

# **Internship Program Report**

**By**

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**18481A0281**



**In association with**



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## Introduction

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

## Program organizer

SmartBridge, Hyderabad.

Pioneer in organizing Internships, knowledge workshops, debates, hackathons, technical sessions and Industrial Automation projects.



## Courtesy

Dr.B.Dasu (HOD of EEE), GEC

Dr. G. Srinivasa Rao (Internship coordinator)  
Mr. Ramesh V – Mentor of internship Program  
Mr. Vinay Kumar - System Support  
Mr. Harikanth - Software/Technical Support

## Program details

Smart Internz program schedule: 4 weeks starting 3<sup>rd</sup> May 2021

Daily schedule time shall be 4PM to

6PM Mode

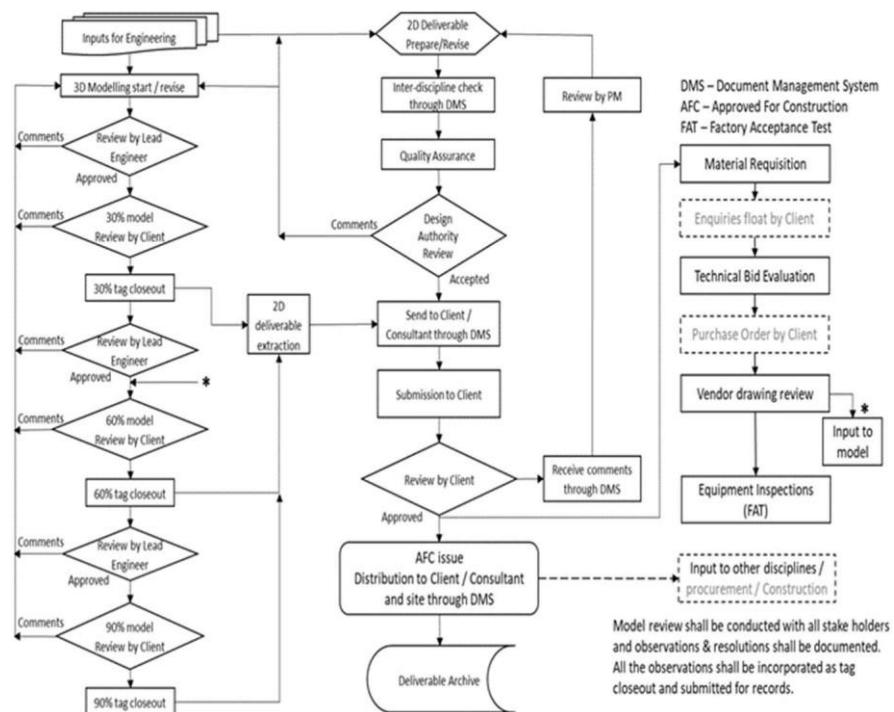
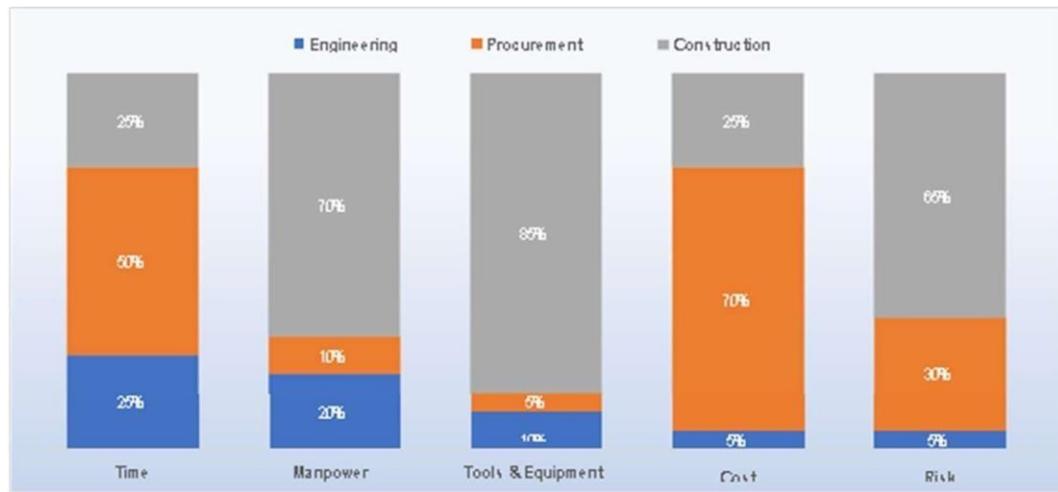
of classes: Online through ZOOM App

## Internship program

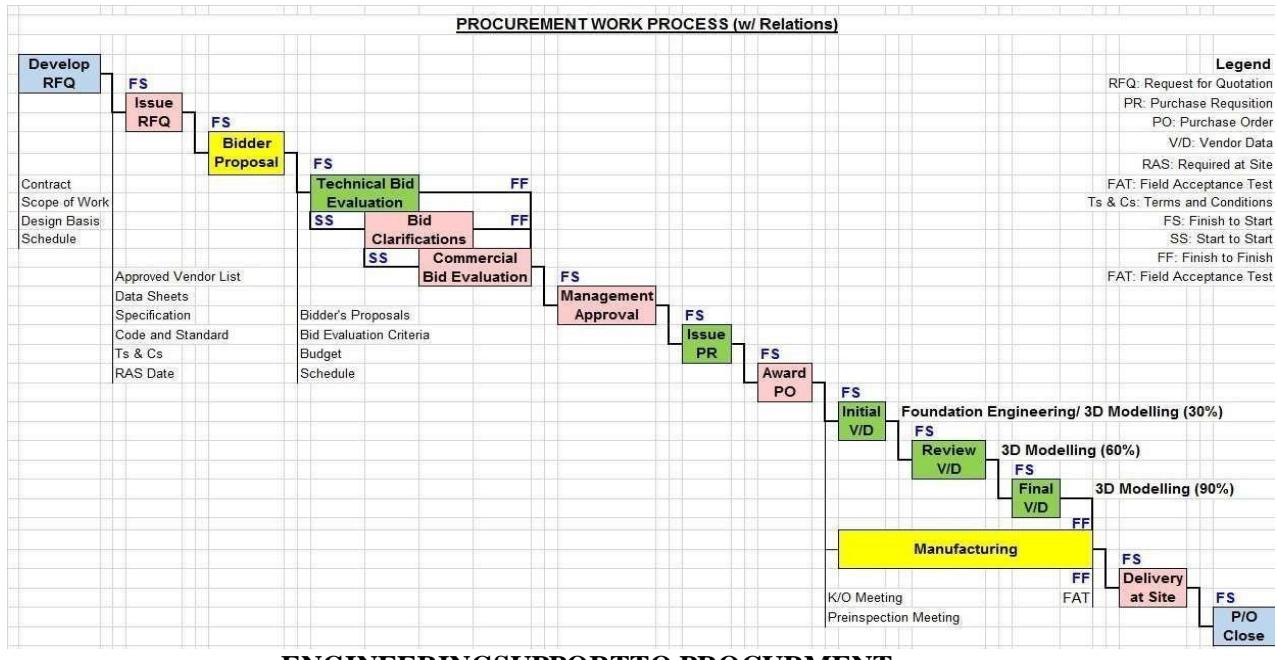
We have been given the opportunity to learn and interact with industry experienced engineering specialist to learn the Electrical detailed design engineering for various industrial sectors.

3<sup>rd</sup> May 2021: Introduction to EPC Industry

1	EPC Industry & Electrical Detailed Engineering	EPC Industry Engineering Procurement  Construction	Introduction Types of Engineering Engineering role in procurement  Engineering role during construction
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**TOPIC DETAILS:****ENGINEERING:****Engineering Design & Detailed Engineering Process**

## **PROCUREMENT:**



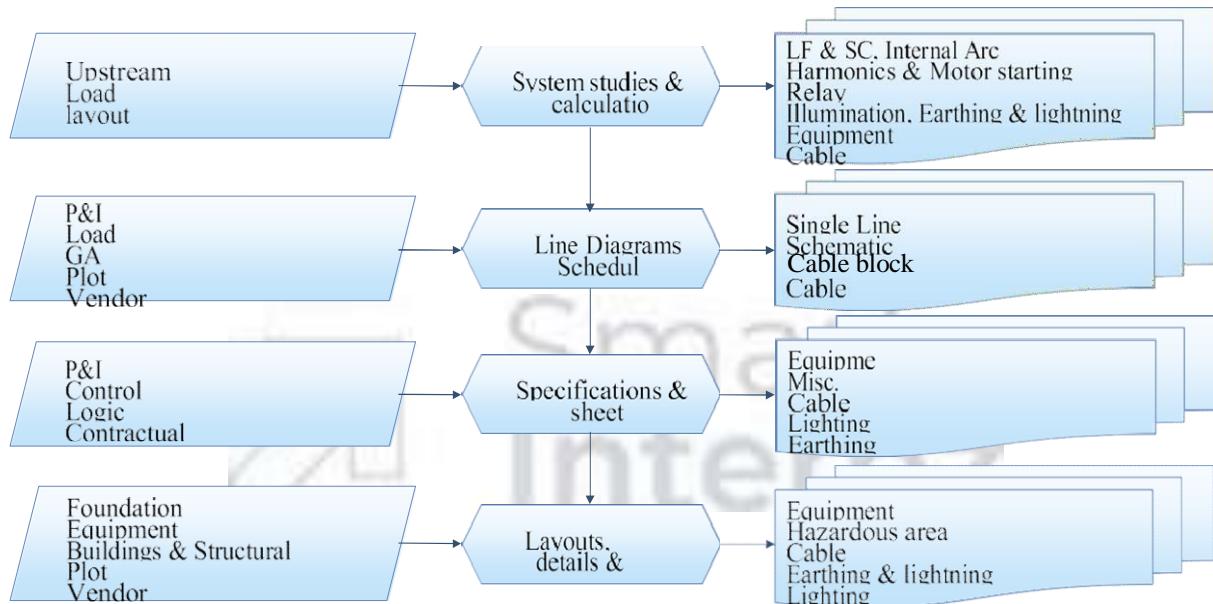
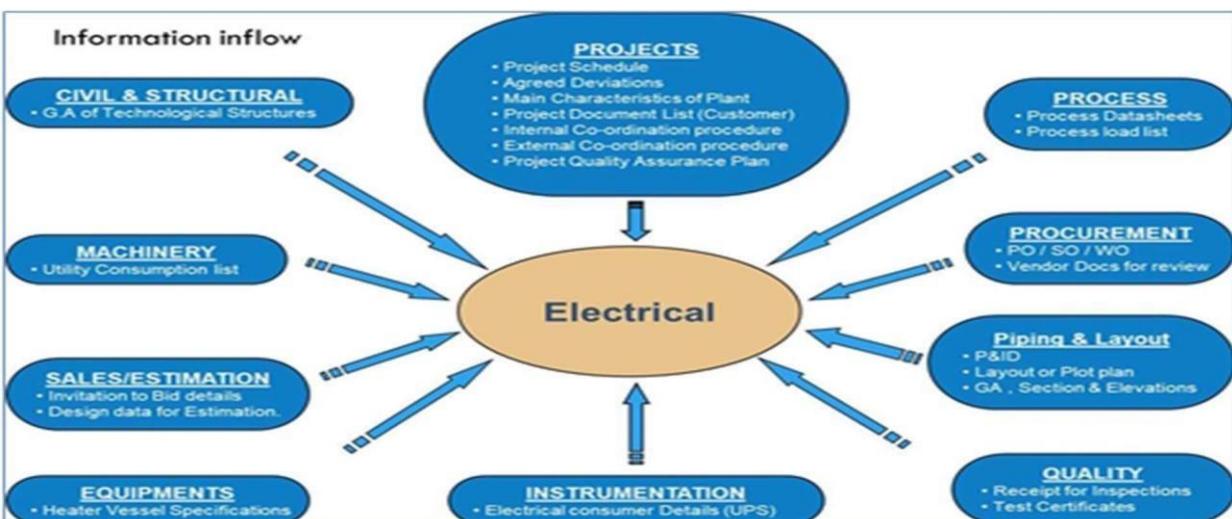
## **ENGINEERINGSUPPORTTO PROCUREMENT**

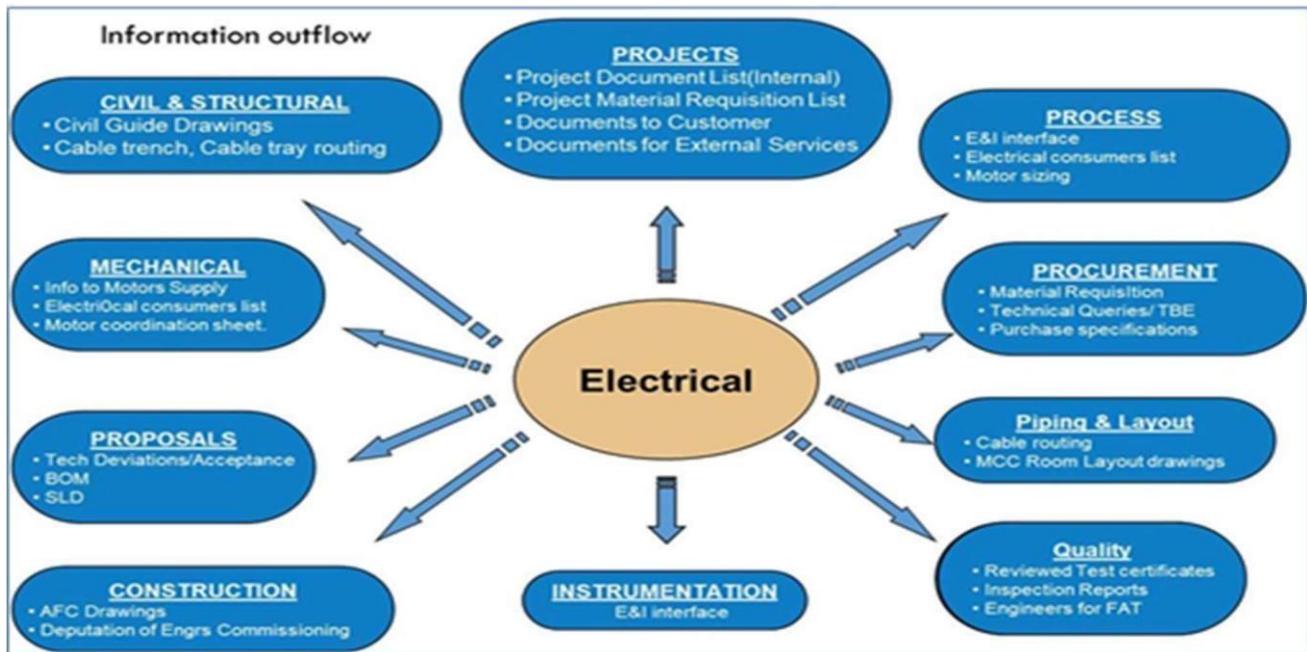
## **CONSTRUCTION:**

This brief applies to engineering support for engineering-procurement-construction projects, also known as design-bid-build projects, with construction management by others. This brief is intended to be used as an aid to determining the level of engineering support required during construction, from the office and in the field. For purposes of this brief, when the term "engineer" is used, it applies to the engineering firm or its representatives, that were responsible for the design of the project. Engineering support is typically required for any industrial construction project. The roles of the construction manager and the owner are usually well understood. The role of the engineer during construction needs to complement the roles of the construction manager and the owner. This is not clear cut as the owner and construction manager often have capabilities that overlap with those of the engineer. What divisions of responsibilities represent the best use of resources and best promotes the timely and successful completion of the project. Further, when owners are looking for ways to control construction costs, one option considered is to reduce costs by restricting or eliminating on-site representation from engineering.

