Internship Program Report

By

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GUDLAVALLERU ENGINEERING COLLEGE
(An Autonomous Institute with Permanent Affiliation to JNTUK, Kakinada)
(Sponsored by A. A. N. M & V. V. R. S. R Educational Society, Gudlavalleru)
Approved by AICTE, New Delhi and Permitted by AP State Government
Accredited by NAAC with 'A' Grade
Counselling Code : GDLV

In association with

Smart Internz

Contents

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.

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

sessions and Industrial Automation projects.

Courtesy

Dr. Sri B. Dasu – HOD – EEE, GEC

Mr. G. Srinivasa Rao – Internship coordinator

Mr. Ramesh V - Mentor

Mr. Vinay Kumar - System Support

Mr. Harikanth – Software/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: On line through ZOOM

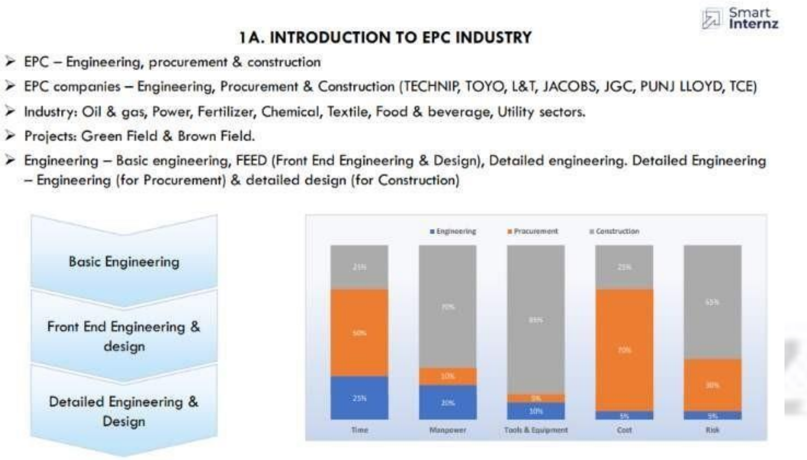
Presenter: Mr Ramesh V

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 May2021: Introduction to EPC Industry

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



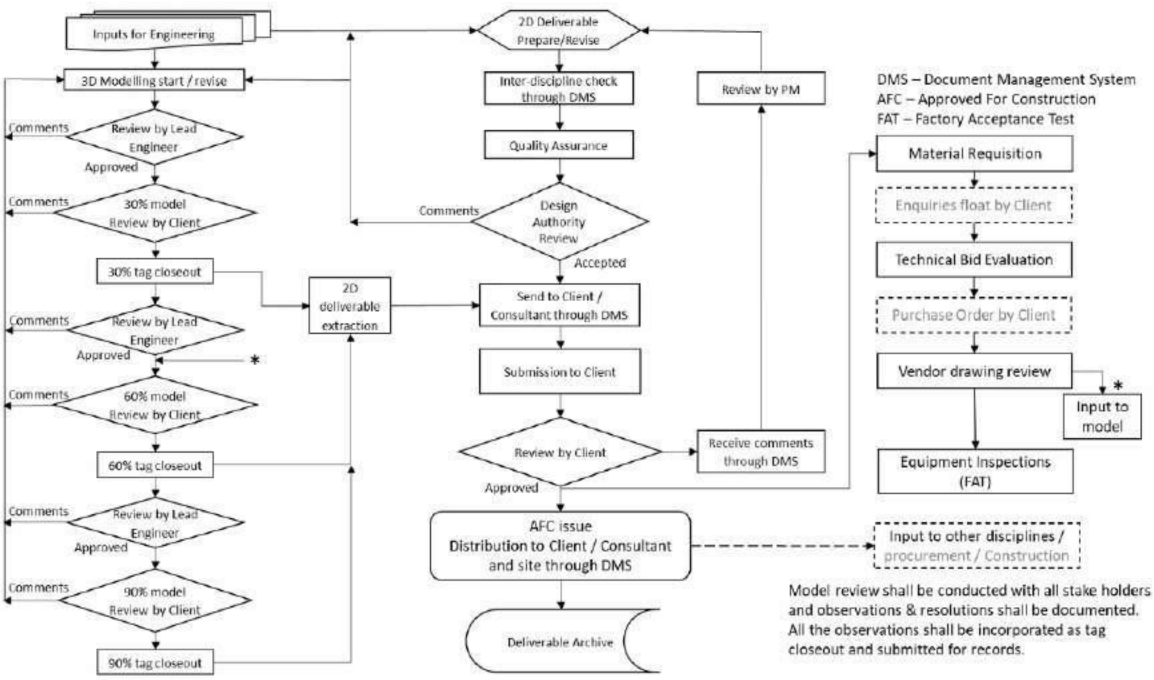
Topic details:

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

4th May2021: Engineering documentation for EPC projects

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

3. ELECTRICAL DESIGN & DETAILED ENGINEERING - PROCESS



Topic details:

Engineering deliverables list, detailed engineering flow, engineering support flow,engineering support to procurements.

5 th May2021: Engineering documentation for commands and formulae

3	Document & Drawing tools	MS Word	Report / Calculations formats
		MS Excel	Basic excel commands
		Autocad	Basic line diagrams and layout commends

3C. AUTOCAD BASIC COMMANDS

Smart Internz

AUTOCAD BASIC KEYS

STANDARD		DRAW		MODIFY		FORMAT	
NEW	Ctrl+N	LINE	L	ERASE	E	PROPERTIES	MO
OPEN	Ctrl+O	RAY	RAY	COPY	CO	SELECT COLOR	COL
SAVE	Ctrl+S	PLINE	PL	MIRROR	MI	LAYER	LA
PLOT	Ctrl+P	3DPOLY	3P	OFFSET	O	LINETYPE	LT
PLOT PREVIEW	PRE	POLIGONE	POL	ARRAY	AR	LINEWEIGHTS	LW
CUT	Ctrl+X	RECTANGLE	REC	MOVE	M	LT SCALE	LTS
COPY	Ctrl+C	ARC	A	ROTATE	RO	LIST	LI
PASTE	Ctrl+V	CIRCLE	C	SCALE	SC	DIMEN. STYLE	D
MATCH PROPE.	MA	SPLINE	SPL	STRECH	S	RENAME	REN
CLOSE	Ctrl+F4	ELLIPSE	EL	TRIM	TR	OPTION	OP
EXIT	Ctrl+Q	BLOCK	B	EXTENED	EX		
		POINT	PO	BRAKE	BR		
		HATCH	H	CHAMFER	CHA		
		GRADIENT	GD	FILLET	F		
		REGION	REG	EXPLODE	X		
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EXTRA				DRAFTING		PAPER SIZE
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LIMITS	LIMITS	SINGLE TEXT	DT	OSNAP	F3, Ctrl+F	A3=297*420
(0,0; 1000,1000)		MULTILINE TEXT	MT	POLAR	F10, Ctrl+U	A2=420*594
ZOOM	Z	EDIT TEXT	ED	GRID	F7, Ctrl+G	A1=594*841
ALL	A	OBJECT SNAP	OB	OTRACK	F11	A0=841*1189
PAN	P	DIMENTION	DIM	SNAP	F9	
CLEAN SCREEN	Ctrl+0	HORIZONTAL	HOR			
COMMAMD WIN	Ctrl+9	VERTICAL	VER			

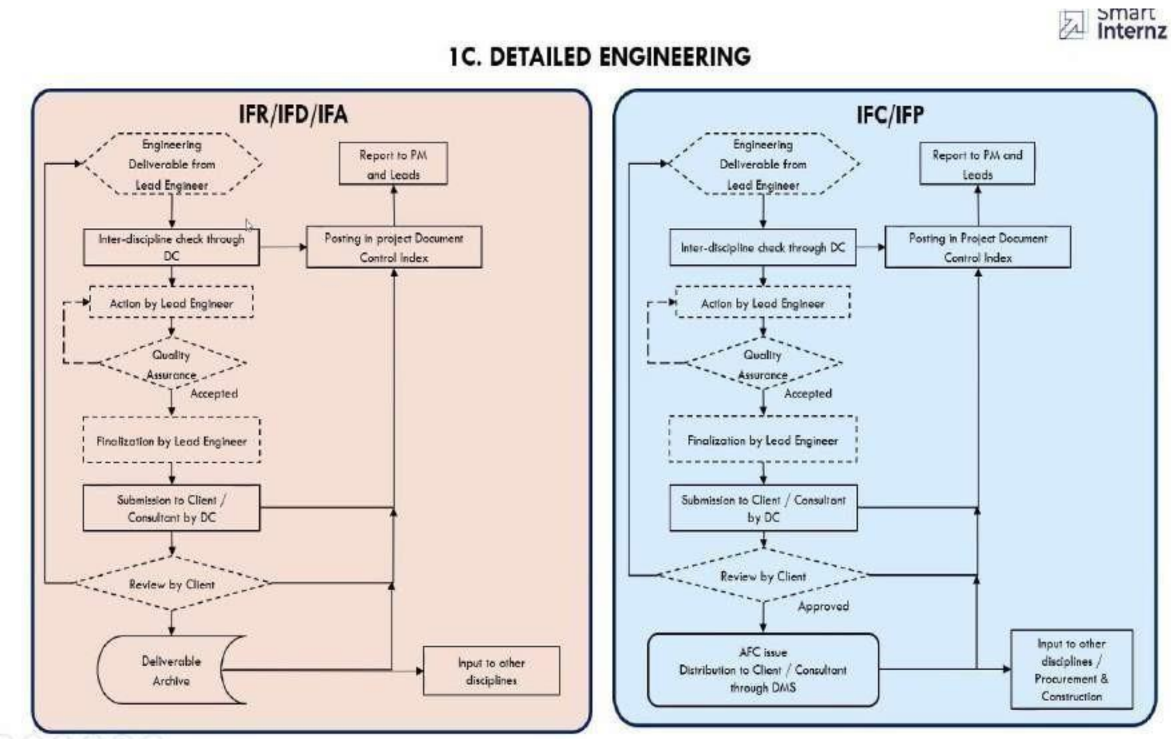
Topic details:

Here we need to learn the basis of the autocadbasic keys like standard, modify,draw,format,papersize etc..

7 th May2021: 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

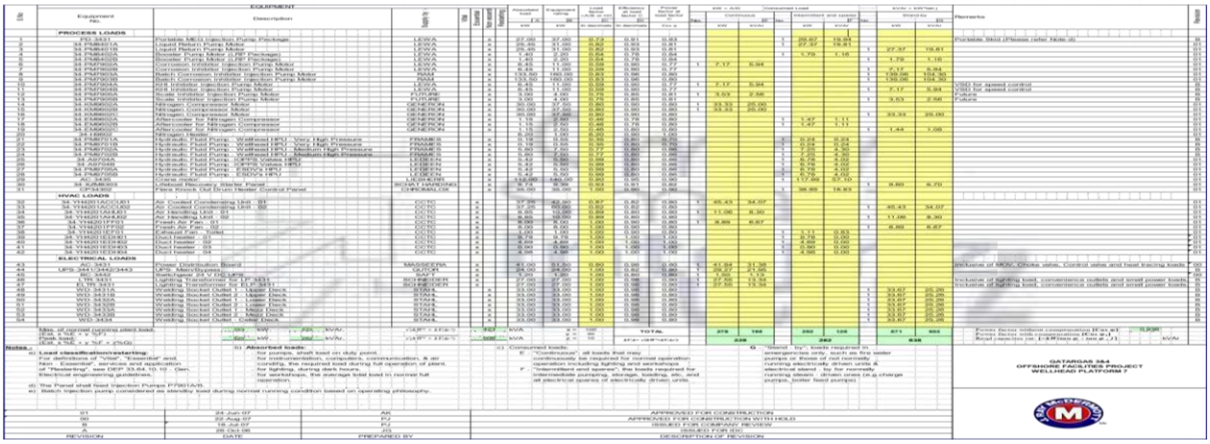
Topic details:



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

10th May2021: Engineering documentation for Typical diagrams

5	Electrical system design for typical diagrams		
		Load lists shedule	Power flow diagram
		Single line diagram	Typical schematic diagram



Topic details:

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

11th May2021: Classification of Transformers and Generators

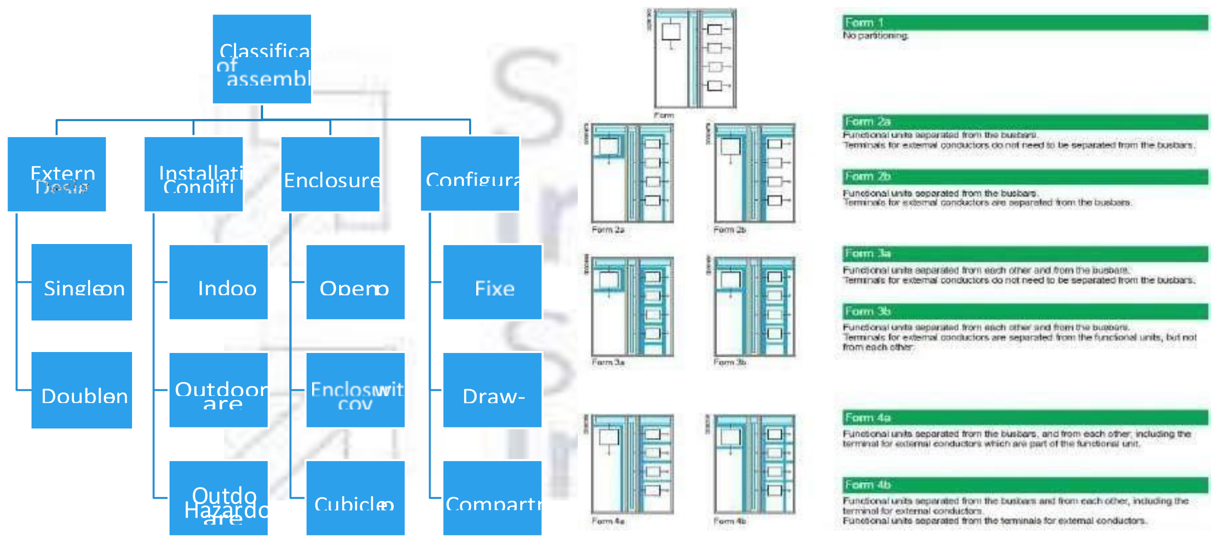
6	Classification of Transformers and Generators	Different types of Transformers	Different types of Generators

Topic details:

Classification of Transformers and Generators

12th May2021: 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

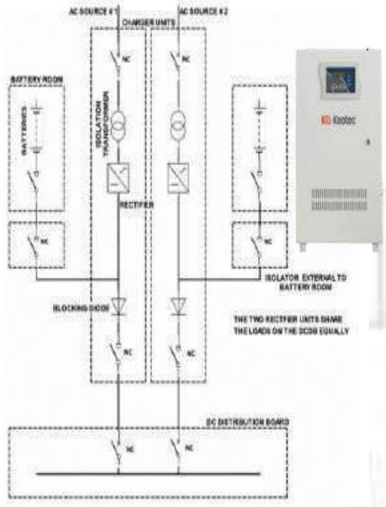


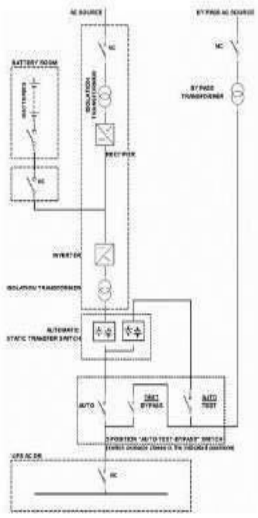
Topic details:

Classification of Switchgare contruction and Power Factor Improvement

17th May2021: Detailing about UPS system and Busducts.

8	Detailing about UPS system and Busducts	Uninterruptible power supply system	Busduts of the system





110V or 220V DC UPS System

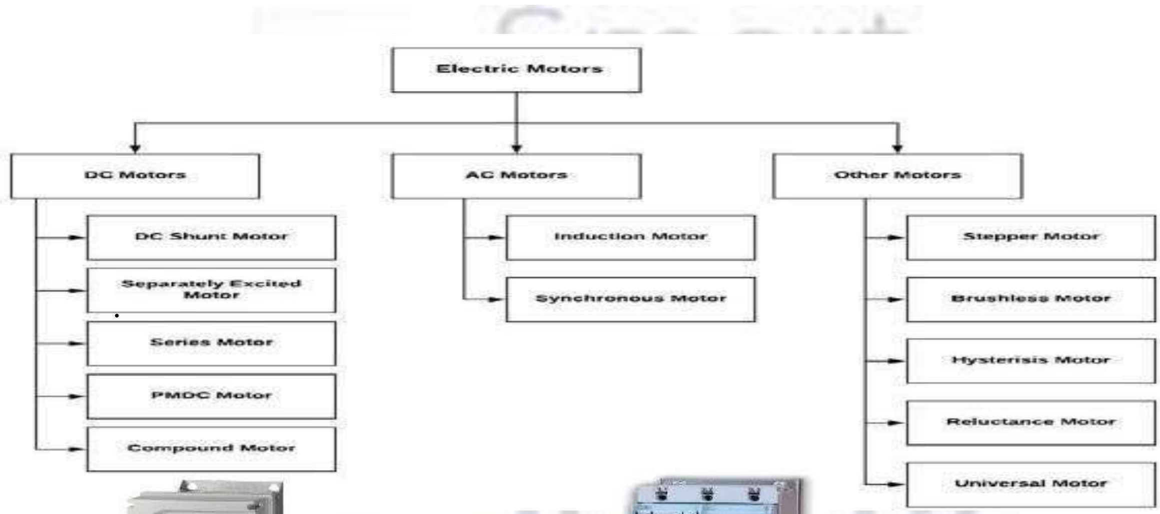
110V or 230V AC UPS System

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.

