المرجع الشامل فى

الأعمال الكهربائية للمنشآت

لإستشارى ومقاولى الكهرباء

الإصدار الثانى

مهندس استشارى / محمد عثمان الشافعى

Foreword:

Mohamed Osman Al Shafey has been with United Consultant in Doha – Qatar for 15 years / Head of Electrical Department for Design and Supervision; he has Grade (A) license from Kahramaa and Grade (A) license from Professional Engineering Committee in Qatar. He has Consultant Certificate from Egyptian Engineers Syndicate, he previously worked for Electrical Consultants Companies in Egypt like Arab consulting Engineers (Moharum-Bakhoum),Arab Council for design and Engineering Consultants, Executive organization for industrial and mining projects and Egyptian Consultant office during that, he was deeply involved in many International Projects. In additional, he has attended many scientific conferences all over the world like Italy / Belgium / India / UAE / France / Germany.
It's my great pleasure and honor to introduce these guidelines.
It will prove very useful in meeting consultants and contractors concerns.

Electrical Guidelines

For Consultants and contractors

Design and Supervision for Buildings

Consultant Engineer
MOHAMED OSMAN AL SHAFEY

Second Edition

GUIDELINES FOR ELECTRICAL CONSULTANTS AND CONTRACTORS IN "DESIGN AND SUPERVISION FOR BUILDINGS"

"المرجع الشامل في الأعمال الكهربية للمنشآت لإستشاري ومقاولي الكهرباء"

CONSULTANT ENGINEER

MOHAMED OSMAN AL SHAFEY

مهندس إستشاري / محمد عثمان الشافعي

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Section (A)
Introductions

- These guidelines are applicable to electrical installation of buildings in a general, including residential, shops, offices, industrial establishments, public buildings, 11KV networks and (66/11) KV substation.

- Some of calculation programs were done by manufacturers but the consultant engineers should involve with fundamental engineering formulas to know all effected factors and the relation between each others.

- We did our best to give integrated solution for all design issue with complete details for calculations for all electrical items; Load estimation, short circuit, voltage Dip, cable size calculation, H.V network, Lux calculation, earthing system, lightning, P. factor and obstruction lighting, solar energy , structure cabling (data/telephone) and data center infrastructure requirement; we illustrated sample or example for some cases as a guide.

- There are complete section for special requirements by occupancies for all type of building and projects refer to IEEE Std.

- Details sample for design criteria is included.

- There are also some important design considerations; form separation, IP rating, 11KV cubicle panel's S.L.D, protection devices, layout of substation; design consideration for transformers, diesel generator and induction motors all designers should involve for its.

- There are supervision issues like materials check list, shop drawings check list and how to inspect in the site.

- Variety of important electrical details are included.

- We did our best to give these guidelines for all electrical consultants and contractors, and we are hoping to be on satisfaction situation for all.

Section (B)
Definitions

- **Accessory:** any device, other than a lighting fitting, associated with the wiring and current using appliances of an installation, e.g. a switch, a fuse, a plug, a socket outlet, a lamp holder or a ceiling rose.

- **Adapter, Socket Outlets:** An accessory for insertion into a socket outlet and containing metal contacts, to which may be fitted one or more plugs for the purpose of connecting to the supply, portable lighting fitting or current using appliances.

- **Ambient Temperature (For Cable):** the temperature of the surrounding medium under normal conditions, at a suitable in which cables are installed, or are to be installed, including the effect of any artificial heating used in the building by any local sources of heat.

- **Apparatus:** Electrical apparatus, including all machines, equipment and fittings in which conductors are used or of which they form a part.

- **Appliance:** any device which utilize electricity for a particular purpose, excluding a lighting or an independent motor.

- **Bonded (As applied to Items of Metal Work):** Connected together electrically, not normally for the purpose of carrying current but so as to ensure a common potential.

- **Channel (For Cables):** A groove cut or formed in part of a building and intended to receive on a more cables, the groove having removable or hinged covers to allow cables to be laid there in.

- **Circuit Breaker:** A Mechanical device for making and breaking circuit, both under normal conditions and under abnormal conditions, such as those of an overload or short circuit being broken automatically.

- **Circuit Conductor:** A current carrying conductor forming part a circuit or final sub circuit, but excluding the earth continuity conductor.

- **Conductor (Of Core or Cable):** The conducting portion, consisting of a single wire or a group of wires in contact with each other. For earthed concentric wiring, the term may also denote the metal sheath of a cable.

- **Connector:** A device intended for connection to a flexible core of flexible cable, which has protected current carrying contact tubes similar to those of a socket outlet.

- **Customer's Terminals:** The point in the customer's installation at which the incoming supply of energy is delivered to that installation.

- **Dump and Dust Proof:** Applied to apparatus and accessories to denote that the live and other component parts are protected by an enclosure or enclosures being so protected and / or fitted as to prevent the ready ingress of dust and / or moisture.

- **Distribution Board:** an assemblage of parts, including one or more fuse or circuit breakers, arranged for the distribution of electrical energy.

- **Duct (for Cables):** A Closed passage way formed underground in a structure and intended to receive one or more cables which may be drawn in.

- **Earth Continuity Conductor:** the conductor, including any clamp, connecting to customer's earthing terminal or to the frame terminal of a voltage operated earth leakage circuit breaker or to each other, those parts of an installation which are required to be earthed. It may be the metal sheath and / or armouring if a cable or the special earth continuity conductor of a cable or flexible cord incorporating such a conductor.

- **Earth Electrode:** A metal rod or rods, a system of underground metal pipes or other conducting object, providing an effective connection with the general mass of the earth.

- **Earthed:** Effectively connected to the general mass of the earth.

- **Earthed Lead:** The final conductor by which the connection to the earth electrode or other means of earthing is made.

- **Electric Discharge Lamp:** An electric lamp comprising as hermetically sealed bulb or tube containing gas and / or metal intended to be vaporised during operation and fitted with electrodes between which a discharge of electricity takes places, the useful light being emitted either by the discharge through the gas or vapour or by the fluorescence of a translucent coating which may be on the inner surface of the outer tube or bulb.

- **Final Sub Circuit:** An out going circuit connected to a distribution board and intended to supply electrical energy to current using apparatus, either directly or through socket outlets.

- **Flameproof:** Applied to apparatus to denote that the containing case or other enclose with withstand without injury any explosion of prescribed flammable gas that may occur within it under practical conditions of operation within the rating of the apparatus (and recognized overloads, if any, associated therewith) and will prevent the transmission of flame such as will ignite any prescribed flammable gas that may be present in the surrounding atmosphere.

- **Flammable:** A flammable material is one capable of being easily ignited.

- **Flexible Cord:** A flexible cable in which the cross sectional area of each conductor does not exceed 4 mm.

- **Fuse:** A device for opening circuit by means of a fuse element designed to melt when an excessive current flows. It normally consists of a fuse base and fuse link. The fuse link may take the form of a cartridge or a carrier supporting a fuse element.

- **Fuse Element:** That part of a fuse which designed to melt and thus open a circuit.

- **Insulation:** suitable non conducting material enclosing, surrounding or supporting a conductor.

- **Isolator:** A mechanical device capable of opening or closing a circuit under conditions of no load or negligible current. ***Not to be used for the main disconnecting device of a main switchboard.*** The isolator shall be complying with BS EN 60947 Part 03: 1999 (Switches, Disconnectors, Switch – Disconnectors and fuse – Combination Units).

- **Neutral Conductor:** The neutral conductor of a 3 Phase 4 wire system, the conductor of a Single Phase of D.C. installation which is earthed by the supply undertaking (or otherwise at the source of the supply) or the middle wire or common return conductor of a 3 wire D.C. or 3 wire single phase system.

- **Non – Conducting:** Presenting a barrier against risk of electric shock when interposed in series with a source of low voltage.

- **Point (In wiring):** Any termination of the fixed wiring intended for the attachment of a lighting fitting or of device for connecting to the supply a current using appliance.

- **Plug:** A device intended for connection to a flexible cord or flexible cable which can be engaged manually with a socket of connector or adapter and which has currently contact pins which may be exposed when not engaged.

- **PVC (Cable Sheath or Installation):** Polyvinyl Chloride compound complying the BS 6746: 1990 (Specification for PVC Insulation and Sheath of Electric Cables).

- **Socket Outlet:** A device with protected currently carrying contacts intended to mounted in a fixed position a permanently connected to the fixed wiring of the installation, to enable the connection to it of a flexible cord or flexible cable means of a plug.

- **Space Factor:** The ratio (Expressed as a percentage) of the sum of the effective overall cross sectional area of cable forming a bunch to the internal cross sectional area of the conduit, pipe, duct, trucking or channel in which they are installed. The effective overall cross sectional area of non circular cable is taken as that of a circle of diameter equal to the major axis of the cable.

- **Switch:** A mechanical device for making and breaking, non automatically, a circuit carrying current not greatly in excess of the rated normal current.

- **Switchgear:** Apparatus for controlling the distribution of electrical energy, or for controlling or protecting electrical circuits, machines and current using appliances.

- **Trench Open:** A trench without covering, or covered by an open grille.

- **Trunking (for Cable):** A Fabricated casing for cables, normally of rectangular cross section, of which one side is removable or hinged to allow cables to lair therein.

Section (C)
Electrical Design Calculations

C.1 ESTIMATION OF BUILDING LOAD RELATED TO SPECIFIC SURFACE AREA LOADING

C.1.1 Estimated load are based on VA/m2 of total built up area (for A/c, lighting, small power, fire pumps ., water pumps. etc , as well as future or unseen loads as per NEC Article 220 (Branch circuit, Feeder & service Calculations), IEEE and IES

C.1.1.1 Total Specific Surface Area Loading for Buildings (VA/m^2) Refer to NEC article 220.12 & IEEE STd 241-1990

IT	Bldg. Type	Lighting (VA/m^2)	Small Power (VA /m^2)	A/C (VA /m^2)	W.H (VA /m^2)	Others (VA /m^2)	M.D.L (VA) / m^2
1	Office School	39	17	110	8	36	210
2	Residential	33	15	100	17	25	190
3	Hotel	22	15	100	20	43	200
4	Malls	39	28	110	10	33	220
5	Hospitals	23	17	110	25	60	220
6	Retail Shops	39	28	110	10	23	210
7	Hyper	39	28	110	10	33	220
8	Gym	33	5	110	10	22	180
9	Auditoriums	22	3	110	10	30	175
10	Bank	39	25	100	10	36	210
11	Restaurant	22	13	110	40	50	235

Table (1)

C.1.1.2 Industrial Areas S.S.A.L (VA /m^2)

Industry Type	S.S.A.L		(VA/M^2)
Textile Industry	150	VA/m^2	(Total plot area)
Electronic Industry	125	VA/m^2	(Total plot area)
Chemical Industry	150	VA/m^2	(Total plot area)
Paper Industry	170	VA/m^2	(Total plot area)
Cigarette Industry	135	VA/m^2	(Total plot area)
Repairing a workshop Industry	100	VA/m^2	(Total plot area)
Mineral Industry	150	VA/m^2	(Total plot area)
Food Industry	75	VA/m^2	(Total plot area)
Wood Industry	75	VA/m^2	(Total plot area)
Mining Industry	150	VA/m^2	(Total plot area)

Table (2)

C.1.1.3 <u>The Maximum demand Loads obtained from (C.1.1.1, C.1.1.2) = ……KVA</u>

The Max. Demand Load (KW) = …kVA x 0.85 (P.F) = ……KW

Estimated No. of T_X = M.D.L (KVA)/1600 * 0.85 (Tx. Percentage load) =

……Transformer Dry Type

No. of Transformer = ………. X 1600 KVA / (Dry Type)

C.1.2 <u>Comparison of Maximum Demand for three shopping center (A, B,C) Refer to IEEE STd 241-1990</u>

Type of Store	Shopping Center A, New Jersey No Refrigeration*		Shopping Center B, New Jersey Refrigeration		Shopping Center C, New York Refrigeration	
	Gross Area m^2	VA/m^2	Gross Area m^2	VA/m^2	Gross Area m^2	VA/m^2
Bank	60	150			400	140
Book	370	100	250	110		
Candy	160	110			200	160
Department	34350	80	22200	110	22690	120
	8400	50	11400	90		
Drug	700	100	600	120		
Men's wear	1700	90	1700	150	200	160
	2800	80	910	140		
Paint					1560	130
Pet					200	180
Restaurant	40	150			400	140
Shoe	1100	100	700	180	330	225
	400	120	440	180	210	190
Supermarket	3200	90	2500	130	3760	170
Variety	3100	80	2400	110	3740	110
	3000	80			3000	110
Women's wear	2040	80	1930	135	136	190
	100	90	450	150	100	180

Table (3)

* Loads include all lighting and power, but no power for air-conditioning refrigeration (chilled water), which is supplied from a central plant.

- Referance to above table we can consider the maximum demand for tenant areas which is supplied from central plant for chilled water for A/C shall be 150 VA/m^2
- But for tenant classification with A/C refrigeration the maximum demand shall be 220 VA/m^2

C.1.3 **Sample Calculation for (Mall) By Specific Surface Area Loading (VA/m^2) Refer to the table (1) and Table (3)**

The requirement can be changed depending on the changes of the project built up area mall's retail mix, types and sizes of anchor shops, restaurant and other features.

<table>
<tr><th colspan="2">Floor</th><th>Area (m^2)</th><th>(VA/m^2) (Average)</th><th>M.D.L. Power (KVA)</th></tr>
<tr><td colspan="2">2nd basement</td><td>11780</td><td>50</td><td>589</td></tr>
<tr><td colspan="2">Chillers + C.Tower+ pumps</td><td>119919.9</td><td>100</td><td>11991.99</td></tr>
<tr><td rowspan="4">1st Basement (Refrigeration)</td><td>Hyper</td><td>6110.0</td><td>150</td><td>916.5</td></tr>
<tr><td>Retail shops</td><td>3337.17</td><td>150</td><td>500.57</td></tr>
<tr><td>Kiosks area</td><td>304.31</td><td>75</td><td>22.823</td></tr>
<tr><td>Car parking</td><td>83800</td><td>50</td><td>4190</td></tr>
<tr><td colspan="2">Ground Floor (Refrigeration)</td><td>55250</td><td>150</td><td>8287.5</td></tr>
<tr><td colspan="2">Mezzanine Floor (Refrigeration)</td><td>55000</td><td>150</td><td>8250</td></tr>
<tr><td colspan="4">M.D.L. (KVA)</td><td>34159.38</td></tr>
<tr><td colspan="5">No. of transformers 1600 KVA (11/0.415) KV = 34159.38/(1600X0.85) = 25 trans. (refer to item C.1.1.3)</td></tr>
<tr><td colspan="5">No. of (11/0.415) KV substation = 5 No. S/S
S.S(1) / 5 Tr – S.S(2)/5 Tr. – S.S(3)/ 5 Tr.
S.S(4) / 5 Tr. – S.S (5) / 5 Tr</td></tr>
<tr><td colspan="5">For (66/11) KV Power Transformer required $= \dfrac{34159.38 \times 0.8 \text{ (D.F at H.V)}}{0.85 \text{ (Tx. Load \%)}} = 32.15$ MVA</td></tr>
<tr><td colspan="5">So Applicable 40 MVA, (66/11) KV Transformer</td></tr>
</table>

Table (4)

C.1.4 <u>Maximum Demand Loads (D.F) Refer to BS Standard and IEEE</u>

So, demand (or demand load). The electrical load at the receiving terminals averaged over a specified interval of time. Demand is expressed in kilowatts, kilovolt-amperes. The interval of time generally 15 minutes, 30 minutes, or 60 minutes. Shown in Fig. (1)

Note: if there are two 50 hp motors (which drive 45 hp loads) connected to the electric power system but only one load is operating at any time, the demand load is only 45 hp but the connected load is 100 hp.

Demand factor. The ration of the maximum demand of a system to the total connected load of the system.

Notes:

(1) since demand load cannot be greater than the connected load, the demand factor cannot be greater than unity.

(2) Those demand factors permitted by the standard (for example, services and feeders) should be considered when sizing the electric system (with few exceptions, this is 100%); otherwise, the circuit may be sized to support the load.

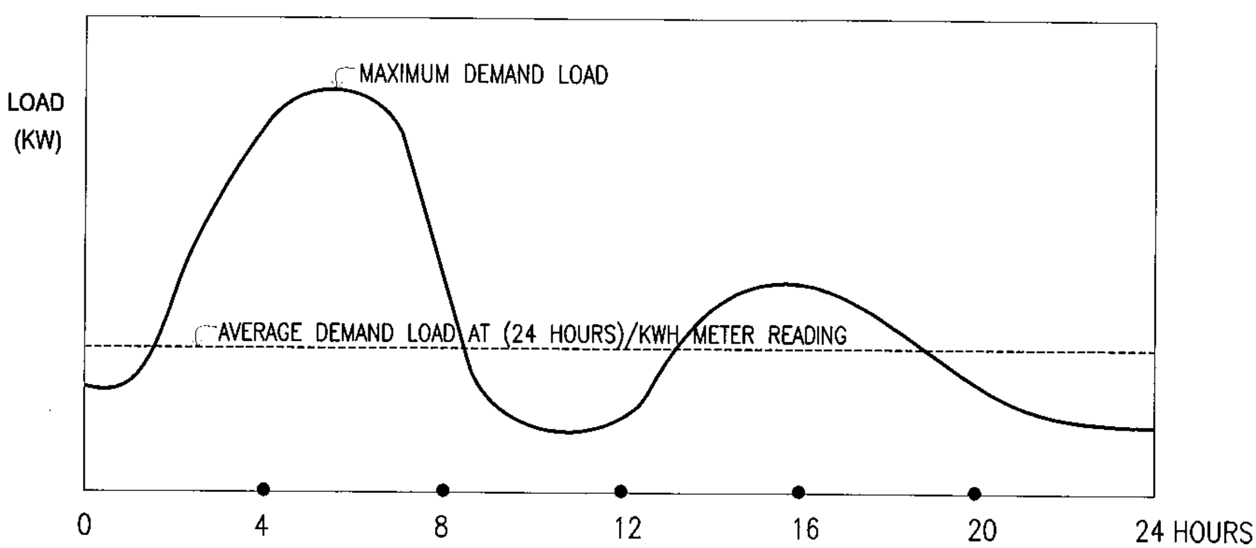


Figure (1)

DEMAND LOAD WITH DAY HOURS

C.1.4.1 <u>Maximum Demand Factor According to BS standard</u>

	A/C	WATER HEATER	COOKER	POWER LOAD	LIGHTING LOAD
RESIDENTIAL BUILDING	1	0.3	0.4	0.66	0.66
OFFICE BUILDING	1	0.3	0.4	0.8	0.9

Notes: Average Demand during 24 Hours (Actual Power Consumption KWh)

= M.D.L x 24 (hr) x (0.5-0.6)

C.1.4.2 <u>Demand Factor According to IEEE STd 241-1990</u>

Connected Load and Maximum Demand by Tenant Classification

Classification	Demand Factor
Women's wear	0.75
Men's wear	0.78
Shoe store	0.79
Department store	0.74
Variety Store	0.45
Drug store	0.57
Household goods	0.76
Specialty shop	0.79
Bakery and candy	0.71
Food store (supermarkets)	0.60
Restaurant	0.45
School, offices	0.8
Residential	0.7
Hotel	0.7
Hospitals	0.75

C.1.5 <u>Diversity Factor Refer to IEEE</u>

Diversity factor. The ratio of the sum of the individual maximum demands of the subdivisions of the system (D_1, D_2, D_3,…..) to the maximum demand of the complete system (D_5) as shown in Fig. (2)

Note: Since maximum demand of system cannot be greater than the sum of the individual demands, the diversity factor will always be equal to or greater than unity.

$$\text{DIVERSITY FACTOR} = \frac{D1 + D2 + D + \ldots + Dn}{Ds} \geq 1$$

EXAMPLE

M.D.L(1)/D1 = 100KW AT 9:00 AM
M.D.L(2)/D2 = 200KW AT 10:00 AM
M.D.L(3)/D3 = 300KW AT 11:00 AM

SO (D1 + D2 + D3) = 600KW…. (Individually)

BUT Ds (FROM LOAD CURVE) = 500KW…….(24 Hours operation with each others)

$$\text{DIV. FACTOR} = \frac{D1 + D2 + D3}{Ds} = \frac{600}{500} = 1.2$$

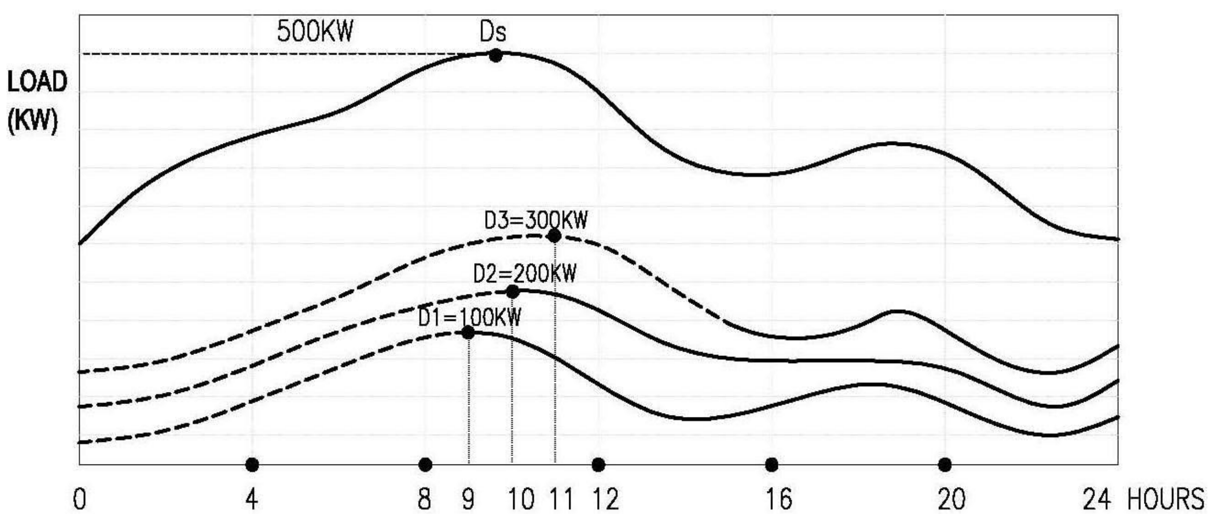


Figure (2)

DIVERSITY LOAD WITH DAY HOURS

C.1.6 <u>CONCLUSION</u>

$$\text{ACTUAL REQUIRED LOAD} = \frac{\text{T.C.L X D.F}}{\text{DIV. FACTOR}}$$

C.2 ILLUMINATION CALCULATIONS.

C.2.1 Calculations for Indoor Lighting Refer to IES Standard

DEFINATION

Lux. The metric measure of illuminance that is equal to 1 lumen uniformly incident upon 1 m^2 (1 lux = 0.0929 fc)

Reflectance. The ratio of light reflected by surface to the light incident. An approximation of diffuse surface's reflectance may be obtained with a light meter. Surface specularity will greatly affect reflectance measurement.

Coefficient of utilization (CU). For a specific room, the ratio of the average lumens delivered by a luminaire to a horizontal work plane to the lumens generated by the luminaire's lamps alone.

Efficacy. See lumens per watt (lm/W)

Fixture. See luminaire.

Footcandle (fc). A unit of illuminance (light incident upon a surface) that is equal to 1 lm/ft^2. In the international system, the unit of illuminance is lux (1 fc = 10.76 lux).

Glare. The undesirable sensation produced by luminance within the visual field. It may cause annoyance.

High-intensity discharge (HID) lamps. A group of lamps filled with various gases that are generically known as mercury, metal halide, high-pressure sodium, and low-pressure sodium.

illuminance. The unit density of light flux (lm/unit area) that is incident on a surface system the metric system, 1 lm/m^2 = 1 lux.

Lamp. Generic term for manmade source of light.

Lumen (lm). The International unit of luminous flux or the time rate of the flow of light.

Luminaire. A complete lighting unit that consists of parts designed to position a lamp (or lamps) in order to connect it to the power supply and to distribute its light.

Luminaire efficiency. The ratio of lumens emitted by luminaire and of the lumens generated by the lamp (or lamps) used.

RCR	room cavity ratio
CCR	ceiling cavity ratio
FCR	floor cavity ratio
K	room index factor

❖ **<u>Best and accurate method for calculations Refer to IES it is (Zonal – cavity method) 5 steps for calculation as following:-</u>**

C.2.1.1 **<u>Selection of levels of illumination (E)</u>** according to type of activity from table (5)

C.2.1.2 **<u>Calculate coefficient of utilization factor (U)</u>** which define the relation between lumen reaching to working plan compared to lumen emitted from light fixtures in the space.

To calculate (U) it is important to determine the following:-

- RCR (Room Cavity Ratio) = 5 h (L+W)/LxW

  L Length of the room

  W Width of the room

  h Distance between fitting & working plan

  h_{cc} Distance between ceiling and fitting

  h_f Distance between floor and working plan
- CCR (Ceiling Cavity Ratio) = 5 h_{cc} (L+W)/LxW
- FCR (Floor Cavity Ratio) = 5h_f (L+W)/LxW
- Determine PCC (Effective Floor Cavity Reflectance) from table (2) by using CCR and reflectances
- By using reflectances of (Ceiling – wall – floor), Pcc and RCR we can determine (U) from table (3)

C.2.1.3 **Depreciation factor (d): for environment, diffuser and maintenance from table (1)**

	Depreciation Factor (d)	
Environment	Open Fittings	Suitable for the Environment
Clean	0.8	0.9
Average	0.72	0.8
Dirty	0.64	0.7

Table (1)

C.2.1.4 **<u>Calculation No. of light fittings by using the following formula:</u>**

N = E*A/ nxØxUxd

Where E : Average required illuminance refer to table (5)

n : Number of tubes per fitting

U : Utilization factor from table (3)

Ø : Lumen Flux of one tube from table (4)

N : Number of Lumenaires (Fittings)

A : Area of the room (L x W)

C.2.1.5 **<u>Distribution and Location of Lighting Fixtures</u>**

C.2.2 Illumination Calculation form

Project: (……XXXX……….) / Floor: (……XXXX………..) / Room: (…OFFICE………..)

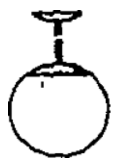
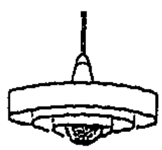
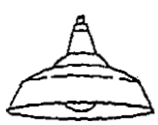
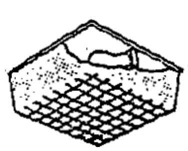
Width (Room) w(m)	10.0
Length (Room) l (m)	15.0
Area (Room) (A) = lxw(m2)	150
Room height hr (m)	3.0
Working plan height h_f (m)	0.85
Height of lumenaire above working level (m) h=hr – 0.85	2.15
Distance between ceiling and fitting h_c (m)	0
Room index factor k=lxw/h (l+w)	2.79
Reflectances at (ceiling / wall / working plane)	70/50/30
RCR (room cavity ratio) = 5/k = 5h (L+W)/LxW	1.79
CCR (Ceiling cavity ratio) = 5 h_c (L+W) / LxW	0
FCR (Floor cavity ratio) = 5 h_f (L+W) / LxW	0.759
PCC from table (2)	70
U (utilization factor) from table (3)	0.57
Purpose of room	OFFICE
Nominal Illuminace (E) from table (5)	500
Luminair type	4X18W FL.
n (No. of lamps per fitting)	4
Nominal luminous flux (Ø) per tube from table (4)	1100
Depreciation factor (d) from table (1)	0.8
Calculated Number of fittings (N) = E.A / nxØxuxd	37.38
Distribution	5 Row x 8 Columns = (40 Luminair)

PCC, PW According To IES Standard

جدول رقم (٢): القيمة الفعالة لمعاملات إنعكاس فجوتي السقف والأرضية																					
Percent Ceiling Or Floor Reflectance		90				80				70			50			30				10		
Percent Wall Reflectance		90	70	50	30	80	70	50	30	70	50	30	70	50	30	65	50	30	10	50	30	10
Ceiling Or Floor Cavity Ratio	0	90	90	90	90	80	80	80	80	70	70	70	50	50	50	30	30	30	30	10	10	10
	0.1	90	89	88	87	79	79	78	78	69	69	68	59	49	48	30	30	29	29	10	10	10
	0.2	89	88	86	85	79	78	77	76	68	67	66	49	48	47	30	29	29	28	10	10	9
	0.3	89	87	85	83	78	77	75	74	68	66	64	49	47	46	30	29	28	27	10	10	9
	0.4	88	86	83	81	78	76	74	72	67	65	63	48	46	45	30	29	27	26	11	10	9
	0.5	88	85	81	78	77	75	73	70	66	64	61	48	46	44	29	28	27	25	11	10	9
	0.6	88	84	80	76	77	75	71	68	65	62	59	47	45	43	29	28	26	25	11	10	9
	0.7	88	83	78	74	76	74	70	66	65	61	58	47	44	42	29	28	26	24	11	10	8
	0.8	87	82	77	73	75	73	69	65	64	60	56	47	43	41	29	27	25	23	11	10	8
	0.9	87	81	76	71	75	72	68	63	63	59	55	46	43	40	29	27	25	22	11	9	8
	1.0	86	80	74	69	74	71	66	61	63	58	53	46	42	39	29	27	24	22	11	9	8
	1.1	86	79	73	67	74	71	65	60	62	57	52	46	41	38	29	26	24	21	11	9	8
	1.2	86	78	72	65	73	70	64	58	61	56	50	45	41	37	29	26	23	20	12	9	7
	1.3	85	78	70	64	73	69	63	57	61	55	49	45	40	36	29	26	23	20	12	9	7
	1.4	85	77	69	62	72	68	62	55	60	54	48	45	40	35	28	26	22	19	12	9	7
	1.5	85	76	68	61	72	68	61	54	59	53	47	44	39	34	28	25	22	18	12	9	7
	1.6	85	75	66	59	71	67	60	53	59	52	45	44	39	33	28	25	21	18	12	9	7
	1.7	84	74	65	58	71	66	59	52	58	51	44	44	38	32	28	25	21	17	12	9	7
	1.8	84	73	64	56	70	65	58	50	57	50	43	43	37	32	28	25	21	17	12	9	6
	1.9	84	73	63	55	70	65	57	49	57	49	42	43	37	31	28	25	20	16	12	9	6
	2.0	83	72	62	53	69	64	56	48	56	48	41	43	37	30	28	24	20	16	12	9	6

Table (2)

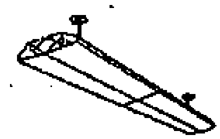
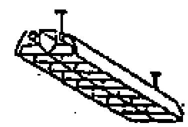
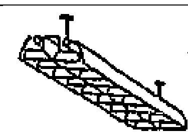
PCC, PW According to IES Standard

Typical Luminaire	PCC [a]	80			70			50			30			10			0
	PW [b]	50	30	10	50	30	10	50	30	10	50	30	10	50	30	10	0
	RCR [c]	Coefficients of Utilization for 20 Per Cent Effective Floor Cavity Reflectance (PFC = 20)															
1	0	.87	.87	.87	.81	.81	.81	.69	.69	.69	.59	.59	.59	.49	.49	.49	.44
	1	.71	.67	.63	.66	.62	.59	.50	.53	.50	.47	.45	.43	.39	.37	.35	.31
	2	.61	.54	.49	.56	.50	.46	.47	.43	.39	.39	.36	.33	.32	.29	.27	.23
	3	.52	.45	.39	.48	.42	.37	.41	.36	.31	.34	.30	.26	.27	.24	.22	.18
	4	.46	.38	.33	.42	.36	.30	.36	.30	.26	.30	.26	.22	.24	.21	.18	.15
	5	.40	.33	.27	.37	.30	.25	.32	.26	.22	.26	.22	.10	.21	.18	.15	.12
	6	.36	.28	.23	.33	.26	.21	.28	.23	.19	.23	.19	.16	.19	.15	.13	.10
	7	.32	.25	.20	.29	.23	.18	.25	.20	.16	.21	.16	.13	.17	.13	.11	.09
	8	.29	.22	.17	.27	.20	.16	.23	.17	.14	.19	.15	.12	.15	.12	.09	.07
Pendant diffusing sphere	9	.26	.19	.15	.24	.18	.14	.20	.15	.12	.17	.13	.10	.14	.11	.08	.06
with incandescent lamp	10	.23	.17	.13	.22	.16	.12	.19	.14	.10	.16	.12	.09	.13	.09	.07	.05
2	0	.83	.83	.83	.71	.71	.71	.49	.49	.49	.30	.30	.30	.12	.12	.12	.03
	1	.72	.69	.66	.62	.60	.57	.43	.42	.40	.26	.25	.25	.10	.10	.10	.03
	2	.63	.58	.54	.54	.50	.47	.38	.36	.33	.23	.22	.21	.09	.09	.08	.02
	3	.55	.49	.45	.48	.43	.39	.33	.30	.28	.20	.19	.17	.08	.08	.07	.02
	4	.48	.42	.37	.42	.37	.33	.29	.26	.24	.18	.16	.15	.07	.07	.06	.02
	5	.43	.36	.32	.37	.32	.28	.26	.23	.20	.16	.14	.13	.06	.06	.05	.01
	6	.38	.32	.27	.33	.28	.24	.23	.20	.17	.14	.12	.11	.06	.05	.04	.01
	7	.34	.28	.23	.30	.24	.21	.21	.17	.15	.13	.11	.09	.05	.04	.04	.01
Concentric ring unit with	8	.31	.25	.20	.27	.21	.18	.19	.15	.13	.12	.10	.08	.05	.04	.03	.01
incandescent. silvered -	9	.28	.22	.18	.24	.19	.16	.17	.14	.11	.10	.09	.07	.04	.03	.03	.01
bowl lamp	10	.25	.20	.16	.22	.17	.14	.16	.12	.10	.10	.08	.06	.04	.03	.03	.01
3	0	.99	.99	.99	.97	.97	.97	.92	.92	.92	.88	.88	.88	.85	.85	.85	.83
	1	.88	.85	.82	.86	.83	.81	.83	.80	.78	.79	.78	.76	.77	.75	.73	.72
	2	.78	.73	.68	.76	.72	.67	.73	.89	.66	.71	.67	.64	.68	.65	.63	.61
	3	.69	.62	.57	.67	.61	.57	.65	.60	.56	.63	.58	.55	.61	.57	.54	.52
	4	.61	.54	.49	.60	.53	.48	.58	.52	.48	.56	.51	.47	.54	.50	.46	.45
	5	.54	.47	.41	.53	.46	.41	.51	.45	.41	.50	.44	.40	.48	.43	.40	.28
	6	.48	.41	.35	.47	.40	.35	.46	.39	.35	.44	.39	.34	.43	.38	.34	.32
	7	.43	.35	.30	.42	.35	.30	.41	.24	.30	.39	.34	.30	.38	.33	.29	.28
Porcelain-enameled venti-	8	.38	.31	.26	.38	.31	.26	.37	.30	.26	.36	.30	.26	.35	.30	.26	.24
lated standard dome with	9	.35	.28	.23	.34	.27	.23	.33	.27	.23	.32	.27	.23	.31	.26	.22	.21
incandescent lamp	10	.31	.25	.20	.31	.24	.20	.30	.24	.20	.29	.24	.20	.29	.23	20	.16
4	0	.89	.89	.89	.85	.85	.85	.77	.77	.77	.70	.70	.70	.63	.63	.63	.60
	1	.78	.75	.72	.74	.72	.69	.68	.66	.64	.62	.60	.58	.56	.55	.54	.51
	2	.69	.65	.61	.66	.62	.58	.61	.57	.54	.56	.53	.50	.51	.49	.47	.44
	3	.62	.57	.52	.60	.55	.50	.55	.51	.47	.50	.47	.44	.46	.44	.41	.39
	4	.56	.50	.46	.54	.49	.44	.50	.45	.42	.46	.42	.39	.42	.39	.37	.35
	5	.51	.45	.40	.49	.43	.39	.45	.41	.37	42	.38	.35	.39	.36	.33	.31
	6	.46	.40	.36	.45	.39	.35	.42	.37	.33	.39	.35	.31	.36	.32	.30	.28
	7	.42	.36	.32	.41	.35	.31	.38	.33	.29	.35	.31	.28	.33	.29	27	.25
	8	.39	.32	.28	.37	.32	.28	.35	.30	.26	.32	.28	.25	.30	.27	.24	.22
Prismatic square surface	9	.35	.29	.25	.34	.29	.25	.32	.27	.24	.30	.26	.23	.28	.24	.22	.20
drum	10	.32	.27	.23	.31	.26	.22	.29	.25	.21	.27	.23	.20	.26	.22	.20	.18

a. PCC = Per Cent Effective Ceiling Cavity Reflectance.
b. PW = Per Cent Wall Reflectance.
c. RCR = Room Cavity Ratio.
d. Maximum S/MH = Guide-Ratio of Maximum Luminaire Spacing to Mounting or Ceiling Height above Work-Plane.

Table (3)

PCC, PW According to IES Standard

PCC	80			70			50			30			10			0	Typical Luminaries And Luminaire Maintenance Category
PW	50	30	10	50	30	10	50	30	10	50	30	10	50	30	10	0	
RCR	Coefficients Of Utilization For 20 Percent Effective Floor Cavity Reflectance Prc																
1	.70	.68	.65	.65	.63	.61	.55	.53	.52	.45	.45	.44	.37	.36	.36	.32	
2	.62	.58	.55	.58	.54	.51	.49	.47	.44	.41	.39	.38	.34	.33	.32	.28	
3	.56	.50	.47	.52	.47	.44	.44	.41	.38	.37	.35	.33	.30	.29	.28	.25	
4	.49	.44	.40	.46	.41	.38	.40	.36	.33	.33	.31	.29	.28	.26	.25	.22	
5	.44	.39	.35	.41	.36	.33	.36	.32	.29	.30	.27	.25	.25	.23	.22	.20	
6	.40	.34	.30	.37	.32	.29	.32	.28	.25	.27	.24	.22	.23	.21	.19	.17	2- Lamp Prismatic Lens Bottom Unit With Open Top LDD Maint. Category II
7	.36	.30	.26	.34	.28	.25	.29	.25	.22	.25	.22	.19	.21	.19	.17	.15	
8	.33	.27	.23	.30	.25	.22	.26	.22	.20	.22	.20	.17	.19	.16	.15	.13	
9	.29	.24	.20	.27	.22	.19	.24	.20	.17	.20	.17	.15	.17	.15	.13	.11	
10	.27	.21	.18	.25	.20	.17	.22	.18	.15	.19	.15	.13	.16	.13	.12	.11	
1	.79	.76	.73	.73	.70	.68	.62	.60	.58	.51	.50	.49	.42	.41	.40	.36	
2	.70	.65	.61	.65	.61	.57	.55	.52	.50	.46	.44	.42	.38	.36	.35	.32	
3	.62	.56	.52	.58	.53	.49	.49	.46	.43	.41	.39	.36	.34	.33	.31	.28	
4	.55	.49	.44	.51	.46	.42	.44	.40	.37	.37	.34	.32	.31	.29	.27	.24	
5	.49	.43	.38	.46	.42	.36	.42	.35	.32	.34	.3	.27	.29	.25	.24	.21	Direct Indirect With Metal Or Dense Diffusing Sides And 35° X 45° Louver Shielding LDD Maint. Category II
6	.44	.39	.31	.41	.35	.31	.36	.31	.28	.3	.27	.24	.25	.23	.21	.19	
7	.40	.34	.29	.37	.31	.27	.32	.28	.24	.27	.24	.21	.23	.20	.19	.18	
8	.35	.29	.25	.33	.27	.24	.29	.24	.21	.24	.21	.18	.20	.18	.16	.14	
9	.32	.25	.21	.30	.24	.20	.26	.21	.18	.22	.19	.16	.19	.16	.14	.12	
10	.30	.23	.19	.28	.22	.19	.24	.20	.16	.20	.17	.14	.17	.14	.12	.12	
1	.70	.67	.65	.64	.61	.60	.52	.31	.50	.42	.41	.40	.32	.32	.31	.27	
2	.62	.58	.54	.57	.53	.50	.47	.45	.42	.38	.36	.35	.29	.29	.28	.24	
3	.55	.50	.46	.50	.46	.43	.42	.39	.37	.34	.32	.30	.27	.26	.25	.21	
4	.49	.44	.40	.45	.40	.37	.38	.35	.32	.31	.29	.27	.25	.23	.22	.19	Direct Indirect With Metal Or Dense Diffusing Sides And 45° Louver Shielding LDD Maint. Category II
5	.44	.38	.34	.40	.36	.32	.34	.30	.28	.28	.25	.24	.22	.20	.19	.17	
6	.40	.34	.30	.37	.32	.28	.31	.27	.25	.25	.23	.21	.20	.19	.17	.15	
7	.36	.30	.26	.33	.28	.25	.28	.24	.22	.23	.20	.18	.19	.17	.15	.14	
8	.32	.27	.23	.30	.25	.22	.26	.22	.19	.21	.19	.17	.17	.15	.14	.12	
9	.39	.24	.20	.27	.22	.19	.23	.19	.17	.19	.16	.15	.16	.14	.12	.11	
10	.27	.22	.18	.25	.20	.17	.21	.18	.15	.18	.15	.13	.14	.12	.11	.10	

Continues of Table (3)

Table (4)

The lamps lumen acc to (IES)

LAMP TYPE	***WATT***	***DIAMETER mm***	***LENGTH mm***	***LUMEN***
Standard fluorescent T26	18	26	590	1050
				1100
				1150
	36	26	1200	2500
				2600
				2850
	58	26	1500	4000
				4100
				4600
High efficiency fluorescent	18	26	590	1300
				1350
	36	26	1200	3250
				3350
	58	26	1500	5200
Compact fluorescent lamp TC-D	10	-	112	600
	13	-	141	900
	18	-	171	1200
	26	-	184	1800
Compact fluorescent lamp TC	5	-	108	250
	7	-	138	400
	9	-	168	600
	11	-	238	900
Compact fluorescent lamp TC-L	18	-	217	1200
	24	-	317	1800
	36	-	411	2900
Low voltage tungsten halogen lamp	10	9	31	140
	20	9	31	350
	50	12	44	950

LAMP TYPE	***WATT***	***DIAMETER mm***	***LENGTH mm***	***LUMEN***
Mercury vapor lamp	50	55	130	1800
	80	70	156	3800
	125	75	170	6300
	250	90	226	13000
	400	120	290	22000
	700	140	330	40000
	1000	165	390	58000
Metal halide	35	25	84	2400
	70 single ended	25	84	5200
	70 double ended	20	114.2	5500
	150 single ended	25	84	12500
	150 double ended	23	132	11250
	250	46	225	19000
	250	90	226	17000
	400	46	285	33000
	400	120	290	31000
	400	120	290	40000
	1000	76	340	80000
	2000	100	430	170000
High pressure sodium lamp	50	70	156	3500
	70	70	156	5600
	150	90	226	14500
	250	90	226	25000
	400	120	290	47000
	400	46	275	48000
	1000	165	400	120000
	1000	65	400	130000

☻ *the table refeer to IES*

Table (5)

ROOM ILLUMINATION LEVEL (E) ACC. TO (IES)

GENERAL BUILDING AREA	IES STANDARD ILLUMINATION LEVEL
Fine bench and machine work fine sanding, finishing	750
OFFICE	
General office with mainly electrical task and typing office	500
Deep plan general offices	750
Business machine and typing	750
Filing room	300
Conference rooms	750
OFFICES AND SHOPS	
Executive office	500
Computer rooms	500
Punch card rooms	750
Drawing offices drawing board	750
Reference table and general	500
Print room	300
SHOP	
Conventional with counters	500
Conventional with wall display	500
SHOP	
Self service	500
Supermarkets	500
Hypermarkets	500
General	500
PUBLIC AND EDUCATIONAL BUILDING ASSEMBLY AND CONCERT HALLS	
Theatre and concert halls	100
Cinemas	50
Multipurpose	500
FURTHER EDUCATION ESTABLISHMENT	
Lecture theatre general	500
Chalkboard	500
Demonstration benches	500
Examination halls, seminar rooms, teaching spaces	500
Laboratories	500

GENERAL BUILDING AREA	IES STANDARD ILLUMINATION LEVEL
FURTHER EDUCATION ESTABLISHMENT	
Workshop	300
Staff rooms, student rooms / student hostels etc.	300
LIBRARIES	
Shelves, book stack	150
Reading table	300
Reading rooms, newspaper and magazine	300
Reference libraries	500
Counters	500
Cataloging and sorting	500
Binding	500
Closed book store	100
MUSEUM AND ART GALLERIES GENERAL	
Exhibits insensitive to light	300
Light sensitive exhibits	150
Specially light sensitive exhibits	50
SCHOOL	
Assembly halls general	300
Platform and stage	Special lighting
Teaching spaces general	300
Teaching spaces general	300
General where also used for further education	500
Chalkboard	500
Beedlework rooms	500
Art rooms	500
Laboratories	500
Workshop	300
Gymnasium	300
Music practice rooms	300

GENERAL BUILDING AREA	IES STANDARD ILLUMINATION LEVEL
TRANSPORTS TERMINAL BUILDING	
Airport coach and railway station	
Reception area (desk)	500
Customs and immigration halls	500
Railways station booking offices	500
Railways station parcel and left luggage offices counter	300
Circulation area	150
Waiting area	300
HOSPITALS	
Ward unit bed heads general	30-50
General	150
Night	0.1
Nurse station evening	300
Pharmacies dispensing bench	500
Shelves	150
Reception general	300
Enquiry desk	500
Laboratories	500
Operating theatre suits general	400
Operating area	Special
Recovery room and intensive care units	30-50
X-ray department radio- diagnostic and rooms fluoroscopy	500
Dental surgeries	500
HOMES	
Living rooms general	50
Casual reading	150
Sewing darningsrudies desk and protuges	300
Bedroom general	50
Bedlead kitchen	150
Kitchen working areas	300
Bathrooms	100
Halls and landings	150
Stairs	100
Workshops	300
Garages	50

GENERAL BUILDING AREA	IES STANDARD ILLUMINATION LEVEL
INDOOR SPORTS AND RECREATIONAL BUILDING	
MULTIPURPOSE SPORTS HALLS	
Athletics, basketball, bowls, judo	300
Hockey	700
BADMINTON COURTS	300
BILLIARD ROOMS	
General	100
Table	Special lighting
CARD ROOMS	300
GYMNASIA GENERAL	500
SWIMMING POOL	
Top pool	500
Spectator areas	150
Club recreational	300
GENERAL	
Changing rooms showers lookers rooms	150
TABLE TENNIS	
Club	300
Recreational	200
CIRCULATION AREA	
Corridors, Passageway	100
Lift	150
Stairs	150
Escalator	150
External Covered ways	30
ENTRANCES	
Entrance halls, lobbies, waiting rooms	150
Enquiry desk	500
Gate houses	300

GENERAL BUILDING AREA	IES STANDARD ILLUMINATION LEVEL
KITCHENS	
Food store	150
General	500
OUTDOOR	
Controlled entrance halls or exits gate	150
Entrance and exit car park	30
Stores, stockyards	30
Industrial covered ways	50
STAFF RESTAURANTS	
Centre cafeterias, dining room	300
MEDICAL AND FIRST AIDS CENTRES	
Consultant room, treatment area	500
Medical stores	100
Rest room	150
STAFF ROOM	
Changing locker and cleaner’s room, cloakrooms lavatories	150
Rest rooms	150
STORE AND STOCK ROOMS	150
Telecommunication board switchboard rooms	
Cordless switchboard	300
Apparatus rooms	150
Teteprinter rooms	500
AIRCRAFT MAINTENANCE HANGERS	
Aircraft engine testing	750
Inspection and repairs (hanger)	500
BOILER HOUSE GENERAL	150
FIRE STATIONS	
Appliance room	300
External apron	30

GENERAL BUILDING AREA	IES STANDARD ILLUMINATION LEVEL
GARAGES	
External apron general	50
Pumps	300
Parking areas (interior) general repairs servicing	30
Greasing, pits washing, polishing	500
GAS WORKS	
Exterior walkways and platforms	50
Exterior stairs and ladders	100
Resort house, oil gas plants, watergas plant purifier, indoor cook, screening and handling plants	100
Booster and exhauster houses	150
GAUGE TOOLS ROOMS	
General	1000
INSPECTION & TESTING SHOP	
Rough work e.g. counting rough Checking of stock parts	300
Medium work e.g. ‘go’ & ‘no go’ gauges sub-assemblies	500
Fine work e.g. radio and telecommunication equipment, calibrated scales, precision mechanism, instruments	1000
Very fine work e.g. gauging and inspections of small intricate parts	1500
Minute work e.g. very small instruments	3000
LABORATORIES	
(General)	750
LAUNDARIES & DRY CLEANING WORKS	
Receiving, sorting, washing, drying, ironing (clending) dispatch, drying cleaning, bulk machine work	300
Hand ironing, pressing, inspection, mending, spotting	

GENERAL BUILDING AREA	IES STANDARD ILLUMINATION LEVEL
MACHINE & FITTING SHOP	
Rough bench and machine work	300
Medium bench and machine work, ordinary automatic machines, rough grinding, medium buffing, polishing	500
Fine bench and machine work, ordinary automatic machines rough grinding, medium buffing, polishing	1000
PARMACEUTICAL & FINE CHEMICAL WORKS PHARMACEUTICAL MANUFACTURE	
Grinding, granulating mixing and drying, tableting, sterilizing and washing, preparation of solutions and filling, labeling capping, cartooning, warping.	500
Inspection	750
Fine Chemical manufacture, plant processing	300
Fine chemical finishing	500
Raw material store	300
Inspection	750
PRINTING WORKS TYPE FOUNDRIES	
Matrix making, dressing type hand and machine casting	300
Front assembly sorting	750
COMPOSING PRESS	
Hand composing, imposition and distribution	750
Machine Composition-keyboard	750
Machine Composition-casting	300
Proof press	500
Illuminated tables general lighting	300
PRINTING MACHINE ROOM	
PRESSES	500
PREMAKE ready	500
Printed-sheet inspection	1000

GENERAL BUILDING AREA	IES STANDARD ILLUMINATION LEVEL
GRAPHIC REPRODUCTION	
General	500
Precision proofing, retouching, etching	1000
RUBBER PROCESSING FACTORIES	
Preparation needs, dipping molding, compounding calendaring	300
Type and tube making	500
SHEET METAL WORKS	
Bench, scribing, inspection	750
Pressing, punching, shearing stamping, spinning, folding	500
SLAUGHTER HOUSE	
General	500
Inspection	750
WELDING & SOLDERING SHOP	
Gas and are welding rough spot welding	300
Medium soldering, brazing spot welding e.g. domestic hand ware	500
Fine soldering, spot welding e.g. instrument	1000
Very fine soldering, spot welding e.g. radio valves	1500
WOODWORKING SHOP	
Rough sawing, benchwork	300
Sizing, planning, rough sanding medium and bench work gluing cooperage.	500

C.2.3 Referance handbook for LED's Lighting Calculation by dialux program

Items	11 (W) Spot light			31 (W) Spot light			Recessed (type -1) (600x1200mm)		
	Spacing	w/m²	Lux	Space (m)	w/m²	Lux	Space (m)	w/m²	Lux
Illumination	1.2x1.2	7.3	275	1.2x1.2	20.6	900	2.4x2.4	3.8 6.9 8.6	22w-250 40w-400 50w-550
	1.8x1.8	3.4	135	1.8x1.8	9.6	455	2.4x3	3 5.5 6.9	22w-220 40w-350 50w-500
	2.4x2.4	1.8	100	2.4x2.4	5.2	250	3x3	2.4 4.4 5.5	22w-200 40w-300 50w-420
	3x3	1.22	70	3x3	3.4	220	3x3.6	2 3.7 4.6	22w-160 40w-275 50w-370
Lumens	630			2000			22w / 40w / 50w 2000 / 3900/ 5000		
LPW (efficacy)	57			64			90-100		
CRI color rundering	90			90			90		
CCT (Kelvin)	3000K			4000K			4000K		
Warranty	(5-10) years			5 years			5 years		
Ceiling height	3.0m			3.0m			3.0m		
Reflectances	(80/50/20) %			(80/50/20) %			(80/50/20) %		
Working plan	0.75m			0.75m			0.75m		
Life time	50,000 HR			50,000 HR			75,000 HR		

Items	Recessed (type -2) (300x1200mm)			Recessed (type -3) (600x600mm)		
Illumination	Space (m)	w/m^2	Lux	Space (m)	w/m^2	Lux
	2.4x2.4	3.8 5.4 8.6	22w-240 31w-375 50w-550	2.4x2.4	3.8 5.6 8.6	22w-220 32w-360 50w-500
	2.4x3	3 4.3 6.9	22w-210 31w-330 50w-460	2.4x3	3 4.4 6.9	22w-200 32w-320 50w-430
	3x3	2.4 3.4 5.5	22w-180 31w-280 50w-400	3x3	2.4 3.5 5.5	22w-170 32w-275 50w-375
	3x3.6	2 2.8 4.6	22w-160 31w-250 50w-350	3x3.6	2 2.9 4.6	22w-150 32w-240 50w-330
Lumens	22w / 31w / 50w 2000 / 3300 / 5000			22w / 32w / 50w 2000 / 3200 / 5000		
LPW (efficacy)	90-100			90-110		
CRI color rundering	90			90		
CCT (Kelvin)	4000K			4000K		
Warranty	5-7 years			5-7 years		
Ceiling height	3.0m			3.0m		
Reflectances	(80/50/20) %			(80/50/20) %		
Working plan	0.75m			0.75m		
Life time	75,000 HR			75,000 HR		

C.3 CABLE SIZE CALCULATION FOR L. V NETWORK

C.3.1 Low voltage network cable size shall be selected according to three factors:

- Current carrying capacity (C.C.C).
- Voltage drop allowance (V.D).
- Short circuit current (S.C).

★ The designer should know that the short circuit current factor for L.V Network is negligible value and other two factor should be considered.

★ Most Important Calculation

Considered Calculation	L.V Networks	M.V. Networks
Current Carrying Capacity (I-Rated)	Mandatory	Mandatory
Voltage Drop Allowance (V.D)	Mandatory	Negligible effect
Short Circuit Current and Duration ($I_{S.C}$)	Negligible effect	Mandatory

★ A new appendix (12) is included in BS7671: 2008 for consumers' installations which deemed to comply with voltage drop design requirements of the Regulations.

This is 3% voltage drop for lighting and 5% voltage drop for others.

★ Find attached one case for cable size calculation.

C.3.2 <u>Cable Size Calculation Form</u>

Project **: XXX**

From **: MSB – A** **To: DB-1**

1. Current Carrying Capacity:

Voltage	415 (V)
Circuit Design Current (1_r)	71.77 (A)
Derating Factor for Ambient Temperature (K_1) table (5)	1.0
Derating Factor for Soil Resistivity (K_2) – table (6)	0.9
Derating Factor for Grouping (K_3) – table (7)	0.8
Derating Factor for Depth of Laying (K_4) – table (8)	0.985
Nominal Current for Protective Device	100 (A)
K= K1 x K2 x K3 x K4 = 0.709	
Derating Current (1_d) = Ir (A) /K = 71.77 / 0.709 = 101.2 (A)	
Minimum Cross Section = (4C, 50, PVC / PVC) mm^2	
Rated Current for this cable (C.C.C) (see attached table 1,2,3,4,5)= 119 (A)	
Rated current of the cable (C.C.C) > derating current (I_d)	OK

2. Voltage Drop:

Cable Length	65 (m)
Voltage Drop per meter Length per Amp from table (1,2,3,4,5)	0.81 mv/A/m
Circuit Design Current (Ir)	71.7 (A)
$V.D = \dfrac{Ir \times (mv/A/m) \times L}{1000} = 3.775$ Volt	
V.D= 0.9% ≤ (2.5 – 3) % General, / 5% for Motors	OK

★ Reference to (1) & (2) The minimum Cross Section = 50 mm^2

★ So, cable is fulfill C.C.C. & V.D requirement

Date	Eng.
XXX	XXX

Current Ratings for Cables and Voltage Drop Refer To B.S Standard

Table No. 01
Single Core PVC Insulated Cables in Conduit or Trunking at an Air Temperature of 45 °C BS.6004 Std

mm^2	1.5	2.5	4	6	10	16	25	35	50	70	95	120	150	185	240	300	400
Current Rating Amperes 2 Cables Single Phase	14	19	25	33	44	60	80	100	114	150	182	205	250	277	350	402	486
Voltage Drop Per Ampere Per Meter MV	27	16	10	6.8	4.0	2.6	1.6	1.2	0.97	0.71	0.56	0.48	0.41	0.38	0.37	0.36	0.34
Current Rating Amperes 3 Or 4 Cables Three Phase	12	17	23	30	41	53	70	90	100	140	170	200	215	250	300	350	407
Voltage Drop Per Ampere Per Meter MV	23	14	8.8	5.9	3.5	2.2	1.4	1.0	0.84	0.62	0.48	0.42	0.39	0.36	0.35	0.34	0.33

All Cables to be of 600 / 1000 Volts Grade. Solid Conductors Permitted only In The Case of 1.5 mm^2 and 2.5 mm^2 Cable.

Table No. 02
Two Core PVC Insulated, Steel Wire Armoured, PVC Sheathed Refer to BS 6346

mm^2	1.5	2.5	4	6	10	16	25	35	50	70	95	120	150	185	240	300	400
Voltage Drop Per Ampere Per Meter MV	28	17	11	4.1	4.0	2.6	1.6	1.2	0.97	0.71	0.56	0.48	0.41	0.38	0.37	0.36	0.34
Current Rating For Cable Laid Directly In The Ground Amperes	18	24	31	39	51	66	84	104	121	150	176	200	222	252	300	325	360
Current Rating For Cable Run In Underground Pipe Or Trench Amperes	18	24	30	37	50	65	83	100	119	143	172	200	220	250	240	320	360
Current Rating For Cable Run In Air Within A Building Amperes	17	23	30	39	53	70	100	115	150	180	215	260	300	350	400	450	500
Current Rating For Cable Run In Air On Exterior Of A Building Or Part Thereof Amperes	15	20	26	34	47	61	82	101	125	160	200	230	260	300	350	400	460

Table No. 03

Three And Four Cores PVC Insulated, Steel Wire Armoured, PVC Sheathed And PVC Insulated, PVC Sheathed (Unarmoured) Cables Refer to BS 6346 & BS 6004

mm^2	1.5	2.5	4	6	10	16	25	35	50	70	95	120	150	185	240	300	400
Voltage Drop Per Ampere Per Meter MV	24	15	9.1	6	3.6	2.2	1.5	1	0.81	0.57	0.42	0.34	0.29	0.24	0.2	0.18	0.17
Current Rating For Cable Laid Directly In The Ground Ampere	14	20	26	33	50	65	73	87	104	123	150	170	190	215	250	280	315
Current Rating For Cable Run In Underground Pipe Or Trench Ampere	14	20	25	32	42	54	70	82	100	120	150	164	190	210	250	262	300
Current Rating For Cable Run In Air Within A Building Ampere	15	20	26	33	45	60	80	100	119	150	200	220	300	350	400	450	-
Current Rating For Cable Run In Air On Exterior Of A Building Or Part Thereof Ampere	13	17	23	30	40	52	75	85	110	140	170	200	230	250	300	350	400

Table No. 04

Three and Four Cores XLPE Insulated, Steel Wire Armoured, PVC Sheathed Cables Refer to BS 5467

mm^2	16	25	35	50	70	95	120	150	185	240	300
Voltage Drop Per Ampere Per Meter MV	2.6	1.5	1.2	0.87	0.61	0.45	0.36	0.29	0.24	0.2	0.18
Current Rating For Cable Laid Directly In The Ground Amperes	71	93	112	133	164	195	223	251	285	329	366
Current Rating For Cable Run In Underground Pipe Or Trench Amperes	65	84	100	123	151	182	210	235	266	308	350
Current Rating For Cable Run In Air Within A Building Amperes	81	110	150	170	208	255	300	350	400	476	550
Current Rating For Cable Run In Air On Exterior Of A Building Or Part Thereof Amperes	80	102	136	150	200	250	276	323	367	450	500

Reference to BS Standard

TABLE (5)
Rating Factor for Ambient Temperature
(K1)

Ambient Temperature °C	25	30	35	40	45	50	55
PVC Insulated Cables	1.49	1.40	1.31	1.22	1.11	1.0	0.86
XLPE Insulated Cables	1.27	1.22	1.17	1.12	1.06	1.0	0.94

TABLE (6)
Rating Factors for Variation in Thermal Resistivity of Soil for Twin or Multi-Core Cables Laid Direct In The Ground
(K2)

Nominal Area Of Conductor mm^2	Thermal Resistivity Of Soil In K.M/W										
	0.7	0.8	0.9	1.0	1.2	1.5	2.0	2.5	3.0	3.5	4.0
1.5/2.5	1.12	1.09	1.07	1.04	1.0	0.94	0.86	0.80	0.75	0.70	0.66
4	1.13	1.10	1.07	1.05	1.0	0.94	0.85	0.79	0.74	0.69	0.65
6	1.14	1.10	1.07	1.05	1.0	0.93	0.85	0.79	0.74	0.68	0.64
10	1.15	1.11	1.08	1.05	1.0	0.93	0.85	0.78	0.73	0.67	0.63
16	1.16	1.12	1.08	1.05	1.0	0.93	0.84	0.77	0.72	0.66	0.62
25	1.17	1.13	1.09	1.05	1.0	0.93	0.83	0.77	0.71	0.65	0.61
35	1.17	1.13	1.09	1.06	1.0	0.92	0.83	0.76	0.71	0.65	0.61
50	1.17	1.13	1.09	1.06	1.0	0.92	0.83	0.76	0.71	0.65	0.61
70	1.18	1.14	1.09	1.06	1.0	0.92	0.83	0.75	0.70	0.64	0.60
95	1.18	1.14	1.09	1.06	1.0	0.92	0.83	0.75	0.70	0.64	0.60
120	1.19	1.14	1.10	1.06	1.0	0.92	0.82	0.75	0.69	0.63	0.59
150	1.19	1.14	1.10	1.06	1.0	0.92	0.82	0.75	0.69	0.63	0.59
185	1.19	1.14	1.10	1.06	1.0	0.92	0.82	0.74	0.69	0.63	0.59
240	1.20	1.15	1.10	1.07	1.0	0.92	0.81	0.74	0.69	0.63	0.69
300	1.20	1.15	1.10	1.07	1.0	0.92	0.81	0.74	0.69	0.63	,0.59
400	1.20	1.15	1.10	1.07	1.0	0.92	0.81	0.74	0.69	0.63	0.59

TABLE (7)
Group Rating Factors for More Than One Multi-Core Armoured or Unarmoured Cables
(K3)

No. of load conductors	2	3	4	6	6	8	10	12	14	16	18	20
Correction factor	0.8	0.7	0.65	0.6	0.57	0.52	0.48	0.45	0.43	0.41	0.39	0.38

TABLE (8)
Rating Factors for Depths of Laying For Cables Laid Direct In Ground or In Ducts
(K4)

Depth of laying meter		0.5	0.6	0.75	0.8	1.0	1.25	1.5	1.75	2.0	2.5	3 or more
Cables laid direct in ground	Up to 50 mm^2	1.000	0.990	0.976	0.971	0.951	0.941	0.931	0.921	0.910	0.900	0.891
	70 mm^2 to 300 mm^2	1.000	0.985	0.965	0.960	0.930	0.920	0.901	0.890	0.880	0.871	0.849

C.3.3 V.Drop and Impedance for Busbar at L.V Refer to BS EN 61439 Part 2 and IEEE STd 241-1990

Copper Busbur (Rated Current) in amper	Calculated actual Current Considered for V.D (Amp.)	Impedance (Z) at 3Ø / 50Hz ohm / KM	V.Drop (V) / 100m at 0.85 P.F / 50 Hz (at FLC)
600	600	0.127	13.2
800	800	0.096	13.3
1000	1000	0.05	8.7
1200	1250	0.045	9.4
1400	1400	0.039	9.47
1600	1600	0.033	9.05
2000	2000	0.0268	9.28
2500	2500	0.02	8.7
3000	3000	0.016	8.3
3500	3500	0.014	8.48
4000	4000	0.013	8.96
5000	5000	0.01	8.57
6300	6300	0.008	8.64

Table No. (9)

FLC – Full Load Current

EX: B.B(size)=1000A I (Actual)=800A

V.D (Table) =8.7V L(Meter)=150M

$$V.D=8.7\times\left(\frac{150}{100}\right)\times\left(\frac{800}{1000}\right)=10.44(v)$$

C.4 MAIN L.V SWITCH BOARD MANUFACTURING DIMENSIONS.
REFER TO IEC 61439-2 STANDARD

C.4.1 Size of main Switch Board is depending on horizontal and vertical arrangement for protection devices, cables compartments and spaces for devices and compartments should be calculated by (module) where the module is considered (126mm) vertically or horizontally. As shown in figure (1).

C.4.1.1 CALCULATION CONCEPT

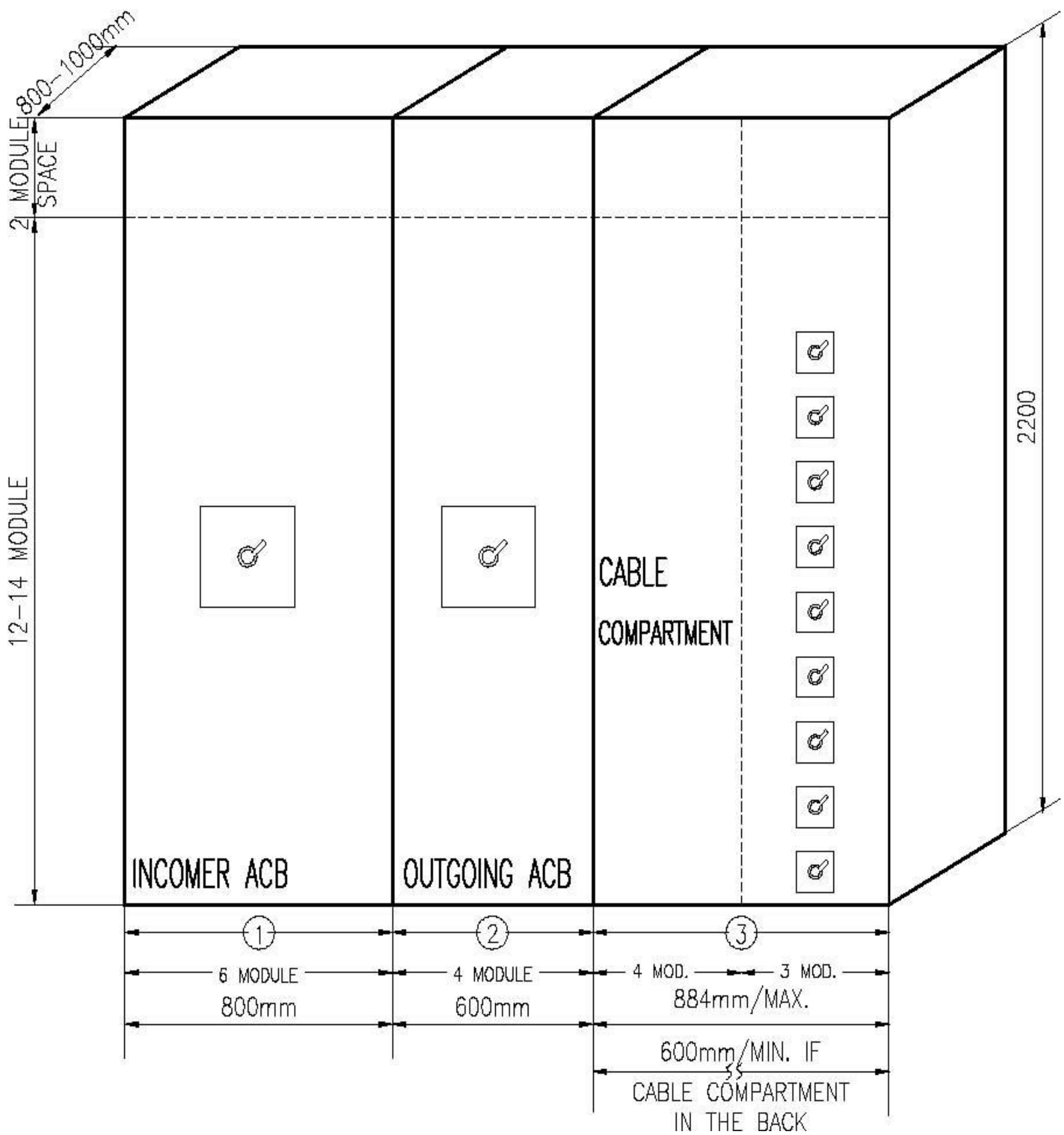


Fig. (1)

C.4.1.2 <u>HORIZONTAL ARRANGEMENT REFER TO IEC 61439-2</u>

- - Transformer ACB incoming

  - GEN. ACB incoming

  - Bus Coupler ACB

  - 4 POLE ACB (incoming or outgoing)

  For all the above 4 types of ACB,s typical size to be

  6 Module x 126mm (to be independent cubicle)

  = 756mm

  = 800mm

- For Outgoing ACB / TP = 4 Module x 126mm (to be independent cubicles)

  = 506mm = 600mm

- For MCCB (Outgoing) = 4 Module for cable + 3 Module for MCCB's

  = (4 x 126mm + 3 x 126mm)

  = (506mm + 378mm)

  = 884mm max. / 600mm min (if cable comp. in the back)

C.4.1.3 <u>VERTICAL ARRANGEMENT FOR ONE CUBICLE OF MCCB,s</u>

- Up to 160A (MCCB) frame size Space is (1.5 module)
- 200A to 400A (MCCB) frame size Space is (2.0 module)
- 500A to 630A (MCCB) frame size Space is (5.0 module)

And maximum number of modules for one cubicle = (12-14) Module

C.4.2 EXAMPLE

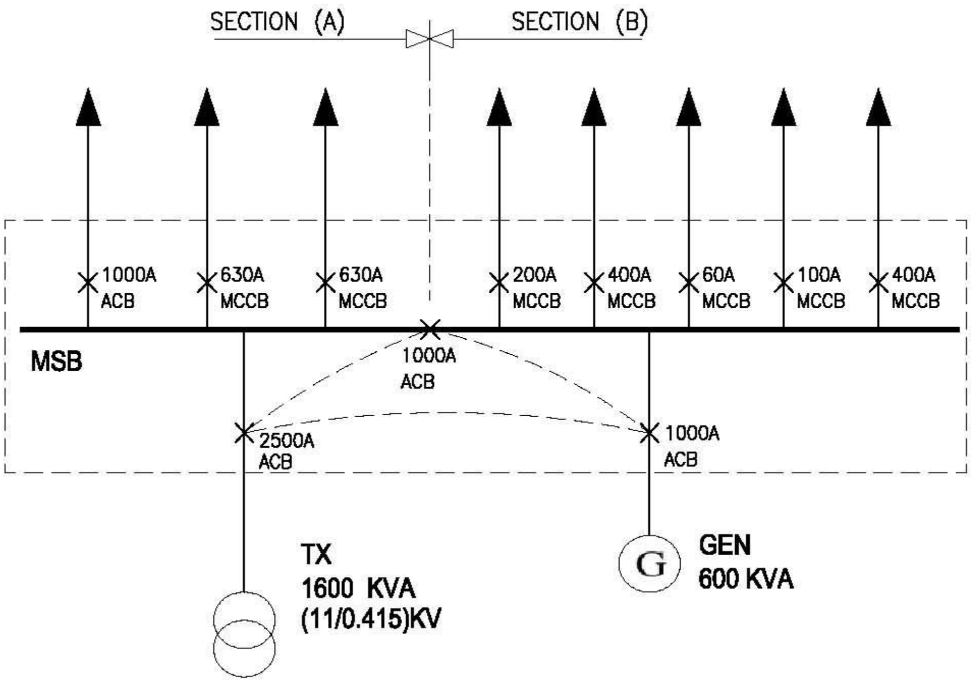


FIGURE (2)

TABLE (1)

CUBICLE CALCULATION				HORIZONTAL(mm)
INCOMING	TX(ACB)			800
	GENERATOR (ACB)			800
	B.C (ACB)			800
OUTGOING	SECTION (A)	(ACB)		600
		MCCB'S	2 x 630A = 2 x 5 MODULE TOTAL = 10 MODULES ∴ 10 MODULES / 12 MODULES = 0.83 = 1 CUBICLE	1 x 600 MIN. 1 x 884 MAX.
	SECTION (B)	MCCB'S	2 x 400A = 2 x 2 MODULE 1 x 200A = 1 x 2 MODULE 1 x 100A = 1 x 1.5 MODULE 1 x 60A = 1 x 1.5 MODULE TOTAL = 9 MODULES ∴ 9 MODULES / 12 MODULES = 0.75 = 1 CUBICLE	1 x 600 MIN. 1 x 884 MAX.
TOTAL LENGHT OF MSB				4.2 METERS MIN. 4.768 METERS MAX.

C.5 Determination of Short-Circuit Current ($I_{S.C}$) Detailed at any Given Point.

C.5.1 Short circuits study and analysis refer to IEEE STd 241-1990 CH(9.1)

C.5.1.1 Sources of Short-Circuit Currents.

When determining the magnitude of short-circuit currents, it is extremely important that all sources of short circuit be considered and that the impedance characteristics of these sources be known.

There are four basic sources for short-circuit current

1) Local system generators
2) Synchronous motors
3) Induction motors
4) Electric utility systems (remote generation)

All of these can feed current into a fault

C.5.1.2 Rotating Machine Reactance.

The impedance of a rotating machine consists primarily of reactance and is not one simple value.

Three values of reactance are assigned to rotating machines (motors and generators) for the purpose of calculating short-circuit currents at specified times.

These values are called the subtransient reactance, transient reactance, and synchronous reactance. They are described as follows:

1) The sub transient reactance X''_d is the apparent reactance of the stator winding at the instant the short circuit occurs, and it determines the current flow during the first few cycles after the short circuit.
2) The transient reactance X'_d determines the current during the period following that when the subtransient reactance is the controlling value, it is effective up to 0.5 second or longer, depending upon the design of the machine.
3) The synchronous reactance X_d is the reactance that determines the current flow when a steady-state condition is reached. It is not effective until several seconds after the short circuit occurs; consequently, it is not generally used in short-circuit current calculations.

A synchronous motor (or generator) has the same kinds of reactance as an induction motor but usually has different values. Induction motors have no field coils; but the rotor bars act like the amortisseur winding in a generator. Therefore, induction motors are said to have substransient reactance only.

C.5.1.3 Symmetrical and Asymmetrical Currents.

The word "symmetrical" describes the displacement of the ac waves from the zero axis. If the envelopes of the peaks of the current waves are symmetrical around the zero axis, they are called "symmetrical current envelopes". If the envelopes are not symmetrical around the zero axis they are called "asymmetrical current envelopes".

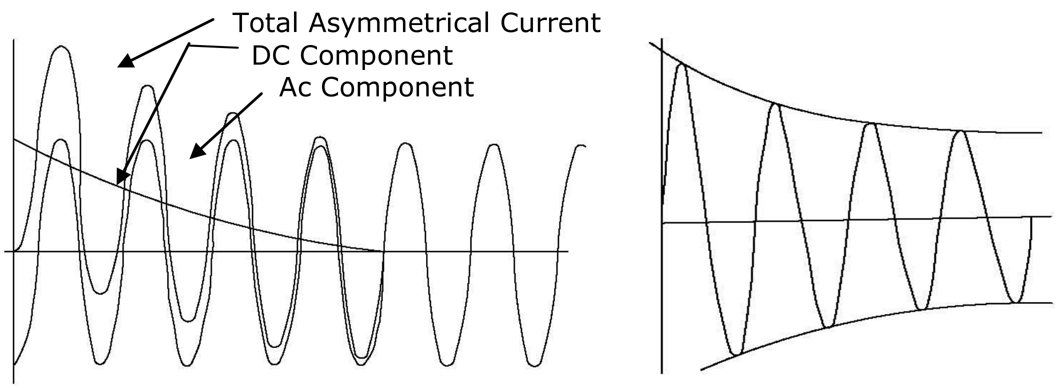
Most short circuit currents are asymmetrical during the first few cycles after the short circuit occurs. The asymmetrical current is at a maximum during the first cycle after the short circuit occurs and, in a few cycles, gradually becomes symmetrical.

If a short circuit occurs at the peak of the voltage wave in a circuit containing only reactance, the short-circuit current will start at zero and trace a sine wave, which will be symmetrical about the zero axis. *If a short circuit occurs at the zero point of the voltage wave,* the current will start at zero; but it cannot follow a sine wave symmetrically about the zero axis because the current should lag behind the voltage by 90^{o}. This can only happen if the current is displaced from the zero axis.

If the fault occurs at any point between zero voltage and peak voltage, the current will be asymmetrical to a degree dependent upon the point at which the short circuit occurs on the voltage wave.

To produce maximum asymmetry, when a circuit contains resistance, the short circuit should always occur at the zero point on the voltage wave. However, the point on the voltage wave at which the short circuit should occur to produce a symmetrical short-circuit current wave depends on the ratio of reactance to resistance (X/R ratio). The actual point on the voltage wave at which a short circuit should be initiated to produce a symmetrical current is the angle whose tangent equals the X/R ratio of the circuit.

C.5.1.4 **__Total Short-Circuit Current.__** The total symmetrical short-circuit current usually has several sources, as illustrated in Fig (1). The first source is the utility, the second is local generation, and synchronous motors, if any are a third source Induction motors, a fourth source, are located in every building. Because rotating machine currents usually decay over time due to the reduction of flux in the machine after a short circuit, the total short-circuit current decays with time considering only the symmetrical part of the short-circuit. Magnitude during the first few cycles is further increased by the dc component which also decay with time, accentuating the difference in magnitude of a short-circuit current at the first cycle after a short circuit occurs a few cycles later. The maximum asymmetrical current is available on only phase of a three-phase system due to a three-phase fault.



