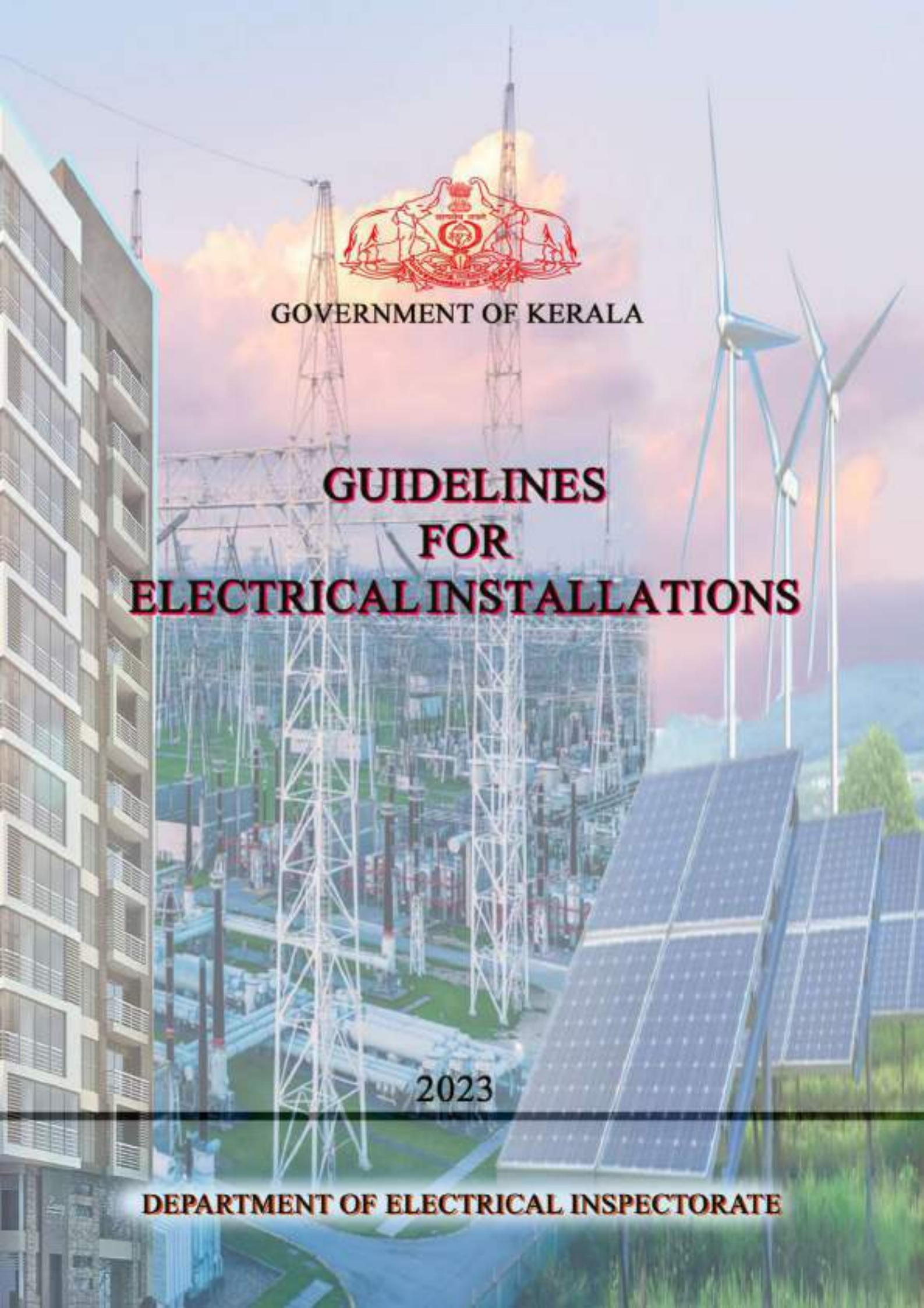

GOVERNMENT OF KERALA

GUIDELINES FOR ELECTRICAL INSTALLATIONS

2023

DEPARTMENT OF ELECTRICAL INSPECTORATE

"മനുഷ്യനെ മാറ്റുക"

കേരള സർക്കാർ

സംഗ്രഹം

ഊർജ്ജ വകുപ്പ് - ഇലക്ട്രിക്കൽ ഇൻസ്പെക്ടറേറ്റ് വകുപ്പിലെ പുതുക്കിയ സാങ്കേതിക മാർഗ്ഗനിർദ്ദേശങ്ങൾ അംഗീകരിച്ച് ഉത്തരവ് പുറപ്പെടുവിക്കുന്നു.

ഊർജ്ജ (എ) വകുപ്പ്

സ.ഉ.(കൈ) നം.1/2023/POWER തീയതി,തിരുവനന്തപുരം, 13-01-2023

പരാമർശം:- ചീഫ് ഇലക്ട്രിക്കൽ ഇൻസ്പെക്ടറുടെ 27.10.2022-ലെ ബി2-12440/2020/സി.ഇ.ഐ. നമ്പർ കത്ത്.

ഉത്തരവ്

വൈദ്യുത പ്രതിഷ്ഠാപനങ്ങളുമായി ബന്ധപ്പെട്ട നിലവിലെ സാങ്കേതിക മാർഗ്ഗനിർദ്ദേശങ്ങൾ കാലോചിതമായി പരിഷ്ക്കരിക്കുന്നതിനായി **KELCON, HT/EHT Consumer Association, PWD Electrical Wing, National Safety Council,** ഇലക്ട്രിക്കൽ ഇൻസ്പെക്ടറേറ്റ് വകുപ്പിലെ ജില്ലാതല ഓഫീസർമാർ, പ്രസ്തുത വകുപ്പിൽ നിന്നും വിരമിച്ചതും ഇപ്പോൾ കൺസൾട്ടൻസി മേഖലയിൽ പ്രവർത്തിക്കുന്നവരുമായ വിദഗ്ധർ എന്നിവരെ ഉൾപ്പെടുത്തി രൂപീകരിച്ച കമ്മിറ്റി വൈദ്യുത മേഖലയുമായി ബന്ധപ്പെട്ട ഓരോ വിഷയത്തെക്കുറിച്ചും പഠിച്ച് വിശകലനം ചെയ്ത് നിലവിലെ സാങ്കേതിക മാർഗ്ഗനിർദ്ദേശങ്ങൾ പുതുക്കുകയും ആയതിന് അന്തിമ അംഗീകാരം നൽകുകയും ചെയ്തിട്ടുണ്ട്. പ്രസ്തുത മാർഗ്ഗനിർദ്ദേശങ്ങളിന്മേൽ പൊതുജനങ്ങളുടെ അഭിപ്രായം ആരായുകയും ആയതിൻ പ്രകാരം മാറ്റങ്ങൾ വരുത്തിയ പുതുക്കിയ സാങ്കേതിക മാർഗ്ഗനിർദ്ദേശങ്ങൾ സർക്കാർ അംഗീകാരത്തിനായി പരാമർശിത കത്ത് പ്രകാരം ചീഫ് ഇലക്ട്രിക്കൽ ഇൻസ്പെക്ടർ ലഭ്യമാക്കിയിട്ടുണ്ട്.

സർക്കാർ ഇക്കാര്യം വിശദമായി പരിശോധിച്ചു. ആയതിന്റെ അടിസ്ഥാനത്തിൽ ഇതോടൊപ്പം അനുബന്ധമായി ചേർത്തിരിക്കുന്ന ഇലക്ട്രിക്കൽ ഇൻസ്പെക്ടറേറ്റ് വകുപ്പിലെ പുതുക്കിയ സാങ്കേതിക മാർഗ്ഗനിർദ്ദേശങ്ങൾ അംഗീകരിച്ച് ഉത്തരവ് പുറപ്പെടുവിക്കുന്നു.

(ഗവർണറുടെ ഉത്തരവിൻ പ്രകാരം)
കെ ആർ ജ്യോതിലാൽ
അഡീഷണൽ ചീഫ് സെക്രട്ടറി

ചീഫ് ഇലക്ട്രിക്കൽ ഇൻസ്പെക്ടർ, ഹൗസിംഗ് ബോർഡ് ബിൽഡിംഗ്സ്, തിരുവനന്തപുരം.
പ്രിൻസിപ്പൽ അക്കൗണ്ടന്റ് ജനറൽ (ആഡിറ്റ്) കേരള,തിരുവനന്തപുരം.
അക്കൗണ്ടന്റ് ജനറൽ (എ&ഇ), കേരള, തിരുവനന്തപുരം.
ബീവര പൊളിജന സമ്പർക്ക (വെബ് & സൂഷ്മീഡിയ) വകുപ്പ്
കൂടുതൽ ഫയൽ/ഓഫീസ് കോപ്പി.

ഉത്തരവിൻ പ്രകാരം
Signed by
Manoj S
സെക്ഷൻ ഓഫീസർ
Date: 17-01-2023 12:02:15

Guidelines for Electrical Installations

Department of Electrical Inspectorate, Govt. of Kerala

2023

Committee for the formulation of Guidelines for Electrical Installations

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Preface

The power sector in the country is on a transformation track in all aspects. The state of Kerala too has kept the tempo of transformation with enthusiasm. The Electrical Inspectorate Department has made a significant contribution to the standardisation and enforcement of safety standards in the nation's and state's power sector.

The introduction of Electricity Act 2003 has brought in sea changes in the power sector. Subordinate legislations were brought in conforming to the Act. All these reformed statutes and standards necessitated re-defining of the prevailing guidelines for power sector of the state.

Taking stock of all the technicalities of the emerging energy sector, committee was formed for updating the guidelines to be followed in the power sector. The committee was made up of representatives from KELCON, HT/EHT consumer association, PWD-Electrical wing, National Safety council and Department officials including retired officials. Also, comments from general public were invited to offer their suggestions for designing a robust set of guidelines for the safe and efficient functioning of the power sector. Valuable suggestions were offered by all the stakeholders.

Henceforth a set of guidelines were prepared and submitted to the government for scrutiny and approval. On being given approval for the proposals, the department is publishing the guidelines for the benefit of all the stakeholders in the state.

This recommendation may be updated from time to time in accordance with the latest standards and regulations.

I would like to acknowledge the contributions made by all the committee members.

Chief Electrical Inspector

Contents

1. Extra High Voltage Substations

1.	A circuit breaker of adequate rating shall be provided immediately after the point of commencement of supply. (Regulation 35(2) (iv))
2.	Circuit breakers of adequate rating shall be provided both at primary and secondary side of all transformers except Unit Auxiliary transformers and Generator transformers (Regulation 35 (3)(i)(b) & (ii))
3.	Minimum safety working clearance shall be provided for bare conductors and live parts as shown in table 1. Values given in table are for locations of altitudes up to and including 1000m. A correction factor of 1.25 percent per 100m. is to be applied for increasing the clearance for altitudes more than 1000m. and up to 3000m. The safety working clearance is based on an insulation height of 2.44m, which is the height of the lowest point on the insulator (where it meets the earthed metal) from the ground. Regulation 44(2)(iii)
4.	Oil soak pit shall be provided for apparatus having more than 2000 litres of oil and oil draining facility shall be provided if oil content in any one oil tank, receptacle or chamber is more than 9000 litres. Regulation 44(2)(vii)(b)
5.	All the transformers and switch gears shall be maintained in accordance with the maintenance schedule given in the relevant code of practice of BIS as required under Regulation 44(2) (vii)(d) and the Safety Officer under Regulation 5 shall keep a record thereof and shall be made available to the Electrical Inspector as required under Regulation 5(4).
6.	For a Sub station or Switching station where apparatus having more than 2000 litres of oil is installed, it should be ensured that adequate fire protection arrangement for quenching the fire in the apparatus is provided. Regulation 44(2)(viii)
7.	For transformers of 10MVA and above rating or in case of oil filled transformers with oil capacity more than 2000 litres are provided ,fire fighting system as per IS 3034/1993 or nitrogen injection fire protection system shall be provided. Transformers /reactors of 220kV & above shall be provided with both. (Regulation 44(2)(ix) , Technical Standards for Construction of Electrical Plants and Electric Lines) Regulations, 2010 - 43(3)(b)(i)))
8.	Cable trenches shall be filled with sand or pebbles or shall be covered with non-inflammable slabs.Regulation 44(2)(xii)
9.	All apparatus shall be protected against lightning and apparatus exceeding 220kV shall also be protected against switching over voltages. Regulation 44(3)
10.	Isolators and the controlling circuit breakers shall be interlocked so that isolators cannot be operated when the circuit breaker is in closed position. Regulation 45(1)(i)
11.	Isolators and the corresponding earthing switches shall be interlocked in such a way that earthing switch can be closed only if isolator is open. Regulation 45(1)(ii)
12.	When two or more transformers operate in parallel, system shall be arranged so as to trip the secondary breaker of a transformer in case the primary breaker of that transformer trips Regulation 45(1)(iv)
13.	Minimum protections as shown below shall be provided for lines, transformers, reactors and bus bars. (Central Electricity Authority (Technical Standards for Construction of Electrical Plants and Electric Lines) Regulations, 2010) (1) Transmission Lines a) Distance protection relays b) Over current and earth fault relays c) Over voltage, two stage - above 220kV d) Auto reclosing - • 220kV & above – single phase & three phase

	• 66kV to 132kV – three phase (2) Transformers (EHV) a) Differential b) REF c) Over fluxing – 132kV & above d) Over current & Earth Fault at H.V. & L.V. side. Better to have both instantaneous and IDMT elements in primary side for short Circuit protection. e) Buchholz & winding and oil temperature alarm and tripping & MOG with alarm, OSR, PRD & Surge arrestor on both primary and secondary side located outdoor and connected to overhead lines. f) Tertiary winding protection – 132kV & above g) Over load alarm - 132kV & above h) over voltage protection if automatic on load tap changing is adopted. (protection against out of step tap changing) (3) Reactors – 400kV & above a) Differential b) REF c) O/C & E/F d) Buchholz & WTI and OTI & MOG with alarm, & Surge arrestor (if required) (4) Bus bar protection a) High speed differential protection with local breaker back up for 220kV & above
14.	Over current and earth fault relays having high set elements shall be provided for HV feeders.
15.	Every generating station and sub-station connected to the grid at 220kV and above shall be provided with disturbance recording and event logging facilities and all such equipment shall be provided with time synchronization facility for global common time reference but wherever numerical relays with provision of recording fault data are installed disturbance recorder and event logger may not be installed.
16.	There shall be no tapping of another transmission line from the main line of feeders of 66kV and above class of lines.
17.	Failures of transformers and reactors of 20MVA and above shall be reported to the Electrical Inspector and Central Electricity Authority within 48 hours of occurrence of the failure. Reasons for failure and measures taken to prevent it in future shall be reported to Electrical Inspector and Central Electricity Authority within one month. Regulation 46(8)
18.	Earth mat shall be provided in EHV substations to limit touch-voltage and step voltage to tolerable and safe values. Regulation 48
19.	Fire buckets filled with sand, fire extinguishers and first aid boxes, artificial respiration charts etc shall be provided in substation. If transformer capacity is 5MVA and above gas masks shall also be provided. Artificial respirator shall also be provided in every manned substation. Regulation 27, 28
20.	Fencing shall be provided for outdoor substations. Regulation 12
21.	Breakers in the yard shall have remote and local operation facility.
22.	If there is more than one incomer, isolators shall be provided at both sides of line breakers.
23.	All outgoing feeders shall be controlled by breakers.
24.	45 mm of Granite jelly size shall be spread to a thickness of 150 mm uniformly in the yard and extended to a minimum width of 1m outside the fencing.
25.	Separate cable trenches shall be provided for power cables and control cables. If not possible these shall be laid in same cable trench in different racks.
26.	Battery room shall be separated and only flame proof fittings shall be used there if lead acid type batteries are used. Exhaust fan shall be provided .(section 6.4.13 of IS 3034-1993)

27.	Breaking current rating of breakers shall be minimum 31.5kA for 66 & 110kV and 40kA for 220kV & above –Regulation 41(1)
28.	Earthing system shall be designed for fault current of minimum 31.5kA for 66kV & 110kV and 40kA for 220kV & above – Regulation 42(5)
29.	Surge arrestors shall be provided with surge counters & leakage current monitors - Regulation 43(2)(g)
30.	Disconnectors of 220kV & above shall have provision for remote & manual operation. Only local operation is recommended for earthing switches. – Regulation 43(2)(d)
31.	Two trip coils shall be provided for circuit breakers of 132kV & above - Regulation 43(2(c)(i)
32.	Smoke detectors with alarm shall be provided in control room –Regulation 43(3)(b)(iii)
33.	Oil evacuating, filtering, testing and filling apparatus shall be provided. - Regulation 43(3)(e)
34.	SF6 filling, evacuation, filtering, & recycling plant shall be provided.- Regulation 43(3)(f)
35.	PLCC shall be provided for each transmission line of 132kV & above. - Regulation 43(4)(e)
36.	Diagnostic equipments like dissolved gas analyser, winding resistance meter, frequency response analyser, capacitance & tan-delta measuring units, contact resistance meter, leakage current monitor, relay test kit etc shall be provided in sub-stations of 132kV & above. - Regulation 46

2.Transformer Installations

2.1.Outdoor Transformer Installations (11 kV / 433 V)

1.	Minimum clearance between supplier's and consumer's 11 kV structures shall be 3m. If it is 5 m or more they should be braced together both at top and middle.
2.	Minimum size of RSJ poles shall be 175 x 85 mm. Channels shall be of minimum 75 x 50 mm.
3.	Phase to phase and phase to earth clearances at AB switch shall be minimum 915mm and 610mm respectively.
4.	Minimum size of 11 kV jumpers shall be Number '0' SWG copper.
5.	Maximum length of unsupported 11 kV jumpers shall be 2.44 m for solid conductors and 1.5 m for stranded conductors.
6.	Minimum safety working clearance of 2.6 m shall be maintained for bare conductors and live parts.
7.	Lightning arrestors shall be provided between AB switch and D.O. / H.G. fuse.
8.	Group control AB switch shall be provided for multiple transformer installations.
9.	The minimum clearance from ground to the 11kV bushings of the transformers shall be 2.6m for plinth mounted transformer.
10.	AB switch operating handle shall be fixed at a height of 1m to 1.25m from ground level and shall be kept under lock and key
11.	11 kV AB switch shall be three insulator type.
12.	1.8m height fencing shall be provided, keeping a minimum clearance of 1.25m from the transformer body/plinth.
13.	Minimum clearance between 11 kV up and down jumpers shall be 75 cm.
14.	Outdoor transformer is not permitted in corporation areas and at the premises of high-rise apartment buildings. However outdoor transformers with cable end boxes at both sides and indoor breaker / SFU at primary side may be permitted judiciously.
15.	If two or more transformers are installed side by side, they shall be separated by fire-separation walls. Fire separation walls are deemed to be adequate from fire-safety point of view, even if oil capacity of individual transformers do not exceed 2000litres, and total oil

	capacity of all transformers installed side by side exceeds 2000 litres. (IS 10028 Part 2 , clause 3.6.2).
16	As per Electrical Transformer (Quality Controller) Order, 2014 oil filled transformer is an equipment which requires mandatory ISI marking.