4<sup>th</sup> May 2021: Engineering documentation for EPC projects

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

**Topic details:****SEQUENCE OF DELIVERABLES**



### DETAILED ENGINEERING WORKFLOW

ISno.	Description	Equivalent IEC no.
IS:1885	Electrotechnical Vocabulary	IEC 60050
IS:2206	Flameproof electric lighting fittings	
IS:3646	Code of practice for interior illumination	
IS:6665	Code of practice for industrial lighting	
IS:10322	Luminaires	IEC 60598
IS:3043	Code of practice for earthing	IEC 60364
IS: 2309	Code of practice for the protection of buildings and allied structures against lightning	IEC 62305
IS: 10116	Code of Practice for Selection, Installation and Maintenance	IEC 60092
IS:13234	Guide for Short-circuit Current Calculation in Three-phase A.C. Systems	IECPub 909
IS:1188	Outdoor type three-phased distribution transformers	
IS:2026	Power transformers	IEC 60076
IS:325	Three-phase induction motors	IEC 60034
IS:1554	PVC Insulated (Heavy Duty) Electric Cables	IEC 60502
IS:7098	XLPE insulated PVC sheathed cables	IEC 60502
IS: 10810	Tests on Electric and Optical Fibre cables under fire conditions	IEC 60332
IS:8623	Low-Voltage Switchgear and Controlgear	IECPub 439 & IEC 60947
IS:10918	Vented type nickel cadmium batteries	IEC 60623
IS:5571	Guide for Selection and Installation of Electrical Equipment for Hazardous Areas	IEC 60079
IS:5572	Classification of hazardous areas (other than mines) having flammable gases and vapours for electrical installation	IEC 60079
IS:2705	Current transformers	IEC 60185
IS:3156	Voltage transformers	IEC 60186
IS:398	Aluminium conductors for overhead transmission purposes	IEC 60889
	Electric Heat Tracing for Safe Industrial locations	IEC 62395
	Electric Heat Tracing for Hazardous locations	IEC 60079-30

Fig: RELAVANT NATIONAL & INTERNATIONAL STANDARDS

## 5<sup>th</sup> May 2021: Engineering documentation for commands and formulae

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

MS Word, Excel and AutoCAD COMMANDS.

#### Word Shortcut Keys

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

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

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

Here we need to check

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

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+O	HORIZONTAL	HOR				
COMMAND WIN	Ctrl+9	VERTICAL	VER				

Fig:AUTOCADKEYS

**Excel Formulas****Basic math**

Function	Formula	Example
To add up the total	=SUM(cell range)	=SUM(B2:B9)
To add individual items	=Value1 + Value 2	=B2+C2
Subtract	=Value1 - Value 2	=B2-C2
Multiply	=Value1 * Value2	=B2*C2
Divide	=Value1 / Value2	=B2/C2
Exponents	=Value1 ^ Value2	=B2^C2
Average	=AVERAGE(cell range)	=AVERAGE(B2:B9)
Median	=MEDIAN(cell range)	=MEDIAN(B2:B9)
Max	=MAX(cell range)	=MAX(B2:B9)
Min	=MIN(cell range)	=MIN(B2:B9)

**Simple formatting tricks**

Function	Formula	Example
To change a cell to proper case	=PROPER(cell)	=PROPER(A2)
To change a cell to upper case	=UPPER(cell)	=UPPER(A2)
To change a cell to lower case	=LOWER(cell)	=LOWER(A2)

**Conditional statements**

Function	Formula	Example
If statement	=IF(logical test, "result if the test answer is true", "result if the test answer is false")	=IF(B2>69,"Pass","Fail")
Exact	=EXACT(Value1, value2)	=EXACT(B2, C2)

**Absolute cell references**

When a formula contains an absolute reference, no matter which cell the formula occupies the cell reference does not change: if you copy or move the formula, it refers to the same cell as it did in its original location. In an absolute reference, each part of the reference (the letter that refers to the row and the number that refers to the column) is preceded by a "\$" – for example, \$A\$1 is an absolute reference to cell A1. Wherever the formula is copied or moved, it always refers to cell A1.

**Pulling things apart**

Function	Formula	Example
To select a certain number of characters from the left	=LEFT(cellwithtext, number of characters to be returned)	=LEFT(A2, 6)
To select a certain number of characters from the right	=RIGHT(cellwithtext, number of characters to be returned)	=RIGHT(A2, 6)
Find text in a field	=SEARCH("text you want to find", where you want to find it)	=SEARCH(" ", A2)
Extract information from the middle	=MID(cellwithtext, start position, number of characters you want returned)	=MID(A2, 9, 4)
Separate a last name (Example: Smith, Jane)	LEFT and SEARCH functions	=LEFT(A2, SEARCH(" ", A2)-1)
Separate a first name (Example: Smith, Jane)	MID and SEARCH functions	=MID(A2, SEARCH(" ", A2)+2, 20)

**Putting things together**

Function	Formula	Example
To combine cells with a space in-between	=CONCATENATE(text, " ", text)	=CONCATENATE(A2, " ", B2)
To combine cells with a space in-between (second option)	=text & " " & text	=A2 & " " & B2

**Dealing with dates**

Function	Formula	Example
Return the year	=YEAR(datefield)	=YEAR(A2)
Return the month	=MONTH(datefield)	=MONTH(A2)
Return the day	=DAY(datefield)	=DAY(A2)
Return the day of the week (1 = Sunday, 2 = Monday, 3 = Tuesday, etc.)	=WEEKDAY(datefield)	=WEEKDAY(A2)
To create a date from year, month, and day	=DATE(year, month, day)	=DATE(B2, C2, D2)

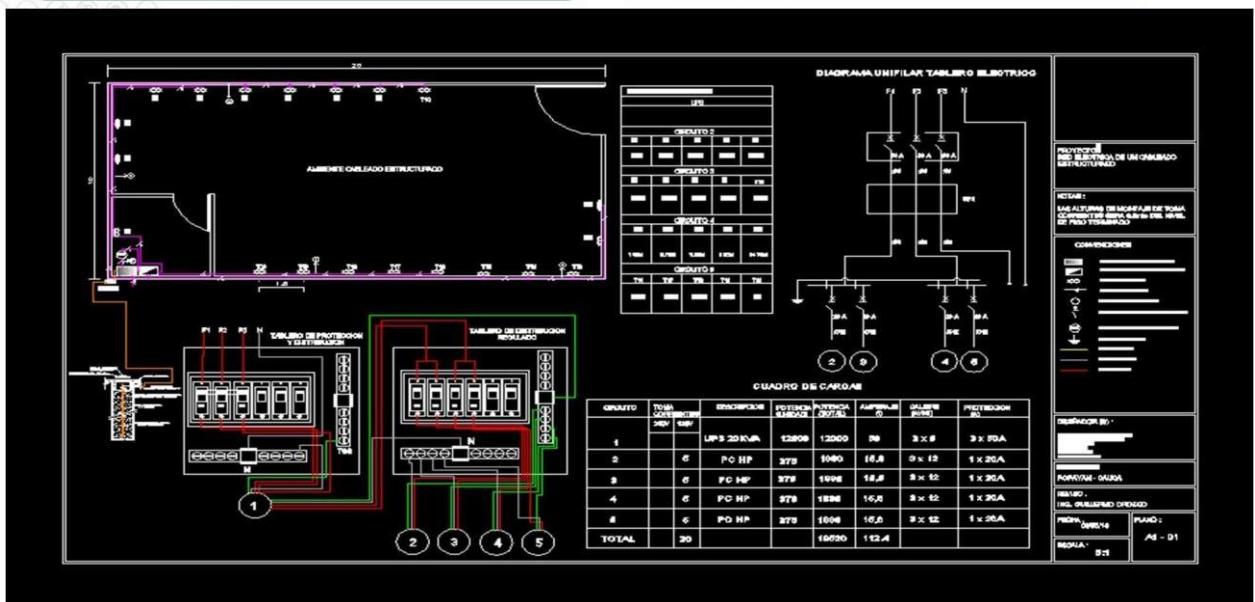
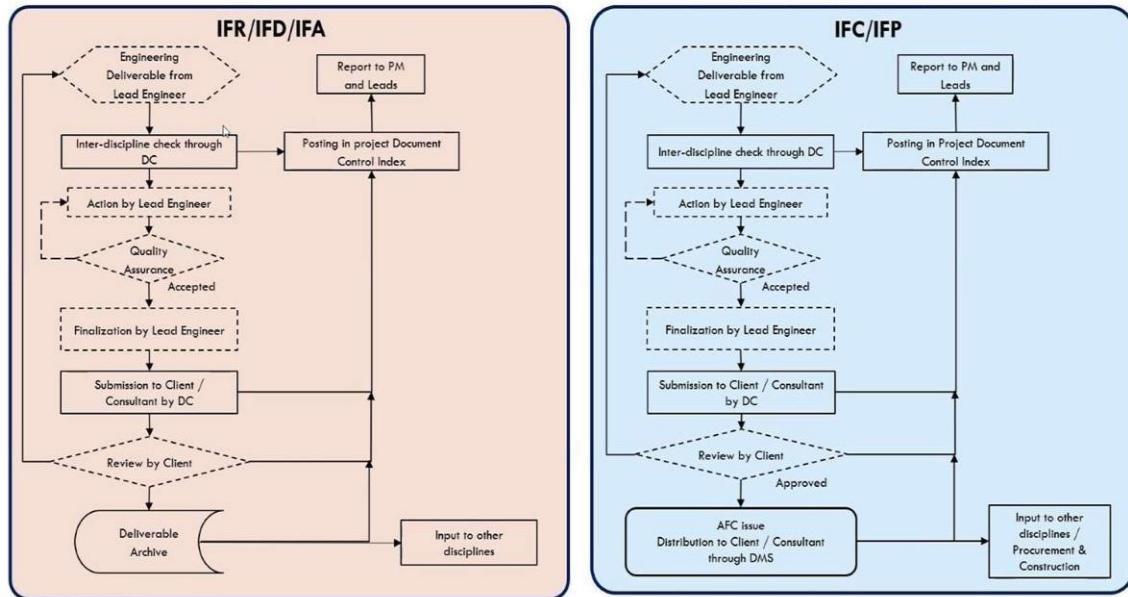
7<sup>th</sup>May2021: Engineering documentation for Electrical system design

