

Internship Program Report

By

**KORAMPALLI ASHOK
19485A0241**



In association with



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Introduction

Internship program arranged by GUDLAVALLERU ENGINEERING COLLEGE in association with Smart Internz, Hyderabad for the benefit of 3rd year EEE batch 2018-2022 on Electrical Detailed design Engineering for Oil& Gas, Power and Utility industrial sectors.

Program organiser

Smart Bridge, Hyderabad.

Industrial Automation projects.

Pioneer in organising Internships, knowledge workshops, debates, hackathons, Technical sessions and



Courtesy

Dr. Sri B. Dasu – HOD – EEE, GEC

Dr.G.Srinivasa Rao-Coordinator

Mr. Ramesh V - Mentor

Mr. Vinay Kumar - System Support

Mr. Harikanth – Softwar/Technical Support

Program details

Smart Internz program schedule: 4 weeks starting from 3rd May 2021

Daily schedule time shall be 4PM to 6.30PM

Mode of Classes: Online through ZOOM

Presenter: Mr Ramesh V

Internship program

We have been given the opportunity to learn and interact with industry experienced engineering specialist to learn the Electrical detailed design engineering for various industrial sectors.

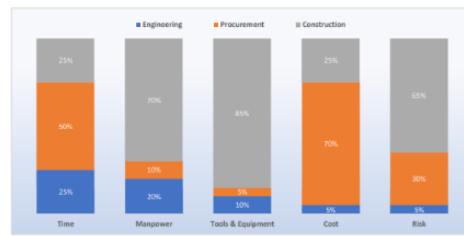
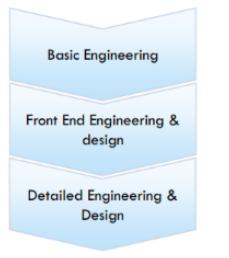
3rd May 2021: Introduction to EPC Industry

1	EPC Industry & Electrical Detailed Engineering	EPC Industry Engineering Procurement Construction	Introduction Types of Engineering Engineering role in procurement Engineering role during construction
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Topic details:

1A. INTRODUCTION TO EPC INDUSTRY

- EPC – Engineering, procurement & construction
- EPC companies – Engineering, Procurement & Construction (TECHNIPI, TOYO, L&T, JACOBS, JGC, PUNJ LLOYD, TCE)
- Industry: Oil & gas, Power, Fertilizer, Chemical, Textile, Food & beverage, Utility sectors.
- Projects: Green Field & Brown Field.
- Engineering – Basic engineering, FEED (Front End Engineering & Design), Detailed engineering. Detailed Engineering – Engineering (for Procurement) & detailed design (for Construction)



Internz

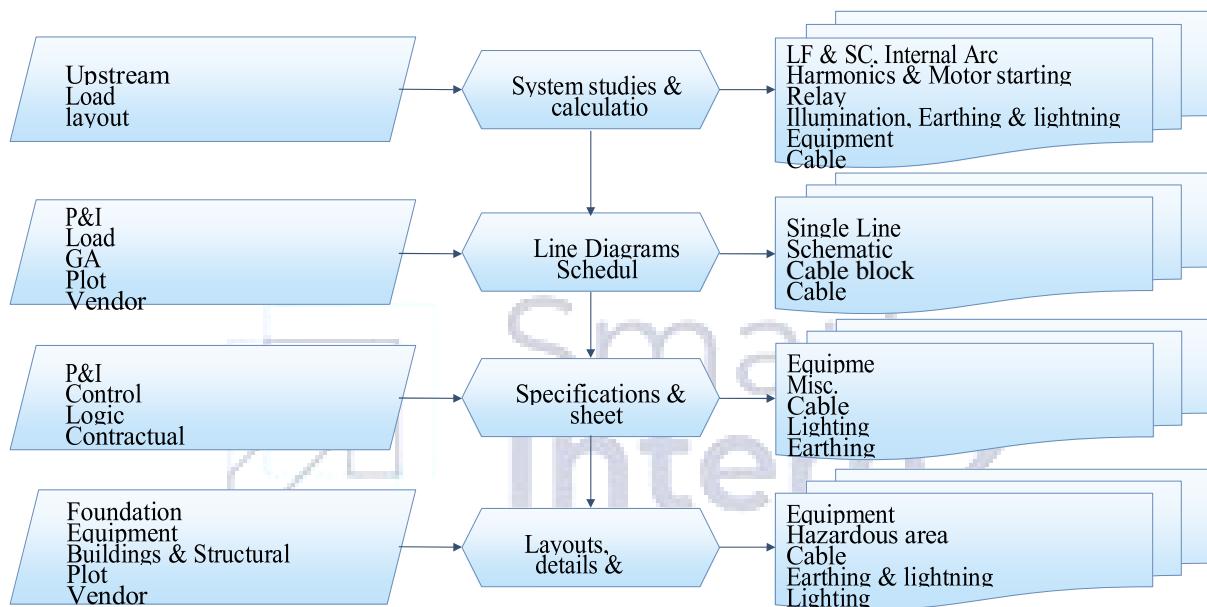
Engineering phases, Engineering deliverables (drawings & documents) list, Design Engineer role at various phases of project.

4th May 2021: Engineering documentation for EPC projects

2	Electrical Design Documentation	Engineering Deliverables list Detailed Engineering work flow Document transmission Deliverables types	Sequence of deliverables Detailed engineering process Document submission and info exchange Different types of deliverables
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Topic details:

SEQUENCE OF DELIVERABLES



On this day I have learned the Deliverable list of details and work flow in electrical design. And after sequence of deliverables, Detailed engineering process, Document submission and exchange process, and at last I learned about different types of deliverables.

5th May 2021: Engineering documentation for commands and formulae

3	Electrical Design Documentation	Ms word commands Ms excel formulae Auto cad basic commands
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Topic details:

MS Word, Excel and Auto cad COMMANDS.

Word Shortcut Keys

Command Name	Keys
All Caps	Ctrl+Shift+A
Apply List Bullet	Ctrl+Shift+L
Auto Format	Alt+Ctrl+K
Auto Text	F3
Bold	Ctrl+B
Cancel	ESC
Center Para	Ctrl+E
Change Case	Shift+F3
Clear	Del
Close or Exit	Alt+F4
Copy	Ctrl+C
Create Auto Text	Alt+F3
Cut	Ctrl+X
Double Underline	Ctrl+Shift+D
Find	Ctrl+F
Help	F1
Hyperlink	Ctrl+K
Indent	Ctrl+M
Italic	Ctrl+I
Justify Para	Ctrl+J
Merge Field	Alt+Shift+F
New Document	Ctrl+N
Open	Ctrl+O
Outline	Alt+Ctrl+O
Overtype	Insert
Page	Alt+Ctrl+P
Page Break	Ctrl+Return
Paste	Ctrl+V
Paste Format	Ctrl+Shift+V
Print	Ctrl+P
Print Preview	Ctrl+F2
Redo	Alt+Shift+Backspace
Redo or Repeat	Ctrl+Y
Save	Ctrl+S
Select All	Ctrl+A
Small Caps	Ctrl+Shift+K
Style	Ctrl+Shift+S
Subscript	Ctrl+=
Superscript	Ctrl+Shift+=
Task Pane	Ctrl+F1
Time Field	Alt+Shift+T

Underline	Ctrl+U
Undo	Ctrl+Z
Update Fields	F9
Word Count List	Ctrl+Shift+G

Function Keys	
F1	Get Help or visit Microsoft Office Online.
F2	Move text or graphics.
F3	Insert an AutoText (AutoText: A storage location for text or graphics you want to use again, such as a standard contract clause or a long distribution list. Each selection of text or graphics is recorded as an AutoText entry and is assigned a unique name.) entry (after Microsoft Word displays the entry).
F4	Repeat the last action.
F5	Choose the Go To command (Edit menu).
F6	Go to the next pane or frame.
F7	Choose the Spelling command (Tools menu).
F8	Extend a selection.
F9	Update selected fields.
F10	Activate the menu bar.
F11	Go to the next field.
F12	Choose the Save As command (File menu).

Here we need to check the Page setup, spelling, Grammar, Punctuation, Paragraphs, Overall presentations, Tables & pictures to be numbered and titled at last we check the Document name & date of versions.

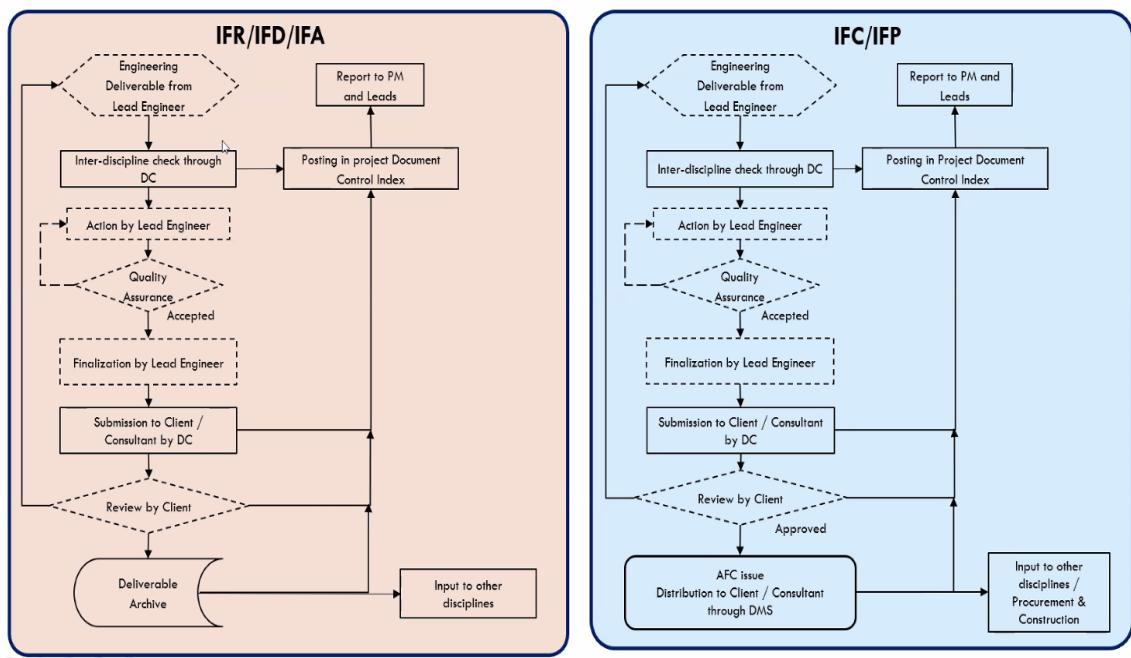
7th May 2021: Engineering documentation for Electrical system design

4	Electrical system design for a small small project	Overall plant description Sequence of approach Approach to detailed design
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Topic details: Overall plant description ,approach to detailed design.



