	--	--	--	--
	Small/ Medium Angle	600	0	360	- 200	--	--	--	--
	Large Angle	600	0	360	- 300	--	--	--	--
± 500kV HVDC	Suspension	600	200	360	100	--	--	--	--
	Small/ Medium Angle	600	0	360	- 200	--	--	--	--
	Large Angle	600	0	360	- 300	--	--	--	--

CALCULATION FOR WEIGHT SPAN

Distance of Low / Null point from centre of span in meter (X) = (T*h)/(w*L)

T – Conductor Tension in Kg. h – difference between conductor supports level in meter.

L- Span in meter. w- unit weight of conductor in Kg/meter.

Weight Span = L/2 ± X

(±sign to be taken considering the Levels or Height /Position between towers)

Total Weight Span of a Tower = (Weight span on right side + Weight span on left side) of Tower.

If total weight span is negative then Tower is under uplift.

0 - 3 Deg.	3 - 15 Deg.	15 - 30 Deg.	30 – 60 Deg.
SUSPENSION	SMALL ANGLE	MEDIUM ANGLE	LARGE ANGLE/DEAD END OR TERMINAL TOWER
	3 - 30 Deg. - SMALL / MEDIUM ANGLE		

DISTANCE OF DAMPERS FROM SUPPORTS

Conductor	Distance from points of support	
	First damper 'p' cms	Second damper 'q' cms
Mink	61	122
Dog	84	168
Tiger	99	198
Wolf	107	213
Lynx	114	229
Panther	114	229
Kundah	137	279

VIBRATION DAMPERS

	At Suspension points	At Tension points
For Span below 366 m	Not required	1
For Span 367 to 671 m	1	2
For Spans above 671 m	Requires special study	

DISC INSULATORS FOR EHT LINES

Voltage (KV)	Normal Suspension		Normal Tension	
	No. of Discs	UTS (KN)	No. of Discs	UTS (KN)
66	5	45	6	50
110	7	70	8	70
220	14	90	15	120
400	23	115	2 x 23	165

Line Construction Procedures

(1)Investigation, selection of line route and preparation of route map. (2) Clearing way leaves. (3) Detailed survey (4) Action for getting PTCC, Railway-clearance for crossings if any (5) Profile plotting (6) Preparation of Tower Schedules (7) Check survey (8) Stub setting and concreting (9)Final tree cutting (10)Tower erection (11)Line stringing (12) Action for approval from Electrical Inspectorate. (13) Protective works and fitting accessories (14)Getting clearance from PTCC, and Railways for crossings (15)Getting Approval from Electrical inspectorate (16) Testing, test charging and commissioning.

TRANSMISSION LINE PARTICULARS

Voltage	400 KV	220 KV	110KV	66KV
Span in M	400	300	300	280
Minimum Mid Span Clearence in M	9	8.5	6.1	3.0
Supports	Angle Iron Lattice Fully galvanised	Angle Iron Lattice Fully galvanised	Angle Iron Lattice Fully galvanised	Angle Iron Lattice Fully galvanised
No. of supports per km	25	34	34	34
Total Weight of towers in M. T. per 10km.	27SC	19.4DC	12.9DC	7.6DC
Insulators E.M. Strength in Kg.				
Suspension	11,500			
Tension	16,500	12,000	7,000	4,500
Conductor	Moose	Kundah	Wolf	DOG
Conductor per phase	2	1	1	1
Total Conductor length Km	6.18SC	6.09DC	6.09DC	6.09DC
Ground wire	2	1	1	1
Strength (kg/mm^2)	100	70	70	70
Size of ground wire	7/3.66	7/3.66	7/3.66	7/3.66
Length of ground wire	2.06	1.015	1.015	1.015
Diameter of power conductor (mm)	32	26.82	18.13	14.25

DIMENSIONS OF MULTI CIRCUIT TOWERS (L&T)

Type	Height (peak) in mm	Height bottom X-arm (mm)	Height Second x-arm (mm)	Height Third x-arm (mm)	Height Fourth x-arm (mm)	Height Fifth x-arm (mm)	Height Sixth x-arm (mm)	Bottom dim (mm)	Wing span (mm)	Approx Weight per Tower (MT)
110 kV MC Towers (Refer data of M/s SAE)										
Suspension M3 (0-3Deg)	41615	17655	21705	25705	29655	33605	37555	9006	3450/4850	7.936
Tension M30 (3-30Deg)	41675	15575	19825	23875	27775	31675	35575	9849	3500 / 5150	12.923
Tension M60/DE (30-60Deg)	41675	15575	19775	23975	27875	31775	35675	13119	3400 / 5350	18.766
220 kV MC Towers (Refer data of M/s L& T)										
X Type -Suspension (0-2 Deg)	49625	19875	24875	29875	34875	39875	44875	7600	3500	9.054
Y Type -Tension (2-30 Deg)	49830	17295	22295	27295	32295	37295	42295	10500	3500	13.419
Z Type -Tension (30-60 Deg)	51295	17295	22495	27695	32795	37845	42895	13200	3500	19.674

WEIGHT OF TOWERS, EXTENSIONS, BEAMS, COLUMN, GIRDERS, TEMPLATES etc.

Type of Tower/Structure Structure	Weight in Kg.	Type of Tower/Structure	Weight in Kg.	Type of Tower/Structure	Weight in Kg.
220KV D2 TOWER	4930.140	110KV D3 TOWER	2489.377	66KV S.C. S30 TOWER	1486.414
4.5M EXTN	926.680	3M EXTN.	465.668	5EXTN	208.824
TEMPLATE	497.400	4.5M EXTN	712.169	10' EXTN	385.140
220 KV D15 TOWER	7133.590	TEMPLATE	322.848	15 EXTN.	561.340
4.5 M EXTN	1328.870	110KV D30 TOWER	3729.053	TEMPLATE	154.544
220KV D 30 TOWER	7236.750	3M EXTN	857.296	66KV S.C. S60 TOWER	1961.138
4.5M EXTN.	1572.680	4.5M EXTN.	1154.800	5' EXTN.	279.684
TEMPLATE	860.880	TEMPLATE	591.184	10' EXTN	508.276
220KV D60 TOWER	10039.230	110KV D60 TOWER	5564.057	15' EXTN	742.452
4.5M EXTN	2325.840	3M EXTN	1098.306	TEMPLATE	233.712
220KV P TYPE (20)	3915.800	4.5M EXTN	1451.708	10M SPAN GIRDER	550.980
STUB & CLEAT	193.200	TEMPLATE	686.932	9M BEAM	482.220
3M EXTN.	721.120	110KV S.C. TOWER (Special)	2008.310	8M BEAM	445.220
6M EXTN.	1242.880	TTA TOWER (66KV)	2528.830	13M COLUMN	1323.050
TEMPLATE	473.200	3M EXTN.	439.160	110KV ISOLATOR STRUCTURE	604.720
220KV Q TYPE TOWE R(15°)	5633.700	4.5M EXTN.	564.800	110KV CT/PT STRUCTURE	405.540
STUB & CLEAT	345.680	TEMPLATE	321.720	110KV LA & BUS BAR SUPPORTING STRUCTURE	316.540
3M EXTN.	1101.720	T.T.B. TOWER	3477.830	66KV ISOLATOR STRUCTURE	481.590
6M EXTN.	1906.360	3M EXTN.	640.520	66KV LA & BUS BAR SUPPORTING STRUCTURE	291.460
TEMPLATE	715.720	4.5M EXTN.	1010.520	66KV CT/PT STRUCTURE	373.600
220KV R TYPE TOWER(30°)	6672.700	TEMPLATE	441.520	220KV MULTI CIRCUIT	
STUB & CLEAT	390.480	T.T.C. TOWER	4145.580	X TYPE TOWER	9054.00
3M EXTN.	1301.280	3M EXTN.	788.840	Y TYPE TOWER	13419:00
6M EXTN.	2180.0	4.5M EXTN	1085.880	Z TYPE TOWER	19674.00
TEMPLATE	946.520	TEMPLATE	640.480		
220KV S TYPE TOWER (60°)	9464.500	66KV S.C. S3 TOWER	1244.954		
STUB & CLEAT	643.280	5'EXTN.	136.960		
3 MEXTN.	1598.640	10 'EXTN.	273.836		
6 MEXTN.	2857.200	5'EXTN.	415.808		
TEMPLATE	1133.400	TEMPLATE	132.208		