2.2.Indoor Transformer Installations (11 kV / 433 V)

1.	Only dry type transformers shall be installed inside residential/commercial buildings. Regulation 44(2)vii(e)
2.	Oil filled transformers are permitted outside residential and commercial buildings subject to the following conditions.
	(a) The substation building shall be of weatherproof and fire proof construction. Walls shall be of 355mm thick brick or 230mm thick RCC. If there is any window/door opening towards the residential/commercial building, there shall be a fire resistant wall between the substation building and residential/commercial building keeping a minimum clear distance of 1.5m from both the buildings.
3.	Oil filled transformers installed indoors in other than residential or commercial buildings shall be placed at the ground floor or not below the first basement; Regulation 44(2) (xi)
4.	ABSF unit / VCB shall be provided at primary side. At hospital premises breaker shall be recommended.
5.	Size of cable at 11kV side shall be based on actual short circuit current but minimum size shall be 150sq.mm A2XFY.
6.	Fire separation walls shall be provided in between oil filled transformers. Thickness of the wall shall be minimum 30cm (Brick) or 20cm (RCC)
7.	Oil filled transformers shall be segregated from HT and MV switchgears using fire separation wall.
8.	Oil drainage facility / soak pits shall be insisted for oil filled transformers if quantity of oil is more than 2000 litres.
9.	All-round clearance shall be provided for indoor transformers. Minimum clearance from walls shall be 1.25m, 1m, 0.75m and 0.5m if walls are provided at 4 sides,3 sides, 2 sides and one side respectively. (IS 10028 Part 2 Cl. 7.3.1.5)
10.	Transformers shall be installed at the periphery of the building for getting easy access and adequate ventilation.
11.	Doors and windows of transformer room shall be of non-inflammable materials and the door of electrical room shall open outwards.
12.	Minimum 50cm headroom clearance shall be provided for the transformer. (IS 10028 clause 7.3.1.5)
13.	If dry type transformers are installed above ground level in multi-storied building, 11kV ABSFU/Breaker shall be provided at ground floor. Structural fitness certificate from a competent structural engineer shall also be furnished.
14.	Minimum phase to phase and phase to earth clearance of bus bars in 11 kV panel shall be 130 mm and 80 mm respectively.
15.	Minimum 1.0 metre clear space shall be available in front of H.T panel in breaker drawn out position.

2.3. Unitised Substation

1.	Transformer shall be dry type or hermetically sealed type of rating below 1000kVA. Switchgear attached shall not be oil filled type.
2.	Transformer and control gears in the Unitized Sub-Stations shall be clearly segregated using metallic / FRP barriers. If the oil filled transformer is used, metallic barrier should be used.
3.	Earthing switch if any attached to the 11kV ABSF unit shall be at the outgoing side. This earthing switch and the 11kV ABSF unit shall be properly interlocked to prevent accidental closing of earthing switch when ABSF unit is in ON position.
4.	There shall be proper interlocking to prevent opening of the enclosure of the unit when the 11kV control gear is in 'ON' position.
5.	There shall be a metallic / FRP barrier between supply incoming live parts and HRC fuse units in ABSF unit.
6.	The incoming supply shall be connected to the fixed contact of 11kV ABSF unit.
7.	The interconnection between transformer and control gear shall be with rigid strips/XLPE insulated conductor of adequate normal current and short time current capacity.
8.	Phase to phase clearance of 11kV interconnecting strips shall be minimum 13cm and phase to earth clearance shall be minimum 8cm.
9.	In the case of off load tap changing transformers, 11kV control gear and tap changer of the transformer shall be properly interlocked to prevent tap changing when the 11kV control gear is in ON position.
10.	If potential transformer is provided in the unit, separate chamber shall be provided for housing the same.
11.	Seal off bushings shall be provided when 11kV buses passes from one chamber to another.

General	
1.	If there are more than one transformer and aggregate transformer capacity exceeds 1000kVA,a circuit breaker of adequate rating shall be provided after point of commencement of supply. (Regulation 35(2)(ii))
2.	Minimum 1.5m clearance shall be provided between dry type transformer and D.G. set with acoustic enclosure .
3.	Minimum 2 m clearance shall be provided between two dry type transformers installed in the same room.
4.	Baffle wall of 4 hrs fire rating shall be provided between apparatus having more than 2000 litres of oil (i) at consumers' premises. (ii) single phase transformer banks (iii)where adequate clearance is not available." – Regulation 44(2)(vii)(a) Note :- Adequate clearance required according to clause 7.11 of I.S.1646-1997 is as given below

Oil in individual transformer	Clearance required (from any building including substation)
2000 litres to 5000 litres	Minimum 6 M
5000 litres to 20000 litres	8 M
More than 20000 litres	15 M

5.	Transformer installation shall conform to I.S. 10028 (Part II) – 1981.
6.	Earthing shall conform to I.S.3043 – 2018.

General	
7.	Minimum values of insulation resistance of transformer shall be as given in Table 2.
8.	Minimum size of cables laid underground at secondary side of transformers are given in Table 3.
9.	Minimum protections required for transformers of different ratings are given in Table 4.
10.	Transformer oil shall conform to standards given in Table 13.
11.	Maximum rating of 11kV/433V transformers may be 2500kVA
12.	L.V. side installation shall conform to I.S.732 – 2019
13.	Current rating of 11kV, XLPE, cables are given in Table 16 and 17.
14.	For CSS installed along walk ways ,play grounds etc .,a fencing or barrier with materials like wire mesh shall be provided at the distance of 0.75m from CSS. The fencing shall be earthed (NBC,Part8,52 4.2.1(16)).
15.	Neutral conductor shall be of the same size as the phase conductor, if triple harmonic currents are anticipated and shall conform to IS 732-2019.(5.2.6.6)
16.	A comprehensive fire protection system having detection, alarm and fire fighting arrangement, shall be installed for the Sub- station and Switch yard in conformity with relevant IS. CEA ((Technical Standards for Construction of Electrical Plants and Electric Lines), Regulations, 2010 43(3)(b))
17.	a). Tapping from the overhead HT feeder shall be taken to the fixed contact of the AB Switch b). Bucket loop arrangement shall be used for tapping. PG clamps shall be used when conductor materials are different c). Double break type AB Switches shall be used when AB Switch is intended to be used as interlinkingAB Switch. Conspicuous Identification for interlink shall be provided.
18.	Substation shall not be located immediately above or below plumbing water tanks or sewage treatment plant water tanks.(Clause 4.2.1.6 of Part 8 NBC)
19.	All door openings of substation, electrical rooms, etc, should open outwards. When vertical shutters (like fire rated rolling shutters, grilled preferably) are used, a single leaf door opening outwards for exit in case of emergency should also be provided. For large substation room/electrical room having multiple equipment, two or more doors shall be provided which shall be remotely located from each other. (Clause 4.2.1.7 of Part 8 NBC)
20.	In case of HV panel and transformers located at different floors or at a distance more than 20 m, HV isolator /remote push button with lockable facility shall be provided at transformer end . (Clause 4.2.1 of Part 8 NBC)
21.	In case of main MV/LV panel and transformers located at different floors or at a distance more than 20 m, MV/LV breaker/SFU having isolation facility shall be provided at transformer end . (Clause 4.2.1 Part 8 NBC)

2.4.Parallel Operation of Transformers

1.	Identical phase displacement for all transformers.
2.	Same voltage ratio for all transformers.
3.	Equal percentage impedance, with in permissible tolerance, for all transformers.
4.	The rated output of smallest transformer in the group shall not be less than 33 percent of the rated output of the largest transformer in the group.
5.	Provided the polarities of the winding correspond transformers with the following connections operate satisfactorily in parallel. Connections in Group A shall not be paralleled with those in Group B.

6.	Group A - Star/star, delta/delta and delta/zig-zag Group B - Delta/star, star /delta and star/zig-zag
7.	Transformers designed for parallel operation shall not be required to divide the load within limits closer than to permit an individual variation from the rated output of any transformer of the group amounting to ±10 percent of such rated output when the total load on the group is equal to the sum of the rated outputs of all the transformers so connected.
8.	When connecting a new transformer, care should be taken to do so in accordance with the diagram of connections supplied by the manufacturer and of the correct phase sequence of the supply.
9.	Reverse power relay shall be provided for transformers.
10.	The system shall be arranged so as to trip the secondary breaker of a transformer in case the primary breaker of that transformer trips. Regulation 45(1)(iv)

Table - 1

Minimum Safety Working Clearance for Bare Conductors or Live parts in Outdoor Substation - R 44 (2) (iii) Schedule VII

Highest System Voltage- kV	12	36	72.5	145	245	420	800
Safety working Clearance - (Metres)	2.6	2.8	3.1	3.7	4.3	6.4	10.3

Table - 2

Minimum IR values at 30⁰ C for new oil filled transformers

Related Voltage	<6.6kV	6.6kV-22kV	33kV	>66kV	415Volts
Value in Mega Ohms	200	300	400	500	100

1. IR Values in oil-drained condition shall be 15 to 20 times more than that in oil filled condition.
2. Polarisation index (IR at 10 minutes/IR at One minute) shall be more than 1.5

Table – 3

Cables on Secondary Side of Transformers(11kV/433V)

Capacity of Transformer (kVA)	Secondary Current (A)	Minimum size of AYFY cable (mm^2)
63	84	50
100	133.3	95(2*50)
160	213.3	185(2*95)
200	266.6	300(2*120)
250	333	(2*185)
315	420	(2*300) or(3*185) or equivalent
400	533	(3*300) or(2*400) or equivalent
500	666.5	(3*400) or (4*240) or equivalent
630	840	(4*400) or equivalent
800	1067	Bus bar Trunking/(4*400)sq.mm A2XFY
1000	1333	Bus bar Trunking/(4*400)sq.mm YFY
1250	1667	Bus bar Trunking/(4*400)sq.mm 2XFY
1600	2133	Bus bar Trunking
2000	2666	Bus bar Trunking

Table 4
Protection of Transformers 11kV/433V

Rating	Method of installation	Primary control and protection	Secondary control and protection
Up to and including 400kVA	Outdoor	A.B. switch, lightning arrestor, D.O. fuse	MCCB having isolation duty• and E/F release and standby Low set E/F relay using CT at neutral earthing conductor or ACB with proper current setting facility with 3 O/C and 1 E/ F release.
Up to and including 400kVA	Indoor	ABSF unit or VCB/ GCB with 2 O/C and 1 E/F relays preferably with DC trip	MCCB having isolation duty 3 O//C and E/F releases or ACB with proper current setting facility with 3 O/C and 1 E/ F release. stand by low set E/F relay using CT at neutral earthing strip
Above 400kVA and below 1000kVA	Outdoor	A.B. switch, lightning arrestor, D.O. fuse	ACB draw out type with 3 O/C & 1 E/F release and stand by low set E/F relay usingCT at neutral earthing conductor. **For transformers up to 630kVA, MCCB(rack out type) having isolation duty is permitted instead of ACB
Above 400kVA and below 1000kVA	Indoor	ABSF unit or VCB / GCB with 2 or 3 O/C and 1 E/F relays with DC trip	ACB draw out type with 3 O/C & 1 E/F release and standby low set EIF relay using CT at neutral earthing conductor. **For transformers up to 630kVA, MCCB(rack out type) having isolation duty is permitted instead of ACB
1000kVA and above	Indoor	VCB/GCB with 2 or 3 O/C relays with high set elements , one instantaneous E/F relay, Buchholz relay, oil* and winding temperature relays with alarm and trip. .	ACB draw out type with 3 O/C and 1 EIF release, stand by low set E/F relay with CT a t neutral earthing strip,. If breaker is incorporated with micro processor based programmable releases 2 O/C and 1 E/F relay may be avoided. *REF protection relay with primary trip shall be provided for transformers of rating above 1600kVA.

Note: For transformers incorporated with OLTC, O/V relay to be provided at secondary with primary trip. Oil surge relay shall also be provided

3. Generator Installations

3.1 HV Generators

1.	Neutral of the generator may be earthed through NGR or earthing transformer. NGR shall be rated for 10 second or maximum tripping time on earth fault whichever is higher.	
2.	VCB / GCB with DC trip shall be provided for generator control.	
3.	Acoustic arrangements shall be provided for generator sets according to CPCB/SPCB norms.	
4.	Following meters shall be provided in the control panel.	
	(a)	Ammeters

	(b)	Voltmeter
	(c)	Frequency meter
	(d)	kW meter
	(e)	kWh meter
	(f)	kVA meter
	(g)	kVAr meter
	(h)	P.F. meter
	(i)	Winding temperature indicator
	(j)	Bearing temperature indicator (above 3MW)
5.	Following protections shall be provided for HV generators	
	(a)	Voltage restraint O/C relay
	(b)	E/F Relay
	(c)	Standby E/F relay using CT in neutral earthing conductor
	(d)	Over voltage relay.
	(e)	Under voltage relay
	(f)	REF / Differential relay
	(g)	Negative sequence relay
	(h)	Rotor E/F relay (above 3MW)
	(i)	Field Failure relay (above 3MW)
	(j)	Winding temperature high, alarm and trip
	(k)	Vector surge relay (when connected to grid
	(l)	Reverse Power and Reverse reactive Power relays (when running parallel or connected to grid)
	(m)	Synchro-check relay (When running parallel or connected to grid)
	(n)	Under current relay may also be included for generators connected to grid
6.	Following protections shall be provided for Diesel Engine	
	(1)	High vibration (above 3MW) - alarm and trip (Max: 7mm/s)
	(2)	High bearing temperature (above 3MW) - alarm and trip (Max: 95°C)
	(3)	Over speed and under speed - alarm and trip
	(4)	Jacket water temperature high - alarm and trip (Max: 95°C)
	(5)	Lubricating oil temperature high - alarm and trip (Max: 65°C)
	(6)	Lubricating oil pressure low - alarm and trip (Min: 2.5 bar)
	(7)	Low fuel level alarm

3.2 Generators Voltage not exceeding 650V

1.	For generators of 10kVA to 30kVA rating completion report and single line diagram shall be submitted with a certification by the owner and the contractor stating that the electrical installation work is carried out by using change over switch, cable, MCB, etc. of standard make and with ISI mark for issuing the sanction for energisation. For generators above 30kVA prior scheme approval shall be obtained.
2.	Minimum 1m clearances shall be provided on three sides of a generator set. When two generator sets are installed side-by-side, minimum 2.0 m clearance shall be provided between them.
3.	Fuel tank of DG sets shall be installed outside the generator room if does not have built-in fuel tank.
4.	Exhaust pipe of DG sets shall maintain a minimum height of 1.8 m clearance from floor level

	and shall be extended to a height of at least 1m above the building.
5.	Voltmeters and frequency meter shall be connected before the breaker in generator control panel.
6.	Watt-hour meter and ammeters in each phase shall also be provided in GCP. For generators of 500 kVA and above, kVA/KW meter and P.F. meter shall also be provided.
7.	Change over switches of approved make is permitted up to and including 1250A.
8.	Above 1250A, breakers with castle key interlock shall be provided.
9.	Auto transfer switch of adequate ampere rating and having lockable OFF position may be permitted for supply change over
10.	Separate isolators shall be provided before the COS, if it has no off position.
11.	U/V coil may be provided at grid side ACB/MCCB on respective switch boards at installations where generators are installed for preventing chances of back feeding from generators to grid side.
12.	When generator is directly connected to the main bus, it may not be possible some-times to maintain grading of outlets. Stipulation with respect to maximum single motor rating is also difficult to insist. Generator capacity can be deemed as sufficient even if it is called upon to start induction motors of 60% of its rating, provided suitable starters are employed for limiting starting current, and grading is affected. However in such cases, it should be ensured that generator is not getting over-loaded which can be achieved by providing thermal O/L protection in the generator circuit.
13.	Generator room shall be made of non-inflammable materials.
14.	Three pole inter locked breakers/ isolators are permitted for supply change over, provided neutral of all sources is earthed at neutral bus in the panel.
15.	CPCB approved type Acoustic enclosure shall be provided for all generators. For generators without inbuilt enclosure arrangements, room acoustic shall be provided.
16.	Protections required, standard size of cables and earthing conductors for generators are given in Table 5.
17.	Electricity duty @ Rs 2/kVA is payable for generators up to and including 10kVA rating. For generators above 10kVA electricity duty is 1.2 Paise/unit.

3.3 Generators Running in Parallel

1.	P.F. meters shall be provided in generator control panels. For 1MVA and above generators kVA and kVAr meters shall be provided.
2.	Reverse power relays shall be provided for generators. For 1MVA and above generators Reverse Reactive Power relays shall also be provided.
3.	Neutral switching facility shall be provided. Interlock shall be provided to ensure that the generator breaker cannot be closed unless one of the neutral is connected to the earthing system
4.	Neutral of largest capacity generator shall only be connected to the system.
5.	Neutral of largest capacity generator shall only be earthed. Neutrals of other generators, running in parallel, shall be in floating condition.
6.	Also ensure that generator breakers can be made 'ON' only if functional neutral is earthed and closed.
7.	Synchronising breakers and neutral switches / contactors shall be electrically operating type having remote switching facility.
8.	There shall be facility for remote control of generator voltage and engine speed.
9.	Double frequency meter and double voltmeter shall be provided in synchronising panel.
10.	For generators of one MVA and above synchro check relay shall also be provided in synchronising panel.

11.	Switch ratings, cable sizes, earthing conductor sizes etc shall be designed considering fault current contribution by all generators running in parallel.
12.	Bus bars shall be designed for maximum current during parallel running.