1C. DETAILED ENGINEERING



Here we observed that how to do a project and Sequence of approach, Approach to detail design and Overall plant distribution system.

10th May 2021: Engineering documentation for Typical diagrams

5	Electrical system design for typical diagrams	Load lists schedule Single line diagram	Power flow diagram Typical schematic diagram
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Topic details: Typical diagrams and Load calculations.

We conclude here how to do load calculations and Typical diagrams and internal structure and also about the power flow diagram.

11th May 2021: Classification of Transformers and Generators

6	Classification of Transformers and Generators	Different types of Transformers	Different types of Generators
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Topic Details: Classification of Transformers and Generators.



1 Ph. Pad mounted 3 Ph Pole mounted Commercial/ 3 Ph Oil filled (ONAN) Distribution Residential lighting Residential/ street lighting type for industrial & commercial.



415V Diesel generator sets for standby / 240V 1 ph diesel generator set for lighting and & small power only Emergency power supply.

Transformer shall include a primary disconnect on the incoming power source. The disconnect means shall be either a breaker or a load break primary switch that is fused. Transformers are sized to carry the peak running load of all busses connected to them. In addition, feeders to and from power transformers shall be rated to carry full current at the maximum rating.

The packaged combination of a diesel engine, an alternator and various ancillary devices such as base, canopy, sound attenuation, control systems, circuit breakers, jacket water heaters, starting systems etc., is referred to as a Diesel Generating Set or a DG Set in short.

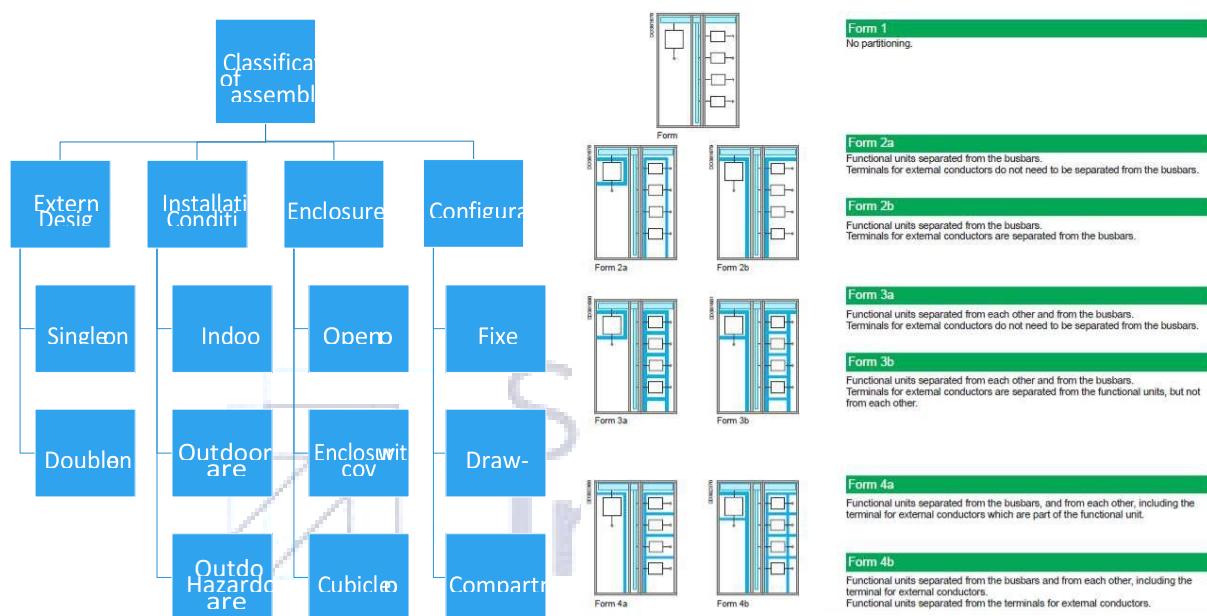
12th May 2021: Classification of Switchgare construction and power factor improvement

7 Classification of
Switchgare
construction and
power factor
improvement

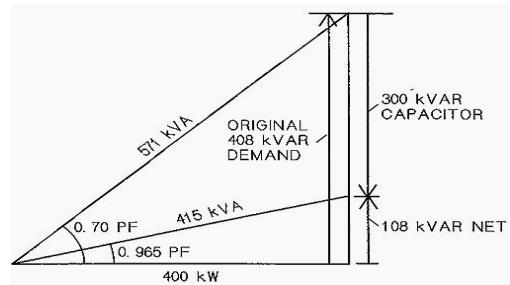
Different types of Switchgare
assembles

Power factor improvement

Topic details: Classifiaction of Switchgare contruction and Power Factor Improvement.



Switchgear includes switching & protecting devices like fuses, switches, CTs, VTs, relays, circuit breakers, etc. This device allows operating devices like electrical equipment, generators, distributors, transmission lines, etc.



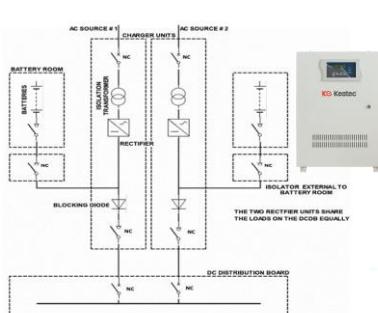
Power factor defined as the ratio of real power to volt-amperes and is the cosine of the phase angle between the voltage and current in an AC circuit.

17th May 2021: Detailing about UPS system and Busducts.

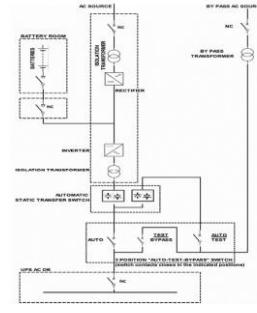
8	Detailing about UPS system and Busducts	Uninterruptible power supply system	Busducts of the system
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Topic details: Power distribution of UPS system and Busducts.

UPS systems are designed to provide continuous power to a load, even with an interruption or loss of utility supply power. UPS generally involves a balance of cost Vs need.



110V or 220V DC
UPS System



110V or 230V
AC UPS System

Smart
Internz

Busducts are classified into various types depending on its application viz phase separated Busducts, segregated phase busducts, non-segregated phase busducts.



18th May 2021: Detailing about Motor Starters and Sizing of motors.

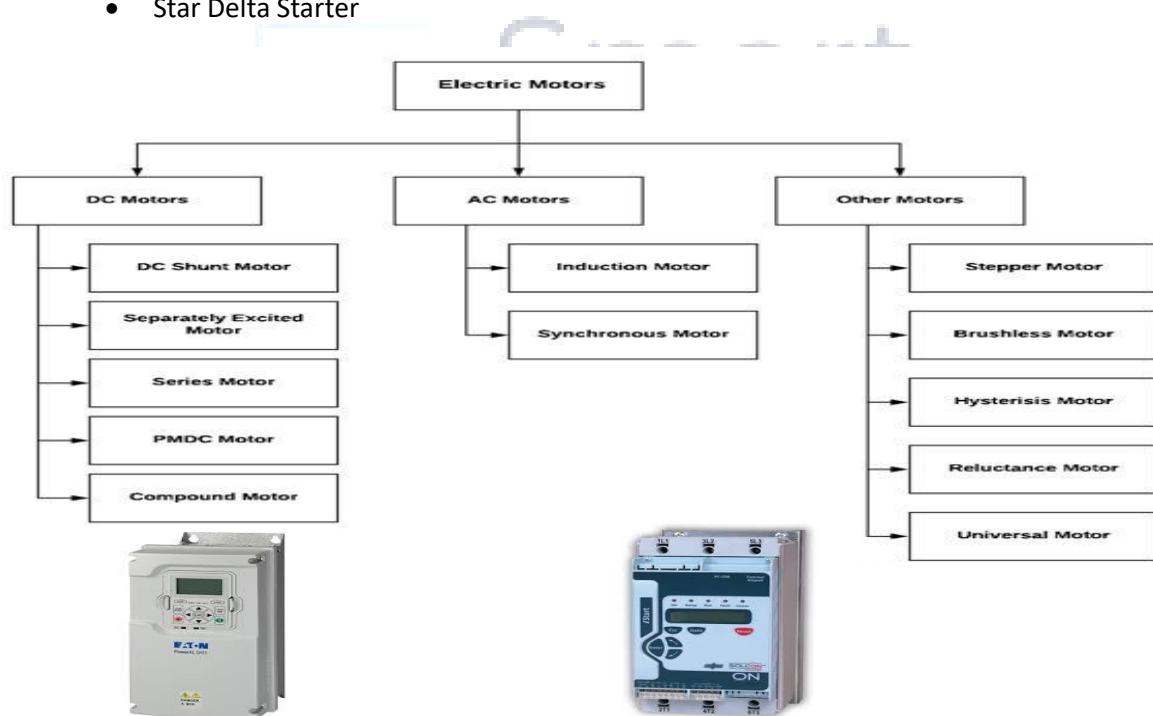
9	Detailing about Motor Starters and Sizing of motors	Motor starters and drives	Sizing and selection of motors
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Topic details: Detailing about Motor Starter and Sizing of motors and their selection.