18th May2021: 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



Topic details: Detailing about Motor Starter and Sizing of motors and their selection.

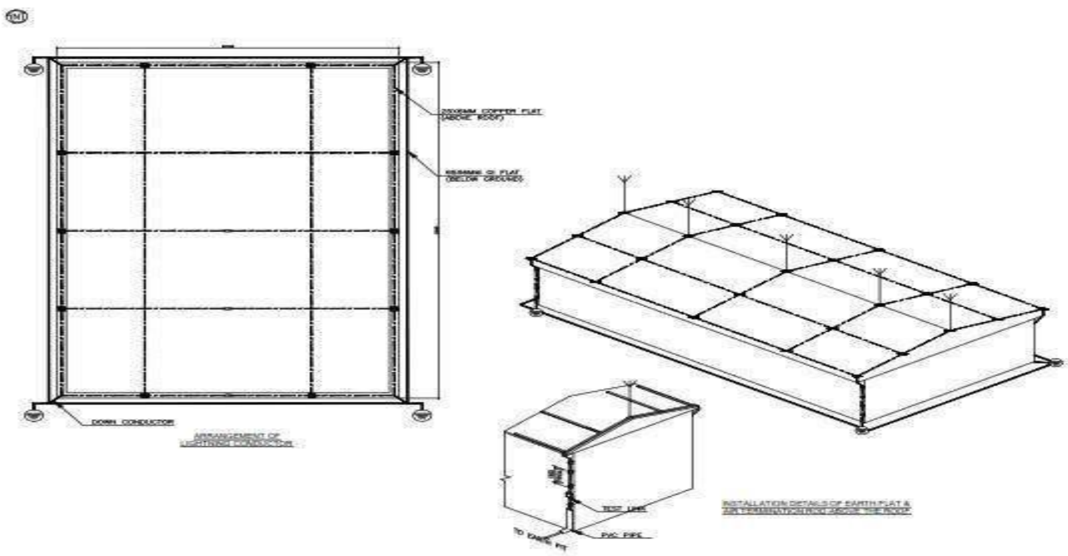
The principal function of a motor starter is to start and stop the respective motor connected with specially designed electromechanical switches which are similar in some ways to relays. The main difference between a relay and a starter is that a starter has overload protection for the motor that is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

19th May2021: Discribing about Earthing system and Lighting Protection.

10	Discribing about Earthing system and Lighting Protection.	Plant Earthing system	Lighting Protection materials



Topic details: Discribing about Earthing system and Lighting Protection.

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 May2021: 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.

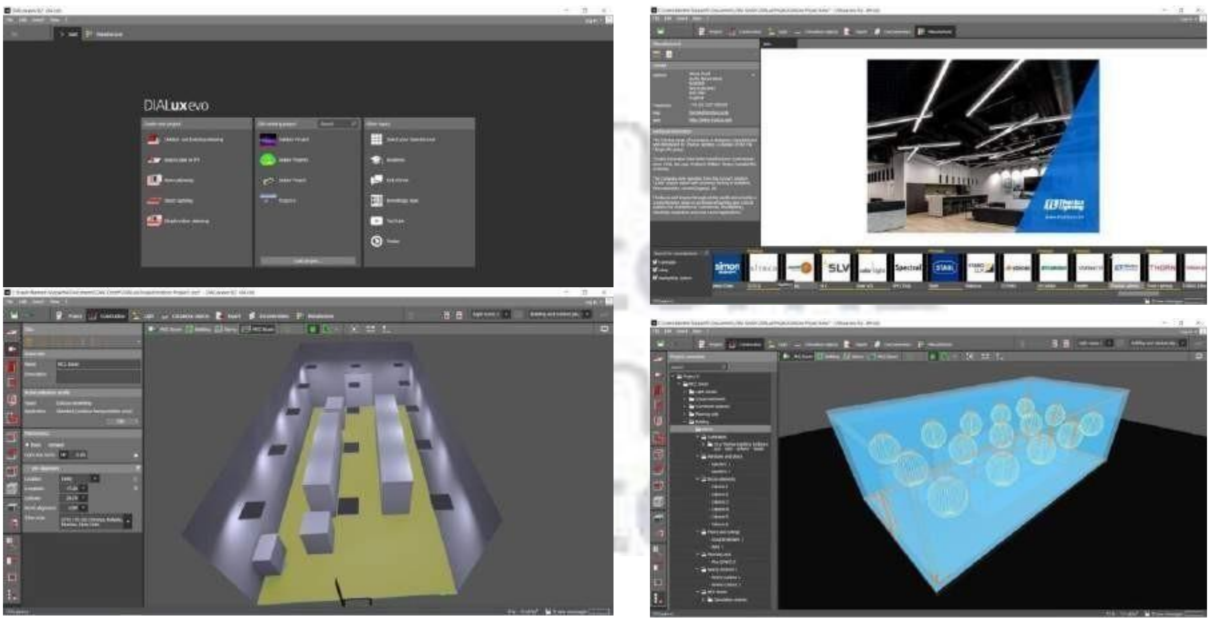
Types of light fittings: Industrial, flame proof type (EX d), increased safety type (Ex e).

21th May2021: 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.

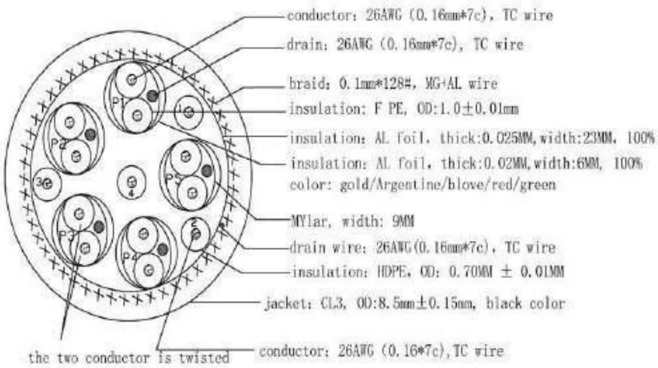
Here we are using this Dialux evo 5.9.2 software windows to construct the power plant and we can perform the operation from this software.

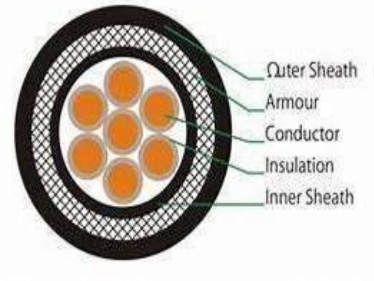


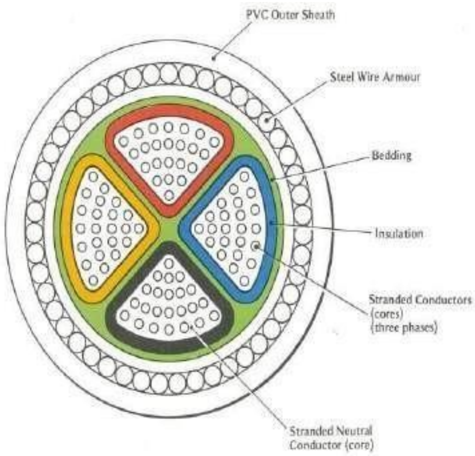
24th May2021: Cabling and their calculations and types.

13	Cabling and their types and claculations	Cabling calculations	Types of cabling materials

Topic details: Cabling and their types and claculations .







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.

25th May2021: Cabling calculations and Cable gland selection.

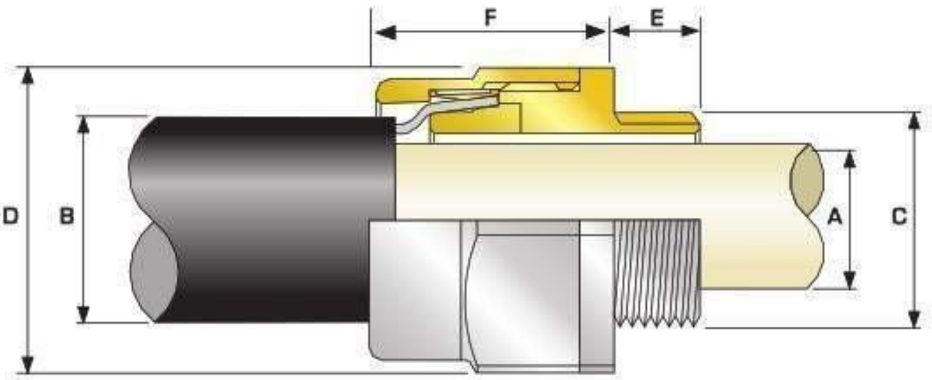
14	Cabling claculations and cable gland selection	Cabling calculations	Cable gland selection

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	Min	Max	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.