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



### 1C. DETAILED ENGINEERING



**Fig: ELECTRICAL SYSTEM DESIGN**

10<sup>th</sup>May2021: Engineering documentation for Typical diagrams

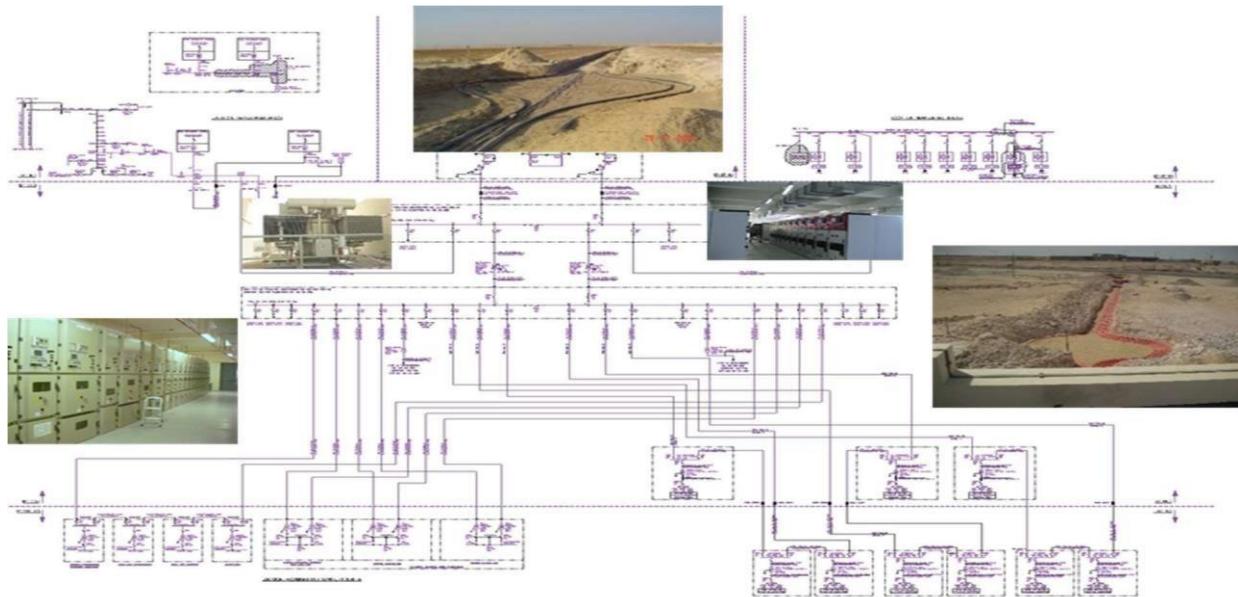
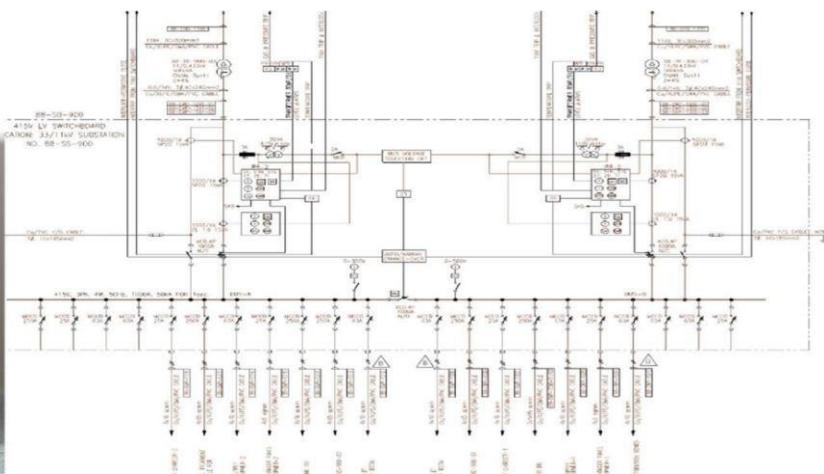
5 Electrical  
system design for  
typical diagrams

Loadlistsschedule  
Singlelinediagram

Powerflowdiagram  
Typicalschematicdiagram

### **Topic details:**

#### **Singleline Diagram:**



**Fig:POWER FLOWDIAGRAM**

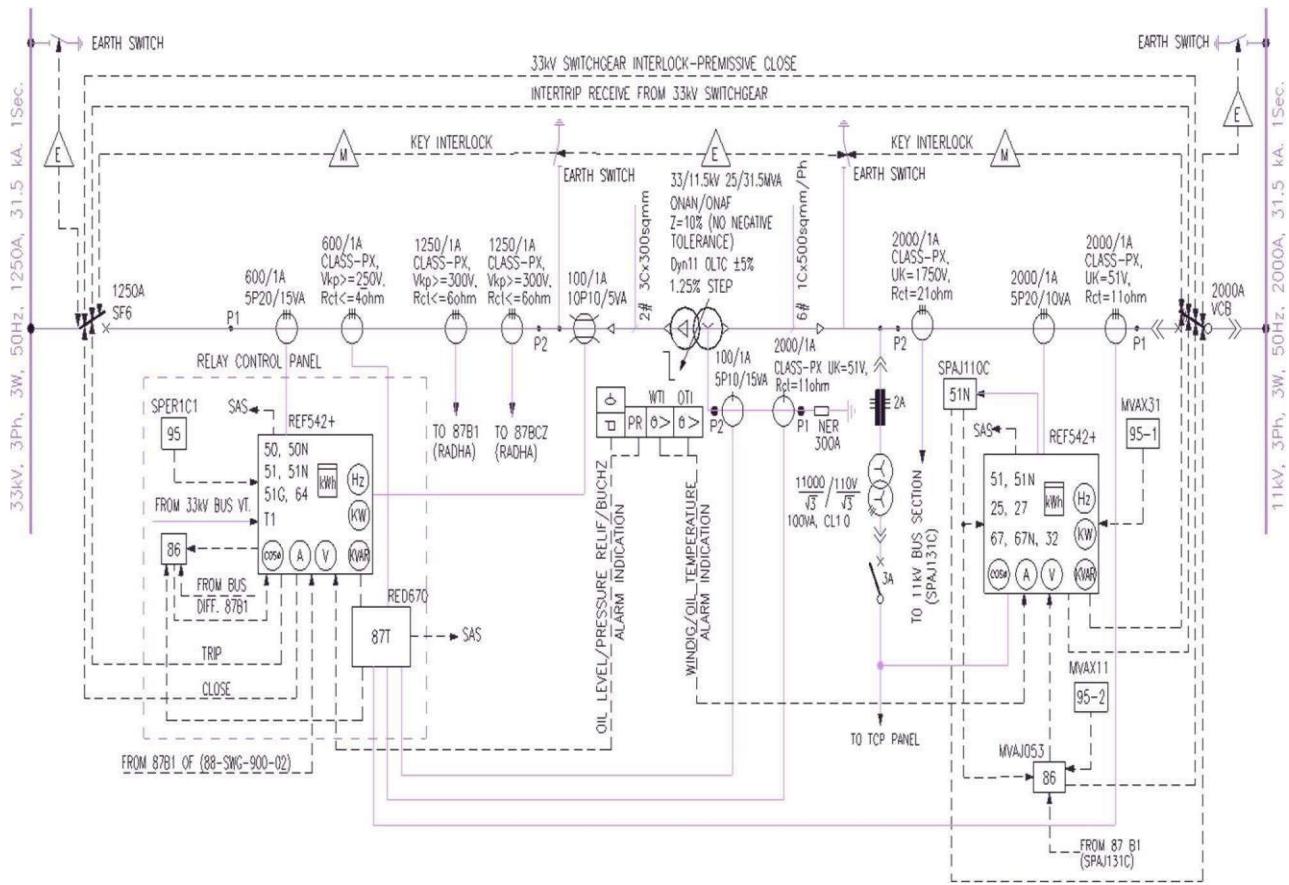


Fig:TYPICAL SCHEMATIC DIAGRAM

11<sup>th</sup>May2021:Classificationof TransformersandGenerators6 Classification  
ofTransformers  
andGenerators

Differenttypesof Transformers

DifferenttypesofGenerators

**TopicDetails:**Classificationof TransformersandGenerators.

Transformers can be classified on different basis, like types of construction, types of cooling etc.

- On the basis of construction, transformers can be classified into two types as;
  - (I) Core type transformer and
  - (ii) Shell type transformer, which are described below.
- On the basis of their purpose
  - Step up transformer: Voltage increases (with subsequent decrease in current) at secondary.
  - Step down transformer: Voltage decreases (with subsequent increase in current) at secondary.
- On the basis of type of supply
  - Single phase transformer
  - Three phase transformers
- On the basis of cooling employed
  - Oil-filled self-cooled type (ONAN - Oil Natural Air Natural)
  - Oil-filled Forced Air Cooling (ONAF - Oil Natural Air Forced)
  - Oil-filled Forced Air Cooling (OFAF - Oil Forced Air Forced)
  - Oil-filled water-cooled type (ONWF - Oil Natural Water Forced)
  - Dry Type resin cast with natural cooling

**TYPES OF TRANSFORMERS:**

Pole Mounted Commercial



Oil Filled Distribution Type



Oil Filled Power Transformer Commercial

**TYPES OF DG GENERATORS:**

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



415V Diesel generator sets for standby / Emergency power

**TRANSFORMERS AND DG GENERATORS:**

Transformer shall include a primary disconnect on the incoming power source. The disconnect means shall be either a breaker or a loadbreak primary switch that is fused. On a single feed radial system, the distribution transformer base rating shall be sized for the total connected load and 125% of the largest motor; in addition, the transformer may have 20% spare capacity as per design basis. Also, the transformer shall be sized to allow starting the large motor on the system. Load diversities shall be taken into account when calculating the total connected load. Load calculations shall be completed and approved before final sizing of the transformers. When two transformers are connected to buses with a tie breaker, each transformer shall have its rating sized to handle the total connected load

from both buses with the tie breaker closed and the other transformer out of service. Also, each transformer needs to be sized to allow starting the largest motor on the system. When two transformers are connected to buses with a tie breaker, the fault study must include the condition of having the short circuit MVA contribution from one transformer during a fault and the switchgear shall be sized appropriately to be able to withstand rating of both transformers during a short period defined in the standards.

Transformers are sized to carry the peak running load of all busses connected to them. In addition, feeders to and from power transformers shall be rated to carry full current at the maximum rating.

The packaged combination of a diesel engine, an alternator and various ancillary devices such as base, canopy, sound attenuation, control systems, circuit breakers, jacket water heaters, starting systems etc., is referred to as a Diesel Generating Set or a DG Set in short. DG sets are selected based on the load they are intended to supply power for, taking into account the type of load, i.e. emergency (stand by) or for continuous power (prime), and the size of the load, and size of any motors to be started which is normally the critical parameter.

Depending upon the projected growth, availability of space etc. projected expansion to be considered. Diversity factor of load will determine the optimum size of DG set. Quantities & ratings of motors with their starting methods and largest size motor, influence the Right sizing of the DG set. CPCB (Central Pollution Control Board) norms to be followed for DG sets up to 1000 KVA rating with acoustic enclosures and pollution norms for larger sizes.

12<sup>th</sup>May2021:ClassificationofSwitchgearconstructionandpowerfactorimprovement

7	Classificationof Switchgearconst ruction andpower factorimprovem ent	Different types of Switchgearassembl e	Power factorimprovement
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**Topicdetails:** SwitchgearconstructionandPower FactorImprovement.

Switchgear includesswitching & protecting devices like fuses,switches, CTs, VTs, relays,circuitbreakers, etc. This device allows operating devices like electrical equipment, generators, distributors,transmission lines, etc. Once the short circuit occurs within the power system, then a huge current willflow through the devices. So that the equipment can be damaged & the interruption will occur to theoperators. To overcome this problem, it is used to detect the fault in the power system to protect humansand equipment. There are three types of switch gears namely LV (Low voltage), MV (Medium voltage)and HV(High voltage)Switchgear.

**Low Voltage Switchgear (LV):** The power system which deals up to 1KV is called as LV or lowvoltageswitchgearconsistsswitches,LVcircuitbreakers,HRCfuses,earthleakage(EL)circuitbreakers, offload electrical isolators, MCBs (miniature circuit breakers) and MCCBs (molded casecircuitbreakers),etc.

**MediumVoltageSwitchgear(MV):** Thepowersystemwhichdealsupto36kViscalledMV(mediumvoltages witchgear).Theseareavailableindifferenttypeslikewithoutmetalclosureoutdoor type, metal-enclosed indoor & outdoor type, etc. consisting devices like minimum oil CBs, bulkoilCBs,SF6gas-insulated,airmagnetic,gas-insulated,vacuum,etc. Thedisruptionmediumofthistype of switchgear can be vacuum or SF6. The main condition of this type of power network is to breakoffcurrentthroughoutfaultyconditionsinthissystem.ThisiscapableofON/OFFoperation,interruption of short circuit current, capacitive current switching, inductive current switching andusedinsomespecial applications.

**HighVoltageSwitchgear(HV):**

Switch the most fundamental device in making or isolating a circuit from the supply manually. It shallnot protect the connected circuit from short circuit. Switches/ or Disconnect switches in outdoor EHVswitchyardaremanualand/ormotoroperatedforeaseofroutineoperation.Requiredelectricalclearances, ‘safety clearances’ required for maintenance personnel to safely work in the adjacent bays inthe switchyard. These switches need to be of the snap action type while making/ breaking to prevent arcinducedcontact welding.

**POWERFACTORIMPROVEMENT:**

Power factor defined as the ratio of real power to volt-amperes and is the cosine of the phase anglebetween the voltage and current in an AC circuit. Power factor can be improved by adding capacitors onthe power line to draw a leading current and supply lagging vars to the system. Capacitors can beswitched in and out as necessary to maintain var and voltage control. Many utilities charge industrialcustomersacertainrateforkilowatt-hoursofenergyconsumedinamonth, andanotherchargerelatedto the infrastructure necessary to supply that power under the customer’s conditions of operation. If thecustomer is operating with a low power factor load, the demand charge is higher, because the currentrequirement is higher. Power factor penalties on demand charges range from none to a factor of 2 on thepeakpowerdemand.