The principal function of a motor starter is to start and stop the respective motor connected with specially designed electromechanical switches which are similar in some ways to relays. The main difference between a relay and a starter is that a starter has overload protection for the motor that is missing in a relay.

Different types of motor starters are as follows:

- Direct-On-Line Starter
- Rotor Resistance Starter
- Stator Resistance Starter
- Auto Transformer Starter
- Star Delta Starter



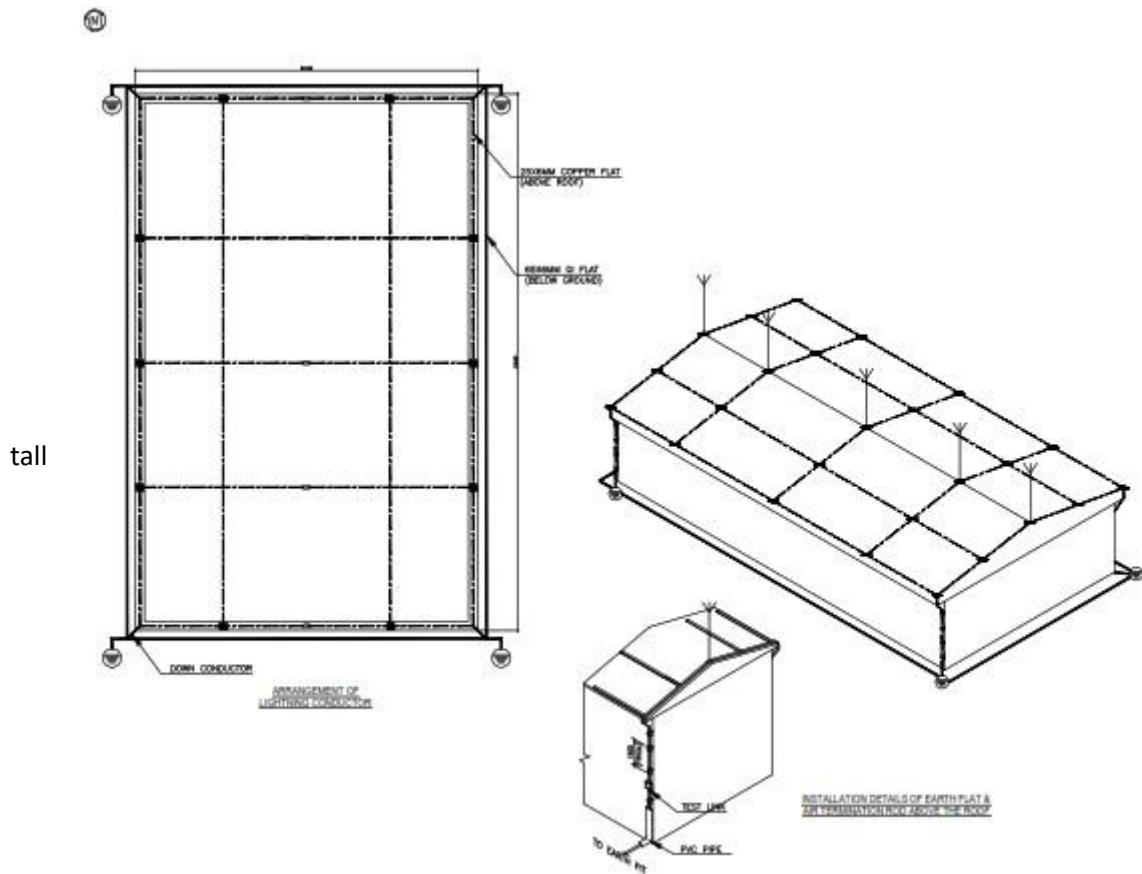
- Starting method – soft starter, Auto transformer, Star/Delta
- Speed variation – Constant speed, variable speed for VFD
- Frame Size – 56 to 280
- Insulation class & Temp rise – A, E, B, F & H
- Protection – Protection based on voltage & KW rating
- Cable entry, size & termination – Cable sizing based on starting/running voltage drop and short circuit current Vibration – monitoring based on KW rating.

19th May 2021: Describing about Earthing system and Lighting Protection.

10	Describing about Earthing system and Lighting Protection.	Plant Earthing system	Lighting Protection materials
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Topic details: Describing about Earthing system and Lighting Protection.

The purpose of earthing is to prevent damage to people and prevent or limit plant damage. Various earthing systems are provided with each earthing system is isolated from the other.



Lightning protection required for high rise structures and important buildings against lightning currents during thunder storms. Primarily Lightning protection system calculations are done based on soil resistivity, conductor material, coverage structure / Building to determine whether lightning protection is required or not.

20th May 2021: Lighting or illumination systems and calculations.

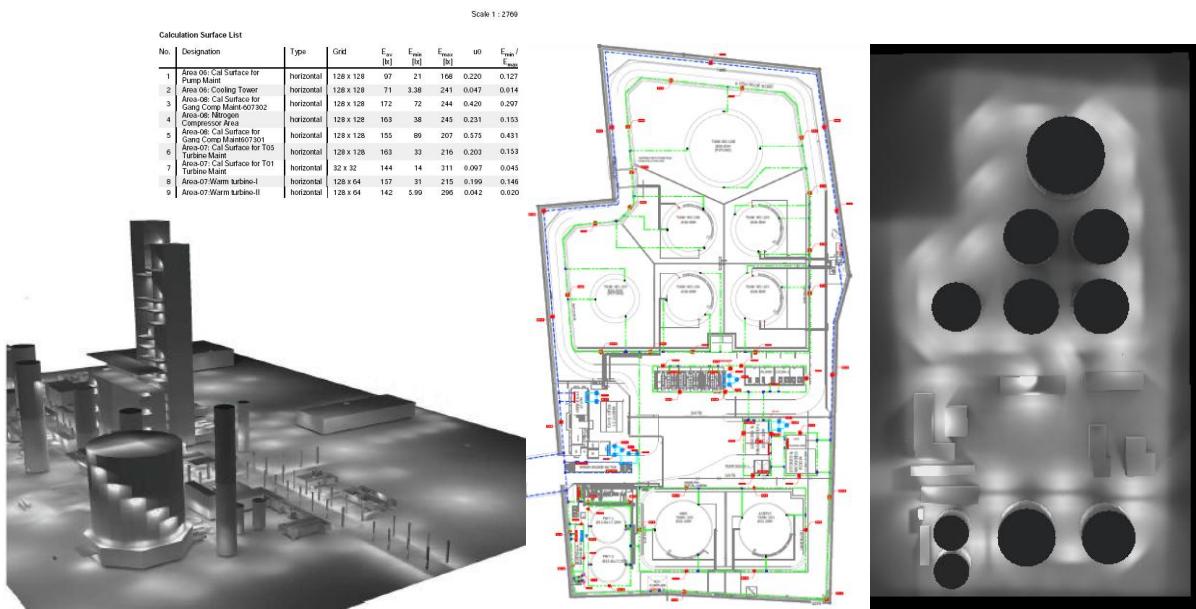
**11 Lighting or
Illumination
systems and
Calculations**

Lighting or illumination systems

Lighting calculations

Topic details: Lighting or Illumination systems and Calculations.

All outdoor lighting fittings shall be connected with armoured PVC cable of suitable no. of cores and size. Necessary type and no. of junction boxes shall be provided for branch connections. Indoor light fittings shall be connected with FRLS PVC wires laid in cable trunks or conduits.



Inputs required: Equipment and cable routing layouts, lighting calculations, Design basis for type of light fittings to be used, required lux levels

Lighting calculations software: Dialux, Chalmlite, Calculux, Relux, Luxicon, CG Lux

Applicable Standards: IS 6665: Code of practice for industrial lighting, IS 3646: Code of practice for interior illumination, IEC 60598: Luminaires, IEC 62493: Assessment of lighting equipment related to human exposure to electromagnetic field

Deliverables: Indoor Lighting layouts, socket outlet layouts, Street lighting and area lighting layouts. BOQ.

Types of light fittings: Industrial, flame proof type (Ex d), increased safety type (Ex e).

21th May 2021: Lighting or illumination systems using DIALUX software.

