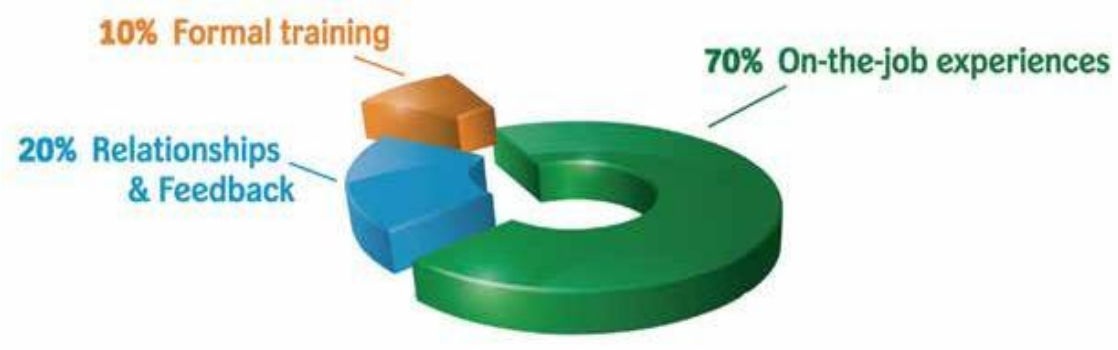
Electrical Standards
&
Power Systems
Level 1

70:20:10 Philosophy in execution



Learning Distribution	What	How	Driven By
10%	Theory level	Tutoring	Trainer
	Practical & Hands-On	Simulation / Workshop	Trainer
	Reading	Self Study	Trainee
	E-Learning Modules	Self Study	Trainee
20%	Understudying, process analysis, questioning, Laboratory works and assignments	Shop floor shadowing	Trainer
		Best practice visits	Line Manager
		Feedback	SME
70%	Shadowing, hands on practice, relief work and attachments, Maintenance and Troubleshooting	Relief work and practice	Line Manager
		Projects	Line Manager
		Assignments	Line Manager
		Maintenance	Line Manager
		Troubleshooting	Line Manager

Target

Target Group: AEs, Automation Specialist / Mechatronics Level 1

Pre-requisites:

1. Electrical Standard & Power Systems (Appreciation)

Table of Content

HEINEKEN

Learning Objectives

At the end of this Training Participants should be able to:

- know Heineken Standard for electrical drawings, cable colour for electrical signals, electrical symbols and coding, Instrument symbols and coding, Electrical Panel coding & panel protection standards.
- Know IEC standards i.e. Ingress Protection (IP) & it's application
- know basic panel components and their functions. (Circuit Breakers, Contactors, Relays, push buttons)
- know basic safety components (Emergency Switch, Safety door switch)
- know and replace panel signal & pilot lamps
- use basic Electrical Tools i.e. Voltmeter, Ammeter, Megger
- use Heineken standards to design and draw electrical diagrams
- use basic electrical components with the right specification to wire a control panel.
- use right size of cable glands, cable trucking & cable trays as required in E&I standards.
- use component tags to trace components & cabling from field to electrical panel.
- know Power generation, Transmission & Distribution from Generators, Transformers, Switch distribution Board to Machines
- maintain Electrical Panel (machine and power distribution panels)

Basic Electrical Safety

Basic Electrical Safety

Electrical Hazards

Electrical hazards can be categorized into three types;

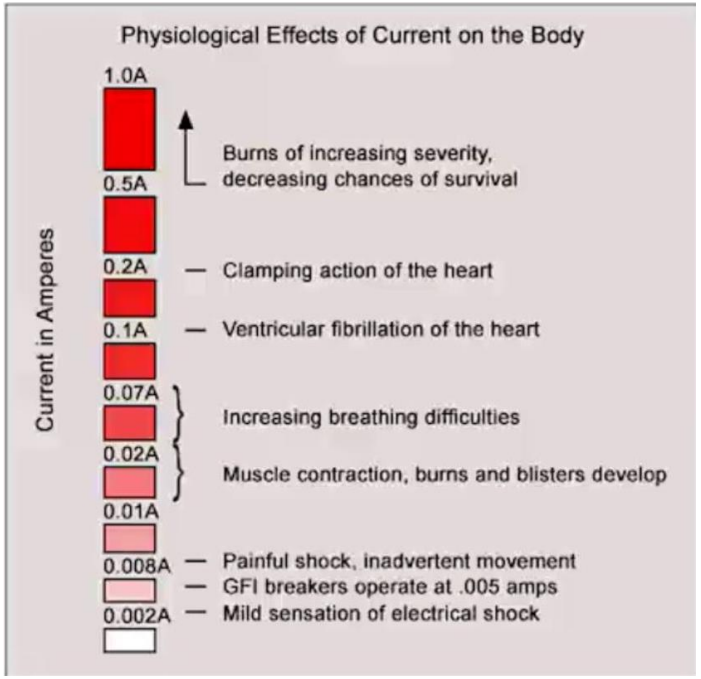
- the first and most commonly recognized hazard is electrical shock (exposure to electric current).
- the second type of hazard is electrical burns (exposure to electric current).
- the effects of blasts which include pressure impact, flying particles from vaporized conductors and first breath considerations. (effect of an arc flash)

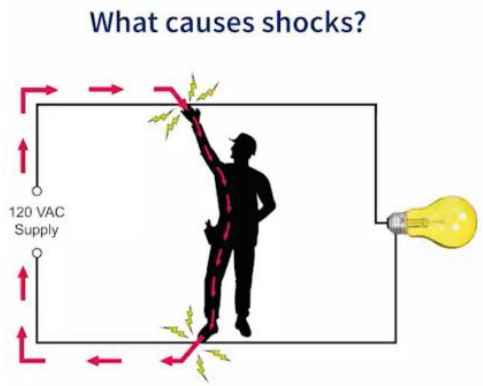
Basic Electrical Safety

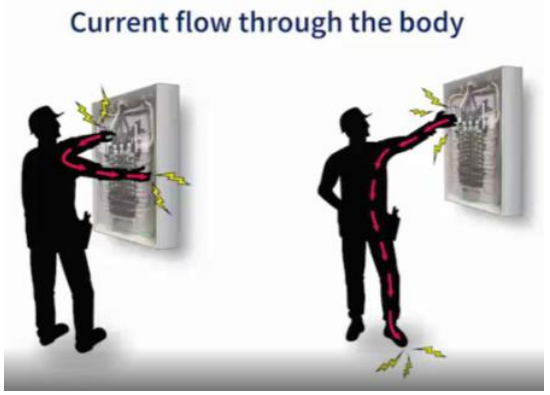
Electrical Hazards

Electric shock occurs when the body becomes part of an electrical circuit. Shocks can happen in three ways.

- A person may come in contact with both conductors in a circuit.
- A person may provide a path between an ungrounded conductor and the ground.
- A person may provide a path between the ground and a conducting material that is in contact with an ungrounded conductor.





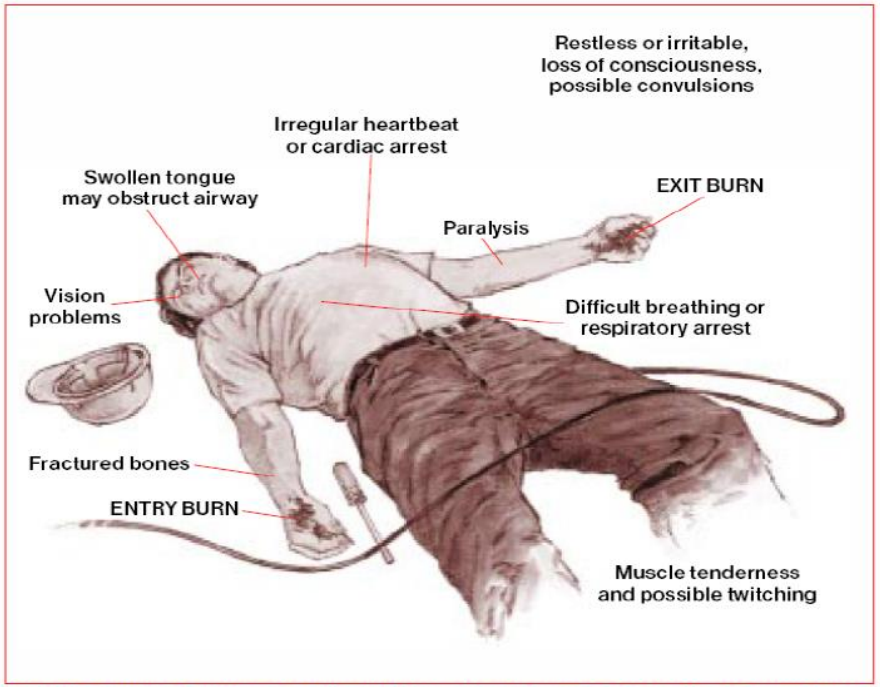


Basic Electrical Safety

Electrical Hazards

Electrical Burns

- An electrical burn is a skin burn that happens when electricity comes in contact with your body. When electricity comes in contact with your body, it can travel through your body.
- When this happens, the electricity can damage tissues and organs. This damage can be mild or severe – and it can even cause death.



A worker with an electrical injury may have any of a number of signs and symptoms.

Basic Electrical Safety

Electrical Hazards

Arc flash

- An arc flash (also called a flashover) is the light and heat produced as part of an arc fault, a type of electrical explosion or discharge that results from a low-impedance connection through air to ground or another voltage phase in an electrical system.

What causes arc faults?

- One of the major causes of arc flash is voltage transients (spikes), resulting from switching reactive loads or lightning strikes.
- Touching a test probe to the wrong surface
- Worn or loose connections
- Gaps in insulation
- Improperly installed parts
- Dust
- Corrosion

Basic Electrical Safety

Electrical safety tips to prevent shock & burn

- Use the tool only for its designed purpose.
- Read the Owner's Manual and follow manufacturer's safety instructions.
- Remember electric-powered tools must have a three-wire plug with ground or be double insulated.
- Use of electric-powered tools with a Ground Fault Circuit Interrupters (GFCIs) breakers will drastically reduce the possibility of electric shock or electrocution.
- wear appropriate & recommended Personal Protective Equipment (PPE) when working on electrical systems.
- If an extension cord is required, make sure it is for the correct wattage and has the proper plugs.
- Verify condition of the cord and plugs and check for rated use: indoor or outdoor.
- Ensure the power switch is "OFF" before plugging or unplugging tools.
- Never carry a tool by the cord & never disconnect power by pulling on the cord – use the PLUG.

Basic Electrical Safety

Electrical safety tips to prevent shock & burn

- Unplug the cord before making adjustments, changing/replacing parts/accessories.
- Inspect tool before each use. Replace worn or damaged tools. Remove from service & tag “Danger, Do Not Operate.”
- Do not use electric-powered tools in damp or wet locations.
- Keep the cord away from heat, oil/chemicals, sharp edges & ensure it doesn’t become a trip hazard
- Do not use conductive ladders near any energized power line. Conductive ladders should be clearly marked to inform workers they can not be used around electrical equipment.
- Verify that the travel paths (e.g. forklift area) used to move stock is free from electrical outlets, controls, and power panels that may be damaged by moving equipment.
- Power panels and high voltage switches and disconnects should be guarded if they are not physically separated from the work area. Panel doors & covers should always be closed.
- All safety zone workers should know where disconnects, circuit breakers and switches are located in their area of responsibility.

Basic Electrical Standards

Basic Electrical Standards

Electrical Standards used in the Brewery

The standards in use in the brewery are implemented for installation operations & maintenance in electrical & automation systems.

In this training we would review the following standards below.

- **IEC standards**
  - IEC 60204-1 / EN 60204 Safety of machinery – Electrical equipment
  - IEC 60529 – (ANSI/IEC 60529-2004) Degrees of Protection Provided by Enclosures (IP Code).

- **Heineken Materials Equipment Standards & Codes (HMESC) standards**
  - HMESC : 01.04.01.730 Electrical Safety Standard
  - HMESC : 99.04.07.202 E & I (Electrical Engineering and Instrumentation) design guidelines
  - HMESC : 99.04.02.070 Electrical Coding
  - HMESC : 99.04.02.060 Location Coding

- **Local regulatory standards**

Basic Electrical Standards

Why Electrical & Installation Standards ?

- To ensure ease of Troubleshooting electrical installations and reduce downtime, maintenance & repair cost.
- To advise on makes & types for Electrical, Instrumentation and Automation (E, I & A) components.
- To ensure legal standard and regulations are always be followed. The electrical installation shall comply with the national and /or local authorities of the country in which the installation will be installed and is not limited to:
  - Local applicable Standards and Regulations
  - International Standards e.g. IEC

- Heineken E&I Design Guideline advise the best practices for Electrical Engineering and Instrumentation

Basic Electrical Standards

IEC Standards

- IEC 60204 – (ANSI/IEC 60204) Safety of Machinery – Electrical Equipment

The International Electrotechnical Commission (IEC) is an international standards organisation that prepares and publishes international standards for all electrical, electronics and related technologies – collectively know as “electro-technology”.