Assignment - 1
ELECTRICAL LOAD CALCULATIONS LV MCC

Sl. No.	Equipment No.	Equipment Description	Breaker Rating (A)	Breaker Type	Breaker No. of Poles	ELCB Rating (mA)	Absorbed Load [A] (kW)	Motor / Load Rating [B] (kW)	Load Factor [A] / [B] [C] (decimal)	Efficiency at Load Factor [C] [D] (decimal)	Power Factor at Load Factor [C] (cos φ)	Consumed Load, kW = [A] / [D]: Continuous kW	Continuous kVAR	Intermittent kW	Intermittent kVAR	Stand-by kW (kVAR = kW x tan φ)	Stand-by kVAR	Remarks
1	PU2315	Silica filter feed pump					33.15	37.00	0.90	0.91	0.78	36.43	29.23					
2	PU 2314-A	Absorbesnt/Neutral oil pump (W)					9.63	11.00	0.88	0.85	0.73	11.3	10.6					
3	PU 2314 -B	Absorbesnt/Neutral oil pump (S)					8.29	9.20	0.90	0.85	0.73					9.8	9.1	
4	PU2305	Feed Pump (Seperator)					33.48	37.00	0.90	0.91	0.78	36.8	29.5					
5	MX2305	MIXER (W)					33.74	37.00	0.91	0.91	0.78	37.1	29.7					
6	MX 2308	MIXER (S)					33.74	37.00	0.91	0.91	0.78					37.1	29.7	
7	BW2313	Blower					14.49	15.00	0.97	0.85	0.73	17.0	16.0					
8	Rotary valve	TK 2313B (I)					1.41	1.50	0.94	0.85	0.73			1.7	1.6			
9	SC2314	Screw conveyor (I)					3.25	3.70	0.88	0.85	0.73			3.82	3.58			
10	AG 2324A	Citric acid tan agitator (W)					2.44	3.00	0.81	0.85	0.73	2.87	2.69					
11	AG 2324B	Citric acid tank agitator (S)					2.44	3.00	0.81	0.85	0.73					2.9	2.7	
12	AG 2305	Citric oil rection vessol agitator					8.89	9.20	0.97	0.85	0.73	10.46	9.79					
13	AG 2309	Lye oil reaction vessel agitator					3.23	3.70	0.87	0.85	0.73	3.80	3.56					
14	AG 2310	Lye oil reaction vessel agitator					3.23	3.70	0.87	0.85	0.73	3.80	3.56					
15	AG 2314	Soap Adsorbant Tank Agitator					5.65	7.50	0.75	0.85	0.73	6.65	6.22					
											TOTAL	166.25	140.87	5.48	5.13	49.70	41.56	
											kVA	217.91		7.51		64.79		

Maximum of normal running plant load : (Est. x%E + y%F) 167.9 kW 142.4 kVAR sqrt (kW² +kVAR²) = 220.2 kVA

Peak Load : (Est. x%E + y%F + z%G) 172.9 kW 146.6 kVAR sqrt (kW² +kVAR²) = 226.6 kVA

Assumptions

1) Load factor, Efficiency and Power factor.

Load Rating (kW)	Efficiency	Power factor
<= 20	0.85	0.73
> 20 - <= 45	0.91	0.78
> 45 - < 150	0.93	0.82
>= 150	0.94	0.91

2) Coincidence factors x= 1.0, y= 0.3, and z=0.1 considered for contnious, intermittent and standby load.

T/F calculation:

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	166.25	140.9	217.91	--- (i)
b. Intermittent load / Diversity Factor	5.48	5.1	7.51	--- (ii)
c. Stand-by load required as consumed load	49.7	41.6	64.79	--- (iii)
Max. Consumed load = ((i) + 30% (ii) + 10% (ii	172.9	146.6	226.63	
Future expansion load (20% capacity)	34.6	29.3	45.33	
Total Load =	207.4	175.9	271.96	

1.2 Calculation for 3.3kV / 0.433 kV transformer capacity

Max. Consumed load = 226.6 kVA
Spare capacity = 45.3 kVA
Required capacity = 272.0 kVA
Transformer rated capacity = 300 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

PT = 300 KVA (%Z)= 2 & Ratio X/R = 1.5

Hence , %R = = 1.109 %

%X = = 1.66 %

PM = 37 KW having (K = 6 & C = 1 & Cos θ = 0.74 & Eff.h = 0.87 & Cos Qs = 0.25
PS = = 344.827 KVA

Cos θS = 0.25 ,Corresponding to Angle θs = 75.5224 Degrees for which Sin qs = 0.97
PB = 160.43 KVA & PB in KW is 118.718 & PB in Kvar = 107.9 \ Cos θB = 0.740
Cos θB = 0.85 ,Corresponding to Angle θs = .268584 Degrees, for which Sin θs = 0.67

PCP = = 204.925 KW
PCQ = = 441.777 KVAR
PC = = 486.992 KVA
Cos θC = = 0.42079 , where as Sin θC = 0.907

Voltage Regulation e = 3.2 %

Result During starting of max. capacity motor, while all other loads are running , the voltage regulation at Transformer secondary terminals is approx. 5.3% , which meets the criteria to maintain less than 15% voltage regulation.

1.4 Selection of rated capacity

300 kVA transformer selected.

29th May2021: DG set calculations

16	DG set calculations

Topic details:

Transformer and DG set calculations,types ,sizing or selections

Assignment - 3

DG SIZING CALCULATIONS

	Design Data		
	Rated Volatge	415	KV
	Power factor (CosØ)	0.74	Avg
	Efficiency	0.87	Avg
	Total operating load on DG set in kVA at 0.74 power factor	**272.0**	
	Largest motor to start in the sequence - load in KW	37	KW
	Running kVA of last motor (CosØ= 0.91)	57	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)	**345**	KVA
	Base load of DG set in KVA (Total operating load in kVA – Running kVA of last motor)	**215**	KVA
A	**Continous operation under load -P1**		
	Capacity of DG set based on continuous operation under load P1	**215**	**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	559	KVA
	Subtransient Reactance of Generator (Xd'')	7.91%	(Assumed)
	Transient Reactance of Generator (Xd')	10.065%	(Assumed)
	Xd''' =(Xd''+Xd')/2	0.089875	
	Transient Voltage Dip	15%	(Max)
	Transient Voltage dip during Soft starter starting of Last motor P2 = Total momentary load in KVA x Xd''' x (1-Transient Voltage (Transient	**285**	**KVA**
C	**Overload capacity P3**		
	Capacity of DG set required considering overload capacity		
	Total momentary load in KVA	559	KVA
	overcurrent capacity of DG (K) (Ref: IS/IEC 60034-1, Clause 9.3.2)	150%	
	Capacity of DG set required considering overload capacity (P3) = Total momentary load in KVA / overcurrent capacity of DG (K)	**373**	**KVA**
	Considering the last value amongst P1, P2 and P3		
	Continous operation under load -P1	215	KVA
	Transient Voltage dip during Soft starter starting of Last motor P2	285	KVA
	Overload capacity P3	373	KVA
	Considering the last value amongst P1, P2 and P3	**373**	**KVA**

Hence, Existing Generator 373 KVA is adequate to cater the loads as per re-scheduled loads

NOTE:VOLTAGE DIP CONSIDERED - 15%

2nd june2021: Caluculations of Earthing and Lighting protection.

17	Calculation of Earthing and Lighting protection calculations	Earthing calculations	Lighting protection calculation

Topic details:

Calculation of Earthing and Lighting protection calculations

Assignment - 5

Lightning Calculations

1

Location		surat	
Building		Concrete, Industrial	
Type of Building		Flat Roofs (a)	
Building Length (L)		14	
Building breadth (W)		8	
Building Height (H)		5	

Risk Factor Calculation

1 Collection Area (Ac)				
Ac		=	(L*W) + (2*L*H) + (2*W*H) + (3.14*H*H)	
			410.5	
2 Probability of Being Struck (P)				
P		=	Ac * Ng * 10-6	
			0.000082	
3 Overall weighing factor				
a) Use of structure (A)		=	1.0	
b) Type of construction (B)		=	0.4	
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	
		=	0.096	
4 Overall Risk Factor	Po	=	P * Wo	
	Po	=	0.000008	
	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.