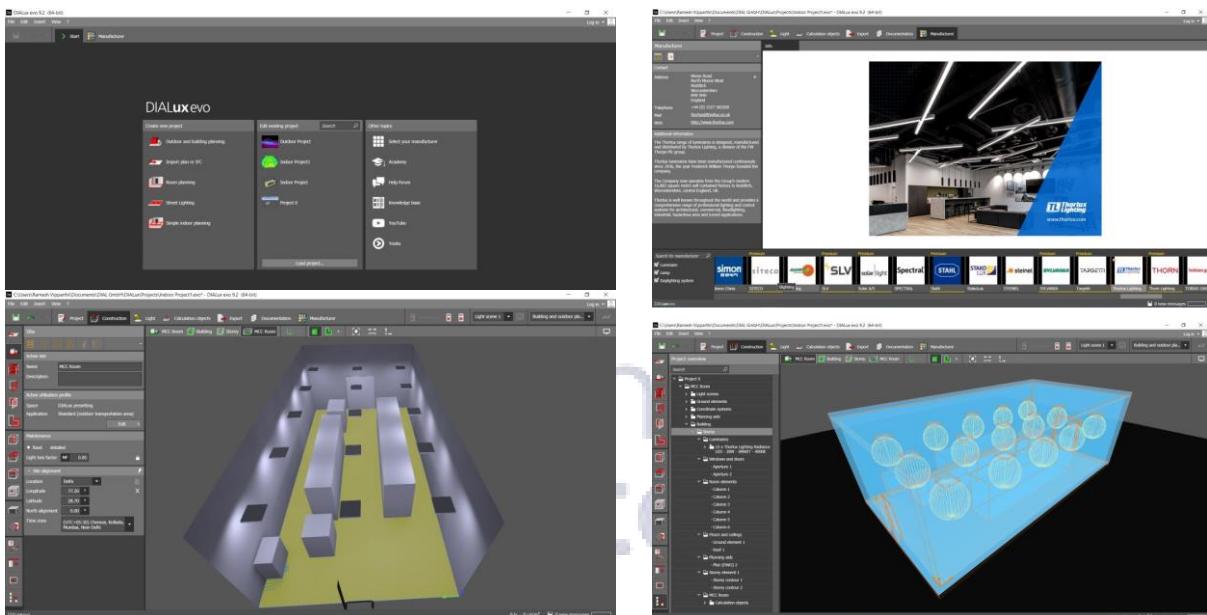
12 Lighting or
Illumination using
DIALUX software

Lighting or illumination systems

Operation of dialux software

Topic details: Lighting or Illumination Calculations using DIALUX software.

Here we are using this Dialux evo 5.9.2 software windows to construct the power plant and we can perform the operation from this software.



We have the indoor calculations and outdoor calculations too.

Results

	Symbol	Calculated	Target	Check	Index
Workplane	$\bar{E}_{\text{perpendicular}}$	264 lx	$\geq 500 \text{ lx}$	✗	
	\bar{g}_i	0.077	-	-	
Consumption values	Consumption	1300 kWh/a	max. 3400 kWh/a	✓	
Lighting power density	Room	4.82 W/m ²	-	-	
		1.83 W/m ² /100 lx	-	-	

Utilisation profile: DIALux presetting, Standard [office]

Luminaire list

pcs.	Manufacturer	Article No.	Article name	P	Φ	Luminous efficacy
15	THORLUX	RAD16401	Radiance LED - 28W - SMART - 4000K	31.0 W	4130 lm	133.2 lm/W

Piperack

Luminaire list

Φ _{total}	P _{total}	Luminous efficacy
15850 lm	360.0 W	44.0 lm/W

5	CEAG	122658811 eLLK 92018/18 CG-5 03	72.0 W	3170 lm	44.0 lm/W
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Indoor calculation

outdoor calculations

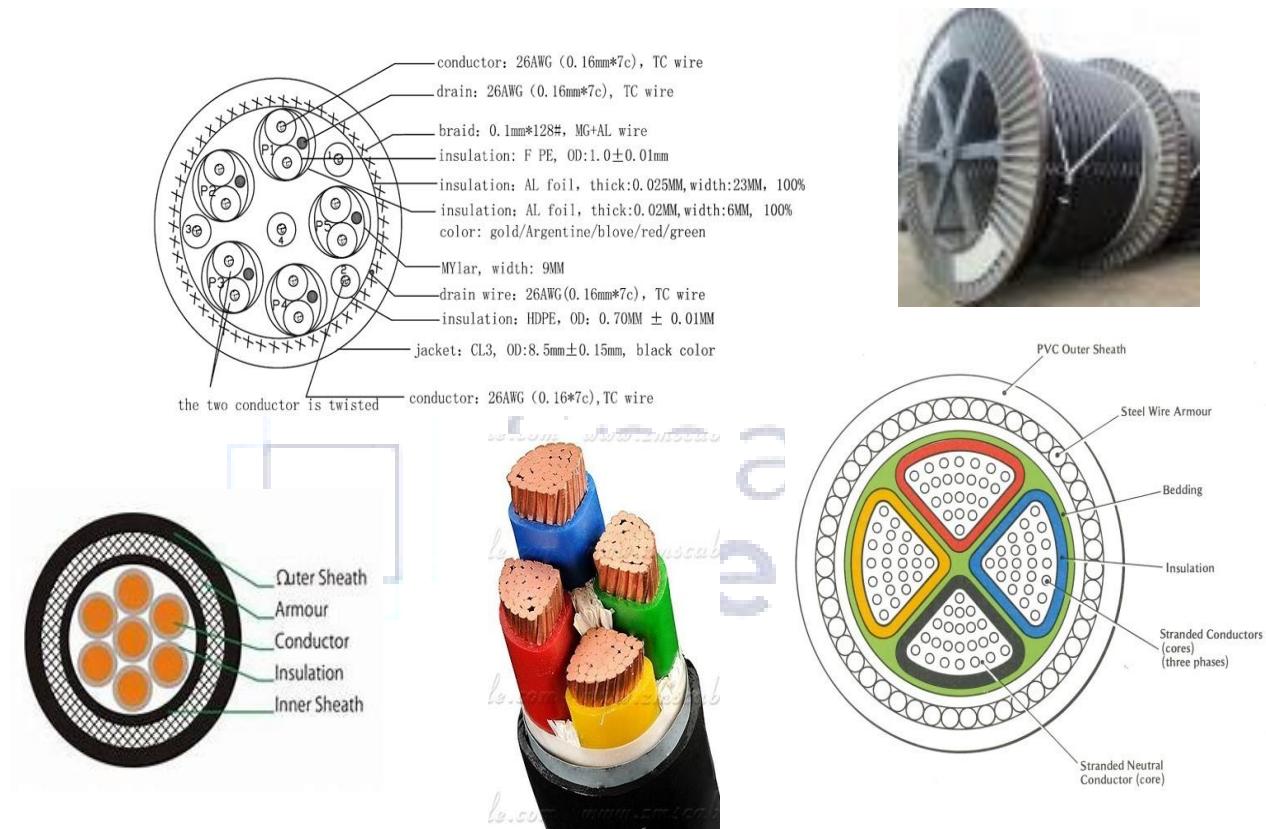
24th May 2021: Cabling and their calculations and types.

13 Cabling and their types and calculations

Cabling calculations

Types of cabling materials

Topic details: Cabling and their types and calculations .



Electrical cables must be properly supported to relieve mechanical stresses on the conductors, and protected from harsh conditions such as abrasion which might degrade the insulation.

Cables generally laid in the cable trays above ground, direct buried underground and in metallic or PVC conduits. Derating factors may be applicable for each type of cable laying conditions.

Cable trays shall be generally loaded 60 to 70% leaving space for future use.
Underground cabling shall be done in concrete cable trenches with cable trays in paved areas and directly buried with mandatory gap of 300mm between different systems of cables.

25th May 2021: Cabling calculations and Cable gland selection.

14 Cabling
calculations and
cable gland
selection

Cabling calculations

Cable gland selection

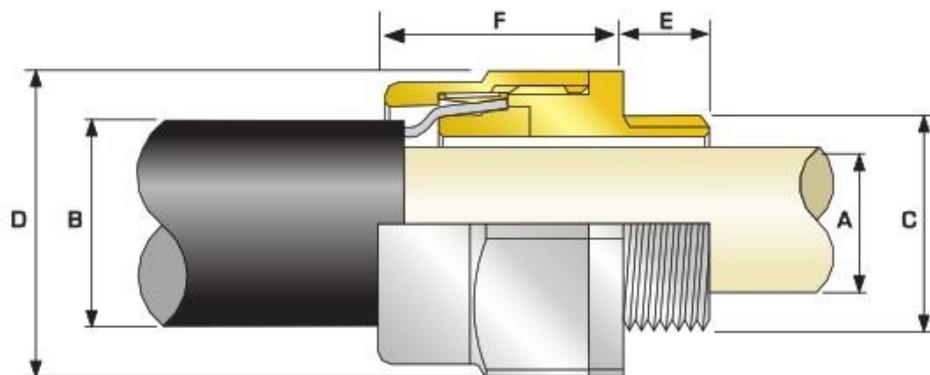
Topic details: Cable sizing calculation and cable gland selection.

Inputs required: Load List, Design basis, Electrical equipment layout, cable schedule, vendor catalogues for cable tray.

Cable tray sizing shall be performed for each branch of cable tray routing up to the load point.

Results shall be checked with specified limits mentioned in design basis.

Cable gland:



Cable Gland Selection Table

Refer to illustration at the top of the page.

