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الهيئة السعودية للمقيّمين المعتمدين
Saudi Authority for Accredited Valuers

Part 1: Applied Machinery and Equipment Valuation

Common Utilities, Infrastructure and Plant Services

Objective

These notes are for reference only by the TAQEEM trainees. The objective of this publication is to provide knowledge on applied machinery and equipment valuation for common utilities, infrastructure and plant services.

Disclaimer

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MODULE 403
INTERMEDIATE 2: APPLIED MACHINERY AND EQUIPMENT VALUATION - COMMON UTILITIES, INFRASTRUCTURE AND PLANT SERVICES

Objective

At the end of this module, participants will have gained an understanding of plant services commonly found within many facilities, common utilities and infrastructure that deliver those services to manufacturing facilities and the wider community, as well as writing ME valuation reports for both simple machines and complicated plants.

Contents

- Utilities and infrastructure
- Plant services
- Understanding manufacturing
  - Introduction
  - Process plant technology
  - Workflow planning
  - Anatomy of process plant: case study - substation
- ME valuation report
- Assignment: Machine shop and vehicle valuation

Methodology

- Lecture
- Discussion
- Q and A

Duration

- 5 days

PROGRAMME SCHEDULE

TRAINING PROGRAMME **Intermediate 2: Applied Machinery and Equipment Valuation - Common Utilities, Infrastructure and Plant Services**

DURATION **5 Days**

DATE/ TIME	Day 1	Day 2	Day 3	Day 4	Day 5
0830 – 1030	**Session 1** Utilities and Infrastructure & Plant Services	**Session 2** Technology and Process Flow Planning	**Session 5** Project Briefing on Machine Shop and Vehicle Valuation	**Session 7** Project Preparation and Presentation	
1030 – 1100					
1100 – 1200	**Continue Session 1**	**Session 3** Anatomy of Process Plant: Case Study - Substation	**Session 6** Site Inspection	**Continue Session 7**	**Examination** **(11.00 – 14.00)** **(3 hours)**
1200 – 1300					
1300 – 1330					
1330 – 1530	**Continue Session 1**	**Session 4** Report Writing	**Continue Session 6**	**Continue Session 7**	

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APPLIED MACHINERY AND EQUIPMENT VALUATION

COMMON UTILITIES, INFRASTRUCTURE AND PLANT SERVICES

403

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UTILITIES AND INFRASTRUCTURE

1.0 UTILITIES AND INFRASTRUCTURE

For the purpose of this document, utilities and infrastructure comprise the physical assets required to provide electricity, gas, water and wastewater services to industry and the wider community.

More generally, infrastructure can extend to include roads, rail, telecommunications, etc. Such assets are typically owned and maintained by utility companies that may either be in public or private ownership. Infrastructure can also include networks of assets such as those used to deliver healthcare and education services.

2.0 ELECTRICITY INFRASTRUCTURE

2.1 Overview

Electricity supply systems comprise of generation plants that produce electricity, transmission and sub-transmission systems that transmit high voltage electricity from the power generation facilities to major points of supply, and distribution systems that distribute medium and low voltage electricity to industrial and domestic consumers.

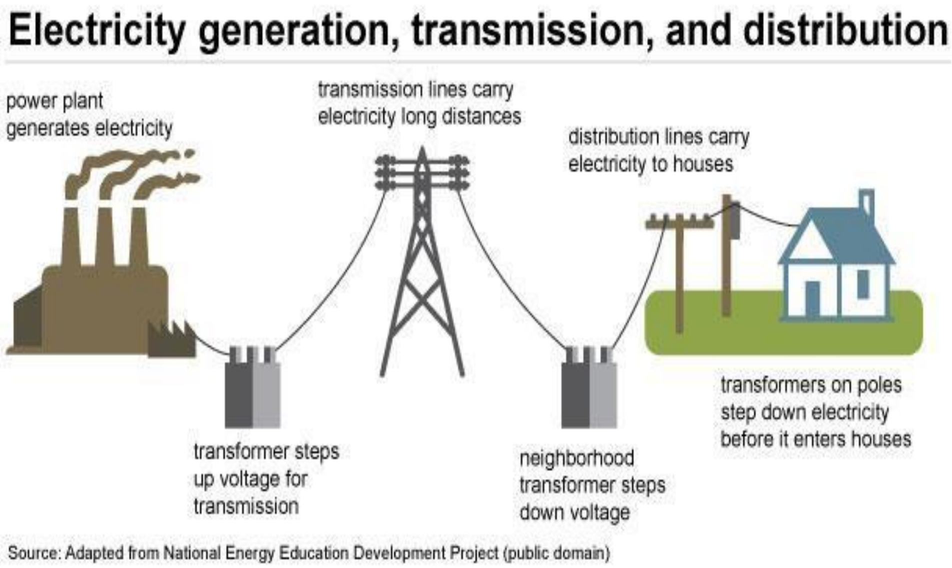


Figure 1: Electric Supply

In the context of power generation, transmission and distribution, voltages are typically classified as follows:

- Ultra-high voltage (UHV) - > 800 kV
- Extra-high voltage (EHV) – 345 kV to 745 kV
- High voltage (HV) – 100 kV to 275 kV
- Medium voltage (MV) – 2.4 kV to 69 kV
- Low voltage (LV) - < 2.4 kV

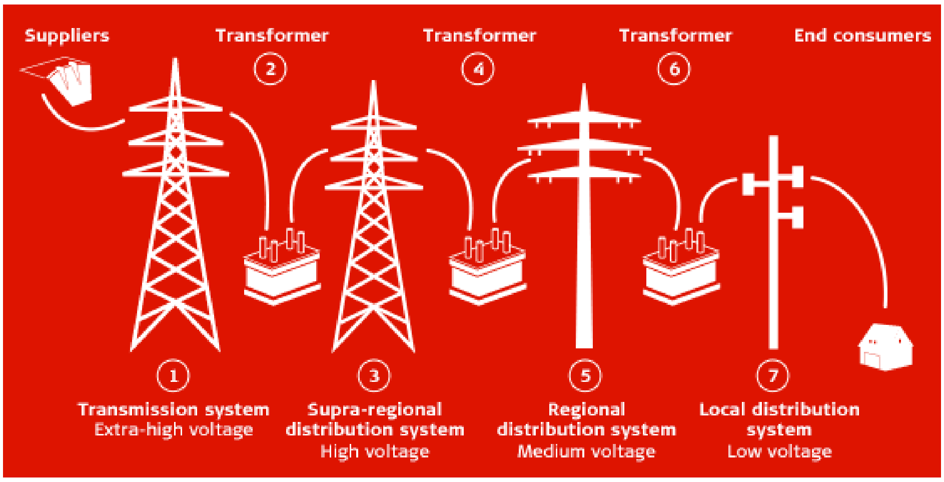


Figure 2: Extra-high voltage, high voltage, medium voltage

2.2 Electricity Generation

Electricity generation plants can be categorized in several different ways. For the purpose of this module the categorization focusses on the way in which electrical energy is generated.

Note: The capacity of most generators is typical measured in either kW/MW or kVA/MVA depending on the size of the unit.

2.2.1 Thermal Power Plants

A thermal power plant is a facility where heat energy is converted to electrical power. In many thermal energy power plants, water is heated and turned to steam, which is then used to spin a steam turbine which is the prime mover used to drive an electricity generator. After the steam has passed through the steam turbine it is passed to a condenser where the steam condenses and is returned to the water supply system of the boiler. This process is known as the Rankine cycle.

Thermal power plants designed around the Rankine cycle may be fueled by oil, gas, coal, nuclear fission, municipal or domestic waste, solar[1] or biofuels.

Types of thermal power plant include:

- Natural gas/oil/coal-fired steam turbine
- Open cycle gas turbine
- Combined cycle gas turbine
- Geothermal turbine

[1] Solar thermal power plants use the power of the sun to heat water to raise steam which is in turn used to drive a steam turbine generator. These are distinct from solar photo-voltaic plants which convert solar energy to electrical energy using photo-voltaic cestlls or solar panels.

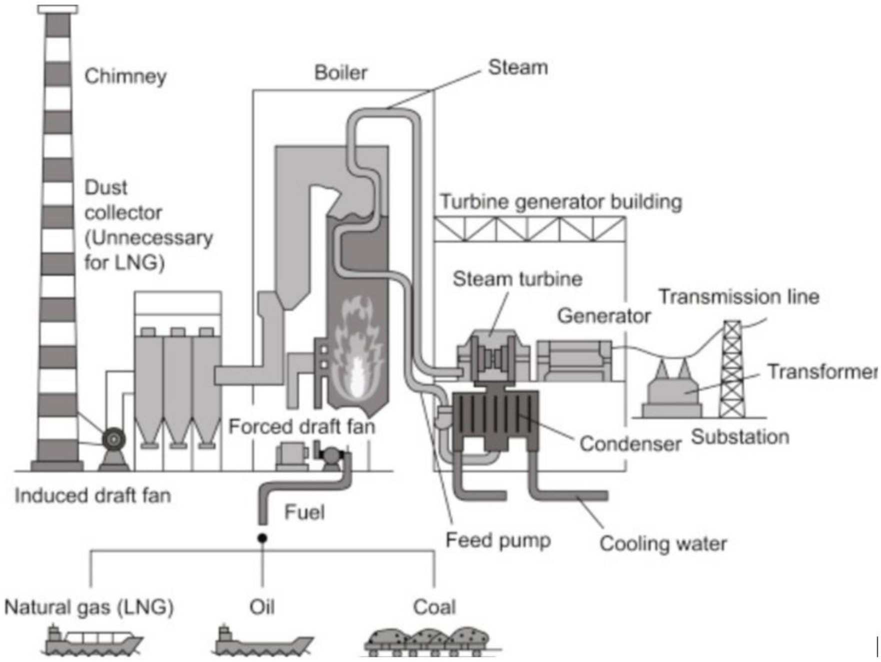


Figure 3: Natural Gas/Oil/Coal-fired Thermal Power Plant

Open Cycle Gas Turbine (OCGT) and Combined Cycle Gas Turbine (CCGT) power plants use gas turbines, similar to those used in jet aircraft. In the case of OCGT plants, gas is compressed and then burnt in a combustion chamber, and the hot gases released then drive a gas turbine which is the prime mover used to drive a generator. Waste heat is exhausted to the atmosphere.

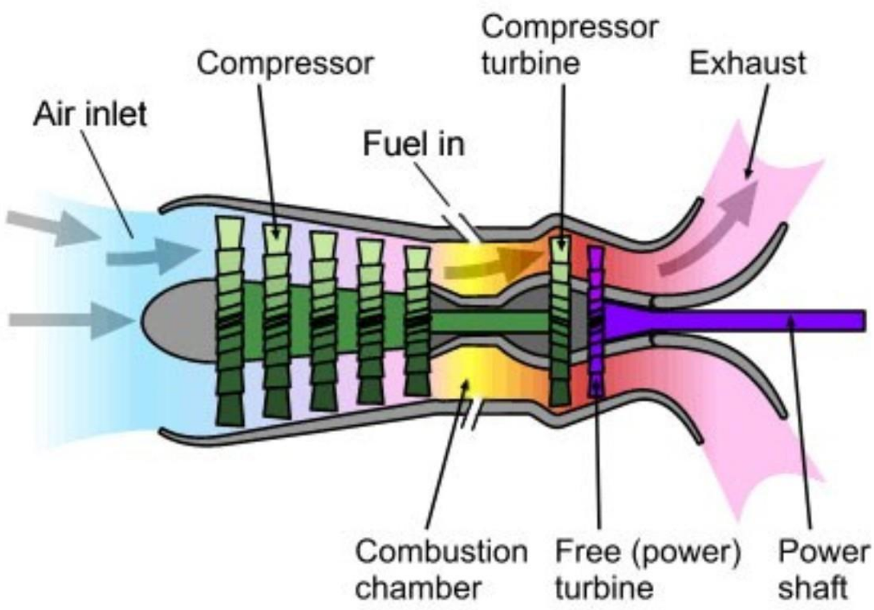


Figure 4: Open-Cycle Gas Turbine (OCGT)

In a CCGT plant, in addition to the components described above, the waste heat exhausted from the gas turbine is captured and directed to a heat recovery steam generator (HRSG) to produce steam which is then used to drive a steam turbine which is the prime mover used to drive an additional generator.

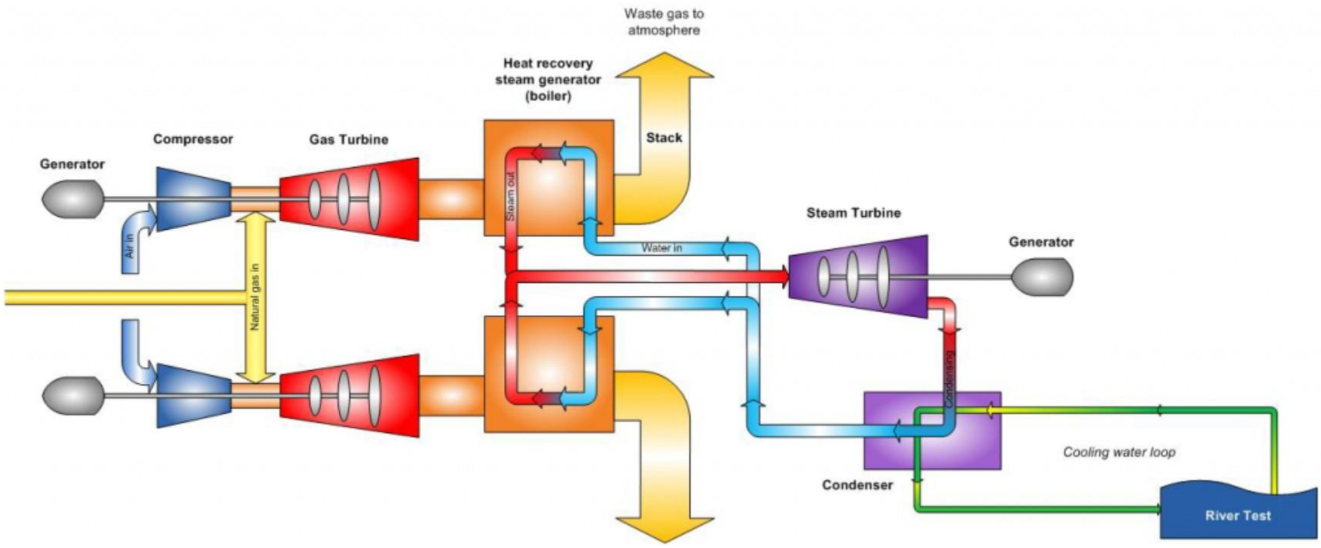


Figure 5: Combined-Cycle Gas Turbine (CCGT) Plant

Sources of fuel for OCGT and CCGT power plants are primarily natural gas, diesel and Jet A1 fuel.

Geothermal power plants, which use steam naturally generated and stored in the earth, are also a form of thermal power plant.

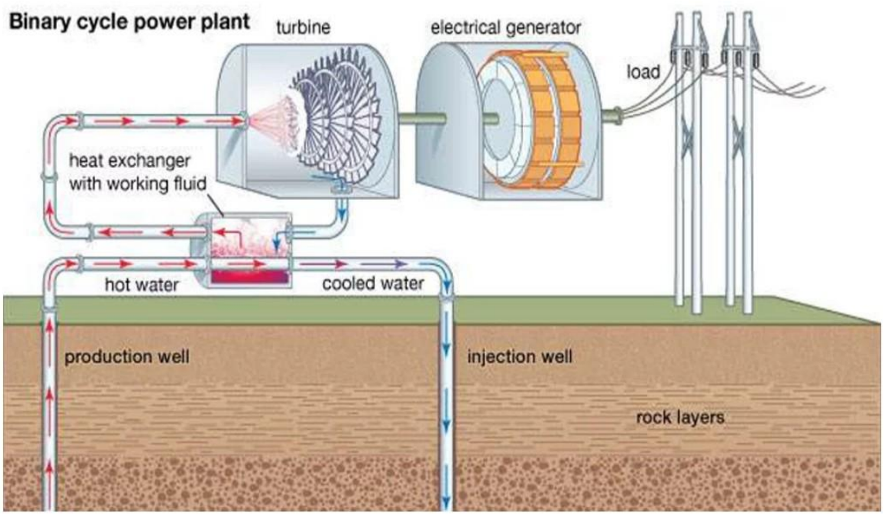


Figure 6: Geothermal Power Plant

2.2.2 Solar Photo-Voltaic (PV) Power Plants

Solar PV power plants derive energy from sunlight, which is captured by PV cells or solar panels. PV cells are made of silica which release electrons when heated by the sun.

Figure 7: Solar PV Plant

2.2.3 Hydroelectric Power Plants

A hydroelectric power plant is a facility where the kinetic energy of falling water is converted to electric power. Hydroelectric power plants comprise impoundment (dam), diversion (run-of-river) and pumped storage systems.

In a typical impoundment system, river water is captured and stored by using a dam to create a reservoir at one level, and then released at a controlled rate to fall to a water turbine which is the prime mover used to drive an electricity generator.

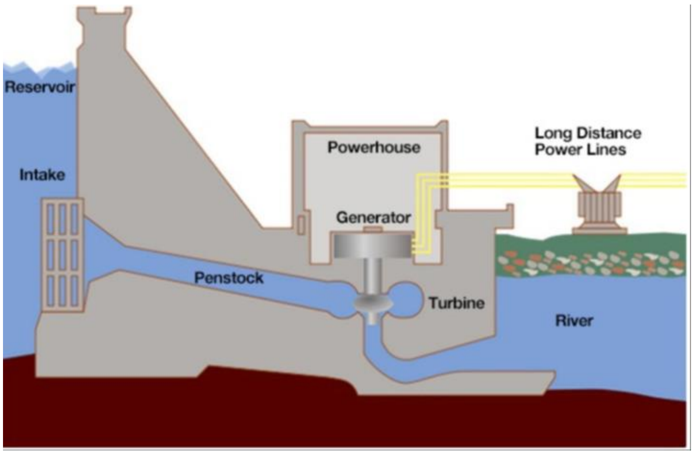


Figure 8: Impoundment Hydro Plant

In a diversion system, river water is diverted and channeled through a canal or penstock to a water turbine which is the prime mover used to drive an electricity generator.

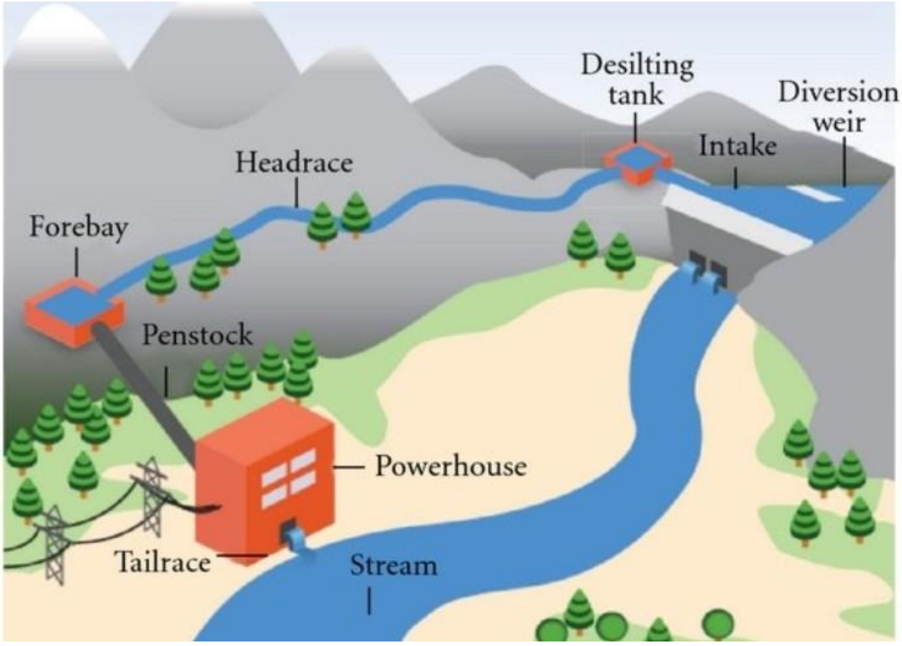


Figure 9: Diversion Hydro Plant

A pumped storage system is like an impoundment system, however once the water has passed through the turbine(s) it is captured in a lower storage reservoir to be pumped back to the higher reservoir at times of lower power demand (typically at night), to be reused for power generation at times of higher power demand (typically during the day).

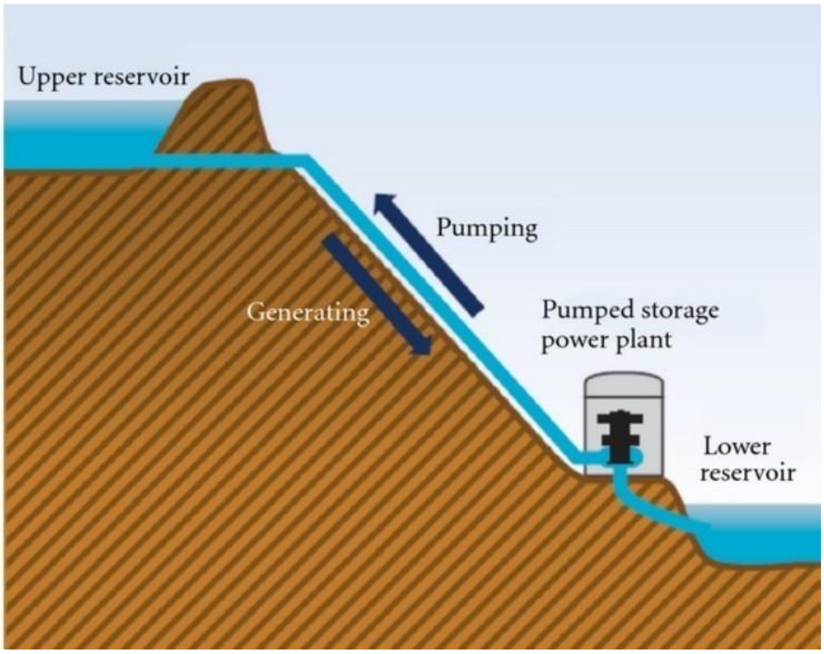


Figure 10: Pumped Storage Hydro Plant

There are two main types of hydro turbines: impulse turbines and reaction turbines. The type of hydro turbine selected for a project is based on the height of standing water, referred to as "head", and the flow, or volume of water, at the site. Other deciding factors include how deep the turbine must be set, efficiency, and cost.

i. Impulse turbines

Impulse turbines generally use the velocity of the water to move the runner and discharge to atmospheric pressure.

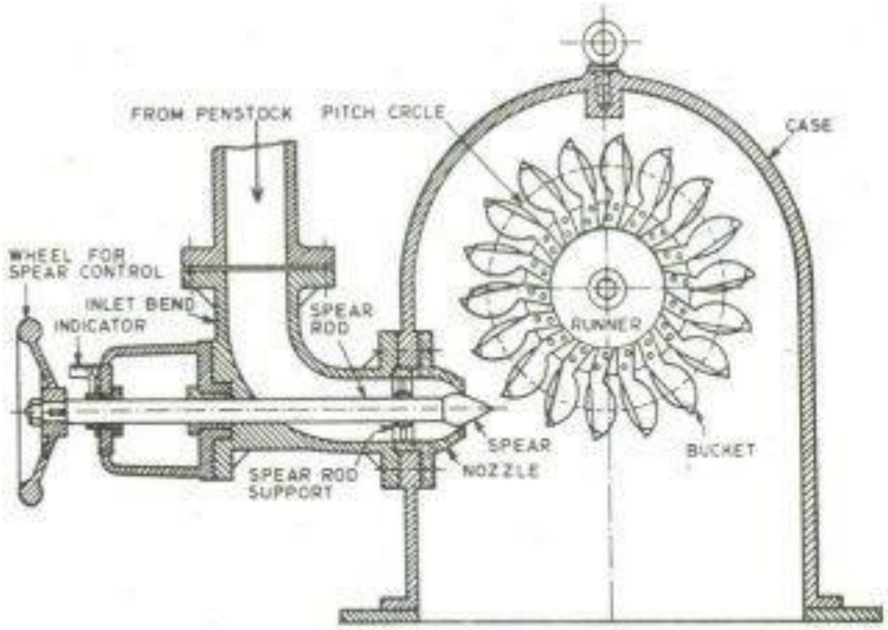


Figure 11: Impulse (Pelton Wheel) Turbine

An impulse turbine is generally suitable for high head, low flow applications. Sub-types of turbines classified as impulse turbines include:

- Pelton wheel turbines
- Cross flow turbines

ii. Reaction turbines

Reaction turbines develop power from the combined action of pressure and moving water. Reaction turbines are generally used for sites with lower head and higher flows and include the following sub-types:

- Propeller turbines
- Bulb turbines
- Straflo turbines
- Tube turbines

- Kaplan turbines
- Francis turbines
- Kinetic turbines

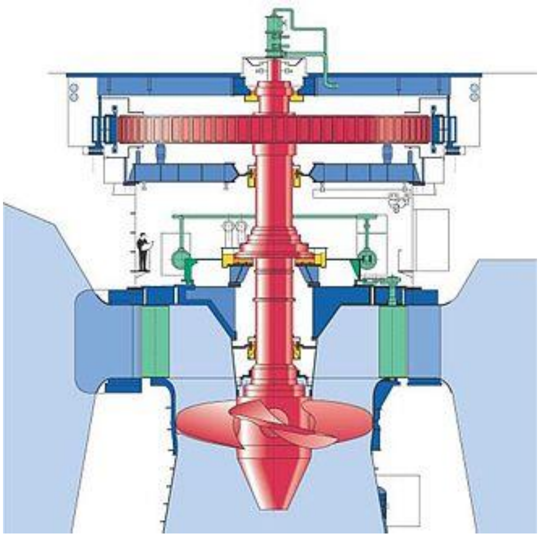


Figure 12: Reaction (Vertical Kaplan) Turbine

2.2.4 Wind Power Plants

Wind power plants, or wind farms, use the wind to drive a wind turbine which is the prime mover used to drive a generator.

Figure 13: Wind Farm

2.2.5 Other Types of Power Plants

Conventional generators use an internal combustion engine as a prime mover to drive a generator. These may use diesel, petroleum or gas as fuel for the internal combustion engine.

Figure 14: Diesel Generator Set

Other types of less commonly encountered power plants include wave power plants, tidal power plants, biomass power plants and hydrogen power plants. Battery storage systems are also becoming more prevalent as part of an overall electricity supply system.

2.3 Electricity Transmission and Sub-Transmission

Electricity transmission and sub-transmission networks comprise the link between power production and power usage.

In general, transmission networks carry electricity at voltages in the Ultra-high voltage (UHV), Extra-high voltage (EHV) and High voltage (HV) ranges and sub-transmission networks carry electricity at Medium voltage (MV) range over long distances from power plants to users. Transmission is divided into 2 categories:

i. Overhead Transmission

This is a system used in electric power transmission and distribution to transmit electrical energy along large distances. It consists of one or more conductors suspended from towers or poles.

ii. Underground Transmission

It is more expensive since the cost of burying cables at transmission voltages is several times greater than overhead power lines, and the life-cycle cost of an underground power cable is two to four times the cost of an overhead power line.

2.3.1 Overhead Transmission Lines

UHV, EHV and HV are used for electric power transmission to reduce the energy lost in the resistance of the wires. However, these voltages cannot easily be used for lighting and motors, and so transmission-level voltages must be reduced to values compatible with end-user equipment. Transformers are used to change the voltage level in alternating current (AC) transmission circuits.

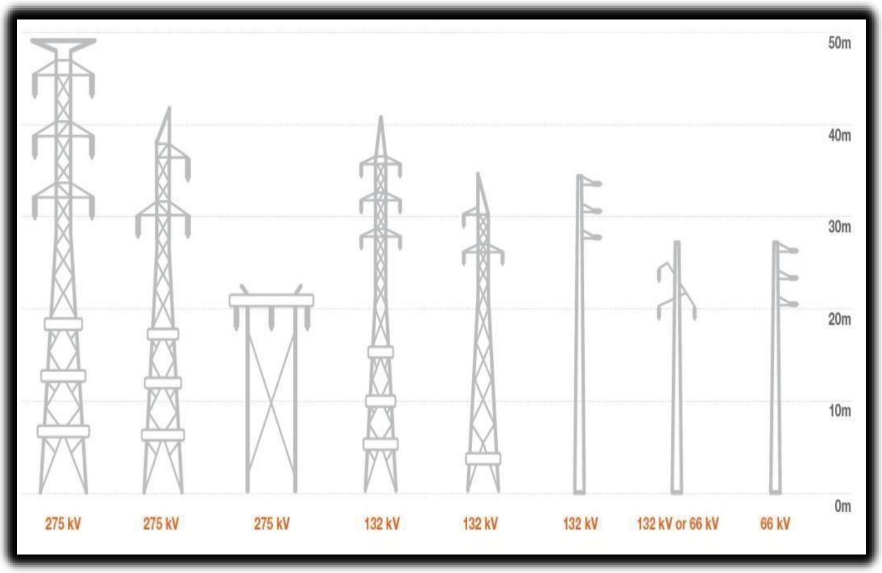


Figure 15: HV Overhead Transmission Line Towers

The elements of a transmission line are:

- Step-up & Step-down transformers.
- Line insulators-mechanically support the line conductors and isolate them from the ground.