SALIENT DIMENSIONS OF TOWERS

Type of Tower	Height (mm)	Top X arm (mm.)	Middle X arm (mm)	Bottom X arm (mm)	Bottom square (mm)	Wing span (mm)	App. weight per tower (MT)
TTA (66KV)	21793	20726	18440	16154	3810	4572	234
TTB (66KV)	21946	19964	17526	15088	4572	5182	3.64
TTC (66KV)	21946	19964	17526	15088	5182	5334	4.21
D3 (110KV)	21768	18059	15011	11963	.4267	2896/3048	2.76
D30 (110KV)	21488	16459	13411	10363	5182	2896/3200	4.22
D60 (110KV)	22060	16549	13411	10363	5486	3200/3657	6.36
Kamani D2 (220KV)	33775	28300	23000	17600	5300	4650/5225	5.54
D15 (220KV)	33849	24399	19749	14424	6150	5150/5850	8.08
D30 (220KV)	32529	25124	19974	14724	72.00	5150/5500	9.60
D60 (220KV)	34332	25322	20032	14732	9500	5200/5600	10.67
Rockwell D2	32960	27900	22700	17500	4900	4380/4600	5.50
D15	34600	25200	20000	14800	6800	5000/5200	8.05
D60	34600	25200	20000	14800	9000	5300/6800	12.02
220KV P Type Tower (2°)	32215	28475	23575	18675	5300	4900	4.109
220KV Q Type Tower (15°)	31980	25440	20840	16165	7000	4000	5.979
220KV R Type Tower (30°)	33145	25835	21015	16165	8000	4000	7.063
220KV S Type Tower (60°)	35505	26585	21435	16175	8800	4000	10.108

DETAILS OF TRANSGRID TOWERS

Type of Tower		MLA	MLB	MLC	MLD	GLA	GLB	GLC	GLD	KLA	KLB	KLC	KLD
Height (mm)		60825	60825	60825	60825	47045	46355	46670	46085	46790	46805	46805	48535
Lower Ckt clearance (mm)	Bottom Cross arm	21750	19120	19120	19120	15480	13655	15655	13655	15450	13880	13880	14105
	Middle Cross arm	5750	5450	5450	5450	3250	3200	3200	3200	3250	3200	3200	3200
	Top Cross arm	5750	5450	5450	5450	3250	3200	3200	3200	3250	3200	3200	3200
Upper CktMiddle Cross clearance arm (mm)	Bottom Cross arm	7500	7500	7500	7500	7500	7500	7500	7500	7500	7500	7500	7500
	Middle Cross arm	8000	8000	8000	8000	5750	5500	5500	5500	5750	5500	5500	5500
	Top Cross arm	8000	8000	8000	8000	5750	5500	5500	5500	5750	5500	5500	5500
	Top Cross arm to Peak	4015	7305	7305	7305	5840	5500	8315	9580	5840	7800	7800	9530
Bottom Square		9600	10800	10800	12000	8000	9000	10000	11000	5000	6500	6500	8500
Tower Weight (MT)	Wind Span	335	335	335	335	335	335	335	335	335	335	335	335
	Normal	30.339	42.033	47.008	57.221	13.749	16.824	2.725	29.204	12.631	18.972	23.406	27.55
	3m	3.195	3.966	4.321	5.501	1.285	1.74	2.775	3.75	1.117	1.974	2.422	2.924
	6m	4.577	5.793	6.432	8.526	2.435	3.188	4.679	7.06	2.155	3.364	4.101	4.533
	9m	6.646	8.413	9.536	12.435	3.848	4.17	6.054	8.815	3.314	5.414	6.711	6.392
Conductor	Lower Ckt	ACCC Ernad	ACCC Ernad	ACCC Ernad	ACCC Ernad	Single Panther	Single Panther	Single Panther	Single Panther	Single Panther	Single Panther	Single Panther	Single Panther
	Upper Ckt	The Great Horn Bill	The Great Horn Bill	The Great Horn Bill	The Great Horn Bill	Twin Panther	Twin Panther	Twin Panther	Twin Panther	Twin Panther	Twin Panther	Twin Panther	Twin Panther

SAFETY CLEARANCE
SUBSTATION

Highest system Voltage (kV)	Lightening impulse Voltage (kVP)	Clearance (cm) between		Safety Clearances (cm)
		Phase & Earth	between phases	
36	170	32	32	280
72.5	325	63	63	310
125	450	90	90	340
	550	110	110	370
145	550	110	110	370
	650	130	130	380
245	950	190	190	430
	1050	210	210	460
420	1425	340	420	640

Safety clearences are based on the insulation height of 2.44 m which is the height of lowest point on the insulator where it meets the earthed metal. Values in table refer to an altitude not exceeding 1000 meters and take into account the most unfavourable conditions. A correction factor of 1.25% per 100 m is to be applied for increasing the air clearence for altitudes above 1000 m and upto 3000 m

SUB STATION: Clearance for enclosed bus bars - Indoor

(Where no insulating medium such as compound etc. is not used in the space between conductor)

Voltage in kV	Minimum clearance in mm	
	Phase–Phase	Phase–Earth
33	346	232
22	241	140
11	178	113

MAXIMUM BREAK TIME FOR CIRCUIT BREAKERS

Voltage Level in kV	765 kV	400 kV	220 kV	132 kV	66 kV
Maximum Break Time	40 ms	40 ms	60 ms	100 ms	100 ms
Circuit Breakers 132 kV and above shall be provided with 2 Nos. of trip coils					

BREAKING CAPACITY OF CIRCUIT BREAKERS

The rate of rupturing capacity of the Circuit Breaker to be installed at any new substation or switch yard shall be at least 25% higher than the calculated maximum fault level at the bus to take care of the increase in short circuit levels as the system grows. The rated breaking current capability of switchgear and breakers to be installed at different voltage levels, base round available capacities of the breakers, shall be:

11/33 kV	25kA (for 1 Sec.)
66 kV	31.5 kA (for 1 Sec.)
110/132 kV	31.5 kA (for 1 Sec.)
220 kV	40 kA (for 1 Sec.)
400 kV	40 or 50 kA (for 1 Sec.)
765 kV	40 or 50 kA (for 1 Sec.)

SAFETY CLEARANCE TRANSMISSION

Voltage	Clearance to Ground		Elsewhere		Clearance from Building	
	Across the street	Along the street	Bare	Insulated	Vertical clearance from the highest roof	Horizontal clearance from the nearest point
	m	m	m	m	m	m
Up to 650 v	5.8	5.5	4.6	4	2.5	1.2
up to 11 KV	6.1	5.8	4.6	4	2.5	1.2
11 - 33 KV	6.1	5.8	5.2	-	3.7	2
66 KV*	6.1	6.1	6.1	-	4.0	2.3
110 KV*	6.402	6.402	6.402	-	4.6	2.9
220 KV*	7.012	7.012	7.012	-	5.5	3.8
400 KV*	9.76	9.45	8.85	-	7.3	5.6

*For EHV lines, the clearance above the ground shall not be less than 5.2 metres plus 0.3 metres for every 33 KV or part there of by which the voltage of the line exceeds 33 KV. The minimum clearance along or across any street shall not be less than 6.1 metres.