Cable Gland Size	Available Entry Threads "C" (Alternate Metric Thread Lengths Available)		Cable Bedding Diameter "A"	Overall Cable Diameter "B"	Armour Range		Across Flats "D"	Across Corners "D"	Protrusion Length "F"
	Metric	Thread Length (Metric) "E"			Max	Max			
20S16	M20	10.0	8.7	13.2	0.8	1.25	24.0	26.4	35.2
20S	M20	10.0	11.7	15.9	0.8	1.25	24.0	26.4	32.2
20	M20	10.0	14.0	20.9	0.8	1.25	30.5	33.6	30.6
25	M25	10.0	20.0	26.2	1.25	1.6	36.0	39.6	36.4
32	M32	10.0	26.3	33.9	1.6	2.0	46.0	50.6	32.6
40	M40	15.0	32.2	40.4	1.6	2.0	55.0	60.5	36.6
50S	M50	15.0	38.2	46.7	2.0	2.5	60.0	66.0	39.6
50	M50	15.0	44.1	53.1	2.0	2.5	70.1	77.1	39.1
63S	M63	15.0	50.0	59.4	2.0	2.5	75.0	82.5	52.0
63	M63	15.0	56.0	65.9	2.0	2.5	80.0	88.0	49.8
75S	M75	15.0	62.0	72.1	2.0	2.5	90.0	99.0	63.7
75	M75	15.0	68.0	78.5	2.5	3.0	100.0	110.0	57.3
90	M90	24.0	80.0	90.4	3.15	4.0	114.3	125.7	66.6

28 th May2021: Load calculations and Transformer sizing calculations

**15 Load calculations
and TR
calculations**

Load calculations**TR calculations****Topic details:****List of electrical load calculations.**

Sl No.	Equipment No.	Equipment Description	Breaker Rating	Breaker Type	Breaker No. of Poles	ELCB Rating	Absorbed Load	Motor / Load Rating	Load Factor (A)/(B)	Efficiency Factor at Load (C)	Power Factor at Load (D)	Consumed Load (E) = (A)/(D)	kVAR = kVAR at stand-by	Continuous		Intermittent		Stand-by	
														(A) mA	(B) kW	(C) decimal	(D) decimal	(E) kW	(F) kVAR
1	PUS16	Silica filter feed pump					12.49	15.00	0.83	0.95	0.73	14.67	13.74						
2	PU2314-A	Absorbent(Neutral oil pump (b))					3.62	0.77	0.95	0.73	0.73	4.3	4.0						
3	PU2314-B	Absorbent(Neutral oil pump (S))					3.11	3.70	0.84	0.95	0.73			3.7	3.4				
4	PU2305	Feed Pump (Separator)					12.58	15.00	0.84	0.95	0.73	14.8	13.9						
5	MK2305	Mixer (v)					12.69	15.00	0.85	0.95	0.73	14.9	14.0						
6	AG2309	Mixer (b)					12.69	15.00	0.85	0.95	0.73			14.9	14.0				
7	BV2313	Blower					5.45	7.59	0.73	0.95	0.73	6.4	6.0						
8	Rotary valve	TK 2313-1					0.53	0.75	0.71	0.95	0.73			0.6	0.6				
9	SC2322	Screen separator (b)					1.22	1.50	0.95	0.95	0.73			1.45	1.35				
10	SC2324A	Chlorine acid tank agitator (b)					0.91	1.10	0.83	0.95	0.73	1.07	1.00						
11	AG2324B	Chlorine acid tank agitator (S)					0.91	1.10	0.83	0.95	0.73			1.1	1.0				
12	AG2305	Chlorine reaction vessel agitator					3.34	3.70	0.90	0.95	0.73	3.93	3.68						
13	AG2309	Lime solution vessel agitator					1.21	1.50	0.95	0.95	0.73	1.42	1.35						
14	AG2310	Lime solution vessel agitator					1.21	1.50	0.81	0.95	0.73	1.42	1.33						
15	AG2314	Soap Adsorbant Tank Agitator					2.12	3.00	0.71	0.95	0.73	2.43	2.34						
Maximum of normal running plant load : (Est. $x\%E + y\%F + z\%G$)																			
66.0 kW																			
61.8 kVAR																			
$\sqrt{P^2 + Q^2} = 90.4 \text{ kVA}$																			
TOTAL										65.40	61.23	2.07	1.94	19.65	18.39				
Peak Load : (Est. $x\%E + y\%F + z\%G$)																			
68.0 kW																			
63.7 kVAR																			
$\sqrt{P^2 + Q^2} = 93.1 \text{ kVA}$																			
kVA										89.59		2.84		26.31					
Assumptions:																			
1. Load factor, Efficiency and Power factor.																			
Load Rating (kW)																			
<> 10 <> 20																			
> 20 <> 45																			
> 45 <> 150																			
> 150																			
Efficiency																			
0.85																			
Power factor																			
0.95																			
0.91																			
0.93																			
0.94																			

TR sizing calculations:**Calculation for Transformer Capacity****1.0 Example of calculation for Transformer Capacity****1.1 Calculation for consumed load**

Consumed loads used for this example are as follows :

	kW	kVar	kVA	
a. Continuous load	65.4	61.2	89.57	---
b. Intermittent load / Diversity Factor	2.07	1.9	2.81	---
c. Stand-by load required as consumed load	19.65	18.4	26.92	---
Max. Consumed load = ((i) + 30% (ii) + 10% (iii)) =	66.0	61.8	90.42	
Future expansion load (20% capacity)	13.2	12.4	18.08	
Total Load =	79.2	74.2	108.50	

1.2 Calculation for 3.3kV / 0.433 kW transformer capacityMax. Consumed load = 90.4 kVA
Spare capacity = 18.1 kVA
Required capacity = 108.5 kVA
Transformer rated capacity = 120 kVA**1.3 Voltage regulation check**

During starting or reacceleration of max. capacity motor (3400 kW), while all the other loads running, the voltage regulation is as follows :

$$P_T = 120 \text{ kVA} \quad (\times Z) = 4.19 \quad \& \text{ Ratio } X/R = 3.2$$

$$\text{Hence, } \times R = = 1.236 \%$$

$$\times X = = 4.00 \%$$

$$P_H = 15 \text{ kW having (K = 6 \& C = 1) } \quad \& \text{ Cos } \theta = 0.73 \quad \& \text{ Eff.m = 0.85 } \quad \& \text{ Cos } \theta_s = 0.25$$

$$P_S = 145.04 \text{ kVA}$$

$$P_C = 94.941 \text{ kW}$$

$$P_Q = 176.82 \text{ kVAR}$$

$$P_C = 200.7 \text{ kVA}$$

$$\text{Cos } \theta_{C_s} = 0.4731, \text{ where as } \text{Sin } \theta_{C_s} = 0.881$$

$$\text{Voltage Regulation s} = = 6.9 \%$$

Result During starting of max. capacity motor, while all other loads are running, the voltage regulation at Transformer secondary terminals is approx: 6.90%

29th May2021: DG set calculations.

16 DG set
calculations

Topic details:

Transformer and DG set calculations, types ,sizing or selections

Design Data		
Rated Voltage	415	KV
Power factor ($\cos\theta$)	0.73	Avg
Efficiency	0.85	Avg
Total operating load on DG set in kVA at 0.73 power factor	90.4	
Largest motor to start in the sequence - load in KW	15	KW
Running kVA of last motor ($\cos\theta=0.91$)	24	KVA
Starting current ratio of motor	6	(Considering starting method as Soft starter)
Starting KVA of the largest motor (Running kVA of last motor X Starting current ratio of motor)	145	KVA
Base load of DG set in KVA (Total operating load in kVA - Running kVA of last motor)	66	KVA
A Continuous operation under load -P1 Capacity of DG set based on continuous operation under load P1	66	KVA
B P2 Transient Voltage dip during starting of Last motor		
Total momentary load in KVA (Starting KVA of the last motor+Base load of DG set in KVA)	211	KVA
Subtransient Reactance of Generator (X_d'')	7.91%	(Assumed)
Transient Reactance of Generator (X_d')	10.065%	(Assumed)
$X_d''' = (X_d'' + X_d')/2$	0.089875	
Transient Voltage Dip	15%	(Max)
Transient Voltage dip during Soft starter starting of Last motor $P_2 = \text{Total momentary load in KVA} \times X_d''' \times [1-\text{Transient}]$ (Transient Voltage Dip)	108	KVA
C Overload capacity P3		
Capacity of DG set required considering overload capacity		
Total momentary load in KVA	211	KVA
overcurrent capacity of DG (K)	150%	
(Ref: IS/IEC 60034-1, Clause 9.3.2)		
Capacity of DG set required considering overload capacity ($P_3 = \frac{\text{Total momentary load in KVA}}{\text{overcurrent capacity of DG (K)}}$)	141	KVA
Considering the last value amongst P1, P2 and P3		
Continuous operation under load -P1	66	KVA
Transient Voltage dip during Soft starter starting of Last motor P2	108	KVA
Overload capacity P3	141	KVA
Considering the last value amongst P1, P2 and P3 ----- Starting	141	KVA
	150	KVA

2nd june2021: Calculations of Earthing and Lighting protection.

17	Calculation of Earthing and Lighting protection calculations	Earthing calculations	Lighting protection calculation
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Topic details:

Calculation of Earthing and Lighting protection calculations

Location	2	Bangalore	
Building		Srtuctural, Industrial	
Type of Building		Triangle Roofs (c)	
Building Length (L)	18		
Building breadth (W)	8		
Building Height (H)	6		
Risk Factor Calculation			
Collection Area (A _c)		=	(3.14*H*H)+(2*H*W) 209.04
A _c		=	A _c * N _g * 10 ⁻⁶ 0.000585312
Probability of Being Struck (P)		=	P
P		=	A _c * N _g * 10 ⁻⁶ 0.000585312
Overall weighing factor		=	1.0
a) Use of structure (A)		=	0.8
b) Type of construction (B)		=	0.8
c) Contents or consequential effects (C)		=	1.0
d) Degree of isolation (D)		=	0.3
e) Type of country (E)		=	A * B * C * D * E 0.192
Wo - Overall weighing factor		=	P * Wo 0.00011238
Overall Risk Factor		Po	
		Po	=
		Pa	=
			10 ⁻⁵
As per clause no. 9.7 of BS- 6651, suggested acceptable risk factor (Po) has been taken as 10 ⁻⁵ Since Po > Pa lightning protection required.			