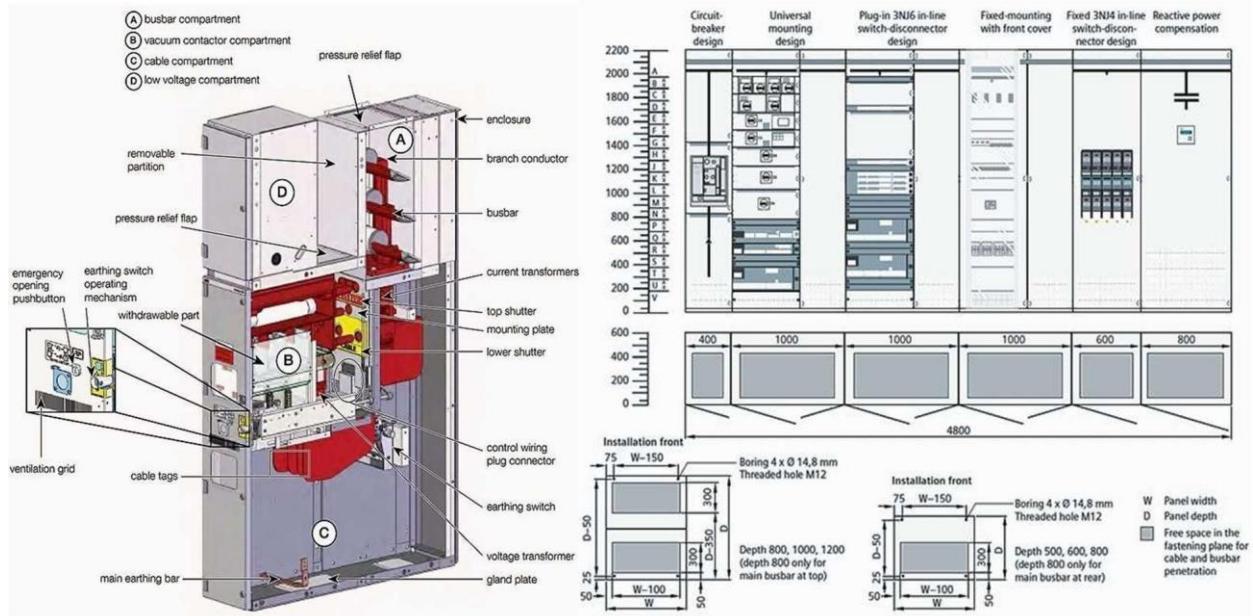


Fig:SWITCHGEARCONSTRUCTIONALFEATURES

**TYPES OF SWITCHGEARS:**

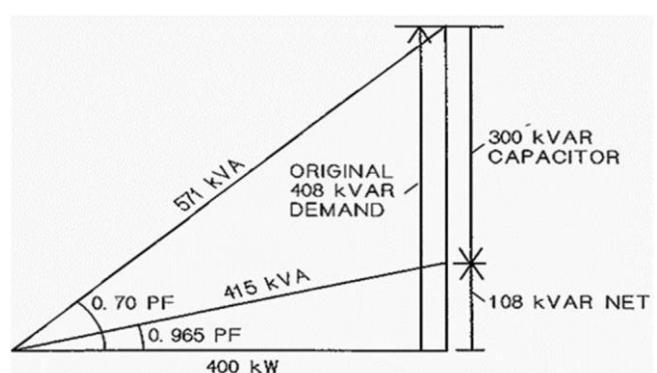
LV415V Indoor Air Insulated Switchgear for Industrial/



HV33kV or 220kV Outdoor Switchgear for large Industries &amp; substations



220VDC power supply for emergency applications

**POWER FACTOR IMPROVEMENT:**

17<sup>th</sup>May2021:Detailingabout UPSsystemandBusducts.

8	Detailing aboutUPS system andBusducts	Uninterruptible power supplysystem	Busducts ofthesystem
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**Topic details:**UPSsystemandBusducts.

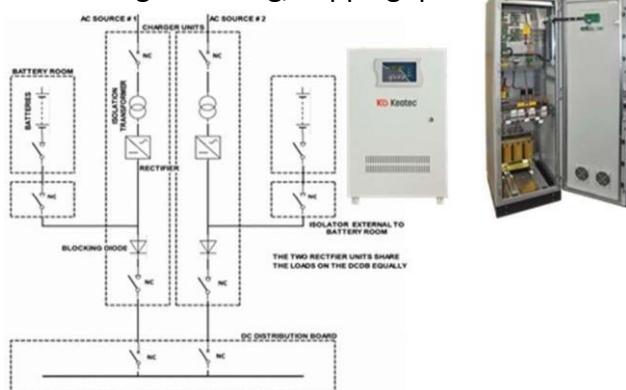
### **UPSSYSTEMS:**

Power disturbances occur in the electrical system environment and critical applications like plant control systems, computer-based operations, telecommunications or any other system critical for operations shall have uninterrupted power supply. 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.

#### **UPSSystems shall be two types:**

AC UPS – 48V, 110V, 230V Single phase & 415V three phase AC UPS power is required to feed power without any interruption to critical consumers in a facility during loss of normal power to critical plant loads like plant control systems, Emergency shutdown systems. AC UPS derives its power from batteries. It also provides stabilized quality power even if it is from normal sources.

DC UPS – 24V 48V, 110V, 220V DC Uninterrupted Power Supply System (DC UPS) always available to the identified loads fed from a DC Distribution board that fed from the AC mains via a rectifier and when source supply outage charged batteries shall supply to the loads. These are required mainly for the Electrical Control & Protection system loads apart from a few other loads in certain plants like Switchgear closing/Tripping operation on loss of power supply, critical DC lighting, DG starting.



**DCUPSSYSTEM**



**ACUPSSYSTEM**

### **BUSDUCTOFSYSTEM:**

A sheet metal duct with aluminum or copper bus bars as conductor, and used as a reliable link for transferring power from one equipment to other at desired voltage levels, used as an alternate means for conducting electricity to cable bus and power cables. Busducts are classified into various types depending on its application viz phase separated Busducts, segregated phase busducts, non-segregated phase busducts.

#### **SegregatedPhaseBusduct**

These are metal enclosed busducts wherein all the three phase busbars are enclosed in a common enclosure and the all the phases are segregated by means of non-magnetic metal barriers preferably made of the same materials as that of the bus enclosure with degree of protection IP65. Busbars are generally mounted on high creep porcelain insulators or high quality epoxy resin cast insulators

of suitable rated voltage. These Segregated phase busducts are commonly used in medium voltage applications with rated voltages from 3.3KV to 33KV and with rated continuous currents up to 5000Amps with short circuit fault currents of 50KA for 1 or 3 seconds.

#### **Non-segregatedPhaseBusduct**

Non-segregated busduct, on the other hand, is almost similar to the above in construction wherein all the phase / neutral conductors are enclosed in a common enclosure with air as medium of insulation between phases. As the name implies, there is no metallic barriers between phases. These busducts are relatively compact in comparison with segregated phase bus since the same are generally used for low voltage applications and thus needing much lower electrical clearances between phases and phases to earth. These non-segregated phase busducts are offered in two variants - one with ~~HVS~~ N separated



**NON-SEGREGATEDBUSKET**



**SANDWITCHTYPEBUSKET**

18<sup>th</sup>May2021:Detailingabout MotorStartersandSizing ofmotors.

9	Detailing aboutMotorStarter sandSizing ofmotors	Motorstartersanddrives	Sizingandselectionofmotors
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**Topicdetails:** Detailing aboutMotorStarterandSizing of motors andtheir selection.

The principal function of a motor starter is to start and stop the respective motor connected withspecially designed electromechanical switches which are similar in some ways to relays. The maindifference between a relay and a starter is that a starter has overload protection for the motor that ismissing in a relay. So, a starter has two main roles - to switch the power automatically or manually toamotor and at the sametimeprotect the motor fromoverload orfaults.

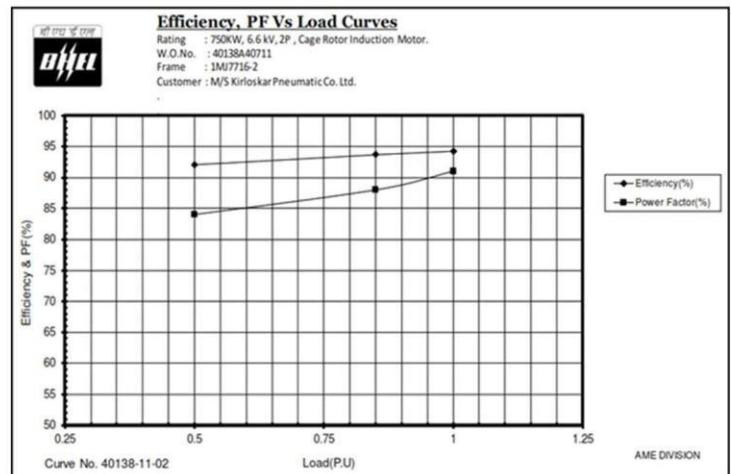
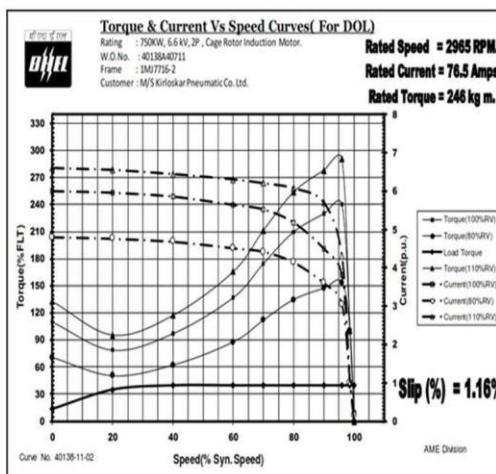
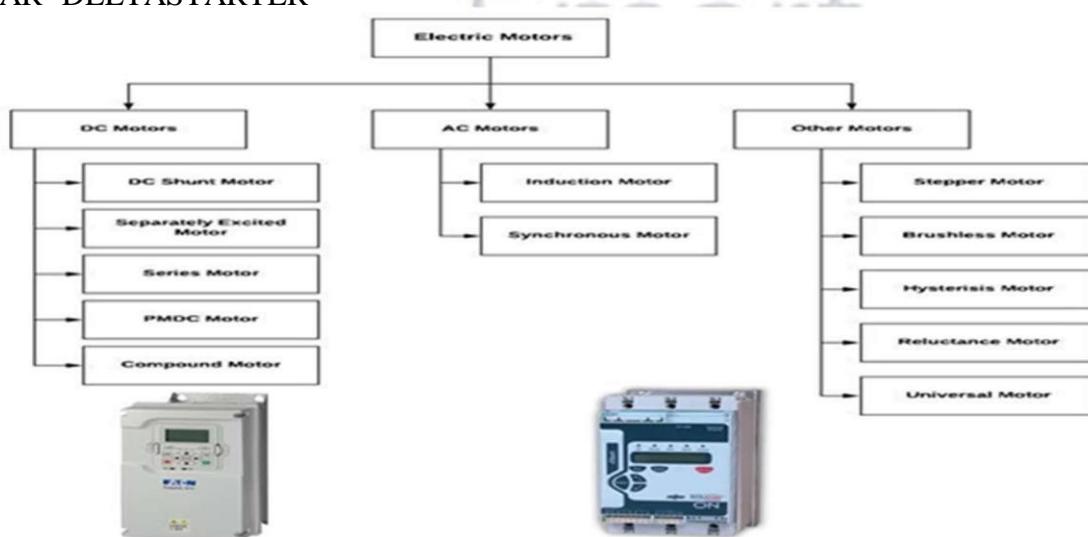
1.DOLSTARTER