CLEARANCES AT POWER LINE CROSSINGS

The minimum electrical clearances(All values in metres) between the lowest power conductor of crossing line over the crossed line as per regulation 69 of CEA regulations on Safety and Electricity Supply-2010 is given as under

Nominal System Voltage / Highest system voltage - AC (All clearences in m)	11-66 kV	110-132 kV	220/245 kV	400/420 kV	765/800 kV	1150/1200 kV
250 Volts to 11 kV	2.440	3.050	4.580	5.490	7.940	10.440
11-66 kV	2.440	3.050	4.580	5.490	7.940	10.440
110-132 kV	3.050	3.050	4.580	5.490	7.940	10.440
220/245 kV	4.580	4.580	4.580	5.490	7.940	10.440
400/420 kV	5.490	5.490	5.490	5.490	7.940	10.440
765/800 kV	7.940	7.940	7.940	7.940	7.940	10.440
1150/1200 kV	10.440	10.440	10.440	10.440	10.440	10.440

ARCING HORN GAPS

Tower	Arcing Horn gap in mm for Voltage		
	66 kV	110 kV	220 kV
Yard strain gantry	432	686	1200
Terminal Tower	381	635	1150
Second Tower	407	661	1200
Third Tower	432	686	1225
Fourth Tower	456	712	1250
Other Towers	700	965	1840

EQUIVALENT SPACING OF CONDUCTORS IN TRANSMISSION LINE TOWERS

Line Voltage	Single Circuit	Double Circuit
66 kV	3.056m	3.880m
110 kV	4.200m	5.206m
220 kV	7.026m	8.915m

Clearance between OH power lines and Railway tracks/structures

Voltage	Broad Gauge		Metre & Narrow Gauge		Min Clearance between Conductors and any Railway structure m
	Inside station area m	Outside station area m	Inside station area m	Outside station area m	
Upto and including 11 KV	10.0	7.6	8.6	6.3	2.90
Above 11 KV including 33 KV	10.0	7.6	8.8	6.4	2.90
Above 33 Kv Including 66KV	10.3	7.9	9.1	6.7	3.20
Above 66 KV Including 110 KV	10.6	8.2	9.5	7.0	3.51
For 220 KV	11.2	8.8	10.0	7.6	4.11
For 400 KV	13.14	10.97	12.19	9.76	6.25

Right of way - For Transmission Lines

VOLTAGE LEVEL	MINIMUM RIGHT OF WAY WIDTH / CORRIDOR REQUIREMENT (M)	MINIMUM CLEARANCE BETWEEN TREE & CONDUCTOR (M)
66 kV	18	3.4
110 kV	22	3.7
132 kV	27	4.0
220 kV	35	4.6
400 kV	52 (SINGLE CKT)	5.5
400 kV	48 (DOUBLE CKT)	5.5
765 kV	85 (HORIZONTAL CONFIG)	9.0
765 kV	64 (DELTA / VERTICAL CONFIG)	9.0
765 kV	67 (DOUBLE CKT)	9.0
1200 kV	89	13.0
± 320kV HVDC	48	5.5
± 500kV HVDC	52	7.4
± 800kV HVDC	69	10.7

Note: R-0-W clearance are same for plains and forest areas as per Forest (Conservation) Act 1980

Clearance over Rivers

Minimum 3.048 m over the highest flood level for river which are not navigable. For navigable rivers clearance to be fixed in relation to the tallest mast in consultation with the navigational authorities.

Clearance from supporting structure for another line

(a) Low or medium voltage lines : 1.219 m
(b) High voltage lines : 1.829 m
(c) EHV lines : 2.744 m

Vertical clearance between lines and guard wires

(a) L.T. : 1.219 m
(b) Voltage up to 66 KV : 1.219 m
(c) For 110 KV : 1.829 m

Note (i) Every guard wire shall be securely bound to earth at each point where its electrical continuity is broken.
(ii) Guard wire shall have an actual breaking load of not less than 635 kg and shall be galvanised.
(iii) The earth resistance should not exceed 10 ohms

CONDUCTOR / CABLES DATA
ACSR CONDUCTORS

	No. of Strands and dia				Dia Meter of complete cable mm	Gross Area of Alumi-nium Sq.mm	Gross Area of complete cable Sq.mm	Ultimate Strength KN	Resistance at 20°C Ohms/Km	Current rating for 30°. C temp rise above 40° C ambient	Weight Kg/km
	Aluminium		Steel								
	No	Dia. mm	No	Dia mm							
Squirrel	6	2.11	1	2.11	6.33	20.71	24.44	7.70	1.366	70	85.00
Weasel	6	2.59	1	2.59	7.77	31.63	36.90	11.35	0.905	100	127.70
Rabbit	6	3.35	1	3.35	10.05	52.95	61.78	18.60	0.540	148	213.00
Mink	6	3.66	1	3.66	10.98	63.06	73.57	22.05	0.454	167	255.00
Racoon	6	4.09	1	4.09	12.27	77.83	90.81	27.46	0.3656	197	318.40
Dog	6	4.72	7	1.57	14.15	105.20	118.80	33.10	0.281	254	394.00
Tiger	30	2.36	7	2.36	16.52	131.50	162.10	57.90	0.220	296	603.80
Wolf	30	2.59	7	2.59	18.13	158.10	195.00	68.75	0.183	343	727.40
Lynx	30	2.79	7	2.79	19.53	183.90	226.80	79.45	0.158	385	844.20
Panther	30	3.00	7	3.00	21.00	211.70	261.30	90.95	0.137	427	976.00
Kundah	42	3.49	7	1.94	26.76	402.90	423.57	95.50	0.074	726	1276.60
Zebra	54	3.18	7	3.18	28.62	428.91	484.5	130.32	0.0674	737	1621
Moose	54	3.53	7	3.53	31.77	528.50	597.00	162.80	0.0548	880	2001.50
Finch	54	3.64	19	2.18	32.83	564.00	635.50	182.35	0.0512	1000	2129.20

PVC Cables

No. Cores and cross Secional Area mm^2	Approx. overall dia (mm)	Approx. net wt. of Cables kg / km	Max.d.c. resistance at 20°C	Current Ratings	
				In ground Amps (max)	In Air Amps (Max)
3x25	43.0	2400	1.102	70	69
3x35	45.0	2500	0.8846	83	82
3x50	44.5	2380	0.6143	98	100
3 x 70	46.1	2800	0.4068	120	125
3x 95	48.4	3080	0.3262	145	150
3x120	50.9	3510	0.2471	160	170
3x150	52.6	3830	0.2090	185	195
3x185	59.1	5000	0.1337	225	245
3x240	62.6	5430	0.1155	235	255

Three Core Aluminium & Copper Conductor, XLPE Insulated, Armoured Cable Conforming to IS 7098 Part-2/1985

Voltage Grade : 11/11 kV (UE)

