# Internship Program Report

## By

## MANNE SAI LAKSHMAN-18481A0261

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

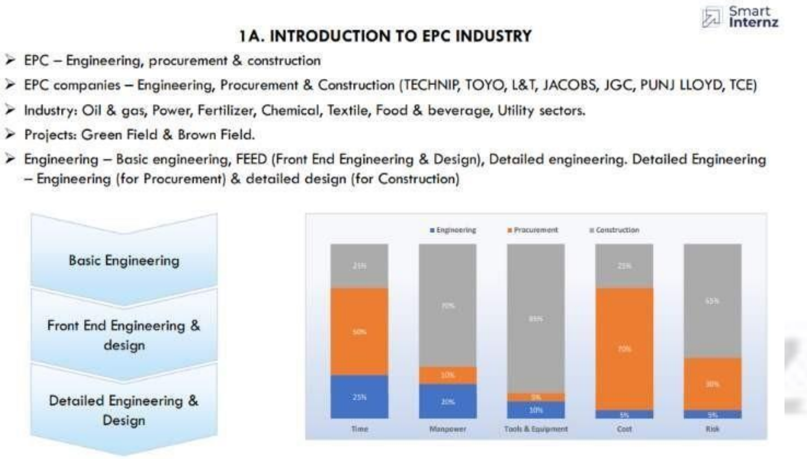
Presenter: Mr Ramesh V

# 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 |

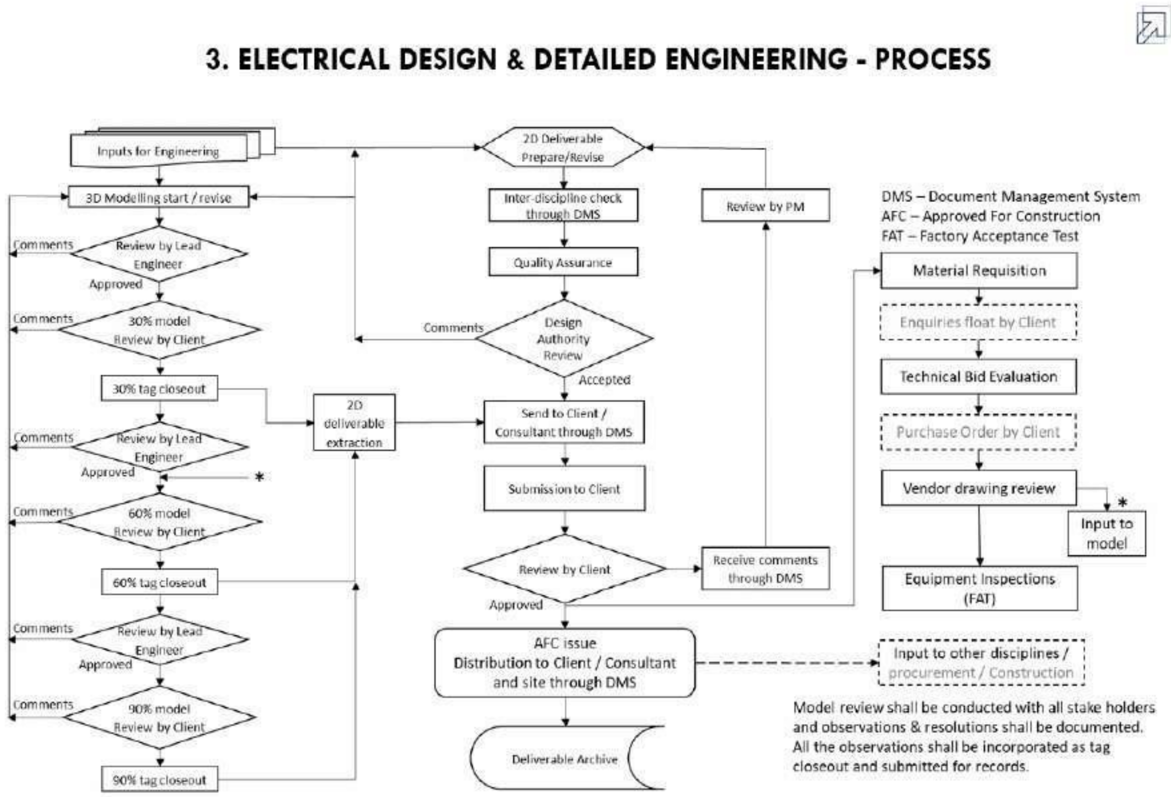



Topic details:

