INDUSTRIAL ELECTRICAL PANEL DESIGN

TIPS & STANDARDS

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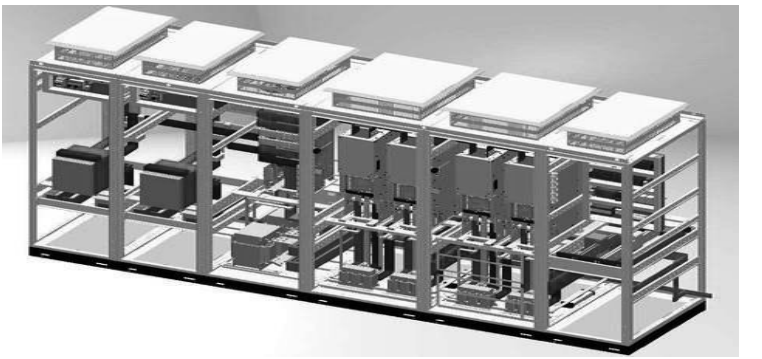
VFD Panel Engineering Design - Safety Testing & QualityAccording to IEC STANDARD For Low Voltage Control Panel



Directed by

Siddharth Dodiya &
Sanjay Chauhan

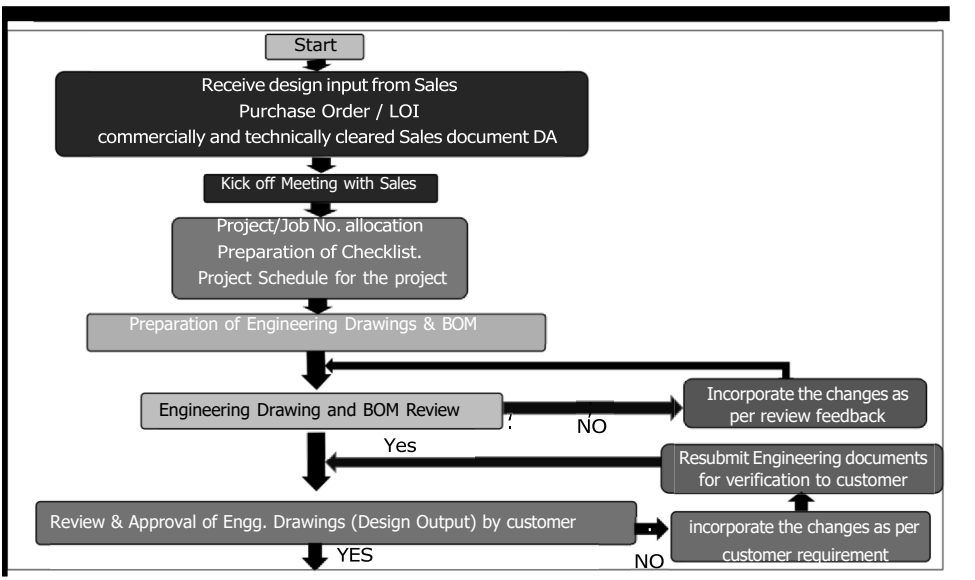
Engineering Design as per IEC Standard

All Our VFD panel enclosures are Designed as per IEC Standard For Design, Safety ,Testing & Quality

IEC stands for theInternational Electrotechnical Commission: An "organization that prepares and publishes international standards for all electrical, electronic and related technologies."

IEC: 60947 -Low Voltage Switchgear and Control Gear Selection
IEC: 60529 –Ingress Protection for enclosures
IEC: 61439 –L V Switchgear and Control Gear Assemblies, Design, Testing ,Quality & Verification
IEC: 60204 - Panel Enclosure safety , Service & Maintenance & Quality
IEC: 61800 –For VFD requirements safety, Testing ,Electrical, thermal and energy

Engineered System Solution Process Outline



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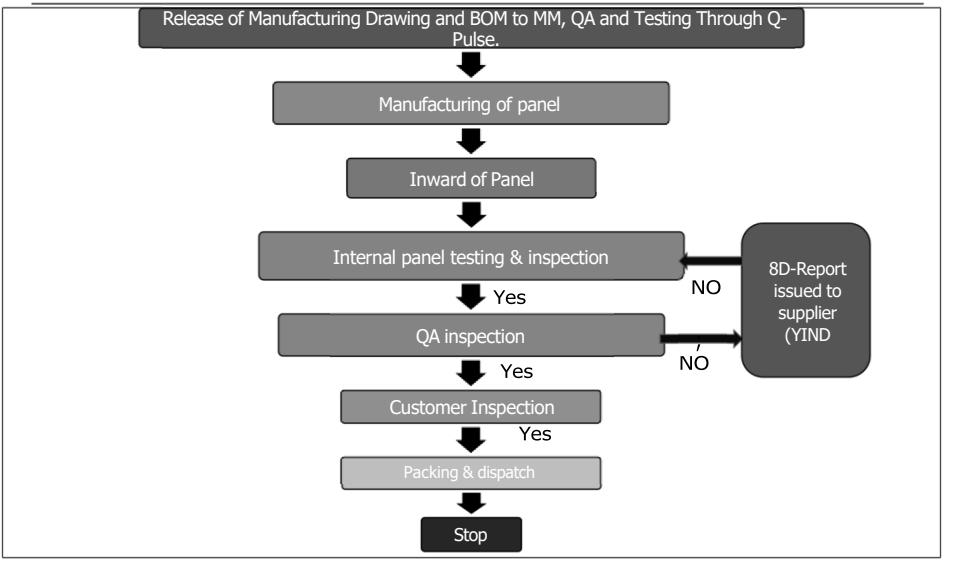
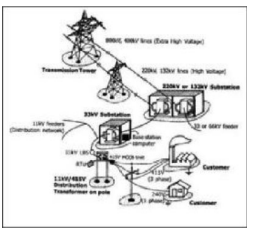


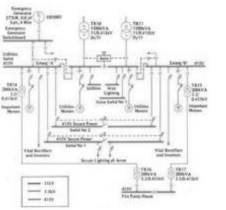
Basics of LV Control Panel

What is LV Control Panel?

LV –Low Voltage
Control –Switching & Operation
Panel –Assembled components to form circuit

□ Distribution,
□ Switching & Control/ Interface
□ Protection to feeding equipment &
□ Protect environment & Equipment from environment

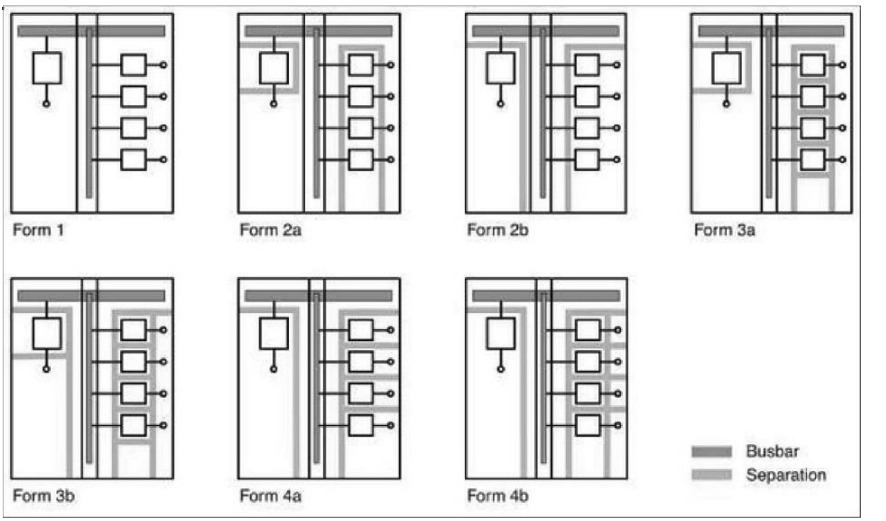




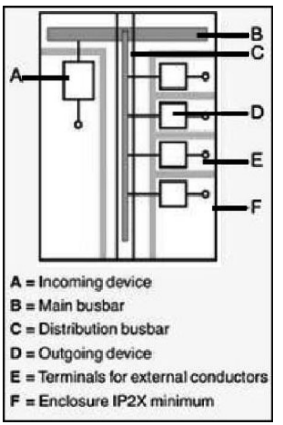
Best Practices of Panel Engineering as per IECs

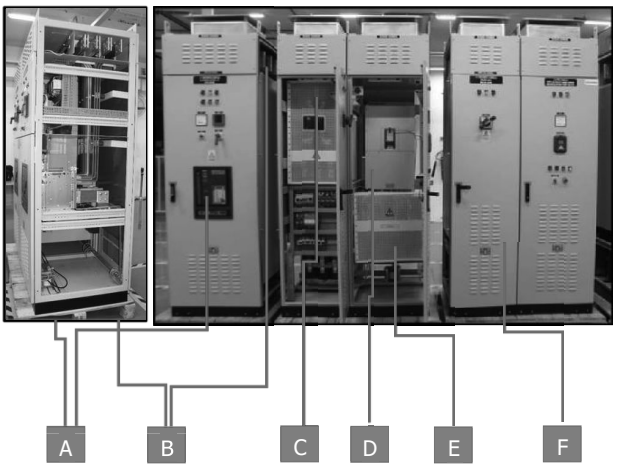
- Safe & Best cabinet design practice
  - Selection of right enclosure protection class
  - Best cooling arrangement inside the cabinet
  - Best EMC practices guaranteed noise free solution by proper power ,Control & Communication cable routing.
  - Proper component assembly arrangements.
  - Trouble free installation of VFD & other components during maintenance
- Service & Easy Maintenance
  - Easy accessibility of power ,Control & Field cabling
- Performance & Reliability
  - Optimizing control panel design, construction
  - Improving productivity & Achieving operational efficiency
  - Eliminate most hardwiring
  - Connect to industry-standard networks and fieldbuses.
- Best quality control practice & process
  - Ensuring 100% quality check
  - Bestengineering, assembly, documentation ,Quality control testing, and commissioning processes
- Control panel connectivity to next generation
  - Semi modular panel construction –Flexibility on intercomponent assembly

Forms Of Internal Separation of Panel Enclosure

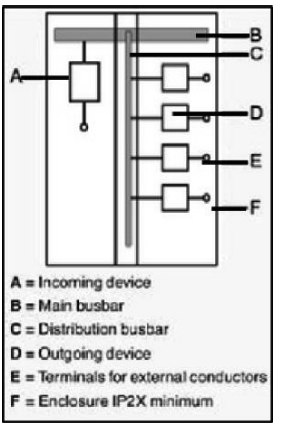


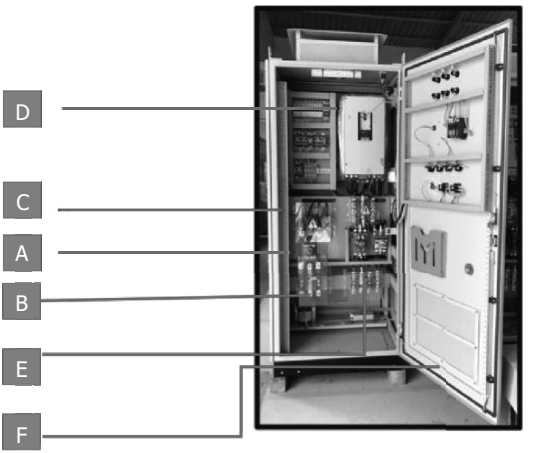
FORMSOFINTERNALSEPARATION-1A&4A





FORMS OF INTERNAL SEPARATION -1A





Selection of Switchgears according to IEC 60947

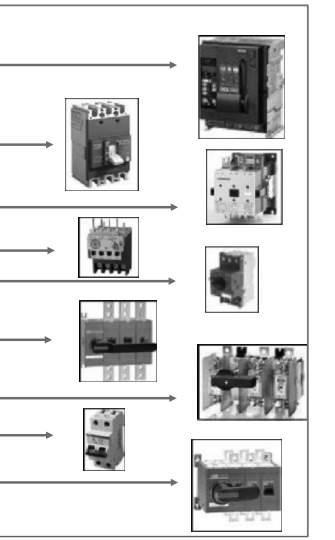
Defines about Switchgear components with Rated voltage not exceeding 1000V AC & 1500 V DC

- General rules for switchgear characteristics, installation , mounting , performance,
- specifications etc.
- Selection of switchgears with specifications
- Utilization categories
  Types of coordination

60947-1: General rules
60947-2: Part 2: Circuit-breakers
60947-3: Part 3: Switches, disconnectors, switch-disconnectors and fuse combination units
60947-4: Part 4: Contactors and motor starters
60947-5: Part 5: Control-circuit devices and switching elements
60947-6: Part 6: Multiple function switching devices
60947-7: Part 7: ancillary equipment
60947-8: Part 8: Control units for built-in thermal protection (PTC) for rotating electrical machines.

Selection of Switchgears with minimum specifications according to IEC 60947

SR No	Discription	Minimum Specification the component
1	ACB	Current, Voltage, Pole, Short circuit, type of operation, type of Mechanism, type of release
2	MCCB	Current, Voltage, Pole, Short circuit, type of release
3	Power Contactor	Current, Voltage, Pole , Coil Voltage
4	Over Load relay	Current, Voltage, Pole
5	MPCB	Current, Voltage, Pole
6	Switch disconnector	Current, Voltage, Pole
7	Switch Fuse unit	Current, Voltage, Pole
8	MCB	Current, Voltage, Pole
9	Change Over switch	Current, Voltage, Pole



Types of coordination according to IEC 60947

Type of coordination 1

co-ordination requires that under short-circuit conditions, the contactor or the starter shall cause no danger to persons or installation.