WEIGHT & DIMENSIONS

Nominal Size as per IS 8130/84 Sq.mm.	Form of Conductor Circular	Nom. Thickness of XLPE Insulation mm	Min. hickness of PVC Inner Sheath mm	Strip Armoured Cable					Round Wire Armoured Cable						Approx. Weight Kg./Km.	Current rating	
				Nom. Dimension G.I. Flat Strip mm	Min. Thickness of PVC Outer Sheath mm	Approx. Overall Diameter of Cable mm	AI. Approx. Weight of Cable Kg/Km	Cu. Approx. weight of Cable Kg./Km.	Nom. Dimension alGI Round Wire mm	Min. Thickness of PVC Outer Sheath mm	Approx. Overall Diameter of Cable mm	Approx Weight of Cable Kg./Km.	Current rating			In ground Amps.	In air Amps.
													In ground Amps.	In air Amps.			
35	Circular	5.5	0.5	4 X 0.8	2.04	55.0	2630.0	2845	2.00	1.9	49	3525	113	123	3740	137	142
50	Circular	5.5	0.6	4 X 0.8	2.20	58.0	2950.0	3200	2.50	2.0	53	4325	132	147	4635	167	177
70	Circular	5.5	0.6	4 X 0.8	2.20	62.0	3400.0	3830	2.50	2.0	57	4875	162	183	5300	202	217
90	Circular	5.5	0.6	4 X 0.8	2.36	66.5	4000.00	4585	2.50	2.2	62	5600	193	223	6190	237	257
120	Circular	5.5	0.7	4 X 0.8	2.36	69.0	4480.0	5220	2.50	2.2	65	6100	219	2:x3	6840	262	292
150	Circular	5.5	0.7	4 X 0.8	2.52	72.5	4900.0	5825	2.50	2.4	68	6760	245	292	7090	302	337
185	Circular	5.5	0.7	4 X 0.8	2.68	76.5	5600.0	6745	3.15	2.5	74	8400	276	332	9545	332	372
240	Circular	5.5	0.7	4 X 0.8	2.84	82.0	6650.0	8135	3.15	2.7	79	9600	319	392	11085	387	442
300	Circular	5.5	0.7	4 X 0.8	3.00	87.5	7650.0	9505	3.15	2.8	84	10800	360	452	12655	442	507
400	Circular	5.5	0.7	4 X 0.8	3.00	94.0	9000.0	11475	4.00	3.0	93	13690	410	527	16150	517	602

Comparison of Aluminium with Copper Conductor

	Area ratio	Diameter Ratio	Weight Ratio
For equalresistance	1.61	1.27	0.48
For equal current and temp.rise	1.39	1.18	0.42

For equal diameter	Resistance Ratio	Current Carrying Capacity	Weight Ratio
	1.61	0.78	0.3041

Unarmoured PVC Control Cable IS:1554 (Pt-1) - 1988

No. of cores & Cross Sectional Area No x mm2	Thickness of PVC Insulation (Nom) mm	Thickness of PVC Innesheath (min.) Extruded mm	Thickness of PCV Iutersheath (Nom.) mm	Approx. O.D mm	Approx. Net weight of Cable kg/km	Standard Delivery Length in Mtrs. Amps	Current Raing	
							Direct in Ground Amps.	In Air/ Duct Amps.
2 x 1.5	0.8	0.3	1.8	11.8	185	1000	23	20
3 x 1.5	0.8	0.3	1.8	12.3	190	1000	21	17
4 x 1.5	0.8	0.3	1.8	13.2	225	1000	21	17
5 x 1.5	0.8	0.3	1.8	14.1	260	1000	16	14
6 x 1.5	0.8	0.3	1.8	15.1	295	1000	15	13
7 x 1.5	0.8	0.3	1.8	15.1	315	1000	14	13
10 x 1.5	0.8	0.3	1.8	18.4	425	1000	13	11
12 x 1.5	0.8	0.3	1.8	18.9	480	1000	12	10
14 x 1.5	0.8	0.3	1.8	19.8	535	1000	11	10
16 x 1.5	0.8	0.3	1.8	20.7	595	1000	11	9
19 x 1.5	0.8	0.3	2.0	22.5	720	1000	10	9
24 x 1.5	0.8	0.3	2.0	25.8	880	1000	9	8
27 x1.5	0.8	0.3	2.0	26.3	960	1000	9	8
30 x 1.5	0.8	0.3	2.0	27.2	1040	1000	9	7
37 x 1.5	0.8	0.3	2.0	29.1	1230	1000	8	7
2 x 2.5	0.9	0.3	1.8	13.0	230	1000	32	27
3 x 2.5	0.9	0.3	1.8	13.6	240	1000	27	24
4 x 2.5	0.9	0.3	1.8	14.6	290	1000	27	24
5 x 2.5	0.9	0.3	1.8	15.7	335	1000	23	19
6 x 2.5	0.9	0.3	1.8	16.9	385	1000	21	18
7 x 2.5	0.9	0.3	1.8	16.9	420	1000	20	17
10 x 2.5	0.9	0.3	1.8	20.8	570	1000	18	15
12 x 2.5	0.9	0.3	2.0	22.2	690	1000	17	14
14 x 2.5	0.9	0.3	2.0	23.2	775	1000	16	13
16 x 2.5	0.9	0.3	2.0	24.3	860	1000	15	13
19 x 2.5	0.9	0.3	2.0	25.5	985	1000	14	12
24 x 2.5	0.9	0.3	2.0	29.4	1215	1000	13	11
27 x 2.5	0.9	0.3	2.0	30.0	1330	1000	12	10
30 x 2.5	0.9	0.3	2.0	31.0	1450	1000	12	10
37 x 2.5	0.9	0.4	2.2	34.1	1790	1000	11	9

