INTERNSHIP PROGRAM REPORT

By

YAKKATI REVATHI - 18481A0297

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 /4th 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

Dr. Sri G. Srinivasa Rao – Internship coordinator

Mr. Rama Krishna – 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

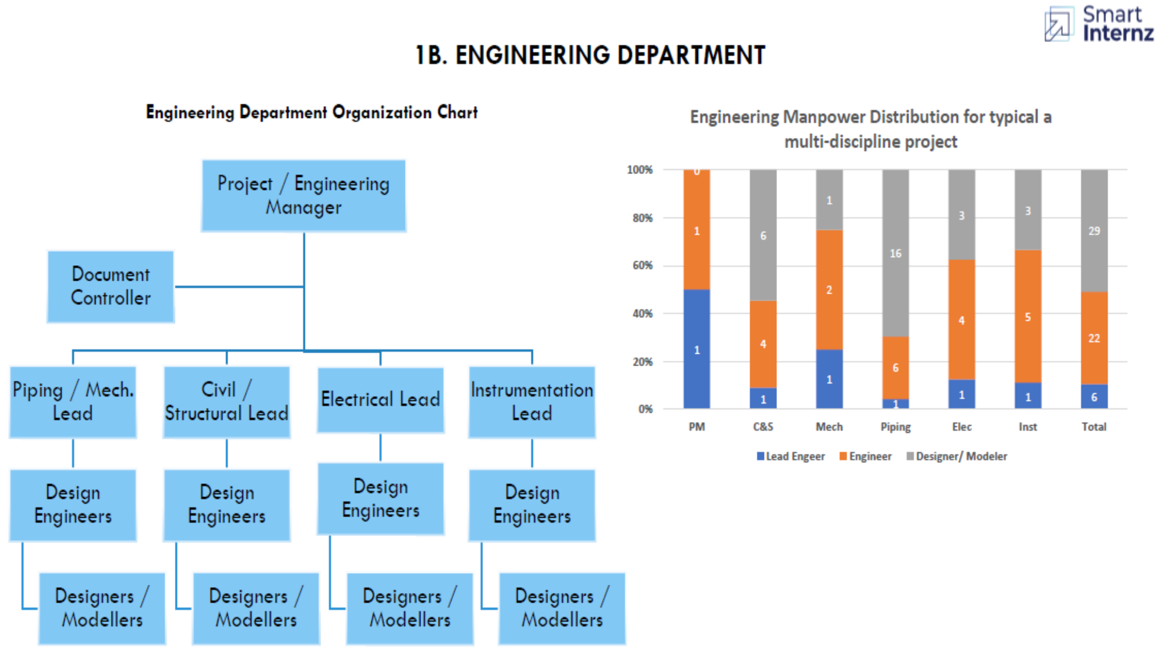
Presenter: Mr Ramesh V

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

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

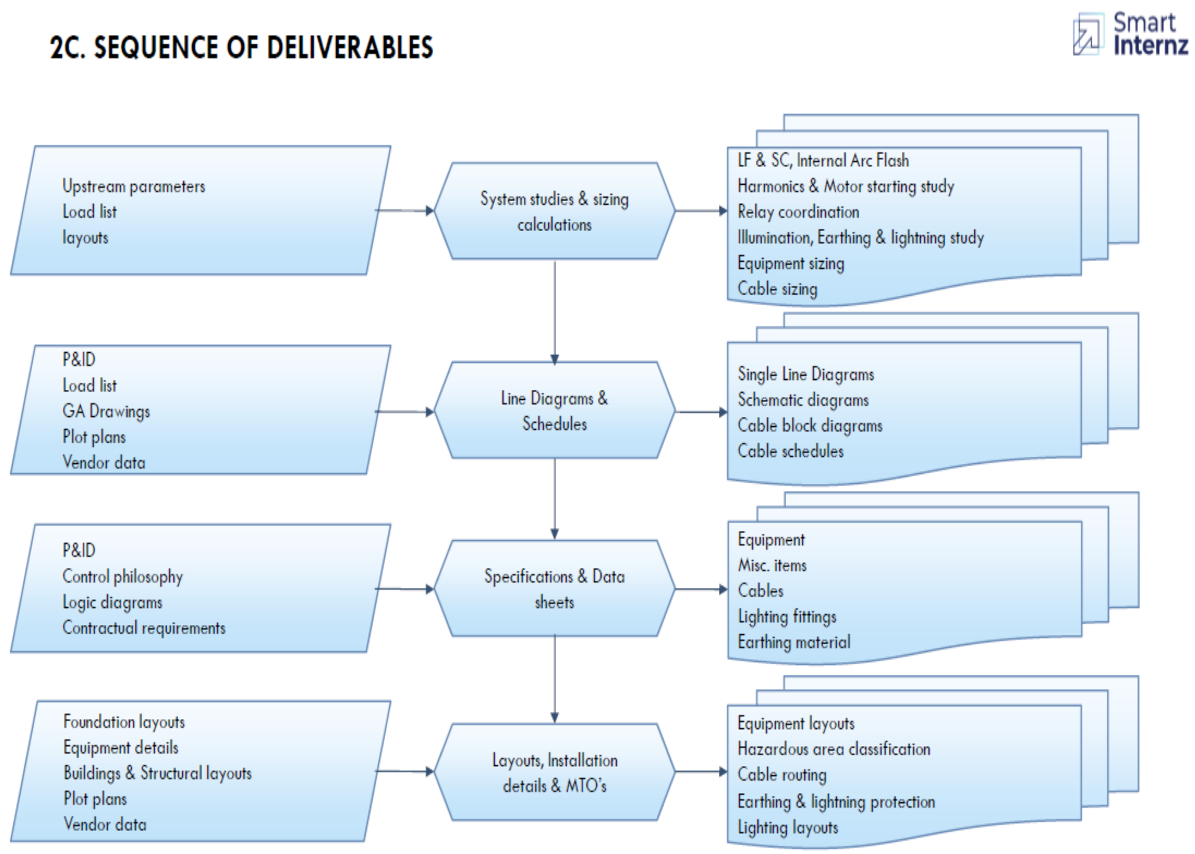


Topic details:

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

4th May2021: Engineering documentation for EPC projects

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



Topic details:

Engineering deliverable list, detailed engineering flow, engineering support flow, engineering support to procuments.

5th May2021: Engineering Documentation for command and formulae

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

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
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(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	
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COMMAMD WIN	Ctrl+9	VERTICAL	VER			

Topic details:

Basics commands for Ms Word, Ms excel, autocad.

6th May2021: Engineering documentation for Electrical system design

Estimation of Plant Electrical Load & SLD	Load List / Power balance	Load / Maximum demand calculation
	Single Line Diagram	Development of SLD
	Power flow diagram	Overall SLD
	Schematic diagram	Schematic diagrams of plant


IMCO ENGINEERING AND CONSTRUCTION COMPANY

DOCUMENT TRANSMITTAL

Project/Contract Ref.: GTC 06/152/ED - EPIC FOR POWER SUPPLY TO DSSA & NEW WESTERN DISTRICT HOSPITAL

Transmittal Number: IMCO-GTC 06/152/T/ 351

Date: 27/01/08

FORWARDED TO: QATAR PETROLEUM

Attn.: Mr. Sultan A. Sultan (EDD)

Cc: Mr. Mark Kenning (EDD/2)

DOC./ DRWG. No.	SHEETS	REV.	SET	DESCRIPTION	CODE
2257 4120	1	4	1+3	Lightning Protection Layout (88-SS-900)	5

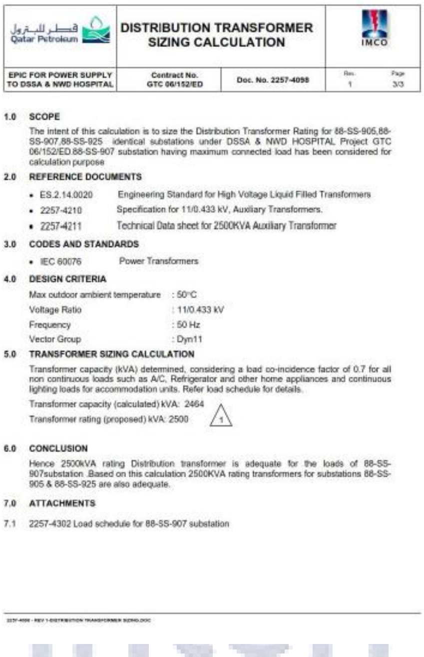
Remarks: * Comments Compliance sheet attached

Abdulkarim El Mahmoud, EXECUTIVE MANAGER PROJECTS GROUP — 27.01.08

PLEASE SIGN & RETURN THE ATTACHED COPY

RECEIVER'S SIGNATURE — DESIGNATION — DATE

Page 1 of 1


DISTRIBUTION TRANSFORMER SIZING CALCULATION

EPIC FOR POWER SUPPLY TO DSSA & NWD HOSPITAL — Contract No. GTC 06/152/ED — Doc. No. 2257-4098 — Rev. 1 — Page 3/3

1.0 SCOPE

The intent of this calculation is to size the Distribution Transformer Rating for 88-SS-905,88-SS-907,88-SS-925 identical substations under DSSA & NWD HOSPITAL Project GTC 06/152/ED.88-SS-907 substation having maximum connected load has been considered for calculation purpose

2.0 REFERENCE DOCUMENTS

- ES.2.14.0020 Engineering Standard for High Voltage Liquid Filled Transformers
- 2257-4210 Specification for 11/0.433 kV, Auxiliary Transformers.
- 2257-4211 Technical Data sheet for 2500KVA Auxiliary Transformer

3.0 CODES AND STANDARDS

- IEC 60076 Power Transformers

4.0 DESIGN CRITERIA

Max outdoor ambient temperature : 50°C
Voltage Ratio : 11/0.433 kV
Frequency : 50 Hz
Vector Group : Dyn11

5.0 TRANSFORMER SIZING CALCULATION

Transformer capacity (kVA) determined, considering a load co-incidence factor of 0.7 for all non continuous loads such as A/C, Refrigerator and other home appliances and continuous lighting loads for accommodation units. Refer load schedule for details.