An example is IEC 60204-1 / EN 60204 Safety of machinery – Electrical equipment

The standard contains the following:

- Electrical Supply Requirements;
- electromagnetic compatibility (EMC) requirements;
- over current and over voltage protection requirements;
- requirements for determination of the short circuit current rating of the electrical equipment;
- protective bonding requirements, terminology, and protection against electric shock;
- Incoming supply requirements and switching;
- requirements pertaining to safe torque off, emergency stop, and control circuit protection;
- symbols for actuators of control devices

Basic Electrical Standards

IEC Standards

- IEC 60529 – (ANSI/IEC 60529-2004) Degrees of Protection Provided by Enclosures (IP Code).
- The IP rating or ingress protection rating is an international standard set up for conformity in solid and liquid protection for electrical enclosures & devices.

First index figure (foreign bodies protection)

Degree of protection		
0		**No protection** against accidental contact
1		Protection against contact with any large area by hand and against large foreign bodies with **Ø > 50 mm**
2		Protection against contact with the fingers **Ø > 12 mm**
3		Protection against tools, wires or similar objects with **Ø > 2.5 mm**
4		Protection against granular foreign bodies with **Ø > 1 mm**
5		Total protection against contact, protection from **deposit of dust**
6		Total protection against contact, protection against **penetration of dust**

Basic Electrical Standards

IEC Standards

- IEC 60529 – (ANSI/IEC 60529-2004) Degrees of Protection Provided by Enclosures (IP Code).
- The IP rating or ingress protection rating is an international standard set up for conformity in solid and liquid protection for electrical enclosures & devices.

Second index figure (water protection)

Degree of protection		
0		**No protection** against water
1		Protection against vertical water **drips**
2		Protection against water drips **(up to a 15° angle)**
3		Protection against diagonal water drips **(up to a 60° angle)**
4		Protection against splashed water from **all directions**
5		Protection against water (out of a nozzle) from **all directions**
6		Protection against **temporary flooding**
7		Protection against **temporary immersion**
8		Protection against **water pressure**

Basic Electrical Standards

IEC Standards

Example of IP Code

- **IP68**
  - If a device has a rating of IP68, for example, the device will be dust-tight and protected against long periods of immersion in water under pressure.
  - This example is both dust-tight and watertight according to the standards set up in the IP rating.

- **IP34**
  - This device would be protected against larger solid objects, something over 2.5mm, and protected against water sprayed from all direction.
  - With this rating, the device would most likely need to be in some sort of enclosure because the solids protection is only against large objects.

- **IP61**
  - Here there is full dust protection but the only liquid protection is for vertically falling drops of water.
  - This device could be outside of an enclosure assuming water is not going to be used anywhere near the device.

Basic Electrical Standards

Heineken Standards

- HMESC : 01.04.01.730 Electrical Safety Standard

The objective of this Standard is to ensure safe working conditions regarding the operation of electrical equipment and installations and safe execution of electrical work.

The standard contains the following:

- Definitions e.g. Responsible person, Voltage levels, Last Minute Risk Assessment (LMRA)
- Requirements
  - General responsibilities of unit manager
  - Organization diagram indicating responsible person(s)
  - Starting points for electrical installation activities
  - Work procedures
- Implementation schedule
- Verification
- References
  - IEC-50110-1 Operation of electrical installations
  - IEC 60204-1 Safety of machines
  - HMESC: 01.40.01.702: Safe interventions (LOTO)
  - HMESC: 01.40.01.312: Risk Assessment.
  - HMESC: 01.40.01.313: Safe Work Permit

Basic Electrical Standards

Heineken Standards

- HMESC : 99.04.07.202 E & I (Electrical Engineering and Instrumentation) design guidelines

The **E&I** Design Guideline can be read with other engineering documents for brewery installations.
Other engineering documents can be:

- Brewery Basic Electrical specification.
- E & I components Guideline

The standard contains the following:

- Electrical Guidelines
- Instrumentation guidelines
- Drawing guidelines
- Training
- Commissioning, start-up and hand-over

Basic Electrical Standards

Heineken Standards

- HMESC : 99.04.02.070 Electrical Coding

The coding of electrical components benefits an efficient engineering process and operational trouble shooting and maintenance subsequently.

The standard contains the following:

- Component Coding
- Terminal Coding
- Type Coding
  - Type Code e.g. F, H, K, M
  - Group of Devices e.g. Safety Devices, Signalling apparatus, Electro-magnetic switching elements, Motors
  - Examples e.g. Safety Fuses,

Where Type Code:

- F is Safety Devices e.g. Safety Fuses, Overvoltage protection, Earth protection.
- M is Motors e.g. Electric Motor

Basic Electrical Standards

Heineken Standards

- HMESC : 99.04.02.070 Electrical Coding

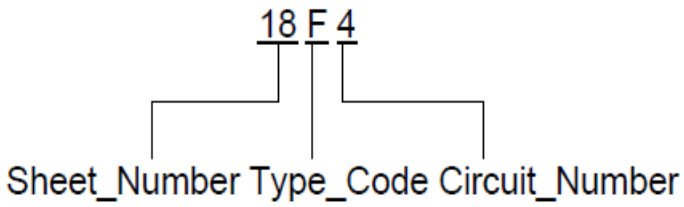
Electric components should be given a unique code on the basis of the sheet number, a type code letter and the circuit number.

Component code : **18F4**
Where:
18 is sheet number
F is type code letter and
4 is circuit number
When more components with the same type code are drawn in one circuit, the code gets a sequence number (18F4/1).

COMPONENT CODING

Electric components should uniquely coded within a panel based on sheet number, type code and circuit number (1-9). In layouts and circuit diagrams of other panels, the panel name should be added.

Component code:



Basic Electrical Standards

Heineken Standards

- HMESC : 99.04.02.060 Location Coding

The Panel Code is used for electrical installations. It is achieved by substituting the two last zeros of the Geo-code into a number from 01-99 and for sub panels in same location adding a character suffix from A-Z.

Examples:

- B13-11 Panel 11 for packaging line 3 within bottling hall 1
- B22-03A Sub-panel to panel B2203 within the same location

GEO-CODE

The Geo-code is used as registration/retrieval issue in our Drawing Management System. It is built up of a one character Location Code and a four digit Section Code:

Format: X|pnnn e.g. **B 1100, Z 2100**

LOCATION CODE (A - Z) SECTION CODE

For an explanation on Location Code and Section Code, see the sections 3 and 4 respectively.

The code is subject to multi-disciplinary agreement coordinated by Engineering Back Office.

LOCATION CODE

For the assignment of codes to locations see Table 060.1. The code could be represented by one character (A - Z) or by corresponding numeric value (01 - 26). Character representation applies to Geo-coding and electrical Panel Coding - see paragraph 5 and 7.

Table 060.1 – Location Codes

CODE		LOCATION	CODE		LOCATION
A	01	Area general	N	14	Fuel Storage
B	02	Bottling hall	O	15	Office
C	03	Cellars /Tank room	P	16	Pipe bridge
D	04	Bright Beer Cellar	n/a	17	
E	05	Engine room	R	18	Full - empty product store
F	06	Service Block	S	19	Auxiliary and general stores
G	07	Entrance area	T	20	Electricity
H	08	Head-Office & Parking Area	U	21	General
n/a	09 /10		V	22	Waste Water Treatment
K	11	Canteen /Lockers /Welfare Block /	W	23	Clear Water Treatment
		Sports accommodation /Compound	X	24	Revaluation of by-products
L	12	Laboratory	Y	25	Workshop
M	13	Malt Store /Treatment	Z	26	Brew house /Milling

To character code always an instance number is used at position "p" while this in numeric representation only is used in case more buildings in the same location category exist e.g. for more F/S Cellar buildings 03.1 (C 1nnn), 03.2 (C 2nnn), 03.3 (C 3nnn) .....are recommended.

Note: a building could be seen as a specific appearance of a location.

Basic Electrical Standards

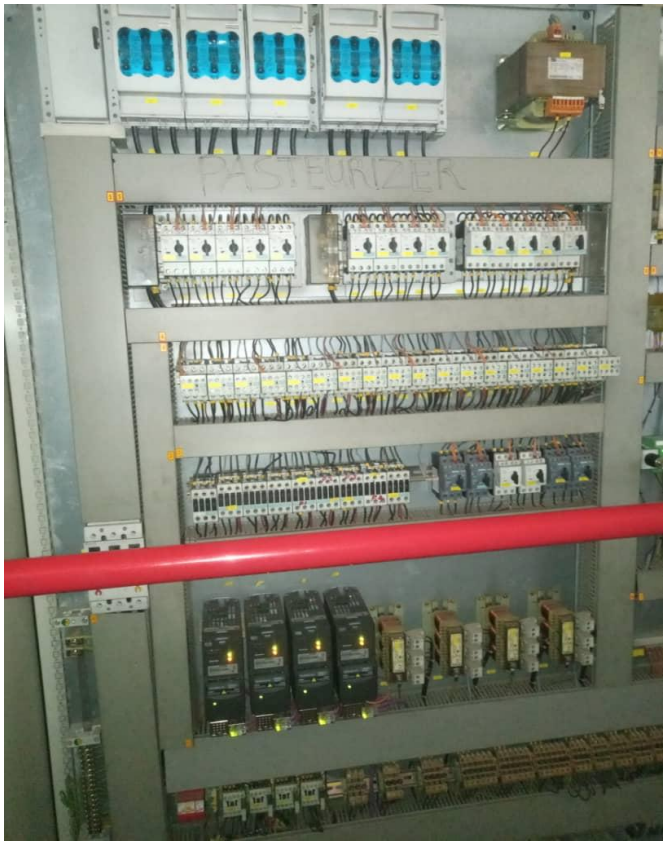
Heineken Standards

- HMESC : 99.04.07.202 E & I (Electrical Engineering and Instrumentation) design guidelines

CENTRAL PANEL ROOM CONTROL PANELS

If the control panels will be located in a central panel room, the hereafter listed specifications is applicable:

- See all items in chapter 4.3.
- Panel make: Rittal, or equivalent
- Panels, in principle, without doors with a red antifall-in safety bar for each panel section.
- Protection class of the hole panel minimal IP2X.
- Panel dimensions:
  - Width : 800 mm or 1200mm (per section).
  - Height : 2000 mm (without plinth).
  - Depth : 500 mm (600/800 in special cases).
- Panel(s) executed in mild steel,
- Colour Supplier standard.
- 100mm mild steel plinth.
- Cable entry: bottom.
- Cables pull relief to be integrated.



Further information can be found in 99.04.07.202 E & I design

Basic Electrical Standards

Heineken Standards

- HMESC : 99.04.07.202 E & I (Electrical Engineering and Instrumentation) design guidelines

FIELD REMOTE I/O PANELS, OPERATOR PANELS AND TERMINAL BOXES

For field remote IO panels, operator panels, terminal boxes, the hereafter listed specifications and accessories are applicable:

- See all items in chapter 4.3..
- Panel make: Rittal (or equivalent)
- Degree of protection of the panel IP55.
- Panel dimensions: depending on application.
- Dry area panel(s) executed in mild steel, colour supplier standard.
- Dry area panel(s) executed with a stainless steel support made of rectangular conduit.
- Wet Area panel(s) executed in stainless steel.
- Wet Area panel(s) executed with a stainless steel support made of rectangular conduit.
- Cable entry bottom by means of cable glands.
- Internal lighting switched on/off by door-switches (or infrared switch), the socket outlet(s) not switched.
- Each field panel door to be foreseen with a key-lock, with standard key number 3524. (or different if specified separately)
- Handgrip to be used for all door locks.

Further information can be found in 99.04.07.202 E & I design

Basic Electrical Standards

Heineken Standards

- HMESC : 99.04.07.202 E & I (Electrical Engineering and Instrumentation) design guidelines

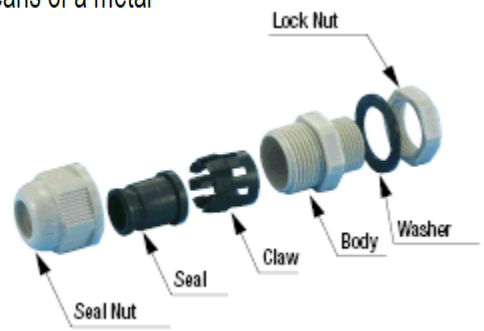
CABLE GLANDS

All cable entrances in electrical components (eg. motors, junction boxes, switches, instruments, etc) shall be with cable glands. Cable glands of good quality shall be used in general.Cable glands shall be installed with the opening to the bottom to avoid water entrance from above.

Cable glands must be suitable for the used cable diameter.

Use of additional filling materials to make the gland (better) weatherproof is not allowed.

In case of EMC specifications screened signal cables and frequency controlled motor cable, appropriate metal EMC glands shall be used. The EMC gland shall be connected galvanically, by means of a metal plate in the maintenance switch.