The advantages of UHV, EHV and HV transmission are:

- Reduces volume of conductor material.
- Considers the transmission of electric power by a three-phase line.
- Increases transmission efficiency.
- Decreases percentage line drop.

2.3.2 Underground Transmission Lines

Underground transmission lines are one of the means used for the transmission and distribution of electric power in addition to overhead lines.

High Voltage Underground Cables may be:

- Directly buried underground.
- Placed inside an underground track.
- Placed inside underground ducts.

This system is considered safer than overhead lines, where the probability of touching people, animals or small metal objects with live conductors appears to be very rare.

Advantages:

- Better general appearance.
- Less liable to be damaged through storms or lighting.
- Low maintenance cost.
- Less chances of faults and small voltage drops.

Figure 16: HV Underground Cables

2.4 Electricity Distribution Lines

A distribution line is a line or system for distributing power from a transmission system to a consumer that operates at the lower end of the MV range and in the LV range.

Distribution systems are further classified based on voltage:

a. Primary (MV) distribution systems: typically, 11 kV, 6.6 kV or 3.3 kV

b. Secondary (LV) distribution systems: typically, 415 V or 240 V

Distribution lines generally consist of:

- Feeders
- Distributors

2.5 Electrical System Components

a. Transformer

A transformer is a static device. It is not an energy conversion device, but it is device that changes electrical power at one voltage level into electrical power at another voltage level through the action of a magnetic field but with a proportional increase or decrease in the current ratings without a change in frequency. It can either step-up or step-down the voltage.

i. Step-Up Transformer

- A transformer in which the secondary voltage is greater than the primary voltage is called a step-up transformer.
- In this type of transformer, the number of turns in the secondary coil is greater than that in the primary coil, so this creates a higher voltage across the secondary coil to get a higher output voltage than given through the primary coil.

Figure 17: Step-Up Transformer

ii. Step-Down Transformer

- A transformer in which the secondary voltage is lower than the primary voltage is called a step-down transformer.
- In this type of transformer, the number of turns in the secondary coil is less than that in primary coil, so this creates a lower voltage across the secondary coil, to get a lower output voltage than given through primary coil.

Figure 18: Step-Down Transformer

b. Electrical Substations

Substations use transformers to transform the voltage from high to low, or vice versa. They generally have switching, protection and control equipment, as well as transformers. Substations do not (usually) have generators, although a power plant may have a substation nearby.

i. Between the generating station and consumer, electric power may flow through several substations at different voltage levels.

ii. In a large substation, circuit breakers are used to interrupt any short circuits or overload currents that may occur on the network.

iii. Other devices such as capacitors and voltage regulators may also be located at a substation.

iv. Substations may be on the surface in fenced enclosures, underground, or located in special-purpose buildings.

v. Earth bars at a substation can cause a ground potential rise. Currents flowing in the Earth's surface during a fault can cause metal objects to have a significantly different voltage than the ground under a person's feet and this touch potential presents a hazard of electrocution

Figure 19: Electrical Substation

vi. Earth bars at a substation can cause a ground potential rise. Currents flowing in the Earth's surface during a fault can cause metal objects to have a significantly different voltage than the ground under a person's feet and this touch potential presents a hazard of electrocution.

c. Electrical Switchgear

Switchgear broadly comprises electrical disconnect switches, fuses or circuit breakers used to control, protect and isolate electrical equipment.

Figure 20**: Electrical Switchgear**

Switchgear is used both to de-energize equipment to allow work to be done and to clear faults downstream. This type of equipment is important because it is directly linked to the reliability of the electricity supply.

Typically, the switchgear in substations is located on both the HV and LV side of large power transformers. The switchgear on the LV side of the transformers may be located in a building, with MV circuit breakers for distribution circuits, along with metering, control, and protection equipment.

d. Busbar System

A busbar is a system of electrical conductors in a generating or receiving station on which power is concentrated for distribution.

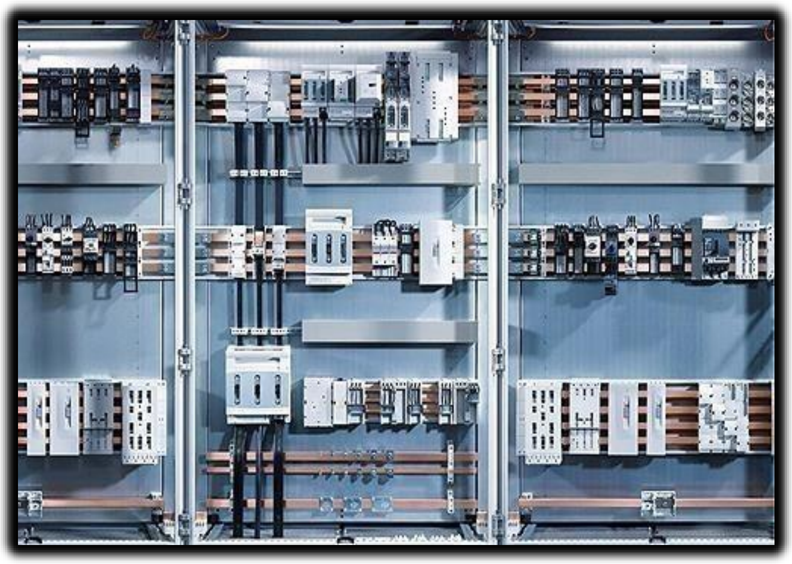


Figure 21: Busbar System

3.0 WATER INFRASTRUCTURE

3.1 Overview

Water infrastructure may comprise desalination and water treatment plants that treat raw water so that it is potable, and transmission and distribution networks that transport the raw and treated water from the reservoirs and treatment plants to consumers.

In some cases, raw water may be drawn directly from a river system and then treated and distributed to consumers.

3.2 Water Storage

Raw water is typically stored in reservoirs or tanks. Reservoirs are typically created by damming a river. Such dams may range from simple earthen dams to large-scale mass concrete structures.

Figure 22: Earthen Dam

Figure 23: Mass Concrete Dam

3.3 Desalination

Desalination is a process to remove mineral components from saline water and produce water which is suitable for human consumption or irrigation purposes.

Principal assets include power generation & water production equipment (including pre-treatment, membrane-based processes (e.g. reverse osmosis) and thermal-based (e.g. multistage flash distillation) or distillation, post treatment and in some instances also includes transmission (including pipelines, pumping stations & storage facilities).

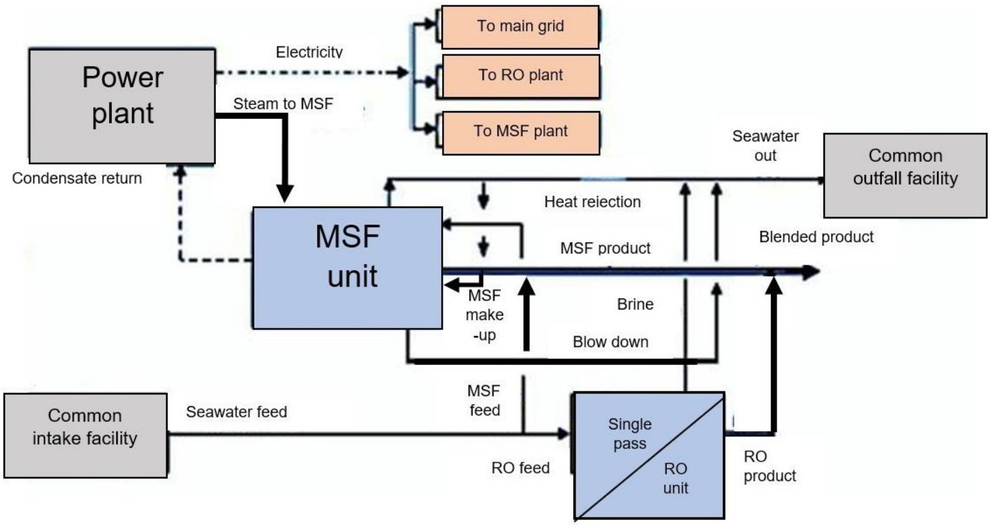


Figure 24: Desalination Plant

3.4 Water Treatment

Water treatment plants typically comprise the following processes:

- **Coagulation** – Chemicals, usually liquid aluminum sulphate (alum), are added to help bacteria and small particles stick together, forming larger particles.
- **Flocculation** (sedimentation/clarification) and floatation - Particles are made to sink or float to separate them from the water, allowing them to be easily removed. Depending on the treatment plant, this stage uses:
  - mechanical settling basins, called clarifiers or
  - diffusers, which create fine bubbles that stick to particles to make them float
- **Filtration** - Filters or membranes remove most of the remaining particles as water passes through them. Types of filters include:
  - gravity media filters with layers of sand
  - membrane filters with billions of microscopic pores
- **Disinfection** - Chlorine, chloramine (chlorine and ammonia) or ultraviolet light destroy any disease-causing bacteria.
- **Fluoridation and pH Correction** – Fluoride is typically added, and the pH adjusted by the addition of chemicals before the treated water is distributed to consumers.

3.5 Water Transmission and Distribution

Water is transported between reservoirs and water treatment plants and from the water treatment plants to consumers via a network of pipelines.

Typically, the pipelines transporting raw water from the reservoir to the treatment plant are classified as transmission lines and those delivering treated water from the treatment plant to consumer supply pipes as distribution mains. Supply pipes connect from the distribution mains to individual consumers' premises.

3.6 Methods of Water Distribution

There are three methods of water distribution system:

a. Gravity Distribution

- Suitable when the source of supply is at sufficient height.
- Most reliable and economical distribution system.
- The remaining water head is consumed in the friction losses or other losses.

b. Pumping System

- Water is directly pumped into the distribution main without storing.
- Called pumping without storage system.
- High lift pumps are required.
- If power supply fails, complete stoppage of water supply.
- This method is not generally used.

c. Combined Gravity and Pumping System

- Most common system.
- Treated water is pumped and stored in an elevated distribution reservoir.
- Then supplied to consumer by action of gravity.
- The excess water during low demand periods is stored in the reservoir and supplied during high demand periods.
- Economical, efficient and reliable system.

3.7 Water Pipes

The difference of the pipe sizes is based on the usage:

- Large diameter main pipes, which supply entire towns.
- Smaller branch lines that supply a street or group of buildings.
- Small diameter pipes located within individual buildings.

Water pipes can be divided into the following broad categories:

a. Metallic Pipes

Metallic pipes include steel, galvanized iron (GI), cast iron and copper pipes.

Figure 25: Metallic pipes

b. Cement Pipes

Cement pipes include concrete cement, steel reinforced concrete and fiber cement pipes.

Figure 26: Cement pipes

c. Plastic Pipes

Plastic pipes include polyvinyl chloride (PVC), un-plasticized polyvinyl chloride (UPVC), chlorinated polyvinyl chloride (CPVC), polyethylene (PE) and polypropylene random (PP-R) pipes.

Figure 27: Plastic Pipes

4.0 WASTEWATER INFRASTRUCTURE

4.1 Overview

Wastewater infrastructure refers to the system of piping used to collect and transport wastewater, wastewater treatment plants and treated wastewater discharge systems.

4.2 Wastewater Collection

Wastewater is typically collected via clay or plastic pipe, to the collecting sewers. Collecting sewers are sized to carry the maximum anticipated peak flows without surcharging (filling up) and are ordinarily made of plastic, clay, cement, concrete, or cast iron pipe. They discharge into intercepting sewers, or interceptors, that collect from large areas and discharge finally into the wastewater treatment plant. Many older sewers were constructed of brick.

4.3 Wastewater Treatment

Wastewater or sewage treatment plants can involve four stages, called pre-treatment, primary, secondary and tertiary treatment.

- Pre-treatment typically consists of screens, chambers, equalization basins and skimmers to remove large debris, grit, oils and fats from the input stream.
- Primary treatment consists of large sedimentation tanks, commonly called pre-settling basins, primary sedimentation tanks or primary clarifiers.
- Secondary treatment systems are classified as fixed-film or suspended-growth systems.
    - Fixed-film or attached growth systems include trickling filters, constructed wetlands, bio-towers, and rotating biological contactors, where the biomass grows on media and the sewage passes over its surface.
    - Suspended-growth systems include activated sludge, where the biomass is mixed with the sewage and can be operated in a smaller space than trickling filters that treat the same amount of water.
    - Some secondary treatment methods include a secondary clarifier to settle out and separate biological floc or filter material grown in the secondary treatment bioreactor.
- Tertiary treatment is sometimes defined as anything more than primary and secondary treatment. Treated water is sometimes disinfected chemically or physically (for example, by lagoons

and microfiltration) prior to discharge. This process is known as 'effluent polishing'.

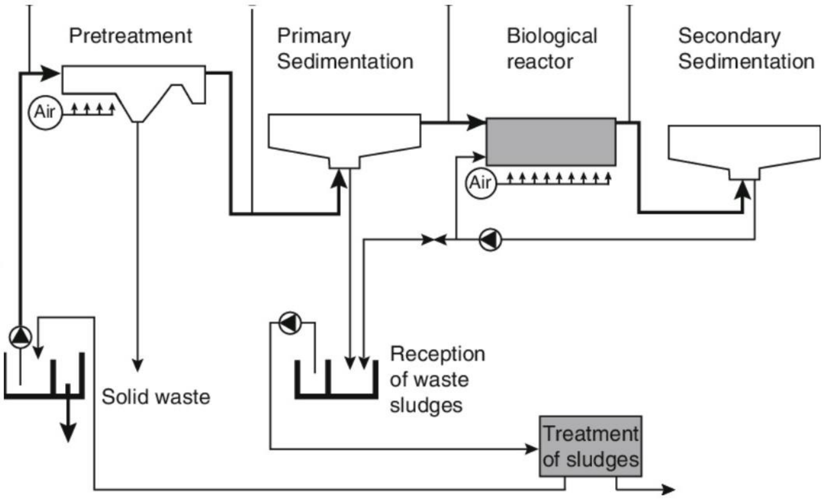


Figure 28: Waste-water Treatment Plant Diagram

5.0 GAS INFRASTRUCTURE

5.1 Overview

Natural gas infrastructure refers to the pipelines used to gather, transport and distribute natural gas from producing wells to end-users. It also includes the facilities used in transportation, like compression and metering stations.

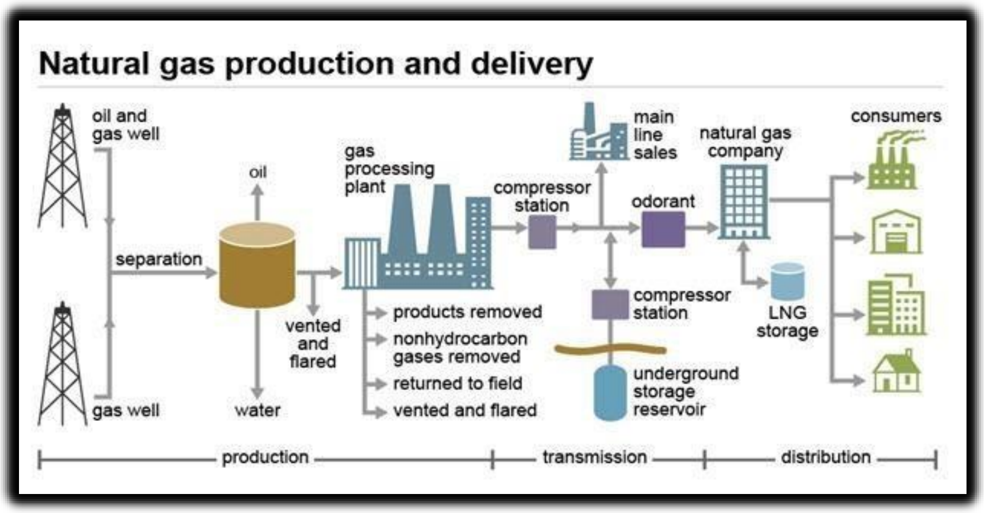


Figure 29: Natural Gas Production, Transmission and Distribution

Key infrastructure components comprise:

- Transmission pipelines: Large diameter pipelines are used to transport gas from producing areas directly to large consumers (like power plants) and to local distribution companies.

- Distribution pipelines: Smaller diameter pipelines deliver gas to industrial and domestic consumers within a defined area.

For the purpose of this module, only gas transmission and distribution systems are covered, as gas processing and storage facilities form part of specialized production facilities rather than utilities and infrastructure.

5.2 Gas Transmission

5.2.1 Pipelines

Gas transmission systems are constructed of "line pipe" which is a strong carbon steel material constructed to American Petroleum Institute (API) standards.

It is covered with a specialized coating to prevent corrosion when placed underground. Gas transmission pipelines may be anywhere from 150 mm (6 inches) to 1,220 mm (48 inches) in diameter and operate at pressures between 1,400 kPA (200 psi) to 10,500 kPA (1,500 psi).

5.2.2 Compressor and Booster Stations

Additional compression may be provided by one or more compressor or booster stations constructed at intervals along the length of the pipeline. These compressor stations maintain the gas pressure at intervals along the pipeline and typically comprise one or more centrifugal gas compressors each driven by a gas turbine.

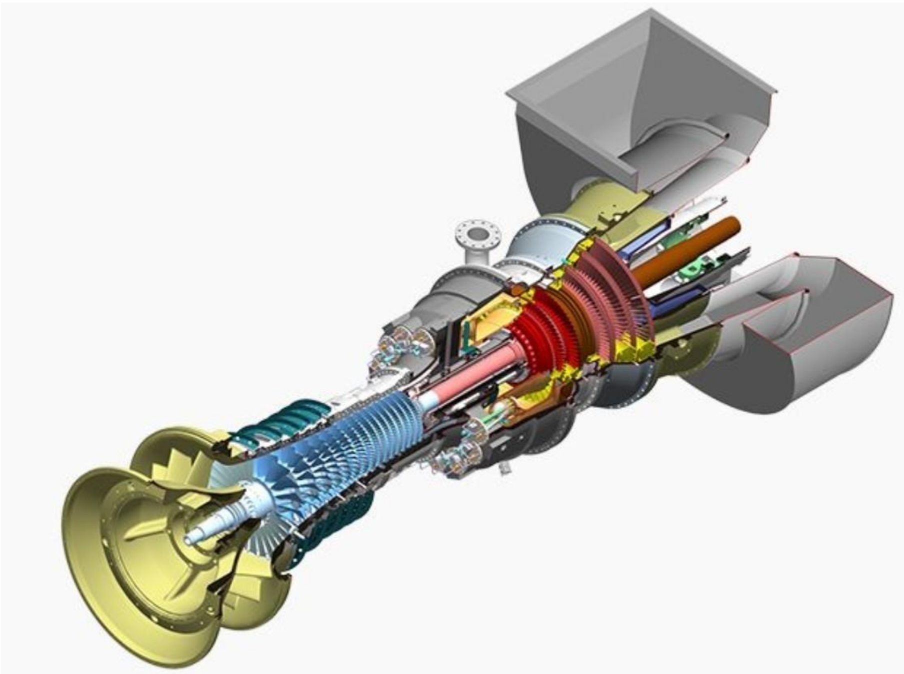


Figure 30: Gas turbine Driven Centrifugal Gas Compressor

5.2.3 Metering Stations

Metering stations measure the flow of gas along the pipeline. They are placed periodically along the pipelines and allow monitoring and management of gas in the pipelines.

5.2.4 Valves

- Gateways: allow free flow or restriction of gas flow.
- Interstate lines: include valves along entire length.
- Gas flow may be restricted if a section of pipe requires.
- Maintenance and replacement

5.2.5 Control Stations and SCADA Systems

- Monitor and control gas in the pipeline.
- Collect, assimilate, and manage data received from compressor and metering stations.
- Data received is provided by Supervisory Control and Data Acquisition (SCADA) systems.

Figure 31: Gas Pipeline, Metering and Regulating Stations

5.3 Gas Distribution

There are three types of gas distribution systems, namely:

a. One Level System

The system provides users with gas under single pressure. It is for low-density population areas.

b. Two Level System

The system provides users with gas under combined pressure that is medium and low or high. It is for medium-sized cities.

c. Three Level System

The system provides users with gas under three pressures that is high, medium and low. It is to fulfil the need in big cities.

PLANT SERVICES

1.0 PLANT SERVICES

1.1 Overview

This section covers services commonly found within a manufacturing facility. Many are delivered to the facility via the utilities and infrastructure described in the preceding sections. Others are fully self-contained within the site.

1.2 Electrical Services

Typically, electrical services within a manufacturing facility commence at the point of supply from the electricity utility provider. Whilst physical inspections of the facility provide one way of identifying the major electrical plant service assets, single line diagrams, provide a useful source of information, especially where access to on-site substations is limited.

In a major manufacturing facility, the plant electrical service components may include:

- Incomer or feeder load-break switch(es)
- Ring main unit(s) (RMUs)
- Step down transformer(s)
- Motor control center(s) (MCCs)
- Distribution board(s)
- Stand-by generators
- Electrical cabling and wiring

A single line diagram (SLD) provided by the client, can often provide a useful way to identify some of the major elements of an electrical system within a manufacturing facility. An example is shown in Figure 1: Single Line Diagram**.**

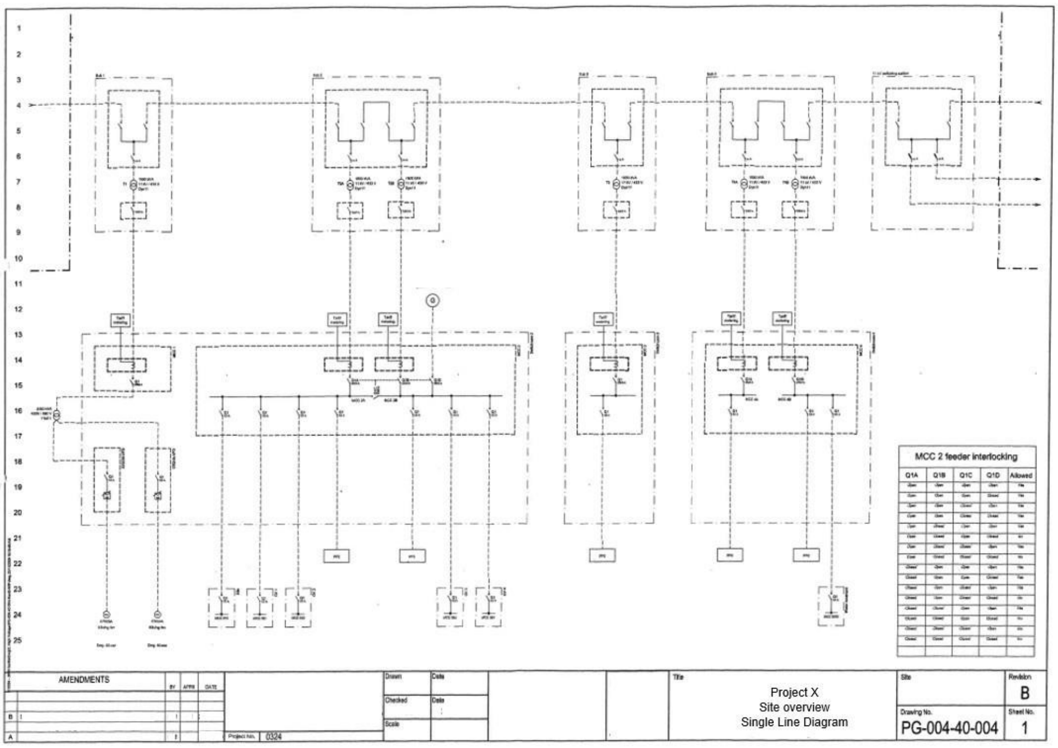


Figure 1: Single Line Diagram

Symbols commonly used to identify some of the major components are:

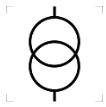
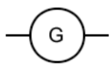
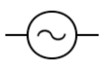
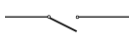
Transformer	
Generator	
Alternator (AC Generator)	
Switch	

Figure 2: Single Line Diagram Common Symbols

1.2.1 Incomer or Feeder Load-Break Switch

Incomer or feeder load-break switches are placed on the inlet side of the power supply to the site. They provide a mechanism to switch the power supply to the site on and off. They match the supply voltage to the site and are most commonly within the medium voltage (MV) range. Common types include air/vacuum and gas insulated switchgear.

1.2.2 Ring Main Unit

A ring main unit (RMU) is a set of switchgear used at the load connection points of a ring-type distribution network within a plant. They are usually within the MV range and may be air, oil or gas insulated and may be combined with a transformer.

The basic technical information to be recorded for an RMU includes:

- Manufacturer
- Model
- Type
- Voltage rating in kilo Volts (kV)
- Short time current rating in kilo Amps (kA)

1.2.3 Step-Down Transformer

Step-down transformers are as described within the electricity infrastructure section but typically have a lower rating. In the context of a manufacturing facility they step the voltage down from the supply voltage (typically in the MV range) to that required within the facility (typically 415 V or 240 V).

The basic technical information to be recorded for a step-down (or step-up) transformer includes:

- Manufacturer
- Type
- Rating in Kilovolt-Ampere(kVA) or Megavolt-Ampere (MVA)
- Low and high voltages in Volts (V), kilo Volts (kV) or Mega Volts (MV)

1.2.4 Motor Control Center (MCC)

MCCs consist of circuit breakers, starters and controls which generally have higher capacity to feed larger loads. MCC panels consist of starters are used to start or control the motors, water pumps, compressors, fans, conveyor belts etc.

The basic technical information to be recorded for an MCC includes:

- Manufacturer
- Number of sections
- Voltage in Volts (V) or kilo Volts (kV)
- Load measured in Amperage (A) or kilo Amps (kA)

An MCC is an assembly of one or more enclosed sections having a common bus bar and principally containing motor control units.

MCCs are typically a factory assembly of several motor starters. MCCs can include variable frequency drives, programmable controllers, and metering and may also be the electrical service entrance for the building.

MCCs can be identified by voltage, the number of sections and/or the load measured in amps.

Figure 3: Motor Control Center (MCC)

1.2.5 Distribution Board

A distribution board is a system by which the electrical energy is transmitted via branches to reach the exact user. Distribution boards consist of main incomer of 250A/400A/630A up to 2500A or 4000A with metering and indicators and various numbers of outgoing feeders of different rating.

Distribution boards may be categorized into low voltage (LV) panels, Main Distribution Board, Sub-Main Distribution Board and the Final Distribution Board.

The basic technical information to be recorded for a distribution board includes:

- Type (as described in the preceding paragraph)
- Voltage

Figure 4: Main Distribution Board (MDB)

Figure 5: Sub-Main Distribution Board (SMDB)

Figure 6: Final Distribution Board (FDB)

Figure 7: Feeder Pillar

For industrial applications, a transformer and switchgear line-up may be combined in a single housing, called a unitized substation. Other switchgear typically found includes programmable logic controllers (PLCs), which are industrial computer control systems that continuously monitor and control equipment.

Figure 8: Electrical Switchgear

1.2.6 Stand-By Generators

Many manufacturing facilities have stand-by generator(s) to allow full or partial operation during a power outage. Stand-by generators are typically internal combustion engine (diesel/petrol) driven generators (alternators) and include fuel supply and controls. They are often supplied as packaged units.

The basic technical information to be captured for a stand-by generator includes:

- Manufacturer
- Type of driver (diesel, petrol, etc. engine)
- Rating measured in Kilovolt-Ampere(kVA)
- Working hours

Figure 9: Stand-By Generator Set

1.2.7 Cabling and Wiring

A network of cabling and wiring connects all the above electrical equipment and the operating machinery within the facility. This may be quantified by voltage and length for major ring mains or for local connections to individual pieces of equipment, included within the replacement cost of each machine using factorial cost estimating techniques.

1.3 Water and Wastewater Services

Typically, water and wastewater services within a manufacturing facility may include:

- Tanks
- Boilers (for the provision of hot water or steam)
- Pumps
- Water and wastewater treatment plants
- Pipework and valves

1.3.1 Tanks

Tanks may be constructed of mild/carbon steel, galvanized steel, corrugated iron, reinforced concrete or plastic. They may be vertical cylindrical, horizontal cylindrical or cuboid and may be enclosed or open. Tanks are typically measured by capacity and physical dimensions.