Transformer capacity (calculated) kVA: 2464
Transformer rating (proposed) kVA: 2500

6.0 CONCLUSION

Hence 2500kVA rating Distribution transformer is adequate for the loads of 88-SS-907substation .Based on this calculation 2500KVA rating transformers for substations 88-SS-905 & 88-SS-925 are also adequate.

7.0 ATTACHMENTS

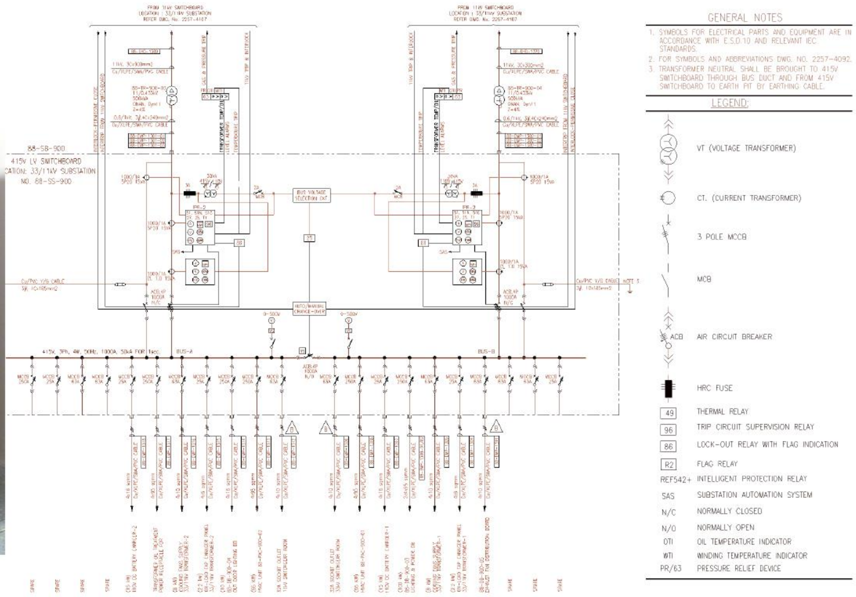
7.1 2257-4302 Load schedule for 88-SS-907 substation

Topic details:

List of electrical loads indicating continuous, intermittent & standby loads.

7th May2021: Equipment documentation for Typical diagrams

Estimation of Plant Electrical Load & SLD	Load List / Power balance	Load / Maximum demand calculation
	Single Line Diagram	Development of SLD
	Power flow diagram	Overall SLD
	Schematic diagram	Schematic diagrams of plant



Topic details:

Single line diagram, power flow diagram, schematic diagram.

9th May2021: Classification of transformers and generators

Equipment Selection & Sizing	Transformer	Types, Sizing / selection
	Generator	Types, Sizing / selection


1 Ph. Pad mounted Residential lighting


3 Ph Pole mounted Commercial/ Residential/ street lighting


3 Ph Oil filled (ONAN) Distribution type for industrial & commercial


3 Ph Oil filled (ONAF) Power transformer for industrial


3 Ph. Auto transformer for large motor starting & line regulation


3 Ph. Servo Stabilizer for hospital and critical equipment


3 Ph. Dry type indoor for commercial/industrial/data centers

11kV/6.6kV Diesel generator sets for standby / Emergency power supply


415V Diesel generator sets for standby / Emergency power supply


240V 1 ph diesel generator set for lighting and & small power only

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Topic details:

Transformer and DG set calculations, types, sizing or selections

12th May2021: Classification of switchgear construction and power factor improvement

Switchgear & power factor	SWGR	Types, Sizing / selection
	APFC	Types, Sizing / selection

LV 415V Indoor Air Insulated Switchgear for Industrial / commercial power supply

HV 33kV/ 220kV Indoor Gas Insulated Switchgear for large Industries & substations

HV 33kV or 220kV Outdoor Switchgear for large Industries & substations

415V/240V Distribution panels for commercial / Domestic distribution

240V Uninterruptible Power Supply panels for critical applications

220V DC power supply for emergency applications

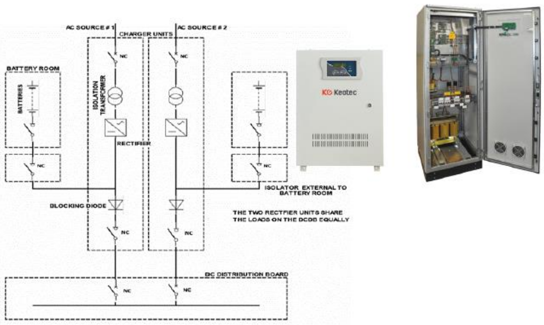
Topics:

About switch gear characteristics and power factor improvement.

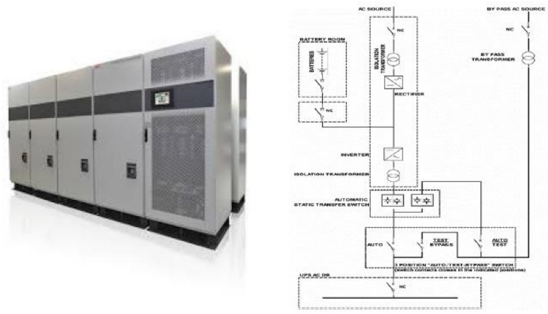
17th May2021: Detailing about UPS system and busducts

UPS	Types, Sizing / selection
Bus Duct	Types, Sizing / selection

A variety of design approaches are used to implement UPS systems, each with distinct performance characteristics. The most common design approaches are as follows:



110V or 220V DC
UPS System



110V or 230V
AC UPS System

Phase Separated busduct

Non-segregated busduct

Sandwich type busduct

Topics:

Types of uninterruptable power supplies, busducts.

18th May2021: Detailing about motor starters and sizing of motors

	Motor starters /Drives	Types, Sizing / selection
	Motors	Types, Sizing / selection

Motor Sizing

LV motors – based on driven equipment shaft power + 10-15% margin to select nearest standard size.

MV Motors - based on driven equipment shaft power + 5-10% margin and rounded off to nearest 10s.

Voltage: 0.18 to 160kW LV, 200 to 1800kW 3.3/6.6KV, >2000 11kV also depends on availability

Selection after sizing

Type - Synchronous or Induction motor

Environment – hazardous area, dusty, saliferous, altitude,

Application – Pump, Compressor, fan, Lift/Hoist/Crane etc.

Duty – based on application S1, S2, S3, S4, S5, S6

Ingress protection – Dust & water, Enclosure – Explosion proof, industrial

Mounting – Horizontal, Vertical

Bearings – Single Ball, Double Ball, Roller, Sleeve.

Cooling – TEFC, TETV, TENV, TEWC

Temperature detectors – Winding (6 nos.) & Bearing (2 nos.)

Starting & running torque – Based application

Load factor – 10 – 15 %

Efficiency – Energy efficient motors

415V LV motors for industrial applications; Pumps, fans, agitators

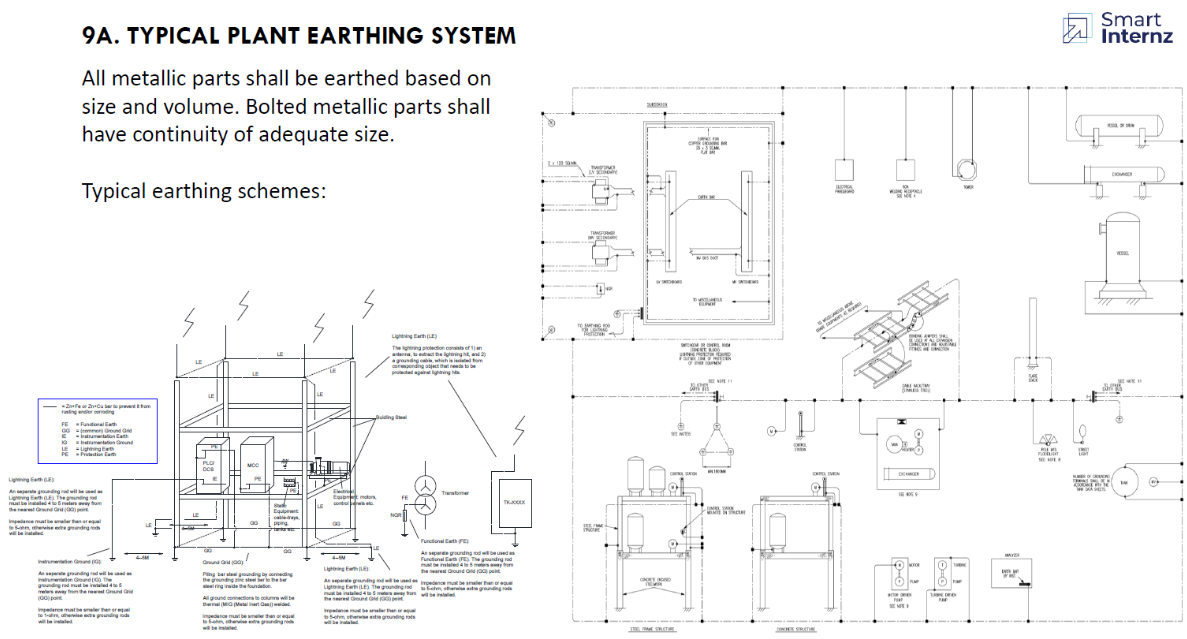
Large capacity MV motor for heavy industrial applications