Armoured PVC Control Cable IS:1554 (Pt-1) - 1988

No. of Cores & Cross Sectional Area (No x mm^2)	Thickness of PVC Insulation (Nom,) mm	Thickness of Inner-sheath (min) Extruded mm	Strip Armoured cable				Wire Armoured Cable				Standard Delivery Length in Mtrs	Current Rating	
			Strip size mm	Thickness of PVC Outer Sheath (mm)	Approx. OD. mm	Approx. Net weight of Cable Kg/km	Round Wire Dia mm	Thickness of PVC Outer sheath (Min) mm	Approx OD mm	Approx. Net weight of Cable Kg/Km		Direct in Ground Amps	In Air/ Duct Amps
2 X 1.5	0.8	0.3	-	-	-	-	1.4	1.24	13.6	415	1000	23	20
3 X 1.5	0.8	0.3	-	-	-	-	1.4	1.24	14.1	430	1000	21	17
4 X 1.5	0.8	0.3	-	-	-	-	1.4	1.24	15.0	490	1000	21	17
5 X 1.5	0.8	0.3	-	-	-	-	1.4	1.24	15.9	545	1000	16	14
6 x1.5	0.8	0.3	-	-	-	-	1.4	1.24	16.9	605	1000	15	13
7 X 1.5	0.8	0.3	-	-	-	-	1.4	1.24	16.9	630	1000	14	13
10 X 1.5	0.8	0.3	-	-	-	-	1.4	1.40	20.6	835	1000	13	11
12 X 1.5	0.8	0.3	4 X 0.8	1.24	19.5	760	1.6	1.40	21.5	950	1000	12	10
14 X 1.5	0.8	0.3	4 X 0.8	1.40	20.8	830	1.6	1.40	22.4	1040	1000	11	10
16 X 1.5	0.8	0.3	4 X 0.8	1.40	21.7	920	1.6	1.40	23.3	1130	1000	11	9
19 X 1.5	0.8	0.3	4 X 0.8	1.40	23.1	1040	1.6	1.40	24.7	1265	1000	10	9
24 X 1.5	0.8	0.3	4x 0.8	1.40	26.4	1250	1.6	1.40	28.0	1510	1000	9	8
27 X 1.5	0.8	0.3	4 X 0.8	1.40	26.9	1355	1.6	1.40	28.5	1610	1000	9	8
30 X 1.5	0.8	0.3	4 X 0.8	1.40	27.8	1430	1.6	1.40	29.4	1700	1000	9	7
37 X 1.5	0.8	0.3	4 X 0.8	1.40	29.7	1670	1.6	1.40	31.3	1960	1000	8	7
2 X 2.5	0.9	0.3	-	-	-	-	1.4	1.24	14.8	500	1000	32	27
3 X 2.5	0.9	0.3	-	-	-	-	1.4	1.24	15.4	520	1000	27	24
4 X 2.5	0.9	0.3	-	-	-	-	1.4	1.24	16.4	590	1000	27	24
5 X 2.5	0.9	0.3	-	-	-	-	1.4	1.24	17.5	660	1000	23	19
6 X 2.5	0.9	0.3	-	-	-	-	1.4	1.24	18.7	745	1000	21	18
7 X 2.5	0.9	0.3	-	-	-	-	1.4	1.24	18.7	780	1000	20	17
10 X 2.5	0.9	0.3	4 X 0.8	1.40	21.8	900	1.6	1.40	23.4	1110	1000	18	15
12 X 2.5	0.9	0.3	4 X 0.8	1.40	22.8	1020	1.6	1.40	24.4	1240	1000	17	14
14X 2.5	0.9	0.3	4 X 0.8	1.40	23.8	1130	1.6	1.40	25.4	1340	1000	16	13
16 X 2.5	0.9	0.3	4 X 0.8	1.40	24.9	1210	1.6	1.40	26.5	1455	1000	15	13
19 X 2.5	0.9	0.3	4 X 0.8	1.40	26.1	1355	1.6	1.40	27.7	1605	1000	14	12
24 X 2.5	0.9	0.3	4 X 0.8	1.40	30.0	1655	1.6	1.56	32.0	1970	1000	13	11
27 X 2.5	0.9	0.3	4 X 0.8	1.40	30.6	1770	1.6	1.56	32.6	2100	1000	12	10
30 X 2.5	0.9	0.3	4x 0.8	1.56	32.0	1940	1.6	1.56	33.6	2250	1000	12	10
37 X 2.5	0.9	0.4	4 X 0.8	1.56	34.7	2300	2.0	1.56	37.1	2900	1000	11	9

CURRENT CARRYING CAPACITY OF A CABLE OPERATING AT DIFFERENT CONDITIONS FROM THE STANDARD

Ia = K x Is Where Ia - Current rating at actual operating conditions (amperes)
Is = Current rating at standard operating conditions (amperes)
K = Rating factor as applicable

RATING FACTORS

Variation of rating factor with temperature

Temperature in °C	**15**	**20**	**25**	**30**	**35**	**40**	**45**	**50**
Rating factor with ambient air temp.			1.14	1.10	1.04	1.00	0.95	0.9
Rating factor with ground temp.	1.12	1.08	1.03	1.00	0.96	0.91	0.87	

Variation with Depth					
Depth in Cm	**90**	**105**	**120**	**150**	**180 and more**
Rating factor for 3.3KV, 6.6 KV, 11KV all size	1.0	0.99	0.98	0.96	0.95
Rating factor for 22KV & 33KV all size	-	1.00	0.99	0.97	0.96

Variation with thermal resistivity							
Thermal resistivity of soil °ccm/w	100	120	150	200	250	300	
Rating factor	1.2	1.11	1.00	0.89	0.8	0.73	

Max. conductor temperature - 90°C
Ambient ground temperature - 30°C
Ambient air temperature - 40°C
Thermal resistivity of soil - 150°ccm/w
Max. conductor temperature for short circuit - 250°C

Depth of laying (to the highest point of the cables laid direct in the ground

3.3, 6.6 and 11 kV cables - 91 cm
22 kV cables - 107 cm
33 kV cables - 120 cm
110kV and Above - 135 cm
Radius of complete cable to be added to the above

Permissible Bending Radius of cables for fixed installations

Voltage Level	PILC		PVC & XLPE	
	Single core	Multi core	Single core	Multi core
Up to 1.1kV	20 D	15 D	15 D	12 D
1.1 to 11 kV	20 D	15 D	15 D	15 D
Above 11 kV	25 D	20 D	20 D	15 D

D = Outer diameter of Cable

SIZING A BATTERY CHARGER

Correct size battery charger shall be selected for the intended application. The ampere requirement may be determined as follows:

A = (AH ×1.15 /T) +L

Where A =min. rated ampere charger capacity. AH =Ampere-hour discharge from battery.

T =time allowed for recharge in hours. L =continuous connected load on the battery in amps. 1.15=efficiency charge factor.

Example: If a 100 AH battery is 50% discharged, and it is to be re-charged in 10 hours, and a continuous load of 6 Amps to be supplied, ampere requirement will be,

A = {(100×0.5)×1.15 /10}+6 = (5.75+6) = 11.75Amps.

As this is not a standard rating, the nearest rating of 15 Amps shall be selected. If lower rate is selected it shall not be less than 95% of the calculated value required. Hence a 10 Amp rating is not sufficient.

DISTRIBUTION TRANSFORMERS

KVA	Full Load Current HT (Amps)	Full Load Current LT (Amps)	Minimum size of LT cable mm^2	Total wt. (kg)	Qty. of Oil (Litres)	Neutral Earthing conductor (Cu)
63*	3.3	84	70	470	140	25 x 3mm
100	5.25	133.3	2 x 50	645	205	25 x 3mm
160	8.40	213.3	2 x 95	935	255	25 x 3mm
200	10.49	266.7	2 x 120	1065	280	25 x 3mm
250	13.12	333.3	2 x 185	1190	345	25 x 3mm
400**	21	533.3	3 x 300	1840	390	38 x 3mm
500	26.2	666.6	3 x 400	1960	430	25 x 6mm
630	33	840.0	4 x 400	2450	600	31 x 6mm
750	39.36	1000.0	-	2815	645	31 x 6mm
800	42.00	1067.0	-	2925	660	
1000	52.50	1333.0	-	3270	725	
1250	65.60	1666.5	-	4730	850	

*63 to 250 KVA Aluminum Winding ** 400 to 1250 Copper Winding

L T LEADS AND FUSES FOR DISTRIBUTION TRANSFORMERS

Transformer Capacity (KVA) units	Full load Amps 11KV	Full load Amps 433 V	Fuse Wire SWG 11 KV	Fuse Wire SWG 433 V	Size of SC Aluminium LT cable (Sq.mm)	Size of G.I Pipe to be used (mm)	Size of fuse Units (Amps)
25	1.31	33.4	3	21	25		100
50	2.62	66.7	33	18 or 2 of 20	50	50	100
63	3.32	84.5	33	2 of 20	95	-	200
100	5.25	133.5	32	2 of 18 or 2 of 16	185	75	200
200	10.50	267.0	26	2 of 15	2 Circuits	2 of 75	2x200 each

SIZE OF EARTH LEADS (TRANSFORMER NEUTRAL POINT EARTHING)

Transformer rating KVA	Electrolytic bare copper conductor or strip	Insulated (PVC) Single core stranded Aluminium sq.mm	Galvanised Iron Conductor or strip
50 & below	8 SWG	16	25 mm x 3mm
75	8 SWG	25	40 mm x 6mm
100	4 SWG	35	40 mm x 6mm
150	2 SWG	70	40 mm x 6 mm
200	25 mm x 1.5 mm	95	40 mm x 6 mm
250	25 mm x 1.3 mm	150	40 mm x 6 mm
300	25 mm x 6 mm	300	40 mm x 6 mm
500	25 mm x 6 mm	300	40 mm x 6 mm
750	25 mm x 6 mm	300	40 mm x 6 mm