Further information can be found in 99.04.07.202 E & I design

Basic Electrical Standards

Heineken Standards

- HMESC : 99.04.07.202 E & I (Electrical Engineering and Instrumentation) design guidelines

WIRING COLOURS AND IDENTIFICATION

The wire collars shall be as indicated in NEN-EN-IEC60204 paragraph 13.2 as follows:

- Main power circuits : Black
- Control circuits AC: Red
- Control circuits DC: Blue
- External voltages (and potential free contacts) : Orange
- Others : Supplier standard

Wiring colours shall always be indicated in the schematic diagrams

Further information can be found in 99.04.07.202 E & I design

Basic Electrical Standards

Heineken Standards

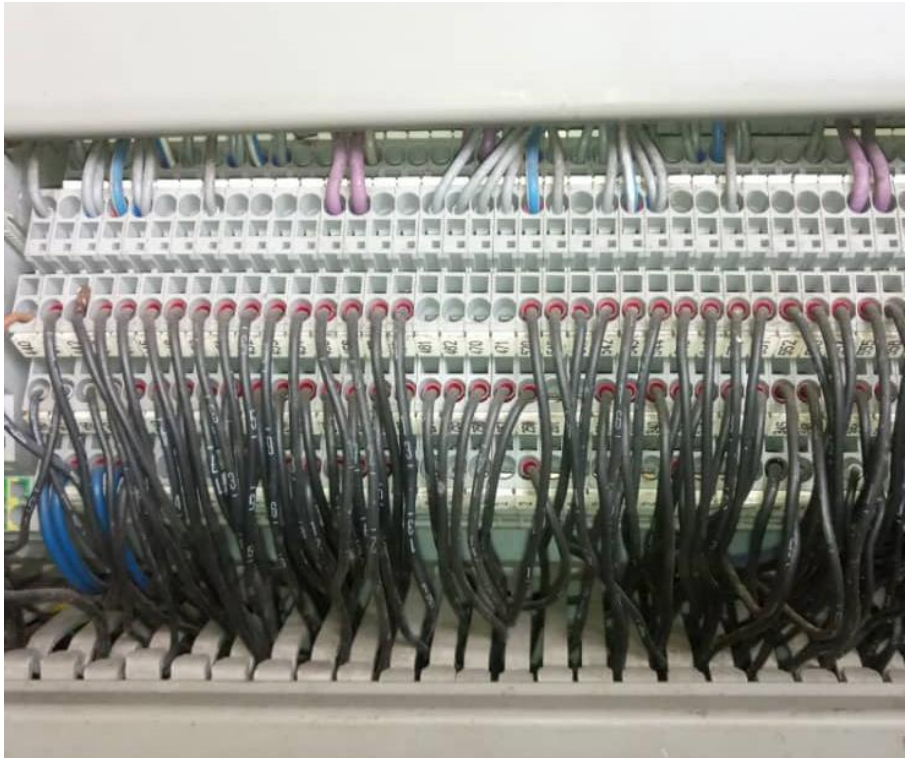
- HMESC : 99.04.07.202 E & I (Electrical Engineering and Instrumentation) design guidelines

4.3.9 TERMINALS

All wiring for connections to field equipment shall be terminated on terminal strips.
The terminal strips are located at the bottom side of the panel.
If there is insufficient space available to fit all terminals horizontally, vertically mounted terminal shall be applied
The maximum number of wires that may be connected to one screw connection is 2.
Each outgoing motor and power cable shall be executed with a PE-terminal.
Each terminal strip shall provide 10% spare terminals with a minimum of 5 terminals.

The cable connection terminal lists shall be coded as follows:

X0	400V AC
X1	230V AC
X2	24V DC
X3	External voltage, potential free contacts
X4	230V AC for panel lighting, socket outlets and panel air-coolers system (with warning plate
X5	Speed monitoring
X6	24V AC
X7	Brake contacts
X8	Down time registration
X9	24V AC (vessel lighting)
X10	Internal not defined other voltages
X13	Analogue signals (4-20mA / 1 - 5 V eso)
X14	Other signals
X15	Pt100 signals
X16	Pneumatic signals
X17	Different signals (NOT 230V) in one connection cable to field instrument (standard instrument connection cable)



Further information can be found in 99.04.07.202 E & I design

Basic Electrical Standards

Heineken Standards

- HMESC : 99.04.07.202 E & I (Electrical Engineering and Instrumentation) design guidelines

CABLE LADDERS & TRAYS

If not mentioned otherwise, the following cable ladder and trays shall be used in the following situation. Deviations in consultation with the brewery representative.

- Vertical cable ladders and trays
- Cable ladders and trays outside buildings to protect cables against sunlight .
- Cable ladder and trays, on locations from where cables can be seen in the cable ladder under three meters
- Cable trays in machines

Data cable shall be always installed in a cable duct executed with a cover. This cable duct can be installed into the signal part of the cable ladder.

Motor cables, control and signal/data cables are allowed to be installed in one and the same cable tray (duct) by using a metal partition between the motor and control/signal/data cables.

Further information can be found in 99.04.07.202 E & I design

Basic Electrical Standards

Heineken Standards

- HMESC : 99.04.07.202 E & I (Electrical Engineering and Instrumentation) design guidelines

Requirements For Electric Motors

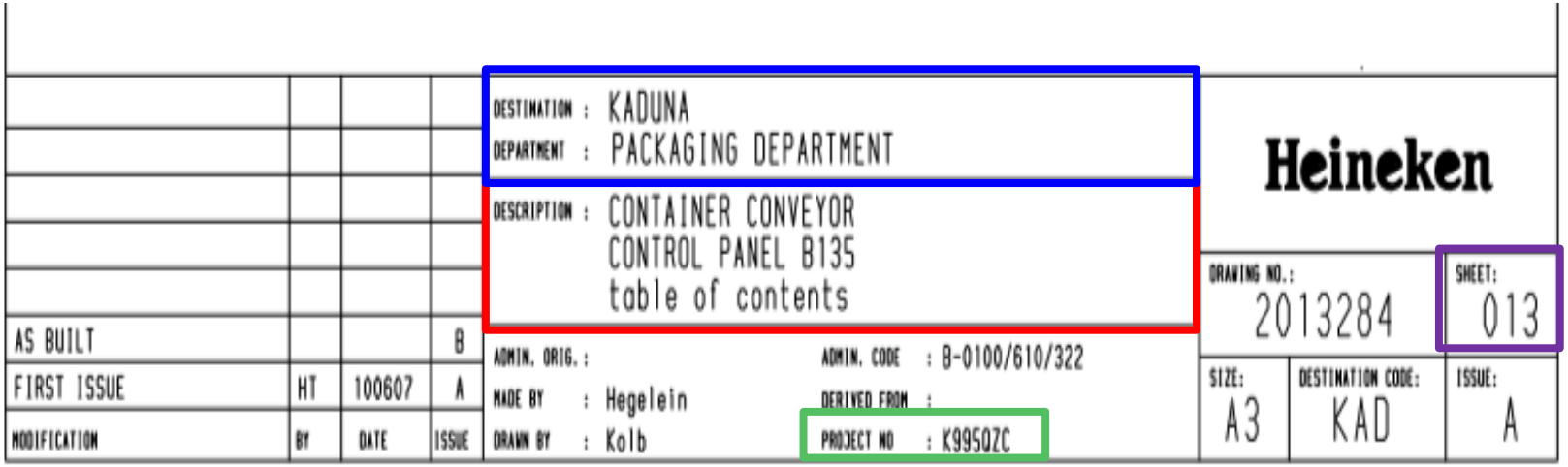
Norms	In accordance with IEC standards
Insulation class	B or F
Enclosure (housing)	IP55*
Thermistor protection for frequency converter controlled motors	≥ 7.5kW
Thermistor protection for all motors	≥ 55kW
Thermistor protection for all motors in malt intake/storage/treatment installation	For all sizes
Frequency controlled motors	Motor construction must be suitable for this application.
Efficiency class	≥ IE3**
Voltage & Frequency	3 phase Delta connection is accordance with Basic E&I brewery specification
Condense drain plugs	For outside motors or indicated in the RFQ.
Conveyor belt motors	Permanent magnet or IE4
Starting conditions	As indicated in the basic brewery specification

Further information can be found in 99.04.07.202 E & I design

Basic Electrical Standards

Heineken Standard Electrical drawing circuit structure and components

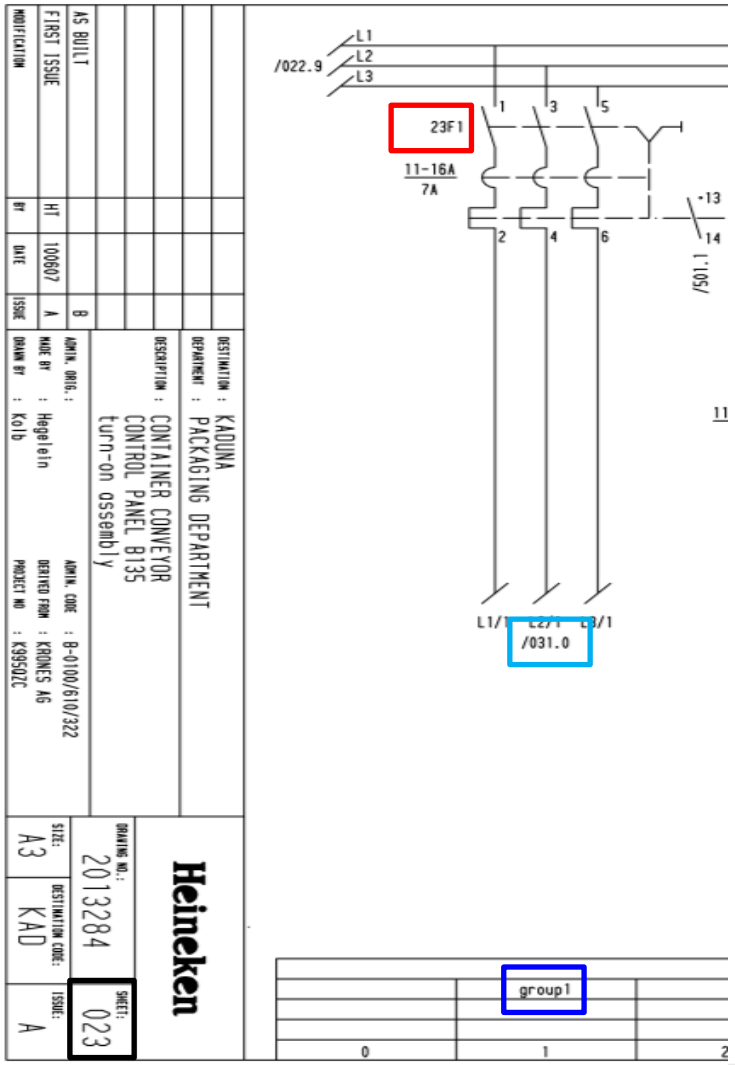
- The information on the drawing below is detailed to tell the user the panel location, (i.e. destination & the department).
- The description shows that it is a container or bottle conveyor and pointing at B135 panel.
- The project number is the OEM (Original Equipment manufacturer) machine number. The sheet number is the same as the page number. These are important information one must know in other to understand how to trace a closed loop system.