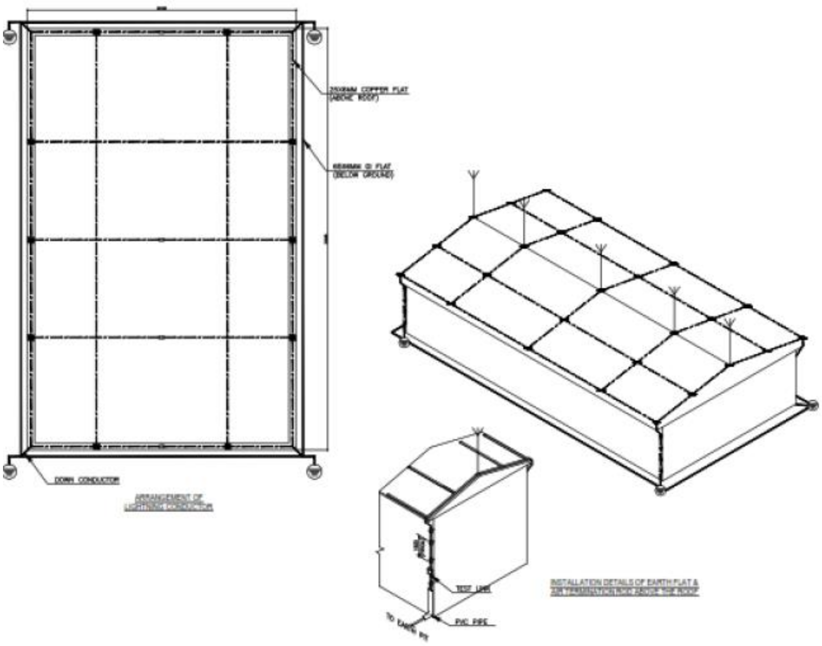
Topics:

Motor starters/ drivers, sizing of motors.

19th May2021: Describing about Earthing system and lighting protection

Earthing & Lightningprotection	Earthing	Calculations, Procedure & Layouts
	Lightning Protection	Calculations, Procedure & Layouts

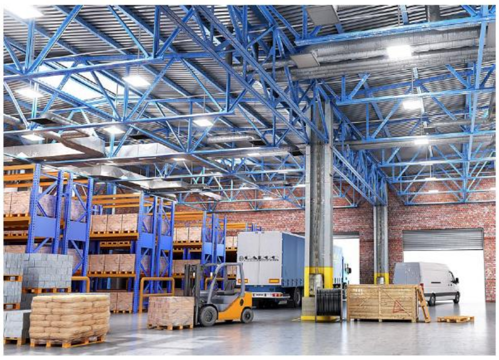




Topics:

Lightning and earthing protection calculations and procedure.

20th May2021: Lighting or illumination system and calculations



Pole mounted LED lighting fixtures for platforms

Well glass flame proof type outdoor light fitting for Oil & Gas industry

High bay LED lighting fitting used in workshops compressor stations

240V LED light fittings for indoor industrial

Junction box for connecting looping light fittings

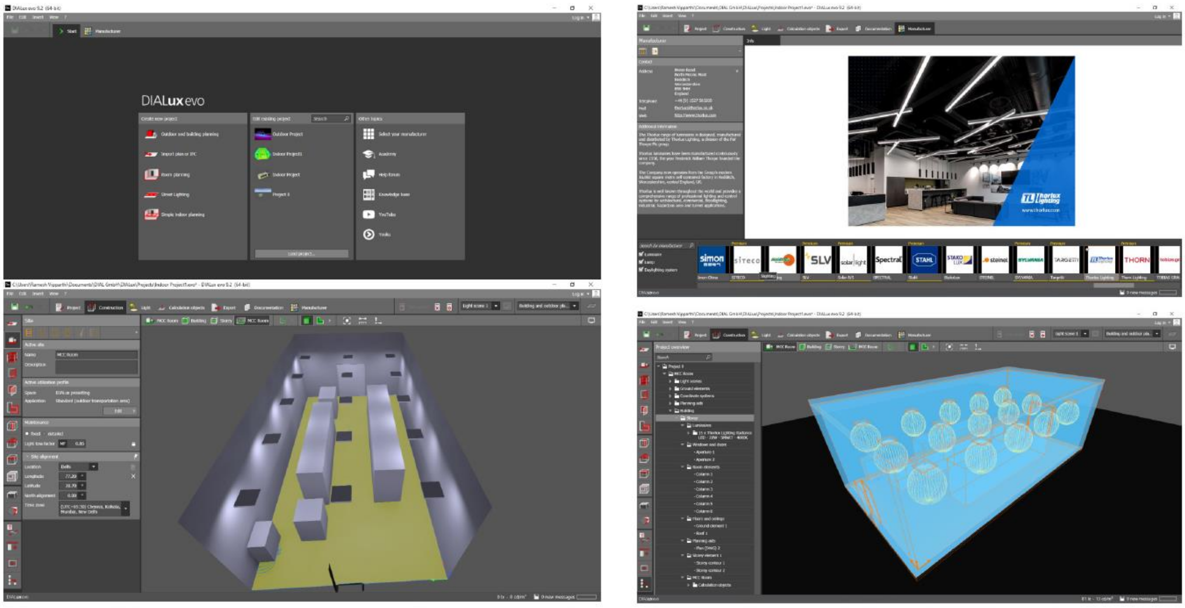
415V 3Ph 63A outdoor Welding Socket maintenance work

Topics:

Lightning or illumination calculations and procedure.

21th May2021: Lighting or illumination using DIALUX software

Illumination system	Indoor & Outdoor	Procedure & Layouts
	Indoor & Outdoor	Calculations with Dialux software



Topic details:

Indoor and outdoor procedure and layouts calculations with Dialux software.

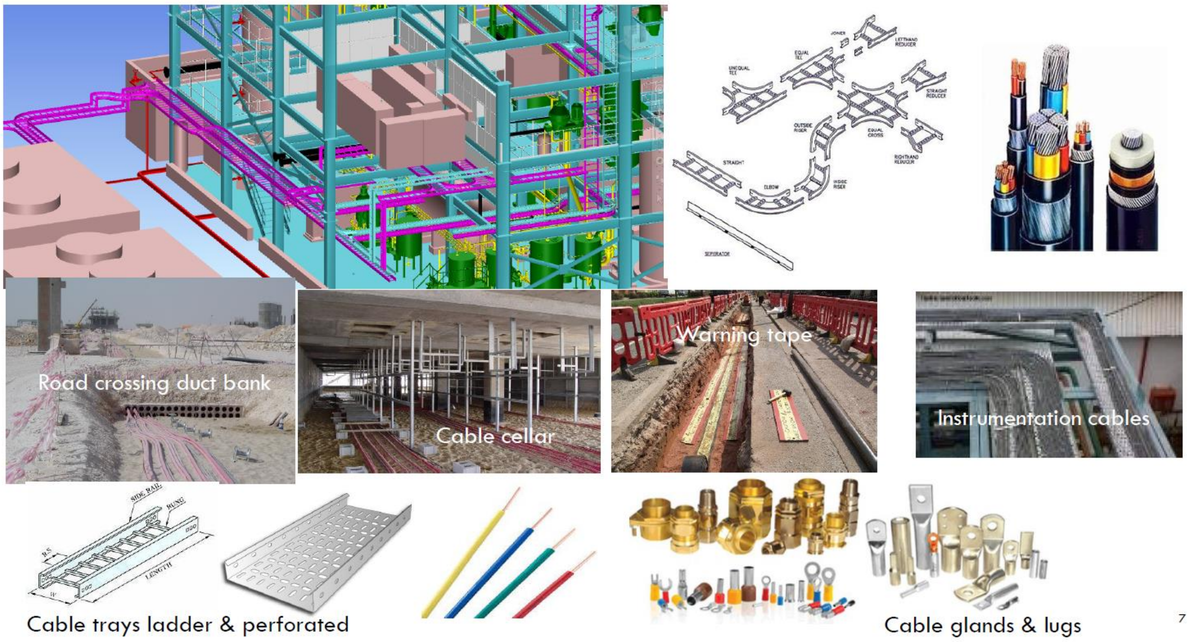
24th May2021: Cable calculations and their types

Cabling	Types of cables	Cables usage
		Types of laying
	Cable sizing calculations	Types of calculations

Topic details:

Cable sizing calculations for LV cables and MV/HV cables shall be performed foreach load based on cable laying conditions

25th May2021: Cabiling calculations and gland selection

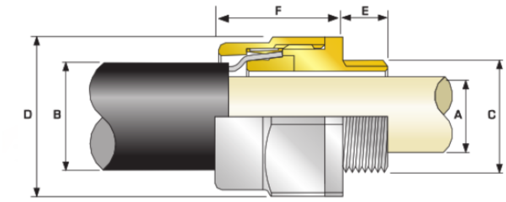


Cable glands are mechanical cable entry devices and can be constructed from metallic or non-metallic materials. Cable glands are used on all types of electrical power, control, instrumentation, data and telecommunications cables. They are used as a sealing and termination device to ensure that the characteristics of the enclosure which the cable enters can be maintained adequately.

Cable glands are made from Plastic, Brass Nickle plated, Aluminium & Stainless steel and they are Single compression type & Double compression type.

Important specifications for cable glands:

- The hole diameter is the maximum diameter of a cable.
- The cable diameter specifies the diameter of the cable that can be through the cable gland.
- The mounting hole diameter refers to the diameter of the barrier on which the gland is to be installed.



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

Topic details:

Cable sizing, gland selection.

