

## Internship Report

Kohinoor Energy Limited 124MW Diesel Power Plant

35-Km Link Manga Raiwind Road Lahore

29 January 2019 – 29 April 2019

Muhammad Shamaas

mshamaas1997@gmail.com

0423-5414441; 03160146282



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## Introduction

This report summarizes my experience of the three-month internship in Kohinoor Energy Limited 124 MW Diesel Power Plant. I am immensely thankful to Mr. Muhammad Asif for granting me this wonderful learning opportunity, and I am grateful for the KEL staff members who accommodated me. Overall, it was a grand experience and I got to observe the practical applications of what I had studied in Electrical Engineering.

KEL was incorporated in April 1994 as a joint venture of Saigols Group of Companies and Toyota Tsusho Corporation. Some of the shareholders include: M. Naseem Saigol, Mrs. Shehyr Saigol, Mrs. Amber Haroon Saigol, Dinaz Cassim, Durain Cassim, Toyota Tsusho Corporation, Tomen Power Singapore (Pvt.) Limited, Wartsila Finland Oy, NIT and Syed Iftikhar ul Hasan Zaidi. The current Directors include: M. Naseem Saigol, Mrs. S M Shakeel, Ichiro Kawano, Shingo Ito and Ms. Mariko Ueda. Situated at 35-KM Link Manga Raiwind Road Lahore, this Independent Power Producer generates and sells Electric Power to the Pakistan Water and Power Development Authority.

My research is presented by a qualitative analysis of the different plant subsystems, with more focus on the Electrical components as compared to Mechanical subsystems. The Power Plant has eight 19.6 MVA 11 kV Diesel Generators and a 10 MVA 11kV Combined Cycle Heat Recovery Peter Brotherhood Steam Turbine Generator. Three ABB 63 MVA Step-Up Transformers convert the Electrical Output from 11 kV to 132 kV for connection to the Electrical Grid. The working hours of the 267 workers are meticulously monitored. In my opinion, the technical work is very tortuous, dangerous, exhausting and stressful. The workers carry out very dangerous, life threatening activities every day. Workers are exposed to high currents, heavy power tools and machinery, biohazards, poisonous chemicals and fumes, dark and confined work areas, long and exhausting work shifts etc. Through the Environment, Health and Safety Program, the company takes great precautions to make sure that the workers do not face any physical or psychological harm.

## Research and Learning

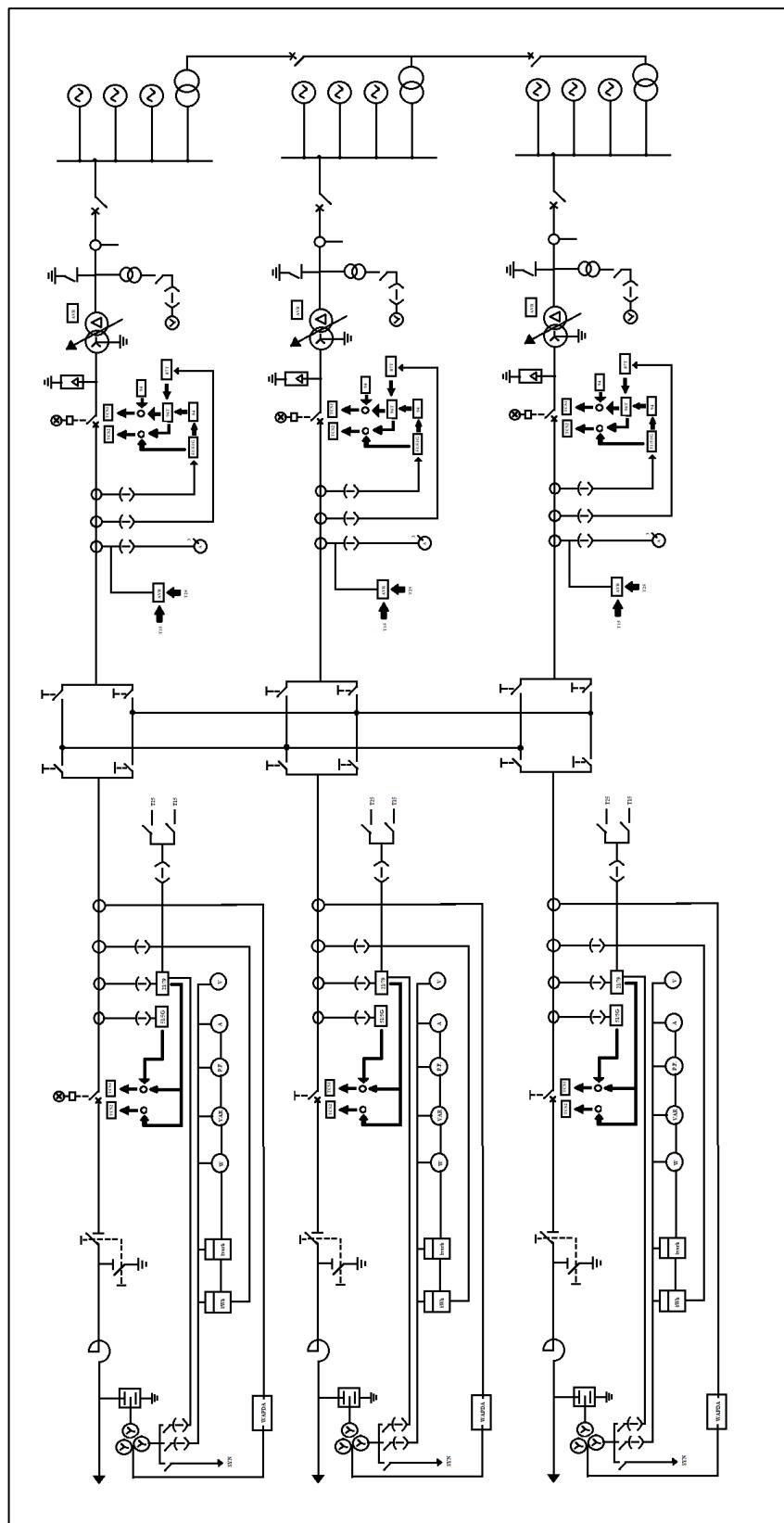
During my research and conversations with the Power Plant employees, the following questions were discussed; and these are the new topics that I learned about:

1	What is the function of line trap in using transmission lines for communication purposes?
2	What is Electrical Energy? Why does charge never run out in a wire when it is being continuously consumed in the electrical load?
3	What is the principal of operation of Capacitor Voltage Transformer? What are its advantages? What is its symbol?
4	What are the maximum number of poles in a synchronous machine?
5	What are the different methods of starting a synchronous generator?
6	At what voltage level does corona effect start? How is it related to magnetic flux and wire turns? Why does it affect Live wire but not the Neutral wire?
7	What is the difference between DG-SET and STG?
8	What work hazards do workers face in Hot work, Hazardous work, Work at height, Confined space work and Scaffolding work?
9	What is the function of magnetic Contactor in Variable Speed Motor?
10	How does a Motor Circuit Breaker work?
11	What do rotating diodes look like? What does bridge circuit look like?
12	What is the function of diode Monitor?
13	What is the function of under reactance relay?
14	How does frequency, phase and voltage synchronizer work?
15	What can cause fluctuations of voltage, phase and frequency in a grid connected plant?
16	What were the different modes of the Engine and Generators? How are they operated before and after grid connection?
17	What is D-Bearing and ND-Bearing in a Synchronous Generator?
18	What is the function of Pt-100 RTDs? How do they work?
19	What is the function of Neutral Point Cubicle?
20	What is the function of microprocessor based Digital Excitation Control System?
21	How does Torsional Vibration Monitor work?
22	How does Oil Mist Detector work?
23	How does a 10 ton 3 Dimensional Electric Crane work?
24	Why is oxygen tank used for soldering?
25	How are electrical cables named? How are they cut, strapped and insulated? What is a wiring table?
26	What is the importance of safety signs, safety guards, tags, colors, lines, "CAUTION" tape, labelling and numbering?
27	What does a work permit entail?
28	What is the function of ECTs?
29	How does sludge treatment work?
30	What do Power Transformer Protection Devices look like? How do they operate?
31	How does AVR function?
32	What are the different Insulation classes?
33	What are the different Accuracy classes?
34	What are the different Temperature Rise classes?
35	How generators are internally heated/ cooled?
36	What are the different Mounting Standards?
37	What are the different Protection Standards?
38	What are the different Cooling Standards?

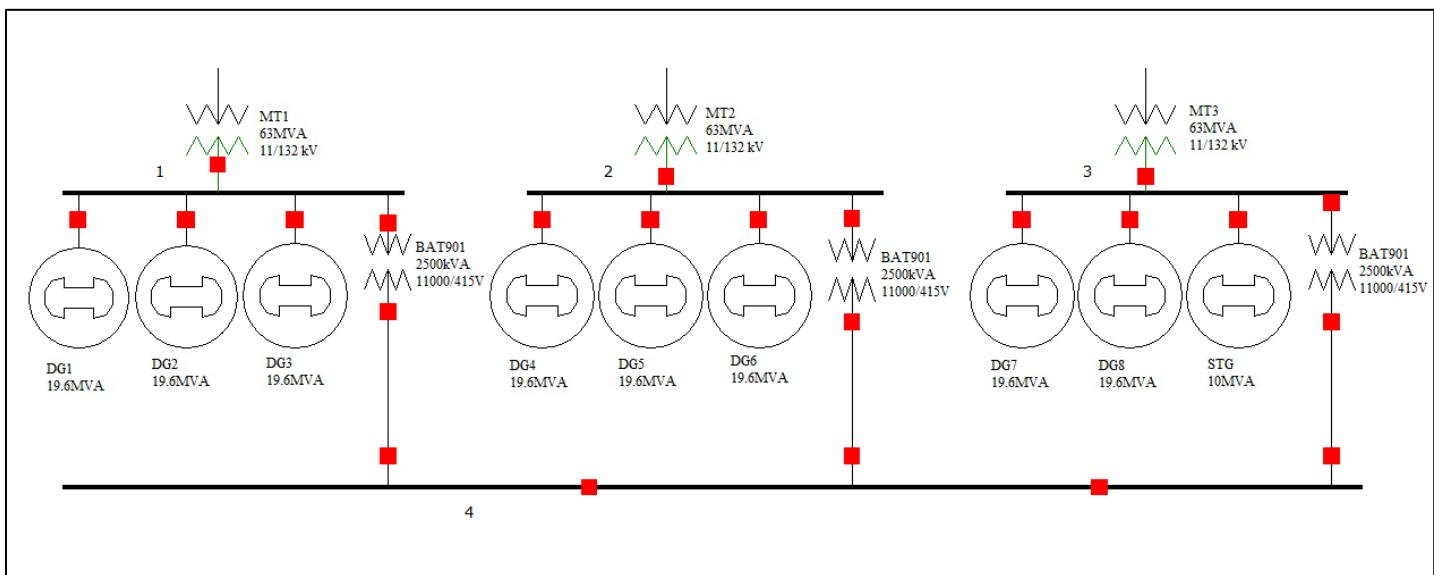
39	What are the different Sound Level Standards?
40	What is Black Start Unit?
41	What are ear muffs needed in Engine Hall?
42	Where is the Exciter located on the Synchronous Generator? How does it excite Field winding?
43	Where is the Stator Winding located on the Synchronous Generator?
44	What is the function of a paralleling relay?
45	What are the System, Generation and Transmission Voltage Levels in the Plant?
46	What are the different components of the Generator Protection Panel?
47	How does a current transformer work?
48	What are the different Insulation Tests? How is Megger Test done?
49	Why is Generator Winding Insulation approved from WAPDA?
50	How is motor run in Star Delta?
51	How does Synchronous Condenser provide Reactive Power Compensation?
52	What is mobile foam and foam water used for?
53	How is transformer oil tested in Laboratory?
54	What are the different maintenance schedules and procedures?
55	How are high voltage lines discharged before maintenance work?
56	Why the generator is never operated above rated power?
57	What are SMSB, MCP and DB Panels?
58	What kind of fumes are the workers exposed to?
59	What is RO, DI and RAW water used for?
60	Why are the running hours of generators recorded? Why is the STG shut down after 8000 running hours?
61	What is the chemical composition of Furnace Oil? How is it extracted?
62	What is the use of Viscosine Oil in the running of Diesel Engine?
63	What are linear Alkyl benzene and Sulphonic Acid used for?
64	Why is steam heating of Engines and Fuel Tanks important? What is the purpose of Anti condensation and trace heaters?
65	How does Exhaust Gas Boiler and Charge Air Filter clean Exhaust gases?
66	What products did these power companies manufacture for the power plant: SACO, PHILIPS, BROTHER, PANASONIC, CANON, ICATEC, ABB, DEIF, CROMPTON, OMRON, SCHRACK, TELEMECANIQUE, SQUARED, ETA, KAMSTRUP, MERLINGERIN, RED LION CONTROLS, TUNGSTONE, SELCO, STEWER SCHALTER, BACO, FINDER, RELECO, REVALCO, SAHKOLEHTO, PFANENBERG, MODICON, NEMATRON, SCHENIDER, AAS, LOVAL OY, TRAFOTEK, RENK, UC4, SEMICRON, PLIOTRON, BASLER DECS.
67	How does a current cable transformer function?
68	Why is underground cabling important? Why are metal tubes used for cabling?
69	Why is varnish applied on insulated cables?
70	Why are fire alarm call points, fire hose reels, fire extinguishers, fire phones, sand buckets located at different places on the power plant?
71	What is the purpose of installing chemical showers?
72	What is the meaning of plant Reliability, Utilization, Peak Capacity, Availability, Dispatch Response, Emissions, Operation and Maintenance costs, Heat Rate, Commissioning, Inspection, Aging, Yield, Installed Capacity, Reserve Capacity, Hot Reserve, Spinning Reserve, Average Demand, Peak Demand, Loss Indicator and Load Forecast?
73	What is the purpose of Lock-out Tag-out strategy?
74	What is the purpose of switchgear room?
75	What is soot blowing?

76	What is lamp test?
77	How does a manual fork lift and push trolley operate?
78	What is Dissolved Gas Analysis?
79	How are High Voltage Bushings constructed?
80	What functions does Modicon 984 PLC perform? How is telemetry done? How many alarms does it control?
81	How is transformer core designed for Power Transformer, Current Transformer, Protection and Measurement Transformers?
82	Why do workers need to wear uniform, boots, gloves, eye protection, face masks, ear muff and helmets?
83	Why is Emergency drill conducted?
84	How do overcurrent relays, distance relays, differential current relays, directional relays and synchronism check relays work?
85	What is the function of STG Condenser?
86	Why are Frequency Drive Units installed in switchgear room?
87	Why are Capacitor Banks installed in switchgear room?
88	What is the purpose of BGR EGB control boxes in Engine Hall?
89	How is grounding of Transformers and grid area done? Why are rocks placed around them? Why is fencing important? Why are wooden planks placed for walking?
90	Why are transmission line bushings supported on elevated steel platforms? How are transformer terminals connected to transmission lines?
91	How is metering done in grid area?
92	What are the different reasons for power losses in power transformers?
93	Why are the power transformers force air cooled?