3.4 Portable Generators

1.	Generators up to 10kVA in rating are treated as portable generators.
2.	A residual current device (ELCB) having an operating time of 20 ms at a residual current of 30mA shall be provided.
3.	(a)In single-phase generators one terminal shall be connected to earth and designated as the neutral.
	(b)Three-phase generators should have their windings connected in star, with the star connection made available and connected to earth.
4.	All the exposed metal work of the generator should be adequately connected to the earth terminal.
5. T	The installation where both licensee/KSEBL supply and DG supply are available, change over switch(COS) with adequate rating shall be provided, such a way that 4 pole COS for 3 phase and 2 pole for single phase applications.
6.	The supply from a single-phase generator can be changed over to a 3-phase supply system through a 4-pole change over switch subject to the following conditions.
	(a) The neutral conductors of the load side and generator side should be of adequate capacity to carry the total current in the neutral.
	(b) The 3 poles in the 4 pole change over switch shall be linked by using rigid conductors of adequate short circuit and continuous current rating capacity.
	(c)The copper strip/rigid conductors used for linking the poles should be insulated by using tapes or sleeves.
7.	Shielding should be provided when the generator is kept exposed to weather.
8.	Electricity duty @ Rs.2/- per kVA per year shall be levied for portable generators. Duty shall be payable for five years period.
9.	Portable generators shall be kept at a place, sufficiently ventilated so as to avoid possible hazards due to the accumulation of smoke and pollution
10.	In the case of single phase generators, the size of the earthing conductor shall be of equivalent size of phase conductor.

3.5 Generator mounted on Trolley, Mobile Van, and for Off Shore Operation.

1.	The platform shall be structurally strong and stable.
2.	When a control panel is installed separately, a minimum clearance of 1m shall be maintained from the generator set for easy operation.
3.	Generator and control panel shall be permanently fixed. Permanent cabling shall be provided between the generator and control panel. The cable shall be glanded at both ends and firmly clamped on to the platform.
4.	MCB/MCCB rated at the full load current of the generator shall be provided in the control panel for the protection of the generator. An energy meter of adequate rating shall be mounted on the control panel for recording the energy generated. Energy meter should be got tested and sealed by Electrical Inspectorate / KSEBL. Voltmeters and ammeters shall be mounted on the control panel.
5.	Adequate lighting shall be provided inside the cabin. A few lamps shall be connected to the battery of the vehicle for lighting when the generator is not in operation.
6.	The light wiring inside the vehicle shall be of permanent nature and done through electrical grade conductors or by using armored cables.
7.	(a) In the case of D.G. sets which are used as a standby source to be changed over to an earthed system or vice versa the neutral and body of the generator shall be earthed to 2

	separate and distinct earth electrodes as per standards.
	(b) An equipotential bonding conductor shall be formed in the vehicle/carriage by inter-connecting the generator, engine, control panel and other metallic parts of the carriage with conductor of adequate size.
	(c)The equipotential bonding conductor shall be connected to the ground earth electrode system. Atleast 2 Nos earth electrodes of 38 mm. diameter and 2.5 m length with necessary interconnecting earthing conductors shall be kept available in the van/carriage for use as the earth electrodes at places where the supply is used as a standby.
8.	In the case of generator sets in which supply is used as an isolated/separate source, earthing to the ground is not required. But continuity conductors shall be taken from the equipotential bonding conductor of the vehicle carriage, for the return of the fault current. The neutral and body of the generator shall be connected to the chassis/ equipotential-bonding conductor.
9.	(a) Where supply is extended for off-shore works in dredgers, pontoons etc. earth grid/equipotential bonding conductor of the dredger, pontoon etc. shall be connected to the generator earthing system provided on the shore with insulated conductor of adequate size.
	(b) Alternately one core of the 4-core cable to the generator from the offshore equipment shall be treated as earthing conductor.
	(c) The generator body and neutral shall be connected to at least 3 earth electrodes as per standards. For marine applications, only marine cables shall be used for extending supply to the offshore carriage.
10.	Distribution from the generator control panel to the actual load center shall be taken through joint less insulated and tough sheathed PVC cable or weather proof cables or through armored cables laid properly. The sub-switch boards shall be earthed as per standards by running earth continuity conductors.
11.	Suitable ELCBs shall be provided for each feeder separately or as a group for protection against earth leakage.
12.	Sub switch boards and DBs shall be installed as per Regulation 37 and temporary wiring, if any used shall conform to G.O. (Ms.) 795/85/RD date. 20-8-1985.
13.	At least one 5 kg. DCP type fire extinguisher and 2 Nos. fire buckets filled with dry sand shall be kept in the mobile van or vehicle.
14.	The mobile unit shall be parked sufficiently away from crowded areas, temporary thatched sheds, and hazardous areas.
15.	In case the mobile van is used solely for carrying D.G. set and the control gears, a safety certificate, valid for one year shall be obtained from the Electrical Inspector of the area where the unit is used and it shall be displayed in the van.
16.	A competent operator possessing a valid supervisor permit issued by the K.S.E.L Board shall be in the charge of the installation throughout the period when the D.G. set is in operation.

3.6 General

1	Based on the protections given, generators may be divided into three categories. Below 100kVA -Small generators 100 kVA - below1000kVA -Medium generators 1000kVA and above -Large generators
2	In generating station with more than one Generator with capacity of 5MW and above is installed , at least two separate gas masks per generator place shall be made available in an accessible and conspicuous.

3	If the Generator is to be installed in a raised platform, then 1. Stability certificate from the chartered structural Engineer shall be required. 2. Fuel drain facility should be provided. 3. Emergency engine stop should be provided at the ground level. 4. There should not be any passage underneath the structure.
4	For generators up to 30kVA, manufacturer's test certificate shall be accepted for energy meters.
5	For PWD work, structural stability certificate shall be submitted by a civil engineer of the department not below the rank of Assistant Engineer.
6	For D.G Sets above 600kVA, provided with AMF Logic and Synchronising Logic along with Engine and Alternator protections, as part of the Engine Controller, additional logic and protection systems need not be insisted to be provided in the PCC. Details of protection provided and settings shall be marked as note in the drawing.
7	In Sandwitch Bus Trunking with internal grounding conductors, which work as its protective Earthing, are available, separate parallel Earth conductors need not be insisted.

Table - 5

Size of Cables, Earthing conductors and protection of Generators

Generator Capacity kVA	Full load Current rating A	Cable size AYFY mm^2	Earth conductor size mm^2/SWG	Protection	Panel meters
5	7	4	8.3/10	MCB/MCCB	
7.5	10.5	4	8.3/10	MCB/MCCB	
10	14	4	8.3/10	MCB/MCCB	
12.5	17.5	6	8.3/10	MCB/MCCB	
15	21	10	8.3/10	MCB/MCCB	
20	28	10	8.3/10	MCB/MCCB	
25	35	16	18.6/6	MCB/MCCB	
30	42	16	18.6/6	MCB/MCCB	
35	49	25	18.6/6	MCB/MCCB	AM,VM, FM&EM
40	56	35	27.27/4	MCB/MCCB	
45	63	35	27.27/4	MCB/MCCB	
50	70	35	27.27/4	MCB/MCCB	
63	88	50	27.27/4	MCB/MCCB	
75	105	95	25x3	MCB/MCCB	
82.5	115	95	25x3	MCB/MCCB	
100	140	120	25x3	MCCB + standby low set earth fault relay using CT in neutral earthing conductor	AM,VM, FM&EM
125	175	150	25x3		
160	224	185	25x3		
180	252	185	25x3		
200	280	2x120	25x3		
225	315	2x120	25x3		
250	350	2x185	25x3		
320	448	2x300	25x3		
400	560	2x400	25x3		
500	700	3x400	25x3	ACB with overload and E/F release and	AM,VM, FM, EM,
625	875	4x400	25x3		

750	1050	4 x400 YFY or 4 x400 Al XLPE cable or Bus Trunking.	25x3	stand by low set earth fault relay using CT in neutral earthing conductor	PFM, kVAM or kWM
1000 kVA and above,	ACB with thermal O/L, voltage controlled O/C relay, over voltage, under voltage, negative sequence, low set stand by earth fault relays and REF/Differential relay with fuel shut off facilities. Over speed protection shall be provided for the engine.				

Note: Equivalent XLPE cable also can be used (Refer Table 20)

4. Motors

4.1. H V Motors

1.	Cables shall be rated for appropriate voltage and current. Cables shall have adequate short circuit current rating also.
2.	Contactors used for HV motors shall be vacuum type and rated for appropriate voltage and current
3.	Contactors shall be AC - 2, AC - 3 or AC - 4 types depending upon type of motor and mode of operation.
4.	For auto transformer starting, the auto transformer shall be completely isolated from supply during normal running of motor.
5.	Local supply isolation facility with locking arrangement at OFF position shall be provided with in 3m from the motor.
6.	Protections against the following shall be provided for HV motors.
	(a) Thermal over load
	(b) Short circuit
	(c) Locked Rotor
	(d) Earth Fault
	(e) Under voltage
	(f) Negative sequence
	(g) Reverse phase sequence
	(h) Prolonged start
	(i) Repeat start
	(j) Loss of load

4.2. MV Motors

1.	Isolation facility with lockable feature in OFF position shall be provided for all motors with in 3 m.
2.	Contactors used for motors shall be AC-3 or AC-4 type depending upon type of motor and mode of operation.
3.	Motors shall conform to the Ingress Protection (IP) classification recommended for the particular location / function.
4.	Maximum earth resistance at HT premises shall be limited to 1 ohm.(IS 3043, clause 25.1)
5.	Recommended capacitor rating for direct connection to induction motors are given in Table 8.

5. Power Factor Improvement

Important points regarding capacitor selection and compensation:

1.	Never connect the capacitor directly to the motor when solid state starters are used.
2.	Never disconnect discharging resistors from capacitor terminals unless zero cross switching is used.
3.	Charged capacitors connected to same bus bar discharges instantaneously to uncharged capacitor at the time of switching on with very high inrush current. This should be taken care while designing APFC panel.
4.	Harmonics can reduce the life of capacitor. Proper filters shall be provided at such units.
5.	In installations where harmonics exceeds the permissible limit Series block reactor shall be provided along with the power factor correction capacitor.
6.	Breakers / Switches used for controlling capacitors shall be preferably rated to 2times the normal current of capacitors.
7.	Contactors used for controlling capacitor banks shall have required capacitor switching duty.
8.	Backup fuses shall be 1.5 times the normal current of capacitors.
9.	Generator supply shall not be connected to capacitor banks alone. Capacitors shall be connected to generator circuit only after the other loads are connected. This may be achieved by providing Contactors for controlling capacitors.
10.	Ammeters shall be provided in each phase for capacitor bank feeders.
11.	Recommended cable size and backup fuses for capacitor feeders are given in Table 9.
12.	Approximate values of capacitors for direct connection to welding transformers are given in Table 10.
13.	Losses in capacitors are tabulated in Table 11.
14.	Approximate capacitor ratings for required degree of power factor correction are given in Table 12.
15.	When individual correction is provided, capacitor current shall not exceed the no load current of motor

Table-6

Standard size of cables and Backup Fuse Rating for Motors

Motor Rating		Approx full load current	Backup fuse rating		Cable size AYFY
KW	HP	A	DOL	Assisted	mm²
0.75	1	1.8	6	-	4
1.50	2	3.5	10	-	4
2.25	3	5.0	16	-	4
3.75	5	7.5	25	-	4
5.50	7.5	11.0	32	25	6
7.5	10	14.0	32	25	6
9.3	12.5	18.0	50	32	10
11.2	15	21.0	50	32	10
15.0	20	28.0	63	50	16
18.7	25	36.0	80	63	25
22.5	30	40.0	100	63	25
26.0	35	47.0	120	100	35
30.0	40	55.0	120	100	35
37.5	50	66.0	160	100	50
45.0	60	80.0	200	120	70

55.0	75	95.0	200	120	95
59.0	80	105.0	250	200	150
67.0	90	118.0	250	200	185
75.0	100	135.0	250	200	185
90.0	125	165.0	320	250	240
110.0	150	200.0	350	320	300
131.0	175	230.0	400	320	2*150
150.0	200	270.0	500	350	2*185
185.0	250	325.0	600	500	2*240

For motors of rating 250 HP and above, breaker shall be provided and following protections shall be incorporated			
(a)	Thermal O/L	(b)	Short circuit
(b)	Earth fault	(d)	Negative sequence
(c)	Under Voltage	(f)	Locked rotor

Table-7
Minimum cross-sectional area of Protective Conductors (IS3043:2018)

Cross sectional area of Phase conductor S mm²	Minimum cross-sectional area of the corresponding protective conductor
S<16	S
16<S<35	16
S>35	(I√t)/k (IS 3043 clause 17.2.2.1)

Table-8
Recommended Maximum Capacitor rating for direct connection To Induction Motors in kVAr

Motor	Capacitor rating for motor speed in rpm					
HP/kW	3000	1500	1000	750	600	500
3/2.5	1	1	1.5	2	2.5	2.5
5/3.7	2	2	2.5	3.5	4	4
7.5/5.7	2.5	3	3.5	4.5	5	5.5
10/7.5	3	4	4.5	5.5	6	6.5
15/11.2	4	5	6.7	7.5	8.5	9
20/15	5	6	7	9	11	12
25/18.7	6	7	9	10.5	13	14.5
30/22.8	7	8	10	12	15	17
50/37	11	12.5	16	18	23	25
75/57	16	17	21	23	29	32
100/75	21	17	21	23	29	32
130/102	31	33	36	38	48	55
200/150	40	42	45	47	60	67
250/187	46	50	53	55	68	76

Table - 9

Recommended cable size for group power factor improvement capacitors

kVAr	Backup Fuse/ breaker	Size of AYFY cable in sq.mm
25	63	16
30	100	25
40	100	35
50	120	50
60	150	70
70	160	120

kVAr	Backup Fuse/ breaker	Size of AYFY cable in sq.mm
80	200	150
90	200	185
100	250	240
200	Breaker	2*185
300	Breaker	2*300
400	Breaker	2*400

Table - 10

Capacitors for Welding transformers

Welding Transformer Rating (kVA)	Capacitor kVAr
9(Single Phase)	4
12(Single Phase)	6
18(Single Phase)	8
24(Single Phase)	12
30(Single Phase)	18

Welding Transformer Rating (kVA)	Capacitor kVAr
57 (Three Phase)	16.5
95 (Three Phase)	30
128 (Three Phase)	45
160 (Three Phase)	60

Table - 11

Losses in Capacitors

Type of Capacitor	Loss W/kVAr
Paper Oil Impregnated	2.0 to 2.5
Paper PCB Impregnated	3.0 to 3.5
Plastic Film/Paper, PCB	0.5 to 1.0
Plastic Film/Paper, Oil	0.5 to 1.0
Metalised Film	Less than 0.5

Table - 12

Capacitors in kVAR for required power factor correction

Initial power factor	Correction to					Initial power factor	Correction to				
	0.85	0.90	0.95	0.98	1.00		0.85	0.90	0.95	0.98	1.00
0.50	1.112	1.248	1.403	1.529	1.732	0.75	0.262	0.398	0.535	0.673	0882
0.51	1.066	1.202	1.357	1.483	1.686	0.76	0.235	0.371	0.526	0.652	0.855
0.52	1.024	1.160	1.315	1.441	1.644	0.77	0.209	0.345	0.500	0.620	0.829
0.53	1.980	1.116	1.271	1.397	1.600	0.78	0.183	0.319	0.473	0.594	0.833

0.54	0.939	1.075	1.230	1.356	1.559	0.79	0.156	0.292	0.447	0.567	0.776
0.55	0.899	1.035	1.190	1.316	1.519	0.80	1.130	0.266	0.421	0.541	0.750
0.56	0.860	0.996	1.151	1.277	1.450	0.81	0.104	0.250	0.395	0.515	0.725
0.57	0.822	0.958	1.113	1.239	1.442	0.82	0.078	0.214	0.369	0.489	0.698
0.58	0.785	0.921	1.076	1.202	1.405	0.83	0.052	0.188	0.343	0.463	0.672
0.59	0.748	0.884	1.039	1.165	1.368	0.84	0.026	0.162	0.317	0.437	0.645
0.60	0.714	0.849	1.005	1.131	1.334	0.85	-	0.136	0.291	0.417	0.620
0.61	0.679	0.815	0.970	1.096	1.299	0.86	-	0.109	0.264	0.390	0.593
0.62	0.645	0.781	0.936	1.062	1.265	0.87	-	0.083	0.238	0.364	0.567
0.63	0.613	0.749	0.904	1.030	1.233	0.88	-	0.054	0.209	0.335	0.538
0.64	0.580	0.716	0.871	0.997	1.200	0.89	-	0.028	0.183	0.309	0.512
0.65	0.549	0.685	0.840	0.966	1.169	0.90	-	-	0.155	0.251	0.484
0.66	0.518	0.654	0.809	0.935	1.138	0.91	-	-	0.124	0.250	0.453
0.67	0.488	0.624	0.779	0.905	1.108	0.92	-	-	0.097	0.223	0.426
0.68	0.459	0.595	0.750	0.876	1.076	0.93	-	-	0.066	0.192	0.395
0.69	0.429	0.565	0.720	0.840	1049	0.94		-	0.034	0.160	0.363
0.70	0.400	0.536	0.691	0.811	1.020	0.95		-	-	0.126	0.239
0.71	0.372	0.508	0.663	0.753	0.992	0.96		-	-	0.089	0.292
0.72	0.343	0.479	0.634	0.754	0.963	0.97		-	-	0.47	0.25
0.73	0.316	0.452	0.607	0.727	0.863	0.98		-	-	-	0.203
0.74	0.289	0.425	0.580	0.700	0.909	0.99		-	-	-	0.143

6. Earthing Standards

1.	Earthing shall conform to I.S. 3043 / 2018 and IS 732:2019.
2.	NGR used for HV generator/ Transformer shall be rated for 10 seconds or maximum tripping time on earth fault whichever is higher.
3.	Minimum fault level at 11 kV side shall be assumed as 150MVA for all earthing designs, if the actual fault level is less than 150MVA.
4.	Number of earth electrodes required shall be calculated for fault current at HV side.Current loading of 1.2M x 1.2M plate shall not exceed 1300A. (I.S. 3043 – Cl.14.2.1)
5.	Duration of fault current shall be taken as 3 sec for earthing design at HT installations and 1 sec for EHT installation.
6.	All earth electrodes shall be interconnected using the conductors of largest size in the earthing system.
7.	Maximum earth resistance at HT premises shall be limited to 1 ohm.(IS 3043, clause 25.1)
8.	Earth mat shall be provided at EHT premises for limiting step voltage and touch voltage to tolerable values according to IEEE 80.
9.	All non-current carrying metal parts of electrical equipments shall be earthed and if voltage of equipment exceeds 250V, it shall be connected in duplicate(CEA (MR&ES) Regulation – Cl. 41(xii))
10.	Transformer and generator neutral shall be connected in duplicate. One direct connection from neutral to an earth electrode shall be provided for neutral earthing. Links shall also be provided in neutral earthing conductor. Generator neutral shall be earthed at control panel.
11.	Lightning arrestor shall be directly connected to an earth electrode using No. 6 SWG Cu. The L.A. earth electrode may be interconnected with other earth electrodes.
12.	When Steel conductors are used for earthing, the following allowances in cross section area of earthing conductor are recommended to take effect of corrosion into account as per IS 3043-2018.