28th May2021: Load calculations and Transformer sizing calculations

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]	Consumed Load (kW = [A] / [D]; kVAR = kW x tan φ): Continuous		Intermittent		Stand-by		Remarks
			A			mA	kW	kW	decimal	decimal	cos φ	kW	kVAR	kW	kVAR	kW	kVAR	
1	PU2315	Silica filter feed pump					88.18	90.00	0.98	0.93	0.82	94.82	66.18					
2	PU 2314-A	Absorbesnt/Neutral oil pump (W)					25.62	30.00	0.85	0.91	0.78	28.2	22.6					
3	PU 2314 -B	Absorbesnt/Neutral oil pump (S)					22.03	30.00	0.73	0.91	0.78					24.2	19.4	
4	PU2305	Feed Pump (Seperator)					89.06	90.00	0.99	0.93	0.82	95.8	66.8					
5	MX2305	MIXER (W)					89.75	90.00	1.00	0.93	0.82	96.5	67.4					
6	MX 2308	MIXER (S)					89.75	90.00	1.00	0.93	0.82					96.5	67.4	
7	BW2313	Blower					38.53	45.00	0.86	0.91	0.78	42.3	34.0					
8	Rotary valve	TK 2313B (I)					3.74	4.70	0.80	0.85	0.73			4.4	4.1			
9	SC2314	Screw conveyor (I)					8.65	9.20	0.94	0.85	0.73			10.18	9.53			
10	AG 2324A	Citric acid tan agitator (W)					6.50	7.50	0.87	0.85	0.73	7.65	7.16					
11	AG 2324B	Citric acid tank agitator (S)					6.50	7.50	0.87	0.85	0.73					7.6	7.2	
12	AG 2305	Citric oil rection vessol agitator					23.63	30.00	0.79	0.91	0.78	25.97	20.83					
13	AG 2309	Lye oil reaction vessel agitator					8.60	9.20	0.93	0.85	0.73	10.12	9.47					
14	AG 2310	Lye oil reaction vessel agitator					8.60	9.20	0.93	0.85	0.73	10.12	9.47					
15	AG 2314	Soap Adsorbant Tank Agitator					15.04	18.50	0.81	0.85	0.73	17.69	16.57					
											TOTAL	429.12	320.45	14.58	13.65	128.36	93.94	
											kVA	535.57		19.97		159.07		

Maximum of normal running plant load : 433.5 kW 324.5 kVAR sqrt (kW² +kVAR²) = 541.5 kVA
(Est. x%E + y%F)

Peak Load : 446.3 kW 333.9 kVAR sqrt (kW² +kVAR²) = 557.4 kVA
(Est. x%E + y%F + z%G)

<u>Assumptions</u>
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

<u>Calculation for Transformer Capacity</u>

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	429.12	320.5	535.57	--- (I)
b. Intermittent load / Diversity Factor	14.58	13.7	19.97	--- (II)
c. Stand-by load required as consumed load	128.36	93.9	159.06	--- (III)
Max. Consumed load = ((I) + 30% (II) + 10% (III)) =	446.3	333.9	557.43	
Future expansion load (20% capacity)	89.3	66.8	111.49	
Total Load =	535.6	400.7	668.91	

1.2 Calculation for 3.3kV / 0.433 kV transformer capacity

Max. Consumed load = 557.4 kVA
Spare capacity = 111.5 kVA
Required capacity = 668.9 kVA
Transformer rated capacity = 750 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 = 750 KVA (%Z)= 5.19 & Ratio X/R = 5.4

Hence , %R = = 0.941 %

%X = = 5.10 %

P_M = 90 KW having (K = 6 & C = 1 & Cos θ = 0.76 & Eff.η = 0.88 & Cos θs = 0.21
P_S = = 807.416 KVA

Cos θ_S = 0.25 ,Corresponding to Angle θ_s = 77.8776 Degrees for which Sin θ_s = 0.98
P_B = 423.75 KVA & PB in KW is = 360.188 & P_B in Kvar = 66.18 ∴ Cos θ_B = 0.850
Cos θ_B = 0.85 ,Corresponding to Angle θ_s = 31.7883 Degrees, for which Sin θ_s = 0.53

P_{CP} = = 529.745 KW
P_{CQ} = = 855.592 KVAR
P_C = = 1006.31 KVA
Cos θ_C = = 0.52642 , where as Sin θ_C = 0.850

Voltage Regulation ε = 6.5 %

Result: During starting of max. capacity motor, while all other loads are running , the voltage regulation at Transformer secondary terminals is approx. 6.5% , which meets the criteria to maintain less than 15% voltage regulation.

1.4 Selection of rated capacity

750 kVA transformer selected.

Topics:

Load calculations and transformer sizing calculations.

29th May2021: DG set calculations

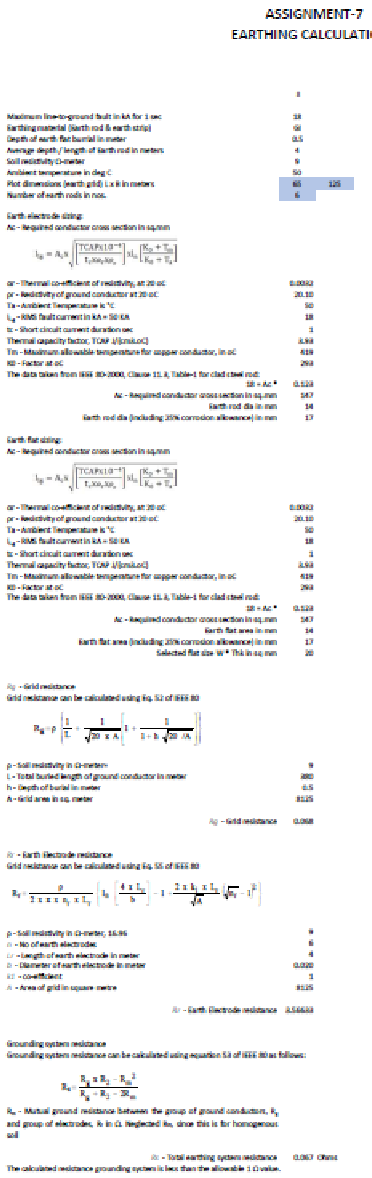
ASSIGNMENT-4

	DG SIZING CALCULATIONS		
	Design Data		
	Rated Volatge	415	KV
	Power factor (CosØ)	0.76	Avg
	Efficiency	0.88	Avg
	Total operating load on DG set in kVA at 0.76 power factor	**541.5**	
	Largest motor to start in the sequence - load in KW	90	KW
	Running KVA of last motor (CosØ= 0.91)	135	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)	**807**	KVA
	Base load of DG set in KVA (Total operating load in KVA – Running KVA of last motor)	**407**	KVA
A	**Continous operation under load -P1**		
	Capacity of DG set based on continuous operation under load P1	**407**	**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	**1214**	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 Dip) / (Transient Voltage Dip)	**618**	**KVA**
C	**Overload capacity P3**		
	Capacity of DG set required considering overload capacity		
	Total momentary load in KVA	**1214**	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)	**810**	**KVA**
	Considering the last value amongst P1, P2 and P3		
	Continous operation under load -P1	407	KVA
	Transient Voltage dip during Soft starter starting of Last motor P2	618	KVA
	Overload capacity P3	810	KVA
	Considering the last value amongst P1, P2 and P3	**810**	**KVA**
	Hence, Existing Generator 810 KVA is adequate to cater the loads as per re-scheduled loads		
	NOTE:VOLTAGE DIP CONSIDERED - 15%		

Topics:

DG set calculations

2nd June2021: Calculations of earthing and lighting protection



ASSIGNMENT-7
EARTHING CALCULATIONS

Maximum line-to-ground fault in kA for 1 sec	18	
Earthing material (Earth rod & earth strip)	GI	
Depth of earth flat burial in meter	0.5	
Average depth / length of Earth rod in meters	4	
Soil resistivity Ω-meter	9	
Ambient temperature in deg C	50	
Plot dimensions (earth grid) L x B in meters	65	125
Number of earth rods in nos.	6	

Earth electrode sizing:
Ac - Required conductor cross section in sq.mm

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

αr - Thermal co-efficient of resistivity, at 20 oC	0.0032
ρr - Resistivity of ground conductor at 20 oC	20.10
Ta - Ambient Temperature in °C	50
I_g - RMS fault current in kA = 50 KA	18
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:	
18 = Ac *	0.123
Ac - Required conductor cross section in sq.mm	147
Earth rod dia in mm	14
Earth rod dia (including 25% corrosion allowance) in mm	17

Earth flat sizing:
Ac - Required conductor cross section in sq.mm

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

αr - Thermal co-efficient of resistivity, at 20 oC	0.0032
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I_g - RMS fault current in kA = 50 KA	18
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The data taken from IEEE 80-2000, Clause 11.3, Table-1 for clad steel rod:	
18 = Ac *	0.123
Ac - Required conductor cross section in sq.mm	147
Earth flat area in mm	14
Earth flat area (including 25% corrosion allowance) in mm	17
Selected flat size W * Thk in sq.mm	20

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

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

ρ - Soil resistivity in Ω-meter=	9
L - Total buried length of ground conductor in meter	380
h - Depth of burial in meter	0.5
A - Grid area in sq. meter	8125
Rg - Grid resistance	0.068

Rr - Earth Electrode resistance
Grid resistance can be calculated using Eq. 55 of IEEE 80

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

ρ - Soil resistivity in Ω-meter, 16.96	9
n - No of earth electrodes	6
Lr - Length of earth electrode in meter	4
b - Diameter of earth electrode in meter	0.020
k1 - co-efficient	1
A - Area of grid in square metre	8125
Rr - Earth Electrode resistance	3.56663

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, Rr in Ω. Neglected R_m, since this is for homogenous soil

Rs - Total earthing system resistance 0.067 Ohms
The calculated resistance grounding system is less than the allowable 1 Ω value.