The contactormay not be suitable for further service without repair and replacement of parts."

Contactor and/or overload relay is/are possibly defective.

- Components may possibly be unsuitable for further service.
- Operator and machine protection are unsafe in the event of continued service.
- Functionality of components is uncertain. ⇒The components should be replaced.

Advantage

- The costs of manufacturing the control panel are lower than with type of coordination 2 because smaller switching devices can be used

Disadvantage

- Long downtimes
- High outlay for repairs

Types of coordination according to IEC 60947

Type of coordination 2

co-ordination requires that under short-circuit conditions, the contactor or the starter shall cause no danger to persons or installation and shall be suitable for further use.
The contactor shall be suitable for further service.
The risk of contact welding is recognized, in which case, the manufacturer shall indicate the measures to be taken as regards the maintenance of the equipment." The instructions on maintenance shall describe how the permitted contact welds can be broken apart again.

Note The coordination is at risk if the manufacturer's recommendations are not followed during use of a Short Circuit Protective Device (SCPD).

Advantage

- Short downtimes
- Low outlay for repairs

Disadvantage

- The costs of manufacturing the control panel are higher than with type of coordination 1 because larger switching devices shall be used

Utilization categories according to IEC 60947

Utilization categories for contactors specifies the nominal electrical performance of the contactor referred to a specific type of load

AC-1 duty-Non-inductive or slightly inductive

AC-2 duty-Starting of slip-ring motors

AC-3 duty-Starting of squirrel-cage motors and switching off only after the motor is up to speed

AC-4 duty-Starting of squirrel-cage motors with inching and plugging duty. Rapid Start/Stop.

Widely used:

AC-1 duty

- This category applies to all AC loads where the power factor is more than 0.95.
- These are primarily non-inductive or slightly inductive loads, such as heating.
- Breaking the arc remains easy with minimal arcing and contact wear.

AC-3 duty

- This category applies to squirrel cage motors with breaking during normal running of the motor.
- On closing, the contactor makes the inrush current, which is about 5 to 7 times the rated full load current of the motor.
- On opening, the contactor breaks the rated full load current of the motor.

AC-11 –Auxiliary (control) circuits

Utilization categories according to IEC 60947

Utilization categories for switch disconnectors & Switch Fuse Unit

AC-20 -Connecting and disconnecting under no-load conditions
AC-21 -Switching of resistive loads, including moderate overloads
AC-22 -Switching of mixed resistive and inductive loads, including moderate overloads
AC-23 -Switching of motorloads or other highly inductive loads

IEC 60204-Clause 5.3.2 All our panels are provided with supply isolating device with utilizationcategory AC23

Selection & Functionality of Power components

Input Busbars either Aluminum /Copper/Busbar Type or Stud Type Terminal blocks-0.8 AL & 1.6 CU

MCCB/ACB for Incomer protection against Over current & Short circuit 1.1 / 1.5 In for ND/HD

Current transformer for measurement metering & for protection , Based on Burden -5VA ,10 VA ,15 VA PS class & 1A or 5A , Class of protection 1 or 0.5 accuracy

Power contactors for switching & Isolation, AC1 or AC3 type based on operations generally for VFD input AC1

Fuses for Short circuit protection aR-Semiconductor protection

Input Chokes : to protect the AC drive from transient overvoltage &also as current limiting devices to oppose rapid changes in current due to their impedance. 3% Impedance

VFD's for Speed control & protection of OC, OL, SC, EF ,GF, Monitoring & control, selected based on Application Either HD / ND 110% /150% for 60sec

DC-link reactor to reduce the harmonic currents on the DC side & to reduce the risk of commutation failures by limiting the rate of rise of the DC line current at transient disturbances

Dynamic Braking Unit above 22kW for Regenerative application

Dynamic Braking Resistor for regenerative application

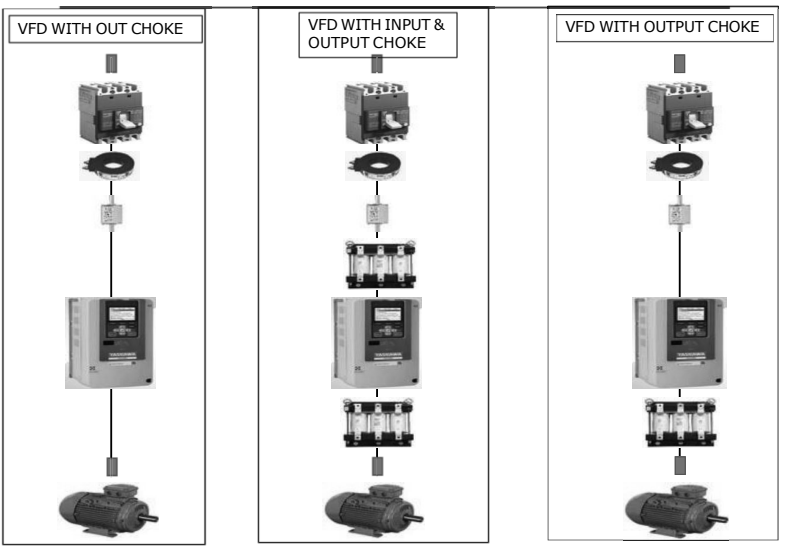
Output Chokes for protection against Voltage spikes cause due to VFD switching high frequency damages insulation of cable & motor winding, To reduce Bearing current due to longer cables . 3 % impedance & min 2khz & 160% Saturation

Power contactors for switching & Isolation, AC3type based on operations generally for VFD output AC3

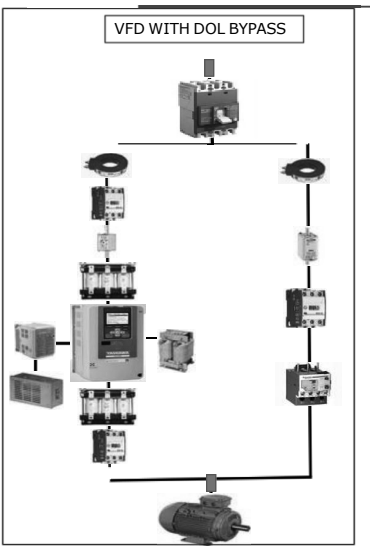
o/p Busbars: Aluminum /Copper Busbar Type or Stud Type Terminal blocks-0.8 AL & 1.6 CU

Motor

Different Types of Variants

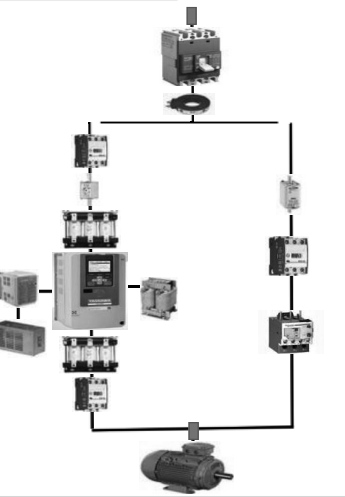


Different Types of Variants

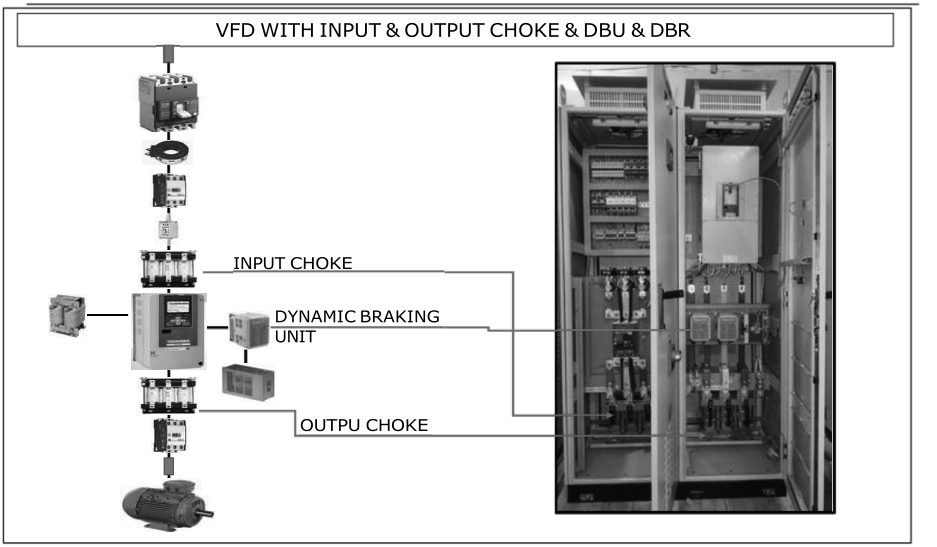


Different Types of Variants

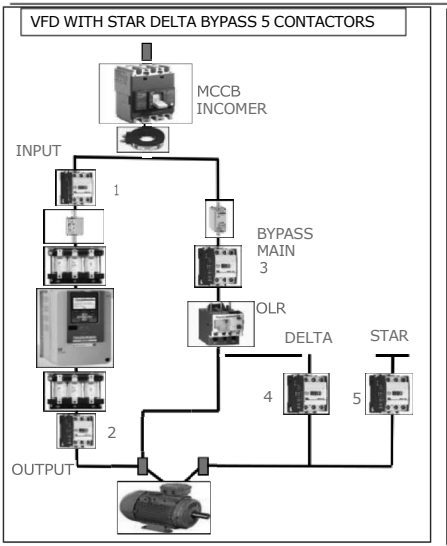
VFD WITH DOL BYPASS PANEL

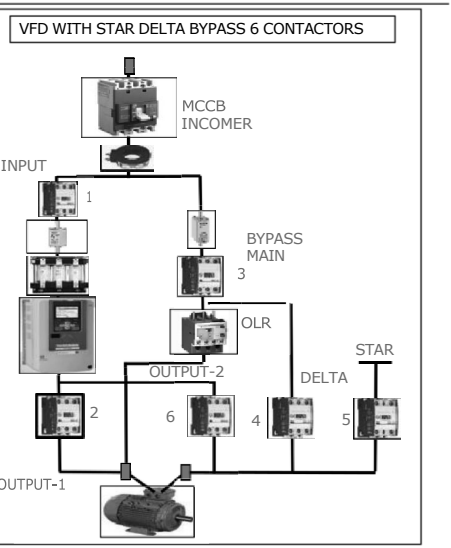


Different Types of Variants

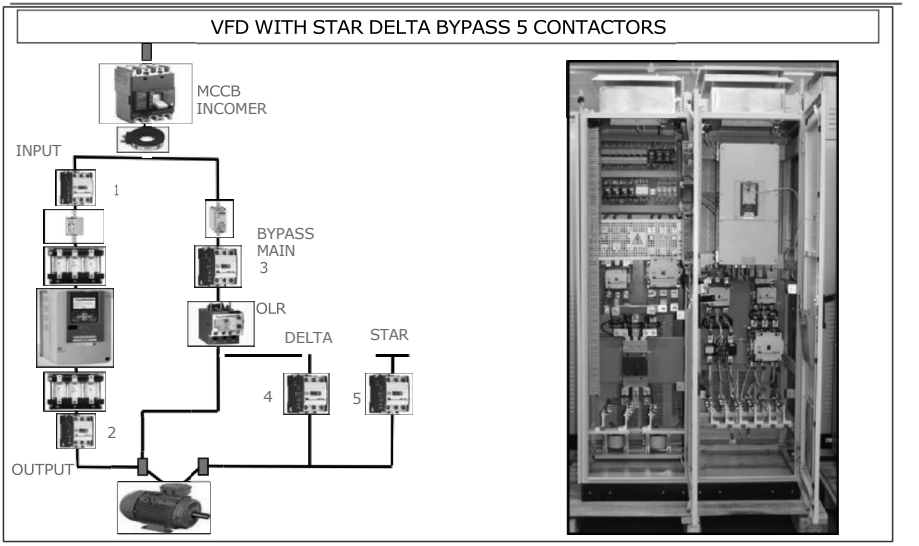


VFD & Star Delta 5 & 6 contactor logic

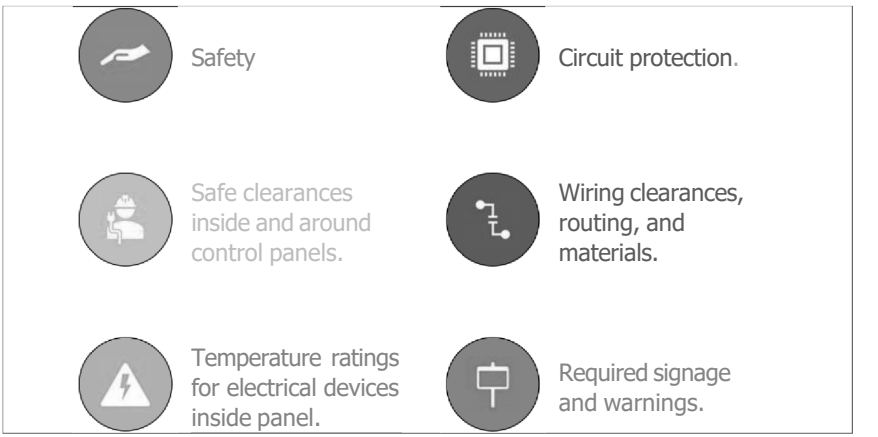




VFD & Star Delta 5 & 6 contactor logic



Panel Design According to IEC 60204 for safety standard



Control Panel Design Considering Electrical Safety Standards according to IEC 60204

The IEC 60204-1 electrical safety standards related to machine control panels must be considered.