Decay of DC Component and Effect of Asymmetry of Current

Symmetrical Short-Circuit Current from Four Sources Combined into Total

Fig. (1)

C.5.1.5 <u>Step-by-Step Calculation Acc. To IEEE STd.241-1990 CH(9.2).</u>

The following steps identify the basic considerations in making short-circuit current calculations. In the simpler systems, several steps may be combined; for example, a combined single-line and impedance diagram may be used.

1. Prepare a system single-line diagram, which is fundamental to short-circuit analysis. It should include all significant equipment and components and show their interconnections.
2. Decide on fault locations and the type of short-circuit current calculations required, based on the type of equipment being applied.
3. Prepare an impedance diagram for systems.

❖ Calculate R_t Summation of resistances upstream of the point

R_t = R1+R2+R3+….(m.ohm)

❖ Calculate X_t Summation of reactances upstream of the point

$X_t = X_1+X_2+X_3+$….(m.ohm)

❖ $Z_t = \sqrt{R^2_t + X^2_t}$

4. For the designated fault locations and system conditions, resolve the impedance network and calculate the required symmetrical currents (*E/Z*).

❖ $I_{SC} = \dfrac{V_O}{\sqrt{3} \times Z_t}$ ………..(KA)

Vo-No load voltage between phases of the transformer (Volt)

C.5.1.6 Typical Percentage U Value for indoor, Open Dry-Type, Three-Phase, 2.5-15 kV Primaries and 208, 480, 600 V Wye or Delta Secondaries from IEEE Std 241-1990 CH.(9)

kVA	MV (kV)	LV (V)	%U	X/R
15	2.5-15	208Y-600	3.00	0.5
30	2.5-15	208Y-600	5.00	1.0
45	2.5-15	208Y-600	5.00	1.0
75	2.5-15	208Y-600	5.50	2.0
112.5	2.5-15	208Y-600	4.50	1.5
150	2.5-15	208Y-600	4.50	2.0
225	2.5-15	208Y-600	5.00	2.5
300	2.5-15	208Y-600	5.00	2.8
500	2.5-15	208Y-600	5.00	4.0
800	2.5-15	208Y-600	5.75	2.0
1000	2.5-15	208Y-600	5.75	2.5
1500	2.5-15	208Y-600	5.75	3.3
2000	2.5-15	208Y-600	5.75	4.0
2500	2.5-15	208Y-600	5.75	4.3

Table (1)

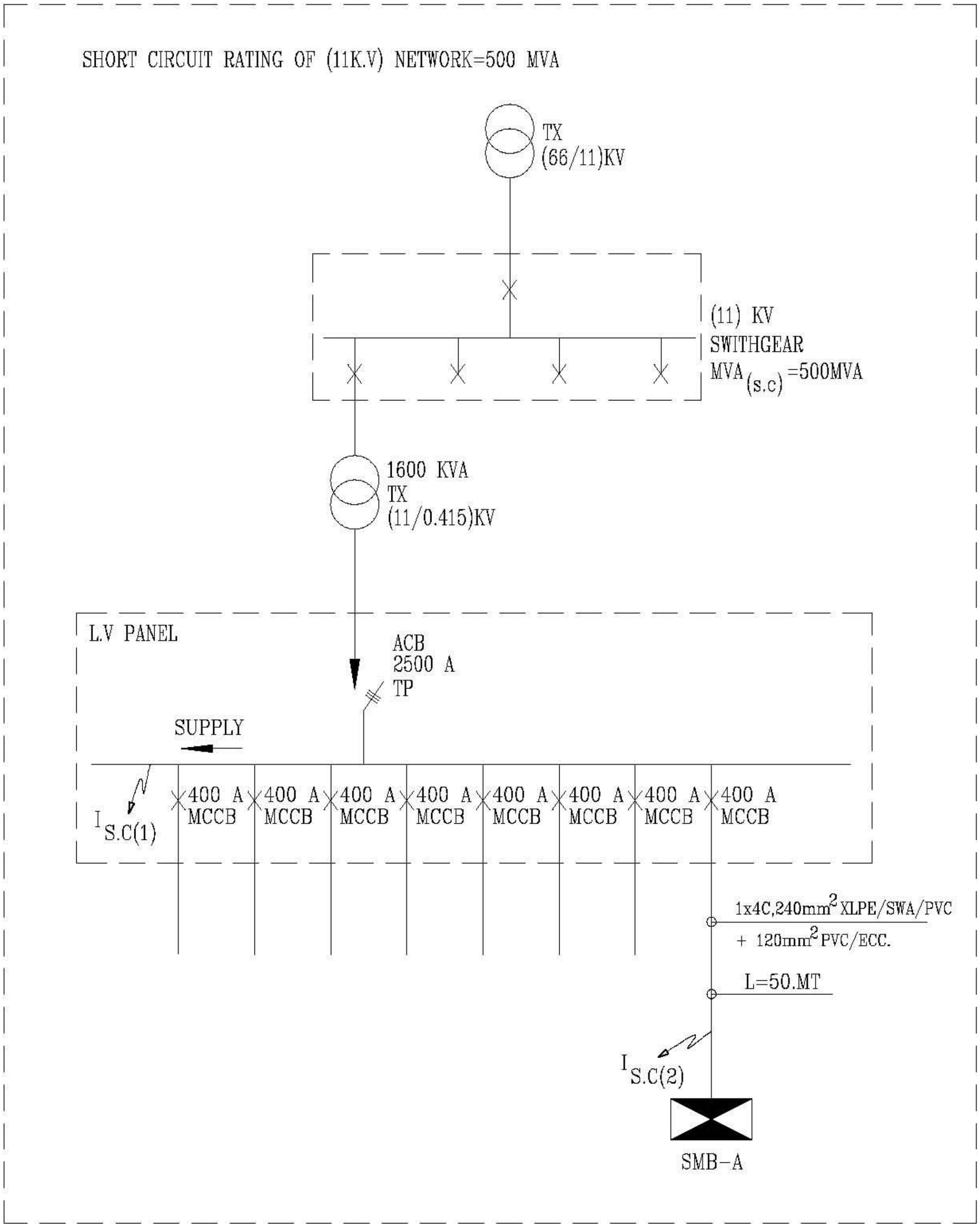
C.5.1.7 Very Important Notes:

- *If there is several cables in parallel per phase, divide the resistance and reactance of one cable by the number of cables.*
- *If there are parallel operation of transformers, equivalent impedance should be calculated for two or three transformers as a parallel connection*

  $Z_{T(eg)} = Z_1 Z_2 / (Z_1 + Z_2)$ …….(for two transformer)

- Maximum short circuit current at the point of installation which determines the minimum breaking capacity of the protection device (by MVA).
- Calculated short circuit is three phase (L.L.L.G) fault which is the maximum prospective value in the circuit symmetrical short-circuit current.

C.5.1.8 <u>SHORT CIRCUIT CALCULATION FOR L.V PANEL & SMB-A.</u>



<u>Fig. (2)</u>

❖ 11 KV NETWORK (IMPEDANCE)-Z1

MVA_{SC} = 500 MVA

Z_1 (mΩ) $= \dfrac{(V)^2 \times 10^3}{MVA_{SC}} = \dfrac{(11)^2 \times 1000}{500}$ = 242 mΩ

Z_1 (referring to 415V SIDE) $= 242 \times \dfrac{(0.415)^2}{(11)^2}$ = 0.344 mΩ --------- (1)

❖ 1600KVA TRANSFORMER IMPEDANCE/Z2

Z_2 (mΩ) $= \dfrac{(V)^2}{S_{(TR)}} \times U \dfrac{(s.c)}{100} \times 10^3$

S (TR) = Apparent Power of Transformer (1.6 MVA)

U (sc) = Short Circuit Voltage of Transformer (%) (TX Impedance Volatage)

TX	U (s.c) %
1600 KVA	5.75% (FROM IEEE/ Table (1)

Z (2) $= \dfrac{(0.415)^2}{1.6} \times \dfrac{5.75}{100} \times 10^3$

Z (TR) = 6.189 mΩ ------- (2)

❖ CABLE IMPEDANCE / Z3

L = 150 Meter

Cable 4C, 240 mm^2 XLPE/SWA/PVC+120mm^2 PVC/ECC

From Cable Tech. Catalogue

R3 = 0.098 / mΩ / Mt R3 = 4.9 mΩ

X3 = 0.07 / mΩ / Mt X3 = 3.5 mΩ

Z3 = $\sqrt{X_3^2 + R_3^2}$ = 6.02 mΩ -------------------------------------(3)

❖ CONCLUSION

From (1), (2) & (3)

$$I_{S.C} = \frac{V}{\sqrt{3} \times Z(eq)}$$

$I_{S.C}$ (1) For main L.V.P

$Z_{(eq.)}$ = Z_1 (11 KV Network) + Z_2

= 0.344 + 6.189 = 6.533 mΩ

$$I_{S.C}(1) = \frac{415}{\sqrt{3} \times 6.533} = 36.7 \quad KA$$

$I_{S.C}$ (2) For SMB-A

$Z_{(eq.)}$ = $Z_1 + Z_2 + Z_3$

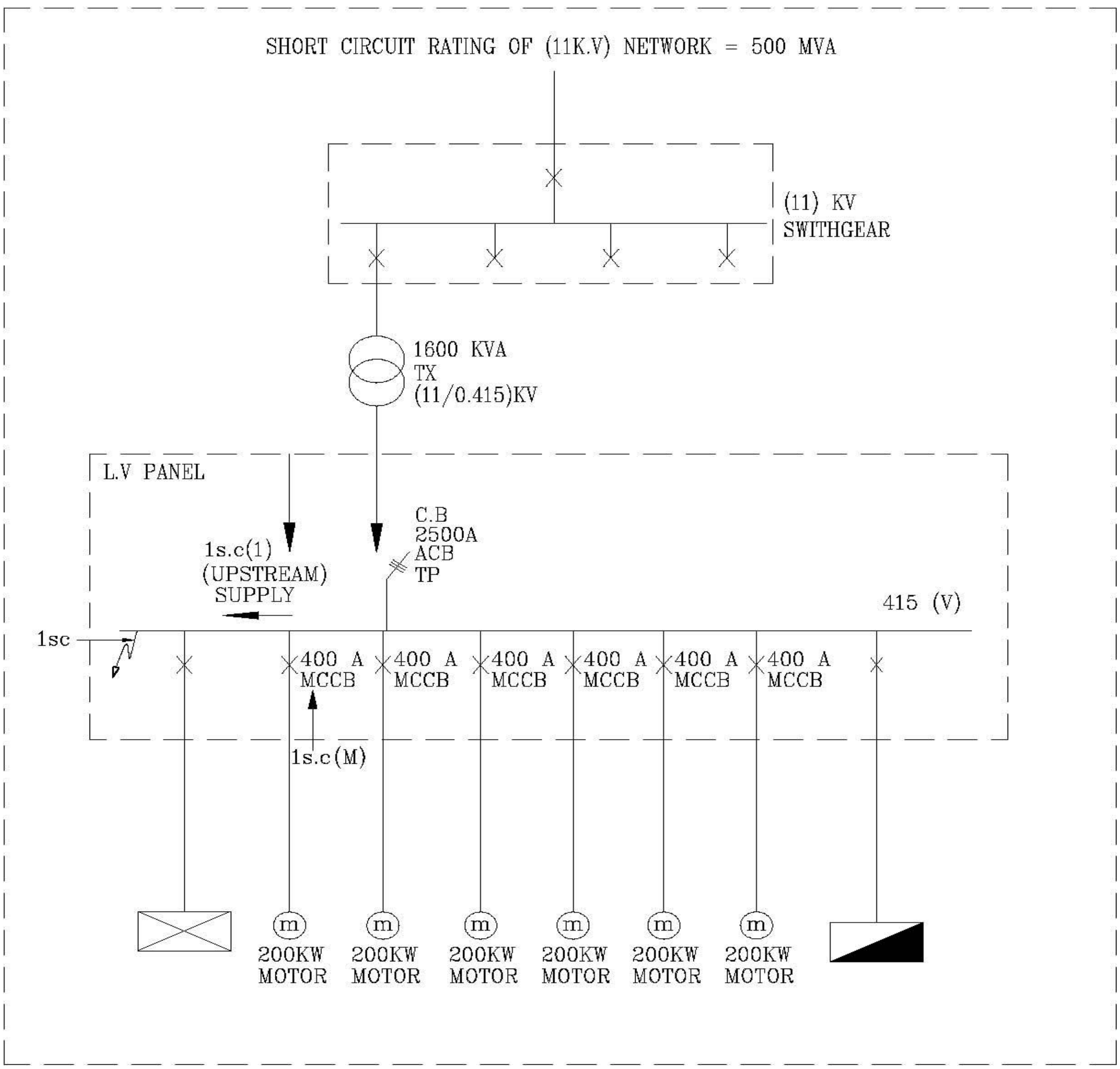
= 0.344 + 6.189 + 6.02 = 12.553 mΩ

$$I_{S.C}(2) = \frac{415}{\sqrt{3} \times 12.553} = 19.1 \quad KA$$

C.5.2 <u>SHORT CIRCUIT CALCULATION FOR L.V PANELS WITH RATING INDUCTION MOTORS</u>

Motors contribution – Synchronous and induction motors will feed additional short-circuit current to a fault at their terminals at a value approximately equal to their locked-rotor rating for this reason, they can be represented in equivalent circuits by their locked-rotor impedances that are fed by line voltage. The locked-rotor current rating usually is assumed to be four to five times the motor full-load current. This is a conservative figure and on the safe side. Actual contribution is normally somewhat less.

In order to develop accurate fault currents, it is necessary to know the substransient and transient reactances of synchronous machines and the substransient reactances of induction machines. In calculating the short-circuit currents of low-voltage systems, a realistic approximation involving a mix of synchronous and induction machines assumes a contribution at the machine terminals under bolted conditions of four times rated full-load current. This implies a source reactance of approximately 25%.



<u>Fig. (2)</u>

C.5.2.1 11 KV NETWORK (IMPEDANCE)-Z1

$MVA_{SC.} = 500\ MVA$

$$Z_1\ (m\Omega) = \frac{(V)^2 \times 10^3}{MVA_{SC}}$$

$$Z_1\ (m\Omega) = \frac{(11)^2 \times 1000}{500} = 242.0\ m\Omega$$

$$Z_1\ (m\Omega)\ \text{(referring to 415V side)} = 242\ \frac{(0.415)^2}{(11)^2} = 0.344\ m\Omega \text{ -------- (1)}$$

C.5.2.2 1600KVA TRANSFORMER IMPEDANCE/Z2

$$Z_2\ (m\Omega) = \frac{(V)^2}{S(TR)} \times U\ \frac{(s.c)}{100} \times 10^3$$

$S_{(TR)}$ = Apparent Power of Transformer (1.6 MVA)

$U_{(sc)}$ = Short Circuit Voltage of Transformer (%)

(From Table-1 Sect. C.1.1.6)

$$Z_2 = \frac{(0.415)^2}{1.6} \times \frac{5.75}{100}\ 10^3$$

Z_2 = 6.189 mΩ -------------- (2)

C.5.2.3 Short Circuit from Supply (Upstream)

From (1) & (2)

$$I_{s.c(1)}\ \text{(From Main Supply) Upstream} = \frac{V}{\sqrt{3}\ Zeq}$$

$Z_{eq.}$ = Z_1 (11 KV Network) + Z_2 (TX)

= 0.344 + 6.189 = 6.533 mΩ

$$I_{s.c(1)}\ \text{(From Main Supply)} = \frac{415}{\sqrt{3} \times 6.533}$$

$I_{s.c(1)}$ = 36.7 KA

C.5.2.4 Short Circuit from the Motors (Down Stream)

- **FOR DRIVE MACHINE (MOTORS)DURING SHORT CIRCUIT IT WILL BE NOTED THAT**

  - Voltage dip will occur and voltage of main bus bar will be decreased.
  - The motors will still running according to the moment of inertia of the motors.
  - So reverse (E.M.F) will be induced from motors then the motor is working as a generator during the fault.

- ***BACK CURRENT WILL BE INJECTED TO MAIN BUSBAR FROM INDU. MOTORS (DOWNSTREAM)***

The back current for the motor will be calculated as follows:

$$MVA_{s.c(M)} = \frac{MVA_{(m)}}{Xd}$$

X_d = Substransient Reactance for Ind. Motor

= 0.25…. (As Percentage)

I_M = Rated Current for Motor

$$I_M = \frac{200(KW)}{\sqrt{3} \times 0.415 \times 0.8} = 347.8\ A$$

$$I_{s.c(M)} = \frac{I_M}{0.25} = \frac{347.8}{0.25} = 1.39\ KA$$

$I_{s.c\ (All\ Motors)}$ = $I_{s.c(M)}$ x No. of Motors = 1.39 x 6 = 6.95 KA

C.5.2.5 CONCLUTION

TOTAL $I_{s.c}$

$I_{s.c}$ = $I_{s.c\ (1)} + I_{s.c\ (All\ Motors)}$

= 36.7 + 6.95 = 43.65 KA

C.5.3 SHORT CIRCUIT CURRENT FOR GENERATOR SET AND SYNCHRONOUS MOTORS REFER TO IEEE SRABDARD 241-1990 CH.(9.2).

$I_{SC} = \dfrac{I_N}{X_d}$ (for generator or Synchronous Motor)

I_N = Current Rating at Full Load

X_d = Transient Reactance

	TURBO GENERATOR	SAILENT POLAR GENERATOR
X_d	15% TO 20%	15% TO 30%

EXAMPLE

Generator Size = 1600 KVA

X_d = 25%

$I_N = \dfrac{1600}{\sqrt{3} \times 0.415} = 2226.0$ A

$I_{SC} = \dfrac{I_N}{X_d}$

$= \dfrac{2226}{0.25} = 8.9$ KA

Note:

- *If there is more than on generator connected to automatic synchronizing panel, divide the reactance of one generator by number of generators if generators are equally in the size.*

C.5.4 BATTERIES

$I_{S.C}$

$I_{S.C}$ Values downstream of an accumulator Bank are approximately.

- $I_{S.C}$ = 15 x Q (Open Lead Acid)
- $I_{S.C}$ = 40 x Q (Air-tight Lead Acid)
- $I_{S.C}$ = 20 x Q (NI-Ca)

Q (Ah) : Capacity in Ampers-Hour.

C.5.5 **Method of Decreasing the Available Short-Circuit Current and BS STd 241-1990 CH.(9).**

Short-circuit current on a distribution system decreases from the source to the load because the circuit impedance increases. The rate of current decrease or impedance increase is a function of the circuit design. With the design and insertion of impedance in the circuit between the power source and the building protective equipment, the short-circuit values throughout the building may be appreciably decreased and, at some points, may be lowered enough to permit lower rated, less expensive equipment to be used.

Limiting Fault Current – the asymmetrical short-circuit current will continue to flow for several cycles depending upon the X/R ratio of the system. The asymmetrical fault current will eventually decay to the final symmetrical value of the current that was calculated in the examples. Since the asymmetrical current is always greater than the symmetrical, the largest amount of destructive energy flows during the first few cycles after the fault.

C.5.5.1 **Effect of distribution Circuit Length on Short-Circuit Current.** When the available short-circuit current is high, a small increase in the impedance of the service entrance feeders and parts of the network system, as can be accomplished by using increased spacing between phase conductors, is very effective in reducing the maximum fault currents.

C.5.5.2 **Current Limiting Fuses and C.L.C.B.** The short-circuit current is greater in magnitude, it is necessary for the fuse to operate as quickly as possible. When a fuse operates in its current-limiting range, it will clear in less than a half-cycle (0.008 second). A current-limiting fuse is one which, when operating its current-limiting range, limits the instantaneous peak current to a value much less than that to which the short-circuit current would rise if the fuse or C.L.C.B were not in the circuit and clears in a half-cycle or less. Total clearing

C.5.5.3 **Current-Limiting Reactors.** When a reactor can be used to reduce the rating of several circuit breakers or to reduce interrupting duty to within the capacity of standard circuit breakers, the installation may be economically justified. When installing reactors, consideration should be given to power loss, space, and voltage drop. If they are to be installed in combination power and lighting circuits, lamp flicker problems, as well as motor starting torque requirements should be investigated. The addition of reactors will increase the X/R ratios discussed previously, so special attention is required to check asymmetrical withstand or interrupting ratings.

C.5.5.4 **Current-Limiting Busways.** Current-limiting busways are another means reducing short-circuit currents. They are available in ratings of approximately 1000-4000 A.

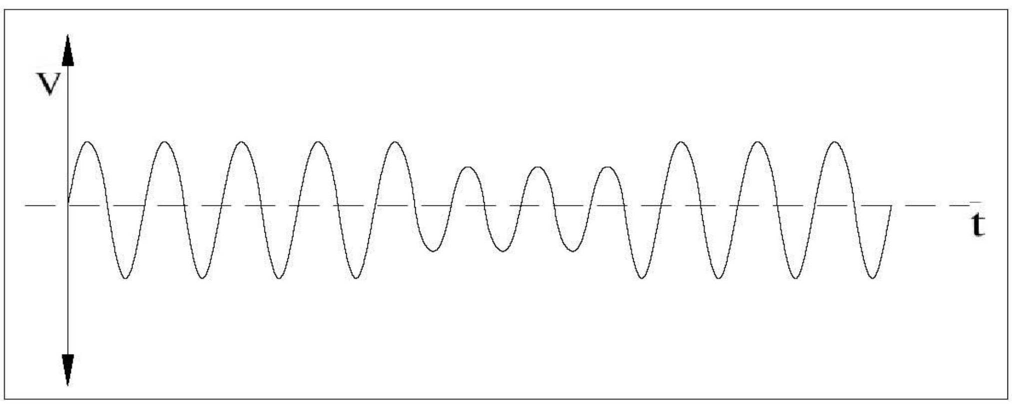
C.6 VOLTAGE DIP AND CUT-OFF CALCULATION

C.6.1 Definition:

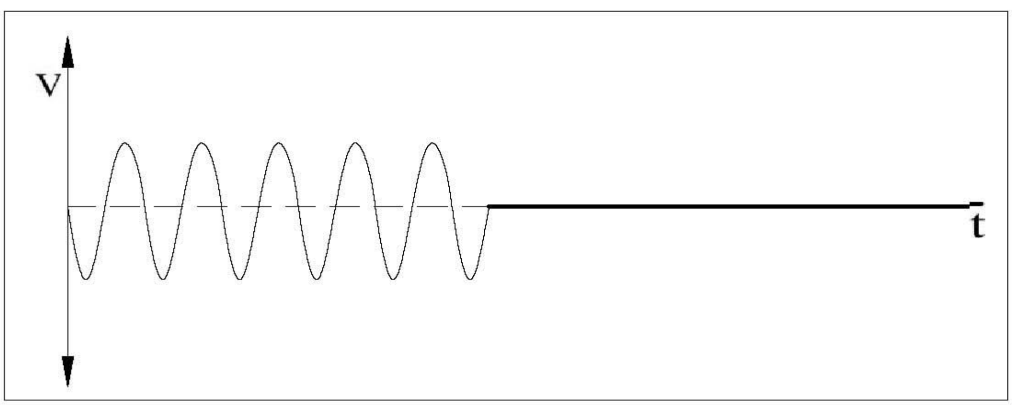
Voltage Dip is a decrease of voltage amplitude for a period of time ranging from 10 ms to 1 s. Voltage Variation Related to nominal Voltage (10% to 100%) a 100% voltage Dip is Turned a cut – off. See figure (1) and figure (2)

Momentary Voltage Variations – Voltage Dips, Sudden voltage changes should be given special consideration. Lighting equipment output is sensitive to sudden applied voltage, and people are sensitive to changes in light. Intermittently operated equipment, such as compressor motors, elevators, x-ray machines, and flashing signs may produce a flicker when connected to lighting circuits. Care should be taken to design systems that will not irritate building occupants with flickering lights. In extreme cases, sudden voltage changes may even disrupt sensitive electronic equipment.

The voltage Dip followed by voltage recovery after short period of time from a few seconds, (IEC 61050-161), IEEE 1159



Fig(1) Voltage Dip (10 ms TO 1 s)



Fig(2) CUT-OFF

C.6.2 **Consequences of V. Dip**

- Opening Contactor
- Synchronism motor Synchronism loss
- Computer data loss
- Disturbance of lighting with gas dischoarage Lamps and the available motor torque are greatly affected
- Emergency generator

C.6.3 **Voltage Dip Calculations Refer to IEC 50160, IEEE 1159**

Calculation of Voltage Dips. The following methods are good approximations for the calculation of voltage dips. A more accurate method would be to convert the motor locked-rotor kVA to an equipment impedance and build a voltage divider network between the motor and the source. This method is more complicated and often employs the assistance programs.

At 10 dips per hour, people begin to detect incandescent lamp flicker for voltage dips larger than 1% and begin to object when the magnitude exceeds 3%.
One source of voltage dips in commercial buildings is the inrush current while starting large motors on a distribution transformer that also supplies incandescent lights.

The estimated 3% dip associated with starting motor reaches the borderline of irritations at 10 starts/hour. If the voltage dip combined with the starting frequency approaches the objectionable zone, more accurate calculations should be made using the actual locked-rotor current of the motor. Accurate locked-rotor kVA for motors is available from the motor manufacturer and from the starting code letter on the motor nameplate. The values for the code letters are listed in ANSI / NEMA MGI-1978 [4] and in the NEC, Article 430 [5]. Section 3.10 describes more accurate methods for calculating motor-starting voltage dips.

When the amount of the voltage dip in combination with the frequency falls within the objectionable range, *then consideration should be given to methods of reducing the dip* to acceptable values, such as;

- Using two or more smaller motors.
- Providing a separate distribution transformer for motors
- Using reduced voltage starting
- IF there is no initial load the voltage regulator will restore voltage to 100% after dip for generator
- *Then if we would like to decrease V.Dip we should connect the motors to other Busbar with higher fault level value* ($MVA_{S.C}$)

C.6.4 **Sample Calculation for 11 KV Two Speed Motor.**

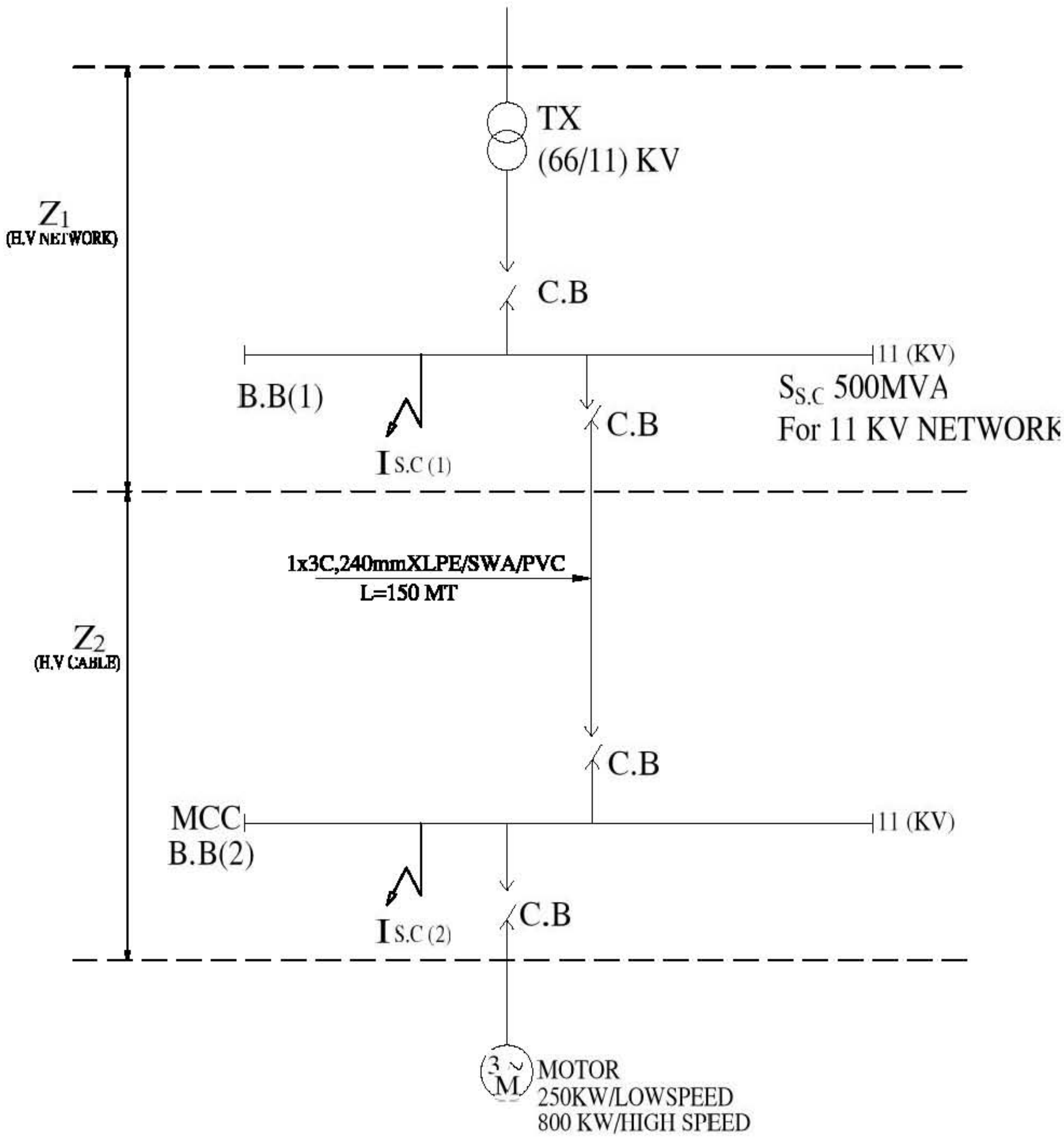


Fig. (1)

$$\text{Voltage Dip \%} = \frac{\text{MVA (starting)} \times 100}{\text{MVA (s.c) at MCC}} \ \% \quad \text{should be} \leq 3\%$$

(ACC. IEC 50160, IEEE1159)

C.6.4.1 11 (KV) NETWORK (AMPEDANCE)

$MVA_{S.C}$ = 500 MVA

$X_1 = (m\Omega) = \dfrac{(V)^2 \times 10^3}{MVA_{\ S.C}}$

$X_1 = Z_1 = \dfrac{(11)^2 \times 1000}{500}$

= 241.9 mΩ

C.6.4.2 CABLE (3x240) XLPE/SWA/PVC (Z_2)

R_2 = 0.0933 mΩ/mt (From Cable Catalogue)

L = 150 mt

R_2 = 0.0933 x 150

R_2 = 14 mΩ

X_2 = 75.5×10^{-3} mΩ/mt (From Cable Catalogue)

= $75.5^3 \times 10 \times 150$

X_2 = 11.3 mΩ

$Z_2 = \sqrt{R^2+X^2} = \sqrt{(14^2)+(11.3^2)}$

Z_2 = 18 mΩ

C.6.4.3 FAULT LEVEL AT 11 (KV)-MCC

Z_T = Z_1 (11 KV Network) + Z_2 (Cable

From (1) & (2)

Z_T = 18+241.9 = 259.9 mΩ

$1_{2\ S.C} = \dfrac{V}{\sqrt{3} \times Z_T}$

$= \dfrac{11}{\sqrt{3} \times 259.9 \times 10^{-3}}$

$1_{2\ S.C}$ = 24.4 K.A

$MVA_{2(S.C)} = \sqrt{3} \times V \times 1_{2\ S.C}$

$= \sqrt{3} \times 11 \times 24.4$

$S_{(S.C)}$ = 464.87 MVA AT-MCC

-----------(3)

C.6.4.4 MOTOR STARTING MVA (ST.) ACC. TO (NEC) & IEEE

I(Starting) = 600% - 700% of full load current (FLC)

= 800% (FLC) at high efficiently motors

I_N (Actual Current) $= \dfrac{P}{\sqrt{3} \times V \times P.F}$

I_N = 16A (L. Speed)

I_N = 51A (H. Speed)

Low Speed Power (250 KW) / Starting Current (16 x 7 = 112A)

High Speed Power (800 KW) / Starting Current (51 x 5 = 357A)

MVA(ST) at Low Speed $= \sqrt{3} \times 11 \times 112$

= **2.1338 MVA** ---------(4)

MVA(ST) at High Speed $= \sqrt{3} \times 11 \times 357$

= **6.8 MVA** ---------(5)

C.6.4.5 CONCLUSION

_Voltage Dip (Low speed) $= \dfrac{MVA_{(ST)}}{MVA_{(S.C)\ at\ mcc}}$

❖ From (3), (4) & (5)

V.Dip % (Low Speed) $= \dfrac{(2.1338)100}{464.87}$

= **0.459 %** -------(A)

V.Dip % (High Speed) $\dfrac{(6.8)100}{464.87}$

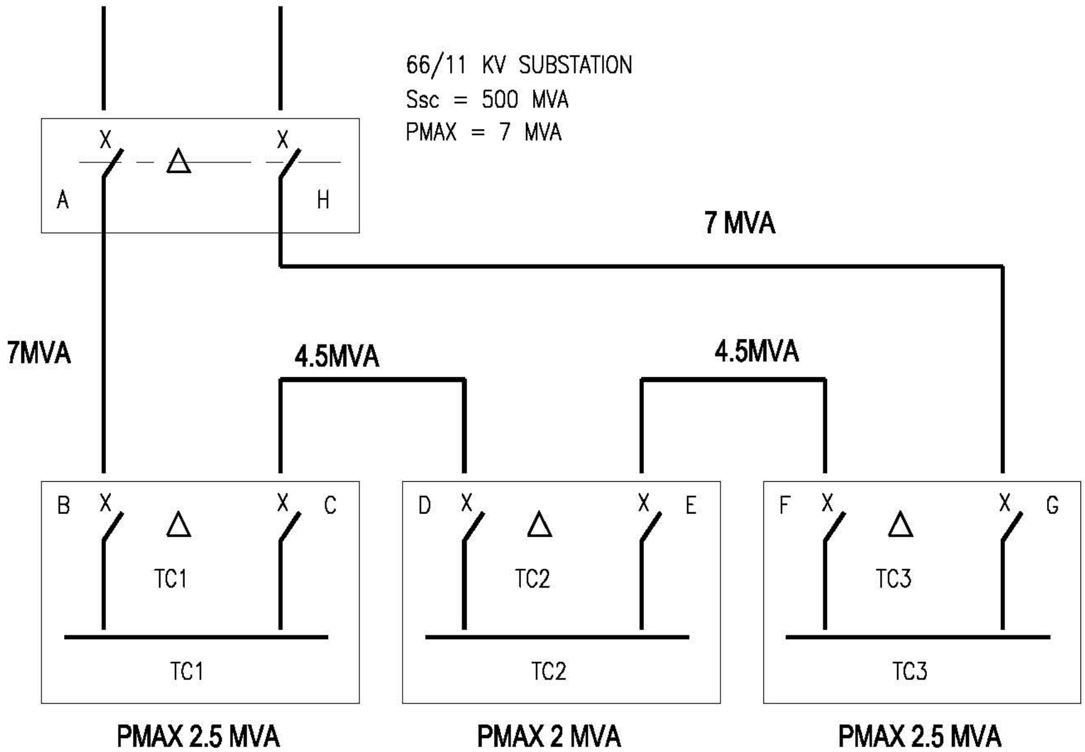
= **1.46 %** -------(B)

From (A) & (B)

❖ V.Dip < 3% So it is within acceptable range according to IEC 50160 and IEEE 1159

C.7 11 KV CABLE SIZES CALCULATION

C.7.1 NETWORK PRINCIPLE



THE 3 SUBSTATIONS TC1, TC2, AND TC3 ARE FEEDED BY THE BRANCH AB OR BRANCH HG.

C.7.2 FEEDERS AB OR HG CALCULATION

C.7.2.1 MINIMAL SECTION IN ACCORDANCE WITH SHORT CIRCUIT CURRENT

SHORT CIRCUIT POWER Ssc = 500MVA(IN MAIN SUBSTATION 66/11KV)
CIRCUIT BREAKER TRIPPING TIME t = 1.5 S

$$I_{sc} = \frac{S_{sc}}{V\sqrt{3}} = \frac{500 \times 10^6}{11 \times 10^3 \sqrt{3}} = 26243 \text{ A}$$

$$S_1 = \frac{I_{sc}}{K}\sqrt{\frac{t}{\Delta\theta}}$$

K = 11 for copper & 7 for aluminium

$\Delta\theta$ = Differential temperature between maximum temperature after short circuit (250 °c) and initial temperature (90°c) for XLPE insulation.

$$S_1 = \frac{26243}{11} \times \sqrt{\frac{1.5}{160}} = 231\text{MM}^2$$

The minimal section IS S_1 = 3 x 240 mm²

C.7.2.2 MINIMAL SECTION IN ACCORDANCE WITH NOMINAL CURRENT

- Cables laid in trenches
- Derating factor
- Temperature ($45^{O}C$) K = 0.85
- Proximity (2) K = 085 (laying, grouping,…..)
- Derated Current (I_d)

$$I_d = \frac{In}{K} \qquad In = \frac{Pmax}{Vx\sqrt{3}} = \frac{7 \times 10^6}{11 \times 10^3 \sqrt{3}} = 367\ A$$

$$I_d = \frac{367}{0.85 \times 0.85} = 508\ A$$

Rated current for 3 x $240mm^2$ cable

XLPE (11 KV cable data sheet) 556 A

C.7.2.3 CONCLUSION

For each liaison AB and HG, one cable 3 x $240mm^2$

AB 1 (3 x $240mm^2$)

HG 1 (3 x $240mm^2$)

C.7.3 Liasons CD, EF Calculation

C.7.3.1 Minimal Section in Accordance with Short Circuit Current

I_{SC} calculation A + B point (Available for G point).

	X in Ω	R in Ω
Network 500 MVA 11 KVA	$\frac{(11 \times 10^3)^2}{500 \times 10^6} = 0.242$	0.15x = 0.036
Cable AB 1500m 1 Cable (3 x 240)	1.5 x 0.088 = 0.132	1.5 x 0.099 = 0.1485
Total	0.374	0.1845

$$Z_{SC} = \sqrt{X^2 + R^2} = 0.417$$

$$I_{SC\,(B)} = \frac{11000}{\sqrt{3} \times 0.417} = 15230 \text{ A}$$

Circuit breakers tripping time:

$$t = 1 \text{ Sec.}$$

$$S_2 = \frac{15230}{11} \sqrt{\frac{1}{160}} = 109 \text{ mm}^2$$

The minimal section is : 3 x 120mm^2:

C.7.3.2 Minimal Section in Accordance with Minimal Current.

- Cables laid in trenches
- Derating factor
- Temperature ($45^{O}C$) K = 0.85
- Proximity (2) K = 085 (laying, grouping,…..)
- Derated Current (I_d)

$$I_d = \frac{In}{K} \qquad In = \frac{P(CD\ or\ EF)}{V x \sqrt{3}} = \frac{4.5 \times 10^6}{11 \times 10^3 \sqrt{3}} = 236\ A$$

$$I_d = \frac{236}{0.85 \times 0.85} = 326\ A$$

Rated current for 3 x $120mm^2$ cable

370 A

C.7.3.3 Conclusion

For each liaison CD and EF, cable 3 x $120mm^2$

CD (3 x $120mm^2$)

EF (3 x $120mm^2$)

C.8 Calculation of Earthing Protective Conductor size & Types of Earthing Systems.

C.8.1 Conductor Calculation Refer to BS EN 60947-2

- For the cables up to and including 16mm^2 cross section area, the protective conductor should have the same cross-section as phase and neutral.
- For cables sizes more than 16mm^2 , the protective conductor should have 50% of cross section as phase conductor.
- For all cables larger sizes have protective conductors smaller than phase conductors. By using the formula (I), it is possible to determine the conductor minimum section (s)

$$S = \frac{\sqrt{(I)^2 t}}{K} \quad ....(1)$$

Where:

- S is the cross section [mm^2];
- I is the value (r.m.s) of prospective fault current for a fault of negligible impedance, which can flow through the protective device [A];
- t is the operating time of the protective device for automatic disconnection [s];
- K can be evaluated using the tables (I).

Calculation of the coefficient K for the cables, table (1). Refer to BS 7671-2008

Conductor Insulation	PVC ≤300 mm^2	PVC ≥300 mm^2	EPR XLPE	Rubber 60 °C	Mineral	
					PVC	Bare
Initial temperature °C	70	70	90	60	70	105
Final temperature °C	160	140	250	200	160	250
Copper (K)	115	103	143	141	115	135/115
Aluminum (K)	76	68	94	93	-	-
Tin-soldered joints in copper conductors (K)	115	-	-	-	-	-

Table (1)

- **Example:**

If Is.c = 44000A

t = 0.5 sec.

By using copper conductor with PVC insulation ≤300 mm^2

K = 115 from table (1)

$$S = \frac{\sqrt{(44000)^2 \times 0.5}}{115} = 270.5 \text{ mm}^2$$

S = 300 mm^2

C.8.2 <u>Types of System Earthing Refer to BS 7671 Standard.</u>

- Classification of systems and letters indications.

T – all exposed conductive metalwork connected directly to earth.
N – all exposed conductive metalwork connected directly to the earthed supply conductor.

The third and fourth letters indicate the earthed supply conductor arrangement:

S – separate neutral and earthed conductors.
C – Neutral and earth combined in a single conductor.

A number of combinations of these arrangements is possible, the most important being shown in the following subsections.

C.8.2.1 <u>TT system Fig. (I)</u>

This is the standard arrangement for most installations fed from an overhead supply. Earth and neutral conductors are quite separate within the installation and no earthing terminal is provided by the supply authority. The consumer's earthing terminal is connected to the earth electrode by means of an earthing conductor. Effective earth connection is sometimes difficult. For plug circuits as earth leakage circuit breaker will be necessary.

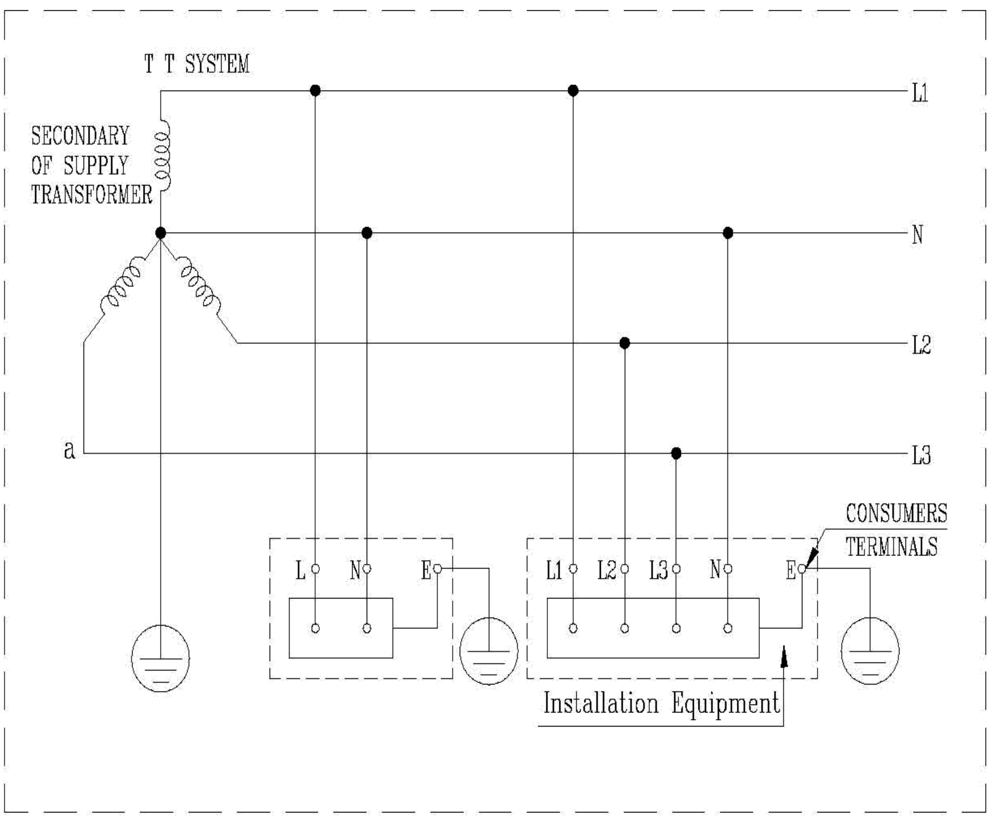


Fig. (1)

C.8.2.2 TN-S system

The majority of installations with an underground supply will be part of a system of this sort. (Fig. 2). The consumer's earthing terminal is connected by the Supply Authority to their protective conductor (PE), which consists of the sheath and armour of their cable and provides a continuous metallic.

Path back to the start point of their transformer, which is also connected to their earth electrode.

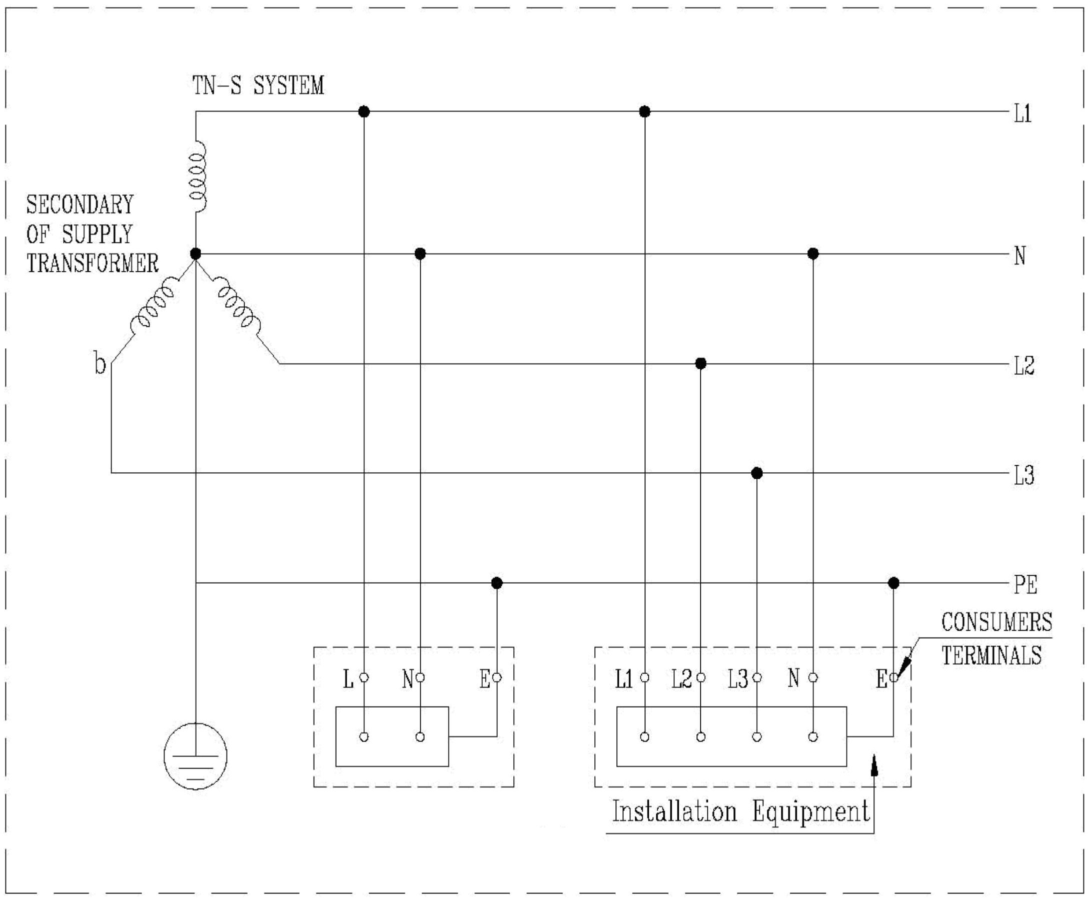


Fig. (2)

C.8.2.3 TN-C-S system

This type of installation is TN-S with separate neutral and earth systems, connected to a TN-C supply with a combined protective and neutral (PEN) conductor, sometimes also called a combined neutral and earth (CNE) conductor. This is the protective multiple earthing (PME) system, (Fig. 3)

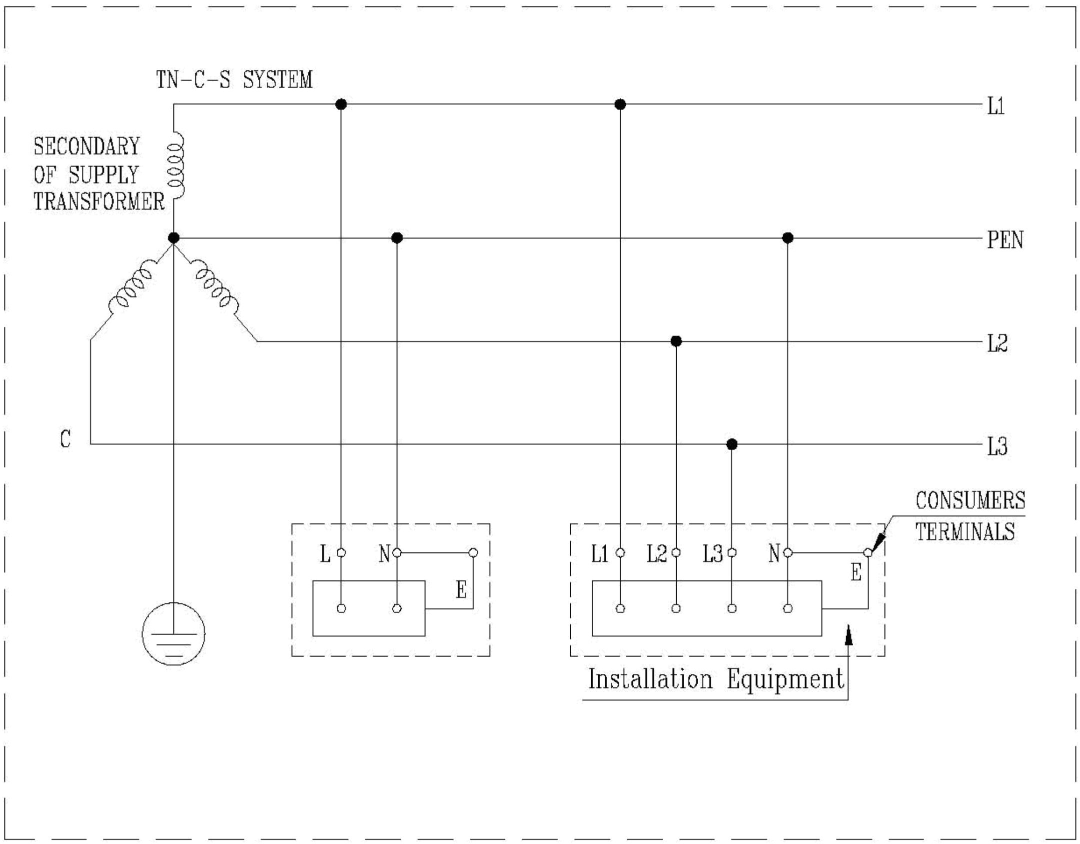


Fig. (3)

C.8.2.4 TN-C system

A combined neutral and earth (PEN) conductor is used in both the supply and the installation. Such an installation would be one using the earthed concentric wiring system.

C.8.3 Installation Consideration for Protective Conductor.

C.8.3.1 Continuity of Conductor:

A test shall be made to verify the continuity of all conductors, including the earth continuity conductor of every ring circuit.

No switching device shall be inserted in a protective conductor but jonts only.

C.8.3.2 Armoured Cables.

- Cable to be terminated with cable glands to clamp the armour of the cables, glands is hold with suitable locknut with an earthing terminal and insulated earthing conductor from cable gland to the earth bar to be used.
- The armouring must not be used as the sole earthing conductor. A separate single insulated PVC copper cable with colour is green and yellow to be used.

C.8.3.3 Unarmoured Cables:

Where unarmoured cables are installed, earthing shall be provided by means of separate cable whose insulation colour is green and yellow.

C.8.3.4 M.I.C.C. Cables:

Where M.I.C.C. cables are installed, the outer copper sheath may be used as the earth conductor.

C.8.4 Sizing protective bonding conductors Refer to BS 7671

The sizing of bonding conductors as to BS 7671. minimum sizes relate to the size of the line and earthing conductor for TN-S supplies, could be obtained from Table (2).

TN-S, PNB, TT main protective bonding conductor sizes

Line conductor size (mm^2)	25	35	50	70	95	120	150	185	240	300	400	500	600
Earthing conductor min.size (mm^2)	16	16	25	35	50	70	95	95	120	150	240	300	300
Bonding conductor Non Ele. Equip. min.size (mm^2)	10	10	16	16	25	25	25	25	25	25	25	25	25
Bonding Cond. To enclosure Elec. Equip.	35		70										
Bonding cond. To small Elec. Equip. (J.Boxes)	6												

Table (2)

C.9 Power Factor Correction Calculation

C.9.1 Introduction

The distribution authority is responsible for the production and transmission of the reactive power required by the user installations, and therefore has a series of further inconveniences which can be summarized as:

- Oversizing of the conductors and of the components of the transmission lines;
- Higher Joule-effect losses and higher voltage drops in the components and lines.

The same inconveniences are present in the distribution installation of the final user. The power factor is an excellent index of the size of the added costs and is therefore used by the distribution authority to define the purchase price of the energy for the final user

The ideal situation would be to have a cosφ slightly higher than the set reference so as to avoid payment of legal penalties, and at the same time not to risk having, with a cosφ too close to the unit, a leading power factor when the power factor corrected device is working with a low load.

The distribution authority generally does not allow others to supply reactive power to the network, also due to the possibility of unexpected overvoltages.

Power capacitors provide many benefits.

- Reduced electric utility bills
- Increased system capacity
- Improved voltage
- Reduced losses

C.9.2 Reactive Power Calculation

In the case of a sinusoidal waveform, the reactive power necessary to pass from one power factor $\cos\varphi_1$ to a power factor $\cos\varphi_2$ is given by the formula:

$$Q_c = Q_l - Q_s = P.(\tan\varphi_1 - \tan\varphi_2) = P.\ K_c$$

See fig. (1)

Where:

P is the activate power (kw) = $\sqrt{3}$ x V x I x Cos Φ_1

Q_L are the reactive power and the phase shifting before power factor correction (KVAR)

Q_S are the reactive power and the phase shifting after power factor correction; (KVAR)

Q_C is the reactive power for the power factor correction (KVAR).

K_C deference between $\tan\varphi_1$ and $\tan\varphi_2$ from (table -1)

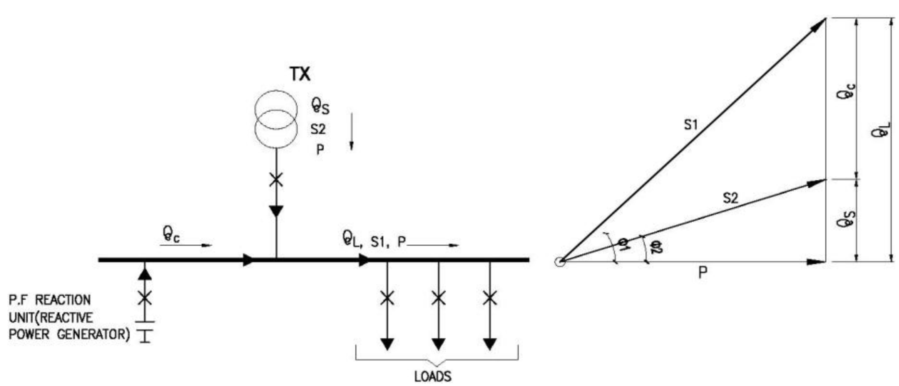


Fig. (1)

For Different Values of the Power Factor before and after the Correction

Table (1): Factor K_c

K_c						Cosφ2							
Cosφ1	0.80	0.85	0.90	0.91	0.92	0.93	0.94	0.95	0.96	0.97	0.98	0.99	1
0.60	0.583	0.714	0.849	0.878	0.907	0.938	0.970	1.005	1.042	1.083	1.130	1.191	1.333
0.61	0.549	0.679	0.815	0.843	0.873	0.904	0.936	0.970	1.007	1.048	1.096	1.157	1.299
0.62	0.515	0.646	0.781	0.810	0.839	0870	0.903	0.937	0.974	1.015	1.062	1.123	1.265
0.63	0.483	0.613	0.748	0.777	0.807	0.837	0.870	0.904	0.941	0.982	1.030	1.090	1.233
0.64	0.451	0.581	0.716	0.745	0.775	0.805	0.838	0.872	0.909	0.950	0.998	1.058	1.201
0.65	0.419	0.549	0.685	0.714	0.743	0.774	0.806	0.840	0.877	0.919	0.966	1.027	1.169
0.66	0.388	0.519	0.654	0.683	0.712	0.743	0.775	0.810	0.847	0.888	0.935	0.996	1.138
0.67	0.358	0.488	0.624	0.652	0.682	0.713	0.745	0.779	0.816	0.857	0.905	0.966	1.108
0.68	0.328	0.459	0.594	0.623	0.652	0.683	0.715	0.750	0.787	0.828	0.875	0.936	1.078
0.69	0.299	0.429	0.565	0.593	0.623	0.654	0.686	0.720	0.757	0.798	0.846	0.907	1.049
0.70	0.270	0.400	0.536	0.565	0.594	0.625	0.657	0.692	0.729	0.770	0.817	0.878	1.020
0.71	0.242	0.372	0.508	0.536	0.566	0.597	0.629	0.663	0.700	0.741	0.789	0.849	0.992
0.72	0.214	0.344	0.480	0.508	0.538	0.569	0.601	0.635	0.672	0.713	0.761	0.821	0.964
0.73	0.186	0.316	0.452	0.481	0.510	0.541	0.573	0.608	0.645	0.686	0.733	0.794	0.936
0.74	0.159	0.289	0.425	0.453	0.483	0.514	0.546	0.580	0.617	0.658	0.706	0.766	0.909
0.75	0.132	0.262	0.398	0.426	0.456	0.487	0.519	0.553	0.590.	0.631	0.679	0.739	0.882
0.76	0.105	0.235	0.371	0.400	0.429	0.460	0.492	0.526	0.563	0.605	0.652	0.713	0.855
0.77	0.079	0.209	0.344	0.373	0.403	0.433	0.466	0.500	0.537	0.578	0.626	0.686	0.829
0.78	0.052	0.183	0.318	0.347	0.376	0.407	0.439	0.474	0.511	0.552	0.599	0.660	0.802
0.79	0.026	0.156	0.292	0.320	0.350	0.381	0.413	0.447	0.484	0.525	0.573	0.634	0.776
0.80		0.130	0.266	0.294	0.324	0.355	0.387	0.421	0.458	0.499	0.547	0.608	0.750
0.81		0.104	0.240	0.268	0.298	0.329	0.361	0.395	0.432	0.473	0.521	0.581	0.724
0.82		0.078	0.214	0.242	0.272	0.303	0.335	0.369	0.406	0.447	0.495	0.556	0.698
0.83		0.052	0.188	0.216	0.246	0.277	0.309	0343	0.380	0.421	0.469	0.530	0.672
0.84		0.026	0.162	0.190	0.220	0.251	0.283	0.317	0.354	0.395	0.443	0.503	0.646
0.85			0.135	0.164	0.194	0.225	0.257	0.291	0.328	0.369	0.417	0.477	0.620
0.86			0.109	0.138	0.167	0.198	0.230	0.265	0.302	0.343	0.390	0.451	0.593
0.87			0.082	0.111	0.141	0.172	0.204	0.238	0.275	0.316	0.364	0.424	0.567
0.88			0.055	0.084	0.114	0.145	0.177	0.211	0.248	0.289	0.337	0.397	0.540
0.89			0.028	0.057	0.086	0.117	0.149	0.184	0.221	0.262	0.309	0.370	0.512
0.90				0.029	0.058	0.089	0.121	0.156	0.193	0.234	0.281	0.342	0.484

Table (1)

C.9.3 Where to install correction capacitors

	Individual capacitor units (A)	Fixed and automatic capacitor banks (B)
Definition	Located directly at the inductive load (Motor in most case)	- fixed capacitor banks – individual capacitors racked in a common enclosure with no switching or stepping capability - Automatic capacitor banks individual capacitor racked in a common enclosure with switching and stepping capability.
Advantages	1. Increasing distribution system capacity, improve power consumption 2. Stabilized voltage levels 3. Lower losses, line losses are reduced 4. Capacitor & load can be switched ON/OFF together 5. Extra switching not required. 6. Easier selection for the capacitor needed for each motor	1. More economical reduces the utility power bills or reduce the current in primary feeders 2. Low installation cost 3. Switching – Automatic capacitor banks can switch all or part of capacitance automatically depending on load requirements.

C.9.4 Choice of Protection Devices, Capacitors and Damping Reactor in P.F.C Panel

For capacitors, the current is a function of:

- The applied voltage and its harmonics
- The capacitance value

The nominal current (In) of a 3-phase capacitor bank is equal to:

$$In = \frac{Q}{\sqrt{3}\ Vn} \ (A)$$

- Q : Kvar rating
- Vn: Phase-to-phase Voltage (Kv)

C.9.4.1 Capacitor to be with the following specs. Refer to Standard IEC 60831-1 and 2

- Continuous rated volt 130% from the nominal voltage.
- 110 rated current from nominal current.
- UL listed.
- CSA approval.
- 0.5 watt losses per one KVAR.
- Non flammable insulation with ambient temperature. 50^{o}C.
- Shunt resistor to discharge the value of (Capacitor) to be 50V during 1min.
- Dry type.

C.9.4.2 Rated current for main circuit breaker. Contactor to be 130% from minimal current at 50°C. for (long time delay setting) and (10 In) for (short time delay setting) to withstand inrush current. Contactor to be AC-4 category. (According to BS 60947)

C.9.4.3 Thermostat to be installed inside panel with ventilation fans to work automatically in case of exceeding temperature.

C.9.4.4 Power factor correction panel (To be comply with IEC 61439 and IEC 61912) and should include damping reactor with enough reactance before capacitor in services connection in this case capacitor and services connected reactor must have a turning frequency below the lowest critical order of harmonic which is usually the 5th see attached Figure (2).

On 50/60 HZ systems, these damping reactors should be used to make harmonic order approximately mid-way between 3rd and 5th harmonics.

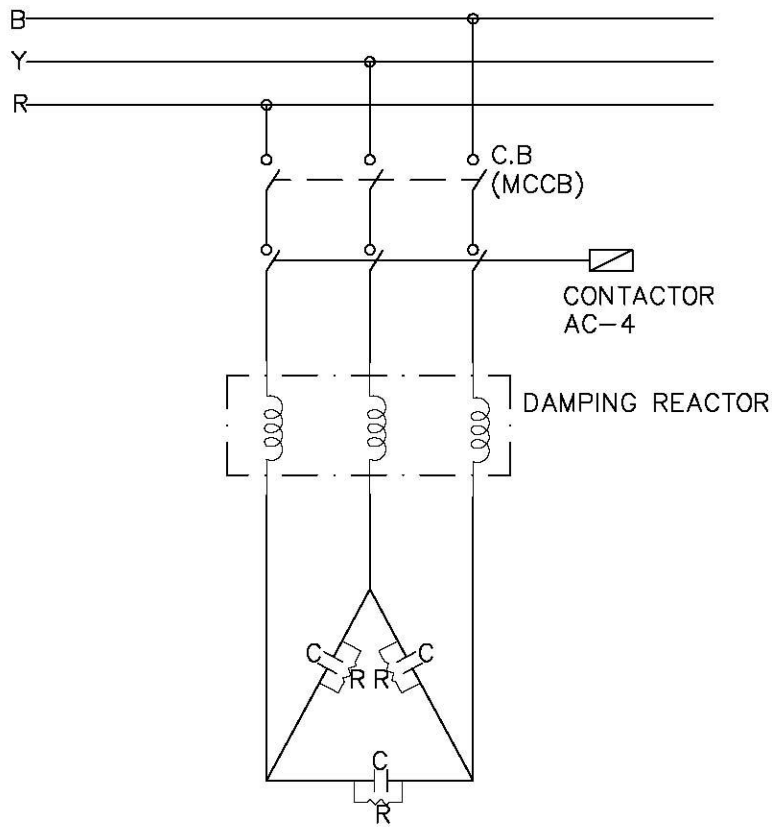


FIGURE (2)

S.L.D. FOR ONE STEP OF CAPACITOR BANK

Fig. (2)

C.9.5 Harmonics and Harmonics Filters Refer to IEEE 519

C.9.5.1 Introduction

As the supply impedance is generally considered to be inductive, the network impedance increases with frequency while the impedance of a capacitor decreases. This causes a greater proportion of the currents circulating at frequencies, and all equipment associated with the capacitor.

In certain circumstances, harmonic currents can exceed the value of the fundamental capacitor current. These harmonic problems can also cause an increased voltage maximum voltage across the dielectric of the capacitor which could exceed the maximum voltage rating of the capacitor, which means excessive heat resulting in premature capacitor failure.

Harmonic analysis study due to resonant frequency should be done by specialist to show the harmonic, distortion factor, excess of voltage, which shall guide us. To use harmonic filter with enough capacity. Referring to actual measurement and specialist advice.

Harmonic currents can cause a disturbance on the supply network and adversely affect the operation of the other electrical equipment including power factor correction capacitors.

We are concentrating our discussions on harmonic current sources associated with many sources of harmonic currents:

- Power electronic equipment (drivers, rectifiers, inverter,…)
- Are furnaces, welding machines lighting discharge lamps, electronic starter for motors.
- Domestic load with power inverters such as television, microwave, oven, computers, photo copiers, dimmer switches.

C.9.5.2 SOLUTION OF HARMONICS

C.9.5.2.1 Harmonic Filter Parallel with Capacitor

$XC = 1 / 2 \pi fc$
So, increasing of frequency due to harmonics, Xc shall be decreased. So, capacitor shall be as short circuit.

In case we used a harmonic filter the result is harmonic currents can significantly reduced in an electrical system.

It is basic form, a Filter consists of a capacitor connected in series with a reactor tuned to a specific harmonic frequency. In theory, the impedance of the Filter is zero at the tuning frequency; therefore, the harmonic current is absorbed by the filter. This is together with the natural resistance of the circuit, means that only a small level of harmonic current will flow in the network. *See attached Figure (3)*

Design of the filter is very important to ensure that distortion is not amplified to unacceptable levels. There are several harmonics present, a filter may reduce some harmonics while increasing others. So it is often necessary to use a multiple filter design.

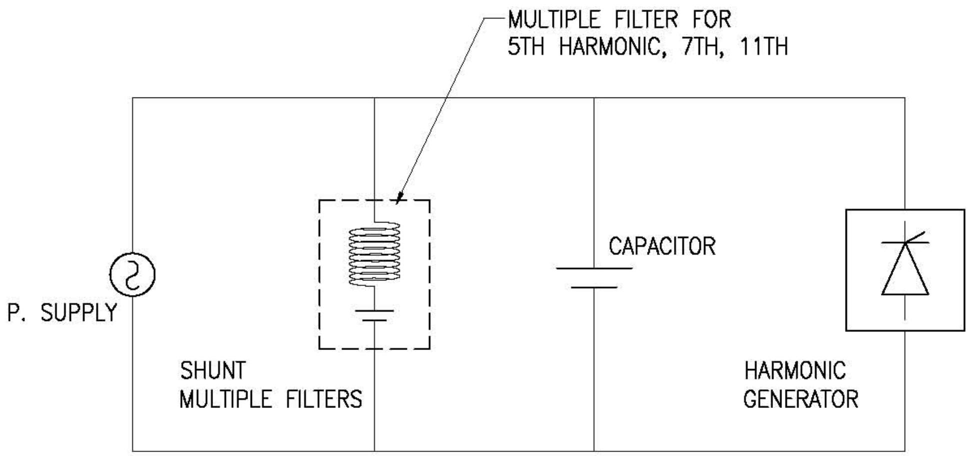


Fig. (3)

C.9.5.2.2 <u>Filter Types</u>

❖ **Passive Filter**

The closer a natural frequency approaches one of the harmonics present on the system, the greater will be the (undesirable) effect. In the above example, strong resonant conditions with the 3^{rd} harmonic component of a distorted wave would certainly occur.

In such cases, steps are taken to change the natural frequency to a value which will not reasonate with any of the harmonics known to be present. This is achieved by the addition of a harmonic-suppression inductor connected in series with the capacitor bank.

Natural frequency of the capacitor / system – inductance combination is closed to the 3^{rd} harmonic frequency of the system

- No limits in harmonic current.
- Compensation of reactive power
- Case by case engineering study

❖ **Active Filter**

Active filters analyse the harmonics drawn by the load and then inject the same harmonic current to the load with the appropriate phase. As a result, the harmonic currents are totally neutralized at the point considered. This means they no longer flow upstream and are no longer supplied by the source.
A main advantage of active conditioners is that they continue to guarantee efficient harmonic compensation even when changes are made to the installation. They are also exceptionally easy to use as they feature:

- Auto-configuration to harmonic loads whatever their order of magnitude
- Elimination of overload risks
- Compatibility with electrical generator sets
- Connection to any point of the electrical network
- Several conditioners can be used in the same installation to increase depollution efficiency (for example when a new machine is installed)
  Active filters may provide also power factor correction

❖ **Hybrid Filter**

This type of filter combines advantages of passive and active filter. One frequency can be filtered by passive filter and all the other frequencies are filtered by active filter.

C.10 Obstruction Light
Refer to ICAO Standard and FAA Clarification

C.10.1 PURPOSE

This specification sets for obstruction lighting system/equipment and marking painting used to increase conspicuity of structures to permit early obstruction recognition by pilots. Lighting standards in this circular are the minimum necessary for aviation safety. The lights should be positioned to ensure that a pilot has an unobstructed view of at least one light at each level.

Structure such as crane chimneys, tall buildings, extensive buildings, television, radio and telecommunications towers, flares stacks, electricity transmission lines, bridge, wind turbines and military radar required lighting and making.

C.10.2 LIGHTING

High-rising structures and other geographical obstructions are hazardous to aviation safety because of their heights and location. Due to the numerous threat pose to airplanes in poor visibility, high-rising structures should be illuminated with obstruction lights according to ICAO standards. Table 1 provides International Civil Aviation Organization ICAO classification of obstruction lighting and compatible light units (FAA classification).

Obstruction light, defined as light indicating the presence of an object which is dangerous to an aircraft in flight. All tall structure must be lit at the topmost point of the structure and the light units must show at all radials throughout the Omni directional 360 degrees. Obstruction light combinations and levels to be installed on structures as given in table 2.

C.10.2.1 INTENSITY STEP CHANGING

Obstruction lights should be operated by satisfactory photocell (control device) adjusted so that the lights will be turned on when the sky luminance reaching a vertical surface falls below a level 60 foot candles (645.8 lux). But before reaching a level of 35 foot – candles (367.7 lux).

The control device should turn the lights off when the northern sky illuminance rises to a level of not more than 60 foor-candles (645.8 lux). The lights may also remain on continuously.

The Intensity stel changing given in Table 2 will depend on the ambient light intensity. The ambient intensity is the light available in the environment. There is no particular direction to the light source.

In contrast, the light intensity is the effect of a simulated light source placed at the viewer's line of sight. The light intensity affects the intensity of the highlights and shadows, while the ambient intensity affects the brightness of the objects in the overall scene. The following is the ambient background lighting conditions:

Day	:	> 500 candles/m^2
Twilight	:	= 50 – 500 candles/m^2
Night	:	< 50 candles/m^2

C.10.2.2 White Obstruction Lights.

Steady white light must not be used for obstruction lighting purposes. White obstruction lights shall automatically change intensity steps when the ambient light changes as follows:

- From day to twilight & twilight to day the illumination is 60-35 foot candles
- From twilight to night & night to twilight intensity when the illumination decreases 5-2 foot-candles.

C.10.2.3 Red Obstruction Lights

If automatic control is utilized, the light unit shall turn on when the ambient light decrease to not less than 35 foot-candles and turn off when the ambient light increase to not more than 60 foot-candles. Single L-810 light units are controlled in a manner compatible with the particular installation.

C.10.2.4 Dual Obstruction Lighting System

White obstruction light shall turn off and white obstruction lights shall turn on when ambient light changes from twilight to night when the illumination is 5-2-candles.

Red obstruction lights shall turn off and white obstruction lights shall turn on when ambient light changes from night to twilight when the illumination increase 2-5 foot-candles.

C.10.2.5 Table 1 – Classification of Obstruction Lighting *According to ICAO Standards and FAA Classification*

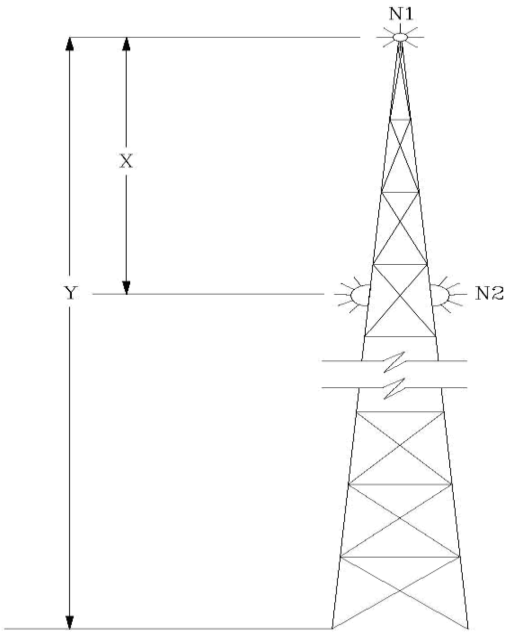
Obstruction Light	**ICAO Type**			
	A	**B**	**C**	**D**
Low Intensity Less extensive objects height**<45m**	**Steady Red** Lights (for fixed obstacle) **Compatible light units** L-810 **Intensity Step Changing** Night ≥10 candelas	**Steady Red** Lights (for fixed obstacle) **Compatible light units** L-810 **Intensity Step Changing** Night ≥32 candelas	**Flashing Yellow / Blue** lights (60-90fpm) (for mobile obstacle) **Compatible light units** **Intensity Step Changing** ≥40 candelas	**Flashing Yellow** lights (60-90fpm) (for "Fellow-me" vehicle) **Compatible light units** **Intensity Step Changing** ≥200 candelas
Medium Intensity Extensive objects or height>45m. <150m	**Flashing White** (20-60 fpm) **Compatible light units** L-865; 40fpm L-866; 60fpm **Intensity Step Changing** Day ≥20,000 cd Twilight ≥20,000 cd Night ≥2000 cd	**Flashing Red** Lights (20-60 fpm) **Compatible light units** L-864;20-40fpm L-885;60fpm **Intensity Step Changing** Night ≥2000 candelas	**Steady Red** Lights **Compatible light units** L-810 **Intensity Step Changing** Night ≥2000 candelas	
High Intensity (Object height >150m)	**Flashing White** Lights (40-60 fpm) **Compatible light units** L-856; 40fpm L-857; 60fpm **Intensity Step Changing** Day ≥20,000 cd Twilight ≥20,000 cd Night ≥2000 cd			

FPM – Flashing per minutes
(L-810/L-856/L-857-864/L-865/L-866/L-885) – type of light units.

C.10.2.6 <u>Table 2 – Structure Height & Light Units Application / Combinations</u>
<u>Refer to ICAO and FAA Specification</u>

HEIGHT OF STRUCTURE ABOVE SURROUNDING GROUND	MARKED	OBSTRUCTION LIGHTING
<45m	YES	At night /low visibility conditions **Low Intensity Type-A/B-**
>45m<105m	YES	At night /low visibility conditions **Low Intensity Type-A/B-** (Lower Level) & **Medium Intensity Light Type-B/C-** (Upper level)
>45m<105m	YES	At night /low visibility conditions **Medium Intensity Light Type-A**
>105m<150m	YES	At night /low visibility conditions **Low Intensity Obstruction Type-A/B-** (Lower Level) & **Medium Intensity Light Type-B/C-** (Upper level)
>105m<150m	YES	At night /low visibility conditions **Medium Intensity Light Type-A**
>105m	YES	At night /low visibility conditions **Low Intensity Obstruction Type-A/B-** (at Multiple Lower Levels) & **Medium Intensity Light Type-B/C-** (Upper level)
>105m	YES	Day & Night /low visibility conditions **Medium Intensity Light Type-A** (At multiple levels)
>105m	YES	Day & Night /low visibility conditions **High Intensity Obstruction Light Type-A** (At multiple levels)

C.10.3 <u>Number of obstruction lights to be placed on tall structures can be calculated by the following formula.</u>



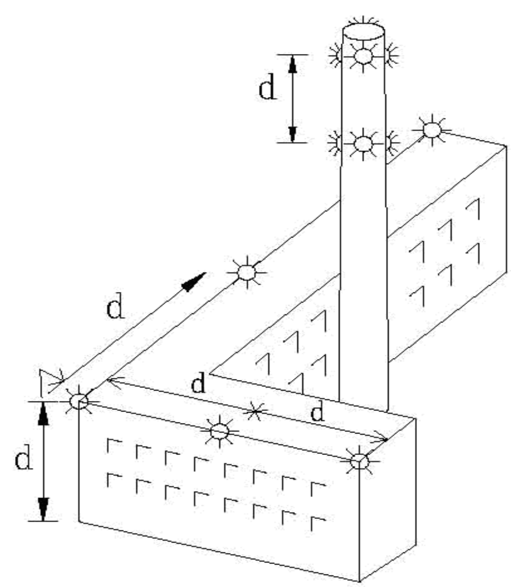
Number of levels of lights = N = $\frac{Y \text{ (meter)}}{45}$

Light spacing = X = $\frac{Y}{N} \leq 45$m

Where; Y is the height of the Obstruction

Note – There should be at least 45 meter gap between two obstruction lights installed on tall structure.

<u>Figure 1 – Lighting of tall structures (No. and Spacing)</u>



D<45mt

<u>Figure 2 – Lighting of Building</u>

C.11 LIGHTNING SYSTEM CALCULATION REFER TO BS EN 62305: 2011

Lightning System Details As BSI (British Standard Institution)

C.11.1 Definitions

The main parameters of a typical scheme normally consist of:

- Air termination network
- Down conductors
- Earth system
- Bonds and clamps for connecting the above
- Protection of electrical - Electronic Systems from Transients caused due to lightning.

C.11.1.1 Air Termination Work

The air termination network normally consist of a series of conductors correctly spaced around the upper part of a building. Its purpose is to attract any local lightning strike and direct it into the lightning protection system.