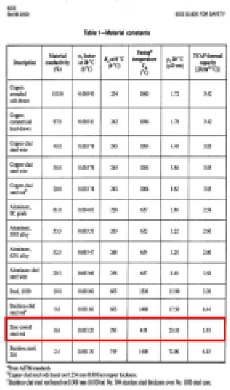

Table 1—Material constants

ASSIGNMENT-4
LIGHTNING PROTECTION CALCULATIONS

	16		
Location	Rajkot		
Building	Concrete, school		
Type of Building	triangle Roofs (c)		
Building Length (L)	12		
Building breadth (W)	6		
Building Height (H)	8		

Risk Factor Calculation

1 Collection Area (A_c)

A_c		=	(L*W) + (2*L*H) + (2*W*H) + (3.14*H*H)
			560.96

2 Probability of Being Struck (P)

P		=	$A_c * N_g * 10^{-6}$
			0.00028048

3 Overall weighing factor

a) Use of structure (A)		=	1.7
b) Type of construction (B)		=	1.7
c) Contents or consequential effects (C)		=	1.7
d) Degree of isolation (D)		=	1.0
e) Type of country (E)		=	0.3
Wo - Overall weighing factor		=	A * B * C * D * E
		=	1.474

4 Overall Risk Factor

	Po	=	P * Wo
	Po	=	0.000413399
	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)	
	=	36	Mts.

6 Down Conductors

Perimeter of building	=	36	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)

Topic:

Earthing and lighting protection calculations

5th June2021: Cable sizing and cable tray sizing

ASSIGNMENT-5
CABLE SIZING

S.NO.	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
3	LV MCC	PU2315	Silica filter feed pump	88.16	90.00	415	3	153.4	920.10	0.8	0.6	0.8	0.5	2	1	4.0
4	LV MCC	PU2322A	Soft water pump	25.62	30.00	415	3	44.6	267.33	0.8	0.6	0.8	0.5	2	1	4.0
5	LV MCC	PU 2314A	Absorbent/Neutral oil pump	22.03	30.00	415	3	38.3	229.87	0.8	0.6	0.8	0.5	2	1	4.0
6	LV MCC	PU2324	Citric Acid Tank pump	89.06	90.00	415	3	154.9	929.28	0.8	0.6	0.8	0.5	2	1	4.0
7	LV MCC	PU2333	Slop Oil pump	89.75	90.00	415	3	156.1	936.48	0.8	0.6	0.8	0.5	2	1	4.0
8	LV MCC	PU 2322B	Soft water pump-Stand by	89.75	90.00	415	3	156.1	936.48	0.8	0.6	0.8	0.5	2	1	4.0
9	LV MCC	PU2321A	Lye/Simplex Metering Pump	38.53	45.00	415	3	67.0	402.04	0.8	0.6	0.8	0.5	2	1	4.0
10	LV MCC	PU2321B	Lye storage tank pump	3.74	4.70	415	3	6.5	39.02	0.8	0.6	0.8	0.5	2	1	4.0
11	LV MCC	PU2305	Feed Pump(Seperator)	8.65	9.20	415	3	15.0	90.26	0.8	0.6	0.8	0.5	2	1	4.0
12	LV MCC	PU2332	Soap Stock Pump	6.50	7.50	415	3	11.3	67.82	0.8	0.6	0.8	0.5	2	1	4.0
13	LV MCC	MX2305	Mixer	6.50	7.50	415	3	11.3	67.82	0.8	0.6	0.8	0.5	2	1	4.0
14	LV MCC	MX2306	Mixer	23.63	30.00	415	3	41.1	246.56	0.8	0.6	0.8	0.5	2	1	4.0
15	LV MCC	CF2312	Separator	8.60	9.20	415	3	15.0	89.74	0.8	0.6	0.8	0.5	2	1	4.0
16	LV MCC	BW2313	Blower	8.60	9.20	415	3	15.0	89.74	0.8	0.6	0.8	0.5	2	1	4.0
17	LV MCC	RV 2314	Rotary valve	15.04	18.50	415	3	26.2	156.93	0.8	0.6	0.8	0.5	2	1	4.0
18	LV MCC	SC2314	Screw conveyor			415	3			0.8	0.6	0.8	0.5	2	1	4.0
19	LV MCC	AG2324A	citric acid tan agitator			415	3			0.8	0.6	0.8	0.5	2	1	4.0
20	LV MCC	AG2305	citric oil rection vessel agitator			415	3			0.8	0.6	0.8	0.5	2	1	4.0
21	LV MCC	AG2309	lye oil reaction vessel agitator			415	3			0.8	0.6	0.8	0.5	2	1	4.0
22	LV MCC	AG2310	lye oil reaction vessel agitator			415	3			0.8	0.6	0.8	0.5	2	1	4.0
23	LV MCC	AG2321A	lye tank agitator			415	3			0.8	0.6	0.8	0.5	2	1	4.0
24	LV MCC	AG2321B	lye tank agitator			415	3			0.8	0.6	0.8	0.5	2	1	4.0
25	LV MCC	AG2314	Soap adsorbent tank agitator			415	3			0.8	0.6	0.8	0.5	2	1	4.0
26	LV MCC	AG2300	Crude oil tank agitator			415	3			0.8	0.6	0.8	0.5	2	1	4.0
27	LV MCC	APFC	APFC PANEL			415	3			0.8	0.6			2	1	3.0

S.NO.	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 (Running) (%)	Voltage drop (Starting) (V)	Voltage drop (starting) (%)	Cable size result	OD of Cable (mm)	Gland size
3	70	230	0.98	0.9	1	1	0.882	202.9	95	0.3430	0.0752	8.06	1.94	47.23	11.38	OK	29	20
4	16	85	0.98	0.9	1	1	0.882	75.0	95	1.4700	0.0815	8.98	2.16	53.52	12.90	OK	21	20s
5	10	66	0.98	0.9	1	1	0.882	58.2	60	2.3400	0.0852	7.66	1.84	45.74	11.02	OK	18	20s
6	50	181	0.98	0.9	1	1	0.882	159.6	85	0.4950	0.0792	10.11	2.44	59.59	14.36	OK	26	20s
7	50	181	0.98	0.9	1	1	0.882	159.6	75	0.4950	0.0792	8.99	2.17	52.99	12.77	OK	26	20s
8	70	230	0.98	0.9	1	1	0.882	202.9	105	0.3430	0.0752	9.07	2.19	53.14	12.80	OK	29	20s
9	25	122	0.98	0.9	1	1	0.882	107.6	100	0.9300	0.0816	9.20	2.22	54.65	13.17	OK	22	20s
10	2.5	28	0.98	0.9	1	1	0.882	24.7	100	9.4800	0.1007	8.61	2.08	51.60	12.43	OK	16	20s
11	6	51	0.98	0.9	1	1	0.882	45.0	75	3.9400	0.0902	6.26	1.51	37.48	9.03	OK	18	20
12	4	38	0.98	0.9	1	1	0.882	33.5	110	5.9000	0.0947	10.29	2.48	61.60	14.84	OK	17	20s
13	6	51	0.98	0.9	1	1	0.882	45.0	75	3.9400	0.0902	4.71	1.13	28.17	6.79	OK	18	20
14	16	85	0.98	0.9	1	1	0.882	75.0	105	1.4700	0.0815	9.15	2.21	54.56	13.15	OK	21	20
15	25	122	0.98	0.9	1	1	0.882	107.6	85	0.9300	0.0816	1.75	0.42	10.37	2.50	OK	22	32
16	6	51	0.98	0.9	1	1	0.882	45.0	95	3.9400	0.0902	7.89	1.90	47.21	11.37	OK	18	20s
17	6	51	0.98	0.9	1	1	0.882	45.0	65	3.9400	0.0902	9.44	2.27	56.48	13.61	OK	18	20s
18	2.5	28	0.98	0.9	1	1	0.882	24.7	65	9.4800	0.1007					OK	16	20s
19	2.5	28	0.98	0.9	1	1	0.882	24.7	85	9.4800	0.1007					OK	16	20s
20	2.5	28	0.98	0.9	1	1	0.882	24.7	75	9.4800	0.1007					OK	16	20s
21	2.5	28	0.98	0.9	1	1	0.882	24.7	65	9.4800	0.1007					OK	16	20s
22	2.5	28	0.98	0.9	1	1	0.882	24.7	65	9.4800	0.1007					OK	16	20s
23	2.5	28	0.98	0.9	1	1	0.882	24.7	115	9.4800	0.1007					OK	16	20s
24	2.5	28	0.98	0.9	1	1	0.882	24.7	115	9.4800	0.1007					OK	16	20s
25	2.5	28	0.98	0.9	1	1	0.882	24.7	65	9.4800	0.1007					OK	16	20s
26	2.5	28	0.98	0.9	1	1	0.882	24.7	115	9.4800	0.1007					OK	16	20s
27	25	122	0.98	0.9	1	1	0.882	107.6	30	0.9300	0.0816					OK	22	25

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-6
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	4	70	1	29	29	3.25	3.25	
2	PU2322A	4	16	1	21	21	1	1	
3	PU 2314A	4	10	1	18	18	0.9	0.9	
4	PU2316	4	50	1	26	26	2.3	2.3	
5	PU2322A	4	50	1	26	26	2.3	2.3	
6	PU 2314A	4	70	1	29	29	3.25	3.25	
7	PU2317	4	25	1	22	22	1.4	1.4	
8	PU2322A	4	2.5	1	16	16	0.5	0.5	
9	PU 2314A	4	6	1	18	18	0.7	0.7	
10	PU2318	4	4	1	17	17	0.6	0.6	
11	PU2322A	4	6	1	18	18	0.7	0.7	
12	PU 2314A	4	16	1	21	21	1	1	
13	PU2319	4	25	1	22	22	1.4	1.4	
14	PMCC-2 TO AUXILIARY PANEL-	4	6	1	18	18	0.7	0.7	
15	PMCC-2 TO COOLING TOWER	4	6	1	18	18	0.7	0.7	

Calculation			Result		
Maximum Cable Diameter:	29	mm	Selected Cable Tra	O.K	
Consider Spare Capacity of Cable T	30%		Selected Cable Tra	O.K	
Distance between each Cable:	0	mm	Selectrd Cable Tra	O.K	Including Spare Capacity
Calculated Width of Cable Tray:	0	mm	Selected Cable Tra	ot adequa	Including Spare Capacity
Calculated Area of Cable Tray:	0	Sq.mm	of Cable Tray or w		
No of Layer of Cables in Cable Tray:	1		Required Cable Tra		mm
Selected No of Cable Tray:	1	Nos.	Required Nos of Ca		No
Selected Cable Tray Width:	300	mm	Required Cable Tra		Kg/Meter/Tray
Selected Cable Tray Depth:	100	mm	Type of Cable Tray	Ladder	
Selected Cable Tray Weight Capacit	90	Kg/Meter			
Type of Cable Tray:	Ladder		Cable Tray Width A	#DIV/0!	
Total Area of Cable Tray:	30000	Sq.mm	Cable Tray Area Re	#DIV/0!	