5 Air Terminations			
Perimeter of the building	=	2(L+W)	
	=	44	Mts.
6 Down Conductors			
Perimeter of building	=	44	Mts.
No. of down conductors based on perimeter	=	2	Nos.

Hence 2 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)

Earthing calculation

2

Maximum line-to-ground fault in kA for 1 sec	12	
Earthing material (Earth rod & earth strip)	GI	
Depth of earth flat burrial in meter	0.5	
Average depth / length of Earth rod in meters	3.5	
Soil resistivity Ω-meter	13	
Ambient temperature in deg C	45	
Plot dimensions (earth grid) L x B in meters	60	120
Number of earth rods in nos.	6	

Earth electrode sizing:

Ac - Required conductor cross section in sq.mm

$$I_{lg} = A_c x \sqrt{\left[\frac{TCAPx10^{-4}}{t_c x \alpha_r x \rho_r}\right] x l_n \left[\frac{K_0 + T_m}{K_0 + T_a}\right]}$$

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	45
Il-g - RMS fault current in kA = 50 KA	12
tc - 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
The data taken from IEEE 80-2000, Clause 11.3, Table-1 for clad steel rod:	
12 = Ac *	0.123
Ac - Required conductor cross section in sq.mm	98
Earth rod dia in mm	11
Earth rod dia (including 25% corrosion allowance) in mm	14

Earth flat sizing:

Ac - Required conductor cross section in sq.mm

$$I_{lg} = A_c x \sqrt{\left[\frac{TCAPx10^{-4}}{t_c x \alpha_r x \rho_r}\right] x l_n \left[\frac{K_0 + T_m}{K_0 + T_a}\right]}$$

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	45
Il-g - RMS fault current in kA = 50 KA	12
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Thermal capacity factor, TCAP J/(cm3.oC)	3.93
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K0 - Factor at oC	293
The data taken from IEEE 80-2000, Clause 11.3, Table-1 for clad steel rod:	
12 = Ac *	0.123
Ac - Required conductor cross section in sq.mm	98
Earth flat area in mm	11
Earth flat area (including 25% corrosion allowance) in mm	14
Selected flat size W * Thk in sq mm	20

Rg - Grid resistance

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

$$R_g \quad \rho \quad \frac{1}{L} \quad \frac{1}{\sqrt{20 \ x \ A}} \ 1 \quad \frac{1}{1 \quad h \sqrt{20 \ /A}}$$

ρ - Soil resistivity in Ω-meter=	13
L - Total buried length of ground conductor in meter	360
h - Depth of burial in meter	0.5
A - Grid area in sq. meter	7200
Rg - Grid resistance	0.104

Rr - Earth Electrode resistance

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

$$R_r \quad \frac{\rho}{2 \ x \ \pi \ x \ n_r \ x \ L_r} \quad l_n \quad \frac{4 \ x \ L_r}{b} \quad 1 \quad \frac{2 \ x \ k_1 \ x \ L_r}{\sqrt{A}} \sqrt{n_r} \quad 1^2$$

ρ - Soil resistivity in Ω-meter, 16.96	13
n - No of earth electrodes	6
Lr - Length of earth electrode in meter	3.5
b - Diameter of earth electrode in meter	0.020
k1 - co-efficient	1
A - Area of grid in square metre	7200
Rr - Earth Electrode resistance	5.604718

Grounding system resistance

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

$$R_s \quad \frac{R_g \ x \ R_2 \quad {R_m}^2}{R_g \quad R_2 \quad 2R_m}$$

Rm - Mutual ground resistance between the group of ground conductors, Rg and group of electrodes, Rr in Ω. Neglected Rm, since this is for homogenous soil

Rs - Total earthing system resistance 0.102 Ohms

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

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.

Assignment - 7

Assignment - 6

Cable Sizing

S.NO.	Equipment No.	Description	Consumed Load KW	Load Rating	Voltage (V)	No. of	Full Load	Motor Starting	Load P.F. Running	SIN Φ Running	Motor P.F Starting	SIN Φ Starting	Type	No. of Runs	No. of Cores	Size (mm2)
1	PU2315	Silica filter feed pump	33.15	37.00	415	3	57.6	345.90	0.8	0.6	0.8	0.5	2	1	4.0	25
2	PU 2314-A	Absorbesnt/Neutral oil pump (W)	9.63	11.00	415	3	16.7	100.48	0.8	0.6	0.8	0.5	2	1	4.0	6
3	PU 2314 -B	Absorbesnt/Neutral oil pump (S)	8.29	9.20	415	3	14.4	86.50	0.8	0.6	0.8	0.5	2	1	4.0	6
4	PU2305	Feed Pump (Seperator)	33.48	37.00	415	3	58.2	349.34	0.8	0.6	0.8	0.5	2	1	4.0	25
5	MX2305	MIXER (W)	33.74	37.00	415	3	58.7	352.05	0.8	0.6	0.8	0.5	2	1	4.0	16
6	MX 2308	MIXER (S)	33.74	37.00	415	3	58.7	352.05	0.8	0.6	0.8	0.5	2	1	4.0	25
7	BW2313	Blower	14.49	15.00	415	3	25.2	151.19	0.8	0.6	0.8	0.5	2	1	4.0	10
8	Rotary valve	TK 2313B (I)	1.41	1.50	415	3	2.5	14.71	0.8	0.6	0.8	0.5	2	1	4.0	1.5
9	SC2314	Screw conveyor (I)	3.25	3.70	415	3	5.7	33.91	0.8	0.6	0.8	0.5	2	1	4.0	1.5
10	AG 2324A	Citric acid tan agitator (W)	2.44	3.00	415	3	4.2	25.46	0.8	0.6	0.8	0.5	2	1	4.0	1.5
11	AG 2324B	Citric acid tank agitator (S)	2.44	3.00	415	3	4.2	25.46	0.8	0.6	0.8	0.5	2	1	4.0	1.5
12	AG 2305	Citric oil rection vessal agitator	8.89	9.20	415	3	15.5	92.76	0.8	0.6	0.8	0.5	2	1	4.0	6
13	AG 2309	Lye oil reaction vessel agitator	3.23	3.70	415	3	5.6	33.70	0.8	0.6	0.8	0.5	2	1	4.0	1.5
14	AG 2310	Lye oil reaction vessel agitator	3.23	3.70	415	3	5.6	33.70	0.8	0.6	0.8	0.5	2	1	4.0	2.5
15	AG 2314	Soap Adsorbant Tank Agitator	5.65	7.50	415	3	9.8	58.95	0.8	0.6	0.8	0.5	2	1	4.0	2.5

S.NO.	Current Rating	Derating factor	Derating factor	Derating factor	Derating factor	Overall Derating	Derated Current	Cable Length	Cable Resistance	Cable Reactance	Voltage drop	Voltage drop	Voltage drop	Voltage drop	Cable size	OD of Cable	Gland size
1	122	0.98	0.9	1	1	0.882	107.6	95	0.9300	0.0816	7.52	1.81	44.67	10.76	OK	22	20
2	51	0.98	0.9	1	1	0.882	45.0	95	3.9400	0.0902	8.83	2.13	52.86	12.74	OK	18	20s
3	51	0.98	0.9	1	1	0.882	45.0	60	3.9400	0.0902	4.80	1.16	28.74	6.93	OK	18	20s
4	122	0.98	0.9	1	1	0.882	107.6	85	0.9300	0.0816	6.80	1.64	40.36	9.73	OK	22	20s
5	85	0.98	0.9	1	1	0.882	75.0	75	1.4700	0.0815	9.34	2.25	55.64	13.41	OK	21	20s
6	122	0.98	0.9	1	1	0.882	107.6	105	0.9300	0.0816	8.46	2.04	50.25	12.11	OK	22	20s
7	66	0.98	0.9	1	1	0.882	58.2	100	2.3400	0.0852	8.39	2.02	50.14	12.08	OK	18	20s
8	22	0.98	0.9	1	1	0.882	19.4	100	15.5000	0.1080	5.29	1.28	31.74	7.65	OK	15	20s
9	22	0.98	0.9	1	1	0.882	19.4	75	15.5000	0.1080	9.15	2.21	54.86	13.22	OK	15	20
10	22	0.98	0.9	1	1	0.882	19.4	110	15.5000	0.1080	10.08	2.43	60.41	14.56	OK	15	20s
11	22	0.98	0.9	1	1	0.882	19.4	75	15.5000	0.1080	6.87	1.66	41.19	9.92	OK	15	20
12	51	0.98	0.9	1	1	0.882	45.0	105	3.9400	0.0902	9.01	2.17	53.93	13.00	OK	18	20
13	22	0.98	0.9	1	1	0.882	19.4	85	15.5000	0.1080	10.31	2.48	61.79	14.89	OK	15	32
14	28	0.98	0.9	1	1	0.882	24.7	95	9.4800	0.1007	7.07	1.70	42.34	10.20	OK	16	20s
15	28	0.98	0.9	1	1	0.882	24.7	65	9.4800	0.1007	8.46	2.04	50.67	12.21	OK	16	20s