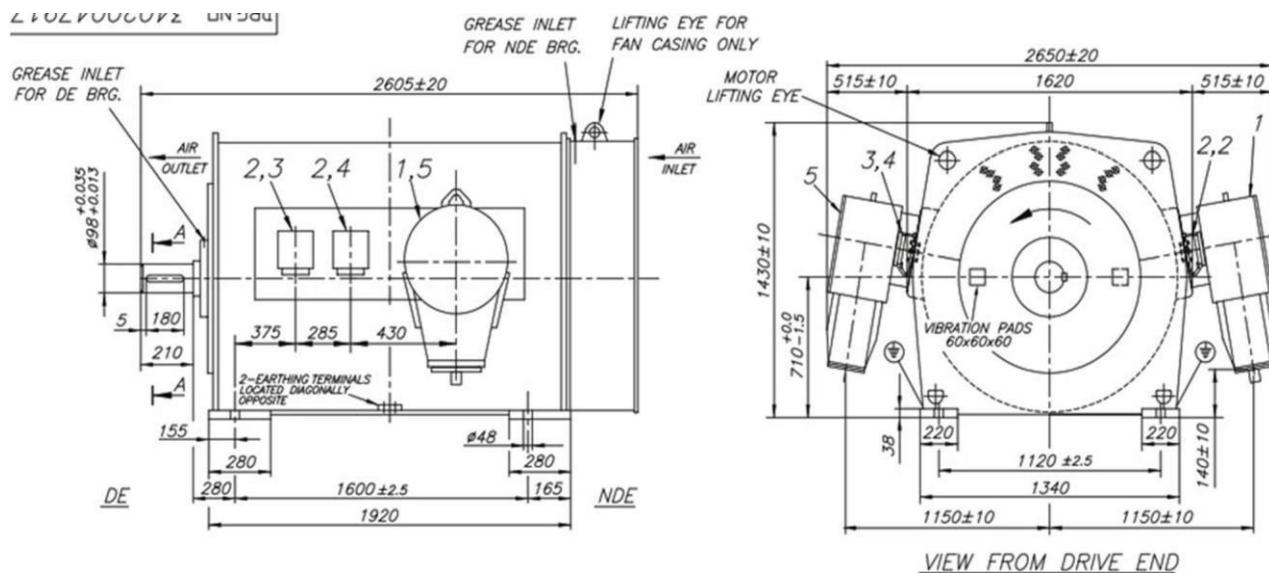
2.ROTORRESISTANCESTARTER

3.STATORRESISTANCESTARTER

4.AUTOTRANSFORMERSTARTER

5.STAR- DELTASTARTER





Large capacity MV motor for  
industrial heavy industrial applications

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

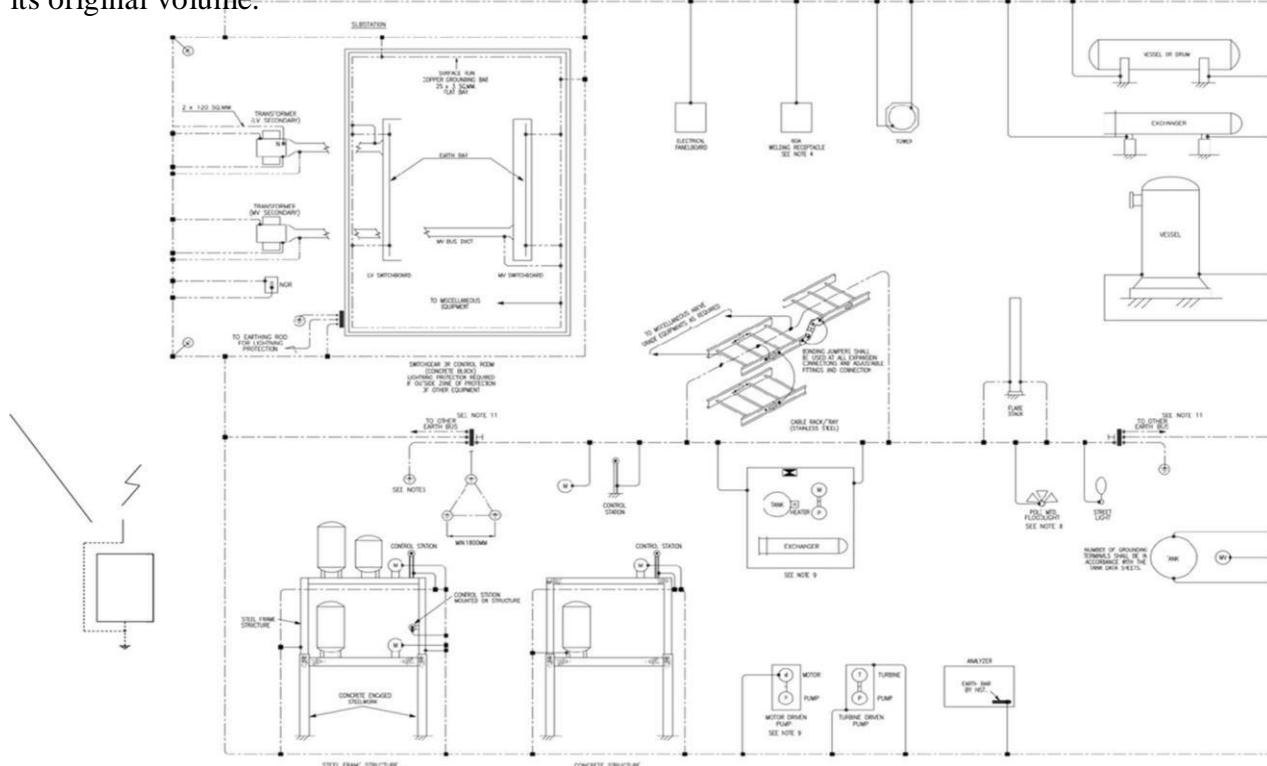


19<sup>th</sup>May2021:DescribingaboutEarthing systemandLighting Protection.

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

The purpose of earthing is to prevent damage to people and prevent or limit plant damage. Various earthing systems are provided with each earthing system isolated from the other. System earthing (usually copper material), body earthing (also called dirty earth, usually GI/copper material), earthing for lightning protection (usually GI/copper material), Clean earth system for instrumentation (usually copper material) and Telecom earthing system (usually copper material). Earth pits are back-filled with earthing compound - Bentonite or Marcionite. Bentonite is a moisture retaining clay used as an earth electrode back-fill to help lower soil resistivity. Marcionite is a conductive compound mixed with cement. The Bentonite clay is a sodium activated montmorillonite which when mixed with water swells to many times its original volume.



**TYPICAL PLANT EARTHING SYSTEM**

## LIGHTING PROTECTION SYSTEM:

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. Earthing calculation for lightning protection system shall be same as described in previous chapter. Lightning protection layouts are prepared for showing lightning protection to tall structures/buildings, important/heritage buildings, Buildings with electrical & instrumentation control panels etc.

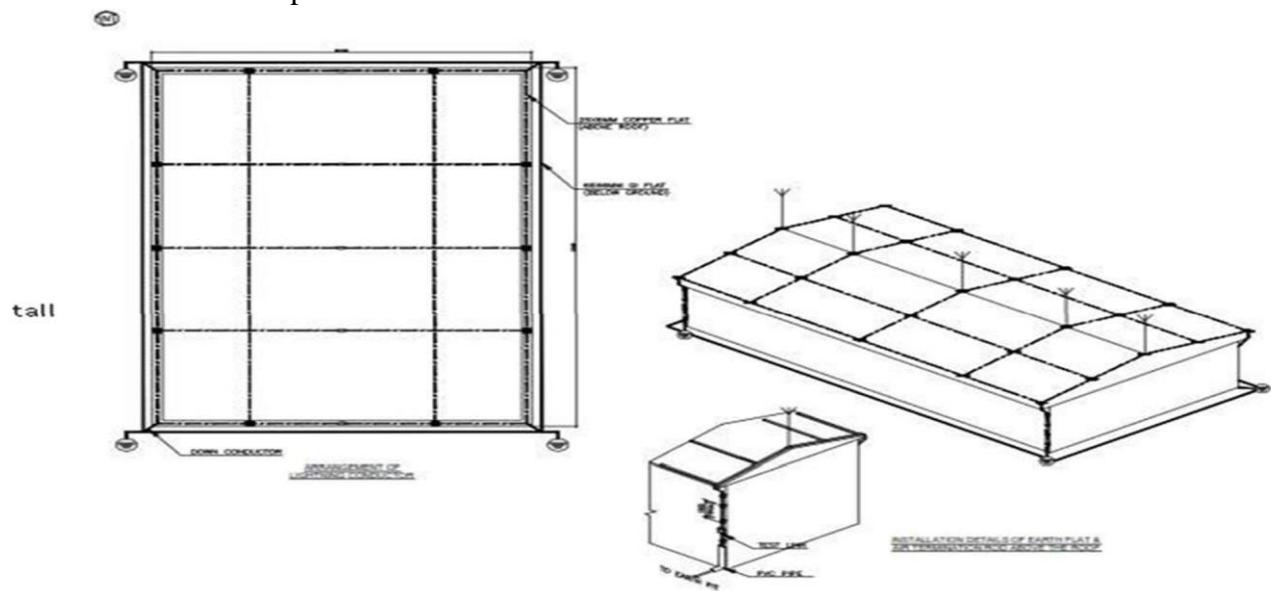
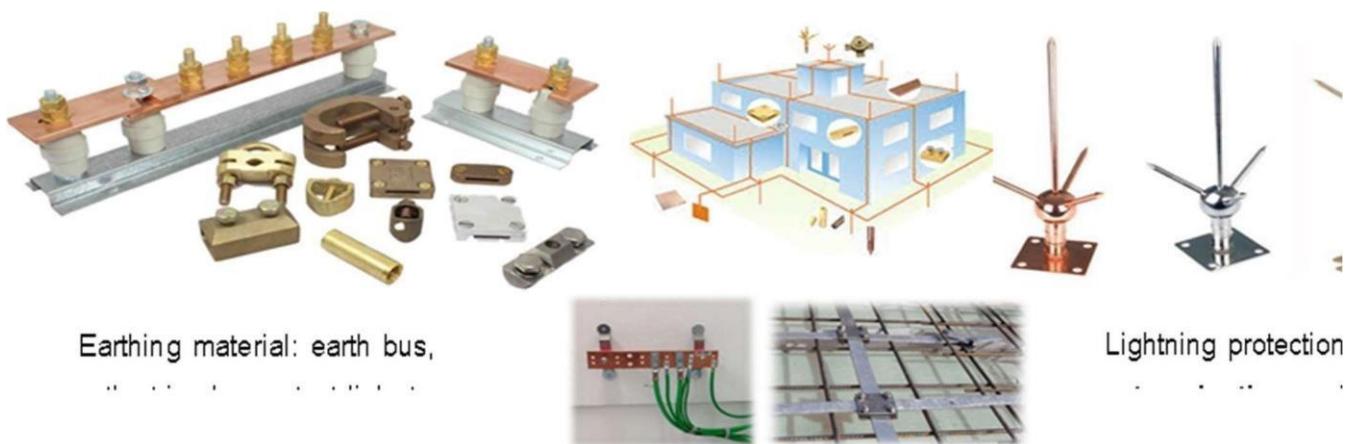


Fig:LIGHTINGPROTECTIONSYSTEM



Earthing material: earth bus,

Lightning protection

20<sup>th</sup>May2021:Lightingorilluminationsystemsandcalculations.

11	Lighting orIlluminati onsystems andCalculati ons	Lightingorilluminationsystems	Lightingcalculations
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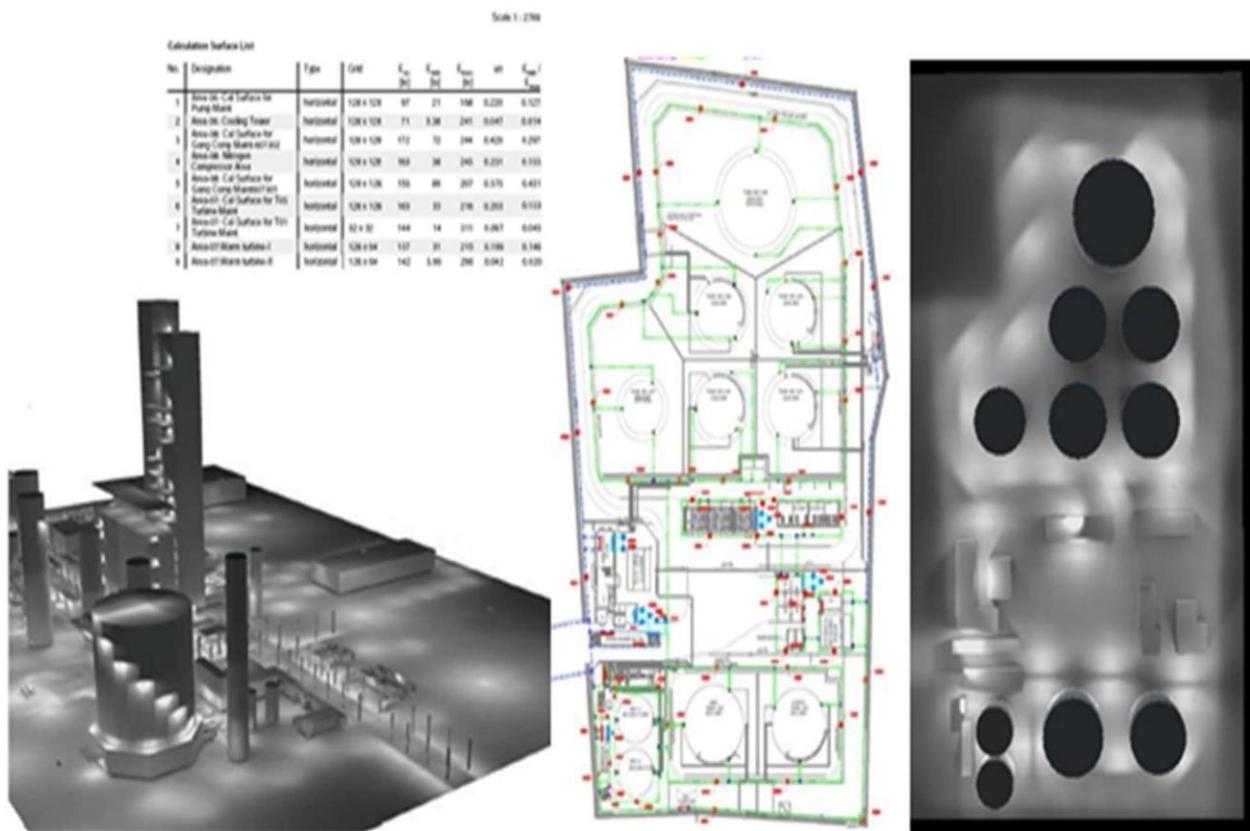
### Topicdetails:Lightingorilluminationsystems andCalculations.

Industrial lighting load shall be grouped as normal, emergency and critical. Separate lighting DBs shall be provided for critical and emergency lighting load. Emergency lighting shall be 30% of total lighting fittings as per calculations. However, the circuiting shall be done such that the emergency lights shall also be switched on during normal condition. Critical light fittings shall be in off condition during normal plant operation. In case of failure of emergency supply which feeds emergency lighting load, critical supply shall be fed automatically, switching on the critical lighting fittings. Critical lighting load shall be 110V DC, for substations/ MCC rooms, control rooms, critical operating locations, entry exit location and near staircases. Critical lighting may be 15% of emergency lighting limited operating areas and escape routes.

	Area						Lux(min)		
Roadsandtankfarm							15-25		
Pumphouse,sheds							100		
Mainoperatingplatforms							100		
Ordinaryplatforms&accessstairs							60		
Processareas,piperacks,exchangers,heater,coolingtower,separatortetc.							80		
Switchgearroom							200		
Cablecellar							70		
Batteryroom							150		
Controlroom,laboratory							500		
Warehouse							100		
Compressorarea							150		
Office							300		
	Utilization factor						Fixture efficiency		
Ceiling(%)	70			50			30		
Walls(%)	50	30	10	50	30	10	50	30	10
Floor(%)	30 10	30 10	30 10	30 10	30 10	30 10	30 10	30 10	30 10
0.80	27.26	22.22	19.19	26.24	22.21	19.18	26.25	21.21	19.18
0.80	30.31	26.27	23.23	32.30	27.26	24.23	31.30	27.26	23.23
1.00	38.36	32.30	28.28	36.95	32.31	29.27	35.94	31.30	28.27
1.25	43.40	37.35	33.32	41.38	36.35	33.32	39.37	35.34	32.31
1.50	47.43	41.38	37.35	44.42	40.37	36.35	42.40	38.37	35.35
2.00	52.47	47.44	43.41	49.46	45.43	42.40	47.45	44.42	41.40
2.50	56.50	51.47	48.44	53.49	49.46	46.44	50.48	47.45	45.43
3.00	59.52	55.49	51.47	56.52	52.48	49.46	52.50	50.48	47.46
4.00	62.55	59.52	56.51	58.53	56.52	53.50	55.52	53.51	51.49
5.00	64.56	62.55	59.53	60.55	58.53	56.52	57.54	55.52	52.51

TABLEFORUTILISATION FACTORS

All outdoor lighting fittings shall be connected with armored 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, flameproof type (EX d), increased safety type (Ex).