Figure 10: Corrugated Iron Water Tank

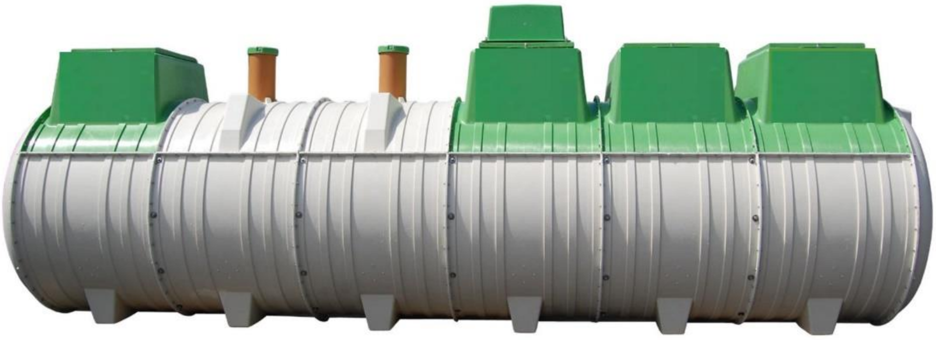


Figure 11: Plastic Water Tank

Figure 12: Carbon Steel Water Tank

The basic technical information to be recorded for tanks includes:

- Type & orientation (e.g. vertical cylindrical, horizontal cylindrical, cuboid, enclosed, open, etc.)
- Materials of construction
- Dimensions
- Capacity
- Foundations (as appropriate)
- Duty (e.g. water storage, fuel storage, condensate return, etc. – assists with identification when there are multiple tanks)

1.3.2 Boilers

In a process plant, the most common types of boiler can be broadly categorized as:

- Fire-tube boilers
- Water-tube boilers

In fire-tube boilers, combustion gases pass through the inside of the tubes with water surrounding the outside of the tubes. The advantages of a fire-tube boiler are its simple construction and less rigid water treatment requirements.

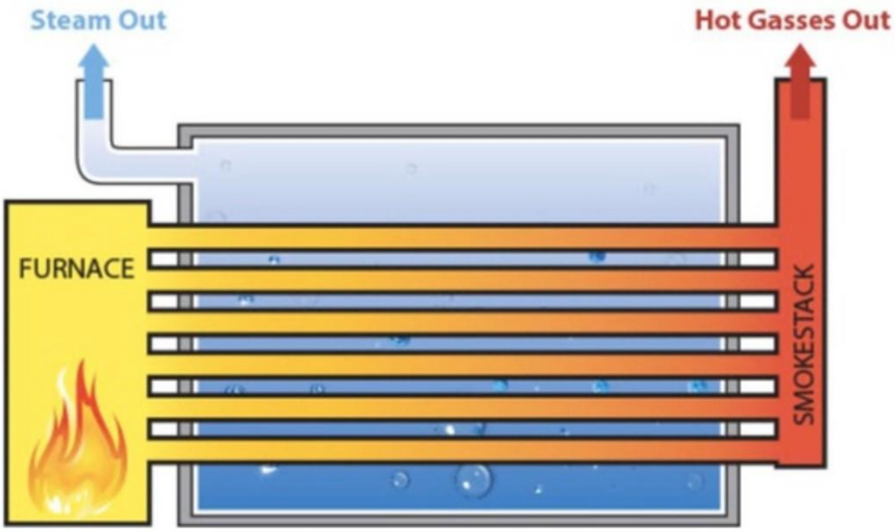


Figure 13: Fire-Tube Boiler

In water-tube boilers, the water is inside the tubes and combustion gases pass around the outside of the tubes. The advantages of a water-tube boiler are a lower unit weight per unit of steam generated, less time required to raise steam pressure, a greater flexibility for responding to load changes, and a greater ability to operate at high rates of steam generation.

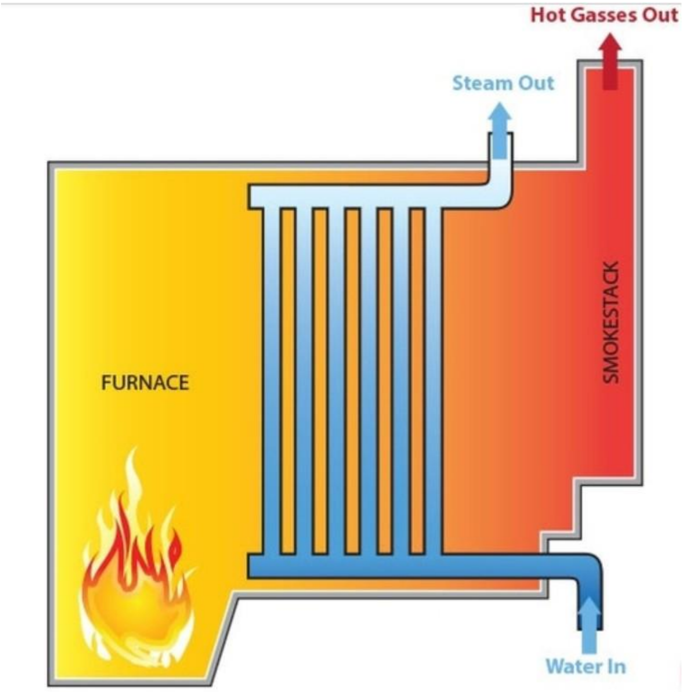


Figure 14: Water-Tube Boiler

Both types of boiler may be fired by oil, gas or solid fuels. They may be packaged or fabricated in situ, depending upon the size.

Typically, the capacity of a boiler is measured in either kW/MW (or hp) or kg/hr (or lbs/hr) of steam generated.

The basic technical information to be recorded for a boiler includes:

- Manufacturer
- Type (e.g. water-tube, fire-tube, packaged, etc.)
- Type of firing (e.g. oil, gas, solid fuel)
- Capacity measured in either kW/MW (or hp) or kg/hr (or lbs/hr) of steam generated

1.3.3 Pumps

There are three basic types of pump: positive displacement pump, centrifugal pump and axial flow pump. Positive displacement pumps include gear, rotary lobe and screw pumps (amongst others) and are commonly used to transfer more viscous liquids.

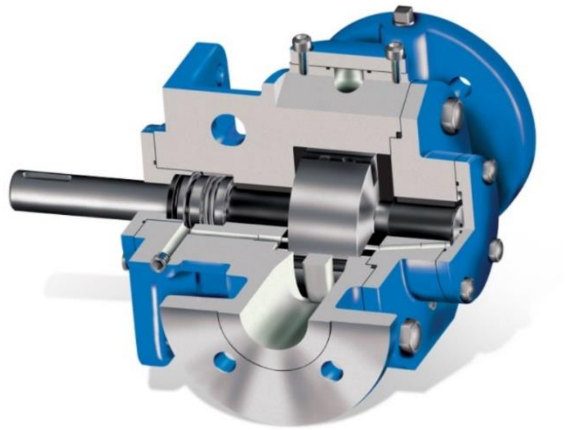


Figure 15: Positive Displacement Pump

The basic technical information to be recorded for a positive displacement pump includes:

- Manufacturer
- Model (which typically includes the size)
- Type (gear, rotary lobe, screw, etc.)
- Motor rating (kW)
- Duty (oil transfer, syrup delivery, etc. – assists with identification when there are multiple pumps)

Centrifugal pumps include split case, vertical centrifugal and multi-stage pumps amongst others. In centrifugal pumps the direction of flow of the fluid changes by ninety degrees as it flows over impeller. Centrifugal pumps are the type of pump most commonly used to transfer water and wastewater.

The basic technical information to be recorded for a centrifugal pump includes:

- Manufacturer
- Model (which often includes the size)
- Size (inlet dia. x outlet dia. x impellor dia.) – sometimes cast into the casing
- Type (split case, vertical, multi-stage, etc.)
- Motor rating (kW)
- Duty

Figure 16: Centrifugal Pump

Axial-flow pumps are a common type of pump that consist of a propeller (an axial impeller) in a pipe. The propeller can be driven directly by a sealed motor in the pipe or by an electric motor or petrol/diesel engine mounted to the pipe from the outside or by a right-angle drive shaft that pierces the pipe.

Figure 17: Axial Flow Pump

The basic technical information to be recorded for an axial flow pump includes:

- Manufacturer
- Model (which may include the size)
- Size (propeller dia.)
- Motor rating (kW)
- Duty

1.3.4 Water and Wastewater Treatment Plants

Water and wastewater treatment plants within a manufacturing facility, typically comprise one or more components described within the preceding infrastructure section, but on a smaller scale.

1.3.5 Pipework and Valves

Pipework may be identified by diameter, length and materials of construction for major runs or captured with individual items of equipment using factorial cost estimating techniques.

1.4 Gas Services

Typically, gas services within an industrial plant comprise a gas meter (usually the property of the utility company) and gas pipework and valves. The pipework may be identified by diameter, length and materials of construction for major pipe runs, or captured with individual items of equipment using factorial cost estimating techniques.

1.5 Compressed Air Services

Compressed air service within an industrial plant may comprise air compressors, compressed air dryers, air receivers and compressed air pipework and valves.

1.5.1 Air Compressors

The three most common types of air compressor are reciprocating, rotary screw and centrifugal.

Reciprocating air compressors are considered positive displacement machines, which means they increase the pressure of the air by reducing its volume.

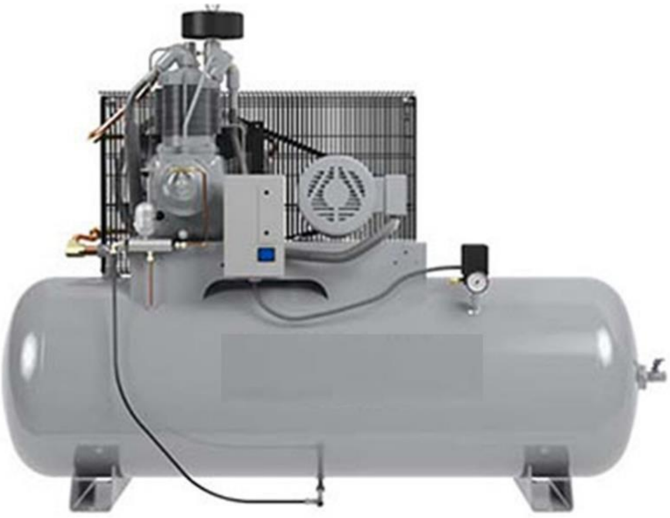


Figure 18: Receiver Mounted Twin-Cylinder Reciprocating Air Compressor

Rotary screw compressors are considered positive displacement compressors. The most common rotary air compressor is the single stage helical or spiral lobe oil flooded screw air compressor.

This type of air compressor consists of two rotors that are in a casing, and the rotors compress the air internally.

Figure 19: Rotary Air Compressor

Centrifugal air compressors are dynamic compressors based on a transfer of energy from a rotating impeller to the air. This type of compressor is designed for higher capacity because flow through the compressor is continuous.

Figure 20: Centrifugal Air Compressor

The basic technical information to be recorded for air compressors includes:

- Manufacturer
- Model (this usually defines capacity and motor rating)

- Type (reciprocating, rotary screw, rotary vane, centrifugal, receiver mounted, etc.)
- Capacity (if available measured in cfm, m3/m, L/s)
- Motor rating (if available measured in kW)

1.5.2 Air Dryers

There are various types of compressed air dryers. These generally fall into two different categories: primary, which includes coalescing, refrigerated, and deliquescent; and secondary, which includes desiccant, absorption, and membrane. The most common type is refrigerated.

Figure 21: Refrigerated Air Dryer

The basic technical information to be recorded for air dyers includes:

- Manufacturer
- Model (this usually defines capacity and motor rating)
- Type of air dryer

1.5.3 Air Receivers

Air receivers are steel pressure vessels that store compressed air for distribution around the facility. They may be vertical cylindrical or horizontal cylindrical with dished ends. Some smaller air compressors are receiver mounted.

The basic technical information to be recorded for air receivers includes:

- Manufacturer (if available)
- Materials of construction

- Orientation (vertical or horizontal cylindrical)
- Dimensions (dia. x height/length) and/or capacity (m3, cu.ft., litres, etc.)

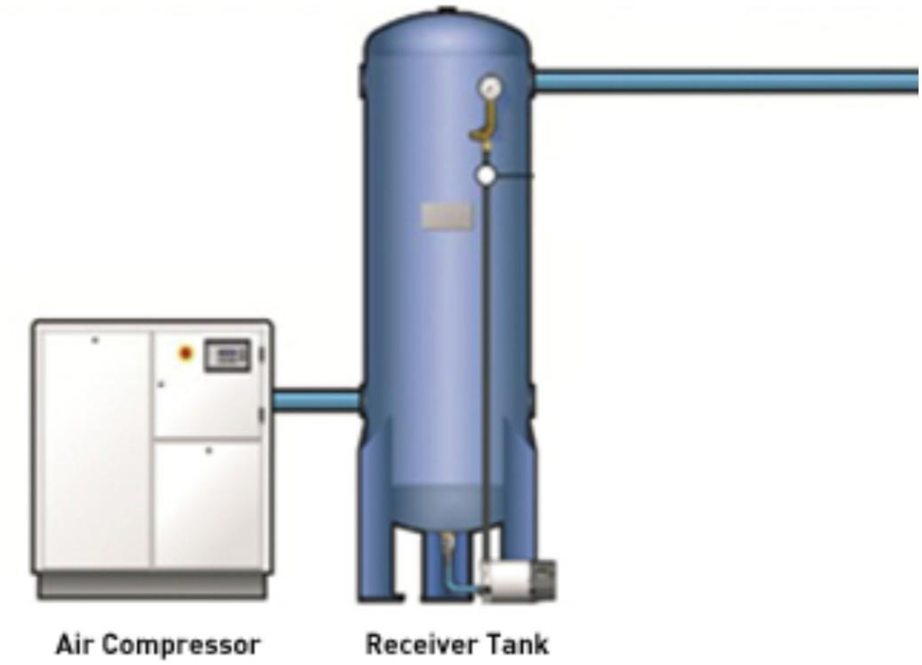


Figure 22: Air Receiver

1.5.4 Pipework and Valves

Pipework may be identified by diameter, length and materials of construction for major runs or captured with individual items of equipment using factorial cost estimating techniques.

1.6 Air Conditioning Systems

Air conditioning is the process of altering the properties of air (primarily temperature and humidity) to more favorable conditions.

Air conditioning includes the cooling and heating of air, cleaning and controlling its moisture level as well as conditioning it to provide maximum indoor comfort.

The control of these conditions may be desirable to maintain the health and comfort of the occupants, or to meet the requirements of industrial processes irrespective of the external climatic conditions.

An air conditioner transfers heat from the inside of a building, where it is not wanted, to the outside. Refrigerant in the system absorbs the excess heat and is then pumped through a closed system of piping to an outside coil. A fan blows outside air over the hot coil, transferring heat from the refrigerant to the outdoor air. Because the heat is removed from the indoor air, the indoor area is cooled.

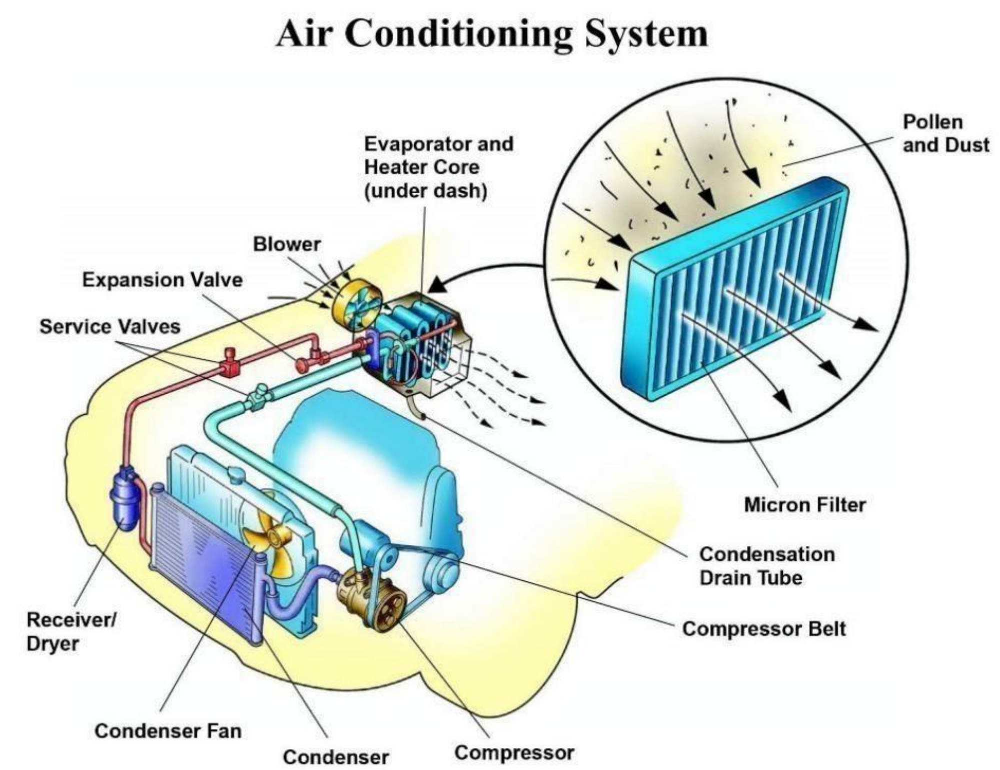


Figure 23: Air Conditioning System

Air conditioning systems can be categorized according to the means by which the controllable cooling is accomplished in the conditioned space.

The different types of air conditioning systems are discussed below.

1.6.1 Window Air Conditioning System

Window air conditioners are one of the most commonly used and cheapest types of air conditioners. To install one of these units, you need some space to make a slot in the wall, and there should also be some open space behind the wall.

Window air conditioner units are reliable and simple to install and a solution to keep a room cool while avoiding the costly construction of a central air conditioning system. Better yet, when the summer heat dies down, these units can be easily removed for storage, and you can use the window for other purposes.

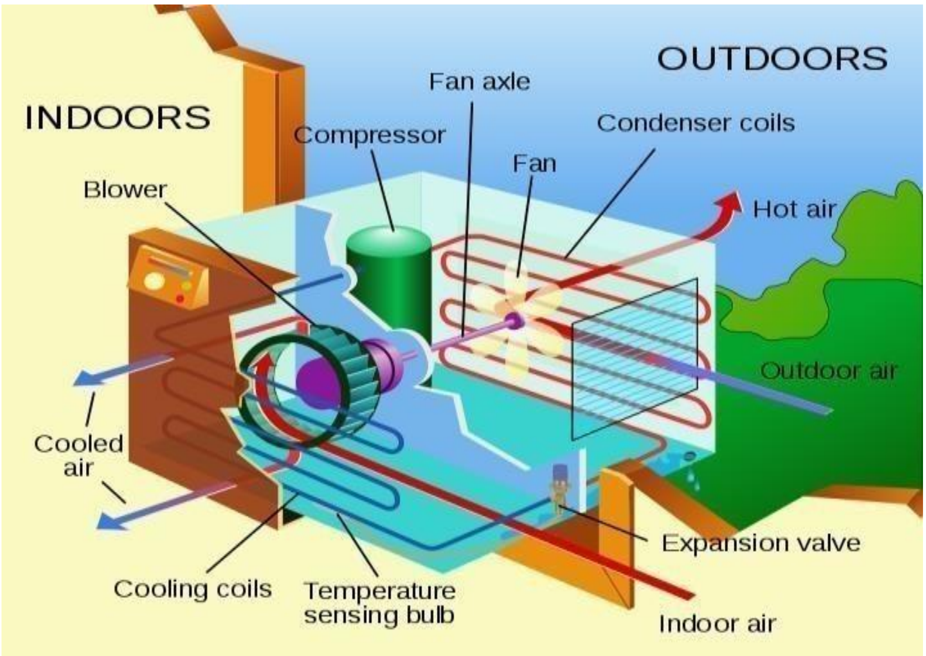


Figure 24: Components of Window Air Conditioning System

Figure 25: Window Air Conditioning Unit

1.6.2 Split Air Conditioning System

Window and split air conditioners are used for single rooms or small office spaces. The split air conditioner comprises of two parts:

i. **The Outdoor Unit**

The outdoor unit, fitted outside the room, houses components like the compressor, condenser and expansion valve.

ii. **The Indoor Unit**

The indoor unit comprises the evaporator or cooling coil and the cooling fan. This unit does not need to make any slot in the wall of the room.

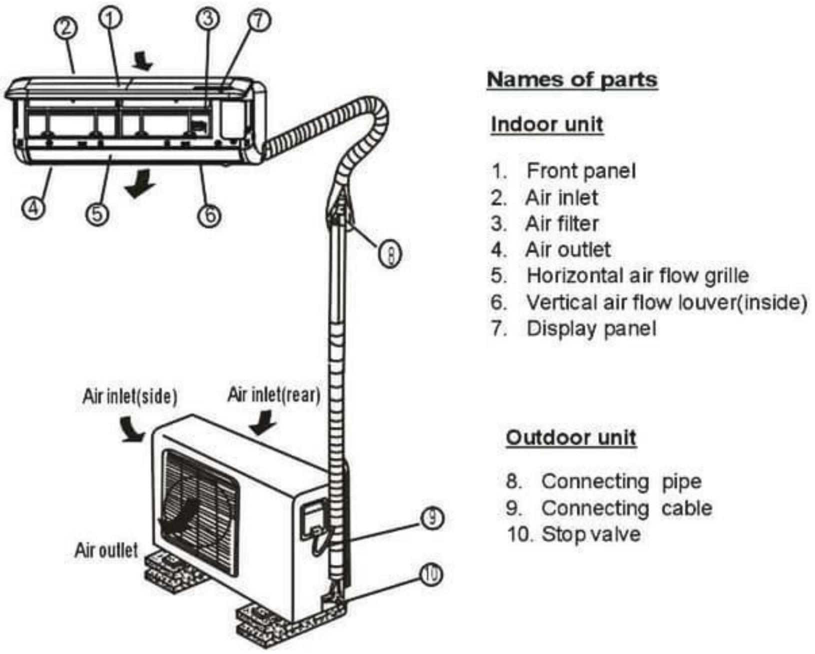


Figure 26: Components of Split Air Conditioning System

Figure 27: Split Air Conditioning Unit

1.6.3 Centralized Air Conditioning System

Centralized air conditioning systems are used when large buildings, hotels, theatres, airports, shopping malls etc. are to be air conditioned completely.

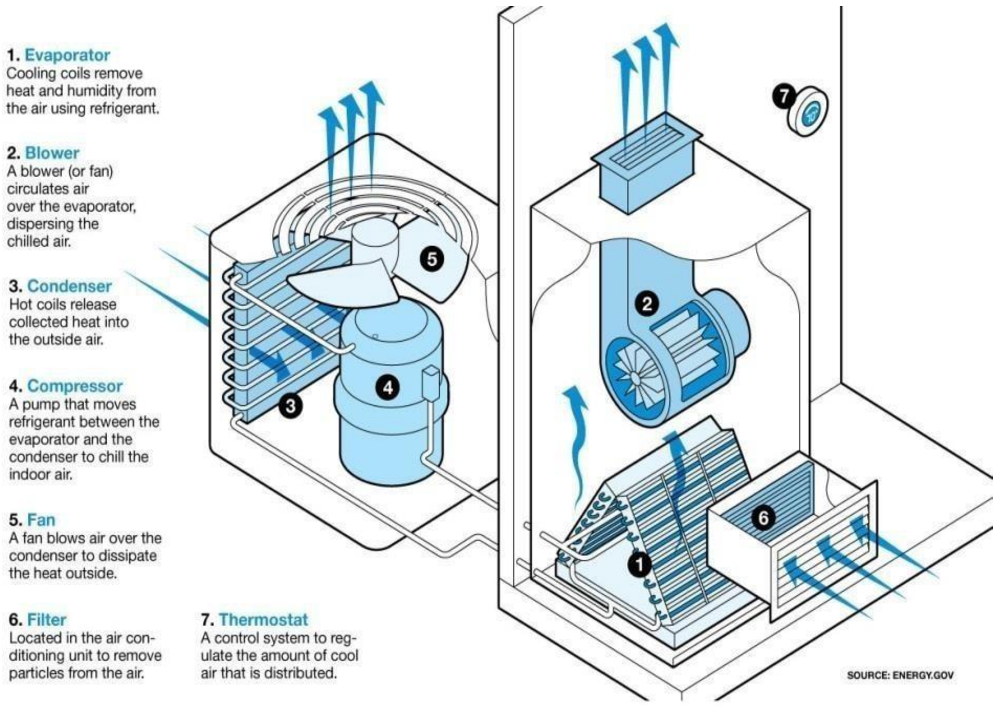


Figure 28: Components of Centralized Air Conditioning Unit

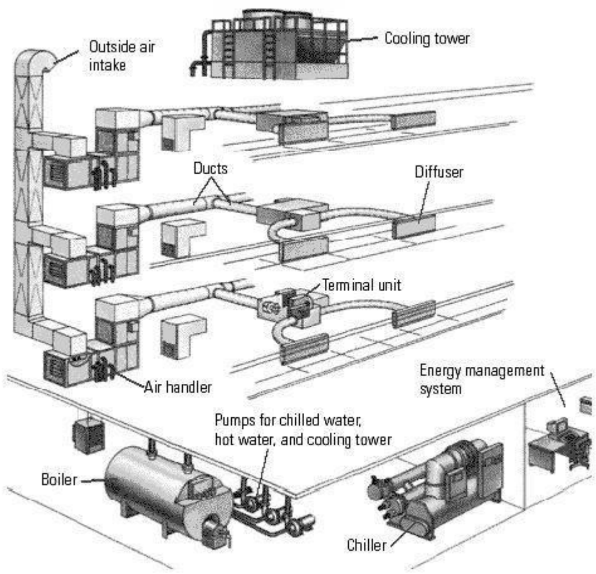


Figure 29: Centralized Air Conditioning System

Figure 30: Centralized Air Conditioning Equipment

1.6.4 Packaged Air Conditioning System

Window and split air conditioners are usually used for small air conditioning capacities up to 5 tons. Central air conditioning systems are used for when the cooling loads extend beyond 20 tons. Packaged air conditioners are used for cooling capacities in between these two extremes. Packaged air conditioners are available in the fixed rated capacities of 3, 5, 7, 10 and 15 tons.

These units are used commonly in places like restaurants, telephone exchanges, homes, small halls, etc.

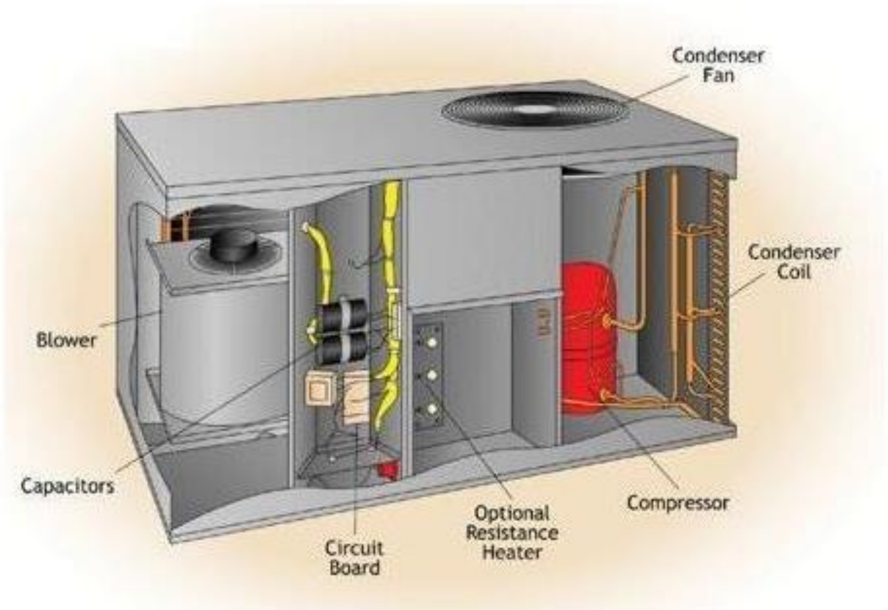


Figure 31: Components of Packaged Air Conditioning System

Figure 32: Packaged Air Conditioning Unit

1.6.5 District Cooling System

District Cooling Systems (DCS) distribute chilled water or other media, usually provided from a dedicated cooling plant, to multiple buildings for air conditioning or other uses.

Chilled water is delivered via an underground insulated pipeline to office, industrial and residential buildings to cool the indoor air of the buildings within a district. The objective is to centralize production of chilled water by using district cooling plant. The generated chilled water will then be channeled to various building blocks through pre-insulated seamless underground pipes.

DCS components include:

- Central Chiller Plant – generates chilled water for cooling purposes.
- Distribution Network – distribute chilled water to building.
- User Station – interface own building air-conditioning circuit.