Topic:

Cable sizing and cable tray sizing calculations.

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, workshops, debates, hackthons, technical sessions.

Method of conducting program

Online virtual program with presentation slides, explanation on the topic, practical usage of topic with some examples and some assignments for hands on experience.

Program highlights

It is for the detailed design of any industrial sectors.

Material

After every session we have received material and it was good.

Benefits

It gave us an oppurtunity to learn about what is happening in industry sectors and gave knowledge of calculating things like load list, transformer sizing, cable sizing, cable tray sizing, lightning and earthing calculations. It gave us knowledge about how to use word, excel and autocad.

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]	Consumed Load: Continuous (kW = [A] / [D])		Intermittent		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					88.18	90.00	0.98	0.93	0.82	94.82	66.18					
2	PU 2314-A	Absorbesnt/Neutral oil pump (W)					25.62	30.00	0.85	0.91	0.78	28.2	22.6					
3	PU 2314 -B	Absorbesnt/Neutral oil pump (S)					22.03	30.00	0.73	0.91	0.78					24.2	19.4	
4	PU2305	Feed Pump (Seperator)					89.06	90.00	0.99	0.93	0.82	95.8	66.8					
5	MX2305	MIXER (W)					89.75	90.00	1.00	0.93	0.82	96.5	67.4					
6	MX 2308	MIXER (S)					89.75	90.00	1.00	0.93	0.82					96.5	67.4	
7	BW2313	Blower					38.53	45.00	0.86	0.91	0.78	42.3	34.0					
8	Rotary valve	TK 2313B (I)					3.74	4.70	0.80	0.85	0.73			4.4	4.1			
9	SC2314	Screw conveyor (I)					8.65	9.20	0.94	0.85	0.73			10.18	9.53			
10	AG 2324A	Citric acid tan agitator (W)					6.50	7.50	0.87	0.85	0.73	7.65	7.16					
11	AG 2324B	Citric acid tank agitator (S)					6.50	7.50	0.87	0.85	0.73					7.6	7.2	
12	AG 2305	Citric oil rection vessol agitator					23.63	30.00	0.79	0.91	0.78	25.97	20.83					
13	AG 2309	Lye oil reaction vessel agitator					8.60	9.20	0.93	0.85	0.73	10.12	9.47					
14	AG 2310	Lye oil reaction vessel agitator					8.60	9.20	0.93	0.85	0.73	10.12	9.47					
15	AG 2314	Soap Adsorbant Tank Agitator					15.04	18.50	0.81	0.85	0.73	17.69	16.57					

TOTAL	429.12	320.45	14.58	13.65	128.36	93.94
kVA	535.57		19.97		159.07	

Maximum of normal running plant load : 433.5 kW 324.5 kVAR sqrt (kW² +kVAR²) = 541.5 kVA
(Est. x%E + y%F)

Peak Load : 446.3 kW 333.9 kVAR sqrt (kW² +kVAR²) = 557.4 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	429.12	320.5	535.57	--- (i)
b. Intermittent load / Diversity Factor	14.58	13.7	19.97	--- (ii)
c. Stand-by load required as consumed load	128.36	93.9	159.06	--- (iii)
Max. Consumed load = ((i) + 30% (ii) + 10% (iii)) =	446.3	333.9	557.43	
Future expansion load (20% capacity)	89.3	66.8	111.49	
Total Load =	535.6	400.7	668.91	

1.2 Calculation for 3.3kV / 0.433 kV transformer capacity

Max. Consumed load	=	557.4 kVA
Spare capacity	=	111.5 kVA
Required capacity	=	668.9 kVA
Transformer rated capacity	=	750 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 = 750 KVA (%Z)= 5.19 & Ratio X/R = 5.4

Hence , **%R** = = 0.941 %

%X = = 5.10 %

P_M = 90 KW having (K = 6 & C = 1 & Cos θ = 0.76 & Eff.η = 0.88 & Cos Θs = 0.21

P_S = = 807.416 KVA

Cos θ_S = 0.25 ,Corresponding to Angle θ_s = 77.8776 Degrees for which Sin θ_s = 0.98

P_B = 423.75 KVA & PB in KW is = 360.188 & P_B in Kvar = 66.18 ∴ Cos θ_B = 0.850

Cos θ_B = 0.85 ,Corresponding to Angle θ_s = 31.7883 Degrees, for which Sin θ_s = 0.53

P_{CP} = = 529.745 KW

P_{CQ} = = 855.592 KVAR

P_C = = 1006.31 KVA

Cos θ_C = = 0.52642 , where as Sin θ_C = 0.850

Voltage Regulation ε = 6.5 %

Result: During starting of max. capacity motor, while all other loads are running , the voltage regulation at Transformer secondary terminals is approx. 6.5% , which meets the criteria to maintain less than 15% voltage regulation.

1.4 Selection of rated capacity

750 kVA transformer selected.

ASSIGNMENT-4

DG SIZING CALCULATIONS

	Design Data		
	Rated Volatge	415	KV
	Power factor (CosØ)	0.76	Avg
	Efficiency	0.88	Avg
	Total operating load on DG set in kVA at 0.76 power factor	**541.5**	
	Largest motor to start in the sequence - load in KW	90	KW
	Running kVA of last motor (CosØ= 0.91)	135	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)	**807**	KVA
	Base load of DG set in KVA (Total operating load in kVA – Running kVA of last motor)	**407**	KVA
A	**Continous operation under load -P1**		
	Capacity of DG set based on continuous operation under load P1	**407**	**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	1214	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 $\frac{\text{(1-Transient Voltage Dip)}}{\text{(Transient Voltage Dip)}}$	**618**	**KVA**
C	**Overload capacity P3**		
	Capacity of DG set required considering overload capacity		
	Total momentary load in KVA	1214	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) = $\frac{\text{Total momentary load in KVA}}{\text{overcurrent capacity of DG (K)}}$	**810**	**KVA**
	Considering the last value amongst P1, P2 and P3		
	Continous operation under load -P1	407	KVA
	Transient Voltage dip during Soft starter starting of Last motor P2	618	KVA
	Overload capacity P3	810	KVA
	Considering the last value amongst P1, P2 and P3	**810**	**KVA**

Hence, Existing Generator 810 KVA is adequate to cater the loads as per re-scheduled loads

NOTE:VOLTAGE DIP CONSIDERED - 15%

ASSIGNMENT-4
LIGHTNING PROTECTION CALCULATIONS

	16
Location	Rajkot
Building	Concrete, school
Type of Building	triangle Roofs (c)
Building Length (L)	12
Building breadth (W)	6
Building Height (H)	8

Risk Factor Calculation

1 **Collection Area (A_c)**

A_c		=	(L*W) + (2*L*H) + (2*W*H) + (3.14*H*H)	
			560.96	

2 **Probability of Being Struck (P)**

P		=	$A_c * N_g * 10^{-6}$	
			0.00028048	

3 **Overall weighing factor**

a) Use of structure (A)		=	1.7	
b) Type of construction (B)		=	1.7	
c) Contents or consequential effects (C)		=	1.7	
d) Degree of isolation (D)		=	1.0	
e) Type of country (E)		=	0.3	
Wo - Overall weighing factor		=	A * B * C * D * E	
		=	1.474	

4 **Overall Risk Factor**	Po	=	P * Wo	
	Po	=	0.000413399	
	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)	
		=	36	Mts.

6 **Down Conductors**

Perimeter of building		=	36	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-5