## Power Plant Block Diagram



## Electrical System



### 1 DG-SET 1-8

The eight HSG 1600 S12 Brushless Synchronous Generators were manufactured by ABB. This is the nameplate data of one generator:

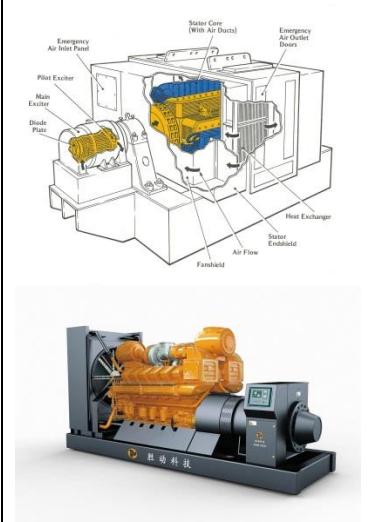
Power Rating: 19.6 MVA	Voltage: Y, 11 KV
Current 1028 A	Frequency: 50 Hz
Poles: 12	Exciter: 107V, 9.8 A
Power Factor: 0.8	Speed: 500 rpm
Cooling Class: IC OA1	Mounting Class: IM 7201
Protection Class: IP 21	Insulation Class: F
Standard: IEC 34	Mass: 55 tons
Ambient Temperature: 50 °C	Duty: S1

The generators require regular checking for power, current, power factor, excitation current, winding temperatures, bearing temperatures, cooling air temperatures, bearing vibration, heat exchangers, contamination, cleanliness of inner parts, diode bridge, windings and locking, possible shifting of slot wedges, winding insulation and finishing varnish, loosening of field windings, insulation resistance of windings, condition of fans, paint, seals, relays, control and regulation equipment, rotor winding supports, soldering, broken bars and bearings

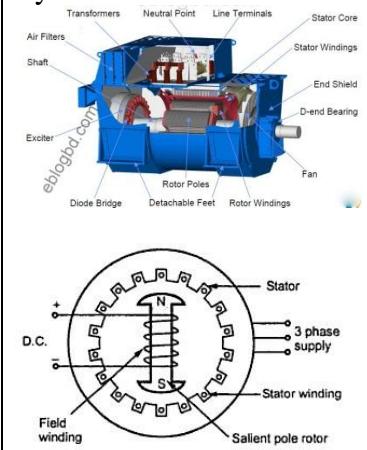
The PLC Engine Panel contains Safety and Monitoring Indicators, Fuel Oil System Monitors, Generator Protection Unit and an Enclosure Cooling Unit. The Generator Panels contain Voltage Meters, Current Meters, Frequency Meters, Energy Meters, Power Factor Meters, Tachometers, Active and Reactive Power Meters etc. Special Measurement Current Transformers and Voltage Transformers are used for the measurements.

The Generator Protection Panel includes Overvoltage relays, under voltage relays. Reverse Power Relays, Overcurrent relays, Differential Current Relays, Diode Monitors, Earth Fault Relays, frequency Relays,

### DG-SET



### Synchronous Generator



synchronizing relays and under reactance relays etc.

Generators produce current by moving an exciter, or mobile electromagnet, against the field generated by a stator, or stationary, electromagnet. This distorts the field and generates an electric current. A brushless generator uses a solid-state rectifier assembly consisting of a diode bridge. The rotating diodes are placed on the rotor. This assembly contains no moving parts. This is important, as it makes the system more reliable and less prone to mechanical breakdown, jamming or seizing as a result of obstructions in the casing.

The diesel generator is the combination of a diesel engine with an electric generator to generate electrical energy. The diesel compression-ignition engine is designed to run on diesel fuel. Diesel generating sets are used for more complex applications such as peak-lapping, grid support and export to the power grid.

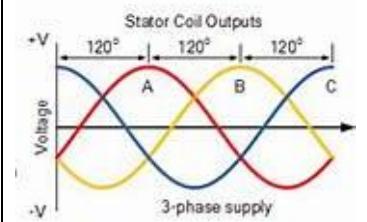
The Generators must provide the anticipated power required reliably and without damage and this is achieved by the manufacturer giving one or more ratings to a specific generator set model. A model operated as a prime power generator must operate continuously. Manufacturers give each set a rating based on internationally agreed definitions. These standard rating definitions are designed to allow valid comparisons among manufacturers, to prevent manufacturers from misrating their machines, and to guide designers.

**Prime Rating (Prime Power or Overload Power)** is the output available with varying load for an unlimited time. A 10% overload capability is available for limited time. **Base Load Rating** is applicable for supplying power continuously to a constant load up to the full output rating for unlimited hours. No sustained overload capability is available for this rating.

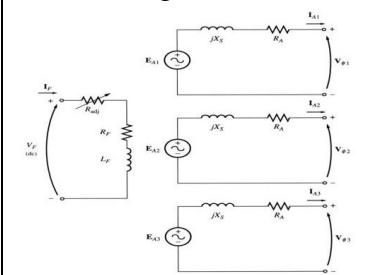
Proper sizing of diesel generators is critical to avoid low-load or a shortage of power. Sizing is complicated by the characteristics of modern electronics, specifically non-linear loads. Diesel generator arrays are sometimes preferred to open cycle gas turbines, due to their superior efficiencies. The size of the maximum load that has to be connected and the acceptable maximum voltage drop determine the set size. Sizing is based on site conditions and the type of appliances, equipment, and devices that will be powered by the generator set.

The Diesel engines are compression-ignition engines, and can operate on a variety of different fuels. Where a gas grid connection is available, gas is often used, as the gas grid will remain pressurized during almost all power cuts. This is implemented by introducing gas with the intake air and using a small amount of diesel fuel for ignition. Diesel fuel derived from crude oil is a common fuel; it is less likely to freeze than heavier oils. Diesel engines can work with the full spectrum of crude oil distillates, from natural gas, alcohols, gasoline, wood gas to the fuel oils from diesel oil to cheaper residual fuels that are like lard at room temperature, and must be heated to

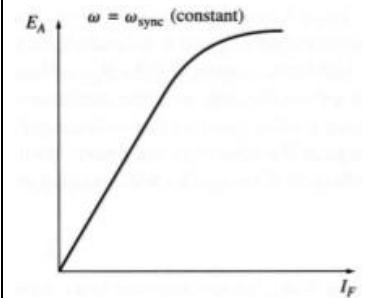
### Stator Output Voltage



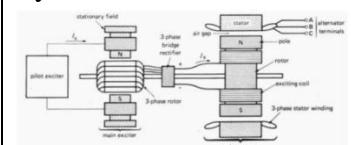
### Circuit Diagram



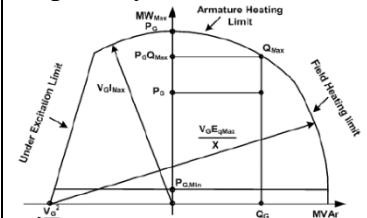
### Magnetization Curve



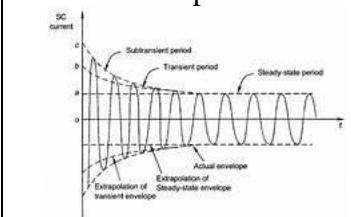
### Brushless Excitation System



### Capability Curve



### Transient Response



enable them to flow down a fuel line. Larger engines use heavy oils, essentially tars, derived from the end of the refining process. The fuel oil must be heated to enable it to flow, whilst mitigating the fire risks that come from over-heating fuel. Other possible fuels include: biodiesel, straight vegetable oil, animal fats and tallow, glycerin, and coal-water slurry.

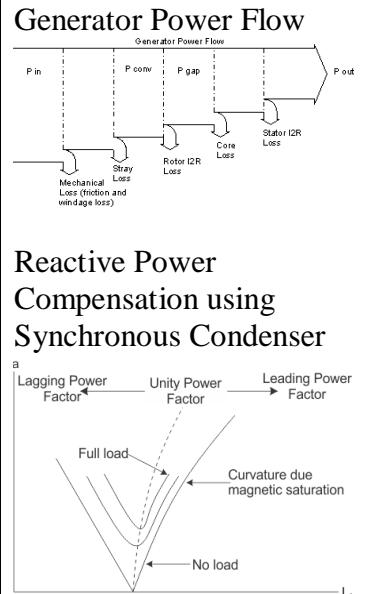
The rotor speed (rpm) of the synchronous generator with P poles and operating frequency f is dictated by:

$$n_m = \frac{120 f}{P}$$

The minimum number of poles is 2, which corresponds to a speed of 3000 rpm. The maximum number of poles is 3000 with an operational speed of 2 rpm.

A stationary generator must not be connected to live Bus bars because the induced EMF is zero at standstill resulting in a short circuit. The synchronization is the process of matching the speed and frequency of a generator or other source to a running network. An AC generator cannot deliver power to an electrical grid unless it is running at the same frequency as the network. If two segments of a grid are disconnected, they cannot exchange AC power again until they are brought back into exact synchronization. An AC generator must match both the amplitude and the timing of the network voltage, which requires both speed and excitation to be systematically controlled for synchronization. These features are controlled by the Speed governor and Automatic Voltage Regulator. The two operating modes are constant speed mode and constant power mode. In constant speed mode, the speed is constant per system nominal frequency but the power output is varied. In constant power mode, the speed is changed while the governor is base loaded. Constant power mode is used when generator is being interfaced with the grid at a slightly higher frequency than system frequency. Constant speed mode is used after grid integration.

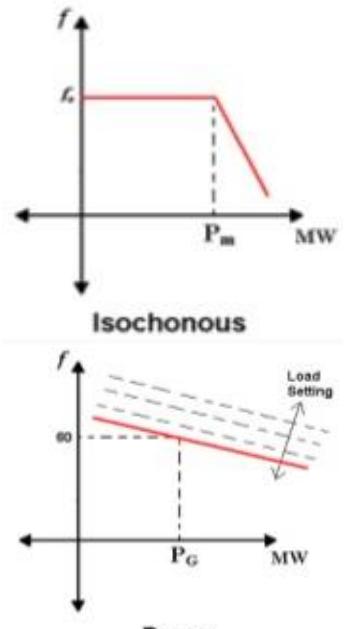
Grid Interfacing can cause voltage, phase and frequency fluctuations when new Generators are added or taken out. The Generator Capability curve shows that it draws reactive power for normal operation. The Generators must not draw excessive reactive power from the grid. Hence capacitor banks or synchronous condensers are used to deliver reactive power to the generators. The capacitor banks are located in the switchgear room. This increases the power factor toward unity. If the power factor is not close to unity, a penalty is imposed. During transients or power system faults, the generators are required to draw limited current in sub-transient and transient phases. This is dictated by their sub-transient and transient reactance. The expensive Generator must never be operated at maximum power limit because this can lead to damage or reduction in life. It is always operated below steady state stability limit to allow room for grid system fluctuations and transients like voltage, current, frequency, power and phase swings. The running hours of the generators are recorded. They are shut down after 8000 hours.



Capacitor Banks



Operating Modes



## 2 Steam Turbine Generator 9

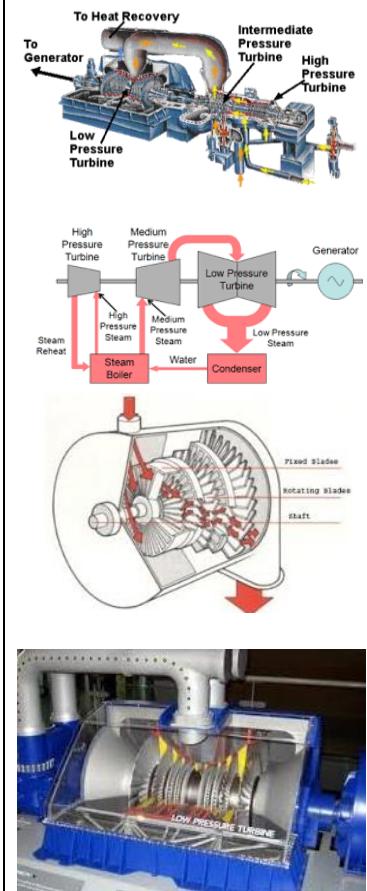
The HSG 900 LP4 Brushless Synchronous Generator was manufactured by ABB. This is the nameplate data:

Power Rating: 10 MVA	Voltage: 11 KV
Current 525 A	Frequency: 50 Hz
Ambient Temperature: < 50 °C	Exciter: 25.5V, 1.7 A
Power Factor: 0.8	Rated Speed: 1500 rpm
Cooling Class: IC O1	Insulation Class: F
Standard: IEC 34	Mass: 21.5 tons

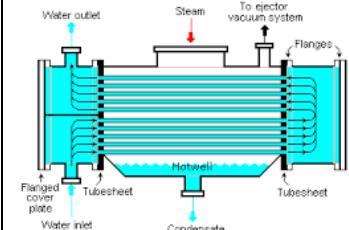
It required regular checking for power, current, power factor, excitation current, winding temperatures, bearing temperatures, cooling air temperatures, bearing vibration, heat exchangers, contamination, cleanliness of inner parts, diode bridge, windings and locking, possible shifting of slot wedges, winding insulation and finishing varnish, loosening of field windings, insulation resistance of windings, condition of fans, paint, seals, relays, control and regulation equipment, rotor winding supports, soldering, broken bars and bearings

The Combined Cycle Heat Recovery Peter Brotherhood Steam Turbine Generator extracts thermal energy from pressurized steam and uses it to do mechanical work on a rotating output shaft. Because the turbine generates rotary motion, it is particularly suited to be used to drive an electrical generator. The steam turbine is a form of heat engine that derives much of its improvement in thermodynamic efficiency from the use of multiple stages in the expansion of the steam, which results in a closer approach to the ideal reversible expansion process.

## Steam Turbine Generator



## Condenser



### 3 Transformers MT1, MT2, MT3

Three ABB 63 MVA Step-Up Transformers convert the Electrical Output from 11 kV to 132 kV for connection to the Electrical Grid. The 3 phase transformers used in power distribution have their core and coils immersed in oil, which cools and insulates. Oil circulates through ducts in the coil and around the coil and core assembly, moved by convection. The oil is cooled by an air-cooled radiator. Oil pumps circulate the oil.

These Transformers are essential for the transmission, distribution, and utilization of alternating current electric power. A wide range of transformer designs is encountered in electronic and electric power applications. Transformers weighing hundreds of tons are used to interconnect the power grid. Transformers are used for increasing or decreasing the alternating voltages in electric power applications, and for coupling the stages of signal processing circuits.

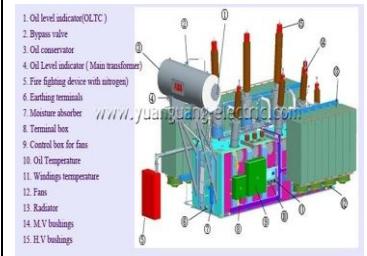
The transformer transfers electrical energy between two or more circuits. A varying current in one coil of the transformer produces a varying magnetic flux, which, in turn, induces a varying electromotive force across a second coil wound around the same core. Electrical energy can be transferred between the two coils, without a metallic connection between the two circuits. Faraday's law described the induced voltage effect in any coil due to changing magnetic flux encircled by the coil.

Transformers can be classified in many ways, such as the following: Power capacity, Duty of a transformer, Frequency range; Voltage class, cooling type, Circuit application, Utilization, Basic magnetic form, Constant-potential transformer descriptor, General winding configuration, Rectifier phase-shift winding configuration.

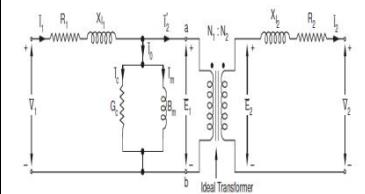
Transformer energy losses are dominated by winding and core losses. Transformers' efficiency tends to improve with increasing transformer capacity. The efficiency of typical distribution transformers is between about 98 and 99 percent. As transformer losses vary with load, it is often useful to tabulate no-load loss, full-load loss, half-load loss, and so on. Hysteresis and eddy current losses are constant at all load levels and dominate overwhelmingly without load, while variable winding joule losses dominating increasingly as load increases. The no-load loss can be significant, so that even an idle transformer constitutes a drain on the electrical supply. Designing energy efficient transformers for lower loss requires a larger core, good-quality silicon steel, or even amorphous steel for the core and thicker wire, increasing initial cost. The choice of construction represents a trade-off between initial cost and operating cost.