#### CALCULATION OF ILLUMINATION RESULTS

21<sup>th</sup>May2021: Lighting orilluminationsystems usingDIALUXsoftware.

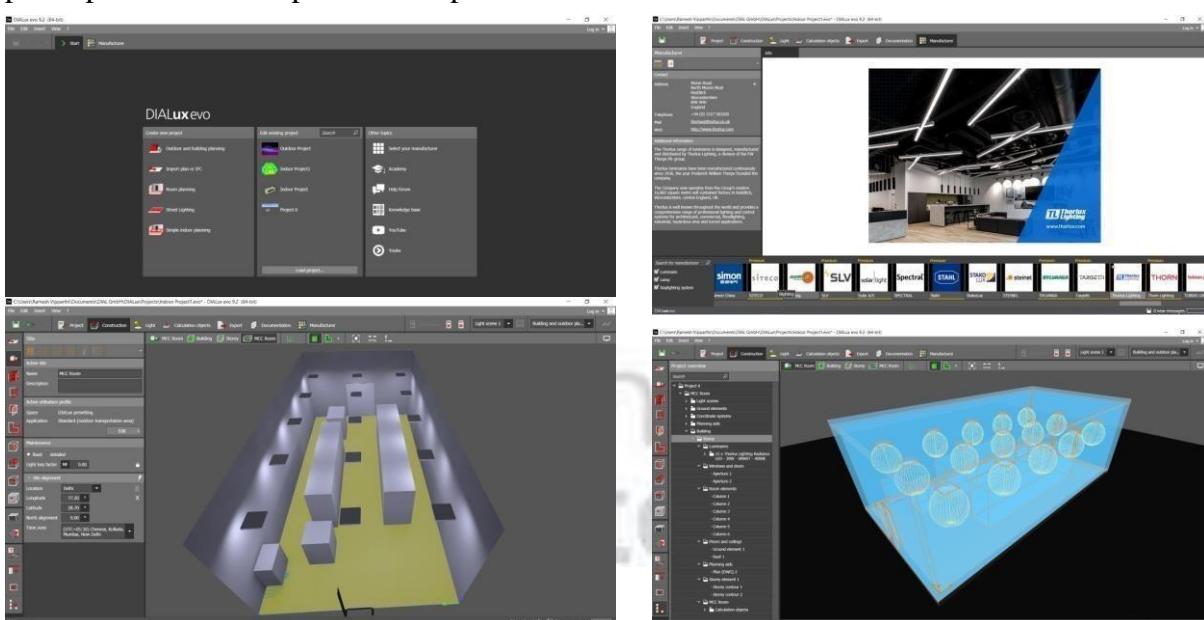
## 12      Lighting orIllumination usingDIALUXsoft ware

### LightingorIlluminationsystems

### Operationof dialuxsoftware

Topicdetails: LightingorIlluminationCalculationsusingDIALUXsoftware.

Here we are using this Dialuxevo 5.9.2 software windows to construct the powerplantand wecan performtheoperation fromthis software.



We havetheindoorcalculationsand outdoorcalculations too.

Results

	Symbol	Calculated	Target	Check	Index
Workplane	$\bar{E}_{\text{perpendicular}}$	264 lx	$\geq 500$ lx	<input checked="" type="checkbox"/>	52
	$\beta_i$	0.077	-	-	53
Consumption values	Consumption	1300 kWh/a	max. 3400 kWh/a	<input checked="" type="checkbox"/>	
Lighting power density	Room	4.82 W/m <sup>2</sup>	-	-	
		1.83 W/m <sup>2</sup> /100 lx	-	-	

Piperack

Luminaire list

	$\Phi_{\text{total}}$	$P_{\text{total}}$	Luminous efficacy
	15850 lm	360.0 W	44.0 lm/W

(Utilization profile: DILux presetting: Standard (office))

Luminaire list

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

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

Indoorcalculation

outdoorcalculations

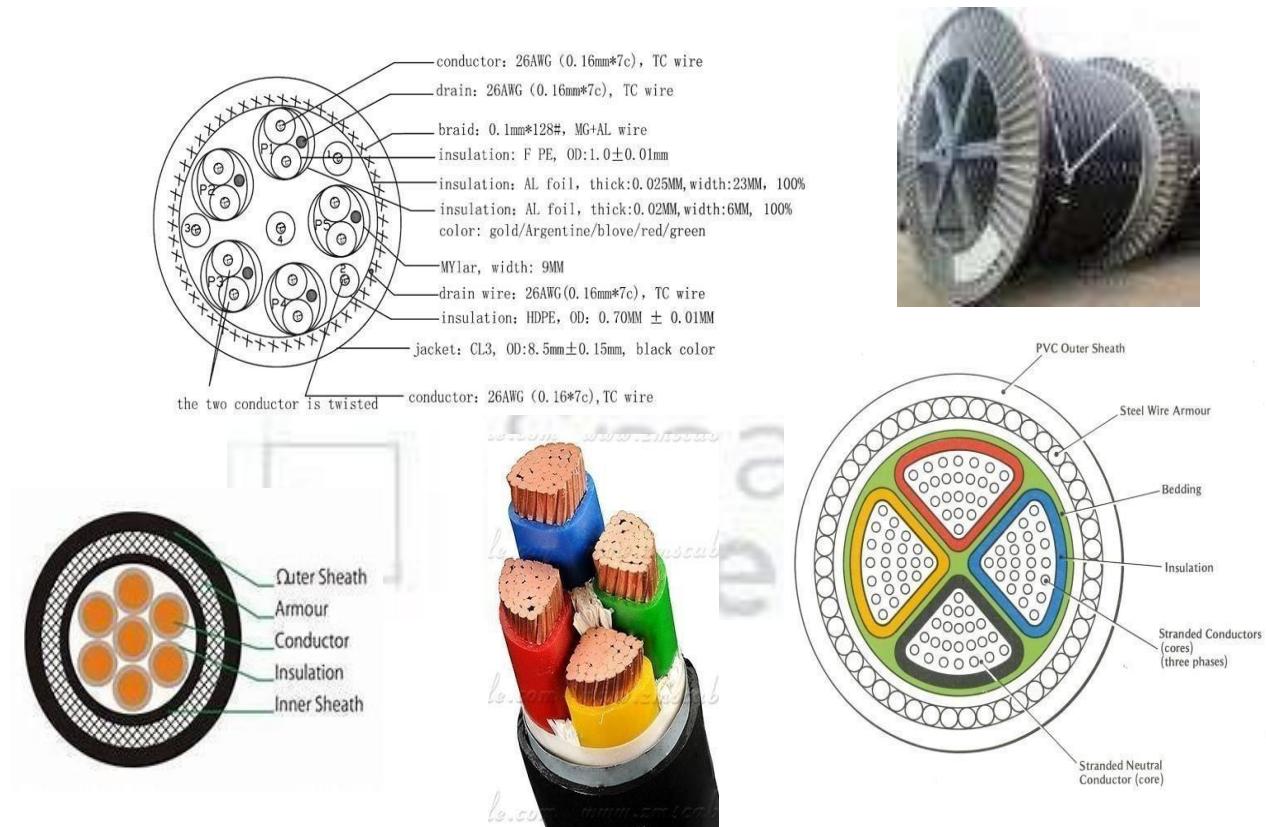
24<sup>th</sup>May2021: Cablingandtheircalculationsandtypes.

13 Cabling and themtypes andcalculations

Cablingcalculations

Types of cablingmaterials

Topic details: Cablingandtheirtytypes andcalculations.



Electricalcablesmustbeproperlysupportedtorelievemechanicalstressesontheconductors, and protected from harsh conditions such as abrasion which might degrade theinsulation. Cables generally laid in the cable trays above ground, direct buried undergroundand in metallic or PVC conduits. Derating factors may be applicable for each type of cablelaying conditions. Cable trays shall be generally loaded 60 to 70% leaving space for futureuse. Underground cabling shall be done in concrete cable trenches with cable trays in pavedareasanddirectlyburiedwith mandatorygapof 300mmbetweendifferentsystems ofcables.

25<sup>th</sup>May2021:CablingcalculationsandCable glandselection.

14 Cablingcalculations andcable glandselection

Cablingcalculations

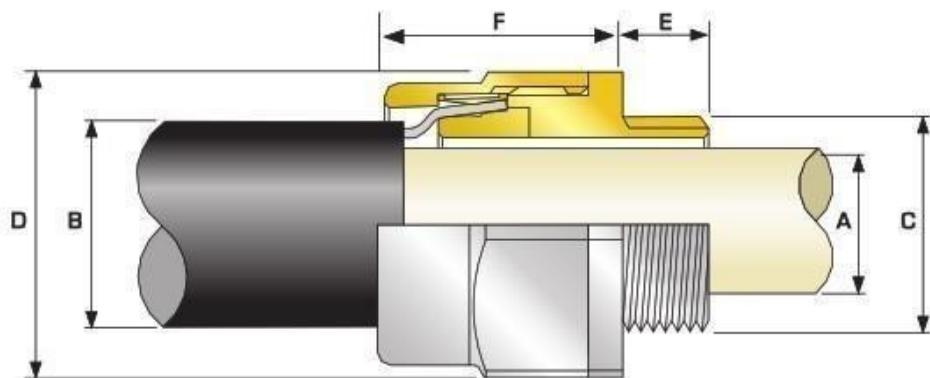
Cable glandselection

Topic details: Cablesizingcalculation andcableglandselection.

Inputs required: Load List, Design basis, Electrical equipment layout, cable schedule, vendorcataloguesfor cabletray.

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

Cablegland:



#### Cable Gland Selection Table

Refer to illustration at the top of the page.

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

## 28th May 2021: Load calculations and Transformer sizing calculations

15      Load  
calculations and  
TRcalculations

Load calculations

TR calculations

### Topic details:

List of electrical load calculations:

#### ELECTRICAL LOAD CALCULATIONS LV MCC

Sl. No.	Equipment No.	Equipment Description	Breaker Rating	Breaker Type	Breaker No. of Poles	ELCB Rating	Absorbed Load	Motor / Load Rating	Load Factor [A] / [B]	Efficiency at Load Factor [C]	Power Factor at Load Factor [C]	kW + [A] / [C]		Consumed Load		kVAR = kW x tan $\phi$		Remarks			
												[A] mA	[B] kW	[C] decimal	[D] cos $\phi$	kW	kVAR	kW	kVAR		
1	PU2315	Silica filter feed pump							18.96	22.00	0.86	0.91	0.79		20.94	16.72					
2	PU 2314-A	Absorbent/Natural oil pump (W)							5.50	7.50	0.73	0.85	0.73		6.5	6.1					
3	PU 2314-B	Absorbent/Natural oil pump (S)							4.74	5.50	0.86	0.85	0.73					5.6	5.2		
4	PU2305	Feed Pump (Separator)							10.14	22.00	0.87	0.91	0.79		21.0	16.9					
5	MK2305	MIXER (W)							18.29	22.00	0.88	0.91	0.78		21.2	17.0					
6	MX 2308	MIXER (S)							19.29	22.00	0.88	0.91	0.78					21.2	17.0		
7	BW2313	Blower							8.29	9.20	0.90	0.85	0.73		9.8	9.1					
8	Rotary valve	TK 2318 (I)							0.81	1.10	0.74	0.89	0.73				1.0	0.9			
9	SC2314	Screw conveyor (I)							1.86	2.20	0.85	0.85	0.73				2.19	2.05			
10	AG 2304A	Citric acid tank agitator (W)							1.38	1.50	0.93	0.85	0.73		1.84	1.53					
11	AG 2304B	Citric acid tank agitator (S)							1.38	1.50	0.93	0.85	0.73				1.9	1.5			
12	AG 2305	Citric oil reaction vessel agitator							5.08	5.50	0.93	0.85	0.73		5.98	5.60					
13	AG 2309	Lye oil reaction vessel agitator							1.84	2.20	0.84	0.85	0.73		2.16	2.03					
14	AG 2310	Lye oil reaction vessel agitator							1.84	2.20	0.84	0.85	0.73		2.16	2.03					
15	AG 2314	Soap Accountant Tank Agitator							3.23	3.70	0.87	0.85	0.73		3.80	3.56					
										Maximum of normal running plant load: (Est. $x^2E + y^2F$ )	96.0 kW	81.5 kVAR	$\sqrt{E^2 + F^2} =$	125.9 VA	TOTAL	95.08	80.57	3.19	2.95	28.41	23.76
										Peak Load: (Est. $x^2E + y^2F + z^2G$ )	98.9 kW	83.8 kVAR	$\sqrt{E^2 + F^2 + G^2} =$	129.6 kVA	kVA	124.63		4.34		37.03	

#### Assumptions

1) Load factor, Efficiency and Power factor:

Load Rating (kW)	Efficiency	Power factor
$\leq 20$	0.85	0.75
$> 20 - < 45$	0.91	0.78
$> 45 - < 150$	0.93	0.82
$\geq 150$	0.94	0.91

2) Constante factors  $x=1.0$ ,  $y=0.3$ , and  $z=0.1$  considered for continuous, intermittent and standby load.