CABLE SIZING

S.NO.	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 (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 (Running) (%)	Voltage drop (Starting) (V)	Voltage drop (starting) (%)	Cable size result	OD of Cable (mm)	Gland size
3	LV MCC	PU2315	Silica filter feed pump	88.18	90.00	415	3	153.4	920.10	0.8	0.6	0.8	0.5	2	1	4.0	70	230	0.98	0.9	1	1	0.882	202.9	95	0.3430	0.0752	8.06	1.94	47.23	11.38	OK	29	20
4	LV MCC	PU2322A	Soft water pump	25.62	30.00	415	3	44.6	267.33	0.8	0.6	0.8	0.5	2	1	4.0	16	85	0.98	0.9	1	1	0.882	75.0	95	1.4700	0.0815	8.98	2.16	53.52	12.90	OK	21	20s
5	LV MCC	PU 2314A	Absorbesnt/Neutral oil pump	22.03	30.00	415	3	38.3	229.87	0.8	0.6	0.8	0.5	2	1	4.0	10	66	0.98	0.9	1	1	0.882	58.2	60	2.3400	0.0852	7.66	1.84	45.74	11.02	OK	18	20s
6	LV MCC	PU2324	Citric Acid Tank pump	89.06	90.00	415	3	154.9	929.28	0.8	0.6	0.8	0.5	2	1	4.0	50	181	0.98	0.9	1	1	0.882	159.6	85	0.4950	0.0792	10.11	2.44	59.59	14.36	OK	26	20s
7	LV MCC	PU2333	Slop Oil pump	89.75	90.00	415	3	156.1	936.48	0.8	0.6	0.8	0.5	2	1	4.0	50	181	0.98	0.9	1	1	0.882	159.6	75	0.4950	0.0792	8.99	2.17	52.99	12.77	OK	26	20s
8	LV MCC	PU 2322B	Soft water pump-Stand by	89.75	90.00	415	3	156.1	936.48	0.8	0.6	0.8	0.5	2	1	4.0	70	230	0.98	0.9	1	1	0.882	202.9	105	0.3430	0.0752	9.07	2.19	53.14	12.80	OK	29	20s
9	LV MCC	PU2321A	Lye/Simplex Metering Pump	38.53	45.00	415	3	67.0	402.04	0.8	0.6	0.8	0.5	2	1	4.0	25	122	0.98	0.9	1	1	0.882	107.6	100	0.9300	0.0816	9.20	2.22	54.65	13.17	OK	22	20s
10	LV MCC	PU2321B	Lye storage tank pump	3.74	4.70	415	3	6.5	39.02	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	100	9.4800	0.1007	8.61	2.08	51.60	12.43	OK	16	20s
11	LV MCC	PU2305	Feed Pump(Seperator)	8.65	9.20	415	3	15.0	90.26	0.8	0.6	0.8	0.5	2	1	4.0	6	51	0.98	0.9	1	1	0.882	45.0	75	3.9400	0.0902	6.26	1.51	37.48	9.03	OK	18	20
12	LV MCC	PU2332	Saop Stock Pump	6.50	7.50	415	3	11.3	67.82	0.8	0.6	0.8	0.5	2	1	4.0	4	38	0.98	0.9	1	1	0.882	33.5	110	5.9000	0.0947	10.29	2.48	61.60	14.84	OK	17	20s
13	LV MCC	MX2305	Mixer	6.50	7.50	415	3	11.3	67.82	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	4.71	1.13	28.17	6.79	OK	18	20
14	LV MCC	MX2308	Mixer	23.63	30.00	415	3	41.1	246.56	0.8	0.6	0.8	0.5	2	1	4.0	16	85	0.98	0.9	1	1	0.882	75.0	105	1.4700	0.0815	9.15	2.21	54.56	13.15	OK	21	20
15	LV MCC	CF2312	Separator	8.60	9.20	415	3	15.0	89.74	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	1.75	0.42	10.37	2.50	OK	22	32
16	LV MCC	BW2313	Blower	8.60	9.20	415	3	15.0	89.74	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	7.89	1.90	47.21	11.37	OK	18	20s
17	LV MCC	RV 2314	Rotary valve	15.04	18.50	415	3	26.2	156.93	0.8	0.6	0.8	0.5	2	1	4.0	6	51	0.98	0.9	1	1	0.882	45.0	65	3.9400	0.0902	9.44	2.27	56.48	13.61	OK	18	20s
18	LV MCC	SC2314	Screw conveyor			415	3			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					OK	16	20s
19	LV MCC	AG2324A	citric acid tan agitator			415	3			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					OK	16	20s
20	LV MCC	AG2305	citric oil rection vessol agitator			415	3			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	75	9.4800	0.1007					OK	16	20s
21	LV MCC	AG2309	lye oil reaction vessel agitator			415	3			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					OK	16	20s
22	LV MCC	AG2310	lye oil reaction vessel agitator			415	3			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					OK	16	20s
23	LV MCC	AG2321A	lye tank agitator			415	3			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	115	9.4800	0.1007					OK	16	20s
24	LV MCC	AG2321B	lye tank agitator			415	3			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	115	9.4800	0.1007					OK	16	20s
25	LV MCC	AG2314	Soap adsorbant tank agitator			415	3			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					OK	16	20s
26	LV MCC	AG2300	Crude oil tank agitator			415	3			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	115	9.4800	0.1007					OK	16	20s
27	LV MCC	APFC	APFC PANEL			415	3			0.8	0.6			2	1	3.0	25	122	0.98	0.9	1	1	0.882	107.6	30	0.9300	0.0816					OK	22	25

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-5
CABLE SCHEDULE

CABLE TAG NO.	CABLE FROM			CABLE TO			CABLE DESCRIPTION					REMARKS
	EQUIPMENT	EQUIPMENT LOCATION	GLAND SIZE	EQUIPMENT	EQUIPMENT LOCATION	GLAND SIZE	CORE	SIZE SQMM	TYPE	VOLTAGE LEVEL	LENGTH (M)	
NU PU2315 - VFD	LV MCC	ELECTRICAL ROOM GF	20	PU2315 - VFD	ELECTRICAL ROOM GF	20	4	70	2	1100	35	VFD DRIVEN
NU PU2315 - P	PU2315 - VFD	ELECTRICAL ROOM GF	20	PU2315	Silica filter feed pump	20	4	70	2	1100	95	
NU PU2315 - C	PU2315 - VFD	ELECTRICAL ROOM GF	20s	PU2315 LSPB	Silica filter feed pump LOCAL STOP PB	20s	5	1.5	2	1100	105	
NU PU2322A - P	LV MCC	ELECTRICAL ROOM GF	20s	PU2322A	Soft water pump	20s	4	16	2	1100	95	
NU PU2322A - C	LV MCC	ELECTRICAL ROOM GF	20s	PU2322A LSPB	Soft water pump LOCAL STOP PB	20s	5	1.5	2	1100	105	
NU PU 2314A - VFD	LV MCC	ELECTRICAL ROOM GF	20s	PU 2314A- VFD	ELECTRICAL ROOM GF	20s	4	10	2	1100	35	VFD DRIVEN
NU PU 2314A - P	PU 2314A- VFD	ELECTRICAL ROOM GF	20s	PU 2314A	Absorbesnt/Neutral oil pump	20s	4	10	2	1100	60	
NU PU 2314A- C	PU 2314A- VFD	ELECTRICAL ROOM GF	20s	PU 2314A LSPB	Absorbesnt/Neutral oil pump LOCAL STOP PB	20s	5	1.5	2	1100	70	
NU PU2324 - VFD	LV MCC	ELECTRICAL ROOM GF	20s	PU2324 - VFD	ELECTRICAL ROOM GF	20s	4	50	2	1100	35	VFD DRIVEN
NU PU2324 - P	PU2324 - VFD	ELECTRICAL ROOM GF	20s	PU2324	Citric Acid Tank pump	20s	4	50	2	1100	85	
NU PU2324 - C	PU2324 - VFD	ELECTRICAL ROOM GF	20s	PU2324 LSPB	Citric Acid Tank pump LOCAL STOP PB	20s	5	1.5	2	1100	95	
NU PU2333 - P	LV MCC	ELECTRICAL ROOM GF	20s	PU2333	Slop Oil pump	20s	4	50	2	1100	75	
NU PU2333 - C	LV MCC	ELECTRICAL ROOM GF	20s	PU2333 LSPB	Slop Oil pump LOCAL STOP PB	20s	5	1.5	2	1100	85	
NU PU 2322B - P	LV MCC	ELECTRICAL ROOM GF	20s	PU 2322B	Soft water pump-Stand by	20s	4	70	2	1100	105	
NU PU 2322B - C	LV MCC	ELECTRICAL ROOM GF	20s	PU 2322B LSPB	Soft water pump-Stand by LOCAL STOP PB	20s	5	1.5	2	1100	115	
NU PU2321A - VFD	LV MCC	ELECTRICAL ROOM GF	20s	PU2321A- VFD	ELECTRICAL ROOM GF	20s	4	25	2	1100	35	VFD DRIVEN
NU PU2321A - P	PU2321A- VFD	ELECTRICAL ROOM GF	20s	PU2321A	Lye/Simplex Metering Pump	20s	4	25	2	1100	100	
NU PU2321A- C	PU2321A- VFD	ELECTRICAL ROOM GF	20s	PU2321A LSPB	Lye/Simplex Metering Pump LOCAL STOP PB	20s	5	1.5	2	1100	110	
NU PU2321B- P	LV MCC	ELECTRICAL ROOM GF	20s	PU2321B	Lye storage tank pump	20s	4	2.5	2	1100	100	
NU PU2321B- C	LV MCC	ELECTRICAL ROOM GF	20s	PU2321B LSPB	Lye storage tank pump LOCAL STOP PB	20s	5	1.5	2	1100	110	
NU PU2305 - VFD	LV MCC	ELECTRICAL ROOM GF	20	PU2305- VFD	ELECTRICAL ROOM GF	20	4	6	2	1100	35	VFD DRIVEN
NU PU2305 - P	PU2305- VFD	ELECTRICAL ROOM GF	20	PU2305	Feed Pump(Seperator)	20	4	6	2	1100	75	
NU PU2305- C	PU2305- VFD	ELECTRICAL ROOM GF	20s	PU2305 LSPB	Feed Pump(Seperator) LOCAL STOP PB	20s	5	1.5	2	1100	85	
NU PU2332- P	LV MCC	ELECTRICAL ROOM GF	20s	PU2332	Saop Stock Pump	20s	4	4	2	1100	110	
NU PU2332- C	LV MCC	ELECTRICAL ROOM GF	20s	PU2332 LSPB	Saop Stock Pump LOCAL STOP PB	20s	5	1.5	2	1100	120	
NU MX2305- P	LV MCC	ELECTRICAL ROOM GF	20	MX2305	Mixer	20	4	6	2	1100	75	
NU MX2305- C	LV MCC	ELECTRICAL ROOM GF	20s	MX2305 LSPB	Mixer LOCAL STOP PB	20s	5	1.5	2	1100	85	
NU MX2308- P	LV MCC	ELECTRICAL ROOM GF	20	MX2308	Mixer	20	4	16	2	1100	105	
NU MX2308- C	LV MCC	ELECTRICAL ROOM GF	20s	MX2308 LSPB	Mixer LOCAL STOP PB	20s	5	1.5	2	1100	115	
NU CF2312- P	LV MCC	ELECTRICAL ROOM GF	32	CF2312	Separator	32	4	25	2	1100	85	
NU CF2312- C	LV MCC	ELECTRICAL ROOM GF	20s	CF2312 LSPB	Separator LOCAL STOP PB	20s	5	1.5	2	1100	95	
NU BW2313- P	LV MCC	ELECTRICAL ROOM GF	20s	BW2313	Blower	20s	4	6	2	1100	95	
NU BW2313- C	LV MCC	ELECTRICAL ROOM GF	20s	BW2313 LSPB	Blower LOCAL STOP PB	20s	5	1.5	2	1100	105	
NU RV 2314 - VFD	LV MCC	ELECTRICAL ROOM GF	20s	RV 2314- VFD	ELECTRICAL ROOM GF	20s	4	6	2	1100	35	VFD DRIVEN
NU RV 2314 - P	RV 2314- VFD	ELECTRICAL ROOM GF	20s	RV 2314	Rotary valve	20s	4	6	2	1100	65	
NU RV 2314- C	RV 2314- VFD	ELECTRICAL ROOM GF	20s	RV 2314 LSPB	Rotary valve LOCAL STOP PB	20s	5	1.5	2	1100	75	
NU SC2314 - VFD	LV MCC	ELECTRICAL ROOM GF	20s	SC2314- VFD	ELECTRICAL ROOM GF	20s	4	2.5	2	1100	35	VFD DRIVEN
NU SC2314 - P	SC2314- VFD	ELECTRICAL ROOM GF	20s	SC2314	Screw conveyor	20s	4	2.5	2	1100	65	
NU SC2314- C	SC2314- VFD	ELECTRICAL ROOM GF	20s	SC2314 LSPB	Screw conveyor LOCAL STOP PB	20s	5	1.5	2	1100	75	
NU AG2324A- P	LV MCC	ELECTRICAL ROOM GF	20s	AG2324A	citric acid tan agitator	20s	4	2.5	2	1100	85	
NU AG2324A- C	LV MCC	ELECTRICAL ROOM GF	20s	AG2324A LSPB	citric acid tan agitator LOCAL STOP PB	20s	5	1.5	2	1100	95	
NU AG2305- P	LV MCC	ELECTRICAL ROOM GF	20s	AG2305	citric oil rection vessol agitator	20s	4	2.5	2	1100	75	
NU AG2305- C	LV MCC	ELECTRICAL ROOM GF	20s	AG2305 LSPB	citric oil rection vessol agitator LOCAL STOP PB	20s	5	1.5	2	1100	85	
NU AG2309- P	LV MCC	ELECTRICAL ROOM GF	20s	AG2309	lye oil reaction vessel agitator	20s	4	2.5	2	1100	65	
NU AG2309- C	LV MCC	ELECTRICAL ROOM GF	20s	AG2309 LSPB	lye oil reaction vessel agitator LOCAL STOP PB	20s	5	1.5	2	1100	75	
NU AG2310- P	LV MCC	ELECTRICAL ROOM GF	20s	AG2310	lye oil reaction vessel agitator	20s	4	2.5	2	1100	65	
NU AG2310- C	LV MCC	ELECTRICAL ROOM GF	20s	AG2310 LSPB	lye oil reaction vessel agitator LOCAL STOP PB	20s	5	1.5	2	1100	75	
NU AG2321A- P	LV MCC	ELECTRICAL ROOM GF	20s	AG2321A	lye tank agitator	20s	4	2.5	2	1100	115	
NU AG2321A- C	LV MCC	ELECTRICAL ROOM GF	20s	AG2321A LSPB	lye tank agitator LOCAL STOP PB	20s	5	1.5	2	1100	125	
NU AG2321B- P	LV MCC	ELECTRICAL ROOM GF	20s	AG2321B	lye tank agitator	20s	4	2.5	2	1100	115	
NU AG2321B- C	LV MCC	ELECTRICAL ROOM GF	20s	AG2321B LSPB	lye tank agitator LOCAL STOP PB	20s	5	1.5	2	1100	125	
NU AG2314 - VFD	LV MCC	ELECTRICAL ROOM GF	20s	AG2314- VFD	ELECTRICAL ROOM GF	20s	4	2.5	2	1100	35	VFD DRIVEN
NU AG2314 - P	AG2314- VFD	ELECTRICAL ROOM GF	20s	AG2314	Soap adsorbant tank agitator	20s	4	2.5	2	1100	65	
NU AG2314- C	AG2314- VFD	ELECTRICAL ROOM GF	20s	AG2314 LSPB	Soap adsorbant tank agitator LOCAL STOP PB	20s	5	1.5	2	1100	75	
NU AG2300- P	LV MCC	ELECTRICAL ROOM GF	20s	AG2300	Crude oil tank agitator	20s	4	2.5	2	1100	115	
NU AG2300- C	LV MCC	ELECTRICAL ROOM GF	20s	AG2300 LSPB	Crude oil tank agitator LOCAL STOP PB	20s	5	1.5	2	1100	125	
NU APFC- C	LV MCC	ELECTRICAL ROOM GF	25	APFC	APFC PANEL	25	3	25	2	1100	30	