Traditionally, the air termination network has been positioned on the upper most part of the building only, on the theory that is afforded protection to all parts of the structure (depending on the standards used) from the vertical.
However, reports of tall structures suffering damage on their sides has led to a modification of the zone of protection theory.

Air termination network requirement based on the height of the structure :
Structures shorter than 60m :
Probability of low amplitude strikes to the vertical side of a structure of less than 60m in height are low enough that they need not be considered. Roofs and horizontal protrusions shall be protected in accordance with the class of LPS determined by the risk calculations of BS EN 62305-2.

Structures taller than 60m :

An air-termination system shall be installed to protect the upper part of tall structures (i.e. typically the topmost 20% of the height of the structure as far as this part exceeds 60m in height) and the equipment installed on it.

C.11.1.2 Down Conductors

The function of a down conductor is to take a lightning strike from the roof network down to earth as efficiently as possible. Ideally, conductors must take the most direct, vertical path with a minimum of bends and connections.
The spacing of the down conductors is given in the relevant national codes and, as with roof networks, any metal work close to down conductors should be bonded into the system to prevent flash-over.

The British Code gives a formula for calculating approximate flash-over distances, and if any metalwork is at a greater distance than the calculated value, it can be regarded as safe due to isolation and no bonding is needed.

The formula for the simplified approach of separation calculation is:

$$s = (k_i \cdot k_c \cdot l) / k_m$$

where, s = minimum separation required.

k_i depends on the selected class of the LPS,

k_c depends on the lightning current flowing in the downconductors,

k_m depends on the electrical insulation material,

l is the shortest length, along the air-termination or the down-conductor, from the point where the separation distance is to be considered, to the nearest equipotential bonding point.

(see table in item C-11.3.4 as aguidance)

C.11.1.3 Earthing or Grounding System

The earthing system should include:

- Low electrical resistance to earth
- Good corrosion resistance
- An ability to carry high current repeatedly
- An ability to perform the above functions for 30 years or more

There are many methods of providing a good earth and the final choice will depend, to a great extent, on the prevailing ground conditions at site.

Ideally, soil receptivity tests and surveys should be carried out to decide on the most effective system.

Typically earths can be provided by:

- Deep driven earth rods
- Interconnected parallel driven earth rods
- Buried horizontal conductors (wires or types, etc)
- Earth plates or mats
- Steel reinforcing rods and / or wires in concrete

The British Code has a requirement for lightning protection systems to have an earth resistance of 10 ohms or less between the earth rods and the mass of earth. In case the down conductors are connected to the steel reinforcement bar network, the overall effective resistance of the reinforcement structure has to be less than 0.2 ohms. The Resistance of a higher value can lead to high rise in potential voltages; this is obviously undesirable.

C.11.1.4 Bonds and Clamps

The whole lightning protection system is connected together by a series of bonds and clamps. If these are not of adequate size and corrosion resistant they can become the weak link in the chain and lead to complete system failure.

The Bonding and Clamping accessories used for this purpose should ensure a perfect EQUIPOTENTIAL bonding application/usage.

Specifiers often devote a great amount of time to the actual layout and routing of conductors only to overlook completely the quality of materials being used.

When lightning strikes, the forces imposed on a system can be extremely high, both mechanically and electrically. The magnetic force to which a conductor could be subjected, may cause it to be stripped from the building altogether unless adequate fixings are used. IF a clamp is not capable of being tightened to its optimum level, then over a period of years a joint may loosen, which could lead to a catastrophe.

C.11.2 Need for Lightning Protection AS BSEN 62305: Part 2

The need for lightning protection of an object to be protected in order to reduce the loss of social values.

In order to evaluate whether or not lightning protection of an object is needed, a risk assessment in accordance with the procedures contained in IEC 62305-2 shall be made. The following risks shall be taken into account, corresponding to the types of loss.

R_1: risk of loss of human life;
R_2: risk of loss of services to the public;
R_3: risk of loss of cultural heritage.
R4: risk of loss of economic value
Overall risk factor R (R_1 to R_4)

C.11.2.1 *Protection against lightning is need if the risk R is higher than the tolerable level* $R_T = 0.00001 / (10^{-5})$
$R > R_T (10^{-5})$

C.11.2.2 *In this case, protection measures shall be adopted in order reduce the risk to the tolerable level* R_T
$R \leq R_T (10^{-5})$

C.11.2.3 A sample calculation of overall Risk Factor as BSEN 62305: Part 2

For example:-
A small factory in the Midlands with brick walls and a metal roof, located in an area with few other structures or trees at a similar height, where the dimensions of the factory are:-

L = 40m
H = 6m
W = 15m

The risk factor can be calculated as follows using the maps and tables shown above.

Step 1

Determine the number of flashes to ground per km squared per year (Ng). (Map from BSEN 62305 Part 2) is:

0.6 for England
0.1 for Qatar
0.5 for North of Africa and Egypt
0.5 Part of Saudi Arabia

Step 2

Determine the collection area (Ac) of the building

$Ac = LW + 2LH + 2WH + \pi\ H^2$

$= (40 \times 15) + 2\ (40 \times 6) + 2\ (15 \times 6) + \pi \times 6^2$

$= 600 + 480 + 180 + 113$

$= 1373\ m^2$

Step 3

Determine the probability of being struck (P)

When $P = Ac \times Ng \times 10^{-6}$

$= 1373 \times 0.6 \times 10^{-6}$

$= 8.238 \times 10^{-4}$

(or 0.0008238)

Step 4

Applying the relevant weighting factors from (Table 1,2,3,4 and 5)

Factor A = 1.0
B = 1.7
C = 0.3
D = 1.0
E = 0.3

The overall weighting factor = A x B x C x D x E = 0.153

Step 5

Therefore, the overall risk factor

= Probability of being struck x overall weighting factor

$= 8.238 \times 10^{-4} \times 0.153$

$= 1.261 \times 10^{-4}$ (or 0.000126)

As the 10^{-5} is the criteria for determining whether protection is necessary, we can see that 0.000126 is greater than $(10)^{-5}$"and so protection is necessary.

Having determined that lightning protection is necessary, we must now consider the actual design of the installation. To do this we must understand the principles of the Zone of Protection.

Notes:

Risk management calculation as per BSEN 62305 including collection area. Calculation attached for your reference.

Items B to G inclusive are interpreted from Table 1,2,3,4 and 5 in BSEN 62305 and are termed ‘the weighting factor values’ which denote a relative degree of importance in each case.

Weighting factor A (use of structure) – Table (1)

Use to which structure is put	Value of factor A
Houses and other buildings of comparable size	0.3
Houses and other buildings of comparable size with outside aerial	0.7
Factories, workshops and laboratories	1.0
Office blocks, hotels, blocks of flats and other residential buildings other than those included below	1.2
Places of assembly, e.g. churches, halls, theaters, museums, exhibitions, department stores, post offices, stations airports and stadium structures	1.3
Schools, hospitals, Children’s and other homes	1.7

Weighting factor B (type of construction) – Table (2)

Type of Construction	Value of factor B
Steel framed encased with any roof than metal	0.2
Reinforced concrete with any roof other than metal	0.4
Steel frame encased or reinforced concrete with metal roof	0.8
Brick plain concrete or masonry with any roof other than metal or thatch	1.0
Timber framed or clad with any roof other than metal or thatch	1.4
Brick, plain concrete, masonry, timber framed but with metal roofing	1.7
Any building with a thatch roof	2.0

A structure of exposed metal which is continuous down to ground level is excluded from the table as it requires no lightning protection beyond adequate earthing arrangements.

Weighting factor C (contents or consequential effects) – Table (3)

Contents or consequential effects	Value of factor C
Ordinary domestic or office buildings, factories and workshops not containing valuable or specially susceptible contents	0.3
Industrial and agricultural buildings with specially susceptible contents	0.8
Power stations, gas installations, telephone exchanges, radio stations	1.0
Key industrial plants, ancient monuments and historic buildings, museums, art galleries or other buildings with specially valuable contents	1.3
Schools, hospitals, children's and other Homes, places of assembly	1.7

This means especially valuable plant or materials vulnerable to fire or the results of fire.

Weighting factor D (degree of isolation) – Table (4)

Degree of isolation	Value of factor D
Structure located in a large area of structures or trees of the same or greater height, e.g. in a large town or forest	0.4
Structure located in an area with few other structures or trees of similar height	1.0
Structure completely isolated or exceeding at least twice the height of surrounding structures of trees.	2.0

Weighting factor E (type of country) – Table (5)

Type of country	Value of factor E
Flat country at any level	0.3
Hill country	1.0
Mountain country between 300m and 900m	1.3
Mountain country above 900m	1.7

C.11.3 Design Considerations

C.11.3.1 Steel structure and reinforcement of ferro-concrete structures should have terminal lugs top a bottom for bonding of Conductor.
Provision should be made for thermal expansion and contraction.
Conductors should not be protected by metallic pipes.

C.11.3.2 Air terminal can be single point – minimum 12mm diameter or equal.
Air terminal should project at least 1 foot above structure.
Air terminals should be inter-connected.
Air terminals should be not more than 100 feet / 32m apart.
Salient points, even if less than 100 feet / 32m apart, should each be provided with an air terminal. Distance between the air terminal rods is decided based on the level of protection required and the protrusions of the structure.
All metalwork on or above the structure should be bonded to the air terminal and network.
Care should be exercised to avoid corrosion by the bonding of dissimilar metals.
Ferrous metals should not be used.

C.11.3.3 Air terminals should be inter-connected with CLOSED metal loops having about 100 ft. / 32m mesh with minimum tape cross section (20mm x 3mm).

C.11.3.4 A structure within its Franklin cone may be equipped with one down conductor if its area is 1,000 sq. ft. /100m^2 or less.
One additional down conductor should be provided for 3,000 sq.ft / 300m^2

100	m^2 /	1,000	s.f =	1	Down	tape	2500	m^2 /	25,000	s.f =	9	Down	tape
400	m^2 /	4,000	s.f =	2	Down	tape	2800	m^2 /	28,000	s.f =	10	Down	tape
700	m^2 /	7,000	s.f =	3	Down	tape	3100	m^2 /	31,000	s.f =	11	Down	tape
1000	m^2 /	10,000	s.f =	4	Down	tape	3400	m^2 /	34,000	s.f =	12	Down	tape
1300	m^2 /	13,000	s.f =	5	Down	tape	3700	m^2 /	37,000	s.f =	13	Down	tape
1600	m^2 /	16,000	s.f =	6	Down	tape	4000	m^2 /	40,000	s.f =	14	Down	tape
1900	m^2 /	19,000	s.f =	7	Down	tape	4300	m^2 /	43,000	s.f =	15	Down	tape
2200	m^2 /	22,000	s.f =	8	Down	tape	4600	m^2 /	46,000	s.f =	16	Down	tape

Thus a building 200 feet by 180 feet / (65m x 55m) having as area of 36,000 sq. ft / 3600sq.m would require 13 down tape

Down conductors should be spaced EQUALLY round the OUTSIDE walls of the structure walls of a light-well may be used provided that conductors and earth terminations comply with the recommendations in the Code. This, however, in practice is unreliable because the earth termination relies considerably on moisture in the subsoil which is difficult to maintain in enclosed spaces.

Down conductors should follow the most direct path between air terminal or network and earth.

There should be no "up-turns".
The radius of bends should be as great as possible.
Down conductors for areas of 1,000 sq. ft. / 100sq.m or less and not exceeding 60 feet / 20m high. Should be 18mm x 3mm tape minimum.

C.11.3.5 JOINTS should be as few as possible.
JOINTS should exclude moisture.
BONDS should be as short as possible.
JOINTS should be tinned, soldered and double riveted.
Clamp joints should only be used at test points or bonds to existing metal.
Joints for rods may be clamped or screwed.

C.11.3.6 Test clamps should be provided for each down tape -5 feet / 1.6m above ground is a convenient height for schools 6 feet / 2m is recommended.

No connection should be made to an earth tape below the test clamp, except the earth terminal.

C.11.3.7 The earth resistance in no case should exceed 10 ohms.

When a metallic water pipe buried in the ground is available it should be bonded to the earth, in compliance with the regulations of the Institute of Civil Engineers.
Bonding to the sheath of Electricity Supply cables is permitted provided the Supply Authority concerned agrees. – We do not recommend this practice.

Groups of earth electrodes should be capable of isolation for test purposes.

Pipes conveying inflammable liquids or gas should not be used as a conductor or each terminal.

C.11.3.8 Earth rods should be at least 8feet / 2.5m long.
The distance between driven rods should be equal to their driven depth.

Earth strips should be 18 inche / 0.45m deep and in straight lines of radial formation.

C.11.3.9 A structure containing metal reinforcement or framework of metal roof, wall or floor, this metal when properly bonded may be used as part of the protective system provided that the amount, area and arrangement of metal conform to the regulations.

Metal conductors running parallel to the structures, for example down pipes within 6 feet should be bonded at the top and bottom, also at intermediate positions if necessary.

C.11.4 <u>Lightning Protection Levels (LPL)</u>

For the aim of this standard, four lightning protection levels (I to IV) are introduced. For each LPL a set of maximum and minimum lightning current parameters is fixed.

Note 1 Protection against lightning whose maximum and minimum lightning current parameters exceed those relevant to LPL I is not considered in the standard.

Note 2 the probability of the occurrence of lightning minimum or maximum current parameters outside the range of values defined for LPL I is less than 2%.

The maximum of value of lightning current parameters relevant to LPL I will not be exceed with a probability of 99%. According to the polarity ratio assumed, values taken from positive flashes will have probabilities below 10%, while those from negative flashes will remain below 1%.

The maximum values of lightning current parameters for the different lightning protection levels are given in Table 6 and are used to design lightning protection components (e.g. cross-section of conductors, thickness of metal sheets, current capability of SPDs, separation distance against dangerous sparking) and to define test parameters simulating the effects of lightning on such components.

The minimum values of lightning current amplitude for the different LPL are used to derive the rolling sphere radius in order to define the lightning protection zone which can not be reached by direct strike. The minimum values of lightning current parameters together with the related rolling sphere radius are given in Table 7.

Table 6 - Maximum values of lightning parameters according to LPL

First Short Stroke			LPL			
Current Parameter	Symbol	Unit	I	II	III	IV
Peak Current	*I*	kA	200	150	100	
Subsequent Short Stroke			LPL			
Current Parameter	Symbol	Unit	I	II	III	IV
Peak Current	*I*	kA	50	37.5	25	

Table 7 - Minimum values of lightning parameters and related rolling sphere radius corresponding to LPL

Interception Criteria			LPL			
	Symbol	Unit	I	II	III	IV
Minimum peak current	*I*	kA	3	5	10	16
Rolling sphere radius	*r*	m	20	30	45	60

C.11.5 Damage to a Structure.

Lightning affecting a structure can cause damage to the structure itself and to its occupants and contents, including failure of internal systems. The damages and failures may also extend to the surroundings of the structure and even involve the local environment. The scale of this extension depends on the characteristics of the structure and on the characteristics of the lightning flash.

C.11.6 Effects of lightning on a service refer to BSEN 62305

The main characteristics of services relevant to lightning effects include:

- Construction (line: overhead, underground, screened, unscreened, fibre optic; pipe: above ground, buried, metallic, plastic);
- Function (telecommunication line, power line, pipeline);
- Structure supplied (Construction, contents, dimensions, location);
- Existing or provided protection measures (e.g. shielding wire, SPD, route redundancy, fluid storage systems. Generating sets, uninterruptible power systems).

Table -8 reports the effects of lightning on various types of services.

Type of Service	Effect of Lightning
Telecommunication line	Mechanical damage to line, melting of screens and conductors, breakdown of insulation of cable and equipment leading to a primary failure with immediate loss of service. Secondary failures on the optical fibre cables with damage of the cable but without loss of service.
Power lines	Damage to insulators of low voltage overhead line, puncturing of insulation of cable line, breakdown of insulation of line equipment and of transformers, with consequential loss of service.
Water pipes	Damages to electrical and electronic control equipments likely to cause loss of service
Gas pipes Fuel pipes	Puncturing of non-metallic flange gaskets likely to cause fire and / or explosion. Damage to electrical and electronic control equipments likely to cause loss of service.

C.12 SOLAR ENERGY

Types of Solar Energy SYSTEM

C.12.1 SOLAR On –Grid AS STD. UL 1741 & IEEE 1547

It can be connected together with the electric utility grid and it generates and routes the excess power into main supply.as indicated in fig(1)and fig(2) .

Components:-

1. Photo Voltaic Panel (Pv)
2. Inverter

Important Equation:

(1)Sq. meter for (Pv) should generate	= 150 Watt / Peak
	= 3.5 (hour) x 150 (w)
	= 525 WH / Day
1Watt Peak /1WP	= 3 Dollars (Cost)
1 KW Peak / 1KWP	= 3.5 (KWH) / Day
	= (Cost 3000 Dollars)
	= 7 square meter for (Pv)

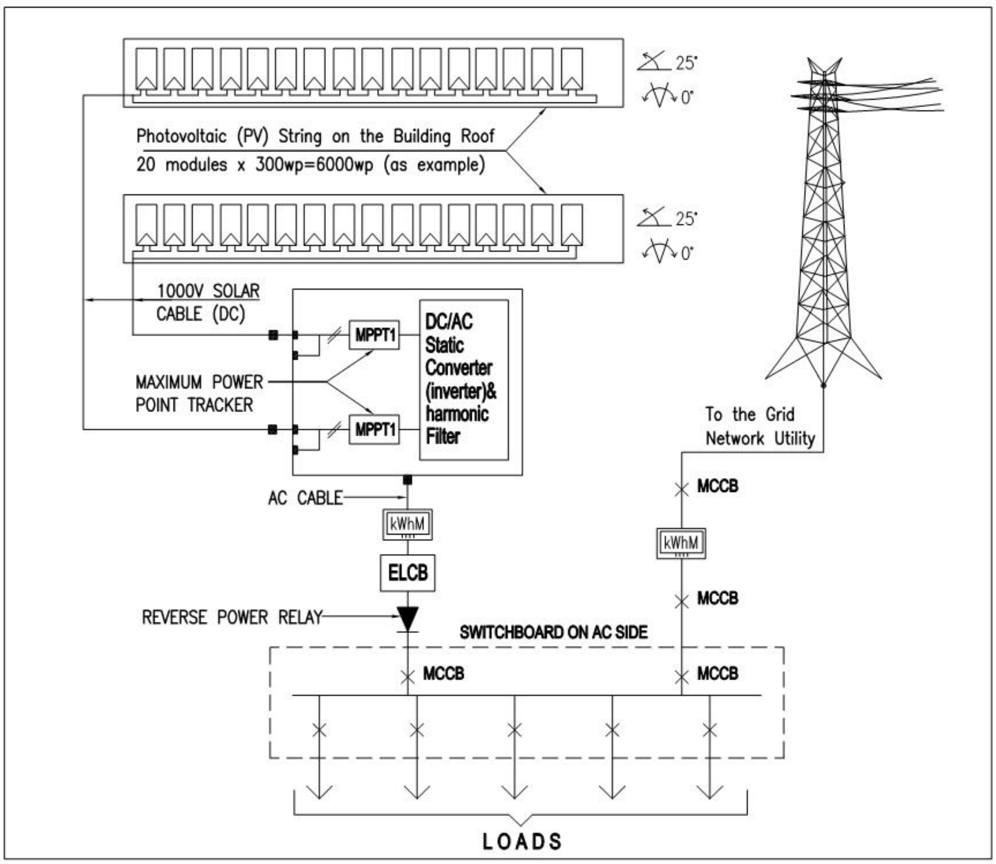


FIG. (1) SINGLE LINE DIAGRAM SOLAR(ON-GRID)

Very Important Notes:

1. Connect solar panels in series to form a single source module (PV) and generate a voltage below 800 volts DC.
2. PV's are connected in parallel to a combiner to generate larger capacity.
3. Solar inverter converts incoming DC voltage/power to outgoing AC voltage power.
4. Solar inverters are designed to be grid-tied to utility power system/standards in compliance for grid-tie are UL 1741 and IEEE 1547.
5. Solar cell with hit (Hetero junction with intrinsic thin layer), solar cell is made of thin mono crystalline silicon wafer surrounded by ultra thin amorphous silicon layer.
6. PV solar panel modules shall be 100% emission free and no moving part.

Features:

1. Electrolyte-free power converter to further increase the life expectancy and long term reliability.
2. True three-phase bridge topology for DC/AC output converter.
3. Each inverter is set on specific grid codes which can be selected in the field.
4. Dual input sections with independent MPP tracking, allows optima energy harvesting from two sub-arrays oriented in different directions wide input range.
5. Detachable wiring box to allow an easy installation.
6. Integrated string combiner with different options of configuration which include DC and AC disconnect switch in compliance with international standards.
7. High speed and precise MPPT algorithm for real time power tracking and improved energy harvesting.

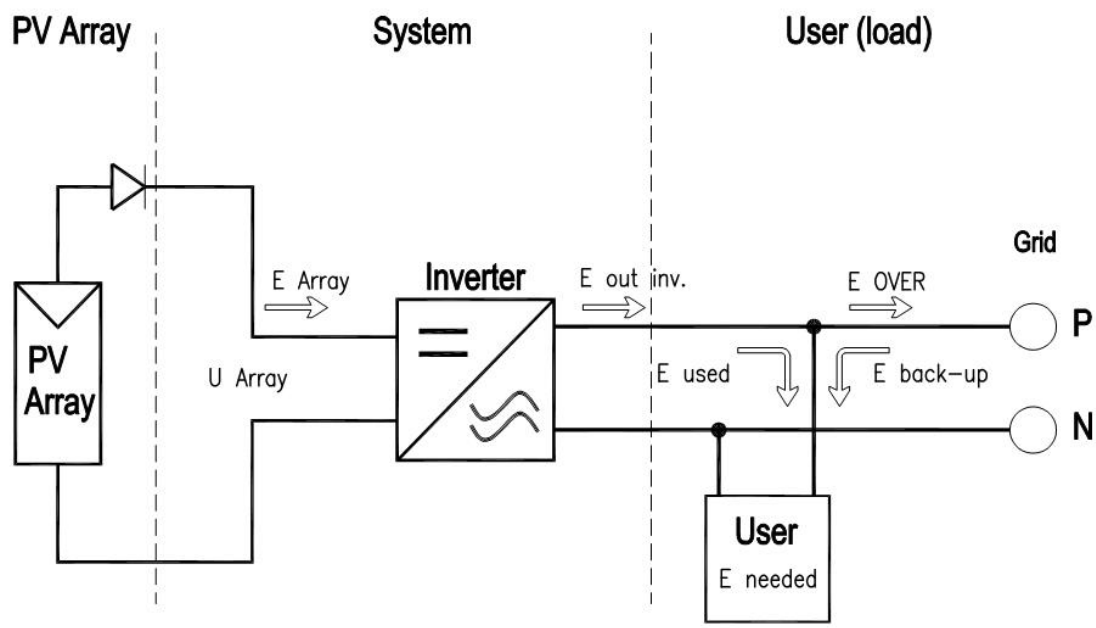


FIG. (2) SCHEMATIC DIAGRAM SOLAR(ON–GRID)

C.12.2 **SOLAR Stand Alone System (Off – Grid) AS UL 1741 & IEEE 1547**

System is used for remote areas (No Electrical Power Supply),as fig(3)and fig(4).
Components:-

1. Photo Voltaic Panel (Pv)
2. Inverter
3. Batteries

Important Equation:

1KW (Peak)/1KWP = 3.5 (KWH) / Day
= (Cost 7000 Dollars)
= 7 square meter for (Pv)

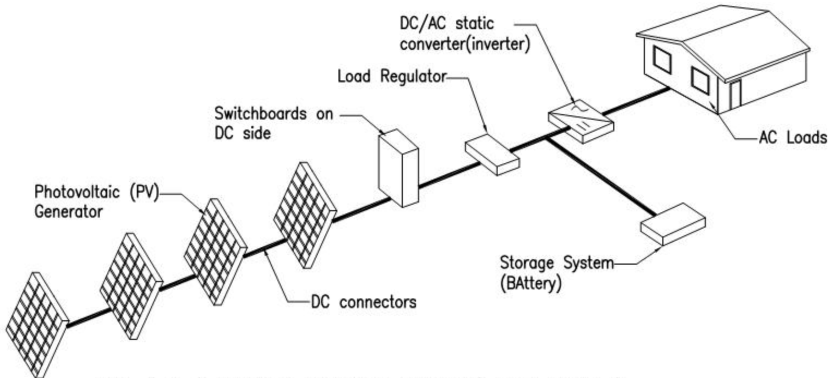


FIG. (3) BLOCK DIAGRAM SOLAR(OFF-GRID)

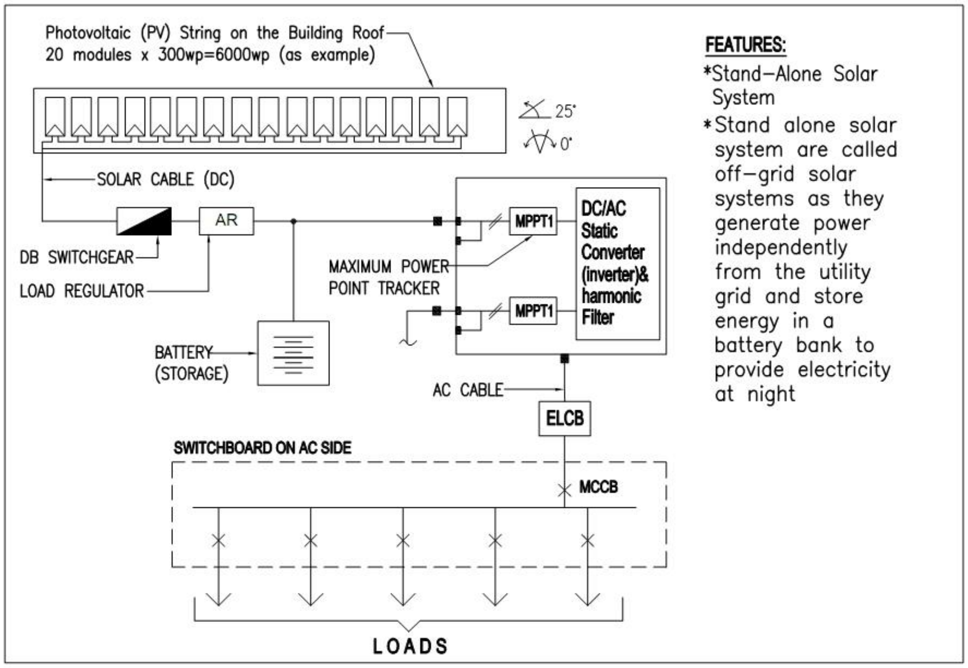


FIG. (4) SINGLE LINE DIAGRAM SOLAR(OFF-GRID)

C.12.3 **<u>BIPV (Building Integrated Photovoltaics)</u>**

Green energy for all types of huge building like stadium, car parking, petrol station. Types of glass modules like:-

- Curved façade module.
- Façade module.
- Roof module.
- Different shapes and sizes, geometries, colors,……..

<u>Important Equation:</u>

1 KWP = (3.5 KWH / Day)
= (Cost 7000 Dollars)
= 7 square meter for (Pv)

<u>Example:</u>

- Total connected load = 50 kW
- Maximum demand load = 35 kW
- Maximum consumption power per day = 35x24(h)x0.4
= 336 kWh/day

- Required power (Peak) = $\frac{336}{3.5}$ = 96 KWP

- (On-grid) / cost = 96x3000 = 288,000 dollar
- (Off-grid) / cost = 96x7000 = 672,000 dollar
- PV area required = 96x7 = 672 m^2

C.12.4 <u>Day Light System</u> – This rates 1 wattage = 1.5mm diameter of upper dome which when placed on the top passes day light on reflective pipe.

C.12.5 <u>Stand alone CCTV</u> security and monitoring system.

C.12.6 <u>LED Solar Street Light</u> – This can be used with DC System as stand alone system and also for garden light.

C.12.7 <u>Solar Generator</u> – This is mobile, stand alone, zero pollution and can be used with movable lighting towers for remote areas.

C.12.8 <u>Solar air-conditioner</u> – This can be used with DC compressor (no inverter required, deep cycle batteries as energy) and also for fridge with DC fridge.

C.12.9 <u>Water heating</u> application.

C.12.10 <u>Solar Pumping</u> – it is powered by photovoltaic panels and the flow rate is determined by the intensity of the sunlight.

C.12.11 <u>Solar Traffic Light</u> – This controls the traffic flow using solar powered devices.

C.13 <u>Structure Cabling (Data – Telephone)</u>

C.13.1 <u>Passive Component</u>

- Patch Panel
- Module
- Face Plate
- Cable
- Cable Manager
- Racks

C.13.2 <u>Active Component</u>

Active component which it shall be fed by power supply such as:

- Switch
- Access Point
- Router
- Servers

C.13.3 <u>Cable Details.STD. IEEE/TIA 568-B.2-1</u>

C.13.3.1 All Cables connected between data outlets or telephone outlets and data patch panel (DPP) shall be CAT6 or CAT6A for IP type and also from DPP to intermediate data frame (IDF) shall be CAT6 for IP (Data / Telephone) as Fig.(1).

C.13.3.2 For analogue system cable with specification (cat-3) can be used for Telephone outlet.

C.13.3.3 Fiber Optics cable shall be used for main supply from IDF to MDF with the following specs:-

***Sizes (4c, 6c, 8c, 12c, 24c)**

4c For small project 2 core for data /2 core for telephone.
6c Major project 2c for data /2 core for telephone & 2c spare.
8c Special application 2 core data & 2c spare, 2c for Telephone & 2c spare.

- Single Mode (Band width is more)/ if distance more than 1 KM
- Multi Mode (Band width is less)
- Armoured (Outdoor installation)
- Unarmoured (Indoor installation)

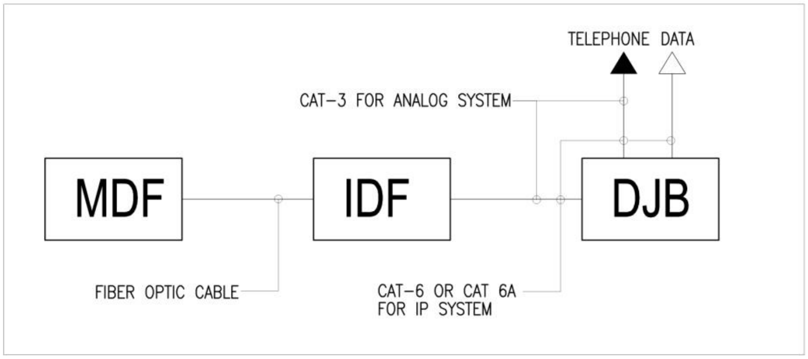


Fig (1)

C.13.4 <u>Coverage Area by (IDF)</u>

We should use (IDF) for the following cases:-

- Distance between IDF and outlets < 90 meter.
- IDF can be used for many floors if distance not more than 90 meter.

C.13.5 <u>Some Design Criteria for IDF.STD. IEEE/TIA 568 B.2-1, EIA,TIA 568 A</u>

- We can use direct connection from patch panel to switches whatever, its located (IDF or MDF).
- No. of ports switches should be more than (Data / Voice / any IP Outlet) by 20% as a spare.
- Height of one "U" is = 44.45mm.
- It is preferable to use separate patch panel for telephone, data and CCTV system.
- IDF include:-
  - Telephone outlets
  - Data outlets
  - CCTV outlets
  - Access point
  - Any other IP / analog points.

- We can connect any number of IDF to MDF.
- One switch shall be used for connection to MDF by Fiber Optics Cables.
- Standard size of IDF (4U, 6U, 9U, 12U, 15U, 18U, 22U, 27U, 32U, 42U).
- Standard size of MDF is (6U, 9U, 12U, 15U, 18U, 22U, 27U, 32U, 42U).
- We can use one fiber optics for data, telephone and CCTV.
- For integration purpose, we can connect analogue CCTV, SMATV if there is an interface to switches.
- In CCTV System we can use racks for Network Video Recorder (NVR) and space is (4-6) U channel, related to no. of cameras and storage capacity.
- (4-6) U for 1KVA UPS, with battery backup and (9-12) U for 3KVA UPS.

C.13.6 Schematic Diagram for IDF.

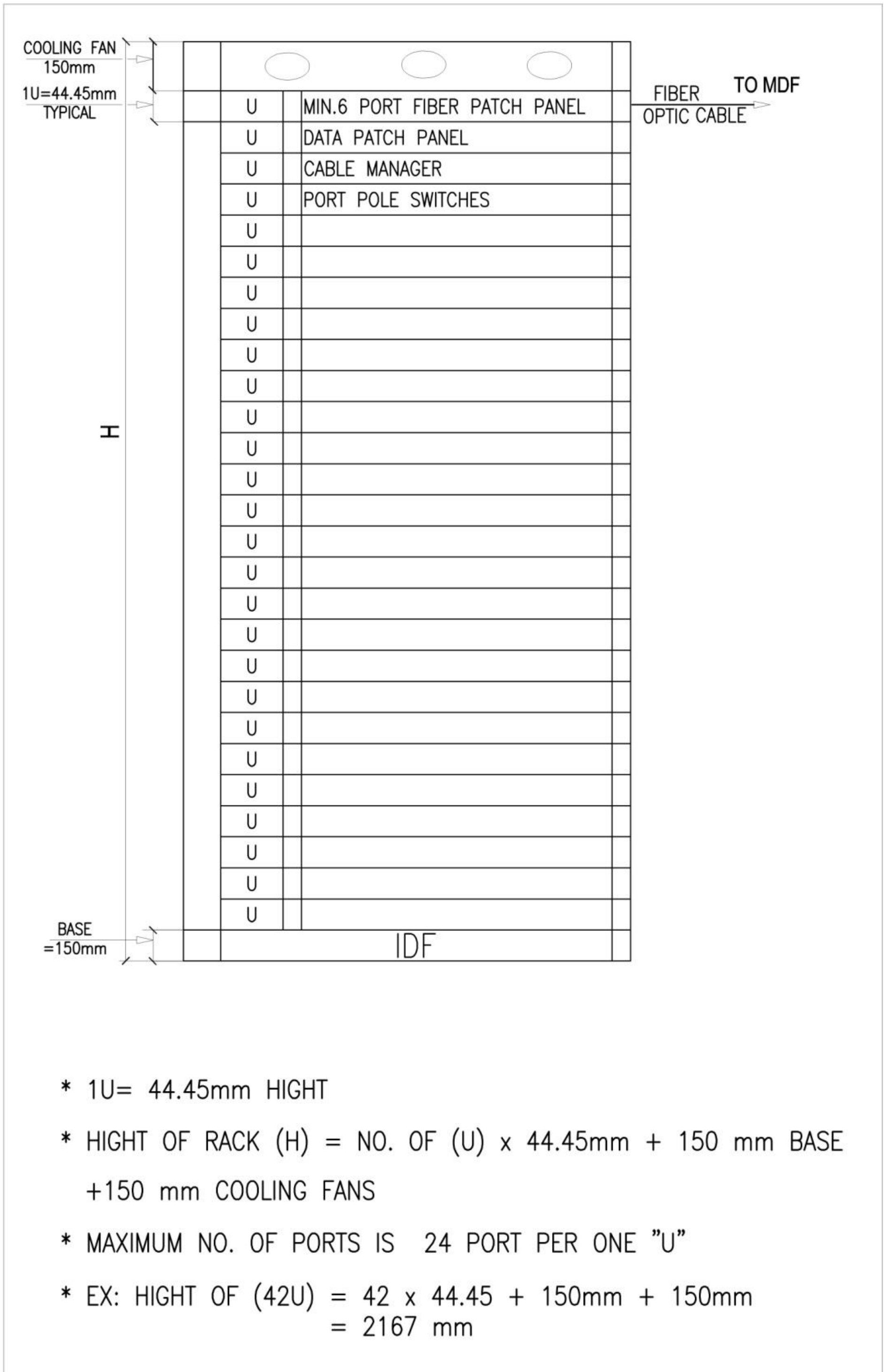


Fig.(2)

C.14 Data Center Site Infrastructure & Tier Standard

C.14.1 Introduction

Standard establishes four distinctive definitions of data center site infrastructure Tier classifications (Tier 1, Tier 2, Tier 3, Tier 4), and the performance confirmation tests for determining compliance to the definitions. The classifications, describe the site-level infrastructure topology required to sustain data center operations, not the characteristics of individual systems or subsystems.

This standard is predicated on the fact that data centers are dependent upon the successful and integrated operation of several separate site infrastructure subsystems, the number of which is dependent upon the individual technologies (e.g., power generation, refrigeration, uninterruptible power sources, etc.) selected to sustain the operation.

Every subsystem and system integrated into the data center site infrastructure must be consistently deployed with the same site uptime objective to satisfy the distinctive Tier requirements.

Compliance with the requirements of each Tier is measured by outcome-based confirmation tests and operational impacts. This method of measurement differs from a prescriptive design approach or a checklist or required equipment.

The purpose of this Standard is to equip design professionals, data center operators, and non-technical managers with an objective and effective means for identifying the anticipated performance of different data center site infrastructure design topologies.

The most critical decision-making perspective owners and designers must consider, when making inevitable tradeoffs, is what effect does the decision have on the life-cycle-integrated operation of the Information Technology (IT) environment in the computer room.

Finally, this Standard focuses on the topology and performance of an individual site. High levels of end-user availability may be attained through the integration of complex IT architectures and network configurations that take advantage of synchronous applications running on multiple sites. However, this Standard is independent of the IT systems operating within the site.

C.14.2 <u>Tier Requirements Summary refer to UTI Std.</u>

	Tier 1	Tier 2	Tier 3	Tier 4
Active Capacity Components to Support the IT Load	N	N+1	N+1	(N) After any failure
Distribution Paths	1	1	1 Active and 1 Alternative	2 Simultaneously Active
Concurrently Maintainable	No	No	Yes	Yes
Fault Tolerance	No	No	No	Yes
Compartmentalization	No	No	No	Yes
Continuous Cooling	No	No	No	Yes

C.14.3 <u>Tier Classifications according to standard (UTI) Uptime Institute, LLC</u>

Tier 1 – See Fig.(1)

- Site Availability: 99.671%
- Annual Downtime:28.8 Hours
- 1 Delivery Path (Server & Internet)
- Zero Redundant Components

Tier 2 – See Fig.(2)

- Site Availability: 99.749%
- Annual Downtime: 22 Hours
- 1 Delivery Path (Server & Internet)
- Redundant Server Hardware

Tier 3 – See Fig.(3)

- Site Availability: 99.982%
- Annual Downtime: 1.6 Hours
- 1 Delivery Path (Server & Internet)
- Redundant power, cooling & hardware components

Tier 4 – See Fig.(4)

- Site Availability: 99.995%
- Annual Downtime: 0.4 Hours
- 2 Delivery Paths
- Redundant power, cooling, hardware and fault tolerance components.

TIER-1 NON-REDUNDANT POWER SUPPLY DATA CENTER

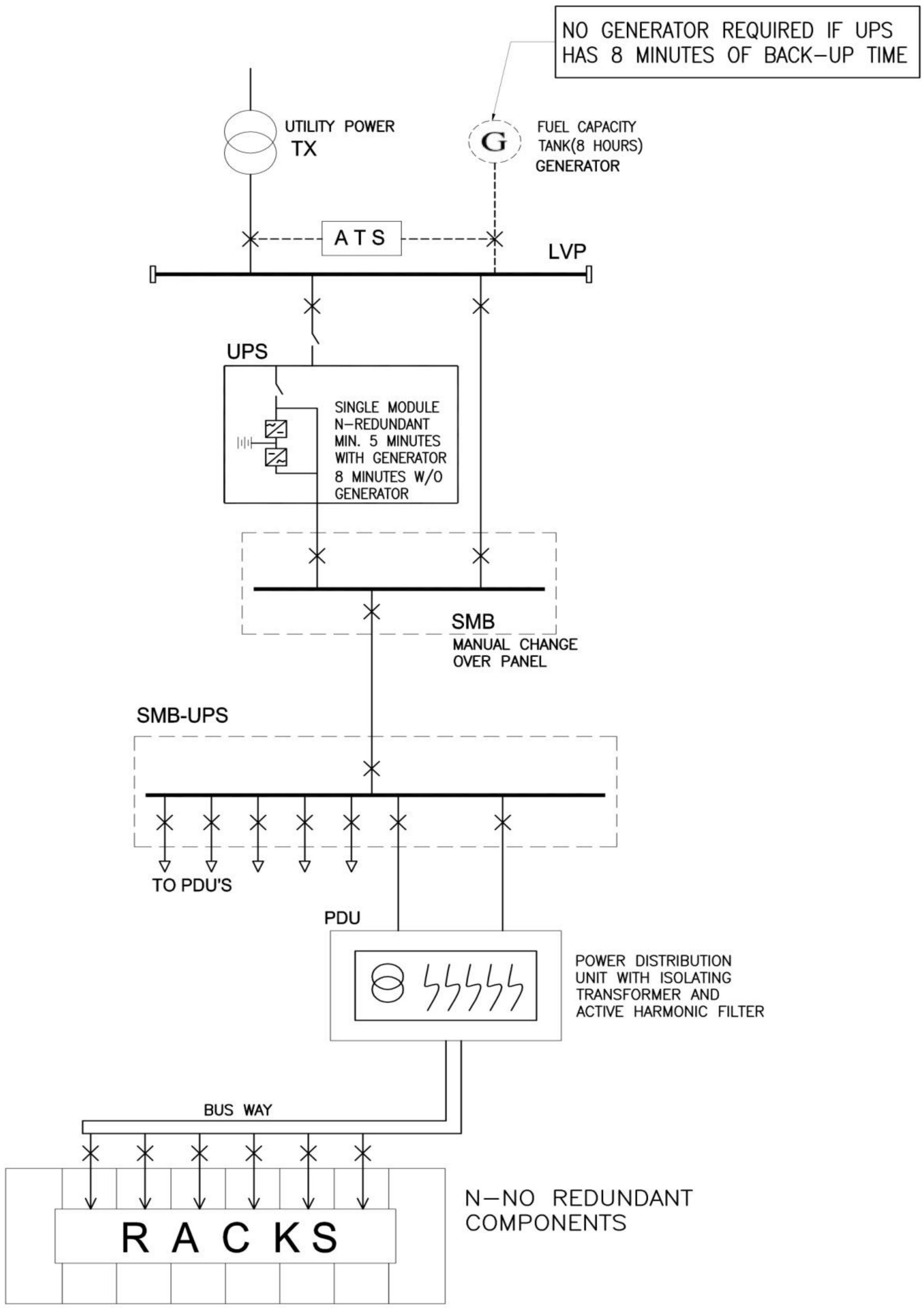


Fig. (1)

TIER-2 ONLY-REDUNDANT SERVER HARDWARE POWER SUPPLY DATA CENTER

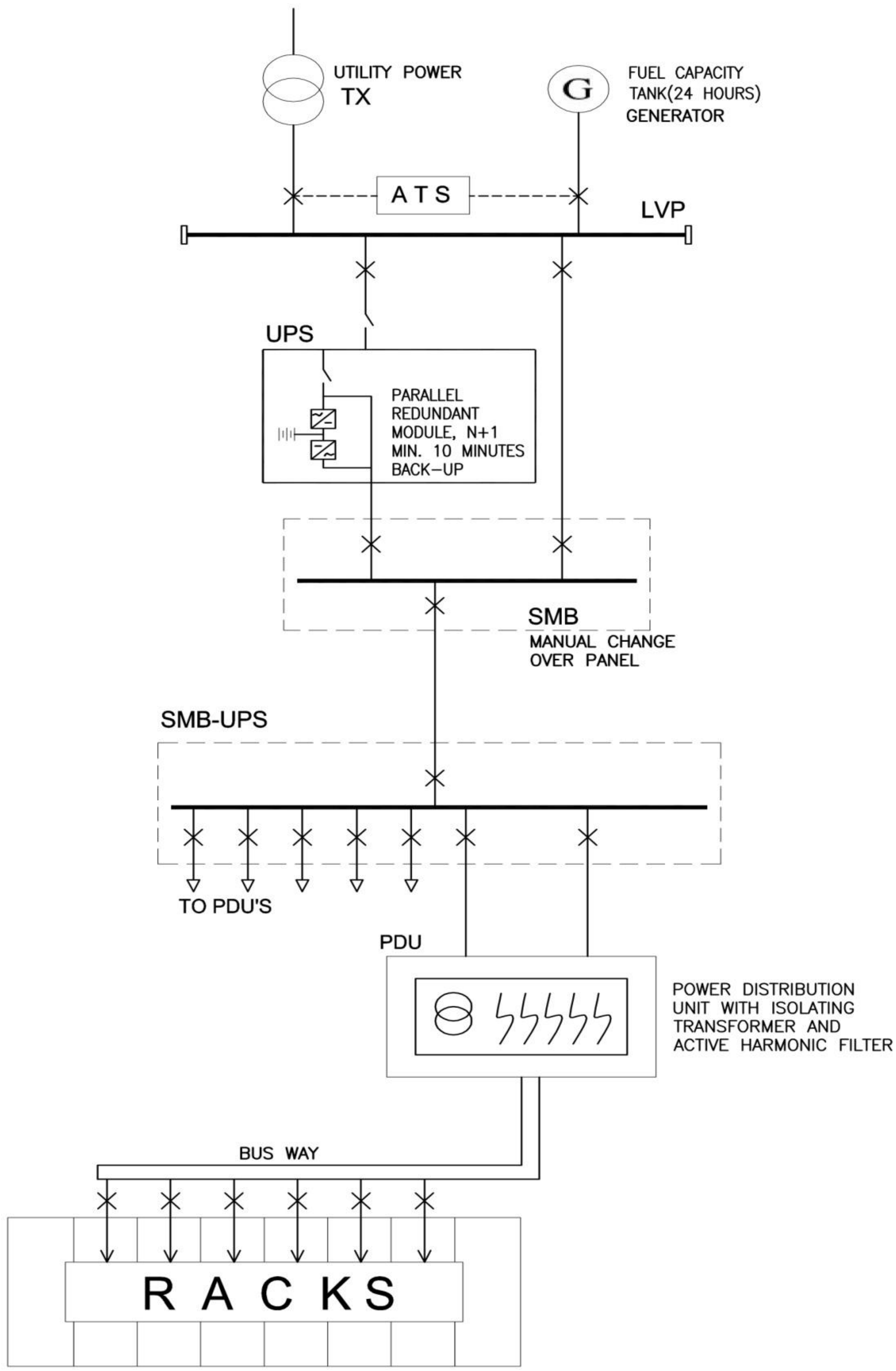


Fig. (2)

TIER-3 FULLY-REDUNDANT POWER SUPPLY DATA CENTER

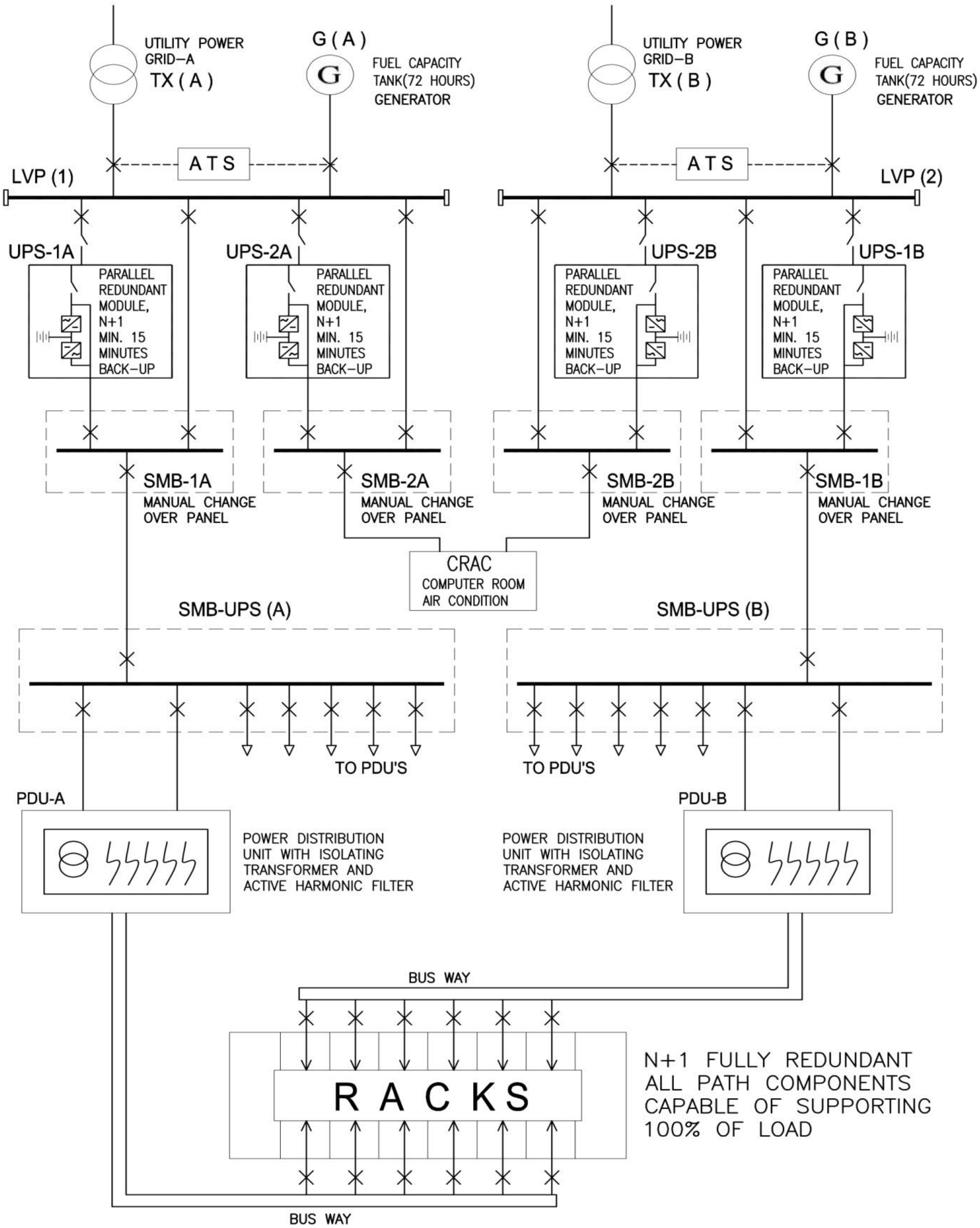


Fig. (3)

TIER-4 FULLY REDUNDANT POWER SUPPLY DATA CENTER

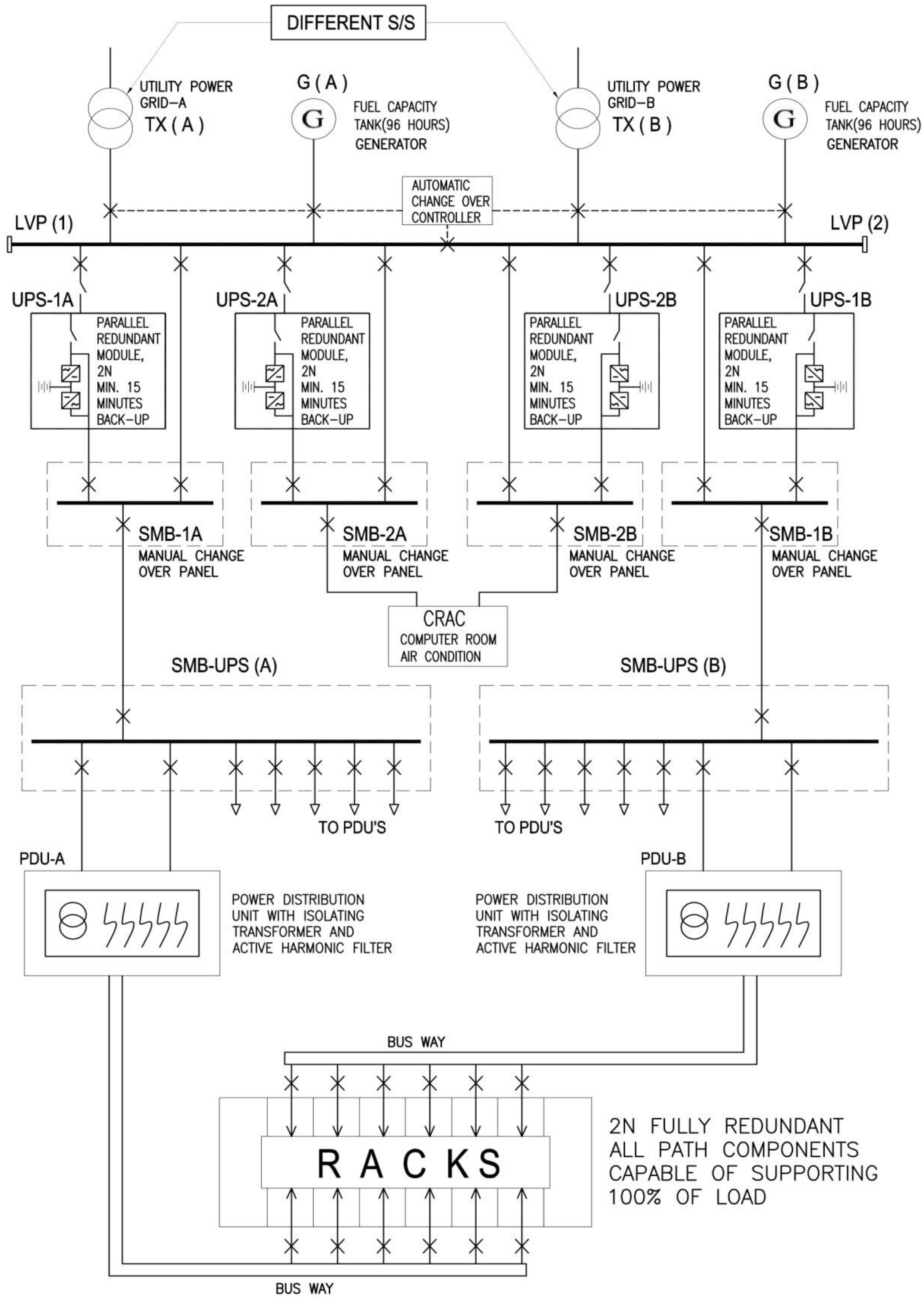


Fig. (4)

C.14.3 **TIA – 942 (Telecommunications Infrastructure Association)**
Tiering Reference Guide (Electrical)

	TIER 1	**TIER 2**	**TIER 3**	**TIER 4**
ELECTRICAL				
General				
Number of Delivery Paths	1	1	1 Active and 1 Passive	2 Active
Utility Entrance	Single Feed	Single Feed	Dual Feed (600 volts or higher)	Dual Feed (600 volts or higher) from different utility substations.
System allows concurrent maintenance	No	No	Yes	Yes
Computer & Telecommunications Equipment Power Cords.	Single Cord Feed with 100% capacity	Dual cord feed with 100% capacity on each cord	Dual cord feed with 100% capacity on each cord	Dual cord feed with 100% capacity on each cord
All electrical system equipment labeled with certification from 3rd party test laboratory	YES	YES	YES	YES
Single Points of Failure	One or more single points of failure for distribution systems serving electrical equipment or mechanical systems	One or more single points of failure for distribution systems serving electrical equipment or mechanical systems	No single points of failure for distribution systems serving electrical equipment or mechanical systems	No single points of failure for distribution systems serving electrical equipment or mechanical systems
Critical Load System Transfer	Automatic Transfer Switch (ATS) with maintenance bypass feature for serving the switch with interruption in power; automatic changeover from utility to generator when a power outage occurs.	Automatic Transfer Switch (ATS) with maintenance bypass feature for serving the switch with interruption in power; automatic changeover from utility to generator when a power outage occurs.	Automatic Transfer Switch (ATS) with maintenance bypass feature for serving the switch with interruption in power; automatic changeover from utility to generator when a power outage occurs.	Automatic Transfer Switch (ATS) with maintenance bypass feature for serving the switch with interruption in power; automatic changeover from utility to generator when a power outage occurs.

	TIER 1	TIER 2	TIER 3	TIER 4
Site Switchgear	None	None	Fixed air circuit breakers of fixed molded case breakers. Mechanical interlocking of breakers. Any switchgear in distribution system can be shutdown for maintenance with by-passes without dropping the critical load	Drawout air circuit breakers or drawout molded case breakers. Mechanical interlocking of breakers. Any switchgear in distribution system can be shutdown for maintenance with by-passes without dropping the critical load
Generators correctly sized according to installed capacity of UPS	YES	YES	YES	YES
General Fuel Capacity (at full load)	8 Hrs. (No generator required if UPS has 8 minutes of backup time)	24 Hrs.	72 Hrs.	96 Hrs.
UPS				
UPS Redundancy	N	N+1	N+1	2N
UPS Topology	Single Module or Parallel Non-Redundant Modules	Parallel Redundant Modules or Distributed Redundant Modules	Parallel Redundant Modules or Distributed Redundant Modules or Block Redundant Sy.	Parallel Redundant Modules or Distributed Redundant Modules or Block Redundant Sy.
UPS Maintenance Bypass Arrangement	By-pass power taken from same utility feeds and UPS modules	By-pass power taken from same utility feeds and UPS modules	By-pass power taken from same utility feeds and UPS modules	By-pass power taken from same utility feeds and UPS modules
UPS Power Distribution – Voltage Level	Voltage Level 120/208V up to loads 1440 kVA and 480V for loads greater than 1440 kVA	Voltage Level 120/208V up to loads 1440 kVA and 480V for loads greater than 1440 kVA	Voltage Level 120/208V up to loads 1440 kVA and 480V for loads greater than 1440 kVA	Voltage Level 120/208V up to loads 1440 kVA and 480V for loads greater than 1440 kVA
UPS Power Distribution – Panel Boards	Incorporating standard thermal magnetic trip breakers	Incorporating standard thermal magnetic trip breakers	Incorporating standard thermal magnetic trip breakers	Incorporating standard thermal magnetic trip breakers
PDUs feed all computer and telecommunications equipment	No	No	Yes	Yes

K-Factor Transformers Installed in PDUs	Yes, but not required if harmonic cancelling transformers are used.	Yes, but not required if harmonic cancelling transformers are used.	Yes, but not required if harmonic cancelling transformers are used.	Yes, but not required if harmonic cancelling transformers are used.
Load Bus Synchronization (LBS)	No	No	Yes	Yes
Redundant Components (UPS)	Static UPS Design	Static or Rotary UPS Design. Rotating M-G Set Converters.	Static or Rotary UPS Design. Static Converters.	Static, Rotary, or Hybrid UPS Design
UPS on separate distribution panel from computer & telecommunications equipment	No	Yes	Yes	Yes
Grounding				
Lighting Protection System	Based on risk analysis as per NFPA 780 and insurance requirements	Based on risk analysis as per NFPA 780 and insurance requirements	Yes	Yes
Service entrance grounds and generator grounds fully conform to NEC	Yes	Yes	Yes	Yes
Lighting fixtures (277v) neutral isolated from service entrance derived from lighting transformer for ground fault isolation	Yes	Yes	Yes	Yes
Data center grounding infrastructure in computer room	Not Required	Not Required	Yes	Yes
Computer Room Emergency Power Off (EPO) System				
Activated by emergency Power Off (EPO) at exits with computer and telecommunications system shutdown only	Yes	Yes	Yes	Yes
Automatic fire suppressant release after computer and telecommunications system shutdown	Yes	Yes	Yes	Yes
Second zone fire alarm system activation with manual Emergency Power Off (EPO) shutdown	No	No	No	Yes
Master control disconnects batteries and releases suppressant from a 24/7 attended station	No	No	No	Yes

Battery Room Emergency Power Off (EPO)System				
Activated by Emergency Power Off (EPO) buttons exits with manual suppressant release	Yes	Yes	Yes	Yes
Fire suppressant release for single zone system after Emergency Power Off (EPO) shutdown	Yes	Yes	Yes	Yes
Second zone fire alarm system activation. Disconnects batteries on first zone with suppressant release on the second zone	No	No	Yes	Yes
Master control disconnects batteries and releases suppressant from a 24/7 attended station	No	No	Yes	Yes
Emergency Power Off (EPO) System				
Shutdown of UPS power receptacles in computer room area.	Yes	Yes	Yes	Yes
Shutdown of AC power for CRACs and chillers	Yes	Yes	Yes	Yes
Compliance with local code (e.g. separate systems for UPS and HVAC)	Yes	Yes	Yes	Yes
System Monitoring				
Locally Displayed at UPS	Yes	Yes	Yes	Yes
Central power and environmental monitoring and control system (PEMCS) with remote engineering console and manual overrides for all automatic controls and set points	No	No	Yes	Yes
Interface with BMS	No	No	Yes	Yes
Remote control	No	No	No	Yes
Automatic Text Messaging to Service Engineer's Pager	No	No	No	Yes
Battery Configuration				
Common battery strings for all modules	Yes	No	No	No
One battery string per module	No	Yes	Yes	Yes
Minimum full load standby by time	5 Minutes	10 Minutes	15 Minutes	15 Minutes
Battery type	Valve regulated lead acid (VRLA) or flooded type	Valve regulated lead acid (VRLA) or flooded type	Valve regulated lead acid (VRLA) or flooded type	Valve regulated lead acid (VRLA) or flooded type
Flooded Type Batteries				
Mounting	Racks or Cabinets	Racks or Cabinets	Open Racks	Open Racks
Wrapped Plates	No	Yes	Yes	Yes
Acid spill containment installed	Yes	Yes	Yes	Yes
Battery full load testing / Inspection schedule	Every two years	Every two years	Every two years	Every two years or annually

Battery Room				
Separate from UPS/ switchgear equipment rooms	No	Yes	Yes	Yes
Individual battery strings isolated from each other	No	Yes	Yes	Yes
Shatterproof viewing glass in battery room door	No	No	No	Yes
Battery disconnects located outside battery room	Yes	Yes	Yes	Yes
Battery monitoring system	UPS self monitoring	UPS self monitoring	UPS self monitoring	Centralized automated system to check each cell for temperature, voltage and impedance
Rotating UPS System Enclosures (With Diesel Generators)				
Units separately enclosed by fire rated walls	No	No	Yes	Yes
Fuel tanks on exterior	No	No	Yes	Yes
Fuel tanks in same room as units	Yes	Yes	No	No
Standby Generating System				
Generating sizing	Sized for computer & telecommunications system electrical & mechanical only	Sized for computer & telecommunications system electrical & mechanical only	Sized for computer & telecommunications system electrical & mechanical only + 1 spare	Total building load + 1 spare
Generators on single bus	Yes	Yes	Yes	No
Single generator per system with (1) spare generator	No	Yes	Yes	Yes
Individual 83 ft. ground fault protection for each generator	No	Yes	Yes	Yes
Loadbank for Testing				
Testing UPS modules only	Yes	Yes	Yes	No
Testing of Generators only	Yes	Yes	Yes	No
Testing of both UPS modules and generators	No	No	No	Yes
UPS switchgear	No	No	No	Yes
Permanently installed	No - Rental	No - Rental	No - Rental	Yes

Section (D)
Design Considerations

D.1 Forms of Separation.

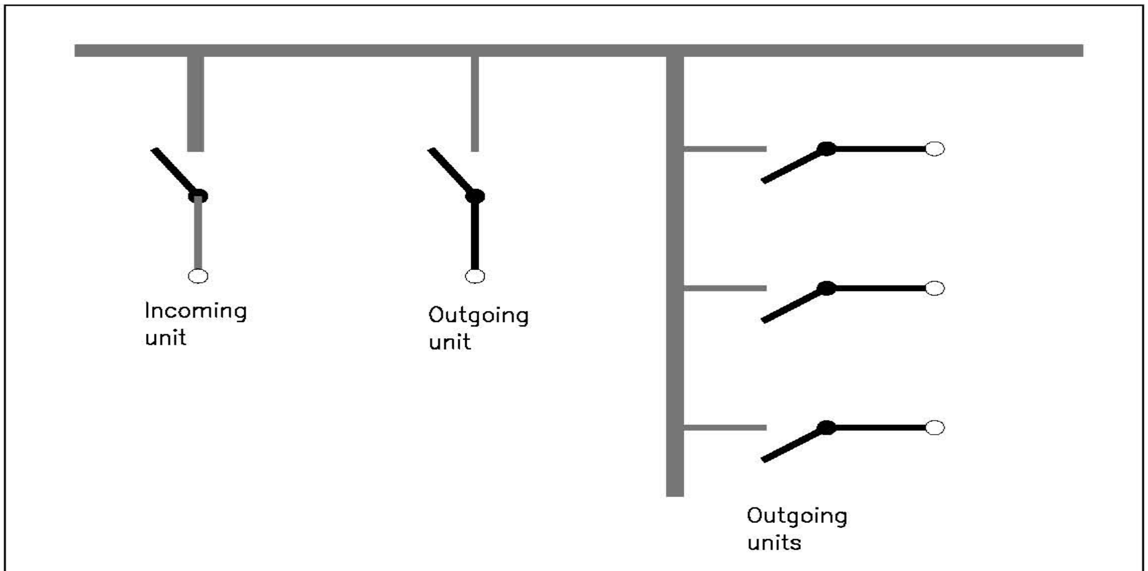
D.1.1 Forms of Separation According to BS EN 61439-2

FORM	CRITERIA	TYPE OF CONSTRUCTION
FORM 1	NO SEPARATION	NO
FORM 2A	SEPARATION OF BUSBARS FROM FUNCTIONAL UNITS. TERMINALS FOR EXTERNAL CONDUCTORS NOT SEPARAATED FROM BUSBARS.	TYPE 1– BUSBAR SEPARATION IS ACHIEVED BY INSULATED COVERING, E.G., SLEEVING, WRAPPING OR COATINGS. TYPE 2– BUSBAR SEPARATION IS BY METALLIC OR NON–METALLIC RIGID BARRIERS OR PARTITIONS.
FORM 2B	SEPARATION OF BUSBARS FROM FUNCTIONAL UNITS. TERMINALS FOR EXTERNAL CONDUCTORS SEPARATED FROM BUSBARS.	
FORM 3A	SEPARATION OF BUSBARS FROM FUNCTIONAL UNITS AND SEPARATION OF ALL FUNCTIONAL UNITS FROM ONE ANOTHER. SEPARATION OF THE TERMINALS FOR EXTERNAL CONDUCTORS FROM THE FUNCTIONAL UNITS, BUT NOT FROM EACH OTHER. TERMINALS FOR EXTERNAL CONDUCTORS NOT SEPARATED FROM BUSBARS.	
FORM 3B	SEPARATION OF BUSBARS FROM FUNCTIONAL UNITS AND SEPARATION OF ALL FUNCTIONAL UNITS FROM ONE ANOTHER. SEPARATION OF THE TERMINALS FOR EXTERNAL CONDUCTORS FROM THE FUNCTIONAL UNITS, BUT NOT FROM EACH OTHER. TERMINALS FOR EXTERNAL CONDUCTORS SEPARATED FROM BUSBARS.	
FORM 4A	SEPARATION OF BUSBARS FROM FUNCTIONAL UNITS AND SEPARATION OF ALL FUNCTIONAL UNITS FROM ONE ANOTHER, INCLUDING THE TERMINALS FOR EXTERNAL CONDUCTORS WHICH ARE AN INTEGRAL PART OF THE FUNCTIONAL UNIT. TERMINALS FOR EXTERNAL CONDUCTORS NOT IN THE SAME COMPARTMENT AS THE ASSOCIATED FUNCTIONAL UNIT.	TYPE 1– BUSBAR SEPARATION IS ACHIEVED BY INSULATED COVERING, E.G., SLEEVING, WRAPPING OR COATINGS. CABLES MAY BE GLANDED ELSEWHERE. TYPE 2– BUSBAR SEPARATION IS BY METALLIC OR NON–METALLIC RIGID BARRIERS OR PARTITIONS. CABLES MAY BE GLANDED ELSEWHERE. TYPE 3– BUSBAR SEPARATION IS BY METALLIC OR NON–METALLIC RIGID BARRIERS OR PARTITIONS. THE TERMINATION FOR EACH FUNCTIONAL UNIT HAS ITS OWN INTEGRAL GLANDING FACILITY.
FORM 4B	SEPARATION OF BUSBARS FROM FUNCTIONAL UNITS AND SEPARATION OF ALL FUNCTIONAL UNITS FROM ONE ANOTHER, INCLUDING THE TERMINALS FOR EXTERNAL CONDUCTORS WHICH ARE AN INTEGRAL PART OF THE FUNCTIONAL UNIT. TERMINALS FOR EXTERNAL CONDUCTORS NOT IN THE SAME COMPARTMENT AS THE ASSOCIATED FUNCTIONAL UNIT, BUT IN INDIVIDUAL, SEPARATE, ENCLOSED PROTECTED SPACES OR COMPARTMENTS.	TYPE 4– BUSBAR SEPARATION IS ACHIEVED BY INSULATED COVERING, E.G., SLEEVING, WRAPPING OR COATINGS. CABLES MAY BE GLANDED ELSEWHERE. TYPE 5– BUSBAR SEPARATION IS BY METALLIC ON NON–METALLIC RIGID BARRIERS OR PARTITIONS. TERMINALS MAY BE SEPARATED BY INSULATED COVERINGS AND GLANDED IN COMMON CABLING CHAMBERS. TYPE 6– ALL SEPARATION REQUIREMENTS ARE BY METALLIC ON NON–METALLIC RIGID BARRIERS OR PARTIONS. CABLES ARE GLANDED IN COMMON CABLING CHAMBERS. TYPE 7– ALL SEPARATION REQUIREMENTS ARE BY METALLIC OR NON–METALLIC RIGID BARRIERS OR PARTITIONS. THE TERMINATION FOR EACH FUNCTIONAL UNITS HAS ITS OWN ENTEGRAL GLANDING FACILITY.