	Type of laying of earthing conductors	Allowances to be considered
	Conductors laid in soils having resistivity lower than 25 ohm meter or where treatment of soil around electrode is carried out	30%
	Conductors laid in soils having resistivity from 25 ohm m to 100 ohm m	15%
	Conductors laid in soils having resistivity Above 100 ohm m	0 (no allowance)
13.	A number of rods or pipes may be connected in parallel and the resistance is then practically proportional to the reciprocal of the number employed so long as each is situated outside the resistance area of any other. In practice, this is satisfied by a mutual separation equal to the driven depth. Little is to be gained by separation beyond twice the driven depth. A substantial gain is effected even at 2 m separation. A Separation of two meter between plate electrode is sufficient to get the earth resistance value with 20% variation. (IS 3043:2018 Cl.14.2.2)	
14.	Minimum distance between earth electrode and adjacent civil structure shall be 1.5 m.	
15.	In location of SBs, DBs etc. sub earth buses of 25x3mm^2 copper or 32*6 mm^2 GI may be provided.	
16.	All Copper joints in earthing conductors shall be properly tinned.	
17.	Following guidelines shall be adhered to when GI earthing is adopted.	
	(a) GI strips used for earthing shall be minimum 6mm thick and hot dip galvanised.	
	(b) The minimum cross - sectional area of the GI should be 50 sq.mm.	
	(c) Where a Copper conductor is to be joined to GI, the joints should be tinned to prevent electrolytic action.	
	(d) Joints shall be invariably done by means of welding except in such locations where intermittent disconnection of joints is necessitated for testing purpose, or for the earthing connection to the body of equipments etc.	
	(e) Barium Chromate or Zinc dichromate treatment should be done at the welds. Joints should be provided with coating alternative layers of red oxide and aluminum. Joints are to be covered with hot bitumen. Also jute band covering of adequate thickness is to be made on the portion of earthing susceptible to higher corrosion and environmental influence.	
	(f) The area of strip electrode covered with bitumen and jute should not be reckoned for the calculation of area of dissipation for the fault current.	
	(g) In places where the resistivity is very high and atmospheric corrosion is not significant even ordinary steel conductors shall be permitted.	
	(h) Earthing system with GI conductors should be subjected to a thorough physical examination after a period of 10 years and modifications made if found necessary on such examination.	
	(i) Joints using GI conductors should be welded as far as possible and kept separated from air by a thick coating of tar or similar non-hygroscopic materials. In case bolted joints cannot be avoided, there should be a minimum of 2 bolts for sizes up to 25mm x 6mm, 3 bolts for sizes up to 31mm x 6 mm and zig zag bolting for large sizes.	
18.	Following guidelines shall be adhered to when covered aluminium is used for earthing	
	(a) Bare Aluminium should not be used for final underground connections to earth electrode.	
	(b) Aluminium shall be used below ground only if efficiently protected or sheathed against contact with soil and moisture. PVC covering shall be allowed.	
	(c) Where a copper conductor is to be joined to Aluminium conductor, the joints should be tinned to prevent electrolytic action.	
	(d) Sharp bends required in Aluminium strip should be formed by the use of a bending machine.	
	(e) Aluminium to Aluminium joints on strip conductor shall be arc welded using either the Tungsten inert gas arc or Metal inert gas arc techniques. Oxy - acetylene gas welding or bracing shall also be allowed.	

	(f) Round and rectangular conductors can be joined with bolted clamps. Rectangular conductors can be joined or terminated by drilling and bolting.
	(g) When making a bolted type joint the surface of the Aluminium strip should be cleaned thoroughly by wire brushing and grease or an approved jointing compound should be applied immediately to both mating – surfaces. Bolts should then be tightened and all excess grease or compound shall be wiped off and discarded.
	(h) Aluminium conductor connections to equipment, whereas possible, should be in the vertical plane. Surface preparation of Aluminium and making of the joint should be as previously described. The finished joint should be protected by bitumastic paint.
19.	Earthing switches shall be provided at appropriate locations to facilitate earthing of outgoing transmission lines to enable maintenance. (CEA (Technical Standards for Construction of Electrical Plants and Electric Lines), Regulations, 2010 43(2)(d))
20.	Enclosure of bus duct may be used as earthing conductor, if continuity is ensured.
21.	Maximum current per metre of rod length for the total rod system should not exceed the values as determined by Equation $I = (1140 \times d) / \sqrt{(\rho \times t)}$ where I = maximum current in amps/meter d = rod diameter in mm ρ = earth resistivity in ohm-cm t = time in seconds (typically one second) If ground currents of high magnitude and long duration are anticipated, the system must cover a relatively large area and employ a sufficient number of electrodes and electrode connections. This will keep the current density in the earth to a low value.
22.	Permissible current density (for 3 seconds) for earthing conductors. a) Copper =118A/mm² b) Aluminium =73Amm² c) Steel(GI) =46A/mm²
23.	Protective equipotential bonding shall be carried out in all buildings as specified in IS 3043/IS 732.
24.	Earth fault protection at every LT consumer premises shall be achieved by the following a) The earth fault loop impedance has to be low enough to allow adequate earth fault current flow to cause and over current protective device (for example, a fuse or circuit breaker) in the faulty circuit to operate in a sufficiently short time : or b) Where it is not possible to achieve a low enough earth fault loop impedance, disconnection may be achieved by fitting a residual current device (RCD) of 30mA sensitivity (IS 3043:2018, clause 23.1)

7. Protection against Lightning

(IS/IEC:62305/2010 Part-3)

1	For lightning current carrying connections, welding and clamping are the preferred methods. Lashed joints as a connection are suitable for additional conductors for equipotentialization and for EMC purposes only. (Clause E.4.3.6)
2.	Welds between reinforcing bars within concrete should be at least 50 mm long. Crossing rods should be bent to run for at least 70 mm in parallel prior to welding. (Clause E.4.3.6)
3.	Where welding to the reinforcing rods is not permitted, clamps or additional dedicated conductors should be used. These additional conductors can be made of steel, mild steel, galvanized steel or copper. The additional conductors should be connected to a large number of reinforcing rods by lashings or clamps to take advantage of the shielding possibilities of the reinforcement steel. (Clause E.4.3.6, E.4.3.9&E.4.3.11)

4.	Where welding is permitted, both conventional welding and exothermic welding are acceptable. (Clause E.4.3.6)
5.	Connections of external circuits to the interconnected reinforcement should be performed by means of clamps or by welding. (Clause E.4.3.6)
6.	Welding to the reinforcing rods is only permitted if the civil works designer consents (Clause E.4.3.3)
7	Internal down-conductors, or internal structural parts used as down–conductors, should be connected to an earth electrode and the reinforcement steel of the floor to avoid step and touch voltages. If internal down-conductors are near expansion joints in the concrete, these joints should be bridged as near to the internal down-conductor as possible. (Clause E.4.3.6)
8.	The reinforcing rods of walls or concrete columns and steel structural frames may be used as natural down-conductors. A termination joint should be provided on the roof to facilitate the connection of the air-termination system and, unless the reinforced concrete foundation is being used as the only earth-termination, termination joints should be provided to facilitate the connection with the earth-termination system. (Clause E.4.3.7)
9	If a particular rod of the reinforcement steel is used as the down-conductor, care should be taken in the route to earth to ensure that the rod that is located in the same position will be used all the way down, thereby providing direct electrical continuity. (Clause E.4.3.7)
10	If the vertical continuity of the natural down-conductors, providing a straight path from roof to ground cannot be guaranteed, additional dedicated conductors should be used. These additional conductors should be lashed or clamped to the reinforcement steel. (ClauseE.4.3.7) In order to avoid confusion between the different types of steel rods in concrete it is recommended that round steel rods of atleast 8mm diameter with a smooth surface be used as additional conductors in contrast to the ordinary ribbed surface of the reinforcing rods.(Clause 4.3.4)
11.	If the direct route of the down-conductor (i.e. for existing buildings) is not clear an external down conductor system should be added. (Clause E.4.3.7)
12.	In the case of large, low buildings such as halls, the roof is supported not only at the building circumference but also by internal columns. Such conductive columns should be connected to the air-termination system at the top and to the equipotential bonding system at the floor, creating internal down-conductors; this is to prevent dangerous sparking inside the building. Increased electromagnetic interference occurs in the vicinity of such internal down-conductors, for which adequate care should be given. (Clause E.4.3.7)
13	When ring conductors are proposed for individual floors of a building for the purpose of equi potentialisation, it should be interconnected by means of vertical rods at intervals not greater than 10 m. (Clause E.4.3.8)
14	If prefabricated reinforced concrete parts are used for lightning protection, connection points should be attached to them to allow later interconnection of the prefabricated reinforcement with the reinforcement of the structure in a simple manner. These connection points should be located so that in the prefabricated concrete part a continuous reinforcing rod runs from one bonding joint to the next. In general, one connection point and a bonding conductor is required at each corner of a plate-like prefabricated reinforced concrete part. (Clause E.4.3.11)
15	When the structure comprises a number of sections with expansion joints, in order to ensure low-impedance potential equalization and effective shielding of the space inside a structure, expansion joints between sections of a structure should be bridged at short intervals (between 1 m and one half of the distance between down-conductors) by flexible or sliding bonding conductors depending on the required shielding factor. (Clause E.4.3.12)

8.Switch Boards

1.	In case of outgoing circuits from the switchboard, where the current rating exceeds 63A, connection between the busbar chamber and the automatic circuit breaker or switch fuse or any other control gear shall be made only by solid connections.(section 5.11 of IS1646-1997)
2.	Current density in buses shall not exceed 1.2 A/mm^2 for copper and 0.8 A/mm^2 for aluminium. Minimum thickness of aluminium buses shall be 6mm.
3.	When ACB is provided at the incoming side of a switchboard the outlet switch rating shall not be less than 1/3 of the incomer setting.
4.	When MCCB is provided at incoming side, the outlet switch rating shall not be less than 1/5th of the incomer setting.
5.	Outlet fuse rating shall not exceed 1/3 of the incomer breaker setting from the point of view of grading.
6.	If ACB is provided as incomer and MCCBs as outlets in a switchboard, outlet MCCB can be set up to 80% of incomer ACB settings.
7.	If MCCB is provided as incomer, the maximum current setting of MCCBs proposed as outlets in switch board shall be half that of incomer MCCB setting.
8.	When a switch fuse is available at the incomer side, outlet switch rating shall not be less than 1/10 of the incomer fuse rating. Maximum rating of fuses at outlets shall be 1/2 of the incomer fuse rating.
9.	In the case of transformers of rating above 1600 kVA only extra current limiting type MCCBs shall be provided as outlets of MSB to limit fault level at down streams.
10.	In the case of switchboards connected to 1600 kVA transformer, the minimum outlet switch fuse rating shall be 630 A.
11.	In the case of switchboards connected to 1250 kVA transformer, 400 A switch fuses can be permitted as outlet.
12.	MCCBs maybe permitted as outlets in MSB irrespective of rating of transformer to which the board is connected. But these MCCBs shall have I_{cs} value above the prospective fault current.
13.	MCCBs that cut off fault current below its rated I_{cs} value are classified as extra current limiting type. MCCBs provided in sub-switch boards shall be extra current limiting type to limit fault level at down streams.
14.	When extra current limiting type MCCBs are used size of down stream cables can be reduced based on maximum let through energy of MCCB, during short circuit.
15.	When extra current limiting type MCCBs are used, breakers of lower Ics value may be permitted at down streams. Either 50% of Ics value of extra current limiting type MCCB or the prospective fault current at location whichever is less may be adequate for breakers at down stream.
16.	When ordinary MCCBs are used, cables at down stream shall have capacity to withstand prospective fault current for a minimum time of 40 milli seconds and breakers used at downstream shall have Ics value equal to or above prospective fault current.
17.	In the case of breaker controlled switching centers, even though out let switch rating is fixed as 1/3 of incomer setting, the feeders can be derated by reducing the fuses as per requirements.
18.	Bus coupler shall be of same rating as that of busbar. Bus coupler breaker shall be drawout type.
19.	Minimum front clearance of 1.5m shall be provided for draw out type breakers.
20.	When two switchgear panels are installed face to face, a minimum clearance of 1m shall be provided in between the breakers keeping the breakers in draw-out position or two such panels may be kept 2.0 m apart.
21.	For panels having no draw-out type breakers, minimum 1 m clearance shall be provided at front. Clearance on other sides shall conform to Regulation 37.
22.	Trenches of adequate depth and width shall be provided below floor-mounted switchboards, having cable entry at bottom, for convenient maintenance/replacement works.

23.	Door interlocking shall be provided for the switch to prevent its accidental opening in 'ON' position.
24.	Incomer live terminals at switchgears shall be shrouded with minimum 3mm thick SMC, DMC, FRP or acrylic sheets.
25.	Only SMC, DMC or FRP supports shall be used for bus bars.
26.	Switching chambers, bus bar chamber, cable alleys, metering and relay chambers etc shall be properly compartmentalised.
27.	Maximum rating of a distribution board shall be 100 A. Maximum rating of motor connected to a DB shall be 7.5kW. MCB DBs are better than HRC DBs. Vertical Distribution Boards may be used upto 125A.
28.	Minimum phase to phase and phase to earth clearance of bus bars in MV panel shall be 20 mm.
29.	Considering the harmonic current, only 4 core cables up to and including size 25 sq.mm shall be used for lighting loads, UPS etc.
30.	MV installation shall conform to I.S. 732/2019.
31.	Competent persons duly designated under Regulation 3 of CEA (Measures relating to Safety and Electric Supply) Regulations, 2010, shall be appointed/authorised to do maintenance / operation on any electrical system. The designated person should possess a certificate of competency or electrical work permit issued by the State Government.
32.	Wherever unearthed system (IT) is adopted, insulation monitoring arrangement shall be provided as specified in IS732.
33.	Test certificates may be insisted for electronic change over switches regarding its ampere rating and proper supply change over.

9. Low Voltage Cables

1.	Adequate support shall be provided for cables using metallic clamps. Spacing shall not exceed 50cm
2.	LV cables shall be laid below ground at minimum depth of 75 cm.
3.	When cables are laid across public roads, cables shall be drawn through hume/HDPE pipes of minimum 10cm diameter or 1.5 times of conductor diameter. Outer diameter of cable whichever is higher, laid at a minimum depth of 1.0m. Permission from local authority shall be obtained.(IS 3961;IS1255)
4.	Armour of multi-core cables shall be earthed at both ends.
5.	Different racks shall be provided in cable trenches /duct for cables of different voltages.
6.	Minimum size of cables for power loads shall be 4 sq.mm aluminium or 2.5 sq.mm copper.
7.	While designating the cable, codes shown in Table 18 shall be used.
8.	Cables shall have adequate normal current carrying capacity and short circuit current carrying capacity. Refer Table 19, 20 and 21.
9.	Size of feeder cables and corresponding fuse ratings are given in Table 21.
10.	Voltage drop in cables shall not exceed 3%. Refer Table 22 & 23.
11.	Power loss in cables shall also be considered while selecting cables; resistance of aluminium cables is given in Table 24 and 25.
12.	For current rating of medium voltage XLPE cables, IEC 60364-5-523 may be followed as per Table 24 and 25..
13.	Insulation monitoring system shall be provided if unearthed system is adopted.

Table -13
Standard requirements for insulating oils

Characteristics	Equipment Voltage	Permissible Limits
Dielectric Strength	145 kV and above	30 kV(Min)
Break down voltage	Below72.5 kV	40 kV (Min)
	72.5 kV and <145 kV	50 kV (Min)
Water content	Below 145 kV	35ppm (Max)
	145 kV and above	25ppm (Max)
Specific resistance (Ohm-cm)at 90°C	All voltages	0.1 x 1012ohm-cm (Min)
Dielectric dissipation factor (tan -o) at 900 c	All voltages	0.005(Max):
Neutralisation value (Total acidity)	All voltages	0.4 mg KGIH/gr (Max)
Interfacial tension at 27°C	All voltages	0.018N/M (Min)
Flashpoint	All voltages	Min. -125°C Max - 15°C decrease of initial value
Sediment or precipitable sludge	All voltages	No sediment or precipitable sludge should be detectable
Dissolved gas analysis	145 kV and above	Refer I.S. 10593 - 1993 & DGA study chart

Table -14
Current Ratings for Three-Core Cables with XLPE Insulation, Copper Conductor and Rated Voltage 1.9/3.3 kV to 3.8 /6.6 kV (IS 3961 (part 7):2017 Clause 3)

Sl.No (1)	Nominal Area of Conductor mm2 (2)	Buried in Ground A (3)	Buried in Duct A (4)	In Air A (5)
i.	25	121	104	132
ii.	35	144	124	159
iii.	50	169	146	188
iv.	70	206	178	234
v.	95	246	212	284
vi.	120	278	240	326
vii.	150	310	268	368
viii.	185	350	302	422
ix.	240	401	352	492
x.	300	449	395	559
xi.	400	506	445	642
xii.	500	565	497	730

Table -15

Current Rating for three-core cables with XLPE insulation, Aluminium conductor and Rated Voltage 1.9/3.3 kV to 3.8/6.6 kV (IS 3961 (part 7):2017 Clause 3)

Sl.No (1)	Nominal Area of Conductor mm2 (2)	Buried in Ground A (3)	Buried in Duct A (4)	In Air A (5)
i.	25	94	81	102
ii.	35	112	96	123
iii.	50	131	113	146
iv.	70	160	138	182
v.	95	191	165	221
vi.	120	216	187	254
vii.	150	241	208	286
viii.	185	273	236	330
ix.	240	315	277	385
x.	300	354	312	440
xi.	400	403	355	512
xii.	500	457	403	590

Table -16

Current Rating for three-core cables with XLPE insulation, Copper conductor and Rated Voltage 6.6/6.6 kV to 11/11 kV (IS 3961 (part 7):2017 Clause 3)

Sl.No (1)	Nominal Area of Conductor mm2 (2)	Buried in Ground A (3)	Buried in Duct A (4)	In Air A (5)
i.	25	121	105	133
ii.	35	144	125	160
iii.	50	169	146	191
iv.	70	207	179	237
v.	95	245	213	286
vi.	120	278	241	329
vii.	150	311	269	371
viii.	185	349	308	422
ix.	240	401	354	493
x.	300	449	396	560
xi.	400	506	446	643
xii.	500	565	497	731