Basis:

1. Overall derating factor k = k1 x k2 x k3 x k4
   - 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 ± 5%
5. Combined Effect of Voltage & Frequency Variation ± 10%

Assignment - 7

Cable Tray Sizing

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	PU2315	2	25	1	22	22	1.4	1.4	
2	PU 2314-A	2	6	1	18	18	0.7	0.7	
3	PU 2314 -B	2	6	1	18	18	0.7	0.7	
4	PU2305	2	25	1	22	22	1.4	1.4	
5	MX2305	2	16	1	21	21	1	1	
6	MX 2308	2	25	1	22	22	1.4	1.4	
7	BW2313	2	10	1	18	18	0.9	0.9	
8	Rotary valve	2	1.5	1	15	15	0.4	0.4	
9	SC2314	2	1.5	1	15	15	0.4	0.4	
10	AG 2324A	2	1.5	1	15	15	0.4	0.4	
11	AG 2324B	2	1.5	1	15	15	0.4	0.4	
12	AG 2305	2	6	1	18	18	0.7	0.7	
13	AG 2309	2	1.5	1	15	15	0.4	0.4	
14	AG 2310	2	2.5	1	16	16	0.5	0.5	
15	AG 2314	2	2.5	1	16	16	0.5	0.5	
	Total			15		266	11.2	11.2	

Calculation

Maximum Cable Diameter:	22	mm
Consider Spare Capacity of Cable Tray:	30%	
Distance between each Cable:	0	mm
Calculated Width of Cable Tray:	346	mm
Calculated Area of Cable Tray:	7608	Sq.mm
No of Layer of Cables in Cable Tray:	1	
Selected No of Cable Tray:	1	Nos.
Selected Cable Tray Width:	600	mm
Selected Cable Tray Depth:	100	mm
Selected Cable Tray Weight Capacity:	90	Kg/Meter
Type of Cable Tray:	Ladder	
Total Area of Cable Tray:	60000	Sq.mm

Result

Selected Cable Tray width:	O.K	
Selected Cable Tray Depth:	O.K	
Selectrd Cable Tray Weight:	O.K	Including Spare Capacity
Selected Cable Tray Size:	O.K	Including Spare Capacity
Required Cable Tray Size:	600 x 100	mm
Required Nos of Cable Tray:	1	No
Required Cable Tray Weight:	90.00	Kg/Meter/Tray
Type of Cable Tray:	Ladder	
Cable Tray Width Area Remaning	42%	
Cable Tray Area Remaning:	87%	

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, hackthons, 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	Breaker Type	Breaker No. of Poles	ELCB Rating	Absorbed Load [A]	Motor / Load Rating [B]	Load Factor [A] / [B] [C]	Efficiency at Load Factor [C] [D]	Power Factor at Load Factor [C]	Continuous (kW = [A] / [D])		Intermittent (Consumed Load)		Stand-by (kVAR = kW x tan φ)		Remarks
			A			mA	kW	kW	decimal	decimal	cos φ	kW	kVAR	kW	kVAR	kW	kVAR	
1	PU2315	Silica filter feed pump					33.15	37.00	0.90	0.91	0.78	36.43	29.23					
2	PU 2314-A	Absorbesnt/Neutral oil pump (W)					9.63	11.00	0.88	0.85	0.73	11.3	10.6					
3	PU 2314 -B	Absorbesnt/Neutral oil pump (S)					8.29	9.20	0.90	0.85	0.73					9.8	9.1	
4	PU2305	Feed Pump (Seperator)					33.48	37.00	0.90	0.91	0.78	36.8	29.5					
5	MX2305	MIXER (W)					33.74	37.00	0.91	0.91	0.78	37.1	29.7					
6	MX 2308	MIXER (S)					33.74	37.00	0.91	0.91	0.78					37.1	29.7	
7	BW2313	Blower					14.49	15.00	0.97	0.85	0.73	17.0	16.0					
8	Rotary valve	TK 2313B (I)					1.41	1.50	0.94	0.85	0.73			1.7	1.6			
9	SC2314	Screw conveyor (I)					3.25	3.70	0.88	0.85	0.73			3.82	3.58			
10	AG 2324A	Citric acid tan agitator (W)					2.44	3.00	0.81	0.85	0.73	2.87	2.69					
11	AG 2324B	Citric acid tank agitator (S)					2.44	3.00	0.81	0.85	0.73					2.9	2.7	
12	AG 2305	Citric oil rection vessel agitator					8.89	9.20	0.97	0.85	0.73	10.46	9.79					
13	AG 2309	Lye oil reaction vessel agitator					3.23	3.70	0.87	0.85	0.73	3.80	3.56					
14	AG 2310	Lye oil reaction vessel agitator					3.23	3.70	0.87	0.85	0.73	3.80	3.56					
15	AG 2314	Soap Adsorbant Tank Agitator					5.65	7.50	0.75	0.85	0.73	6.65	6.22					
		TOTAL										166.25	140.87	5.48	5.13	49.70	41.56	
		kVA										217.91		7.51		64.79		

Maximum of normal running plant load : 167.9 kW 142.4 kVAR sqrt (kW² +kVAR²) = 220.2 kVA
(Est. x%E + y%F)

Peak Load : 172.9 kW 146.6 kVAR sqrt (kW² +kVAR²) = 226.6 kVA
(Est. x%E + y%F + z%G)

Assumptions

1) Load factor, Efficiency and Power factor.

Load Rating (kW)	Efficiency	Power factor
<= 20	0.85	0.73
> 20 - <= 45	0.91	0.78
> 45 - < 150	0.93	0.82
>= 150	0.94	0.91

2) Coincidence factors x= 1.0, y= 0.3, and z=0.1 considered for contnious, intermittent and standby load.

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	166.25	140.9	217.91	--- (i)
b.	Intermittent load / Diversity Factor	5.48	5.1	7.51	--- (ii)
c.	Stand-by load required as consumed load	49.7	41.6	64.79	--- (iii)

	kW	kVar	kVA
Max. Consumed load = ((i) + 30% (ii) + 10% (iii	172.9	146.6	226.63
Future expansion load (20% capacity)	34.6	29.3	45.33
Total Load =	207.4	175.9	271.96

1.2 Calculation for 3.3kV / 0.433 kV transformer capacity

Max. Consumed load	=	226.6 kVA
Spare capacity	=	45.3 kVA
Required capacity	=	272.0 kVA
Transformer rated capacity	=	300 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 : e

PT = 300 KVA (%Z)= 2 & Ratio X/R = 1.5

Hence , **%R** = = 1.109 %

%X = = 1.66 %

PM = 37 KW having (K 6 & C = 1 & Cos θ = 0.74 & Eff.h = 0.87 & Cos Qs = 0.25

PS = = 344.82 KVA

Cos θS = 0.25 ,Corresponding to Angle θs = 75.522 Degrees for which Sin qs = 0.97 PB = 160.43 KVA & PB in KW is 118.718 & PB in Kvar = 107.9 \ Cos θB = 0.740

Cos θB = 0.85 ,Corresponding to Angle θs = .268584 Degrees, for which Sin θs = 0.67

PCP = = 204.92 KW

PCQ = = 441.77 KVAR

PC = = 486.99 KVA

Cos θC = = 0.42079 , where as Sin θC = 0.907

Voltage Regulation e = 3.2 %

Result: During starting of max. capacity motor, while all other loads are running , the voltage regulation at Transformer secondary terminals is approx. 5.3% , which meets the criteria to maintain less than 15% voltage regulation.

1.4 Selection of rated capacity

300 kVA transformer selected.