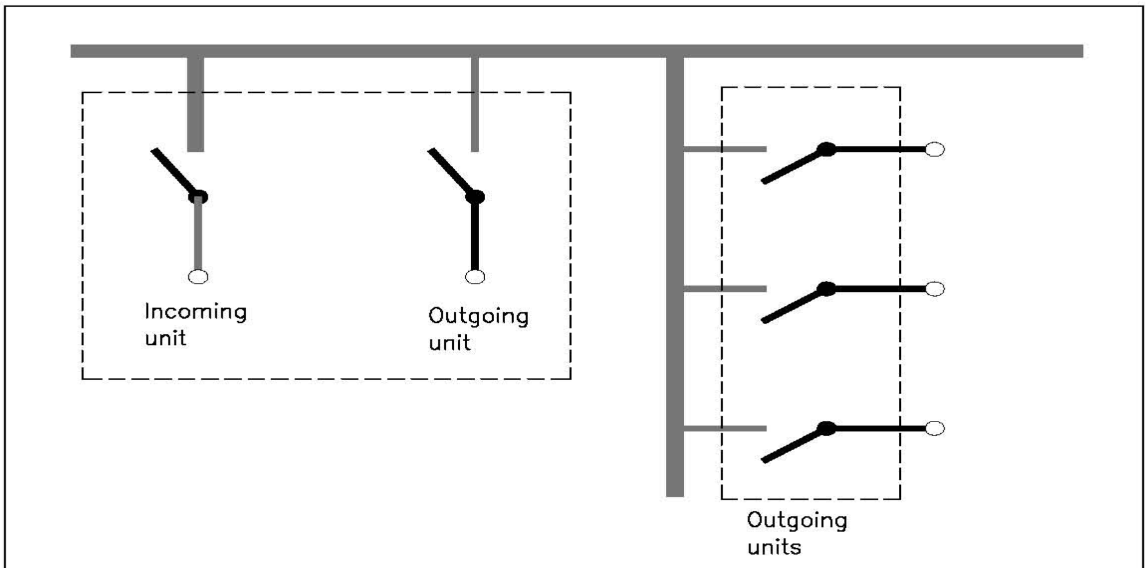
Refer to BS EN 61439-2

LEGENDS:

	BUS BAR		SHORT CIRCUIT PROTECTIVE DEVICES
	INSULATED BUSBARS		TERMINAL
	CONDUCTORS CONNECTING BUSBARS TO OUTGOING CIRCUITS		
	TERMINALS SEPARATED BY INSULATED COVERINGS OR PVC BOOTS		TERMINALS SEPARATED BY RIGID BARRIERS
	TERMINALS WITH INDIVIDUAL RIGID GLANDING FACILITY		CABLE GLAND
			DENOTES SEPARATION



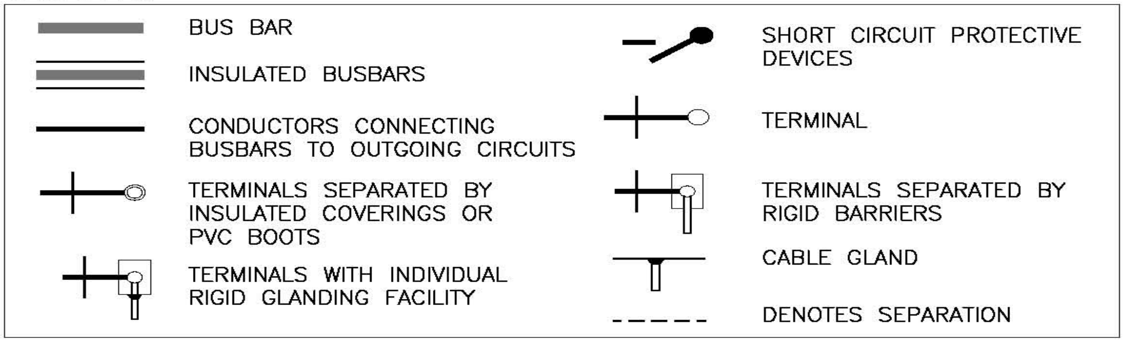
FORM 1

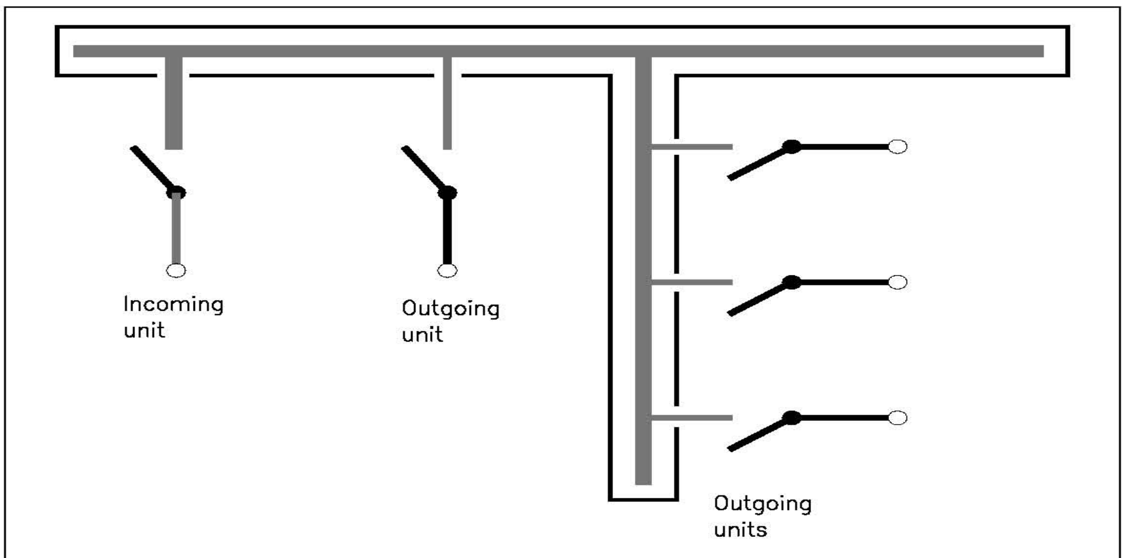


FORM 2A

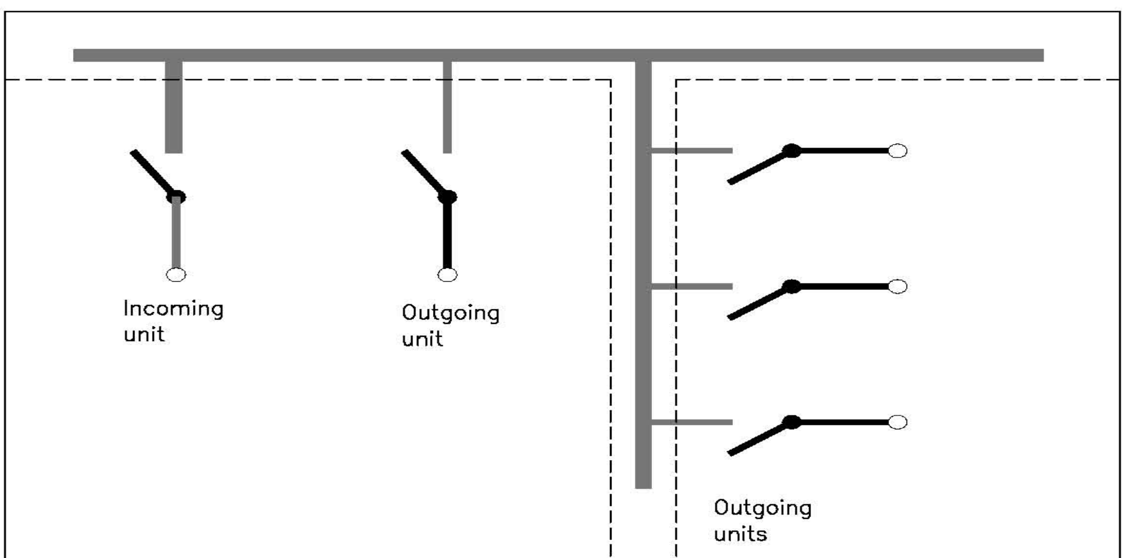
Refer to BS EN 61439-2

LEGENDS:





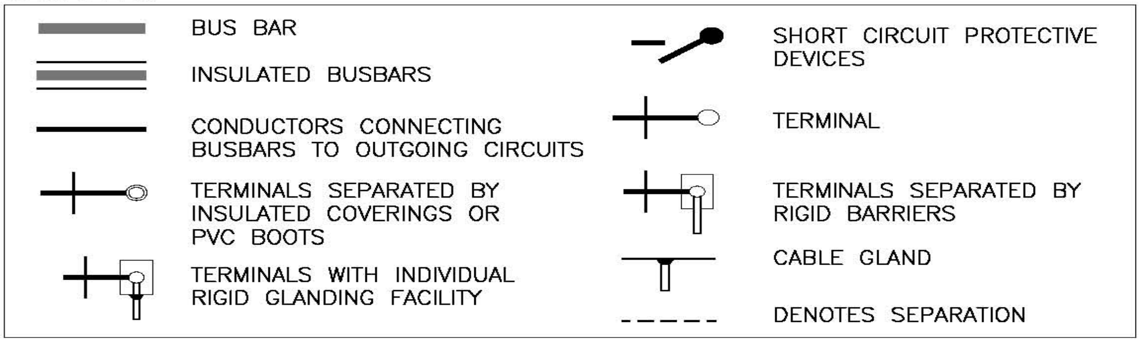
FORM 2B TYPE 1

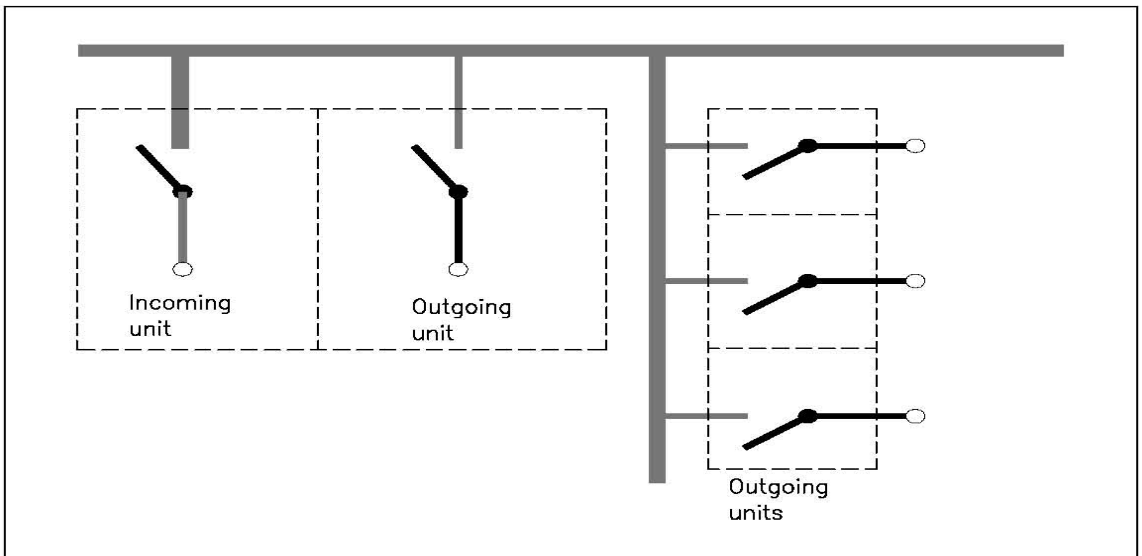


FORM 2B TYPE 2

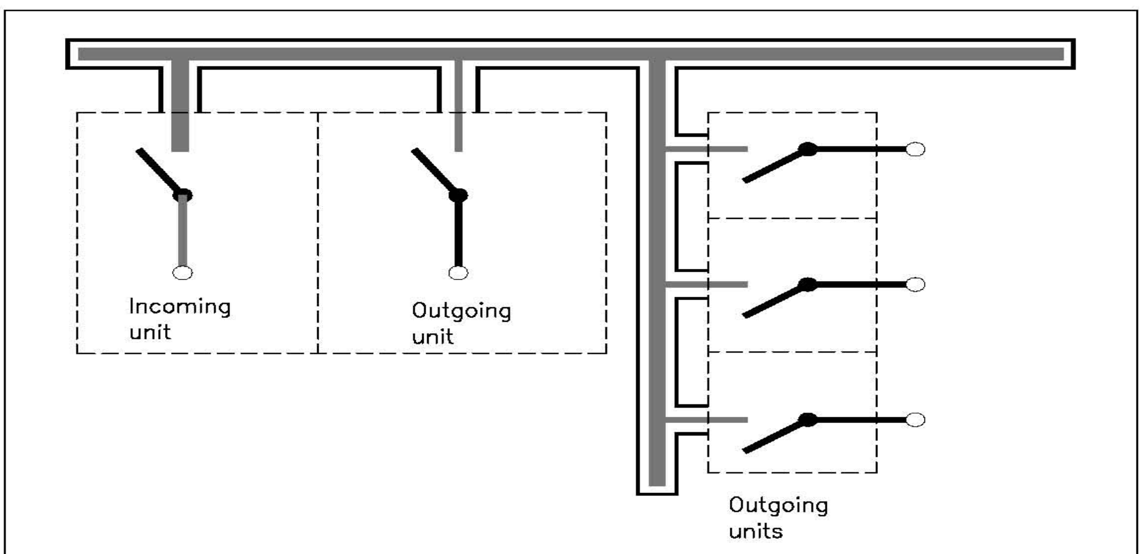
Refer to BS EN 61439-2

LEGENDS:





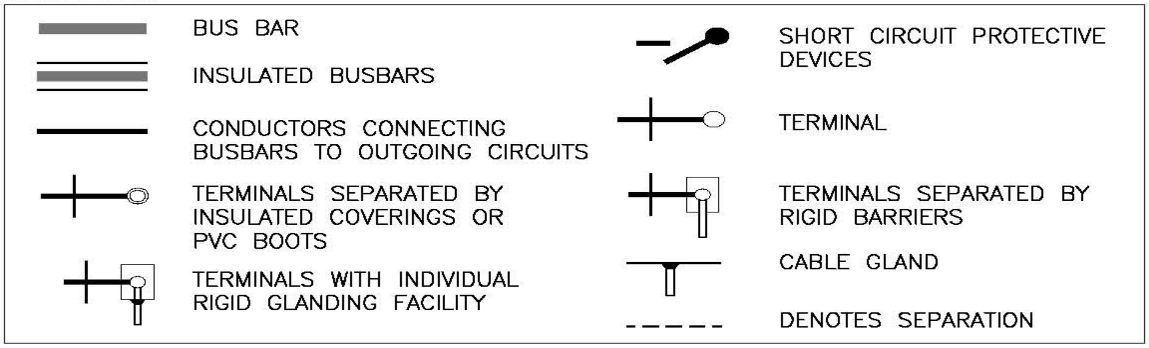
FORM 3A

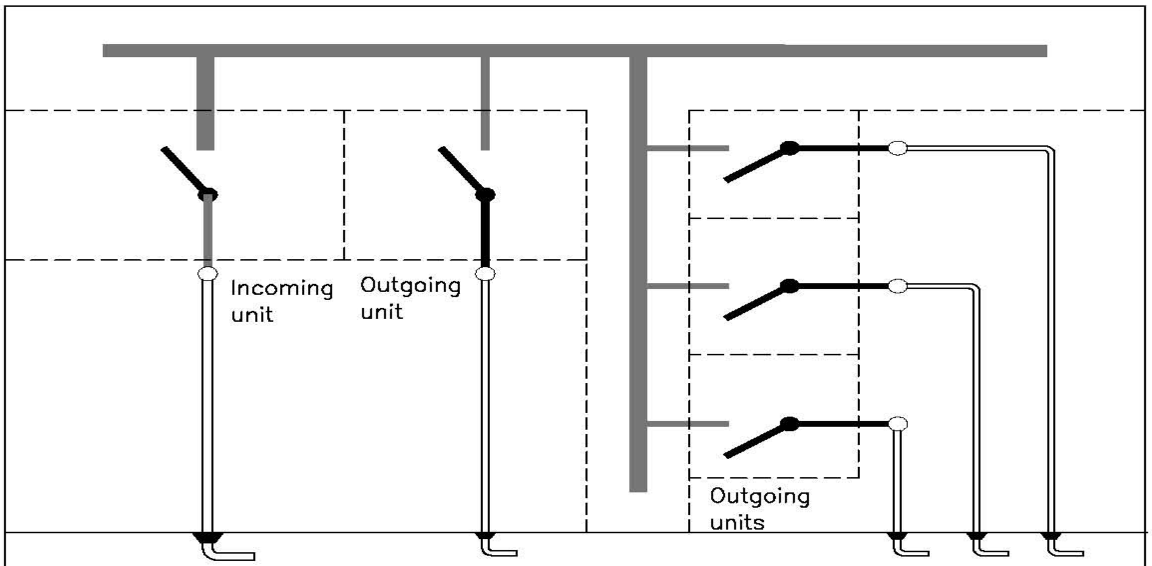


FORM 3B TYPE 1

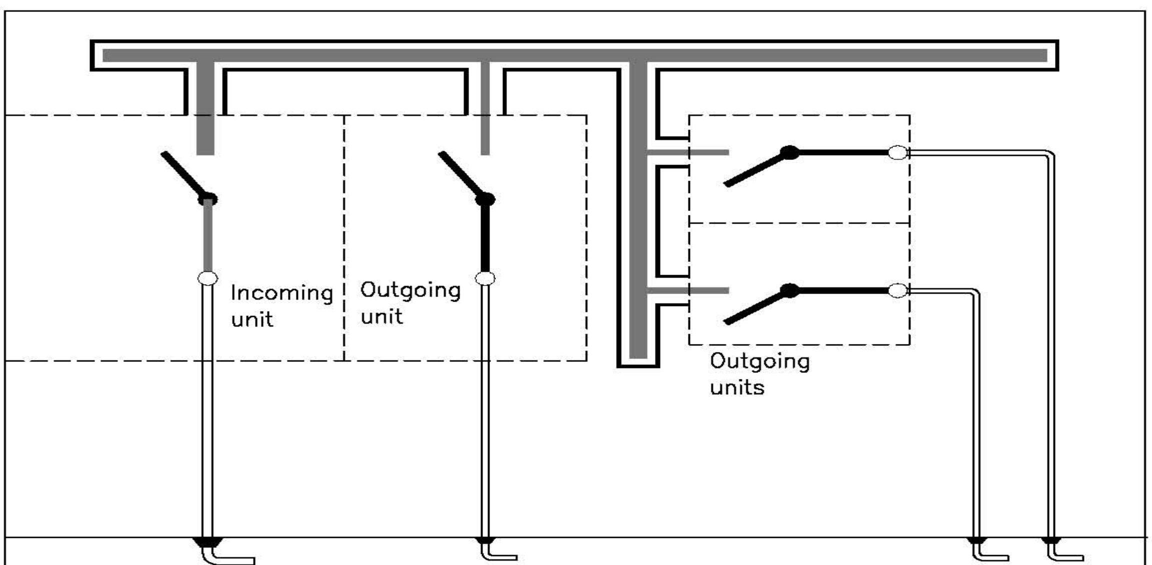
Refer to BS EN 61439-2

LEGENDS:





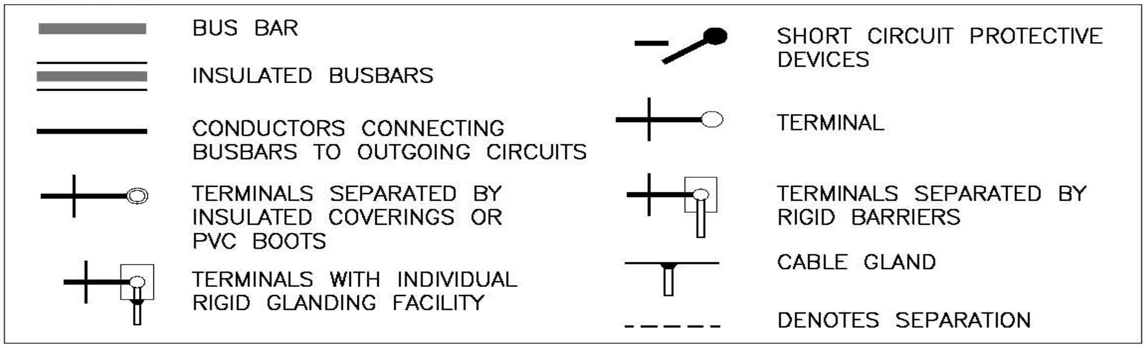
FORM 3B TYPE 2

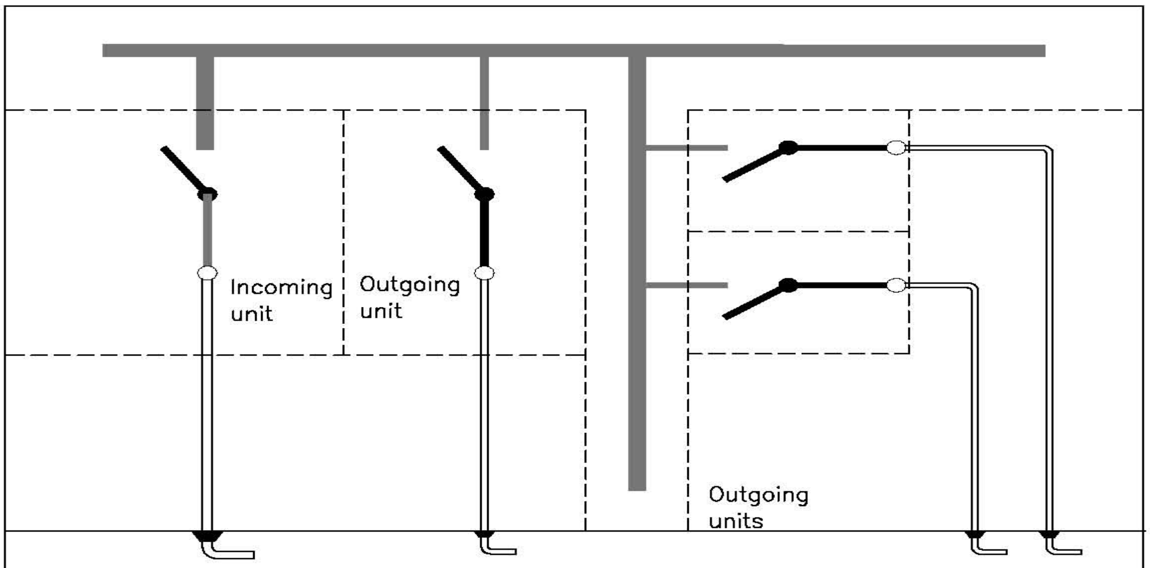


FORM 4A TYPE 1

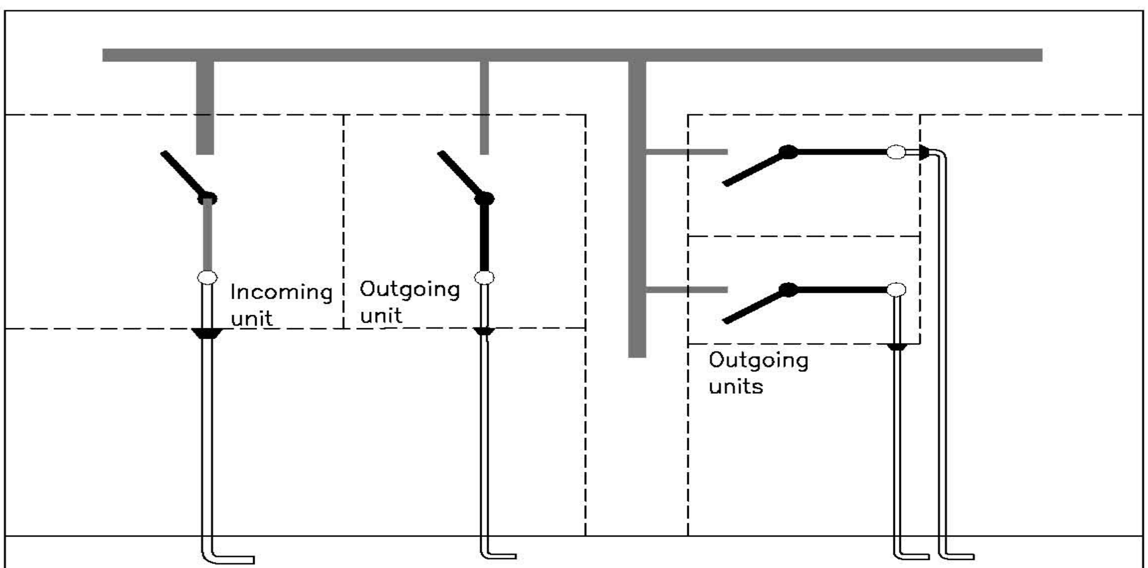
Refer to BS EN 61439-2

LEGENDS:





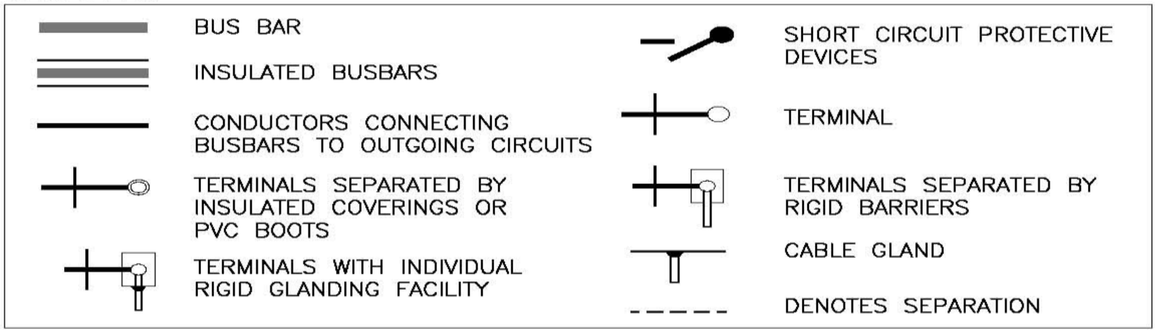
FORM 4A TYPE 2

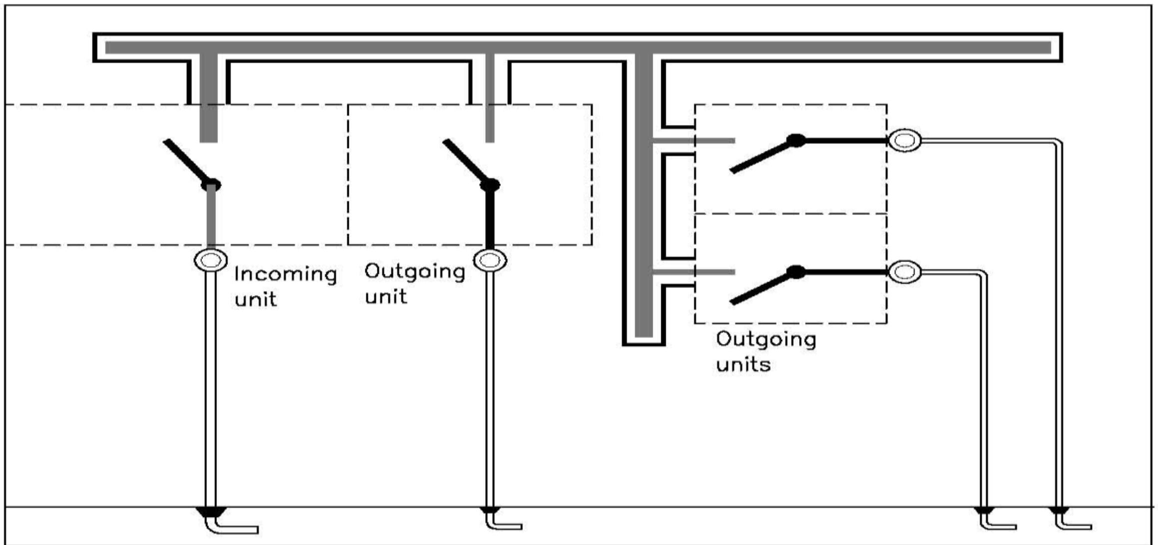


FORM 4A TYPE 3

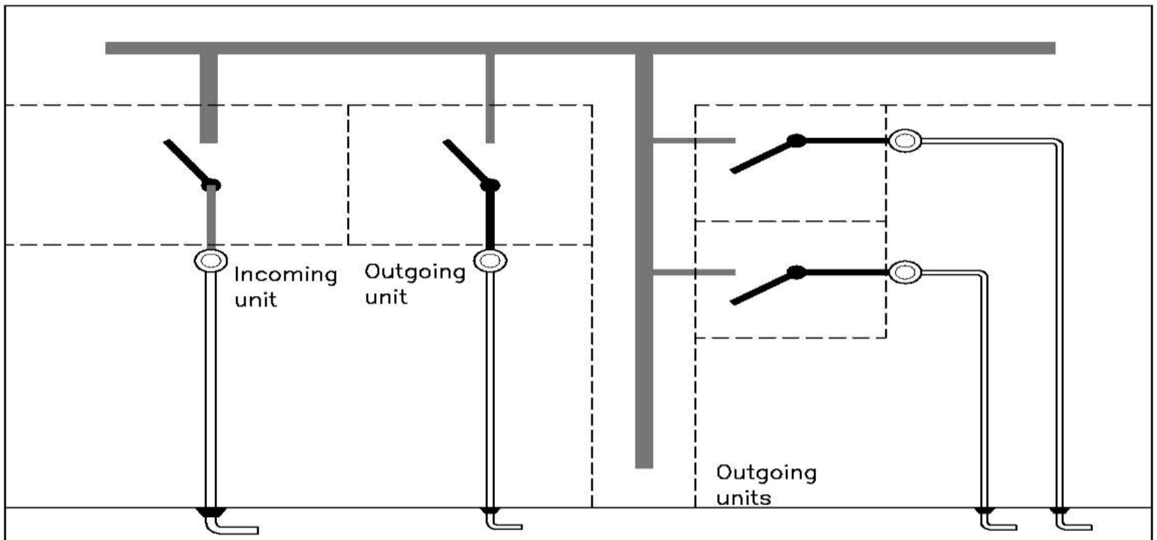
Refer to BS EN 61439-2

LEGENDS:





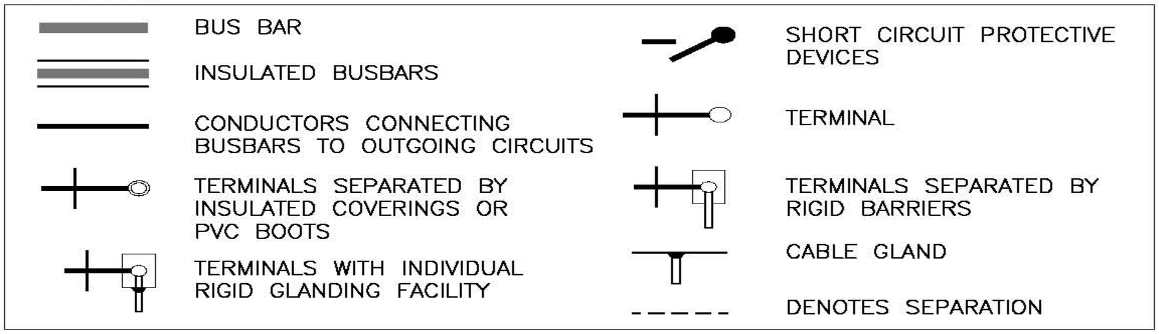
FORM 4B TYPE 4

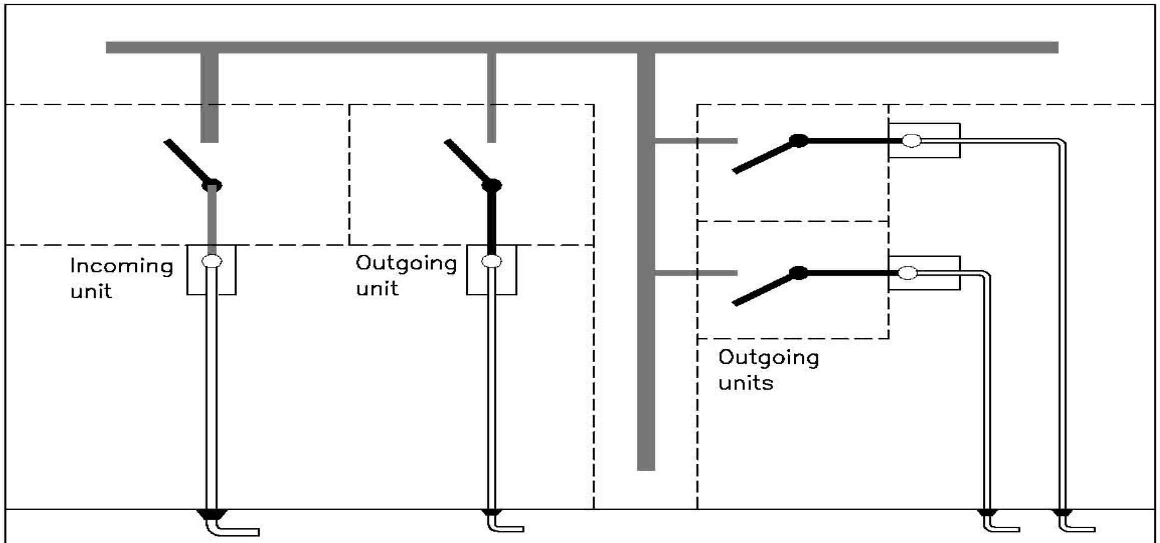


FORM 4B TYPE 5

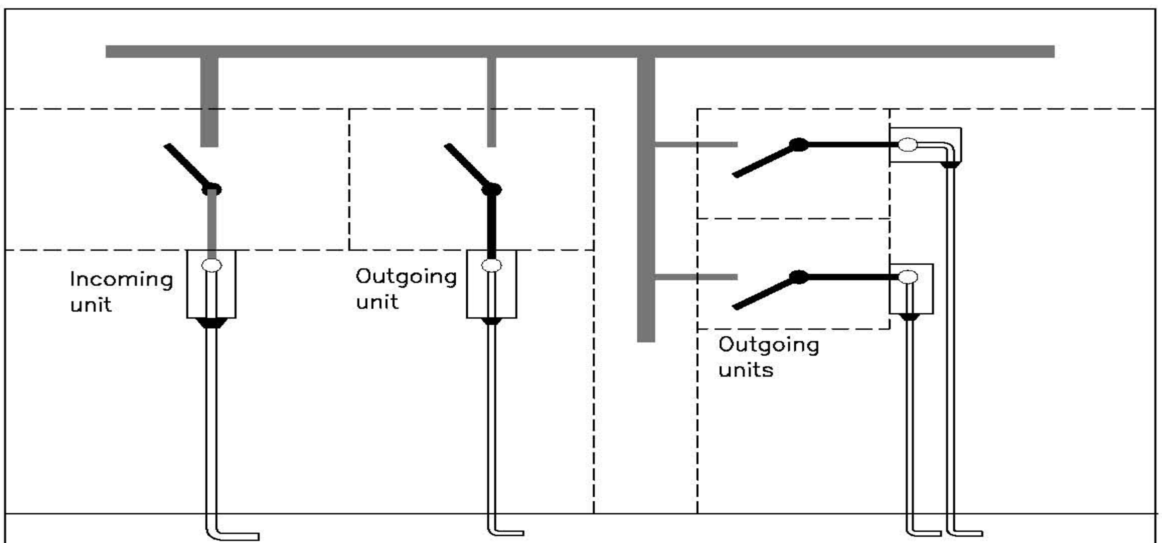
<u>Refer to BS EN 61439-2</u>

LEGENDS:





FORM 4B TYPE 6

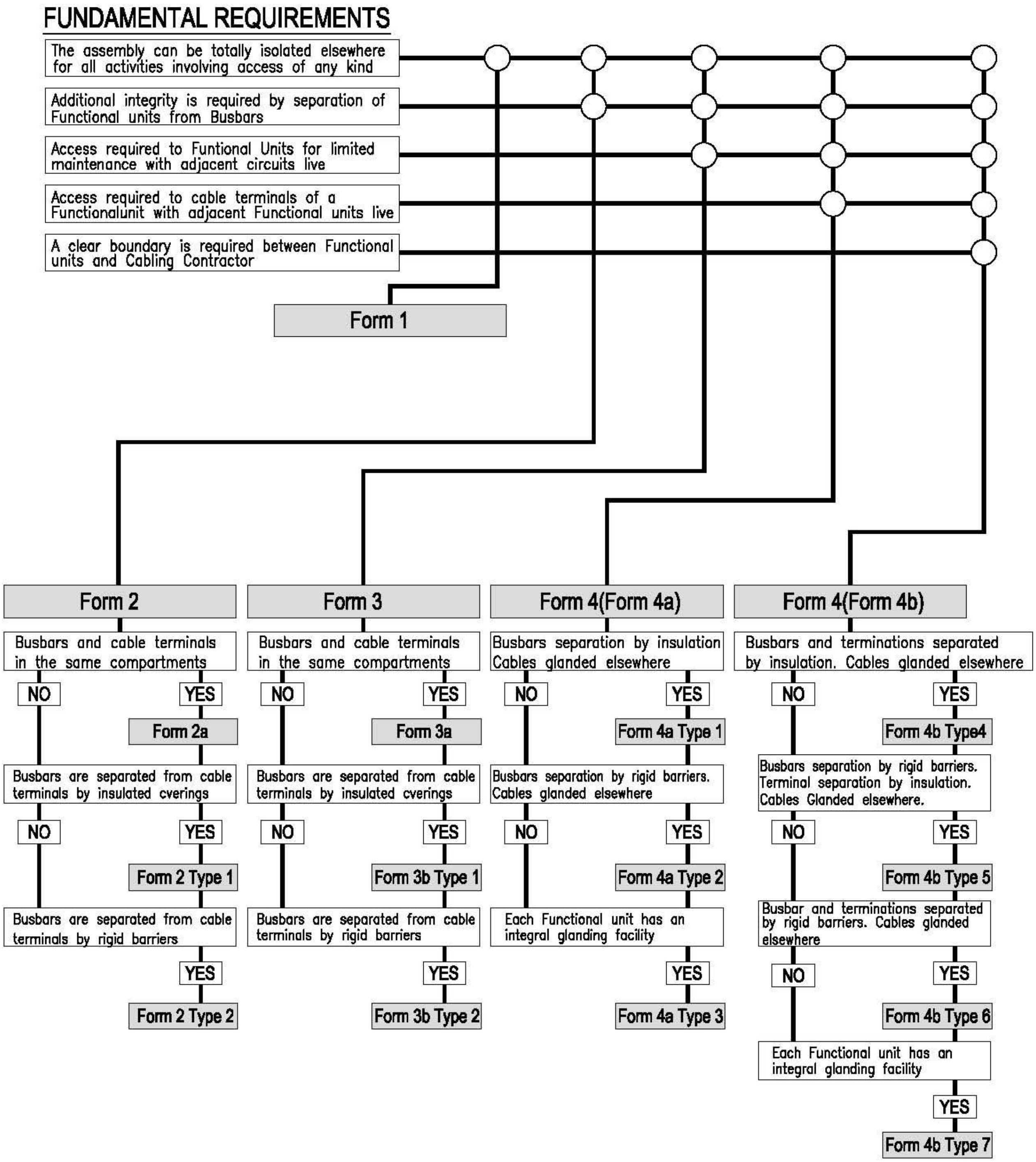


FORM 4B TYPE 7

D.1.2 Decision Tree

The most appropriate solution for each requirement should be established considering all aspects of the particular application as indicated earlier.

This "decision tree" is entended to assist in a logical approach in identifying the preferred Form of separation for the assembly being consdered.



D.2 All Type for 11 KV Indoor Cubicles Panels & Single Line Diagram with all Devices

D.2.1 The Enclosure and Compartment

The enclosure shall be of the enclosed metal-clad type. The minimum degree of protection shall be fully in accordance with.

IP 3 x of IEC 60529 for enclosure.
IP 3 x of IEC 60529 for all compartments.

The enclosure shall confirm to the requirements of IEC Standard 60298.

The construction shall be such that it shall not be possible for vermin to enter any part of the enclosure with access doors closed. In addition all parts of the circuit breaker shall be insulated or shrouds shall be fitted to circuit breaker bushing to prevent vermin gaining access to the busbar spouts when the circuit breaker is in the normal service position. "Vermin" in this context shall include lizards and snakes.

So, 11 KV. Cubicle panel consisting of the following (4) No. compartments:

D.2.1.1 Busbar Compartment.

The switchgear shall be of the single busbar type with the busbar normal rating as given in the Schedule of Specification.

The switchgear shall be designed and constructed such that no conductors operating at medium voltage are accessible under normal service conditions. Busbar section access panels shall be bolted in place and shall not be removable without the use of tools.

Particular care shall be taken to ensure that all demountable panels are secured in a manner which provides a continuous earth between the enclosure and the panels.

The busbar shall be contained in a separate chamber, which does not contain any equipment other than the busbars, busbar support insulators and busbar connections.

The busbars shall be fully insulated and the supply of the switchgear shall include the supply of all components required to insulate busbar connections between panels. Loose taping of busbars is not permitted.

D.2.1.2 11 K.V Voltage Cable Terminations Compartment.

11 KV Cable Terminating Boxes shall be supplied on all feeder and transformer panels. All panels shall be capable of terminating 3 core PILCSTA and 3 core XLPE stranded copper cables up to a maximum size of 300 sq.mm. Terminations will be by heat shrink techniques.

Boxes shall be supplied with gland plates, terminating lugs and lug fixing bolts. Terminating kits will be supplied by others. Glands shall be suitable for terminating cables either with or without a lead sheath, but wire armoured. All uninsulated brass glands shall be Y size as per BS 2562: 1979 Fig 32 with armour clamps.

The terminating lugs shall be of the compression type. The lugs shall be capable of accommodating:

D.2.1.3 Circuit Breaker Compartment.

Independent compartment for C.B so C.B need special truck to achieve withdrawable.

D.2.1.4 Instruments Compartment.

Current, voltage transformers, protection devices and auxiliary wiring and all controls to be in separate component.

D.2.1.5 Specification for 11kV Indoor Switchgear Panels-withdrawable Vacuum Circuit Breaker Type

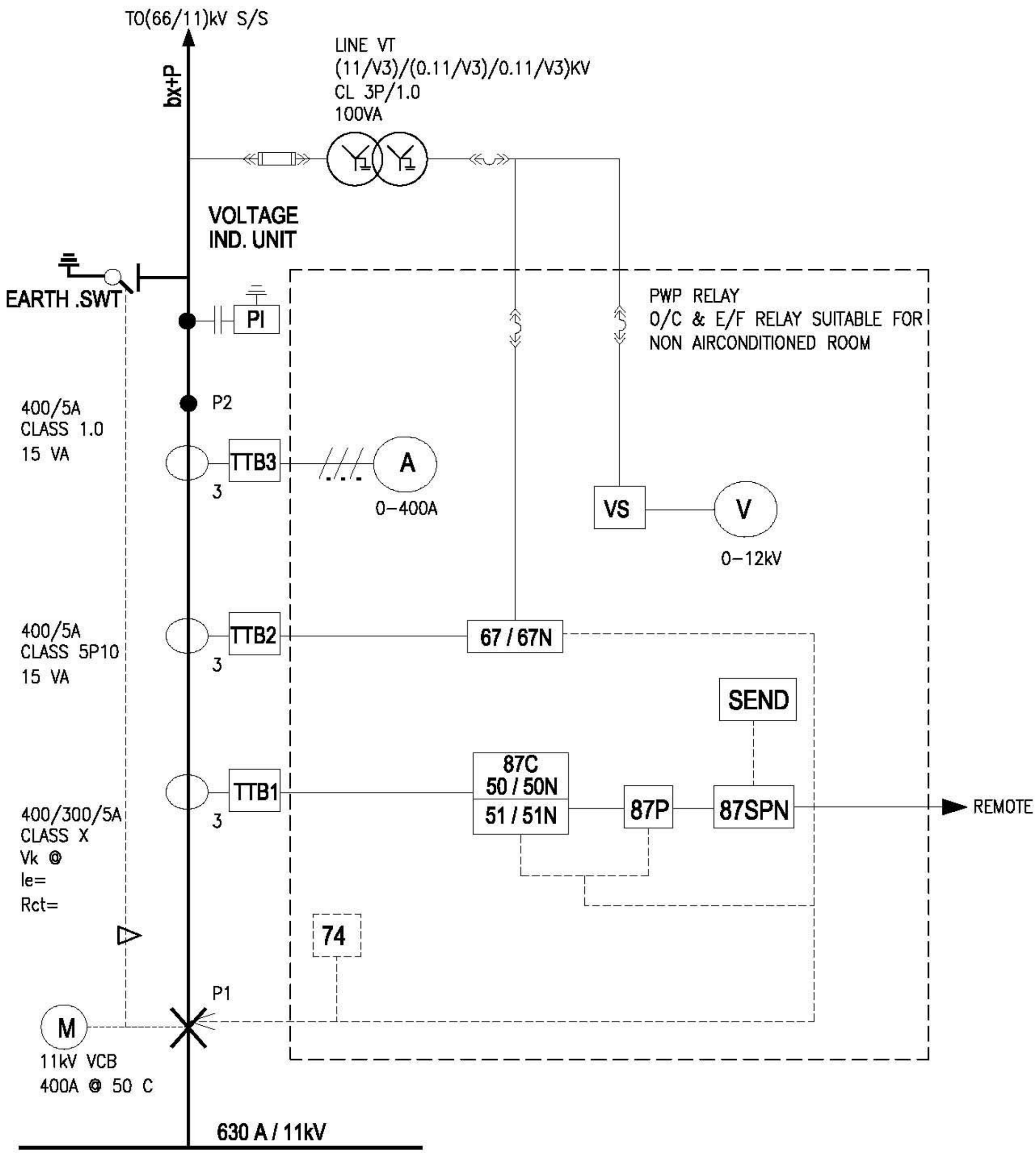
Specified extreme conditions are short-term in nature, the design & construction of switchgear panel shall be such that they are un-affected by repeated expousure of any of these extreme conditions, and capable of operating without any malfunction, over the expected service life period.

SI No	Environmental condition	IEC Category	Exceptions
a	Climatic Condition	3K6	Low Temp. limit +5°C, High temp limit +50 °C, without ice formation and wind driven precipitation,
b	Special climatic conditions	3Z11/3Z4	
c	Biological conditions	3B2	
d	Chemically active substances	3C2	
e	Mechanically active substances	3S3	
f	Mechanical conditions	3M2	

D.2.1.6 Applicable Standards References

SI No	Standard References	Subject
1.	IEC 62271-200	AC Metal enclosed switchgear & control gear for voltages up to 52kV
2.	IEC 62271-1	HV Switchgear & control gear – common specifications
3.	IEC 62271-100	High voltage AC circuit-breakers
4.	IEC 62271-102	High voltage AC dis-connectors & earthing switches
5.	IEC 62271-103	High voltage AC switches for voltages above 1 kV and below 52kV
6.	IEC 60721-1	Classification of environmental conditions – environmental parameters
7.	IEC 60721-3	Classification of groups of environmental parameters and their severities
8.	IEC 60529	Degrees of protection provided by enclosures
9.	IEC 61243-5	Live working – voltage detection systems (CDV)
10.	IEC 60044-1	Current transformers
11.	IEC 60044-2	Voltage transformers
12.	IEC 60050 (441)	International Electro-technical vocabulary – switchgear & control-gear
13.	IEC 60068-2	Environmental testing – Tests
14.	IEC 60947-2	LV circuits breakers (including MCBs)
15.	ISO 3864	Labels
16.	IEC 60270	Partial Discharge measurements
17.	BS 5685	Electricity Meters
18.	IEC 62053	Electricity Metering Equipment
19.	IEC 62052	Electricity Meeting Equipment – Tests and Test conditions
20.	IEC 61243-5	Love working – voltage detectors – voltage detecting system

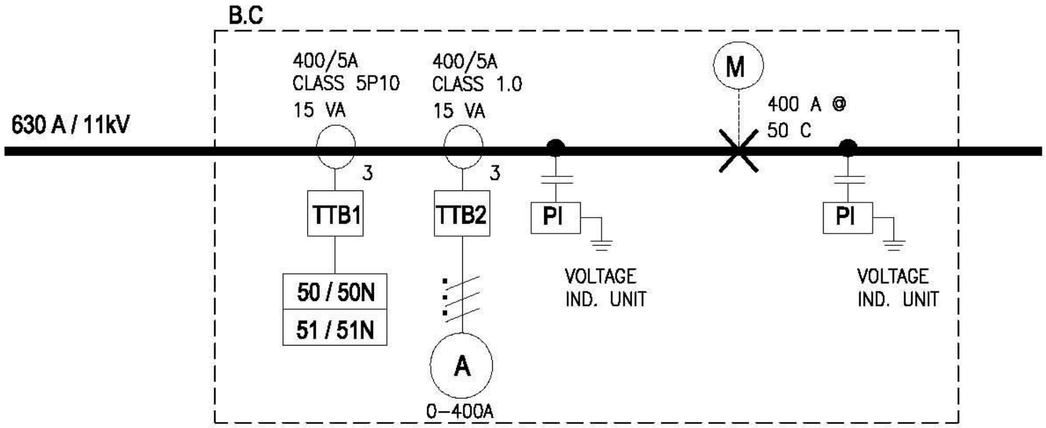
D.2.2 MAIN INCOMING FEEDER (TYPE-1)

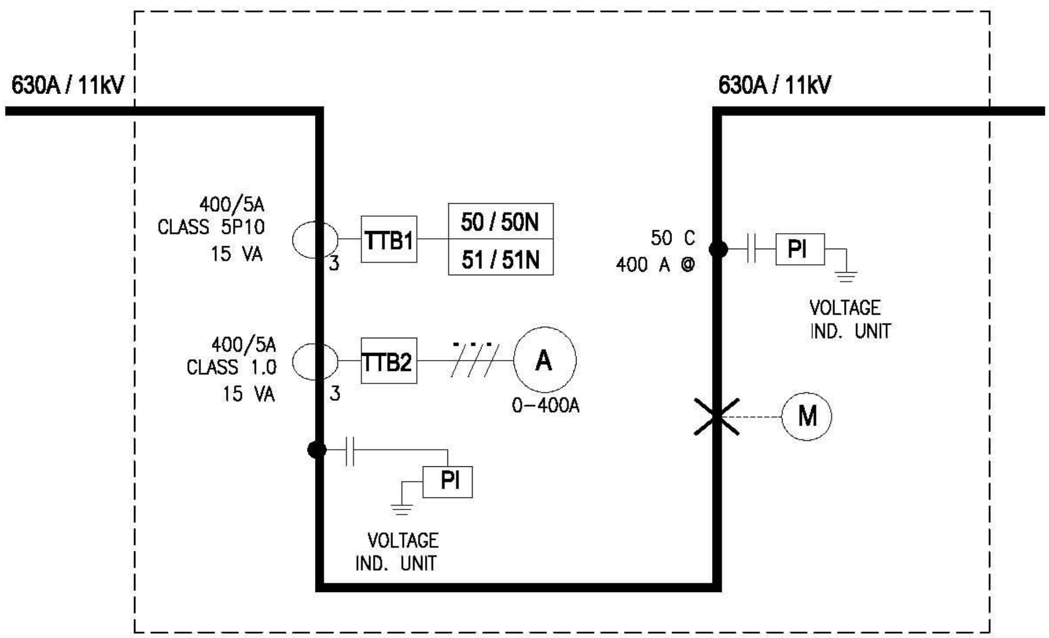


MVA(SC)	$I_{s.c}$ /kA 3sc.
500	26
600	31.5
750	40
1000	52.5

LEGENDS			
TTB1	TEST THERMINAL BLOCK	67/67N	DOC / DEF RELAY
TTB2	TEST THERMINAL BLOCK	A	AMMETER
TTB3	TEST THERMINAL BLOCK	V	VOLT METER
87N	LV REF PROTECTION	VCB	VACUUM CIRCUIT BREAKER
49T	WINDING TEMP TRIP	(M)	MOTORIZED
63T	PRESSURE VALVE TRIP	VCB	VACUUM CIRCUIT BREAKER 11 kV 400A AT 50°C
51/51N	IDMT OC/EF		
50/50N	INSTATANEOUS OC/EF		CONTROL FUSE
87C	CURRENT CHECK GUARD RELAY		VOLTAGE TRANSFORMER
87P	CABLE DIFFERENTIAL RELAY		TRANSFORMER
87 SPN	PILOT CABLE SUPERVISION		

D.2.3 BUS SECTION CUBICLE PANEL (TYPE-2)

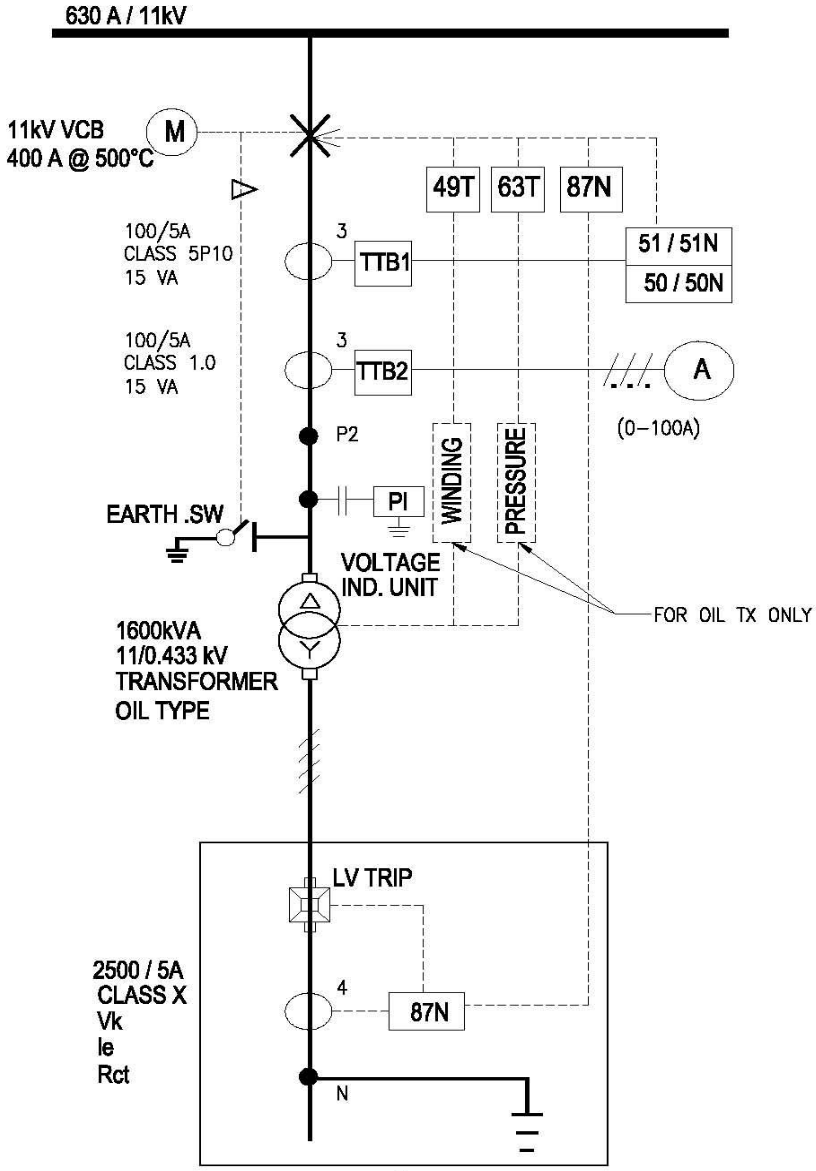




MVA(SC)	$I_{s.c}$ /KA 3sc.
500	26
600	31.5
750	40
1000	52.5

LEGENDS			
TTB1	TEST THERMINAL BLOCK	67/67N	DOC / DEF RELAY
TTB2	TEST THERMINAL BLOCK	A	AMMETER
TTB3	TEST THERMINAL BLOCK	V	VOLT METER
87N	LV REF PROTECTION	VCB	VACUUM CIRCUIT BREAKER
49T	WINDING TEMP TRIP	Ⓜ	MOTORIZED
63T	PRESSURE VALVE TRIP	VCB	VACUUM CIRCUIT BREAKER 11 KV 400A AT 50°C
51/51N	IDMT OC/EF		
50/50N	INSTATANEOUS OC/EF		CONTROL FUSE
87C	CURRENT CHECK GUARD RELAY		VOLTAGE TRANSFORMER
87P	CABLE DIFFERENTIAL RELAY		TRANSFORMER
87 SPN	PILOT CABLE SUPERVISION		

D.2.4 TRANSFORMER CB'S WITHOUT METERING (TYPE-3)

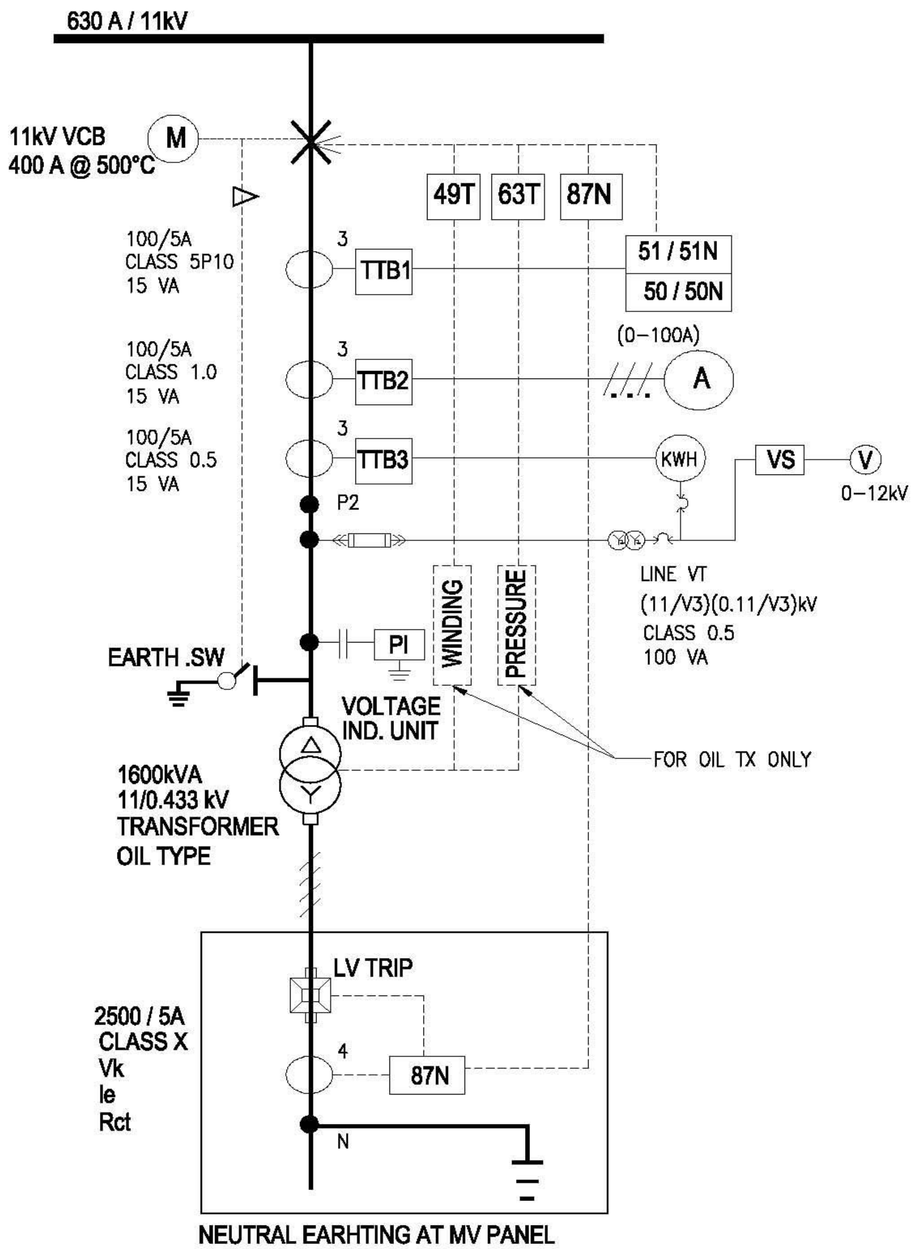


NEUTRAL EARHTING AT MV PANEL

MVA(SC)	$I_{s.c}$ /KA 3sc.
500	26
600	31.5
750	40
1000	52.5

LEGENDS			
TTB1	TEST THERMINAL BLOCK	67/67N	DOC / DEF RELAY
TTB2	TEST THERMINAL BLOCK	A	AMMETER
TTB3	TEST THERMINAL BLOCK	V	VOLT METER
87N	LV REF PROTECTION	VCB	VACUUM CIRCUIT BREAKER
49T	WINDING TEMP TRIP	(M)	MOTORIZED
63T	PRESSURE VALVE TRIP	VCB	VACUUM CIRCUIT BREAKER 11 kV 400A AT 50°C
51/51N	IDMT OC/EF		
50/50N	INSTATANEOUS OC/EF		CONTROL FUSE
87C	CURRENT CHECK GUARD RELAY		VOLTAGE TRANSFORMER
87P	CABLE DIFFERENTIAL RELAY		TRANSFORMER
87 SPN	PILOT CABLE SUPERVISION		

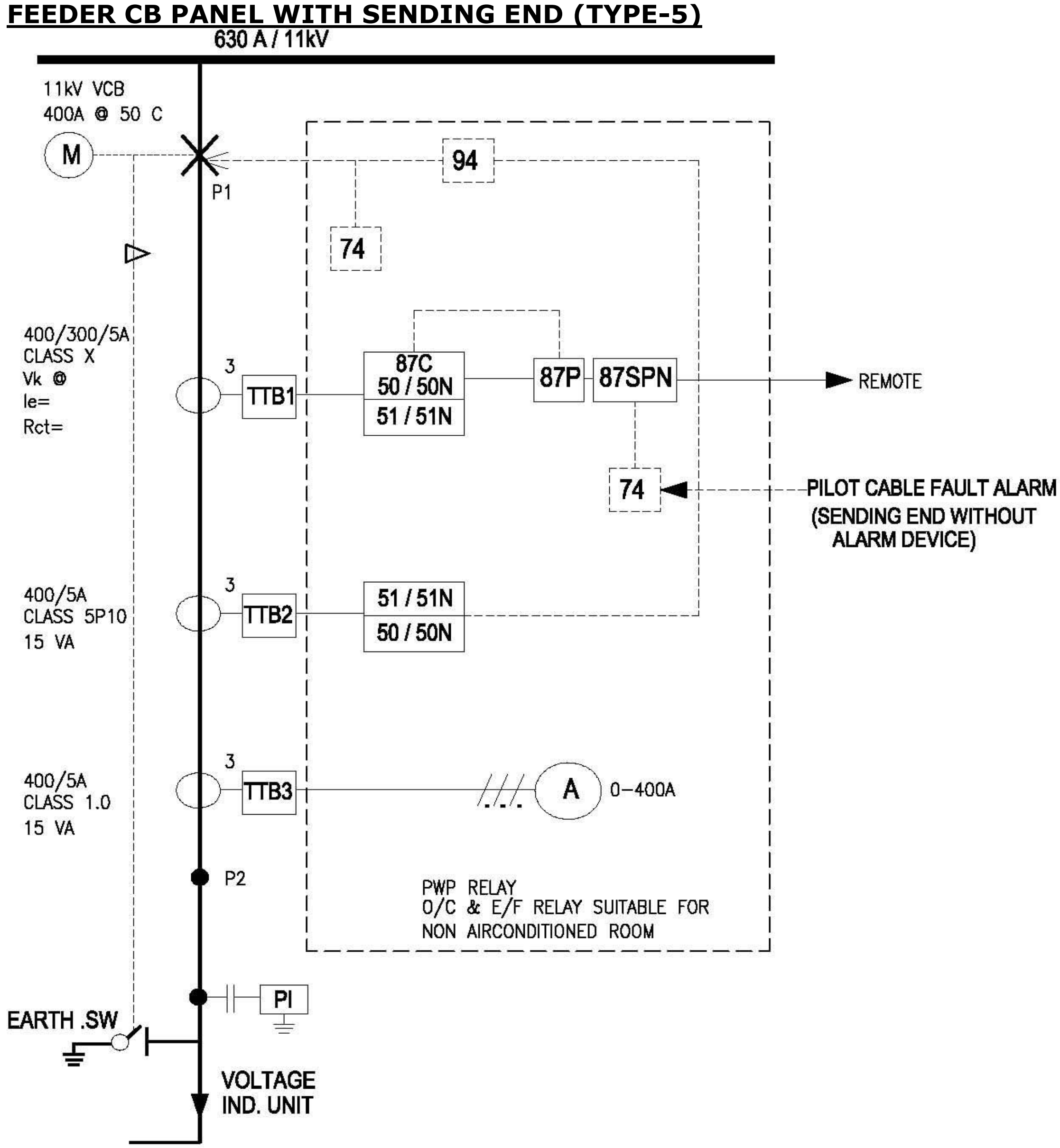
D.2.5 TRANSFORMER CB'S WITH METERING (TYPE-4)



MVA(SC)	$I_{s.c}$ /KA 3sc.
500	26
600	31.5
750	40
1000	52.5

LEGENDS			
TTB1	TEST THERMINAL BLOCK	67/67N	DOC / DEF RELAY
TTB2	TEST THERMINAL BLOCK	A	AMMETER
TTB3	TEST THERMINAL BLOCK	V	VOLT METER
87N	LV REF PROTECTION	VCB	VACUUM CIRCUIT BREAKER
49T	WINDING TEMP TRIP	(M)	MOTORIZED
63T	PRESSURE VALVE TRIP	VCB	VACUUM CIRCUIT BREAKER 11 kV 400A AT 50°C
51/51N	IDMT OC/EF		
50/50N	INSTATANEOUS OC/EF		CONTROL FUSE
87C	CURRENT CHECK GUARD RELAY		VOLTAGE TRANSFORMER
87P	CABLE DIFFERENTIAL RELAY		TRANSFORMER
87 SPN	PILOT CABLE SUPERVISION		

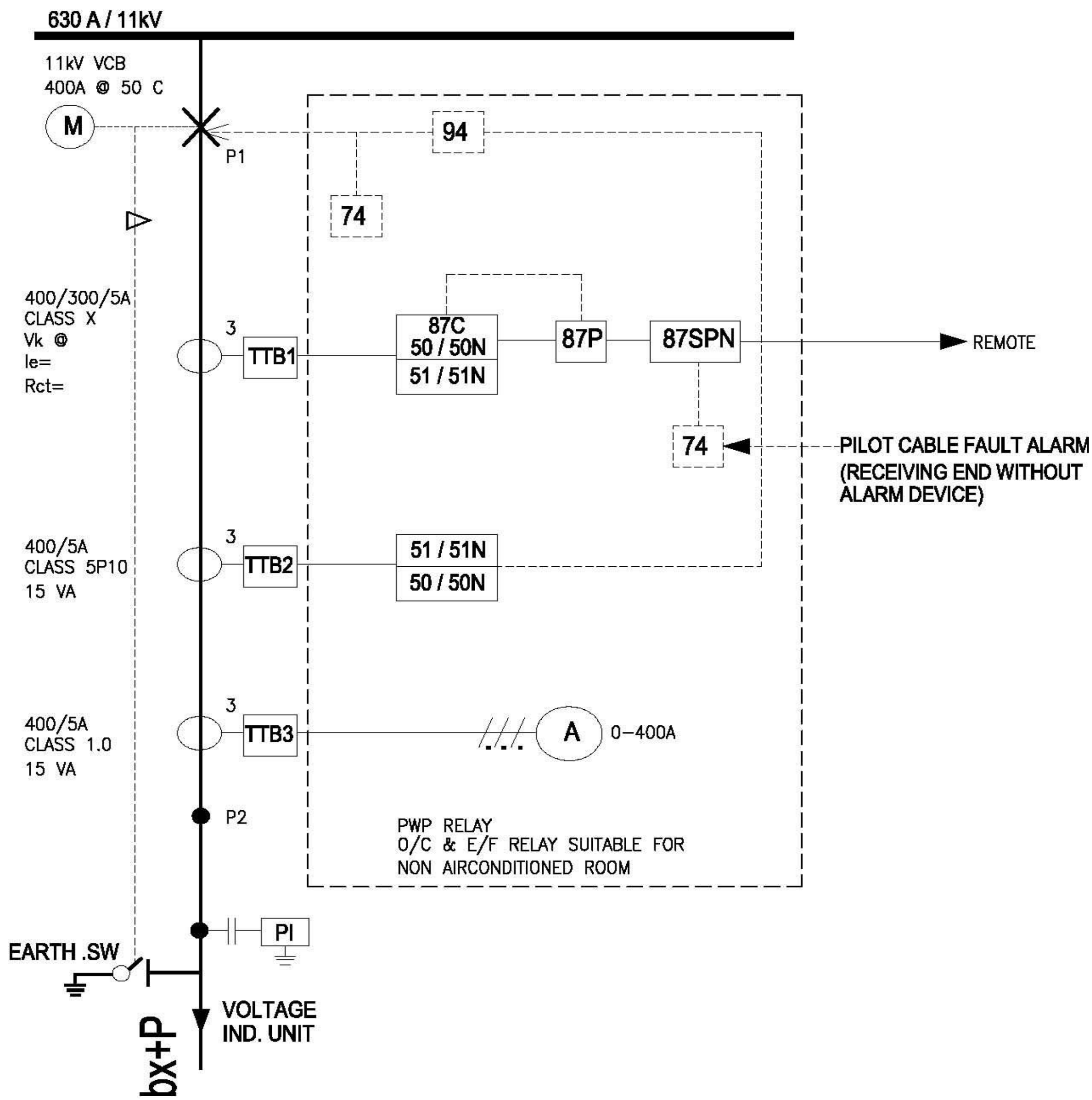
D.2.6 FEEDER CB PANEL WITH SENDING END (TYPE-5)



MVA(SC)	$I_{s.c}$ /KA 3sc.
500	26
600	31.5
750	40
1000	52.5

LEGENDS			
TTB1	TEST THERMINAL BLOCK	67/67N	DOC / DEF RELAY
TTB2	TEST THERMINAL BLOCK	A	AMMETER
TTB3	TEST THERMINAL BLOCK	V	VOLT METER
87N	LV REF PROTECTION	VCB	VACUUM CIRCUIT BREAKER
49T	WINDING TEMP TRIP	(M)	MOTORIZED
63T	PRESSURE VALVE TRIP	VCB	VACUUM CIRCUIT BREAKER 11 kV 400A AT 50°C
51/51N	IDMT OC/EF		
50/50N	INSTATANEOUS OC/EF		CONTROL FUSE
87C	CURRENT CHECK GUARD RELAY		VOLTAGE TRANSFORMER
87P	CABLE DIFFERENTIAL RELAY		TRANSFORMER
87 SPN	PILOT CABLE SUPERVISION		

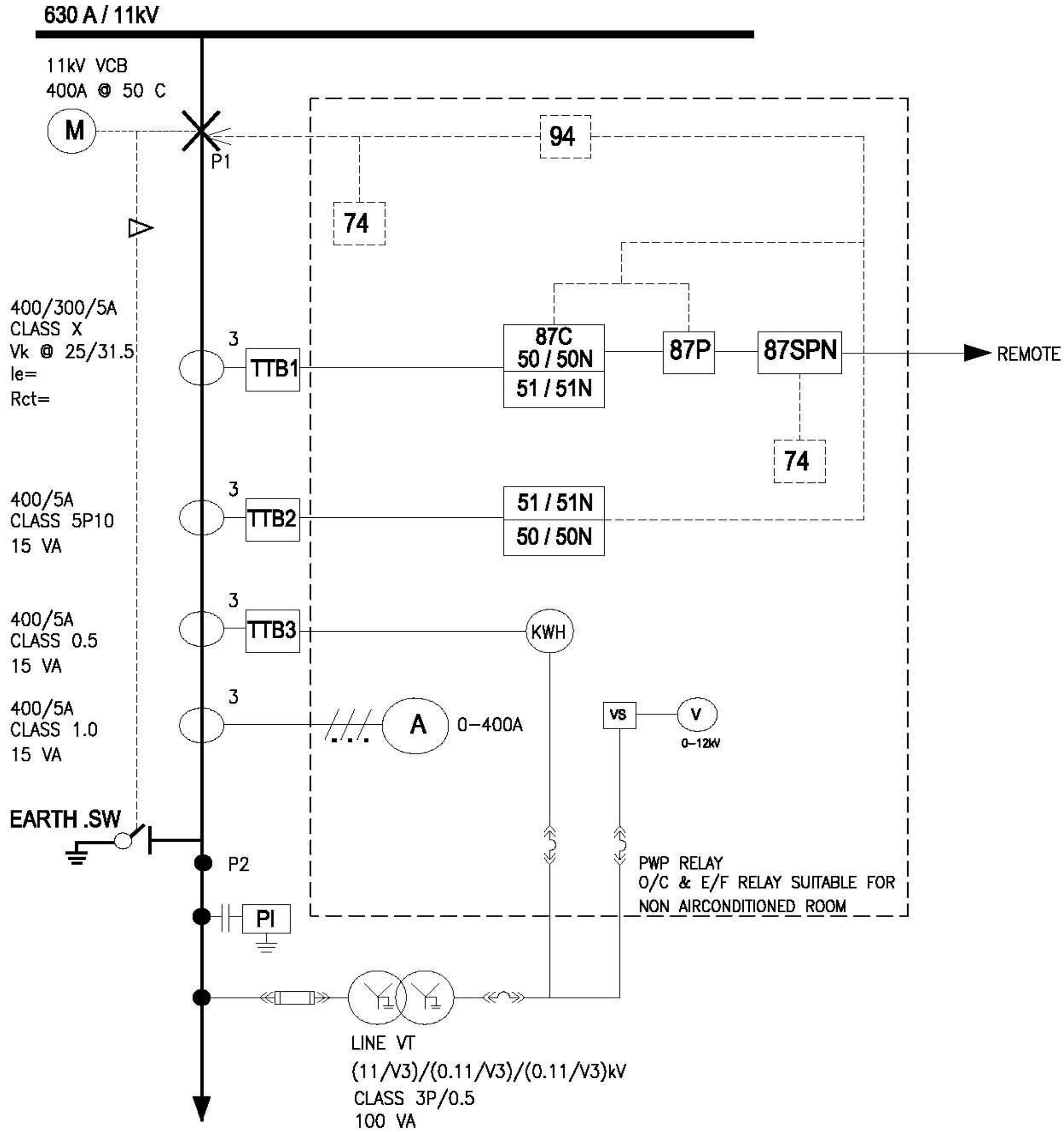
D.2.7 FEEDER CB PANEL WITH RECEIVING END (TYPE-6)



MVA(SC)	$I_{s.c}$ /KA 3sc.
500	26
600	31.5
750	40
1000	52.5

LEGENDS			
TTB1	TEST THERMINAL BLOCK	67/67N	DOC / DEF RELAY
TTB2	TEST THERMINAL BLOCK	A	AMMETER
TTB3	TEST THERMINAL BLOCK	V	VOLT METER
87N	LV REF PROTECTION	VCB	VACUUM CIRCUIT BREAKER
49T	WINDING TEMP TRIP	(M)	MOTORIZED
63T	PRESSURE VALVE TRIP	VCB	VACUUM CIRCUIT BREAKER 11 kV 400A AT 50°C
51/51N	IDMT OC/EF		
50/50N	INSTATANEOUS OC/EF		CONTROL FUSE
87C	CURRENT CHECK GUARD RELAY		VOLTAGE TRANSFORMER
87P	CABLE DIFFERENTIAL RELAY		TRANSFORMER
87 SPN	PILOT CABLE SUPERVISION		

D.2.8 HV CHILLER WITH METERING (TYPE-7)



MVA(SC)	$I_{s.c}$ /KA 3sc.
500	26
600	31.5
750	40
1000	52.5

LEGENDS			
TTB1	TEST THERMINAL BLOCK	67/67N	DOC / DEF RELAY
TTB2	TEST THERMINAL BLOCK	A	AMMETER
TTB3	TEST THERMINAL BLOCK	V	VOLT METER
87N	LV REF PROTECTION	VCB	VACUUM CIRCUIT BREAKER
49T	WINDING TEMP TRIP	(M)	MOTORIZED
63T	PRESSURE VALVE TRIP	VCB	VACUUM CIRCUIT BREAKER 11 kV 400A AT 50°C
51/51N	IDMT OC/EF		
50/50N	INSTATANEOUS OC/EF		CONTROL FUSE
87C	CURRENT CHECK GUARD RELAY		VOLTAGE TRANSFORMER
87P	CABLE DIFFERENTIAL RELAY		TRANSFORMER
87 SPN	PILOT CABLE SUPERVISION		

D.3 IP Ratings and NEMA Rating.

D.3.1 IP Ratings

The first number defines the level of protection against penetration of solid objects into the housing. The second number defines the level of protection against penetration of liquids into the housing. Additional information can be found in the 1976 IEC Publication, Classification of Degrees of Protection Provided by Enclosures.

IP s l

S = solids and l = liquids

Number	Degree of Protection	Number	Degree of Protection
0.	No protection against contact or entry of solids	0	No protection
1.	Protection against accidental contact by hand, but not deliberate contact. Protection against large objects. (greater than 50mm)	1	Protection against drops of condensed water. Condensed water falling on housing shall have no effect.
2.	Protection against contact by fingers. Protection against medium-size foreign objects (greater tan 12mm)	2	Protection against drops of liquid. Drops of falling liquid shall have no effect when housing is tilted to 15 degrees from vertical.
3.	Protection against contact by tools, wire, etc. Protection against small foreign objects. (greater than 2.5mm)	3	Protection against rain. No harmful effect from rain at angle less than 60 degrees from vertical.
4.	Protection against contact by small tools and wires. Protection against small foreign objects (greater than 1mm)	4	Protection against splashing from any direction.
5.	Complete protection against contact with live or moving parts. Protection against harmful deposits of dust.	5	Protection against water jets from any direction.
6.	Complete protection of live or moving parts. Protection against penetration of dust	6	Protection against conditions on ships decks. Water from heavy seas will not enter.
		7	Protection against immersion in water. Water will not enter under stated conditions of pressure and time.
		8	Protection against indefinite immersion in water under a specified pressure.

D.3.2 <u>NEMA Ratings</u>

NEMA 1

Type 1 enclosures are intended for indoor use primarily to provide a degree of protection against contact with the enclosed equipment or locations where unusual service conditions do not exist.

NEMA 2

Type 2 enclosures are intended for indoor use primarily to provide a degree of protection against limited amounts of falling water and dirt.

NEMA 3

Type 3 enclosures are intended for outdoor use primarily to provide a degree of protection against windblown dust, rain, and sleet; and to be undamaged by the formation of ice on the enclosure.

NEMA 3R

Type 3R enclosures are intended for outdoor use primarily to provide a degree of protection against falling rain; and to be undamaged by the formation of ice on the enclosure.

NEMA 4

Type 4 enclosures are intended for indoor or outdoor use primarily to provide a degree of protection against windblown dust and rain, splashing water, and hose directed water; and to be undamaged by the formation of ice on the enclosure.

NEMA 4X

Type 4X enclosures are intended for indoor and outdoor use primarily to provide a degree of protection against corrosion, windblown dust and rain, splashing water, and hose directed water; and to be undamaged by the formation of ice on the enclosure.

NEMA 6

Type 6 enclosures are intended for indoor or outdoor use primarily to provide a degree of protection against the entry of water during temporary submersion at a limited depth; and to be undamaged by the formation of ice on the enclosure.

NEMA 7

Type 7 enclosures are for indoor use in locations classified as Class I, Groups A, B, C, or D, as defined in the National Electrical Code.

Type 7 enclosure shall be capable of withstanding the pressures resulting from an internal explosion of specified gases, and contain such an explosion sufficiently that an explosive gas-air mixture existing in the atmosphere surrounding the enclosure will not be ignited. Enclosed heat generating devices shall not cause external surfaces to reach temperatures capable of igniting explosive gas-air mixtures in the surrounding atmosphere. Enclosures shall meet explosion, hydro-static, and temperature design tests.

NEMA 9

Type 9 enclosures are intended for indoor use in locations classified as Class II, Group s E, F, or G, as defined in the National Electrical Code.

Type 9 enclosures shall be capable of preventing the entrance of dust. Enclosed that generating devices shall not cause external surfaces to reach temperatures capable of igniting or discoloring dust on the enclosure or igniting dust-air mixtures in the surrounding atmosphere. Enclosures shall meet dust penetration and temperature design tests, and aging of gaskets (if used).

NEMA 12

Type 12 enclosures are intended for indoor use primarily to provide a degree of protection against dust, falling dirt, and dripping noncorrosive liquids.

NEMA 13

Type 13 enclosures are intended for indoor use primarily to provide a degree of protection against dust, spraying of water, oil, and noncorrosive coolant.

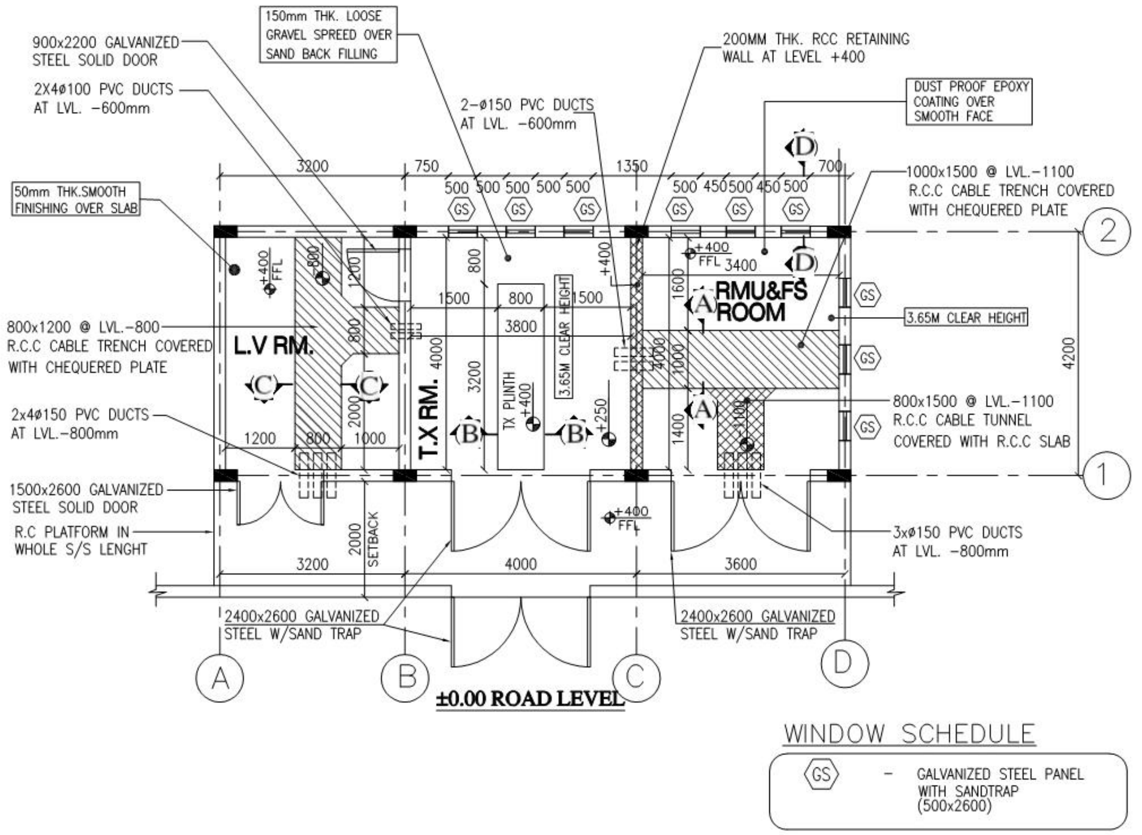
D.3.3 Comparing NEMA and IP enclosure ratings.

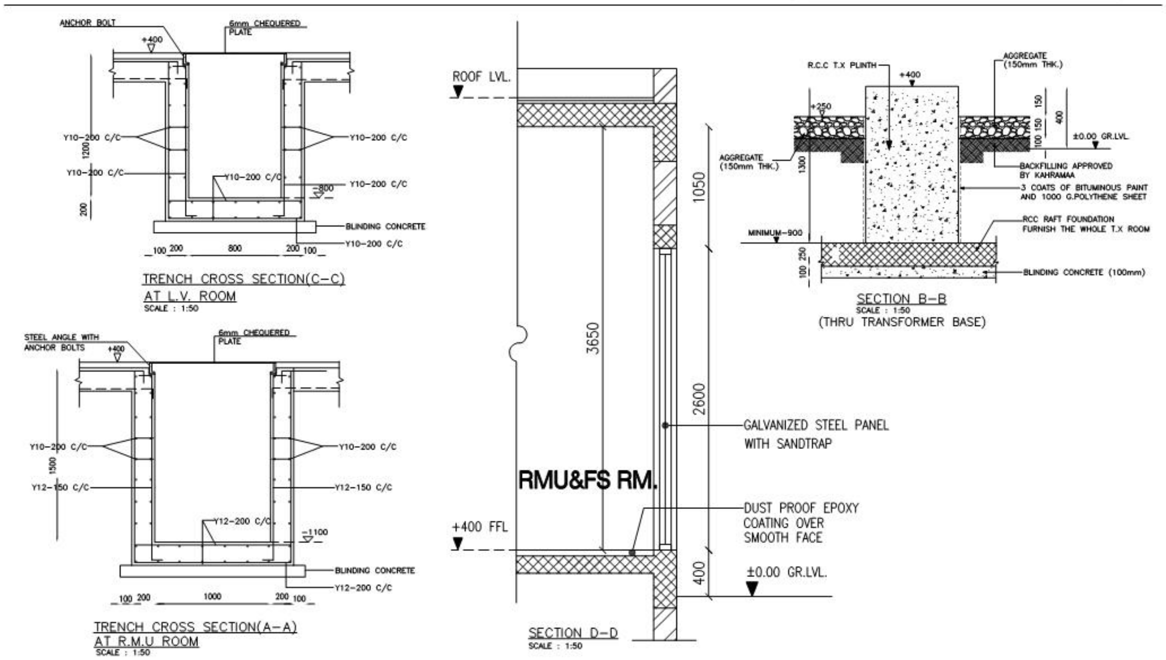
This is a cross reference for comparing NEMA and IP enclosure ratings. This comparison is only approximate, and it is the responsibility of the user to verify the enclosure rating necessary for the given application.