Transformer losses arise from: Winding joule losses, Hysteresis losses in Core, Eddy current losses, Magnetostriction related transformer hum, Stray losses, Radiative Losses, Mechanical vibration and audible noise transmission. Current flowing through a winding's conductor causes joule heating. As frequency increases, skin effect and proximity effect causes the

**Power Transformer**



**Transformer Circuit**



**Buchholz Relay**



**Pressure Relay**



winding's resistance and, hence, losses to increase. Each time the magnetic field is reversed, a small amount of energy is lost due to hysteresis within the core. Eddy currents are produced in the metal transformer core and cause heating of the core. The eddy current loss is a complex function of the square of supply frequency and inverse square of the material thickness. Eddy current losses can be reduced by making the core of a stack of plates electrically insulated from each other, rather than a solid block; all transformers operating at low frequencies use laminated or similar cores. Magnetic flux in a ferromagnetic material, such as the core, causes it to physically expand and contract slightly with each cycle of the magnetic field, an effect known as Magnetostriction, the frictional energy of which produces an audible noise known as mains hum or transformer hum. This transformer hum is especially objectionable in transformers supplied at power frequencies. Leakage inductance is by itself largely lossless, since energy supplied to its magnetic fields is returned to the supply with the next half-cycle. However, any leakage flux that intercepts nearby conductive materials such as the transformer's support structure will give rise to eddy currents and be converted to heat. There are also radiative losses due to the oscillating magnetic field but these are usually small. In addition to Magnetostriction, the alternating magnetic field causes fluctuating forces between the primary and secondary windings. This energy incites vibration transmission in interconnected metalwork, thus amplifying audible transformer hum.

The Transformer is protected using Buchholz Reay, Contact Thermometers, Cooling Fans, Gas Flow Meters, Manometers, Oil Level Indicators, Pressure Relief Devices, Oil Temperature Indicator, Pressure Relay, Radiators, Sampling and Drain Valves, SF<sub>6</sub> Density Monitors, Throttle Valves, Winding Temperature Indicators, Overcurrent Relays etc.

**Oil Level Monitor**



**Winding Thermometer**



**Fuse**



#### 4 Transmission Grid

The wide area synchronous grid directly connects a large number of generators delivering AC power with the same relative frequency to a large number of consumers.

Electric power transmission is the bulk movement of electrical energy from the power plant, to an electrical substation. The transmission network of interconnected lines facilitates the bulk movement of electrical energy. This is distinct from the local wiring between high-voltage substations and customers, which is typically referred to as electric power distribution.

These high potential differences give origin to step potential and touch potential, or a combination of both, that can lead to circulation of an electric current through the human body, that can cause hazardous to people.

Touch voltage can be defined as the maximum potential difference that exists between an earthed metallic structure capable to be touched by the hand and any point of the ground, when a fault current flows. It is usual to consider a distance of 1 m between the metallic structure and the point on the ground.

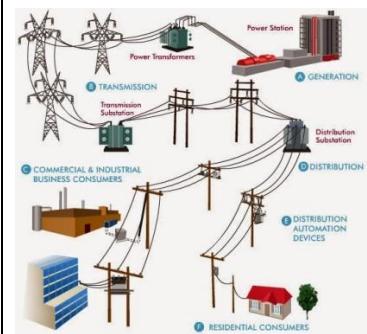
Step voltage is defined as the maximum potential difference that exists between the feet when a fault current flows. It is usual to consider a distance of 1 m between the feet.

Ground potential rise is the maximum electrical potential that a substation grounding grid may attain relative to a distant grounding point assumed to be at the potential of remote earth. This voltage, GPR, is equal to the maximum grid current times the grid resistance.

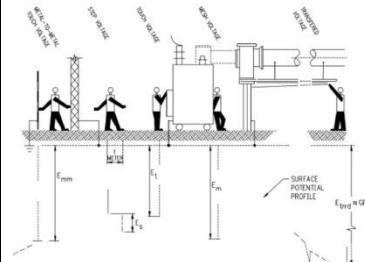
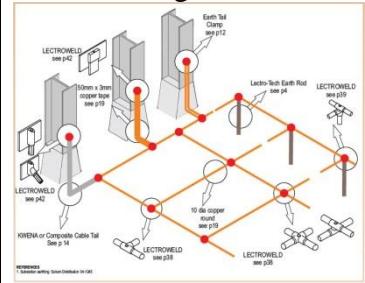
Mesh voltage is the maximum touch voltage within a mesh of a ground grid.

Metal-to-metal touch voltage is the difference in potential between metallic objects or structures within the substation site that may be bridged by direct hand-to-hand or hand-to-feet contact.

#### Transmission Grid



#### Grid Earthing



## 5 PLC System and Control Room

The Power Plant has a Modicon 984 PLC system for the control of the different subsystems.

Modicon offers a wide range of compact, midsize, and high-performance CPUs. All 984 controllers, regardless of their particular hardware implementation, use a common processing architecture; they are all programmed with ladder logic, a powerful and graphical language that emulates relay-equivalent symbology; and they share common instructions drawn from a large set of calculation, data transfer (DX), matrix, and special-application functions. Modicon also provides with various networking strategies, allowing interconnection of multiple controllers—and other devices—for increased application control and data exchange.

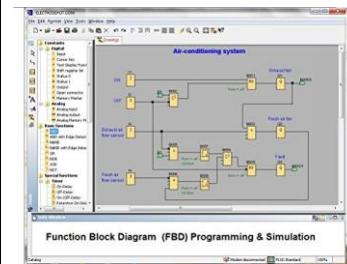
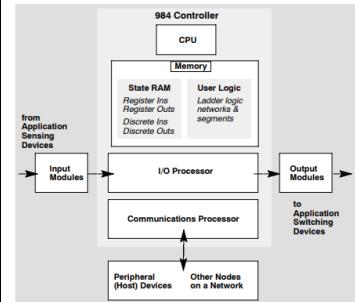
The family approach to 984 controller design allows the operator to make choices based on controller capacity (the number of discrete and analog/register points available for application programming, the number of I/O drops it supports), throughput (the rate at which it solves logic and updates I/O modules), and environmental hardness (the design standards its hardware implementation must meet).

The programmable logic controller (PLC) or programmable controller is an industrial digital computer which has been ruggedized and adapted for the control of manufacturing processes, such as assembly lines, or robotic devices, or any activity that requires high reliability control and ease of programming and process fault diagnosis. PLCs have been widely adopted as high-reliability automation controllers suitable for harsh environments. A PLC is an example of a "hard" real-time system since output results must be produced in response to input conditions within a limited time, otherwise unintended operation will result. PLCs can range from small modular devices with tens of inputs and outputs (I/O), in a housing integral with the processor, to large rack-mounted modular devices with a count of thousands of I/O, and which are often networked to other PLC and SCADA systems. They can be designed for multiple arrangements of digital and analog I/O, extended temperature ranges, immunity to electrical noise, and resistance to vibration and impact. Programs to control machine operation are typically stored in battery-backed-up or non-volatile memory. The PLC would tolerate the shop-floor environment, it would support discrete (bit-form) input and output in an easily extensible manner, it would not require years of training to use, and it would permit its operation to be monitored. Since many industrial processes have timescales easily addressed by millisecond response times, modern (fast, small, reliable) electronics greatly facilitate building reliable controllers, and performance could be traded off for reliability.

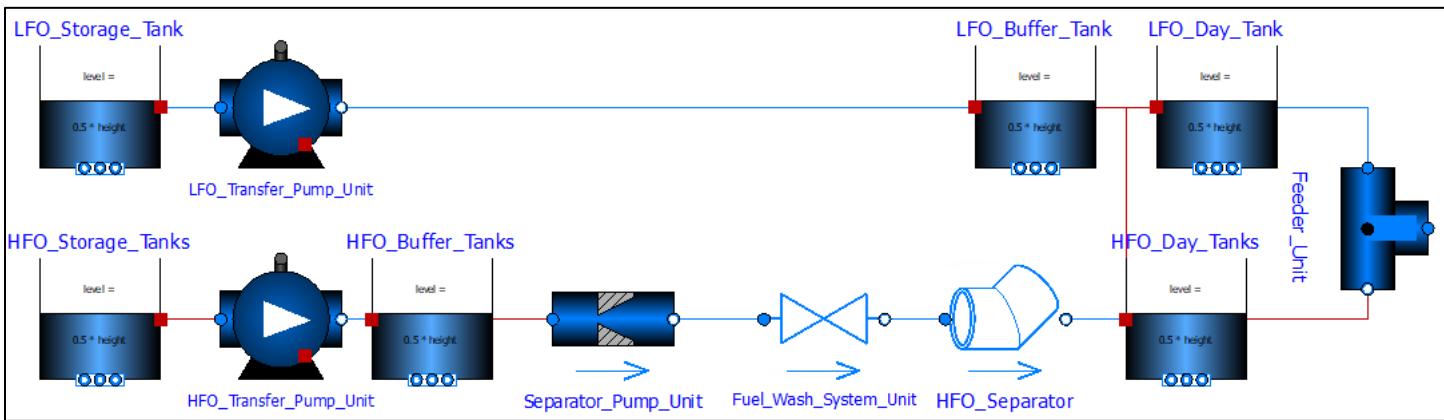
## Control Room



## Modicon 984 PLC



## Common Fuel System



### 1 Fuel Decanting Shed

Decantation is a process for the separation of mixtures of immiscible liquids or of a liquid and a solid mixture such as a suspension. The layer closer to the top of the container—the less dense of the two liquids, or the liquid from which the precipitate or sediment has settled out—is poured off, leaving the other component or the more dense liquid of the mixture behind. An incomplete separation is witnessed during the separation of two immiscible liquids. Decantation can be used to separate immiscible liquids that have different densities. Generally, this technique gives an incomplete separation as it is difficult to pour off all of the top layer without pouring out some parts of the bottom layer. A separatory funnel is an alternative apparatus for separating liquid layers. It has a valve at the bottom to allow draining off the bottom layer. It can give a better separation between the two liquids.

#### Fuel Tankers



### 2 HFO Storage Tanks

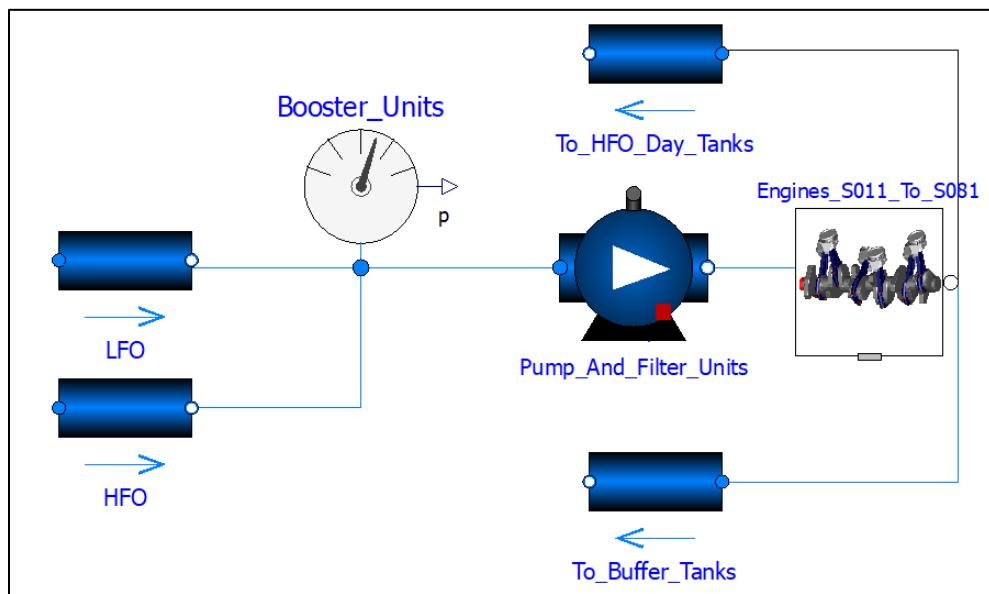
A fuel tank is a safe container for flammable fluids. Though any storage tank for fuel may be so called, the term is typically applied to part of an engine system in which the fuel is stored and propelled (fuel pump) or released (pressurized gas) into an engine. Fuel oil (also known as heavy oil, marine fuel or furnace oil) is a fraction obtained from petroleum distillation, either as a distillate or a residue. In general terms, fuel oil is any liquid fuel that is burned in a furnace or boiler for the generation of heat or used in an engine for the generation of power. Fuel oil is made of long hydrocarbon chains, particularly alkanes, cycloalkanes and aromatics. The term fuel oil is also used in a stricter sense to refer only to the heaviest commercial fuel that can be obtained from crude oil, i.e., heavier than gasoline and naphtha. Small molecules like those in propane, naphtha, gasoline for cars, and jet fuel have relatively low boiling points, and they are removed at the start of the fractional distillation process. Heavier petroleum products like Diesel and lubricating oil are much less volatile and distill out more slowly, while bunker oil is literally the bottom of the barrel; in oil distilling, the only things denser than bunker fuel are carbon black feedstock and bituminous residue (asphalt), which is used for paving roads and sealing roofs.

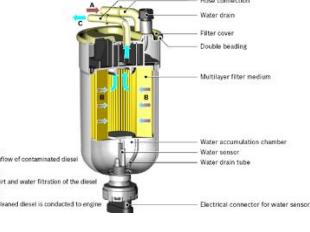
#### Fuel Storage Tanks



3	<b>Transfer Pump Unit</b> A fuel pump is a frequently essential component on internal combustion engine device. Often, carbureted engines use low pressure mechanical pumps that are mounted outside the fuel tank, whereas fuel injected engines often use electric fuel pumps that are mounted inside the fuel tank (and some fuel injected engines have two fuel pumps: one low pressure/high volume supply pump in the tank and one high pressure/low volume pump on or near the engine). Fuel pressure needs to be within certain specifications for the engine to run correctly. If the fuel pressure is too high, the engine will run rough and rich, not combusting all of the fuel being pumped making the engine inefficient and a pollutant. If the pressure is too low, the engine may run lean, misfire, or stall.	<b>Fuel Transfer Pump</b> 
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## Booster System



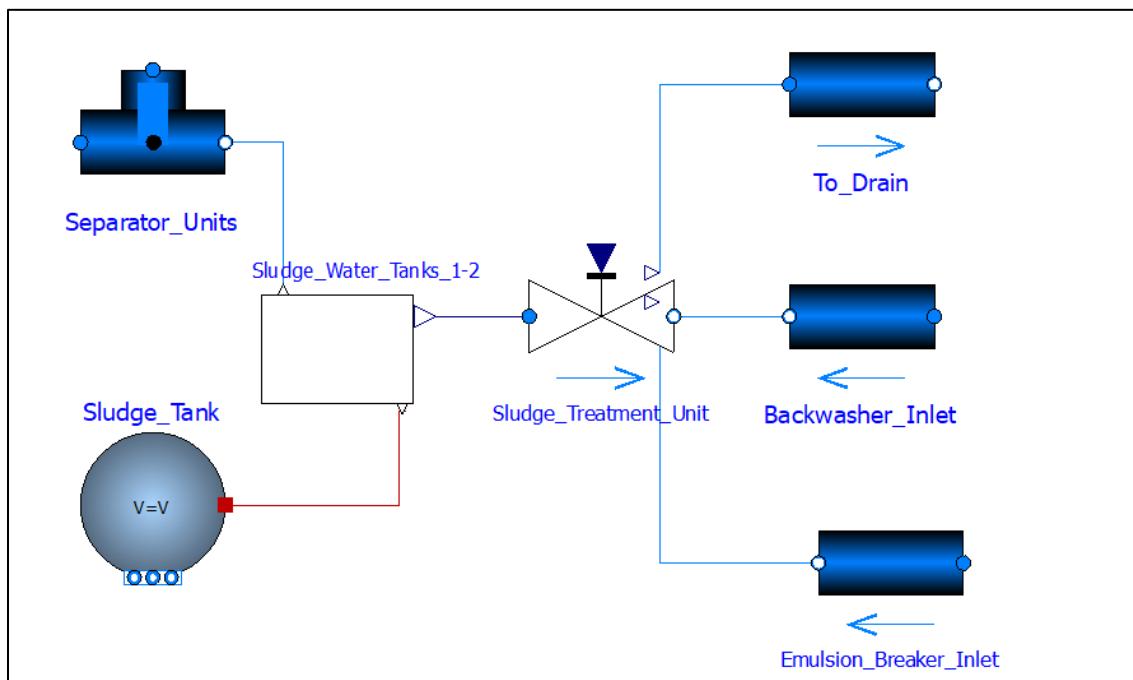
<b>1</b> <b>Booster Units</b> <p>A booster pump is a machine which will increase the pressure of a fluid. They may be used with liquids or gases, but the construction details will vary depending on the fluid. A gas booster is similar to a gas compressor, but generally a simpler mechanism which often has only a single stage of compression, and is used to increase pressure of a gas already above ambient pressure. Two-stage boosters are also made. Boosters may be used for increasing gas pressure, transferring high pressure gas, charging gas cylinders and scavenging.</p>	<p><b>Booster Units</b></p> 
<b>2</b> <b>Fuel Pump and Filter Units</b> <p>A fuel filter is a filter in the fuel line that screens out dirt and dust particles from the fuel, normally made into cartridges containing a filter paper. They are found in most internal combustion engines. Fuel filters serve a vital function in today's modern, tight-tolerance engine fuel systems. Unfiltered fuel may contain several kinds of contamination, for example paint chips and dirt that has been knocked into the tank while filling, or rust caused by moisture in a steel tank. If these substances are not removed before the fuel enters the system, they will cause rapid wear and failure of the fuel pump and injectors, due to the abrasive action of the particles on the high-precision components used in modern injection systems. Fuel filters also improve performance, as the fewer contaminants present in the fuel, the more efficiently it can be burnt. Fuel filters need to be maintained at regular intervals. This is usually a case of simply disconnecting the filter from the fuel line and replacing it with a new one, although some specially designed filters can be cleaned and reused many times. If a filter is not replaced regularly it may become clogged with contaminants and cause a restriction in the fuel flow, causing an appreciable drop in engine performance as the engine struggles to draw enough fuel to continue running normally. Some</p>	<p><b>Fuel Filter</b></p> 

filters, especially found on diesel engines, are of a bowl-like design which collect water in the bottom (as water is denser than diesel). The water can then be drained off by opening a valve in the bottom of the bowl and letting it run out, until the bowl contains only diesel. Many fuel filters contain a water sensor to signal to the engine control unit or directly to the driver (lamp on dashboard) if the water reaches the warning level. It is especially undesirable for water in fuel to be drawn into a diesel engine fuel system, as the system relies on the diesel for lubrication of the moving parts, and if water gets into a moving part which requires constant lubrication (for example an injector valve), it will quickly cause overheating and unnecessary wear. This type of filter may also include a sensor, which will alert the operator when the filter needs to be drained. In proximity of the diesel fuel filter there might be a fuel heater to avoid the forming of paraffin wax (in case of low temperatures) inside the filtrating element which can stop the fuel flow to the engine.