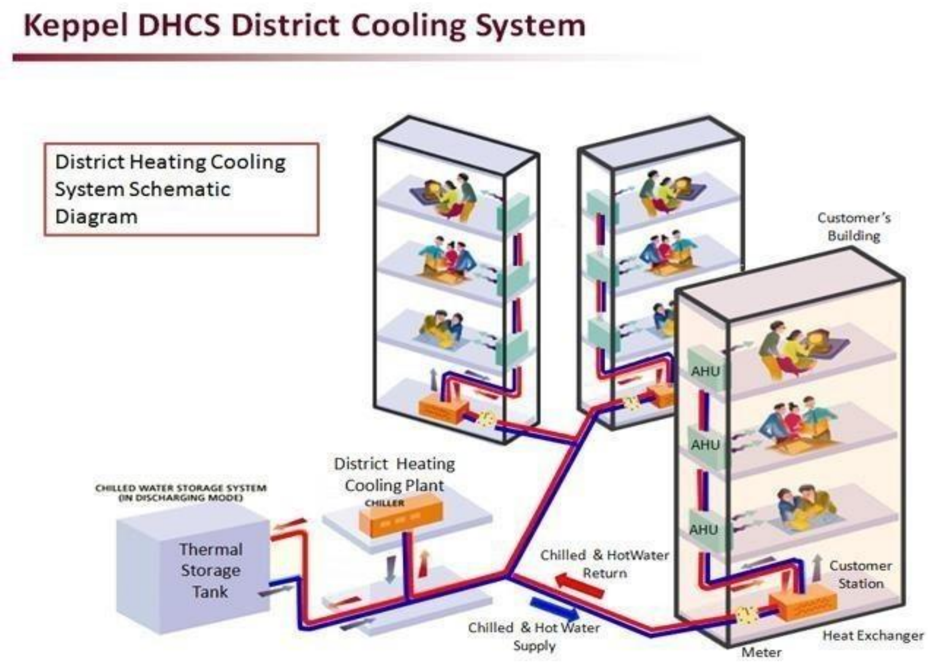


Figure 33: Diagram of District Cooling System

Figure 34: District Cooling System (DCS)

1.6.6 Chilled Beam System (CBS)

Chilled beam systems are a type of convection HVAC (Heating, Ventilation and Air Conditioning) system designed to heat or cool high-rise buildings such as commercial buildings. They primarily provide cooling through convection by using water to remove heat from a room.

Pipes of water passed through the beam suspended a short distance from the ceiling of a room. As the beam chills the air around it, the air becomes denser and falls to the floor. It is replaced by warmer air moving up from below, causing a constant flow of convection thus cooling the room.

There are two types of CBS:

i. Active Chilled Beam System (ACBS)

ACBSs consist of a fin and tube heat exchanger contained in a housing that is suspended from, or recessed in, the ceiling. The primary difference is that an active chilled beam contains an integral air supply. This primary air passes through nozzles, which induce air from the space up through the cooling coil. This induction process allows an active chilled beam to provide much more cooling capacity than a passive chilled beam.

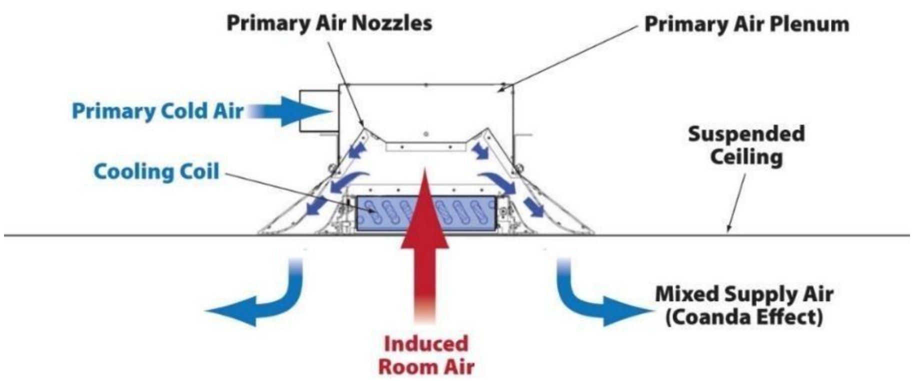


Figure 35: Active Chilled Beam System

ii. Passive Chilled Beam System (PCBS)

PCBSs consist of a fin and tube heat exchanger, contained in a housing (or casing), that is suspended from the ceiling

Chilled water passes through the tubes. Warm air from the space rises toward the ceiling, and the air surrounding the chilled beam is cooled, causing it to descend back toward the floor, creating convective air motion to cool the space. This allows a passive chilled beam to provide space cooling without the use of a fan.

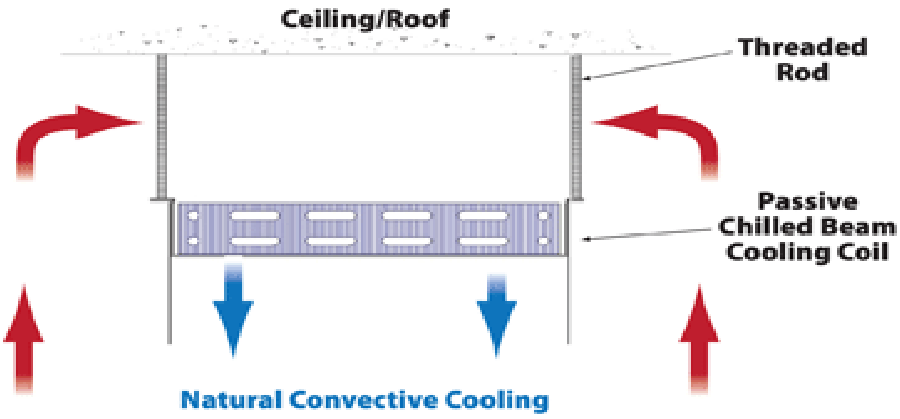


Figure 36: Passive Chilled Beam System

1.6.7 Chilled Water System

Chilled water systems provide cold water to air handling equipment for the purpose of cooling supply air to control space temperature. Water is cooled to a predetermined set-point that is set within the chiller itself.

Components of the chilled water system are:

a. **Evaporator (Cooling coil):**

Area of the chiller that cools the water.

b. **Chiller:**

A machine that removes heat from a liquid via absorption refrigeration cycle.

c. **Cooling Tower:**

It cools water from the condenser by dissipating it into the air.

d. **Pumps:**

The role is to provide sufficient pressure to move the fluid through the chiller and condenser water distribution system at the desired flow rate.

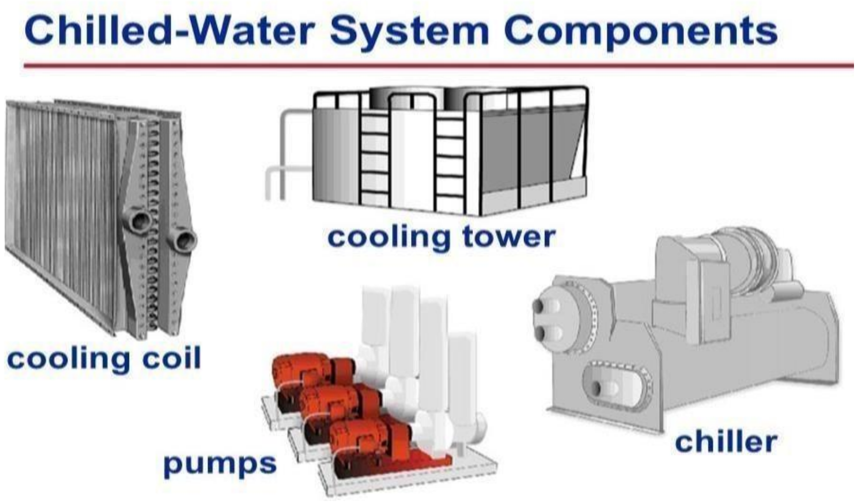


Figure 37: Chilled Water System Components

1.7 Firefighting Services

A firefighting system is an important building service; its aim is to protect human life and property. Buildings must be constructed in accordance with the building code that is in effect when an application for a building permit is made.

Firefighting techniques and equipment are used to extinguish fires and limit the damage caused by them. Firefighting systems consist of large tanks, pumps, pipework, and hydrants or sprinklers.

All types of properties especially industrial and commercial buildings are typically equipped with a fire detection and alarm system wired directly to the local fire department's 24-hour monitor. Most firefighting systems consist of applying water to the burning material, cooling it to the point at which combustion is no longer self-sustaining.

Fires involving flammable liquids, certain chemicals, and combustible metals often require special extinguishing agents and techniques. The use of water may be dangerous with some fuels.

Firefighting systems depend on removing one or more of the three elements essential to combustion: fuel, heat, and oxygen. There are two types of firefighting systems: mechanical such as the hoses and electrical such as sprinklers.

1.7.1 Dry Pipe Fire Sprinkler System

A dry pipe sprinkler system is one in which pipes are filled with pressurized air or nitrogen, rather than water.

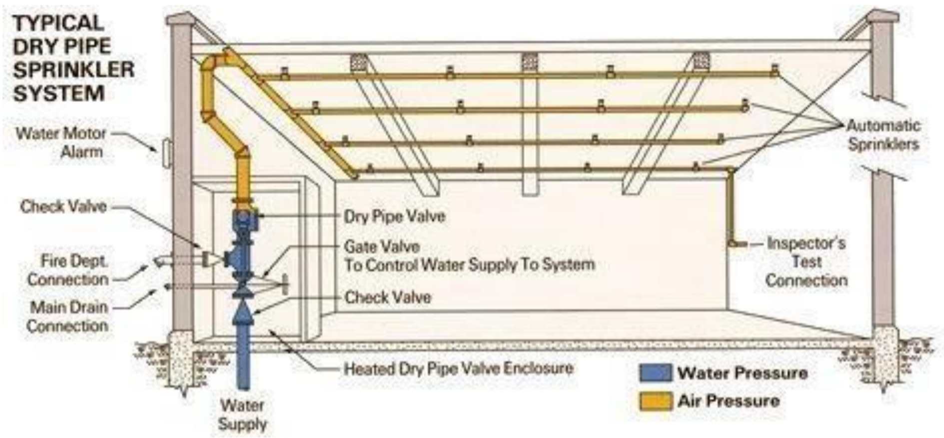


Figure 38: Dry Pipe Fire Sprinkler System

1.7.2 Wet Pipe Fire Sprinkler System

Wet pipe systems are the most common fire sprinkler system. A wet pipe system is one in which water is constantly maintained within the sprinkler piping.

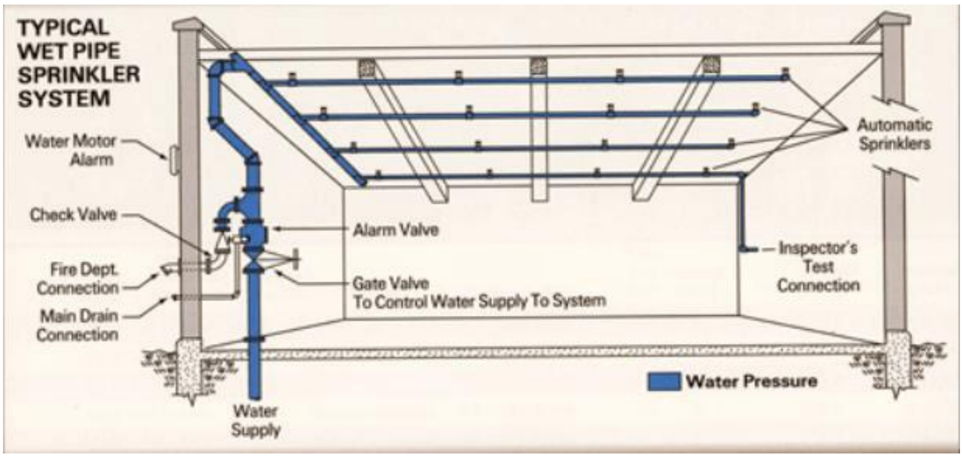


Figure 39: Wet Pipe Fire Sprinkler System

1.7.3 Pre-Action Fire Sprinkler System

Pre-action fire sprinkler systems employ the basic concept of a dry pipe system. The difference, however, is that water is held from piping by an electrically operated valve, known as a pre-action valve. Valve operation is controlled by independent flame, heat, or smoke detection.

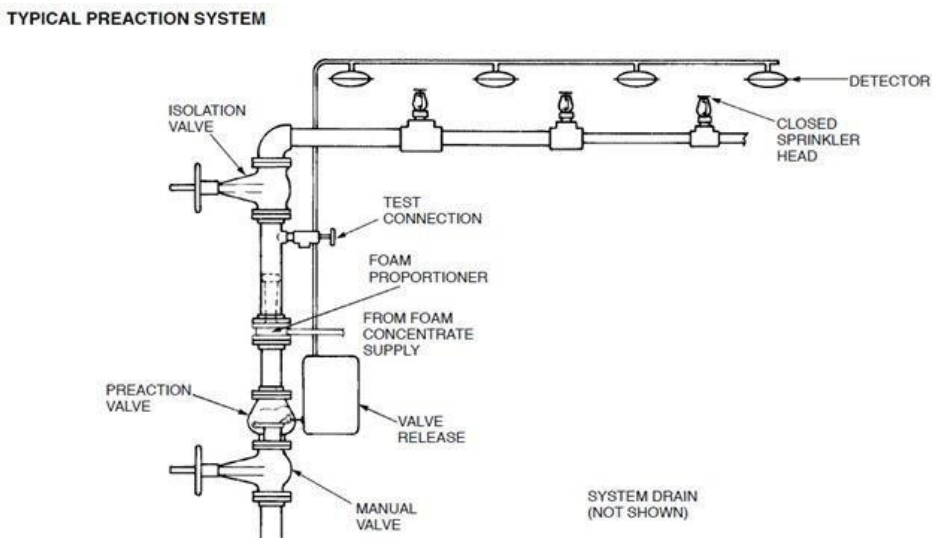


Figure 40: Pre-Action Fire Sprinkler System

1.7.4 In-Rack Sprinkler System

Warehouse fires are extremely challenging, they spread quickly and have immense increases in heat release rate over a short period of time. In-rack fire sprinkler systems are specifically designed for the protection of racked storage areas in warehouses.

Figure 41: In-Rack Sprinkler System

1.7.5 Quell Fire Sprinkler System

The Quell fire sprinkler system is designed for cold storage and/or unheated warehouses using a "surround and drown" method to save the building and goods stored. The Quell fire system is a double interlock pre-action system design scenario developed for the protection of high piled storage.

Figure 42: Quell Fire Sprinkler System

1.7.6 Early Suppression Fast Response (ESFR) Systems

ESFR systems using ceiling mounted sprinklers can be used in warehouses in place of in-rack fire sprinkler systems. ESFR systems provides protection that exceeds that of in-rack systems. ESFR high output, high volume systems are located in ceiling spaces as with conventional fire sprinkler systems. They incorporate very high volume, high-pressure heads to provide the necessary protection without the need for in-rack sprinklers.

Figure 43: ESFR System

1.7.7 Vortex Fire Suppression System

Vortex fire suppression systems use both water and nitrogen homogeneously to extinguish fires. This technology uses a small water drop that will absorb more heat while the nitrogen will reduce the oxygen feeding the fire.

Figure 44: ESFR System

1.7.8 Foam / Chemical Suppression

Foam is used whenever there is a possibility of a liquid fire. The foam will mix with water and then expand over the liquid that is on fire, cool the fire, and finally will be extinguished. The distribution of a foam blanket over a flammable liquid will extinguish a fire by eliminating the fire's oxygen supply and provide a cooling effect on the burning fuel. Foam is also available for the protection of hydrocarbon fuels and polar solvent fuels such as ethanol.

Figure 45: Foam / Chemical Suppression

1.7.9 CO2 Fire Suppression Systems

CO2 systems are the preferred choice firefighting system for a multitude of critical facilities. Fast, efficient and adaptable to a wide range of hazards, the discharge of carbon dioxide is non-damaging to property and electrically non-conductive.

Figure 46: CO2 fire suppression systems

1.7.10 Gaseous Fire Suppression: Inert Gases

Gaseous fire suppression is a term used to describe the use of inert gases and chemical agents to extinguish a fire. Inert gases work by removing the oxygen in the hazard area to a point where it will not support a fire.

Figure 47: Gaseous Fire Suppression: Inert Gases

1.7.11 Fire Hydrant System

One of the oldest, most effective and common firefighting solutions. It comprises of heavy duty above and underground piping with accessories.

External fire escape hydrant valves are provided at strategic locations.

Fire hydrant protection systems are designed to fight large fires, in all classes of risks. Dry barrel and wet barrel are the two kinds of fire hydrants.

The fire pump station comprises of:

- A jockey pump
- Electric driven pump
- Stand-by diesel driven pump

1.7.12 Firefighting Control Systems

Firefighting control systems are divided into two parts:

- fire alarm systems that involve detectors,
- a pumping system, and both parts are interconnected by the control panel.

When a fire occurs, sensors in smoke detection devices send a signal to the control panel in the alarm system, which in turn operates a valve, turning on the sprinkler system.

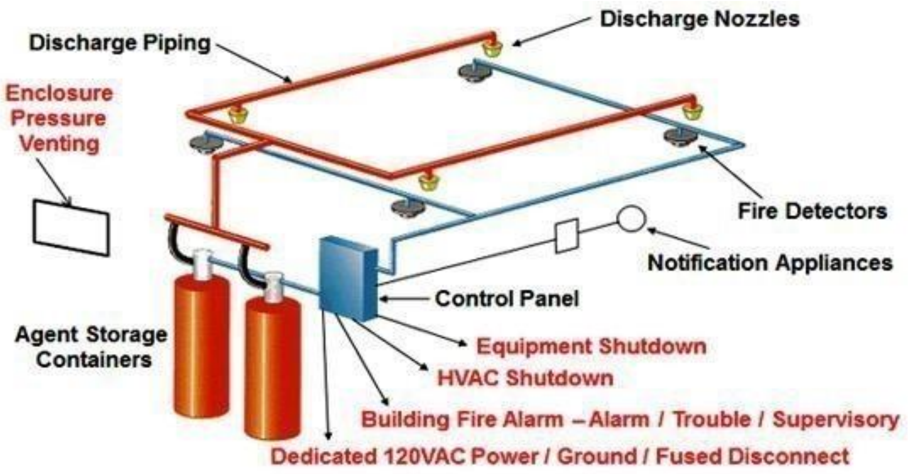


Figure 48: Example of Firefighting Control Systems

Firefighting systems with parallel-connected pumps are equipped with two to six pumps. Each pump is fitted with non-return valves and cut-off fittings at the inlet and outlet. The pumps are connected to the suction and discharge manifolds. These manifolds are fitted with necessary sensors, pressure gauges and pressure vessels.

Figure 49: Example of Firefighting Systems (Parallel-Connected Pumps)

1.7.13 Fire Detection and Alarm Systems

The components of fire detection and alarm systems may operate:

- Mechanically
- Hydraulically
- Pneumatically
- Electrically

Types of Fire Alarm Systems:

a) Conventional Fire Alarm

- manually known as a local system or protected premises (pull station & bell).
- this system is expanded to include fire detection devices to sense the presence of a fire and initiate a signal.

b) Addressable Fire Alarm

- modern type of system and its components have individual unique identifiers.
- If one of the system's components initiate, it indicates the component's address on the fire alarm panel.

The following are examples of automatic alarm initiating devices:

- Heat detectors (Fixed temperature device and Rate of rise)
- Smoke detectors
- Flame detectors
- Fire-gas detectors
- Combination detectors

Heat Detector

Smoke Detector

Fire-Gas Detetor

Combination Detectors (Smoke/Fire/CO/Natural Gas)

Flame Detector

Figure 50: Example of Automatic Alarm Initiating Devices

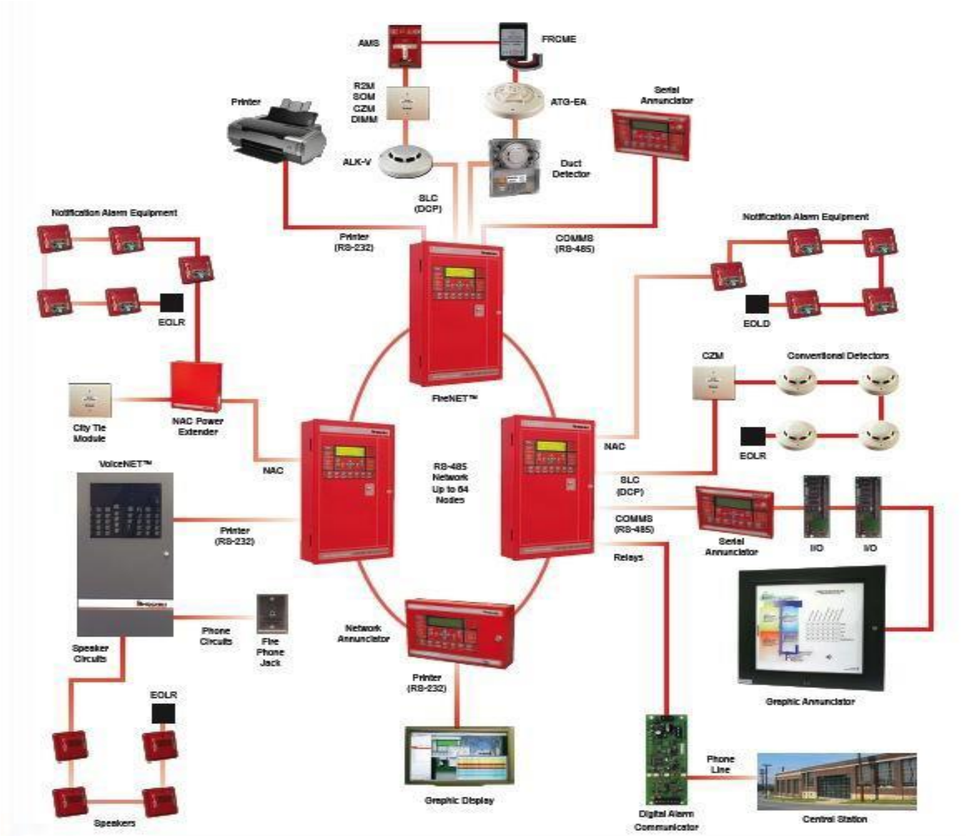


Figure 51: Fire Alarm System

1.8 Materials Handling Equipment

Materials handling technology refers to technologies that are used to move material from one location to another within a manufacturing facility. Typical examples in a manufacturing facility include industrial vehicles, conveyors, and cranes. Materials handling systems are a set of transportation technologies serving transport needs within a manufacturing facility.

There are several types of transportation equipment that can be found in any industrial area such as:

- Cranes
- Conveyors
- Mobile cranes and forklift trucks

1.8.1 Cranes

Cranes are mechanical devices used to move heavy objects from one place to another. They are used at construction sites, manufacturing plants and other facilities such as scraps yards, factories and other areas.

Types of cranes:

i. Monorail Cranes

Monorail cranes, as the name suggests, run on a single ceiling mounted rail or beam.

Monorail cranes use a single overhead track or track network to lift and transport objects on a fixed path, where one or a group of carriers move along the track. Monorail cranes can be fixed, or part of a workstation crane system allowing for positioning of the monorail above the object.

The basic technical information to be recorded for monorail cranes includes:

- Length (measured in m) and size of monorail (depth of section, which is typically cast into the beam, e.g. 150 Universal Beam (UB) = 150 mm)
- Lifting capacity
- Details of hoist(s) attached (see later)

Types of Monorail Cranes:

a. **Straight Monorail Cranes**

Figure 52: Straight Monorail Cranes

b. **Curved Monorail Cranes**

Figure 53: Curved Monorail Cranes

ii. Jib Cranes

Jib cranes consist of a horizontal load supporting boom, which is attached to a pivoting vertical column that is either free standing or building mounted. They enable lifting and lowering of a load within a fixed arc of rotation. Jib cranes can be provided in a variety of capacities and configurations including motorized rotation.

The basic technical information to be recorded for jib cranes includes:

- Radius of jib
- Lifting capacity
- Details of hoist(s) attached (see later)

Types of jib cranes:

a. Wall mounted jib cranes

b. Pillar mounted jib cranes

c. Mast type jib cranes

Figure 54: Jib Crane

iii. Electric Overhead Traveling (EOT) Cranes

This is most common type of overhead crane, found in most factories. These cranes are electrically operated by a control pendant, radio or IR remote pendant or from an operator cabin attached to the crane itself.

EOT cranes are also known as bridge or gantry cranes. EOT crane components:

- Runway beams and rails: Consisting of two runway beams on top of which are mounted a rail, along which the EOT crane travels
- EOT crane bridge frame: It consists of one or two main beams and two end beams.
- EOT crane traveling mechanism: It consists of motor, brake, reducer, coupling, transmission shaft, wheels and other component parts.
- Lifting trolley: It consists of a lifting mechanism and a trolley traveling mechanism.

The basic technical information to be recorded for EOT cranes includes:

- Span of crane
- Lifting capacity
- Length and size of runway beams and rails

- Details of hoist(s) attached (see later)

Types of EOT Cranes:

a. **Single Girder EOT Cranes**

Figure 55: Single girder EOT cranes

b. **Double Girder EOT Cranes**

Figure 56: Double Girder EOT Crane

c. **Single Girder Under-Slung Cranes**

Figure 57: Single Girder Under-Slung Crane

d. Double girder under-slung cranes

Figure 58: Double Girder Under-Slung Crane

iv. Moving Cranes

The basic technical information to be recorded for moving cranes includes:

- Span of crane
- Lifting capacity
- Length and size of runway beams and rails (as applicable)
- Details of hoist(s) attached (see later)

Types of Moving Cranes:

a. **Goliath / A-Frame / Portal Cranes**

Figure 59: Goliath Crane

b. **Semi Goliath / Semi Portal Cranes**

Figure 60: Semi Goliath Cranes

c. **Wall Travelling Cranes**

Wall travelling cranes are ideal for transporting materials to individual, adjacent workstations within the operating range and also for operation below big overhead cranes.

Figure 61: Wall Travelling Cranes

d. **Light Cranes**

Figure 62: Light Crane

v. Overhead Hoists

Overhead hoists are machinery units that are used for vertical lifting involving material handling of freely suspended (unguided) loads. They may be electrically or pneumatically driven and employ wire ropes or chains.

The basic technical information to be recorded for hoists includes:

- Manufacturer
- Type (manual/electric/pneumatic lifting, manual/electric travelling carriage, chain/wire rope, etc.)
- Lifting capacity

Figure 63: Electric Overhead Wire Rope Hoist

1.8.2 Conveyors

A conveyor system is a common piece of mechanical handling equipment that moves materials from one location to another. Conveyor systems can be divided into two classes:

- Those that are part of a machine for processing product.
- Those that move products in various stages of fabrication

The basic technical information to be recorded for most conveyors and elevators includes:

- Type of conveyor (as outlined in the following pages)
- Dimensions (width/diameter x length/height)

- Materials of construction (e.g. rubber belt, stainless steel screw, mild steel screw, etc.)
- Motor size
- Duty (e.g. cement transfer, product feed, machine discharge – assists with identification where there are many conveyors)

Types of Conveyors:

i. Screw Conveyors

The screw conveyor usually consists of a long-pitch plate-steel helix mounted on shaft or spindle carried in bearings within u-shaped trough. Screw conveyors are commonly manufactured in either stainless steel or mild steel depending upon the product to be conveyed.

Figure 64: Screw conveyor

ii. Flight Conveyors

The flight conveyor has an endless chain or twin chains passing around sprockets at the head and foot ends, with spaced transverse scrapers or "flights" which push the material along a trough.

Types of flight conveyors:

- Scraper flight conveyors
- Suspended flight conveyors
- Roller flight conveyors

- Roller chain conveyors
- Drag chain conveyors

Figure 65: Flight conveyor

iii. Apron Conveyors

The alternative to a flight conveyor may be an apron conveyor. The apron conveyor consists of overlapping beaded steel pans supported between or mounted upon two strands of roller chain.

Figure 66: Apron conveyor

iv. Bucket Elevator

It is a mechanism for hauling flow able bulk materials vertically. Vertical elevators depend entirely on the action of centrifugal force to get the material into the discharge chute.

Figure 67: Bucket Elevator

v. Spiral Chute

The simplest method and lowest cost when a direct lowering of package or boxed materials is involved.

Figure 68: Spiral Chute

vi. Roller Conveyors

A conveyor consisting of fixed-location rollers over which materials are moved by gravity or propulsion.

Figure 69: Roller Conveyor

vii. Belt Conveyors

A belt conveyor system consists of two or more pulleys, with an endless loop of carrying medium that rotate about them.

Figure 70: Belt Conveyor

viii. Overhead Trams and Conveyors

Manufacturing operations may preferably be by overhead transport, keeping the aisles clear and eliminating damage to the floors.

- Overhead conveyors, or trolley conveyors, consist of a power-propelled chain traveling at moderate speed.
- Suspended by trolleys from a suitable track.
- Provided with attachments of various forms adapted to the work to be done.