Earthing calculations:

	2	
Maximum line-to-ground fault in kA for 1 sec	14	
Earthing material (Earth rod & earth strip)	GI	
Depth of earth flat burrial in meter	0.5	
Average depth / length of Earth rod in meters	4.5	
Soil resistivity Ω-meter	13	
Ambient temperature in deg C	55	
Plot dimensions (earth grid) L x B in meters	75	135
Number of earth rods in nos.	6	

Earth electrode sizing:

Ac - Required conductor cross section in sq.mm

$$I_{lg} = A_c \times \sqrt{\left[\frac{TCAP \times 10^{-4}}{t_c \times \alpha_r \times \rho_r} \right] \times \ln \left[\frac{K_0 + T_m}{K_0 + T_a} \right]}$$

αr - Thermal co-efficient of resistivity, at 20 oC

0.0032

ρr - Resistivity of ground conductor at 20 oC

20.10

Ta - Ambient Temperature is °C

55

I_{lg} - RMS fault current in kA = 50 KA

14

t_c - Short circuit current duration sec

1

Thermal capacity factor, TCAP J/(cm³.oC)

3.93

Tm - Maximum allowable temperature for copper conductor, in oC

419

K0 - Factor at oC

293

5 th june 2021: Cable sizing and cable tray sizing calculations.

18 Cable sizing and cable tray sizing calculations

Cable sizing calculations

Cable tray calculation

Topic details: Cable sizing and cable tray sizing calculations for LV cables and MV/HV cables.

Description	Consumed Load KW	Load Rating KW	Voltage (V)	No. of ph	Full Load Current [A]	Starting Current [A]	P.F.	SIN of Running	Motor P.F.	SIN of Starting	Type	No. of Runs	No. of Cores	Size (mm²)	Current Rating [A]	Derating factor k1	Derating factor k2	Derating factor k3	Derating factor k4	Overall Derating factor k	Derated Current [A]	Cable Length [M]	Cable Resistance (Ohms/kM)	Cable Reactance (Ohms/kM)	Voltage drop (Running) [V]	Voltage drop (Starting) [V]	Voltage drop (%)	Voltage drop starting (%)	Cable size result
Generator	0.47	50	415	3	217	130.12	0.8	0.6	0.8	0.5	2	1	40	10	66	0.98	0.9	1	1	0.882	58.2	95	2.3400	0.0852	6.86	165	40.99	9.88	OK
Generator/Variable speed	3.42	50	415	3	6.3	37.77	0.8	0.6	0.8	0.5	2	1	40	25	28	0.98	0.9	1	1	0.882	24.7	95	9.4800	0.1007	7.92	191	47.45	11.43	OK
Generator/Variable speed	2.11	50	415	3	5.4	32.45	0.8	0.6	0.8	0.5	2	1	40	25	28	0.98	0.9	1	1	0.882	24.7	60	9.4800	0.1007	4.30	104	25.75	5.20	OK
Generator/Variable speed	0.85	50	415	3	21.9	131.26	0.8	0.6	0.8	0.5	2	1	40	6	51	0.98	0.9	1	1	0.882	45.0	85	3.9400	0.0902	10.33	249	67.78	14.89	OK
Generator	0.48	50	415	3	22.1	132.31	0.8	0.6	0.8	0.5	2	1	40	6	51	0.98	0.9	1	1	0.882	45.0	75	3.9400	0.0902	9.18	221	54.95	13.24	OK
Generator	0.48	50	415	3	22.1	132.31	0.8	0.6	0.8	0.5	2	1	40	10	66	0.98	0.9	1	1	0.882	58.2	105	2.3400	0.0852	7.71	186	46.07	11.10	OK
Generator	5.65	110	415	3	9.5	56.87	0.8	0.6	0.8	0.5	2	1	40	6	51	0.98	0.9	1	1	0.882	45.0	100	3.9400	0.0902	5.26	127	31.49	7.59	OK
Generator	0.57	110	415	3	0.9	5.53	0.8	0.6	0.8	0.5	2	1	40	6	51	0.98	0.9	1	1	0.882	45.0	75	3.9400	0.0902	0.51	0.12	3.06	0.74	OK
Generator	1.22	110	415	3	21	12.83	0.8	0.6	0.8	0.5	2	1	40	6	51	0.98	0.9	1	1	0.882	45.0	100	3.9400	0.0902	0.89	0.21	5.33	1.28	OK
Generator	0.85	110	415	3	16	9.50	0.8	0.6	0.8	0.5	2	1	40	25	28	0.98	0.9	1	1	0.882	24.7	110	9.4800	0.1007	2.30	0.56	13.81	3.33	OK
Generator	0.89	110	415	3	16	9.50	0.8	0.6	0.8	0.5	2	1	40	6	51	0.98	0.9	1	1	0.882	45.0	75	3.9400	0.0902	0.66	0.16	3.94	0.95	OK
Generator	1.24	110	415	3	5.8	34.85	0.8	0.6	0.8	0.5	2	1	40	6	51	0.98	0.9	1	1	0.882	45.0	105	3.9400	0.0902	3.88	0.82	20.26	4.88	OK
Generator	1.25	110	415	3	21	12.63	0.8	0.6	0.8	0.5	2	1	40	25	28	0.98	0.9	1	1	0.882	24.7	85	9.4800	0.1007	2.37	0.57	14.19	3.42	OK
Generator	1.25	110	415	3	21	12.63	0.8	0.6	0.8	0.5	2	1	40	25	28	0.98	0.9	1	1	0.882	24.7	95	9.4800	0.1007	2.65	0.64	15.86	3.82	OK
Generator	2.16	110	415	3	3.7	22.12	0.8	0.6	0.8	0.5	2	1	40	25	28	0.98	0.9	1	1	0.882	24.7	65	9.4800	0.1007	3.17	0.76	19.01	4.58	OK
Cable Tray calculations:																													
Sr. No.	Cable Route (From-To)		Type & Cable Size		Size of Cable (mm²)	No. of Cable	Overall Diameter of each Cable (mm)	Sum of Cable OD (mm)	Self Weight of Cable (Kg/Mt)	Total Weight of Cable (Kg/Mt)	Remarks																		
1	LV MCC		4		10	1	18	18	3.95	0.9																			
2	PU2315-VFD		4		10	1	18	18	0.37	0.9																			
3	PU2315-VFD		5		15	1	15	15	3.95	0.4																			
4	LV MCC		4		25	1	16	16	0.37	0.5																			
5	LV MCC		5		15	1	15	15	3.95	0.4																			
6	LV MCC		4		25	1	16	16	0.37	0.5																			
7	PU 2314 -B- VFD		4		25	1	16	16	0.9	0.5																			
8	PU 2314 -B- VFD		5		15	1	15	15	0.9	0.4																			
9	LV MCC		4		6	1	18	18	2.9	0.7																			
10	PU2305- VFD		4		6	1	18	18	1.2	0.7																			
11	PU2305- VFD		5		15	1	15	15	1.2	0.4																			
12	LV MCC		4		6	1	18	18	1.2	0.7																			
13	LV MCC		5		15	1	15	15	1.45	0.4																			
14	LV MCC		4		10	1	18	18	2	0.9																			
15	LV MCC		5		15	1	15	15	2.4	0.4																			
16	LV MCC		4		6	1	18	18	2.4	0.7																			
17	BW2313- VFD		4		6	1	18	18	0.85	0.7																			
18	BW2313- VFD		5		15	1	15	15	0.85	0.4																			
19	LV MCC		4		6	1	18	18	0.85	0.7																			
20	LV MCC		5		15	1	15	15	1	0.4																			
21	LV MCC		4		6	1	18	18	0.85	0.7																			
Total					21		348	33.91	12.3																				
Calculation																													
Maximum Cable Diameter:																													
Consider Spare Capacity of Cable Tray:																													
Distance between each Cable:																													
Calculated Width of Cable Tray:																													
Calculated Area of Cable Tray:																													
No of Layer of Cables in Cable Tray:																													
Selected No of Cable Tray:																													
Selected Cable Tray Width:																													
Selected Cable Tray Depth:																													
Selected Cable Tray Weight Capacity:																													
Type of Cable Tray:																													
Total Area of Cable Tray:																													
Selected Cable Tray width:																													
Selected Cable Tray Depth:																													
Selected Cable Tray Weight:																													
Selected Cable Tray Size:																													
Including Spare Capacity																													
Including Spare Capacity																													
Required Cable Tray Size:																													
Required Nos of Cable Tray:																													
Required Cable Tray Weight:																													
Type of Cable Tray:																													
Ladder																													
Cable Tray Width Area Remain:																													
25%																													
Cable Tray Area Remaining:																													
46%																													

Conclusion:

We have been taught many aspects of engineering activities during the EPC stages for all electrical and related other disciplines also.

Feedback:

Smart Bridge

They conduct summer internships, work shops, debates, hackathons, technical sessions.

Method of conducting program

Online virtual program with presentation slides and explanation on the topic and practical usage of topic and with some examples.

Program highlights

It is for the detailed design of any industrial sectors.



Material

The material was good .

Benefits

It has been given the opportunity to learn and interact with industry experienced engineering specialist to learn the Electrical detailed design engineering for various industrial sectors.