Table -17
Current Ratings for Three-Core Cables with XLPE Insulation, Aluminium Conductor and RAted Voltage 6.6/6.6 kV to 11 /11 kV (IS 3961 (part 7):2017 Clause 3)

Sl.No (1)	Nominal Area of Conductor mm2 (2)	Buried in Ground A (3)	Buried in Duct A (4)	In Air A (5)
I.	25	94	81	103
II.	35	112	97	124
III.	50	131	114	148
IV.	70	161	139	184
V.	95	190	165	222
VI.	120	216	188	256
VII.	150	242	209	288
VIII.	185	273	240	330
IX.	240	315	278	387
X.	300	354	312	441
XI.	400	404	356	512
XII.	500	457	403	590

Table -18
Cable Code (IS 7098-Part 2- 2011)

Sl.No	Constitute	Code Letter
I.	Aluminium Conductor	A
II.	XLPE insulation	2X
III.	Steel round wire armour	W
IV.	Non-magnetic round wire armour	Wa
V.	Steel strip armour	F
VI.	Non-Magnetic strip armour	Fa
VII.	Double steel strip round wire armour	WW
VIII.	Double steel strip armour	FF
IX.	PVC outer sheath	Y
X.	Polyethylene outer sheath	2Y

Note: No code letter for conductor is required when the conductor material is copper

Table 19
Current Rating (a.c) for Three-, Four-, and Five-Core General Purpose 70°C PVC Insulatre Cables, 1 100V (IS : 3961 Part 2:2017)

Sl.No	Nominal Area of conductor mm²	Buried Direct in the Ground		Buried Direct in the Ground		In Air	
		Copper A	Aluminium A	Copper A	Aluminium A	Copper A	Aluminium A
i.	1.5	21	18	18	15	17	14
ii.	2.5	28	22	24	19	23	18
iii.	4	37	29	31	25	30	24
iv.	6	46	38	39	32	39	32

v.	10	61	47	51	40	53	40
vi.	16	78	61	66	51	67	52
vii.	25	101	78	85	66	90	70
viii.	35	121	94	102	79	110	85
ix.	50	143	111	120	93	134	104
x.	70	175	136	147	115	169	131
xi.	95	210	163	177	138	209	162
xii.	120	237	185	200	156	238	186
xiii.	150	265	206	224	175	272	212
xiv.	185	300	234	254	198	314	245
xv.	240	345	271	293	230	371	291
xvi.	300	387	305	330	260	425	335
xvii.	400	436	348	372	297	490	390
xviii.	500	488	395	424	343	560	452
xix.	630	544	447	473	389	640	525

Table - 20

Current Ratings (a.c) for three, four, and five-core cables with XLPE insulation and rated voltage 1 100V (IS : 3961 Part 6:2017)

Sl.No	Nominal Area of conductor mm^2	Buried Direct in the Ground		Buried Direct in the Ground		In Air	
		Copper A	Aluminium A	Copper A	Aluminium A	Copper A	Aluminium A
i.	1.5	26	22	22	18	23	19
ii.	2.5	34	27	29	23	30	24
iii.	4	45	35	38	30	41	32
iv.	6	56	46	47	38	52	42
v.	10	74	57	62	48	70	54
vi.	16	95	74	79	61	89	69
vii.	25	122	95	102	79	119	93
viii.	35	146	114	122	94	147	114
ix.	50	173	134	144	112	179	138
x.	70	212	164	177	137	226	175
xi.	95	254	197	212	164	279	216
xii.	120	287	223	240	187	320	249
xiii.	150	321	249	269	209	365	284
xiv.	185	362	282	304	238	422	329
xv.	240	418	327	352	276	500	392
xvi.	300	469	369	396	312	574	452
xvii.	400	528	420	447	356	662	526
xviii.	500	593	478	511	412	760	612
xix.	630	661	542	571	468	870	712

Note: various rating factors which affects the current carrying capacity of cables also shall be considered. Refer IS 3961 (Part 6):2017 and IS 3961 (Part 7) :2016

Table - 21
Current rating of AYFY Feeder cables

Fuse/Feeder Rating in A	Size in sq.mm	Feeder rating in A	Size in sq.mm
16	4	150	150
25	6	160	185
32	10	200	240
40	16	250	400
50	25	320	2x185
63	35	400	2x240
80	50	500	2x240
100	70	630	3x400
120	95	800	4x400
125	120		

Table - 22
Voltage drop and resistance of AYFY Cables
(reference: IS 1255:1983, Reaffirmed 2016 & IS:8130/2013)

Conductor Cross-Sectional Area mm²	Installation method (Clipped direct)				Backup Fuse A	AC resistance at 20°c Ohm/km (apprx.)
	One Twin Single Phase		Three Core Three Phase			
	Current Carrying Capacity A	Volt Drop(mV)/ A /m	Current Carrying Capacity A	Volt Drop(mV)/ A /m		
1.5	16	-	-	-	10	-
2.5	21	29	19	25.1	16	14.491
4	28	18.2	25	15.8	16	9.122
6	35	12.1	32	10.5	25	6.062
10	46	7.3	43	6.3	32	3.637
16	60	4.5	58	3.9	40	2.252
25	76	2.9	74	2.5	50	1.443
35	92	2.1	90	1.8	63	1.039
50	110	1.6	115	1.3	80	0.751
70	135	1.1	135	0.93	100	0.537
95	165	0.79	165	0.68	120	0.393
120	185	0.65	190	0.54	125	0.312
150	210	0.53	215	0.45	150	0.250
185	235	0.45	250	0.37	160	0.214
240	275	0.36	295	0.30	200	0.173
300	305	0.31	340	0.25	225	0.144
400	335	0.26	415	0.225	250	0.090
2x185	423	-	-	-	320	-

2x240	495	-	-	-	400	-
2x300	549	-	-	-	425	-
2x400	603	-	-	-	450	-
3x185	620	-	-	-	450	-
3x240	726	-	-	-	500	-
3x300	805	-	-	-	630	-
3x400	884	-	-	-	630	-
4x400	-	-	-	-	800	-

Table - 23
Voltage drop in PVC insulated Copper Cables
(reference: IS 1255:1983, Reaffirmed 2016)

Conductor Cross-Sectional Area mm²	Installation method (Clipped direct)			
	Twin Core		Three Core	
	Current Carrying Capacity A	Volt Drop(mV)/ A /m	Current Carrying Capacity A	Volt Drop(mV)/ A /m
1.5	20	29	18	25
2.5	29	18	24	16
4	37	12	31	9.5
6	48	7.4	41	6.3
10	66	4.3	56	3.8
16	86	2.7	73	2.3
25	115	1.8	97	1.6
35	142	1.3	119	1.1
50	168	0.92	147	0.81
70	209	0.65	180	0.57
95	257	0.48	219	0.42
120	295	0.40	257	0.34
150	337	0.32	295	0.29
185	390	0.29	333	0.24
240	461	0.25	399	0.18
300	523	0.23	451	0.18
400	589	0.22	523	0.17

Table -24

XLPE Cable current rating

3.5core Aluminum conductor, XLPE insulated and PVC sheathed unarmored/armoured cable

(reference: IS:8130/2013)

Nom. Cross sectional area mm²	Unarmoured		Armoured		Max. D.C Resistance Temp. 20°C /Km	Max. A.C Resistance Operating Temp. 90°C /Km	Current Rating	
	Overall Diameter (Approx.) (mm)	Net wt. of cable (Approx.) (Kg/Km)	Overall Diameter (Approx.) (mm)	Net wt. of cable (Approx.) (Kg/Km)			Direct in Ground Amps	In Air Amps
25	22	600	24	870	1.200	1.054	94	96
35	24	720	26	1030	0.868	1.110	113	117
50	27	910	29	1230	0.641	0.820	133	142
70	31	1230	33	1610	0.443	0.567	164	179
95	35	1550	37	2000	0.320	0.410	196	221
120	36	2000	40	2460	0.253	0.325	223	257
150	43	2300	45	2840	0.206	0.265	249	292
185	48	2860	50	3480	0.164	0.211	282	337
240	54	3610	56	4290	0.125	0.162	326	399
300	59	4410	59	5170	0.100	0.130	367	455
400	67	5650	68	6480	0.0778	0.1023	418	530

Table : 25

4 core Aluminum conductor, XLPE insulated and PVC sheathed unarmored/armoured cable

(reference: IS:8130/2013)

Nom. Cross sectional area mm²	Unarmoured		Armoured		Max. D.C Resistance Temp. 20°C /Km	Max. A.C Resistance OperatingTemp. 90°C /Km	Current Rating	
	Overall Diameter (Approx.) (mm)	Net wt. of cable (Approx.) (Kg/Km)	Overall Diameter (Approx.) (mm)	Net wt. of cable (Approx.) (Kg/Km)			Direct in Ground Amps	In Air Amps
4	15	242	17	596	7.140	9.50	34	31
6	16	289	18	664	4.610	5.90	43	40
10	17	378	20	750	3.080	3.940	57	53
16	19	445	22	700	1.910	2.440	73	70
25	22	650	24	940	1.200	1.540	94	96
35	25	800	27	1130	0.868	1.110	113	117
50	28	1000	30	1400	0.641	0.820	133	142
70	33	1370	34	1800	0.443	0.567	164	179
95	35	1740	38	2190	0.320	0.410	196	221
120	39	2170	42	2690	0.253	0.325	223	257
150	44	2630	47	3220	0.206	0.265	249	292
185	49	3250	52	3920	0.164	0.211	282	337
240	55	4110	59	4850	0.125	0.162	326	399
300	61	5070	64	5900	0.100	0.130	367	455
400	69	6420	72	7310	0.0778	0.1023	418	530

10. Multi-Storeyed Buildings (more than 15m height)

1.	Buildings having more than one floor is categorized as multistoried building. Multistoried building having height more than 15m attract the provisions of Regulation 36 of CEA (Measures relating to Safety and Electric Supply) Regulations, 2010. NEC 2011 Part 3 Section 7 explains the requirements of electrical installations in such category of buildings. Height of the building is the vertical distance measured from the average level of the ground contiguous to the building or the center line of the adjoining street to the terrace of last livable floor of the building adjacent to the street level (NBC & KMBR).
2.	Only dry type transformers shall be used for the electrification of residential or commercial buildings or if necessary oil filled transformers shall be installed in separate utility building.(NBC Part 8)
3.	For common and essential loads of 100 kVA and above, separate transformer with HT metering may be installed exclusively for such loads by the consumer / promoter (at the building premises at his own cost) (Supply Code 2014, 11(3))
4.	a) HT metering arrangement shall be attached to the primary control device. Time of day meter of tamper proof type shall be provided for metering. b) Tapings from PT is permitted and shall be taken with separate fuse control for connection to indication lamps, volt meter, power factor meter watt-hour meter etc.
5.	Locking and sealing facility shall be provided in all metering panels, all un-metered switch boards provided before metering provision, HT panel etc. to prevent theft of energy and illicit use of electricity.
6.	HT panel including group control isolator, LT panels including metering panels shall be installed by the promoter / consumer at his own cost. It is the responsibility of the KSEBL/Licensee to effect supply up to the incoming terminal of the HT panel.
7.	Energy meters for individual consumers shall be purchased and installed by the consumer / promoter /licensee at his own cost. These meters shall be got tested and certified by Electrical Inspectorate or KSEBL/Licensee.
8.	Fuse / Breaker protection shall be provided for the feeders from energy meters. The breaker shall have isolation duty and a separate door with locking facility for the use of supplier, shall be provided.
9.	Emergency supply of adequate capacity shall be installed to feed essential loads. Power supply to fire pumps, pressurisaters and smoke venting systems, fire men lifts, emergency lightning, fire alarms etc. shall be fed from normal and emergency power source, with change over facility(NBC 16,part 4,3.4.6.2).
10.	Floor wise single point supply isolation facility shall be provided. However single point isolation is permitted for two adjacent floors.
11.	For calculation of total connected load, minimum 1.2 kW or actual shall be taken for single-phase connection and 5 kW for 3-phase connection. For residential apartments minimum 50 watts shall be envisaged for one sq.m. of residential area. (Supply code 2014:Section 50)
12.	Cables shall be taken to different floors through cable duct only. There shall be access to duct from all floors. Fire barriers shall be provided in the duct at floor crossings. Generator cables and grid cables shall be segregated in the duct. No other service pipes shall be taken through electrical duct. Two numbers of earthing strips shall be taken through the duct
13.	Only lifts with imperforated doors shall be provided in high-rise buildings.
14.	When lift is operated through generator, the capacity of generator should be minimum 6 times the rating of lift motor in kW and 3 times in the case of variable voltage variable frequency controller.
15.	Oil filled breakers/ SFUs are not permitted in high-rise buildings.
16.	Low set E/F protection using neutral CT need not be insisted for transformers feeding high-rise buildings where LT metering is adopted, But ELCBs shall be provided for all DBs and motor loads except for fire pump motors.

17.	Metering panels shall be fixed preferably on the ground floor having proper ventilation and dequate illumination (Supply code 2014, 109 (6))
18.	Unmetered spare outlets shall not be permitted from MSB / SSBs / metering panels without sealing provision.
19.	Lightning protection shall be provided and shall conform to IS/IEC 62305 Class of LPS and details are given in Table 26.
20.	When generator supply is extended to individual consumers, it shall be through an emergency DB.
21.	Emergency supply isolation facility using push buttons shall be provided in a conspicuous place at ground floor at a maximum height of 1.70 metres above the ground. (CEA Regulation – Cl. 36(3))
22.	Transformers and generators shall be installed at the periphery of the building having easy access and ventilation.
23.	Exhaust pipe of DG set shall be brought above roof top level as per CPCB.
24.	Acoustic arrangements of DG shall be provided as per CPCB.
25.	Relevant standards shall be followed in selection of wiring materials and for maintenance. Wiring shall conform to I.S. 732, I.S. 4648 and NEC.
26.	For fire pumps, starters without over load relay shall be provided.
27.	Height of meter display in metering panels shall be 0.75M to 1.8M. (CEA Installation of Meters Regulations – Cl. 7(2) (c) & I.S. 15707 – Cl. 11.3.1(b))
28.	Independent feeders shall be provided for installations such as fire lift, fire alarm,fire pumps, etc.
29.	In commercial premises and high-rise buildings, a few lifts and circulation area lights and fire-fighting equipment have to be kept working by supply from stand-by sets (NEC part 2, 8.2)
30.	In multi-storeyed building with HT metering, use of bus ducts are advisable than cable ducts.
31.	The power supply HV cables voltage shall not be more than 12 kV and a separate dedicated and fire compartmented shaft should be provided for carrying such high voltage cables to upper floors in a building. Clause 4.2.1 of Part 8 NBC
32.	If dry type transformers are installed above ground level in multi-storied building of height more than 15m, 11kV ABSFU/Breaker shall be provided at ground floor. Structural fitness certificate from a competent structural engineer shall also be furnished. Regulation 36(3). Also refer section General (under transformer) Sl. No 20

10.1 Selection of fire pumps for high-rise building

1.	The minimum requirements for firefighting installation in high rise building are given in the National Building Code Part IV, Table 31.
2.	Installation and selection of Fire extinguishers shall conform to IS 2190 :2010 and IS 15683:2006.
3.	Electrically operated fire pumps along with booster pumps of adequate rating as per National Building Code shall be provided.
4.	Main fire pumps (electric & diesel) and jockey fire pump are to be provided near surface level, under-ground static tank.
5.	Booster fire pump is to be provided at terrace level.
6.	Concurrence from fire and safety department, shall be obtained for the fire protection system.

Table 26
Lightning Protection

Class of LPS	Mesh size in meters	Protection angle w.r.t height					Rolling Sphere redius in meters	Distance between down Conductor
		10 meter	20 meter	30 meter	45 meter	60 meter		
I	5 x 5	46	23	NA	NA		20	10
II	10 x 10	54	38	23	NA		30	10
III	15 x 15	62	48	36	23	NA	45	15
IV	20 x 20	65	53	46	33	23	60	20

11. Electrical Layout in Residential Buildings

IS: 4648-1968 (Reaffirmed 1997)

1.	Energy meter shall be at such a place which is readily accessible to both consumer and supplier.
2.	Isolating and protecting device shall be placed immediately after the energy meter and should be readily accessible to consumer.
3.	Fuses or other protective devices used shall have adequate breaking capacity.
4.	Insulation of conductors connected to live lines shall be either red, yellow or blue colour. Neutral shall be black.
5.	Earthing conductor may be uninsulated. If insulated, the covering shall be finished to show a green colour. For protective conductor, bi-color combination green and yellow shall be used. (IS 3043, Sec 11.2.1, IS 11353 Table 1)
6.	After the main switch there shall be a Distribution board.
7.	There shall be separate circuits for power and lighting.
8.	There shall be minimum two sub circuits for lighting.
9.	Total load on a lighting sub-circuit shall be 800 Watts. Number of points shall not exceed 10.
10.	Total load on a power sub-circuit shall be 3000 Watts. There shall not be more than 2 outlets in a power sub-circuit.
11.	A switch shall be provided adjacent to the normal entrance to any area for controlling the general lighting in that area.
12.	Two way switching is recommended for halls and staircases.
13.	Switches and bell pushes should be self illuminating where they are often operated in dark.
14.	Local light fittings in kitchen should be so placed that all working surfaces are well illuminated.
15.	In bedroom it is recommended that some lighting be controlled from the bed location.
16.	It is recommended to use ceiling lighting with the switch located outside for bathroom.
17.	Water proof light fittings shall only be used for outdoor lighting.
18.	All socket outlets shall be three pin types.
19.	Each 16A socket-outlet provided in buildings for use of domestic appliances such as air-conditioner, water cooler etc shall be provided with its own individual fuse.(IS 732_11.7_appn_C2).
20.	All socket outlets shall be controlled by a switch located adjacent to it.
21.	Only shuttered type sockets shall be provided at location accessible to children.
22.	For socket outlets of rating more than 16A, double pole switch shall be provided.
23.	As per IS 732 no power sockets are permitted in bathroom. In unavoidable situations it shall be at inaccessible distance.
24.	All ceiling fans shall be provided with a switch beside its regulator.
25.	Ceiling fan blades shall be hung not less than 2.75m above floor.
26.	Flexible cords shall be used only in the following cases
	a. For pendants b. For wiring of fixtures and c. For connection of transportable and house hold appliances.