Figure 71: Overhead Conveyors

ix. Continuous-Flow Conveyors

The continuous-flow conveyor is a machine in which the material moves slowly within a duct as a continuous core.

Figure 72: Continuous-Flow Conveyors

x. Pneumatic Conveyors

The pneumatic conveyor depends on a high-velocity air stream to move material in about the same manner as the wind.

Figure 73: Pneumatic Conveyor System

1.8.3 Mobile Cranes and Forklift Trucks

Mobile cranes are mounted on crawlers or wheels and offer greater mobility than fixed cranes. Some mobile cranes can be driven on the highway. Their ability to navigate around job sites and carry heavy weights provide a flexible means of transporting materials around a site.

The basic technical information to be recorded for mobile cranes includes:

- Manufacturer
- Type (as outlined in the following sections)
- Model (which typically defines the capacity)
- Lifting capacity

There are several different types of mobile crane, including:

i. Carry Deck or Pick and Carry Cranes

Carry deck cranes, also known as pick and carry cranes, are small, four-wheeled cranes that can rotate a full 360 degrees and are more portable than other types of cranes. Carry deck cranes are simple to set up, and their small size easily allows them to navigate around confined and open spaces.

Figure 74: Carry Deck Crane

ii. Crawler Cranes

Instead of wheels, crawler cranes are built on an undercarriage fitted with a pair of steel tracks. Though this limits the crawler's turning capacity, the tracks make it possible to use on soft ground and sites with limited improvement without sinking.

Some crawler cranes have an attached telescopic arm that allows it to change its size, making them highly adaptable on many terrains.

Figure 75: Crawler Crane

iii. Rough or All Terrain Cranes

Rough terrain cranes are built similarly to crawler cranes, but instead of tracks, the undercarriage is outfitted with four large rubber tires that are typically equipped with four-wheel drive. Rough terrain cranes are also fitted with telescopic booms and outriggers to improve stability and make mobility much more manageable in tight and rough areas.

Figure 76: Rough Terrain Crane

iv. Forklift Trucks

A forklift truck or a forklift is a small vehicle with two movable forks on the front, used to lift and carry heavy loads over short distances. Forklift trucks are made in a number of different design types.

The basic technical information to be recorded for forklift trucks includes:

- Manufacturer
- Type (as outlined in the following sections)
- Model (which typically defines the capacity)
- Lifting capacity

Some of the more common types include:

Figure 77: Forklift truck

- Low lift trucks – Typically an electrically powered pallet truck that can be operated either by a person seated on the machine or by a person walking alongside. Lighter duty pallet trucks have a manual hydraulic lifting mechanism and are un-powered.
- Stacker truck - Usually electrically powered. A stacker may be operated by a person seated on the machine, or by a person walking alongside, depending on the design.
- Reach truck - Variant of a stacker truck, designed for small aisles, usually electrically powered, named because the forks can extend to reach the load.
- Counterbalanced forklift truck – These may be electrically, LPG, petrol or diesel powered and may be either sit-down rider operated or stand-on rider operated. Sit-down rider operated forklift trucks are the most common type of forklift.
- Side loader - These may be electrically, LPG, petrol or diesel powered and may be either sit-down rider operated or stand-on rider operated. As the name suggest the forks are fitted on the side of the vehicle.
- Telescopic handler (telehandler) – These have a telescopic boom on which the forks are mounted. They are typically sit-down rider operated and are driven by an internal combustion engine. In appearance they have some resemblance to a carry deck crane.

2.0 COMPUTERIZED SYSTEMS FOR MACHINERY AND EQUIPMENT

A computerized system is a system of interconnected computers that share a central storage system and various peripheral devices such as printers, scanners, or routers. Each computer connected to the system can operate independently but has the ability to communicate with other external devices and computers.

Each computer is made up of the central processing unit (CPU), memory and related electronics, peripheral connected devices, all of which are accessed and controlled through the internal operating system.

A computer system is sized for the number of users it handles simultaneously, the type of work performed and the volume of data that must be stored.

2.1 Computer System

A computer system is a combination of hardware and software. A typical computer system has memory and set of states that define the relationship between the system inputs and outputs.

a. Hardware

The physical structure of a computer, i.e., the physical parts that make up the structure. Three broad categories of hardware are input devices, the CPU, data/tape drives, and output devices, back-up storage devices or secondary memory.

b. Software

Software is a general term used to describe the non-physical elements of a computer, in essence the system that controls the computer's processing and communicates data. The software system that runs the computer is called a computer program, which includes operating systems and data storage tapes, discs, collectively called "media".

Most software is considered an intangible (not physical) asset unless bundled within the wider computer system. Standard or "packaged" off-the-shelf software packages are often classified as a fixed-assets, but self-developed, specialist software is generally classified as an intangible asset. Software is not typically valued as part of a computer system.

Important terms in computer system are:

- **Data**

  The collection of information to be processed by a computer, usually by means of conversion into mathematical code.

- **Processing**

  The electronic manipulation of data.

- **Result**

  The useful information after processing of data.

- **Information**

  The collection of data according to a set parameter.

- **Input**

  The process of collecting and entering data into the computer.

- **Output**

  The result we get after the processing of data and extracting it from the memory.

2.2 Information Technology (IT) Equipment

Information technology (IT) equipment comprises of computer hardware, software, servers and ancillary equipment.

a. Server

A server is a computer system dedicated to managing network resources and is used as the central repository of data and various programs.

There are various types of servers including web servers, mail servers and network servers. A server is the generalized term which refers to a host which is deployed in executing many programs.

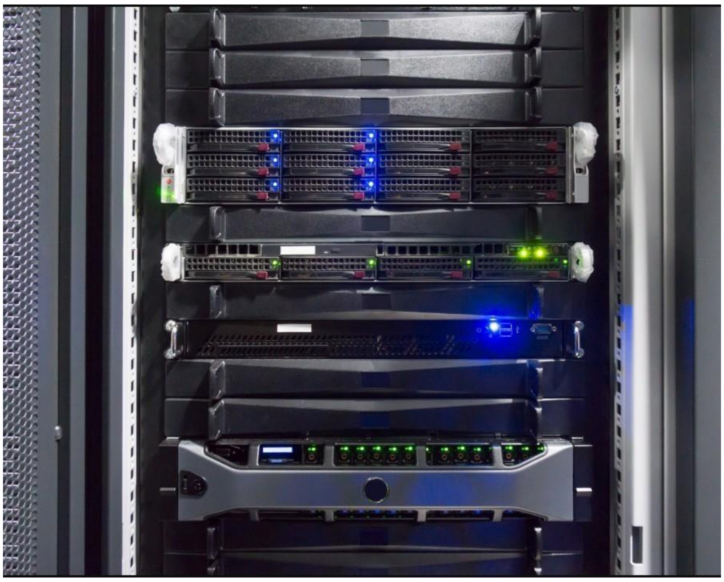


Figure 78: Server

b. Uninterruptable Power Supply (UPS)

Uninterruptable power supply (UPS) is an electrical apparatus that provides backup power when regular power sources fail, or voltage drops to an unacceptable level. UPS systems contain batteries which store energy when the mains supply is available. In the event of a mains failure, the UPS power inverter circuit converts the battery charge into an alternating current supply.

Figure 79: Uninterruptable Power Supply

c. Internet Modem

An internet modem modulates signals so that the digital information is encoded and transmitted and then demodulated. The sending modem modulates the data into a signal that is compatible with the transmission system (which could be cable, phone, radio/satellite or microwave).

Figure 80: Internet Modem

d. Router

A router connects multiple networks and routes network traffic. A wireless network uses radio waves. A computer’s wireless adapter translates data into a radio signal and transmits it using an antenna. A wireless router receives the signal and decodes it. The router sends the information to the internet usually using a physical, wired ethernet connection.

The process also works in reverse, with the router receiving information from the internet, translating it into a radio signal and sending it to the computer’s wireless adapter.

Figure 81: Router

e. Network Switches

Switches allow different nodes (a network point, typically a computer) of a network to communicate directly with one another. There are various types of switches. Local Area Network (LAN) switches provide a connection for each node in an internal network. Essentially, a switch creates a series of instant networks that contain only the two devices communicating with each other at that moment in time.

Figure 82: Network Switches

f. Central Processing Unit

An electronic processor chip inside the computer. It controls all decisions, calculations and controls other parts of a computer.

CPU consists of:

a. Control Unit (CU)

It controls operations of other parts of CPU as well as all parts of computer by sending a control signal.

b. Arithmetic and Logic Unit (ALU)

The ALU consist of a complicated set of logic circuit and accumulator. It is mainly responsible for calculating logical comparison and decision.

c. Main Memory

The main memory holds the program instructions and data. It contains two types of memory chips, called read only memory (ROM) and random-access memory (RAM). RAM is the part of the computer that temporarily stores the instructions that the computer is running, and the data it is processing. RAM is a volatile storage device.

d. Output Devices

Output devices are used to get the result of the processing done by the computer. Most common output devices include monitor and printer.

Secondary storage devices or backing storage is used to store programs and data when they are not being used i.e. used to store permanently. Secondary storage is non-volatile, so data that is stored on these devices remains there safely. A hard drive, a CD-ROM, a floppy disc and a USB memory stick are all examples of secondary storage devices.

2.3 Supervisory Control and Data Acquisition (SCADA) Systems

SCADA systems are industrial control systems that provide supervisory-level control over machinery and/or industrial processes.

SCADA systems utilize programmable logic controllers (PLCs), Remote Terminal Units (RTUs) and other sensors to automate responses to system alarms. SCADA systems enable plant supervisors to monitor and manage alarms and to collect and analyze real-time production data that help make critical decisions. SCADA is a data-gathering, production orientated system and therefore cannot implement advanced process control techniques.

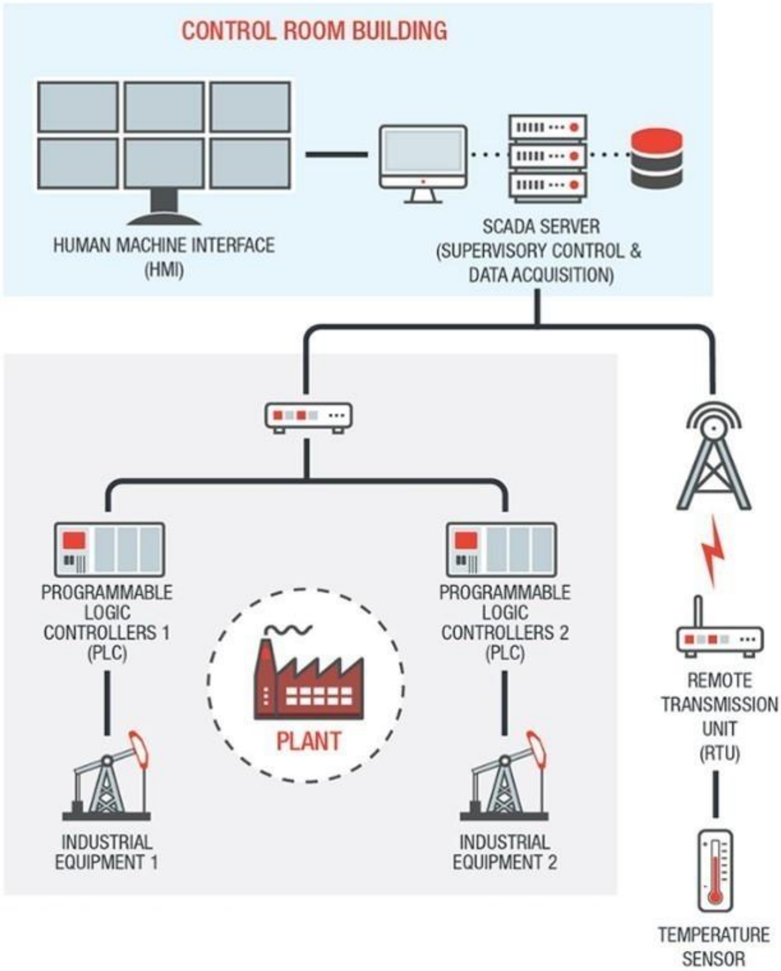


Figure 83: SCADA system

2.3.1 Remote Terminal Units (RTUs)

RTUs are microprocessor-based devices that monitor and control field devices and communicates data to plant control such as SCADA systems.

Figure 84: Remote Terminal Units (RTUs)

RTUs support a range of functions, from monitoring, remote control and automation, communication gateway and local data storage.

Figure 85: Remote Terminal Unit (RTU) Cabinet for block valve station in the desert

2.3.2 Programmable Logic Controllers (PLCs)

A PLC is a digital operating system designed especially for usage in an industrial environment, using a programmable memory for its internal operation of user-orientated instructions and to implement specific functions. PLCs are used for monitoring and control from a centralized plant control such as a SCADA system.

PLCs can monitor and record run-time data such as machine productivity or operating temperature, automatically start and stop processes, generate alarms for machine malfunction.

Figure 86: Programmable Logic Controllers (PLCs)

2.3.3 Field Instruments

Field instruments are sensors and actuators that are directly connected to equipment throughout the process plant that produce analog and digital signals to communicate with the input/out of the RTU or the PLC. Field instruments can measure pressure, level, temperature, flow etc., and hence have replaced plant operatives in many industries.

Field devices control local operations such as opening and closing valves, collecting data from sensor systems and monitoring the local environment for alarm conditions. Examples include transmitters and control valves.

Figure 87: Temperature Transmitter

2.4 Distributed Control System (DCS)

A DCS is a computerized control system consisting of computer-software packages communicating with autonomous control hardware providing a centralized human-machine interface (HMI) for controlled equipment.

A DCS differs from a SCADA system as the system is process state driven and implements advanced process control techniques.

DCS are designed to control large, complex and geographically distributed applications in industrial processes. Within the system, controllers are distributed throughout the entire plant area. The controllers are connected to both field devices and operating PCs through high-speed communication networks. DCS can enable plant-wide control and optimization in complex process industries such as oil and gas refineries and power generation plants.

DCS' are developed specifically for the process plant and are often considered to be part of the overall plant process, rather than as a separate asset. While each DCS is unique, they include many of the same elements of a computerized IT system, but as they are dispersed across the production process, much of the costs associated with these are attributed to the configuration, process monitoring equipment and set up. A high-level example of a DCS is illustrated below.

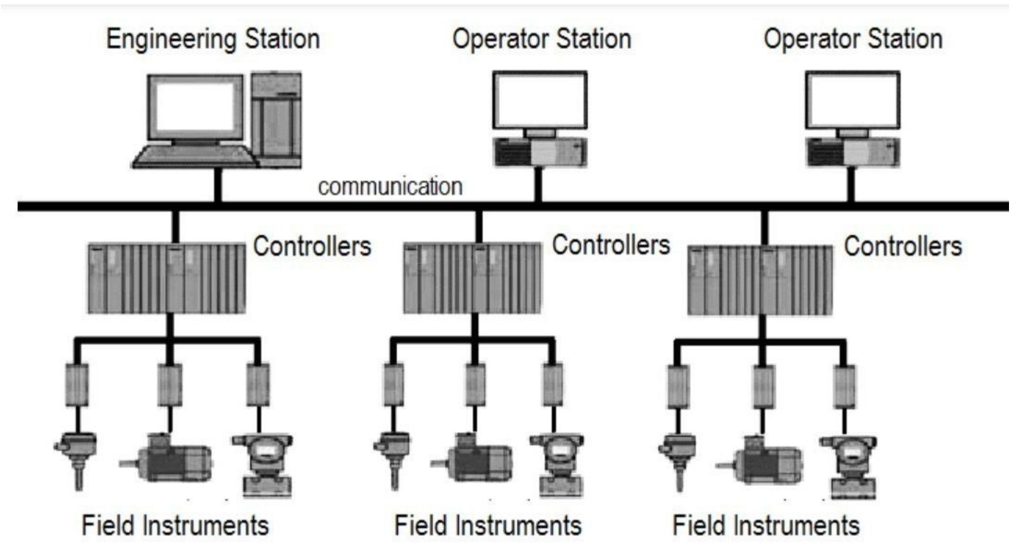


Figure 88: Distributed Control System (DCS)

2.5 Valuation of Computerized Systems in A Process Plant Environment

The approach to the valuation of computerized systems depends on the extent and complexity of the system, for example:

2.5.1 Computer Systems & IT Equipment

Typically, the material assets can be identified, and would be valued based on a combination of the cost and market approaches, ideally by obtaining the new replacement cost of a modern equivalent asset from and original equipment manufacturer (OEM) and benchmarking the resulting value to comparable sales data.

2.5.2 DCS

These are typically more complex and are developed to meet the specific needs of the process plant. Much of the value is embedded in the design, development & configuration of the DCS and therefore market comparables rarely exist.

Due to the above, in most instances, DCS' are valued as a component of the wider process plant (as with other process instrumentation) and are not valued separately.

Computerized systems often include other assets which are difficult to quantify, for example costs for installing wiring and clean operating environments for control equipment. The cost for these assets may not be clearly defined, and (depending on the extent of the system) may require additional discussions with the client's IT and finance teams to understand these costs. Historical costs may also be identified through reviewing historical purchase/construction invoices to identify the proportion of costs attributed to these assets.

It should also be noted that these costs may also be included in the building valuation (as building services), so the valuer should liaise with the building valuer to ensure they are not omitted, or double counted.

It is also worth noting that DCS equipment may be replaced if the software or technology evolves – this may happen before the process plant computer systems will be included within reaches the end of its useful life, therefore, it may be necessary to identify what proportion of the overall plant value relates to these assets, so they can be depreciated separately from the rest of the plant.

3.0 UNDERGROUND UTILITY COLOR CODES

Underground utility color codes are used to differentiate and identify underground utilities to protect it from damage during excavation.

They help mark the location and indicate the type of utility that is buried underground.

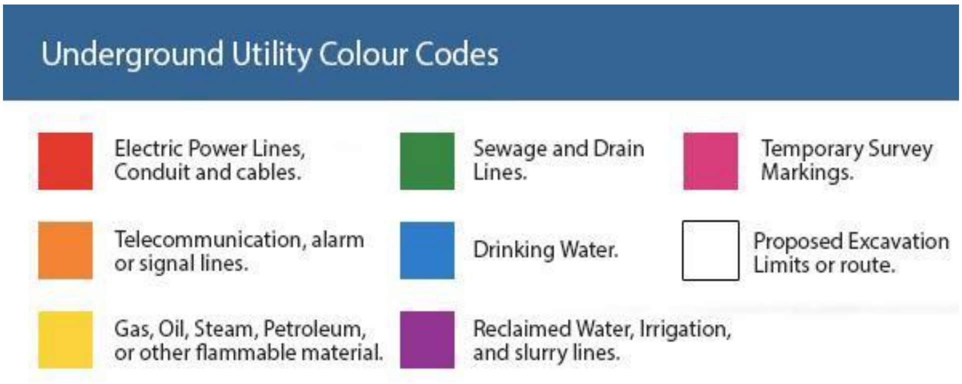


Figure 89: Underground Utility Color Codes

NOTE:

There are several other additional components involved in the industrial process plant that machinery and equipment valuers need to know in assessing machinery and equipment valuation. The additional components involved are:

- Ventilation System
- Security System
- Communication System

Refer to **4.0 Annex 1** for the detailed notes.

4.0 ANNEX 1

Note: This additional information is for personal reading only and will not be included in the examination questions.

4.1 VENTILATION SYSTEMS

Ventilation is the process by which fresh air is introduced and ventilated air is removed from an occupied space. The primary aim of ventilation is to preserve the qualities of air. Sometimes, ventilation may also be used to lower the temperature inside an occupied area.

Listed below are some reasons why ventilation is required:

- Keep fresh air for respiratory system.
- Preserve correct level of oxygen in the air.
- Control carbon dioxide.
- Control the moisture level.
- Lower the heat level.
- Remove dust and odors.

There are two types of ventilation:

- Natural ventilation
- Mechanical ventilation

4.1.1 Natural Ventilation

Ventilation is the process of pulling fresh air into a building from the outside. In turn, this fresh air helps force the warm, dirty air inside of the building out through the opening in the roof. All of this is done, without mechanical assistance. It refers to the flow of external air to an indoor space as a result of pressure or temperature differences.

System of natural ventilation:

- Wind effect.
- Stack effect.
- Combination of wind effect and stack effect.

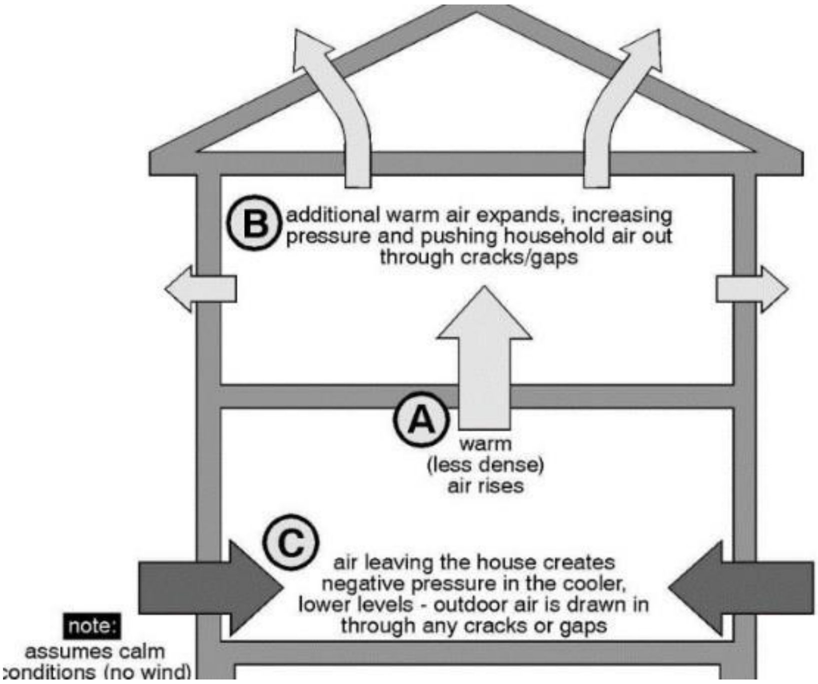


Figure 90: Stack Effect of Natural Ventilation

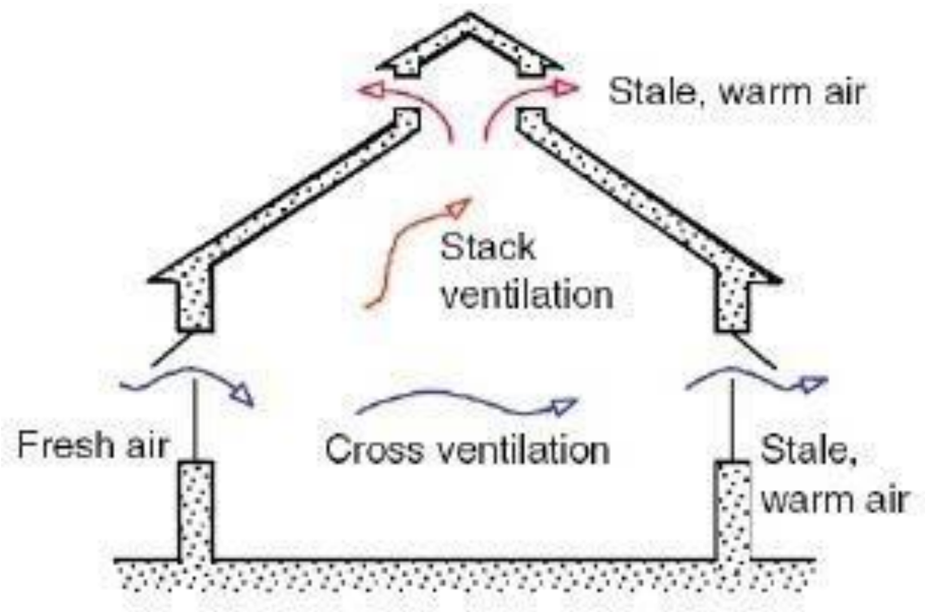


Figure 91: Combination of Wind Effect

4.1.2 Mechanical Ventilation

Mechanical ventilation systems circulate fresh air using ducts and fans rather than relying on airflow through small holes or cracks in a home's wall, roof or windows.

These systems employ an electricity driven fan or fans to provide necessary air movement within a building. They also ensure a specified air change and the air under fan pressure can be forced through filters. Air-conditioning is an example of mechanical ventilation.

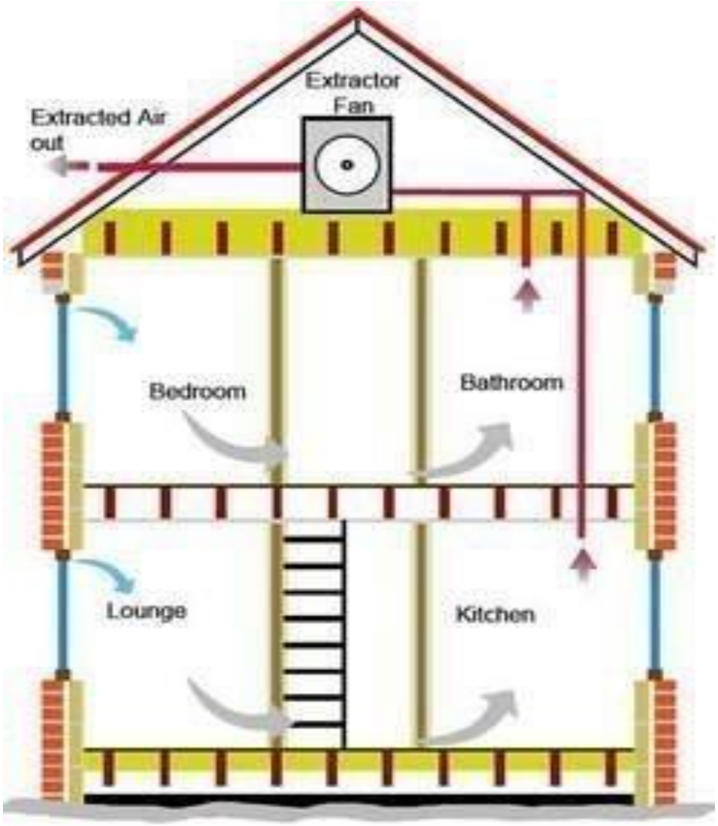


Figure 92: Mechanical Ventilation

There are three types of mechanical ventilation systems:

4.1.2.1 Natural Inlet and Mechanical Extract System (Exhaust System)

This is the most common type of system. The fan creates negative pressure on its inlet side, and this causes the air inside the room to move towards the fan, and the room air is displaced by the fresh air from outside the room.

An exhaust ventilation system removes the indoor air and airborne contaminants from the workplace.

Types of exhaust systems are:

a. General Exhaust System:

- Used for heat control in an area by introducing large quantities of air in the area. The air may be tempered and recycled.
- Used for removal of contaminants generated in an area by mixing enough outdoor air with the contaminant so that the average concentration is reduced to a safe level.

b. Local Exhaust System:

- The objective of a local exhaust system is to remove the contaminant as it is generated at the source itself.

Components:

- Hood.
- The duct system including the exhaust stack and/or re- circulation duct.
- Air cleaning device.
- Fan, which serves as an air moving device.

Figure 93: Exhaust Systems

4.1.2.2 Mechanical Inlet and Natural Extract

It is essential with this system that the air is heated before it is forced into the building. The air may be heated in a central plant and ducted to various rooms, or a unit fan convector may be used.

4.1.2.3 Mechanical Inlet and Extract

This provides the best possible system of ventilation, but it is also the most expensive and is used for many types of buildings.

4.1.3 Types of Fans

a. Propeller Fans

Propeller fans do not create a great deal of air pressure and have limited effect in duct work. However, they work effectively in openings in windows and walls.

Figure 94: Propeller Fan

b. Axial Flow Fans

Axial flow fans develop high pressure and are often used for moving air through long sections of duct work. These fans may be integrated within ducting or as stand-alone units.

Figure 95: Axial Flow Fan

c. **Centrifugal Fans**

Centrifugal fans produce high pressure and have the capacity for large volumes of air. They are most suited to larger installations. They may have one or two inlets. Various forms of impeller can be selected depending on the application. Variable impellers and pulley ratios from the drive motor make these the most versatile of fans.

Figure 96: Centrifugal Fan

4.1.4 Types of Air Filters

a. **Cell or Panel Type Air Filters**

This type is available in dry or wet (viscous) composition in disposable format for simple fitting within the duct work. A rigid outer frame is necessary to prevent flanking leakage of dirty air.

Figure 97: Cell or Panel Type Air Filter

b. **Bag Type Air Filter**

A form of filtration material providing a large air contact area. Fabric bags can be washed periodically and replaced.

Figure 98: Bag Type Air Filter

c. **Roller Type Air Filter**

This type of filter is operated manually or by a pressure sensitive switch.

Figure 99: Roller Type Air Filter

d. **Viscous Type Filter**

This has a high dust retention capacity and is often specified for application to industrial situations.