Assignment-1
ELECTRICAL LOAD CALCULATIONS LV MCC

Sl. No.	Equipment No.	Equipment Description	Breaker Rating A	Breaker Type	Breaker No. of Poles	ELCB Rating	Absorbed Load [A] mA	Motor / Load Rating [B] kW	Load Factor [A] / [B] [C]	Efficiency at Load Factor [C] [D]	Power Factor at Load Factor [C]	kW = [A] / [D]		Consumed Load		kVAR = kW x tan φ		Remarks									
												Continuous	Intermittent	Stand-by	kW	kVAR											
1	PU2315	Silica filter feed pump						12.47	15.00	0.83	0.85	0.73	14.67	13.74													
2	PU 2314-A	Absorbesnt/Neutral oil pump (W)						3.62	4.70	0.77	0.85	0.73	4.3	4.0													
3	PU 2314 -B	Absorbesnt/Neutral oil pump (S)						3.11	3.70	0.84	0.85	0.73					3.7 3.4										
4	PU2305	Feed Pump (Seperator)						12.58	15.00	0.84	0.85	0.73	14.8	13.9													
5	MX2305	MIXER (W)						12.68	15.00	0.85	0.85	0.73	14.9	14.0													
6	MX 2308	MIXER (S)						12.68	15.00	0.85	0.85	0.73					14.9 14.0										
7	BW2313	Blower						5.45	7.50	0.73	0.85	0.73	6.4	6.0													
8	Rotary valve	TK 2313B (I)						0.53	0.75	0.71	0.85	0.73			0.6	0.6											
9	SC2314	Screw conveyor (I)						1.23	1.50	0.82	0.85	0.73			1.45	1.35											
10	AG 2324A	Citric acid tan agitator (W)						0.91	1.10	0.83	0.85	0.73	1.07	1.00													
11	AG 2324B	Citric acid tank agitator (S)						0.91	1.10	0.83	0.85	0.73					1.1 1.0										
12	AG 2305	Citric oil rection vessol agitator						3.34	3.70	0.90	0.85	0.73	3.93	3.68													
13	AG 2309	Lye oil reaction vessel agitator						1.21	1.50	0.81	0.85	0.73	1.42	1.33													
14	AG 2310	Lye oil reaction vessel agitator						1.21	1.50	0.81	0.85	0.73	1.42	1.33													
15	AG 2314	Soap Adsorbant Tank Agitator						2.12	3.00	0.71	0.85	0.73	2.49	2.34													
<hr/>																											
Maximum of normal running plant load : (Est. x%E + y%F)				66.0 kW		61.8 kVAR		sqrt (kW ² +kVAR ²) =		90.4 kVA		TOTAL	65.40	61.23	2.07	1.94	19.65 18.39										
Peak Load : (Est. x%E + y%F + z%G)				68.0 kW		63.7 kVAR		sqrt (kW ² +kVAR ²) =		93.1 kVA			89.59	2.84	2.07	1.94	19.65 18.39										
<hr/>																											
Assumptions																											
1) Load factor, Efficiency and Power factor.																											
Load Rating (kW)																											
<= 20																											
> 20 - <= 45																											
> 45 - < 150																											
>= 150																											
2) Coincidence factors x= 1.0, y= 0.3, and z=0.1 considered for continuous, intermittent and standby load.																											
<hr/>																											

Assignment-2

Calculation for Transformer Capacity

1.0 Example of calculation for Transformer Capacity

1.1 Calculation for consumed load

Consumed loads used for this example are as follows :

	kW	kVar	kVA	
a. Continuous load	65.4	61.2	89.57	--- (i)
b. Intermittent load / Diversity Factor	2.07	1.9	2.81	--- (ii)
c. Stand-by load required as consumed load	19.65	18.4	26.92	--- (iii)
Max. Consumed load = ((i) + 30% (ii) + 10% (iii)) =	66.0	61.8	90.42	
Future expansion load (20% capacity)	13.2	12.4	18.08	
Total Load =	79.2	74.2	108.50	

1.2 Calculation for 3.3kV / 0.433 kV transformer capacity

Max. Consumed load	=	90.4 kVA
Spare capacity	=	18.1 kVA
Required capacity	=	108.5 kVA
Transformer rated capacity	=	120 kVA

1.3 Voltage regulation check

During starting or reacceleration of max. capacity motor (3400 kW), while all the other loads running, the voltage regulation is as follows :

$$P_T = 120 \text{ KVA} \quad (\%Z) = 4.19 \quad \& \text{Ratio X/R} = 3.2$$

$$\text{Hence, } \%R = 1.236 \%$$

$$\%X = 4.00 \%$$

$$P_M = 15 \text{ KW having } (K = 6 \& C = 1 \& \cos \theta = 0.73 \& \text{Eff.} \eta = 0.85 \& \cos \theta_s = 0.25 \\ P_S = 145.044 \text{ KVA}$$

$$\cos \theta_s = 0.25, \text{Corresponding to Angle } \theta_s = 75.5225 \text{ Degrees for which } \sin \theta_s = 0.97 \\ P_B = 69.04 \text{ KVA} \& P_B \text{ in KW is } 58.68 \& P_B \text{ in Kvar} = 36.38 \therefore \cos \theta_B = 0.850 \\ \cos \theta_B = 0.85, \text{Corresponding to Angle } \theta_s = 31.7946 \text{ Degrees, for which } \sin \theta_s = 0.53$$

$$P_{CP} = 94.9411 \text{ KW} \\ P_{CQ} = 176.819 \text{ KVAR} \\ P_C = 200.695 \text{ KVA}$$

$$\cos \theta_C = 0.47306, \text{ where as } \sin \theta_C = 0.881$$

$$\text{Voltage Regulation } \varepsilon = 6.9 \%$$

Result: During starting of max. capacity motor, while all other loads are running, the voltage regulation at Transformer secondary terminals is approx 6.90%

1.4 Selection of rated capacity

120 kVA transformer selected.

Assignment-3		
DG SIZING CALCULATIONS		
Design Data		
Rated Volatge	415	KV
Power factor ($\cos\phi$)	0.73	Avg
Efficiency	0.85	Avg
Total operating load on DG set in kVA at 0.73 power factor	90.4	
Largest motor to start in the sequence - load in KW	15	KW
Running kVA of last motor ($\cos\phi = 0.91$)	24	KVA
Starting current ratio of motor	6	(Considering starting method as Soft starter)
Starting KVA of the largest motor (Running KVA of last motor X Starting current ratio of motor)	145	KVA
Base load of DG set in KVA (Total operating load in kVA – Running kVA of last motor)	66	KVA
A Continous operation under load -P1		
Capacity of DG set based on continuous operation under load P1	66	KVA
B Transient Voltage dip during starting of Last motor P2		
Total momentary load in KVA (Starting KVA of the last motor+Base load of DG set in KVA)	211	KVA
Subtransient Reactance of Generator (X_d'')	7.91%	(Assumed)
Transient Reactance of Generator (X_d')	10.065%	(Assumed)
$X_d''' = (X_d'' + X_d')/2$	0.089875	
Transient Voltage Dip	15%	(Max)
Transient Voltage dip during Soft starter starting of Last motor $P_2 = \text{Total momentary load in KVA} \times X_d''' \times \frac{(1-\text{Transient Voltage Dip})}{(\text{Transient Voltage Dip})}$	108	KVA
C Overload capacity P3		
Capacity of DG set required considering overload capacity		
Total momentary load in KVA	211	KVA
overcurrent capacity of DG (K) (Ref: IS/IEC 60034-1, Clause 9.3.2)	150%	
Capacity of DG set required considering overload capacity ($P_3 = \frac{\text{Total momentary load in KVA}}{\text{overcurrent capacity of DG (K)}}$)	141	KVA
Considering the last value amongst P1, P2 and P3		
Continous operation under load -P1	66	KVA
Transient Voltage dip during Soft starter starting of Last motor P2	108	KVA
Overload capacity P3	141	KVA
Considering the last value amongst P1, P2 and P3	141	KVA
starting capacity	150	KVA
Hence,DG set is 150 KVA is adequated and catch		
NOTE:VOLTAGE DIP CONSIDERED - 15%		

R_g - Grid resistance

Grid resistance can be calculated using Eq. 52 of IEEE 80

$$R_g = \rho \left\{ \frac{1}{L} + \frac{1}{\sqrt{20 \times A}} \left[1 + \frac{1}{1 + h \sqrt{20/A}} \right] \right\}$$

ρ - Soil resistivity in Ω-meter=

13

L - Total buried length of ground conductor in meter

420

h - Depth of burial in meter

0.5

A - Grid area in sq. meter

10125

R_g - Grid resistance 0.088

R_r - Earth Electrode resistance

Grid resistance can be calculated using Eq. 55 of IEEE 80

$$R_r = \frac{\rho}{2 \times \pi \times n_r \times L_r} \left\{ l_n \left[\frac{4 \times L_r}{b} \right] - 1 + \frac{2 \times k_1 \times L_r (\sqrt{n_r} - 1)^2}{\sqrt{A}} \right\}$$

ρ - Soil resistivity in Ω-meter, 16.96

13

n - No of earth electrodes

6

L_r - Length of earth electrode in meter

4.5

b - Diameter of earth electrode in meter

0.020

k₁ - co-efficient

1

A - Area of grid in square metre

10125

R_r - Earth Electrode resistance 4.7747

Grounding system resistance

Grounding system resistance can be calculated using equation 53 of IEEE 80 as follows:

$$R_s = \frac{R_g \times R_2 - R_m^2}{R_g + R_2 - 2R_m}$$

R_m - Mutual ground resistance between the group of ground conductors, *R_g* and group of electrodes, *R_r* in Ω. Neglected *R_m*, since this is for homogenous soil

R_s - Total earthing system resistance 0.087 Ohms

The calculated resistance grounding system is less than the allowable 1 Ω value.