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 |




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 | | |
| | | BOUNDARY | BO | | | | |
| | | DONUT | DO | | | | |

| EXTRA | | | | DRAFTING | | PAPER SIZE |
|---|---|---|---|---|---|---|
| UNIT | UN | UCS | UCS | ORTHO | F8, Ctrl+L | A4=210*297 |
| 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 | | | |

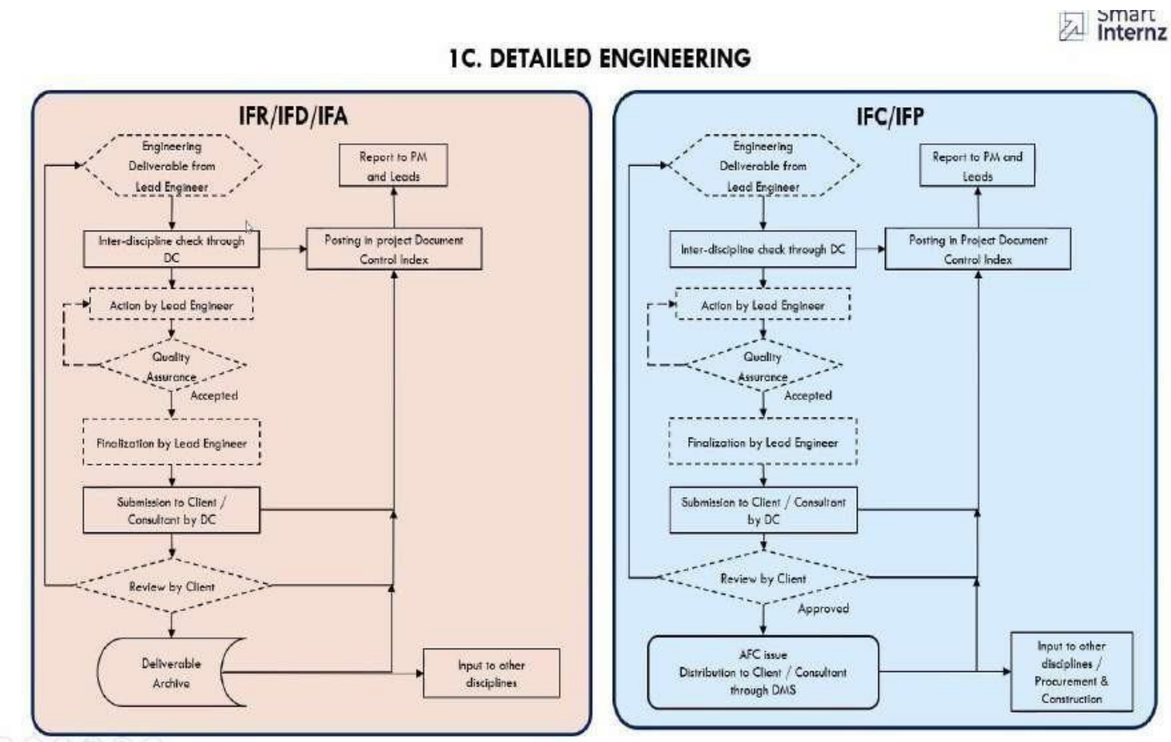
## Topic details:

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 |

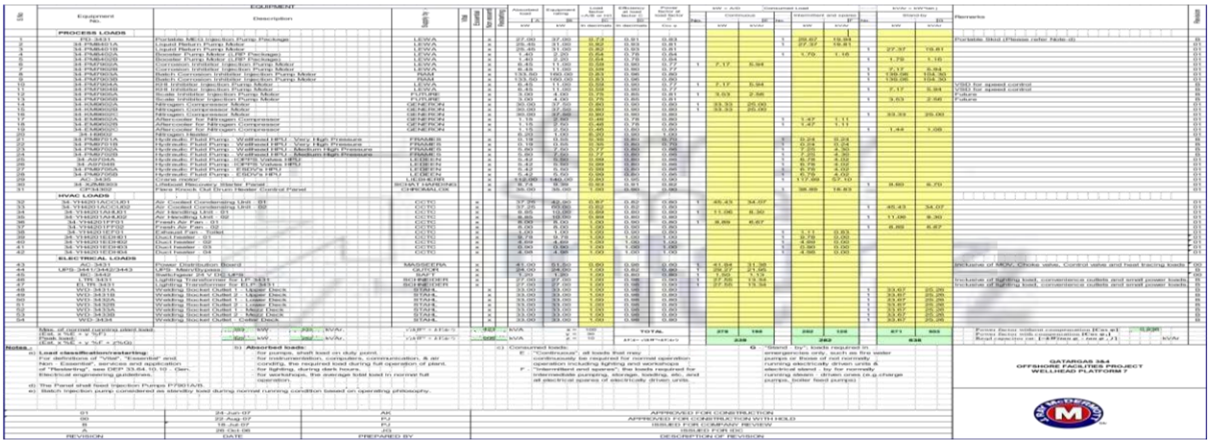
## Topic details:




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

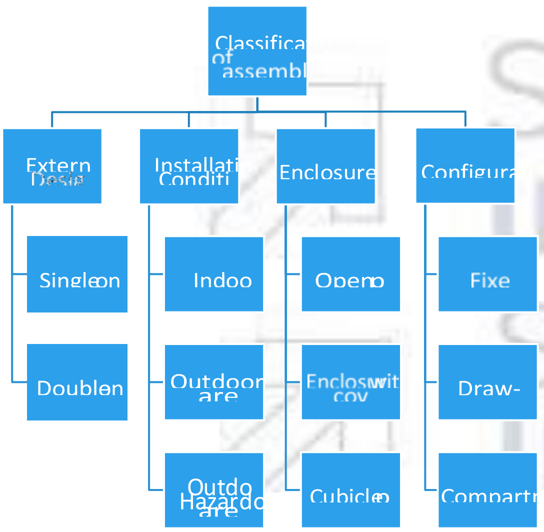
| | | | |
|---|---|---|---|
| 6 | Classification of Transformers and Generators | Different types of Transformers | Different types of Generators |

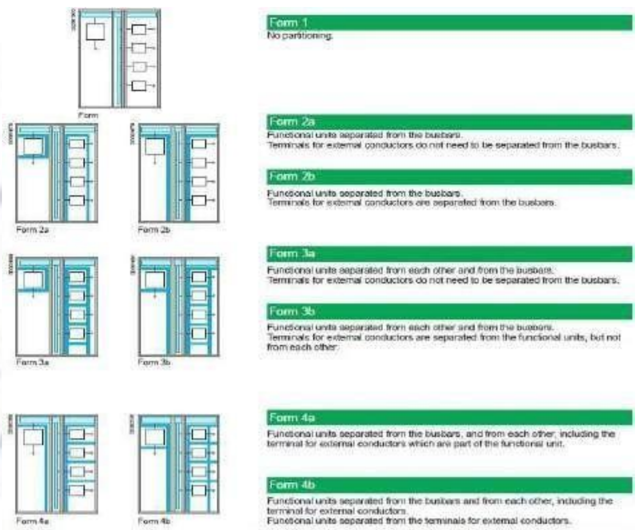
## Topic details:

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 |



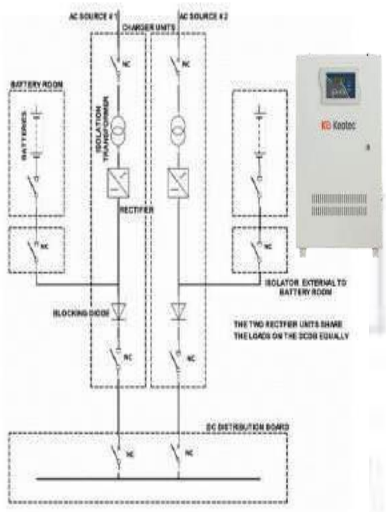



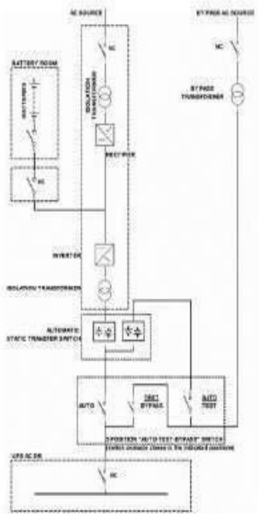

### Topic details:

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

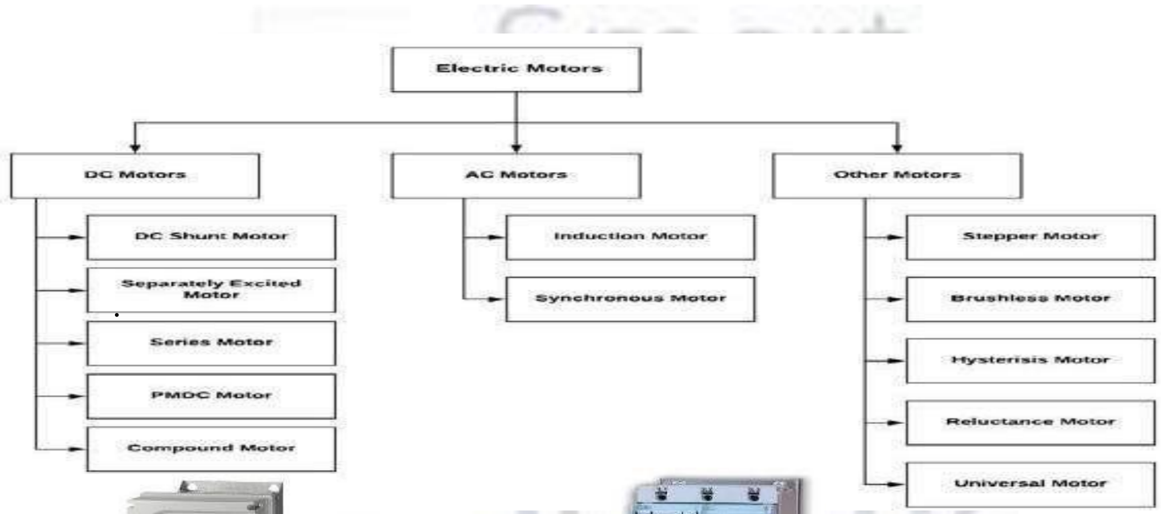
110V or 230V AC UPS System

**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.

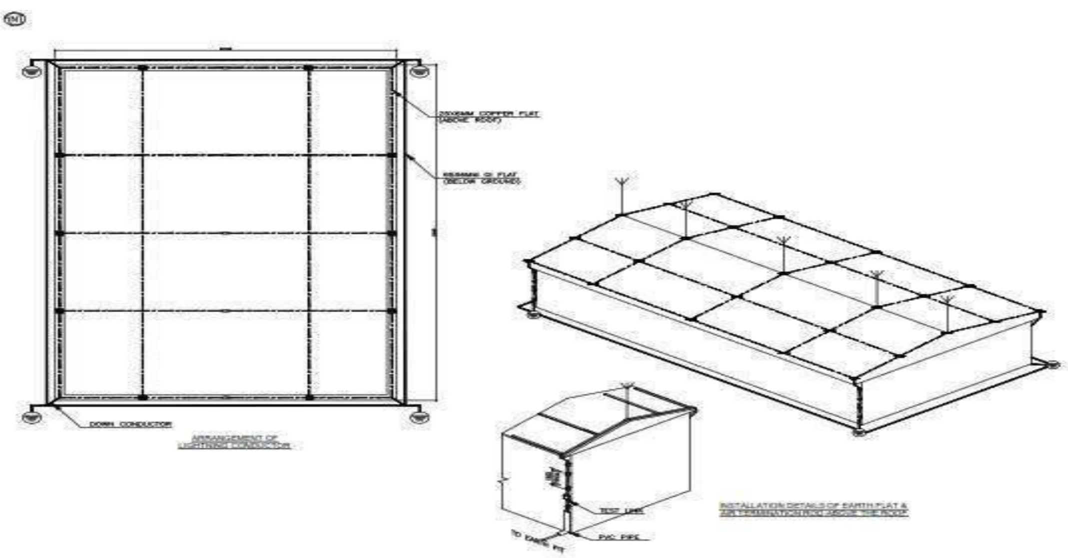
The principal function of a motor starter is to start and stop the respective motor connected with specially designed electromechanical switches which are similar in some ways to relays. The main difference between a relay and a starter is that a starter has overload protection for the motor that is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

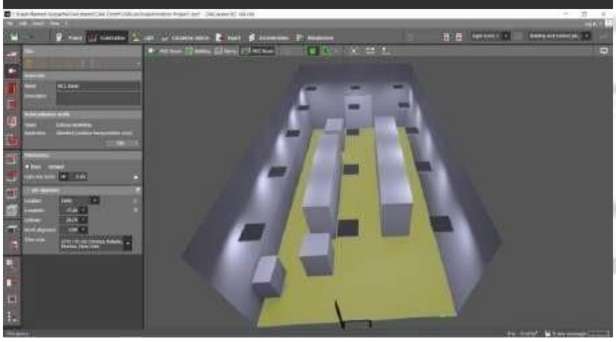
Types of light fittings: Industrial, flame proof type (EX d), increased safety type (Ex e).