- The power supply breakers, device locations, and electric-shock prevention for control panel design are described from the viewpoint of safety standards.
- Power Supply Cutoff (Breaker) Devices

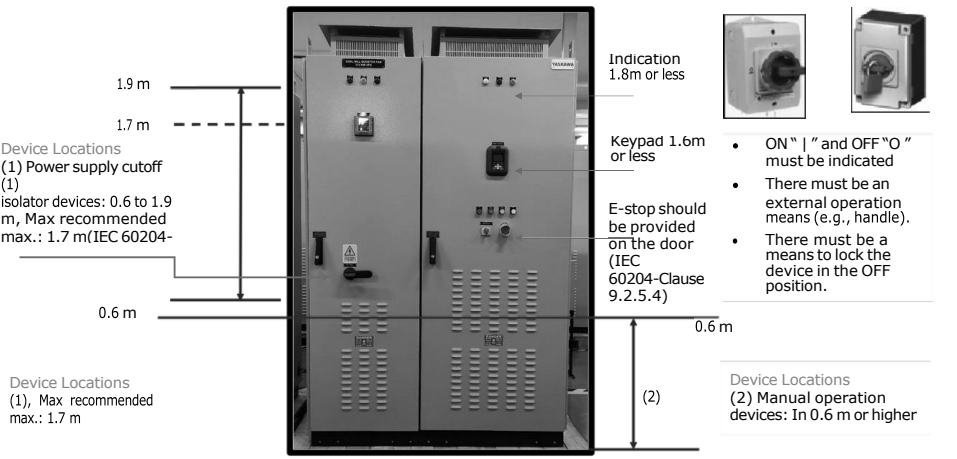
1 ON " | " and OFF "O " must be indicated
. There must be an external operation means (e.g., handle).
2 There must be a means to lock the device in the OFF position.
. There must be a suitable cutoff devices

3• Device Locations

.1 Power supply cutoff devices: 0.6 to 1.9 m, recommended max.: 1.7 m
4. Manual operation devices: 0.6 m or higher
.2 Terminals: 0.2 m or higher
. Devices that must be approached for periodic maintenance or
3 adjustments: 0.4 to 2.0 m

Control Panel Design Considering Electrical Safety Standards according to IEC 60204

The power supply breakers, device locations, and electric-shock prevention for control panel design are described from the viewpoint of safety standards.



Control Panel Design Considering Electrical Safety Standards according to IEC 60204

Device Locations
(4) Devices that must be approached for periodic maintenance or adjustments: 0.4 to 2.0 meters

Personnel safety

is ensured by Insulation of live parts by means of transparent polycarbonate & FRP sheets(IEC 60204-Clause 6.2)

Dimensions
All the Panel enclosuresare either 400mm 600mm 800mm or 900mm wide with dooropening of 120 degree. (IEC60204-Clause 11.3 &11.4)
Minimum required is 90 degree opening.

Input & Output terminal Locations
(3) : 0.2 m or higher
(IEC 60204-
Clause 6.4)control transformer neutral are earthed

IEC 60204-Clause 7.2.4)primary side all the transformers are protected by either fuse or MCB or MPCB

Control Panel Design Considering Electrical Safety Standards according to IEC 60204

□Operating handle of isolating device is located at the height between 0.6 m to 1.9 m (IEC 60204-Clause5.3.4)

□(IEC 60204-Clause 4.4.3)
The panels shall be run at full capacity from +5°C to +40°C

□ The panels are capable to operate at full capacity at altitude up to 1000 m above sea level
(IEC 60204 Clause 4.4.5)

□Panels shallprovide with supply isolating device with utilization category AC23 (IEC 60204-Clause 5.3.2)

□ panel shall be supplied with a Plug / socket for flexible cable supply (IEC 60204-Clause 5.3.2)

□At the output side drive provides protection to the motor against short circuit, over current, ground fault etc. (IEC 60204-Clause 7.3 to 7.9)

□All exposed conductive parts are bonded to the protective earth in the panel (IEC 60204-Clause 8)

□Control circuit voltage of the panels are either 230 volts or 110 volts. (IEC 60204-Clause 9.1.2)

□Control circuit is provided with the over current protection device in accordance with clause no. 7.2.4

Control Panel Component Colors as per IEC 60204 & IEC 60073

Colour coding for Push buttons

COLOUR	COMMAND	SYMBOL
RED	STOP	
GREEN	START	
YELLOW	SPEED INCREASE	
BLUE/BLACK	SPEED DECREASE	
RED	E-STOP –MUSHROOM HEAD PUSH TO ACTUATE AND TWIST TO RELEASE	
GREY BLACK WHITE BLUE	RESET	Blue, White, Grey, Black.

Control Panel Component Colors as per IEC 60204 & IEC 60073

Colour coding for Indications lamps

COLOUR	CONDUCTOR	SYMBOL
RED	R – PHASE CIRCUIT INDICATION LAMP	
YELLOW	Y – PHASE CIRCUIT INDICATION LAMP	
BLUE	B – PHASE CIRCUIT INDICATION LAMP	
GREEN	RUN INDICATION	
WHITE	READY INDICATION	
RED	STOP INDICATION/ CONTROL SUPPLY ON	
AMBER	TRIP INDICATION	

Note : Indication colourmay vary depending upon manufacturer

Control Panel Component Colors as per IEC 60204 & IEC 60073

Colour coding for

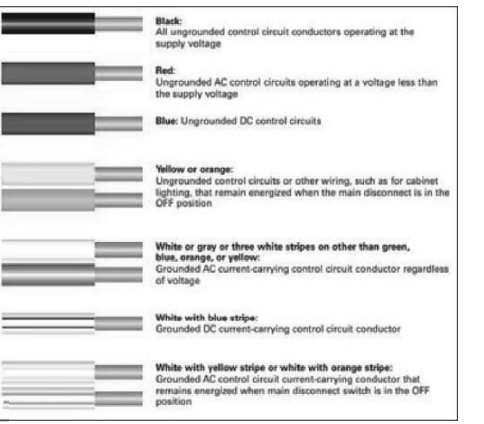
Wire Colors (IEC 60204-1)		
Applicable conductor	Color	
Ground (earth) circuit	Green-yellow spiral	
Power neutral circuits	Light blue	
Primary power circuit	Black	
DC control circuit	Blue	
AC control circuits	Red	
Excepted circuits (e.g., interlock circuits)	Orange	

Controlcable sizes

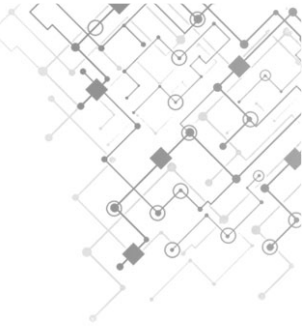
- 1.5 sqmmfor control
- 1sqmmfor DC VFD inputs
- 2.5 sqmmfor CT circuit
- 4 sqmmor minimum 2.5 sqmmfor earthing components & panel door

Cable are identified at termination in accordance with schematic drawings. (IEC 60204- Clause 13.2)

Control cables are identified by color coding for different voltages as well as ferrule numbers.

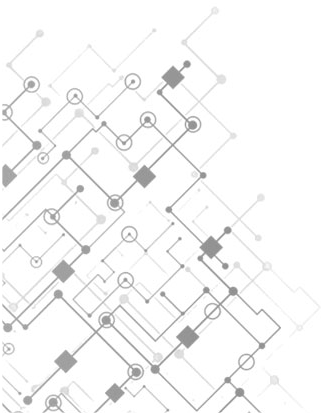


Note : Color may vary depending upon manufacturer as per IEC 61439-1



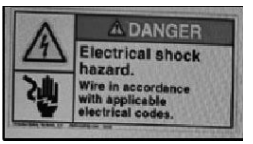
Control Panel component color Considering Electrical Safety Standards according to IEC 60204

		MACHINE STATUS INDICATED BY INDICATOR COLOR		GENERAL MEANING OF OPERATION DEVICE (OPERATION PART) COLOR		GENERAL RULES	
COLOR	MEANING	DESCRIPTION	OPERATOR ACTION	DESCRIPTION	APPLICATION EXAMPLE	HUMAN OR ENVIRONMENTAL SAFETY	PROCESS STATUS
Red	Emergency	Hazardoussituation	Immediate action for the hazardous situation	Actuate in the event of a hazardous situation or emergency	● Emergency stop ● Stopping or turning OFF for emergency stop ● Initiation of emergency function	Hazard	Emergency
Yellow	Caution	Abnormal situation An impending critical situation	Monitoring and/ or intervention	Actuate in the event of an abnormal condition	● Intervention to suppress abnormal condition ● Intervention to restart an interrupted automatic cycle	Caution	Abnormality
Green	Normal	Normal situation	No specific action required	Actuate to initiate normal conditions	● White is the most suitable color for a device (operation part) for starting or turning ON something, but green is also acceptable.	Safe	Normal
Blue	Mandatory	Indication of situation requiring operator action Other situations	Required action	Actuate for a condition requiring mandatory action	● Reset function	Mandatory	
White	Neutral	Situation in which the use of red, yellow, green, or blue does not seem appropriate	Monitoring	Initiation of functions	● White can be used for any function other than an emergency stop		



IEC 60204 For Warning signs, Nameplates, Markings

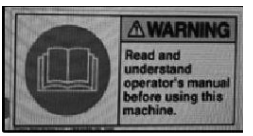
WARNING SIGNS , NAMEPLATES, MARKINGS, AND IDENTIFICATION PLATES TO BE PROVIDED FOR COMPONENTS INSIDE THE PANEL AS WELL AS ON DOOR. (IEC 60204-CLAUSE 16)



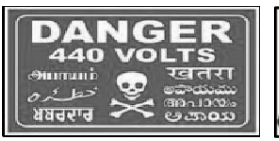
CAUTION

NAME PLATE

DANGER



WARNING



DANGER

CAUTION

IEC: 60529 for Panel Ingress protection

Ingress protection :

Electrical enclosures are rated based on their ability to withstand a varying degree of environmental elements, including dust, water, and ice.

Ingress Protection (IP) ratings are developed by the European Committee for Electro Technical Standardization .

The International Electrotechnical Commission (IEC)has developed rating system, the IP **standard, which stands for Ingress Protection.**

In the United States, the National Electrical Manufacturers Association developed the NEMA rating for classifying an enclosure's level of protection from those environmental elements.

The standard format is "IP' followed by two numbers which designate the level of protection. The first digit, which ranges from 1-6, specifies the level of protection from solids, and the second digit, which ranges from 1-8, specifies the level of protection from water. The higher the number is, the greater the level of protection. For instance, an enclosure with a rating of IP10 would offer less protection than an enclosure that is rated at IP54.

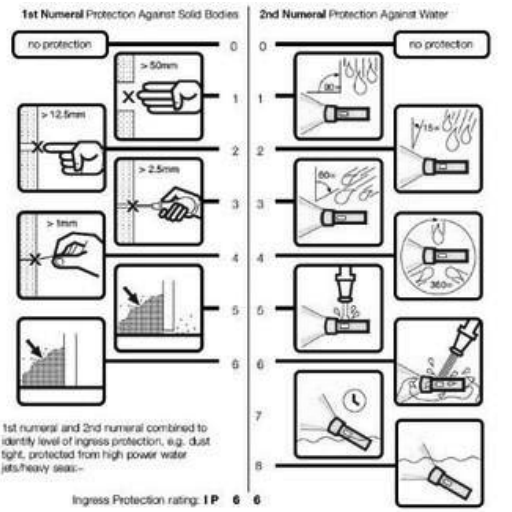
IEC: 60529 for Panel Ingress protection

Ingress protection :

First Number	Protection From Solid Objects	Second Number	Protection From Water
0	No protection	0	No protection
1	Protected from solid objects over 50mm	1	Protected from vertically falling drops of water
2	Protected from solid objects over 12mm	2	Protected from direct sprays of water up to 15 degrees from vertical
3	Protected from solid objects over 2.5mm	3	Protected from direct sprays of water up to 60 degrees from vertical
4	Protected from solid objects over 1mm	4	Protected against sprays from all directions - limited ingress permitted
5	Protected from dust-limited ingress	5	Protected from low pressure jets of water from all directions - limited ingress permitted
6	Totally protected from dust	6	Protected against strong jets of water - limited ingress permitted
NA		7	Protected from the effects of temporary immersion between 15cm and 1m
NA		8	Protected against long periods of immersion under pressure

IEC: 60529 for Panel Ingress protection

Ingress protection :



VFD PANEL ENCLOSURES designed for Degree of pollution

DEGREE OF PROTECTION -refers to the pollution present in environmental conditions in which the switchgear or the control panel can operate.

- There are 4 pollution degrees defined by IEC/EN 60664-1 standards.
- Pollution degree 1 is the cleanest and pollution degree 4 is the harshest environment
- Degree of pollution 3 can be regarded as standard in industry.