Fuel Transfer



## Common Sludge Oil System



### 1 Sludge Treatment Unit

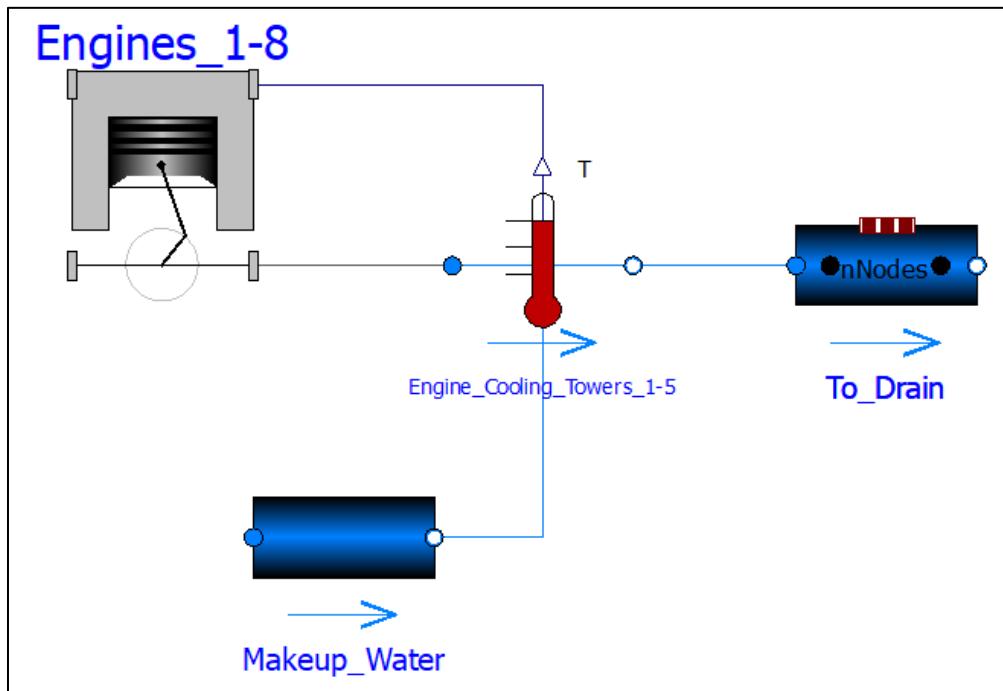
Sludge oil means sludge from the fuel or lubricating oil separators, waste lubricating oil from the main or auxiliary machinery, or waste oil from bilge water separators, oil filtering equipment or drip trays. It is a solid or gel in furnace oil caused by the oil gelling or solidifying, usually at temperatures higher than 100 degrees Celsius. Oil sludge can be a major contributor to engine problems, and can require the engine to be replaced, if the damage is severe.

The sludge from the HFO Separator Units enters the sludge water tanks. The sludge is treated using backwashing and Emulsion Breaker. After the chemical treatment, the yellow waste liquids are poured down the drain while the black sludge is transferred to the Sludge Tank for disposal. The Stainless Steel Sludge Treatment Tank has a corrosion anode. The oil content (ppm) is measured using a meter.

Sludge Oil



## Common Engine Cooling System



### 1 Engine Cooling System

Internal combustion engine cooling uses either air or liquid to remove the waste heat from an internal combustion engine. For small or special purpose engines, cooling using air from the atmosphere makes for a lightweight and relatively simple system. Watercraft can use water directly from the surrounding environment to cool their engines. For water-cooled engines, waste heat is transferred from a closed loop of water pumped through the engine to the surrounding atmosphere by a radiator. Water has a higher heat capacity than air, and can thus move heat more quickly away from the engine, but a radiator and pumping system add weight, complexity, and cost. Higher-power engines generate more waste heat, but can move more weight, meaning they are generally water-cooled. Radial engines allow air to flow around each cylinder directly, giving them an advantage for air cooling over straight engines, flat engines, and V engines. Rotary engines have a similar configuration, but the cylinders also continually rotate, creating an air flow even when the vehicle is stationary.

### Engine Cooling Towers



## Common Steam Turbine Cooling System

### **1 Steam Turbine Cooling System**

Heat engines generate mechanical power by extracting energy from heat flows, much as a water wheel extracts mechanical power from a flow of mass falling through a distance. Engines are inefficient, so more heat energy enters the engine than comes out as mechanical power; the difference is waste heat which must be removed. Internal combustion engines remove waste heat through cool intake air, hot exhaust gases, and explicit engine cooling. Engines with higher efficiency have more energy leave as mechanical motion and less as waste heat. Some waste heat is essential: it guides heat through the engine, much as a water wheel works only if there is some exit velocity in the waste water to carry it away and make room for more water. Thus, all heat engines need cooling to operate. Cooling is also needed because high temperatures damage engine materials and lubricants and becomes even more important in hot climates. Internal-combustion engines burn fuel hotter than the melting temperature of engine materials, and hot enough to set fire to lubricants. Engine cooling removes energy fast enough to keep temperatures low so the engine can survive. Some high-efficiency engines run without explicit cooling and with only incidental heat loss, a design called adiabatic. Such engines can achieve high efficiency but compromise power output, duty cycle, engine weight, durability, and emissions.

## Starting Air System

### **1 Starting Air System**

An air-start system is a power source used to provide the initial rotation to start large diesel and gas turbine engines. A Diesel engine has a very high compression ratio as it is the heat of compression that ignites the fuel. An electric starter with sufficient power to "crank" a large Diesel engine would itself be so large as to be impractical, thus the need for an alternative system. When starting the engine, compressed air is admitted to whichever cylinder has a piston just over top dead center, forcing it downward. As the engine starts to turn, the air-start valve on the next cylinder in line opens to continue the rotation. After several rotations, fuel is injected into the cylinders, the engine starts running and the air is cut off.

The air from the working air unit is supplied to the Starting Air unit. It is then compressed and fed to the eight Diesel Engines and Steam Turbine.

## Common Water Treatment System

### **1 Common Water Treatment System**

Water treatment includes boiler water treatment and cooling water treatment. A large amount of proper water treatment can lead to the reaction of solids and bacteria within pipe work and boiler housing. Steam boilers can suffer from scale or corrosion when left untreated. Scale deposits can lead to weak and dangerous machinery, while additional fuel is required to heat the same level of water because of the rise in thermal resistance. Poor quality dirty water can become a breeding ground for bacteria such as Legionella causing a risk to public health.

Corrosion in low pressure boilers can be caused by dissolved oxygen, acidity and excessive alkalinity. Water treatment therefore should remove the dissolved oxygen and maintain the boiler water with the appropriate pH and alkalinity levels. Without effective water treatment, a cooling water system can suffer from scale formation, corrosion and fouling and may become a breeding ground for harmful bacteria. This

reduces efficiency, shortens plant life and makes operations unreliable and unsafe.

The water enters the Priming Tank from the water basin. It is then pumped by the pump house to the water treatment system where deionizers produce DI water and reverse osmosis system produces RO water from the RAW water. The water is then transferred into a buffer tank before being supplied to consumers using the hydrophore unit.

## DG-SET Lube Oil System

### 1 DG-SET Lube Oil System

The lubrication system of the engines provides a supply of lubricating oil to the various moving parts in the engine. Its main function is to enable the formation of a film of oil between the moving parts, which reduces friction and wear. The lubricating oil is also used as a cleaner and in some engines as a coolant.

Lubricating oil for the eight engines is stored in a drain tank for flood lubrication. The oil is drawn from this tank through a strainer, one of a pair of pumps, into one of a pair of fine filters. It is then passed through a cooler before entering the engine and being distributed to the various branch pipes. The branch pipe for a particular cylinder feed the bearings etc. Some of this oil passes along a drilled passage in the crankshaft to the bottom end bearing and then up a drilled passage in the connecting rod.

The temperature, flow rate and pressure of the lube oil is monitored using the Lube Oil Separator Unit. A gravity tank is used to control the viscosity of the mixture. After use, the Lube oil is pumped to the system oil tank.

## DG-SET Exhaust Gas and Charge Air System

### 1 DG-SET Exhaust Gas and Charge Air System

As the exhaust gas stream cools following discharge from the combustion chamber, much of the SO<sub>2</sub> that further oxidizes to SO<sub>3</sub> in the exhaust stream, will also be included in the particulate fraction mixture of mainly soot, fuel oil ash containing heavy metals such as vanadium and nickel, sulphates and associated water, nitrates, carbonates and a variety of non, or partially combusted hydrocarbon components, derived from the fuel oil and engine lubricant.

A proportion of the SO<sub>3</sub> formed during the cooling of the exhaust gas will react with some of the water vapor present to exist as sulphuric acid and will thereafter absorb water vapor. The remainder will undergo either gas phase oxidation and condense as sub-micronic droplets or will oxidize onto the particles formed during combustion and is collectively known as sulphates.

The exhaust gases must be treated before release to prevent damage to the environment and organisms. The exhaust gases are transferred to the exhaust gas boiler and charge air filter units for treatment. The electrostatic precipitators remove most of the harmful agents in the exhaust gases. The clean gases are released through eight chimneys. The emission of all harmful pollutants is controlled below the NEQS standard limits.

## Environment, Health and Safety Program (QEHS)

<b>1</b>	<p><b>Employee Responsibilities</b></p> <ol style="list-style-type: none"> <li>1. Place Safety and Health requirements as first importance in performance of work duties. Protect fellow Employees, Company Property and Public.</li> <li>2. Notify violation or deficiency in working conditions to supervisor (injuries, accident, near miss etc.)</li> <li>3. Participate in Environment, Health and Safety Program.</li> <li>4. Obey Environment, Health and Safety instructions, policy and procedures.</li> <li>5. Use Safety devices/ equipment.</li> <li>6. Properly dispose all hazardous materials in acceptable manner.</li> <li>7. working while drugged is forbidden. All prescription drugs must be reported to supervisor.</li> <li>8. Failure to comply with or enforce Environment Health and Safety rules may result in disciplinary action or dismissal. Do not violate work rules.</li> </ol>	 <small>PHOTO: NORM BEITS/BLOOMBERG VIA GETTY IMAGES</small>
<b>2</b>	<p><b>General Safety and Health rules</b></p> <ol style="list-style-type: none"> <li>1. Asbestos: Do not remove material suspected of containing Asbestos (adhesives, mastics, insulation, lab fume hoods, vented enclosures). If such material is damaged, inform EHS Department immediately.</li> <li>2. Confined Space: Do not enter Confined Space (restricted means of entry or exit, unfavorable natural ventilation, not designed for occupancy) like tanks, manholes, sewers, trenches etc. as it can involve suffocation, oxygen deficiency, fire, explosion hazards, exposure to dangerous vapors or toxic gases, physical hazards etc.</li> </ol>	
<b>3</b>	<p><b>Emergency Response Plan</b></p> <p>In case of fire, chemical release, bomb threat etc.:</p> <ol style="list-style-type: none"> <li>1. Locate local fire alarms or Emergency alarm systems and learn how to operate them.</li> <li>2. learn location of all exits (exit stairs) from work area, primary and alternate exit routes.</li> <li>3. Know your designated Assembly point outside the building for your accountability and coworkers.</li> <li>4. immediately Respond by following Plans for appropriate Emergency Response.</li> <li>5. If a continuous alarm sounds, immediately evacuate the building.</li> <li>6. Do not run. Use stair wells.</li> <li>7. Report to designated Assembly point outside the building immediately.</li> <li>8. Escort visitors to Assembly point.</li> <li>9. Do not enter building after evacuation until instructed by Management.</li> </ol>	  <small>PROFESSION VECTOR SET FIREMAN, FIREFIGHTER www.shutterstock.com • 1129377779</small>

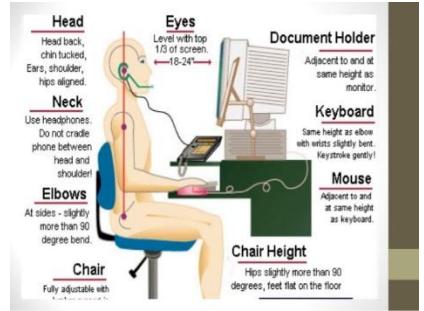
<p><b>4</b></p> <h3>Electrical Safety</h3> <ol style="list-style-type: none"> <li>Follow legal and Regulatory requirements and good industry practices. Work on Electrical circuits with power off.</li> <li>A Safety warning, tagging and locking system will be used to ensure that all power is removed from the system. circuits will be checked by Proper equipment to make sure no voltage is present.</li> <li>Non-current carrying metal parts of portable/ plug connected equipment shall be grounded or Protected by double insulation.</li> <li>Keep working Spaces, walkways etc. clear of cords.</li> <li>Worn, frayed or damaged Electrical cords or connectors shall not be used. Must be tagged DANGER, OUT OF SERVICE or DO NOT USE.</li> <li>Extension cords, shall be Protected from damage by traffic, sharp corners, projections, pinching etc.</li> <li>Extension cords are temporary (90 days of maximum use).</li> <li>temporary lighting shall be de-energized when not in use. Guards must be used to prevent accidental contact with bulb. Temporary lighting must not be suspended by Electric cords unless cords and lights are designated for suspension.</li> </ol>	
<p><b>5</b></p> <h3>Fails</h3> <ol style="list-style-type: none"> <li>Always use hand rail on staircase.</li> <li>Use caution on surface containing water or oil etc.</li> <li>immediately clean up spills.</li> <li>Keep stairs, walkways, aisles clear of boxes, loose materials, wires or other objects.</li> <li>Use Safety shoes that are compatible with work Environment.</li> <li>Do not stand or climb on desk or chair to reach high. Use a ladder.</li> </ol>	
<p><b>6</b></p> <h3>Fire prevention</h3> <ol style="list-style-type: none"> <li>Know the Emergency plan for your work area. Know location of fire equipment, Proper method of turning in a final alarm, using a fire extinguisher (portable Protected equipment)</li> <li>Obey all rules, Regulatory and signs for fire Safety (Smoking, open flames, sources of ignition, storage, handling and use of flammable liquids and hazardous materials)</li> <li>practice good housekeeping and fire prevention.</li> <li>flammable liquids must be stored in approved Safety containers with flame arrestors.</li> <li>Do not use acids, bases or oxidizers and reducers in same cabinet due to possibility of reaction.</li> <li>Keep hand operated fire equipment in fully accessible, mounted and unobstructed at all times.</li> <li>Notify supervisor before use of fire equipment so that it can be replaced.</li> <li>If your clothing catches fire, roll on floor or ground. Do not run.</li> <li>Do not clean clothing with gasoline, solvents or flammable liquids.</li> <li>Do not use oil or grease on oxygen equipment (cylinders).</li> <li>In case of fire, find location of fire, inform control room, shout</li> </ol>	