Enclosure type	IP23	IP30	IP32	IP55	IP64	IP65	IP66	IP67
1	X							
2		X						
3					X			
4							X	
4X							X	
6								X
12				X		X		
13						X		

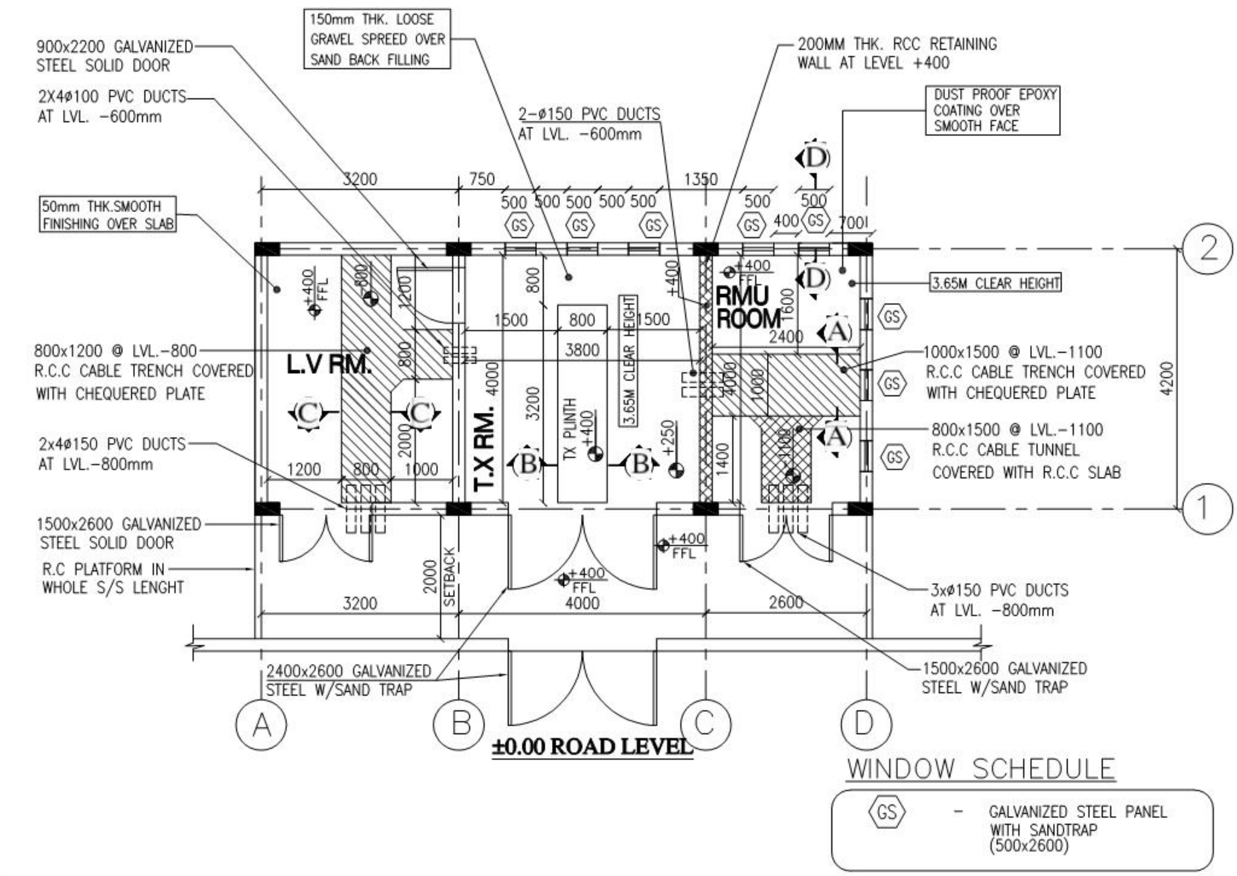
D.4 Layout Details for all Types of (11/0.415) KV Substations Refer to BS Standard.

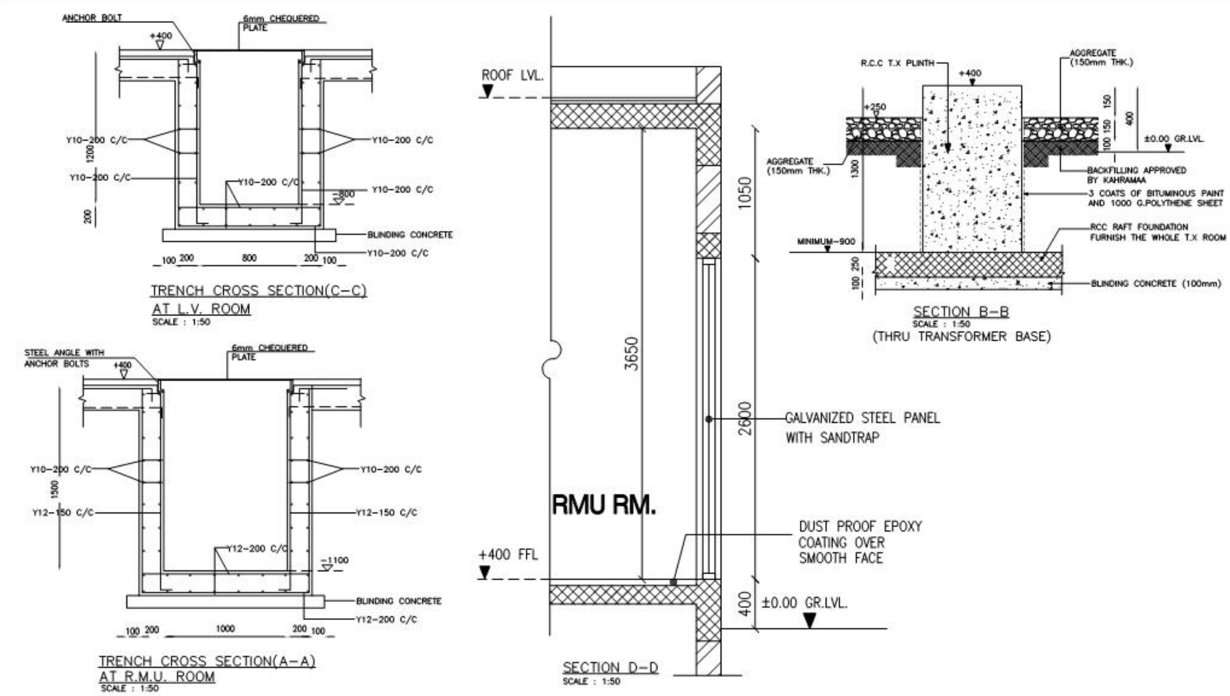
D.4.1 O/D SUB-STATION DETAILS WITH RMU & FEEDER SWITCH



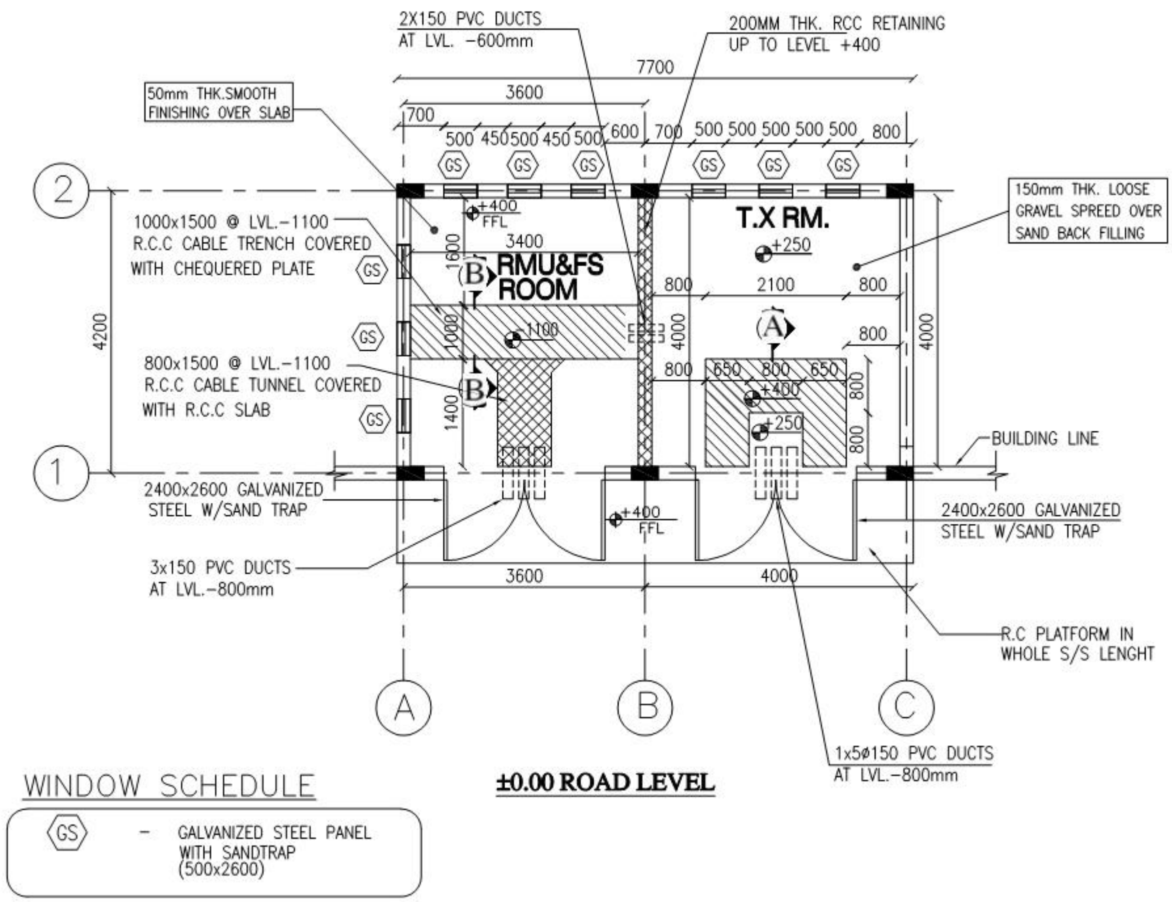


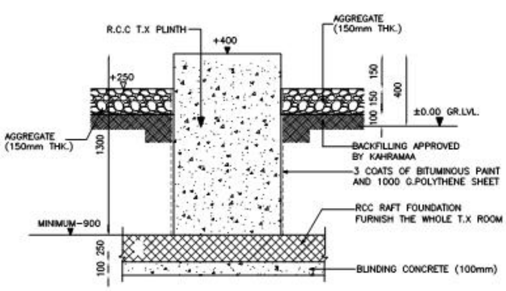
D.4.2 O/D SUB-STATION DETAILS WITH RMU ONLY



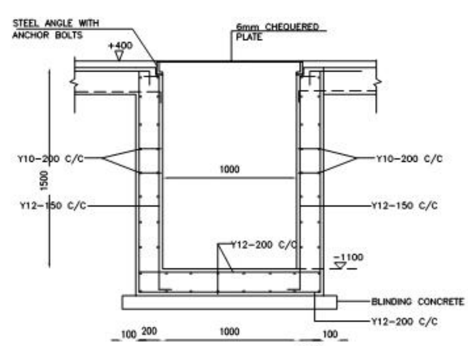


D.4.3 <u>O/D SUB-STATION DETAILS WITH RMU & FEEDER SWITCH WITHOUT L.V. ROOM</u>



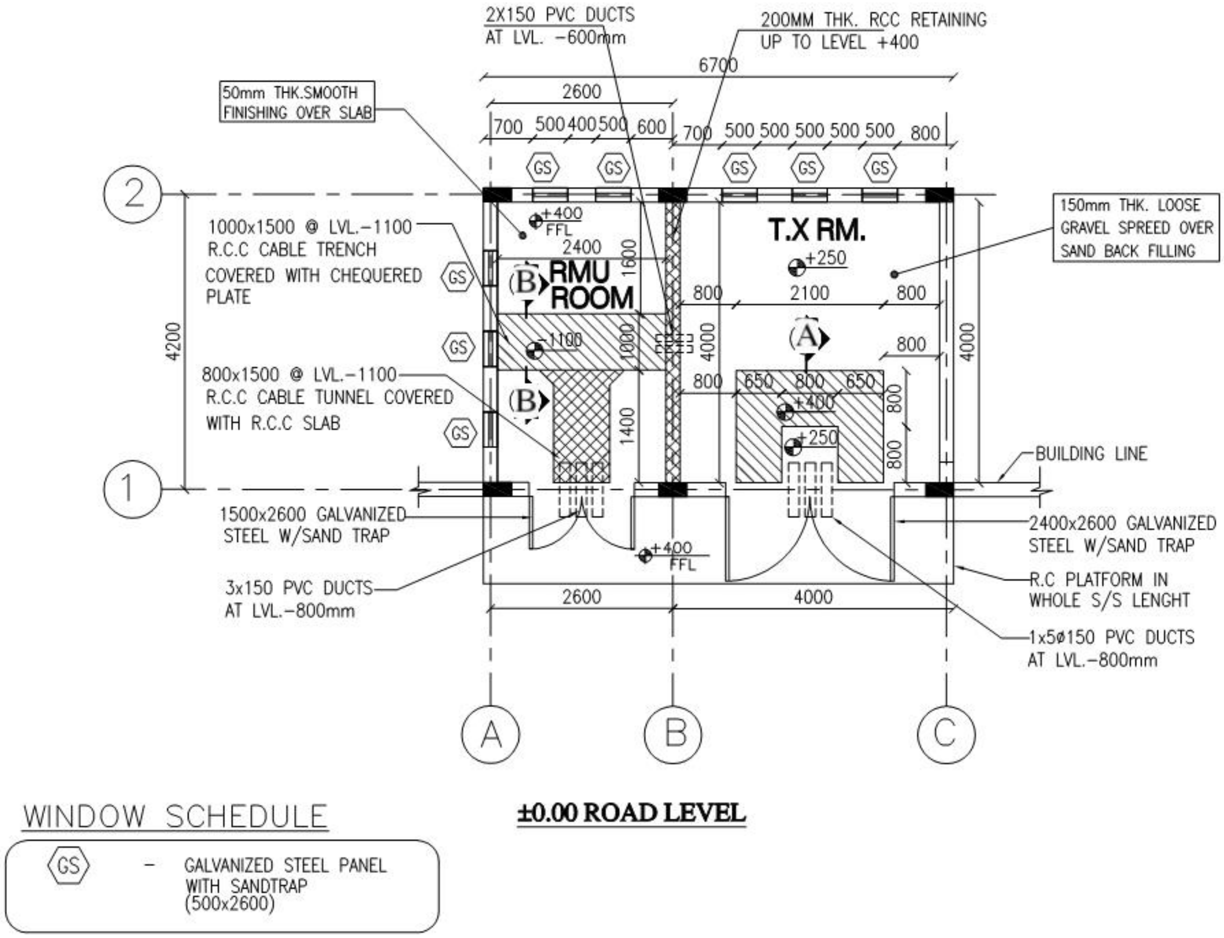


SECTION A−A
SCALE : 1:50

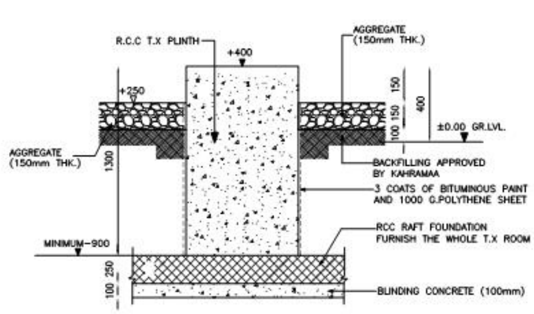


TRENCH CROSS SECTION(B−B)
SCALE : 1:50

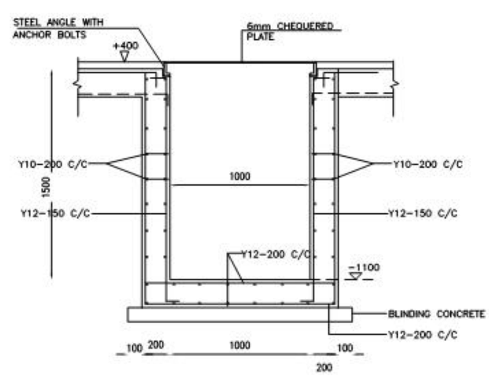
D.4.4 O/D SUB-STATION DETAILS WITH RMU ONLY WITHOUT L.V ROOM



±0.00 ROAD LEVEL



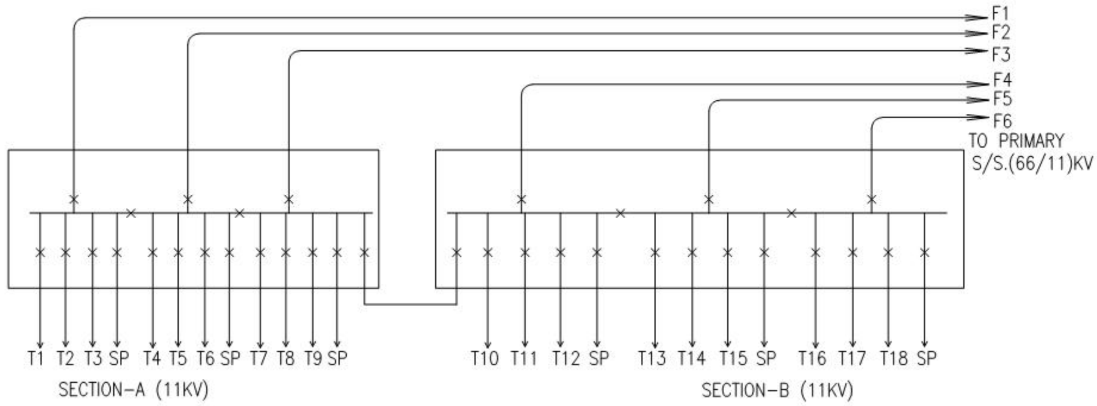
SECTION A-A
SCALE : 1:50

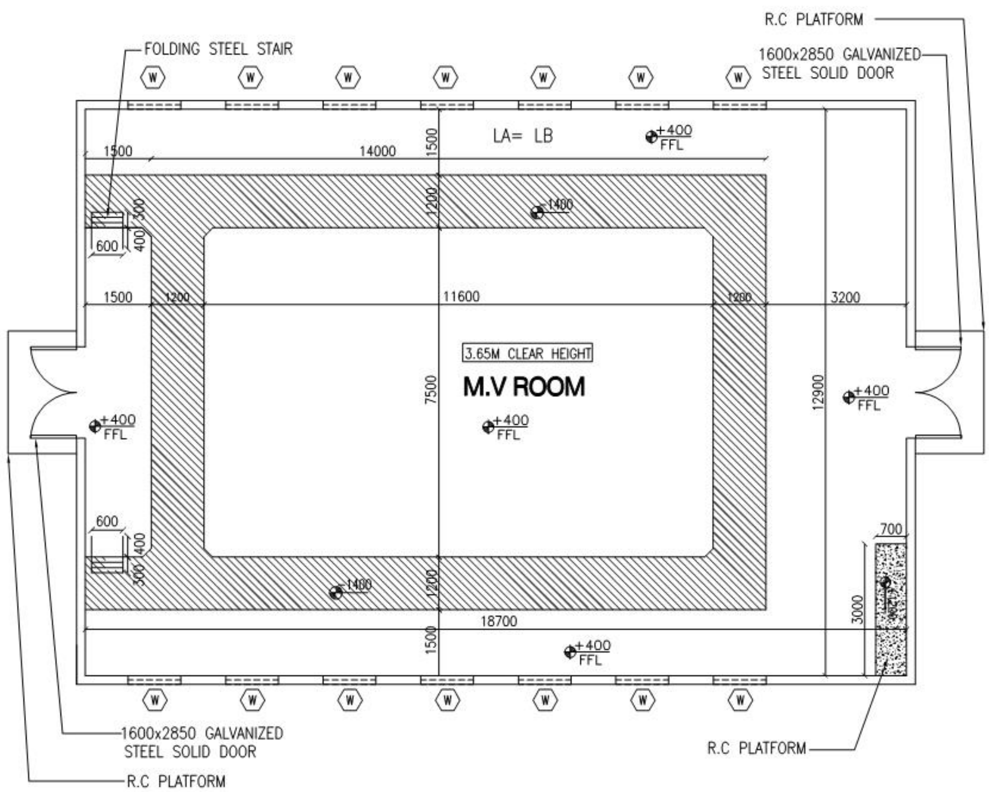


TRENCH CROSS SECTION(B-B)
SCALE : 1:50

D.4.5 M.V. ROOM FROM S/S 66 / 11 KV (FOR 18 TX).

D.4.5.1 OPTION (1) TWO SECTION



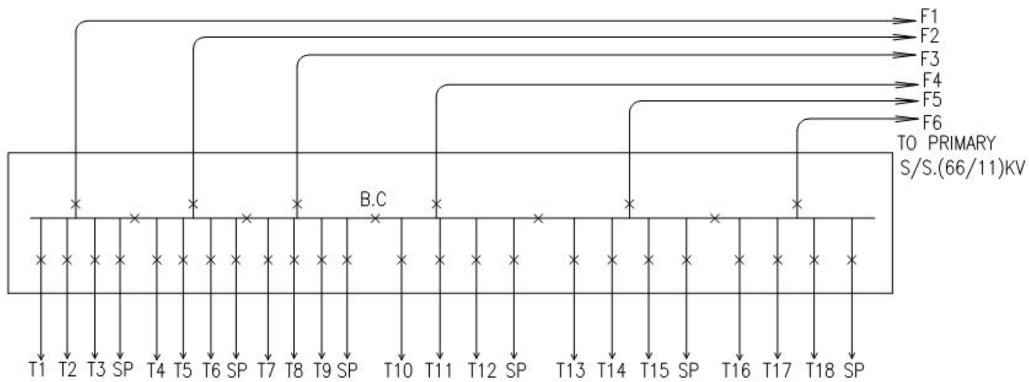


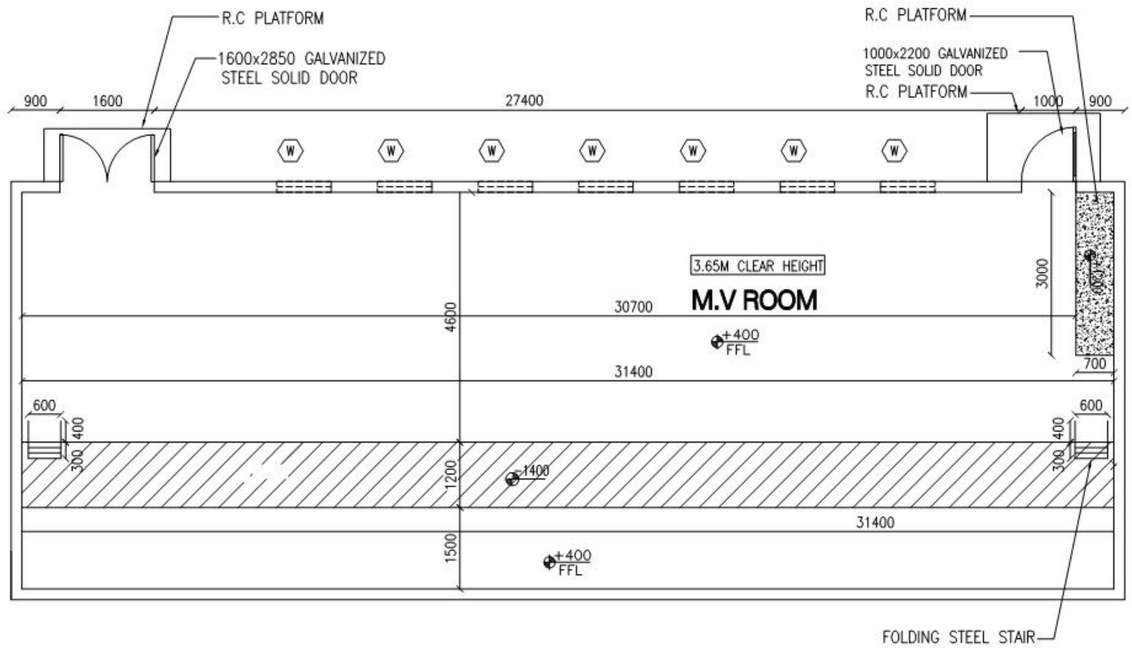
SECTION–A	LA= 13 VCB'S+2 B.C+3 FEEDER=(16)x0.7+2x1.4=14.0METER
SECTION–B	LB= 13 VCB'S+2 B.C+3 FEEDER=(16)x0.7+2x1.4=14.0METER

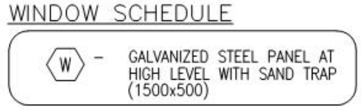
WINDOW SCHEDULE

D.4.5.2 OPTION (2) ONE SECTION

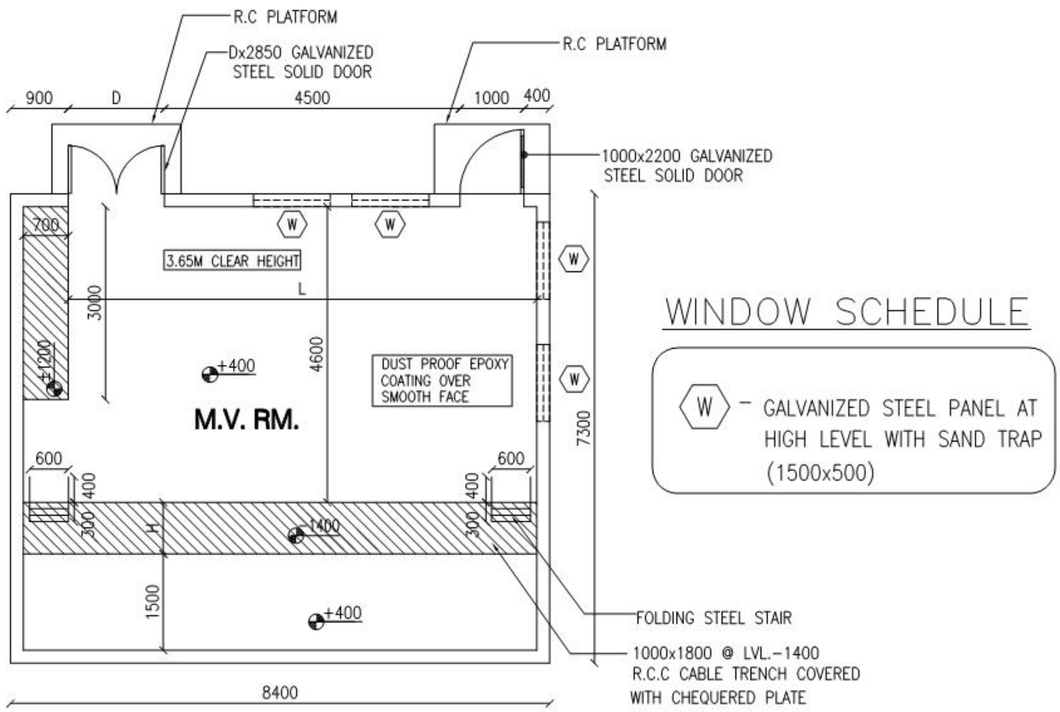
SECTION–A	LA= 24 VCB'S+5 B.C+6 FEEDER=(30)x0.7+5x1.4=28.0METER







D.4.6 M.V. ROOM FOR I/D SUB-STATION 11 KV



D= 1.5 METERS (NO BUS SECTION)
1.6 METERS (THERE IS BUS SECTION)

H= 1 METER MINIMUM.
1.2 METERS FOR M.V.(SWITCH GEAR MORE THAN 9 CUBICLE)

L= DEPEND ON NUMBER OF M.V.CUBICLE

- -FEEDER(VCB)&TX(VCB) =0.7 METER
- -BUS COUPLER = 2x0.7METER = 1.4METER.
- -L(MTS.)=(TX+FEEDER)x0.7+B.Cx1.4+2.0(SIDE SPACE)

APPROXIMATE LENGTH OF M.V.ROOM RELATED TO NO.OF TRANSFORMER

	1 TX	2 TX	3 TX	4 TX	5 TX	6 TX
S.L.D	SS(X) SS(Y) SP FEEDER					
L (METER)	5.5	6.2	8.3	9.0	9.7	11.8
M.V LENGTH	6.2	6.9	9.0	9.7	10.4	12.5

D.5 Design Considerations for Stand By Diesel Generator

D.5.1 Grounding of Generators.

Use 4-pole transfer switches where required to avoid GFP sensing problems, typically where the normal service has two or more levels of GFP installed and multiple transfer switches are used. 4-pole transfer switches are also required where indication of ground fault is provided on the emergency generator, so that the sensing will detect downstream faults rather than look backwards into the generator. Future consideration of the initial installation of 4-pole pole transfer switches.

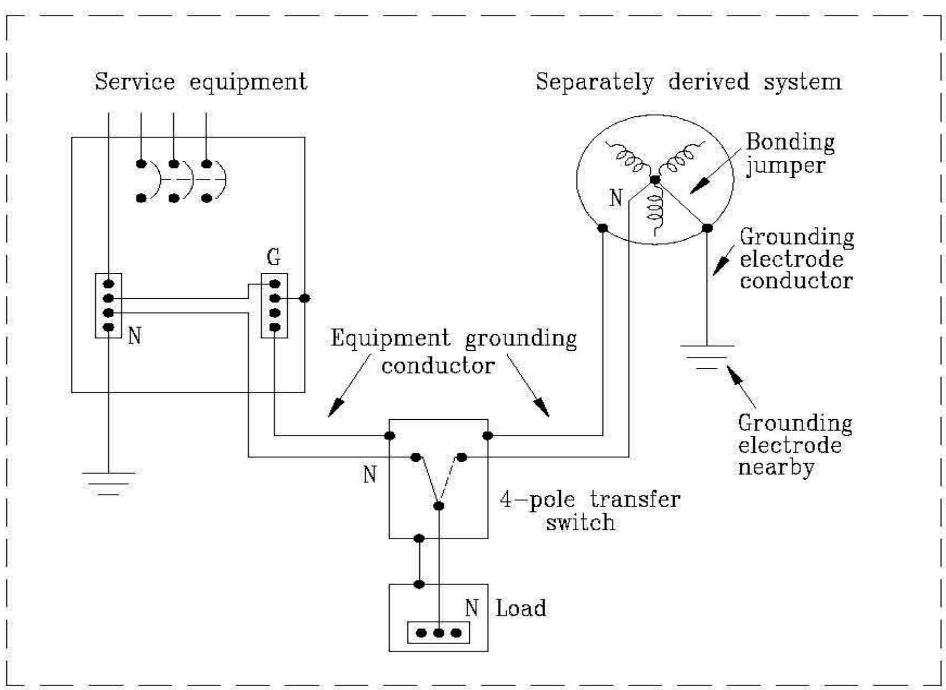
If, 4-pole transfer switches are used the generator must be grounded as a separately derived system. The generator neutral should not be bonded to its equipment grounding electrode where the generator neutral is solidly interconnected with the grounded neutral transfer equipment is required.

Based on the premises that arcing ground faults can escalate to a balanced arcing fault in 2 cycles or less, and that overlapping contact neutral devices may require significant reduction in GFP sensitivity, simultaneously switched 4-pole switches are recommended where neutral switching is required.

What are the Grounding requirements for the generators as NEC code Article 250-6, 7?

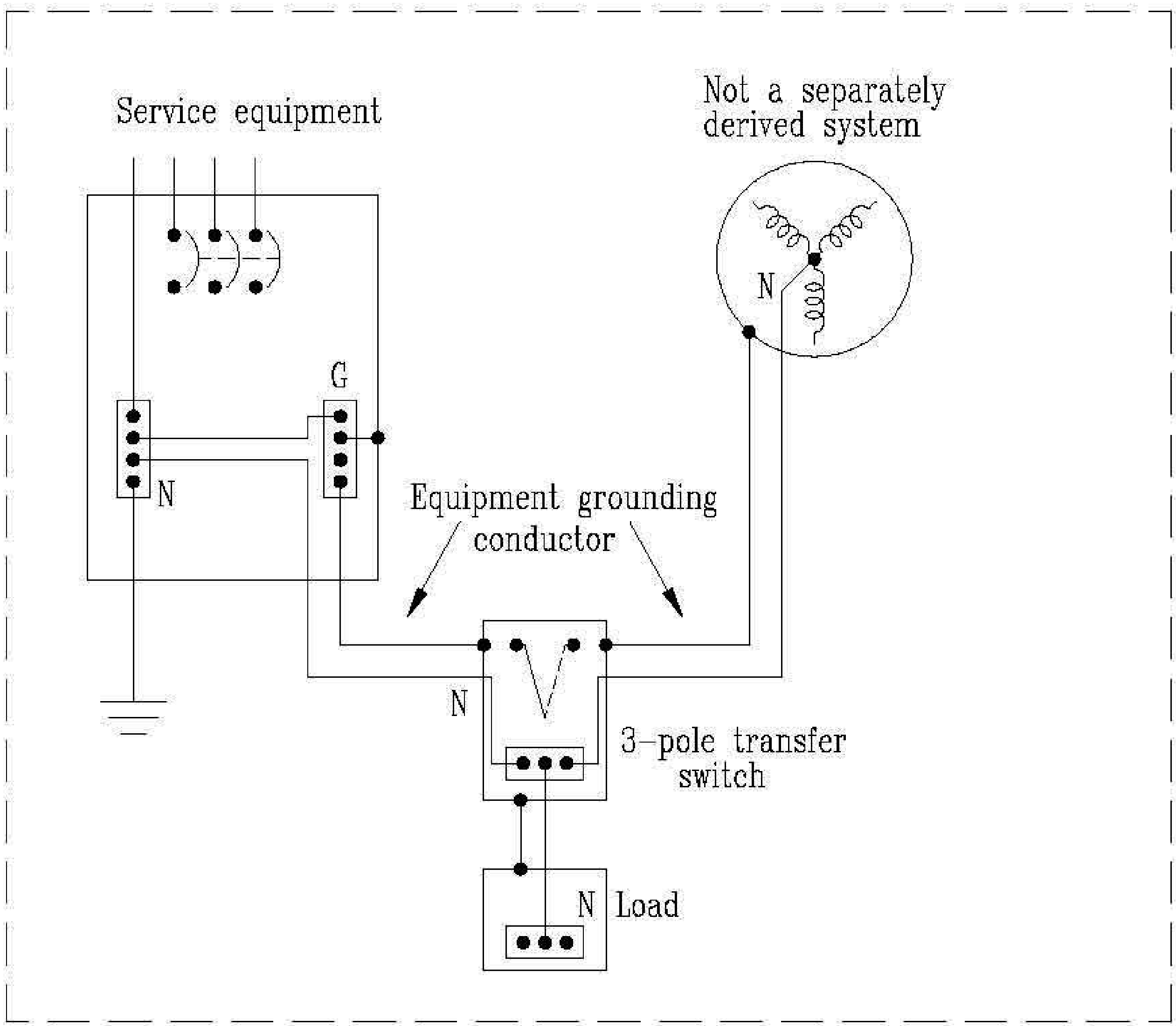
D.5.1.1 Separately derived system (4 Pole ATS) / NEC – Article 250-7

- Generator neutral bonded to system ground at the generator.
- Generator frame requires equipment grounding connection to ATS.
- Grounding electrode (s) needs to be "nearby"



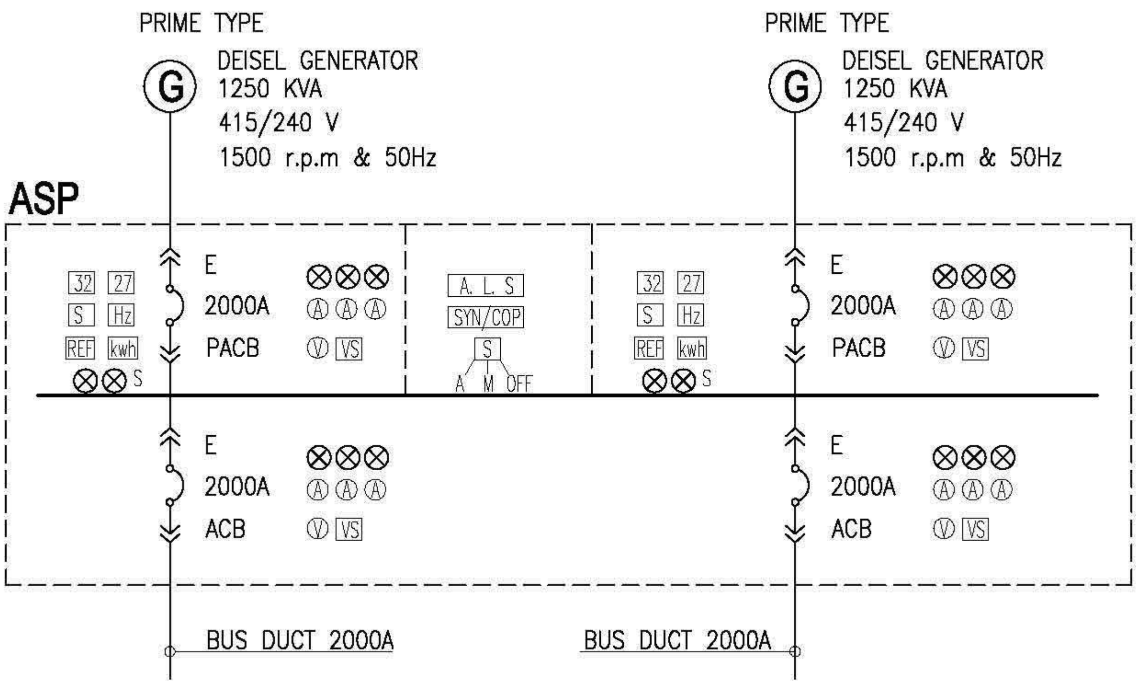
D.5.1.2 <u>Non-Separately derived system (3 Pole ATS) / NEC – Article 250-6</u>

- Generator neutral bonded to system ground at service.
- Generator frame requires equipment grounding conductor.
- Ground rod at generator is not adequate.



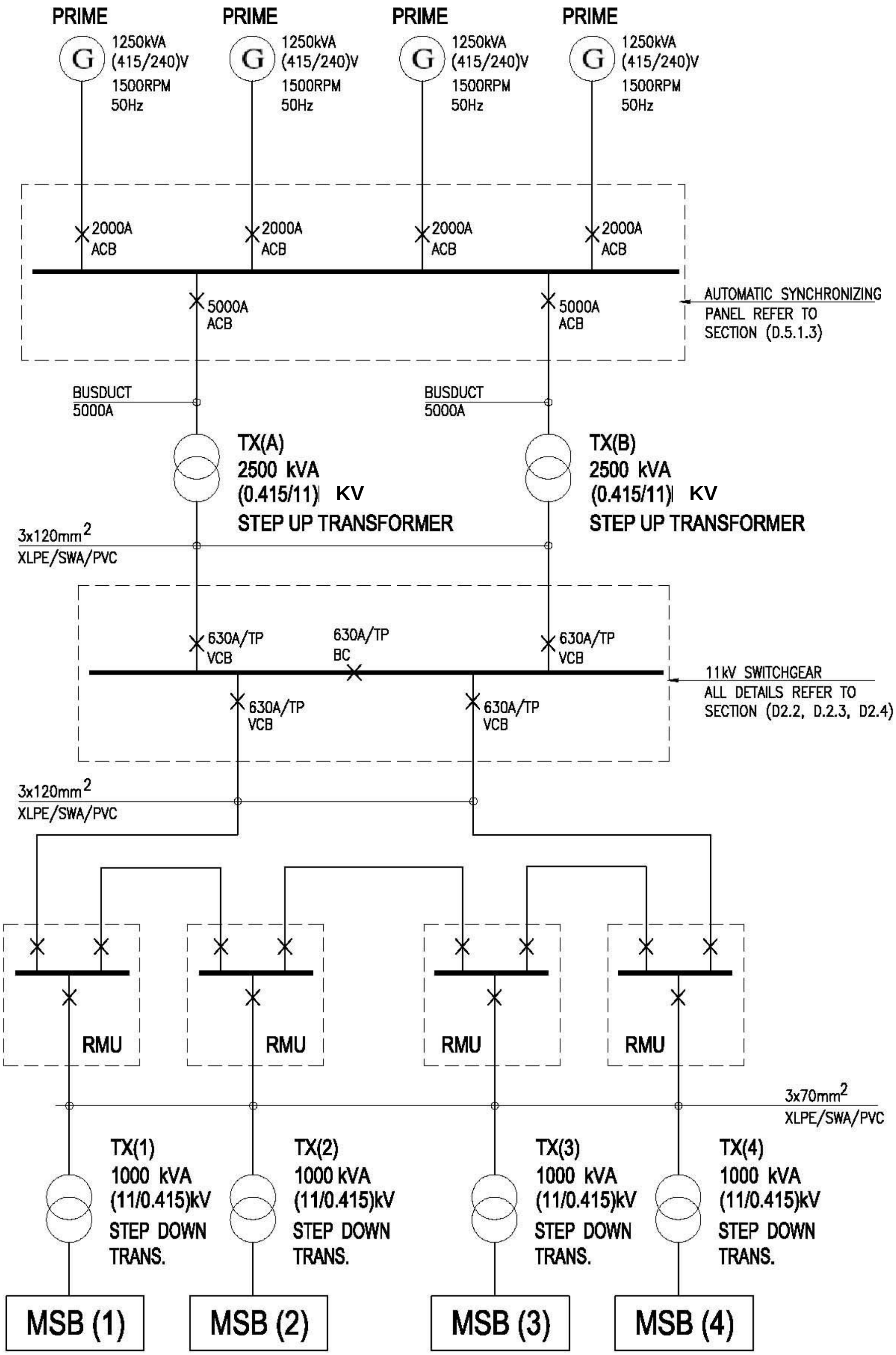
D.5.1.3 <u>AUTOMATIC SYNCHRONIZING PANEL DETAILS</u>

<u>For Generators (Parallel Connection)</u>



LEGEND	
Ⓐ	AMMETER
VT	VOLTAGE TRANSFORMER
Ⓥ	VOLTMETER
	HIGH RUPTURE FUSE
⊗	INDICATING LAMP
⊗S	SYNCHRONIZING LAMP
kwh	KILOWATT HOUR METER
27	UNDER VOLTAGE RELAY
32	REVERSE POWER SUPPLY
S	SYNCHRONIZING CHECK RELAY
HZ	FREQUENCY METER
REF	RESTRICTED EARTH FAULT RELAY
A.L.S	AUTOMATIC LOAD SHARING
SYN/COP	SYNCHRONOSCOPE
S (A M OFF)	SYNCHRO. MODE SWITCH
NO	NORMALLY OPEN
NC	NORMALLY CLOSED
PACB	POWER AIR CIRCUIT BREAKER
ASP	AUTOMATIC SYNCHRONIZING PANEL

D.5.1.4 <u>Generation Power Station at Low Voltage with Step up Transformers there is no authority power supply (Generators Room 1200 meter away from the load)</u>



D.5.2 Generators Data sheet According to Manufacturers (KOHLER - CATERPILLAR - MTU)

Item	**1**	**2**	**3**	**4**	**5**
Size (KVA)	300	400	500	800	1000
L1*W1*H1 Gen. dimension (m)	3.2*1.35*1.75	3.2*1.35*1.9	3.8*1.5*2.1	4.5*1.75*2.15	4.7*2.1*2.3
plinth Dimensions L2*W2 (m)	4*1.85	4*1.85	4.5*2	5*2.25	5.2*2.75
Room Dimensions L3*W3*H3 (m)	6*3.8*3.6	6*3.8*3.6	6.5*4*3.8	7*4.25*3.8	7.2*5*3.85
Weight (Ton)	3	3.6	5.3	7	8.3
Fuel consume (liter/hours)	68.1	83.15	102	174	236
Daily tank (Capacity 8 Hrs) (m^3)	0.5	0.65	0.8	1.4	1.7
F,A intake-Engine (C.F.M)	625	990	1350	2405	2545
F,A intake-Radiator (C.F.M)	12500	14200	23100	30000	48000
Engine Exhaust gas (C.F.M)	1645	2385	3245	5720	6995
Exh. Back per max. allaw. (Kpa)	9.8	9.8	9.8	6.7	10
Exh gas Temp. (^oC)	519	465	513	538	560
Exh. Internal Diameter (Inch)	5	6	7	8	10

Note:

- No fuel Tank attached with generator for sizes above 250 KVA.
- Main Fuel Tank not important (Up to 24 Hours) only if recommended.
- Exhaust pipe size to be from black steel & Variable Diameter refer to Height.

Generators Data sheet According to Manufacturers (KOHLER - CATERPILLAR - MTU)

Item	6	7	8	9
Size (KVA)	1250	1500	1600	2000
L1*W1*H1 (m) Gen. dimension	4.7*2.1*2.4	5.2*2.2*2.5	5.5*2.3*2.5	6.5*2.8*2.5
plinth Dimensions L2*W2 (m)	5*2.75	6*2.8	6*2.8	7.2*3.5
Room Dimensions L3*W3*H3 (m)	7.2*5*3.85	8*5*4	8*5*4	9.5*6*4
Weight (Ton)	11	14	14.5	16
Fuel consume (liter/hours)	271	320	353	458
Daily tank (Capacity 8 Hrs) (m^3)	2.2	2.5	2.75	3.5
F,A intake-Engine (C.F.M)	3145	4630	5135	6780
F,A intake-Radiator (C.F.M)	54000	63000	70000	80155
Engine Exhaust gas (C.F.M)	8300	12220	13915	16105
Exh. Back per max. allaw. (Kpa)	6.7	6.7	6.7	6.7
Exh gas Temp. (^oC)	550	550	540	480
Exh. Internal Diameter (Inch)	10	12	12	2*10

Note:

- No fuel Tank attached with generator for sizes above 250 KVA.
- Main Fuel Tank not important (Up to 24 Hours) only if recommended.
- Exhaust pipe size to be from black steel & Variable Diameter refer to Height.

D.6 Induction Motors

D.6.1 Motors Frequency.

Condition	Motor Torque	Speed	Output Power	Current
50 HZ motors working in 60 HZ system / system voltage increase proportion to frequency $\frac{V\ (v)}{F\ (HZ)}$ = Const.	Unchanged	Increased by 20%	Increased by 15%	Slightly increased
50 HZ motors operating in 60 HZ system without rising voltage	Reduced by 18%	Increased by 20%	Constant	Reduced by 10%
60 HZ motors operating in 50 HZ system with reducing voltage proportion to frequency $\frac{V}{F}$ = Const.	Unchanged	Decreased by 20%	Increased by 15%	Slightly decreased

D.6.2 Motor Starting Methods Refer to IEEE STd 241-1990

Full voltage starting of the motor requires only that the contractor connect the motor terminals directly to the distribution system. Starting a squirrel-cage motor form standstill by connecting it directly across the line may allow inrush currents of approximately 500%-600% of rated current at a lagging power factor of 35% -50%. The inrush current of motors rated 5 hp and below usually exceeds 600% of the rated current. Small motors, for example, 0.5 hp, may have inrush currents of 10 time's full load motor current. Energy-efficient motors may even draw higher currents. For applications, such as ventilating fans or small pumps, this type of starting is not objectionable; As a result, most of these controllers are full voltage types. However, some applications, such as large compressors for air-conditioning and pumping installations, may require motors as large as several thousand horsepower. For many of the larger motors, the starting inrush current may be great enough to cause voltage dips, which may adversely affect the building's lighting system.

Electric utilities also have restrictions on starting currents, so that voltage fluctuations can be held to prescribed limits. Before applying large motors, starting limitations should be checked with the utility. Some type of starting that limits the current may be necessary. Some couplings or driven equipment have limitations on torque that may be safely applied. Such as maximum torque limits may require reduced voltage starting.

Motor size < 15HP (11kw) working direct on line
Motor size ≥ 15HP (11kw) starter to be applicable

D.6.2.1 Star – Delta starter

The most common reduced voltage starter is the Star-Delta starter (Y-Δ), in which:

- The NEMA rating of a wye-delta starter is higher than that of a full voltage starter that of a full voltage starter that has the same contactor. In closed transition, contactor 2S is usually one size smaller than IS. An overload relay is included in each phase and set at 58% of the full-load motor current. The time setting should be set somewhat longer than for part winding starters; That is, 3-4 seconds on open transition and 3-5 seconds on closed transition autotransformer and wye-delata starters.
- On starting, the stator winding are star-connected, thus achieving the reduction of peak inrush current;
- Once the normal speed of the motor is nearly reached, the switchover to delta is carried out.
- After the switchover, the current and the torque follow the progress of the curves associated with normal service connections (delta)
- As can be easily checked, starting the motor with star-connection gives a voltage reduction of $\sqrt{3}$, and the current absorbed from the line is reduced by 1/3 compared with that absorbed with delta-connection.
- The start-up torque, proportional to the square of the voltage, is reduced by 3 times, compared with the torque that the same motor would supply when delta-connected.

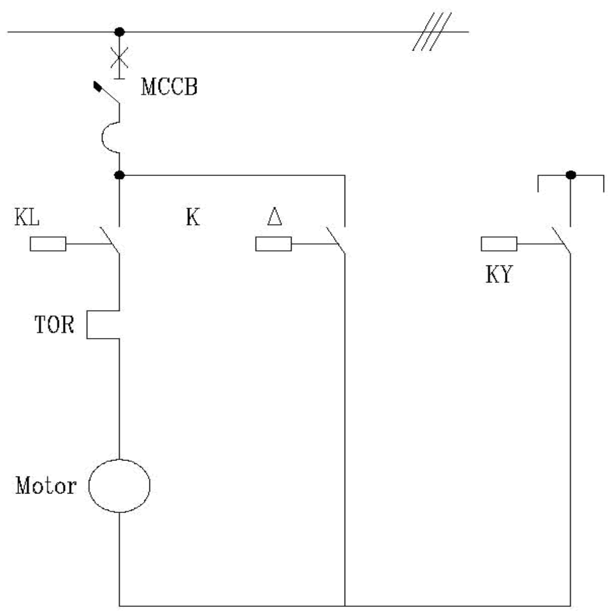


Fig. (1)

- $I_{(Y)} = \frac{1}{3} I_{\Delta}$

- $Torque_{(Y)} = \frac{1}{3} Torque_{(\Delta)}$

Star-Delta connection related to changing supply voltage Refer to IEEE

Motor winding arranged for	Supply voltage	Direct-on-line starting in	Y/Δ starting
220 Δ / 380 Y	220 V 380 V	Δ Y	Yes No
380 Δ / 660 Y	380 V 660 V	Δ Y	Yes No
500 Δ 600 Y	500 V 500 V	Δ Y	Yes No
660 Δ	660 V	Δ	Yes

D.6.2.2 Soft- Starter (Solid-State).

Solid-state or electronic reduced voltage starters provide a smooth, stepless method of acceleration for standard squirrel-cage motors. Three methods of acceleration are available:

1. Constant current acceleration, in which the motor is accelerated to full speed at a field-selectable, preset current level.
2. Current ramp acceleration, in which the voltage is gradually increased to provide smooth stepless acceleration under varying loads.
3. Linear timed acceleration, in which the motor is accelerated at a linear rate that is field-adjustable.

A solid-rate control circuit provides control for the silicon controlled rectifiers, which are used to provide the variable voltage to the motor. Contactors are often used in the power circuit or provide isolation between the motor and the load.

Solid-state starters are particularly suitable for applications that require extremely fast or a large number of operations, or both (several million under load). In addition to starting motors, solid-state controllers are also used for speed control of ac and dc motors.

The cost of solid-state controllers varies considerably, depending on rating and features. As shown, they are generally more expensive than electromagnetic controllers.

Variable voltage with variable frequency to maintain flux constant to keep rotor torque unchanged.

E(v) = 4.44 x F (HZ) XN (turns) x φ

$$\frac{E}{F} = \text{Constant}$$

So, it is the best method for motor starting but it is costly. So, it is used for high power rating motors and for important applications.

D.6.2.3 Resistor or Reactor Starters. The simplest reduced voltage starting is obtained through a primary reactor or resistor. The voltage impressed across the motor terminals is reduced by the voltage drop across the reactor or resistor, and the inrush current is reduced proportionately. When the motor has accelerated for a predetermined interval, a timer initiates the closing of a second contactor to short the primary resistor, or reactor, and connect the motor to the full line voltage. The transition from starting to running is smooth since the motor is not disconnected during this transition.

D.6.2.4 Autotransformer Starters. An autotransformer starter has characteristics that are similar, but at the same time more efficient, than the resistor-reactor starter. Since an autotransformer controller reduces the voltage by transformation, the starting torque of the motor will vary directly as the line current, even though the motor current is reduced directly with the voltage impressed on the motors.

D.6.3 <u>An Important Protection for the motors.</u>

- Short circuit protection
- Overload Protection
- Earth fault protection
- Phase failier protection
- Phase sequence protection
- Over temperature protection

  (Thermostatic control to disconnect supply IF motor temperature, more than its insulation class)
- For hazardous area the motors should be (drip proof type totally enclosed – fan cooled) and terminal box to be weather proof.
- Motor class (B) winding insulation should not use in the sun.

D.6.4 <u>Voltage deviation Affection Refer to ABB Motors Hand Book</u>

If the supply voltage at constant output power deviates from the rated voltage of the motor, the starting and maximum torques of the motor vary approximately as the square of the voltage. The change in torque will also result in a change in the speed. The efficiency and the power factor are also affected.

Voltage deviations also affect the temperature rise in the winding of the motor. If the voltage is low, the temperature rises in both small and large motors; if the voltage is high the temperature may drop slightly in large motors, but rises sharply in motors with small output powers. It is therefore essential to dimension the windings generously enough to ensure that there is no significant voltage drop in them on starting or in service. See fig. (2)

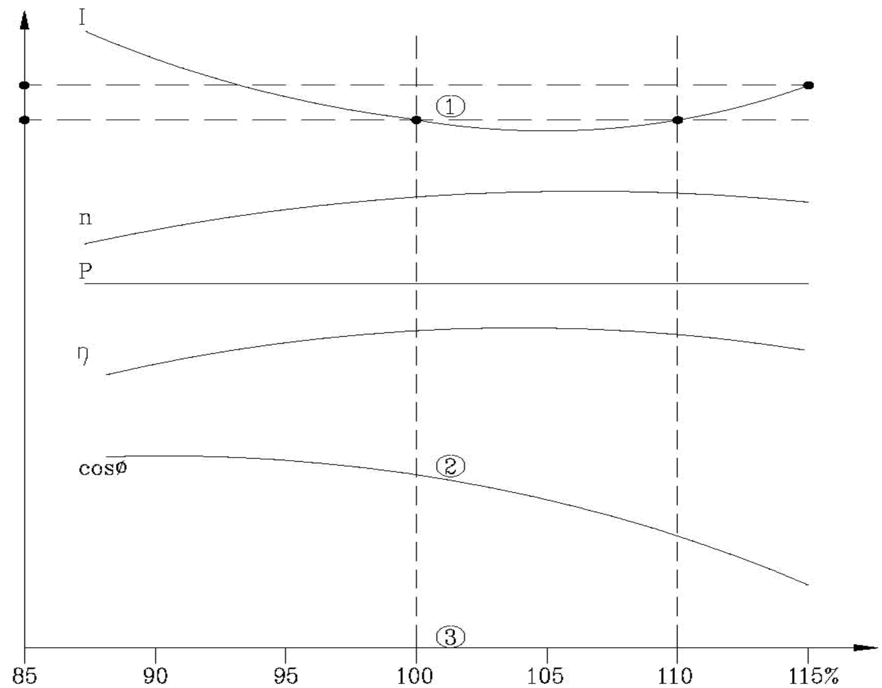


Fig. (2)

Example showing current (I), speed (n), efficiency (n) and power factor (cosφ) as a function of the voltage at constant output (P).

D.7 Design Considerations of Transformers

D.7.1 Parallel Operation of Transformers

Two or more transformers are said to be operating in parallel when their high and low voltage windings are connected in parallel. For the correct parallel operation of transformers there should not be any closed currents, and the loadings of all transformers should conform to their output.

D.7.1.1 In order to achieve parallel operation

- Transformers must belong to the same type of phase shift / wiring group (see Fig.2).
- The transformers should have equal transformation relations to operate in the same primary and secondary voltage.
- Tolerances of + 0.5% of the no-load voltage or 1/10 of the impedance voltage are acceptable.
- It's should have equal impedance voltages (Z%), for all parallel transformers.
- Transformers of smaller output should have the highest impedance voltage.
- The parallel transformers should have an output ratio lower than 2:1 (If difference will be excessive, the voltage drops during operation will also differ excessively which cause unequally loading percentages for transformers)
- Same frequency.

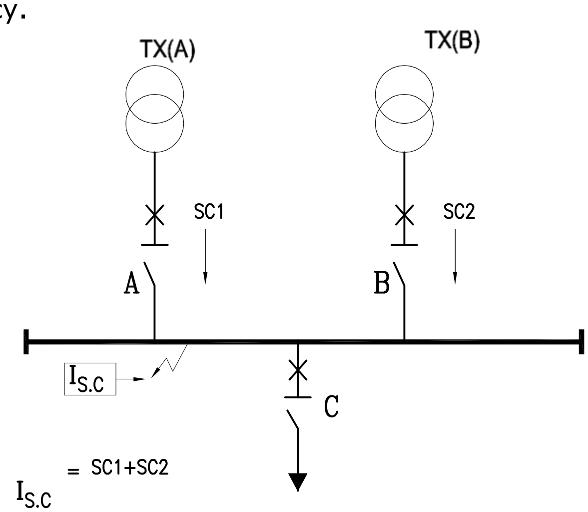


Fig. (1)

Note: (1)

- For a correct dimensioning, incoming circuit-breaker (A or B) with a breaking capacity higher than the larger of the 2 values $I_{(s.C)1}$ or $I_{(s.C)2}$ for two transformers must be chosen.
- The circuit-breakers positioned on the outgoing feeders (circuit-breakers C) shall have a breaking capacity higher than the sum of the short-circuit currents of the two transformers.

D.7.1.2 <u>Load Distribution of Parallel Operating of Transformers</u>

The distribution of load in transformers operating in parallel and having impedance voltages, computed as % of nominal output is inversely proportional to the impedance voltage.

<u>Example 1st case (Not Comply)</u>

A	B
P_N = 200 kVA	P_N = 400 kVA
Z_A = 5%	Z_B = 4%

Total output A+B = 600kVA

Load distribution

If the transformer with the smallest impedance voltage must be protected from overloading, we have:

B = 100% = 400kVA

$$A = 200\text{ kVA}\ \frac{4}{5} = 160\text{ kVA} = 80\%$$

Therefore A+B = 560 kVA

When the smaller output has largest impedance voltage

<u>Example 2nd case (Comply)</u>

A	B
P_N = 200 kVA	P_N = 400 kVA
Z_A = 5%	Z_B = 5%

Total output A+B = 600kVA

B = 100% = 400kVA

$$A = 200\text{ kVA}\ \frac{5}{5} = 200\text{ kVA}$$

Therefore A+B = 400 + 200 = 600 kVA

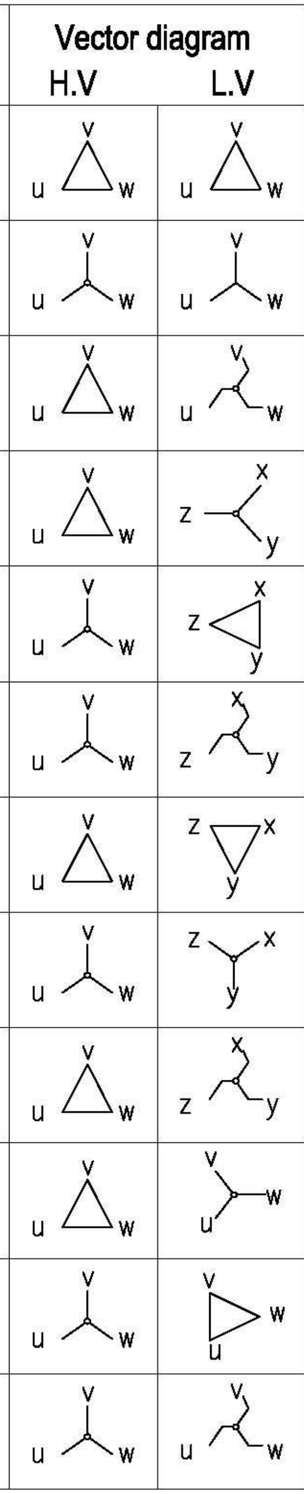
Thus, transformers can increase their output by 40 kVA without overloading the one with the smaller output.

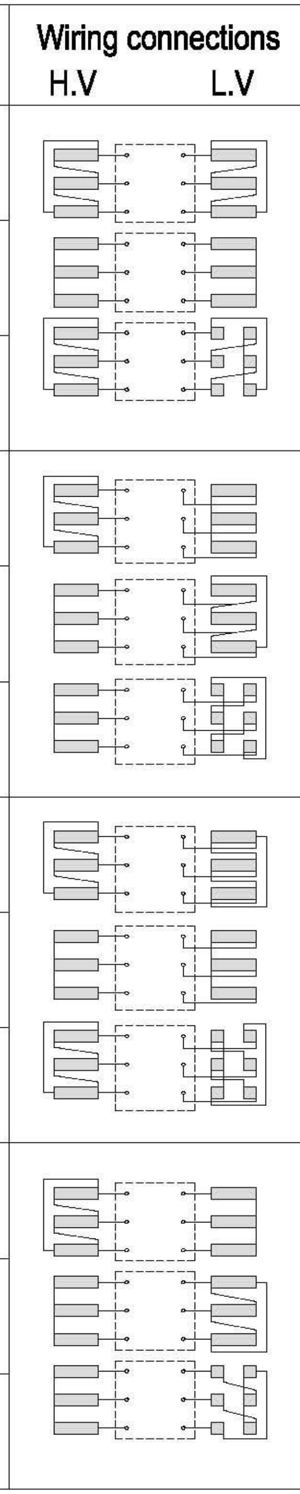
Transformers with the same impedance voltage operating in parallel can produce to their full capacity and it will be loaded automatically in proportion to their rating and the load will share correctly.

D.7.2 <u>VECTOR GROUP</u>

The usual transformer rations, *in compliance with VDE 0532 Teil 1*, appear in the table below.

Wiring Connections of Three-Phase Transformer





Group	Symbol	Voltage ratio
0	Dd0	$\frac{W1}{W2}$
	Yyo	$\frac{W1}{W2}$
	Dzo	$\frac{2W1}{3W2}$
5	Dy5	$\frac{W1}{\sqrt{3}W2}$
	Yd5	$\frac{\sqrt{3}W2}{W2}$
	Yz5	$\frac{2W1}{\sqrt{3}W2}$
6	Dd5	$\frac{W1}{W2}$
	Yy6	$\frac{W1}{W2}$
	Dz6	$\frac{2W1}{3W2}$
11	Dy11	$\frac{W1}{\sqrt{3}W2}$
	Yd11	$\frac{\sqrt{3}W1}{W2}$
	Yz11	$\frac{2W1}{\sqrt{3}W2}$

Fig. (2)

D.7.3 Transformer Starting (Inrush Current).

D.7.3.1 During transformer starting the main issue is inrush current which shall be induced due to increasing of magnetic Flux (Ø) and magnetic saturation and the magnitude of inrush current shall be depend on voltage sinsoidal waveform as following:-

D.7.3.2 Minimum value of inrush current occurs when (V) is maximum and magnetic Flux is minimum in this case low magnetizing shall be happened because of low saturation as Fig. (3).

D.7.3.3 Maximum value of inrush current at (V) is zero and magnetic Flux is maximum in this case high magnetizing shall be happened and increasing in saturation as shown in fig. (3).

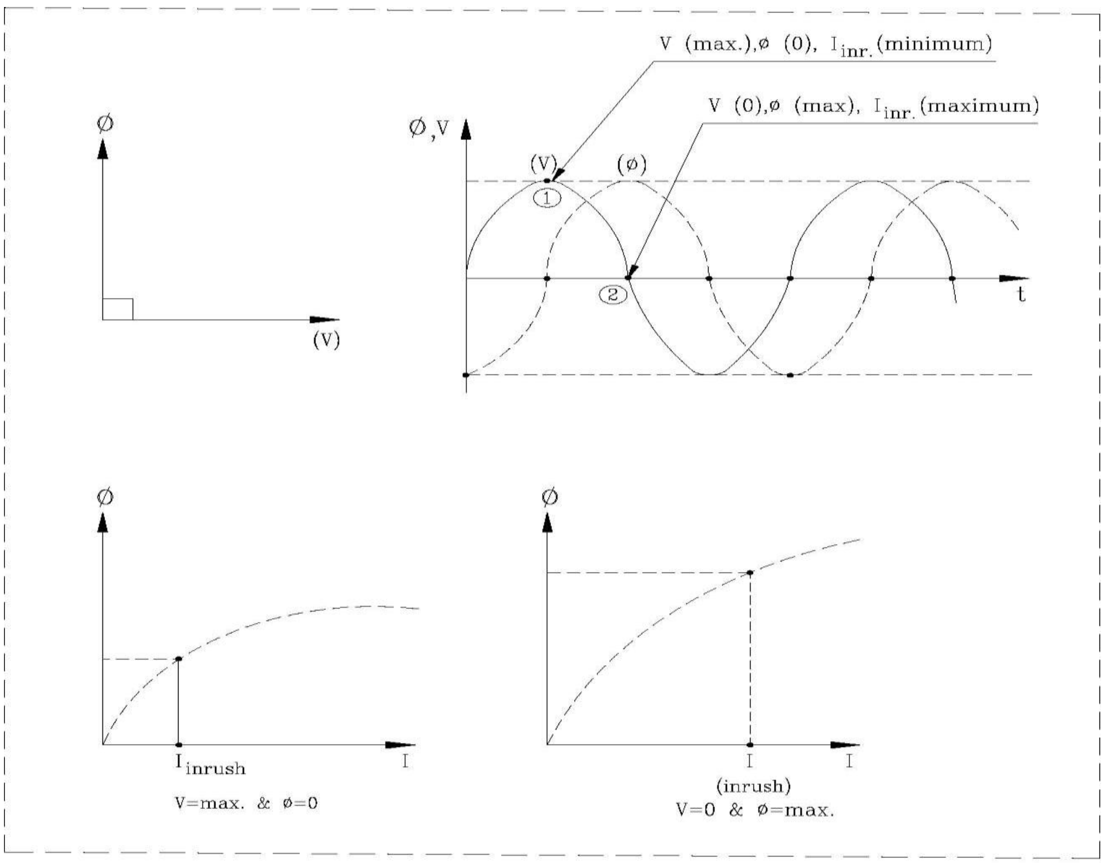


Fig. (3)

D.7.3.4 Precautions:

Refer to NEC Article 450.3

- If impedance of transformer not more than 6% and secondary 600volts or less secondary protection C.B 125% (FLC)
- But if impedance is more than 6% and not more than 10% with secondary voltage 600 (V) or less C.B should be 250% (FLC)

D.7.4 <u>Phase Voltage Unbalanced in Three-Phase Systems. Refer to IEEE STd 241-1990 CH.(3.11)</u>

Causes of Phase Voltage Unbalance. Most utilities use four-wire, grounded-wye distribution systems so that single-phase distribution transformers can be connected phase-to-neutral to supply a single-phase load, such as in residences and street lights. Variations in single-phase loading cause the currents in the three-phase conductors to be different, producing different voltage drops and causing the phase voltages to become unbalanced. Normally, the maximum phase voltage unbalance will occur at the end of the primary distribution system; but the actual amount will depend on how well the single-phase loads are balanced between the phases on the system. However, a perfect balance can never be maintained because the loads are continually changing. Causing the phase voltage unbalance to also be continually changing blown fuses on three-phase capacitor banks will also unbalance the load and cause phase voltage unbalance. Most distribution transformers used to step the distribution voltage down to a utilization voltage have delta connected primaries. Unbalanced primary voltage will introduce a circulating current into the delta winding, which tends to rebalance the secondary voltage. Under these conditions, phase voltage unbalance in the primary distribution system tends to correct itself and should not be a problem.

The proper balancing of single-phase loads among the three phases on both branch circuits and feeders is necessary to keep the load unbalance and the corresponding phase voltage unbalance within reasonable limit.

D.7.5 <u>Standard Data Sheet for Transformers Refer to IEEE STd 241-1990 CH (9.2)</u>

Transformer size (KVA)	Incomer for M.L.V.P Ampere Acc. To NEC (450.3)	$I_{s.c}$ (KA) at M.L.V.P, at 415 (V)	$I_{s.c}$ (KA) at M.L.V.P, at 380 (V)	XLPE/CWA/PVC cables from transformer to M.L.V.P
100	160	3.1	3.4	4C, 95mm^2
160	250	5	5.45	4C, 185mm^2
200	320	5.6	6.2	4C, 240mm^2
315	500	8.8	9.6	4x1C, 400mm^2
500	800	14	15.3	7x1C,400mm^2
630	1000	15.3	16.7	7x1C, 400mm^2
800	1200	19.4	21.2	7x1C, 630mm^2
1000	1600	24.2	26.5	7x1C, 630mm^2
1250	2000	30.3	33.1	7x1C, 800mm^2
1600	2500	38.7	42.2	7x1C, 800mm^2
2000	3200	48.4	53	7x1C, 1000mm^2
2500	4000	60.5	66.1	BUS DUCT
3200	5000	66	72.1	BUS DUCT
4000	6300	82.5	90.1	BUS DUCT

Notes:

- Transformer rated 2500kVA or more, it is preferable to use busbar duct between transformer and M.L.V.P.
- $I_{s.c}$ determined based on ignoring H.V reactance

D.8 Protection Devices Details

D.8.1 Restricted Earth Fault Relay Protection (REF) Refer to BS Standard

D.8.1.1 REF it is called differential protection or unit protection, the basic method for busbar protection, transformer or generator is the differential scheme in which currents entering and leaving are totalized.

D.8.1.2 During normal load condition if earth fault happened out of protection zone like I(f/o) in fig. (1) the relay will be stable I_R = zero. So, there is no tripping in protection device. The sum of these currents is equal to zero or $(I_R + I_y + I_B) - I_{Neut.}$ = zero, as shown in fig. (1).

D.8.1.3 When earth fault occurs inside projection zone, the fault current upsets the balance and produces a differential current which shall operate the relay.

$(I_R + I_y + I_B) - I_N = I_F \neq 0$ as shown in fig. (1)

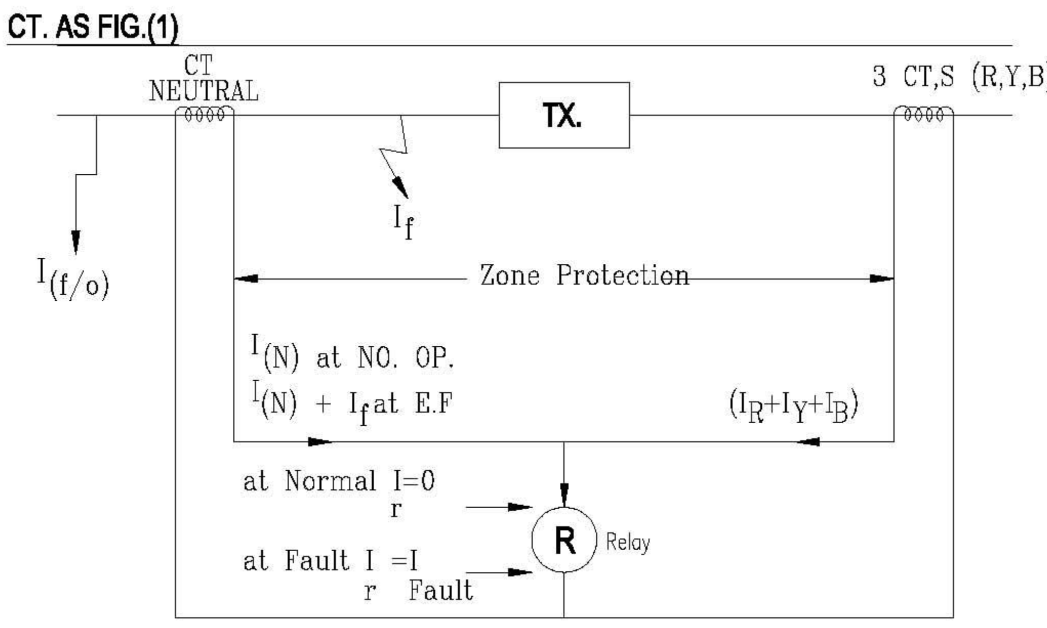


FIG.(1)

D.8.1.4 CONNECTION WIRING DIAGRAM FOR (REF)

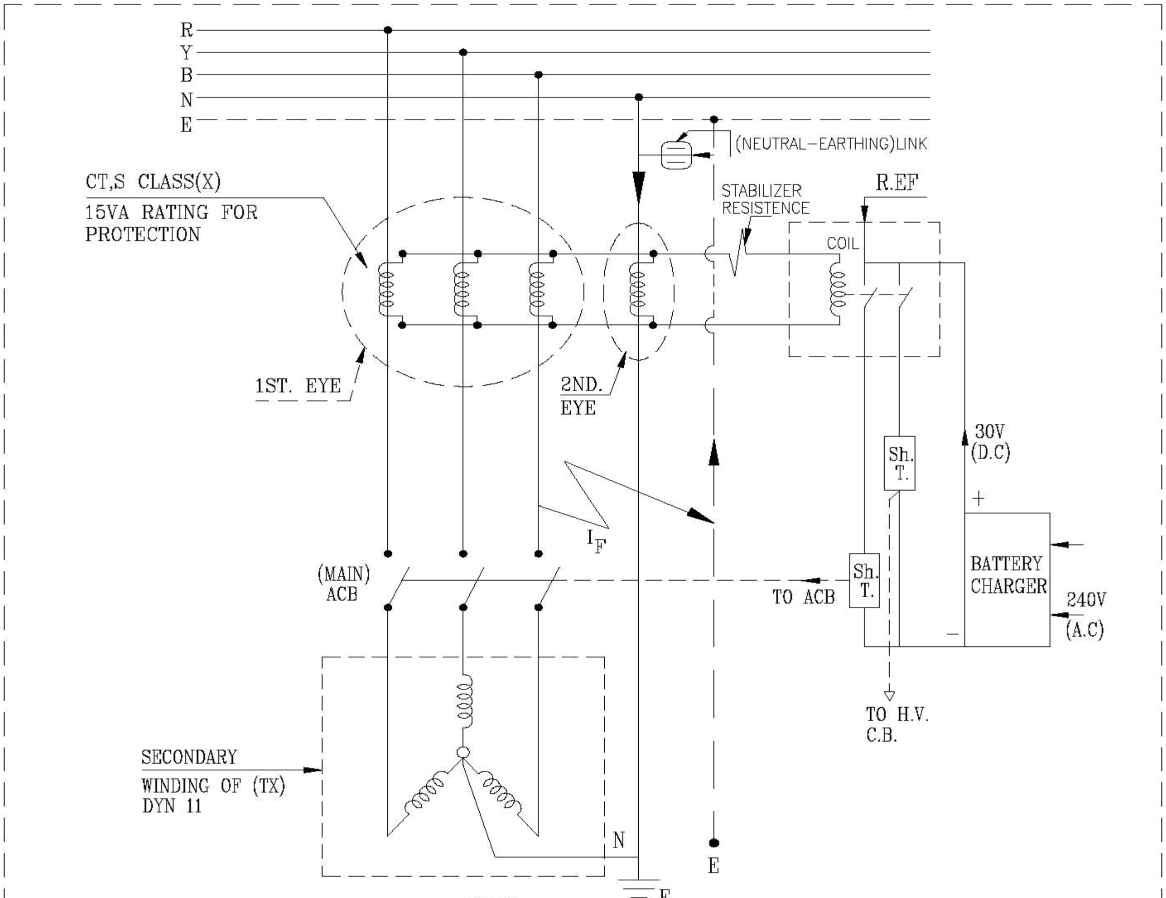


FIG.(2)

- No common earthing permitted with using (REF) otherwise earth fault current shall pass directly to ground **NOT** through (N-E) link.
- So, it is important to avoid solid earthing for common star winding of transformer if we shall connect REF relay.
- Solid connection for star winding of Tx. shall cause decreasing the voltage of neutral during earth fault as advantages but shall increase ground fault current comparing to common star earthing connection through resistor.
- If the current transformer saturates during an external fault, a certain current will flow in REF. Relay remains stable as long as the setting ration is below the set stability limit (normally 20%). So, adjustable to be done by current not by time. Ration is determine by the resistance in REF circuit (Additional to stabilizer resistance) compared to the resistance in the circuit with saturated current transformer. Hence, the conditions for complete stability in case of external faults are easily determined as shown in fig. (2).

D.8.2 L.V Air Circuit Breaker

D.8.2.1 Important protections of A.C.B

- Separate cubicle (section) in MSB
- Drawable type.
- 30 V (D.C) shunt trip.
- Motorized type.
- Short circuit protection.
- Over current protection.
- Earth fault protection.
- Thermal adjustable & magnetic adjustable.
- Residual current relay with external transformer. It is guarantee protection against direct contact and an additional measure against direct contact.
- No. of operation ≥ 10000/ electrical life.
- No. of operation ≥ 25000/ mechanical life.

D.8.2.2 General characteristic as fig. (3) trip curves of thermomagnetic and magnetic only release.