Basic Electrical Standards

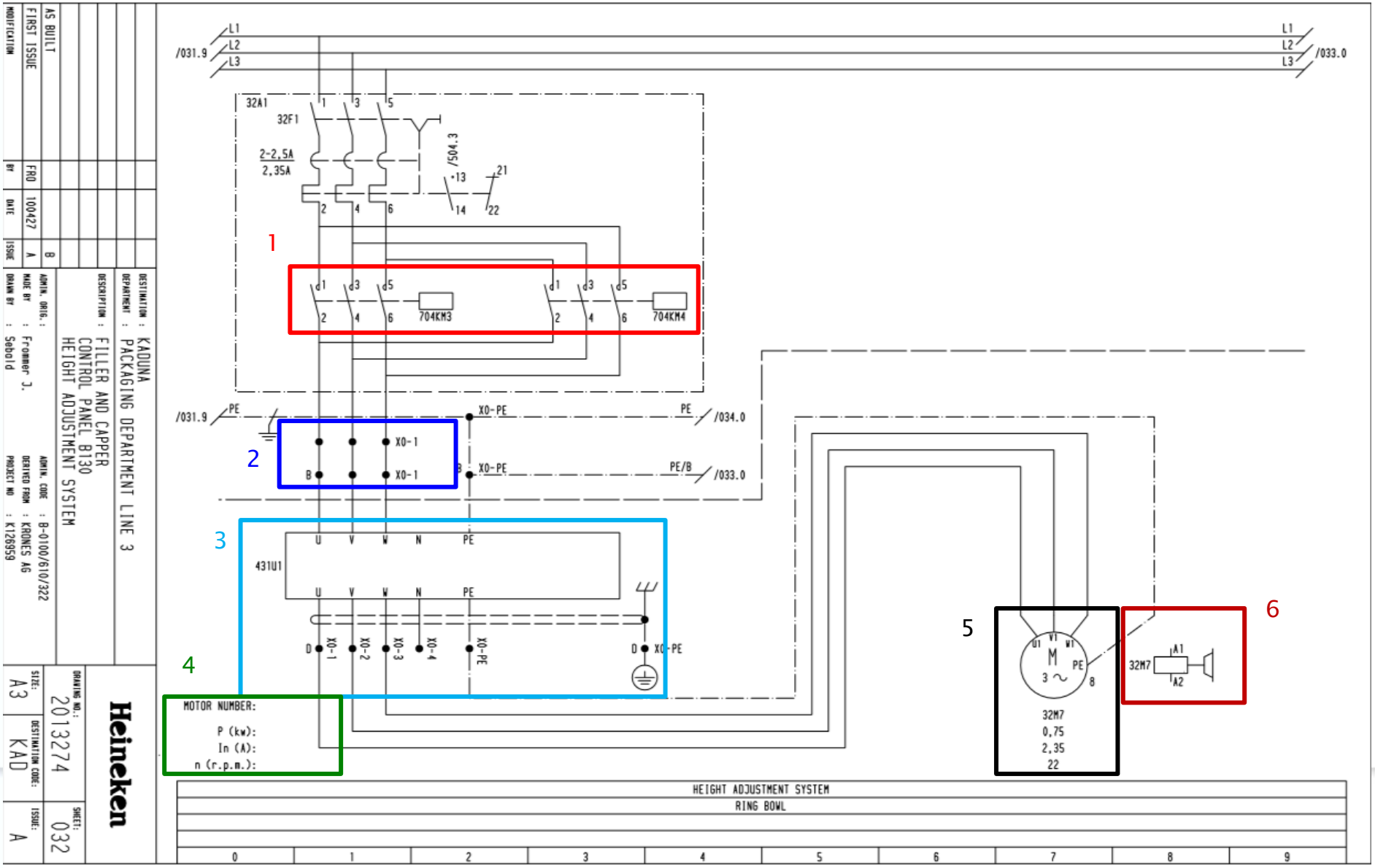
Heineken Standard Electrical drawing circuit structure and components

- Fuses: These are protectives devices which is used to protect either an entire circuitry or a single component in an installation.
- It can be a bottle or knife fuse (becoming obsolete) or as well as a circuit breaker with overload function as shown in the example.
- The identification number is 23F1 which is used to protect drives under group1 while the number /031.0 shows the page number where group1 drives are located.
- Note that 23F1 is on page 023 while the component it is protecting is on page 31.



Basic Electrical Standards

Heineken Standard Electrical drawing circuit structure and components



Basic Electrical Standards

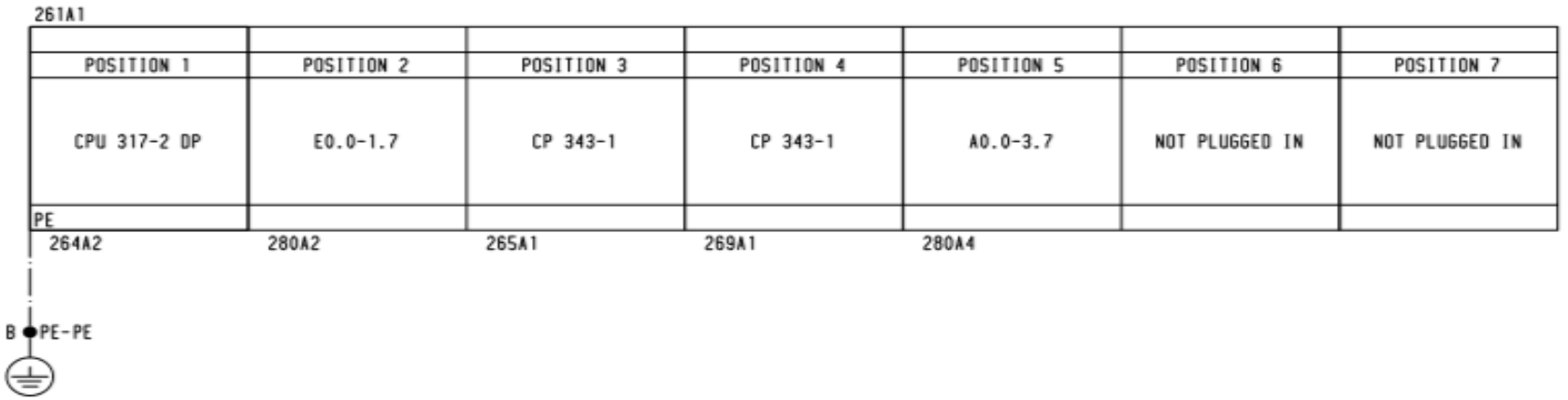
Heineken Standard Electrical drawing circuit structure and components

- In the drawing above, you can see the tag 704KM3 and 704KM4 which represents the main contactors (1) for the height adjustment system.
- The tag X0 – 1 tells you that there is a termination link (2) which links the power from the contactors to the frequency drive.
- The tag 431U1 represents the Variable frequency drive (VFD) (3) with the pins identification.
- The information for the electric motor is shown as (4) is linked with (5), although it is not the full motor description but it gives the reader or user an idea of the size of the motor in Kilowatts(KW), its rated current in ampere (A) and speed in terms of R.P.M. More so it is important you note the motor tagged as 32M7.
- The last tag (6) is an information telling the user that it is a brake motor. As the tags are seen on the drawing that's how they tally on the physical device itself and can be found on the same page number in the drawing.

- In the example shown below, the PLC module is tagged as 261A1 however it is further tagged individually to indicate what each module functions as.
- The main CPU is tagged as 264A2 identifying CPU 317-2DP, 280A2 is a digital interrupt input module while tags 265A1 and 269A1 are communication processors at which the PLC interacts with other devices. Then lastly the analog output module with the tag 280A4.

Basic Electrical Standards

Heineken Standard Electrical drawing circuit structure and components

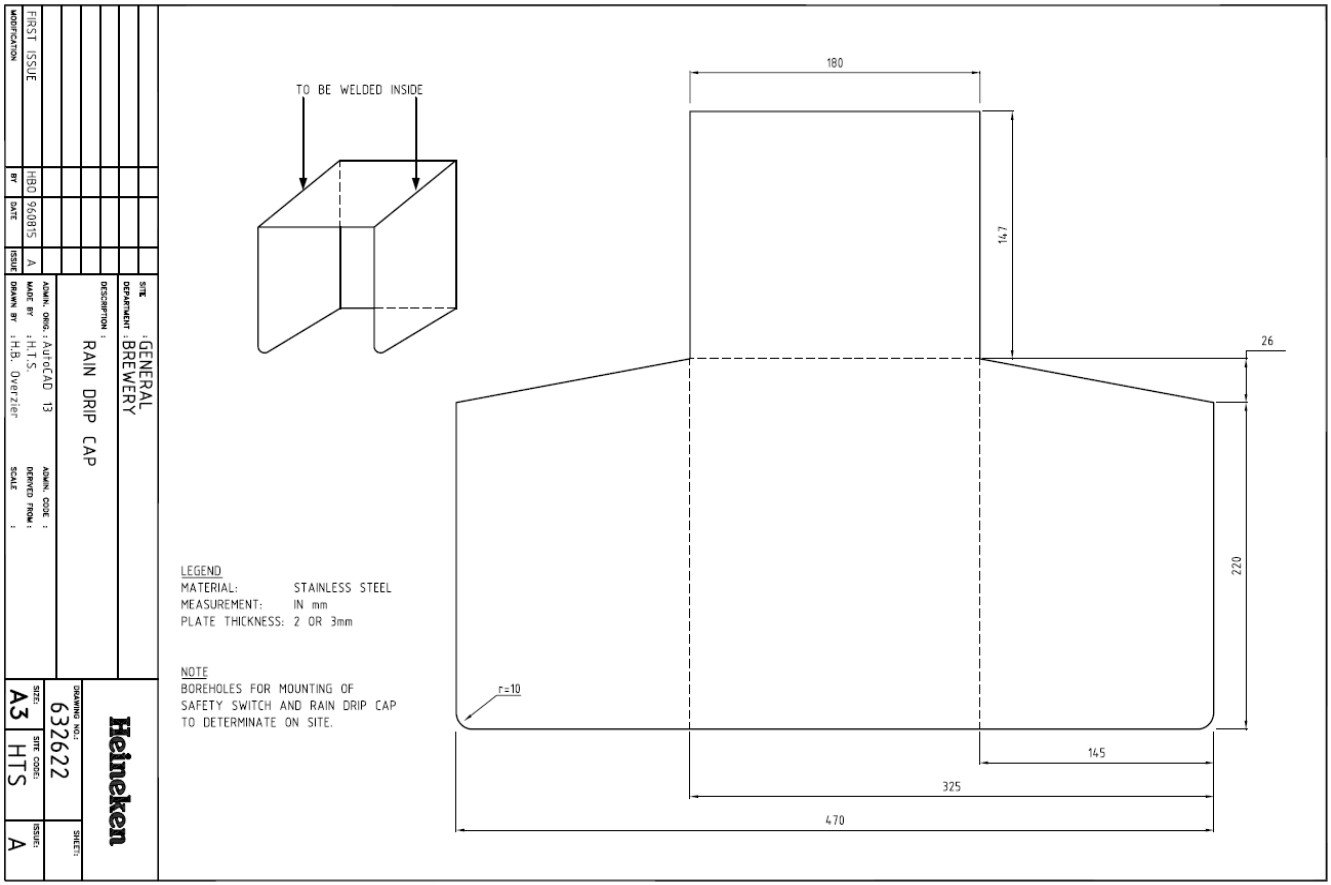


	TERMINAL BOX RACK 1							
	POSITION 1	POSITION 2	POSITION 3	POSITION 4	POSITION 5	POSITION 6	POSITION 7	
	CPU 317-2 PN/DP	INPUT BOARD	COMMUNICATION	COMMUNICATION	OUTPUT BOARD	RESERVE	RESERVE	
	SECTION RAIL	INTERRUPT	PROCESSOR	PROCESSOR				
	1	2	3	4	5	6	7	

Basic Electrical Standards

Drip Cover for Isolators

- Cover all field Isolators (Maintenance switch) with a rain drip cap



Basic Electrical Standards

Electrical Symbols

- Graphic Symbols (IEC 60617 and CEI 3-14...3-26 Standards)

	Thermal effect		Terminal		Change-over break before make contact
	Electromagnetic effect		Plug and socket (male and female)		Circuit-breaker with automatic release
	Mechanical connection (link)		Resistor (general symbol)		Operating device (general symbol)
	Operated by pushing		Current transformer		Instantaneous overcurrent or rate-of-rise relay
	Operated by turning		Make contact		Overcurrent relay with inverse long time-lag characteristic
	Connection of conductors		Break contact		

Basic Electrical Tools

Basic Electrical Tools

What are Electrical Tools ?

- Before you tackle any electrical project, having the proper tools is essential to getting the job done efficiently, correctly & more importantly, safely! The old saying, use the right tool for the job, couldn't be more relevant, especially when it comes to electrical work.

- Electrical tools are tools used to work on an electrical system. These can include a wide range of tools such as wire and cable cutters, wire strippers, measuring tools, accessories and even more. By using this tool we can do the installation of electrical wire properly, quickly & effortlessly.

Why do we test ?

- Testing is the only way to identify faults that could compromise the electrical safety of a product out in the field. Thorough electrical safety testing protects against the risk of electrical shock, so that product can be used for their intended purpose with minimal chance of injury occurring.

Basic Electrical Tools

Voltmeter

- A Voltmeter is an instrument used for measuring electrical potential difference between two points in an electric circuit.
- The unit of measurement is volts (V)

Basic Electrical Tools

Ammeter

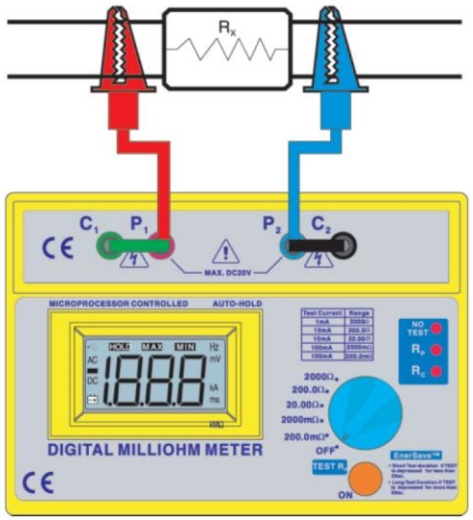
- An Ammeters is an instrument for measuring electric current.
- The unit of measurement is Amperes (A)
- An clamp meter allows you to measure the current without disconnecting the device or the circuit, i.e. it measures current without direct contact to the current.
- It is designed to be attached around the conductor, enabling you to measure the current or amperage on a single conductor.

Basic Electrical Tools

Ohm Meter

- An Ohm meter is an electrical instrument that measures electrical resistance (the opposition offered by a substance to the flow of electric current).
- The unit of measurement is Ohms (Ω)
- Micro-ohmmeters (microhmmeter or micro ohmmeter) make low resistance measurements & checking the continuity of electrical circuits.