Note :
Above 500 KVA only copper/aluminium strips to be used
Above 750 KVA size of earth lead to be determined as per IS: 166/1967

D.O. Fuse Protection (In ampere)

Transformer Capacity KVA	11 KV		22 KV	
	Transformer	Feeder	Transformer	Feeder
25	3	2	2	2
50	5	3	3	3
100	10	7.5	5	3
150	15	10	7.5	5
200	20	15	10	7.5
300	30	25	15	10
400	40	30	25	15
500	50	40	25	20
750	60	-	40	-
1000	75	-	50	-

Horn Gap Fuses (HT. Side of Transformer)

33 KV (Gap 385 mm)		11 KV (Gap 205 mm)	
Tr. Capacity	SWG	Tr. Capacity	SWG
5 MVA	2 X 20	500 KVA	20
3 MVA	20	300 KVA	23
2 MVA	21	200 KVA	24
1.5 MVA	21	100 KVA	33
1 MVA	22	63 KVA	35
0.75 MVA	23	50 KVA	35
0.5 MVA	26	25 KVA	38

LT CAPACITORS FOR TRANSFORMERS

Transformer rating	Load KVAR for switching ON capacitor bank	Load KVAR for switching OFF capacitor bank
25 KVA One step (9 KVAR)	13	10
63 KVA 1st step (9KVAR)	13	10
2nd step (9KVAR)	22	19
3rd step (9KVAR)	31	28
100 KVA 1st step (9KVAR)	13	10
2nd step (9KVAR)	22	19
3rd step (9KVAR)	31	28
4th step (9KVAR)	40	37

Power Factor of Some Common Types of Loads

SL. No	Load	Power factor
1.	Incandescent lamps	1.00
2.	Fluorescent lamps	0.6 to 0.8
3.	Induction motors	0.8
4.	Neon signs	0.4 to 0.5
5.	Arc lamps (Cinema)	0.3 to 0.7
6.	Arc furnaces	0.85
7.	Arc welding	0.3 to 0.4
8.	Resistance welding	0.65
9.	Induction furnace	0.60
10.	Induction heating	0.85

GENERATORS

Generator capacity in KVA	Cable size (mm^2) PVC/APVC	Earthing Conductor
15	10	10 SWG
63	50	4 SWG
100	95	25 x 3
160	185	25 x 3
200	2 x 120	25 x 3
250	2 x 185	25 x 3
400	2 x 400 / 3 x 300	25 x 3
500	3 x 400 / 4 x 300	25 x 3

MOTORS

Motor rating HP	Back up fuse		Aluminium Cable size mm^2	Earthing Conductor	
	DOL Starting	Assisted Starting		Copper	Aluminium mm^2
Upto 5	25		4	10 SWG	25
6 to 10	35	25	6	10 SWG	25
11 to 17.5	50	35	10	10 SWG	25
18 to 20	63	53	16	10 SWG	25
21 to 25	80	63	25	10 SWG	25
26 to 30	100	65	26	6 SWG	25
31 to 40	120	100	35	6 SWG	25
41 to 50	160	100	50	6 SWG	25
51 to 60	200	120	70	4 SWG	25
61 to 75	200	120	95	4 SWG	25
76 to 100	250	200	185	2 SWG	25

Assumptions

1. Cut-off value of the back up HRC Fuses is taken for deciding size of earthing conductors of motors
2. Short time rating of cable suggested are based upon the cut-off value of the back up HRC Fuses
3. Overload protection of the cables suggested for motor is supposed to be offered by over load relays in the motor starters.
4. Values given above are for length within 75 to 100m. If more, voltage drop to be taken into account and suitable size to be chosen.

THREE - PHASE AC MOTORS
MAXIMUM PERMISSIBLE RATING IN KW

Rated current of fuses Amps	Direct-on-line started squirrel cage motors Starting current = 6 x rated current (Starting period 5 sec)		Slip-ring motors and star-delta started squirrel cage motors Starting current = 2 x rated current (Starting period - 15 sec)	
	220 V	380 V	220 V	380 V
2	0.17	0.3	0.43	0.75
4	0.42	0.72	1	1.7
6	0.63	1.1	1.55	2.7
10	1.25	2.2	2.6	4.5
20	2.7	4.8	5.5	9.5
36	5.1	8.7	10	17.5
50	7.5	13	14.5	25
63	9.5	16.5	18	31
80	15	25	24	41
100	16.5	34	31	53
160	32	55	49	85
200	38	65	62	107
250	57	99	81	140
300	105	180	132	225
500	129	225	155	-

VOLTAGE REGULATION

Regulation of a line is the voltage drop along the line expressed as fraction of the receiving end voltage. When a feeder is tapped at various points, the voltage drop in each individual section is calculated and added up to get the total drop.

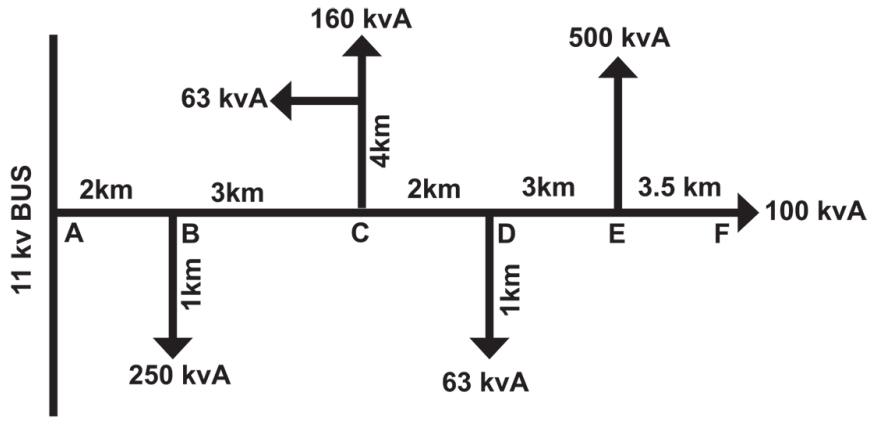
Voltage Regulation = (Es – Er)/ Er x 100; Where Es = Sending end Volts Er = Receiving end Volts
Allowable voltage variations: (a) E.H.T. + 10% to -12.5%, (b) H.T + 6% to -9%, (c) L.T. ± 6%

kW-km moment for over head lines with REC specified spacing and @ 0.9 pf

Sl No	Conductor	Voltage Class	Resistance (Ohms /km @60^{0}C)	Reactance (Ohms / km)	kVA-km for1% drop
1	Squirrel	11 kV	1.59384	0.39000	753
2	Weasel	11 kV	1.05746	0.38200	1081
3	Rabbit	11 kV	0.63208	0.43200	1594
4	Raccoon	11 kV	0.42410	0.442200	2100
5	Squirrel	22 kV	1.59384	0.39000	3104
6	Weasel	22 kV	1.05746	0.38200	4322
7	Rabbit	22 kV	0.63208	0.43200	6377
8	Dog	22 kV	0.31842	0.42900	10182
9	Rabbit	33 kV	0.63208	0.43200	14349
10	Raccoon	33kV	0.42410	0.44200	18901
11	Dog	33 kV	0.31842	0.42900	22910
12	Squirrel	415 V	1.59384	0.39000	1.04
13	Weasel	415 V	1.05746	0.38200	1.46
14	Rabbit	415 V	0.63208	0.43200	2.20
15	3 x300 Sq.mm XLPE Al UG	11 kV	0.129	0.075	1455

Typical calculation of Voltage Regulation of 11 kV line

In the diagram shown below, for calculating the voltage drop on the main feeder (AF), the tap line loads are assumed to be concentrated at tapping point.