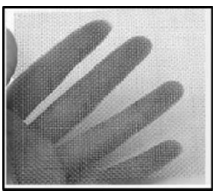
Office & laboratories	Industries with less dust	Industries	Out door installation	Out door
1	2	3	4	4
IP-00 VFD PANEL	IP-42	IP-54	IP-55	IP-55
				

IEC: 60529 for Panel Ingress protection

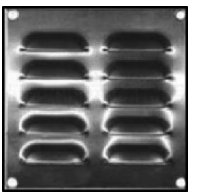
IP 42 ENCLOSURE SPECIFICATION

- Suitable for Indoor Installation with greater 1 mm dust
- Protection from foreign particle & dust environment greater than 1 mm
- Designed with Front doors,rear & side covers for easy maintenance
- Louvres for Air inlet required with less than 1mm holes
- Canopyfor Fan installation& also required for Air exhaust .
- Mesh with less than or equal to 1mm holes
- Control panel with side & rear covers for

  easy maintenance and service from all the sides



1 MM SS MESH



15 DEGREE PUNCHED AIR INLET LOURES

IP 42-VFD PANEL

IEC: 60529 for Panel Ingress protection

IP42 Panel Enclosures Advantages

- Sufficient Cooling & Better air circulation
- Canopy allows hot air exhaust and panel temperature within the limits.(Natural ventilation)
- More louvres allow air natural without any requirement of forced cooling.(Natural convention
- Drive deration not required , decreases the VFD capacity, panel size , cost reduction
- Suitable For cabinet mounting with proper air inlet and exhaust
- No Requirement of AC , reduced additional space & cost
- Suitable for Indoor control rooms and closed rooms
- The temperature is equalized throughout the enclosure.
- Control panel with side & rear covers for easy maintenance and service from all the sides.
- Higher efficiency,
- Lower heat losses
- Lesser thermal failures
- More Reliability and rigid

IP 42-VFD PANEL

EC:60529 for Panel Ingress protection P54 Panel Enclosures Spec & Advanatages

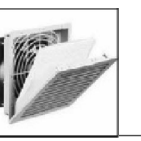
- Suitable for Indoor control rooms .
- Suitable for filtering fine dust material entering VFD panels
- Control panel with side & rear covers for easy maintenance and service from all the sides.
- Dust free control panels with longer lifetime of component

Disadvantages

In Sufficient Cooling & improper air circulation
Forced air exhaust is necessary (forced air ventilation)
Insufficient air due to absence of louvres demands forced air cooling (Forced convention)

Drive deration requires,
Increase drive capacity , increases size , increases cost
Not Suitable For cabinet mounting with proper air inlet and exhaust
Requirement of AC , increase additional cost and space
The temperature may increase inside the enclosure.
Lower efficiency,Higher heat losses, Higherthermal failures

IP 54-VFD PANEL WITH IP 54 AIR FILTERS



IEC: 60529 for Panel Ingress protection

IP54 ENCLOSURE WITH AC

- Suitable for Indoor Installations
- Protection from dirt, dust environment
- Designed with Single door for
- protection against water
- No Air inlet & Air exhaustlouvres / Filters/ ducts /Canopy required
- Air cooling with AC unit
- Single door for components mounting
- Shell type construction for protection against water & dust
- Base channels provided with open space for cable laying

IP 54-VFD PANEL WITH AC UNIT

IP55 ENCLOSURE

IP-55 Suitable for outdoor Installation Protection from Water & dirt, dust

Shell type design with top Rain hood canopy

Shell type construction for protection against water & dust

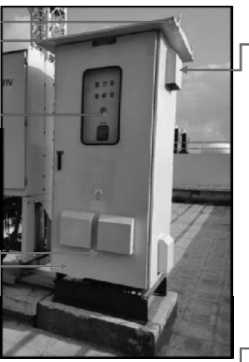
Viewing windows for status monitoring

Outside door protection from dust

Air inlet ducts provided with IP54 Air filters

90 degree bent Frames to avoid water entering inside

Base channels provided with open space for cable laying



Air exhaust ducts provided with fans & IP54 Air filters

Inside door for components mounting

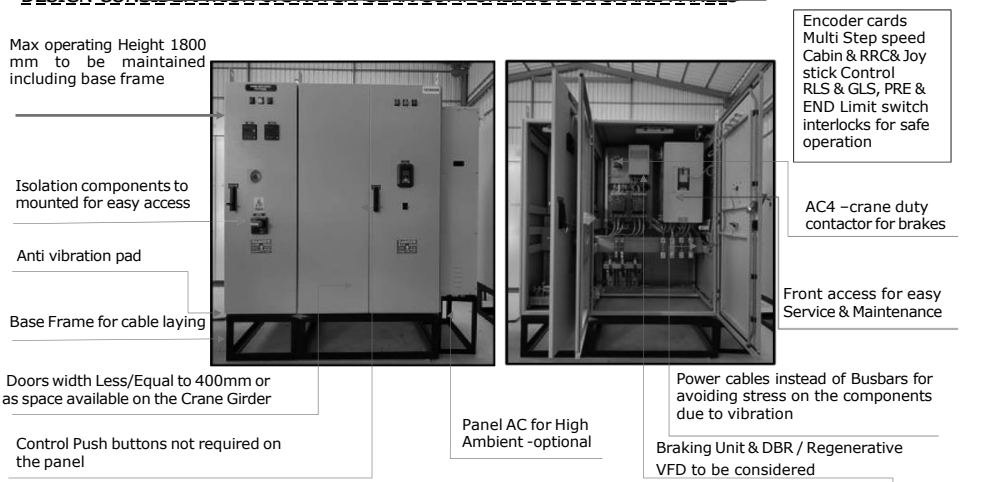
Designed with double door for protection against water & dust

Exhaust fan for air outlet

IP 54-VFD PANEL GENERAL ARRANGEMENT

Best Practices for Designing Crane Panel Enclosure

DESIGN CONSIDERATION & SWITCH GEAR COMPONENTS FOR CRANE PANELS



IP 54-WITH AC FOR CRANE VFD PANEL GENERAL ARRANGEMENT

IP55 ENCLOSURE WITH AC UNIT

IP55 ENCLOSURE

- Suitable for outdoor open area Installation
- Protection from Water & dirt, dust
- Designed with Double door for protection against water & dust
- AC for Air cooling is must
- Inside door for components mounting
- Shell type construction for protection against water & dust

IP 55-VFD PANEL WITHAC UNIT

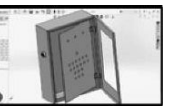
Design & Process Tools for Panel Enclosures

- Design software for the Mechanical drawing preparation
  - AutoCAD & Solid works -3D software
- Design software for the for the Electrical drawing preparation
  - ECAD & EPLAN software

Fabrication Process Tools : _

- High Speed & High Precision with Time efficient & Best Quality
  - CNC Punching machines & Laser cutting machines
- Powder Coating:
  - Advanced 7 tank & 9 Tank Process
- for better finish & protection against different environmental conditions


AutoCAD Mec

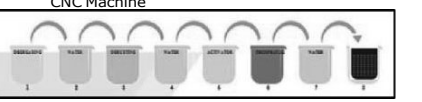

Solid works


AutoCAD Elec


Eplan


CNC Machine


Laser machine

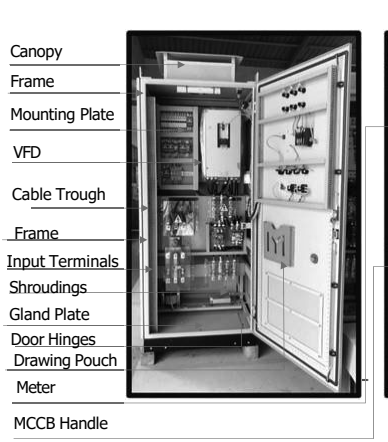

Powder coating 7 & 9 Tank Process

STANDARD PANEL ENCLOSURE SPECIFICATION

Sl no	Specification	
1	All Dimensions	are in mm
2	Type of design	single frontor double front
3	Mounting arrangement	floor or wall mounting
4	Enclosure	Ip-xx Eg-IP 42 & IP 54
5	Cable Entry	Top Or Bottom
6	Cable Exit	Top Or Bottom
7	Sheet Steel	CRCA/Al/SS Etc
8	Frame	2.5 Mm CRCA
9	Front Door & Rear Door	2mm CRCA
10	Rear Cover	1.6mm Mm CRCA
11	Side Cover	1.6mm CRCA
12	Mounting Plate / Support Channels	3mm CRCA
13	Gland Plate	3mm CRCA

Slno		
14	Specification BaseFrame	3mm Crca
15	Access	Front Hinged Door Rear Bolted Type Cover Or Rear Hinged Door
16	Panel Lifting	Eye" Bolt For Single Cubical Only 'L' Angle To Be Provided For More Than 2 Cubical Coupling Panel
17	Shade	Interior/Exterior : Ral Xxxx7035/7032 & as per customer requirement
18	Mounting Plate	Ral 2000 (Semi Glossy)
19	BaseFrame	Ral 9005 Jet Black
2	Finish	Structure Finish
0	Inscriptions	Anodized Aluminumengraved Plate
21	EarthBus	Busbar Size Tinned Cu.
22		

STANDARD PANEL ENCLOSURE COMPONENTS



Internal General Arrangement

General Arrangement

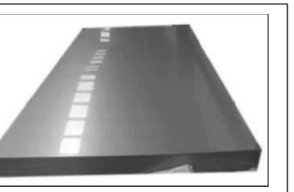
Side & Rear View

Panel Enclosures Fabrication Material

SheetMetal used for Fabrication of Enclosures

Types of Sheet Metal:

1. CRCA SHEET (Cold Rolled Close Annealed)
2. GI SHEET(Galvanized Iron)
3. SS SHEET (Stainless Steel)
4. ALUMINUM SHEET



CRCA SHEET :

Used widely due its mechanical & Physical properties surface finish ,Dimensional tolerance& Cost

Weight calculation formula-

W x L x T x specific gravity(For steel 7.86X10-6)

Where W-Width ,L-Length T-Thickness

Process of Fabrication & Manufacturing of Panel Enclosures

Fabrication Process

Bending

Cutting & Punching

Welding

Manufacturin

Assembl

Powder coating

Grinding &

Panel Enclosures Powder Coating Process

Powder coating –
Powder coating is a type of coating that is applied as a free flowing, dry powder.

7 tank process-

1. Degreasing –Removal of oil and grease .
2. Water wash-
3. Derusting -removal of Rust from the surface.
4. Water wash
5. Surface activation-This gives more compact and uniform coating to phosphate.
6. Phospating –This forms coating of 4-6 micron on the clean surface.
7. Passivation-This will seal the pores of phosphating.

1.Base material: Sheet Metal

	Standard	IS-513

1.Powder coating process specification

S.No.	Inspection Check point	Acceptance Criteria
1	Powder coating thickness	60-120 Micron
2	Process type	7 Tank Process

Standard Colour Codes Of VFD Panels

Standard Colour Codes of Panels

RAL 7032
Structured
Finish

IS 631
Structured
Finish
BSP

RAL 7035
Structured
Finish

RAL 7035
Semi Glossy
Finish
Rittal

IS 502 Semi
Glossy
Finish NTPC

VFD PANEL ENCLOSURES-IP designed Considering IEC

VFD PANEL ENCLOSURES WITH VARIOUS IP

IP 55
OUTDOOR
PANEL

IP 42
INDOOR
STAND ALONE
PANEL

IP 54
INDOOR
STAND ALONE
PANEL

IP 54
INDOOR
LINEUP PANEL

IP 54
OUTDOOR
STAND ALONE
PANEL

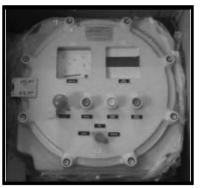
Types of LCS Panel Design

ALUMINIUM DIE CAST IP 65

CRCA WITH IP 55 DOUBLE DOOR WITH VIEWING WINDOW

FRP WITH IP 65

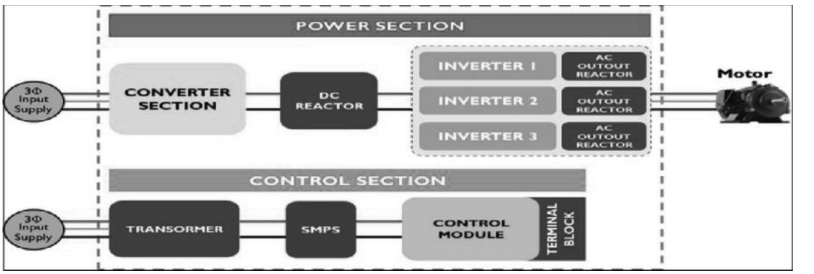
CRCA with IP 55



ALUMINIUM CAST ALLOY WITH IP 66 FLAME PROOF PENDENT IEC-60079

CRCA with IP 55

SPECIFICATION



Same for both 400V and 690V Class

0466	CONVERTER 1	INVERTER 466A
0900	CONVERTER 1	INVERTER 466A, INVERTER 466A
1350	CONVERTER 2	INVERTER 466A, INVERTER 466A, INVERTER 466A
1800	CONVERTER 2	INVERTER 466A, INVERTER 466A, INVERTER 466A, INVERTER 466A
2250	CONVERTER 3	INVERTER 466A, INVERTER 466A, INVERTER 466A, INVERTER 466A, INVERTER 466A

CIMR	-	A	D	4	H	2250	A
Drive		A1000 SERIES	INDIA	VOLTAGE CLASS	HHP SERIES	AMPS RATING	INPUT
				4: 415VAC		0466	A: 6 Pulse
				6: 690VAC		0900	B: 12 Pulse
				6: 575VAC		1350	
						1800	
						2250	

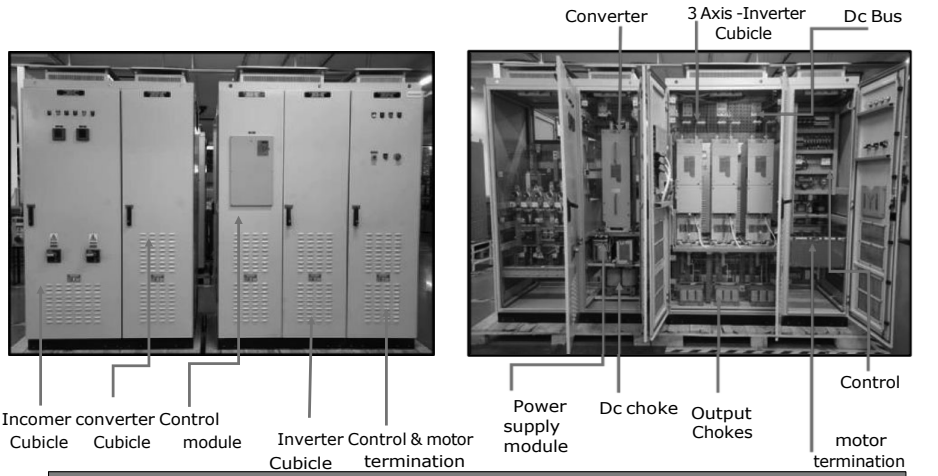
PANEL DESIGN REQUIREMENTS.