	FIRE three times, try to put it out, evacuate area and report to respective Assembly point.	
7	<p><b>First Aid</b></p> <ol style="list-style-type: none"> <li>1. It is immediate Emergency treatment provided for injury or sudden illness before professional medical care is available.</li> <li>2. Never minimize the seriousness of injury or illness. Seek medical attention.</li> <li>3. In case of Emergency, call control Room EXT #222.</li> <li>4. Use First Aid Kits for minor cuts and scratches. Get medical attention.</li> <li>5. Routine Administration must be done by qualified First Aider.</li> </ol>	
8	<p><b>Housekeeping/ Sanitation</b></p> <ol style="list-style-type: none"> <li>1. Maintain Safe working conditions.</li> <li>2. Keep work area clean, materials Properly stored, keep walkways and floor areas clear of slip, trip and fall hazards.</li> <li>3. Place all waste and debris in designated containers for Proper disposal.</li> <li>4. Do not litter. Use containers or recycle.</li> <li>5. clean up all water or beverage spills.</li> <li>6. Barricade spills areas, Notify EHS Department or designated person for cleanup.</li> <li>7. Store oily waste and rags and other flammable waste in Safety containers.</li> <li>8. Maintain 3 feet clearance from all Electrical panels, switch boxes, switchboards. Switchgear rooms must not be used for storage.</li> <li>9. Do not obstruct or block exit routes.</li> <li>10. Do not block ladders, stairways, Electrical switches, firefighting, rescue or Emergency equipment.</li> <li>11. Keep tools stored neatly, racked etc.</li> <li>12. Wash hands before eating.</li> </ol>	 
9	<p><b>Standardized Chemicals</b></p> <p>Physical hazards (Combustible, flammable, explosive, reactive, pressurized)</p> <p>Health hazards (toxic, carcinogenic, corrosive, irritant, sensitizer)</p> <p>Carcinogenic chemicals are regulated by OSHA.</p>	

<p><b>10 EHS Department</b></p> <p>EHS Department ensures that</p> <ol style="list-style-type: none"> <li>1. Containers are Properly labeled</li> <li>2. Appropriate signs are posted.</li> <li>3. Material Safety datasheets are available.</li> <li>4. Chemical Safety training is provided.</li> <li>5. An inventory of hazardous chemicals is Maintained. Chemical Safety training must be received by all Employees. hazard communication training must be received by all Employees by EHS Department or supervisor. Contractors must submit list of chemicals to EHS. Note down all MSDs on work site.</li> </ol>	
<p><b>11 Health hazards</b></p> <ol style="list-style-type: none"> <li>1. Dusts: Asbestos, Lead, Silica, wood dusts.</li> <li>2. Mists: acid, oil, paint, poisons</li> <li>3. Gases: CO, waste anesthetic gases etc.</li> <li>4. Vapors: Degreasing Vapors, trichloroethylene.</li> <li>5. Fumes: Metal fumes from welding, cutting, soldering</li> <li>6. Ingested, skin absorption, breathing of toxic gases.</li> </ol>	
<p><b>12 Workplace precautions</b></p> <ol style="list-style-type: none"> <li>1. Read labels</li> <li>2. Do not mix cleaning compounds or chemicals.</li> <li>3. Learn about excessive exposure to chemicals</li> <li>4. Take precautions to Protect from exposure.</li> <li>5. Do not work with hazardous materials until trained.</li> <li>6. Report unusual symptoms to doctor or medical provider.</li> </ol>	
<p><b>13 Biological hazards</b></p> <ol style="list-style-type: none"> <li>1. Biological Agents or substances which may harm Health.</li> <li>2. Infectious Organisms.</li> <li>3. toxic Biological substances</li> <li>4. Biological Allergens etc.</li> </ol>	
<p><b>14 Laboratory Safety</b></p> <ol style="list-style-type: none"> <li>1. Know all exits, Safety equipment and Emergency procedures.</li> <li>2. Do not smoke</li> <li>3. Do not smell chemicals</li> <li>4. Do not use mouth suction in filling pipettes. Use suction bulb.</li> <li>5. Do not force glass tubing into rubber stoppers.</li> <li>6. Use Safety devices, PPE for handling hot items.</li> <li>7. Label all waste containers.</li> <li>8. Confine long hair and loose clothing.</li> <li>9. Never conduct experiments alone in lab.</li> <li>10. Wear eye Protection while handling chemicals</li> <li>11. Use Laboratory hoods to control chemical fumes, mist, vapors, Biological hazards.</li> </ol>	

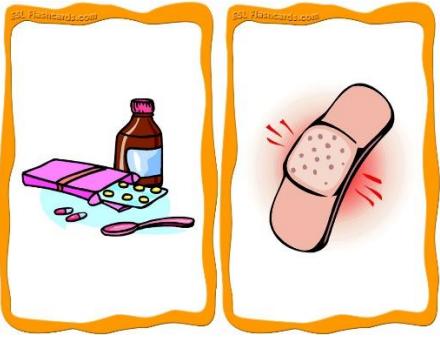
	<p>12. Turn off all hotplates, open burners, hazardous devices when leaving Laboratory</p> <p>13. Decontaminate and clean work surfaces daily and after spills.</p> <p>14. Minimize production of aerosols.</p> <p>15. Do not store food with chemicals in fridge or Biological materials.</p> <p>16. Decontaminate solid and liquid waste that contains Organisms.</p> <p>17. Properly label hazardous waste for disposal.</p>	
15	<p><b>Safe Lifting</b></p> <p>1. Get Proper Excuse, maintain good diet and manage stress. Build up leg and abdominal muscles and keep off excess weight.</p> <p>2. Do not place objects on floor if they must be picked up later.</p> <p>3. Use a mechanical device if possible. Inspect device before use. Get help if object is too heavy, large or awkward.</p> <p>4. Avoid lifting above shoulder height. Use ladder or step tool to move objects above shoulders.</p> <p>5. Push rather than pull objects. Maintain lumbar curve and Push with your legs.</p> <p>6. Wear slip resistant shoes and check to make sure that footing is firm.</p> <p>7. Check the path before lifting and or moving a load so that path is clear.</p> <p>8. Spread feet apart to keep wide base of support.</p> <p>9. Bend at your knees instead of at your waist and Maintain lumbar curve at all times.</p> <p>10. Hold lifted object as close to your body as possible. Avoid long reach.</p> <p>11. Lift slowly, smoothly and without jerking.</p> <p>12. Avoid unnecessary twisting. Turn your feet, not your hips or shoulders. Do not twist.</p> <p>13. Take your time while setting the object down</p> <p>14. Report work related back pain to supervisor</p>	
16	<p><b>Lockout-Tag out-control of hazardous energy</b></p> <p>1. Uncontrolled hazardous energy must be controlled e.g. flow of solids, liquids, gases into Confined spaces or Environments.</p> <p>2. tag out: Placing tag on power source. Do not operate or Restore energy.</p> <p>3. Tags must clearly state: "DO NOT OPERATE"</p> <p>4. Tags must be applied by hand</p> <p>5. Do not service or Maintain machine without disconnecting power and implementing Lockout-Tag out procedure.</p>	

<p><b>17 Machine Guarding</b> Safeguards on machines protect us from injury while operating machines</p> <p><b>Hazardous motions</b></p> <ol style="list-style-type: none"> <li>1. Rotating</li> <li>2. Reciprocating</li> <li>3. Transverse</li> </ol> <p><b>Hazardous actions</b></p> <ol style="list-style-type: none"> <li>1. cutting, pinching</li> <li>2. Shearing</li> <li>3. Bending</li> </ol> <p><b>Precautions</b></p> <ol style="list-style-type: none"> <li>1. Safeguard machine part, function or process to avoid injury.</li> <li>2. Never start a machine unless you have been trained in the use of it.</li> <li>3. Do not operate a machine without personal protective equipment (PPE) and appropriate clothing.</li> <li>4. Do not wear loose clothing, neck ties, rings or jewelry.</li> <li>5. Do not operate machine without Guards in place.</li> <li>6. Treat unguarded machine as if it were out of order. Tag it: "OUT OF ORDER-DO NOT USE"</li> <li>7. Report missing Guards to supervisor immediately.</li> <li>8. Do not adjust or remove Guard barrier or enclosure of any machine</li> </ol>	 
<p><b>18 Motor Vehicles</b></p> <ol style="list-style-type: none"> <li>1. Do not operate Company Vehicles without driver's license or driving privileges</li> <li>2. Have knowledge of Company and Government rules</li> <li>3. make sure Vehicle is in Safe operating condition (lights, horns, windshield, wipers, washer, brakes, tires, fuel gauge, rear view mirrors, seat belts, windows)</li> <li>4. Drivers must report Vehicle defects and maintenance needs in writing to Administration Department. Vehicles with Safety deficiencies must be removed from service or repaired.</li> <li>5. Do not drive in unsafe/ unlawful manner. Drive safe arrive safe. Follow traffic laws and regulations.</li> </ol>	
<p><b>19 Noise</b></p> <ol style="list-style-type: none"> <li>1. excessive noise around equipment or machinery could result in gradual loss of hearing</li> <li>2. If noise levels exceed limits of OSHA and WB, engineering control or hearing conservation (ear plugs, ear muffs, hearing tests) must be used</li> <li>3. Contact supervisor/ EHS Department for noise control/ Protection.</li> </ol>	

<p><b>20</b> <b>Office Safety</b></p> <ol style="list-style-type: none"> <li>1. No running in Office</li> <li>2. Walk to right of passageway</li> <li>3. Do not stand in front of doors</li> <li>4. Keep stairways, aisles, walkways clear of boxes, loose materials, wires etc.</li> <li>5. immediately clean up spilled liquids.</li> <li>6. Use handrails when using stairways.</li> <li>7. Pay attention while ascending or descending stairs</li> <li>8. Do not lean from a chair to pick up something from the floor.</li> <li>9. Do not sit on edge of desks, tables, boxes, low filing cabinets.</li> <li>10. Use staple remover. dispose broken staple removers</li> <li>11. Keep fingers away from sharp edges of paper cutters</li> <li>12. Wear shoes at all times.</li> <li>13. Properly store Office supplies.</li> </ol>	 <p>The poster is titled "Office Safety" and is divided into two main sections: "FIRE HAZARDS" and "TRIPS/FALLS &amp; COLLISIONS".</p> <ul style="list-style-type: none"> <li><b>FIRE HAZARDS:</b> <ul style="list-style-type: none"> <li>Ensure power outlets have circuit breakers or residual current devices (RCDs).</li> <li>Keep electrical cables and power strips away from water sources.</li> <li>Never overheat electrical sockets.</li> <li>Know the location of fire extinguishers and how they function.</li> <li>Familiarise yourself with evacuation routes.</li> </ul> </li> <li><b>TRIPS/FALLS &amp; COLLISIONS:</b> <ul style="list-style-type: none"> <li>Ensure all slippery surfaces and cluttered areas are cleared.</li> <li>Keep pathways clear of any loose carpets, line cables, or debris.</li> <li>Be aware of any loose carpets, line cables, or debris.</li> <li>Never climb on desks or chairs.</li> <li>Always use a step-ladder when climbing.</li> <li>Walk around corners slow.</li> <li>Avoid trips by keeping paths clear through office areas.</li> <li>Do not leave long cabinet drawers open.</li> <li>Avoid trips when reaching across a desk or when walking around machinery. Also ensure bags are not left on the floor.</li> <li>Remove any clutter from desks and work areas.</li> </ul> </li> </ul>
<p><b>21</b> <b>Computer Workstations</b></p> <ol style="list-style-type: none"> <li>1. Sit with lower back against the chair, upper legs parallel to floor and feet flat on the floor or on a foot rest.</li> <li>2. Adjust table and chair so that elbows are bent at right angles and your arms are approximately parallel to the floor.</li> <li>3. Keep wrists neutral (straight) by using wrist rest that is the same height as the keyboard</li> <li>4. Place mouse on a surface at the same height as the keyboard</li> <li>5. Position monitor directly in front of you, at an arm's length away, with the top of the screen at or slightly below eye level. Tip the monitor back at an angle similar to that used when reading a book.</li> <li>6. Adjust lighting and monitor to prevent glare or use an antiglare filter.</li> <li>7. When performing tasks involving repetitive motions or awkward positions, take periodic stretching breaks or alternate with other tasks.</li> </ol>	 <p>The diagram illustrates the correct ergonomic setup for a computer workstation, showing the ideal posture and alignment for various body parts:</p> <ul style="list-style-type: none"> <li><b>Head:</b> Head back, chin tucked, ears, shoulder, hips aligned.</li> <li><b>Eyes:</b> Level with top 1/3 of screen, 18-24" from eyes.</li> <li><b>Document Holder:</b> Adjacent to and at same height as monitor.</li> <li><b>Keyboard:</b> Same height as elbow with wrists straight. Keystroke gently!</li> <li><b>Mouse:</b> Adjacent to and at same height as keyboard.</li> <li><b>Chair:</b> Fully adjustable with back support.</li> <li><b>Chair Height:</b> Hips slightly more than 90 degrees, feet flat on the floor.</li> <li><b>Neck:</b> Use headphones. Do not cradle phone between head and shoulder!</li> <li><b>Elbows:</b> At sides - slightly more than 90 degree bend.</li> </ul>
<p><b>22</b> <b>Fire hazards</b></p> <ol style="list-style-type: none"> <li>1. Flammable solvents and cleaning solutions shall be dispensed only from approved chemicals containers.</li> <li>2. Solvent soaked or oily rags used for cleaning office equipment shall be kept in metal, self-closing metal cans and contents properly disposed of daily.</li> <li>3. Smoking is only permitted at designated areas</li> <li>4. Handle solvents carefully to avoid personal injury or damage to materials or equipment.</li> <li>5. Do not throw matches, cigars, cigarettes etc. into waste buckets. Soldering butts can cause fires.</li> <li>6. All Electrical appliances must be unplugged at end of work day.</li> <li>7. Do not use extension cords or permanent wiring.</li> </ol>	 <p>A row of red fire extinguishers is shown, ready for use in case of emergency.</p>