PBHP	=	Absorbed load (kW)
h	=	Load efficiency
Cos q	=	Load Power Factor
PP	=	Consumed Active Power (kW)
PQ	=	Consumed Reactive Power (kVar)
P	=	Consumed Apperant Power (kVA)
PB	=	Base load (kVA)
Cos qB	=	Power Factor of base load
PM	=	Rated output of largest motor (kW)
PS	=	Starting capacity of largest motor
Cos qS	=	Starting power factor of largest motor
K	=	Current ratio of motor (= starting current / rated current)
C	=	Reduced current ratio of motor starting current (1 for DOL start , 0.33 for Y-D start , tap p.u. For reactor or auto transforme
%R	=	Percent resistance for transformer
%X	=	Percent reactance for transformer
PCP	=	Active Power of combined load (kW)
PCQ	=	Reactive Power of combined load (kVar)
PC	=	Apparent Power of combined load (kVA)
Cos qC	=	Power Factor of combined load
PT	=	Transformer rated capacity (kVA)
e	=	Voltage Regulation of transformer

Percent R, X and Z based on Transformer KVA

Transformer Rating KVA	X/R	R %	X %	Z %
150	3.24	1.23	4.0	4.19
225	3.35	1.19	4.0	4.17
300	3.50	1.14	4.0	4.16
500	3.85	1.04	4.0	4.12
750	5.45	0.94	5.1	5.19
1000	5.70	0.89	5.1	5.19
1500	6.15	0.83	5.1	5.18
2000	6.63	0.77	5.1	5.17
150	1.5	1.111	1.665	2.0
225	1.5	1.111	1.665	2.0
300	1.5	1.111	1.665	2.0
500	1.5	1.111	1.665	2.0

Note 1: These values are for three phase, liquid filled, self-cooled transformers.

Note 2: Due to the trend toward lower impedance transformers for better voltage regulation, the actual transformer impedances may deviate from the NEMA Standard given at left. Therefore, for actual values, obtain nameplate impedance from owner or manufacturer. The percent X and percent R values are desirable for calculation.

Absorbed Load(PBHP)

Motor : For medium / large machines , " Load BHP " column of " Motor / Load requirement s be reffered .

For small machines , the values may generally be estimated as follows :

Rated output (kW) x Demand Factor (standard value 0.85)

Other Loads : For instrumentation , computer , communication , air conditioning , lighting , etc. estimated as follows :

Rated kVA x Power Factor x Demand Factor

Consumed Load

Active Power PP = $S \dfrac{PBHP}{h}$ (kW)

Reactive Pow PQ = $S \dfrac{PBHP}{h} \times \tan\theta$ (kVAr)

Apparent pow P = Ö(PP2 + PQ2 (kVA)

oltage Regulation e $= \dfrac{PC \times (\%R \,.\, \cos\theta C + \%X \,.\, \sin\theta C)}{PT}$ in (%)

where PC = Ö PCP2 + PCQ2 (kVA)

PCP = PB . Cos θB + PS .Co (kW)

PCQ = PB . Sin θB + PS . Sin (kVar)

PS = $K \,.\, C \,.\, \dfrac{PM}{\cos\theta \,.\, \eta}$

Cos θCCP / PC

Sin θC CQ / PC

Assignment - 3

DG SIZING CALCULATIONS

	Design Data		
	Rated Volatge	415	KV
	Power factor (CosØ)	0.74	Avg
	Efficiency	0.87	Avg
	Total operating load on DG set in kVA at 0.74 power factor	**272.0**	
	Largest motor to start in the sequence - load in KW	37	KW
	Running kVA of last motor (CosØ= 0.91)	57	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)	**345**	KVA
	Base load of DG set in KVA (Total operating load in kVA – Running kVA of last motor)	**215**	KVA
A	**Continous operation under load -P1**		
	Capacity of DG set based on continuous operation under load P1	**215**	**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	559	KVA
	Subtransient Reactance of Generator (Xd")	7.91%	(Assumed)
	Transient Reactance of Generator (Xd')	10.065%	(Assumed)
	Xd''' =(Xd"+Xd')/2	0.089875	
	Transient Voltage Dip	15%	(Max)
	Transient Voltage dip during Soft starter starting of Last motor P2 = Total momentary load in KVA x Xd''' x (1-Transient Voltage (Transient	**285**	**KVA**
C	**Overload capacity P3**		
	Capacity of DG set required considering overload capacity		
	Total momentary load in KVA	559	KVA
	overcurrent capacity of DG (K) (Ref: IS/IEC 60034-1, Clause 9.3.2)	150%	
	Capacity of DG set required considering overload capacity (P3) = Total momentary load in KVA / overcurrent capacity of DG (K)	**373**	**KVA**
	Considering the last value amongst P1, P2 and P3		
	Continous operation under load -P1	215	KVA
	Transient Voltage dip during Soft starter starting of Last motor P2	285	KVA
	Overload capacity P3	373	KVA
	Considering the last value amongst P1, P2 and P3	**373**	**KVA**

Hence, Existing Generator 373 KVA is adequate to cater the loads as per re-scheduled loads

NOTE:VOLTAGE DIP CONSIDERED - 15%

Assignment - 4

Earthing calculations

	2	
Maximum line-to-ground fault in kA for 1 sec	12	
Earthing material (Earth rod & earth strip)	GI	
Depth of earth flat burrial in meter	0.5	
Average depth / length of Earth rod in meters	3.5	
Soil resistivity Ω-meter	13	
Ambient temperature in deg C	45	
Plot dimensions (earth grid) L x B in meters	60	120
Number of earth rods in nos.	6	

Earth electrode sizing:

Ac - Required conductor cross section in sq.mm

$$I_{lg} = A_c x \sqrt{\left[\frac{TCAPx10^{-4}}{t_c x \alpha_r x \rho_r}\right] x l_n \left[\frac{K_0 + T_m}{K_0 + T_a}\right]}$$

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	45
Il-g - RMS fault current in kA = 50 KA	12
tc - 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
The data taken from IEEE 80-2000, Clause 11.3, Table-1 for clad steel rod:	
12 = Ac *	0.123
Ac - Required conductor cross section in sq.mm	98
Earth rod dia in mm	11
Earth rod dia (including 25% corrosion allowance) in mm	14

Earth flat sizing:

Ac - Required conductor cross section in sq.mm

$$I_{lg} = A_c x \sqrt{\left[\frac{TCAPx10^{-4}}{t_c x \alpha_r x \rho_r}\right] x l_n \left[\frac{K_0 + T_m}{K_0 + T_a}\right]}$$

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	45
Il-g - RMS fault current in kA = 50 KA	12
tc - 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
The data taken from IEEE 80-2000, Clause 11.3, Table-1 for clad steel rod:	
12 = Ac *	0.123
Ac - Required conductor cross section in sq.mm	98
Earth flat area in mm	11
Earth flat area (including 25% corrosion allowance) in mm	14
Selected flat size W * Thk in sq mm	20

Rg - Grid resistance

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

$$R_g \quad \rho \frac{1}{L} \quad \frac{1}{\sqrt{20 \ x \ A}} \; 1 \quad 1 \quad h \; \frac{1}{\sqrt{20 \ /A}}$$

ρ - Soil resistivity in Ω-meter=	13
L - Total buried length of ground conductor in meter	360
h - Depth of burial in meter	0.5
A - Grid area in sq. meter	7200
Rg - Grid resistance	0.104

Rr - Earth Electrode resistance

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

$$R_r \quad \frac{\rho}{2 \ x \ \pi \ x \ n_r \ x \ L_r} \quad l_n \quad \frac{4 \ x \ L_r}{b} \quad 1 \quad \frac{2 \ x \ k_1 x \ L_r}{\sqrt{A}} \sqrt{n_r} \quad 1^{2}$$

ρ - Soil resistivity in Ω-meter, 16.96	13
n - No of earth electrodes	6
Lr - Length of earth electrode in meter	3.5
b - Diameter of earth electrode in meter	0.020
k1 - co-efficient	1
A - Area of grid in square metre	7200
Rr - Earth Electrode resistance	5.604718

Grounding system resistance

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

$$R_s \quad \frac{R_g \ x \ R_2 \quad R_m{}^2}{R_g \quad R_2 \quad 2R_m}$$

Rm - Mutual ground resistance between the group of ground conductors, Rg and group of electrodes, Rr in Ω. Neglected Rm, since this is for homogenous soil

Rs - Total earthing system resistance 0.102 Ohms

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

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Table 1—Material constants

Description	Material conductivity (%)	α_r factor at 20 °C (1/°C)	K_o at 0 °C (0 °C)	Fusing[a] temperature T_m (°C)	ρ_r 20 °C (μΩ·cm)	TCAP thermal capacity [J/(cm³·°C)]
Copper, annealed soft-drawn	100.0	0.003 93	234	1083	1.72	3.42
Copper, commercial hard-drawn	97.0	0.003 81	242	1084	1.78	3.42
Copper-clad steel wire	40.0	0.003 78	245	1084	4.40	3.85
Copper-clad steel wire	30.0	0.003 78	245	1084	5.86	3.85
Copper-clad steel rod[b]	20.0	0.003 78	245	1084	8.62	3.85
Aluminum, EC grade	61.0	0.004 03	228	657	2.86	2.56
Aluminum, 5005 alloy	53.5	0.003 53	263	652	3.22	2.60
Aluminum, 6201 alloy	52.5	0.003 47	268	654	3.28	2.60
Aluminum-clad steel wire	20.3	0.003 60	258	657	8.48	3.58
Steel, 1020	10.8	0.001 60	605	1510	15.90	3.28
Stainless-clad steel rod[c]	9.8	0.001 60	605	1400	17.50	4.44
Zinc-coated steel rod	8.6	0.003 20	293	419	20.10	3.93
Stainless steel, 304	2.4	0.001 30	749	1400	72.00	4.03

[a]From ASTM standards.