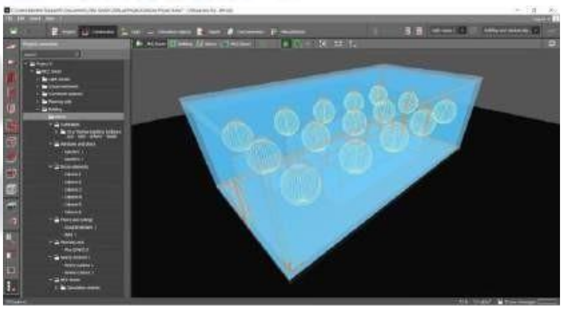
## 21th May2021: Lighting or illumination systems using DIALUX software.

| | | | |
|---|---|---|---|
| 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.

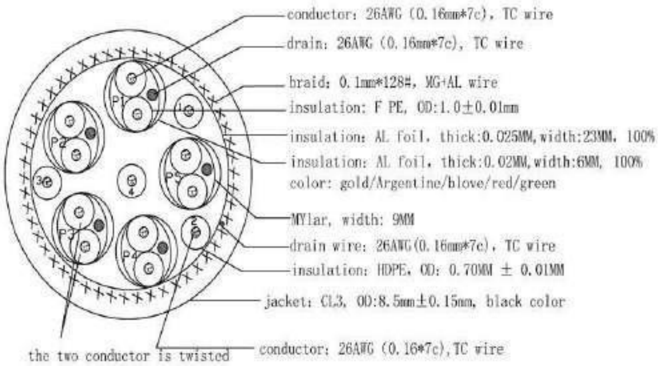



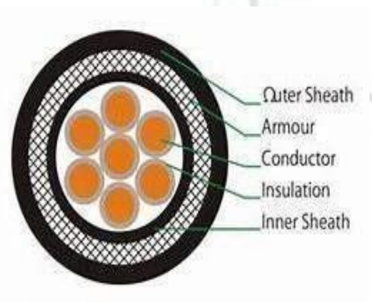


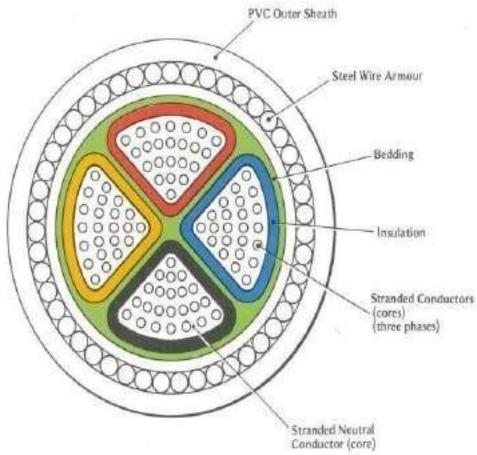
## 24th May2021: Cabling and their calculations and types.

| | | | |
|---|---|---|---|
| 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.

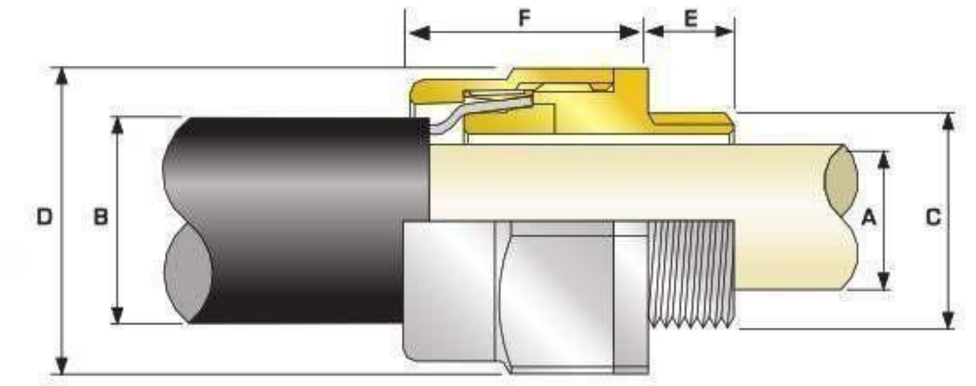
| | | | |
|---|---|---|---|
| 14 | Cabling claculations and cable gland selection | Cabling calculations | Cable gland selection |