Taking kVA-km moment along the main feeder -

Point	Point Load (kVA)	Cumulative Load (KVA)	Corresponding Section	Length (km)	Moment (kVA – km)
A	--	--	--	--	--
B	250	1136	AB	2.00	2272
C	223	886	BC	3.00	2658
D	63	663	CD	2.00	1326
E	500	600	DE	3.00	1800
F	100	100	EF	3.50	350
TOTAL	**1136**			**TOTAL**	**8406**

Regulation Calculation:

(This simplified Calculation is based on REC Standards)

Conductor used : **Raccoon**.

Therefore, Moment required for 1% voltage drop (See Table) = 2100 kVA-km @ 0.9 pf

Percentage Regulation (Voltage drop of the main feeder (AF) = 8406 /2100 = 4%

Diversity factor of feeder (is taken instead of actual loading) =

Total Transformer KVA / (1.73 x 11 kV x Peak Current)

Peak current recorded in normal feeding arrangement = 50 A

Therefore, Diversity factor = 1136 kVA / (1.73 x 11 kV x 50 A) = 1.2

Thus, the line regulation with 1.2 Diversity Factor = 4.3 / 1.2 = 3.3 %

STANDARD WIRE GAUGES

SWG	Inch	mm	SWG	Inch	mm
1	0.300	7.620	26	0.018	0.457
2	0.276	6.910	27	0.0164	0.3166
3	0.252	6.401	28	0.0148	0.3759
4	0.232	5.893	29	0.0316	0.3454
5	0.212	5.385	30	0.0214	0.3154
6	0.192	4.877	31	0.0116	0.2646
7	0.175	4.445	32	0.0108	0.2743
8	0.160	4.064	33	0.0100	0.2540
9	0.144	3.658	34	0.0092	0.2337
10	0.128	3.251	35	0.0084	0.02134
11	0.116	2.946	36	0.0068	0.01930
12	0.092	2.642	37	0.0063	0.01930
13	0.092	2.337	38	0.0060	0.1524
14	0.082	0.032	39	0.0052	0.1321
15	0.072	1.629	40	0.0048	0.1219
16	0.064	1.226	41	0.0044	0.1118
17	0.056	1.442	42	0.0040	0.1016
18	0.048	1.219	43	0.0036	0.0914
19	0.040	1.016	44	0.0032	0.0813
20	0.036	0.914	45	0.0028	0.0711
21	0.032	0.813	46	0.0024	0.0061
22	0.028	0.711	47	0.0020	0.0508
23	0.024	0.610	48	0.0016	0.0906
24	0.022	0.059	49	0.0017	0.0305
25	0.020	0.508	50	0.0010	0.0240

ENERGY CONSUMPTION
DOMESTIC APPLIANCES / EQUIPMENT

Normally the actual load of each item will be considered to determine the connected load at the premises. In case of non-availability of the rated capacity of any item, the load shown below shall be considered as recommended in Annexure 7 of Kerala Electricity Supply Code 2014.

Item / Appliances	Load Rating (in Watts)	Time for 1 Unit consumption
CFL	18	55 hrs 34 mins.
Bulb (Incandescent Lamp)	40	25 hrs
Tube Light (Fluorescent Lamp)	40	25 hrs
Fan	60	16 hrs 40 mins
Tape recorder / Music System	100	10 hrs
Television	200	5 hrs
Mixer	375	2 hrs 40 mins
Electric Iron	750	1 hrs 20 mins
Fridge (Refrigerator)	150	6 hrs 40 mins
Room Cooler	250	4 hrs
Heater (for cooking and water heating)	1000	1 hr
Washing Machine	750	1 hrs 20 mins
Geyser	2000	30 mins
Microwave Oven	2000	30 mins
Air Conditioner – 1 ton	1500	40 mins
Air Conditioner – 1.5 ton	2250	27 mins
Computer	100	10 hrs
Printer	150	6 hrs 40 mins

Connected load of plug sockets estimated as recommended in Annexure 7 of Kerala Electricity Supply Code 2014.

Sl No.	Rating of Plug Socket	Load in Watts
1	5 Ampere	60
2	16 Ampere	500
3	32 Ampere	1500

Note: 1. Where actual load is not known, the above loads shall be considered as guidance.
2. Stand by loads such as fire pumps etc. shall not be considered for determination of loads.

FUSE RATINGS OF DOMESTIC SERVICES

Load in Watts	T.C Wires SWG	Fuse rating Amps	Fusing current Amps
500	39	2.5	4
1000	35	5.0	8
1500	32	7.0	11
2000	29	10.0	16
2500	28	12.0	18
3000	27	13.0	23
4000	23	20.0	38

BOLT AND NUT, ANGLES, BEAMS, FLATS
WEIGHT OF BOLTS AND NUTS - IN KG

For length of bolts in inches (mm) from under head including nut

Dia in inch/ (mm)	1" (25)	11/4" (32)	11/2" (38)	13/4"	2" (50)	21/4"	21/2" (65)	23/4"	3" (75)	4" (100)	5" (125)	6" (150)	7" (180)	8" (200)	9" (230)	10" (255)
1/4(6)	0.013	0.14	0.016	0.017	0.019	0.02	0.022	0.023	0.024	0.03	0.036	0.042	0.148			
3/8 (10)	0.031	0.034	0.038	0.041	0.045	0.048	0.051	0.055	0.058	0.072	0.085	0.098	0.112	0.125		
1/2 (12)	0.071	0.077	0.083	0.089	0.095	0.101	0.107	0.113	0.119	0.143	0.167	0.191	0.216	0.24	0.264	
5/8 (16)		0.139	0.149	0.159	0.169	0.179	0.189	0.199	0.209	0.249	0.288	0.328	0.368	0.408	0.447	0.487
3/4 (19)			0.239	0.253	0.267	0.282	0.296	0.311	0.325	0.382	0.44	0.497	0.554	0612	0.67	0.727
7/8 (22)			0.299	0.318	0.337	0.356	0.375	0.394	0.413	0.489	0.564	0.64	0.715	0.791	0.866	0.942
1 (25)				0.463	0.488	0.512	0.537	0.562	0.586	0.685	0.783	0.882	0.981	1.08	1.178	1.277
11/4 (32)							1.022	1.061	1.1	1.254	1.408	1.563	1.718	1.872	2.027	2.182
11/2 (38)							1.641	1.694	1.747	1.96	2.174	2.387	2.6	2.813	3.026	3.24

WEIGHTS OF SHEET METAL kg/m2

Sheet	Plate thickness in mm							
	0.5	1.0	1.5	2.0	3.0	4.0	5.0	6.0
Aluminium	1.35	2.70	4.05	5.40	8.10	10.80	13.50	16.20
Zinc	3.59	7.18	10.8	14.40	21.50	28.72	35.90	43.08
Iron	3.90	7.80	11.70	15.60	23.40	31.20	39.00	46.80
Steel	4.0	8.0	12.0	16.0	24.0	32.0	40.0	48.0
Brass	4.25	8.50	12.80	17.0	25.50	34.0	42.5	51.0
Copper	4.45	8.90	13.40	17.80	26.70	35.60	44.5	53.40