AXIS	1	2	3	4	5
Amp	0466	900A	1350	1800	2250A

- No of AXIS-1,2,3,4 & 5 in 415V/690V
- Converter cubicle.
- Inverter cubicle.
- Door mounting control borard
- Power supply & control supply transformer
- DC & AC output chokes
- Cables
- 50 Pin connector .
- Channels top & bottom
- Rails for Inverter & converter wheel movement.
- DC Bus
- Input & ouputterminals
- Front & rear door access for easy maintenance

IP 42-MULTI VFD PANEL GENERAL ARRANGEMENT

SYSTEM ENGINEERED VFD PANEL



IP 42-VFD PANELGENERAL ARRANGEMENT

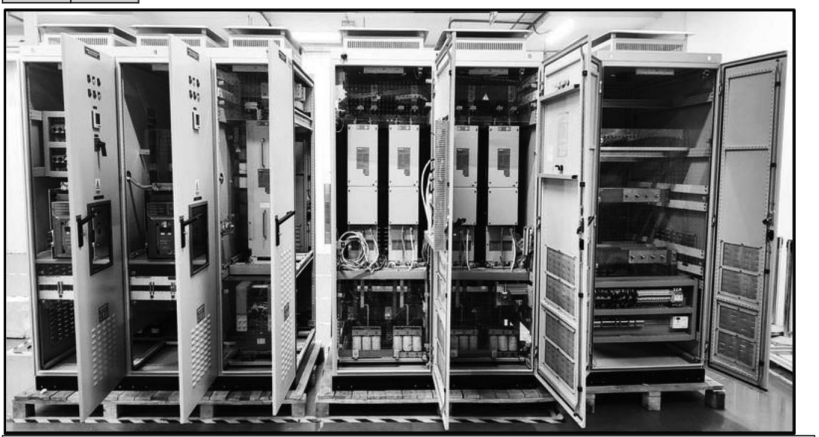
System Engineered VFD Panel

AXIS	3
Amp	1350

IP 42-3 AXIS MULTI VFD PANEL GENERAL ARRANGEMENT

SYSTEM ENGINEERED VFD PANEL

AXIS	4
Amp	1800



IP 42- 4 AXIS MULTI VFD PANEL GENERAL ARRANGEMENT

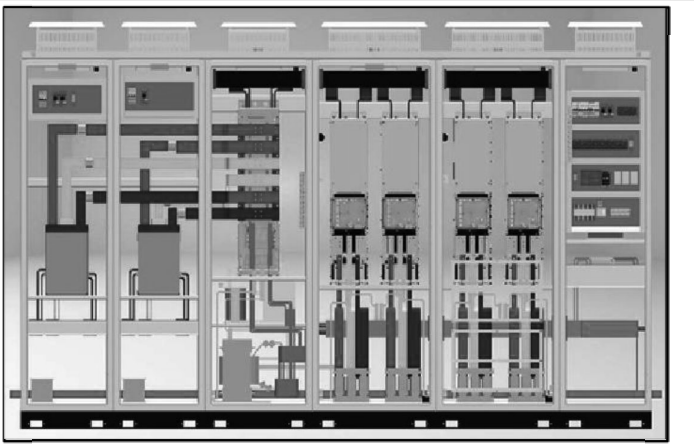
SYSTEM ENGINEERED VFD PANEL

AXIS	5
Amp	2250A

IP 42-5 AXIS MULTI VFD PANEL GENERAL ARRANGEMENT

SYSTEM ENGINEERED VFD PANEL

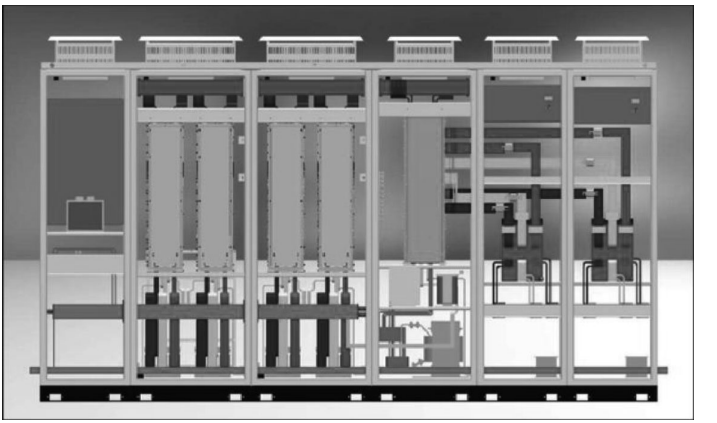
INTERNAL VIEW FOR BUSBAR CONNECTIONS & ASSEMBLY



IP 42-4 AXIS MULTI VFD PANEL GENERAL ARRANGEMENT

SYSTEM ENGINEERED VFD PANEL

INTERNAL REAR VIEW FOR BUSBAR CONNECTIONS & ASSEMBLY

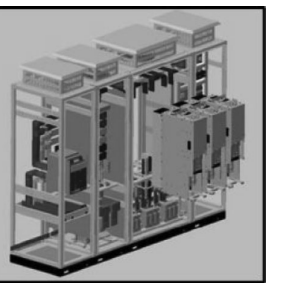


IP 42-4 AXIS MULTI VFD PANEL GENERAL ARRANGEMENT

Retrofit Solution for PANELS

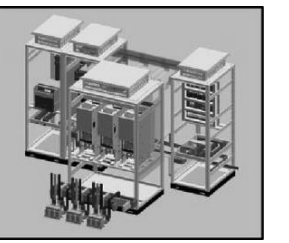
Retrofit Solution with Existing VFD's G5 SLIM TO New Updated Version Models

Retrofit Solution with Existing Any other Make VFD's with VFD module Replacement



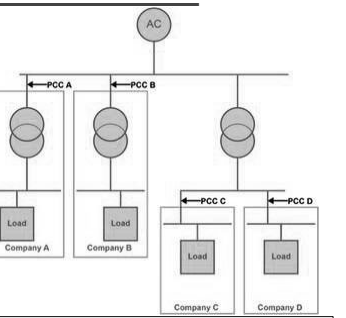
Retrofit Solution with Cubicle Semi modular solution

Retrofit Solution with complete Panel Replacement or Only Cubicle



Panel Designed for Low Harmonic Distortion as Per IEEE 519 & IEC 61000

IEEE 519 & IEC 61000
Total Harmonic Distortion

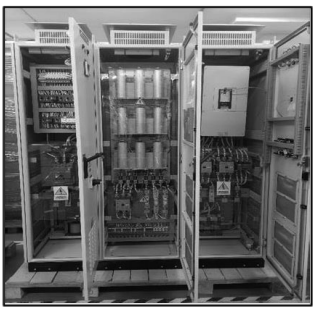


- VFDs shall comply with the latest edition of IEEE 519 & IEC 61000
- For both individual as well as total harmonic voltage and current distortion limits.
- The Voltage and Current limits shall be applicable at the Point of Common Coupling (PCC),
- which shall be the MCC/ Switchgear/ from which the VFD system is fed.

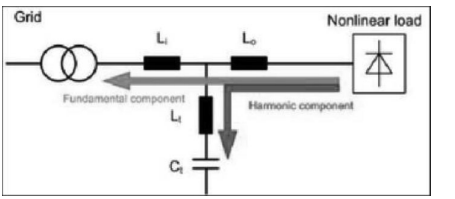
- IEC 61800-2:2021applies to adjustable speed electric AC power drive systems, which include semiconductor power conversion and the means for their control, protection, monitoring, measurement and the AC motors.

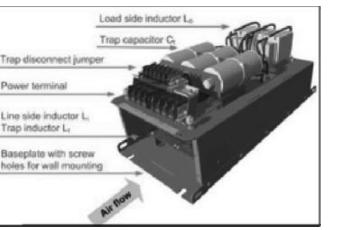
Panel Designed for Low Harmonic Distortion as Per IEEE 519 & IEC 61000

Low Harmonic Solution with PHF



- Panel with Input Passive Harmonics filters for less than 5% Harmonics with Standard VFD
- Low cost economic design



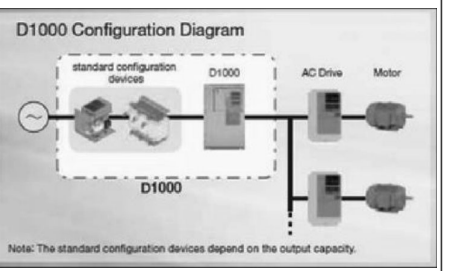


Panel Designed for Low Harmonic Distortion as Per IEEE 519 &

IEC 61000

Low harmonic & Regenerative solution with D1000 VFD for Crane

- Reduced Footprint with Common DC optimized Solution
- Eliminating Braking Choppers & DBR's
- Energy saving with Regenerative solution

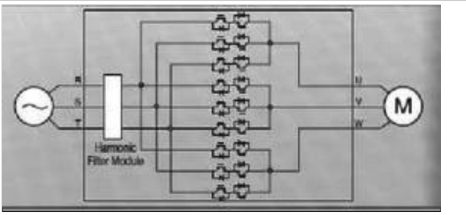


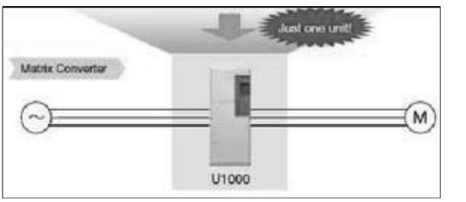
- Power regeneration with energy savings.
- Low harmonics
- Improved Power factors
- Connecting Multiple units with Common DC

Panel Designed for Low Harmonic Distortion as Per IEEE 519 & IEC 61000

Low harmonic & Regenerative solutionwithU1000 VFD

- Reduced Footprint
- weight reduces
- Inbuilt Harmonic filter & Fuse
- Energy saving with Regenerative solution



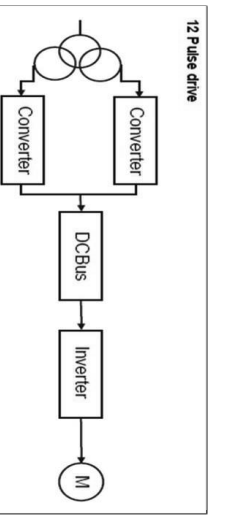


- Wiring Reduced
- Low power loss
- Eliminate DBR & Choppers

Panel Designed for Low Harmonic Distortion as Per IEEE 519 & IEC 61000

Low Harmonic Solution With 12 pulse

- Panel designed for 12 pulse
- Configuration for less than 12% Harmonics with Standard VFD
- Low cost economic design



Bus Bar Design as per IEC/DIN

bus bar calculation are based onIEC/DIN43670 for aluminum bus bar and DIN 43671 for Copper bus bar

I cont.= I table*K1*K2*K3*K4

Wher e

K1 = Correction factor for Temperature Rise.
K2 = Correction factor for Enclosure.
K3 = Correction factor for Proximity effect.
K4 = Correction factor for Altitude.