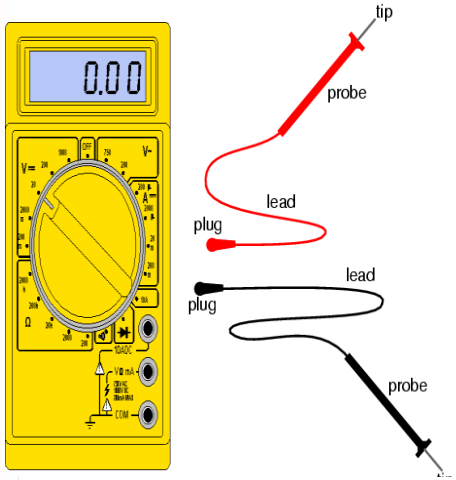
Simplified Measurement

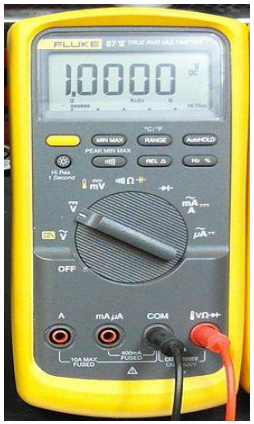


Basic Electrical Tools

Multimeter

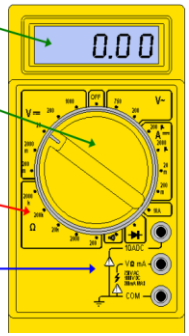
The functions of each instrument above & possibly some additional ones as well, can be combined into a single instrument known as a Multimeter.





Digital Multimeter

- **Digital Display**
  Shows measured value.
- **Meter Dial**
  Turn dial to change functions.
  Turn dial to OFF position after use.
- **Panel Indicator**
  Shows each function and setting range to turn the dial to.
- **Probe Connections**
  Specific for each function.



Analog Multimeter

~	AC Voltage	⏚	Ground
⎓	DC Voltage	⊣⊢	Capacitor
Hz	Hertz	µF	Microfarad
+	Positive	µ	Micro
—	Negative	m	Milli
Ω	Ohms	M	Mega
⊣◁	Diode	K	Kilo
•)))	Audible Continuity	OL	Overload

Basic Electrical Measuring Tools

Insulation Resistance Tester

- A commonly used insulation resistance tester is called the Megger tester.
- This is an industrial-grade handheld high voltage insulation tester suitable for testing insulation resistance up to 200GΩ to 10000GΩ
- It includes fixed voltage ranges of 50V, 100V, 250V, 500V, 1000V (1kV) and 2500V (2.5kV).
- This high voltage insulation tester is highly recommended for use in electrical and industrial applications such as single and three phase rotating machinery, single and multi-core cable testing or for the testing of motors.

Basic Electrical Devices

Basic Electrical Devices

Control Panel Device

Circuit Breaker

- Circuit breakers are protection devices that can automatically stop the flow of electricity in a circuit if there is too much current as a result of short circuit to operate safely.

Thermal Overload Relays

- Thermal overload relays are protection devices that can automatically stop the flow of electricity in a circuit if there is too much current as a result of heating effect to operate safely.
- Thermal overload relays are also used in protecting the life of electric motors against overload.

Basic Electrical Components

Control Panel Device

Fuses, Fuse base & Fuse Link

- Fuse (Diazed <50A)
- Diazed Fuse Base
- Screw Cap (Porcelain) For Diazed Fuse

- This is used as protection in lighting panels.

Basic Electrical Components

Control Panel Device

- Circuit Breaker: Circuit breakers are protection devices that can automatically stop the flow of electricity in a circuit if there is too much current as a result of short circuit to operate safely.
- Unlike fuses, which must be replaced when they open, a circuit breaker can be reset once the overcurrent condition has been corrected.
- A simple push of the handle to the “OFF” and back to the “ON” position restores the circuit.
- Miniature circuit breaker (MCBs)
  - A mini circuit breaker automatically switches off electrical control circuit during an abnormal condition of the wiring network. i.e. an overload condition as well as faulty condition.
  - It is used in low voltage electrical network
- Moulded-case circuit-breakers (MCCB)

moulded-case circuit-breakers

Basic Electrical Components

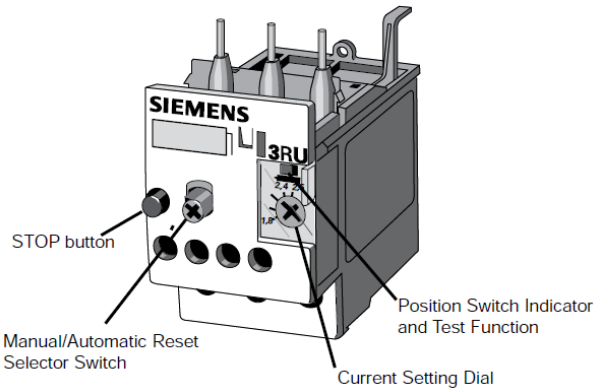
Control Panel Device

Thermal Overload Relays

- Thermal overload relays are protection devices that can automatically stop the flow of electricity in a circuit if there is too much current as a result of heating effect to operate safely.
- Thermal overload relays are also used in protecting the life of electric motors against overload.

Motor protection switch

Thermal overload protection



Solid State Overload Relay

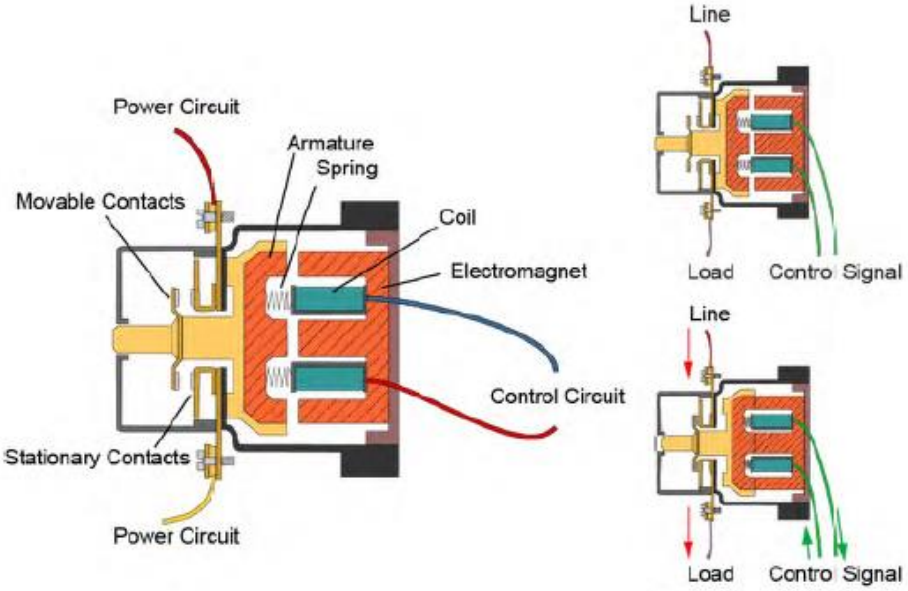
Basic Electrical Devices

Control Panel Device

Contactors

- Contactors are electromechanical switching device, typically operated by a low voltage, that controls a higher-voltage circuit and switches it on or off. The switching current of contactors are usually higher than that of a relay

- Varistor Surge suppressor
- A Varistor is an electronic component with an electrical resistance that varies with the applied voltage



Basic Electrical Components

Control Panel Device

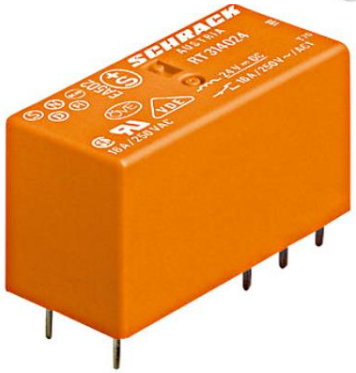
Auxiliary (Control) relay (ABB, Siemens)

- Relay that operates in response to the opening or closing of its operating circuit to assist another relay or device in performing a function
  - Miniature relay sockets

Interface relay (Omron, Weidmuller)

- Interface relay is a special class of electrical relays designed to provide informational and electrical compatibility between functional components isolated from each other and not allowing for a direct connection due to a high difference of potentials. A common design principle of these devices is a special galvanic isolation module between the input (control) and the output (switching) circuits of the relay

Auxiliary relay



Pluggable Relay

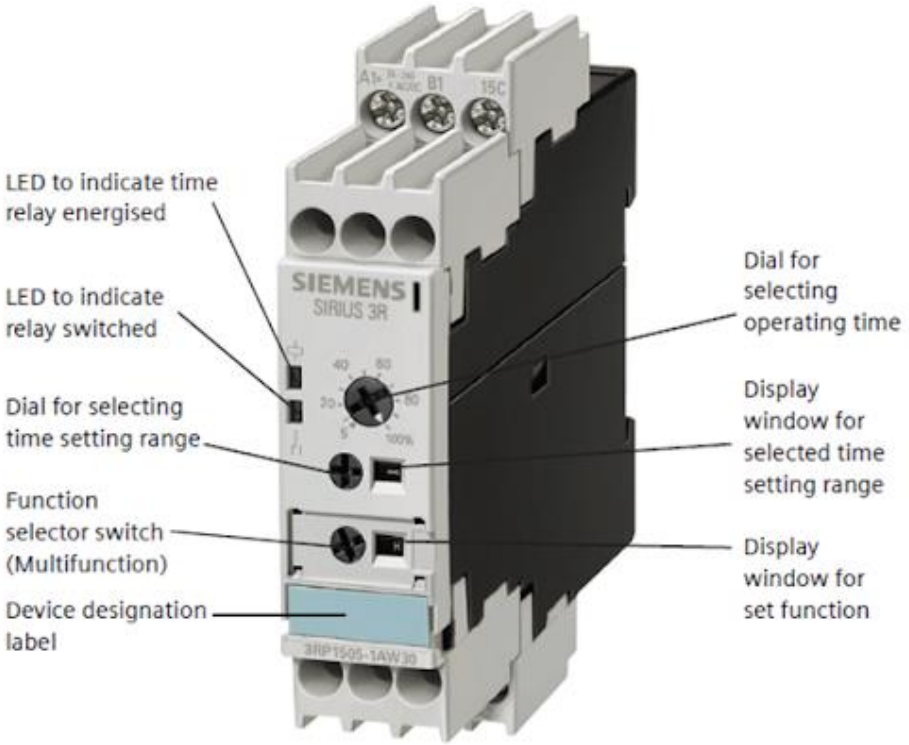
Interface relay

Basic Electrical Devices

Control Panel Device

Timers

- Timers are electrical switches too that switch at the end of a pre-set time value.
- They are usually mechanical or electronic
- Timers are of different types:
  - On delay timer
  - Off delay timer
  - Pulse timer etc.



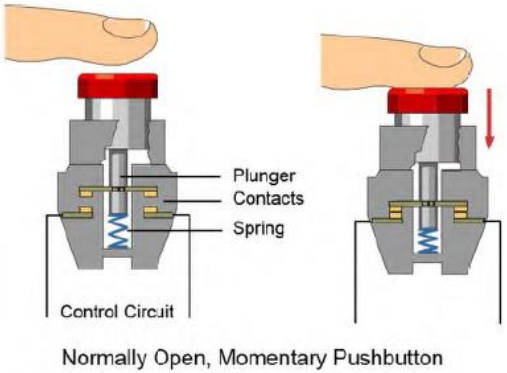
Basic Electrical Devices

Control Panel Device

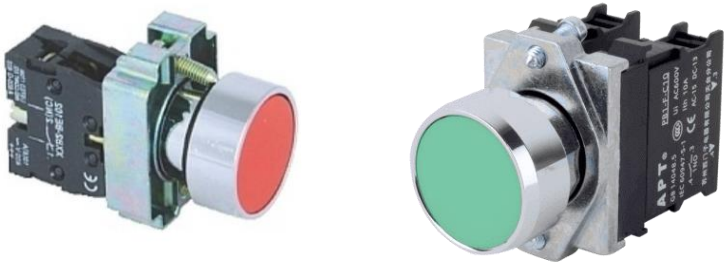
Push Buttons

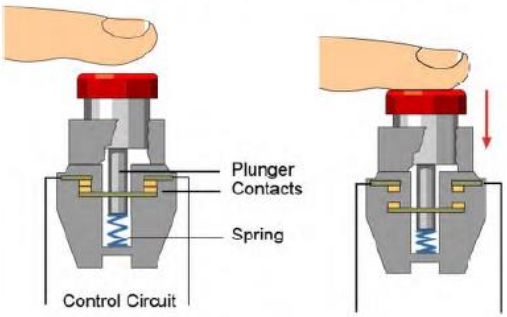
Push buttons are used for control purposes and are in different colours. According to IEC60204-1 paragraph 10.2 standard each colour has its function e.g.