23	<p><b>Lifting and Moving objects</b></p> <p>Improper lifting would result in serious strains. Use hand truck or unpack and handle in small parcels. Do not obstruct view with bulky objects in handrails or stairways.</p>	
24	<p><b>Personal Protective Equipment</b></p> <p>The Annual Hazard Assessment is used to identify PPE:</p> <ol style="list-style-type: none"> <li>1. Head protection is used to prevent head injury from impact and falling or flying objects. Hard hats are required for construction, high voltage electricity.</li> <li>2. Ear protection protects from noise.</li> <li>3. Eye and face protection protects from flying particles, molten metal, dust, chemicals, gases, steam, vapors, objects, biohazards, glare, light or heat radiation etc.</li> <li>4. Respiratory protective equipment protects from airborne contaminants measured above threshold limit of OSHA standards.</li> <li>5. Foot protection protects from foot injuries due to falling or rolling objects, Electrical or chemical hazards.</li> <li>6. Hand protection protects from physical, radiation, Electrical or chemical hazards.</li> <li>7. Gloves protect from Electrical hazards.</li> <li>8. Fall protection protects from falling from height of 6 feet or more not protected by standard guardrails when working in confined spaces.</li> </ol>	
25	<p><b>Portable ladders and scaffolds</b></p> <p><b>Ladders</b></p> <ol style="list-style-type: none"> <li>1. Ladders must be inspected frequently and rechecked for soundness and proper working condition prior to use.</li> <li>2. Ladders which have developed defects shall be withdrawn from service for repair or destruction and tagged or marked as DANGEROUS, DO NOT USE.</li> <li>3. Ladders must not be used near power lines or other electrical devices</li> <li>4. Ladders must extend 3 feet above the point of support of gutters or roof line and should be tied off.</li> <li>5. Ladders must have suitable safety feet positioned firmly on the floor, ground or concrete which provides a stable flat level surface.</li> <li>6. Work facing the ladder with both feet of the rungs</li> <li>7. Ladders must be Maintained free of oil, grease or other slippery hazards.</li> <li>8. Straight and extension ladders must be tied off and secured to the upright structure against which they lean.</li> <li>9. Raise and lower tools or equipment by a hand line and tool bag.</li> <li>10. Do not stand on top step of a step ladder.</li> <li>11. Ladders shall be maintained in good condition at all times. The joint between the steps and side rails shall be tight, all fitting and hardware tightly attached and the movable parts shall operate freely without binding or undue play.</li> </ol>	

	<p><b>Scaffolds</b></p> <ol style="list-style-type: none"> <li>1. Only authorized Employees shall erect scaffolds, platforms and staging. Scaffolds and their parts shall be sound, rigid and capable of supporting at least four times their maximum intended loads.</li> <li>2. Footing and anchorage of scaffolds shall also be sound, rigid and capable of carrying at least four times their maximum intended loads without settling or displacement.</li> <li>3. Unstable objects shall not be used to support scaffolds or planks</li> <li>4. Platforms shall be sufficiently wide and secured to prevent slipping.</li> <li>5. Guard rails and toe boards are required on all open sides where the platform is greater than 6 feet above the ground or floor.</li> <li>6. Scaffolds shall not be load in excess of the maximum workload for which they are intended.</li> <li>7. Damaged or weakened scaffolds shall be immediately repaired and shall not be used until repairs have been completed.</li> <li>8. Equipment shall be inspected prior to use and maintained in good operating condition.</li> <li>9. Defective or damaged equipment shall be tagged “DANGEROUS, OUT OF SERVICE, DO NOT USE”.</li> </ol>	
26	<p><b>Smoking policy</b></p> <ol style="list-style-type: none"> <li>1. Smoking is only permitted in smoking cabins placed by Admin and HR Department at different areas of the plant away from hazardous areas. Rs. 500 fine will be charged for violation of policy.</li> </ol>	
27	<p><b>Tools-Hands and power</b></p> <ol style="list-style-type: none"> <li>1. Use PPE safety glasses, goggles, face shields etc. when operating near hand or power tools.</li> <li>2. hand or power tools shall be Maintained in a safe operating condition.</li> <li>3. Power operated tools and equipment guards shall be inspected before each use and shall not be removed or tampered with.</li> <li>4. Portable Electric Power tools shall be double insulated or grounded using a 3-conductor cord and a three prong plug. Electric on/off switches will operate properly.</li> <li>5. Any damaged, unsafe, defective plug, cord or tool shall be reported to the supervisor immediately. The tag out Program shall be used.</li> <li>6. All Employees using abrasive wheels shall be protected by eye protection equipment and eye shield shall be Maintained.</li> <li>7. All fixed power driven metal and wooden working tools and equipment shall be provided with labeled disconnect switch near the tool that can be locked or tagged in the off position.</li> </ol>	<p><b>POWER TOOL SAFETY TIPS</b></p>  <p>Ref No - ELSH1222      © 2015 Safety Images 365.com - All Rights Reserved</p>

	<p>8. Only trained Employees can use tools of certain make and model.      9. Power actuated tools must be in hands of operator, locked in container, removed from site, follow all safety instructions when using power actuated tools.</p>	
28	<p><b>Workspace injuries and illnesses</b>      Immediately notify supervisor if you are injured or sick so that medical procedure can be followed for medical treatment.</p> <p><b>Workspace Violence</b></p> <ol style="list-style-type: none"> <li>1. Safe Healthy Environment to all Employees and public.</li> <li>2. Procedure for prevention and management of incidents and threats of violence. Provide violence free workspace by establishing preventive measures, holding perpetrators accountable and provide assistance and support to victims.</li> <li>3. The Factory Act 1934, Punjab Factory Rules 1978, NFPA and OSHA require Employees to provide a safe and healthy work environment.</li> <li>4. Victims of workspace violence must be provided by support and reasonable security measures must be taken. Talk to supervisor, Admin and HR for confidential assistance.</li> </ol>	
29	<p><b>Off the Job Environment, Health and Safety</b>      Do not leave this training at work. Follow same self-practice in outside environment as an extension of Company EHS Program.</p>	

## Work Permit

Work Permit is required for any out of routine work done in the plant. It is displayed at a conspicuous place close to work area. The permit is valid for the specified time and specified job only. It can be extended/ reissued if the job has to continue for a longer time (up to extra 7 days). I got a chance to study a work permit for the soldering and cutting of crimping joints of Diesel Generator 4. The work involved cutting thick 245-W 2 cables using big cable cutters, silicon insulation taping of cables, Hammering, Oxygen cylinders for soldering, confined space work, changing connections of Current Transformer and Potential Transformer on top of the generator, Electric grinding and scrape paper to smooth cable connector sides, taking pictures for approval from supervisors, hot air blower to clean dusty cables, Electric screw drivers, moving large objects on trolleys, wrapping components in plastic wrap, portable light, swapping live (cable was degraded due to corona effect at high voltage) and neutral cable generator connections, portable staircase set, moving heavy metal panels/ boards, cleaning/ scraping dust/ grease, sawing, varnish, greasing/ lubrication and clamping of objects. The work permit had the following components:

<b>Form Information</b>	Form Number, Serial Number
<b>Time</b>	Start/ End date, Minimum/ Maximum Duration
<b>Category</b>	Hot, Hazardous, Height, Confined Space, Scaffolding
<b>Involves</b>	<u>Hot Work</u> : Open Fire/ Flame, Cutting/ Grinding, Welding, Soldering <u>Hazardous Work</u> : Piping/ Vessels containing hazardous/ flammable chemical/ fuel. <u>Height Work</u> : Paint work, Repair work, A/C filling, Wiring, Inspection <u>Confined Space</u> : Lower Explosive Limit Minimum/ Maximum time. <u>Scaffolding Work</u> : Fixing of scaffolding pipes, Fixing of planks, Overhead Hazards
<b>Required Isolation</b>	Yes/ No
<b>Signatures</b>	Maintenance Engineer Signature, Shift Engineer Signature, Executor Signature
<b>Safety Requirements</b>	<u>Hot Work</u> : Fire Extinguisher, Welding Hood, Goggles, Face Shield, Gas Mask, Respirator, Gloves, APR, Safety Signs, Qualified Standby, Fire Blanket. <u>Hazardous Work</u> : Face Shield, Mask, Steam Gloves, Transparent Shield, Attendant, Ear Muffs, Ambulance standby, Goggles, Safety Signs, Qualified standby. <u>Height Work</u> : Helmet, Safety Harness, Ladder, Scaffolding, Lanyard, Attendant, Gloves, Goggles, Qualified standby. <u>Confined Space</u> : Self Contained Breathing Apparatus, Respirator, Face Protection, Gas Test, and Qualified standby. <u>Scaffolding Work</u> : Helmet, Safety Harness, Ladder, Double Lanyard, Attendant, Gloves, Goggles, Qualified standby.
<b>Maintenance</b>	<ol style="list-style-type: none"> <li>1. Initial Cleanup</li> <li>2. Actions for Easy to clean, inspect, lubricate</li> <li>3. Implement Tentative Standards</li> <li>4. General Inspection</li> <li>5. Autonomous Inspection</li> <li>6. Standardization</li> <li>7. Full Autonomous Maintenance</li> </ol>

## Devices

<b>1</b>	<p><b>Pumps</b></p> <p>A pump moves fluids (liquids or gases), or sometimes slurries, by mechanical action. Pumps can be classified into direct lift, displacement, and gravity pumps. Pumps operate by some mechanism (typically reciprocating or rotary), and consume energy to perform mechanical work moving the fluid. Pumps operate via many energy sources, including manual operation, electricity, engines, or wind power. They come in many sizes, from microscopic for use in medical applications to large industrial pumps. When a casing contains only one revolving impeller, it is called a single-stage pump. When a casing contains two or more revolving impellers, it is called a double- or multi-stage pump. Other pumps include the Rotary lobe pump, Progressive cavity pump, Rotary gear pump, Piston pump, Diaphragm pump, Screw pump, Gear pump, Hydraulic pump, Rotary vane pump, Peristaltic pump, Rope pump, Flexible impeller pump, Air Compressor.</p>	
<b>2</b>	<p><b>Lathe Machine</b></p> <p>A lathe is a machine that rotates a work piece about an axis of rotation to perform various operations such as cutting, sanding, knurling, drilling, deformation, facing, and turning, with tools that are applied to the work piece to create an object with symmetry about that axis.</p>	

3	<p><b>Actuators</b></p> <p>Actuators offer continuous control with a virtually wear-free operation, as well as the highest positioning accuracy and stability regardless of positioning time.</p> <p>Compact actuators are used for the operation of final control elements with rotary/ linear movement. They can provide continuous positioning whereby the actuator thrust rod transfers the force directly to the final control element.</p> <p>Pneumatic Universal Rotary/ Linear Actuators regulate dampers, fan inlet vanes, lever-operated valves, turbine governors, fluid drives and other final control elements.</p> <p>The input signals provide modulating control to position the final control element in a linear motion or rotary motion via the lever linkage.</p>	
4	<p><b>Analytical Measurement Systems</b></p> <p>Analytical instruments are used for the laboratory, process, environmental, steam and power industries. Laser diffraction analysis, also known as laser diffraction spectroscopy, is a technology that utilizes diffraction patterns of a laser beam passed through any object ranging from nanometers to millimeters in size to quickly measure geometrical dimensions of a particle. This process does not depend on volumetric flow rate.</p> <p>Laser diffraction analysis is based on the Fraunhofer diffraction theory, stating that the intensity of light scattered by a particle is directly proportional to the particle size. The angle of the laser beam and particle size have an inversely proportional relationship, where the laser beam angle increases as particle size decreases and vice versa.</p> <p>Laser diffraction analysis is accomplished via a red He-Ne laser, a commonly used gas laser for physics experiments that is made up of a laser tube, a high-voltage power supply, and structural packaging. Alternatively, blue laser diodes or LEDs of shorter wavelength may be used. Angling of the light energy produced by the laser is detected by having a beam of light go through a suspension and then onto a sensor. A lens is placed between the object being analyzed and the detector's focal point, causing only the surrounding laser diffraction to appear. The sizes the laser can analyze depend on the lens' focal length, the distance from the lens to its point of focus. As the focal length increases, the area the laser can detect increases as well, displaying a proportional relationship. A computer can then be used to detect the object's particle sizes from the light energy produced and its layout, which the computer derives from the data collected on the particle frequencies and wavelengths.</p>	<p>Laser process analyzer</p>  <p>Isotope Analyzer</p>  <p>Trace Gas Analyzers</p> 

<b>5</b>	<p><b>Continuous Gas Analyzers</b></p> <p>Continuous Gas Analyzers include Multiwave Photometers, Integrated Analyzers, Flue Gas Analyzers, Sample Gas Coolers, Continuous Emission Monitoring Data Acquisition Systems, Predictive Emission Monitoring Systems etc.</p> <p>Dissolved gas analysis (DGA) is the study of dissolved gases in transformer oil. Insulating materials within transformers and electrical equipment break down to liberate gases within the unit. The distribution of these gases can be related to the type of electrical fault, and the rate of gas generation can indicate the severity of the fault. The identity of the gases being generated by a particular unit can be very useful information in any preventative maintenance program.</p> <p>DGA usually consists of sampling the oil and sending the sample to a laboratory for analysis. Mobile DGA units can be transported and used on site as well; some units can be directly connected to a transformer. Online monitoring of electrical equipment is an integral part of the smart grid. Large power transformers are filled with oil that cools and insulates the transformer windings. Mineral oil is the most common type in outdoor transformers; fire-resistant fluids also used include polychlorinated biphenyls (PCB)s and silicone. The insulating liquid is in contact with the internal components. Gases, formed by normal and abnormal events within the transformer, are dissolved in the oil.</p> <p>By analyzing the volume, types, proportions, and rate of production of dissolved gases, much diagnostic information can be gathered. Since these gases can reveal the faults of a transformer, they are known as "fault gases". Gases are produced by oxidation, vaporization, insulation decomposition, oil breakdown and electrolytic action.</p> <p>Evolved gas analysis (EGA) is a method used to study the gas evolved from a heated sample that undergoes decomposition or desorption. It is either possible just to detect evolved gases using evolved gas detection (EGD) or to explicitly analyze which gases evolved using evolved gas analysis (EGA). Therefore, different analytical methods can be employed such as mass spectrometry, Fourier transform spectroscopy, gas chromatography, or optical in-situ evolved gas analysis. By coupling the thermal analysis instrument, e. g. TGA (thermogravimetry) or DSC (differential scanning calorimetry), with a fast Quadrupole Mass Spectrometer (QMS) the detection of gas separation and identification of the separated components are possible in exact time correlation with the other thermal analysis signals.</p> <p>DSC/TGA-QMS or TGA-QMS yields information on the composition (mass numbers of elements and molecules) of the evolved gases. It allows fast and easy interpretation of atomic/inorganic vapors and standard gases like H<sub>2</sub>, H<sub>2</sub>O, CO<sub>2</sub>, etc. Fragmentation, interpretation of</p>	<p><b>Multi-wave Photometer</b></p>  <p><b>Integrated Analyzer</b></p>  <p><b>Flue Gas Analyzer</b></p>  <p><b>Sample Gas Cooler</b></p> 
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	<p>organic molecules is sometimes difficult. The combination with an FTIR (Fourier transform infrared spectrometer) has become popular, especially in the polymer producing, chemical and pharmaceutical industry.</p>
	<p>DSC/TGA-FTIR or TGA-FTIR yields information on the composition (absorption bands) of the evolved gases (bonding conditions). The advantage is an easy interpretation (spectra data bases) of organic vapors without fragmentation. Symmetrical molecules cannot be detected</p>
	<p>Gas chromatography (GC) is a common type of chromatography used in analytical chemistry for separating and analyzing compounds that can be vaporized without decomposition. Typical uses of GC include testing the purity of a particular substance, or separating the different components of a mixture (the relative amounts of such components can also be determined).</p>
	<p>In some situations, GC may help in identifying a compound. In preparative chromatography, GC can be used to prepare pure compounds from a mixture. In gas chromatography, the mobile phase (or "moving phase") is a carrier gas, usually an inert gas such as helium or an unreactive gas such as nitrogen. Helium remains the most commonly used carrier gas in about 90% of instruments although hydrogen is preferred for improved separations. The stationary phase is a microscopic layer of liquid or polymer on an inert solid support, inside a piece of glass or metal tubing called a column (an homage to the fractionating column used in distillation). The instrument used to perform gas chromatography is called a gas chromatograph (or "aerograph", "gas separator").</p>
	<p>A spectrometer is a scientific instrument used to separate and measure spectral components of a physical phenomenon. Spectrometer is a broad term often used to describe instruments that measure a continuous variable of a phenomenon where the spectral components are somehow mixed.</p>
	<p>In visible light a spectrometer can for instance separate white light and measure individual narrow bands of color, called a spectrum, while a mass spectrometer measures the spectrum of the masses of the atoms or molecules present in a gas.</p>

**6**

## Continuous Water Analysis

Corrosion and erosion are major concerns in thermal power plant operating on steam. The steam reaching the turbines need to be ultra-pure and hence needs to be monitored for its quality. A well designed Steam and Water Analysis system (SWAS) can help in monitoring the critical parameters in the steam.