G.I WIRES

SWG	Meters/Kg	kg / metre
16	42.35	0.024
14	27.50	0.036
12	22.73	0.044
10	18.25	0.055
8	9.80	0.102
4	4.587	0.218

STAY WIRE (Guy wires)

No. & Guage of wire	Over all dia (inches)	Wt. of 1000 yds (ld)
7/8	0.480	1470
7/9	0.432	1185
7/10	0.384	938
7/12	0.312	617
7/14	0 .240	421

UNIT WEIGHT OF CONSTRUCTION MATERIALS

Descriptions	Kg / cu. metre
Cement-Ordinary & Aluminious	1440
Cement concrete Plain	2240
Sand (Dry)	1600
Sand (Wet)	1700 to 2000
Mild steel	7840
Cast iron	7200
Brass	8550
Lead	11350
Tar	1010
Alumiium	2800

FLATS

Size (mm)	Wt (Kg/m)	Sectional are (cm^2)
25 x 5.0	1.0	1.25
50 x 6.0	2.355	3.00
50 x 10	3.9	5.00
65 x 6	3.1	3.90
75 x 8	4.7	6.00
75 x 10	5.9	7.15
80 x 10	6.3	8.00

EQUAL ANGLES

Designation	Size (mm xmm)	Thickness (mm)	Sec. Area (cm^2)	Weight Kg/m
ISA 2020	20 x 20	3.0	1.12	0.9
ISA 4040	40 x 40	3.0	2.34	1.8
ISA 6060	60 x 60	5.0	5.75	4.5
ISA 8080	80 x 80	6.0	9.29	7.3
ISA 100100	100 x 100	6.0	11.67	9.2
ISA 200200	200 x 200	12.0	46.94	36.9

UNEQUAL ANGLES

Designation	Size (mm x mm)	Thickness (mm)	Sec. Area (cm^2)	Weight kg/m
ISA 3020	30 x 20	3.0	1.41	1.1
ISA 5030	50 x 30	3.0	2.34	1.8
ISA 10065	100 x 65	6.0	9.55	7.5
ISA 200100	200 x 100	10.0	29.21	22.9
ISA 200150	200 x 150	10.0	34.29	26.9

REQUIREMENT OF CEMENT

Sl.No.	Particulars				Qty. of cement
Brick Masonry					
1.	Brick works in CM	1:4	with wire cut	[22.9 cm x 11.2 cm x 7 cm]	72 kg/m^3
2.	-do-	1:5	-do-	[19 cm x 9 cm x 9 cm]	72 Kg/m^3
3.	-do-	1:5	-do-	[22.9 cm x 11.2 cm x 7 cm]	58 Kg/m^3
4.	-do-	1:5	with country burnt bricks	[19 cm x 9 cm x 9cm]	69 Kg/m^3
5.	-do-	1:5	-do-	[22.9 cm x 11.2 cm x 7 cm]	69 Kg/m^3
6.	-do-	1:6	-do-	[19 cm x 9 cm x 9 cm]	58 Kg/m^3
7.	-do-	1:6	-do-	[22.9 cm x 11.2 cm x 7.0 cm]	58 Kg/m^3
Laterite Masonry					
8.	Laterite Masonry in C.M		1:4	[44cm x 24 cm x 14 cm]	58 Kg/m^3
9.	-do-		1:5	[44 cm x 24 cm x 14 cm]	46 Kg/m^3
Stone Masonry					
10.	Cut stone work in steps 15 to 22 cm size in C.M			1:2	62 Kg/m^3
11.	Coars rubble work in split stone in C.M			1:2	101 Kg/m^3
12.	-do-	11 sort in C.M		1:4	79 Kg/m^3
13.	-do-	-do-		1:5	63 Kg/m^3
14.	Random rubble work in cement mortar			1:4	108 Kg/m^3
15.	-do-	-do-		1:5	86 Kg/m^3
16.	-do-	-do-		1:6	72 Kg/m^3
17.	-do-	-do-		1:8	54 Kg/m^3
Plastering					
18.	Plastering with C.M		1:3 12 mm thick one coat		66 Kg /10 m^2
19	-do-	-do-	1:3: 15 mm	-do-	72 Kg/10 m^2
20.	-do-	-do-	1:4 12 mm	-do-	54 Kg/10m^2
21.	-do-	-do-	1:4 15 mm	-do-	59 Kg/10m^2
22.	-do-	-do-	1:5 12 mm	-do-	43 Kg/10m^2
23.	-do-	-do-	1:5 15 mm	-do-	48 Kg/10m^2
24.	-do-	-do-	1:6 15 mm	-do-	40 Kg/10 m^2
25.	Cement fleshing coat				22kg/10m^2
Cement Concrete					
26.	Cement Concrete		1:1 1/2 :3	Using 20 mm nominal size broken stone.	4.32 kg/10dm^3
27.	-do-			1:3:6 -do-	2.16 KG/10dm^3
28.	-do-			1:2:4 -do-	3.3 kg/10dm^3
29.	-do-			1:4:8 -do-	1.62 kg/10dm^3

YEAR PLANNER 2026

DAY	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE
SUN		1	1			
MON		2	2			1
TUE		3	3			2
WED		4	4	1		3
THU	1	5	5	2		4
FRI	2	6	6	3	1	5
SAT	3	7	7	4	2	6
SUN	4	8	8	5	3	7
MON	5	9	9	6	4	8
TUE	6	10	10	7	5	9
WED	7	11	11	8	6	10
THU	8	12	12	9	7	11
FRI	9	13	13	10	8	12
SAT	10	14	14	11	9	13
SUN	11	15	15	12	10	14
MON	12	16	16	13	11	15
TUE	13	17	17	14	12	16
WED	14	18	18	15	13	17
THU	15	19	19	16	14	18
FRI	16	20	20	17	15	19
SAT	17	21	21	18	16	20
SUN	18	22	22	19	17	21
MON	19	23	23	20	18	22
TUE	20	24	24	21	19	23
WED	21	25	25	22	20	24
THU	22	26	26	23	21	25
FRI	23	27	27	24	22	26
SAT	24	28	28	25	23	27
SUN	25		29	26	24	28
MON	26		30	27	25	29
TUE	27		31	28	26	30
WED	28			29	27	
THU	29			30	28	
FRI	30				29	
SAT	31				30	
SUN					31	
MON						

YEAR PLANNER 2026

DAY	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER
SUN					1	
MON					2	
TUE			1		3	1
WED	1		2		4	2
THU	2		3	1	5	3
FRI	3		4	2	6	4
SAT	4	1	5	3	7	5
SUN	5	2	6	4	8	6
MON	6	3	7	5	9	7
TUE	7	4	8	6	10	8
WED	8	5	9	7	11	9
THU	9	6	10	8	12	10
FRI	10	7	11	9	13	11
SAT	11	8	12	10	14	12
SUN	12	9	13	11	15	13
MON	13	10	14	12	16	14
TUE	14	11	15	13	17	15
WED	15	12	16	14	18	16
THU	16	13	17	15	19	17
FRI	17	14	18	16	20	18
SAT	18	15	19	17	21	19
SUN	19	16	20	18	22	20
MON	20	17	21	19	23	21
TUE	21	18	22	20	24	22
WED	22	19	23	21	25	23
THU	23	20	24	22	26	24
FRI	24	21	25	23	27	25
SAT	25	22	26	24	28	26
SUN	26	23	27	25	29	27
MON	27	24	28	26	30	28
TUE	28	25	29	27		29
WED	29	26	30	28		30
THU	30	27		29		31
FRI	31	28		30		
SAT		29		31		
SUN		30				
MON		31				

HOME AWAY FROM HOME

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