ASSIGNMENT-6

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	4	70	1	29	**29**	3.25	**3.25**	
2	PU2322A	4	16	1	21	**21**	1	**1**	
3	PU 2314A	4	10	1	18	**18**	0.9	**0.9**	
4	PU2316	4	50	1	26	**26**	2.3	**2.3**	
5	PU2322A	4	50	1	26	**26**	2.3	**2.3**	
6	PU 2314A	4	70	1	29	**29**	3.25	**3.25**	
7	PU2317	4	25	1	22	**22**	1.4	**1.4**	
8	PU2322A	4	2.5	1	16	**16**	0.5	**0.5**	
9	PU 2314A	4	6	1	18	**18**	0.7	**0.7**	
10	PU2318	4	4	1	17	**17**	0.6	**0.6**	
11	PU2322A	4	6	1	18	**18**	0.7	**0.7**	
12	PU 2314A	4	16	1	21	**21**	1	**1**	
13	PU2319	4	25	1	22	**22**	1.4	**1.4**	
14	PMCC-2 TO AUXILIARY PANEL-	4	6	1	18	**18**	0.7	**0.7**	
15	PMCC-2 TO COOLING TOWER	4	6	1	18	**18**	0.7	**0.7**	

Calculation

Maximum Cable Diameter:	29	mm
Consider Spare Capacity of Cable Tı	30%	
Distance between each Cable:	0	mm
Calculated Width of Cable Tray:	0	mm
Calculated Area of Cable Tray:	0	Sq.mm
No of Layer of Cables in Cable Tray:	1	
Selected No of Cable Tray:	1	Nos.
Selected Cable Tray Width:	300	mm
Selected Cable Tray Depth:	100	mm
Selected Cable Tray Weight Capacit	90	Kg/Meter
Type of Cable Tray:	Ladder	
Total Area of Cable Tray:	30000	Sq.mm

Result

Selected Cable Tra	O.K	
Selected Cable Tra	O.K	
Selectrd Cable Tra	O.K	Including Spare Capacity
Selected Cable Tra	ot adequa	Including Spare Capacity
› of Cable Tray or w		
Required Cable Tra		mm
Required Nos of Ca		No
Required Cable Tra		Kg/Meter/Tray
Type of Cable Tray	Ladder	
Cable Tray Width A	#DIV/0!	
Cable Tray Area Re	#DIV/0!	

ASSIGNMENT-7
EARTHING CALCULATIONS

	8	
Maximum line-to-ground fault in kA for 1 sec	18	
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	
Soil resistivity Ω-meter	9	
Ambient temperature in deg C	50	
Plot dimensions (earth grid) L x B in meters	65	125
Number of earth rods in nos.	6	

Earth electrode sizing:
Ac - Required conductor cross section in sq.mm

$$I_{1g} = A_c x \sqrt{\left[\frac{TCAPx10^{-4}}{t_c x\alpha_r x\rho_r}\right] x l_n \left[\frac{K_0 + T_m}{K_0 + T_a}\right]}$$

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	50
I_{l-g} - RMS fault current in kA = 50 KA	18
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:	
18 = Ac *	0.123
Ac - Required conductor cross section in sq.mm	147
Earth rod dia in mm	14
Earth rod dia (including 25% corrosion allowance) in mm	17

Earth flat sizing:
Ac - Required conductor cross section in sq.mm

$$I_{1g} = A_c x \sqrt{\left[\frac{TCAPx10^{-4}}{t_c x\alpha_r x\rho_r}\right] x l_n \left[\frac{K_0 + T_m}{K_0 + T_a}\right]}$$

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	50
I_{l-g} - RMS fault current in kA = 50 KA	18
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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:	
18 = Ac *	0.123
Ac - Required conductor cross section in sq.mm	147
Earth flat area in mm	14
Earth flat area (including 25% corrosion allowance) in mm	17
Selected flat size W * Thk in sq mm	20

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

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

ρ - Soil resistivity in Ω-meter=	9
L - Total buried length of ground conductor in meter	380
h - Depth of burial in meter	0.5
A - Grid area in sq. meter	8125
Rg - Grid resistance	0.068

Rr - Earth Electrode resistance
Grid resistance can be calculated using Eq. 55 of IEEE 80

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

ρ - Soil resistivity in Ω-meter, 16.96	9
n - No of earth electrodes	6
Lr - Length of earth electrode in meter	4
b - Diameter of earth electrode in meter	0.020
k1 - co-efficient	1
A - Area of grid in square metre	8125
Rr - Earth Electrode resistance	3.56633

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

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

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

Rs - Total earthing system resistance 0.067 Ohms

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

IEEE
Std 80-2000 IEEE GUIDE FOR SAFETY

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.