These parameters include pH, conductivity, silica, sodium, dissolved oxygen, phosphate and chlorides. A well designed SWAS must ensure that the sample is representative till the point of analysis.

To achieve this, it is important to take care of the Extraction, Transport, Conditioning, Analysis and Hygiene. Specific conductivity gives overall conductivity value of the sample and is the most generic measurement.

Cation conductivity is conductivity measurement after the Cation Column. At the Cation Column, the H<sup>+</sup> resins replace the positive ions of all dissolved matter in the solution. When this happens, the treatment chemicals, which are desired ones (and are of basic or alkaline in nature) get converted to H<sub>2</sub>O, i.e. water. (e.g. NH<sub>4</sub>OH + H (+) gives NH<sub>4</sub><sup>+</sup> and H<sub>2</sub>O). The impurities are nothing but salts of different natures. These get converted to respective acids (e.g. NaCl + H (+) gives HCl and Cl<sup>-</sup>). Thus masking effects of treatment chemicals on the conductivity value are eliminated, while the conversion of salts to corresponding acids has an effect of increase in their corresponding conductivity value to around 3 times its original value. Thus, in effect, cation conductivity acts as amplifier of conductivity due to impurities and eliminator of conductivity due to treatment chemicals.

De-gassed conductivity is the finest level of conductivity measurement. Here one removes the masking effects of dissolved gases, mainly CO<sub>2</sub>, on the conductivity measurement. In the De-Gassed conductivity system, there is a reboil chamber to heat the sample, so that the dissolved gases are liberated and then there is cooling mechanism, by which the hot liquid is cooled again. The conductivity measured after this process is indeed the 'real' value of conductivity because of 'dissolved' impurities after eliminating the dissolved gases.

Continuous Water Analysis is used to detect Aluminum, Ammonia, Chlorine, Color, Conductivity, Dissolved Organics, Oxygen, Fluoride, Hydrazine, Iron, Manganese and Nitrate, pH, phosphate, turbidity, silica and sodium in water.

Color Analyzer



Turbidity and Total Suspended Solids Sensor



pH Sensor



7	<p><b>Metallurgical Analyzers</b></p> <p>A Metallurgical analyzer is a device used to measure the hydrogen concentration in steels and alloys. It also has industrial applications for corrosion monitoring. It can directly monitor the dissolved inclusion content in liquid metals.</p>	<p>Metallurgical Analyzer</p> 
8	<p><b>Arc fault detection system</b></p> <p>A fast and selective arc fault mitigation for air-insulated low voltage and medium voltage switchgear is a natural constituent of modern switchgear panels and a safety and security investment for older switchgear panels to protect human lives and prevent or reduce material damage.</p>	
9	<p><b>Cable Distribution Cabinets</b></p> <p>Distribution Cabinets are sustainable and fit well in most environments. They come in various design and sizes, doing extremely well even under very tough conditions. The enclosures are developed based on long experience of systems for demanding environments. At the same time, they satisfy current requirements for long life with undiminished safety and low operating and maintenance costs.</p>	
10	<p><b>Capacitors and filters</b></p> <p>They improve the power quality of electrical networks by eliminating disturbances and improving power factor in line with grid requirements. Power quality products and solutions are available for low-voltage (LV), medium-voltage (MV) and high-voltage (HV) systems. In transmission systems, reactive power is needed to maintain the voltage to deliver active power. A lack of reactive power leads to an inefficient use of the electrical network and results in voltage sags, overloaded transformers, lines, cables, etc. In industry, motor loads and other electrical loads require reactive power to convert electrical energy into useful work. Capacitors are very beneficial in power grids. They provide the reactive power needed by electrical motors, transformers, etc. This increases the transmission capacity and reduces losses thanks to higher power factors. They enable power factor targets of the utilities to be met. Capacitors are also a key component in various filter solutions that reduce harmonic content. They reduce the risk of disturbances in production processes, metering errors and malfunctioning of relay protections. This extends the service life of connected equipment. Power Quality of the low voltage network is an important challenge for Industrial and commercial applications. Good Power Quality leads to trouble free and efficient operation of installations.</p>	

11	<h3>Circuit Breakers</h3> <p>Circuit breakers are judged based on reliability, performance and long life. High quality, accuracy and reliability are key features for low voltage circuit-breakers to ensure high performances in any conditions.</p>	
12	<h3>Communication Networks</h3> <p>Communication Networks include Optical, Power Line Carrier, Copper, Voice Networks and Wireless Networks etc.</p> <p>Communication solutions are needed for various real-time applications in wide area networks. They incorporate TDM (SDH/PDH), latest packet-based technologies, integrated teleprotection, Ethernet over SDH (EoS), Ethernet switches, routers and firewalls, digital communication systems etc.</p> <p>PLC is still often the most cost effective, and reliable, solution to cover the operational needs of a power system. This applies particularly when only low volumes of data have to be transmitted over long distances. An existing PLC network represents a considerable investment made over many years, and for reasons of cost and system operation it is seldom possible, or necessary, to replace it with a digital system in a short space of time. An existing PLC network can often be usefully expanded rather than replaced, and in such cases frequency allocation must be carefully planned to mitigate any channel shortage. In other instances, a PLC channel is used as a back-up to fiber-based digital channels, providing a dependable communication link in the most demanding of circumstances. The latest technologies to PLC systems include five-step variable bandwidth and flexible partitioning of digital and analog data, backed with a formidable capability in systems and applications engineering.</p> <p>The Ethernet/SHDSL managed switches and FSK-based analog modems are specifically designed for critical infrastructure and industrial applications with enhanced, robust communication technology that ensures minimal downtime and enables predictive failure notification and encrypted management.</p> <p>Data communication features two-wire copper lines, starting at very low</p>	<p>Modems</p>  <p>Routers</p> 

	<p>baud rates (FSK-based analog modems) or SHDSL/EFM connections with up to 15 Mbps data rate, and ranges up to Ethernet (copper and optical). SFP slots and suitable SFP modules provide connectivity over optical multimode or single mode fibers for Duplex LC (two fibers) and Simplex LC (bi-directional over one fiber).</p> <p>The Ethernet/SHDSL switches support a variety of useful, reliable and intelligent functions, such as MSTP/RSTP/STP (IEEE 802.1Q/w/D), VLAN, IEEE 802.1X, HTTPS, SNMPv3, SSH, QoS, rate limiting, ACL/packet filter, RMON, LLDP, L2TP, IGMP snooping, and many more.</p>	
13	<p><b>Conduits and fittings</b></p> <p>Conduit systems and fittings provide unsurpassed protection for wire and cables in the most demanding applications. Conduits are available in many different materials, ranging from lightweight to heavyweight with enhanced low fire hazard properties, EMI screening and incorporating high fatigue life. Overbraided conduits are used in abrasive environments. The corrugated construction provides good flexibility and low weight. A range of fittings are specifically designed to maintain system integrity. High-specification protective cable glands are suitable for harsh conditions, including high or extreme temperature ranges, oil and UV exposure, food &amp; beverage use or highly corrosive environments. Non-metallic elbows and fittings are designed for use above- and below-ground.</p>	  
14	<p><b>Connection Blocks</b></p> <p>Connection Blocks include Terminal Blocks, Test Blocks, Distribution Blocks etc.</p> <p>High quality connection Blocks provide simplification and acceleration of flows, minimum delivery times and perfect connection reliability in response to all connection challenges.</p>	
15	<p><b>Connection Devices</b></p> <p>Connection Devices include Overhead Connectors, Compression Connectors, Wire termination, Grounding Systems etc. to connect overhead distribution power lines and equipment. Compression, mechanical and exothermic connectors and accessories make a safe, code compliant and reliable grounding system.</p>	

16	<p><b>Control Panels</b></p> <p>Control panels offer many different performance levels including economic applications, robust standard operator panels, high end multi-touch human machine interfaces (HMIs) and control panels designed for reliable operation in harsh environmental conditions.</p>	
17	<p><b>Control Room</b></p> <p>Control room operators make hundreds of decisions - decisions that have a great impact on productivity, quality and safety. The more alert, stimulated and harmonious they are, the better decisions they make. They can be applied to any industry or utility like transport, oil and gas, power generation, mining and manufacturing process control.</p>	
18	<p><b>Power Diodes</b></p> <p>Diodes can be subdivided into two main classes: Rectifier diodes (standard recovery) and fast diodes. Rectifier diodes are generally used for conversion of AC (alternating current) to DC (direct current). While optimized for low conduction losses, Rectifier diodes withstand only moderate dynamic stress in transition from conducting to the blocking state. Fast diodes, on the other hand, are companion devices to switches in DC to AC conversion. Every switch (GTO, IGCT or IGBT) requires a complementary diode (e.g. for "free-wheeling" reactive power) in order to enable operation of the DC-AC conversion system with inductive loads. Fast diodes are optimized to accept high dynamic stress (fast transition from conducting to blocking state). However, they generally have higher conduction losses than rectifier diodes. For every switch family (GTO, IGCT and IGBT), fast diodes are optimized for the switch application. Welding diodes are designed for medium and high frequency welding equipment and optimized for high current rectifiers. The on-state voltage is very low and the output current is high. Both normal housed and housing-less welding diodes are available. The latter is more important in high current welding applications for joining of high refractory materials.</p>	
19	<p><b>Disconnectors</b></p> <p>Reliable and energy efficient disconnectors are needed to meet the requirements of different sites, voltage levels and network conditions. Disconnectors are designed as per IEEE, GOST, and GB standards. Accredited testing laboratories carry out type tests on the disconnectors in accordance with the latest regulations. Comprehensive electrical and mechanical routine tests are carried out on the poles and operating mechanism of disconnectors.</p>	

20	<p><b>Motor Drives</b></p> <p>DC drives give design flexibility and dependable performance. DC drives are used in almost any industrial application, either as part of a new installation or as a cost-effective retrofit. Latest control technology is employed in three phase DC drives with programmability, built-in control programs, communication and I/O options. Low voltage AC drives boost the productivity, improve energy efficiency and cut maintenance costs. DC drives are used in micro and machinery drives for machine building, industrial drives for controlling processing lines etc. Industry specific drives with purpose-designed features and functionality are also available.</p>	
21	<p><b>Electrical Boxes, Covers, Housing and Enclosures</b></p> <p>These include Metallic, non-metallic, indoor, outdoor, weatherproof, and floor boxes.</p> <p>Electrical walk-in modular outdoor enclosures house medium voltage (MV) and low voltage (LV) switchgear as well as auxiliary equipment. They can be skid or wheel mounted and are ready to operate in the field with minimum installation, commissioning and start up time - as an alternative to traditional on-site building construction (concrete block, brick construction or similar). Proximity to major suppliers during design / construction makes the changes and integration easier. Their mobility makes them easy and cost effective to install and relocate. They can be installed close to the main loads which reduces the power and control cable size and length. By being close to the loads the energy cost is lower.</p>	
22	<p><b>Enclosed Switches</b></p> <p>Enclosed switches are used as main disconnects in many applications. They include high quality enclosed switch-disconnectors, in enclosures made of plastic, steel sheet, acid proof stainless steel and aluminum; covering all NEMA classes.</p> <p>Various DC voltage ratings and a control of multiple circuits within the same footprint area can be achieved. They are suitable for applications in high ambient temperatures. Enclosed switches save installation space, time and cost. The mounting options include door, base, DIN rail etc. Padlockable handles and cover interlock ensure safe maintenance and installation work. The enclosures are made of high quality, UV resistant materials suitable for indoors and outdoors.</p> <p>Heavy duty safety switches offer a complete range of fusible and non-fusible solutions to meet all relevant standards UL98, UL50, UL50E and NEMA KS-1 and CSA.</p>	

23	<p><b>Energy storage solutions</b></p> <p>The advent of volatile and decentralized power generation from renewable sources and unpredictable consumers like electric vehicles, as well as obstacles for reinforcing the grid infrastructure, accentuate the unbalance between production and consumption of electrical energy in the power system. This results in grid instabilities, i.e., voltage and frequency deviations affecting consumers. Energy storage solutions can make a major contribution in alleviating these effects. Energy storage systems can be connected to medium- or high-voltage grids and cover a power range of hundreds of kilowatts to tens of megawatts. The optimized systems enable fast response times to variations in demand and supply, helping to maintain grid stability and ensuring reliable and high-quality energy supplies through a range of applications. An energy storage system is a packaged solution that stores energy for use at a later time. The system's two main components are the DC-charged batteries and bi-directional inverter. Battery enclosures and Connection Equipment Modules (CEM) are provided as separate components. They are used for load leveling, peak shaving, capacity firming, frequency regulation, power quality and spinning reserve.</p>	 
24	<p><b>FACTS Devices</b></p> <p>Flexible Alternating Current Transmission Systems technologies provide more power and control in existing AC as well as green-field networks and have minimal environmental impact. Fixed series compensation has long been the preferred solution for optimizing performance in very large bulk transmission corridors. Installing a capacitive reactance in series in a long (typically more than 200 km) transmission line reduces both the angular deviation and the voltage drop, which increases the loadability and stability of the line. Since the current through the transmission line directly "drives" the MVAr output from the capacitor, the compensation concept is "self-regulating", and this straightforward principle ensures that series compensation is an extremely cost effective solution. Series compensation provides increased transient (angular) stability of a power corridor and increased voltage stability of the grid. It also improves the voltage profile along the power corridor and optimizes power sharing between parallel circuits.</p> <p>Series Compensation with Thyristor Control (TCSC) enables rapid dynamic modulation of the inserted reactance. At interconnection points between transmission grids, this modulation will provide strong damping torque on inter-area electromechanical oscillations. As a consequence, a TCSC rated at around 100 Mvar makes it possible to interconnect grids having generating capacity in the many thousands of megawatts. Often the TCSC is combined with fixed series compensation to increase transient stability in the most cost effective way. The TCSC concept also enables inherent immunity against subsynchronous resonance (SSR), and thus allows for extended use of series capacitors in specific transmission grids comprising thermal generation. The</p>	<p>Series compensation</p>  <p>TCSC</p>  <p>SVC</p> 

<p>immunity to SSR is a result of the ABB patented SVR control strategy.</p> <p>Static Var Compensators (SVCs) are devices that can quickly and reliably control line voltages. An SVC will typically regulate and control the voltage to the required set point under normal steady state and contingency conditions and thereby provide dynamic, fast response reactive power following system contingencies (e.g. network short circuits, line and generator disconnections). In addition, an SVC can also increase transfer capability, reduce losses, mitigate active power oscillations and prevent over voltages at loss of load. The SVC consists of a number of fixed or switched branches, of which at least one branch includes thyristors, and the combination of branches can be varied a lot depending on requirements. An SVC typically includes a combination of Thyristor controlled reactor (TCR), Thyristor switched capacitor (TSC) and Harmonic filter (FC).</p> <p>Mechanically switched capacitor bank (MSC) or reactor bank (MSR) The main advantage for using a topology with TSC branches is to reduce the losses (by reducing the filter size). Mechanically switched banks can be included both on HV and LV side of SVC transformer to increase the total reactive power support outside the dynamic range. SVC control system can be utilized for controlling new or existing external shunt banks.</p> <p>Electrical loads both generate and absorb reactive power. Since the transmitted load often varies considerably from one hour to the next, the reactive power balance in a grid varies as well. This can result in unacceptable variations in voltage, including voltage depression or even voltage collapse.</p> <p>Like SVC but faster, STATCOM continuously provides variable reactive power in response to voltage variations, supporting the stability of the grid. STATCOM operates according to voltage source converter (VSC) principles, combining unique PWM (pulse width modulation) with millisecond switching. STATCOM functions with a very limited need for harmonic filters, contributing to a small physical footprint. If required, switched or fixed air core reactors and capacitors can be used with the VSC as additional reactive power elements to achieve any desired range. Installing a STATCOM at one or more suitable points in a grid will increase power transfer capability by enhancing voltage stability and maintaining a smooth voltage profile under different network conditions. Its ability to perform active filtering is also very useful for improvements in power quality.</p> <p>High inertia rotating condensers support efficient and reliable operation of power grids, balancing voltage fluctuations through reactive power compensation and offering additional short-circuit power capacity and high power quality. To ensure enduring and reliable operation synchronous condensers are designed for high reliability, durability and the capability to operate for long periods of time between recommended</p>	<p><b>STATCOM</b></p> 	<p><b>Synchronous Condenser</b></p> 	<p><b>SFC</b></p> 
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	<p>service intervals.</p> <p>Frequency converters with flexible converter based technology maximize power availability and deliver continuous clean power.</p>	
25	<p><b>Flow Measurement Devices</b></p> <p>Mass flowmeters feature low pressure drop, high capacity, intuitive display, I/Os etc. Electromagnetic flowmeters provide a modular transmitter design to deliver a clear business and performance benefit. Sensor designs can withstand harshest environmental conditions. They have Industry optimized liner and electrode materials, and are resistant to abrasion and corrosion.</p> <p>Multiphase flowmeter, tailored for wet gas applications are able to provide outstanding accuracy also in the most challenging operating regions. They offer a high quality and cost effective solution for precise and dynamic direct mass flow measurements of gases in low and medium pressure conditions. This adds high accuracy and extended functionality for advanced applications.</p> <p>High grade thermal sensor elements provide superior long-term stability. They use a two-wire transmitter with DSP-Technology and excellent vibration compensation to enables user friendly intuitive operation directly through the glass. The installation is flexible due to low required inlet and outlet sections.</p>	
26	<p><b>Fuses</b></p> <p>Fuses provide short circuit and overload protection in low voltage electrical distribution networks. Fuse gear products are designed for an easy, safe and reliable installation and operation in substations, Cable Distribution Cabinets, distribution boards in Compact Secondary Substations and distribution boards in industrial, commercial and residential applications.</p> <p>Medium voltage current limiting and expulsion fuses are suitable for the protection of distribution transformers, voltage transformers, capacitor banks, motor circuits and installations with other switching apparatus. They are Capable to control full range of overload currents either in combination with switching apparatus or as sole protection. Fuses are economic protection devices for immediate interruption of high short circuit currents that significantly increase isolation life time.</p> <p>High mechanical and thermal resistance of housing materials – porcelain and resin-fiberglass ensures optimized operation in outdoor and indoor applications.</p>	