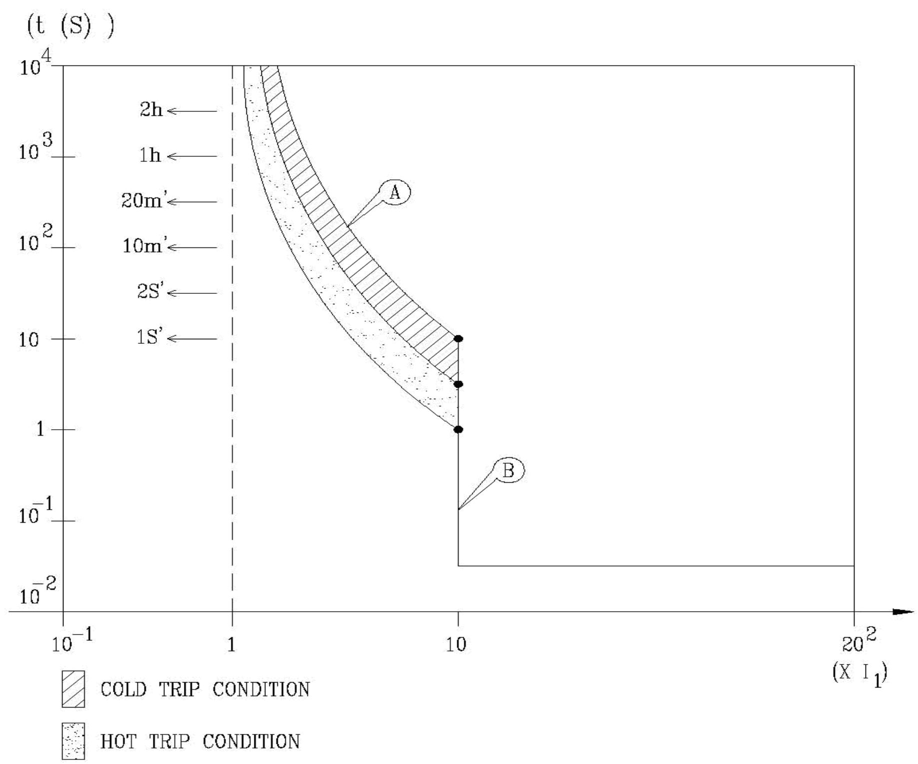


FIG. (3)

- Curve (A) is over load protection it is occurs when has not reached to normal working temperature.
- At hot trip condition C.B having reached the normal working temperature with rating current flowing through before overload current occurs for this reason time of cold trip condition greater than time of hot trip condition.
- Curve (B) is indicating time – current curve by vertical line corresponding to the rated value of the trip threshold current. So, it is the protection function against short circuit.

D.8.2.3 <u>Rated Performance for Protection Devices</u>

❖ **<u>Voltages</u>**

- **Rated Operational Voltage (U_e)**
  A rated operational voltage of an equipment is a value which, combined with a rated operational current, determines the application of the equipment and to which the relevant tests and the utilization categories are referred to.

- **Rated Insulation Voltage (U_i)**
  The rated insulation voltage of an equipment is the value of voltage to which dielectric tests voltage and creepage distances are referred. In no case the maximum value of the rated operational voltage shall exceed that of the rated insulation voltage.

- **Rated Impulse withstand Volatage (U_{imp})**
  The peak value of an impulse voltage of prescribed from and polarity which the equipment is capable of withstanding without failure under specified conditions of test and to which the values of the clearances are referred.

❖ **<u>Performance under short-circuit conditions</u>**

- **Rated ultimate short-circuit breaking capacity (I_{cu})**
  The rated ultimate short-circuit breaking capacity of a circuit-breaker is the maximum short-circuit current which the circuit-breaker can break twice (in accordance with sequence o-t-co), at the corresponding rated operational voltage. After the opening and closing sequence the circuit-breaker is not required to carry its rated current.

o-t-co

o	-	refers to breaking operation
co	-	refers to a making operation followed by a breaking operation
t	-	refers to the time separating two operations, equal to 3 minutes or the length of time needed to reset the breaker, whichever is longer

- **Rated service short-circuit breaking capacity (I_{cs})**
  The rated service short-circuit breaking capacity of a circuit-breaker is the maximum short-circuit current value which the circuit-breaker can break three time in accordance with a sequence of opening and closing operations (o-t-co-t-co) at a defined rated operational voltage (U_e) and at a defined power factor. After this sequence the circuit-breaker is required to carry its rated current.

  I_{CS} is expressed as a percentage of Icu (eg 25%, 50%, 75% or 100% of Icu). In a nutshell, this is the maximum current that the breaker can break for 3 times and yet returned to service with its operational integrity intact.

- **Rated short-time withstand current (I_{cw})**
  The rated short-time withstand current is the current that circuit-breaker in the closed position can carry during a specified short-time under prescribed conditions of use and behavior, the circuit-breaker shall be able to carry this current during the associated short-time delay in order to ensure discrimination between the circuit-breaker in series.

- **Rated short-circuit making current (I_{cm})**
  The rated short-circuit making capacity of an equipment is the value of short-circuit making capacity assigned to that equipment by the manufacturer for the rated operational voltage, at rated frequency, and at a specified power-factor for ac.

❖ **<u>Utilization Categories for C.B.S</u>**
The utilization category of a circuit-breaker shall be stated with reference to whether or not it is specifically intended for selectivity by means of an international time delay with respect to other circuit-breaker in series on the load side, under short-circuit conditions.

- **Category (A) -** circuit-breakers not specifically intended for selectivity under short-circuit conditions with respect to other short-circuit protective devices in series on the load side, i.e. without a short-time withstand current rating.

- **Category (B) -** circuit-breakers not specifically intended for selectivity under short-circuit conditions with respect to other short-circuit protective devices in series on the load side, i.e. with and international short-time delay provided for selectivity under short-circuit conditions. Such circuit-breakers have a short-time withstand current rating.

❖ **<u>Current-limiting circuit-breaker</u>**
A circuit-breaker with break-time short enough to prevent the short-circuit current reaching its otherwise attainable peak value.

D.8.3 <u>KWH Meter</u>

Current transforms (CT,s)-class (1) shall be installed on the main busbars immediately after the main incoming for three phase KWHM connection as fig. (4).

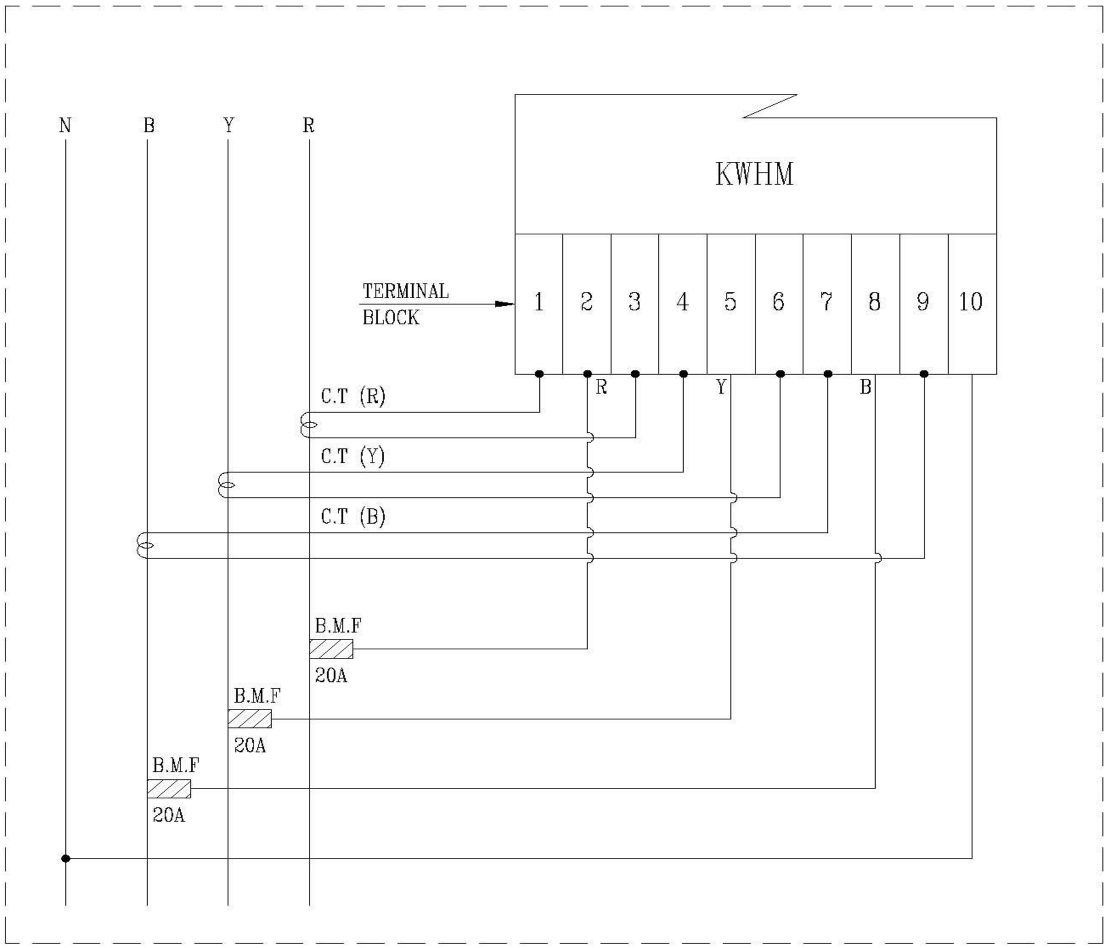


FIG.(4)

❖ The following standard size of CT,s are used.

CT,s	100/5	200/5	300/5	400/5	500/5	800/5	1000/5
Rating (VA)	7.5	7.5	7.5	7.5	7.5	7.5	7.5

CT,s	1200/5	1600/5	2000/5	2500/5	3200/5	4000/5
Rating (VA)	7.5	7.5	7.5	7.5	7.5	7.5

Table (1)

D.8.4 Automatic change over controller

Q_T	√	X
Q_G	X	√
Q_C	√	X

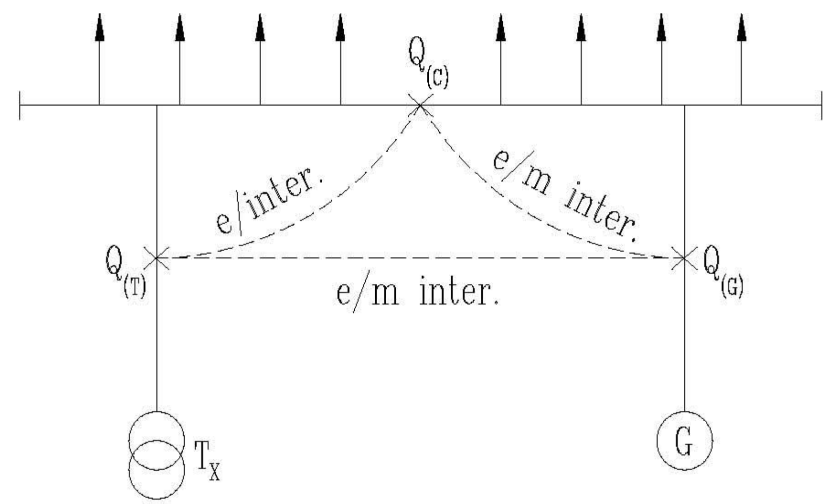


fig.(5)

D.8.4.1 Component of Automatic Change Over Controller

- Under voltage relay (before C.B,s)
- Contractor
- Two timer first for time delay on starting of generator (0-30 sec.) preset time at interrupting of main supply, and second for time delay for shutting down of generator (0-15 min.) preset time at restoring main supply.
- Control shall give the following position (Auto start-manual start buttons – test to simulate main failure – off)
- Lamp indicate (main health-main ON – generator on – generator fails to start).

D.8.4.2 Sequences of Operation.

- Under voltage relay shall send signal to C.B to shunt trip IF:-
  - ❖ $V_{supply} < 0.85\ V_{rated}$.
  - ❖ Phase failure or more.

- If above condition is happened so $Q_{(T)}$ shall trip (open) and also Q_c.
- Generator shall automatic start by signal from controller.
- Q_G shall be closed when $V_G \geq 0.85\ V_{rated}$.
- IF main supply restore Q_G shall open and ($Q_{(T)}$ & Q_c) shall be closed.
- Generator shall still working for preset time (0-15 min.).

D.8.5 <u>11 KV Circuit Breaker</u>

D.8.5.1 <u>Characteristics of Circuit Breaker</u>

The following characteristics and ratings are required:

1.	Number of Poles	-	3
2.	Class	-	Indoor
3.	Rated Voltage	-	12 kV
4.	Rated Insulation Level	-	75 kV
5.	Rated Frequency	-	50 Hz
6.	Rated Normal Current (Busbar)	-	1250 A
7.	Rated Normal Current (Transformer)	-	630 A
8.	Rated Normal Current (Feeder)	-	630 A
9.	Rated Transient Recovery Voltage	-	20.6 kV
10.	Rated Short Circuit Breaking Current (A.C. R.M.S. Component)	-	25 KV/31.5 kA
11.	Rated Duration of Short Circuit	-	3 sec.
12.	Rated Short Circuit Making Current	-	62.5 kV
13.	Rated Operated Sequences O – 3 min – CO – 3 min – CO represents a Closing Operation followed immediately (that is, without any intentional time delay) by an Opening operation.		
14.	Rated Supply Voltage of opening devices	-	30 V d.c.
15.	Rated spring charging Volatage	-	240 AC.

D.8.5.2 <u>CIRCUIT BREAKER WITHDRAWAL</u>

In addition to routine maintenance, operational routines require that clear access to the fixed contracts is available for live phasing operations. To provide these facilities it shall be possible to withdraw the circuit breaker without the need for additional items of equipment, although the use of tools is not precluded for this purpose. Withdrawal shall only be possible when the circuit breaker has been isolated and interlocks shall be provided to prevent any incorrect operation. Circuit breakers shall be one of the following types.

- Truck mounted, vertical isolation, horizontal withdrawal.
- Truck mounted, horizontal isolation, horizontal withdrawal.

In all cases, the action of withdrawal shall be deemed to be complete when access becomes available to the circuit breaker housing including the Busbar and Feeder Shutters. Circuit Breakers which need a special truck to achieve withdrawal are not acceptable.

Where the circuit breakers is truck mounted, rollers and their guide rails shall be designed to facilitate alignment and leveling of the truck relative to the enclosure during movement of the truck into and out of the enclosure. It is deemed to be important that the truck shall have free and unimpeded travel.

Full and automatic isolation of the secondary wiring shall be achieved simultaneously with the withdrawal of the circuit breaker.

D.8.6 Ground-Fault Protection Refer to IEEE STd.241-1990 CH.9.10

The NEC, Sections 230-95 and 517-14 (7) requires knowledge of the levels of ground-fault currents to properly set and coordinate ground-fault protective devices. The NEC, Section 230-95 [7] states that "ground-fault protection of equipment shall be provided for grounded-wye electrical services of more than 150 V to ground, but not exceeding 600 V phase-to-phase for any service disconnecting means rated 1000 A or more. "this ground-fault protection may consist of overcurrent devices and current transformers, or other equivalent protective equipment, which shall operate to cause the service disconnecting means to open all ungrounded conductors of the faulted circuit. The maximum setting of the ground-fault protection shall be 1200 a and the maximum time delay is 1 second for ground faults equal to or greater than 3000 A.

In health care facilities, when ground-fault protection is provided on the service disconnecting means, the NEC, Section 517-14 [7[requires the additional step of ground-fault protection in the next level of feeder down-steam toward the load

is the source of supply and its ground return current can be measured, a simple current transformer may be used to detect the flow of ground-fault current back to the neutral connection of the transformer windings

The term "relay" includes electronic or solid-state relays as well as electromechanical devices. These relays may be specified with various pickup levels or current and with various time delay setting ranges. Full coordination with line or phase protective relaying is desirable. The simplest system involves time delay and current selectivity. A better system utilizes blocking signals or zone-selective interlock from the downstream device to delay the tripping of the upstream device to give the former a chance to clear the fault. A number of systems providing this kind of protection are available for protecting secondary-unit substations, double-ended substations, networks, and other sourced, and information concerning such protection can be obtained from the switch or circuit breaker manufacturer.

Section (E)
Electrical Design Criteria Example

E.1 ENVIRONMENTAL CONDITION AND CONSTRAINS

This section describes the basic design criteria guidelines that will be implemented in the preparation of the electrical design and documents of these projects.

E.1.1 GENERAL OBJECTIVES AND CONSTRAINS

The concept of the electrical installations will be laid, based on the following main objectives:

- To comply with FCD regulation.
- To comply with applicable codes and standards.
- To meet with the specified power and communications requirements of other systems and equipments.
- To achieve expandability, reliability and durability of networks and components.
- To implement safety measurements for the protection and safety of people and equipment.

While achieving the design objectives, other important factors will have to be considered carefully:

- Cost effectiveness.
- Efficiency and energy conservation.
- Coordination with other design elements.
- Simplifying installations, operation and maintenance.
- Utility service continuity and avoiding operation disruption.

E.1.2 CONTROL OVER IMPACT ON THE ENVIRONMENT

- The installations shall be designed with due regard for the environment, particularly:
- Energy
- Energy consumption shall be minimized:
- The sizing of the installations shall be optimized in order to restrict their physical size and their energy consumption.
- Energy recovery systems shall be provided.
- Energy consumption shall be kept at as low a level as possible compatible with guests' comfort requirements. Devices shall be provided to reduce the operation of the installations when rooms are unoccupied.
- The lighting systems shall be selected to provide a good light output without degrading the colors
- Electrical consumption shall be measured for statistical and control purposes.

E.1.3 ENVIRONMENTAL CONDITIONS

All the electrical equipments and materials will be designed, specified and de-rated for continuous and trouble free operation in the ambient conditions, where the equipments are located as follows:

- Maximum daily ambient shade temperature	50 °C
- Maximum yearly average ambient shade temperature	40 °C
- Maximum temperature of metal surface in direct sunlight	60 °C
- Maximum relative humidity	100°C
- Average annual rainfall	50 mm
- Prevailing winds are northerly and gales with gusts approaching	140KPH

E.2 Basis for Electrical Design and Calculations

E.2.1 Codes, Standards and References

The design, manufacture, installation practices and testing of the materials, equipment and systems are to be supplied, constructed and rated in accordance with the standards laid down by the relevant BS or where not covered by such publications by appropriate approved International Standards of design or manufacture unless otherwise specified. In all cases, the latest issue of publications, specifications, standards and/or Codes of Practice shall apply.

- The Local Electrical Standard.
- The Local Building Codes
- The Local Safety Standards
- Standards of local authorities having jurisdiction
- The National Fire Protection Association (NFPA 70, NFPA 72, NFPA 92A, NFPA 101)
- International Electrical Commission (IEC)
- Underwriters Laboratory (UL) Listing
- The British Standards (BS)
- Institute of Electrical And Electronics Engineers IEEE
- National Electric Safety Code NESC
- National Electric Code NEC

E.2.2 Utilization voltage Refer to BS Standard

Utilization voltage and frequency of 415/240V, 50HZ will be used inside the project according to load.

E.2.3 Allowance for Demand factor "D.F" Refer to BS standard

	Residential	Commercial
Lighting	0.66	0.8
Water Heater	0.3	0.3
Others	0.66	0.8
Cooker	0.40	0.4
Power outlets	0.66	0.8
HVAC units	1.0	1.0

E.2.4 Allowance for power factor (P.F) Power Factor to be not less than 0.85.

E.2.5 Loads Calculations

E.2.5.1 Lighting Demand Loads Refer to NEC – Article 220.12

- Lighting design to be based on IES.
- For discharge lamps, take for compensating of losses (control gear losses & harmonic currents) and power factor correction (assuming the fluorescent. Lamps are initially corrected to a power factor of 0.85 lagging).
- Lighting outlets shall be calculated as 100 (W/VA) per each outlets.
- Power for lighting shall be calculated by specific surface area loading (VA/m2) as table below for primary study.

Area	VA/m^2 Classic Fittings	LEDS
Offices Build.	39	7
Meeting	39	7
Corridor	16	3
Kitchen	22	4
Toilets	15	3
Parking	6	1
External	2	0.5
Banks	39	7
Beauty Shops	33	6
Residential	33	6
Court Room	22	4
Clubs	22	4
Hospitals	22	4
Hotels	22	4
Restaurant	22	4
Schools	33	6
Stores	33	6
Ware House (Storage)	3	0.5
Mosques	11	2
Armories & Auditoriums	11	2
Lodge Room	17	3

E.2.5.2 Demand load for General Socket Refer to IEEE STd 241-1990

- Single/duplex switched socket outlet, 13A, 240V shall be (100/200) W per outlets.
- Power socket outlet, shall be calculated referring to Load Details:
- Power for socket shall be calculated by specific surface area loading (VA/m^2) as table for primary study.

Area	VA/m^2
Offices & Meeting	17
Corridor & general area	10
Residential	15

E.2.5.3 Demand Loads for Air Condition:

- Power for A/C shall be calculated by specific surface area loading (VA/m2) as table for primary study.

A/C Loading	VA/m^2
Ducted split unit	115
Package unit	110
Air cooled chiller	100
Water cooled chiller	(80 chill + 20 cooling tower)

E.2.5.4 Other loads:

Pumps (Fire – Domestic water – irrigation – submersible swage – chilled water), Extract Fans, Smoke Fans, Pressurization Fans, Elevators shall be designed as actual loads.

E.2.5.5 ESTIMATED ELECTRICAL LOAD

The load calculation estimated are based on VA/m2 of built up area (for A/c lighting and small power, fire pumps ., water pumps. etc , as well as future or unseen loads as per NEC Article 220.12 (Branch circuit, Feeder & service Calculations)

- **Total Specific Surface Area Loading for Building (VA/m^2) Refer to NEC Article 220.12 and IEEE STd 241-1990**

IT	Bldg. Type	Area (m^2)	Lighting (VA/m^2) (Average)	Small Power (VA/m^2) (Average)	A/C (VA/m^2) (Average)	W.H (VA/m^2)	Others VA/m^2	M.D.L (VA) / m^2
1	Office & Malls	---	39	28	110	8	25	210
2	Residential & Hotel	---	30	15	110	10	35	200

- The Maximum Demand Load = ……… KVA
- Estimated No. of TX.= ….KVA / 1600 * 0.85 =.. Transformer Dry Type /1600KVA

E.2.5.6 THE ESSENTIAL LOAD (Diesel Generator Sets)

The emergency electrical power supply will be provided in case of mains power supply failure.
The sets shall be split into number of substation and to minimize length of expensive emergency cables, the D/G sets room shall be selected as near as possible to corresponding S.S, 8 hours day fuel tank shall be provided in addition (24) hours main fuel tank shall be provided for each set.

E.2.5.7 LOAD SUMMERY (ESSENTIALLY SUPPLY)

- Emergency lights , computer socket, external lighting , 30% lighting in public areas, lighting in electrical rooms ,
  - Domestic pump
  - Submersible pump
  - Fire pump
  - Low current equipment load
  - Smoke fans, Pressurization fans and forced ventilation.
  - Fire Lifts.
  - B.M.S system.
  - Fire alarm system.
  - 100% from stair lighting.
  - Exit and Escape lighting.
  - Security and car parking system.

E.2.5.8 UPS LOAD

Shall be provided for critical loads in case of mains power supply failure and also diesel generator shut down.

E.3 ELECTRICAL SERVICES REQUIREMENTS

E.3.1 11kV/415 V SUBSTATIONS & MV (11kV) ROOMS

- 11kV/415V Substations shall be located in basement floor as per space requirements outlined in the drawing (Tx. Room – L.V. room – generator room).
- MV Rooms shall be located in the ground floor of the building.
- MV Room space requirements are also given in the drawing.

E.3.2 FIRE COMMAND CENTER

- 4M x 4M Space required at the ground floor of the building.
- Direct access to fire command center is required from outside.
- Minimum 2 operator desks required within the room.

E.3.3 ELECTRICAL ROOMS

- Electrical rooms shall of minimum 2m x 3m.
- Electrical rooms shall be vertically aligned from basement floor to roof level.
- Door open to outside.
- Rooms shall be located as shown in the plans.

E.3.4 ELV ROOMS

- ELV rooms shall of minimum 2m x 2m.
- ELV rooms shall be vertically aligned from basement floor to roof level.
- Door open to outside.
- Rooms shall be located as shown in the plans.

E.3.5 TELECOM ROOM

- Telecom Intake room shall be 5m x 5m.
- Can be located at basement level or ground level.

E.3.6 SERVER ROOM & UPS Room

- Server room shall be located adjacent to Telecom room as much as possible, Can be located at basement level.
- Server rooms shall be of minimum 10m x 7m.
- Precision AC units are required with under floor cooling.
- Raised floor of minimum 650mm required.
- Ceiling void minimum 400mm required.
- Room for precision AC is required adjacent to server room.
- UPS room is required adjacent to Server room. 6m x 3m.

E.3.7 CCTV MONITORING ROOM & CCTV STORAGE

- CCTV Monitoring room shall be of 6m x 3m, can be located at basement.
- CCTV monitoring room's 6m side wall will be used to mount the video wall.
- CCTV Storage room is required adjacent to CCTV monitoring room, Size shall be of 4m x 5m.

E.3.8 BMS & PROPERTY CONTROL ROOM

- BMS & Property control room shall be of 6m x 3m.
- Minimum 4 operator desks shall be required in the room.

E.4 SCOPE OF ELECTRICAL POWER , LIGHTING & LOW CURRENT SYSTEMS

The electrical systems shall cover the low voltage (415V) system and shall include but not limited to the following:

E.4.1 Main Power supply 11KV, Transformers and L.V Panels.

E.4.2 L.V Raceways.

E.4.3 L.V Cables & Bus ducts

E.4.4 Lightning system

E.4.5 Power outlet and convenience socket outlet

E.4.6 Earthing system

E.4.7 Lighting System.

E.4.8 Power Factor correction.

E.4.9 Fire Alarm system.

E.4.10 Data & Telephone system.

E.4.11 MATV system.

E.4.12 Public address system for conference/meeting hall.

E.4.13 IP Security System

E.4.14 IP CCTV System

E.4.15 IP Access Control System

E.4.16 Wireless Cable / DSL Router

E.4.1 Main Power Supply 11 KV, Transformers, L.V Panels

11KV incoming feeders power supply and switchgears will be obtained from local Electrical Authority to provide the utility power supply for this project.

A preliminary load estimate study has been done in this stage, from which a total connected load estimate of KW has been obtained. This suggest that the electrical power to this building should be furnished to match the transformer to be used.

Estimate mechanical & electrical loads

Dry type transformers are considered to allow installing these transformers in the S/S

Substation will contain L.V Panels 415, 3 phase, 5 wires and 50 HZ.

The necessary cables between transformers and the L.V Panels shall be provided.

E.4.2 LV Raceways

- Main LV cables shall run in underground conduits from the LV-Panel in the (proposed) / or Existing substation to the distribution main switchboards (MSB's) in both buildings. The MSB for each building is located in the main electrical room in the ground floor. Submain Switch Boards (SMSB's) and final Distribution Boards (DB's) shall be located in the electrical rooms at each floor level which will supply the final circuits of lighting & power systems. Distribution Boards & Lighting Control Panels for the External Lighting shall be outdoor type & shall be located in a suitable location to supply energy to the outdoor lighting fixtures.
- LV cables supplying energy from SMSB's to, HVAC equipments, Lighting Distribution Boards, Power Distribution Boards, Conference Hall, and other loads at the both buildings shall run on cable trays suspended from the ceiling at the service corridor to the required Distribution Board location.
- Diameter center to center spacing arrangement is applied to lay power cables on adequately sized cable trays of hot dip galvanized steel, perforated type and/or heavy duty galvanized steel ladders. All necessary fittings and accessories are of the same cable tray/ladder's manufacturer. Grades of carrying capacities are decided as applicable to ensure no sagging or deformation.
- Final circuits for lighting & small power shall be run in heavy gauge PVC conduits which shall be embedded in ceiling slab or under floor GI trunking for the floor boxes (if any) under the floor screed as per the furniture layout.
- For any exposed conduits above the false ceiling it should be GI conduits, fire rated type.
- Each lighting circuit shall be run in minimum 20mm diameter embedded PVC or exposed GI conduit. Each small power circuit shall be run in minimum 20mm diameter embedded PVC or exposed GI conduit. In no circumstances more than one final circuit should run in one raceway.

E.4.3 Low Voltage Cables

These cables are of 600/1000 volts, copper conductors, multi-core or single core, XLPE installed and PVC sheathed, Steel wire armored for indoor and outdoor installations or PVC installed and sheathed non-armored for indoor installation.

The indoor electrical system shall include:

E.4.3.1 Low Voltage Feeder:

Low voltage feeders shall be sized according to the connected loads with allowance for future increase of loads. Voltage drops in power distribution systems must not exceed 2.5% in normal operation. The following allowance Voltage Drop shall be:

- L.V Panels to sub-main switchboards : 1.5%
- Sub-main switchboard to distribution boards : 0.5%
- Final branch circuits : 0.5%

Multi core or single core cables shall be XLPE steel wire armored and PVC sheath for outdoor installations directly in ground or in uPVC conduits outside the building and non-armored for the indoor installations inside the building on cable trays or running in conduits.

Raceways for cables shall be suitable for the application.. External cables in site shall be laid directly in ground, protected with protective tiles and warning tapes or shall run in conduit banks if their routes cross any landscape features or cross the road.

Feeders (normal, emergency) supplying the sub-main switchboards shall run on cable trays, individually from floor panel boards (SMSB and ESMSB).

Individual feeder distribution from the nearest Sub-main switchboards shall be provided for the following loads:

- Elevators
- HVAC MCC'S
- Ventilation life safety loads
- Lighting and sockets panel boards
- Fire fighting equipment
- Water pump
- Outdoor lighting panel

E.4.3.2 L.V Wires

Wires shall be 450/750 Volts, copper conductors, single core, PVC insulated, running in either trunking or PVC conduits for concealed installations and in heavy galvanized steel conduits
for exposed installations, standard color coding shall be strictly applied.

E.4.4 LIGHTING SYSTEM

E.4.4.1 General Description for Lighting System:

Public areas: mainly shall be designed as per the interior designer including luminaries' types, locations and the corresponding type of control which emphasizes the architectural impact using illumination levels and the selected luminaries under control.

Exterior lighting: Similar to the interior designer's scope of work the landscaper shall design the landscape and other outdoor lighting features.

All Offices / Technical areas: Mainly fluorescent luminaries shall be utilized to cover the illumination levels required as per CIBSE, (IBS) recommendations.

Conference/Meeting Hall or Areas as Client advise: Mainly Dimmable luminaries' Shall be utilized to be controlled by using dimming system.

Car Parking Area: Mainly fluorescent luminaries shall be utilized to cover the illumination levels required as per CIBSE, (IBS) recommendations.

In general, fluorescent luminaries, spot lights and down lights will be utilized in public areas. Fluorescent luminaries will be utilized in offices, storage areas, Mechanical / Electrical room, staircases, parking and other similar areas.

All public areas lighting design shall be as per interior requirement, location, type of fixture and lamp wattage. Decorative lighting.

The use of electronic ballast and high efficacy lamp combinations producing the highest lumen per watt output will be considered.

Leds to be used subject to Client acceptance.

E.4.4.2 <u>ILLUMINATION INTENSITY AS (IES)</u>

LUX. SCHEDULE ACCORDING TO IES STANDARD

ROOM TYPE	***IES***	***ROOM TYPE***	***IES***
ART ROOM	500	*LOBBY*	200
BEDROOM	150	LAUNDRY	300
CLASSROOM (DAY)	300	MULTIPURPOSE-HALLS	300
CLASSROOM (EVENING)	500	MECH,ELEC ROOM	100
CHURCH HALLS	150	*MEDICAL SHOP*	500
CONFERENCE ROOM	300	WAITTING AREA	200
CHANGING ROOMS,SHOWERS	150	*WORK SHOPS*	300
CORRIDORS	150	OFFICES	500
CONTROL ROOM	500	RESTURANTS	300/100
TOILET	100	RECEPTION	300
GARAGES	500	SEMINAR ROOMS	500
GYM	500	SERVICE	150
KITCHEN	150	SWIMMING POOL	500
LECTURE HALLS	300	SEWING	750
LABORATORIES	500	STORE ROOM	100
LIBRARIES	500	SHOPS	500
TECHNICAL DRAWING	750		

E.4.4.3 <u>Indoor Light Fittings</u>

Types of these fittings are selected based on usage of each area. Local and/or central light switches are properly located to ensure the easiest way of control and best possible energy saving. Fluorescent lamps or LEDS shall be power factor corrected to at least 0.9 electronic ballast may be used.

Outdoor Car parks:

With stainless steel or aluminium masts on concrete bases. Providing 50 lux average on the ground (15 lux min in intermediate areas)
The masts shall be located at least 1 m away from the vehicle circulation areas.

E.4.4.4 External lighting

External walls:

This lighting will depend on the architecture. It shall comprise weatherproof floodlights to illuminate the solid parts of the external walls, avoiding the windows.

Landscaped areas:

Shall depend on the layout It shall illuminate plants, pedestrian paths etc.

E.4.4.5 Emergency Lighting

This function shall be provided by means of autonomous emergency lighting units:

- Autonomy: 3 hour,
- With remote switching to standby,
- With panel to permit automatic testing,
- With easily changed batteries, not requiring access to live elements
- Set out so that at least one unit is always visible from any location.

E.4.4.6 Lighting Control

Locally installed on-off switches to control the lighting for all rooms by means of direct connection / disconnection of lighting circuits. Switches shall be 10A 250V, A.C. inductive load rated to their full rated capacity.

Switches installed in mechanical rooms and wet areas, shall be weather proof type. The switches shall be comply to the degree of protection IP44. Switch cover plates shall be provided with earthing terminal lugs.

Contactor control shall be provided for lighting of public areas. The manual/local mode of the contactor shall be controlled by local Push Button (PB) stations and in some areas by B.M.S If any.

Lighting Control Panel (LCP) shall be provided for either manual override of the automatic control of lighting contactors or parallel operation with remote control through PB, two way / intermediate switches, photocell, timer,…etc..

E.4.4.7 Lighting Circuits

- PVC, insulated copper wires 2.5 mm^2 are used for the lighting circuits unless otherwise indicated on drawings. These circuits are protected by 15A rated miniature circuit breakers according to the number & the wattage of the lighting fixtures. Separate circuits are used for emergency lighting systems.
- The exposed conduit systems for lighting circuits are galvanized steel for outdoor wiring and indoor wiring, while heavy gauge PVC conduits are used for concealed wiring.

E.4.5 Power Outlets and Convenient Socket Outlets

E.4.5.1 Power Outlets:

- Each individual room air conditioning unit (1.0 & 1.5 Ton) the rating shall be 2.5KW and shall be connected to an adjacent 20Amp. Double pole switch with a separately mounted 45Amp. rated flex. Outlet.
- Each 20 Ampere double pole switch shall be on a separate circuit from the distribution board using 3x4mm2 PVC cable and shall be protected by a 20Ampere MCB
- Each individual room air conditioning unit 2.0 Ton so, the rating shall be 3.0 KW and shall be connected to a 30Amp. Double pole switch, with a separately mounted 45 Amp. rated flex. Outlet.
- Each 30 Ampere double pole switch shall be on a separate circuit from the distribution board using 3x6mm2 PVC cable and shall be protected by a 30Ampere MCB.
- For A/C more than 2.0 Ton or central A/C it shall be calculated and designed according to the load details.
- Each fan coil unit in a central air conditioning system shall be connected to its own 15 AMP switch fused unit mounted adjacent to the unit using 3x4 mm2 PVC cables and shall be protected by 20 Ampere MCB.
- Central Water Heater unit shall be connected and supplied from the main switch board of the building through a convenient size of XLPE/SWA/PVC cable and shall be protected by 30mA earth leakage circuit breaker

E.4.5.2 Convenient Socket Outlets:

- Switched socket outlets installed in rooms other than Kitchens shall be connected using the ring main principle with the maximum of 8 Nos. socket outlets on any one circuit, or one circuit not covering a floor area of greater than 100 Sqmt. whichever is the less. Twin socket considered as 2 Nos.
- Each socket shall be connected to its distribution board using 4mm2 PVC wire for phase & neutral, 2.5mm2 PVC wire for earth conductor and shall be protected by a 30A ELCB. All circuits shall be protected by a current operated earth leakage circuit breaker having a trip rating of 30mA
- Another particular type of waterproof, earthed type is recommended at wet/damp areas, such as kitchens, bathrooms and similar's. Industrial types of single or three-phase heavy duty, earthed sockets are provided at machine rooms and similar. Switched types of socket outlets are employed where safety operations are necessary. Mounting is surface or recessed as required.

E.4.6 Earthing System

An earthing system is provided to ensure protection of personnel against electrical shocks from faulty electrical circuits, to protect equipment from damage and to achieve proper operation of protective devices on earth faults. Unless otherwise specified, the maximum permissible ground resistance value shall be less than (1) ohms, while the low current earthing system shall be (0.5) ohm.

TN-S earthing systems shall be adopted for the power distribution system, making use of a separate protective earth conductor (PE) starting from the main MV switchboards and ending with any final load termination. Accordingly, all LV switchboards shall be suitable for 5 wire (3ph+N+E) distribution.

Earthing termination comprises a set of earth electrodes enclosed in inspectional hand holes to achieve the minimum earth resistance value. The type and number of electrodes depends on the soil resistivity conditions.

The grounding grids of the project compartments/facilities shall be interconnected to each other through a minimum of two (2) PVC insulated copper cables.
Separate earthing system shall be provided for the power outlets feeding power supply to the low current systems terminal, to provide clean earth. This system shall be connected with the normal earth as per the requirements of BS7671.

Pipelines shall not be used for earthing purposes.

Main earth ring conductors shall have a cross sectional area of 240 sq. mm. unless otherwise higher sizes are require based on the earth fault current and its duration. Branch earth conductors shall have a cross section area as given below:

To metallic enclosures of LV electrical equipment having a supply Cable with a conductor cross section equal 35 sq. mm. or more	:70 sq. mm.
To metallic enclosures of LV electrical equipment having a supply Cable with a conductor cross section less than 35 sq. mm.	:25 sq. mm.
To structures, tanks, process plant equipment and other Non electrical Equipment	:70 sq. mm.
To other non electrical equipment	:16 sq. mm.

Branch earth conductors having cross section of 6 sq. mm. shall only be used in above ground applications for small electrical equipment like junction box, RCU etc.

For offshore installations, all electrical equipment shall be earthed by means of bonding to the jacket steelwork using copper cables. Neutral of generators and transformers shall be connected to the substation copper bus bar and this copper bus bas shall be bonded to the jacket steel work using copper cables.

The armour of cables shall not be used as the sole means of providing earth continuity.

E.4.7 Lightning Protection

Faraday cage type lightning protection system shall be installed to cover all the project compartments in accordance with BS 6651.

Copper down conductor shall be taken through the building structure and shall be bonded to the steel reinforcement of the column. The down conductor shall be terminated into earth pits, which shall be interconnected to provide and equipotential surface around the perimeter of the buildings.

Lightning Protection Earth Rods shall not be connected to any of the Power Earth Electrodes. A minimum distance of separation of 7 meters shall be provided in every case between lightning earth electrode & power earth electrode.

Minimum lightning earthing resistance shall be 10 Ohm or less and the contractor shall increase the number of Pits to fulfill the required resistance.

E.4.8 Power Factor Correction

E.4.8.1 Individual Capacitor Units

The main loads of the project are either lighting or electric drives for mechanical systems. High efficiency lighting has in general low power factor. This will be corrected by installing fixed capacitors within the lighting fixture in order to relief the distribution network from reactive power. Fixed capacitors shall be sized to achieve an overall power factor of 90%.

Electric drive has different nature, especially if thyristor controlled variable speed drives are going to be utilized for all electric motor driven components such as air handling units, pumps, lifts etc. For all the mentioned items group reactive power compensation will be considered. The capacitors shall be sized to achieve an overall power factor of 90% minimum.

E.4.8.2 Automatic Capacitor Bank.

Capacitors racked in a common enclosure with automatic regulator and it shall be sized to achieve an overall power factor of 90% minimum.

Special attention will be given to harmonic currents produced in the network due to the operation of the thyristor-controlled drives such that harmonic filters will be utilized. Exact ratings and locations of power factor equipment shall be decided later during detailed design stage.

Non-linear loads such as computers will cause harmonics, if supplied through UPS's distributed per floors, this UPS is highly recommended to include harmonic filters to relieve the incoming supply from harmonics.

E.4.9 Fire Detection and Alarm System

Analog intelligent addressable Fire Detection and Alarm System shall be used.

The basic architecture of the system shall consist of a Main Fire Alarm Control Panel (M-FACP) located at security and fire control command center at ground floor. An interconnection will take place between the new (M-FACP) & the existing one if any.

- Local Code & Regulations.
- NFPA 70 : National Electrical Code (2008).
- NFPA 72 : National Fire Alarm Code (2007).
- NFPA 92A : Recommended Practice for Smoke Control Systems (2006).
- NFPA 101 : Life Safety Code (2006).

E.4.9.1 Design Considerations:

- The Fire Alarm Control Panels shall have addressable data communication circuits to provide connection with the addressable devices. Each addressable communication circuit shall provide the capability of communication with up to 128 addressable devices.
- No more than 80% from the available addressable loop or audio power amplifiers capacities shall be used to enable future addition of any field devices.
- The alarm shall be via alarm bells / sirens while the evacuation for the building Occupancy shall be by voice evacuation system integrated with the Public Address System. The response time from detection to initiating of voice evacuation will not exceed five seconds. The voice evacuation system will be capable of storing messages for five languages and to be able to advise the location of the fire with every Language.
- An addressable, computer controlled of fully electronic operated hardware system will be used to achieve maximum facilities in identifying the spot of fire outbreak in its very early stages and minimum alarm annunciation of false fire phenomena. The system printer will be used to record all alarm, supervisory and trouble conditions by address number and custom label. The computer system will be connected to UPS power outlet.
- The fire alarm system shall interconnect to the smoke control equipment to provide the proper sequence of fire mode operations and to override the smoke control system to allow the manual operation.
- Two-way telephone communication service shall be provided for fire department use. This system shall be in accordance with NFPA 72, National Fire Alarm Code. The communications system shall operate between the central control station located in the Fire Command Room and each floor level of exit stairs.
- All connection between panels & addressable devices shall be Class A connections (Loop) to provide redundancy and prevent any single point of failure.
- All of the Fire Detection and Alarm System wiring will be fire resistant cables according to BS:6387 Categories C,W & Z. installed in galvanized steel conduit.
- Electrical Supervision for all of the wiring & devices including detectors, speakers, bells, fire fighter telephone, … etc.

E.4.9.2 **Main Equipment:**

Repeater panels shall be installed at locations to be defined in detailed design phase.

Suitable type of detector at proper distribution shall be used.

Fire Fighting Telephone shall be installed on public areas and other defined areas.

All building floors shall be divided into specific fire zones according to architect determination to allow isolated area in evacuation and runway.

The system shall cover but not limited to the areas listed below:

- The entire route of egress to include corridors, stairs, elevators locations, reception areas, exits, etc.
- Public or common access to include administration, business center, Library, Conference hall and indoor parking area.
- Special hazard areas to include mechanical equipment rooms, electrical closets, storage rooms, etc.
- Areas or rooms by the owner to deserve special protection due to high value of security.

The system shall provide manual means of alarm initiation at every exit for every floor level. Elevators are not considered as exit or root of egress.

The Fire Alarm System shall include but shall not be limited to, the following:

- Intelligent addressable Main Fire Alarm Control Panel with PC and graphics software
- Repeater panels
- Control module
- Monitor module
- Addressable intelligent detectors - smoke, heat
- Zoon charts.
- Autodialer module the MFACP.
- Mimic panel
- Beam detectors
- Manual station
- Linear heat detector

- HSSD (High Sensitivity Smoke Detector)
- Alarm speaker
- Horns
- Strobe light
- Remote led
- Fire fighter telephone
- Automatic telephone dialer
- Fault isolation module
- Door holder
- Printer

The Fire Alarm System shall control but not limited to the following:

- Shutdown of air handling equipment
- Operation of smoke purge system
- Elevators

The Fire Alarm shall monitor the operation of the following systems for trouble:

- Fire Protection Systems
- Fire Pumps and Water Storage
- Smoke Purge System

The Fire Alarm shall be interfaced with fire fighting system, HVAC, and any other related system.

E.4.10 DATA AND TELEPHONE NETWORK SYSTEM

Telephone System

A Structure Cabling System shall be designed to provide Infra-Structure Network connectivity solution all over the Building; this structured cabling system shall comply with the following Standards:

- Electronic industries association (EIA), Telecommunications industries association (TIA) for commercial buildings.
- The institute of electrical and electronic engineers, Inc. (IEEE).
- International organization for standardization (ISO).
- American National Standards Institute (ANSI).
- International Electromechanical Commission (IEC).
- ISO 11801.
- EN 50174 parts 1-3.
- Local Autority Standards and practices (current at time of construction).

Individual connection with at least four pairs from the related main distribution frame (MDF) in order to enable subsequent connection for the external telephone line extension.

General

The network shall be universal which means that the accessories of the telephone and data outlets (sockets, cables, put-in panels) shall be the same (RJ 45) in order to provide the facility of the inter-changeability. So at any time, the data outlet can be converted to telephone outlet easily and vice versa.

The Data/Telephone cabling Network system for the building shall support the requirements for fast Data communications according to the configurations, and the topology of the building including the outlet/connector.

The network shall be based on star topology using multimode fiber optic media cables for data riser nodes inter connections.

The data and telephone connectivity shall be very fast using back bone fiber optical cabling system with intelligent patch panels in the equipment rooms and CAT/6 4-pair UTP horizontal network terminated with RJ45 outlets.

The Network shall support to high speed/ high bandwidth access to the users including full video conferencing to all the network points and provide full transparency to building data processing system provided by the premises computer system and incoming communications for voice, video and data.

The network shall be full transparent including all the necessary passive equipment to provide transparent, vendor non-oriented service. Optical Fiber (OF), copper (CAT-6) and patch panels of the network shall be constructed according to ANSI/EIA structured cable network standards.

The system shall consist of group of networks according to floors application.

All data outlet and telephone outlet shall be terminated at patch panels.

Separate patch panels shall be used for telephone network. The maximum distance between outlet and Patch Panel shall not exceed 90 m. Telephone patch panels will be connected to floor IDF, all floors IDFs will connect to the MDF.

The telephone system shall be based on digital Private Automatic Branch Exchange (PABX) equipment with capacity and features suitable for the different exchange systems, which shall be used. These systems shall be interfaced with their own M-FACP

The system shall include but shall not be limited to the following:

- CAT 6 Telephone Riser
- MDF
- Frame IDF
- Patch Panel CAT 6
- UTP CAT 6 Horizontal Cablings
- RJ 45 Outlets
- UTP RJ 45 Patch Cords
- Fiber Optic Patch Panel
- Fiber Optic Cable for Riser Backbone
- Fiber Optic Patch Cord
- PABX Private Automatic Branch Exchanging
- WLAN (wireless LAN) for flexibility and modality

E.4.11 Master Antenna TV System

General

MATV system for distribution of satellite/QCV television signal and FM to all outlet points. The MATV should include but not be limited to amplifiers, tap offs, splitters, conduits and cabling with all necessary accessories.

The system shall be capable of providing all T.V and Radio channels from 3 satellites (NileSat – ArabSat – Hotbird)

Distribution Network Components:

The distribution network shall consist of all necessary equipment and accessory to guarantee a signal level of 65 - 75 dB at the input of each TV set as the followings:

- Satellite Dishes 1.8m installed on the roof.
- Aerials suitable for receiving terrestrial broadcast installed on the roof of the building.
- Multi Switches.
- Low loss Coaxial Cables suitable for frequency up to 862 MHZ.
- IF/RF Amplifiers.
- Tap off units.
- Splitter units.
- TV outlets, which shall be from the same approved manufacturer for the wiring devices.

The RF signals shall be distributed in the main risers using RG11 coaxial cables. The horizontal runs from floor TVJB to each outlet shall use RG6 coaxial in one run.

The distribution system at each floor shall consist of distribution amplifiers, splitters and tap-off mounted inside the floor TVJB. Distribution amplifier shall have a gain of 34/40 dB.

Tap-off units shall be used to distribute the RF signal to each TV socket outlet. The tap-off shall be designed in order to have no more than 5 dB difference between any 2 outlets.

E.4.12 Public Address and Voice Alarm System

A voice alarm and public address system shall be provided. The system shall be interfaced with the fire detection system to provide a voice alarm facility. The primary function of the voice alarm system will be to provide emergency, live and pre-recorded speech broadcasts to all the areas of the building. The system shall also be suitable for making general public address and back ground music broadcast to all the areas of the building.

The system would provide the flowing facilities:

- Live emergency speech broadcasts to all areas from the fireman microphone.
- Pre-recorded emergency speech broadcasts to all areas, on a zoned basis, these message will be activated automatically by the fire detection system.\
- Live public address broadcasts from the general paging microphone (s) on.

The Central System shall have the following Equipment:

- Central Rack Cabinets with Power Distribution Panels and Fan Trays.
- CD / MP3 players.
- DVD Players.
- IPod.
- Zone Paging microphones / Fireman microphone.
- Audio Switching Matrix with network / sources surveillance.
- Monitor Panels.
- Audio Power Amplifiers including Spare power Amplifier.
- Automatic Substation Unit.
- Volume controls.
- Input / output units.
- Emergency power supply as backup.

E.4.13 <u>IP Security System</u>

General

The design strategy takes a balanced approach to security measures considering cost effectiveness and recognizing that buildings should be not bunkers, but open, accessible and attractive to the building users and tenants.

The internal building security is the target to be achieved utilizing state of the art security system, namely:

- IP Based CCTV System.
- IP Based Access Control System.

The above mentioned systems are all connected to the building Local Area Network (LAN) such that each system may be split into subsystems or integrated into different configurations according to the building operation requirements.

E.4.14 <u>IP CCTV System</u>

Fixed and PTZ color cameras are distributed throughout the building. Camera video signals are transmitted back via facility TCP/IP network to a number of monitoring stations located in the Security Room.

Monitoring locations are equipped with video servers connected to operator work stations and large size viewing screens. An appropriate software is used to enable monitoring and controlling the cameras based on location and function of each camera as partitioned by system supervisor.

Monitoring stations are able to monitor single or multi cameras as well as being able to record any camera (s) on the local hard desk or on a mass video storage media. Stored video signals may be retrieved by authorized personal whenever required via the TCP/IP network.

The IP based cameras are distribute throughout the building to monitor the following area:

- Main Entrances / Exits.
- Public Areas.
- Elevator Lobbies.
- Parking Areas.

The following table indicates the type of camera to be used in each of the above mentioned areas and the intended function.

Location	Camera Type
Boundary Wall	Colour video dome camera with PTZ
Gate, Substation	Fixed colour with PTZ dome camera vertical

E.4.15 IP Access Control System

- The system is utilizing distributed control panels throughout the building. Each control panel is to monitor a maximum of 16 doors with provision of two card readers for each door.
- Door status and different transactions are transmitted to a central control station (s) located at the control room (s) via the facility TCP/IP network. All transactions and door status are logged via an event printer as well as being achieved for future retrieval and reporting.
- The provided system is monitoring all emergency exits, or any other areas agreed with the owner / operator.

E.4.16 <u>Wireless Cable / DSL Router</u>

The system allow all PC and Laptops to has access through Internet from any point in the room or from conference rooms, lobbies, or temporary offices.

And to share Internet Access for Wireless and Wired Users
Up to 253 user and wired users can share access to a single cable or DSL modem, so an entire business can use a single Internet connection.

<u>Environmental Range:</u>

Operating Temperature	32º to 131ºF (0º to 55ºC)
Relative Humidity	10% to 90%, non-condensing
Power	12VDC, maximum 1.2A/ 30W

<u>Standards Compliance:</u>

Wired Network	IEEE 802.3u Fast Ethernet IEEE 802.3 Ethernet over 2 pairs of UTP category 3 (10 BaseT) Recommended maximum distance is 328 feet (100 meters) for WAN and LAN connections.
Wireless Network	AerolLAN Wireless module: Interoperable with all IEEE 802.1 lb (DSSS) 2.4GHz-compliant equipment. Operates up to 300 feet (100 meters) from wireless access points with dynamic data transfer rates from 1 to 11 Mbps 2.4 GHz. Compatible with Apple Airport.
Full Duplex	Support for 10/100 Mbps data rates with flow control
Safety	UL 1950,CUL,TUV/GS,CE Safety
Emissions	FCC Class B, CE Mark

<u>Specification:</u>

Connectors	WAN:	Ethernet (RJ-45 10BaseT) to cable/DSL modem
	LAN:	Fast Ethernet (RJ-45, 100BaseTX/10BaseT)
	Wireless:	PCMCIA option slot for Asante AeroLAN wireless module
	Printer:	Standard uni-directional parallel (DB25, Female)
Status Indicators		Power and status. Separate link-activity and speed (100 Mbps) LEDs for each LAN port. WAN link activity. Wireless and Printer status Power

<u>Advance Security:</u>

Log	Records all intrusion attempts in volatile memory
Port Access	User-definable triggers and ports open only upon demand

Group	Assign users to any 3 groups (or default) to allow/block access to specific TCP ports. For example, prevent access to web, email or news.
Tempering	No externally accessible buttons or switches to change router/network configuration, password or operating parameters.
Firewall	Naturl packet filter and router with network address translation (NAT). WAN traffic only sees the router itself; LAN traffic is cloaked.
DMZ	Selectable address for unrestricted 2-way communications
Administration	Password protected. Remote access may be limited only to specific IP address or range of addresses.
Storms	Hardware-based broadcast storm prevention.
Wireless	Supports up to 128 bit WEP data encryption.

Software Feature:

Administration	100% configuration from a web browser (included) with password protection for local and remote management.
Compatibility	Supports static and dynamic IP addresses
Special Modem Support	PPPoE DSL, @Home cable, MediaOne
DHCP	Assign up to 253 IP addresses and users automatically
Virtual Server	Host IP services through re-directed servers
Popular Applications	Supports Internet games, video conferencing and telephony applications through pre-configured and user-definable triggers and ports
Virtual Private Networks	PPPTP (tunneling) and IPSec

Section (F)
Special Requirements by Occupancy
According to IEEE STd 241-1990 CH.(16)

F.1 General Discussion.

- This chapter covers specific considerations for the most common type of commercial facilities. The preceding chapters described in detail the basic electric systems and components that are necessary to meet the needs of commercial facilities insofar as modern power supply, electric distribution, transportation, lighting controls, and communication systems are concerned. However, in each classification of occupancy, there are certain items applicable to each occupancy that are not required in other occupancies.
- The designer of commercial facilities may group the design parameters into four basic categories:
  1) Minimum requirements of applicable codes
  2) Dependability of service and provision for contingency
  3) Flexibility for growth and changes
  4) System safety and efficiency, and user comfort

- The designer should demonstrate to the building owner and electric utility company the need to include, in the original installation, the service capacity for potential future loads, and to make provisions for facility additions at a later date.
- Minimum requirements are generally covered by applicable regulatory codes.
- The design engineer should meet the minimum requirements and expand from that point, as required, by the specific nature of the facility, occupant, and building owner.
- The system should be designed to be maintainable at a high level of performance by assigned maintenance staff.
- Complex protective systems or voltage levels beyond the scope of the maintenance staff should be avoided.

F.2 Auditoriums.

F.2.1 General

- An auditorium may be described as "an indoor area for large gatherings of people for meetings, entertainment, expositions, or sporting events.
- Auditoriums may be a part of schools, office buildings, laboratories, churches, or any building.
- Many auditoriums have a stage, which requires stage lighting that can range from small systems with track lighting and a few spotlights to electronic dimmer systems with extensive use of spot, flood, and border lights.
- The auditorium's general lighting should be controlled from a central location. Motion picture, slide, and overhead projection may be required.
- Service outlets should be provided as well as projection booth equipment, when used.
- Convenience outlets for cleaning and general maintenance should also be provided.

- A dimmer bypass should be provided for the house lights.
- The lighting should be flexible so that it can accommodate the different uses of the main floor area.
- The type of lighting control and the location of the control booth are important.
- Lighting controls may be elaborate for color television, which requires higher intensities and good color rendition.
- Attention should be given to the problems of glare. High lighting levels can become objectionable unless a great deal of care is used in the design of fixtures, shielding, and ventilation.
- Auditoriums may be used for exhibitions. A grid of under floor raceways should also be considered.
- The area under the main floor is sometimes used for industrial exhibits, or storage. This area may have a low ceiling, which may require special attention be given to lighting fixture design to achieve the required lighting levels.
- Large auditoriums may have several entrances. The main entrance lobby and foyer may be very ornate and require careful study to provide a satisfactory plan of illumination and decorative lighting.
- Large signs should be provided so that notices of coming events may be read from a passing vehicle.
- Public address and music systems need special attention. Often, musical programs need good sound reproduction.
- Amplifiers and special lighting for concerts often require relatively large amounts of power.
- Local radio and television stations should also be consulted as to their requirements. Microphone jacks should be positioned at likely points of activity.
- Telephone facilities and press communications maybe required.
- Large numbers of public telephones and facsimile machines may be needed, especially in the lobbies and foyers.
- Power services should be of dual source supply, when practical. A power failure.
- Emergency lighting is usually dictated by local codes; but these are generally minimum requirements.
- High-intensity discharge (HID) lighting is not considered acceptable for emergency lighting due to the excessive time it takes to produce an acceptable lighting level after a momentary power outage.

F.2.2 <u>In auditoriums, the following checklist should be used as a guide:</u>

1) General lighting
2) Stage lighting
3) Exit and emergency lighting/emergency and standby power
4) Public address system
5) Signal and communication systems
6) Radio and television facilities
7) Projectors and sound equipment
8) Telephone and facsimile facilities
9) copying facilities
10) Special event lighting and power outlets
11) Elevators and escalators
12) Parking system
13) Floodlights
14) Fire alarm system

F.3 Automobile Areas.

F.3.1 General

- This classification covers a sales office, showroom, and service shop facilities on one floor.
- A multiple-story building including storage and parking facilities.
- Most parking garages used by tenants, employees, and the general public provide for self-parking with ramps between floors.
- Passenger elevators may be required for facilities with multiple floors

F.3.2 Sales Offices and Showrooms.

- Normally, sales offices include many partitions for salesperson.
- Convenience and telephone outlets are required in each space.
- Showrooms require higher lighting intensities.
- Lighting effects that are to be used for sales promotion material and to display special features of the new cars may be needed.
- A public address system to sales areas is usually necessary.
- Special lighting may also be needed for video display areas.

F.3.3 Service Shops.

- In service shops, lighting intensities should be. set in accordance with the *IES Lighting Handbook* recommendations.
- Wattage may be limited by local energy codes. Surface-mounted raceways with convenience outlets located every 18 inches along the back of the benches Explosion proof systems are required in below-grade inspection pits and certain other areas.
- Service shops have power requirements for hoists, machine shop tools, Air compressors. Welding outlets may be required if extensive body work is done.
- These welders are usually found in ranges up to 45 kW, single-phase and three-phase. Air compressors should be located near the electrical service entrance.
- In the machine shop area, a single length of bus-way with plug-in overcurrent devices will enable the addition and movement of machine tools at will.
- The power supply should be so designed that starting large motors does not adversely affect sensitive electronic test equipment.
- When paint spray booths are provided, lighting intensities require up to 500fc with shadowless distribution.

F.3.4 Parking Lots and Garages.

F.3.4.1 General

- Electronic systems may be provided for the collection of tolls, fees, and tickets.
- Such systems may involve automatic gates, ticket issuing machines, and electronic cash registers.
- Treadle-and-loop systems are used to count vehicles for auditing purposes and lot-full inventories.
- Large self-parking garages may require personal safety systems, including closed-circuit television and "panic stations", which would include pushbuttons that automatically alert building security, two-way communications, and an alarm siren.
- Larger parking lots may require rooms for electronic equipment and perhaps computers.
- Telephone services should be provided in the waiting rooms for customers as well as for the personnel operating the garage.

F.3.4.2 The following checklist should be used for garages in general:

1) Illuminated directional signs
2) Remote door controls
3) Telephone systems
4) Public address systems
5) Signaling and communication systems (including personal safety systems)
6) Fire alarm
7) Lighting (general and localized)
8) Power for tools and testing equipment
9) Elevators and escalators
10) Ventilation systems for enclosed garages
11) Electric infrared heating for waiting customers and attendants
12) Emergency power, especially if handicapped persons are involved
13) Man-lifts for use by parking attendants

F.3.5 Car Wash Facilities.

- Special electrical considerations include pumps, Conveyors, fans, washing roll drives,
- Water heaters, towel washers and dryers.
- Equipment located in the wash area should be watertight.
- GFCI protection should be installed in adjacent work areas when convenience outlets are provided
- "Wet" conditions could exist.

F.3.6 Automated Parking Facilities.

- Completely or partially automated parking facilities may be provided for commercial parking lots, building tenants, and car rental facilities.
- The designs for security and access control systems involve the garage designer.
- Special computer and programming designs.
- Detailed equipment and communications design.
- A significant amount of design work may be required for the installation of automatic gates.
- Treadles, sensors, signals, and interconnections.

F.4 Banks.

F.4.1 General

- Outdoor lighting may include floodlighting the building for decorative purposes.
- The use of electric signs and directional instructions for night banking may require
- Underground cable installations before walks and driveways are constructed.
- Teller exterior walkup windows may need lighting, communication, and electric infrared heating.
- Unattended automatic banking machines require power, lighting, communication.
- Indoor lighting includes general lighting in the main area.
- High ceilings permit the use of spotlights and floodlights.
- Indirect lighting may also be used. The teller's counters should be lighted with care to avoid shadows and glare
- Provisions for closed-circuit television for banks with multiple branches should not be overlooked.
- Alarm and communication systems, both visual and audible, demand top priority in the modern bank.
- Security and alarm systems are normally coordination with suppliers selected by the bank is necessary
- Extensive communications provisions should be provided for computer systems, facsimile machines, and modems.
- Provision will probably be required for computer terminal equipment at tellers' windows.
- Power and data circuits may also be needed.
- Closed-circuit television is used both for checking money and for guard surveillance and protection.
- In a safety deposit department that is to be used by the public, banks desire a pushbutton in each booth to call an attendant.
- Banks also need an intercom system.
- A signal system for calling employees should also be provided.
- The accounting department may have large numbers of business machines.
- An under-floor duct system or a raised floor system of power, data, and communication cables.

F.4.2 The checklist for banks should include the following items:

1) General and decorative lighting
2) Specialty lighting
3) Exterior lighting
4) Security and emergency lighting
5) Fire alarm
6) Burglar alarm and holdup systems
7) Telephone and facsimile communications
8) Intercommunication system
9) Paging annunciators
10) Electric door locks and controlled access systems
11) Closed-circuit television
12) Public address system
13) Business machines, data processing equipment, and cash machines
14) Computer mainframe, local area network (LAN), and tie to remote stations
15) Power outlets
16) Emergency and standby power requirements.
17) Surge protection

F.5 Athletic and Social Clubs.

- The general arrangement of the ground floor for larger clubs may be similar to that of a modern hotel.
- General lighting may be decorative.
- Outlets for reading and table lamps.
- service outlets for maintenance equipment should also be provided.
- Swimming pools, gymnasiums, handball courts, and bowling alleys require special lighting.
- High bay lighting in a gymnasium may require sufficient lighting circuits to serve special events.
- The upper floors of certain clubs have sleeping quarters for members. The power requirements for these floors are the same as for hotels.
- A central antenna, satellite, or cable for television needs of each room should be installed. Telephone, facsimile, or intercommunication systems, or all three, may also be installed in rooms.
- Saunas are standard equipment in most clubs. Sauna electric heaters may vary from 5-15 kW, depending on the size of the room.

F.6 Colleges and Universities.

- These facilities often have a wide divergence of uses. Occupancies, such as auditoriums, gymnasiums, hospitals, clinics, libraries, office buildings, etc., may need to reference those classifications elsewhere in this chapter.

F.6.1 Classrooms.

- Classrooms should be provided with an adequate level of illumination, properly diffused, to eliminate glare, eye strain, and objectionable shadows.
- Properly engineered fluorescent lighting is considered the best illumination system for general classroom use.
- Supplemental lighting on chalkboards and bulletin boards may also be required.
- Public address or intercom systems and clock systems, as well as provisions for a closed-circuit television and master antenna system, may be needed in classrooms.
- The number of convenience outlets should be ample in order to be able to carry the largest of projection equipment loads for illustrated lectures.

F.6.2 Laboratories.

- The various sciences, as well as other curricula, may have laboratories for their particular needs.
- The flexibility and capacity of power circuits for special apparatus is important.
- Surge protection is generally warranted.
- A large range of voltages, frequencies, and dc power supplies may be required.
- Risers containing the various feeders may run the full height of the building.
- Power at frequencies over 60 Hz, such as 400 Hz power, requires short feeders and should be converted to the required frequency near the point of use.
- Special voltage requirements should also be converted locally.
- Heavy-duty portable cables terminating in switched receptacles may be used for feeding the heaviest loads.
- Room panel-boards should include circuit breaker or switch- and fuse-protected circuits to large ampacity outlets for test or converter use.
- The tables and counters may warrant individual panel-boards.

- Convenience outlets may be required across the back of each table.
- Outlets should be polarized for the various voltages, currents, and for grounding purposes.
- Receptacle slot configurations for each type of service should be standardized throughout laboratory spaces so that portable equipment may be used in any location.
- Special panel-boards and controls are frequently installed in laboratories.
- In mechanical laboratories, large machines for testing and even manufacturing parts for research will produce load densities that will require an industrial type of power distribution system.
- Ground- fault circuit interrupters are advisable when wet conditions exist, such as in chemical laboratories. Photobiological laboratories may require special lighting and good air handling.

F.6.3 Dormitories.

- In a modern college, dormitories need many convenience outlets to discourage the dangerous use of "octopus" plugs that are fed from a single receptacle.
- Today, study lamps have been supplemented by personal computers.
- Laundry facilities should be provided on each floor.
- Outlets for steam irons and hair dryers should be installed.
- In the basement, drying equipment is often provided and the use of electric clothes dryers is common.
- Public address, room annunciator, and fire detection alarm and suppression should be provided.
- Telephones should be included on each floor.
- Telephone outlets, cable television system outlets, and outlets for the college local area network (LAN) should also be provided in each dormitory room.
- Lounges and cafeterias should be well lighted and may be provided with food warmers and steam tables to keep the food hot after it is received from a central kitchen.
- Lounges may have several television sets and will also need television and LAN outlets.

F.6.4 Miscellaneous Requirements.

- In addition to the principal types of power requirements, the following requirements should also be considered:
- Outdoor lighting should be provided for the many bikeways, streets, and sidewalks. Because it is private property, this type of lighting is usually the responsibility of the college.
- Telephone and computer systems may be private systems connected to outside networks.
- Public address systems permit rapid and efficient transmission of information between the administrative staff and the instructors.
- An electric clock system with automatic programming can sound the time signals for the various class periods.
- Central monitoring and control of the mechanical, electric, security, and fire alarm systems should be considered. An effective energy management system and computerized maintenance system can prove extremely cost effective for maintenance.
- Automatic ties to municipal fire alarm, sprinkler water-flow, and security systems are desirable and may be required.
- Emergency telephones along campus pathways for student aid.

F.7 Computer Centers.

- Raised floors are mandatory for most computer centers to allow for efficient and flexible installation for power and data cables.
- Specifics on computer equipment should be established in order to determine the following requirements:
  1) Acceptable temperature and humidity ranges
  2) Voltage and frequency constraints (including transients)
  3) Effect of power interruptions

- Generally, computer spaces require air-conditioning and humidity systems that are separate from all other building spaces.
- Generally, normal voltage fluctuations can be tolerated; but transients may upset computer operations.
- Surge protection is also desirable. Special isolating and voltage regulating transformers with electrostatic shielding and transient suppressors have proven effective in eliminating this problem.
- Some computer systems are designed with the capability to pick up and continue after a power outage; others may suffer loss of valuable data.
- Standby power should be considered for any computer that is operated continuously
- An uninterruptible power supply (UPS) may be economical, as determined by a study that loss of data with the owning and operating costs of the UPS.
- Grounding for equipment and computer power circuits requires detailed consideration.
- If isolating transformers are used, neutral grounding should be handled for a separately derived system according to NEC requirements [1].
- Each computer should be grounded to a ground bus and then to an approved ground. Neutral conductors.
- Most microprocessor- and computer-associated electronic equipment in commercial buildings, which generate a high percentage of harmonics increase the size of the neutral above that of the lines.
- Some manufacturers of prefabricated partitions are using double-sized neutrals in electric wiring,
- One equipment ground wire, and one electronic ground wire.
- The designer should be aware of the need to reinforce the neutral under such conditions Specify transformers designed to operate under high-harmonic current conditions.

F.8 Department Stores.

- In many respects, a department store is a combination of many small specialty merchandising establishments.
- The whole building is usually occupied by the same store owner.

F.8.1 Distribution Systems.

- Distribution systems in department stores often resemble those for office buildings.
- Sufficient flexibility should be provided in the distribution system to accommodate increased needs for power and lighting.
- No diversity factor should be used in calculating the lighting loads.
- Maximum electrical load occurs when the store is open in the evening, especially during the summer
- Panel-boards should be sized to supply ambient lighting loads at up to 3 W/ft2 of selling space.
- 1 W/ft2 for spot, accent, and showcase lighting.
- An additional 0.5 W/ft2 for additional non-lighting specialties, such as point-of-sale equipment, pharmacy refrigerators, etc.
- Most department stores require a building automation system that shuts down two-thirds of the lighting at closing.
- The remaining lighting (except pathway and security) as well as general-purpose outlets shut down at a later scheduled time.
- Panel-boards should be located so that they are not accessible to the general public.
- Circuits supplying computers, essential refrigeration, and cleaning equipment outlets should remain energized.
- Cash registers or point-of-sale systems that report back to central-verifying-type registers generally require clean power,
- Surge protection should be included for power and data transmission circuits that are associated with data processing equipment.
- In the case of table and floor lamp displays, a large number of receptacles is usually required.
- Television and sound system areas also require extensive outlets.
- Television and related equipment also require many program source (antenna, satellite dish, and commercial cable) outlets.

F.8.2 Lighting

Lighting problems in a department store should be seriously considered because the public is involved and so much flexibility is required. The designer should consider the following points:

- General overall lighting scheme
- Spotlighting
- Showcase lighting
- Exterior show window lighting
- Special areas
- Exterior site lighting
- Security lighting
- Emergency exit and egress lighting code requirements.
- Intensities of 50-70 fc are typically provided in selling areas.

- Efficient fixtures and light sources with showcase, accent, or display lighting to provide brightness may be used with high-reflectance surfaces to make lighting at lower power consumption per square foot.
- The color of light sources is very important in selling and merchandising areas and requires special engineering attention.
- The use of cove lighting to supplement general illumination is common practice. Illuminated coves serve very important functions.
- The cove-lighted curtain wall provides a terminal or stopping point for the eye when viewing the store generally; hence, it provides space definition.
- Cove lighting usually provides only a small amount of the total illumination for selling areas.
- Spotlighting is required by the display department of practically every department store.
- Showcase lighting may be provided by using reflectors placed in the interior of the case to be illuminated.
- The intensity should be two or three times the intensity of the general lighting in the store. The fluorescent lamp is practically always used (except for jewelry).
- Recent improvements in the color rendition of showcase lamps helps reduce the need for incandescent lamps.
- Show window lighting in a department store should be carefully considered.
- The usual practice is to employ a spotlight every 12 or 18 inches along the length of the window front. Color filters may be used to show the merchandise to its best advantage.
- The heat generated in areas where lamps, particularly incandescent lamps, are near radiated heat from light fixtures can be damaging. Display designers should use bright surfaces and color techniques to reduce the energy requirements for display lighting
- Security lighting should include battery-operated lights for main pathways and spotlights for cash register areas.

F.8.3 <u>Communication and Signaling Systems.</u>

- Telephone and telegraph systems in department stores generally employ a relatively large private branch exchange with telephones in each department as well as in the administrative offices.
- Order receiving equipment that involves a heavy concentration of telephone wires may also be required. Communication circuits for credit card verification systems and computerized cash registers are also commonly utilized.
- Television cameras are extensively used for surveillance in department stores; therefore, adequate power, video, and control circuits should be included in its electrical design.
- Paging systems should be considered. In some large department stores.
- Local paging systems are installed in various departments.
- A clock or dismissal system should also be considered. In public areas,
- These systems require signals or loudspeakers located on walls or columns 8-10 feet above the floor.
- Door protection systems are often installed. When there are many street display windows.

F.9 Fire Stations.

- Radio and television outlets are needed.
- The alarm system should be tied into a central control headquarters
- Special-purpose telephone services are usually connected.
- A cut-out contactor for ranges and other cooking equipment is frequently used to disconnect these items when the station personnel respond to a fire call.
- The central control headquarters contains the central fire alarm system with provision for emergency power, fire siren.
- A two-way radio for communication with the trucks and other mobile equipment is also located here.
- Automatic door openers are installed in all doors for handling firefighting apparatus.
- A tie-in to the traffic signals is provided at many firehouses to flash the red stop signal and halt traffic.
- In rural fire stations, some automatic devices should be added.
- Battery charging on all the truck batteries should be operating continuously when the trucks are in the building.
- Quick-disconnect plug connectors should be used to disconnect the battery charging leads automatically when the trucks go out on a call.
- The lights should be automatically controlled.

F.10 Gymnasiums.

- Gymnasiums are primarily used for active sports, and, particularly in schools, may also serve as multiple-purpose areas.
- All electrical lighting and devices have adequate guards to protect against damage from thrown balls.
- Lighting should be designed to provide minimum shadow and lack of glare for participants.
- Lighting for different sports may require special aiming patterns or fixture construction.
- Metal-halide or high-pressure sodium lamps may provide an effective lighting, the restrike time in case of a momentary power outage makes emergency light mandatory for evacuation purposes.
- Lamps and fixtures are available with standby tungsten halogen or quartz lamps and power failure relays that satisfy the requirements of the NEC [1] and ANSI/ NFPA 101-2013, Life Safety Code [7].
- Fluorescent luminaires may also be included in the system for this purpose.
- Lower wattage high-pressure sodium lamps with an instant restrike feature for emergency lighting are also available.
- Special power requirements include hoist drives for backboards and other gym equipment
- The switches should be of the key type.
- Scoreboard power with convenient control should be considered.
- Public address equipment requires special attention to ensure appropriate selected coverage for each sport and to prevent feedback in an acoustically live space.
- Floor outlets should be avoided, due to potential hazards
- Special fixtures with self- lowering devices are required for high-bay lighting or over swimming pools.
- Cat- walks may also be used in high-bay areas for re-lamping.

F.11 Hospitals

F.11.1 General Discussion.

- Hospital electric systems are complex in design, expensive to construct, and highly regulated by authorities.
- Hospitals have unique electrical requirements and reliability because:-
  1) Patients are particularly vulnerable to electric shock.
  2) The hospital strategy for dealing with fire and other life-threatening emergencies is different from that of other occupancies.
  3) Hospitals have many types of sensitive computer-based medical equipment and instrumentation. Sensitive electrical equipment should have disturbance-free electric service.

F.11.2 Codes and Standards.

The following codes and standards will be of interest to anyone involved in designing or operating health care electric systems:

1) ANSI/NFPA 70-2013, National Electrical Code (Article 517, "Healthcare Facilities") [1].
2) ANSI / NFPA 99-2013, Health Care Facilities (Chapter 3, "Electrical Systems" and Chapter 7, "Electrical Equipment") [6].
3) IEEE Std 602-2013, IEEE Recommended Practice for Electric Systems in Health Care Facilities [10].
4) NFPA 110-2013, Emergency and Standby Power Systems.
5) NFPA llOA-2013, Stored Energy Systems.

While there are a number of codes and standards that deal with hospital design and construction, the designer should be aware of the fact that many different locales have special requirements for the installation of health care electric systems.

F.11.3 Patient Safety.

- The designer of electric systems includes certain features for the protection of occupants, the public, and maintenance personnel. In general, the design strategy includes protecting people
- The usual concerns, hospitals should be concerned with the electrical safety of patients.
- Hospital patients are particularly vulnerable to electric shock because:
  1) Patients relinquish much of the control they normally have over their lives and safety to hospital personnel.
  2) Patients are exposed to, and even connected to, a variety of electrical equipment.
  3) Patients are catheterized with conductive electrical and nonelectrical catheters that penetrate the skin, can lead to cardiac fibrillation as the result of high-current densities.
  4) Patients are often anesthetized or sedated. The loss of normal sensation renders patients wholly or partially defenseless.

- Hospitals use three basic strategies to reduce the risk of electric shock:-
  1) Hospital codes require two ground paths for power circuits in patient care areas: a green ground conductor and a metallic conduit.
  2) Hospitals use "equipotential grounding:- By bonding exposed conductive surfaces together or to a common bus by means of ground conductors.
  3) Method of reducing the risk of electric shock in health care facilities utilizes ungrounded isolation transformers. Two-wire ungrounded system to determine the potential leakage current in that line in the event that the other line becomes solidly grounded. Until recently for anesthetizing areas for operating rooms that use flammable anesthetics and those considered to be wet locations.
- It is important to note that isolated power systems are recommended as an effective tool for improving the level of safety and the continuity of power in certain critical care areas of a hospital.

F.11.4 <u>Standby Generators, Essential Electric Systems.</u>

- Hospitals are required to have very reliable electric systems. Reliability is achieved in three ways:-
  1) Through multiple utility electrical services, when available.
  2) Through standby generators, automatic transfer switches, and essential electric systems.
  3) Electric system design, selectively coordinated overcurrent and ground-fault protection, and reliable end-use devices, such as receptacles and fixtures.

- In general, hospitals are required to have on-site standby electric systems. The essential electric system should consist of:-
  1) An emergency system, which consists of a critical branch and life safety branch-each with its own automatic transfer switch programmed to restore power within 10 seconds.
  2) An equipment system with delayed automatic or manual transfer switches.

- In general, the life safety branch serves exit lighting, egress lighting, the fire alarm system, and other loads related to life safety. The critical branch provides critically important circuits in patient care areas, life support equipment, and other loads that are necessary for patient care. The equipment system serves:-
  1) Heating or A/C for critical care areas and patient rooms (when specifically required)
  2) Clinical air compressors and vacuum pumps
  3) Air systems with special air change, filtration, or pressurization requirements
  4) Equipment, such as elevators, and sump pumps and other types of mechanical equipment, as required for hospital operation

- Medical imaging equipment can be connected to the critical branch or the equipment system.
- Hospital ground-fault and overcurrent protection systems should be selectively coordinated to prevent unnecessary power outages in critical areas
- The coordination study should consider the normal and standby fault current sources.