[b]Copper-clad steel rods based on 0.254 mm (0.010 in) copper thickness.

[c]Stainless-clad steel rod based on 0.508 mm (0.020 in) No. 304 stainless steel thickness over No. 1020 steel core.

Assignment - 5

Lightning Calculations

1

Location	surat
Building	Concrete, Industrial
Type of Building	Flat Roofs (a)
Building Length (L)	14
Building breadth (W)	8
Building Height (H)	5

Risk Factor Calculation

1 Collection Area (Ac)

Ac = (L*W) + (2*L*H) + (2*W*H) + (3.14*H*H)

410.5

2 Probability of Being Struck (P)

P = Ac * Ng * 10-6

0.000082

3 Overall weighing factor

a) Use of structure (A)	=	1.0
b) Type of construction (B)	=	0.4
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
	=	0.096

4 Overall Risk Factor

Po = P * Wo

Po = 0.000008

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.

5 Air Terminations

Perimeter of the building = 2(L+W)

= 44 Mts.

6 Down Conductors

Perimeter of building = 44 Mts.

No. of down conductors based on perimeter = 2 Nos.

Hence 2 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

S.NO.	Equipment No.	Description	Consumed Load KW	Load Rating	Voltage (V)	No. of	Full Load	Motor Starting	Load P.F. Running	SIN Φ Running	Motor P.F Staring	SIN Φ Staring	Type	No. of Runs	No. of Cores	Size (mm2)	Current Rating	Derating factor	Derating factor	Derating factor	Derating factor	Overall Derating	Derated Current	Cable Length	Cable Resistance	Cable Reactance	Voltage drop	Voltage drop	Voltage drop	Voltage drop	Cable size	OD of Cable	Gland size
1	PU2315	Silica filter feed pump	33.15	37.00	415	3	57.6	345.90	0.8	0.6	0.8	0.5	2	1	4.0	25	122	0.98	0.9	1	1	0.882	107.6	95	0.9300	0.0816	7.52	1.81	44.67	10.76	OK	22	20
2	PU 2314-A	Absorbesnt/Neutral oil pump (W)	9.63	11.00	415	3	16.7	100.48	0.8	0.6	0.8	0.5	2	1	4.0	6	51	0.98	0.9	1	1	0.882	45.0	95	3.9400	0.0902	8.83	2.13	52.86	12.74	OK	18	20s
3	PU 2314-B	Absorbesnt/Neutral oil pump (S)	8.29	9.20	415	3	14.4	86.50	0.8	0.6	0.8	0.5	2	1	4.0	6	51	0.98	0.9	1	1	0.882	45.0	60	3.9400	0.0902	4.80	1.16	28.74	6.93	OK	18	20s
4	PU2305	Feed Pump (Seperator)	33.48	37.00	415	3	58.2	349.34	0.8	0.6	0.8	0.5	2	1	4.0	25	122	0.98	0.9	1	1	0.882	107.6	85	0.9300	0.0816	6.80	1.64	40.36	9.73	OK	22	20s
5	MX2305	MIXER (W)	33.74	37.00	415	3	58.7	352.05	0.8	0.6	0.8	0.5	2	1	4.0	16	85	0.98	0.9	1	1	0.882	75.0	75	1.4700	0.0815	9.34	2.25	55.64	13.41	OK	21	20s
6	MX 2308	MIXER (S)	33.74	37.00	415	3	58.7	352.05	0.8	0.6	0.8	0.5	2	1	4.0	25	122	0.98	0.9	1	1	0.882	107.6	50	0.9300	0.0816	8.46	2.04	50.25	12.11	OK	22	20s
7	BW2313	Blower	14.49	15.00	415	3	25.2	151.19	0.8	0.6	0.8	0.5	2	1	4.0	10	66	0.98	0.9	1	1	0.882	58.2	100	2.3400	0.0852	8.39	2.02	50.14	12.08	OK	18	20s
8	Rotary valve	TK 2313B (I)	1.41	1.50	415	3	2.5	14.71	0.8	0.6	0.8	0.5	2	1	4.0	1.5	22	0.98	0.9	1	1	0.882	19.4	100	15.5000	0.1080	5.29	1.28	31.74	7.65	OK	15	20s
9	SC2314	Screw conveyor (I)	3.25	3.70	415	3	5.7	33.91	0.8	0.6	0.8	0.5	2	1	4.0	1.5	22	0.98	0.9	1	1	0.882	19.4	75	15.5000	0.1080	9.15	2.21	54.86	13.22	OK	15	20
10	AG 2324A	Citric acid tan agitator (W)	2.44	3.00	415	3	4.2	25.46	0.8	0.6	0.8	0.5	2	1	4.0	1.5	22	0.98	0.9	1	1	0.882	19.4	110	15.5000	0.1080	10.08	2.43	60.41	14.56	OK	15	20s
11	AG 2324B	Citric acid tank agitator (S)	2.44	3.00	415	3	4.2	25.46	0.8	0.6	0.8	0.5	2	1	4.0	1.5	22	0.98	0.9	1	1	0.882	19.4	75	15.5000	0.1080	6.87	1.66	41.19	9.92	OK	15	20
12	AG 2305	Citric oil rection vessol agitator	8.89	9.20	415	3	15.5	92.76	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	9.01	2.17	53.93	13.00	OK	18	20
13	AG 2309	Lye oil reaction vessel agitator	3.23	3.70	415	3	5.6	33.70	0.8	0.6	0.8	0.5	2	1	4.0	1.5	22	0.98	0.9	1	1	0.882	19.4	85	15.5000	0.1080	10.31	2.48	61.79	14.89	OK	15	32
14	AG 2310	Lye oil reaction vessel agitator	3.23	3.70	415	3	5.6	33.70	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	7.07	1.70	42.34	10.20	OK	16	20s
15	AG 2314	Soap Adsorbant Tank Agitator	5.65	7.50	415	3	9.8	58.95	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	8.46	2.04	50.67	12.21	OK	16	20s

Basis:

1. Overall derating factor k = k1 x k2 x k3 x k4

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 ± 5%

5. Combined Effect of Voltage & Frequency Variation ±10%

Assignment - 7

Cable Tray Sizing

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	**PU2315**	2	25	1	22	22	1.4	1.4	
2	**PU 2314-A**	2	6	1	18	18	0.7	0.7	
3	**PU 2314-B**	2	6	1	18	18	0.7	0.7	
4	**PU2305**	2	25	1	22	22	1.4	1.4	
5	**MX2305**	2	16	1	21	21	1	1	
6	**MX 2308**	2	25	1	22	22	1.4	1.4	
7	**BW2313**	2	10	1	18	18	0.9	0.9	
8	**Rotary valve**	2	1.5	1	15	15	0.4	0.4	
9	**SC2314**	2	1.5	1	15	15	0.4	0.4	
10	**AG 2324A**	2	1.5	1	15	15	0.4	0.4	
11	**AG 2324B**	2	1.5	1	15	15	0.4	0.4	
12	**AG 2305**	2	6	1	18	18	0.7	0.7	
13	**AG 2309**	2	1.5	1	15	15	0.4	0.4	
14	**AG 2310**	2	2.5	1	16	16	0.5	0.5	
15	**AG 2314**	2	2.5	1	16	16	0.5	0.5	
	Total			15		266	11.2	11.2	

Calculation

Maximum Cable Diameter:	22	mm
Consider Spare Capacity of Cable Tray:	30%	
Distance between each Cable:	0	mm
Calculated Width of Cable Tray:	346	mm
Calculated Area of Cable Tray:	7608	Sq.mm
No of Layer of Cables in Cable Tray:	1	
Selected No of Cable Tray:	1	Nos.
Selected Cable Tray Width:	600	mm
Selected Cable Tray Depth:	100	mm
Selected Cable Tray Weight Capacity:	90	Kg/Meter
Type of Cable Tray:	Ladder	
Total Area of Cable Tray:	60000	Sq.mm

Result

Selected Cable Tray width:	O.K	
Selected Cable Tray Depth:	O.K	
Selectrd Cable Tray Weight:	O.K	Including Spare Capacity
Selected Cable Tray Size:	O.K	Including Spare Capacity
Required Cable Tray Size:	600 x 100	mm
Required Nos of Cable Tray:	1	No
Required Cable Tray Weight:	90.00	Kg/Meter/Tray
Type of Cable Tray:	Ladder	
Cable Tray Width Area Remaning	42%	
Cable Tray Area Remaning:	87%	