27	<p><b>Angle Grinder</b></p> <p>An angle grinder, also known as a side grinder or disc grinder, is a handheld power tool used for grinding (abrasive cutting) and polishing. Although developed originally as tools for rigid abrasive discs, the availability of an interchangeable power source has encouraged their use with a wide variety of cutters and attachments. Angle grinders can be powered by an electric motor, petrol engine or compressed air. The motor drives a geared head at a right-angle on which is mounted an abrasive disc or a thinner cut-off disc, either of which can be replaced when worn. Angle grinders typically have an adjustable guard and a side-handle for two-handed operation. Certain angle grinders, depending on their speed range, can be used as sanders, employing a sanding disc with a backing pad or disc. The backing system is typically made of hard plastic, phenolic resin, or medium-hard rubber depending on the amount of flexibility desired.</p>	
28	<p><b>Alligator Shear</b></p> <p>An alligator shear, historically known as a lever shear and sometimes as a crocodile shear, is a metal-cutting shear with a hinged jaw, powered by a flywheel or hydraulic cylinder. The jaw size can range from 4 to 36 in (100 to 910 mm) long. They are generally used to cut steel members, such as rebar, pipe, angle iron, or I-beams.</p>	
29	<p><b>Air Blower</b></p> <p>A blower, is a tool that propels air out of a nozzle to move debris. Blowers are powered by electric or gasoline motors. Gasoline models have traditionally been two-stroke engines, but four-stroke engines were recently introduced to partially address air pollution concerns. Blowers are typically self-contained handheld units, or backpack mounted units with a handheld wand. The latter is more ergonomic for prolonged use. Larger units may rest on wheels and even use a motor for propulsion. Some units can also suck debris via a vacuum, and shred them into a bag. In that role it is called a blower vac.</p>	

30	<p><b>Saw</b></p> <p>A saw is a tool consisting of a tough blade, wire, or chain with a hard toothed edge. It is used to cut through material, very often wood though sometimes metal or stone. The cut is made by placing the toothed edge against the material and moving it forcefully forth and less forcefully back or continuously forward. This force may be applied by hand, or powered by steam, water, electricity or other power source. An abrasive saw has a powered circular blade designed to cut through metal or ceramic.</p>	
31	<p><b>Oscillatory Multi-tool</b></p> <p>Multi-tool is a common name for an oscillating power tool powered by battery or mains. The name "multi-tool" is a reference to the many functions that this tool can perform with the range of attachments available. "Master Tool" is also a trade name used in North America, short for the original tool by Fein called the Multi-Master. So far there are tools available to saw, sand, rasp, grind, scrape, cut and polish.</p> <p>Use of an offset in a fitted blade allows the tool to cut flush with a surface. This is particularly useful when fitting flooring along a skirting board, cutting the skirting to allow the board to slide under for a neat finish. The small form of these tools and the ability to mount the blade/accessory in any orientation allows cutting in areas previously unreachable. The ability to cut a complex or precise recess without the need to remove the work piece from where it is fixed greatly increases productivity. Small and precise cuts are possible even on end grain, a small sliver can be easily removed from timber cut too long for a perfect fit.</p> <p>The accessory is fitted to the tool by a mechanism which allows that accessory to be rapidly rotated back and forth (oscillated). This creates friction with the sanding attachments or rapid cutting motions with the saw and grinding attachments. The narrow angle of oscillation allows for precise control over the tool as it does not kick like a rotating tool can. The angle of oscillation creates increasing friction further from the center of the tool as these areas travel a greater distance. The increased friction is particularly apparent with the triangular sanding and grinding attachments which allow the operator to reach into corners and confined spaces, a feature unique to this type of power tool. The saw blade attachments use the angle of oscillation in the same way.</p> <p>Improvements in battery technology such as lithium ion have allowed for tools which can be small in size and weight but still perform well enough to compete with mains-powered equivalents while freeing the user from the restrictions of cables.</p>	

32	<p><b>Nail Gun</b></p> <p>A nail gun is a type of tool used to drive nails into wood or some other kind of material. It is usually driven by compressed air (pneumatic), electromagnetism, highly flammable gases such as butane or propane, or, for powder-actuated tools, a small explosive charge. Nail guns have in many ways replaced hammers as tools of choice among builders.</p>	
33	<p><b>Needle Scaler</b></p> <p>A needle gun scaler, needle scaler or needle-gun is a tool used to remove rust, mill scale, and old paint from metal surfaces. The tool is used in metalwork applications such as automotive repair.</p>	
34	<p><b>Wrench</b></p> <p>A wrench or spanner is a tool used to provide grip and mechanical advantage in applying torque to turn objects—usually rotary fasteners, such as nuts and bolts—or keep them from turning. The most common shapes are called open-ended spanner and ring spanner. The term wrench is generally used for tools that turn non-fastening devices (e.g. tap wrench and pipe wrench), or may be used for a monkey wrench - an adjustable pipe wrench. The most common shapes are called open-end wrench and box-end wrench. Higher quality wrenches are typically made from chromium-vanadium alloy tool steels and are often drop-forged. They are frequently chrome-plated to resist corrosion and for ease of cleaning.</p>	

35	<p><b>Pressure Washer</b></p> <p>Pressure washing or power washing is the use of high-pressure water spray to remove loose paint, mold, grime, dust, mud, chewing gum and dirt from surfaces and objects such as buildings, vehicles and concrete surfaces. The volume of a mechanical pressure washer is expressed in gallons or liters per minute, often designed into the pump and not variable. The pressure, expressed in pounds per square inch, Pascal, or bar, is designed into the pump but can be varied by adjusting the unloader valve. Machines that produce pressures from 750 to 30,000 psi (5 to 200 MPa) or more are available. A pressure washing surface cleaner is a tool consisting of two to four high-pressure jets on a rotating bar that swivels when water is flowing. This action creates a uniformed cleaning pattern that can clean flat surfaces at a rapid rate. Hydro-jet cleaning is a more powerful form of power washing, employed to remove buildup and debris in tanks and lines.</p>	
36	<p><b>Sander</b></p> <p>A sander is a power tool used to smooth surfaces by abrasion with sandpaper. Sanders have a means to attach the sandpaper and a mechanism to move it rapidly contained within a housing with means to hand-hold it or fix it to a workbench. Woodworking sanders are usually powered electrically, and those used in auto-body repair work by compressed air. There are many different types of sanders for different purposes. Multi-purpose power tools and electric drills may have sander attachments. A disc sander is most commonly implemented as a stationary machine that consists of a replaceable circular shaped sandpaper attached to a wheel turned by an electric motor or compressed air. The usually wooden work piece, (although other materials can be shaped and worked on such as plastics, metals and other soft materials), is sat on a front bench that can be adjusted to various angles. It can be used for rough or fine sanding depending on the sanding grit used. Woodworking sanders include Flap sander or sanding flap wheel, Belt sander, Disc sander, Scuff sander, Oscillating spindle sander, Random orbital sander, Orbital sander, Straight-line sander, Detail Sander, Stroke sander, Table Top Drum sander, Drum sander, Wide-belt sander, Profile Shaper/Sander.</p>	 

37	<p><b>Drill</b></p> <p>A drill is a tool primarily used for making round holes or driving fasteners. It is fitted with a bit, either a drill or driver, depending on application, secured by a chuck. Some powered drills also include a hammer function.</p> <p>Drills vary widely in speed, power, and size. They are characteristically cored electrically driven devices, with hand operated types dramatically decreasing in popularity and cordless battery powered ones proliferating.</p> <p>Drills are commonly used in woodworking, metalworking, machine tool fabrication, and construction and utility projects. Specially designed versions are made for medicine, Space, and miniature applications.</p>	 
38	<p><b>Heat Gun</b></p> <p>A heat gun is a device used to emit a stream of hot air, usually at temperatures between 100 °C and 550 °C (200-1000 °F), with some hotter models running around 760 °C (1400 °F), which can be held by hand. Heat guns usually have the form of an elongated body pointing at what is to be heated, with a handle fixed to it at right angles and a trigger, in the same general layout as a handgun. A lighter duty heat gun is similar to a portable Hair dryer.</p>	
39	<p><b>Hand Tools</b></p> <p>Hand tools include Wrench, Plier, File, Screwdriver, Hammer, Vise, Snip, Knife, Clamp, Ratchet, Wire Stripper, Cable Cutter, Flashlight, Tape measure, Puncher, drill, nuts, nails, rasp, chisel, bits, sand paper, awl, nip etc.</p>	

40	<p><b>Relays</b></p> <p>Relays are characterized as Electromagnetic attraction type relays, Induction type relays, Solid state relays, Numerical based/Microprocessor based relays, Hybrid Relays, Thermal overload relays, Insulation monitoring relays, Liquid monitoring relays, Gas actuating relays, Reed Relays etc.</p> <p>Some Examples include Paralleling Relay, Under Reactance Relay, Over Voltage Relay, Under Voltage Relay, Under Frequency Relay, Over Frequency Relay, and Differential over Current Relay, Thermal Overload Relay, Earth Fault Relay, Excitation Loss Relay, Generator Protection Relay, Multimode Auxiliary Relay, PC Board Relay and Buchholz Relay.</p>	
41	<p><b>Circuit Breakers</b></p> <p>Circuit breakers include Oil Circuit Breaker, Air Circuit Breaker, SF6 Circuit Breaker, Vacuum Circuit Breaker, HVDC Circuit Breaker and Miniature Circuit Breaker, Molded case Circuit Breaker, Single Pole Circuit Breaker, Double Pole Circuit Breaker, Ground Fault Interrupter Circuit Breaker and Arc Fault Circuit Interrupter Circuit Breaker.</p>	
42	<p><b>PLC</b></p> <p>A programmable logic controller or programmable controller is an industrial digital computer which has been ruggedized and adapted for the control of manufacturing processes, such as assembly lines, or robotic devices, or any activity that requires high reliability control and ease of programming and process fault diagnosis. PLCs were first developed to provide flexible, ruggedized and easily programmable controllers to replace hard-wired relays, timers and sequencers. Since then, they have been widely adopted as high-reliability automation controllers suitable for harsh environments. A PLC is an example of a "hard" real-time system since output results must be produced in response to input conditions within a limited time, otherwise unintended operation will result.</p>	
43	<p><b>Mechanical Switches</b></p> <p>Switches include Push Lock Switch, DIP Switch, Push-to-make Switch, Rocker Switch, Rotary Switch, Slide Switch, Tact Switch, Toggle Switch, Limit Switch, Float Switch, Flow Switch, Pressure Switch, Temperature Switch, Joystick Switch etc.</p>	

44	<h3>Electronic Switches</h3> <p>Electronic Switches include Bipolar Junction Transistor, Power Diode, Metal Oxide Semiconductor Field Effect Transistor, Insulated Gate Bipolar Transistor, Silicon Controlled Rectifier, Bidirectional Triode Thyristor, DIAC, JFET, and Gate Turn Off Thyristor.</p>	
45	<h3>Cables</h3> <p>Cables can be characterized as Coaxial cable, Direct-buried cable, Flexible cables, filled cable, Heliax cable, Non-metallic sheathed cable, Metallic sheathed cable, Multicore cable, Paired cable, Portable cord, Ribbon cable, shielded cable, Single cable, Structured cabling, Submersible cable, Twin and earth, Twinax cable, Twin-lead, Twisted pair</p>	
46	<h3>Energy Meters</h3> <p>Energy Meters can be characterized as Electromechanical Meters, Electronic Meters (Digital Meter, Analog Meters), Single Direction Meters, Bidirectional Meters, Smart Meters (Zigbee, GSM/ GPRS, RF, Wi-Fi, PLC based Meters), LT Meters, HT Meters, Three Phase Meters, Single Phase Meters etc.</p> <p>Some Examples include Ammeter, Capacitance meter, Curve tracer, Cos Phi Meter , Distortionmeter, Electricity meter, ESR meter, Frequency counter, Leakage tester, LCR meter, Microwave power meter, Multimeter, Network analyzer, Ohmmeter, Oscilloscope, Psophometer, Q meter, Tachometer, Signal analyzer, Signal generator, Spectrum analyser, Sweep generator, Transistor tester, Tube tester, Wattmeter, Vectorscope, Video signal generator, Voltmeter, VU meter.</p>	
47	<h3>Sensors</h3> <p>Sensors include Active Sensors, Passive Sensors, Analog and Digital Sensors, Electric, Biological, Chemical and Radioactive Sensors, Photoelectric, Thermoelectric, Electrochemical, Electromagnetic and Thermo-Optic Sensors.</p> <p>Some Examples include Temperature Sensor (Thermometer, Resistance Temperature Detector), Proximity Sensor, Accelerometer, IR Sensor (Infrared Sensor), Pressure Sensor, Light Sensor, Ultrasonic Sensor, Smoke, Gas and Alcohol Sensor, Touch Sensor, Color Sensor, Humidity Sensor, Tilt Sensor, Flow and Level Sensor, Oil Mist Sensor, Torsional Vibration Sensor etc.</p>	

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### DC Power Supply

A power supply is an electrical device that supplies electric power to an electrical load. The primary function of a power supply is to convert electric current from a source to the correct voltage, current to power the load. As a result, power supplies are sometimes referred to as electric power converters. Some power supplies are separate standalone pieces of equipment, while others are built into the load appliances that they power. Examples of the latter include power supplies found in desktop computers and consumer electronics devices. Other functions that power supplies may perform include limiting the current drawn by the load to safe levels, shutting off the current in the event of an electrical fault, power conditioning to prevent electronic noise or voltage surges on the input from reaching the load and storing energy so it can continue to power the load in the event of a temporary interruption in the source power (uninterruptible power supply). All power supplies have a power input connection, which receives energy in the form of electric current from a source, and one or more power output connections that deliver current to the load. The source power may come from the electric power grid, such as an electrical outlet, energy storage devices such as batteries or fuel cells, generators or alternators, solar power converters, or another power supply. The input and output are usually hardwired circuit connections, though some power supplies employ wireless energy transfer to power their loads without wired connections. Some power supplies have other types of inputs and outputs as well, for functions such as external monitoring and control.