Figure 100: Viscous Type Air Filter

e. **Electrostatic Unit Type**

This has an ionizing area which gives suspended dust particles a positive electrostatic charge. The unit can have supplementary, preliminary and final filters as shown below, giving an overall efficiency of about 99%.

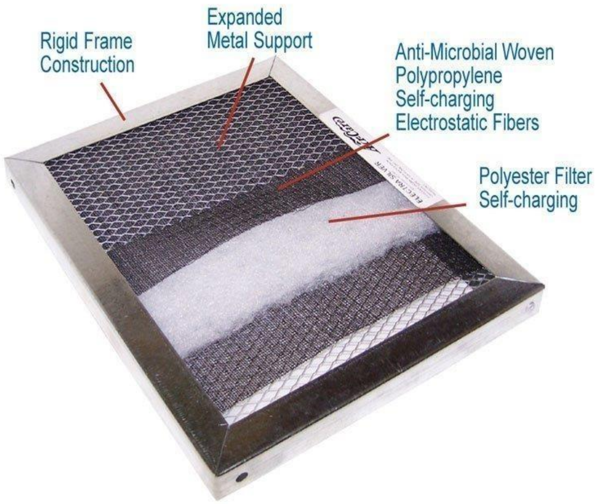


Figure 101: Electrostatic Unit Type Air Filter

4.2 SECURITY SYSTEMS

A security system is a means or method by which something is secured through a system of interworking components and devices.

Types of security systems are:

- Closed circuit television (CCTV)
- Access control systems
- Security alarm systems

4.2.1 Closed Circuit Television (CCTV)

CCTV is a system where the circuit in which the video is transmitted is closed and all the elements (camera, display monitors, recording devices) are directly connected.

In industrial plants, CCTV equipment may be used to observe parts of a process from a central control room, for example when the environment is not suitable for humans.

CCTV systems may operate continuously or only as required to monitor a particular event. A more advanced form of CCTV, utilizing digital video recorders (DVR), provides recording for possibly many years, with a variety of quality and performance options and extra features (such as motion-detection and email alerts).

Decentralized IP based CCTV cameras equipped with megapixel sensors, support recording directly to network attached storage devices, or internal flash for completely stand-alone operation.

Figure 102: Closed Circuit Television (CCTV)

CCTV systems comprise of:

- Camera(s)
- Wires
- Monitoring screen(s)
- Recorder

Types of CCTV Equipment:

a. **Indoor Cameras**

Indoor cameras are used for indoor security.

Figure 103: Indoor Camera

b. **Outdoor Cameras**

Outdoor cameras are used for outdoor applications. They are mostly for entry and exit points with limited night lighting. These cameras have hard shell vandal proof casings.

Figure 104: Outdoor camera

c. **Night Vision Cameras**

Night vision cameras are used for high security areas where surveillance needs to happen day and night. These cameras may be used in military facilities, parking lots and high security zones or where CCTV is required and the light at night is unavailable.

Figure 105: Night Vision Camera

d. **Dome Cameras**

Dome cameras are installed inside a dome housing. These cameras can be rotated and tilted manually. Dome cameras are often used in public places like railway stations, bus terminals, and other similar areas.

Figure 106: Dome Camera

e. **Bullet cameras**

Bullet cameras are placed inside bullet shaped housing and are commonly used in residential places. They are small in size, have an integrated design and are waterproof. They may also be mounted to a wall or any vertical area.

Figure 107: Bullet Camera

f. **Vandal Proof Cameras**

Vandal proof cameras are used as outdoor security cameras. These cameras are housed within solid material and covered by a 'hub' of break-proof glass which doesn't affect the quality of the video. It is difficult to break these cameras, and this makes them perfect for high security.

Figure 108: Vandal Proof Camera

g. **Pan Tilt Zoom Cameras**

Pan tilt zoom cameras offer the ability to view and zoom in all directions. The cameras can be set to automatically rotate to different fields of vision. They are best suited for patrol duty and open area applications such as borders, airports, parking lots, etc.

Figure 109: Pan Tilt Zoom (PTZ) Camera

h. Wireless CCTV

Wireless CCTV systems are similar to wired CCTV systems. The difference is that a radio transmitter is attached to the camera. A radio receiver is then attached to the input on the monitor system or computer. Wireless CCTV is useful when the distance between the camera and the monitor is too far to be practical for a cable run.

Figure 110: Wireless CCTV Camera

i. Digital Video Recorders (DVR)

DVRs are similar to VCRs, but the images they capture from the CCTV camera are digital. There are two types of DVR (Digital Video Recorders):

- Standalone devices.
- Hard drives that are connected to a computer system.

Figure 111: Digital Video Recorder (DVR)

j. IP Cameras

A growing branch in CCTV is internet protocol cameras (IP cameras). IP cameras use the Internet Protocol (IP) used by most Local Area Networks (LAN) to transmit video across data networks in digital form.

Figure 112: IP camera

4.2.2 Access Control Systems

There are three types of Access control systems:

a. Administrative Controls:

- Define roles, responsibilities, policies, and administrative functions to manage the control environment.
- Use hardware and software technology to implement access control.
- Ensure safety and security of the physical environment.

b. Technical Controls:

Examples of technical controls are:

- Encryption

- Biometrics
- Smart cards
- Tokens
- Access control list
- Violation reports
- Audit trails
- Network monitoring and intrusion detection

c. **Physical Controls:**

Examples of physical controls are:

- Heating, Ventilation and Air Conditioning (HVAC)
- Fences
- Locked doors
- Restricted areas
- Guards and dogs
- Motion detectors
- Video cameras
- Fire detectors
- Smoke detectors

4.2.2.1 Biometrics

Biometrics have become more prominent as a recognized means of positive identification and their use in security systems has increased.

Some new electronic locks take advantage of technologies such as fingerprint scanning, retinal scanning and iris scanning, and voice print identification to authenticate users.

Radio-frequency identification (RFID) is the use of an object (typically referred to as an RFID tag) applied to or incorporated into a product, animal, or person for the purpose of identification and tracking using radio waves.

Some tags can be read from several meters away and beyond the line of sight of the reader. This technology is also used in modern electronic locks.

Figure 113: Biometrics

4.2.2.2 Motion Sensors

The term 'motion sensors' can be used to refer to any kind of sensing system which is used to detect motion; motion of any object or motion of human beings. Motion sensors are also called motion detectors.

Motion sensors are commonly used in security systems as triggers for automatic lights or remote alarms and similar applications.

Types of motion sensors:

- Active Sensors
- Passive Sensors

Figure 114: Active Sensors

Figure 115: Passive Sensors

4.2.2.3 Security Alarm Systems

Security alarm systems incorporate an electronic device that emits a loud noise, when unauthorized entry happens in a building. A burglar alarm is a system designed to detect intrusion –unauthorized entry–into a building or area.

Figure 116: Alarm System

a. **Premises Control Unit (PCU):**

The "brain" of the system, it reads sensor inputs, tracks arm or disarm status, and signals intrusions. In modern systems, this is typically one or more computer circuit boards inside a metal enclosure, along with a power supply.

b. **Sensors**:

These are devices which detect intrusions. Sensors may be placed at the perimeter of the protected area, within it, or both. Sensors can detect intruders by a variety of methods, such as monitoring doors and windows for opening, or by monitoring unoccupied interiors for motions, sound, vibration, or other disturbances.

c. **Alerting Devices:**

These indicate an alarm condition. Most commonly, these are bells, sirens, and/or flashing lights. Alerting devices serve the dual purposes of warning occupants of intrusion, and potentially scaring off burglars.

d. **Keypads:**

Small devices that are typically wall mounted. It includes buttons, keypads and indicator lights.

e. **Interconnections Between Components:**

This may consist of direct wiring to the control unit, or wireless links with local power supplies.

f. **Security Devices:**

These devices, such as spotlights, cameras and lasers, detect intruders.

g. **Electronic Locks (or Electric Locks):**

Electronic locks are locking devices which operate by means of electric current. Electric locks are sometimes stand-alone with an electronic control assembly mounted directly to the lock.

h. **Electronic Locks equipped with a variety of means of authentication:**

- Numerical codes
- Passwords

Figure 117: Electronic Lock (Electric Lock)

4.3 COMMUNICATION SYSTEMS

A communication system is a collection of individual communications networks, transmission systems, relay stations, tributary stations, and data terminal equipment (DTE) usually capable of interconnection and inter-operation to form an integrated whole. The components of a communication system serve a common purpose, are technically compatible, use common procedures respond to controls and operate in union.

Communication systems have five (5) basic requirements:

- Data source (where the data originates)
- Transmitter (device used to transmit data)
- Transmission medium (cables or non-cable)
- Receiver (device used to receive data)
- Destination (where the data will be placed)

Components of communication are:

a. Simplex

Example: Radio or Television.

Figure 118: Simplex Transmission Circuits (Channels)

b. Half duplex

Example: Walkie-talkie

Figure 119: Half Duplex Transmission Circuits (Channels)

c. Full Duplex

Example: Telephone

Figure 120: Full Duplex Transmission Circuits (Channels)

Types of communication system are:

4.3.1 Satellite Communication Systems

A communications satellite is a station in space that is used for telecommunications, radio and television signals.

Two stations on earth want to communicate through radio broadcast but are too far away to use conventional means. The two stations can use a satellite as a relay station for their communication. One earth station sends a transmission to the satellite. This is called an up link. The satellite transponder converts the signal and sends it down to the second earth station. This frequency is called a down-link.

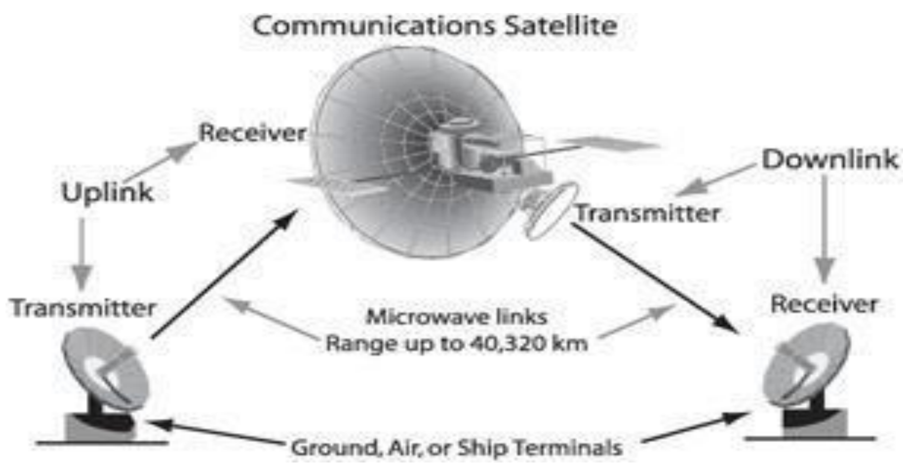


Figure 121: Satellite Communication System

The basic elements of a communication satellite service are divided between:

- Space segment
- Ground segment

The space segment consists of the spacecraft and launch mechanism. The ground segment comprises the earth station and network control center for the satellite system.

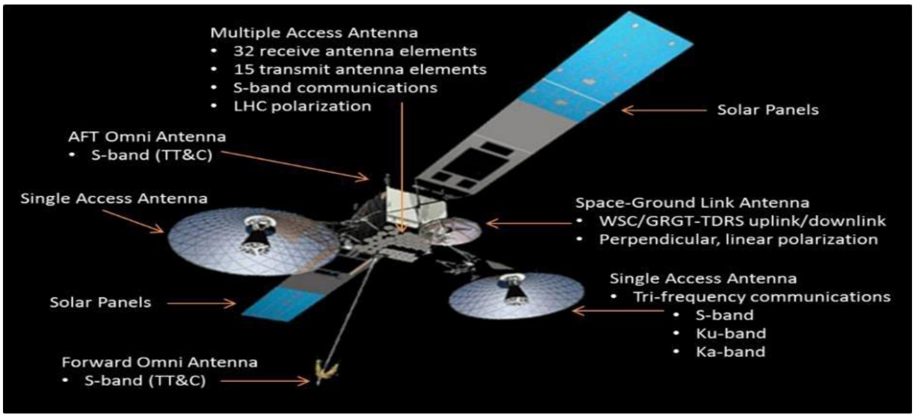


Figure 122: Satellite Communication Components

4.3.2 Radio Detection and Ranging (Radar)

Radar is an object-detection system that uses radio waves to determine the range, angle, or velocity of objects. It can be used to detect aircraft, ships, spacecraft, guided missiles, motor vehicles, weather formations and terrain.

The components of a radar communication system are:

- Transmitter
- Antenna
- Receiver
- Display unit
- Power supply
- Duplexer (improved radar)

Types of radar:

i. Pulse transmission

ii. Continuous wave

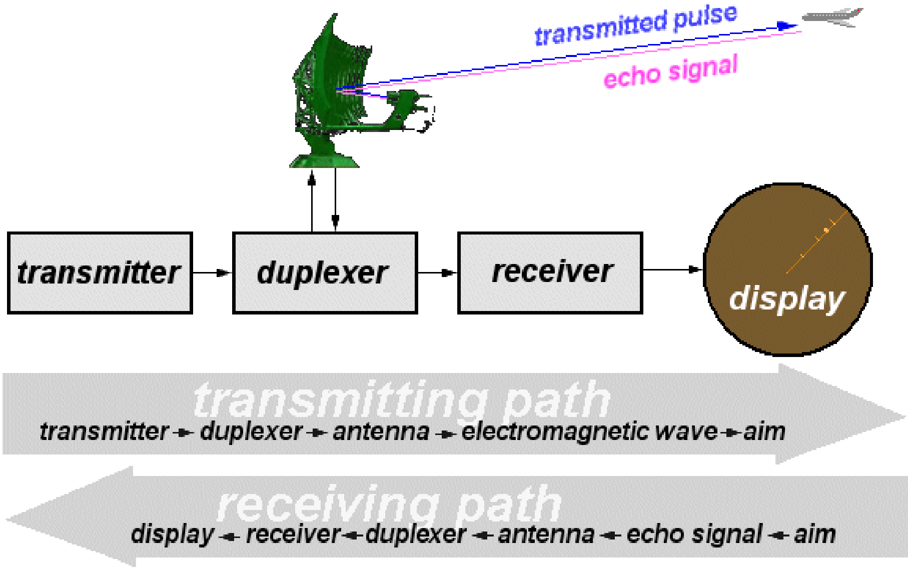


Figure 123: Radar Communication System Principles

4.3.3 Walkie-Talkie Communication Systems

Walkie-talkie communication systems consist of two receivers and two transmitter circuits. In each walkie-talkie, one receiver and one transmitter circuit are used.

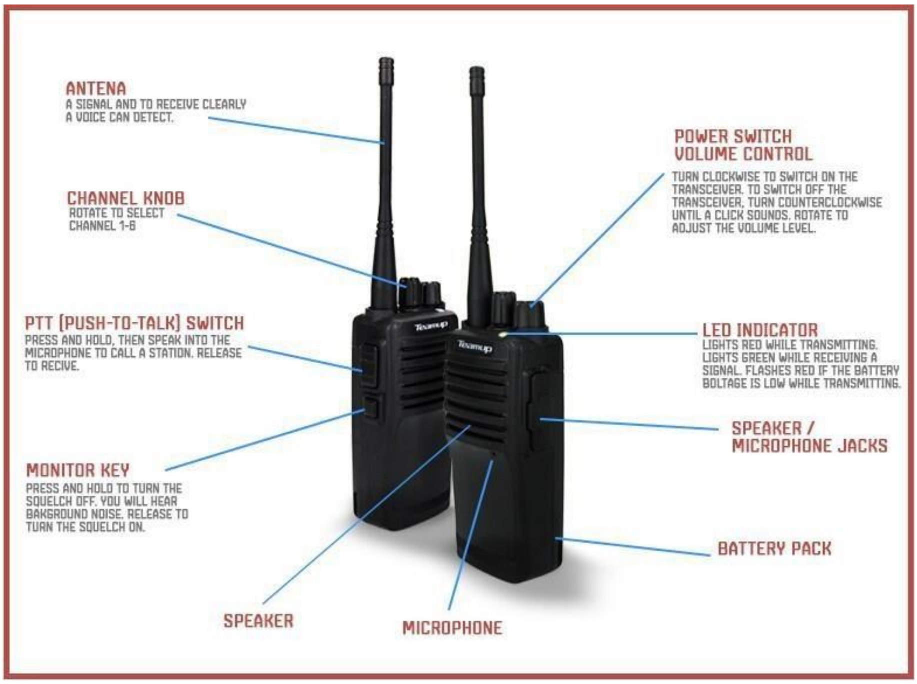


Figure 124: Components of Walkie-Talkie

4.3.4 Internal Communication Systems (Intercom)

An internal communication system is a system that transfers information in the form of an electrical signal from one spot to another within a defined location. It is also a private telecommunication system that typically allows two or more locations to communicate with each other.

An intercom is also a personal telecommunications device which facilitates the exchange of messages between two or more locations where standard vocal communication would be difficult or impossible due to distance or obstructions.

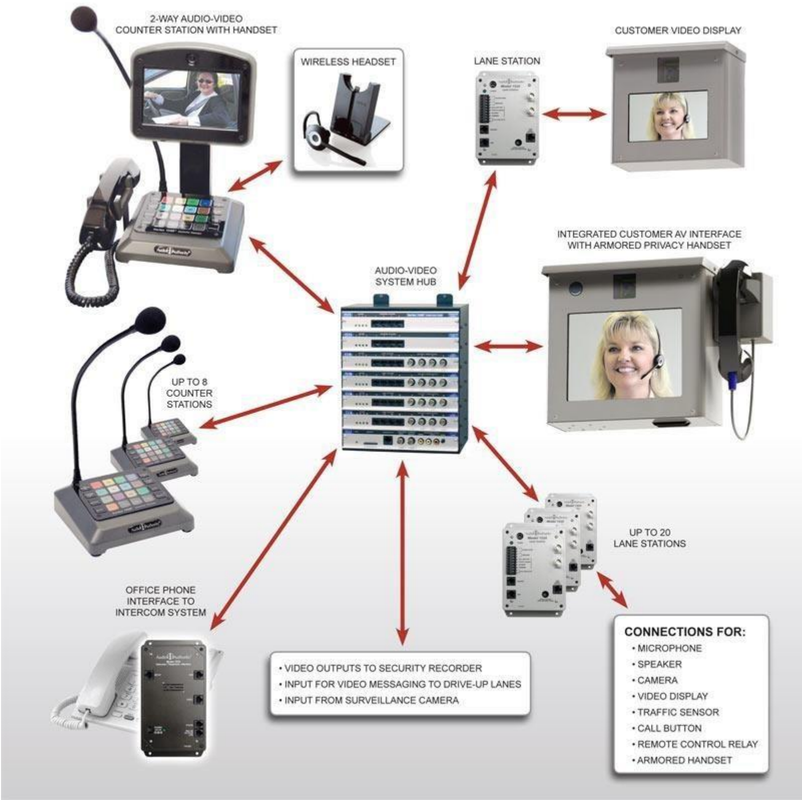


Figure 125: Internal Communication System (Intercom)

4.3.5 Land Mobile Radio (LMR) Communication Systems

LMR systems are wireless communication systems intended for use by terrestrial users in vehicles (mobiles) or on foot (portables).

Such systems are used by emergency first responder organizations such as police, fire, and ambulance services, public works organizations, dispatched services such as taxis, or companies with large vehicle fleets or numerous field staff.

They typically comprise a base station, antenna and multiple mobile two-way radios.

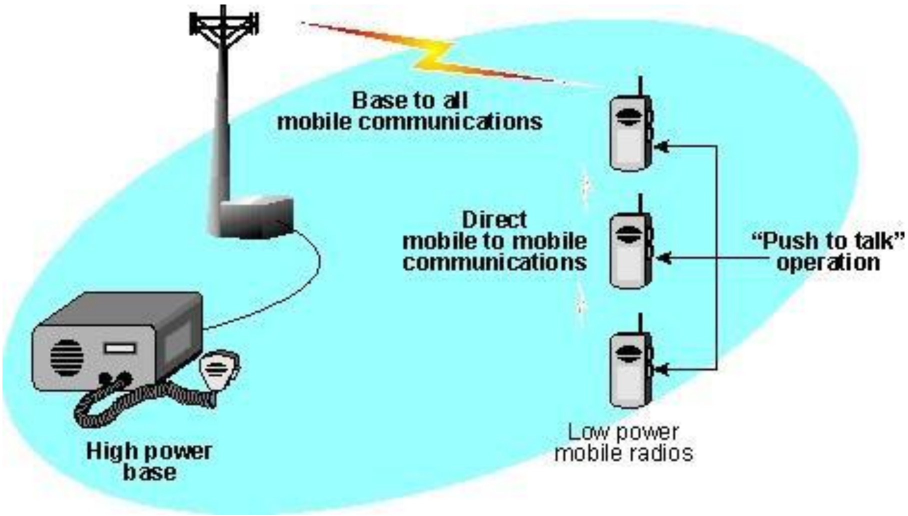


Figure 126: Two-Way Land Mobile Radio (LMR) System Diagram

Figure 127: High Power Base (LMR) Station

4.3.6 Cellular Communication Systems

Cellular communication systems are designed to provide communication between two moving units, or between one mobile unit and one stationary phone or land unit (PSTN).

The main three components in cellular communication system are:

i. Mobile station (MS) – UE, SIM

ii. Base station subsystem (BSS) – BTS, RBS, BSC

iii. Network and switching subsystem (NSS) – MSC, visitor location register (VLR), home location register (HLR)

Figure 128: Cellular Phone

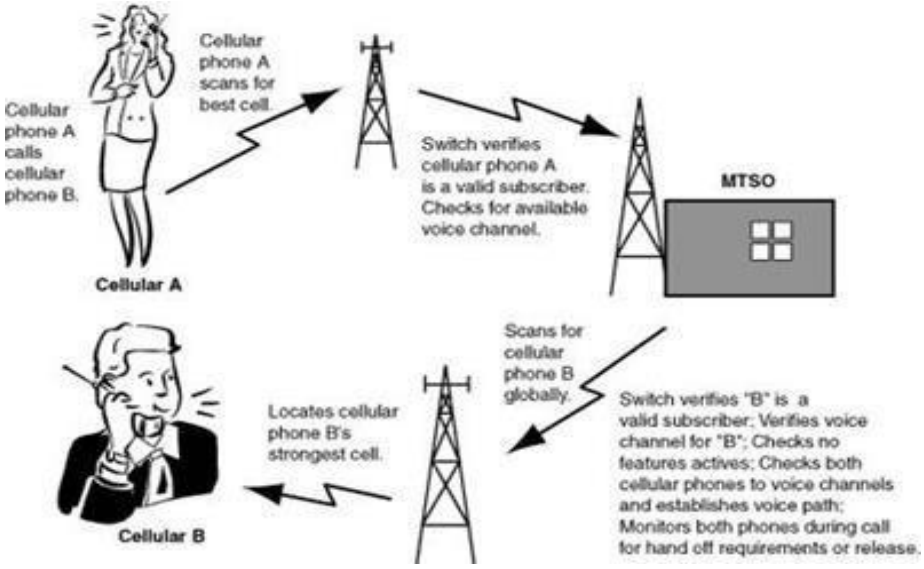


Figure 129: Cellular Communication System

TECHNOLOGY AND PROCESS FLOW PLANNING

1.0 FUNDAMENTALS OF MANUFACTURING

Whilst it would be impossible for most ME valuers to have a detailed knowledge of all the different manufacturing processes and technologies that may exist, it is vital that they know the questions required to obtain the information regarding technologies and process that is necessary for each valuation.

Typically, engineering and operations staff at the manufacturing facility will be key sources of this information, as are manufacturers of equipment and web-based sources.

As part of the initial plant familiarization tour and meetings, the ME valuer should seek to understand:

- the overall manufacturing process,
- the process flow,
- the different types of equipment used in the manufacturing process,
- how capacity is measured at an overall facility, process area/manufacturing line and individual equipment level.

This will inform the ME valuer on the key information to be captured.

Investigations should also be completed with a view to identifying those factors that are likely to have an impact on value. These may be alternative technologies or modern equivalent assets that render the subject assets obsolete to a greater or lesser extent, levels of utilization compared to capacity.

Some useful questions include:

- If you were to replace this facility would you build it exactly as it is today?
- Are there alternative technologies or assets available with either a lower capital or operating cost that can perform the same function as the subject assets?
- How do the subject assets compare to the latest available technologies and assets?
- What would you consider to be the current ‘benchmark’ asset/facility and how does the subject asset/facility compare?
- What are the recent and projected levels of utilization compared to the rated capacity of the facility?
- What is the nominal and actual capacity of the facility and the degree of utility (or ability to deliver a unit of given work capacity) relative to its peer group/competitors?

With regard to the above it is very important to identify the unit(s) of measure that provide(s) the most appropriate basis for comparison.

2.0 APPRECIATION OF PLANT FLOW & LAYOUT

2.1 Introduction to Plant Layouts

The following section provides some examples of different types of plant layout that may be found in different manufacturing facilities.

2.1.1 Department Layout

Room 1	Room 2	Room 3
Painting Department (2)	Assembly Department (1)	Machine Shop Department (3)
Receiving Department (4)	Shipping Department (5)	Testing Department (6)
Room 4	Room 5	Room 6

Figure 1: Department Layout

2.1.2 Functional Layout

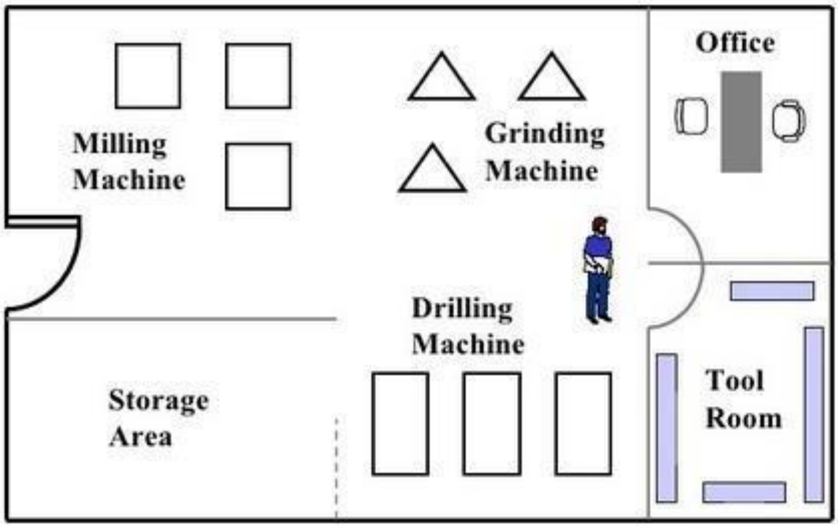


Figure 2: Example of Layout Based on Function

Functional layouts are found primarily in job shops, or firms that produce customized, low-volume products that may require different processing requirements and sequences of operations. Functional layouts are facility configurations in which operations of a similar nature or function are grouped together.

Their purpose is to process goods or provide services that involve a variety of processing requirements. A manufacturing machine such as machine shop generally has separate departments where general- purpose machines are grouped together by function (e.g., milling, grinding, drilling, hydraulic presses, and lathes).

Therefore, facilities that are configured according to individual functions or processes have a functional layout. This type of layout gives the firm the flexibility needed to handle a variety of routes and process requirements.

2.2 Product Layout

Product layouts are found in flow shops (repetitive assembly and process or continuous flow industries). Flow shops produce high-volume, highly standardized products that require highly standardized, repetitive processes. In a product layout, resources are arranged sequentially, based on the routing of the products. In theory, this sequential layout allows the entire process to be laid out in a straight line, which at times may be totally dedicated to the production of only one product or product version. The flow of the line can then be subdivided so that labor and equipment are utilized smoothly throughout the operation.

Two types of lines are used in product layouts: paced and un-paced lines. Paced lines can use some sort of conveyor that moves output along at a continuous rate so that workers can perform operations on the product as it goes by. For longer operating times, the worker may have to walk alongside the work as it moves until he or she is finished and can walk back to the workstation to begin working on another part (this essentially is how automobile manufacturing works).

On an un-paced line, workers build up queues between workstations to allow a variable work pace. However, this type of line does not work well with large, bulky products because too much storage space may be required. Also, it is difficult to balance an extreme variety of output rates without significant idle time. A technique known as assembly-line balancing can be used to group the individual tasks performed into workstations so that there will be a reasonable balance of work among the workstations.

Product layout efficiency is often enhanced through the use of line balancing. Line balancing is the assignment of tasks to workstations in such a way that workstations have approximately equal time requirements. This minimizes the amount of time that some workstations are idle, due to waiting on parts from an upstream process or to avoid building up an inventory queue in front of a downstream process.