12. Lifts and Escalators

12.1.Lifts

1.	Lifts and its installation shall conform to IS. 14665 Part (1-3) 2000, Part 4-2001 and Part 5-1999
2.	Lift Well
	Trap door location is advisable to the extend maximum possible at a place below which no human movement is there. Trap door is not mandatory.
	Even dimensions are to be maintained throughout the lift well with proper plastering.
	Lintel may be cast above a height of 2100 mm for door opening at all floors.
	No column projection should be extended to the lift well area.
	For passenger lifts having sliding door facility till projection of 105 mm to be provided on all landings.
	External power cables (other than lift car and central cables) should not be run through lift well.
3.	Machine Room
	The machines should be as far as possible, be placed immediately above the lift well.
	If construction of machine room is not possible above lift well it shall be below the lift well or in the basement.
	High-speed lift with gearless machine should have machine room above the lift well.
	Lightning protection shall be provided as per I S 62305 over the lift machine room
	The machine room shall be segregated from the lift well by fire resistant separation in the basement.
	The machine room shall be kept closed, except to those who are concerned with the operation and the maintenance of the machinery. When the electrical pressure exceeds 250 Vdc or 125 Vac, a danger notice shall be displayed permanently on the outside of the door.
	The machine room shall be equipped with an insulated portable hand lamp provided with flexible cord for examining the machinery.
	The machine room shall be kept clean.
	There shall be a direct independent access from the topmost landing to the lift machine room.
	All open rotating parts shall be guarded from accidental contact.
	The machine room shall be well ventilated during normal operation.
	The motor of each lift machine or the worm shaft shall be arranged so as to provide hand-winding facilities and shall be suitably marked for the direction of up and down travel of the lift car.
4.	Electrical Wiring
	All electrical supply lines and apparatus in connection with the lift installation shall be so constructed, installed, protected, worked and maintained that there may be no danger to persons there from.
	All metal casings or metallic coverings containing or protecting electric supply lines of apparatus shall be effectively earthed.
	No bare conductor shall be used in any lift car.
	All cable and other wiring in connection with the lift installations shall be of suitable grade for the voltage at which they are intended to be worked and shall confirm to IS 4289-1967.
	Cable to the motor shall be segregated and the power cables should not be mixed with control and safety cables.
	A trailing cable, which incorporates the control circuit, shall be separate and distinct from that which incorporates lighting and signaling circuits.
	Separate feeders shall be provided for power and lighting circuits.
	Proper ventilation shall be provided for the motor control panel and shall be guarded against accessibility to live parts.
	Clearance between lift motor control panels shall be sufficient for easy maintenance from both

	sides of the control panel.
	Dressing of control cables from the motor control panel to lift car shall be checked to ensure trouble free operation and detection of faults.
	Local isolation shall be provided for both power and lighting feeders.
	Cables from the motor control panel to lift motor and electro magnetic brake shall not be laid over the floor directly.
	Insulating mats as per IS 15652 shall be provided in front of panels, switch boards etc.
	The earthing conductor shall be secured to earthing terminal in accordance with recommendation made in IS 3043/2018 and also in conformity with the latest provisions of Central Electricity Authority (Measures Relating to Safety and Electric Supply) Regulation 2010.
	It is recommendatory that lift car be provided either with an emergency signal that is operative from the lift car and audible outside the lift well or with a telephone. The supply to the alarm system should be taken from the machine room light circuit.
	When lift is operated through generator, the capacity of generator should be 6 times the rating of lift motor in kW and 4 times in the case of variable voltage variable frequency lift motors.
	ELCBs shall be provided in lift motor and lighting feeders.
5.	Lift car
	Emergency stopping device in car operating panel for automatically operated lifts with mperforated doors is prohibited.
	An alarm button, yellow in colour shall be provided on the car-operating panel.
	A load plate giving the rated load of the lift shall be fitted in each lift car. For passenger lifts the rated load shall be given in number of persons and kilograms.
	Net inside car areas for various passenger capacities with corresponding minimum rated loads shall be as given in Table 27
6.	Protection
	Every passenger lift shall be provided with an overload protection device, which will prevent the lift from starting in case the lift car is loaded to 110% of the rated capacity of the lift or more. Lift shall remain stationary with door open.
	Audio and visual warning shall be provided to alert the passenger in case of over load.
	Battery operated Automatic Rescue Device (ARD) shall be provided on all lifts to take the lifts to the nearest possible landing in case of power failure. If lifts are equipped with back up generator with AMF Panel the provision of ARD is optional. Capacity of battery for ARD shall be such that minimum three rescue operatations can be performed without recharging.
	For all lifts with ARD, an audio and visual indication shall be provided inside the lift car to alert the person trapped inside that he / she is being rescued.

Table : 27

Minimum and Maximum Net inside Car area for Lifts (IS 14665 (Part 3/Sec.1):2000)

No. of Passengers	Minimum Rate Load Kg	Minimum Net Inside Car Area, M^2	Maximum Net Inside Car Area, M^2
4	272	0.68	0.77
5	340	0.85	0.95
6	408	1.00	1.12
7	476	1.16	1.28
8.	544	1.31	1.45
9	612	1.46	1.60
10	680	1.61	1.76
11	784	1.92	1.91

12	816	1.92	2.05
13	884	2.06	2.20
14	952	2.23	2.34
15	1020	2.35	2.47
16	1088	2.48	2.61
17	1156	2.62	2.74
18	1224	2.75	2.87
19	1292	2.88	3.00
20	1360	3.01	3.13
21	1428	3.14	3.25
22	1496	3.26	3.38
23	1564	3.39	3.50
24	1632	3.51	3.61
25	1700	3.62	3.73
26	1768	3.74	3.85
27	1836	3.86	3.96
28	1904	3.97	4.07
29	1972	4.08	4.18

12.2.Escalators

1.	Escalator and its installation shall conform to IS 4591.
2.	An SDF/CB shall control the escalator circuit.
3.	An electrical motor shall not drive more than one escalator.
4.	Key operated type starting switch shall be provided near the escalator.
5.	Angle of inclination shall not exceed 30 degrees from the horizontal, but for rises not exceeding 6 metres and a nominal speed not exceeding 0.5m/s an angle up to 35 degrees is permitted. (IS 4591:2020, Part 1 sec 5.2.2)
6.	Manually operated type emergency stop switches shall be provided at accessible height at top and bottom landing area.
7.	Local supply isolator shall be provided near the escalator main motor.
8.	Step treads shall be properly illuminated throughout the run.
9.	Each escalator shall be provided with an electrically released, mechanically applied brake capable of stopping the traveling escalator travel with any load up to its rated load.
10.	Rated speed shall not exceed 38 m/min.
11.	A speed governor has to be provided to stop the escalator travel if the speed exceeds a predetermined value subject to maximum 140% of the rated speed.
12.	Broken step chain device shall be provided to cut off power supply to the driving machine, if the step chain breaks.
13.	Balustrades shall be provided at each side and comb plates at top and bottom of escalator.
14.	Finger guards shall be provided at the point where the handrail enters the balustrades.
15.	Skirt guards shall be provided at bottom portion of balustrades.
16.	Clearance between step and skirt guard shall be max. 5mm.
17.	Clearance between step treads shall be max. 4mm.
18.	Handrails shall extend to min. 30cm to top and bottom landing spaces.
19.	Step tread width shall be min. 40cm. and max. 102cm.
20.	The depth of step tread shall be more than 40cm. and the rise between treads shall be less than 22cm.
21.	Door to the machine room shall open outwards.

13. Electrification of Hospitals & Health care premises

(Ref- IS 17512, NEC)

1	The TN-C system is not allowed in medical locations and medical buildings downstream of the main distribution board.
2	In medical locations the distribution system should be designed and installed to facilitate the automatic change-over from the main distribution network to the electrical safety source feeding essential loads • Group 0 Medical location where no applied parts are intended to be used. • Group 1 Medical location where applied parts are intended to be used as follows: –Externally; –Invasively to any part of the body, except where Group 2 applies Group 2 Medical location where applied parts are intended to be used in applications such as intra cardiac procedures, operating theatres and vital treatment where discontinuity (failure) of the supply can cause danger to life.
3	**PROTECTION FOR SAFETY(IS 17512 sec 6,3.12)**
	Protection Against Electric Shock a) Protection Against both Direct and Indirect Contact <u>Safety Extra Low Voltage and Protective Extra Low Voltage</u>: When using SELV and/or PELV circuits in medical locations of group1 and group 2, the nominal voltage applied to current-using equipment shall not exceed 25 V r.m.s.a.c.or 60 V ripple free dc. Protection by insulation of live parts and by barriers or enclosures is essential. In medical locations of group 2, exposed-conductive parts of equipment (for example, operating the atre luminaries), shall be connected to the equi-potential bonding conductor. When safety extra voltage is obtained from supply mains, it is to be through a safety isolating transformer or a convertor with separate winding, the insulation of which complies with the double insulation or reinforced insulation requirement. b) Protection Against Direct Contact: (IS 17512 sec 6.1.2) 1. Obstacles: Protection by obstacles is not permitted. 2. Placing out of reach: Protection by placing out of reach is not permitted. Only protection by insulation of live parts or protection by barriers or enclosures is permitted. c) Protection Against Indirect Contact (IS 17512 sec 6.1.3) 1. Automatic disconnection of supply Disconnection of supply: In medical locations of group 1 and group 2, the following shall apply: –For IT, TN and TT systems, the conventional touch voltage UL shall not exceed 25 V(UL ≤ 25 V); –For TN and IT systems, below table shall apply.

	TN System / IT System Installation Nominal Voltage U_0* V; Disconnecting Time s Installation Nominal Voltage U_0/U V; Disconnecting Time s (Neutral not distributed / Neutral distributed) 120: 0.35; 120-240: 0.4 / 1 230: 0.2; 230/400: 0.2 / 0.5 277: 0.2; 277/480: 0.2 / 0.5 400, 480: 0.05; 400/690: 0.06 / 0.2 580: 0.02*; 580/1 000: 0.02* / 0.08 * U_0 is the voltage between phase and neutral. * If such disconnecting time cannot be guaranteed, it is necessary to take other protective measures, such as supplementary equipotential bonding. NOTE — Disconnection of supply when overload or short-circuit conditions occur, can be achieved by different design methods within the procedures of the general rules in order to satisfy the required safety level.
4	I. TN systems: In medical locations of group 1, in final circuits with over current protective devices rated up to 32 A, residual current protective devices with a rated residual operating current not exceeding 30m A shall be used. In medical locations of group 2, protection by automatic disconnection of supply by means of residual current protective devices with a rated residual-operating current not exceeding 30m A shall only be used on the circuits that are supplying only one single equipment. II. TT systems In medical locations of group 1 and group 2, the requirements of TN systems apply and in all cases residual current protective devices shall be used. III. Medical IT system In Group 2 medical locations, an IT system shall be used for final circuits and where the same final circuit is connected to more than one ME equipment or ME system, located within the patient environment, excluding: –equipment with a rated power greater than5k VA; –X-ray equipment; –the supply of movements of fixed operating tables. For each group of rooms serving the same function, at least one separate medical IT system is necessary. The medical IT system shall be equipped with an insulation monitoring device in accordance with the following specific requirements: –The ac. internal impedance shall be at least100 k Ω; –The test voltage shall not be greater than25 V dc.; –The injected current, even under fault conditions, shall not be greater than 1mA peak; –Indication shall take place at the latest when the insulation resistance has decreased to50 k Ω. A test device shall be provided; For each medical IT system, an acoustic and visual alarm system incorporating the following components shall be arranged at a suitable place so that it can be permanently monitored (audible and visual signals) by the medical staff. –A green signal lamp to indicate normal operation; –A yellow signal lamp which lights when the minimum value set for the insulation resistance is reached. It shall not be possible for this light to be cancelled or disconnected; –An audible alarm which sounds when the minimum value set for the insulation

	resistance is reached. This audible alarm may be silenced. –The yellow signal shall go out on removal of the fault and when the normal condition is restored. Monitoring of overload and high temperature for the medical IT transformer is required. IV. Supplementary equi potential bonding In each medical location of group 1 and group 2,supplementary equipotential bonding conductors shall be installed and connected to the equipotential bonding bus bar for the purpose of equalizing potential differences between the following parts, located in the "patient environment": –Protective conductors; –Extraneous-conductive-parts; –Screening against electrical interference fields, if installed; –Connection to conductive floor grids, if installed; –Metal screen of the isolating transformer, if any.
5	Fixed conductive non-electrical patient supports such as operating theatre tables, physiotherapy couches and dental chairs should be connected to the equipotential bonding conductor unless they are intended to be isolated from earth.
6	In medical locations of group 2, the resistance of the conductors, including the resistance of the connections, between the terminals for the protective conductor of socket-outlets and of fixed equipment or any extraneous- conductive-parts and the equipotential bonding bus bar shall not exceed 0.2 Ω. NOTE — This resistive value can also be determined by the use of a suitable cross-sectional area of the conductor.
7	Fire Protection shall be provided as per National Building Code of India part 4 Fire and Life safety applies.
8	SELECTION AND ERECTION OF ELECTRICAL EQUIPMENT(IS 17512 sec 7)
	a) Transformers for medical IT systems It is recommended that the medical IT distribution board is located within 25 m of the point of use. The distribution board should be easily accessible for maintenance which will require it to be located on the same level and the same fire section as the load it serves. Distribution boards shall be installed outside the group2 medical locations and should be safely guarded against unauthorized persons. The rated voltage Un on the secondary side of transformers shall not exceed 250 V ac. b) Medical IT systems for group 2 medical locations Transformers shall be in accordance with IEC 61558-2-15, with the following additional requirements: 1) The leakage current of the output winding to earth and the leakage current of the enclosure, when measured in no-load condition and the transformer supplied at rated voltage and rated frequency shall not exceed 0.5 m A. 2) Single-phase transformers shall be used to form the medical IT systems for portable and fixed equipment and the rated output shall not be less than 0.5 kVA and shall not exceed 10 kVA. 3) 3)If the supply of three-phase loads via an IT system is also required, a separate three-phase isolation transformer shall be provided for this purpose without put line-to-line voltage not exceeding 250 V.
9	Where appropriate, attention should be given to prevention of electromagnetic interference. <u>Explosion risk</u> 1) Requirements for medical electrical equipment for use in conjunction with flammable gases and vapours are contained of IS 13450 (Part 1).

	2) Where hazardous conditions are likely to occur (for example, in the presence of flammable gases and vapours), special precautions may be required. 3) Prevention of build-up of static electricity is recommended. Electrical devices (for example, socket-outlets and switches) shall be installed at a distance of at least 0.2 m horizontally (centre to centre) from any medical gas- outlets, so as to minimize the risk of ignition of flammable gases.
10	Any wiring system within group 2 medical locations shall be exclusive to the use of equipment and fittings in that location. (IS 17512 sec 7.2)
11	Protection of Wiring Systems in Medical Locations of Group 2: Total selectivity shall be ensured for any prospective over current: In case of a short-circuit in a final circuit, the incoming circuits of the upstream distribution board shall not be interrupted. Over current protection against short-circuit and over load current is necessary for each final circuit. Overload current protection is not allowed in the feeder circuits upstream and downstream of the transformer of medical IT-system.
12	Lighting Circuits In medical locations of group 1 and group 2, at least two different sources of supply shall be provided for some of the luminaries by two circuits. One of the two circuits shall be connected to the safety service. In escape routes, alternate luminaries shall be connected to the safety service (IS 17512 sec 7.4.1)
13	Socket-outlet Circuits in the Medical IT System for Medical Locations of Group 2 At each patient's place of treatment, for example, bed heads, the configuration of socket-outlets shall be as follows: –Either a minimum of two separate circuits feeding socket-outlets shall be installed; or –Each socket-outlet shall be individually protected against over current. Where circuits are supplied from other systems(TN-S or TT systems)in the same medical location, socket-outlets connected to the medical IT system shall either: –be of such construction that prevents their use in other systems, or –be clearly and permanently marked. (IS 17512 sec 7.4.2)
14	Architecture of Special Safety Supply System in Operation Theatre (IS 17512 sec 7.4.3) Operating Rooms require impeccable availability and quality of Electric power to ensure maximum patient safety -There shall be dedicated UPS system to ensure the back-up power for at least 3 hours -In group 2 locations, that is, Operating Rooms, an Isolated Power System panel shall be used for circuits powering medical electrical equipment and systems for survival and surgical applications. -The system architecture shall be supplied as integrated solution comprising of electrical switchgear, insulation monitoring device, medical rated transformer (as per NABH and 7.1.1.1 this standard.) connected to building management system on non-proprietary or open protocol communication system. -Medical Rated Transformer shall conform to IEC 61558-2-15 and need to be protected against overload and short circuit and temperature monitoring of transformer is needed. -Insulation monitoring device shall conform to IEC 61557-8. An audible and visual alarm shall be provided to alert medical and facility personnel. -For optimum operation of medical equipment, prevention of electromagnetic disturbance is necessary. The above system shall be tested to attenuate electromagnetic disturbances
15	SAFETY SERVICES
	-In medical locations, a power supply for safety services is required which, in case of a failure of the normal power supply source, shall be energized to feed the equipment stated in detailed requirements for safety power supply services with electrical energy for a defined period of time

	and within a pre-determined changeover period. -If the voltage at the main distribution board drops in one or several line conductors by more than 10 percent of the nominal voltage, a safety power supply source shall assume the supply automatically. -The supply transfer should be achieved with a delay in order to cater for auto re-closure of circuit-breakers of incoming supplies (short-time interruptions). -Where socket-outlets are supplied from the safety power supply source they shall be readily identifiable
	Detailed Requirements for Safety Power Supply Services (IS 17512 sec 8.3) a) Power Supply Sources with a Change-Over Period less than or equal to 0.5 s In the event of a voltage failure on one or more line conductors at the distribution board, a electrical source for safety services shall be used which is capable of providing power supply for a period of at least 3 h for: –luminaries of operating theatre tables; –ME equipment containing light sources or equipment essential to the application. As an example, this equipment may include: –endoscopes and essential equipment such as monitor; –critical life-supporting ME equipment. The power supply shall be restored within a change-over period not exceeding 0.5 s. The duration of 3 h battery may be reduced to 1 h, if a power source as diesel generator is installed. b) Power Supply Sources with a Change-over Period/less than or equal to 15 s Equipment according to Safety lighting and Other services shall be connected within 15 s to a safety power supply source capable of maintaining it for a minimum period of 24 h, when the voltage of one or more-line conductors at the main distribution board for the safety services has decreased by more than10 percent of the nominal value of supply voltage and of a duration greater than 3 s. c) Power Supply Sources with a Changeover Period greater than 15 s Equipment other than those covered above, which is required for the maintenance of hospital services, may be connected either automatically or manually to a safety power supply source capable of maintaining it for a minimum period of 24 h. This equipment may include, for example: –Sterilization equipment; –Technical building installations, in particular air conditioning, heating and ventilation systems, building services and waste disposal systems; –cooling equipment; –cooking equipment
	<u>Safety Lighting</u> In the event of mains power failure, the necessary minimum illuminance shall be provided from the safety services source for the following locations. a) The changeover period to the safety source shall not exceed 15 s: –escape routes; –Lighting of exit signs; –Locations for switchgear and control gear for emergency generation sets and form a in distribution boards of the normal power supply and for power supply for safety services; –Rooms in which essential services are intended. In each room at least one luminary shall be supplied from the power source for safety services; –Rooms of group 1 medical locations. In each room at least one luminary shall be supplied from the power supply source for safety services; –Rooms of group 2 medical locations. A minimum of 50 percent of the lighting shall be