## LOADCALCULATIONS

### 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	95.08	80.8	124.83	— (i)
b. Intermittent load / Diversity Factor	3.19	3.0	4.38	— (ii)
c. Stand-by load required as consumed load	28.41	23.8	37.06	— (iii)

$$\text{Max. Consumed load} = ((i) + 30\% (ii) + 10\% (iii)) =$$

$$\text{Future expansion load (20% capacity)}$$

$$\text{Total Load} =$$

$$98.9$$

$$19.8$$

$$118.7$$

$$83.9$$

$$18.8$$

$$100.8$$

$$129.64$$

$$25.93$$

$$155.57$$

**1.2 Calculation for 3.3kV / 0.433 kV transformer capacity**

Max. Consumed load	=	129.8 kVA
Spare capacity	=	25.9 kVA
Required capacity	=	155.8 kVA
Transformer rated capacity	=	160 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 :

$$P_T = 160 \text{ kVA} \quad (\%Z) = 4 \quad \& \text{Ratio X/R} = 1.5 \text{ (refer table)}$$

$$\text{Hence } \%R = 2.219 \%$$

$$\%X = 3.33 \%$$

$$P_u = 22 \text{ kW having } K = 6 \quad \& C = 1 \quad \& \cos \theta = 0.78 \quad \& \text{Eff.} \eta = 0.91 \quad \& \cos \theta_s = 0.25$$

$$P_s = 185.968 \text{ kVA}$$

$$\cos \theta_s = 0.25, \text{ Corresponding to Angle } \theta_s = 75.5226 \text{ Degrees for which } \sin \theta_s = 0.97 \\ P_s = 96.42 \text{ kVA} \quad \& P_B \text{ in kW is } 81.957 \quad \& P_s \text{ in kvar} = 50.81 \quad \& \cos \theta_s = 0.850 \\ \cos \theta_B = 0.85, \text{ Corresponding to Angle } \theta_B = 31.7883 \text{ Degrees, for which } \sin \theta_B = 0.53$$

$$P_{C1} = 128.449 \text{ kW} \\ P_{C2} = 230.873 \text{ kVAR} \\ P_C = 264.189 \text{ kVA}$$

$$\cos \theta_C = 0.48618, \text{ where as } \sin \theta_C = 0.874$$

$$\text{Voltage Regulation} = 6.8 \% \quad \text{Selected Transformer rating is adequate.}$$

**Result:** During starting of max. capacity motor, while all other loads are running, the voltage regulation at Transformer secondary terminals shall be approx. 6.8% which meets the criteria to maintain less than 15% voltage regulation.

**1.4 Selection of rated capacity**  
Hence 160kVA Transformer rating selected.

## TRANSFORMERSIZING CALCULATIONS

29th May 2021: DG set calculations.

## 16 DG set calculations

### Topic details:

DG set calculations, types, sizing or selections

DG SIZING CALCULATIONS			
<b>Design Data</b>			
Rated Voltage	415	KV	
Power factor ( $\cos\phi$ )	0.743	Avg	
Efficiency	0.866	Avg	
Total operating load on DG set in kVA at 0.743 power factor	125.9		
Largest motor to start in the sequence - load in kW	22	KW	
Running kVA of last motor ( $\cos\phi = 0.91$ )	34	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)	205	KVA	
Base load of DG set in kVA (Total operating load in kVA - Running kVA of last motor)	92	KVA	
<b>A Continuous operation under load - P1</b>			
Capacity of DG set based on continuous operation under load P1	92	KVA	
<b>B Transient Voltage dip during starting of Last motor P2</b>			
Total momentary load in kVA (Starting KVA of the last motor + Base load of DG set in kVA)	297	KVA	
Subtransient Reactance of Generator ( $X_d''$ )	7.91%	[Assumed]	
Transient Reactance of Generator ( $X_d'$ )	10.065%	[Assumed]	
$X_d''' = (X_d'' + X_d')/2$	0.089875		
Transient Voltage Dip	15%	(Max)	
Transient Voltage dip during Soft starter starting of Last motor $P_2 = \text{Total momentary load in kVA} \times X_d''' \times \frac{(1-\text{Transient Voltage Dip})}{(\text{Transient Voltage Dip})}$	151	KVA	
<b>C Overload capacity P3</b>			
Capacity of DG set required considering overload capacity			
Total momentary load in kVA	297	KVA	
overcurrent capacity of DG (K) (Ref: IEC 60034-1, Clause 9.3.2)	150%		
Capacity of DG set required considering overload capacity (P3) = $\frac{\text{Total momentary load in kVA}}{\text{overcurrent capacity of DG (K)}}$	198	KVA	
Considering the last value amongst P1, P2 and P3			
Continuous operation under load - P1	92	KVA	
Transient Voltage dip during Soft starter starting of Last motor P2	151	KVA	
Overload Capacity P3	198	KVA	
Considering the last value amongst P1, P2 and P3	198	KVA	
DG SET Rating Hence, Existing Generator 198 KVA is adequate to cater the loads as per re-scheduled loads	200	KVA	
NOTE: VOLTAGE DIP CONSIDERED - 15%			

### DGSETCALCULATIONS

## 2ndjune2021: Calculations of Earthing and Lighting protection.

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

Calculation of Earthing and Lighting protection calculations

### LIGHTING CALCULATIONS:

<b>Location:</b> Building Type of Building Building Length (L) Building breadth (W) Building Height (H)	<b>5</b> <b>Karnool</b> Concrete, Industrial Flat Roofs (a)	<b>15</b> <b>5</b> <b>6</b>
<b>Risk Factor Calculation</b>		
<b>1 Collection Area (A<sub>c</sub>)</b>		
A <sub>c</sub>	=	(L*W) + (2*L*H) 428.04
<b>2 Probability of Being Struck (P)</b>		
P	=	A <sub>c</sub> * N <sub>s</sub> * 10 <sup>-6</sup> 0.000813276
<b>3 Overall weighing factor</b>		
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)	=	0.4
e) Type of country (E)	=	0.3
W <sub>o</sub> - Overall weighing factor	=	A * B * C * D * E 0.038
<b>4 Overall Risk Factor</b>		
P <sub>o</sub>	=	P * W <sub>o</sub>
P <sub>o</sub>	=	3.12298E-05
P <sub>a</sub>	=	10 <sup>-8</sup>
As per clause no. 9.7 of BS- 6651, suggested acceptable risk factor ( P <sub>o</sub> ) has been taken as 10 <sup>-8</sup> Since P <sub>o</sub> > P <sub>a</sub> lightning protection required.		
<b>5 Air Terminations</b>		
Perimeter of the building	=	2(L+W) 40
<b>6 Down Conductors</b>		
Perimeter of building	=	40
No. of down conductors based on perimeter	=	2
Hence 2 nos. of Down conductors have been selected.		
Size of Down conductor	=	20 X 2.5 mm Ga
(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)		

	S
Maximum line-to-ground fault in kA for 1 sec	17
Earthing material (Earth rod & earth strip)	GI
Depth of earth flat burial in meter	0.5
Average depth / length of Earth rod in meters	4.5
Soil resistivity Q-meter	9
Ambient temperature in deg C	55
Plot dimensions (earth grid) L x B in meters	80
Number of earth rods in nos.	6

Earth electrode sizing:

Ac - Required conductor cross section in sq.mm

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

$\alpha_r$  - Thermal co-efficient of resistivity, at 20 oC  
 $\rho_r$  - Resistivity of ground conductor at 20 oC

$T_a$  - Ambient Temperature is "C  
 $I_{ig}$  - RMS fault current in kA = 50 KA

$t_c$  - Short circuit current duration sec  
 Thermal capacity factor, TCAP J/(cm<sup>3</sup>.oC)

$T_m$  - Maximum allowable temperature for copper conductor, in oC  
 $K_0$  - Factor at oC

The data taken from IEEE 80-2000, Clause 11.3, Table-1 for clad steel rod:

$14 = Ac * 0.0032$	0.123
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Ac - Required conductor cross section in sq.mm	114
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Earth rod dia in mm	12
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Earth rod dia (including 25% corrosion allowance) in mm	15
---	----

Earth flat sizing:

Ac - Required conductor cross section in sq.mm

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

$\alpha_r$  - Thermal co-efficient of resistivity, at 20 oC  
 $\rho_r$  - Resistivity of ground conductor at 20 oC

$T_a$  - Ambient Temperature is "C  
 $I_{ig}$  - RMS fault current in kA = 50 KA

$t_c$  - Short circuit current duration sec  
 Thermal capacity factor, TCAP J/(cm<sup>3</sup>.oC)

$T_m$  - Maximum allowable temperature for copper conductor, in oC  
 $K_0$  - Factor at oC

The data taken from IEEE 80-2000, Clause 11.3, Table-1 for clad steel rod:

$14 = Ac * 0.0032$	0.123
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20.10	20.10
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50	50
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14	14
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1	1
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3.93	3.93
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419	419
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293	293
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$14 = Ac * 0.123$	0.123
Ac - Required conductor cross section in sq.mm	114
Earth flat area in mm	12
Earth flat area (including 25% corrosion allowance) in mm	15
Selected flat size W * Thk in sq mm	20

 $R_g$  - Grid resistance

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

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

$\rho$  - Soil resistivity in Q-meter= 9

L - Total buried length of ground conductor in meter= 440

h - Depth of burial in meter= 0.5

A - Grid area in sq. meter= 11200

$R_g$ - Grid resistance	0.058
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 $R_r$  - Earth Electrode resistance

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

$$R_r = \frac{\rho}{2 \times \pi \times n_r \times L_r} \left\{ I_r \left[ \frac{4 \times L_r}{b} \right] - 1 + \frac{2 \times K_1 \times L_r}{\sqrt{A}} \left( \sqrt{n_r} - 1 \right)^2 \right\}$$

## EARTHING CALCULATIONS

5thjune 2021:Cablesizingandcable tray sizingcalculations.

18	Cable sizing and cable tray sizing calculations	Cablesizingcalculations	Cabletraycalculation
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**Topic details:** Cablesizing and cabletray sizing calculations for LV cables and MV/HV cables.

## CableTraycalculations:

Sr. No.	Cable Route (From-To)	Type & Cable Size	Size of Cable (mm <sup>2</sup> )	No. of Cable	Overall Diameter of each Cable (mm)	Sum of Cable OD (mm)	Self Weight of Cable (Kg/Mt)	Total Weight of Cable (Kg/Mt)	Remarks
1	LV MCC	4	10	1	18	18	3.95	0.9	
2	PU2315-VFD	4	10	1	18	18	0.37	0.9	
3	PU2315-VFD	5	15	1	15	15	3.95	0.4	
4	LV MCC	4	25	1	16	16	0.37	0.5	
5	LV MCC	5	15	1	15	15	3.95	0.4	
6	LV MCC	4	25	1	16	16	0.37	0.5	
7	PU 2314-B-VFD	4	25	1	16	16	0.9	0.5	
8	PU 2314-B-VFD	5	15	1	15	15	0.9	0.4	
9	LV MCC	4	6	1	18	18	2.9	0.7	
10	PU2305-VFD	4	6	1	18	18	12	0.7	
11	PU2305-VFD	5	15	1	15	15	12	0.4	
12	LV MCC	4	6	1	18	18	1.2	0.7	
13	LV MCC	5	15	1	15	15	1.45	0.4	
14	LV MCC	4	10	1	18	18	2	0.9	
15	LV MCC	5	15	1	15	15	2.4	0.4	
16	LV MCC	4	6	1	18	18	2.4	0.7	
17	BW2313-VFD	4	6	1	18	18	0.85	0.7	
18	BW2313-VFD	5	15	1	15	15	0.85	0.4	
19	LV MCC	4	6	1	18	18	0.85	0.7	
20	LV MCC	5	15	1	15	15	1	0.4	
21	LV MCC	4	6	1	18	18	0.85	0.7	
<b>Total</b>			21		348	33.91	12.3		

## **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, hackathons,technical sessions.

### **Method of conducting program**

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

### **Program highlights**

It is for the detailed design of any industrial sectors.

### **Material**

The material was good.

### **Benefits**

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

# ASSIGNMENT - 1

## ELECTRICAL LOAD CALCULATIONS LV MCC

### 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	282.13	210.7	352.11	— (i)
b. Intermittent load / Diversity Factor	9.59	9.0	13.14	— (ii)
c. Stand-by load required as consumed load	84.40	61.8	104.59	— (iii)
Max. Consumed load = ((i) + 30% (ii) + 10% (iii)) =	293.4	219.6	366.49	
Future expansion load (20% capacity)	58.7	43.9	73.30	
Total Load =	352.1	263.5	439.79	

#### 1.2 Calculation for 3.3kV / 0.433 kV transformer capacity

$$\begin{aligned} \text{Max. Consumed load} &= 366.5 \text{ kVA} \\ \text{Spare capacity} &= 73.3 \text{ kVA} \\ \text{Required capacity} &= 439.8 \text{ kVA} \\ \text{Transformer rated capacity} &= 500 \text{ kVA} \end{aligned}$$

#### 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 follow

$$P_T = 500 \text{ kVA} \quad (\%Z) = 4 \quad \text{& Ratio X/R} = 1.5$$

$$\text{Hence, \%R} = 2.219 \%$$

$$\%X = 3.33 \%$$

$$P_M = 75 \text{ kW having } K = 6 \quad \& C = 1 \quad \& \cos \theta = 0.82 \quad \& \text{Eff.} \eta = 0.93 \quad \& \cos \theta_s = 0.25$$

$$P_S = 590.087 \text{ kVA}$$

$$\cos \theta_s = 0.25, \text{ Corresponding to Angle } \theta_s = 75.5225 \text{ Degrees for which } \sin \theta_s = 0.97$$

$$P_B = 260.65 \text{ kVA} \quad \& P_B \text{ in kW is } 213.733 \quad \& P_B \text{ in kvar} = 190.56 \quad \therefore \cos \theta_B = 0.820$$

$$\cos \theta_B = 0.85, \text{ Corresponding to Angle } \theta_s = 34.9152 \text{ Degrees, for which } \sin \theta_s = 0.57$$

$$P_{CP} = 361.255 \text{ kW}$$

$$P_{CQ} = 761.909 \text{ kvar}$$

$$P_C = 843.214 \text{ kVA}$$

$$\cos \theta_C = 0.42843, \text{ where as } \sin \theta_C = 0.904$$

$$\text{Voltage Regulation } \varepsilon = 6.7 \%$$

**Result:** During starting of max. capacity motor, while all other loads are running, the voltage regulation at Transformer secondary terminals is approx. 6.7 %, which meets the criteria to maintain less than 15% voltage regulation

#### 1.4 Selection of rated capacity

500kVA transformer selected.