Figure 3: An Assembly Line/Product Layout

2.2.1 Fixed-Position Layout

Fixed-position layouts are typical of projects in which the product produced is too fragile, bulky, or heavy to move. Ships, and aircraft are examples. In this layout, the product remains stationary for the entire manufacturing cycle.

Fixed-position layout examples include construction (e.g. buildings, dams, electric or nuclear power plants, shipbuilding, aircraft, aerospace, satellite, etc.). In order to make this work, required resources must be portable so that they can be taken to the job for "on the spot" performance.

Due to the nature of the product, the user has little choice in the use of a fixed-position layout.

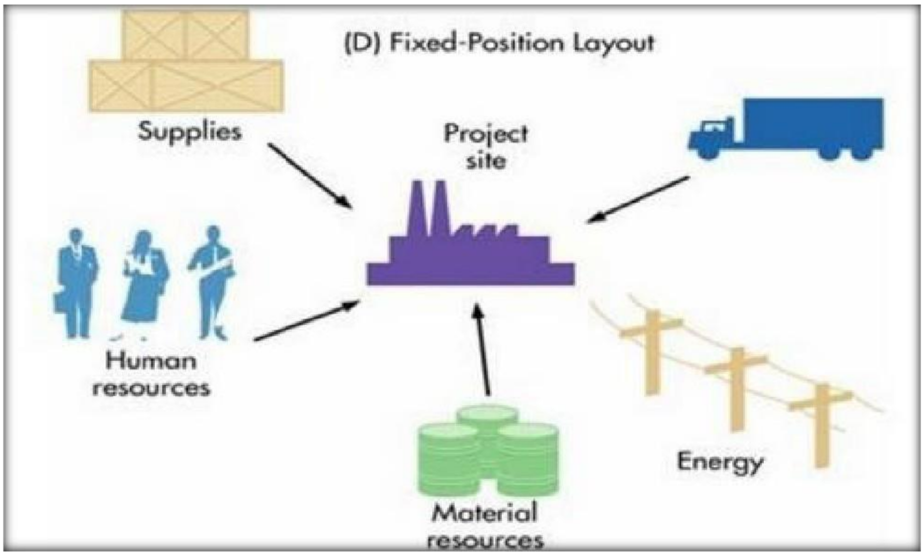


Figure 4: Fixed-Position Layout

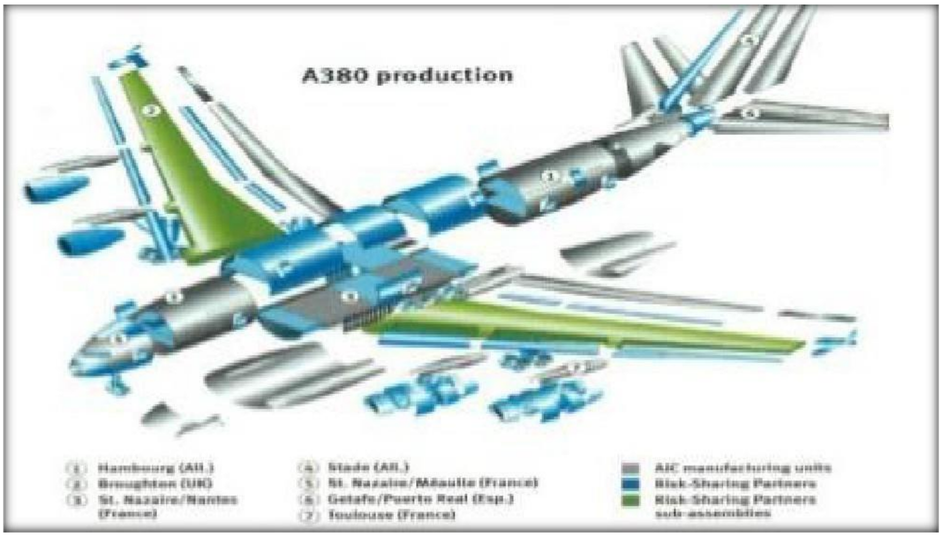


Figure 5: Aircraft Fixed-Position Layout Manufacturing

2.2.2 Cellular Layout

Cellular manufacturing is a type of layout where machines are grouped according to the process requirements for a set of similar items (part families) that require similar processing. These groups are called cells.

Therefore, a cellular layout is an equipment layout configured to support cellular manufacturing.

A lean method of producing similar products using cells, or groups of team members, workstations, or equipment, to facilitate operations by eliminating setup and unneeded costs between operations. Cells might be designed for a specific process, part, or a complete product.

Processes are grouped into cells using a technique known as group technology (GT). Group technology involves identifying parts with similar design characteristics (size, shape, and function) and similar process characteristics (type of processing required, available machinery that performs this type of process, and processing sequence).

Workers in cellular layouts are cross trained so that they can operate all the equipment within the cell and take responsibility for its output. Sometimes the cells feed into an assembly line that produces the final product. In some cases, a cell is formed by dedicating certain equipment to the production of a family of parts without actually moving the equipment into a physical cell (these are called virtual or nominal cells). In this way, the firm avoids the burden of rearranging its current layout.

An automated version of cellular manufacturing is the flexible manufacturing system (FMS). With an FMS, a computer controls the transfer of parts to the various processes, enabling manufacturers to achieve some of the benefits of product layouts while maintaining the flexibility of small batch production.

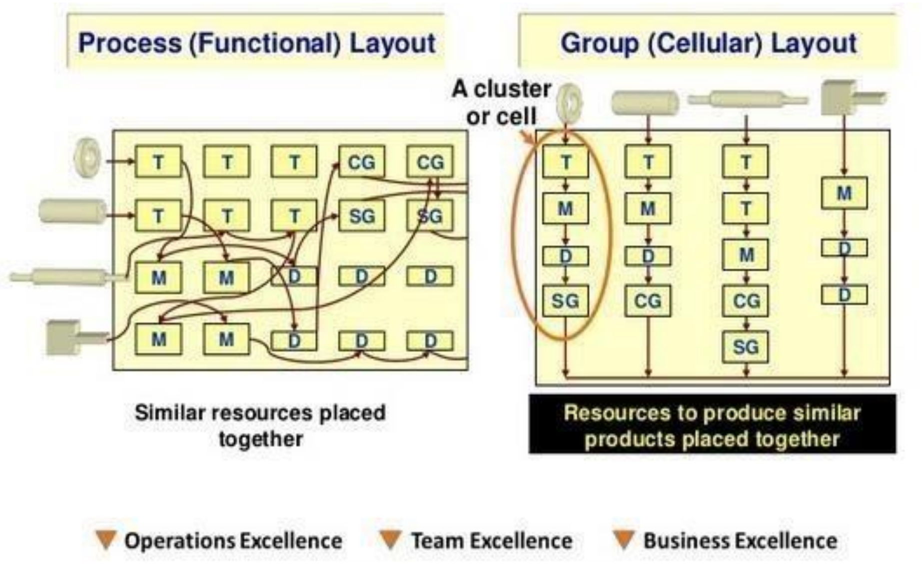


Figure 6: Cellular Layout

2.2.3 Combination Layout

A combination layout (also known as matrix layout combination or matrix layout) combines the advantages of both the process and product layouts. It is used when the same item is being manufactured in different types or sizes.

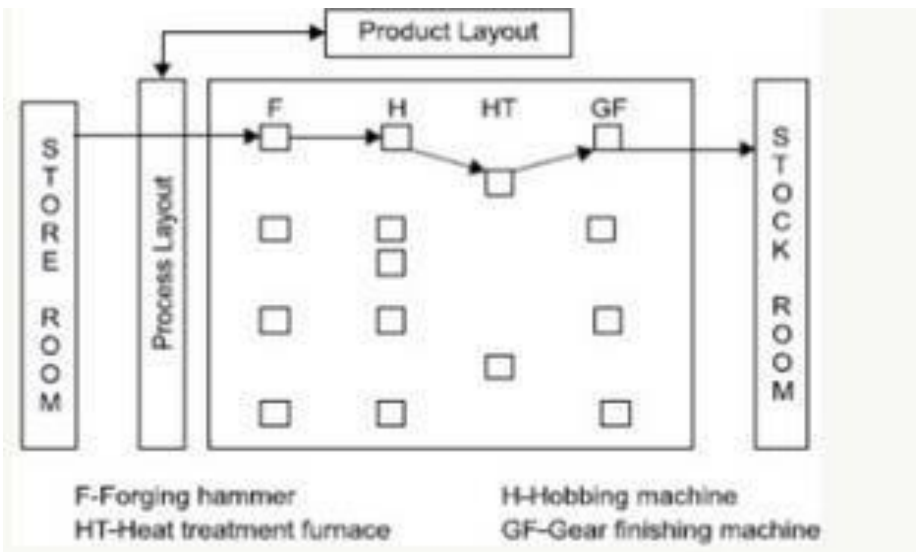


Figure 7: Combination Layout

Many situations call for a mixture of the three main layout types. These mixtures are commonly called combination or hybrid layouts. For example, one firm may utilize a process layout for the majority of its process along with an assembly in one area. Alternatively, a firm may utilize a fixed-position layout for the assembly of its final product but use assembly lines to produce the components and subassemblies that make up the final product (e.g., aircraft). These assembly lines may be on one site or campus, or may be located in varying sites and jurisdictions, but will all work to a common production regime. This will often be based on: “just-in-time” system which reduces inventory holdings by sequencing production and only bringing the required amount of inventory to assembly at the precise time its needed.

3.0 CREATING ASSET SCHEDULES TO REFLECT DIFFERENT PLANT LAYOUTS

One of the key skills to be mastered by a ME valuer, is understanding the most appropriate way to capture the subject assets from a valuation perspective, so that the resulting schedule of assets makes sense to, and can be easily followed by, a reader. Furthermore, using a disciplined approach to capture the assets helps to ensure that there are neither duplications nor omissions.

Some manufacturing operations may be laid out on a geographical or physical basis, where the subject assets are located within separate geographical or physical locations, such as within individual buildings or defined work areas or departments within a building. For instance, machine tools within a larger manufacturing facility, may be located in a separate machine shop or a defined machine shop area within a larger building. It would be logical therefore to capture the assets within this physical location as a separate group of assets.

Further, in a machine shop, where there is no fixed flow of product (or process flow) through the shop, the machine tools and other equipment located within the machine shop, should simply be recorded in a logical walk-round order. This might start in one corner of the machine shop and following the physical layout of the machine tools within the shop.

In other manufacturing operations, within a broad physical location, there may be a clearly defined process flow. This might be a manufacturing or production line where the product passes from one machine, or group of machines, to the next in a defined manufacturing process, where each machine, or group of machines, performs a specific operation in the overall manufacturing process. Car manufacturing, food processing, and building materials production are all examples where logic would dictate that the asset schedule should capture the assets in process flow order.

Plant layout drawings are often available and provide a useful resource to the ME valuer in understanding the components of a manufacturing or production line. Whether the ME valuer uses drawings, physical inspections or a combination of the two, the simple guiding principle is to locate the start of the production line and record the assets sequentially from the start to the end of the line.

In some manufacturing operations, such as oil & gas production and minerals processing, this process flow may have many different circuits and streams, the equipment may be located on different floors within a building, some equipment may be located outside, some in one building and some in another building. The challenge for ME valuers is to understand the process flow and capture the assets in an order that reflects that process flow. This is often very difficult to follow by physical inspection.

Fortunately, in most such operations, process flow diagrams (PFDs) and piping and instrumentation diagrams (P&IDs) provide a valuable resource to ME valuers. Again, the guiding principle is to record the assets in the asset schedule in a process flow order, starting at the beginning of the process and finishing at the end. Separate streams or circuits should be placed logically within the process flow and will typically follow the flow of raw materials through to finished products.

ANATOMY OF PROCESS PLANT: CASE STUDY - SUBSTATION

1.0 DEFINITION

An electrical substation is a subsidiary station of an electricity generation, transmission and distribution system, or within a manufacturing facility, where voltage is transformed from high to low, or the reverse, using transformers. Electric power may flow through several substations between generating plant and consumer and may be changed in voltage in several steps. Between the generating station and consumer, electric power may flow through several substations at different voltage levels. A substation may include transformers to change voltage levels between high transmission voltages and lower distribution voltages, or at the interconnection of two different transmission voltages.

A substation is a high-voltage electric system facility. It can be used to switch generators, equipment, and circuits or lines in and out of a system. It can be used to change AC voltages from one level to another, and/or change alternating current to direct current or direct current to alternating current. Some substations are small with little more than a transformer and associated switches. Others are very large with several transformers and dozens of switches and other equipment.

A substation may be owned and operated by an electrical utility or may be owned by a large industrial or commercial customer.

2.0 ELEMENTS OF A SUBSTATION

Substations generally contain one or more transformers, and have switching, protection and control equipment. In a large substation, circuit breakers are used to interrupt any short-circuits or overload currents that may occur on the network. Smaller distribution stations may use recloser circuit breakers or fuses for protection of branch circuits.

Substations do not (usually) have generators, although a power plant may have a substation nearby. A typical substation will contain, high-voltage switchgear, one or more power transformers, low voltage switchgear, surge protection, controls, grounding (earthing) system, and metering. Earthing is the process of transferring the intermediate discharge of electrical energy directly to the earth via a low resistance wire. Other devices such as power factor correction, capacitors and voltage regulators may also be located at a substation.

Substations may be located on the ground surface in fenced enclosures, underground, or located in special-purpose buildings. High-rise buildings may have indoor substations. Indoor substations are usually found in urban areas to reduce the noise from the transformers, for reasons of appearance, or to protect switchgear from extreme climate or pollution conditions.

3.0 SUBSTATION TYPES

There are two types of substations used in electrical systems:

3.1 Transmission Substation

A **transmission substation** connects two or more transmission lines. The simplest case is where all transmission lines have the same voltage. In such cases, the substation contains high-voltage switches that allow lines to be connected or isolated for fault clearance or maintenance. A transmission substation may have transformers to convert between two transmission voltages, voltage control/power factor correction devices such as capacitors, reactors or static VAR (Volt-Ampere Reactive) compensators and equipment such as phase shifting transformers to control power flow between two adjacent power systems.

Transmission substations can range from simple to complex. A small "switching station" may be little more than a bus plus some circuit breakers. The largest transmission substations can cover a large area (several acres/hectares) with multiple voltage levels, many circuit breakers, and a large amount of protection and control equipment.

A transformer that increases voltage from primary to secondary is called a *step-up* transformer. Conversely, a transformer designed to do just the opposite is called a *step-down* transformer.

- Step-up transmission substation

  Receives electric power from a nearby generating facility and uses a large power transformer to increase the voltage for transmission to distant locations.

- Step-down transmission substation

  These substations are located at switching points in an electrical grid. They connect different parts of a grid and are a source for sub transmission lines.

3.2 Distribution Substation

A distribution substation transfers power from the transmission system to the distribution system of an area. It is uneconomical to directly connect electricity consumers to the main transmission network, unless they use large amounts of power, so the distribution station reduces voltage to a level suitable for local distribution.

The input for a distribution substation is typically at least two transmission or sub-transmission lines. Input voltage may be, for example, 115 kilovolt (kV), or whatever is common in the area. The output is a number of feeders. Distribution voltages are typically medium voltage, between 2.4 KV and 33 KV, depending on the size of the area served and the practices of the local utility. The feeders run along streets overhead (or underground, in some cases) and power the distribution transformers at or near the customer premises.

In addition to transforming voltage, distribution substations also isolate faults in either the transmission or distribution systems. Distribution substations are typically the points of voltage regulation, although on long distribution circuits (of several miles/ kilometers), voltage regulation equipment may also be installed along the line.

The downtown areas of large cities feature complicated distribution substations, with high-voltage switching, and backup systems on the low-voltage side. More typical distribution substations have a switch, one transformer, and minimal facilities on the low-voltage side.

These are located near to the end-users. Distribution substation transformers change the sub transmission voltage to lower levels for use by end-users.

Substations are designed to accomplish:

- Change voltage from one level to another.
- Regulate voltage to compensate for system voltage changes.
- Switch transmission and distribution circuits into and out of the grid system.
- Measure electric power qualities flowing in the circuits.
- Connect communication signals to the circuits.
- Eliminate lightning and other electrical surges from the system.
- Connect electric generation plants to the system.
- Make interconnections between the electric systems of more than one utility.
- Control reactive kilovolt-amperes supplied and the flow of reactive kilovolt-amperes in the circuits

4.0 SUBSTATION COMPONENTS

The substation is an assembly of the following major electrical equipment:

- Switchgear
- Switchboard
- Electrical power transformers
- Instrument transformers
- Conductors and insulators

- Isolators
- Bus bars
- Lightning arresters
- Circuit breakers
- Relays
- Capacitor banks and miscellaneous equipment
- Standby generator set
- Firefighting system

4.1 Switchgear

The switchgear refers to the collection of switching devices required for a low, medium or high voltage electrical circuit. It consists of switching and protection devices such as fuses, circuit breakers, isolators, disconnect switches, relays and other devices that control the flow of electricity.

These devices are used to switch the electric power on and off for transformers, motors, generators, transmission lines and distribution systems.

The switchgear consists of two main components:

- Power switching/conducting component such as a circuit breaker, fuse or lightning arrester that can disconnect the flow of power when there is a fault.
- Power control components such as protective relays, control panels, current transformers and other devices to monitor, protect and control the power conduction components and the electrical equipment.

Switchgear is classified according to the voltage levels involved in the circuit of application. The three classes are:

- High voltage switchgear
- Medium voltage switchgear
- Low voltage switchgear

Switchgear is typically of the metal cubicle enclosed, floor mounted, extensible and indoor type.

The basic technical details to be recorded for switchgear includes:

- Manufacturer
- Type

- Voltage
- Load (amperage)
- Number of sections

Figure 1: Switchgear

4.2 Switchboard

The switchboard refers to a large single panel, assembly of panels, a structural frame, on which busbar, switches and protective and other control devices may be mounted. The mounting may be done on the face, the back side or both.

The electrical distribution equipment is designed to redirect and control the flow of electricity from one or multiple sources, to several different sections or loads. A switchboard can therefore be used to distribute power to individual loads, control equipment, transformer, panel boards etc.

The main role of a switchboard is to allow the incoming electric power to be divided into independent circuits according to their current requirements. The circuit breakers as well as over current protection devices for each of the sections are selected according to the load current.

Once the currents are divided, they are then distributed according to the load, i.e. lighting loads, sockets etc. Some switchboards such as those used in residential apartments have an option of metering to see the amount of power used by individual circuits.

Major components of a switchboard:

- **Panels or frames:** to hold devices such as switches, circuitry indicates and other devices that allow the delivery of power and controlling of the circuits.
- **Controls and monitoring devices:** to connect and control single or multiple power sources to and from the switchboard. These may be including frequency gauges and other instruments to measure the frequency and synchronization of the power generators.
- **Busbars:** to carry and distribute the incoming power from source to different sections of the installation through the switchboard and control devices.

Figure 2: Switchboard

The basic technical details to be recorded for switchboards includes:

- Manufacturer
- Type
- Voltage
- Load (amperage)
- Number of sections

4.3 Electrical Power Transformer

A static electrical machine used for transforming power from one circuit to another without changing frequency is termed as power transformer.

Power transformers are generally used to step down or step up the voltage levels of a system for transmission and generation purposes. These transformers are classified into different types based on their design, utilization purpose, installation methods and so on.

The basic technical information to be recorded for a step-down (or step-up) transformer includes:

- Manufacturer
- Type
- Rating in kilo-volts ampere (kVA) or mega-volts ampere (MVA)
- Low and high voltages in Volts (V) , kilo-volts (kV) or Mega-Volts (MV)

An example of a power transformer shown in below is a three-phase type, oil immersed and hermetically sealed type (with rating shown) with cooling of the oil-natural-air-natural (ONAN) type. This type is suitable for both indoor and outdoor operations.

Figure 3: Power Transformer

4.4 Instrument Transformers

The current and voltage transformers are together called the instrument transformers.

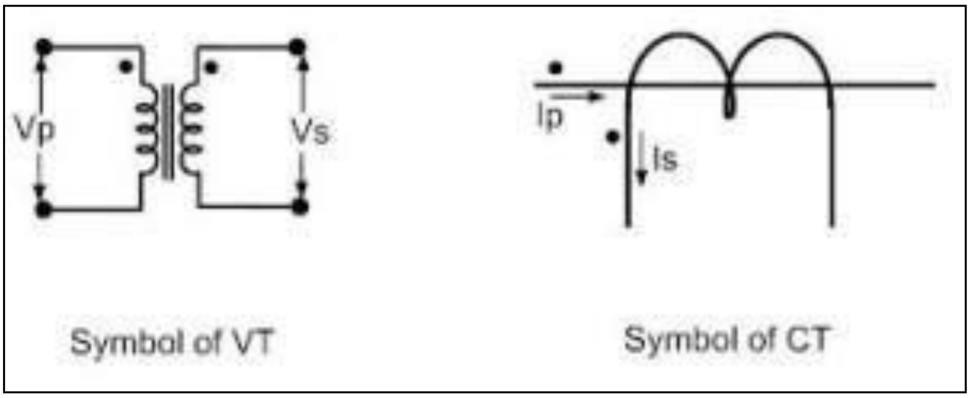


Figure 4: Symbol of VT and CT

There are two types of Instrument Transformer:

a. Current Transformer

Current transformer is used for the measurement of the alternating current by taking samples of higher currents of the system. It provides a secondary current that is in accurate proportions to the current flowing in its primary. These are used for installation and maintenance of the current relays in substations for protection purpose which are normally has low-current ratings for their operation.

b. Potential Transformer

Potential transformer is quite similar to the current transformer. It is used for taking samples of high voltages of a system for providing low- voltage to the relays of protection system and meters for voltage measurement. From this low-voltage measurement, the actual system's high voltage can be calculated without measuring high voltages directly to avoid the cost of the measurement system.

4.5 Conductors and Insulators

a. Conductors

A material that allows the flow of electric charge is called conductor. These are used for the transmission of power or electrical energy from one place to another through substations. Conductors are of different types and mostly aluminum conductors are preferred in practical power systems.

Basic technical details to be recorded for conductors include type/materials of construction, size and length. However, conductors may not be listed as separate assets and are typically included as part of a composite asset such as an overhead power line.

b. Insulators

A material (usually ceramic) which does not allow free movement of electrons or electric charge is called an insulator. Hence, insulators resist electricity with their high resisting property. There are different types of insulators such as suspension type, strain type, stray type, shackle, pin type. Types of insulators are shown in the **Figure 5.** Insulators are used for insulation purposes while erecting electric poles with conductors to avoid short circuit and for other insulation requirements.

Insulators are rarely listed as separate assets and are typically included as part of a composite asset such as an overhead power line.

Figure 5: Types of Insulators

4.6 Isolators

An isolator is a manually operated mechanical switch that isolates one section of a conductor, or a part of a circuit of a substation from another section in order to avoid the occurrence of faults. Hence, it is also called a disconnector or disconnecting switch. There are different types of isolators used for different applications such as single-break isolator, double-break isolator, bus isolator, line isolator, etc.

The basic technical details to be recorded for isolators includes type and voltage.

Figure 6: Isolators

4.7 Busbars

The conductor carrying current and having multiple numbers of incoming and outgoing electrical line can be called bus bar, which is commonly used in substations. These are classified into different types like single bus, double bus and ring bus. Busbars usually from part of a switchboard and as such are not typically listed separately.

Figure 7: Busbars

4.8 Lightning Arresters

Substation equipment such as conductors, transformers, etc., is erected outdoors. Lightning arresters are placed to pass lightning surges to earth, to avoid damage to outdoor electrical equipment.

4.9 Circuit Breakers

For the protection of a substation and its components from over currents or overload due to short circuit or any other fault, the faulty section is disconnected from the healthy section either manually or automatically. Once the fault is rectified, the original circuit can be rebuilt manually or automatically. Different types of circuit breakers are designed based on different criteria and usage, but the most commonly used circuit breakers are oil circuit breakers, air circuit breakers, Sulphur hexafluoride (SF6) circuit breakers, vacuum circuit breakers, etc.

Circuit breakers typically form part of a switchboard and are therefore not typically listed separately.

4.10 Capacitor Banks

A capacitor bank is a set of many identical capacitors connected in series or parallel within an enclosure and is used for the power factor correction and basic protection of substation. These capacitor banks act as a source of reactive power, and thus, the phase difference between voltage and current can be reduced by the capacitor banks. They will increase the ripple current capacity of the supply. It avoids undesirable characteristics in the power system. It is the most economical method for maintaining power factor and of correction of the power lag problems.

The basic technical information to be recorded for capacitor banks includes manufacturer and rating measured in Kilovolt-Ampere Reactive (kVAR).

4.11 Stand-By Generator Sets

A stand-by generator set is the combination of an electrical generator and an internal combustion engine mounted together to form a single piece of equipment that produces electrical power. In the generator, referred to as an alternator, the mechanical work of the engine generates electrical power. Generator sets are used in sites that are not connected to the power grid or to supply emergency power when the grid fails. Generator sets may also be employed to produce energy during peak usage hours when the energy costs are the highest, to decrease the amount of electricity that must be purchased from the utility company, in a power-saving application called peak shaving.

The basic technical information to be captured for a stand-by generator includes:

- Manufacturer
- Type of driver (diesel, petrol, etc. engine)
- Rating measured in kVA or KW
- Working hours

Figure 8: Generator Set

4.12 Firefighting Systems

Among the most common firefighting systems located in substations are:

i. Fixed Automatic Aqueous Firefighting Systems

Fixed automatic aqueous firefighting systems where required, are typically used on external oil transformers and bulk oil equipment. Water spray systems are used for fire protection of the following:

- Flammable liquids associated with transformers;
- Electrical hazards including outside yard transformers and oil switches.

Water spray systems, where required, incorporate automatic deluge valve assemblies and open spray nozzles with pipework arrays to direct water onto the surfaces of external transformers and bulk oil equipment.

ii. Water Supply for Fire Sprinkler Systems

Water based fire suppression systems can be served from the local water mains with a fire brigade booster inlet to allow the brigade to boost the water supply to the system. Where a substation is remote from local water mains, water storage tanks and diesel backed pumps are provided to supply the suppression systems.

iii. Water Sprinkler Systems Activation

Water spray systems are activated automatically with fusible links or bulbs.

The water spray suppression system is monitored with flow switches to signal activation to the Supervisory Control and Data Acquisition (SCADA) system.

iv. Fire Hydrants

Fire hydrants are used to fight substation fires only after full electrical isolation.

v. Gas Suppression System

A specific blend of gases may be used to control, fires in sub stations, especially if they also include any of the following environments:

- DATA centers
- Communications rooms
- Telecommunication facilities
- UPS rooms
- Medical facilities

The basic technical information to be recorded for gas suppression systems includes:

- Manufacturer
- Type

Measures of size/capacity can include (as appropriate):

- Number of sprinklers, nozzles, hydrants, etc.
- Number and size of gas cylinders
- Length and diameter of piping (where covering a large area)
- Area covered

5.0 CASE STUDIES OF VALUATIONS OF SUBSTATION EQUIPMENT

The following are some examples of substation components that are included in the valuation of a substation.