BUS BAR CLEARENCE AS PER IS: 4237-967

All our bus bar design calculation are for following conditions:

- Ambient temperature 45 degree
- Bus bar temperature Max 90 degree
- Gap between same phase bus bar equal tobus bar thickness
- Bus bar are designed for short circuit withstand

Aluminium Bus Bar Selection As Per Load Current

Rated Current Of Busbar = Busbar W *Busbar T * K1 * K2 * K3 * K4

System Load Current = 3000A

Selected Busbar Size = 2R * 200 * 10 = 4000 SQMM

Rated Current Of Busbar = 4000* 0.94 * 0.85 * 0.95 * 1 = 3050A

System Load Current = 3000A

Selected Busbar Rated Current = 3050A

K1 = 1-(θ°Cx α)Correction factor for Temperature Rise.
θ = Temp difference = 50°C –35°C = 15,
α = Resistance-Temp. Coefficient for Al. Bus= 0.00403
K1 = 1-(15 x 0.00403) = 0.94

K2 = Correction factor for Enclosure.
As perbus barmanufactures, K2 Factor will be 0.85

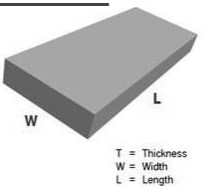
K3 = Correction factor for Proximity effect.
As perbus barmanufactures, K3 Factor will be 0.95

K4 = Correction factor for Altitude.
If no altitude, K4 Factor will be 1

Bus bar Sizing & Selection

Busbar cross-section area per phase (A)

= Bus width x Thickness x Length x No. Of Busbar per phase
= 75 x 10 x 500 x 2
= 750,000 mm



Weight of Metal = Metric density (g/cm3) x T x W x L

Specification of metals	Aluminium	Copper
Density, g/cm3	2.7×10-3	8.93×10-3
Busbar Types		

Weight of Aluminium: 2.7×10-3x10x75x500 = 1.039kg

Weight of Copper : 8.9×10-3x10x75x500= 3.3 kg

Bus bar Sizing & Selection

Bus bar calculation for short circuit withstand capacity of busbars

*S = I/∞ √(t/ΔΘ)

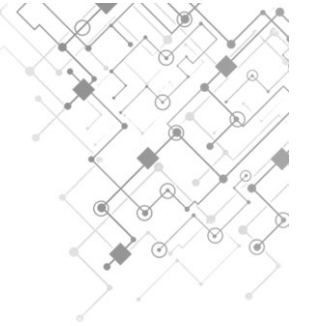
where
S= Cross –sectional area expressed on mm2,
I= rms value of the current in amperes;
∞= a factor expressed in A/mm2 (S/°C)1/2
and has the following values
13 for copper ; 8.5 for Aluminium
4.5 for Iron ; 2.5 for Lead
t= operating time expressed in seconds;
ΔΘ= temperature rise, expressed in °C; it may normally assume the following values
120 °C for insulated conductors
180 °C for uninsulated conductors

Calculation for Aluminiumbus bar cross section for 25KA

Short circuit .....25KA for on second

S = 25 x 1000 /8.5 √(1/120)
= 2941 x 0.0912

MinmumAluminium busbar cross section = sq.268mm



Earth Busbar Sizing & Selection

Earth conductor sizePE measured in Sq.mm can be calculatedfrom:

$$\frac{\sqrt{I_{fault}^2} \times t_{(s)}}{k}$$

$$A = \frac{\sqrt{50000} \times 1}{205}$$

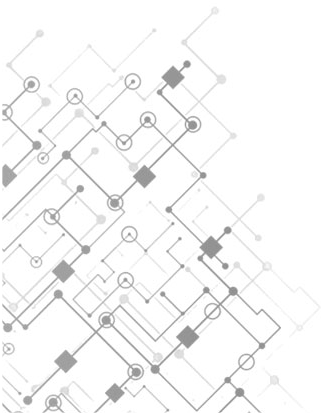
$$A = 240 \text{ sqmm}$$

Where:

I^2_{fault} = fault current (A) = 50KA
t(s) = operating time (s) = 1 Sec
k = constant of the material =205

The constant of the material can be read from the table below

Mater ial	K-Material Constant
GI	80
Copper	205
Aluminium	126



Bus bar Design as per IEC/DIN/IS

Temperature :
Maximum Permissible Temperature Rise for Busbars with bolt -connected devices as per IEC 62271 -1

MATERIAL	DI-ELECTRIC MEDIUM	MAXIMUM PERMISIBLE TEMPERATURE(*C).	TEMPERATURE RISE ABOVE 40*C AMBIENT (C)
Bare copper/Bare Aluminium& Alloy	In AIR	90	50
Tin-coated	In AIR	105	6
Silver-coated or nickel-coated	In AIR	115	5 75

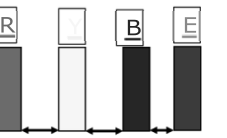
According to IEC-60439-1, table ,specifies Temperature rise limits :

- Amaximumtemperature rise of 105 K forbare copper bus bars and conductors shall not beexceeded.
- The105 K relates to the temperature above whichannealing of copper is likelyto occur.

Bus bar Design as per IEC/DIN/IS

BUS BAR CLEARENCE AS PER IS: 4237-967

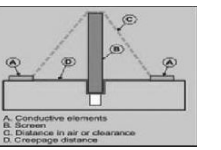
Voltage (V)	Phase to Phase Clearance in mm.	Phase to Earth Clearance in mm.
415	19	16
600	25	19
11000	127	77



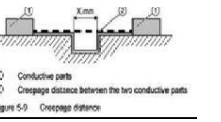
Yaskawa standard Busbar clearance maintained up to 25mm min

Clearance in Air (IEC 60204-Clause 12.7.5)

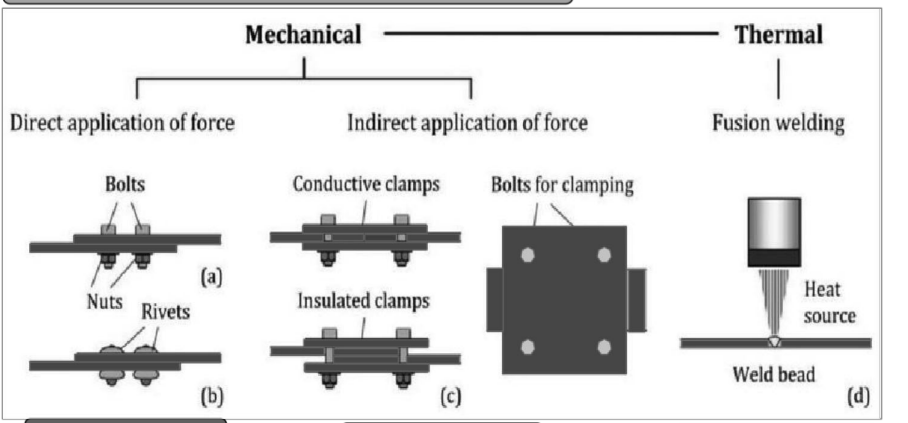
Minimumclearance of 14 mm between conductors in air, but if this is not possible, insulating barriers must be used.



Creepage distance is the shortest path on insulating material between conductive parts.
16mm minimum Creepage distance



Typesof Joints in Busbar distribution system.



Fastener specification

Fastener specification

S.No.	Inspection Check point	Acceptance Criteria
1	Material	Carbon steel quenched and tempered
2	Grade	8.8 C
3	Plating	Zinc Blue
4	Standard	ISO 898-1:1999

Bolts& Nuts for the Busbars recommended

GUIDE VALUES FOR THE CHARACTERISTICS OF THE SCREWS AND RECOMMENDED TIGHT					
Thickness of bar	I [A]		Width of bar (mm)	Min. number of screws	Screw Ø (mm)
	1 bar	2 or more bars			
5 mm	1.5	-	< 25	1	M8
	< 400	-	< 32	1	M10
				2	M6
	< 630	-	< 50	1	M12
				2	M10
				2	M8
	800	1250	< 80	4	M8
				4	M10
	1000	1650	< 100	4	M10
				2	M12
	1600	2000	< 125	3	M12
10 mm	-	2500	< 80	3	M12
	-	3200	< 100	4	M12
	-	4000	< 125	6	M12

Power Cable Lugs selection & Crimping process

Power Cable Lugs specification

S.No.	Inspection Check point	Acceptance Criteria
1	Base material	Copper >99.9%
2	Coating	Tin
3	Type	Heavy duty terminal With Inspection hole

Power Cable Lugs crimping process

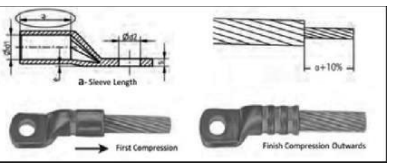
S.No.	Inspection Check point	Acceptance Criteria
1	Lug Size	Should be same as conductor
2	Lug Type	Heavy Duty type with conductor Inspection Hole
3	Crimping Die	Standard die chart. hydraulic
4	Crimping Tool	tool/pneumatic tool

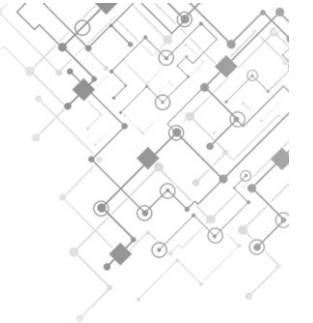
Base material: Aluminum alloy

1	Standard	IS:5082-1998

Base material: Copper

1	Standard	IS 1897-1983





Cable Selection

Power Cabling:

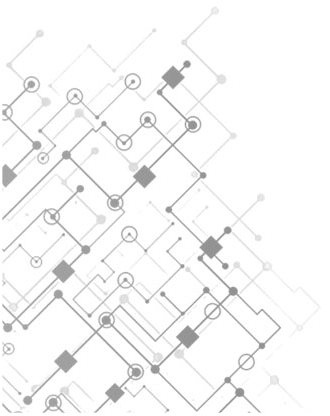
The basic parameters for cable selection are voltage rating, and the currentof the cable. Choosing

correct voltage rating is straight forward especially for input cables, as the required voltage strength is the supply voltage.

The load current of the drive system defines the required current capacity. Parameters affecting cross-

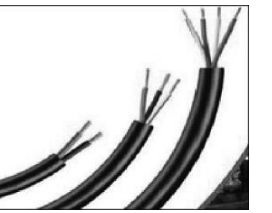
section dimensioning include: • Conductor material

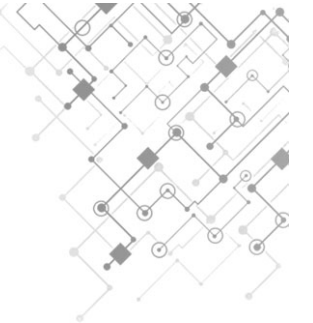
- Insulation material
- Installation method
- Ambient temperature
- Voltage drop
- Short-circuit protection
- Economic considerations



Cable Selection
Insulation material

- Insulation material determines the maximum temperature of a cable under normal operation and short-circuits.
- Cables used with drives should usually withstand at least 70 °C temperature. The most common insulation material, PVC, limits the temperature to 70 °C in normal operation. XLPE (P materials have 90 °C temperature limit.
- Common short-circuit temperature limits are 160 °C for PVC, and 250 °C for XLPE . Typically, this temperature is allowed for a maximum of 5 seconds in short-circuits.
- Temperature limits of cables should be verified case by case.





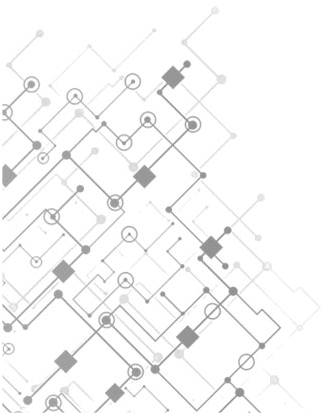
Cable Selection

Ambient temperature

The following table summarizes the correction factors for different ambient temperatures presented in the standards EN 60204-1 and IEC 60364-5-523. 40 °C is the default temperature for the standard EN 60204-1 and 25 °C for the standard IEC 60364-5

Correction factors for ambient temperatures

Insulation material	PVC		XLPE (PEX)
Standard	EN 60204-1	IEC 60364-5-523	
Ambient temperature	Correction factor		
10		1,15	1,11
15		1,10	1,07
20		1,05	1,04
25		1,00	1,00
30	1,15	0,94	0,96
35	1,08	0,88	0,92
40	1,00	0,82	0,88
45	0,91	0,75	0,84
50	0,82	0,67	0,79
55	0,71	0,58	0,73
60	0,58	0,47	0,68
65			0,62
70			0,56
75			0,48
80			0,39



Power Cable Selection

SINGLE CORE / MULTI CORE INDUSTRIAL CABLES AS PER IS 694 - 2010
VOLTAGE GRADE UP TO 1100 VOLTS

TABLE NO.1

POLYCAB BARE COPPER CONDUCTOR, PVC INSULATED UNSHEATHED 1100 V, SINGLE CORE INDUSTRIAL WIRE AND CABLE FOR PANEL BOARD AS PER IS : 694 - 2010 WITH ISI MARK (UP TO 50 SQ.MM)

Nominal Area in Sq. mm.	Max. DC Resistance Ohm/Km at 20°C	Nominal Insulation Thickness in mm.	Outer Diam (Approx)	Current Rating in Amps.	Nominal Area in Sq. mm.	Max. DC Resistance Ohm/Km at 20°C	Nominal Insulation Thickness in mm.	Outer Diam (Approx)	Current Rating in Amps.
0.50	39.00	0.60	2.1	4	70	0.272	1.4	13.44	215
0.75	26	0.60	2.27	7	95	0.206	1.6	15.46	260
1.00	19.50	0.60	2.44	12	120	0.161	1.6	17.16	305
1.50	13.30	0.60	2.66	16	150	0.129	1.8	19.08	355
2.50	7.98	0.70	3.27	22	185	0.106	2.0	21.2	415
4.00	4.95	0.80	3.99	29	240	0.0801	2.2	24.12	500
6.00	3.300	0.80	4.52	37	300	0.0641	2.4	27.04	585
10.00	1.910	1.00	5.9	51	400	0.0486	2.6	30.5	695
16.00	1.210	1.00	7.0	68	500	0.0384	2.8	34.96	790
25.00	0.780	1.20	8.77	86	630	0.0287	2.8	37.98	905
35.00	0.554	1.20	9.67	110	800	0.0224	3.2	43.72	1050
50.00	0.386	1.40	11.44	145	1000	0.0178	3.2	47.72	1185