	supplied from the power source for safety services. b) Services other than lighting which require a safety service supply with a changeover period not exceeding 15 s may include, for example, the following: –selected lifts for firemen; –ventilating systems for smoke extraction; –paging systems; –Medical electrical equipment used in group 2 medical locations which serves for surgical or other measures of vital importance. Such equipment will be defined by responsible staff authorized by the management; –Electrical equipment of medical gas supply including compressed air, vacuum supply and narcosis (anesthetics) exhaustion as well as their monitoring devices;– Fire detection, fire alarms and fire extinguishing systems.
16	VERIFICATION
	The dates and results of each verification shall be recorded. Initial Verification The tests specified below under items a) to e) in addition to the requirements of 6 of IS 732 shall be carried out, both prior to commissioning and after alterations or repairs and before re-commissioning. a) Functional test of insulation monitoring devices of medical IT systems and acoustical/visual alarm systems. b) Measurements to verify that the supplementary equipotential bonding is in accordance with Supplementary equipotential bonding. c) Verification of the integrity of the facilities required with Supplementary equipotential bonding for equipotential bonding. d) Verification of the integrity of the requirements of Safety services for safety services. e) Measurements of leakage current of the output circuit and of the enclosure of medical IT transformers in no-load condition. Periodic Verification Periodic verification of items a) to e) of Initial verification shall be carried out in accordance with local/national regulations. If no local/national regulations exist, the following intervals are recommended: a) Functional testing of changeover devices:12 months; b) Functional testing of insulation monitoring devices: 12 months; c) Checking, by visual inspection, settings of protective devices: 12 months; d) Measurement verifying the supplementary equipotential bonding: 36 months; e) Verifying integrity of facilities required for equipotential bonding: 36 months; f) Monthly functional testing of: –Safety services with batteries: 15 min; –Safety services with combustion engines: until rated running temperature is achieved: 12 months for "endurance run"; –Safety services with batteries: capacity test; –Safety services with combustion engines:60 min; In all cases at least 50 percent to 100 percent of the rated power shall be taken over. g) Measurement of leakage currents of IT transformers: 36 months; h) Checking of the tripping of RCDs at IΔN: not less than 12 months.

General

1.	Equipotential bonding should be completed in theatres and ICUs as per the above standards. Recommended value of earthing conductor resistance should be attained. All metallic bodies like gas lines etc. should come under equipotential bonding.
2.	The entire PE conductor shall be insulated with Y/G PVC sleeve/Insulation. Minimum size of PE is 2.5mm^2 if mechanically protected or 4mm^2 if not protected.
3.	All electrical equipments (specifically arc generating type during its working or ON/OFF operation) should be installed minimum 1.5m above floor level.
4.	Steel clading, if any, should be connected to equipotential bonding and electrical continuity must be ensured including gas lines.
5.	IT system (Unearthed power system) should be used by providing medical isolating transformer in theatres and ICUs for life saving /life supporting equipments after getting the detailed list from surgeons/physicians of life supporting electro medical equipement.
6.	Power distribution for theatre complex should be energised only with redundant cables. In case of a cable failure, redundant cable should restore the supply at the earliest.
7.	All EMI generating equipments must be installed in consultation with medical equipment supplier/electro medical equipment catalogues.
8.	Minimum recommended distance should be strictly implemented for EMI generating equipments. (Eg. High frequency ballast for fluorescent lighting, power cabling etc..)
9.	Minimum 1000 lux shadow-free general lighting other than OT table top lamp should be given in theatres.
10.	A dedicated adequately rated standby supply for thetres and ICUs are strongly recommended with AMF panel. Supply source and AMF logic should be able to restore power supply in less than 15 seconds and enough fuel storage should be available for 24hours continuous operation.
11.	Acceptable time delay in restoring power supply for various devices, areas of medical establishment given in the standards should be followed strictly.
12.	The limits of touch voltage in operation theatre and ICU are limited to 25 V ac rms.
13.	Only TN –S & IT system power supplies are allowed in theatres/ ICUs.
14.	Screening/shielding should be completed for CAT/MRI if required /recommended by manufacturer.

14. X-RAY Installations

1.	X-ray installations shall confirm to Regulation 54.
2.	X-ray room shall be located as far as possible from areas of high occupancy and from maternity / pediatric wards in the hospital.
3.	Only one door is permitted for entry into the X-ray room.
4.	Dark room shall be so located that the primary X-ray beam cannot be directed on it.
5.	Minimum size of X-ray room shall be 18 sq.m. For CT scan 25 sq.m is required. Single dimension of the x-ray room shall not be less than 4m.
6.	Structural shielding shall be provided against radiation for walls. Walls shall be of approximately 23cm thick (Brick masonry)
7.	Unshielded openings in X-ray rooms shall be minimum 2 m above ground.
8.	Room housing fluoroscopy equipment must be so designed that adequate darkness can be achieved conveniently when desired in the room. A suitable red light must be provided in the room for the use of radiologist after dark adaptation.
9.	X-ray equipment shall be installed in such a way that in normal use the primary x-ray beam is not directed towards control panels, doors, windows, dark room or areas of high occupancy.
10.	In the case of diagnostic X-ray equipment operating at 125 kV or above, the control panel must be installed in a separate control room, provided with appropriate shielding, direct viewing and oral communication facilities between the operator and the patient.

11.	Waiting areas must be provided outside X-ray room.
12.	A suitable warning signal such as a red light must be provided at conspicuous place outside the X-ray room and kept 'ON' when the x-ray unit is in use.
13.	ELCBs shall be provided in X-ray circuits.
14.	Adequate clearance shall be provided around equipments and control panel for easy and convenient operation.
15.	Cable size and earthing conductors of X-ray units of different rating are given in Table 28.
16.	Approval shall be obtained from Atomic Energy Regulatory Board (AERB) for X-ray unit installation. Sanction shall be issued only after producing approval certificate from AERB.
17.	Barium sulphate coating should be provided for the walls, if the wall thickness is less than 15cm.
18.	Artificial resuscitation chart should be exhibited at a conspicuous location inside the X-ray room.
19.	The distance between control panel and X-ray unit shall be minimum 3m.

Table 28
Cables for X Rays

Capacity of X Ray			Current rating	Backup Fuse	Cable size AYFY	Earth Conductor
mA	kVA	Phase	A	A	mm^2	mm
30 (Portable)	5	1	22	32	2x6	3.251
50 (Portable)	7.5	3	10.8	32	3x6	3.251
50	7.5	3	10.8	32	3x6	3.251
100	10	3	16	32	3x6	3.251
300	30	3	45	50	3x16	4.064
500	65	3	98	100	3x35	4.064
Note : For equipments such as X Ray, Neon Sign, Lift, Escalator and CT scanner, the fee specified in the Govt. order will be inclusive of the associated switch boards, earth electrodes etc.						

15. NEON – SIGN Installations

1.	Neon installations shall confirm to Regulation 52.
2.	Neon-sign boards should be structurally stable.
3.	HT transformers should be adequately enclosed in a vermin proof and dust proof enclosure and there should not be any exposed live parts.
4.	HT interconnection should be done with cables of adequate insulation and the joints should be soldered and adequately insulated properly.
5.	Midpoint of HT winding of Neon transformers should be rigidly connected to the body of the transformer and there from to the transformer enclosure by duplicate earth connection of No. 10 SWG copper wire. The transformer enclosure should be rigidly connected to the Neon sign frame and the frame provided with duplicate earthing.
6.	Minimum size of the chamber should be 50 x 50 x 6 cm.
7.	Separate circuits with fuse switch isolation at supply end and receiving end should be provided.
8.	Neon-sign board should be provided with separate earthing scheme.
9.	Fire main switch, a linked switch to operate on all phases except the neutral in a three phase four wire circuit, shall be provided at not more than 1.70 m from ground as envisaged in Regulation 52 (1) (ix) of CEA (Measures Relating to Safety and Electric Supply) Regulations, 2010
10.	Main wiring should be done using rigid PVC / metal conduits.
11.	On the Neon transformer enclosure caution notice "DO NOT OPEN WHEN SUPPLY ON" sign should be conspicuously marked and standard danger board provided nearby the Neon-sign.

16. Installation of Electric Fence Energizer

1.	Electric fence installation should conform to IS 302-2-76/1999 and IEC 60335-2-76/2002.	
2.	The applicant will have to submit a formal application containing the location and area covered by the electric fence energizer.	
3.	Erection and maintenance of the fence shall be carried out under the supervision of an authorized person.	
4.	When the fence is crossing public / private property necessary sanction / NOC from appropriate agency shall be obtained.	
5.	The electric fences shall be installed, operated and maintained in a manner that minimizes danger to persons, animals or their surroundings. Electric fencing must have its conducting wires effectively isolated from the ground. The fence structure must be of sufficient strength and capacity to deliver an electric shock sensation to an animal when it touched.	
6.	The Energizer shall be of standard make and having following characteristics.	
	a) The impulse repetition rate shall not exceed 1Hz.	
	b) The out put voltage of energizer shall not exceed 10000 V.	
	c) The impulse duration of the impulse in the 500 Ohm component of standards load does not exceed 0.1 seconds.	
	d) The energy per impulse in the 500 Ohm component of the standard load shall not exceed 5 joules.	
	e) Mains operated and battery operated energizers suitable for connection to the main shall be Class II with respect to protection against electric shock.	
	f) Energizer shall be of minimum degree of protection IPX4 for outdoor installation	
7.	Electric fence construction that is likely to lead the entanglement of animals or persons shall be avoided.	
8.	Fences shall not be supplied from two separate energizer or from independent fence circuits of the same energizer. If the separate fences are supplied from separate energizer, the distance between the wires of electric fences shall be minimum 2 meter. If the distance is to be less, it shall be effected by means of electrically non conductive materials or with an isolated metal barrier.	
9.	If the energizer is provided with more than one fence circuit the impulse for the individual sets of output terminals shall be synchronized. The duration and repetition of impulse shall be the same as for the energizer with one circuit.	
10.	The barbed or razor wires shall not be used.	
11.	The energizer shall be earthed independently and a minimum distance of 10 meter shall be maintained between energizer earth electrodes and any other earthing system.	
12.	Connecting leads of energizer that are run inside building shall be effectively insulated from the earthed structural part of building and if that are run underground shall be run in conduit of insulating materials or with insulated H.V cables. Care must be taken to avoid the damage caused by the effect of animal hooves or rodents or by farming tools.	
13.	Energizer live wires shall not be installed in the same conduits as the electrical domiciliary installation, communication, TV, data etc.	
14.	The connecting leads and fence wires shall not cross OH power lines/communication lines. If such crossing cannot be avoided, it shall be taken underneath of the power lines and as nearly as possible at right angle to it.	
15.	The minimum clearance as shown shall be maintained for connecting leads / electric fences wire which are installed near OH power lines.	
	Less than or equal to 1000V	3 metre
	Between 1000V and 33 kV	4 metre
	Above 33kV	8 metre.
16.	Height of electric fence above ground shall not exceed 3metre for either side of power line for a	

	distance of 2 meter for voltage up to 1000 V and 15 meter for a voltage exceeding 1000 V.
17.	Where an electric fence crossing a public pathway, a non-electrified gate or stiles shall be provided and warning signs shall be provided at adjacent electrified wires. The warning signal at not greater than 50metre interval of fences where there is public access.
18.	The conducting wires of fence shall be made of non-corrosive material. The joints in the wire shall be made either by knotting or with double crimp sleeve joiner.
19.	A cut out switch shall be used to isolate parts of fences without need to turn off the energizer and the switches shall be capable of isolating and insulating a voltage level of 10 kV.
20.	The fence wires running under the telephone wires or parallel to underground telephone cables for any distance shall be avoided.
21.	Electric fence bordering public thoroughfares are required to have a warning sign at least 20 cm x 10 cm size with yellow back ground and black letters. "CAUTION : Electric animal fence".
22.	In dry areas with low rain flow registers there is a severe decrease of the conductivity through the ground. In such place, 'Ground wire return system' of earthing shall be preferable.
23.	For Electric security fences used for security purpose shall comprise an electric fence and a physical barrier not less than 1.5 meter in height intended to prevent inadvertent contact with the pulsed conductors of the Electric fence.
24.	Inspection fee of Rs 2500/- (Rupees Two Thousand and Five Hundred Only) per circuit of energizer shall be remitted by the applicant under the head of account 0043-102.

17. Installationof Digital Projectors in Cinema Theatres

1.	The equipment shall be installed in the cabin itself.
2.	Sufficient working space shall be maintained around the proposed projector.
3.	The height of projection shall not be less than 2.1m from the top most portion of the auditorium floor level.
4.	The cabin shall be in-charge of a licensed Cinema Operator for the operation of Digital Projector.
5.	Separate sanction shall be obtained from the District Electrical Inspector for the installation of Digital Projectors.
6.	This equipment can be permitted in addition to the existing Arc lamp projector or independently.
7.	Separate circuit shall be provided for the Digital Projectors.
8.	Quality of the picture and sound produced by the Digital Projector shall be ensured.
9.	All the relevant rules as per Kerala Cinema (Regulation) Rules 1988 shall be made applicable to the cinema installation with Digital Projectors.

18. Installation of Solar Energy System

a)Technical	
1.	The minimum qualification for carrying out the installation work of solar energy system shall be a licensed B-Class Contractor. Depending up on the capacity of the installation, eligible contractors can carry out the work.
2.	Verify, whether the inverter is grid tied or not. Inverter capacity shall be selected based on the solar PV generation, so that maximum generation can be utilized. The design of inverter should be as per the Indian / International Standard and efficiency of the inverter should be more than 97%.
3.	Solar inverter details and its specifications and Solar PV module details such as number of modules, wattage, voltage, current etc. shall be verified.
4.	PV module shall be MNRE approved. The certificate of MNRE approval shall be verified. If the PV module is not MNRE approved, certificate from MNRE approved lab shall be obtained.
5.	In the grid tied System, ensure that there is no back feeding to the grid when grid supply is off and anti-islanding protection shall be ensured during grid failure. The Inverter should shut down

	automatically if there is a power blackout or a fault with SPV for safety of the personal and other equipments. Certificate from the manufacturer shall be obtained.
6.	In case consumer want to use SPV power for its use at the time of grid failure, he has to install an automatic switching system to isolate grid supply from SPV system to use the supply from SPV with Battery system safely.
7.	The adequacy of cable size for solar PV System shall be verified and ensured. The cable shall be UV Protected. If the inverter is installed in the lower floor, the DC cable shall be laid through the outer wall of the building.
8.	An energy meter shall be provided for recording the solar energy generated.
9.	If it is grid tied, it shall be ensured that Bi-directional meter (Net meter) is provided at the interconnection point to record the import and export of energy.
10.	Battery and inverter shall be segregated properly with fire proof partition or minimum 75 cm clearance shall be ensured between them. Easy and safe accessibility to panel for cleaning shall be provided.
11.	If the proposed installation is having a DG set and intended to work in synchronization with Solar system, reverse power relay shall be provided to avoid back feeding to DG set. In the case of back feeding, reverse power relay shall trip Solar inverter.
12.	A lockable isolator should also be Installed at the point of inter connection with the grid connected SPV system which should be accessible to the utility staff to isolate the system at the time of maintenance of the distribution system.
13.	PV module frames, array structures, equipment and enclosures, AC conductors and lightning conductors shall be earthed as per IS 3043/2018 and section 7.4.2 of IEC 62548/2016. AC and DC side earthing shall be interconnected
14.	Frames of all PV modules shall be connected to one continuous earthing conductor. The earthing conductor shall be rated for 1.56 times the maximum short circuit current of the PV array.
15.	The minimum size of earthig conductor for PV equipment shall be 6 mm^2 if copper, 10 mm' if, aluminium or 70 mm^2 if hot-dipped galvanized iron. Resistance between any point of the PV system and earth should not be greater than 5Ω. All the earthing should be provided with two parallel paths with separate earth electrodes.
16.	Each string should be provided with two fuses, one connected to the positive and the other to the negative terminal of the string.
17.	PV string connected in parallel shall have matched open circuit voltage within 5% per string to avoid circulating current. (Refer section 5.1.6 of IEC 62548/2016).
18.	Cable size for PV string cable, PV sub-array cable and PV array main cable shall be selected as per section 7.3.7 of IEC 62548/2016
19.	DC surge arresters shall be Provided at DC side and it shall be of Type 2 (as per IEC 61643-1 IEC 62548/2016) rated at a continuous operating voltage of at least 125 percent of the open-circuit voltage of the PV string, and a flash current of more than 5 A. As the string inverters used for roof top PV systems do not allow more than 800 VDC, surge arrestors rated for 1,000 VDC are commonly used. The surge arrestors should be connected to both positive and negative outgoing terminal of the string junction box. If the inverter is provided with in-build SPD this may not be insisted. AC side of inverter shall also be provided with a SPD of adequate rating. SPDs shall be selected based on the voltage impulse withstanding capacity of the equipment to be protected.
20.	For large PV systems a dedicated lightning protection system shall be provided as per IEC 62305 and section 7.4.2 of IEC 62548/2016. Existing lightning protection of a building may be considered sufficient for this purpose, provided it adequately protects the installation area.
21.	All PV equipment installed outdoors should have an ingress protection rating of at least IP 65. All the inverters installed outdoors shall be recommended to provide an additional shading