**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 | kW = [A] / [D] Continuous kW | Continuous kVAR | Consumed Load Intermittent kW | Intermittent kVAR | kVAR = kW x tan φ Stand-by kW | 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 | | $10^{-3}$ |

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 |
| 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

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

| | |
|---|---|
| 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 vessel 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 betweentwo 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 | | | Result | | |
|---|---|---|---|---|---|
| Maximum Cable Diameter: | 22 | mm | Selected Cable Tray width: | O.K | |
| Consider Spare Capacity of Cable Tray: | 30% | | Selected Cable Tray Depth: | O.K | |
| Distance between each Cable: | 0 | mm | Selectrd Cable Tray Weight: | O.K | Including Spare Capacity |
| Calculated Width of Cable Tray: | 346 | mm | Selected Cable Tray Size: | O.K | Including Spare Capacity |
| Calculated Area of Cable Tray: | 7608 | Sq.mm | | | |
| No of Layer of Cables in Cable Tray: | 1 | | Required Cable Tray Size: | 600 x 100 | mm |
| Selected No of Cable Tray: | 1 | Nos. | Required Nos of Cable Tray: | 1 | No |
| Selected Cable Tray Width: | 600 | mm | Required Cable Tray Weight: | 90.00 | Kg/Meter/Tray |
| Selected Cable Tray Depth: | 100 | mm | Type of Cable Tray: | Ladder | |
| Selected Cable Tray Weight Capacity: | 90 | Kg/Meter | | | |
| Type of Cable Tray: | Ladder | | Cable Tray Width Area Remaning | 42% | |
| Total Area of Cable Tray: | 60000 | Sq.mm | 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] | kW = [A] / [D] Continuous | | Consumed Load Intermittent | | kVAR = kW x tan φ Stand-by | | 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 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 : 167.9 kW 142.4 kVAR sqrt ($kW^2$ +$kVAR^2$) = 220.2 kVA
(Est. x%E + y%F)

Peak Load : 172.9 kW 146.6 kVAR sqrt ($kW^2$ +$kVAR^2$) = 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 = $S \frac{PBHP}{h}$ ( kW )

Reactive Pow PQ = $S \frac{PBHP}{h}$ x tan θ ( kVAr )

Apparent pow P = Ö( PP2 + PQ2 ( kVA )

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

where PC = Ö PCP2 + PCQ2 ( kVA )
PCP = PB . Cos θB + PS .Co ( kW)
PCQ = PB . Sin θB + PS . Sin ( kVar )

PS = $K \cdot C \cdot \frac{PM}{\cos\theta \cdot \eta}$

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<br>(Running kVA of last motor X Starting current ratio of motor) | **345** | KVA |
| | Base load of DG set in KVA<br>(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<br>(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<br>P2 = Total momentary load in KVA x Xd''' x (1-Transient Voltage<br>(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)<br>(Ref: IS/IEC 60034-1, Clause 9.3.2) | 150% | |
| | Capacity of DG set required considering overload capacity<br>(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

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

| | |
|---|---|
| αr - Thermal co-efficient of resistivity, at 20 oC | 0.0032 |
| pr - 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

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

| | |
|---|---|
| αr - Thermal co-efficient of resistivity, at 20 oC | 0.0032 |
| pr - 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

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

| | |
|---|---|
| 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

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

| | |
|---|---|
| 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.

IEEE
Std 80-2000 IEEE GUIDE FOR SAFETY

**Table 1—Material constants**

| Description | Material conductivity (%) | $\alpha_r$ factor at 20 °C (1/°C) | $K_o$ at 0 °C (0 °C) | Fusing[a] temperature $T_m$ (°C) | $\rho_r$ 20 °C (μΩ·cm) | TCAP thermal capacity [J/(cm$^3$·°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 | 105 | 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% | |