- Green is to start pump motor and open valve.
- Black / blue button on a panel is for Reset
- Red button is for Stop.
- Normal actions (e.g.. On/Off) : White or Grey
- There are push buttons that are incorporated with indicators of different colours. They perform the same functions as the earlier mentioned.
- HMI panels designs also apply the same rules.



Normally Open, Momentary Pushbutton





Normally Closed, Momentary Pushbutton

Basic Electrical Devices

Control Panel Device

Emergency Stop Switch

- Emergency stop switches are used to stop an operation when an unexpected and sudden event that must be dealt with urgently occurs.
- Emergency Stop Button With Key Shroud used on panel doors.
- Emergency stop colour: Red

Basic Electrical Components

Control Panel Device

Door Switch

- The door switch monitors the position of cabinet doors.
- designed as a machine safety to alert an operator / technician when machine doors opens and triggers an emergency stop to prevent accident

Door Switch

Basic Electrical Components

Control Panel Device

Selector Switch

- Selector switches use cams in combination with contact blocks to provide a wide range of circuit openings and/or closings.
- Selector switches are operated by turning a knob instead of pushing a button.
- A very common selector switch is the MAN-OFF-AUTO switch. MAN stands for Manual and AUTO stands for Automatic.
- It can also have the design of OFF /ON or 0 - 1 – 2 for start & stop or selection of pumps to run in redundant systems.

Selector Switch

Basic Electrical Devices

Control Panel Device

Pilot Lamps

The pilot lamps are used to indicate a particular process or function that is in operation.

The lamps have a standard colour code.

- Green indicator represents for machine / Pump running, Panel alive, valve open.
- Blue indicator represents machine faults
- White represents for fuse break, valve closed.
- Yellow / Amber represents standby.
- Red indicates Alarms, Faults, emergency.

Basic Electrical Devices

Control Panel Device

Signal Lamps (LED stack light)

Signal lights shall be based on colours as indicated in the NEN-EN-IEC60204-1 paragraph 10.3

- Signalling columns are important optical aids for supervising complicated workflows on machines or in automated processes.

- In emergency situations, they serve as a visual or acoustic warning system. Thanks to their modularity, the steady, blinking, flashing and all-round light elements, as well as buzzer and siren elements can be flexibly designed and used in a great many ways.

Signal lamp		NEN-EN-IEC 60204		Interpretation	Example
RED	Continue	Emergency	Dangerous situation	Hazardous situation. Immediate action to deal with critical condition	General mail function
	Flashing				Emergency stop pushed
YELLOW	Continue	Abnormal	Action required	Abnormal condition. Monitoring and/or intervention	Operator action needed
	Flashing				Lack of operating materials
BLUE	Continue	Instruction	Action mandatory	Mandatory actions from operator is required	Fault pending
	Flashing				Fault ready to receipt
GREEN	Continue	Normal	Active	Normal condition	Machine is running
	Flashing				Machine is in stand-by (automatic restart)
WHITE	Continue	Neutral	Control	Other condition	
	Flashing				

Basic Electrical Components

Control Panel Device

Maintenance Switch

- A maintenance switch per motor or group of motors within a defined area must be installed as per NEN-EN-60204-1 in order to lock the motor against unforeseen starting. The maintenance switch shall be installed in the power line to the motor unless otherwise agreed (eg. HV motors)
- Maintenance switches shall be able to lock in the off-position
- Load break switch - Mains incoming disconnector

Maintenance Switch

Load break switch

Basic Electrical Devices

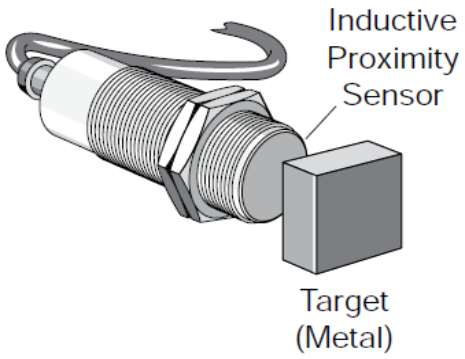
Field Device

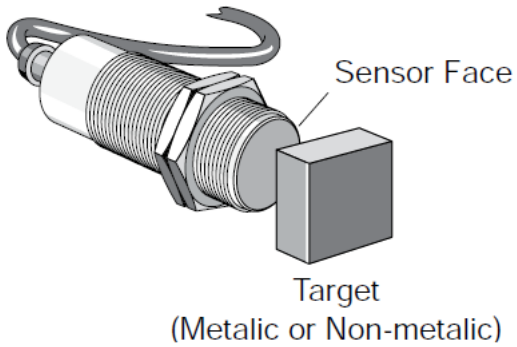
Proximity Sensors & Switches

Proximity switches are non contact switches, that is they switch by closeness of objects to their sensing area.

- Proximity switches that detect metal surfaces are called Inductive Proximity switches.
- Proximity switches that detect both metal & non-metal surfaces are called capacitive Proximity switches types



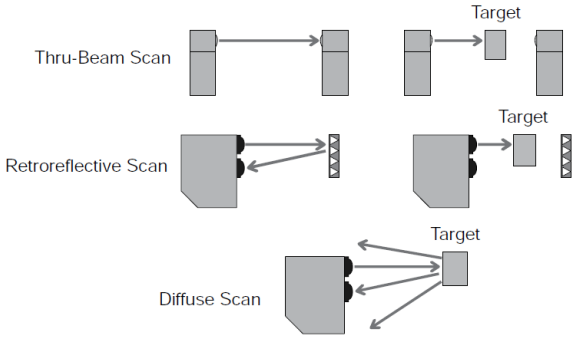


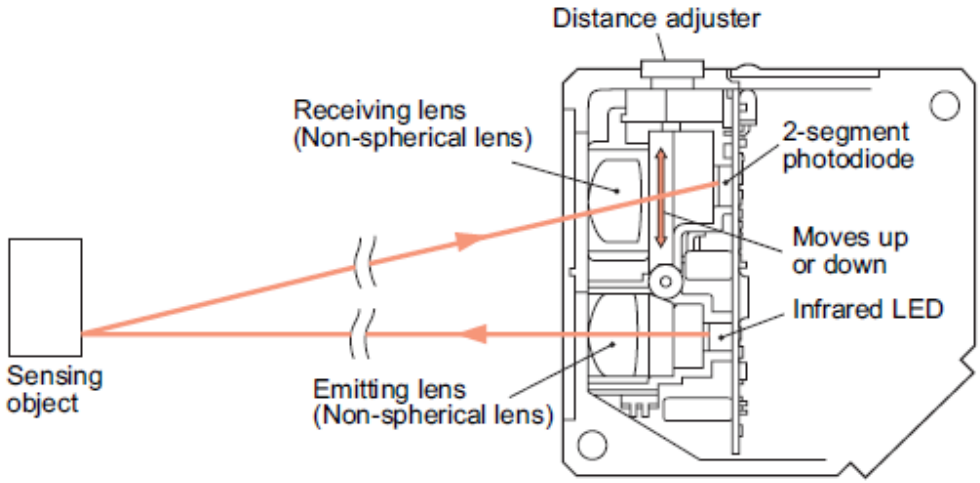
Basic Electrical Devices

Field Device

Photocell

- A photocell is a device that is sensitive to varying levels of light that is used to control an electric circuit.
- A sensor that uses light sensitive elements to detect objects.
- It captures the change in light depending on the object of detection. i.e. is to identify the difference in the quantity of light that enters the sensor when an object is present and wh it is absent.



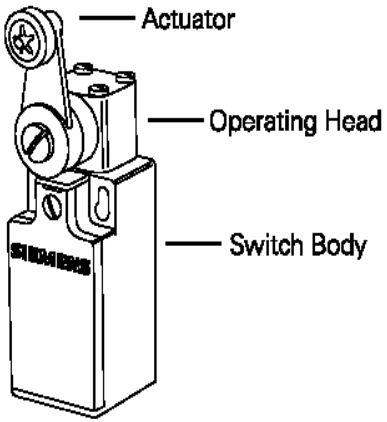


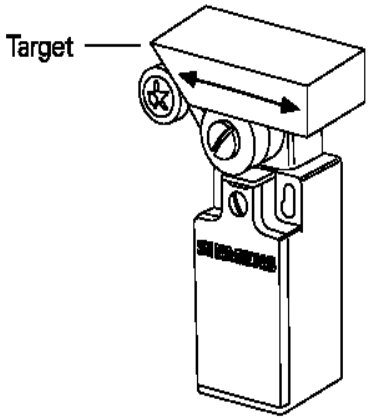
Basic Electrical Devices

Field Device

Limit Switch

- Limit switch is a mechanical device that uses physical contact to detect the presence of an object (target).
- When the target comes in contact with the actuator, the actuator is rotated from its normal position to the operating position.
- This mechanical operation activates contacts within the switch body.





Basic Electrical Devices

Control Panel Device

Soft Starters

- Soft starters are used to reduce the current and torque of a three-phase induction motor during the start-up process.

Soft Starter

Frequency Converters

- A frequency changer or frequency converter is an electronic or electromechanical device that converts alternating current (AC) of one frequency to alternating current of another frequency. Its main advantage is that it is used for speed control of electric motors

Frequency Converter

Basic Electrical Devices

Control Panel Device

DC voltage supply

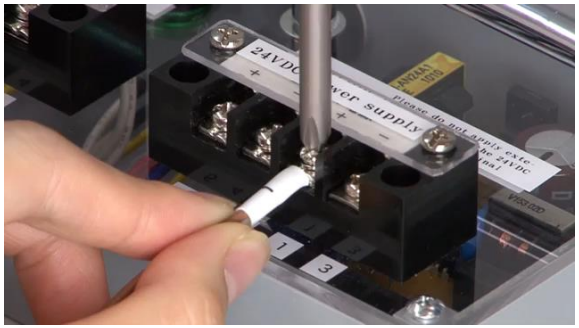
- This is a device that converts our AC voltage supply to our required DC voltage to be used by some devices

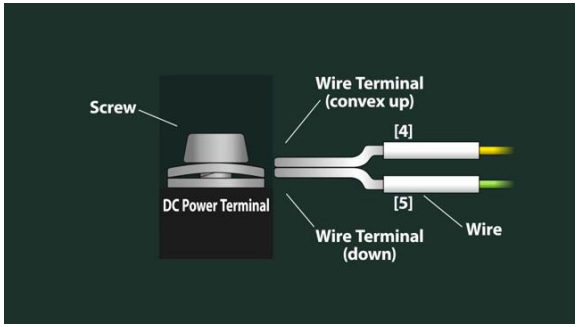
Basic Electrical Devices

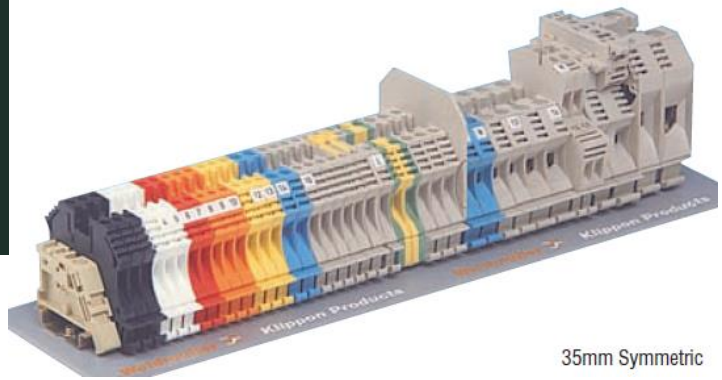
Control Panel Device

Terminal links / blocks

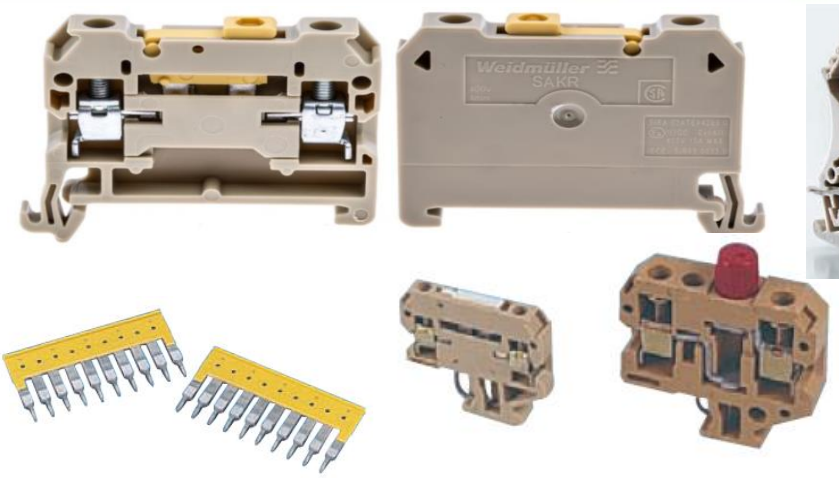
- used to join electrical conductors and create an electrical circuit.