Assignment-5

Lighting Protection Calculations

Location	Bangalore
Building	Srtuctural, Industrial
Type of Building	Triangle Roofs (c)
Building Length (L)	18
Building breadth (W)	8
Building Height (H)	6

Risk Factor Calculation

1 Collection Area (A_c)

$$A_c = \frac{(3.14 * H * H) + (2 * H * W)}{209.04}$$

2 Probability of Being Struck (P)

$$P = \frac{A_c * N_g * 10^{-6}}{0.000585312}$$

3 Overall weighing factor

a) Use of structure (A)	=	1.0
b) Type of construction (B)	=	0.8
c) Contents or consequential effects (C)	=	0.8
d) Degree of isolation (D)	=	1.0
e) Type of country (E)	=	0.3
Wo - Overall weighing factor	=	$A * B * C * D * E$
	=	0.192

4 Overall Risk Factor

$$\begin{aligned} P_o &= P * Wo \\ P_o &= 0.00011238 \\ P_a &= 10^{-5} \end{aligned}$$

As per clause no. 9.7 of BS- 6651, suggested acceptable risk factor (P_o) has been taken as 10^{-5}
Since $P_o > P_a$ lightning protection required.

5 Air Terminations

$$\begin{aligned} \text{Perimeter of the building} &= 2(L+W) \\ &= 52 \quad \text{Mts.} \end{aligned}$$

6 Down Conductors

$$\begin{aligned} \text{Perimeter of building} &= 52 \quad \text{Mts.} \\ \text{No. of down conductors based on perimeter} &= 3 \quad \text{Nos.} \end{aligned}$$

Hence 3 nos. of Down conductors have been selected.

Size of Down conductor = 20 X 2.5 mm Galvanized Steel Strip

(As per BS6651, lightning currents have very short duration, therefore thermal factors are of little consequence in deciding the cross-section of the conductor. The minimum size of Down conductors - 20mm X 2.5 mm Galvanized Steel Strip)

Assignment-6

Cable Sizing Calculations

S.N.O.	Description	Equipment No.	Description	Consumed Load KW	Load Rating KW	Voltage (V)	No. of ph	Full Load Current (A)	Motor Starting Current (A)	Load P.F. Running	SIN Φ Running	Motor P.F. Staring	SIN Φ Staring	Type	No. of Runs	No. of Cores	Size (mm ²)	Current Rating (A)	Derating factor k1	Derating factor k2	Derating factor k3	Derating factor k4	Overall Derating factor k	Derated Current (A)	Cable Length (M)	Cable Resistance (Ohms/kM)	Cable Reactance (Ohms/kM)	Voltage drop (Running) (V)	Voltage drop (Running) (%)	Voltage drop (Starting) (V)	Voltage drop (Starting) (%)	Cable size result	OD of Cable (mm)	Gland size
3	LV MCC	P12115	Silica filter feed pump	12.47	10.00	415	3	21.7	130.12	0.8	0.6	0.8	0.5	2	1	4.0	10	0.98	0.9	1	1	0.882	58.2	95	2.3400	0.0852	6.86	1.65	40.99	9.88	OK	18	20	
4	LV MCC	P12114-A	Akmonostabilized oil pump (H)	3.62	4.77	415	3	6.3	37.77	0.8	0.6	0.8	0.5	2	1	4.0	2.5	28	0.98	0.9	1	1	0.882	24.7	95	9.4800	0.1007	7.92	1.91	47.45	11.43	OK	16	20s
5	LV MCC	P12114-B	Akmonostabilized oil pump (S)	3.11	3.77	415	3	5.4	32.45	0.8	0.6	0.8	0.5	2	1	4.0	2.5	28	0.98	0.9	1	1	0.882	24.7	60	9.4800	0.1007	4.30	1.04	25.75	6.20	OK	16	20s
6	LV MCC	P12114-C	Feed Pump (Separator)	12.58	10.00	415	3	21.9	131.26	0.8	0.6	0.8	0.5	2	1	4.0	6	51	0.98	0.9	1	1	0.882	45.0	85	3.9400	0.0902	10.33	2.49	61.78	14.89	OK	18	20s
7	LV MCC	MZ205	Mixer (W)	12.68	10.00	415	3	22.1	132.31	0.8	0.6	0.8	0.5	2	1	4.0	6	51	0.98	0.9	1	1	0.882	45.0	75	3.9400	0.0902	9.18	2.21	54.95	13.24	OK	18	20s
8	LV MCC	MK-208	Mixer (S)	12.68	10.00	415	3	22.1	132.31	0.8	0.6	0.8	0.5	2	1	4.0	10	66	0.98	0.9	1	1	0.882	58.2	105	2.3400	0.0852	7.71	1.86	46.07	11.10	OK	18	20s
9	LV MCC	BW2113	Blower	6.45	2.00	415	3	9.5	56.87	0.8	0.6	0.8	0.5	2	1	4.0	6	51	0.98	0.9	1	1	0.882	45.0	100	3.9400	0.0902	5.26	1.27	31.49	7.59	OK	18	20s
10	LV MCC	Bw-100	Blower	0.53	0.77	415	3	0.9	5.53	0.8	0.6	0.8	0.5	2	1	4.0	6	51	0.98	0.9	1	1	0.882	45.0	100	3.9400	0.0902	0.51	0.12	3.06	0.74	OK	18	20s
11	LV MCC	SC2114	Screw conveyor (I)	1.23	1.00	415	3	2.1	12.83	0.8	0.6	0.8	0.5	2	1	4.0	6	51	0.98	0.9	1	1	0.882	45.0	75	3.9400	0.0902	0.89	0.21	5.33	1.28	OK	18	20
12	LV MCC	AG2204	Crinic acid tank washer (W)	0.91	1.10	415	3	1.6	9.50	0.8	0.6	0.8	0.5	2	1	4.0	2.5	28	0.98	0.9	1	1	0.882	24.7	110	9.4800	0.1007	2.30	0.56	13.81	3.33	OK	16	20s
13	LV MCC	AG2204B	Crinic acid tank washer (S)	0.91	1.10	415	3	1.6	9.50	0.8	0.6	0.8	0.5	2	1	4.0	6	51	0.98	0.9	1	1	0.882	45.0	75	3.9400	0.0902	0.66	0.16	3.94	0.95	OK	18	20
14	LV MCC	AG2205	Crinic oil reaction vessel washer	3.34	2.77	415	3	5.8	34.85	0.8	0.6	0.8	0.5	2	1	4.0	6	51	0.98	0.9	1	1	0.882	45.0	105	3.9400	0.0902	3.39	0.82	20.26	4.88	OK	18	20
15	LV MCC	AG2205	Lye oil reaction vessel washer	1.21	1.00	415	3	2.1	12.63	0.8	0.6	0.8	0.5	2	1	4.0	2.5	28	0.98	0.9	1	1	0.882	24.7	85	9.4800	0.1007	2.37	0.57	14.19	3.42	OK	16	32
16	LV MCC	AG2210	Lye oil reaction vessel washer	1.21	1.00	415	3	2.1	12.63	0.8	0.6	0.8	0.5	2	1	4.0	2.5	28	0.98	0.9	1	1	0.882	24.7	95	9.4800	0.1007	2.65	0.64	15.86	3.82	OK	16	20s
17	LV MCC	AG2214	Resin Adsorption Tank Washer	2.12	1.00	415	3	3.7	22.12	0.8	0.6	0.8	0.5	2	1	4.0	2.5	28	0.98	0.9	1	1	0.882	24.7	65	9.4800	0.1007	3.17	0.76	19.01	4.58	OK	16	20s
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Basis:

1. Overall derating factor $k = k_1 \times k_2 \times k_3 \times k_4$

K1=Rating factor for variation in air/ground temperature

K2=Rating factor for depth of laying

K3=Rating factor for spacing between two circuits

K4=Rating factor for variation in thermal resistivity of the soil

2. LT Motors : Running Voltage Drop = 3%, Starting Voltage Drop = 15%

3. Cable type:

TYPE 1: Al Conductor, XLPE Insulated, Armoured, PVC outer sheathed

TYPE 2: Cu Conductor, XLPE Insulated, Armoured, PVC outer sheathed

4. Effect of Frequency Variation $\pm 5\%$

5. Combined Effect of Voltage & Frequency Variation $\pm 10\%$

Cable Tray Sizing calculations

LT CABLES									
CABLE TRAY: FROM		LT-4		TO	LT-5				
Sr. No.	Cable Route (From-To)	Type & Cable Size	Size of Cable (mm²)	No. of Cable	Overall Diameter of each Cable (mm)	Sum of Cable OD (mm)	Self Weight of Cable (Kg/Mt)	Total Weight of Cable (Kg/Mt)	Remarks
1	LV MCC	4	10	1	18	18	3.95	0.9	
2	PU2315-VFD	4	10	1	18	18	0.37	0.9	
3	PU2315-VFD	5	1.5	1	15	15	3.95	0.4	
4	LV MCC	4	2.5	1	16	16	0.37	0.5	
5	LV MCC	5	1.5	1	15	15	3.95	0.4	
6	LV MCC	4	2.5	1	16	16	0.37	0.5	
7	PU 2314 -B- VFD	4	2.5	1	16	16	0.9	0.5	
8	PU 2314 -B- VFD	5	1.5	1	15	15	0.9	0.4	
9	LV MCC	4	6	1	18	18	2.9	0.7	
10	PU2305-VFD	4	6	1	18	18	1.2	0.7	
11	PU2305-VFD	5	1.5	1	15	15	1.2	0.4	
12	LV MCC	4	6	1	18	18	1.2	0.7	
13	LV MCC	5	1.5	1	15	15	1.45	0.4	
14	LV MCC	4	10	1	18	18	2	0.9	
15	LV MCC	5	1.5	1	15	15	2.4	0.4	
16	LV MCC	4	6	1	18	18	2.4	0.7	
17	BW2313-VFD	4	6	1	18	18	0.85	0.7	
18	BW2313-VFD	5	1.5	1	15	15	0.85	0.4	
19	LV MCC	4	6	1	18	18	0.85	0.7	
20	LV MCC	5	1.5	1	15	15	1	0.4	
21	LV MCC	4	6	1	18	18	0.85	0.7	
Total				21			348	33.91	12.3