NOTE : Industrial cables above 50 Sq. mm are not covered by IS : 694 but are as per IS. 2465. The conductor will be multi-standed as per class 5 of IS 8130 : 1984

Cable Selection

UNINYVIN CABLES					
Uninyvin Cable	Size(area)	Conductor Diameter "Max"	Overall Diameter "Max"	Conductor Resistance at 20°C "Max"	Max Current Rating "Amps"
Core	"Sq. mm"	"mm"	"mm"	" Ω/ 900m"	BS-G-177
22	0.347	0.838	2.00	49.660	11
20	0.566	1.04	2.30	30.950	14
18	0.966	1.32	2.50	17.820	18
16	1.17	1.55	2.80	14.700	21
14	2.05	1.95	3.40	8.410	31
12	3.22	2.43	3.80	5.350	43
10	5.33	3.15	5.00	3.230	61
8	8.76	4.24	6.30	1.970	87
6	13.3	5.54	7.50	1.300	115
4	21.5	6.90	9.30	0.802	160
2	33.3	8.76	11.00	0.517	200
1	40.7	9.75	12.20	0.423	220
0	53.0	11.0	13.70	0.325	240
00	68.3	12.4	15.40	0.252	270
000	84.2	13.9	16.90	0.204	300
0000	109	15.6	18.70	0.158	350

De-rating Factors of Nyvin Cables for Different ambient

Ambient Tem. °C	40	45	50	55	60	65	70	75	80	85	90	95	100
De rating Factors	1.0	0.96	0.92	0.88	0.83	0.78	0.75	0.73	0.68	0.62	0.53	0.48	0.30

Above current rating are based on a temperature rice of 40°C and allow for an ambient temp. of 65°C.The maximum permissible conductor temperature is 105°C.If the ambient temperature "t" is continuously in excess of 65°C; the current should be multiplied by the factor "k " where

$$k = \sqrt{\frac{105 - t}{40}}$$

Panel Heat Dissipation Calculation

Air flow
Concern of heat generation amount and cooling method to be taken care in designing the cubicle so that inverter ambient temperature and intake air temperature will not exceed the allowable values.

An open-chassis model in a protective enclosure with the heatsink inside the panel allows for intake
air temperature up to 50°C The heatsink can alternatively be mounted outside the enclosure panel, thus reducing the amount of heat inside the panel and allowing for a more compact.

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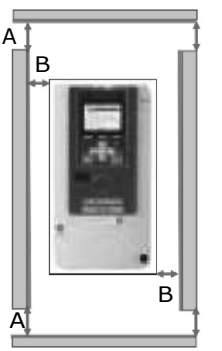
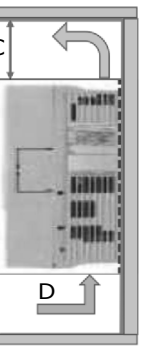


SIDE CLEARENCE



TOP CLEARENCE

A. 50mm minimum C-120mm
B. Minimum 30mm minimumD-Air flow direction

Panel Heat Dissipation

Shrouding with Perforated Meshes are recommended for proper cooling arrangement. Material: GI or Insulated material (if the clearance is less than standard (19mm) between phase & meshes

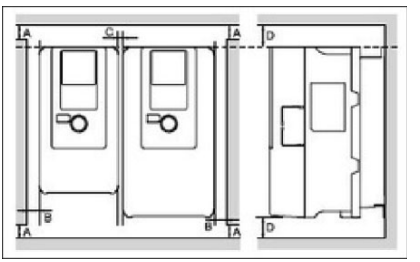
Perforated Meshes
POLYCARBONATE SHEET

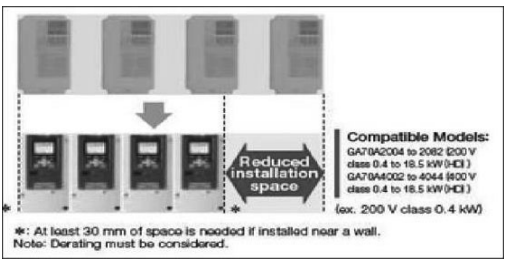
Perforated Meshes
GI WITH PVC COATING

Side-by-Side Installation of VFD Panel

Side-by-Side Installation

Multiple drives can be installed in close proximity (side-by-side installation). The control panel can be designed compactly.



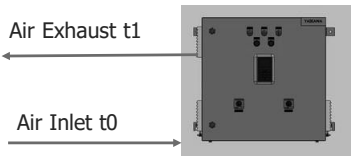


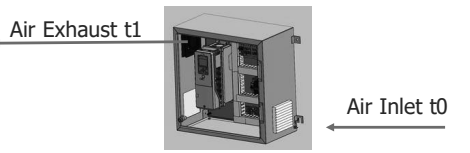
A -50 mm (2 in) minimum
B -30 mm (1.2 in) minimum on each side
C -2 mm (0.08 in) minimum between each drive
D -120 mm (4.7 in) minimum above and below
Figure :Installation Clearances for More than One Drive (Side-by-Side)

Cooling Fan selection for Forced Exhaust Panels

Forced-ventilation Type Panel

- Cooling fan is used to discharge the heat generated from the inverter into the outside of the panel by force
- Cooling fan must be selected considering the cooling wind quantity and cooling wind pressure loss based on the total heat generation in the panel.
- Discharged amount by radiation or convection can be disregarded since they are very small compared to the discharged heat by fan.





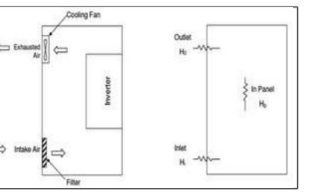
PANEL COOLING FAN CALCULATION

Cooling Fan selection

Assuming that:
P : Total heat generation in panel (kW) and
t0 : Intake-air temperature (0C)

Required wind quantity Q can be calculated as follows when the exhausted air temperature (= in panel temperature) is limited to t1 (0C)

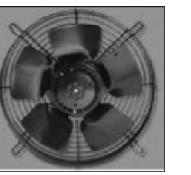
$$Q = \frac{\frac{1}{4.19} \times P \times 60}{Cp \times \gamma \times (t1 - t0)} \quad [m^3/min]$$



In the Equation :
Cp: Air specific heat 0.241 [kcal/kg°C]
γ:Air specific gravity 1,29/1+0.00367 t0 [kg/m^3]

Cooling Fan selection

$$Q = \frac{1}{4.19} \times \frac{P \times 60}{Cp \times \gamma \times (t1 - t0)} \quad [m^3/min]$$



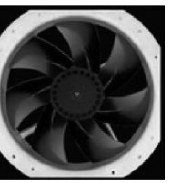
In the Equation :

Cp: Air specific heat 0.241 [kcal/kg°C]

γ:Air specific gravity 1,29/1+0.00367 t0 [kg/m^3]

Exhausted Fan Calculation for CIPR-GA70D401SBMA

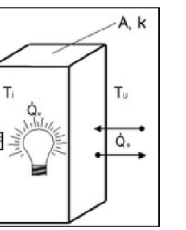
Exhausted air temperature	t1	60Deg C
Intake air temperature	t0	50Deg C
Total heat generation(GA700-038A)	P	0.7865KW
Required Wind Quantity	Q	4.287m3/min
Cooling Fan CMH		260m3/h



Air conditioner Unit Selection Details

Panel Heat Dissipation Calculation					
Qs	=[Qv-k x A x ΔT]				
ΔT	= (Ti -Ta) (Kelvin)				
Ta	Ambient temperature	50	Deg C		
Ti	Max. desired internal temperature	40	Deg C		
k	Heat transfer coefficient K-factor		Sheet steel:	5.5	W/m2 K
			Plastic:	3.5	W/m2 K
			Aluminum enclosure double wall:	3.5	W/m2 K
			Aluminumenclosure single wall:	6	W/m2 K
Qv:	Installed power losses (Heat Generation-(Internal loss of VFD & OTHER components)				
Qs:	Dissipated power via the enclosure surface				
A:	Surface (Kind of installation)				

Formula for cabinet surface area (A) m2 H= height; W= width; D=depth	
Single enclosure free on all sides	A =1.8x H x (W+D) +1.4 x W x D
Single enclosure, wall mounted	A =1.4x W x (H+D) +1.8 x D x H
First or last enclosure in free standing row	:A =1.4x D x (H+W) +1.8 x W x H
First or last enclosure in wall mounted row	A =1.4x H x (W+D) +1.4 x W x D
Middle enclosure in free standing row	A =1.8x W x H +1.4 x W x D + D x H
Middle enclosure in wall mounted row	A =1.4x W x (H+D) +D x H
Middle enclosure in wall mounted row covered top	A =1.4x W x H +0.7 x W x D + D x H



Air conditioner Unit Selection Details

Panel Heat Dissipation Calculation for CIPR-GA70D4675ABMA VFD			
Qs	=[Qv-k x A x ΔT]		
ΔT	= (Ti -Ta) (Kelvin)		
Ta	Ambient temperature	50DegC	
Ti	Max. desired internal temperature	40DegC	
k	Heat transfer coefficient K-factor	Sheet steel:	5.5W/m2 K

Panel Dimension		
H	W	D
1900	2000	800

A: ΔT Qv: Qs:	10.30	
Drive Loading(Di)	-10	
CDF	6925Watts	
Total Heat loss (kW)Hi=	7491Watts	
Di x Qs x CDF	1100%	=Electrical kW/Selected kW
Selected AC Unit AC	40%	
Tonnage calculation		
Total Loss in BTU	2997Watts	
AC Tonnage Required	3500Watts	

VFD PANEL WITH AIR CONDITIONER UNIT

		StandardFormula's Used
	11942.50	1Watts = 3.412141633 BTU
	1.00	**12000BTU = 1Refrigeration tonnage**

Fundamentals of System Climate Control

Climate control of enclosures

Passive Climate Control

Heat dissipation without active components

Active Climate Control

Heat dissipation with active components
(fan-unit, cooling unit ..)

Fundamentals of System Climate Control

Climate control of enclosures

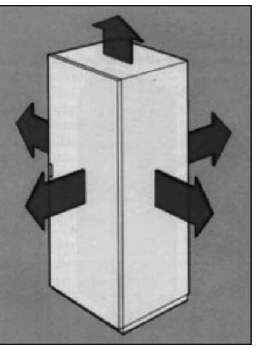
Passive Climate Control:

Heat dissipation without active components

Natural convection

Power losses dissipated via the enclosure surface:

$QS = k \bullet A \bullet \square T$ W

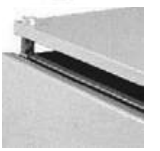


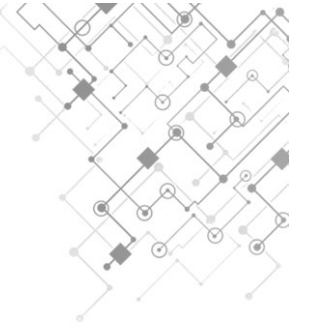
Ta < Ti

Passive components

- Lifted roofs
- Louvers

Perforated surfaces





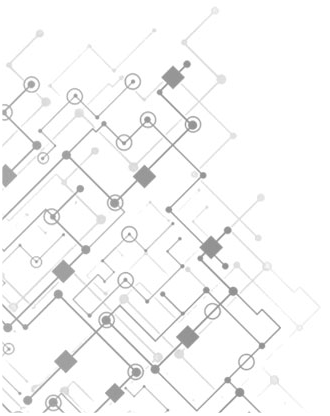
Fundamentals of System Climate Control

Passive Climate Control

Natural convection	Ta < TI

Active Climate Control

Fan-and filter unit Air/air heat exchanger	Ta < TI
Air/water heat exchanger Cooling units	Ta > TI



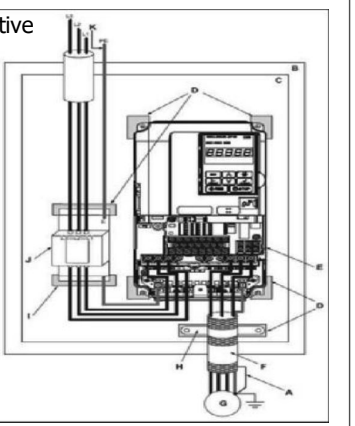
Earthing selection and practices

The object of earthing system is to provide a surface under and around a station, which shall be at a uniform potential (nearly zero or absolute earth potential). 1. To have zero potential

2. To allow Fault current flows toearththrough the protective Earthing conductors.

3. To provide safety

4. Protection of equipment's



A–Ground the cable shield
B –Enclosure panel
C –Metal plate
D –Grounding surface (remove any paint or sealant)
E –Drive
F –Motor cable (braided shield cable, max. 10 m)
G –Motor
H –Cable clamp
I –Ground plate (scrape off any visible paint)
J –EMC noise filter
K –Make sure the ground wire is grounded

Earthing selection and practices according to IEC 61800

Earthing :

In an electrical installation anearthing orgrounding systemconnects specific parts of that installation

with the Earth's conductive surface for safety and functional purposes.