35mm Symmetric



Isolating SAKR type

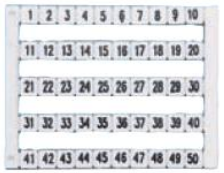
Fused SAKS3 type

Earth EK type

End stop

Jumper Kit

End cap



Markers

Basic Electrical Devices

Control / Field Panel Device

Cable lug

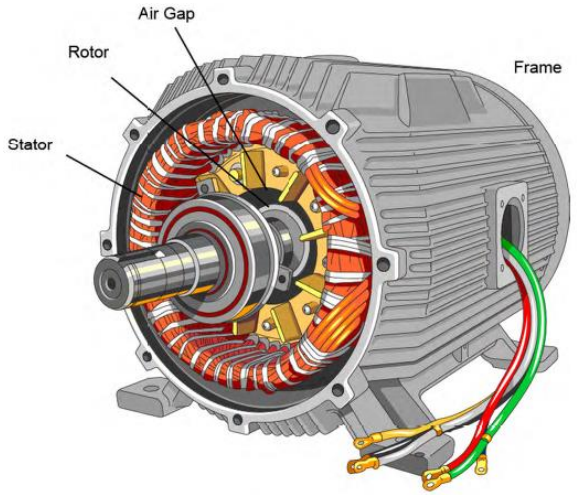
- Insulated Cable lugs
- Cable Lug 1.5mm 2.5mm 4mm 6mm 10mm 16mm 25mm Ring Terminals, Connectors, Tin Plated Pure Copper
- Fork AWG Pre Insulated Terminal Cable Lug
- Ring terminal cable lugs

Basic Electrical Devices

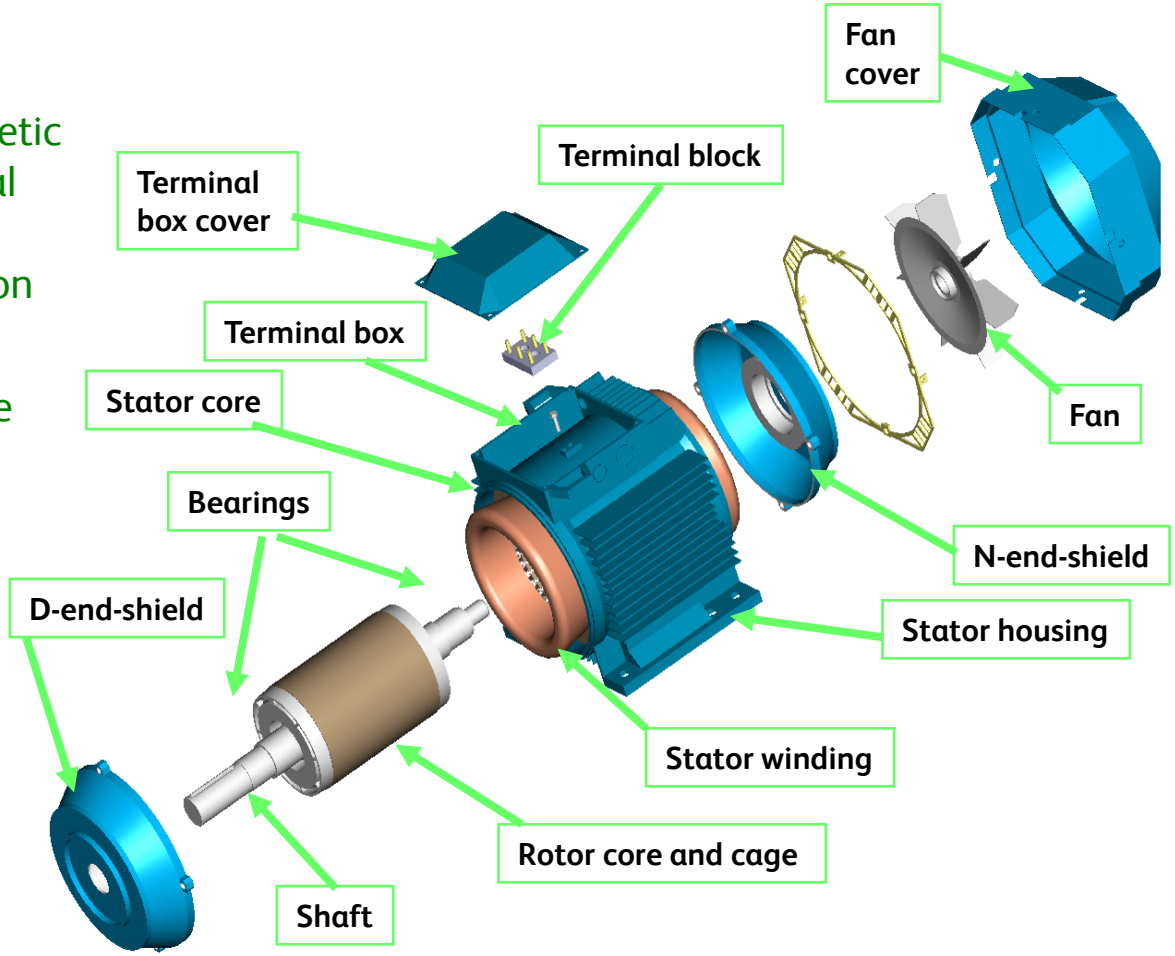
Field Device

Electric Motors

- An Electric motor are electromagnetic transducers , they convert electrical energy into mechanical energy by means of electromagnetic induction
- Squirrel Cage Induction Motors are widely used in the brewery.



Partially Assembled Motor



Basic Power Systems

Basic Power Systems

Power Generation, Transmission & Distribution

Power Generation

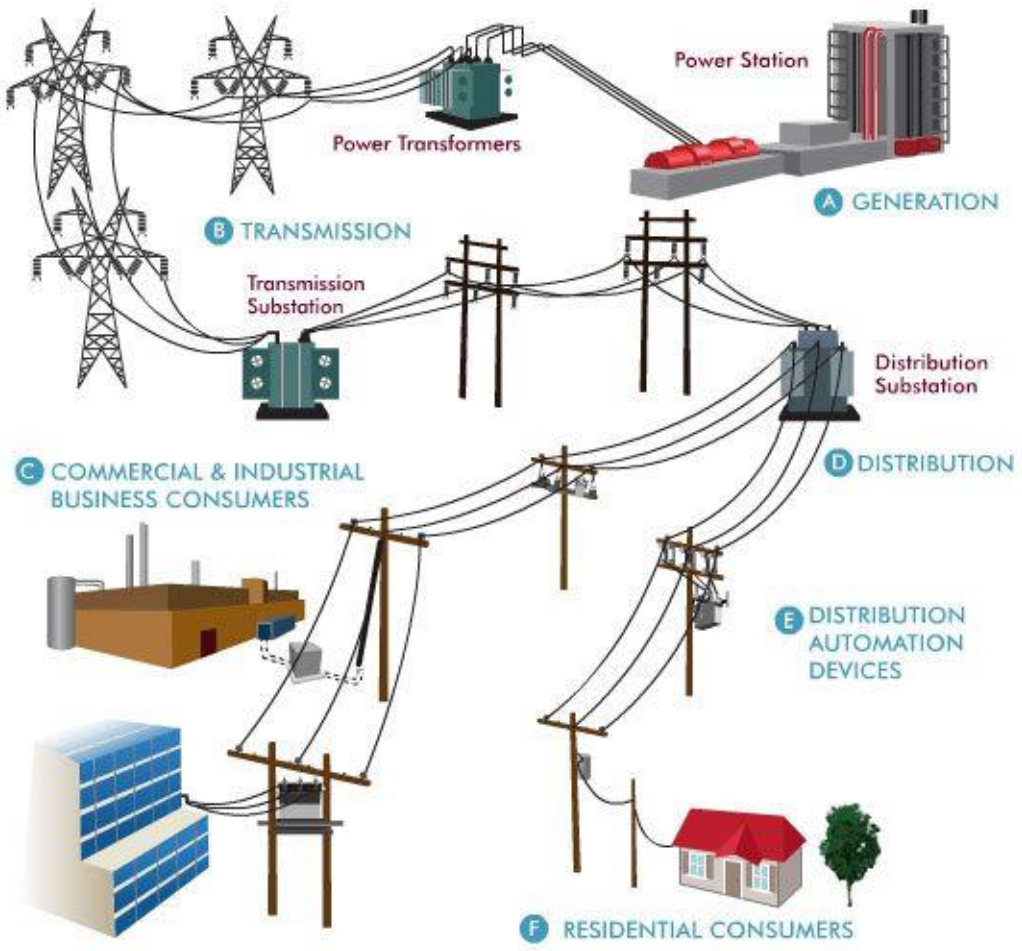
- Power or Electricity generation is the process of generating electric power from sources of primary energy. e.g. Generators

Power Transmission

- Electric power transmission is the bulk movement of electrical energy from a generating site, such as a power plant, to an electrical substation. e.g. Power Transformers

Power Distribution

- Electricity distribution is the final stage in the delivery of electricity to end users. A distribution system's network carries electricity from the transmission system and delivers it to consumers. e.g. Main Switch Board, Distribution Fuse Board.



Power Generation, Transmission & Distribution

Power generation from the Generators to Main distribution switch board (MSB) in the brewery

Generator

Power Generation, Transmission & Distribution

Power generation from the Generators to Main distribution switch board (MSB) in the brewery

Transformer

Basic Power Systems

Power Generation, Transmission & Distribution

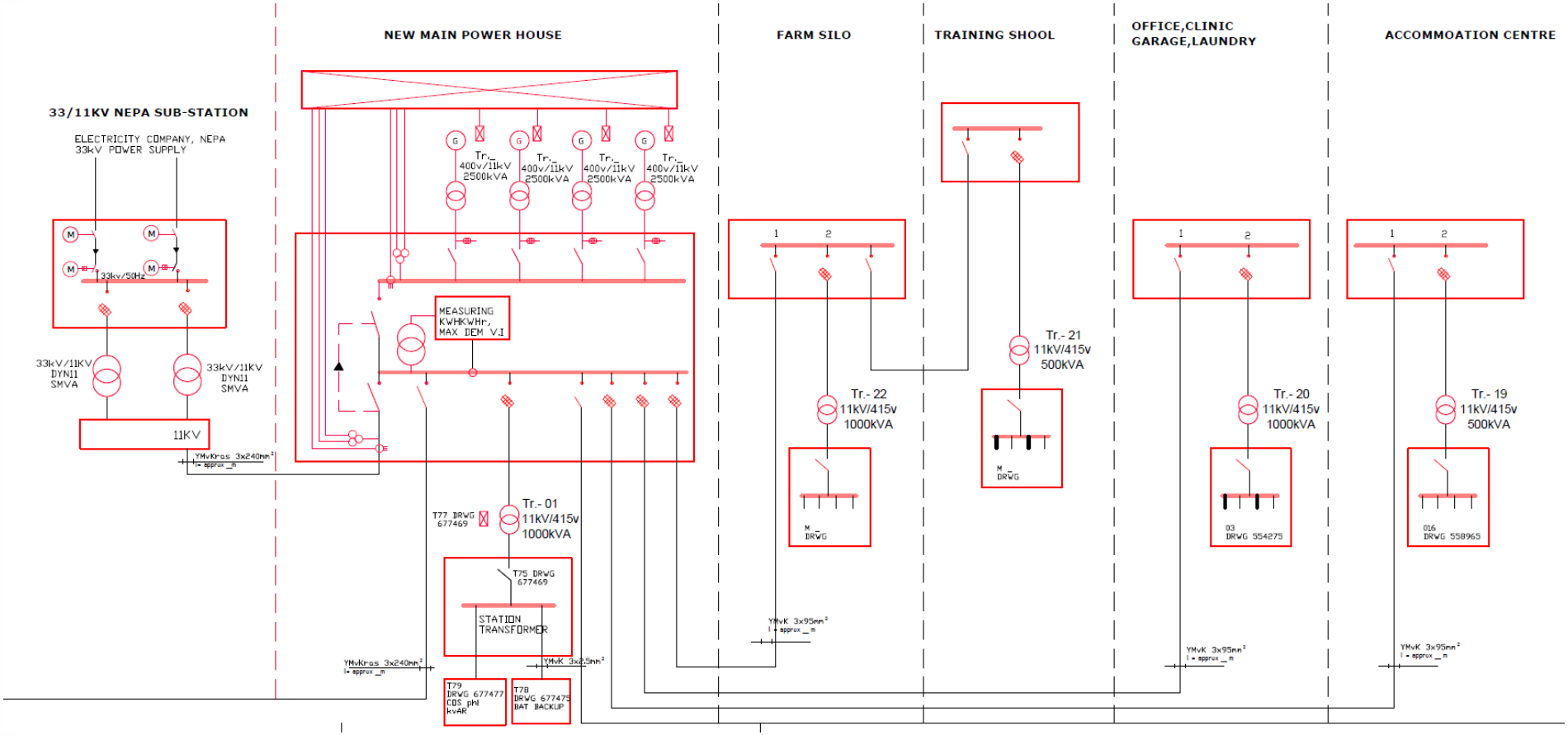
Power generation from the Generators to Main distribution switch board (MSB) in the brewery