## ASSIGNMENT -3

### DG SIZING CALCULATIONS

#### Design Data

Rated Volatge	415	KV
Power factor ( $\cos\phi$ )	0.76	Avg
Efficiency	0.88	Avg
Total operating load on DG set in kVA at 0.76 power factor	350.0	
Largest motor to start in the sequence - load in KW	75	KW
Running kVA of last motor ( $\cos\phi=0.91$ )	112	KVA
Starting current ratio of motor	6	(Considering starting method as Soft starter)
Starting KVA of the largest motor	673	KVA
(Running kVA of last motor X Starting current ratio of motor)		
Base load of DG set in KVA (Total operating load in kVA – Running kVA of last motor)	238	KVA

#### A Continous operation under load -P1

Capacity of DG set based on continuous operation under load P1	238	KVA
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#### 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)	911	KVA
Subtransient Reactance of Generator ( $X_d''$ )	7.91%	(Assumed)
Transient Reactance of Generator ( $X_d'$ )	10.065%	(Assumed)
$X_d''' = (X_d'' + X_d')/2$	0.089875	
Transient Voltage Dip	15%	(Max)

Transient Voltage dip during Soft starter starting of Last motor $P_2 = \text{Total momentary load in KVA} \times X_d''' \times \frac{(1-\text{Transient Voltage Dip})}{(\text{Transient Voltage Dip})}$	464	KVA
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#### C Overload capacity P3

Capacity of DG set required considering overload capacity Total momentary load in KVA	911	KVA
overcurrent capacity of DG (K)	150%	
(Ref: IS/IEC 60034-1, Clause 9.3.2)		
Capacity of DG set required considering overload capacity $(P_3) = \frac{\text{Total momentary load in KVA}}{\text{overcurrent capacity of DG (K)}}$	607	KVA

#### Considering the last value amongst P1, P2 and P3

Continous operation under load -P1	238	KVA
Transient Voltage dip during Soft starter starting of Last motor P2	464	KVA
Overload capacity P3	607	KVA
Hence Existing Generator 607 KVA is adequate to cater the loads as per Considering the last value amongst P1, P2 and P3 re-scheduled loads	607	KVA

NOTE:VOLTAGE DIP CONSIDERED - 15%

## ASSIGNMENT-4

### Earthing calculations

Maximum line-to-ground fault in kA for 1 sec	13
Earthing material (Earth rod & earth strip)	GI
Depth of earth flat burrial in meter	0.5
Average depth / length of Earth rod in meters	4.0
Soil resistivity Ω-meter	7.5
Ambient temperature in deg C	50
Plot dimensions (earth grid) L x B in meters	70      130
Number of earth rods in nos.	6

Earth electrode sizing:

Ac - Required conductor cross section in sq.mm

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

$\alpha_r$  - Thermal co-efficient of resistivity, at 20 oC      0.0032  
 $\rho_r$  - Resistivity of ground conductor at 20 oC      20.10  
 $T_a$  - Ambient Temperature is °C      50

$I_{lg}$  - RMS fault current in kA = 50 KA      3.93  
 $t_c$  - Short circuit current duration sec      41

$K_0$  - Factor at oC      293  
 The data taken from IEEE 80-2000, Clause 11.3, Table 1 for clad steel rod, mm      114  
 Required conductor cross section in mm<sup>2</sup>      0.123  
 Earth rod dia in mm      14 = Ac \* 14

Earth rod dia (including 25% corrosion allowance) in mm      15

Earth flat sizing:

Ac - Required conductor cross section in sq.mm

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

$\alpha_r$  - Thermal co-efficient of resistivity, at 20 oC      0.0032  
 $\rho_r$  - Resistivity of ground conductor at 20 oC      20.10  
 $T_a$  - Ambient Temperature is °C      50

$I_{lg}$  - RMS fault current in kA = 50 KA      14  
 $t_c$  - Short circuit current duration sec      1  
 Thermal capacity factor, TCAP J/(cm3.oC)      3.93

Tm - Maximum allowable temperature for copper conductor, in oC	419
K0 - Factor at oC	293
The data taken from IEEE 80-2000, Clause 11.3, Table-1 for clad steel rod: 14 = Ac *	0.123
Ac - Required conductor cross section in sq.mm	114
Earth flat area in mm	12
Earth flat area (including 25% corrosion allowance) in mm	15
Selected flat size W * Thk in sq mm	20

Rg - Grid resistance

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

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

$\rho$ - Soil resistivity in $\Omega$ -meter=	7.5
L - Total buried length of ground conductor in meter	400
h - Depth of burial in meter	0.5
A - Grid area in sq. meter	9100
Rg - Grid resistance	0.054

Rr - Earth Electrode resistance

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

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

$\rho$ - Soil resistivity in $\Omega$ -meter, 16.96	7.5
n - No of earth electrodes	6
Lr - Length of earth electrode in meter	4
$k_1$ - Diameter of earth electrode in meter	0.020
A - Area of grid in square metre	9100

Rr - Earth Electrode resistance 2.97316

Grounding system resistance

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

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

## ASSIGNMENT-5

### Lighting protection calculations

13

Location	Bhopal
Building	Concrete, Industrial
Type of Building	Flat Roofs (a)
Building Length (L)	15
Building breadth (W)	6
Building Height (H)	6

#### Risk Factor Calculation

##### 1 Collection Area ( $A_c$ )

$$A_c = (L \cdot W) + (2 \cdot L \cdot H) + (2 \cdot W \cdot H) \\ A_c = 455.04$$

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

$$P = A_c \cdot N_g \cdot 10^{-6} \\ P = 0.001274112$$

##### 3 Overall weighing factor

a) Use of structure (A)	=	1.2
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	=	

##### 4 Overall Risk Factor

$$Po = \frac{A \cdot B \cdot C \cdot D \cdot E}{P \cdot Wo} \\ Po = 0.000146778$$

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

#### 5 Air Terminations

$$\text{Perimeter of the building} = \frac{2(L+W)}{42} \text{ Mts.}$$

##### 6 Down Conductors

$$\text{Perimeter of building} = 42 \text{ Mts.}$$

$$\text{No. of down conductors based on perimeter} = 2 \text{ Nos.}$$

Hence 2 nos. of Down conductors have been selected.

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

# ASSIGNMENT-6

## Cable sizing calculations

S.NO.	Description	Equipment No.	Description	Consumed Load KW	Load Rating KW	Voltage Rating [V]	Current ph (A)	Fall Load Setting (A)	Motor Load Setting (A)	No. of Ph	Motor Current (A)	Load P.F	Starting SIne P.F	Starting SIne Starting SIne	Type	No. of Runs	No. of Cores	Size (mm <sup>2</sup> )	Current Rating (A)	Derating factor K1	Derating factor K2	Derating factor K3	Derating factor K4	Overall Derating factor k	Derating current I(A)	Derated Current I(A)	Cable Length (M)	Cable Resistance (Ohms/M)	Cable Reactance (Ohms/M)	Cable Capacitance (Microfarad)	Voltage drop (Starting) (%)	Voltage drop (Running) (%)	Cable size (mm)	Gland size
3	LV MCC	PW2315	Siemens feed pump	3	100.8	604.90	415	3	100.8	415	3	0.6	0.3	0.5	2	1	1	0.58	0.9	1	1	0.382	159.6	0.0702	43.36	7.38	1.27	35.18	8.48	OK	26	20		
4	LV MCC	PW2320A	Siemens feed pump	5	48.48	242.40	415	3	26.9	176.71	3	0.6	0.3	0.5	2	1	1	0.58	0.9	1	1	0.382	75.0	0.0702	1.4700	0.0815	5.50	1.42	21	225				
5	LV MCC	PW2314A	Siemens feed pump	5	22.2	111.19	415	3	22.2	151.19	3	0.6	0.3	0.5	2	1	1	0.58	0.9	1	1	0.382	75.0	0.0702	1.4700	0.0815	3.21	0.77	19.12	4.61	21	225		
6	LV MCC	PW2324	Siemens feed pump	6	101.8	611.04	415	3	101.8	611.04	3	0.6	0.3	0.5	2	1	1	0.58	0.9	1	1	0.382	159.6	0.0702	0.4650	0.0815	6.05	1.42	30.19	8.44	OK	26	205	
7	LV MCC	PW2313	Siemens feed pump	7	102.0	615.73	415	3	102.0	615.73	3	0.6	0.3	0.5	2	1	1	0.58	0.9	1	1	0.382	159.6	0.0702	0.4650	0.0815	5.61	1.42	24.64	8.0	OK	26	205	
8	LV MCC	PW2322B	Siemens feed pump	8	152.5	845.73	415	3	152.5	845.73	3	0.6	0.3	0.5	2	1	1	0.58	0.9	1	1	0.382	159.6	0.0702	0.4650	0.0815	105	1.42	49.75	11.75	OK	26	205	
9	LV MCC	PW2321B	Siemens feed pump	9	46.1	230.40	415	3	46.1	230.40	3	0.6	0.3	0.5	2	1	1	0.58	0.9	1	1	0.382	75.0	0.0702	1.4700	0.0815	6.05	2.15	56.70	13.62	OK	26	205	
10	LV MCC	PW2321F	Siemens feed pump	10	45	230.40	415	3	4.5	230.40	3	0.6	0.3	0.5	2	1	1	0.58	0.9	1	1	0.382	33.5	0.0947	0.4650	0.0815	3.54	21.19	5.61	1.11	21	225		
11	LV MCC	PW2320S	Siemens feed pump	11	9.9	50.27	415	3	9.9	50.27	3	0.6	0.3	0.5	2	1	1	0.58	0.9	1	1	0.382	45.0	0.0947	3.5400	0.0802	4.12	0.99	24.06	5.94	OK	18	23	
12	LV MCC	PW2325	Siemens feed pump	12	4.5	23.45	415	3	7.4	44.55	3	0.6	0.3	0.5	2	1	1	0.58	0.9	1	1	0.382	45.0	0.0947	4.12	1.09	27.14	6.54	OK	18	23			
13	LV MCC	PW2326	Siemens feed pump	13	7.4	44.55	415	3	7.4	44.55	3	0.6	0.3	0.5	2	1	1	0.58	0.9	1	1	0.382	45.0	0.0947	3.5400	0.0802	3.09	0.75	18.50	4.46	OK	18	20	
14	LV MCC	PW2309	Siemens feed pump	14	21.0	102.15	415	3	21.0	102.15	3	0.6	0.3	0.5	2	1	1	0.58	0.9	1	1	0.382	75.0	0.0702	1.4700	0.0815	6.02	1.45	35.88	8.65	OK	21	20	
15	LV MCC	PW2312	Siemens feed pump	15	9.6	53.95	415	3	9.6	53.95	3	0.6	0.3	0.5	2	1	1	0.58	0.9	1	1	0.382	45.0	0.0947	3.5400	0.0802	4.64	1.12	27.75	6.69	OK	18	32	
3. Cable type:																																		
4. Effect of Emissivity Variation ± 15%																																		
5. Combined Effect of Voltage & Frequency variation ± 10%																																		

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## ASSIGNMENT-7

### Cable Tray Sizing Calculations

#### LTCABLES

CABLETRAY:FROM		LT-4		TO	LT-5				
Sr. No.	CableRoute(From-To)	Type&CableSize	Size of Cable(mm <sup>2</sup> )	No. of Cable	Overall Diameter of each Cable(mm)	Sum of CableOD (mm)	Self Weight of Cable(Kg/Mt)	Total Weight of Cable(Kg /Mt)	Remarks
1	PU2315	4	50	1	26	26	2.3	2.3	
2	PU2314A	4	16	1	21	21	1	1	
3	PU2324	4	16	1	21	21	1	1	
4	PU2305	4	50	1	26	26	2.3	2.3	
5	MX2305	4	50	1	26	26	2.3	2.3	
6	MX2308	4	50	1	26	26	2.3	2.3	
7	BW2313	4	16	1	21	21	1	1	
8	SC2314	4	4	1	17	17	0.6	0.6	
9	AG2324A	4	6	1	18	18	0.7	0.7	
10	AG2305	4	6	1	18	18	0.7	0.7	
11	AG2309	4	6	1	18	18	0.7	0.7	
12	AG2310	4	16	1	21	21	1	1	
13	AG2314	4	6	1	18	18	0.7	0.7	
Total				13		277	16.6	16.6	
<b>Calculation</b>									
MaximumCableDiameter:		26	mm						
ConsiderSpareCapacityofCableTray:		30%							
DistancebetweeneachCable:		0	mm						
CalculatedWidthofCableTray:		360	mm						
CalculatedAreaofCableTray:		9363	Sq.mm						
NoofLayersofCablesinCableTray:		2							
SelectedNoofCableTray:		1	Nos.						
SelectedCableTrayWidth:		300	mm						
SelectedCableTrayDepth:		100	mm						
SelectedCableTrayWeightCapacity:		90	Kg/Meter						
TypeofCableTray:		Ladder							
TotalAreaofCableTray:		30000	Sq.mm						
<b>Result</b>									
SelectedCableTraywidth:							O.K		
SelectedCableTrayDepth:							O.K		
SelectedCableTrayWeight:							O.K	IncludingSpareCapacity	
SelectedCableTraySize:							O.K	IncludingSpareCapacity	
RequiredCableTraySize:							300x100	mm	
RequiredNosofCableTray:							1	No	
RequiredCableTrayWeight:							90.00	Kg/Meter/Tray	
TypeofCableTray:							Ladder		
CableTrayWidthAreaRemaining:							40%		
CableTrayAreaRemaining:							69%		