<table>
<tr><td></td><td>arrangement to avoid direct sunlight.</td></tr>
<tr><td>22.</td><td>All The PV Equipment shall be labeled as per IEC 62446-2009-05.
• All circuits, protective devices, switches and terminals shall be suitably labeled.
• All DC junction boxes shall be labelled for indicating active parts inside the boxes fed from a PV array.
• Main AC isolating switch shall be clearly labelled with dual supply warning and a single line wiring diagram shall be displayed.
• Inverter protection settings, installer details and emergency shutdown procedures shall be displayed on site</td></tr>
<tr><td>23.</td><td>PV system shall not inject DC current greater than 1 percent of the inverter rated output current into the grid.</td></tr>
<tr><td>24.</td><td>Solar inverters shall be rated for THD(I) less than 3 percent of power injected into the grid.</td></tr>
<tr><td>25.</td><td>Galvanized iron (GI) or aluminium shall be used for module mounting structures.</td></tr>
<tr><td colspan="2">The installation shall conform to the following Act, Rules, Regulations & Standards</td></tr>
<tr><td></td><td>• Central Electricity Authority(installation and operation of meters) Regulation 2010 as amended from time to time.
• The relevant provision of the Central Electricity Authority (Measures Relating to Safety and Electric Supply) Regulations, 2010 and The Electricity Act, 2003.
• The Relevant provision of CEA regulation as notified by CEA (Standard fot Connectivity of Distributed Generation Resources), Regulations, 2013.
• CEA (Technical Standard for connectivity of the Grid) Regulation 2007 as amended from the time to time.
• Kerala State Electricity Regulatory Commission (Renewable Energy and Net metering) Regulations 2020
• National Solar Mission-Best Practice Guide published by MNRE, Govt of India 2016 shall be referred for general guidelines.
• Various orders/circulars/Technical specifications related to solar plants published by the State Government & Kerala State Electricity Regulatory Commission</td></tr>
<tr><td colspan="2">b) General</td></tr>
<tr><td>1.</td><td><table>
<tr><td>Solar Installation capacity <10kW</td><td>Scheme Approval and sanction for energisation are not required from the department of Electrical Inspectorate.</td></tr>
<tr><td>10kW≥Solar Installation capacity ≤30kW</td><td>Scheme Approval not required from the department of Electrical Inspectorate. Completion report and single line diagram shall be submitted by the consumer through a competent electrical contractor and sanction for energisation shall be obtained from the district office concerned.</td></tr>
<tr><td>Solar Installation capacity >30kW</td><td>Scheme Approval and sanction for energisation shall be obtained from the office concerned.</td></tr>
</table>Note:- If the said installation is an addition to the existing HT installation, then the as-fitted drawings for such changes shall get approved from the district office.</td></tr>
<tr><td>2.</td><td>For the installation above 30kW and below 500kW, prior scheme approval and sanction for energisation orders shall be obtained from the district office concerned.</td></tr>
<tr><td>3.</td><td>For the installations including 500kW and above, prior scheme approval and sanction for energisation orders shall be obtained from the office of the Chief Electrical Inspector.</td></tr>
<tr><td>4.</td><td>for the scrutiny and inspection, the check list given in the annexure shall be followed.</td></tr>
</table>

5.	The following tests shall be conducted at the time of inspection: a. PV Module: Irradiance measurement, angle of inclination, temperature of the PV module and V-I characteristics using PV Array Tester. b. Solar Inverter: Efficiency, input voltage, output voltage, power, THD, DG injection flicker etc. and anti-islanding protection.
6.	While issuing sanction for energisation for Solar Energy System, following conditions to be included in addition to normal conditions: a. Consent from the licensee shall be obtained (In case of grid tied system).
c) scrutiny / inspection of Solar Energy System	
1.	Up to 5kW solar plants, two numbers of earth electrodes are sufficient and LA shall be provided in lightning prone area.
2.	Above 5kW and up to 100kW solar plants, three numbers of earth electrodes are sufficient and LA shall be provided.
3.	These earth electrodes shall be interconnected to existing earth electrodes and total earth resistance shall be less than 5 Ω.
4.	Equipotential bonding shall be done as per IEC TR 63227:2020.
5.	Lockable CB/SFU shall be installed at the point of interconnection with the grid and should be accessible to the utility staff to isolate the system at the time of maintenance of distribution system.

19. Communication /Optical Fibre Cable on Distribution Network Power Line Supports.

1.	A minimum ground clearance of 4000mm shall be maintained for Optical Fibre cables taken along the street.
2.	When cables are drawn across the road, a minimum ground clearance of 5800mm shall be maintained
3.	A minimum vertical clearance of 1200mm shall be maintained for Optical Fibre cables from lowest power conductor when run under LT lines and 2440mm from 11kV lines.
4.	All Dielectric Self Supporting (ADSS) cable shall possess good performance characteristics such as anti-impact, anti-vibration, anti-bending, prevention of thermal aging, flame retardant and UV protected.
5.	ADSS cable specification shall conform to the latest editions of the relevant International Electro Technical Commission (IEC), IEEE and BIS.
6.	Elements consisting of ADSS cable shall be non-metallic, shall possess anti-electromagnetic, strong endurance of electrical effect and in worst case scenario no electricity should be conducted from the surface of the ADSS cable, when charged electrical conductor touches the surface of ADSS cable.
7.	In work sites, all metallic equipment including hardware anchors and structures shall be common bonded together and then grounded to ensure safety. ADSS cable shall be grounded between the work area and the spans when splicing ADSS cable during wet or rainy conditions near active high voltage phase conductors for preventing dangerous leakage currents and transients from flowing through personnel.
8.	Pole Attachment Hardware / Brackets and supporting assembly for Fiber Optic Cable in electric poles shall be earthed.
9.	Optical Fiber Cables Should not pass through/connected to Transformer Structures
10.	Maximum of two cables of all service providers put together per pole may be allowed due to technical constraints and electrical safety concern.

11.	Erection of cables and subsequent maintenance of the network shall be carried out under the supervision of the authorized person of the Utility adopting all safety precautions. No such works shall be carried out on the electric poles from 6PM to 8 AM except on emergency situations.
12.	Copy of the agreement with the KSEB Ltd/Licensee and sanction received, if any shall be forwarded while applying for Safety Certificate.
13.	Optical Fibre Cables should not be run above the power lines. It should always be below power lines.
14.	Pole Attachment Hardware / Brackets and supporting assembly for Optical Fibre Cable shall be fixed to the utility pole, such that, a minimum horizontal clearance of 130mm is maintained between the cable and the pole.
15.	Power supply to the booster unit/Optical Amplifier unit/MUX, if required, should not be taken directly from the power lines. The primary supply to such units shall be controlled by an MCB/MCCB and 30mA rated ELCB. The power cubicle shall be effectively earthed.
16.	When crossing of Public/Private Property, necessary consent from appropriate agency shall be obtained
17.	The network shall be subjected to periodical inspection by the Electrical Inspector and fee for such inspection prescribed by the Government shall be paid on demand.
18.	Statement giving details of number of customers, length of cable network, route map shown, number of poles, number of power connections availed for amplifiers/node, area of jurisdiction of the supplier (Electrical Section) shall be furnished to the Deputy Chief Electrical Inspector/ Electrical Inspector at the end of every financial year ending on 31st March.
19.	Details of the customers, including name, address etc shall be maintained at the administrative office and made available when called for.
20.	The relevant provisions of Regulation 68 & 69 of Central Electricity Authority (Measures relating to Safety and Electric Supply), Regulations,2010 shall be strictly adhered to.
21.	Safety Provision under Electricity Act 2003 and Central Electricity Authority (Measures relating to Safety and Electric Supply), Regulations,2010 shall be strictly adhered to.
22.	The installation shall conform to IS/IEC 60794: 2001.

20. Guidelines for scrutiny / inspection of Public EV Charging Station (PEVCS)

(a) Technical

1.	The minimum qualification for carrying out the installation work of a public EV charging system shall be a licensed B-Class Contractor issued by KSELB(Kerala State Electricity Licensing Board). Depending up on the capacity of the installation, eligible contractors can carry out the work.
2.	All electric vehicle charging stations shall be provided with protection against the overload of input supply and output supply fittings.
3.	The electric vehicle parking place shall be such that the connection on the vehicle when parked for charging shall be within five meters from the electric vehicle charging point/EVSE.
4.	Suitable lightning protection system shall be provided for the electric vehicles charging stations as per Indian Standards Code IS/ IEC 62305.
5.	All residual current device for the protection of supplies for electric vehicle shall, (a) have a residual operating current of not greater than 30 mA; (b) interrupt all live conductors, including the neutral; and (c) have a performance at least equal to Type A and be in conformity with IS 12640. Co-ordination of various protective devices shall be ensured. All electric vehicle charging stations shall be supplied from a sub-circuit protected by a voltage independent residual current device and also providing personal protection that is compatible with the charging supply for an electric vehicle.
6.	Earthing of all electric vehicle charging stations shall be as per IS 3043:2018.
7.	The cable may be fitted with an earth-connected metal shielding and the cable insulation shall be

	wear resistant and maintain flexibility over the full temperature range.
8.	A protective earth conductor shall be provided to establish an equipotential connection between the earth terminal of the supply and the conductive parts of the vehicle and shall be of sufficient rating to satisfy the requirements of IEC 60364-5-54.
9.	Fire detection, alarm and control system shall be provided as per relevant Indian Standards.
10.	Power supply cables used in charging station or charging points shall conform to provision of IEC 62893-1 and its relevant parts.
11.	The safety provisions of all Alternating Current charging stations shall be in accordance with IEC 61851-1, IEC 61851-21 and IEC 61851-22.
12.	The safety provisions of all Direct Current charging stations shall be in accordance with IEC 61851-1, IEC 61851-21, IEC 61851-23 and IEC 61851-24.
13.	Where the connection point is installed outdoors, or in a damp location, the equipment shall have a degree of ingress protection of at least IPX4 in accordance with IEC 60529.
14.	Public Charging Infrastructure (PCI) – Requirements: Every Public Charging Station (PCS) will have the following infrastructure: 1) An exclusive transformer with all related substation equipment including safety appliance (If required). 2) 33/11 kV line/cables with associated equipment including line termination etc (If required). 3) Appropriate civil works. 4) Appropriate cabling and electrical works ensuring safety. 5) Adequate space for charging and entry/exit of vehicles. 6) Public Charging Station shall have, any one one or more chargers or any combination of chargers from the table given below in one or more electric kiosk/boards:

Charger Type	Sl.No.	Charger Connectors*	Rated Output Voltage(V)	No.of Connector guns (CG)	Charging Vehicle type W-Wheeler)
FAST	1	Combined Charging System (CCS)-min. 50kW	200-750 or higher	1CG	4W
	2	CHArge de Move (CHAdeMO) –Min. 50kW	200-500 or higher	1CG	4W
	3	Type-2 AC –Min. 22kW	380-415	1CG	4W,3W,2W
SLOW /MODERATE	4	Bharat DC–001 - Min. 15kW	48	1CG	4W,3W,2W
	5	Bharat DC–001 - Min. 15kW	72 or higher	1CG	4W
	6	Bharat AC–001 - Min. 10kW	230	3CG of 3.3 kW each	4W,3W,2W

*In addition, any other fast/slow/moderate charger as per approved BIS standards whenever notified.

Note: Type -2 AC (Min. 22 kW) is capable of charging e- 2W/3W the provision of an adapter

7) Charging stations for e-two/three wheelers shall be free to install any charger other than those specified above subject to compliance of technical & safety standards as laid down by Central Electricity Authority (CEA).
8) Tie up with at least one online Network Service Providers (NSPs) to enable advance remote/online booking of charging slots by EV owners. Such online information to EV

	owners should also include information regarding location, types and numbers of chargers installed/available, service charges for EV charging etc. 9) Share charging station data with the appropriate DISCOM and adhere to protocols as prescribed by CEA for this purpose. CEA, Central Nodal Agency (CNA) and State Nodal Agency (SNA) shall have access to this database.
15.	Captive charging infrastructure for 100% internal use for a company's own/leased fleet for its own use will not be required to install chargers as per 14 and to have NSP tie ups.
16.	Charging station may also be installed by Housing societies, Malls, Office complexes, Restaurants, Hotels, etc. with a provision to allow charging of visitor's vehicles which are permitted to come in its premises.
17.	Public charging Infrastructure (PCI) for long range EVs and/or heavy duty EVs: Fast Charging Stations (FCS) i.e., public charging stations for long range EVs and/or heavy duty EVs (like trucks, buses etc.) will have the following: (i) At least two chargers of minimum 100 kW (200-750 V or higher) each of different specification (CCS/CHAdeMO or any fast charger as approved by BIS for above capacity) with single connector gun each. (ii) Appropriate Liquid cooled cables high speed charging facility as above [17(i)], for onboard charging of fluid cooled batteries (currently available in some long range EVs), if required.
18.	Fast Charging Stations (FCS) which are meant only for 100% in house/captive utilization, for example buses of a company, would be free to decide the charging specifications as per requirement for its in-house company EVs.
19.	Additional PCS/FCS can be installed even if there exists a PCS/FCS in the required grid or distance.
20.	Separate metering arrangement shall be made for PCS so that consumption may be recorded and billed as per applicable tariff for EV charging stations.
21.	The power quality analysis at each public charging station shall be done. The THD shall be within the limit as per the latest version of IEEE 519 and IEC 61000-3-12/2-4.
22.	An emergency push button shall be provided at the main incomer side for disconnection of power supply to the public EV charging station.
23.	Three phase Electrical Vehicle Supply Equipment (EVSE) shall be equally loaded in all phases.
24.	Battery charging system (BCS) shall be treated as par with public charging station (PCS).
25.	The captive charging station (CCS) shall not be used for commercial purpose.
26.	Safety clearance between the oil based charging point and EV charging point is to be specified from the safety point.
27.	Exclusive transformer of adequate capacity shall be provided for public EV charging station.
28.	Only dry type transformers shall be used.
29.	Only four core cable shall be used for charging points which require three phase power.
30.	Switch boards and panels shall have a degree of ingress protection not less than/of at least IP54.
31.	UG cables shall not cross the UG tank or oil pipe line.
32.	Only double compressed glands shall be used for terminating cables.
33.	UG cables through the charging area or vehicles passage shall be minimized and provided shall be at a minimum depth of 1m.
34.	All residual current devices used for the protection of supplies to electric vehicle shall be permanently marked to identify their function and the location of the charging station or socket outlet they protect.
35.	Each electric vehicle charging points shall be supplied individually by a dedicated final sub-circuit protected by an over current protective device complying with IS/IEC 60947-2, IS/IEC 60947-6-2 or the IEC 60269 series and the over current protective device shall be part of a switchboard.

36.	Where required for service reasons, discrimination (selectivity) shall be maintained between the residual current device protecting a charging point and a residual current device installed upstream.
37.	All electric vehicle charging stations shall be supplied from a sub-circuit protected by a voltage independent residual current device and also providing personal protection that is compatible with a charging supply for an electric vehicle.

(b) Charging Points

1.	All electric vehicle charging points shall be installed so that any socket-outlet of supply is at least 800 millimetre above the finished ground level.
2.	A cord extension set or second supply lead shall not be used in addition to the supply lead for the connection of the electric vehicle to the electric vehicle charging point and it shall be so constructed so that it cannot be used as a cord extension set.
3.	An adaptor shall not be used to connect a vehicle connector to a vehicle inlet.
4.	Portable socket-outlets are not permitted to be used for electric vehicle charging.
5.	Each electric vehicle charging points shall be supplied individually by a dedicated final sub-circuit protected by an over current protective device complying with IEC 60947-2, IEC 60947-6-2 or the IEC 60269 series and the over current protective device shall be part of a switchboard.

(c) EVSE Requirements

1.	The electric vehicle charging station shall be equipped with a protective device against the uncontrolled reverse power flow from vehicle.
2.	One second after having disconnected the electric vehicle from the supply (mains), the voltage between accessible conductive parts or any accessible conductive part and earth shall be less than or equal to 42.4 V peak (30 V rms) , or 60 V D.C., and the stored energy available shall be less than 20 J (as per IEC 60950) and if the voltage is greater than 42.4 V peak (30 V rms) or 60 V D.C., or the energy is 20J or more, a warning label shall be attached in an appropriate position on the charging stations.
3.	A vehicle connector used for Direct Current (D.C.) charging shall be locked on a vehicle inlet if the voltage is higher than 60 V D.C. and the vehicle connector shall not be unlocked (if the locking mechanism is engaged) when hazardous voltage is detected through charging process including after the end of charging and in case of charging system malfunction, a means for safe disconnection shall be provided (non networked).
4.	The Direct Current (D.C.) electric vehicle charging point shall disconnect supply of electricity to prevent overvoltage at the battery, if output voltage exceeds maximum voltage limit set by the vehicle.
5.	The electric vehicle charging points shall not energize the charging cable when the vehicle connector is unlocked and the voltage at which the vehicle connector unlocks shall be lower than 60V.
6.	All electric vehicle charging stations shall be provided with an earth continuity monitoring system that disconnects the supply in the event that the earthing connection to the vehicle becomes ineffective.
7.	Enclosure of charging stations shall be made of fire-retardant material with self-extinguishing property and free from Halogen.
8.	Electric Vehicle Supply Equipment (EVSE) shall be type tested by an agency /lab accredited by National Accreditation Board for Testing and Calibration Laboratories (NABL) from time to time.

(d) Responsibilities of Owner (PEVCS)

1.	The owner of the charging station shall keep records in regard to design, construction and labeling to be compatible with a supply of standard voltage at a nominal frequency of 50 Hertz of the charging station.
2.	The owner of the charging station shall keep records of the relevant test certificate as indicated in the regulations and as per IEC 61851.
3.	Every charging station shall be tested and inspected by the owner or the Electrical Inspector or Chartered Electrical Safety Engineer before energisation of charging stations.

4.	The owner of the charging station shall ensure that test and inspection of charging station (with & without load) is being carried out every year in the initial period of first three years after the energisation of charging station and in every four years thereafter or inspection on request.
5.	The owner of the charging station shall establish and implement a safety assessment program for regular periodic assessment of the electrical safety of charging station.

The installation shall conform to the following Act, Rules, Regulations & Standards:

1.	The relevant provisions of the Central Electricity Authority (Measures Relating to Safety and Electric Supply) Regulations, 2010 and The Electricity Act, 2003 and amendments.
2.	Central Electricity Authority (Measures Relating to Safety and Electric Supply) (Amendment) Regulations, 2019 and amendments.
3.	Ministry of Power, Government of India-"charging infrastructure for electric vehicle (EV)- the revised consolidated guidelines & standards" dated 14th January 2022.
4.	IS 17017 Part I & Part II
5.	Various orders/circulars related to EV charging stations published by government of Kerala and Kerala state Electricity Regulatory commission.


DEPARTMENT OF ELECTRICAL INSPECTORATE