Main Switch Board

Basic Power Systems

Power Generation, Transmission & Distribution

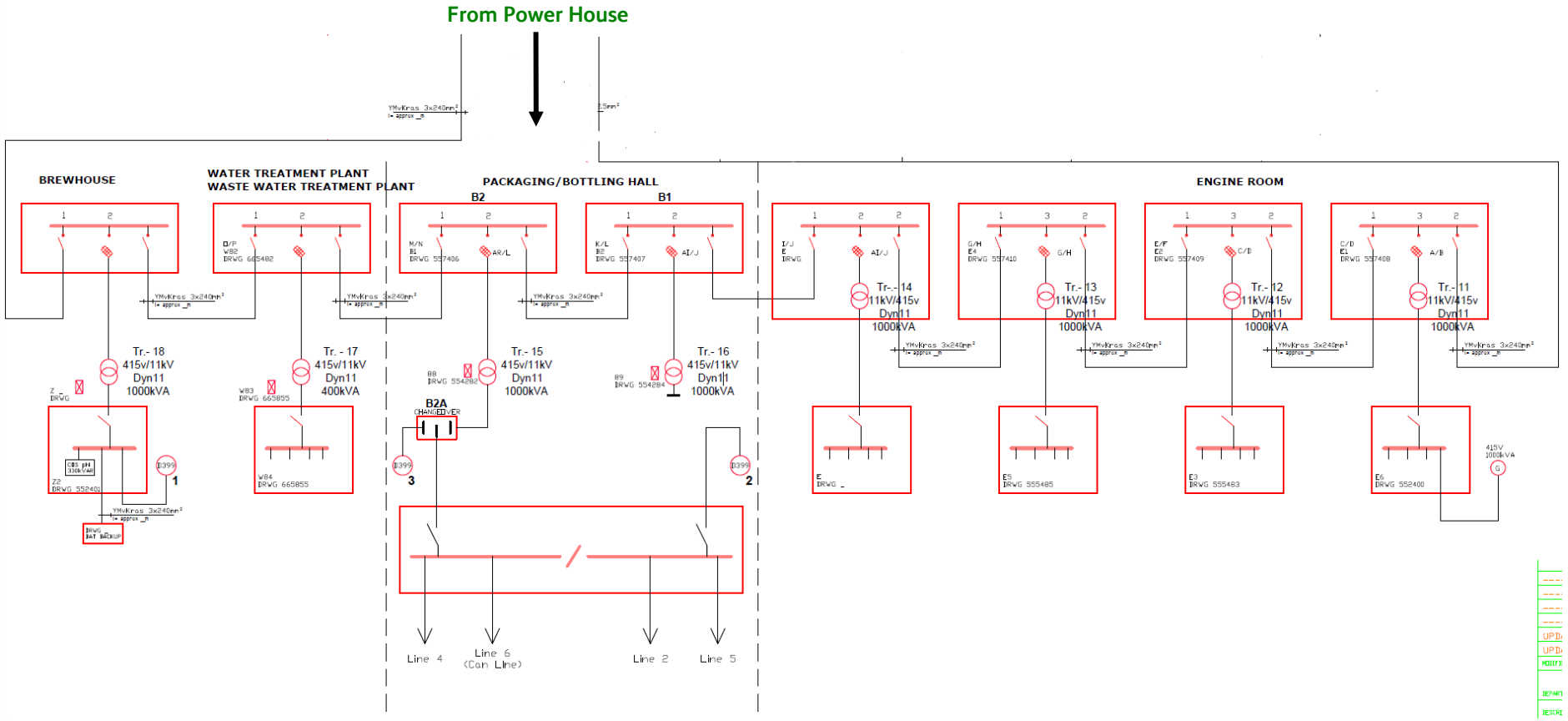
Power generation to Main distribution switch board (MSB) in the brewery (Ibadan Brewery)



Basic Power Systems

Power Generation, Transmission & Distribution

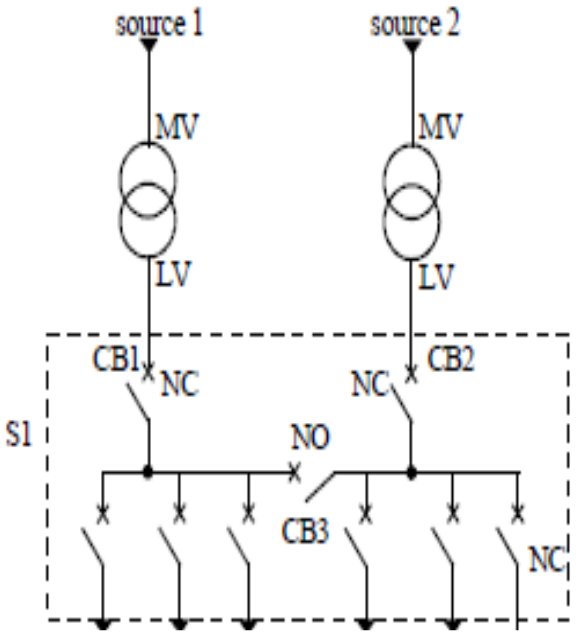
Power generation to Main distribution switch board (MSB) in the brewery (Ibadan Brewery)



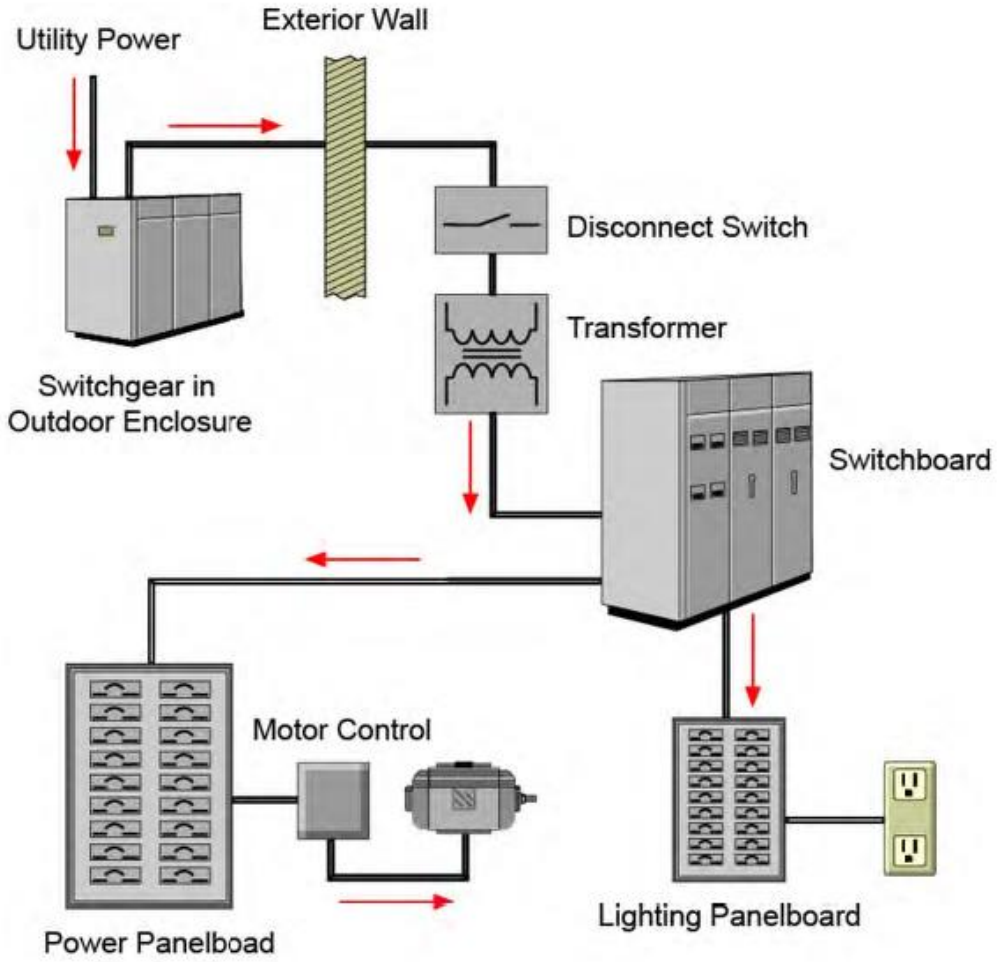
Basic Power Systems

Power Generation, Transmission & Distribution

Power generation from the Generators to Main distribution switch board (MSB) in the brewery



LV Network



Basic Electrical Maintenance & Diagnostics

Basic Electrical Maintenance & Diagnostics

Why we maintain Panels

Electrical maintenance involves the fault diagnosis, routine servicing, and repair of electrical components of a machine. Electrical maintenance types depends upon the types of industry and various types of machines available in the workplace.

Electrical maintenance covers all aspects of testing, monitoring, fixing, and replacing elements of an electrical system. Usually performed by a licensed professional with a complete knowledge of the National Electric Code and local regulations, electrical maintenance covers areas as diverse as:

- Digital communication
- Electrical machines
- Generators
- Hydraulics
- Lighting systems
- Pneumatics
- Surge protection
- Transformers.

With an increased reliance on both data collection and machinery run by computer software, electrical maintenance is more vital than ever. The failure of a single component in the electrical system can cause extensive downtime or data loss.

Advantages Of Electrical Maintenance

By investing in a routine electrical maintenance program, you can detect electrical problems early and fix them before they become a more dangerous

Here are a few of the key benefits of regular electrical maintenance

- Lower costs
- Improves safety.
- Prevent damage before it occurs
- Better equipment performance with significant impact on Maintenance KPIs e.g. MTTR, MTBF, etc.
- Fewer unplanned outages.

Basic Electrical Maintenance & Diagnostics

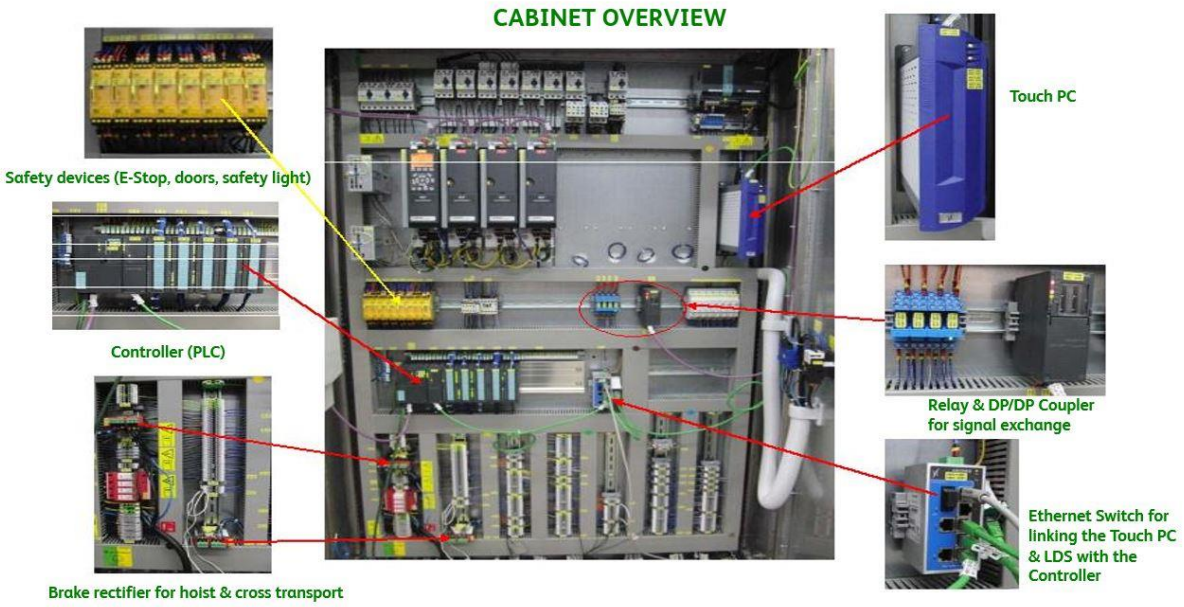
Maintenance of Electrical Panel (machine and power distribution panels)

- Use the required Safe work permit for the planned job.
- Ensure routine cleaning of electrical panel as per CMMS (SAP) plan
- Ensure panel drawings are kept in control panel document holder.
- Confirm panel cooling fans or extractor is working and service schedule is updated.
- Clean panel dust filters to enable heat dissipation.
- Confirm panel cooling AC is working and service schedule is updated.
- Confirm cable glands in panels are secured firmly for cable entry.
- Check for any Loose connections in I/O Modules and retighten.
- Ensure cables are neatly arranged in cable trunks inside the panels.
- Ensure cables on cable trays are secured with cable tie wraps
- Ensure all machine electric panels are always locked & control rooms have access control to prevent unauthorized access.
- Distribution switch boards & Lighting Fuse boards should always be locked.
- Update & sign-off panel inspection checklist

Basic Electrical Maintenance & Diagnostics

Maintenance of Electrical Panel (machine and power distribution panels)

- Electrical panel overview



THANK YOU