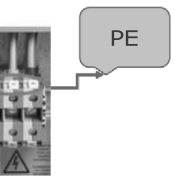
1. To have zero potential / uniform potential (nearly zero or absolute earth potential).
2. To allow Fault current flows toearththrough the protective Earthing conductors.
3. To provide safety
4. Protection ofequipment's

In VFD systems, shielded cables are often the key to appropriate protection, as motor cables are the main source of interference. Grounding also needs special attention.

The standard EN/IEC 61800-5-1 &IEC 60204-1defines the requirement of the PE conductor as follow s:

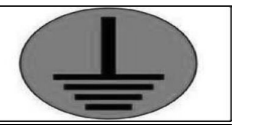
The values are valid only if the protective Earthing conductor is made of the same metal as the phase conductors

Cross-sectionalarea of phase conductors in Sph(mm2)	Minimum cross-sectional area of the protective Earthing conductor Spe(mm2)
Sph < 16	Sph
16 < Sph<35	16
35 < Sph<400	Sph/2
400 < Sph<800	200
Sph>800	Sph/4



Earthing Selection and Practices

- If the cable shield is made of iron, it offers protection from EMC disturbance, but cannot be used as PE.
- A separate PE& Ground conductor must be used.
- For EMC purposes, both ends of the motor cable shield must be 360°grounded
- If there is a potential difference between the devices, it must be equalized by proper grounding.
- Keep the motor cable as short as possible, both inside and outside the drive enclosure
- You can use the shield of the motor cable for grounding purposes when the cross section of the shield is greater than 50% of one phase conductor.
- Do ensure that every earth wire shall be of copper
- If you install components between the motor and the drive, make sure that the shield is continuous.
- We recommend that you use symmetrical three-phase cables with symmetrical phase conductors, symmetrical PE conductors and symmetrical shield, whenever possible. Single core cables are not recommended
- All the components & Panel doors need to be earthed.



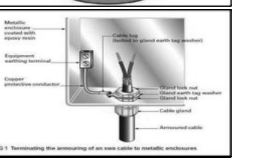
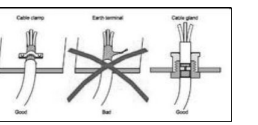


FIG 1 Terminating the armouring of an swa cable to metallic enclosures



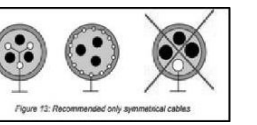
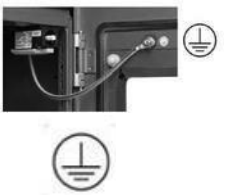


Figure 12: Recommended only symmetrical cables

Earthing Selection and Practices

Identification of Protective Earthing with Marking or Symbol or by Colour



Symbol IEC 60417-5019

Marking by the letters PE

Identification by the bicolor combination GREEN-AND-YELLOW

EARTH CONNECTION

- Ensure that panel Earth is connected to the nearest dedicated Earth Pit. Also make sure that Earth Pit resistance is measured periodically and is within the permissible range (less than 5 Ohms)
- Earth cable size should be 50% of power cable size.
- Drive Earth connection should be connected to the common earth bus bar and along with motor cables, another run of cable (size=50% of power cable size) should go to the motor.

If multiple drives are placed inside the panel, ensure that earth cable is not looped.

Earth Connection

Earthing selection and practices

DO's :

Do ensure the size of earthing wire are proper and according to IS

Do ensure that every earth wire shall be of copper

Do consider all parameters while designing earth system.

Do ensure safety earthing while working on electrical installations.

Do ensure no potential difference, which could cause shock or injury to a person, when short circuit or any other type of abnormalities takes place.

Don'ts :

Don't use paint, enamel and grease on the electrodes.

Don't touch or tamper with any electrical gear or conductor unless you have made sure that it is dead and earthed . High Voltage apparatus may give shock or flashover without touching.

Don't use neutral conductor as earth wire.

Low-voltage switchgear and control gear assemblies Design According to IEC 61439

IEC 61439-1 -Guide for specifying assemblies'General rules IEC 61439-2Power switchgear

and control gear assemblies Why do we need Standards IEC 61439?

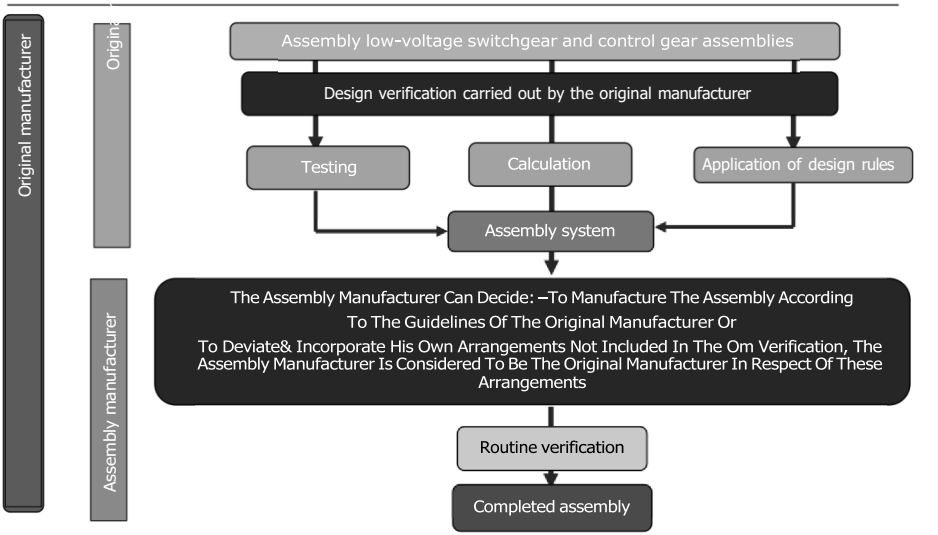
The purpose of standards to understand , design , assembly , test & verify according to environmental Conditions ,Safety , Performance of Equipment & also for

Requirements of Quality ,Testing and Verification .

The standards serves important functions for Yaskawa, as well as for the specifier and user guaranteeing : -

- Performance
- Maintainability
- Safety
- Quality
- Testing & Verification

IEC 61439-1 for Design-Manufacturing-Testing & Verification



Tests to Verify Design in accordance with IEC 61439

All the Yaskawa VFD panels testing carried out in accordance with IEC 61439

Classification of test

Type test: to show that the design meets certain specifications.

Routine test: during or after manufacture to ascertain whether it complies with certain criteria.

Special test: additional to type and routine tests, made either at the discretion of the manufacturer or according to an agreement between the manufacturer and the customer or his representative.

Sampling test: taken at random from a batch.

Workshop test: carried out in the factory or laboratory of the manufacturer to validate the design.

Acceptance test: A contractual test to prove to the customer that the device meets certain conditions of its specification.

Commissioning test: carried out on site, to prove the correctness of installation and operation.
Witness test:Any of the above tests performed in the presence of the customer, the user, or his representative
According to IEC 61800-2 clause 7.2.1, it is recommended to perform only those test which are necessary.
Special tests are only carried out if specified in contract.

FAT & QUALITY PROCESS

Factory Acceptance Test process for the VFD Panels (Performed in 3 stages)
as per IEC 61800-2 & IEC 60146-1-1

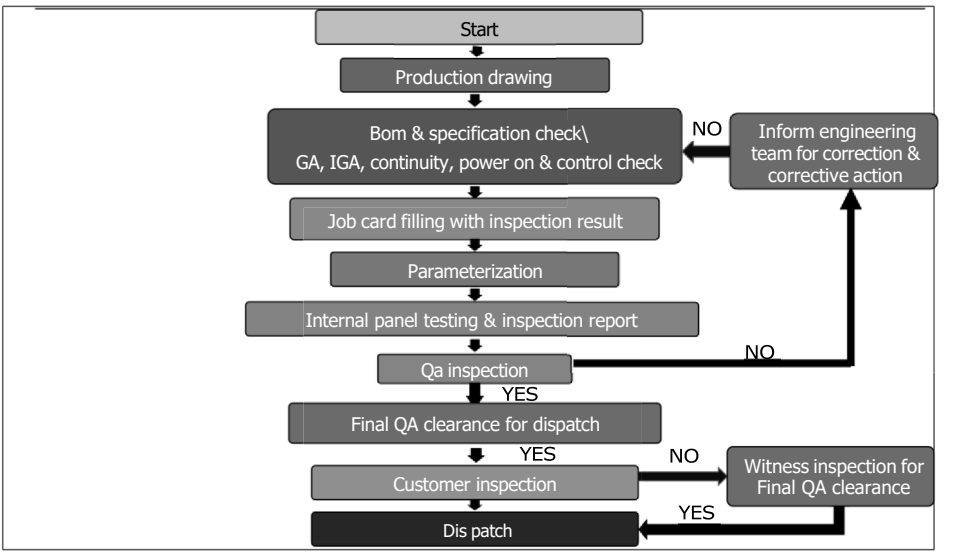
1. Incoming Stage: (Document verification)
   - □ Physical/Electrical/Mechanical verification of the Bought-out component
2. In progress Stage: (Document verification)
   - □ Enclosure fabrication –Sheet steel dimensions, bending, welding, Power coating etc.
3. Final Stage: (Performing & Witnessing)

Routine Test:
- □ Physical Verification
- □ Utility Circuit check
- □ Control circuit check

Functional Test:
- □ VFD Operational check
- □ Measurement of IR before & after HV test
- □ High Voltage test for Power circuit
- □ No load tests

Performance Test:
(At additional cost: If requested by Customer)
- □Load test-Light or Full Load (up to 315kW)
- □Temperature rise test for each VFD Panel rating (up to 315kW)

Testing & Inspection Process Flow chart from Start to End



VFD Enclosures Designed & Tested as per IEC 61800

IEC 1800 VFD:

All our VFD panels designed & Tested (Type & Routing Test)according to IEC 61800 for VFD's safety ,Functionality & Quality

- IEC: 61800-2 –General Requirements & Specifications for LV AC VFD System
- IEC 61800-3–EMC requirement
- IEC 61800-5-1–Electrical Safety
- 61800-5-2-functional safety
- IEC 61800-6–type of load duty
- IEC 61800-7-communication profiles
- IEC 61800-8-power interface voltage specification

Tests to Verify Design in accordance with IEC 61800

According to IEC 61800-2clause 7.2.1, it is recommended to perform only those test which are necessary. Special tests are only carried out if specified in contract.

IEC: 61800–ROUTINE TEST	
1	Visual inspection test
2	High voltage & insulation resistance test
3	Light load & functional test
4	Load characteristic & load duty test
5	Noise level test
6	Restart & resynchronize test
7	4-20ma/0-10V Reference/Feedback Test
8	Ramp up/ ramp down test
9	Fault diagnostic test
10	Voltage per frequency test
11	Control & functional test

IEC: 61800–TYPE TEST	
1	HEAT RUN TEST
2	NOISE LEVEL TEST
3	LINE SIDE HARMONICS MEASUREMENT TEST
4	OUTPUT SIDE HARMONICS MEASUREMENT TEST
5	EFFICIENCY, POWER FACTOR, POWER LOSS TEST
6	RATED LOAD CURRENT Vs SPEED TEST
7	DYNAMIC PERFORMANCE CURRENT & SPEED LOOP TEST
8	dV/dt & Voltage peak(V peak) Test
9	RESTART & RESYNCHRONISE TEST
10	RIDE THROUGH TEST
11	MAXIMUM FREQUENCY TEST

Design verifications tests defined in standard IEC 61439-1&2

The assembly manufacturer hereby certifies that the power switchgear and control gear assembly has been built in conformity with the requirements of standard IEC 61439-2/IEC 61439-1. The components used have been installed in accordance with the instructions of the original manufacturer withregard to the design verifications performed in accordance with IEC 61439-2:

TYPE TEST-Verification

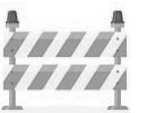
1. Strength Of The Materials And Parts
2. Degree Of Protection
3. Clearances And Creepage Distances
4. Effectiveness Of The Protective Circuit
5. Integration Of The Components
6. Electrical Circuit And The Connections
7. Terminals For External Conductors
8. Dielectric Properties
9. Temperature Rise Limits
10. Short-circuit Withstand Strength
11. Electromagnetic Compatibility
12. Mechanical Operation

Routine tests check

1. Visual check of the degree of protection
2. Visual check of the clearances Visual check
3. of the creepage distances Verification of
4. the protective circuits Visual check of the
5. integrated components Spot check of the
6. connections Visual check of the terminals
7. for external conductors
8. Verification of the mechanical operation
9. Power frequency withstand voltage test
10. Visual check of information and marking & operating test

Personal Protective Equipment for Testing & Commissioning

PPE's Required for testing & Commissioning



IEC 60364-4-41
Panels Barricading required for unauthorized Entry & for personal safety

First Aid Kit in case of emergency

Instruments & Tools for Inspection Testing & Commissioning

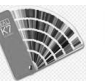
True RMS Multimeter

True RMS AC/ DC Clamp meter

VISUAL IR Thermometer

Coating Thickness Gauge

Measuring Tape



RAL Shade

Digital Sound Level meter

Temperature Recorder

Oscilloscope

Power Analyzer

Tools Box

HV & MEGGAR

Induction Motor