- Hospitals with ground-fault, protection on their mains are required to have a second level of ground-fault protection down- stream.
- Receptacles in hospitals are required to be tested periodically for contact pressure and ground conductivity. Depending on the codes in effect in a particular locale
- Normal system circuits to be installed in critical care areas to prevent a transfer switch failure on the emergency system from interrupting total power to an operating room, intensive care unit, or other critical area.
- Automatic. transfer switches should be listed for emergency use, and consideration should be given to providing bypass/isolation switches.

F.11.5 **<u>Life Safety</u>.**

- Fire alarm systems for health care facilities are designed to alert the public and the hospital staff of a fire emergency and to annunciate the location.
- Hospital fire alarm systems can be coded systems that annunciate the fire location by using a series of coded sounds.
- The fire location at a central location
- Hospitals use a "defend in place" strategy in dealing with fire emergencies. Most patients are unable to evacuate, so the strategy is to contain and suppress the fire while leaving the patient in place or relocating to other place
- Some medical procedures within the facility should continue in the event of a fire.
- In general, voice alarm systems are not recommended for hospitals because patients are unable to respond to the recorded message.
- Multiplex systems are becoming increasingly popular in large and medium-sized hospitals.

F.11.6 **<u>Medical Equipment and Power Quality</u>.**

- It is most important for the electrical design engineer to obtain data sheets, and vendor installation drawings before attempting to design electric systems.
- Diagnostic and treatment areas. Sometimes, elaborate powering, grounding, and shielding will be required.
- Modern medical center will have computers and computer-based diagnostic and treatment equipment.
- Care should be taken to provide proper grounding and to isolate critical loads from elevators, variable frequency drives, and other equipment that can generate voltage drop, noise, and transient over-voltages.
- Uninterruptible power supplies (UPS) are required for computers, and transient voltage surge suppressors are needed to protect hardware.

F.11.7 **<u>Communication, Information, and Signaling Systems.</u>**

- Hospitals have a proliferation of communication, information, and signaling systems. The major systems include:-

  1) Patient nurse call systems
  2) Emergency call systems
  3) Telephone systems
  4) Paging and public address systems
  5) Radio paging (pocket pagers)
  6) Television (commercial and closed-circuit), including antenna systems and cable systems

7) Security (intrusion, door alarm, pharmacy, and television surveillance)
8) Departmental intercoms
9) Emergency services radio
10) Physiological monitoring (hardwired and telemetry
11) Hospital information systems, data processing systems, and data networks
12) Interval timers or elapsed time indicators
13) Central clock systems (hardwired and electronic carrier systems)
14) Building or energy management systems
15) Medical gas alarm systems
16) Isolated power line isolation monitors
17) Standby generator annunciators, trouble alarms, paralleling switchgear, and transfer switch status indicators
18) Blood bank alarms
19) Fire pump and fire alarm annunciators
20) Satellite uplink and other systems for staff training

F.11.8 <u>Hospital Lighting</u>.

- Hospital patient care areas require special lighting.
- Operating rooms require lights that are dimmable and provide thousands of foot candles of light in the surgical area.
- Ambient lighting in operating rooms should be sufficient to prevent visual contrast problems for those working under high-intensity light.
- Consideration should be given to special color rendering lamps (i.e., 5000 K fluorescent lamps) in surgical and laboratory areas.
- Consideration should also be given to providing the same special lighting for prep and scrub areas to give the physician time to adjust eyes to the new light source.
- Other areas of the hospital require special lighting as well. For example, infant nurseries need lights with intensity controls to prevent damaging infant eyes.
- Post-op surgical areas require special exam lights for the physician to examine surgical wounds.
- Sometimes, germicidal lamps are required for infection control.
- Special consideration should also be given to corridors and holding areas where patients may be forced to stare at the ceiling for long periods of time.
- In x-ray room we must use no radiation lamps (fluorescent lamps) – warm light.

F.12 **Hotels.**

F.12.1 **General**

- Restaurants and lobbies will require illumination levels of at least 250 – 350 LUX. Large meeting facilities, such as banquet rooms and ballrooms, generally have movable partitions for dividing a large room into smaller rooms.
- The lighting control system, usually a programmable dimming system, should have the capacity for dividing control capabilities accordingly for ultimate flexibility.
- The sound system should have multiple amplifiers and speaker zones with the same flexibility.
- The meeting facilities may have small stage lighting systems, including controls, for highlighting head tables or certain events.
- The general lighting levels of meeting facilities will range from 60-70 fc for technical meetings and seminars to lower levels for dinner and entertainment functions.
- Emergency lighting may be controlled with the other lighting, but should have an emergency override in case of power failure.
- General-use receptacles should be plentiful, with some high amperage power outlets for use during trade shows and other exhibits.
- Television and telephone outlets should also be provided.
- In the residential type of hotel, the public rooms are usually not as in a transient hotel.
- Power for individual air conditioners should be made available when a common system is not provided.
- A master antenna, radio, and television system may also be required. These hotels approach the apartment house-type of building.

F.12.2 **A checklist for hotels includes the following items:**

1) Medium- or low-voltage service entrance.
2) Primary or secondary unit substations, or both
3) General lighting
4) Special lighting in public rooms
5) Night lighting
6) Emergency and standby generators
7) Building management system
8) Fire detection and alarm systems
9) Electronic security and surveillance system
10) Private telephone system
11) Public telephone line system (phones, facsimile machine, computer, etc.)
12) Intercommunication system
13) Public address system
14) Central television and radio system
15) Television program source provisions
16) Bellhop annunciator
17) Elevators, escalators, and dumbwaiters
18) Message annunciators
19) Lightning protection
20) Safe and vault security systems
21) Sports lighting systems
22) Sign lighting
23) Landscape lighting.
24) Access cards.

F.13 <u>Libraries</u>.

- Libraries need well-distributed general illumination because reading and visual work is done throughout the entire area.
- Lighting should be engineered to provide the required horizontal illumination levels for reading and writing and the required vertical lighting levels in the stacks for identifying book titles.
- In the book1stacks, which may be several tiers high, it may be necessary to provide outlets for motors on book lifts or dumbwaiters for transporting books to the top shelves.
- Special outlets are needed at checkout desks and for copying and facsimile machines.
- In large libraries, and communication or telephone systems, or both, are needed between library stations.
- A closing time signal system may also be needed.
- Security systems for checkout control are becoming more important and raceway for such a system should be included in the building structure.
- Security system normally involves screening equipment at exit points and door control for exterior doors.
- Provisions should be made for electronic catalog files, monitors, and microfiche readers.

F.14 <u>Museums</u>.

- The adequacy of lighting circuits and the convenient location of outlets are important in museums. The lighting of exhibits often requires outlets in unusual locations.
- Multiple-circuit track lighting on walls or hung from ceilings has proven quite effective.
- A high degree of flexibility for supplementary lighting should be provided.
- Special requirements include close temperature and humidity control. As these buildings are usually made of stone and decorative masonry, these outlets cannot be installed economically after the building is finished.
- Some museums exhibit apparatus that may require large power outlets.
- Special types of power requirements may be served best by using a design for flexible power distribution that is similar to that suggested for laboratories.
- An elaborate burglar alarm and fire alarm system as well as a temperature and humidity variation alarm may be needed, especially in large city museums where valuable paintings and other art collections are shown.
- These systems may tie in with proprietary, central station, or municipal police and fire departments.
- Transmission is usually accomplished by wire or radio link, which calls for a close liaison with these agencies.

F.15 Newspaper Buildings.

F.15.1 General

- Newspaper buildings are, in a sense, multiple- storied manufacturing plants, with large motor loads for the presses, conveyors, elevators, and moving stairways.
- Power service should be dual source, if possible.
- Large systems of telephone, telegraph, teletype, computer facilities, and radio services are required.
- Television may be added with facilities available for both reception and transmission.
- Each wire service usually has distinct requirements that may call for careful study of specifications as received from the various companies.
- Radio and television systems will require special shielding to prevent electromagnetic interference.
- Microwave facilities may also be included.
- Local telephone requirements are greater in newspaper buildings than in ordinary buildings.
- Telephone outlets may be provided in floor duct systems on most of the floors or by the use of newer flat cable systems that are laid under carpet tiles.
- Ducts leading to the switchboard should be oversized to accommodate changes in office arrangements.

F.15.2 A checklist for newspaper buildings includes the following items:

1) Large power distribution system at medium voltage
2) Special lighting in many departments
3) Emergency lighting
4) Emergency and standby power systems
5) Clock systems
6) Special requirements for telephone, telegraph, radio, television, computers, facsimile machines, and photography, microfilms machines
7) Intercommunication system
8) Private telephones
9) Fire alarm systems
10) Microwave and satellite links
11) Internet and advanced communication.

F.16 Office Buildings.

F.16.1 General

- Office buildings range in size from the smallest one-story building to the tallest high-rise office building.

  Such analysis should include the following items:

F.16.1.1 Power service

1) Size, location, and composition of expected loads
2) Possible transformer location(s)
3) Primary voltage and feeder arrangement (network or radial)
4) Primary wiring by utility or building owner
5) Transformers supplied by building owner
6) Any utility costs to be assessed to building owner
7) Transformer vault and access requirements
8) Special metering requirements

F.16.1.2 Load considerations

1) Interior-Heating, ventilation, air conditioning, lighting, other loads
2) Exterior-Sign and parking lot lighting, electrically operated gates.

F.16.1.3 Special systems

1) Fire alarm system, including communication and other systems control that is required for high-rise buildings
2) Public address system
3) B.M.S system
4) Wifi system
5) Telephone and data systems
6) Remote equipment status and control systems (central monitoring)
7) Security systems
8) Lighting and power control systems for energy conservation
9) CCTV

F.16.1.4 Emergency and standby power systems

- Load requirements
  1) Pathway and exit lighting
  2) Elevator
  3) Fire pump and booster pump
  4) Stairway exhaust and supply fans
  5) Data processing
  6) Other desired loads, such as sump pumps, house pumps, sewage ejector pumps
- Location
  1) Type (internal combustion engine or combustion turbine).
  2) Intake, exhaust, and unit silencing
  3) Fuel supply and storage
  4) Ambient temperatures and heat rejection
  5) Maintenance
- Potential for peak shaving and load curtailment
- Closed transition capability for parallel operation

F.16.1.5 Raceway Systems

- It is important that the lighting system layout be flexible
- Power and convenience outlets can be added or subtracted quickly and easily. Frequently, these changes should be made with a minimal interruption to full daily occupancy of the space.
- Low-voltage switching is often used to change switching patterns.
- Prefabricated flexible wiring systems should also be considered.
- Under floor raceway systems provide one practical way of providing for system flexibility.
- System, outlets can be provided at the time of construction, outlets can be installed at any time after construction.
- Raceways may have dividers to separate power and communication or telephone circuits.
- When heavy load densities are to be expected in communication and power circuits, for new buildings. Utilities are usually spaced in convenient modular groupings, for example, a 6-8 foot spacing.
- Cables for telephone, data, and convenience power outlet branch circuits to be laid under carpet tiles are now being used (where permitted) instead of under floor systems.
- When the density of power, communication, and data cables is heavy, consideration should also be given to raised access floor systems.

F.16.1.6 Meters

- Office buildings may be occupied by one tenant; however, in most cases, multiple- tenant occupancies are to be expected.
- Provisions should be made for metering or including the cost of the electricity in tenants' bills.
- Tenants may take raw space with only base utilities provided and design their own interiors.
- Some buildings standards should govern the tenant space design, and construction should be monitored to ensure compliance.

F.16.2 Large and High-Rise Office Buildings

F.16.2.1 Layout of Electric Systems.

- The use of multiple systems that are electrically and physically separated is desirable and should be considered if economics permit.
- The risers and electrical closets for these independent systems should, when the size of the project and the degree of protection be physically separated;
- Protection against damage by suitable fire ratings of enclosures, or by fireproofing.
- This also applies to critical control wiring including fire alarm systems, emergency communication systems, and smoke and evacuation control systems.
- Install major substations and other major power installations on mechanical floors
- Protecting building occupants from the effects of catastrophic failures of these systems.
- Installation should be such that the failure of the mechanical systems will not damage electrical equipment.
- Ventilation of electrical areas should be such that smoke is not carried into areas of occupancy.
- In large or tall buildings, the mechanical systems are usually zoned into individual system-designated areas.
- Zoning of the electric systems be compatible with that of the mechanical systems.
- If mechanical or electric systems should be out of service to any given zone, then such service should not be deprived to any other zone.
- New low-smoke, low-flammability, and low-toxicity cables have been developed.
- Cables are often referred to generically as non-halogen types or polyolefin types.
- The designer should consider the use of these cables where safety conditions are critical.
- Small amounts of smoke emitted from conventional cables of the halogen type can damage computer-type equipment
- While high-temperature cables for use as exposed wiring to fire alarm devices; which is very expensive and is not generally used for normal power wiring.
- The acceptable sound levels for transformers and suggest methods for minimizing them.
- Transformers installation can reduce the effects of noise.
- Flexible connections from transformers to heavy-current bus-ways is also important in reducing noise.

F.16.2.2 Maintenance of Electric Systems.

- The sealing of openings between floors and between adjacent areas is essential. Major fires have been transmitted between adjacent areas.
- The building staff should assure that contractors and others doing work in the building maintain such seals.
- It is easier to maintain seals and fire ratings in conduit sleeves than large slots.

F.16.2.3 High-Rise Buildings.

- Vertical transportation systems complex building management and security systems medium-voltage distribution and emergency and legally required standby systems are often required for safety.
- The elevators are normally not used for such evacuations, unless under fire department supervision. In a well-designed, properly operated, and adequately maintained high-rise building,
- Typically, a 30-story building may have substations in the basement and on the top floor or roof.
- Higher buildings might have substations every 20-30 floors, with intermediate floor substations supplying floors above and below.
- Panel boards are usually installed at each floor.
- The NEC, Article 300 [1] indicates the vertical lengths of cable that can be run without intermediate supports. The spacing is also given in a table in the NEC, Article 300 [1].
- Aluminum cables can, usually be run longer distances than copper.
- Cable supports, for more than several floors, may be of the manufactured wedge-type.
- A steel armored cable often referred to as "bore-hole" cable may be used. This cable requires the use of special fittings at the top and, sometimes, at the bottom.
- Cable pulling and other operations that require lots of space; very heavy vertical pulls may be required.
- Consideration should be given to the sizing of equipment (i.e, transformers and switch gear) so that it will fit into the larger passenger to avoid to use outside the building or in an elevator shaft, should replacement be required.
- The elevator recall system automatically brings elevators down from their landings at the time of a fire or other emergency
- The elevators are usually returned to the lobby (unless the fire is there) and held there for possible operation by fire department staff.
- When elevators are operated from emergency generators, controlled switching is provided so that limited number of elevators can be operated to prevent overloading the generators.
- Transformers in high-rise buildings are usually the ventilated-dry-type. Safety and maintenance considerations usually indicate this choice.
- The only use for liquid filled transformers would be in vaults, perhaps in outdoor main substation.
- The fire hazard and maintenance considerations of even the oil type and dry type
- Dry-type transformers can fail in a mode that generates smoke; therefore, all transformers should be ventilated in such a manner that the effects of such a failure will be limited.

F.16.2.4 Building Management Systems.

- Building management systems are covered in detail. While the building management system may incorporate all or most of the building control functions, several design objectives should be achieved
  1) Have backup locations for operations
  2) Provide diversity in equipment through the use or distributed systems (distributed by function or by operating areas).

F.17 Residential Occupancies (Commercial).

F.17.1 General

- Apartment buildings and con- dominium projects can vary greatly in size, number of floors, and number of dwelling units.
- The trend in some cities is toward larger housing developments with buildings up to 40 or more stories.
- The power distribution risers in such buildings approach the size of those in large office buildings. Pumps, fans, elevators, central space heating, water heating and air conditioning can be large loads.
- Clothes washers, dishwashers and other residential type appliances are significant loads.
- People doing housework, such as washing and ironing, at night, add to peak lighting loads and, thus, increase maximum power demand.

F.17.2 The following checklist is for apartment buildings and condominiums:

1) Metering (master or individual)-utility, sub-metering, rent inclusion.
2) Exit and emergency lighting.
3) Telephone system.
4) Security systems, which may include closed-circuit television, vehicle entry gate control, apartment intercom and entry door(s) release, restrictive elevator controls, and identification/ coded card door lock systems.
5) Television signal distribution, either master antenna or from the cable utility company.
6) Individual or central laundry facilities.
7) Exterior lighting.
8) Air conditioning heating, ventilating and water heating (central or individual).
9) Special appliances, such as garbage grinders, compactors, and dishwashers.
10) Fire alarm systems and, for high-rise, special life safety systems, such as smoke detectors may be required for each occupancy.
11) Signal systems for handicapped and senior citizens.
12) Parking and garage facilities.

F.18 Restaurants.

F.18.1 General

- There is substantial electrical load concentration in restaurant kitchens. When gas is used for cooking, a 500w/m^2 connected load is not uncommon.
- Connected loads of over 1000w/m2 have been used in all-electric fast food takeout kitchens.
- It is important that the engineer check the submittal data of the equipment actually furnished to ensure that power load provisions and outlet locations are acceptable.
- Electrical power in restaurants should fulfill the primary needs of the particular type of building.
- It is used to preserve and prepare food and provide appropriate lighting.

F.18.2 The following points are important:

1) Adjustable lighting from high to low levels
2) Electric (or gas) cooking and baking, refrigeration and ice making machine.
3) Public address systems.
4) Provisions for background music.
5) Plug-in telephone outlets.
6) Decorative lighting
7) Parking lot lighting and lighting for drive-through facilities.

8) Television outlets.
9) Kitchen exhaust equipment including fire detection equipment, special ventilation, such as restroom and smoking area exhaust fans.
10) Electric hand dryers.
11) Outlets for janitorial equipment.
12) Business machines in main offices.
13) Exit lighting.
14) Emergency lighting and power.

F.19 <u>Schools (Kindergarten through 12th Grade).</u>

F.19.1 <u>General</u>

- Greater effort should be more efficient use of electrical energy. Except for selected education programs.
- In lighting, more efficient sources and better lenses have enabled designers to achieve reductions in W/ft^2 that is required for good vision.
- Special outlets or extra floor outlets are required in home economics, vocational training, business training, computer skills, and foreign language spaces.
- Requirements for auditoriums, gymnasiums, and libraries are covered elsewhere in this chapter.
- In most areas, lighting should involve at least two levels of control Special systems
- Fire detection and alarm, security control, and program (announcing) systems.
- Both commercial and closed-circuit television.
- Telephone and central monitoring/ control for mechanical systems (BMS) may be included.

F.19.2 <u>Mechanical Systems.</u>

- Fans, pumps, chillers, cooling towers, and air conditioners should be considered.
- Sometimes, electricity is also used for space and water heating. Heat pumps, heat recovery systems.

F.19.3 <u>Laboratories.</u>

- Science laboratories require facilities with semi-flexible power distribution features.
- Convenience outlets and plug-in power outlet race ways may be needed on benches.
- The electric requirements for laboratories should be checked in the early stages of design because, frequently, special equipment may have to be manufactured.
- Type of equipment may require a long delivery time.

F.19.4 <u>Manual Training Department.</u>

- A manual training department may contain large motor powered machine tools and welding equipment.
- Flexible power distribution systems should be provided.
- Appropriate shop and tool lighting should also be provided.
- A master cutoff of power for each shop is recommended for instructor convenience and safety.
- Emergency stop buttons for operating under voltage release devices that disconnect all shop tool power should also be provided.

F.19.5 <u>Kitchen Facilities.</u>

- School lunch programs have expanded the power requirements of kitchens and cafeteria. Ovens, ranges, mixers, freezers, and exhaust systems require large blocks of power.
- Heavy-duty power outlets for hot food carts may also be required.

F.20 Shopping Centers.

F.20.1 General

- A shopping center is a group of stores concentrated in a compact area surrounded by vast parking lots. The majority of these are located on the outskirts of cities and towns.
- The parking areas should be well lighted by lighting standards that are generally controlled by photoelectric an time- clocks.
- The various stores are each wired to the owner's requirements and normally metered separately.
- Because of the height intensity discharge (HID) lighting is often economical and appropriate for this type of installation.
- The design is usually such that the lighting from the store fronts, especially display lighting, should dominate the visual scene.

F.20.2 Supermarkets.

- The supermarket is a fast growing and changing institution. The small margin of profit and the great volume of business cause the supermarket to attempt new merchandising ideas. These require a flexible electric system.
- The lighting may be 500 – 900 lux for general illumination. Auxiliary lighting is also generally used.
- High-intensity incandescent fixtures over the produce and meat sections have been used to give better color to the products when color is important.
- Valance lighting around the perimeter of the store has also used for advertising products as well as for illumination.
- The front areas of the supermarket may be highly illuminated to attract attention.
- The open freezer and refrigerated cases. These loads usually have several banks of compressors. Three-phase power is usually run to the compressor location.
- The freezers cases usually contain electric defrost elements. These defrosting elements may operate when the compressor motor is not in operation. The defroster loads are generally considered to have 40%-60% diversity.
- The checkout systems are designed to move the customers out quickly. Usually, one circuit is provided for each checkout.
- A computer with laser bar code readers which display the price and then enter the price and article name on the tally slip.
- Raceway for data cables from the central computer should be provided.
- The central computer keeps the inventory record, product flow, and suggested reordering schedule.
- When credit cards are accepted, card readers and verifier circuits should be considered.
- Coffee grinder loads have increased. These may range from 1-5 hp, three-phase or single-phase.
- Choppers and grinders may have two motors running simultaneously, which may be 10-15 hp three-phase motors.
- Hot iron sealing machines usually require one circuit per machine.
- Meat saw motors range as high as 10 hp three-phase.
- Electric door openers, meat tracks, rotisseries, and moving displays should be considered in the final survey of loads.

- Communication systems range from the simple single bell and chime system to systems that have speaker boxes located at convenient points in the store where the customer may request the location of items.
- This information is transmitted to the office, and the locations of such items are transmitted back to the customer.
- This system is usually interlinked with cash register locations, enabling the cashiers to communicate with the office.
- Refrigeration failure alarms, burglar alarms, closed-circuit television surveillance, water leak alarms, and other security systems should also be considered.
- Signs are an important part of the load and are sometimes elaborate, with running and neon lights.
- Special consideration should be given to future electrical loads: conveyors to deliver the groceries from the cashier location to the customers' automobiles,
- Pushbutton shopping, automatic meat processing, automatic stocking, etc., are all likely additions to the future supermarket, and all depend on electricity.
- Provisions should be made for a sound system to provide music and announcements to public areas.
- Empty conduits should be installed for private and public coin and calling card/credit card telephones.
- Power for vending machines, ice sales storage and other miscellaneous loads should also be checked.

F.21 <u>Swimming Pools and Fountains</u>.

- When swimming pools or fountains use electric power for motor driven water pumps, underwater lighting, surface lighting, overhead lighting or outlets for pool cleaning, etc., a serious life safety hazard can develop.
- The quality of wire, fixtures, etc., should be the best obtainable for such wet conditions.
- All electric pumps and valves should be isolated from the public.
- The grounding system of all electrical devices, and pump and valve equipment should be of minimum impedance.
- Electrical potential should be prevented when the grounding system fails or deteriorates, it should be removed, replaced, and tested.
- System should be periodically tested to ensure that acceptable ground resistance values are maintained. As a minimum, comply with the NEC, Article 680 [1].
- Lighting luminaires and circuiting, bonding of metal structures, grounding connections, ground-fault interrupters, and low-voltage lighting.
- The trend toward low-voltage lighting, generally 12 V, is gaining attention due to the availability of lighting equipment.
- Two-winding transformers, and ground-fault circuit interrupters.
- When low-voltage lighting is applied, design details on sizing equipment and wiring are of prime importance.
- Lighting fixtures are installed 18 inches below normal water level and mounted in pool walls. Wet niche types of lighting fixtures are preferred.
- If above-water lighting is used, it is imperative that it be designed to reduce surface reflection to ensure that a lifeguard can easily see the entire bottom of the pool.
- Effective bonding of all metallic parts of a pool's structure, including lifeguard stands, ladders, diving board stand, and other metal parts, can be accomplished with a solid copper conductor.
- Under water lumenaires to be IP (68)

F.22 Theaters.

F.22.1 General

- Theaters have a marquee with illuminated signs and decorations, in addition to a concentration of lighting outlets on the soffit to illuminate the entrance to the theater and to attract the eyes of prospective patrons.
- Electric signs that show the name of the theater are also frequently placed on the front of the building.
- The entrance lobby and foyer are generally decorative in nature, and the engineer should study the architectural details so that the lighting will blend properly
- The minimum wattage per squire foot used in the foyer may be about 25w/m2 and, in the lobby, about 30w/m2.
- Ticket booths may require a telephone, a signal system, and, possibly, a special outlet for an electric heater, air conditioner and fan.
- Provision should be made for aisle lights, exit lights, and orchestra and emergency lights.
- The projection booth should have provisions for a minimum of two projection machines, each supplied by a separate circuit, floodlights, spotlights, a rewinder, exhaust fans, an intercommunication signal system.
- dc power supply for projection arc lamps.
- Provisions may be made at several locations for floodlights or spotlights.
- Theaters may have passenger elevators and escalators to serve the patrons who are seated in the mezzanines and balconies, orchestra lifts, stage lifts, and turntables have been provided.
- Large motion picture theaters, auditorium lighting is controlled by dimmers on the stage switchboard. Border lights, floodlights, and spotlights are controlled individually.
- The wiring system may be complicated, depending on the lighting effects required to suit the type of entertainment provided.
- The stage requires several rows of border lights.
- Outlets for special electric effects, and motors for operating the fire curtain, contour curtain, roll curtain, heavy drops, ventilators at gridiron, and numerous other items.

F.22.2 General Lighting Systems.

- General lighting is required for the gridiron, fly galleries, dressing rooms, etc.
- The power load for air conditioning is a major item that deserves careful consideration in the preparation of the electric system.
- Convenience outlets should be provided for cleaning appliances and general maintenance work.

F.22.3 Stage Lighting Systems.

- All lighting fixtures (instruments) involved in a stage presentation are controlled through patch panels and dimmers
- Each fixture or group of similar fixtures is carried back to the patch panel as an individual two wire circuit.
- Common neutrals are not used because phase connections vary.
- Dimmer switchboards produce heat and require ventilation, and should be located in a sound-isolated area.

- A lighting control booth with a good view of the stage is necessary and should contain a stage lighting control panel from the lighting can be controlled.
- The control panel controls the many dimmers and contactors to provide the desired stage lighting for each scene, each scene will require a different illumination configuration, and the sequence of illumination settings is typically repeated for each production.
- All of this may be preset and sequenced by a microcomputer in the control panel.
- An emergency panic switch is usually incorporated and is used to immediately restore the theater egress lighting upon an indication of a threatening condition.
- The booth also will normally contain follow spots, and slide and motion picture projectors.
- Sound control booth is frequently located near the lighting control booth.

F.23 Transportation Terminals.

- Transportation terminals consist of passenger terminals for railroads, buses, and aircraft that interface with platforms, boarding ramps, ticket and reservation areas, as well as concessions or stores, theaters, and entertainment areas for the travelers' convenience. Concession areas require general provisions.
- Provisions should be made for supplying metered or rent-included power to each tenant. In some cases, such as in airports, the terminal may very well be a shell in which most of the areas are built by tenants, which conform to tenant-established building standards and approved construction methods.

F.23.1 Requirements for All Terminals.

- The following general requirements apply to all terminals:

1) Fire alarm systems, which may include smoke detection systems, are usually interconnected to a central station for transmission of alarms to the fire department. The usual fire alarm pull-boxes may be supplemented by a number of telephones that may be used for information, to call police and fire emergencies.
2) Sprinkler supervisory and alarm systems are tied into the fire alarm system for transmission of alarms to the fire department.
3) Public telephones and other telephones served by the local telephone company usually require only conduits. If the system is owned by the phone company, it will install equipment and cables. A room for telephone services, which meets the standards of the telephone company, should be provided. The telephone company will install coin and calling card/ credit card public telephones to meet various architectural requirements; however, local private systems, which may be needed by individual transportation company.
4) Terminals require public address systems that may be controlled from more than one location and that may require zoning so that announcements can be made in different loading, lounge, and baggage areas. One of the major problems in designing public address systems is the use of high-powered speakers that are too widely spaced, which results in distorted announcements. The use of lower powered speakers closely spaced, particularly where noise levels are high, with automatic variable volume control based on ambient sound levels is desirable. Provision should be made for background music, which is often trans. mitted from commercial specialists. Provisions may be required for automatic departure announcements when established schedules require very frequent departures, such as bus terminals.

5) Master clock systems may be used to ensure that all clocks are maintained at the same time, and that manual resetting is not required after temporary power outages, or for changes related to daylight saving time. Carrier frequencies (generally 3000 Hz) for master clock circuits are often superimposed on power distribution systems for clock correction and program signals.
6) Arrival and departure signs may be displayed on closed-circuit television or variable message signs. Both systems are usually driven by microprocessors in newer installations and may contain elaborate storage information systems that involve schedules. Both systems can include an automatic roll down feature in which messages are kept in sequence regardless of changes and, as items are removed or added.
7) In a modern terminal, security systems will usually include closed-circuit television surveillance of public areas, taxi loading areas, and other locations where the public should be protected. Closed-circuit television usually includes a provision for zooming and scanning (pan and tilt). The special purpose telephones may also form part of the terminal security system.
8) Directional signing may consist of backlit or frontlit signs with off/on control. Sign colors and designs, usually designed in conjunction with graphic specialists, are essential to provide adequate terminal control. In some cases, advertisement signing is combined with directional signing; the former often being an important source of revenue for the facility. Outlets should be provided for other signs.
9) Outlet systems should be adequate to serve vending machines, water coolers, temporary displays, and for cleaning and maintenance equipment. Codes may require the use of ground-fault circuit interrupters to ensure the protection of personnel.
10) A modular system of local wiring, outlets, and metering to accommodate future change in rentable space is desirable.
11) Electronic dispatching control and surveillance systems may be used to indicate the departure times of vehicles, trains, or aircraft, to observe such departures, and to direct traffic through the use of special signing systems. The location of vehicles in docks may be detected through loop presence detectors, treadles, or similar sensors. When complex systems are involved, dispatching boards may be used. The dispatching boards may be manually or automatically operated to indicate the status of loading platforms and traffic. Closed-circuit television surveillance of areas where traffic congestion may develop should be provided. Ramps into or out of terminals usually also require close surveillance.
12) Computer systems are frequently used to control terminal and tenant systems. When separate rooms are required for computer installation (as distinct from certain microprocessor intelligent terminals that may be installed in open areas) raised flooring, separate air-conditioning systems, special fire and smoke detection systems, flame suppression agent systems, and separate emergency circuits may be required.
13) Emergency power systems require the use of engine- or turbine-driven alternators. Uninterruptible power supplies are usually only required for special systems, such as computers and alarm systems; however, UPS systems are often furnished as part of the special equipment installation.

14) Building management system. includes alarm detection and indication points for items such as escalators, elevators, fans, pumps, chillers, cooling towers, temperature detectors, and other similar devices. The status of operation, such as up or down for escalators, emergency trip-out of equipment, over temperatures, area lighting status, and similar alarms, will be audibly and visually indicated, usually with a reset provision for audible alarms and always with a provision for indicating multiple alarms. The building supervisory system may also be used to automatically control heating, ventilating, and air conditioning equipment and to interface with building electrical owner demand equipment to optimize overall power utilization.
15) Other communication systems, some of which may be owned by tenants, can include portable radio systems and pagers for larger areas, special building antennas and loops, and automatic printer systems, such as facsimile machines, and annunciators. Provisions may also be made to communicate with special staff by the use of coded announcements on the public address system. It is usually not wise to announce uncoded emergency situations on the public address system.
16) Baggage handling systems are fairly simple, involving the use of manual labor for the most part except at airports where systems become quite complex (described below). A major consideration is to provide telephones at convenient locations for obtaining porter service and to provide some form of alert signal so that porters will know that they are being called.
17) It may be desirable to use special spaces, such as shafts, utility tunnels, or trenches, to provide a practical means of handling cabling at minimum cost. It is often possible to utilize cable trays, particularly for communication wiring. Communication wiring may consist of coaxial, fiber-optic, multi-conductor control, signal, telephone, and data cables.
18) Because new terminals are usually individualized, highly creative architectural designs, the lighting design should be closely coordinated between the engineer and the architect or lighting consultant. When high ceilings are involved, HID sources are usually selected as the primary source of lighting. Energy conservation and maintenance considerations have created a tendency to move away from incandescent lighting.

F.23.2 <u>Airports</u>.

- Automated baggage handling systems of the carousel or moving belt type are supplied from extensive conveyor systems that lead to the airport apron areas.
- For handling aircraft cargo, very extensive electronically controlled systems, some using linear motors, are utilized.
- Most ticketing and reservations operations are handled through computerized systems; however, the main or central computers are often remotely located in an airline building off the airport grounds.
- Extensive communication wiring systems are required for ticketing and communications between baggage, apron, ticketing, and gate areas.
- Extensive signing is required at each gate position as well as signing to indicate the location of gates from which flights will be departing.
- Provisions have to be made for security control, particularly for the installation of detection equipment and control stations, which are usually at the entrance to each gate to detect the presence of weapons and explosives.

- While terminal area lighting may be held to relatively low levels, perhaps 250 LUX much higher levels are utilized in the ticketing areas.
- The control tower design, which will include provisions for air traffic controllers, ground traffic controllers, and possible facility surveillance, should be designed in conjunction with the appropriate air traffic control authorities.
- Special expertise is required in the design of these airport systems and of the related runway and taxiway lighting systems.
- Airport control systems are specified in detail in FAA 150/5360-4B, Utility Airports Advisory Circular [B12], FAA 150/5360-9, Planning and Design of Airport Terminal Facilities at Non-Hub Locations Advisory Circular [B13], FAA 150/5360-11, Energy Conservation for Airport Buildings Advisory Circular [B14], FAA 150/5360-12, Airport Design Standards Advisory Circular [B15], and FAA 150/5360-13, Planning and Design Guidelines for Airport Terminal Facilities Advisory Circular [B16].
- At airline gates, which may be some distance from the ticketing booths, 500 kW or more may be required for 400 Hz alternators that provide power to the planes while they are parked.
- Emergency fuel shutoff and alarm systems are provided when fuel piping systems are used.
- Requirements for plane control at gate positions are usually specified by the airline.
- Provisions should be made for apron lighting when work will be going on while the aircraft is being loaded, serviced, and refueled.
- Hangar lighting is almost always of the HID type supplemented with emergency lighting for power outages.
- A typical large hangar may require in excess of 1000 kW of light. Grounding systems have to be provided for the aircraft both in the hangers and on the aprons, and at loading and fueling positions.
- The power distribution system for larger airports is almost always at medium voltage with energy supplied at individual buildings either from spot-network systems or from medium-voltage primary transfer switches.
- For reliability considerations at larger terminals, multiple-feed selective systems are almost always used.
- Extensive vehicle parking areas are required for short- and long-term parking. Where parking charges apply, toll plazas should be established.
- Newer designs utilize unmanned gate entrances with ticket issuing machines and manned exits that may contain provisions for automatic fee calculations.
- The tendency is to move toward the installation of "intelligent" terminals that perform all fee calculations and report to a central computer.
- Parking lot signing that utilizes changeable message signs and lighting fixed signs is essential when traffic is directed to different lots.

Section (G)
Material Submittals Check List

No.	Main Check Items
G.1	**11 K.V. Switchgear**
1.	C.B Type (SF6 / vacuum)
2.	Size of the C.B (A), position, proper scaling, close fully (No gap)
3.	Arc interrupting media – vacum C.B and drawiable for (VCB)
4.	Altitude is 1000 m above see level max.
5.	Temperature (20 ºC - 50 ºC) & R.H. 100% at 30 ºC
6.	Nominal voltage 11 kv (VCB)
7.	Max voltage 12 kv
8.	Max symmetrical fault level = (25 KA / 31.5 KA) / 3 sec or ACC. to 11 KV fault level
9.	Impulse voltage 75 kv
10.	Frequency 50 Hz
11.	IP to be IP3X
12.	Time duration of Arc shall be ≥ 1 sec.
13.	Supply voltage for opening device = 30 v. (D.C)
14.	Supply voltage for spring charging = 240 v. (AC)
15.	240 v. (CA) / 50 Hz thermally protected motors to charge operating spring in case of motor charge foil, control circuit to be applied to operate manual charge and charging spring motor shall be inter locked in this case.
16.	C.B remote close and opening facility and all the alarm to be remote shall be wired up to terminal block
17.	Drawable type.
18.	Instantaneous OC/EF relay
19.	Pilot cable supervision
20.	Cable differential relay
21.	Winding temp. trip for oil TX.
22.	LV REF protection.
23.	IDMT OC/EF protection.
24.	Pressure valve trip for oil TX.
25.	Current check guard relay.
26.	Measuring C.T,s with class (1) and 15 VA burdin, correct ratio & polarity
27.	Protection C.T,s with class (x) or class 5P10, correct ratio & polarity
28.	Voltage transformer details, correct rating, correct wiring
29.	Level of protection enough to protect on operator in the event of an internal arc within the switchgear accessibility shall be type -A
30.	Interlocks mechanisms shall be mechanical and operated shall be provided with labels which shall be visible
31.	Cable sealing boxes glands and terminal lugs shall be supplied
32.	Set of metallic shutters to be provided to cover eash three – phase group of fixed isolation contacts
33.	Pilot wires shall be isolating type
34.	Switchgear to be connected to SCADA system to fulfill close & open from remote monitoring current and voltage.
35.	Rating of busbar, tightening torque, proper sealing
36.	Cubicle dimension, proper sealing, no physically defects easy opening & closing, paint properly cures.

No.	Main Check Items
G.2	**Transformer**
1.	Transformer Type (dry – oil) – Country origin - Manufactorer
2.	Size in KVA
3.	Voltage at full load (11 / 0.415) KV
4.	Voltage at No load (11 / 0.433) KV
5.	Frequency 50 (HZ)
6.	Ambient Temperature 50Cº
7.	Standard IEC 726
8.	IP Rating (IP23)
9.	Winding insulation Levels Class (F)
10.	Tapping (0, ±2.5%, ± 5%)
11.	Cooling (AN-ONAN)
12.	Cable Box (HV/LV)
13.	Earthing
14.	Impedance Voltage (Z) %
15.	Winding (Copper) / Primary and Secondary
16.	Incoming & Outgoing (Cables or Bus Duct).
17.	Relative Humidity (100%)
18.	Dimension of transformer related to Tx room details
19.	Weight in (kg)
20.	Testing Certificate
21.	Connection group DYN11
22.	Shop drawings
23.	Noise levels to be TEC publication 551 to be with noise reduction support blocks
24.	Off circuit TAP change
25.	Temp sensing theromister in L.V coils to indicate winding (t) to provide alarm and trip for H.V C.B and to operate forced ventilation
26.	No. of phase (3ph)
27.	System neutral 4 wire
28.	H.V insulation level 12kv
29.	Impulse kv 75 kv
30.	H.V. conductor type Bottom / top entry XLPE cable
31.	LV conductor type Cable - Bus way) top / bottom
32.	Insulation resistance test winding
33.	Resistance measuring through bolted connections with low-resistance ohm meter
34.	P.F test Acc. to IEC 76/1967 and VDE 0532/71
35.	Turns ratio Test Acc. to IEC 76/1967 and VDE 0532/71
36.	(R) for each winding and Impedance Test Acc. to IEC 76/1967 and VDE 0532/71
37.	Iron Loss and No Load current Test Acc. to IEC 76/1967 and VDE 0532/71
38.	Insulation Double voltage test Acc. to IEC 76/1967 and VDE 0532/71
39.	Winding Loss and Impedance Voltage measurement.
40.	Polarity measurement test.
41.	Industrial frequency 50 HZ insulation endurance test.
42.	Temperature rise test.
43.	Surge voltage test.
44.	Noise Test.

No.	Main Check Items
G.3	**Main L.V.P.**
1.	3 phase – 4 wire, 415V, 50 HZ
2.	$I_{S.C}$ (KA) and duration (sec.) for enclosure
3.	Thickness of sheet steel for folded steel
4.	Cover (1.6mm) thick sheet steel
5.	Height 2200 mm
6.	900 mm height of ACB terminal (Bottom)
7.	Full neutral busbar
8.	Cable boxes, glands, lugs
9.	Control wiring (2.5mm2) as B.S 5467
10.	Wiring protection with 20A (B.M.F)
11.	Earth bar (300mm2)
12.	Form segregation
13.	Incoming (Top / Bottom)
14.	Outgoing (Top / Bottom)
15.	Busbar rating (vertical – horizontal) / (TP + N) 100% and Earthling 50%
16.	Busbar to comply with IEC-439-2, BSEN 61439-2
17.	Spare capacity than tapping outlets
18.	Busbar to be rectangular and high conductivity copper
19.	Fixing bracket for busbar 1.5mm distance
20.	Busbar material – copper
21.	Neutral system (TNS – 3P+N+E)
22.	Climatic type – normal
23.	Atmosphere type – ordinary
24.	Indoor
25.	Degree of protection (IP)
26.	Ambient t. 50ºC
27.	Apparatus take drawable in fixed component.
28.	Access for (incoming / outgoing)
29.	Cabling from rear
30.	Dimension of L.V.P related to L.V. room approved
31.	Charger with battery (Nickel – Cadmium 30 V. D.C for triping)
32.	All CT'S for measurements class (1)
33.	CT'S for protection class (X)
34.	Burden for CT'S is 5VA
35.	Voltmeter (0-500V) – 7 position (Phase – Phase) & (Phase – Neutral)
36.	R.E.F relay (10% to 40%) or (20% to 80%) setting
37.	All devices to be calibrated at 50 ºC
38.	Tapping boxes to be provided
39.	Ammeters with maximum demand indicator
40.	ASTA certificate for company name for assembling with test by ASTA in the name of company and enclose manufacturing

41.	(7) type test to be included in ASTA as IEC No. 8:21 to 8:27 as following:
	a. Temperature rise limits
	b. Dielectric properties
	c. Short circuit withstand strength
	d. The effectiveness of the protective circuits
	e. Clearances and creepage distance
	f. Mechanical operation
	g. The degree of protection
42.	(3) Years as minimum experience in the market for commission of L.V.P not for Factory (L.V.P operation)
43.	All test equipment should have valid calibration certificates
44.	REF testing facility and qualified engineer to be aware and testing methods and calculations and graphical plots
45.	Factory test (routine) – Meger SKV – primary and secondary injection test kit – all relays test kit MA tester for REF – SHRCK list – Hipot Test Equipment 2.5 KV /1 sec dielectric test)
46.	Factory building (separate store facility, Assembly bay – tools area – working area, QA/QC area – testing area, safety equipment, Proper earthing for safety during testing
47.	N.O.C from the manufacturer of functions (C.B'S) to use the enclosure of this company for his products.
48.	Should be as BS 5486, IEC 439 & IEC 947
49.	C.B coordination study
50.	S.C calculation
51.	I/T characteristic must be plotted on a log papers showing choice of C.B and relay setting are correct for coordination refer to curves plot
52.	3P+N, fully SH rounded, insulated and electro – timed
53.	Insulation voltage 800V and impulse voltage 8KV
54.	**ACB (Main C.B)**
	a. A.C.B to be with drawable and spring charged
	b. Manually / motor closing mechanical
	c. No. of A.C.B poles
	d. Mechanical ON/OFF position according to BS. EN 60947-2
	e. Manual & automatic isolating device
	f. Shunt trip 30 V. D.C
	g. Separate cubicle for all ACB
	h. Is.c (KA) and duration – 50ºC
55.	**MCCB,s**
	a. Triple pole, 415V, 50 HZ
	b. Magnetic short circuit and thermal adjustable
	c. ACC to be B.S.E.N 60947-2
	d. Is.c (KA) and duration

No.	Main Check Items
G.4	**Capacitor Bank**
1.	Size in KVAR – Country origin – compliance statement
2.	No. of steps
3.	Main incomer C.B
4.	C.B for each step in (A) 130% IN
5.	Contactor for each step in (A) 130% IN
6.	Ambient temperature 50ºC
7.	Damping reactor with enough reactance
8.	Damping reactor connected in series
9.	Thermostat inside panel with ventilation fans to work automatically in case of increasing temperature
10.	Capacitor to be dry type
11.	Non flammable insulation for capacitor
12.	Shunt resistance to discharge the value of capacitor to be 50 V. during 1 min.
13.	Continues rating volt 130% from (V_N)
14.	Rated current for capacitor to be 110% (I_N)
15.	UL tested capacitor
16.	CSA approval for capacitor
17.	0.5 watt losses or less per one KVAR of Cap.
18.	C.B to be with short time delay setting
19.	Over pressure disconnector for capacitor
20.	High breaking capacity fuse for capacitor.
21.	Rated frequency 50HZ
22.	Busbar rating (Amp)
23.	Busbar short circuit (KA/Sec)
24.	Enclosure design
25.	ASTA certificate for panels
26.	MCCB'S Type test
27.	Indoor
28.	Relative humidity @ 50ºC
29.	Entry (Top / Bottom)
30.	IP (31)
31.	Neutral system (TNS 3P+N+E)
32.	No parallel operation
33.	Type of climate – normal
34.	Type of atmosphere – ordinary
35.	Lover Ventilation for enclosure
36.	Indicating lamps with fuses
37.	Automatic regulator
38.	On delay timer (0.l-30) Sec
39.	To be furnished with pressure sensitive interrupter for Capacitor in some time
40.	5 years for warranty
41.	LED display to show the stage that are ON
42.	Programmable target cosine selector to provide load P.F

No.	Main Check Items
G.5	**SMDB'S & DB'S**
1.	3 phase / 4 wire / 50HZ / 415 V AC
2.	Wall mounted / recessed
3.	According to BS-EN/61439-2 for SMDB'S & BS-EN/61439-3 for DB'S
4.	Fult level for SMDB'S & for DB'S in (KA)
5.	Ambient (t) 50 ºC
6.	Dimension of materials related to actual dimension of electrical room at the site
7.	Main incomer for DB'S and no. of pole / MCCB
8.	No. of way
9.	Rating, number of outgoing (MCB'S – ELCB'S – MCCB)
10.	Busbar rating
11.	Min breaking capacity is 9KA / 415V for MCB and ELEB,s
12.	Type © sensitivity for MCB'S
13.	Magnetic and thermal trip
14.	For ELCB'S to be 30 mA sensitivity
15.	Operating time not exceeding 20m sec
16.	Designed of minimum 10,000 switching operation of devices
17.	Residual C.C.B with MCB
18.	No of pole & rated current
19.	Form segregation
20.	Glanding providing for cables
21.	Country of Origin
22.	Manufacturer Drawings
23.	Minimum 3 years in service with satisfaction use
24.	Kema Test Certificates
25.	Busbar Rating
26.	IP rating

No.	Main Check Items
G.6	**Busbar**
1.	Country of Origin
2.	Manufacturer data include catalogue cuts
3.	Compliance statement
4.	5 years in service with satisfaction use.
5.	Busbar rating - Kema Certificate
6.	To be copper
7.	Busbars to be IP-54 vertical , IP-65 horizontal
8.	Supporting to be not more than 3.0 meter between each others
9.	Declaration of fire resistance for 240 minutes (If required)
10.	Fire barrier through wall & floor which passing (fire resistance barrier) and additional barrier to be fitted in the mid –way between floor and ceiling if the distance between them exceed 3.0 meter
11.	If length of busbar excess of 4.0 meter in straight length, expansion joints to be fitted
12.	Minimum certified short circuits symmetrical ampere rating shall be as main LV Panel
13.	Busbar insulation and insulating supports will be made from insulation flame retardant and self extinguishing, and hygroscopic properties
14.	Busbar shall be carry it's rated current without exceeding temp. Rise of 55 ºC over an outside temp of 50 ºC at 100% R.H.
15.	Shop drawings in details to be submitted and approved before manufacturing.
16.	Fire rated J 50 834 / if Applicable - Normal type 60 minute F.R refer to IEC 61439 - 129 minute F.R refer to IEC 60331 - 180 minute F.R refer to IEC 60331 - 240 minute F.R (cast resin body) refer to IEC 60331

No.	Main Check Items
G.7	**Central Battery System**
1.	Country of Origin
2.	Manufacturer data include catalogue cuts
3.	Compliance statement
4.	5 years in service with satisfaction use.
5.	Capacity of the CBS is required be adequately sized to take 20% spare capacity
6.	CBS shall be suitable to ambient temperature 50 ^{o}C & 100% humidity
7.	Mode of operation to be submitted
8.	Compliance statement with specs to be submitted
9.	Block diagram of the CBS to indicate input, rectifier, batteries, battery charger, inverter ATS / transformer and output.
10.	Civil defense approval for related emergency & exit sign luminaries
11.	Dimension to substantiate the location of the major equipment as indicated in S.L.D.
12.	Schematic diagram to be submitted
13.	Sample of emergency and exit sign luminaries for approval.
14.	Applicable local codes that is Civil defense regulation.
15.	Specific location of related equipment inside it's room with proper dimension
16.	Coordination with other disciplines
17.	Installation to be done by manufacturer certified personnel
18.	System should have minimum 5 years reference in country
19.	To be comply with ICEL 1004 & 1009
20.	To be comply with BSEN ISO 9001:2006
21.	Permissible transformer time incase of failure of the main supply should be 0.5 sec.
22.	Enclosure shall be resistant to heat and fire comply with section 13 EN60598-1 and clause 13.3.2 @ 850 ^{o}C
23.	Enclosure for battery housing should comply with EN 50272-2
24.	IP not less than (IP 21)
25.	Re-charging of battery to be at the minimum rated voltage for 12 hrs and discharge at rated current to 80% of rated duration
26.	Charger & rectifier should comply with EN 60146-1-1 & EN 50272-2
27.	ATS & electronic devices should comply with EN 60947-4-1 and EN 5027-2
28.	Response time for deep discharge protection to be less than 5 second and consumption valve to be not more than 0.2 A per 100 AH rated capacity of battery.
29.	There should be red light emitting diode type charge indicator and internal control circuit.
30.	Charger to be solid state.
31.	Operating voltage 240V-1 phase 50HZ/AC
32.	Main supply to be two live supplies One switched and one un switched.
33.	Voltage drop calculations shall be submitted for all circuits.
34.	Battery type.

No.	Main Check Items
G.8	**Cables**
1.	Manufacturer of wires & cables has been in satisfactory use in similar service not less than 5 years
2.	Manufacturer to be approved by local authority for electricity
3.	25 cm length cables of each type to be submitted as a sample.
4.	Copper conductor to be stranded for section 2.5 mm^2 and above
5.	Signal & control cables shall have solid conductors.
6.	Conductor size to be as shown on the drawings
7.	Insulation type to be as specified type.
8.	Colour code shall be maintained throughout the entire installation
9.	Sufficient length for straight – through pull from termination to termination
10.	Labels & seals to be delivered to site with cables
11.	Fire resistance cables to be copper conductor XLPE/SWA type, fire rated for 3 hours (950 ^{O}C), category C, W and Z with normal operating temperature (90 ^{O}C) to meet BS (6387)
12.	For emergency light cables shall be FP200 flex and shall be installed in metallic conduit.
13.	Ambient temperature 50 ^{O}C.
14.	Armourd / non armourd
15.	No. of core for each type.
16.	Earthing conductor for each size.
17.	All cables shall mark of identification of the manufacturer and it's standard for manufacturing
18.	Jointing in the cable not permitted.
19.	All wiring & cables shall be terminated with sweated or compression type lugs.
20.	Glands for cables shall be purpose and made.
21.	For joints and taps in cables thermosetting insulation compound (or resim) by use of appropriate tinned copper ferrules crimped on to the conductor and taped before pouring in the compound.
22.	Joints to be accessable as made in tap boxes
23.	For cables sizes up to 10 mm^2 made by barrel type connectors with pinching screws
24.	Means of identification an engraved brass securely fixed to the cable sealing box.
25.	Identification shall give, cable size, number of cores, cable reference number.
26.	Physical damage shall be checked on site
27.	Megger test for continuity phase to phase and phase to ground before connection after installation
28.	Acceptable manufacturers
29.	All cables, wiring to be relevant IEC / DIN / VDE
30.	MICC to be copper conductor copper sheath
31.	Voltage drop calculation to be attached.

No.	Main Check Items
G.9	**Isolators (Disconnector Switches).**
1.	Manufacturer data includes catalogue cuts for all type of safety and disconnected switches.
2.	Compliance statement & country origin.
3.	Switch blades fully visible in the off position when the door is open.
4.	Removable are supperssor where necessary to permit easy access to line side lugs.
5.	Platte all current carrying parts.
6.	Provision for field installed fuse pullers.
7.	Solid neutral where required.
8.	Heavy duty load break type 4 poles.
9.	Rating in ampere
10.	No. of poles.
11.	Voltage rating – 660V
12.	Maximum fault level.
13.	Category AC – 23 or as drawing
14.	Hinged door & cover.
15.	Handle position to indicate if switch is ON or OFF.
16.	Position for padlocking handle
17.	Switch mechanism integral with the box not the cover
18.	Defeatable dual cover interlock to prevent inadvertent opening of the switch door in the on position or closing of the switch mechanism with the door open.
19.	IP rating.
20.	Ambient Temperature ^{O}C.
21.	All isolators to be type Nema-4 for indoor installation.
22.	All isolators to be type Nema-4X for outdoor installation.
23.	Fuse size and type related to fault level for fusable disconnector switch.
24.	Insulation test voltage on each pole phase to phase & phase to ground for one minute.
25.	Fused or unfused type.
26.	To be comply with DIN/VDE, IEC, EN, NEC, UL and Nema standards
27.	Metallic or non metallic body
28.	Rewinable fuses shall not be acceptable.
29.	All fuses to be H.R.C as BS 88
30.	Suitable isolators to be used (plastic / polycarbonate / metallic on closures shall be submitted

No.	Main Check Items
G.10	**Raceways, Boxes and Fittings**
1.	Manufacturer details
2.	5 years in service with satisfaction use.
3.	Comply with VDE/DIN, IEC, BS, NEC, NEMA.
4.	Samples 15 cm length for all types of raceway.
5.	Compliance statement with specification
6.	For (R.G.S.) rigid galvanized steel pipes to be hot Dip galvanized outside.
7.	Galvanizing to be after fabrication.
8.	For polyvinyl chloride conduit (PVC) to be self-extinguishing.
9.	PVC pipe to be heavy gauge.
10.	To meet BS 4607, BS 6099 and BS 7671
11.	To be suit concrete encasement.
12.	Direct burial, schedule 40 conduit.
13.	Minimum 20 mm for lighting and power and minimum 25 mm for telephone & TV
14.	All accessories (elbow fittings – adopters – knockouts…) to be from same manufacturer.
15.	Corrosion resistance metallic conduits fittings (RGS)
16.	Sealing fittings of threaded as iron type. (R.G.S)
17.	Brushings of metallic insulating type (R.G.S)
18.	Locknuts of the bonding type with sharp edge of (R.G.S) digiging into the metal wall of enclosure. (R.G.S)
19.	Jaskets for outdoor pull boxes
20.	Expansion fittings at isolating slab joints vibrating equipment.
21.	Fexible conduits for entries, exits and outlets vibrating equipment.
22.	Rubber jacketed recessed outlets.

No.	Main Check Items
G.11	**Lighting**
1.	Country of Origin
2.	Manufacturer data include catalogue cuts
3.	Compliance statement
4.	5 years in service with satisfaction use.
5.	Electrical rating for ball as 2 lampsum
6.	Mounting
7.	Photometric data
8.	Samples for all fittings
9.	All luminaires to be manufactured IEC.598-1 and 598-2
10.	To be photometrically tested
11.	Lamps to be compatible with control gear used
12.	Sheet steel components to be suitably pre-treated and electrostatically spray – painted using acrylic polyester or epoxy powder.
13.	Luminaires to be fitted with high frequency or electronic control gear shall be disconnected before the circuit is tested for insulation resistance
14.	For indoor fitting to be IP 20 & class (1)
15.	For outdoor fitting to be IP 44 & class (1)
16.	Diffuser and louvers to be restrained to prevent them from falling out of the body of the luminaires when re-lamping
17.	Wattage of lamps and type to be as specs
18.	Minimum life time for lamps to be 12000 hours
19.	Voltage of lamps.
20.	Lamps, ballasts to be daimmable type in case of daimining system
21.	Original certificate to be submitted with materials to show Client name and project title
22.	Lighting illumination calculation for leds lighting

No.	Main Check Items
G.12	**Cable Tray**
1.	Manufacturer details
2.	5 years working with satisfactory for similar services
3.	To be comply with DIN/VDE,IEC,NEC,IEEE and NEMA
4.	Sample required with 30 cm length with all accessories and fittings
5.	Usable minimum clear loading depth: 8cm
6.	Straight sections to be 3.7-4 meters in length
7.	Manufactured from mild steel
8.	To be hot dip galvanized after fabrication
9.	Minimum thickness of cable tray to be 1.5 mm, thickness for cable tray 30 cm width or less and 2 mm for tray width 40 cm and above
10.	Adequate supports shall be provided to prevent stress on cables where they enter or leave the tray
11.	Maximum deflection to be 0.5% in longest spon, so it should be specially reinforced
12.	Bends for tray should be dimentioned such that cables may not be curved less than 15 times of diameter
13.	Galvanizing thickness to be 60-70 microns
14.	Extra heavy duty inside return flange to be used”
15.	Cable tray to be chosen according to number and diameter of cables and laid such that their outer redius as spaced a distance equal to the diameter of the largest cable.
16.	All cable trays installed in mechanical room, plenum rated area and roof to be covered with cover.
17.	Non welded jointing of (Transverse members) to insure integrity of fault ground fault.
18.	For cable tray ventilation, the valleys of the corrected bottom to have 6 cmx10 cm rectangular holes punched along the width of the bottom.
19.	To be heavy duty type.
20.	Ladder type of cable tray shall be used to heavy cabling.

No.	Main Check Items
G.13	**Wiring Accessories**
1.	Samples for all wiring accessories
2.	Manufacturer data
3.	Products for manufacturer to be in statisfactory for not less than 3 years
4.	All products to be from same manufacturer
5.	Compliance statement to be submitted
6.	All accessories to be IP-55 for weather proof in indoor
7.	All accessories to be IP-67 for weather proof in outdoor
8.	Metal boxes to be used for flush mounting wiring accessories
9.	All boxes to be incorporated a suitable earth terminal
10.	For more than one phase multigange switches separation by fixed screens to be used and warning notice showing maximum voltage present for live parts.
11.	Switches
	- To be comply with BS 3676
	- Rated not less than 20A, 240V (AC)
	- Type of switches (oneway-twoway-intermediate-pushbotton)
	- In outside position switches to be polycarbonate
	- All switches to be illuminated type
	- Ceiling rose shall be plug in type.
	- Ceiling rose connection to be by head resistance flexible wire.
12.	Socket outlets
	- Comply with BS 1363
	- Rating to be 13A-240V (AC)
	- Outlets complete with boxes not less than 35mm deep
	- Back box to be equipped with suitable mounting brass protective conductor terminal
13.	Floor boxes.
	- Made from zinc die-cast.
	- Covered with nickel galvanized to withstand 300 kg.
	- Non-permanent deformation.
	- To be suitable for no. of approved outlets as drawings.
	- To be suitable to the used tiles (carpet or marble) to be approved by arch.
	- To be hunk hinged lid without recess, lid offset for used position cable outlets.
	- Depth of floor box to be suitable for finishing screed.
	- Manufacturer details.
	- Compliance statement.
14.	Occupancy sensors.
	- Dual technology (Passive infrared and ultrasonic).
	- Ceiling mounted type 360 (degree).
	- Time delays 5, 10, 15, 20 or 30 minutes.
	- Operating voltage 240V, AC, 50 HZ.
	- UL listed and 5 year warranty.
	- Temperature and humidity resist.

No.	Main Check Items
G.14	**Earthing System**
1.	Country of Origin
2.	Manufacturer data include catalogue cuts
3.	Compliance statement
4.	5 years in service with satisfaction use.
5.	Earthing electrode to be circular cross section
6.	Rode with diameter to be 20 mm
7.	Rods to be copper clad steel
8.	Rod length to be more than 2.0 meter below summer water table
9.	Top of each rode electrode to be housed made of concrete pit for inspection and to be flush with ground level
10.	Thermo weld to be used for connection between rods and earthing copper cables
11.	Space at horizontal distance between parallel connected earth rods to be equal to their buried length.
12.	Buried not less than 44 inches below finished grade
13.	Resistance for earth of the electrode system should not exceed ohm in the drawings and the contractor should increase no. of pits to fulfill required resistance.
14.	Earthing conductors connections to main earthing terminal to be green/yellow PVC insulated.
15.	Minimum of two earthing conductors shall be installed and separately connected to distribution busbars
16.	Main earthing terminal to be from hard copper to IEC, DIN/VDE standards BS1987
17.	Earthing terminal cross section as indicated drawings
18.	Earthing bar mounting to be not less than 450mm above the finished floor level.
19.	Diameter of fixing holes shall not exceed one third of earthing bar width.
20.	Protective conductors between equipment earthing terminals and main earthing bar to be made of stranded copper insulated cables as dwgs.
21.	Appropriate compression type lug, bolt, nut and lock washers to be used for connection
22.	Sockets, lugs, bolts, nuts, washers, screws, rivets, clamps, cleats which come into direct contact with copper protective conductors bars shall be non- ferrous and to be manufactured from brass, bronze to avoid electrolytic or corrosion.
23.	The joints shall be made using zinc free brazing material with melting point of at least 600 ^{O}C
24.	Overlap between the two strips jointed shall not be less than the width of the largest conductor
25.	Manufacturer's data on earthing products and associated accessories
26.	Sample of earthing cables and accessories
27.	Shop drawings with dimensional layouts on architectural background drawings
28.	Manufacturer's qualifications for all earthing materials have been in satisfactory use in similar service for not less than 5 year
29.	To be comply with requirements for local codes DIN/VDE, BS 7430, IEC,NEC, UL and IEEE.
30.	Main earthing terminal to be bonded with metallic pipe services (water pipes, dry risers), non current carrying metal parts, intervening raceways, boxes.

No.	Main Check Items
G.15	**Diesel Generator**
1.	No. of Cylinder
2.	Mack of origin
3.	Compliance statements with specs.
4.	5 years working with satisfaction services
5.	Insulation class (H) stator & rotor with temp. rise according to F 105 ^{O}C over 40 ^{O}C ambient temp.
6.	Altitude
7.	Humidity 100%
8.	Ambient temperature 50 ^{O}C
9.	Rating at P.F 0.8
10.	R.P.M
11.	Net rotating power as drawings at 50 ^{O} Ambient
12.	Cooling system and remote radiator fins
13.	Bruchless with sailent pole type
14.	Field system with rotating exciter.
15.	3 phase, 4 terminal.
16.	Stare with grounding neutral
17.	(415/240) V
18.	0.8 P.F
19.	Frequents 50 HZ
20.	Control panel IP:44
21.	Exciter / AVR system is applicable, automatic voltage regulator (AVR) to be used for maintaining terminal voltage within ±2.5%
22.	Exciter to be 3 phase A.C
23.	Alarm & indication in control panel generator running – circuitry healthy – battery on charge – Gen. failed to start – overloaded – field failure – main ACB open – main ACB closed – battery charger failure – exciter diode failure.
24.	Control panel to supervise the followings: - Manual “test” Off & “Auto” switches - Engin “start” & stop push buttons - Emergency stop push button – close/trip switches - Earth fault relay – ammeters & voltameters - Frequency meter – UVR – attempt start relay – time delay relay for mains failure – Time delay relay for gen. into operation – timer for over run.
25.	Daily fuel tank relay 48 hours, fuel pump, accessories
26.	Independent earthing for generator
27.	Tests for generator (insulation winding resistance – voltage test – voltage regulation – over speed – full load test – temperature riser….)
28.	Alternator & exciter tests (some tests as generator).
29.	Control panel test (Visual inspection – over voltage – function for all alarms – manual function test – auto exciter – insulation resistance test).

No.	Main Check Items
G.16	**UPS**
1.	Manufacturer data
2.	Country of origin
3.	Compliance statement
4.	Size of UPS (KVA)
5.	Input voltage / output voltage ± 10%
6.	Frequency ± 5%
7.	Time duration
8.	Ambient temperature
9.	Relative humidity
10.	Manual load transfer availability
11.	Automatic load transfers between inverter O/P and A/C source
12.	Internal maintenance by pass or alternative path for a fully rated circuit
13.	Controls (Mimic panel – meters – critical output to display simultaneously – isolating transformer for transients – control logic.
14.	Alarm to indicate status (rectifier – failure – ground failure – DC over / under voltage – inverter failure – synchronizing failure – phase error – inverter over load – inverter under/over voltage – main failure – static switch failure.
15.	Operating elements - ON / OFF rectifier selector switch - ON / OFF inverter selector switch - Push button for alarm set/manual high rate charging / led test – phase selector switch – optional manual selector switch for by-pass
16.	DC ripple 1%
17.	P.F 0.8 lag.
18.	Battery overload 130% (0-60) sec.
19.	Harmonic distortion less than 4%
20.	Response protection adjustable (1-10 m. sec.)
21.	Battery IP /20
22.	Battery type (Nicole cadmium / lead acid)
23.	Type (Modular type / Normal type)
24.	System for windows version 4 core software
25.	Power supply details
26.	Modular controller
27.	Software features (Capacity – security – alarms – reports & monitoring – card handling – door control – logical input/output control – controller & modules – RF module – cord & leader
28.	1 phase / 3 phase - 3 phase / 3 phase

No.	Main Check Items
G.17	**Fire Alarm System**
1.	Certificate for fire civil defence department for approval for proposed brand
2.	List of projects supplied by the proposed vendor
3.	All components to be submitted in according with the basic design drawings (Civil Defence approval)
4.	List of all type of equipment and component with (Model Numbers – Mounting Accessories) and bill of quantities
5.	Compliance statement for the proposed system point by point with project specs.
6.	Calculation to support size of standby batteries
7.	(Zone list) with description of zones (alarm – monitor) as they would Appear on FACP
8.	Smoke detector comply with B.S 5445 part 7 and LPCB approved
9.	Heat detector comply with BS. 5445 part 5/1977 & LPCB approved
10.	Manual call points to comply with BS 5839 part 2 – 1983
11.	Main fire alarm control panel (type – No. of zone/ loops) – interfaces ….)
12.	Interface units
13.	Repeater panel as (BS 5839)
14.	Mimic panel
15.	Fire phone response time to be better than 0.25 sec. and system to be non blocking.
16.	Panel to be included twin LED indictors for (System Healthy – system Trouble – A/C supply healthy)
17.	Riser diagram for all equipment, size, type and number of all conductors & conduits and its interfaces.
18.	Fire alarm matrix & fire category
19.	Details for software graphics details
20.	Latest version for software
21.	Interface with (BMS, security – lifts – generator sprinklers – A/C) and other system.
22.	Manual call points response to be less than 1 sec.
23.	Sensor sounder to be with high output sounder and the output shall be 85 dbA.
24.	Sound alarm output 100dbA at 1 m with frequencies 970 HZ and 910 HZ.
25.	All wiring to be fire resistance type as BS 6387 categories C, W & Z - 1st – category for fire alone [cat A/3H/650 ^{O}C – cat B / 3H / 750 ^{O}C – cat C/ 3H / 950 ^{O}C) – cat S/20 min./ 950 ^{O}C]. - 2nd – category resistance - Fires with water spray, [cat W / 15min. / 650 ^{O}C / fire water spray, passing current] - 3rd – category for resistance of fire with mechanical shock [cat-x/650 ^{O}C/ 15 min – cat Y/750 ^{O}C / 15 min.- cat Z 950 ^{O}C / 15 min.
26.	Country of origin
27.	Availability of spare parts for future
28.	Warranty statement as specs.
29.	Manufacturer data and catalogue cuts.
30.	5 years working with satisfaction services.
31.	Approval for all products by fire civil defence

No.	Main Check Items
G.18	**IP Closed Circuit Television System**
1.	Manufacturer qualification
2.	Product data, original catalogue & marked UP for all
3.	Details bill of materials
4.	Details riser diagram
5.	Compliance list with specs point by point
6.	IP CCTV system component
7.	Country of origin
8.	Connection with local area network (LAN)
9.	Standard compliance DIN/VDE, IEC, NEC, NFPA-70
10.	Active component (core switches, Ethernet edge switches,….)
11.	Operating system to be based on Microsoft operating system
12.	IP colour camera - UP to 25 frame / sec – built in web server – built in motion detector – view live images from any network - Digital, 24-bit color – image sensor ½ inch interlaced CCD – resolution 380,000 pixel - Horizontal resolution 480 TV lines - Exposure back light compensating - Automatic gain control - Illumination range < 0.5 lux - Built in support for DC – iris lenses - CS mount lens fitting - DC iris – focal 3.5 – 8 mm - Image motion - Image frame rate up to 25 frame / sec. - 0 – 45 ^{O}C - 80% R-H
13.	Housing for O/D to be IP 66 & protection for sun shield, UV radiation, corrosion
14.	System password at work station level to limit control by the system operators
15.	Context sensitive help screens associated
16.	Keyboard
17.	Server equipments as latest configuration
18.	Work station equipment
19.	Efficient operation software for automatic system function with 5 years guarantee after completion the project in additional to warranty period.
20.	All PC work station to be removable from the system without loss of control
21.	Software should interface with network images, video servers.
22.	Building operating personal training required.
23.	Matrix switcher details
24.	LCD's details
25.	Interfacing with security system
26.	Wiring details

No.	Main Check Items
G.19	**Public Address System**
1.	Manufacturer data.
2.	Country of Origin
3.	Compliance statement
4.	Products of manufacturer to be in satisfactory for not less than 3 years
5.	All products to be from same manufacturer
6.	Battery backup for amplifier
7.	Loud speaker frequency band width to be in the range of 150 HZ to 20 KHZ
8.	Equipment panel and rack shall consist of: - CD player - 1 No triple cassette deck - 1 No AM/FM tuner - 1 No music source selects panel - 1 No patch panel - 1 No zones selector
9.	FM/AM tuner - Provision for up to six preset station - Sensitivity - Output level - Frequency range - Distribution <3% THD at 1 KHZ - Signal to noise ration <49 dB - Tape speed - Fast forward /rewind.
10.	CD Player - Frequency response - Signal to noise ratio 90 dB - Distortion <0.008% THD at 1 KHZ - Channel separation - Quantization
11.	Rack - Plexiglas door and lock - Ventilation panels between each item equipment - Details for equipments shall forward to consultant - Man/Machine interface terminal facilities to allow live speech broadcasts to be addressed to selected areas of the site and allow to initial of stored messages & alarm signals
12.	Speakers - Power in wattage - Operating voltage - On axis frequency not vary by more than ±10 dB over the range (150 HZ-20 KHZ) - Sensitivity - Normal input power - Equipped with fire-dome and thermal fusible link.

13.	Wiring - 2 core 1.5 sq.mm - MICC exposed / fire resistance screed type in embedded PVC conduit - Cable to be comply with BS 6387 - Maximum of 0.5 micro-farad inter core capacitance - Maximum 13 ohm per core - Cable screen must be capable of being earthed at each system device - Connection with FACP through 3 core 1.5 sq.mm - Not permitted to use more than 2 core for loop wiring due to in adequate separation and possible interference problem.
14.	Amplifier - Size in wattage - Operating voltage - Battery backup - Amplify audio signal - Microphone for live speech - Amplifier modules should meet the loud speaker requirements - Frequency band width 150 HZ to 20 KHZ
15.	Details schematic diagram to be submitted.
16.	DVD Players
17.	Zone paging microphones / fire man microphone.
18.	Volume controls
19.	Interface with fire alarm system

No.	Main Check Items
G.20	**Structure Cabling (Data – Telephone)**
1.	Country of origin
2.	Manufacturer Data include catalogue cuts
3.	Compliance statement
4.	5 years in service with satisfaction use.
5.	Details schematic diagram to be submitted.
6.	List of materials to be submitted
7.	Fiber optic cables - Multi-made fiber optic cables from equipment racks to main telephone room. - Suitable for indoor / outdoor, redent resistance, metallic type with LSZH, - Flame retardant outer sheath. - Suitable for 10 / 100 / 1000 base F and to be tested at 1350 & 1500 NM. - Tested according to EIA / TIA-568A, Bell core GR-20 core and iSO 11801:2002
8.	Cat-6 Cables - High performance 4 pair cat-6, UTP.UL listed, solid conductor enclosed by PVC Jasket. - Level III field tester must be provided to meet industry standard IEEE/TIA568-B.2-1 - Copper cable to transmit data for 100 Mbps fast Ethernet, 350 MH3 broadband video.
9.	R.G. 45, cat-6 outlet - Outlets to be eight – position angled RJ-45 - Face plate shall be provided from the same wiring devices manufacturer. - All 4 poire – cat 6 horizontal cable shall be terminated on respective contacts. - Each connector shall provide both T-568A and T-568B color code.
10.	RG-.45, cat-6 copper patch panel - Patch panel shall be rack mouted type. - Cat-6 cable shall be terminated on cat-6 RG.45 patch panel. - All patch panel to be provided for labeling. - Patch panel to be provided by using color code T-568A and T-568B. - Holder for each patch panel shall be provided to locate and clamp to avoid error installation.
11.	RG.45, cat-6 patch cords
12.	Cat-6 copper patch cords RJ45/RJ45 between patch panel and switches
13.	No. of cat-6 patch cord equal no. of outlets
14.	Fiber optic patch panels to be 24 fibers per U in equipment rack
15.	One unit patch organizer for each fiber patch panel
16.	Fiber patch panel to be accessible from front & rear.
17.	Fiber splicing to be (loss<0.2 dB – reflection < 50 dB)
18.	Stable from – 40°C to 85 °C)
19.	Patch panel for telephone - Cat-5 provided for intermediate distribution frame - Patch panel with all needed accessories inside rack - Cat-6 cables for horizontal path - Suitable connection blocks.

No.	Main Check Items
G.21	**T.V. System**
1.	Country of origin
2.	Manufacturer details and catalogue cuts
3.	List of materials
4.	5 years in service with satisfaction use.
5.	Schematic diagram.
6.	Compliance statement
7.	Signal strength
8.	Satellite dishes to be symmetrical parabolic - 1.8 mt - Gain not less than 44db - Aluminium - Frequency range 10.7-12.75 GHZ
9.	Cable to be fully shielded 75 ohm-cu-core coaxial type.
10.	Output impedance 75 ohm
11.	VHF / UHF antenna - Withstand speed up to 130 km - Channels - Front to back ration - Return loss - Gain - Impedance – 75 ohm
12.	Cables - Solid copper - Dielectric solid of foam polyethylene - Shielded - Jacket – Polyvinyle Chloride - Losses not less than 12db / 100mt
13.	Tap Off units - Have 75 ohm back matched units - Low loss - No of wayes
14.	Multi switch units - Terr. input frequency range - Sat. input frequency range - Through loss < 3db - Terr. Tap loss < 14db - Sat. Tap loss < 5db
15.	IF Amplifier according to signal strength calculation
16.	RF Amplifier according to signal strength calculation
17.	Signal strength - IF signal +54:+60db - RF signal +68: 85db - CNR > 48db

Section (H)
Shop Drawings Check List

H.1 **<u>Power Shop Drawings</u>**

- Contractor should be committed with standard color code.
- Contractor shall be responsible for all coordination between other trades.
- Please provide all electrical rooms in separate part plans furnished with all submitted equipment indicating all approved required dimension based on the approved submitted, including the necessary routing.
- All electrical outlets (heights & location) should be coordinated and to approved by the Client to match the ID & the final Arch. construction drawings.
- Two elbows only permitted as possible from outlet to outlet.
- Provide section or detail for ceiling socket with cable tray connection if required.
- Provide missing dimension indicated on drawings.
- Provide back box for all wiring devices.
- Wire phrases in each conduit from outlet to outlet to be provided.
- Exact location of all electrical outlets and other devices shall be from wall, columns, door jambs in line with project requirements and applicable regulations.
- Size of wires, cables, conduits/containment used shall be clearly indicated on the drawing.
- Irrespective of service, conduit and fitting used shall be:
  A. Where embedded: heavy gauge rigid PVC shall be used.
  B. Where surface mounted, exposed, false ceiling and in voids: galvanized steel conduit shall be used.
- Fill area of the conduits shall be as per the regulations.
- Number of outlets in each circuit shall be as per the DB Schedule; however it shall not contradict with applicable regulations.
- Show home runs in the shop drawings, conduit run shall not exceed more than 2 Nos. 90 degree bends and 15meters without pull box.
- Identify wires in each conduit.

H.2 **<u>Lighting Shop Drawings</u>**

- Contractor should be committed with standard color code.
- Contractor shall be responsible for all coordination between other trades.
- Please provide all electrical rooms in separate part plans furnished with all submitted equipment indicating all approved required dimension based on the approved submitted, including the necessary routing.
- All electrical outlets (heights & location) should be coordinated and to approved by the Client to match the ID & the final Arch. Construction drawings.
- Two elbows only permitted as possible from outlet to outlets.
- Maximum accepted vertical hanging with rode shall not exceed 2 meter, for above U channel with suitable cross section should be used to comply with the spec's, it's the contractor responsibility to provide the safe supporting system with the required method to verify its safe.
- Provide missing dimension indicated on drawings.
- Provide back box for all wiring devices.
- Wire phases in each conduit from outlet to outlet to be provide
- Exact location of all light fitting shall be taken from wall and columns in line with project requirement and applicable regulations.

- Further these locations shall be coordinated with other services and the Interior design drawings and project architects to ensure location of light fitting shall be in line with reflected ceiling layout.
- Contractor should provide typical installation details in a separate drawing indicating all installations, connections, mounting heights, conduits routes etc.
- Size of wires, cables, conduits/containment used shall be clearly indicated on the drawing.
- Irrespective of service, conduit and fitting used shall be:
  A. Where embedded: heavy gauge rigid PVC shall be used.
  B. Where surface mounted, exposed, false ceiling and in voids: galvanized steel conduit shall be used.

- Fill area of the conduits shall be as per the regulations.
- Number of outlets in each circuit shall be as per the DB Schedule; however it shall not contradict with applicable regulations.
- Show home runs in the shop drawings, conduit run shall not exceed more than 2 Nos. 90 degree bends and 15meters without pull box.
- Identify wires in each conduit.
- Type of light fixture shall be suitable to the environment as per the project specification and applicable regulations.
- All applicable lighting fixtures shall be as per approved material submittals.

H.3 <u>Power Containment & Tray.</u>

- Exact location of all Power containment shall be taken from wall, columns, grid lines etc to be in line with project requirements and applicable regulations.
- Further these locations shall be coordinated with other MEP drawings to have clearance, accessibility to the containment.
- These power containments shall be for cables where ever it is applicable, for example cables between Transformers, Generators, ATS, LV/ELV Panels, Capacitor Bank panels MCC, control panels, SMDB, DB, Mechanical equipment etc.
- Contractor should provide typical installation details in a separate drawing indicating all installations, connections, mounting heights, routes etc. in line with project requirement and applicable codes and regulations.
- Size of cables used in the containment shall be clearly indicated on the drawing and suitable sections. Which shall also includes schedule indication of origin of cables, destination of cables, tags, % of cable fill area, length, voltage drop etc.
- Length of cables indicated on the sld shall be maintained as much as possible with proposed containment.
- Fill area and the configuration in the containment shall be clearly indicated in sections and shall be as per the regulations.
- Configuration of cables shall be as per the cable sizes selection based on the derating factors and installation methods.
- Spare capacity of atleast 20% shall be maintained for future installations.
- Type containment shall be as indicated in the project submittals and shall be suitable for the purpose.
- Horizontal elbows, bends, intersections shall be suitable for the Bending radius of the cables, shall be properly supported in the regular intervals as per manufacturers recommendation.

- Cable trays shall have adequate strength and rigidity to provide satisfactory support for the cables contained within them. All sharp edges, burrs and projections shall be removed and the tray shall be finished smooth to prevent injury to cables.
- Containment installation shall be as per Kahramaa regulations and QCS inline with project requirement.

H.4 Panel Board's Manufacturing Drawings.

- Dimension of panel indicated.
- Front view of panel shown.
- Front view of left section shown
- Front view of right section shown.
- All the elements of the panel shown in one line and AC/DC schematic drawings are shown in panel layout.
- Nameplate engraving chart shown.
- Top view of panel is shown
- Panel base frame/foundation details are shown.
- Circuit breakers and fuse ratings are correct.
- Conduit and cable numbers are correct.
- UPS distribution system is included for critical equipment as appropriate.
- Equipment numbers checked.
- Consistent with corresponding schematic diagrams.
- Control protection devices are considered as per requirements
- Equipment number checked.
- Appropriate ANSI/IEEE/IEC device function numbers/symbols are used.

H.5 Control Wiring Diagrams.

- Relays and switches are shown in a de-energised state.
- Terminal numbers match all other electrical drawings.
- Wire identifications are shown correctly
- Control design function checked
- Consistent with corresponding single line diagram.
- Appropriate ANSI/IEEE/IEC device function numbers/symbols are used.
- Equipment numbers checked.
- Terminal blocks have adequate spare capacity.
- Spare wires are clearly identified as "spare".
- Wire designation, number and/or colour code are shown correctly
- Terminal numbers match other electrical drawings
- Wire tagging is shown clearly at source and destination.

H.6 Lightning and Earthing Comments:

- The installations should be carried out according to the specs, unless otherwise
- The used material should be the approved material submittals.
- All the approved material for the earthing pits & the other related accessories.
- Should be used with considering the earthing approved material.
- Maximum Earth resistance shall not exceed 2 ohm.

- The earthing detail should be part and verified by the specialist calculations to the achieve the required ohm as per the design documents.
- Ground grid rods and wires are selected as per design calculations.
- Grounding design checked.
- Standard procedure for grounding followed.
- All extraneous metallic parts are connected to the grounding system.

H.7 CCTV and Access Control Shop Drawings:

- Exact location of all devices should be coordinated with ID, and the dimension should be taken from walls or columns.
- Provide earthing conductor for all trunking.
- Contractor to provide trunk size calculation.
- separately.
- Pull boxes should be provided each 15 metres and each two bends. Its dimension should be mentioned.
- Contractor to guarantee enough separation from other service trades for proper installation and to avoid electro-magnetic interferences.
- Contractor to submit detailed riser diagram.
- Contractor should provide typical installation details.
- All material used should be according to last approved submittal, and part number of cable and equipment to be indicated.

H.8 Fire Alarm Shop Drawings:

- Exact location of all devices should be coordinated with ID, and the dimension should be taken from walls or columns.
- Contractor should provide typical installation details in separate plans indicating all installation, connection and wiring as per the manufacturer recommendations.
- Each fire fighter telephone should have its own control module.
- Contractor to submit voltage drop calculation for DC lines.
- End of line devices should be installed as directed by the manufacturer to electrically supervise all wiring (DC/Audio lines and telephone lines)
- Contractor to ensure that all monitor and control modules needed for HVAC and fire fighting system and any other interfaces are provided and its location is coordinated with electrical / mechanical drawings.
- Fault isolator modules shall be installed every 15 devices maximum
- Contractor to provide earthing conductor for all trunking.
- Contractor to guarantee enough separation from other service trades for proper installation and to interferences.
- Contractor to submit detailed riser diagram showing all system component and the interface with all other trades.
- All material used should be according to last approved submittal.

H.9 MATV Shop Drawings:

- Exact location of all devices should be coordinated with ID, and the dimension should be taken from walls or columns.

- Provide earthing conductor for all trunking
- All splitters, tap off, multi-switches to be installed in perforated metal boxes.
- RF and IF TV signal level at each outlets to be indicated.
- Connection to the dish farms to be indicated.
- Location of TV outlets to be coordinated with the advertising outlets.
- Contractor to provide filling ration calculation for the trunk / conduit used.
- Pull boxes should be provided each 15 metres and each two bends and junction boxes to be used where ever needed.
- Contractor to submit detailed riser diagram.
- Contractor should provide typical installation details for all devices.
- All material used should be according to last approved submittal, and part number of cable and equipment to be indicated.

H.10 <u>Public Address Shop Drawings:</u>

- Exact location of all devices should be coordinated with ID, and the dimension should be taken from walls or columns.
- Provide earthing conductor for all trunking
- Back boxes for volume control to be clearly indicated on the drawings.
- Number of speaker/ line to be calculated based on the total wattage and voltage drop.
- Contractor to ensure the use of override cable for volume control.
- Contractor to ensure that public address system cables to run separately and guarantee enough separation from other service trades.
- Pull boxes should be provided each 15 metres and each two bends and junction boxes to be used where ever needed.
- Contractor to submit detailed riser diagram.
- Contractor should provide typical installation details for all devices.
- All material used should be according to last approved submittal, and part number of cable and equipment to be indicated.
- End of lines devices should be installed as directed by the manufacturer to electrically supervise all wirings.
- No PVC flexible conduits should be allowed.

H.11 <u>TELEPHONE & DATA Shop Drawings:</u>

- Exact location/ height of TELE/DATA outlets should be coordinated with ID/Client requirements, and the dimension should be taken from walls or columns.
- Contractor to provide earthing conductor for all trunking.
- Provide separation of trunking between all systems.
- Trunk size and filling ration to be provided.
- Pull boxes dimension & type should be provided.
- Contractor to guarantee enough separation from other service trades for proper installation and to avoid electro-magnetic interferences.
- Contractor to submit detailed riser diagram.
- Contractor should provide typical installation details for all devices.
- All material used should be according to last approved submittal, and part number of cable and equipment to be indicated.

Section (K)
How to Inspect

K.1 <u>DB'S, SMB AND MSB'S</u>

- Height of SMSB.
- Proper termination of sub-main cables.
- Glands tight.
- Gland provided on cable.
- MCCB correct rating.
- MCCB short circuit rating.
- Blank plate in SMSB.
- Safety guard on bus bar of SMSB.
- Sleeves in slots.
- Cupboard for main system.
- Labels on circuits.
- SMSB cover opening properly.
- MSB approved from authority.
- Load Balancing.
- Termination
- Installed materials to be as approved one.

K.2 <u>Lighting, Power and Low Current Circuits.</u>

- All double pole switches should be pilot lamp.
- Polarity to be checked.
- All switch or socket must 2 meter away from water sink.
- Kitchen ring main how connected.
- Metallic e/fan in kitchen.
- Every 10 meter length of PVC pipe 1 draw box to be provided.
- Use glue/cement for jointing of PVC pipe through coupler.
- Any kind circuit not to be passing in bath room floor.
- If switch box deep in wall so extension boxes or extension screw to be provided.
- All switch box third to be taped to clean and use original fixing screw.
- Jointing of s/boxes use coupler with male bush.
- Inside the bath room switch not allowed except pull cord switch.
- Use 25 mm pipe for TV & Tel.
- TV & Tel boxes pulling wire and boxes cover to be provided.
- 6 volt bell to be provided.
- Bell push have 6 volt.

- If direct service cable entry to be checked with slow bend and outside should be exposed.
- Roof to be provided in cable duct.
- Load wire to be checked.
- Cts arrangement to be checked.
- C/No. to be write.
- Area no. to be write.
- Before starting inspection all drawing to be studied.
- Be sure that you have tools, megger, ladder & marker.
- Color code for each circuit.
- High level for all wall mounting outlets.
- Installed materials (to be as approved one).
- Flexible pipes at structure separation.
- Voltage of under water lighting fixtures less than 36 volts & controlled by 30 mA (ELCB).
- Metallic parts of swimming polls & kitchen equipments to be bonded together with earthing for electrical accessories.
- Sub-main conduits bushed.
- Final sub-circuit conduit bushed.
- Photo cell time switch from boundary wall light.
- Intercom/bell wire does not pull in 1 pipe.
- Earth to all s/boxes
- All wire to be checked with migger ohm.
    i. Phase to neutral
    ii. Phase to phase
    iii. Phase to earth
    iv. Phase neutral
- Sub-main checked with migger.
- Ring main continuity to be checked.
- Each room load at each floor to be checked individually.
- Any kind of joint, connector not allowed in pipe junction box or UG only PVC connector to be provided in light box due to all wire not possible to terminate in the holder or ceiling rose or florescent light.
- Where more than 2 bend in pipe drawn box to be provided.
- For pulling of wire do not use oil or soap.
- Garden light proper foundation loop box earth and fixing screw should be brass not steel due to trunk.
- Proper slot to be connected to trunk.
- Proper slot in trunk with sleeves.

- Earth to trunk and cable tray.
- Two colors wire in 1 circuit not allowed.
- Keep off individual ELCB during migger list.
- Balancing of load.
- MCB size to be checked of all application.
- AC local isolator to be checked.
- Kitchen f/light should be IP 65.
- MICC or IP 200 to be provided for fire alarm.
- Fire alarm panel supply should be without switch.
- Two metal threaded rod to support suspended light fittings in the ceiling by raw bolt and fittings by nuts and washers.

K.3 <u>Cables & Trays.</u>

- Size of cables as approved one.
- Manufacturer of cables.
- Arrangements of cables inside cable tray.
- Spacing and laying.
- Minimum internal radius of bends in cables.
- Cable tray dimension.
- Earthing of cable tray.
- Labling for all cables.
- Joint will not be permitted for cables (only cable length more than drum of cables length).
- Cable tray shall not be used in areas with physical damage.
- Sharp edges, burrs to be removed from tray.
- Adequate strength and rigidity for all cables.
- Cable tray to be installed as complete system with bends and accessories.
- Clips for all cables to be used.
- Cable marking tap shall be installed for underground cables.
- Cable shall be laid at one level when installed direct in ground.
- Depth of cables not less than 600 mm.
- Horizontal clearance between cable to be 150mm for under ground cables.

K.4 **Main L. V. Panel.**

- Before the commencement of the installation of LV panels/control panels within erected enclosures, the following works are required to be carried out by the responsible representatives of the company.
- Ensure all necessary Factory certification (Certificates should be under the name of Assembler), and approved construction drawings of current revisions are ready prior to installation.
- Routine test should be done before installation & test certificates should come with the material at the time of deliver.
- Verify the material for LV panels/control panels are as per the approved material submittals.
- Check the LV panels/control panels are correct in respect of Manufacturer, size, type, power rating, suitable starter control and No. of ways to be installed as per the drawing and approved material submittal.
- Check the physical, electrical and mechanical conditions of the LV panels/control panels and verify the absence of all damages.
- Check the cleanliness of the LV panel/control panels from inside and outside of the enclosure.
- Prior to commencement of any installation works, access and installation areas will be inspected to confirm they are in suitable condition to receive the LV panels/control panels for compliance with installation tolerance\s and other conditions.
- Check the area of installation is clean, tidy and safe.
- Before the commencement of installation, the following works are to be carried out by the responsible representative.
- Mark the location of LV panels/control panels to be installed on the floor or wall with the necessary supports mentioned in the approved shop drawings.
- Delivered LV panels/control panels to be erect in the approved manner or purpose made supports and complete all containment connections.
- Containment for power and control cables to be providing segregation as per the approved shop drawing.
- Terminate the incoming supply cable approved gland / termination kit(s).
- After completing all containment and mains installation, install the interiors and connect the incoming supply conductors tightening connections according to manufacturer's torque tightening specifications values.
- Once the enclosure and mains cable are completed, install outgoing circuit cables.
- Following the installation of outgoing circuit wiring, connect cables as per the approved circuit schedule placing core identification markers on every conductor.
- Test outgoing circuits in accordance with the requirements of the specification.
- Install identification labels and safety signs.

- Place the final wiring diagram of LV panels/control panels in drawing pouch located inside the panels.
- Check name plate rating against drawing
- Check enclosure for damage
- Inspect assembly, bolting, levels
- Inspect main power circuits
- Inspect earth bars and earthing
- Check control and signal voltage
- Remove blocking materials
- Inspect safety features
- Check fuse ratings
- Check automatic circuit breakers
- Inspect cables and connections
- Test anti-condensation heaters
- Inspect relays and instruments
- Test alarm Lamps Indication
- Check instruction and warning labels
- Test IR value with 1 KV Megger

K.5 BUSBAR.

- Check the location of bus bar to be installed as per approved shop drawing.
- Ensure all necessary certification of 3.5 KV dielectric test and megger test reports, manufacturer approved drawings, and MEP co-ordination drawings are readily available at site.
- Check the brand, rating of bus bar as per approved shop drawing.
- Check the work area is clean and safe.
- Checks the openings provided on slab / wall are adequate to installed bus bars.
- Check the materials to be used are approved.
- Consultant inspections to be carried out prior to start the installation for the material approval upon receiving the material at site.
- Ensure that all bus bar to be used is free from any damage.
- Megger to be done by using 100V megger before installing each bus bar.
- Bus ducts to be installed with proper manufacturer clamps and supports and aligned properly.
- Horizontal bus bar shall be supported at an interval of 1.5 mtr by 12 mm threaded rod.
- Vertical bus bar shall be supported at an interval of 3.0 mts.
- Busbar coupler to be used for each joint and ensure the tightness of bolts.
- Busbar joint packs are provided with torque indicating double headed joint bolts. The outer head will shear off once the correct torque is attained.

- Busbar will be connected to LV panel by using flange connection.
- Opening end of Busbar to be closed temporarily during the installation.
- Install the tap-off boxes complete with the protection devices of suitable rating as per the approved shop drawings.
- Insulation resistance to be measured by using a 1000V megger after the completion of installation.
- Install the identification labeling and safety signs for the complete bus duct installation.
- Consultant's inspection will be carried out after installation for the approval.
- Check rating of Busbar against approval / specification
- Check for complete installation as per approval drawings and specifications.
- Ensure that all the bolts and connections are tight.
- Ensure that all the floor / wall supports are properly fixed.
- Check all the openings in wall / floors are closed with fire rated material
- Check for proper connection to the panel boards / feeder cables.
- Check on phase sequence
- Check on continuity & insulation resistance.
- Check for proper earth connections
- Check all the outgoing from the Busbars are fitted and connected.

K.6 <u>Cables.</u>

- Ensure that all necessary certification, XLPE Power / FP-400 cables schedule and approved construction drawings of current revision are available prior to installation.
- Check the correct type of XLPE power / FP-400 cables to be installed as indicated on the approved construction drawings / material submittals.
- Check all documentation for materials relevant to a particular section of works of pull boxes, hand holes, trays/ladders have an approved material submittal.
- Check that all race ways (ladder & trays etc), boxes and enclosures are installed and all installation check lists have attended duly signed and are approved by Consultant prior to pulling of cables.
- Ensure temporary protection provided to cable reels to protect from damage while in transit are removed and insulation of cable is free from damage and clean.
- Prior to commencement of any works, access and installation areas will be inspected to confirm they are in suitable condition to receive power cables for compliance with installation tolerances and other conditions.
- Before the installation of the XLPE power / FP-400 cables, check the installation of trays/ladder is completed, securely fastened, tight joints, proper bushing at terminal and is thoroughly clean inside for any debris.
- Care has to be taken for XLPE power / FP-400 cables installation on trays, they shouldn't be pulled over sharp corners of boxes or other objects and that the maximum numbers of conductor are not exceeded then the recommended nos. Excessive force should not be used in pulling the cable. Otherwise the covering on the cable can be easily damaged and can cause trouble after the circuit is put into operation.

- Fix adequate numbers of XLPE power / FP-400 cables pulling rollers on the cable tray/ladders.
- Keep the cable drum as per the rolling direction & pull towards the equipment, either one side as per the site condition.
- The other end to be measured & cut after de-rolled from the drum.
- XLPE power / FP-400 cables should be pulled directly from the reels on to trays and ladders using approved pulling means, so that it will not damage cables on trays/ladders.
- If more than one cable is to be installed on one tray or ladder, then pull them simultaneously on the tray or ladder from the reel directly by using proper means as described in the approved point. During pulling don't apply extra force to pull the cable.
- For vertical pulling necessary cable winch has to be used, if required.
- Install terminations at conductor ends and elsewhere as indicated on the approved construction drawings using standard kit.
- The cable pulling operation will only commence after the successful inspection and acceptance of cable trays and ladder by Consultant.
- Fill approved fire sealant in all penetrations through fire rated walls, floors & slabs.
- If the cables are to be installed on the vertical race ways (trays & ladder), the cables should be supported with the approved supports properly.
- During vertical installation, maintain the required segregation between different cables.
- Attach and fix the identification labels, safety and warning signs, cable cards or tags (on inside / outside cables) at the location as shown in the approved construction drawing / specifications or approved material submittals.
- After completion of installation, remove any dirt, and construction tape & debris.
- Check the approved material is used for installation
- Check the installation is as per the approved / commented shop drawings
- Check the location (Grids)
- Check any physical damages internal / external surface of cables.
- Check the cables are installed properly.
- Check and confirm the quality of workmanship
- Check proper protection provided for the installation
- Check the house keeping of the installation area.

K.7 <u>Generator.</u>

- All works associated with above-mentioned project limited to the installation of generator set works will be the responsibilities of contractor.
- Project engineer will have the overall responsibility for the installation.
- The site engineer / supervisor / foreman will be in-charge for the fabrication / execution of the work at site.

- The QA/QC engineer will be responsible for the quality control of the fabrication and installation works, verification of installed material including documentation.
- Before commencement of generator installation, necessary test to be carried out by the responsible representatives of the company at their factory, the test certificates will be submitted to Consultant for verification.
- Ensure all necessary certification, and approved construction drawings of current revision are available prior to installation.
- Verify the materials are delivered at site as per the approved material submittals and all the accessories are delivered along with the generator.
- Check the physical, electrical and mechanical conditions of the supplied materials and verify the absence of all damages.
- Consultant's inspection will be carried out for the material approval before the installation.
- Check the generator location as per approved consultant's drawing.
- Check the area of installation is clean and safe.
- Install the accessories like battery charger, ACB enclosure, and fuel pumps control as per the approved shop drawings.
- Routine test should be done in the factory prior before shipment as per ISO 8528-1 & test certificates should be delivered with the generator at the time of delivery.
- Proper crane shall be used for shifting of the generator to generator room.
- The exact positioning in the generator room will be done by using proper heavy duty jacks.
- Location of daily fuel tank and storage tank shall be checked and confirmed before installation.
- Install the fuel pipe connection from the tank to the generator as per the approved shop drawings.
- Intake & discharge ducting to be installed as per the approved shop drawings.
- After completion of above works exhaust connection to be done by specialist sub-contractor supervision.
- Check the approved material is used for installation
- Check the installation is as per the approved / commented shop drawings
- Check the location (Grids)
- Check any physical damages internal / external surface of generator.
- Check any debris left above the generator
- Check the generator are installed as per approved method statement
- Check and confirm the quality of workmanship
- Check proper protection provided for the installation
- Check the house keeping of the installation area.
- Check the test certificates prior to installation.

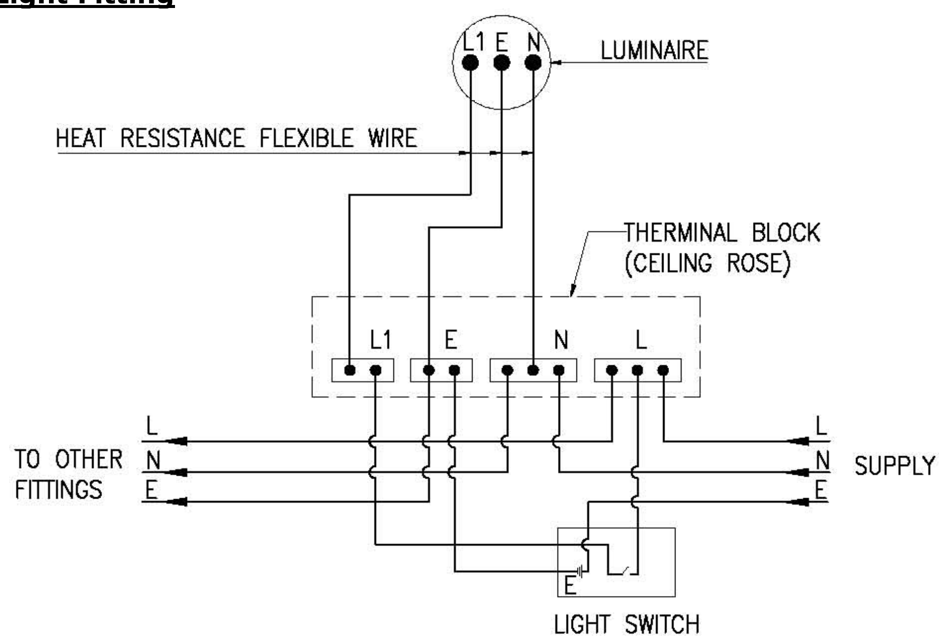
K.8 **Transformer.**

- Ensure all necessary certification and name plate details are readily prior to installation.
- Verify the transformer brand, make and country of origin as per the approved shop drawings and specifications.
- Check the physical, electrical and mechanical conditions of the transformer and verify the absence of all damages.
- Check the area of installation is clean, tidy and safe.
- Ensure the concrete plinth / foundation is ready to install the transformer as per the approved drawings.
- Ensure the necessary substation civil prior to install the transformers.
- Lift the transformer from the storage area equipped with the lifting lugs by using crane.
- Ensure the MV and LV sides while positioning of the transformers on the concrete plinth / foundation.
- Make sure the transformer is erected properly.
- Provide the necessary stopper after final positioning of transformer to avoid moving of transformer.
- Consultant approval to be taken after completing the positioning of transformers.
- Check external damage.
- Check damage of the accessories: tap changer, thermometer, rollers, etc…
- Check rust or damage paint on the transformer or its accessories.
- Check availability of all the accessories and loose parts; some accessories may be dismantled for transportation purposes.
- Check conformity of the name plate to the client requirement.
- Check the approved material is used for installation
- Check the installation is as per the approved / commented shop drawings
- Check any physical damages internal / external surface
- Check and confirm the quality of workmanship
- Check proper protection provided for the installation
- Check the house keeping of the installation area.
- Check for the Kahramaa approval certificate of the transformer site.

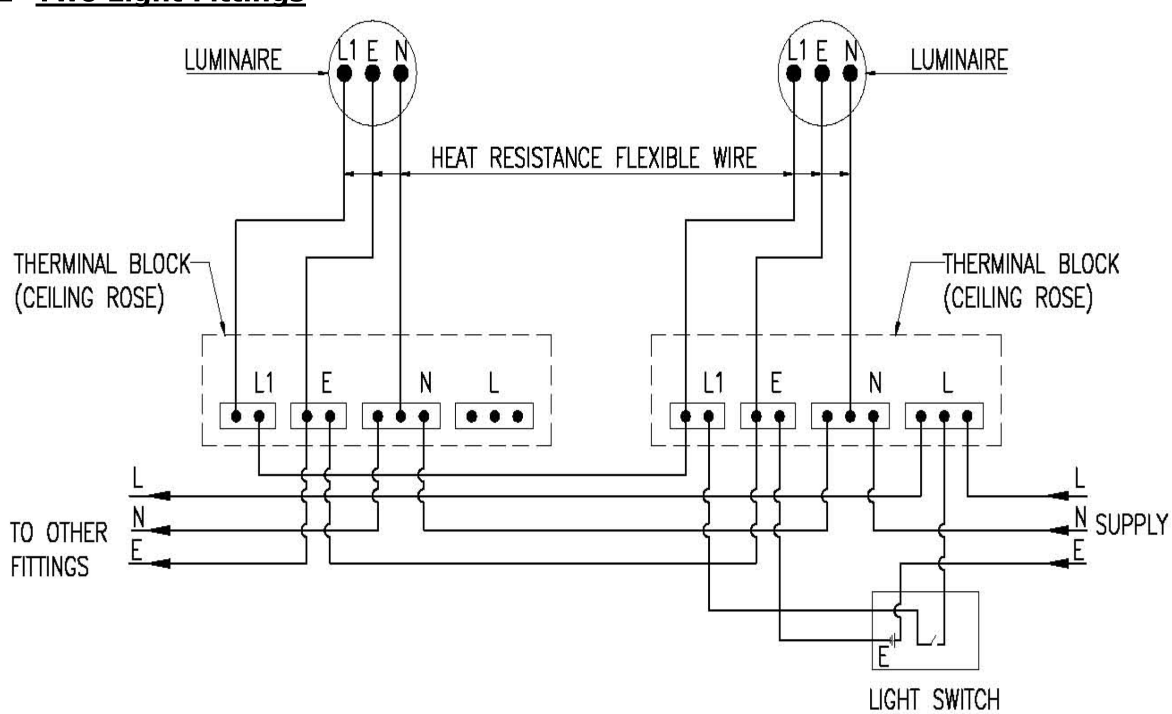
Section (L)
Variety of Important Electrical Details

L.1 Wiring Connection for Ceiling Rose & Lighting Switches.

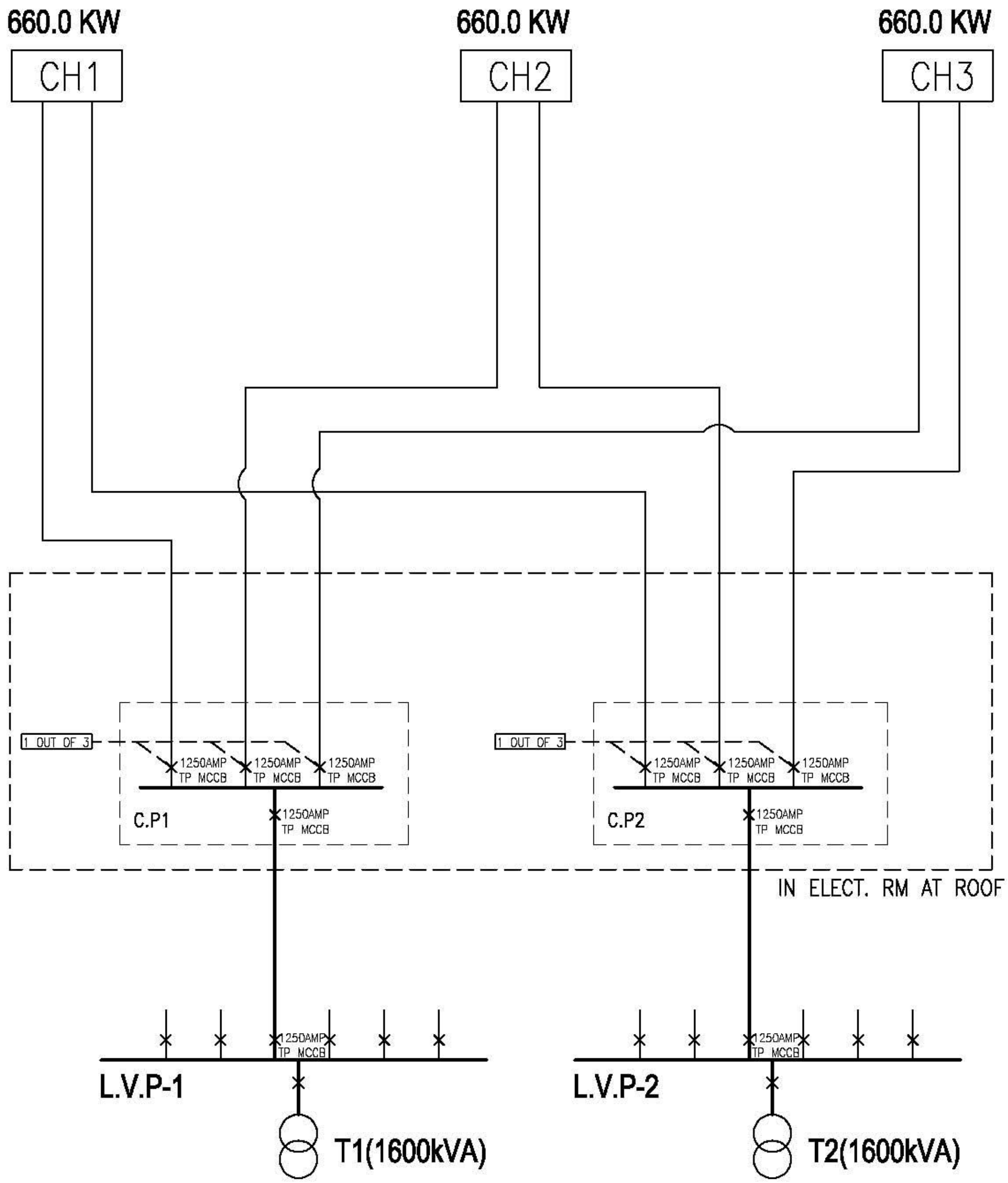
L.1.1 One Light Fitting



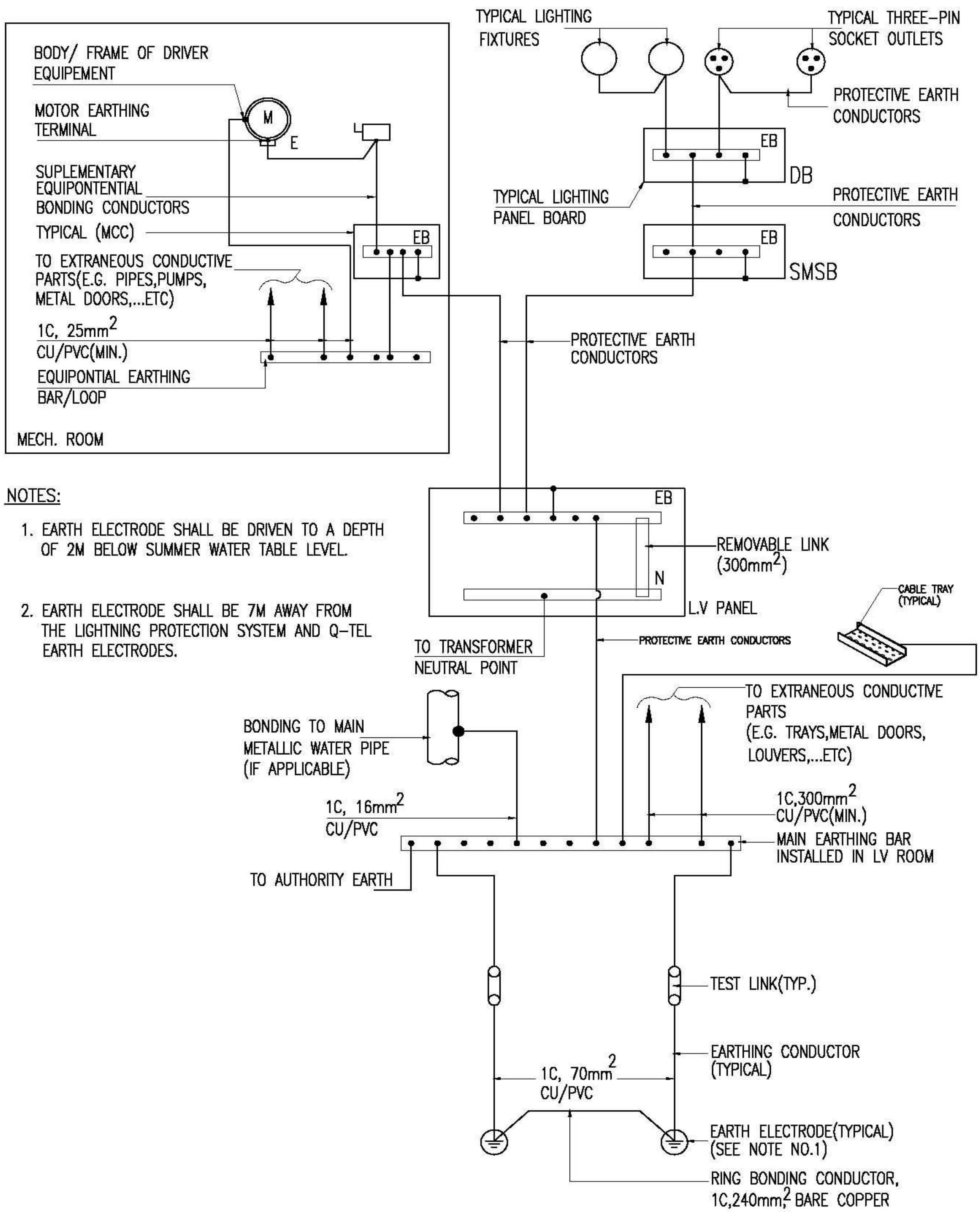
L.1.2 Two Light Fittings



L.2 How to Supply 3 Nos Chillers from Two Transformer with Probability to Operate any one Chiller as Standby.

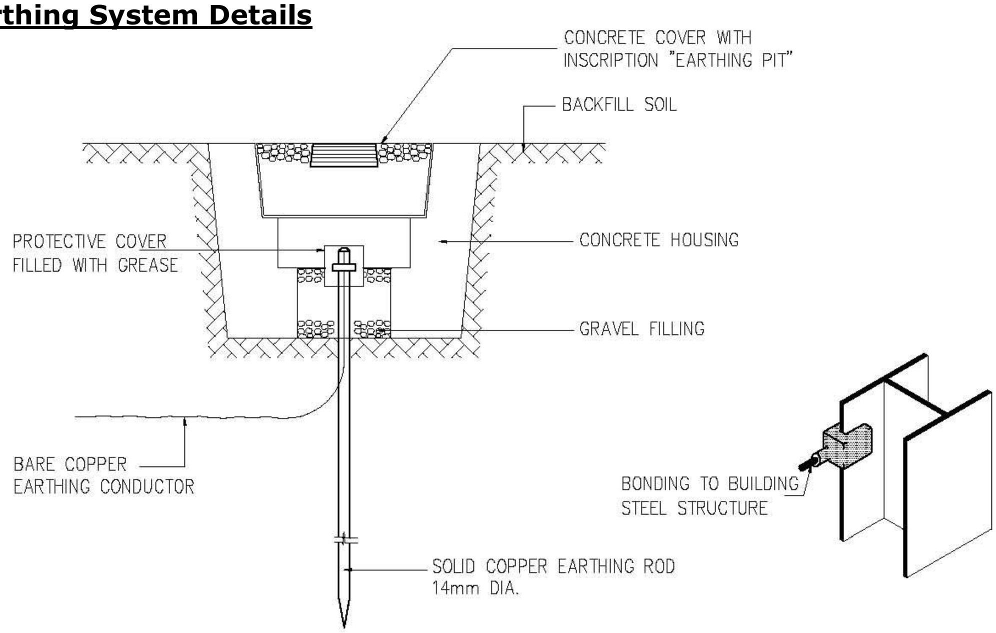


L.3 Earthing System Schematic Diagram



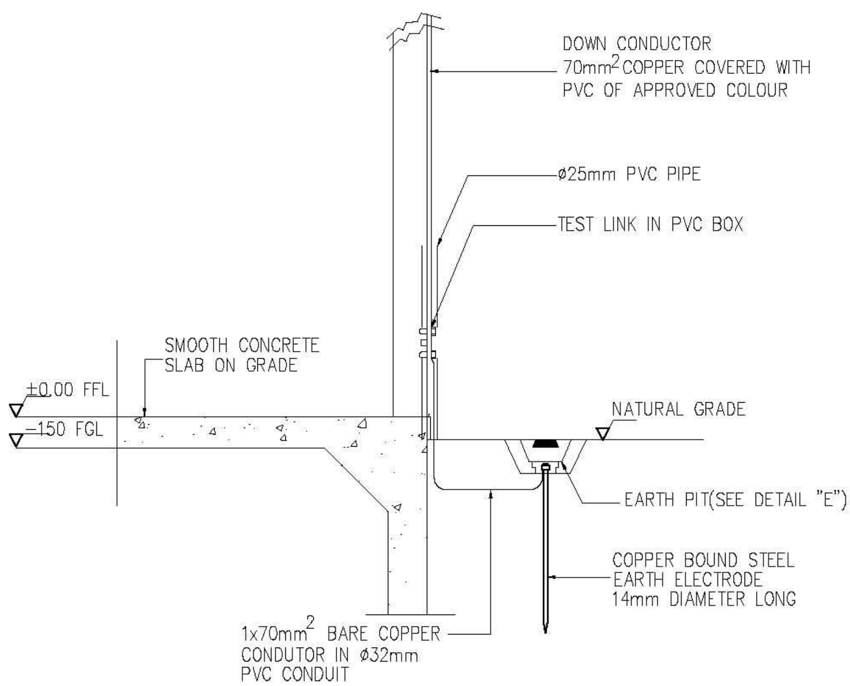
EARTHING AND BONDING FOR L.V PANEL

L.4 Earthing System Details



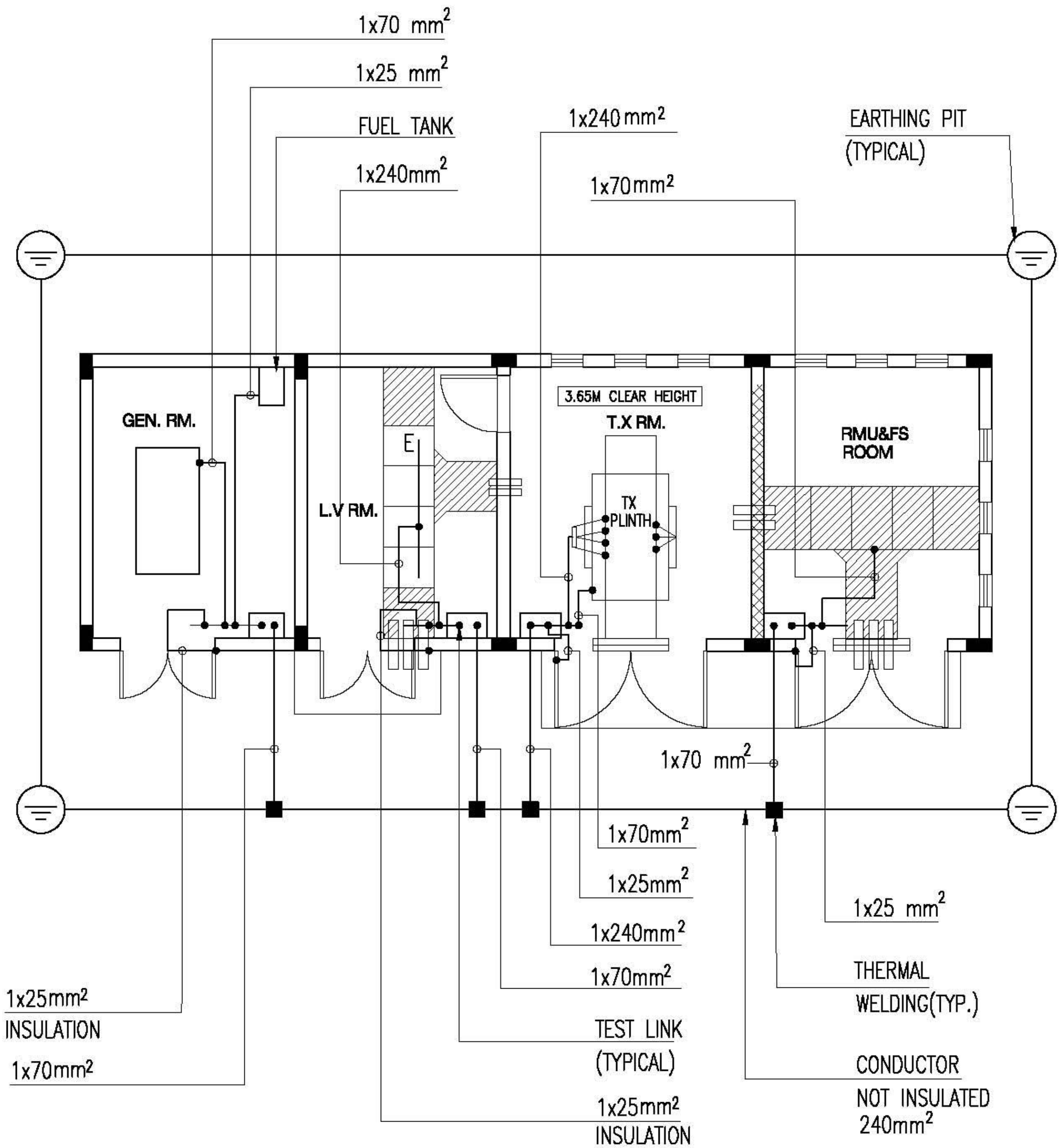
DETAIL-(E)

EARTH PIT (300X300x300mm)

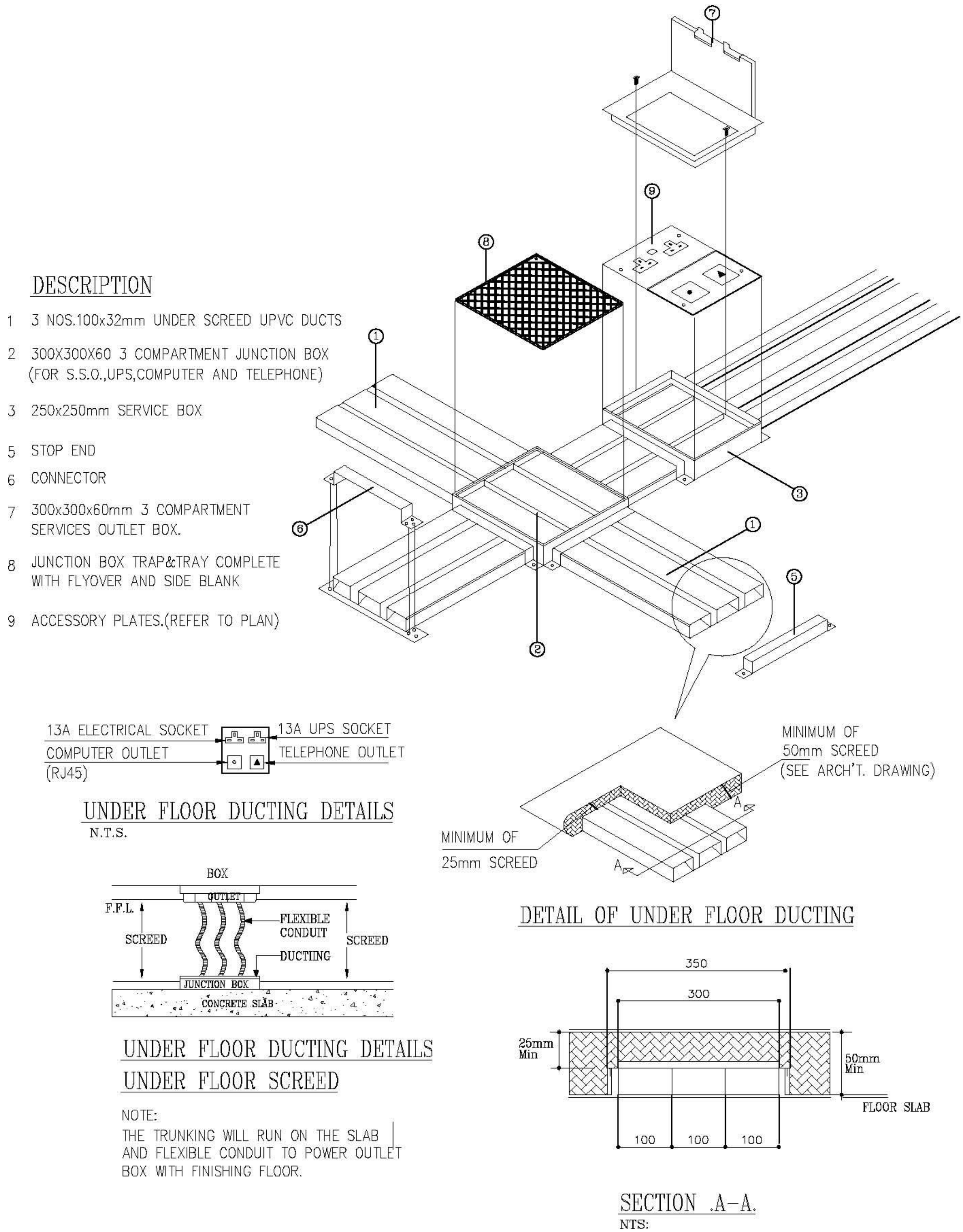


EARTHING PIT AND TEST LINK

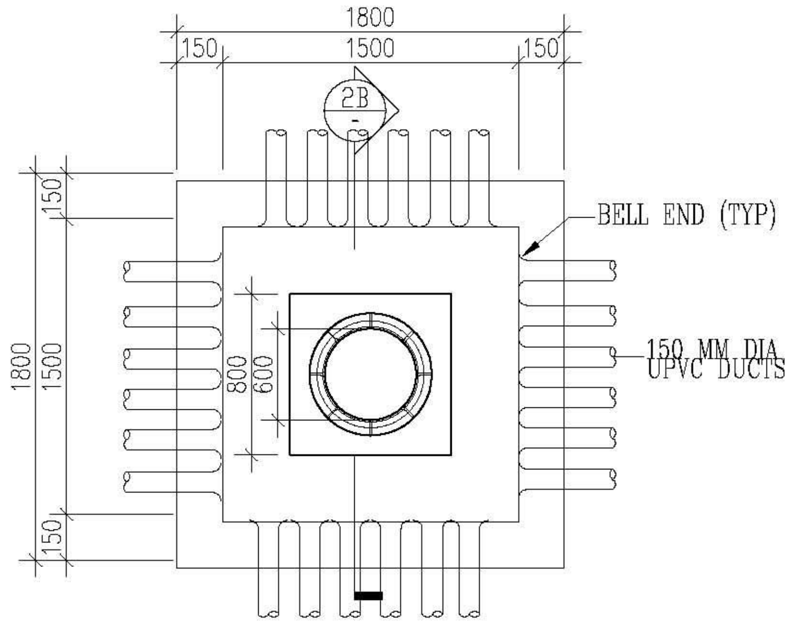
L.5 Earthing System for (11 / 0.415) KV Substation



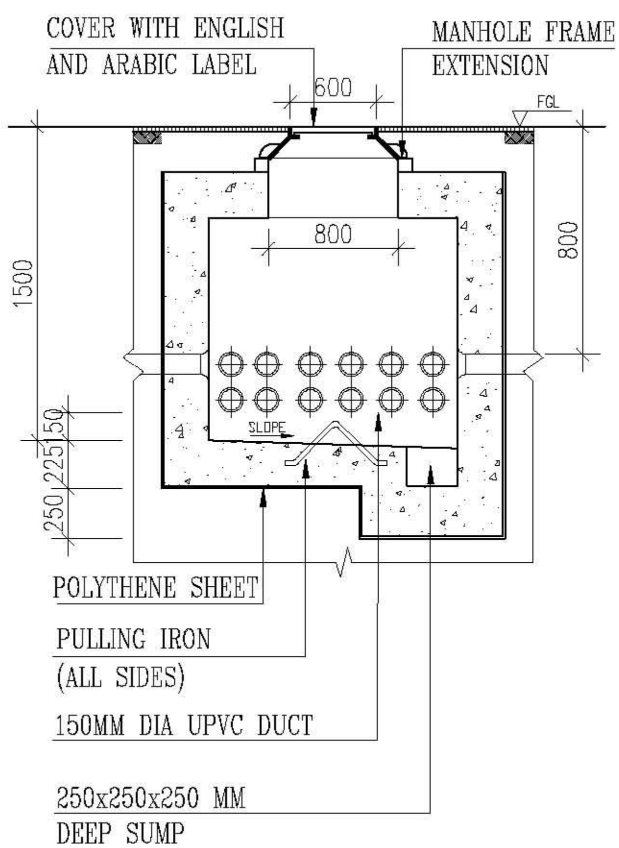
L.6 Under Floor Trunking System



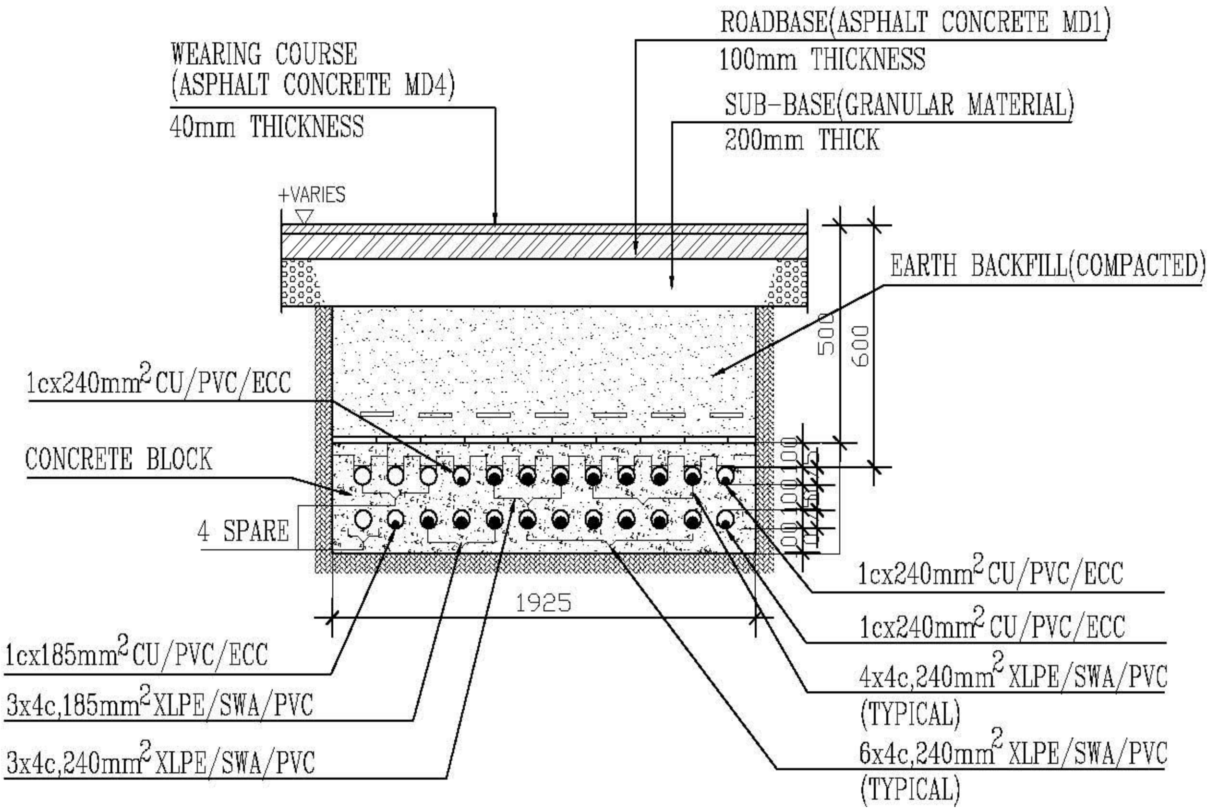
L.7 Electrical Manhole Sample

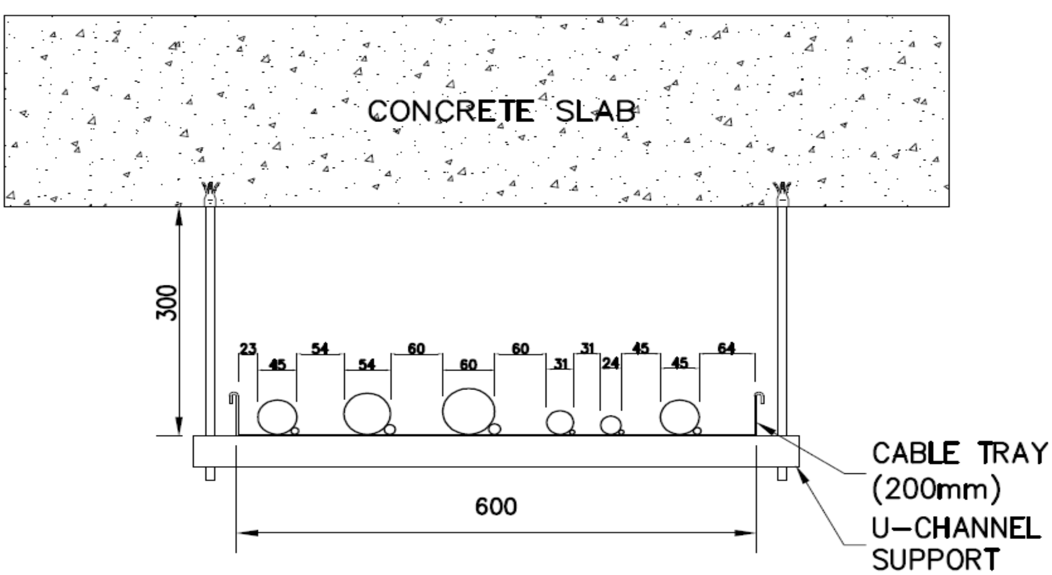


PLAN



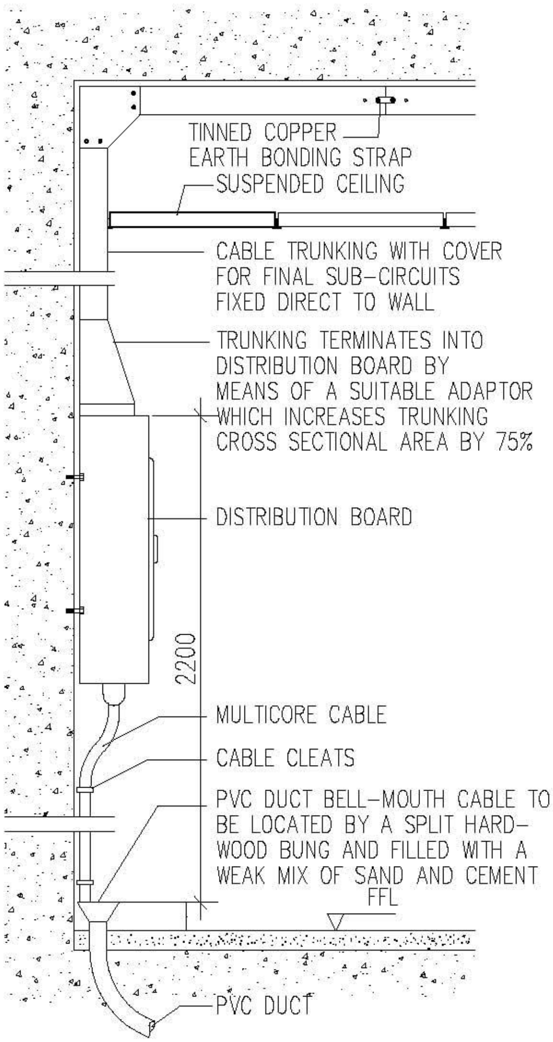
L.8 Road Cross Duct & Cable Tray



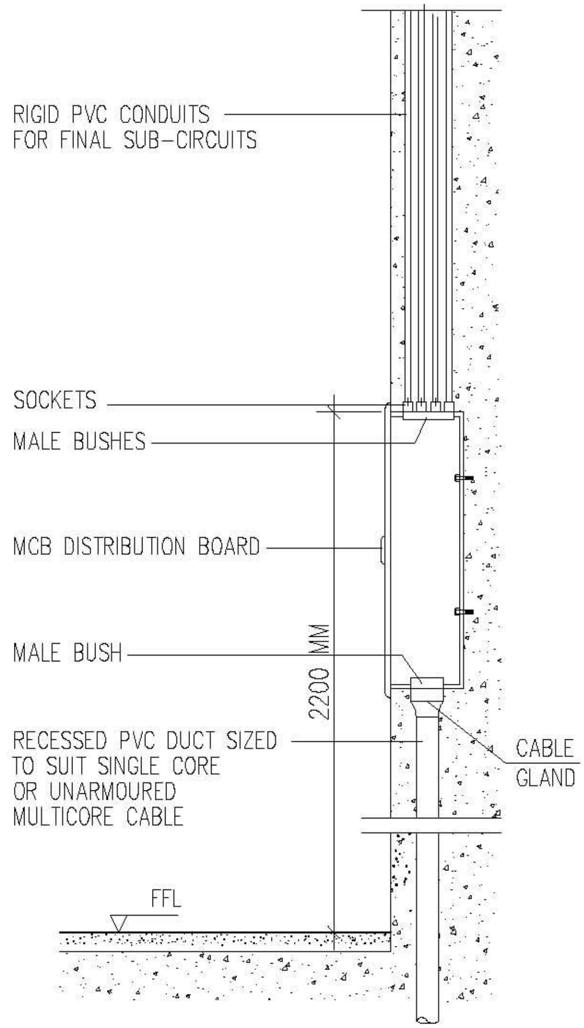


CABLE TRAY
SECTION DETAILS

L.9 Distribution Board Installation

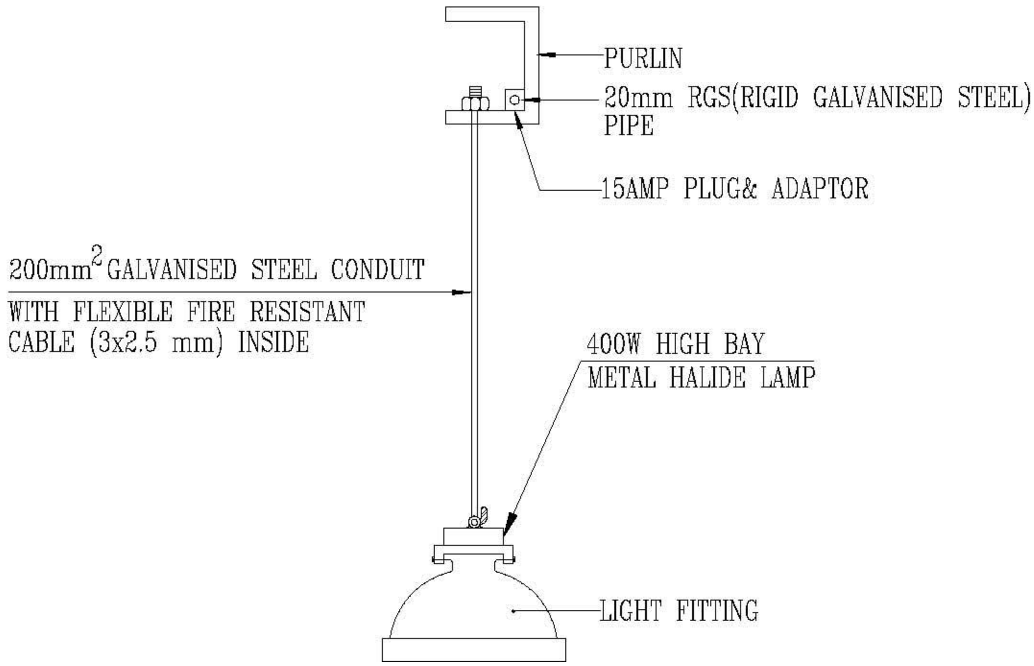


SURFACE MOUNTED DISTRIBUTION BOARD

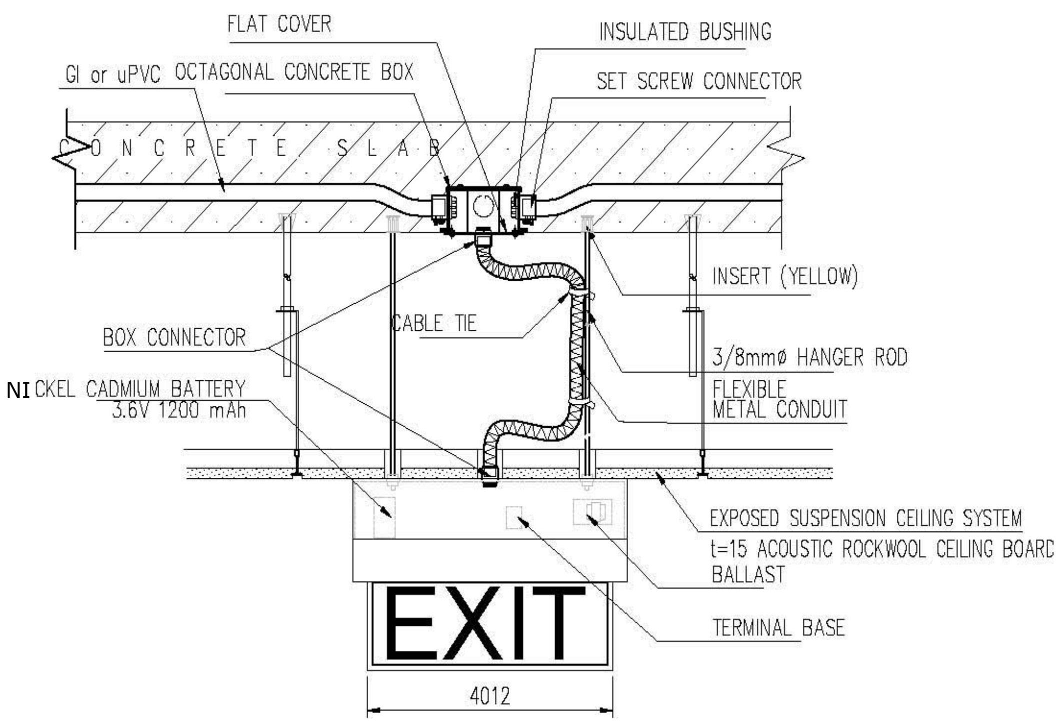


RECESSED MOUNTED DISTRIBUTION BOARD

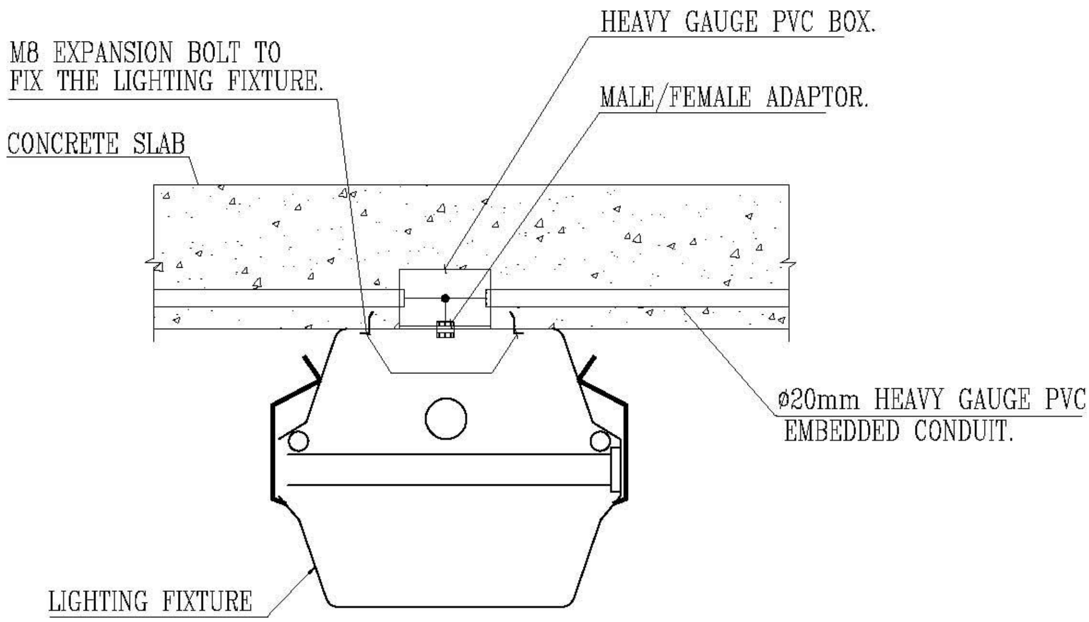
L.10 Light Fitting for Steel Structure



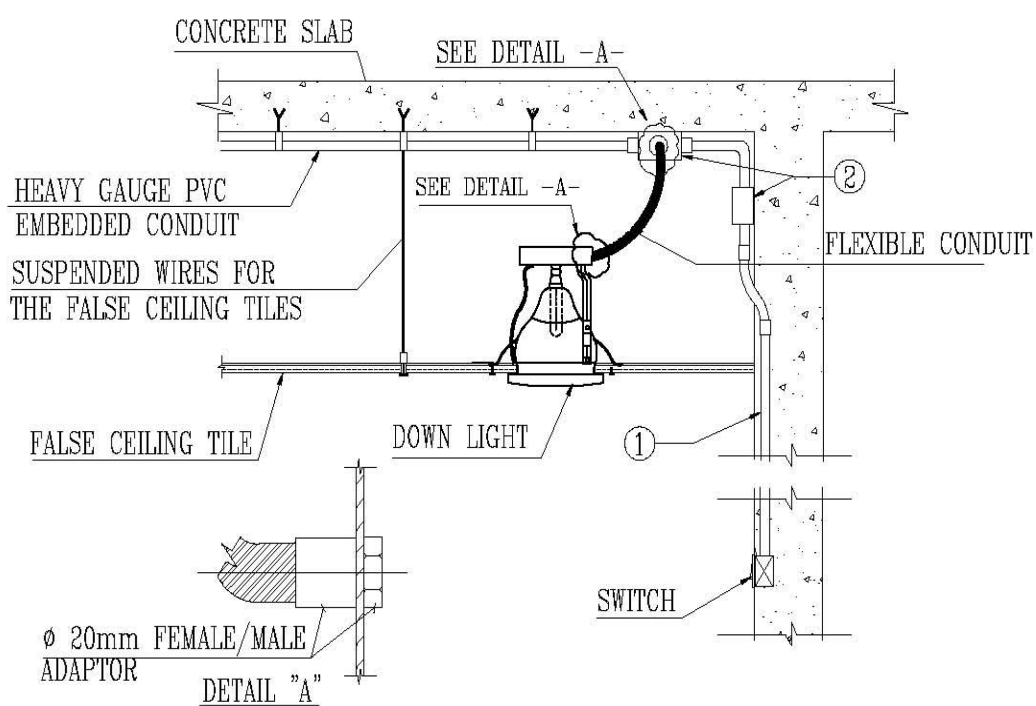
L.11 Exit Light Instalation Details



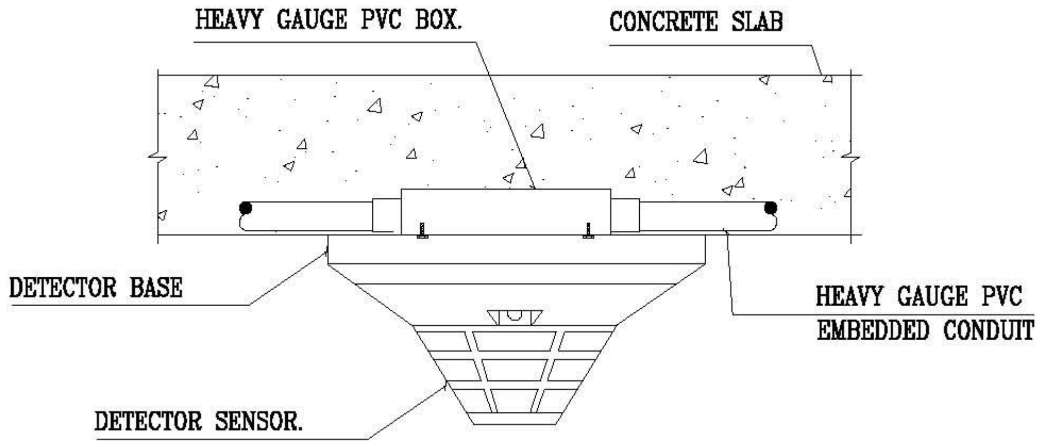
L.12 Installation Details for Surface Mounted Lighting Fixture



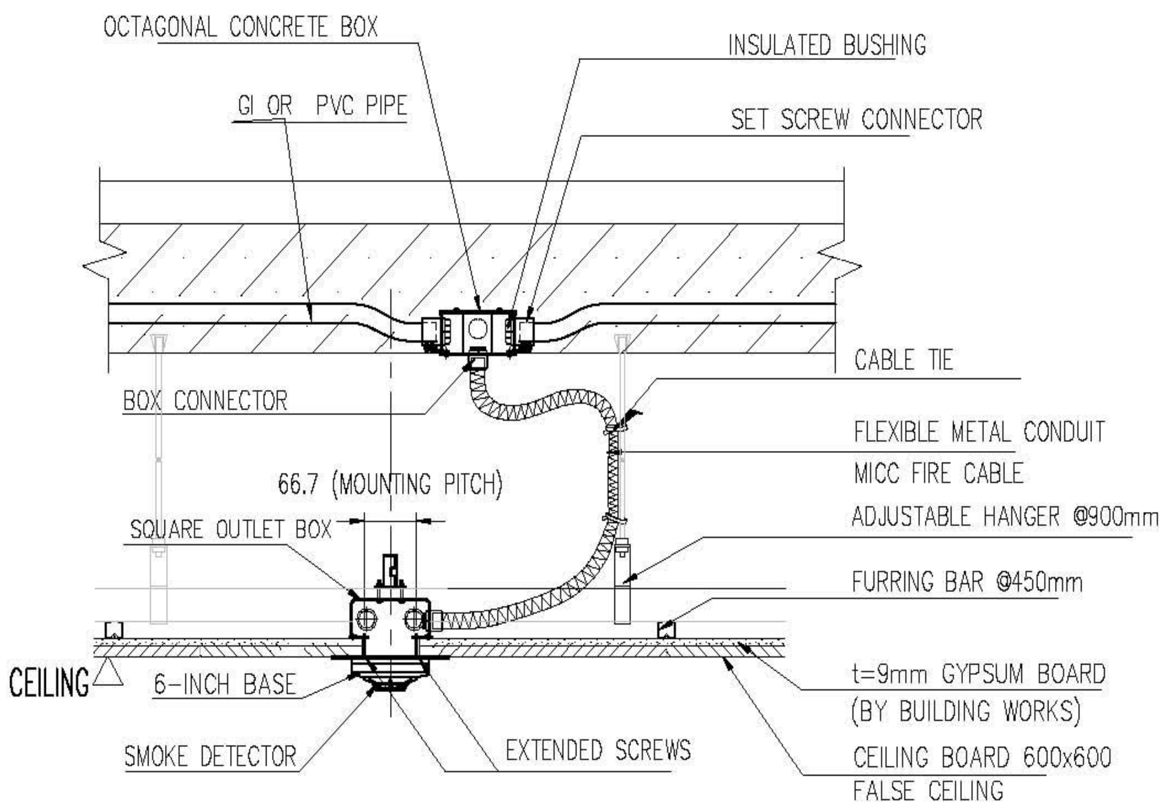
L.13 Installation Details for Down Light Fixture



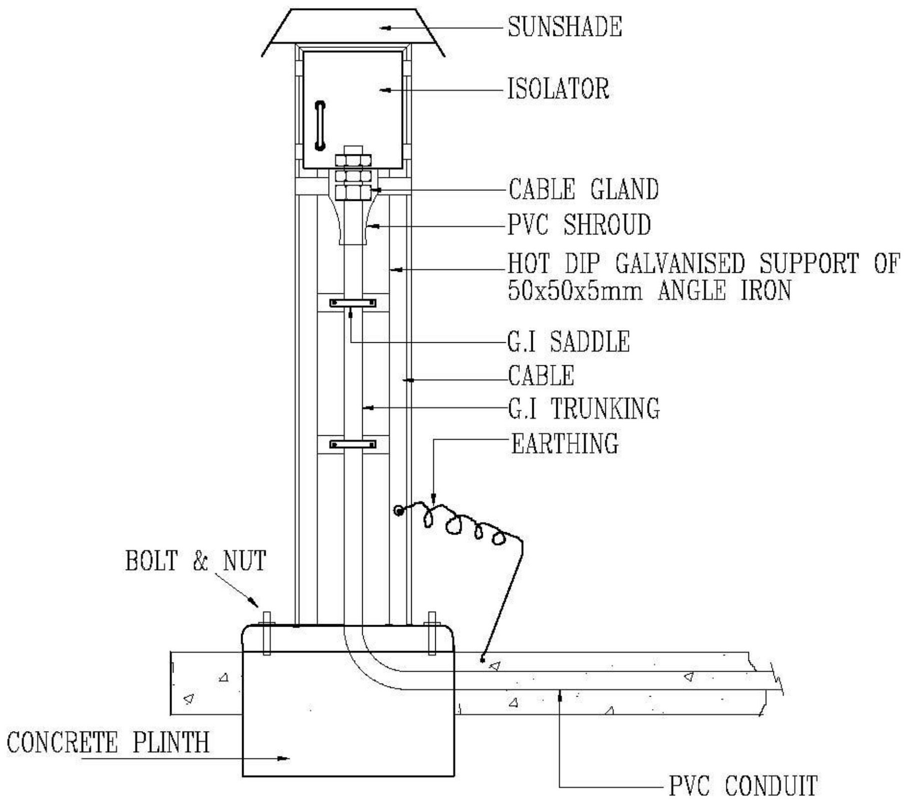
L.14 Installation Details for Fire Alarm Detector Surface Mounted



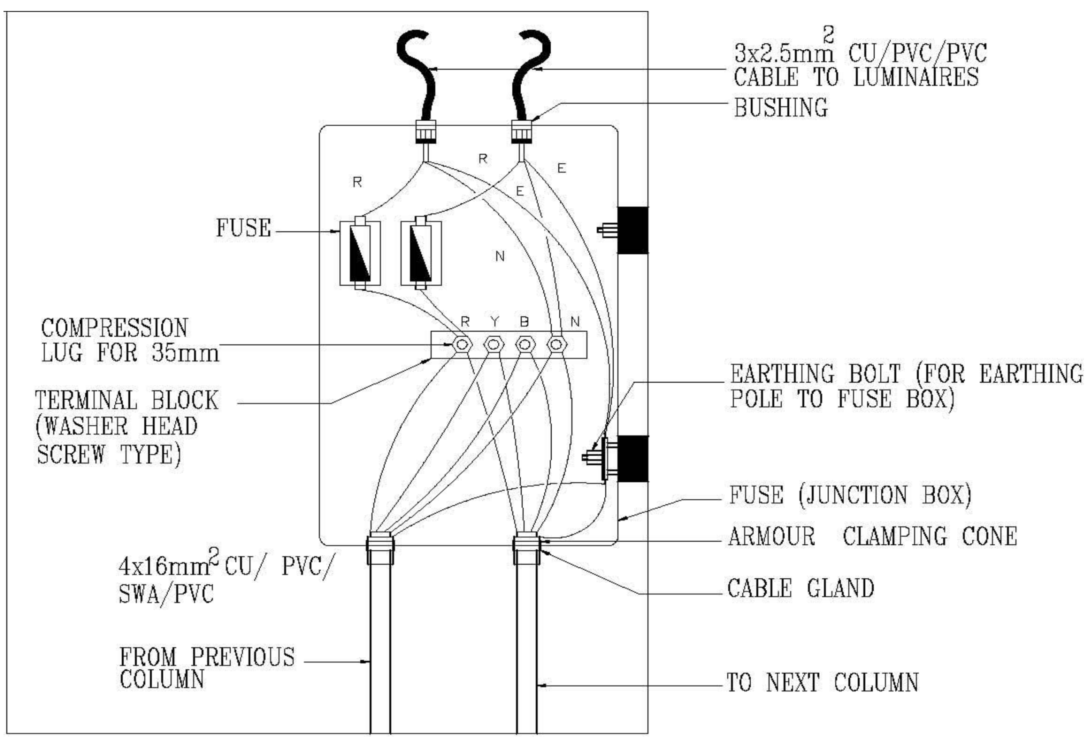
L.15 Installation Details for Recessed Type Detector



L.16 Outdoor Mounting Details of Isolator



L.17 Fuse Junction Box for Lighting Pole Details



REFERENCES

CODE TITEL	ITEMS REFERENCE			
IEEE	241	1159	519	802.3U
	602	802.1	802.3	
BS	60947-03	6004	6346	5467
	61439-2	60947-2	5685	7671
	62305	6651	5486	5027-2
	88	6099	4607	3676
	1363	7430	60947-4-1	5445 PART 7
	5445 PART 5	5839 PART 2	5839	6387
	60598-1	50272-2	60147-1-1	
NEC	ARTICLE 220	ARTICLE220.12	ARTICLE 430(5)	ARTICLE 250-6
	ARTICLE 250-7	ARTICLE 450.3	SECTION 230-95	SECTION 517-14
	ARTICLE 517	ARTICLE 300	ARTICLE 680(1)	
IEC	61439-2	61050-161	50160	62271-100
	62271-102	62271-103	60068-2	60947-2
	947	60331	598-1	60831-1 AND 2
	61912	62305-2	60529	60721-1
	62053	60721-3	598-2	62052
	61243-5	76	60044-1	439-2
	62271-200	60044-2	726	62271-1
	60050(441)	439		
ISO	3864	11801		
VDE	0532/71	0532 TEIL 1		
ICEL	1004 & 1009			
TIA	942	568 A	568-B.2-1	
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