5.1 Components in a Water Treatment Plant Substation

No.	Component/ Substation Area	Description
a	**Transformer Room** "EWT" 2000 kilovolt-Amps (kVA) Oil-Natural- Air-Natural (ONAN) Transformer	**Includes the following:** • Carbon dioxide (CO2) system • Comes with 4 - 75 kilograms of CO2 cylinders and gas pipe work, valves, nozzles, control panel bells, indicator lights, key switches, fuse wiring, detectors and all associated accessories.
b	**Main Switchboard Feeder Panel** 1600 x 800 x 2100 mm Main Switchboard Feeder @ 2 Panels	Consist of 2 panels: 1. Incomer No. 1 and phase indicating light 2. Incomer No. 2 and phase indicating light **Includes the following Fire Fighting Facility:** • Carbon dioxide (CO2) system • Comes with 8 - 75 kilograms of CO2 cylinders and gas pipe work, valves, nozzles, control panel bells, indicator lights, key switches, fuse wiring, detectors and all associated accessories.
c.	**Incoming Supply Main Switchboard** "STARLITE" 'MSB' 1400 x 1000 x 2100 mm Main Switchboard @ 2 Panels	Consists of 2 panels: 1. MSB 1 • 1000A Three Phase Neutral (TPN), Air Circuit Breaker (ACB) Incoming Supply • "Mikro" 'MK1000A' Overcurrent and Earth fault relay meter • Light indicator 2. MSB 2 • 1000A TPN ACB Incoming Supply • "Mikro" 'MK1000A' Overcurrent and Earth fault relay meter • Light indicator
d	**415 Volts Main Switchboard**	Consists of 5 panels: 1. Supply to capacitor bank switch

No.	Component/ Substation Area	Description
	7900 x 800 x 2200 mm Main Switchboard Feeder @ 5Panels	• "Hokkim" 'HL-14' power factor regulator • Light indicator 2. Switch Board • "Mikro" Earth fault relay meter • Dewatering Plant MCC switch • "Mikro" Earth fault relay meter • MCC switch • "Mikro" Earth fault relay meter • Air compressor panel switch • Air blower room switch • 2 spare switches 3. Wash water recovery plant switch • "Mikro" Earth fault relay meter • Starter Panel and 8 switches • Clarifier MCC switch • Chemical MCC switch • Chlorination building MCC switch • 2 - Spare switch 4. Protection relays for 800A TPN ACB • “Mikro” Earth fault relay meter • “Mikro” Over current relay meter 5. 415 v Incoming supply from 2000 kVA Transformer • “Mikro” Earth fault relay meter • “Mikro” Over current relay meter • Switches and light indicator “Tempower” air circuit breaker

Refer to **the table below** for valuation details:

WATER TREATMENT PLANT

Substation	Cost New (SAR)	Adjusted Factor	Adjusted Value (SAR)	DOM	Actual Age	EL	Dep.	Unit	Value (New) (SAR)	Value (DRC) (SAR)
1) Transformer Room "EWT" 2000 kVA ONAN Transformer **Fire Fighting Facility** Co2 System: c/w 4 nos.- 75 kg. Co2 cylinders and gas pipe work, valves, nozzles, control panels bell, indicator light, keys switch, fuse wiring, detectors and all associated accessories.	3,000,000	1.00	3,000,000	2002	13	30	0.36	2	6,000,000	2,160,000
2) Main Switchboard Feeder Panel 1600 X 800 x 2100 mm Main Switchboard Feeder @ 2 panel consist of: Panel 1: Incomer No 1 and phase indicating light Panel 2: Incomer No 2 and phase indicating light **Fire Fighting Facility** Co2 System: c/w 8 nos.- 75 kg. Co2 cylinders and gas pipe work, valves, nozzles, control panels bell, indicator light, keys switch, fuse wiring, detectors and all associated accessories.	40,000	1.00	40,000	2002	13	30	0.36	2	80,000	28,800
3) Incoming Supply Main Switchboard "STARLITE" 'MSB' 1400 X 1000 X 2100 mm Main switchboard @ 2 Panels **Panel 1:** MSB 1 1000 A TPN ACB Incoming Supply "Mikro" 'MK1000A' Overcurrent and earth fault relay meter Light indicator **Panel 2:** MSB 2 1000 A TPN ACB Incoming Supply "Mikro" 'MK1000A' Overcurrent and earth fault relay meter Light indicator.	40,000	1.00	40,000	2002	13	30	0.36	2	80,000	28,800

4) 415V Main Switchboard 7900 X 800 x 2200 mm Main Switchboard Feeder @ 5 panel consist of: **Panel 1:** Supply to capacitor bank switch “Hokkim” ‘HL-14’ Power factor regulator Light indicator **Panel 2:** SSB No. 1 Switch “Mikro” Earth fault relay meter Dewatering Plant MCC switch “Mikro” Earth fault relay meter Damp 1 MCC switch “Mikro” Earth fault relay meter Air compressor panel switch Air blower room switch 2 – spare switch **Panel 3:** Wash water recovery plant switch “Mikro” Earth fault relay meter Starter Panel Damp 2 and Damp 3 switch “Mikro” Earth fault relay meter Clarifier MCC Switch “Mikro” Earth fault relay meter Chemical MCC Switch Chlorination building MCC switch 2 – spare switch **Panel 4:** Protection relays for 800A TPN ACB (SSB 1) “Mikro” Earth fault relay meter “Mikro” Over current relay meter **Panel 5:** 415V Incoming supply from 2000 kVA Transformer “Mikro” Earth fault relay meter “Mikro” Over current relay meter Swithes and light indicator “Tempower” Air circuit breaker	50,000	1.00	50,000	2002	13	30	0.36	5	250,000	90,000
TOTAL									**6,410,000**	**2,307,600**

DOM – Date of Manufactured, EL – Economic Life, Dep. -Depreciation

5.2 Substation Components in An Airport Air Ground Lighting Substation

No.	Component	Description

a.	**33 kV Switchgear**
	
	“ABB" ZVZ with SF 6 Insulated switchgear
		• Cubicle type
		• 33 kV, gas insulated
		• Double switchgear panel for:
		  ○ feeder circuit with translay protection
		  ○ 30 MVA transformer circuit
		  ○ busbar coupler equipment
		  ○ busbar-section equipment

b.	**Power Transformer**
	
	"MTM" ' 30 MVA 33/11 kV power transformer
		• Type NT 1
		• 3-phase
		• 21/30 MVA
		• Cooling ONAN
		• Comes with:
		  ○ Control Panel
		  ○ Testing and commissioning

c.	**11 kV Switchgear**
	
	"ABB" 'Univer C/2 11 kV Double busbar busbar cubicle type switchgear
		• Panel for:
		• 30 MVA transformer circuit
		• 11/0.415 kV 300 kVA transformer circuit
		  ○ 1600A feeder circuit
		  ○ 630A feeder circuit
		  ○ busbar coupler equipment
		  ○ busbar-section equipment

d.	**Auxiliary (Distribution) Transformer** "MTM" '1000 kVA 11/0.415 kV Distribution Transformer	• Outdoor ONAN Type. • Dyn 11 Vector group • Comes with off-load tap charger • Testing and commissioning
e.	**415 V LV Main Switchboard B**" Air Circuit Breaker	• Air Circuit Breaker
f.	**Battery and charger equipment**	• Direct Current (DC) System (10V 35A dual) • "SAFT" SCB 100-110-35 Charger • Comes with DC 110V Distribution Panel • "SBM" '112' Battery

No.	Component	Description

g.	**33 kV Control and Relay Panel**	• "ABB" 'RNC' 33 kV Control and Relay Panel,
		• Control for:
		  ○ feeder circuit
		  ○ 30 MVA circuit
		  ○ busbar coupler equipment
		  ○ busbar-section equipment
		• (to remote operation and monitoring of 33 kV switch gear)
		• Control Circuit Breaker (CB) Via SCADA selected to the Supervisory Control position

h.	**11 kV Master Control Panel**	• "ABB" 'RNC' 11 kV Control and Relay Panel, • (To remote operation and monitoring of 11 kV switchgear) • Control Circuit Breaker (CB) Via SCADA selected to the Supervisory Control position.
i.	**11 kV Neutral Earthing**	• "Post Glover" 11 kV Neutral Earthing Isolator • with Grid Type NER (Neutral Earthing Resistor) • for each 33/11 kV Substation. • NER rated 4 Ohms restrict any fault current • less than 1600A • Plus connection and bonding
j.	**Marshalling Cubicle**	• Equipment for supervising
k.	**Cables**	• Power Cables and all its accessories • 1,828.0 m • Auxiliary and Control Cables, • for 33 kV Switchgear and Control Panel • 2,250 m • Cable Rack and Tray
l.	**Test and commissioning equipment**	• 33 kV Equipment • 11 kV and 415 V related equipment
m.	**Others**	• metalclad • switch • wiring • trenching • lighting

DOM – Date of Manufactured, EL – Economic Life, Dep. -Depreciation

Refer to **the table below** for valuation details:

AIRPORT AIR GROUND LIGHTING SUBSTATION

Substation	Cost New (SAR)	Adjusted Factor	Adjusted Value (SAR)	DOM	Actual Age	EL	Dep.	Unit	Value (New) (SAR)	Value (DRC) (SAR)
5) 33KV Switchgear "ABB" ZVZ with SF 6 Insulated switchgear, Cubicle type. 33kV, Gas Insulated, double switch gear panel for: - Feeder circuit with translay protection - 30 MVA transformer circuit - Busbar coupler equipment - Busbar section equipment	1,070,287 443,352 281,281 2,210,881 2,210,881	1.00	2,210,881	2002	13	30	0.36	1	2,210,881	795,917
6) Power Transformer "MTM'30 MVA 33/11 kV Power Transformer Type NT 1 3 phase 21/30 MVA Cooling ONAN/ONAF c/w Control Panel Testing & Commissioning	705,312 4,200 709,512	1.00	709,512	2002	13	30	0.36	1	709,512	255,424
7) 33 kV Switchgear "ABB" Univer c/2 11 kV Double busbar cubicle type switchgear. Panel for: - 30 MVA transformer circuit - 11/0 415 kV 300 kVA transformer circuit - 1600A feeder circuit - 630A feeder circuit - busbar coupler equipment - Busbar section equipment	288,943 60,242 103,303 461,397 109,473 120,775 1,144,133	1.00	1,144,133	2002	13	30	0.36	1	1,144,133	411,888
8) Auxiliary (Distribution) Transformer "MTM' 1000 kVA 11/0.415 kV Distribution Transformer - Outdoor ONAN Type - Dyn 11 Vector group - c/w off-load tap charger Testing & Commissioning	45,540 367 45,907	1.00	45,907	2002	13	30	0.36	1	45,907	16,526

9) **415 V LV Main Switchboard** "ABB" Air Circuit Breaker	20,045	1.00	20,045	2002	13	30	0.36	1	20,045	7,216
10) **Battery and Charger Equipment** DC System (10V 35A dual) "SAFT" SCB 100-110-35 charger c/w DC 110V Distribution Panel "SBM" '112' Battery	77,900	1.00	77,900	2002	13	30	0.36	1	77,900	28,044
11) **33KV Control and Relay Panel** "ABB" 'RNC' 33 kV control and relay panel. Contro & Control: - feeder circuit - 30 MVA circuit - busbar coupler equipment - Busbar section equipment (to remote operation & monitoring of 33KV switchgear, control CB via SCADA selected to the supervisory control position)	258,961 133,363 168,360 42,246 602,930	1.00	602,930	2002	13	30	0.36	1	602,930	217,055
12) **11 kV Master Control Panel** "ABB" 'RNC' 11 kV control and relay panel (to remote operation & monitoring of 11 kV switchgear, control CB via SCADA selected to the supervisory control position)	68,068	1.00	45,907	2002	13	30	0.36	1	68,068	24,504
13) **11 kV Neutral Earthing** "Post Glover" 11 kV Neutral Earthing Isolator with Grid Type NER (Neutral Earthing Resistor) for each 33/11 kV Substation. NER rated 4 Ohms restrict any fault current less than 1600A Plus, connection & bonding	69,635 46,449 116,084	1.00	116,084	2002	13	30	0.36	1	116,084	41,790
14) **Marshalling Cubicle** For supervising equipment	9,310	1.00	9,310	2002	13	30	0.36	1	9,310	3,351
15) **Cables** Power Cables and all its accessories – 1828 m Auxiliary & Control Cables for 33 kV switchgear & control panel – 2250 m Cable Rack & Tray	344,625 52,550 49,998 446,173	1.00	446,173	2002	13	30	0.36	1	446,173	160,622

16) Testing & Commissioning - 33 kV Equipment - 11 kV & 415 V related equipment -	19,656 15,400 15,400	1.00	15,400	2002	13	30	0.36	1	15,400	5,544
17) Others - Metalcald switch - wiring - trenching - lighting	77,297	1.00	9,310	2002	13	30	0.36	1	77,297	27,826
TOTAL									**5,563,296**	**2,002,786**

REPORT WRITING

1.0 FUNDAMENTALS OF REPORTING

1.1 What is Reporting?

In valuation terms, Reporting refers to informing the client (and potentially other stakeholders who may use or rely upon the valuation) regarding your valuation findings in accordance with the engagement agreement. Valuation findings may be presented in many different forms, and may include preliminary, indicative findings as well as the detailed final narrative valuation report ("the Report").

The Report is the final step in the valuation process and presents the valuers' conclusions with consolidated facts, observations, findings, opinions and recommendations for the client, within the context set out in the engagement scope. The Report also presents a collection of data which is thoughtfully adapted to meet the needs of the report readers to help them make informed decisions within a professional context.

The Report must be able to express the valuation task performed by the valuer and clearly describe the interest to be valued. As the report is an extension of the valuer's professional work, it must be concise, structured and prepared in line with professional valuation standards and corresponding regulations, law and accounting or other financial and/or commercial conventions.

The client may act on/make decisions based on the Report, therefore it is important to ensure it is an accurate reflection of the work performed, and clearly states any underlying assumptions and limitations.

The Report is typically produced solely for the individual/company to whom it is addressed and should not be shared with other parties without the authors' prior, written agreement. This is usually required from a contractual and liability perspective.

However, the valuer must be mindful of the fact that if agreed at the time of engagement, the valuation may be shared with, and/or relied upon, by other stakeholders (e.g. auditors, lending bank etc.). It is also important to understand that other parties may have a different perspective or motivation when considering the valuation conclusion, which may not align with the purpose for which the valuation was performed.

In addition to communicating the relevant information to the client/intended user, a valuation report may also be used as follows:

a. Acts as a legal document supporting a valuation.

b. May be a comparable for future valuations.

c. As a source of future reference in update valuations.

1.2 Basic Requirements of a Quality Report

The Report is often considered to be the final deliverable, submitted to the client on completion of a valuation engagement. Great care must be taken in the presentation and content of such reports, particularly to ensure the legal duty of care under professional standards is fulfilled.

Comprehensive, structured and well-written reports are characterized by:

a. Clear and logical relay of all relevant information and reasoning.

b. Short, concise and simple sentences.

c. Readability and comprehensiveness.

d. Clear reference to the facts and assumptions set out within the report, which lead to the value conclusion.

e. Use of appropriate words, summaries and illustrations (plans, photographs etc.).

f. Thorough research that is convincingly and accurately presented and summarized.

g. Use of language that is readily understood by the client and intended users of the report.

h. Clear from any misrepresentations, omission of importance facts and hearsay evidences.

i. Numbered (indexed) paragraph for easy reference.

j. Availability of a table of contents for easy reference.

k. Fair and reasonable opinion of value that is supported by sound evidences.

l. Valuer's CV which is evidence that the individual is capable of performing the valuation.

International Valuation Standards 2020 (IVS)

According to General Standards IVS 103 Reporting (2020), paragraph 10.3 states that valuation reports may range from comprehensive narrative reports to abbreviated summary reports.

IVS 103 Reporting (2020) paragraph 30.1 requires that a valuation report, which is the result of an assignment involving the valuation of an asset or assets, must convey the following, at a minimum:

a) the scope of the work performed, including the elements noted in para 20.3 of IVS 101 Scope of Work, to the extent that each is applicable to the assignment,

b) the intended use,

c) the approach or approaches adopted,

d) the method or methods applied,

e) the key inputs used,

f) the assumptions made,

g) the conclusion(s) of value and principal reasons for any conclusions reached, and

h) the date of the report (which may differ from the valuation date).

IVS 101 Scope of Work (2020), paragraph 20.3 requires that the scope of work must disclose the following:

a) Identity of the valuer.

b) Identity of the client(s) (if any).

c) Identity of other intended users (if any).

d) Asset(s) being valued.

e) The valuation currency.

f) Purpose of the valuation.

g) Basis/bases of value used.

h) Valuation date.

i) The nature and extent of the valuer's work and any limitations thereon.

j) The nature and sources of information upon which the valuer relies.

k) Significant assumptions and/or special assumptions.

l) The type of report being prepared.

m) Restrictions on use, distribution and publication of the report.

n) That the valuation will be prepared in compliance with IVS and that the valuer will assess the appropriateness of all significant inputs.

2.0 VALUATION REPORT FORMAT AND CONTENTS

The Report must clearly and accurately set out the conclusions of the valuation in a manner that is not ambiguous, misleading, or creates a false impression. It must comply with the Terms of Reference (TOR) and scope of work agreed between the client and the valuer at the beginning of the engagement.

The Report must provide sufficient information to permit those who read and rely upon the report (intended users) to fully understand its data, reasoning, analyses and conclusions. It must state any assumptions and limiting conditions upon which the valuation is based.

The contents of the Report depend on the type of the machinery and equipment valued and the purpose of valuation. The minimum requirements to be contained in the Report include the following:

2.1 Instructions to Value

The Report should clearly state the instructions, establish client's needs and requirements, confirm services to be provided and state that it is confidential to the client for the specific purpose to which it refers, or the terms and conditions if it is to be shared with third parties. In this part, it should include the client's instructions whether verbal or ideally confirmed in writing; if the latter, the date of letter, from whom, and other details.

2.2 Purpose of Valuation

The Report must state clearly the purpose of the valuation such as financial reporting, internal management purposes, loan security, insurance, commercial decision-making purposes, etc. If the valuation is to be adopted in accordance with certain regulations (e.g. International Financial Reporting Standards), this should also be clearly stated.

The purpose of the valuation is important as it will determine the relevant basis of value, the valuation methods, inputs and assumptions adopted, as well as the value conclusion.

2.3 Date of Valuation

The value of an asset may vary at any given point in time; therefore, the date of valuation must be agreed with the client in advance and clearly stated in the Report. The valuation date is typically decided by the client and may be at the date the key information is provided, the date of the site inspection, or at a specified historical date.

If a valuation at a future date is required, the valuer should carefully consider if this is reasonable or possible, based on the nature of the assets and the market in which they operate. Report caveats and limitations should be carefully considered – ideally a valuation at the current or a historical date should also be provided to provide context to the valuation. In general, valuations at a future date are not to be encouraged as they are projections not valuations and if they are to be provided, valuers should agree and document limitations in advance in order to protect the valuer and fully inform the client regarding limitations.

2.4 Inspection

The Report must contain the date on which the machinery and equipment was inspected by the valuer or his designated assistant.

If the inspection was performed with reference to information provided by the client (e.g. equipment inventory listings, fixed asset registers or process flow diagrams), this should be clearly stated in the report.

The report should clearly state the purpose and extent of the inspection, i.e.:

a. To leverage existing data and obtain additional information relevant to the valuation – this may only require an overview physical inspection of a representative sample of the principal assets.

b. To prepare an asset listing or verify the accuracy of existing lists – this may require more time on site to enable the team to obtain relevant factual data regarding the assets, e.g. location, descriptions, make, model, year of construction etc.

c. To prepare a technical listing (this may include a condition assessment) – if any reliance is to be placed on the technical condition assessment, it would typically be performed by an engineer with relevant qualifications/experience regarding the assets.

2.5 Definition of Plant, Machinery and Equipment

Plant, machinery and equipment constitutes a class of property other than real property (in the US, it is referred to as personal property). For accounting standards these are classified as tangible assets – this includes both plant, machinery and equipment and real estate (land and building) assets.

Plant, machinery and equipment are individually defined as follows:

a. Plant includes assemblage of assets that may include specialized non-permanent buildings, machinery and equipment.

b. Machinery includes individual machines or a collection or assemblage of machines. A machine is an apparatus using or applying mechanical power, having several parts each with a definite function, and together performing certain kind of work.

c. Equipment includes ancillary assets that are used to assist the function of the enterprise.

2.6 Description of Plant, Machinery and Equipment

The valuation report must contain a description of the plant, machinery and equipment included in the valuation (often referred to as the "In

Scope Assets", or "Subject Assets") and ideally also the following information:

a. Macro Description

The macro description should include items such as the business operation, roles and functions of the plant, machinery and equipment as a whole. It includes the key components that contribute to the design and capabilities of the plant along with product capacity & output of finished goods. It should include:

i. Name, address and details of the company.

ii. Overview of the production process, production capacity and output/utilization and additional output (if any).

iii. Operational hours / shifts.

iv. Maintenance programs & planned shutdowns.

v. Annual maintenance costs for three years leading up to the valuation.

vi. Process configuration/optimum space utilization compared to the latest plant technology.

vii. Suitability of machinery and equipment for stated purpose.

viii. Modern equivalent technology & identification of obsolete/outdated machinery and equipment.

ix. Quality certifications/accreditations.

x. Compliance with the provisions of existing legislation such as the Environmental, Occupational Health and Safety Act and others.

b. Micro Description

Micro description is a detailed description of each individual item of machinery and equipment inspected. The specific features of each asset should be identified, as follows:

- Description
- Make/brand name
- Manufacturer
- Model
- Type/function
- Capacity / size
- Serial number
- Accessories / ancillary assets
- Additional equipment/extras

- Year of manufacture
- Condition
- Year of commissioning (if different to year of manufacture)
- Country of origin

c. Workflow Process

The detailed description of the process flow of machinery and equipment must be clearly stated and explaining operation the process machinery and equipment from beginning to end. Disclosures should cover every major part of the plant.

2.7 Assumptions

The Valuer may make certain assumptions during the valuation, and these should be discussed and agreed with the client ideally before commencing the work or during the engagement, where necessary.

Such assumptions and special assumptions used in the valuation can have significant impact on the opinion of value and conclusions.

IVS 104 paragraph 200.2 lists two categories of assumptions:

1) **assumed facts that are consistent with, or could be consistent with, those existing at the date of valuation, and**
2) **assumed facts that differ from those existing at the date of valuation.**

These assumptions should be clearly stated in the valuation report.

Examples of valuation assumptions are provided below:

Condition:

"we understand that the assets are maintained in accordance with global manufacturer recommendations, and therefore have assumed that asset condition is commensurate with the stated age of each asset"

Extent of Inspection:

"we have not arranged for nor carried out any mechanical or electrical tests on any of the equipment included in this report, limiting our examination the outward physical appearance and to information received as to the history and condition of the equipment."

Regulatory Compliance:

"we have assumed that the machinery and equipment are fit for the purposes for which they are intended to be used and comply with all the relevant bye-laws and statutory regulations."

Assumed Profitability:

"we have assumed that the in-scope assets will continue in use in their current location and configuration as part on an ongoing, profitable business. Until this assumption is confirmed or rebutted, the outcome of this valuation cannot be relied upon as a definitive measure or fair or market value and hence further advice and input in this regard may be required from auditors and/or business valuers."

Excluded Assets:

"the valuation excludes stock/inventory and any value attributable to goodwill, technical drawings, patterns, patents, software, work-in progress and all other items not specifically referred to in this report."

"we have excluded any third-party assets, or assets located at other locations not specified in this report."

Reliance on Third Party Data:

"our analysis is based primarily on information provided by [xxx] and is limited, relative to the quantity and accuracy of the data provided."

2.8 Basis of Valuation

The valuer should identify the relevant basis or bases of value, based on the purpose of the valuation and terms of engagement. It should then relate with the relevant definition and requirements, including any appropriate assumptions, special assumptions or premises of value adopted.

The official definition should be provided, together with the data source – this may be a regulatory body (i.e. TAQEEM, the IVS), in KSA statute or defined by other parties. The valuer should clearly show the client how the definition is applied.

IVS 104 paragraph 20.1(a) provides list of bases of value which are widely used globally:

1) **Market Value,**
2) **Market Rent,**
3) **Equitable Value,**
4) **Investment Value/Worth**
5) **Synergistic Value, and**

6) **Liquidation Value.**

Note: other non-IVS bases of value relevant to machinery and equipment valuation and prescribed by law, regulation or other international counterparts include:

1) Fair Value (International Financial Reporting Standards).

Any special assumptions should also be clearly stated – these relate solely to the basis of value adopted and may include:

a. The assets are sold:

- In their current location, as part of an ongoing business with assumed profitability (“going concern”)
- In their current location as a single group of assets in isolation from any wider business or undertaking (“in situ”)
- As individual items for removal (“ex situ”)

b. Marketing period – the period of time should be clearly stated and may reflect:

- A reasonable marketing period; or
- A limited marketing period

c. Insurance valuations – may be provided as follows:

- On an indemnity basis, i.e. to reflect compensation for damage/injury
- On a Reinstatement with New basis (on the assumption that the insurance policy includes this clause)

2.9 Valuation Approaches

All available valuation approaches should be clearly stated, with an explanation as to how each approach was considered and which one(s) were selected to determine asset value. Internationally recognized approaches are defined in the IVS and include the market, income and cost approaches.

2.10 Information Provided

The Report should clearly state the key information (including sources) which was relied on as part of the valuation process. The valuer should also explain how they obtained comfort regarding the accuracy of this data, or if their advice is wholly reliant on the information provided.

2.11 Opinion of Value

This is the final part of the Report. All factors take into consideration to derive recommendation value must be stated in the Report.

2.12 Valuer's Qualification

Name and signature of the valuer – the report should be signed by the valuer and the membership number must be stated.

2.13 Appendices

a. Asset Overview

The Report should include a summary of each location, including the production type, capacity & year of construction

b. Photographs

The report shall include relevant photos especially photos of the plant and machinery.

c. Machinery and Equipment Description

The Report shall include details and description of the machinery and equipment to be valued. This may be a limited overview, or the valuation conclusions may be assigned to individual assets, as an addendum to the Report.

3.0 COMMON MISTAKES IN A VALUATION REPORT

Mistakes that are often detected in Reports include:

The following required data is often not clearly stated:

a. Client and or intended user of the Report

b. Terms of Reference (TOR) – may often be a vague reference only

c. No reference to IVS 2020 Standards or Code of Ethics

d. Valuation purpose & accounting/reporting requirements (e.g. IFRS, GAAP, etc.) not clearly stated, or reference to the wrong/out of date Financial Reporting Standards (e.g. Statement of Standard Accounting Practice (SSAP-28)

e. Basis of value – we often see "Fair Market Value" referred to; this is typically a USPAP tax valuation derived basis of value and is not recognized in the IVS. Additionally, "Going Concern Value" is not a term defined in the IVSC glossary and should not be used as it is considered to be a business valuation term. The only defined bases of value in the IVSC glossary relevant to Machinery & Equipment valuations, are

Market Value, Fair Value (IFRS 13/ASC 820) and Liquidation Value although valuations for insurance purposes will be determined on a basis of value consistent with the basis of insurance (either indemnity or reinstatement). Typically, Fair Value should be used (if for the financial reporting purposes) or Market Value (if for other purposes). As Fair Value may have several definitions, always state under which accounting / valuation convention, e.g. IFRS Fair Value and the corresponding accounting standard definition.

f. Clear assumptions and limitations not always provided

g. Inappropriate disclaimers included

h. Marketing period

i. Valuation date

j. Assets to be valued – including summary & location

k. Ownership – the Report does not explicitly state the assumed interest/ownership status of the assets to be valued

Valuation Approach:

a. Should include consideration of all available approaches – this is often missing

b. Adopted approach & methodology is often unclear

c. Valuation inputs, e.g. comparable sales evidence, asset lives, depreciation type, residual value, etc. – are not always included

d. Valuation adjustments/specific assumptions are not always clearly stated

e. Market overview/condition is often not mentioned in the report, but provides good context/background to support the valuation conclusion

Other Considerations:

a. Values do not tally throughout the report – a math-check should be performed to ensure all numbers in tables, figures and text reconcile

b. Figures without comma or reporting currency in valuation summaries

c. Information sources – external reference sources are not always provided

d. Valuation team/CVs – evidence that the valuer has sufficient qualifications & experience to perform the valuation is not always provided

4.0 SAMPLE VALUATION REPORTS

Refer attachment on **Appendix B** for sample of **Mobile Crane Valuation Report and Appendix D** for sample of **Substation Valuation Report**. The corresponding sample engagement letters for the sample valuation reports are detailed in **Appendix A** and **Appendix C** respectively.

APPENDICES

Appendix A: Sample Mobile Crane Valuation Engagement

Private and Confidential

15 January 2020

Your ref: [INSERT]

ABC Company

Our ref: [INSERT]

Attention: [Insert name of individual and title]

ABC Company
ABC Street,
ABC Dist.
123456 Riyadh,
Saudi Arabia

Direct Line: xxxx:

Email: xxx

Letter

Dear Sirs,

Valuation of A Mobile Crane on The Basis of Market Value in Accordance With IVS

Thank you for choosing XYZ Company for Valuation Services ("we") to perform certain professional services (the "Services") for ABC company ("you" or "Client"), relating to the valuation of a mobile crane (the "Subject Asset") effective as of 1 February 2021 (the "Valuation Date"). The valuation will be carried out in accordance with International Valuation Standards (IVS) issued by the International Valuation Standards Council (IVSC) and regulations and guidance published by the Saudi Authority for Accredited Valuers (TAQEEM). We appreciate the opportunity to assist you and look forward to working with you.

This cover letter, together with all of its appendices, exhibits, schedules and other attachments (collectively, this "Agreement"), describes and documents the arrangements between us, including our respective obligations. The scope of the Services is set out in the Statement of Work at Appendix A, together with details of our fees and billing arrangements. Any additional terms and conditions specific to the Services are set out in Appendix B, including restrictions on the disclosure and use of our advice and reports.

Please sign and return the enclosed copy of this Agreement to confirm your agreement with these arrangements and return it to me at your earliest convenience. If you have any questions about these arrangements, please contact [insert contact person's name and telephone number].

Yours faithfully

[Name]

Machinery Equipment Valuer – (100000000) Machinery & Equipment Division

AGREED

ABC Company
By (Authorised Representative):

Signature: ____

By: [Name and Title] ___________________________________

Date: ____

Appendix A – Statement of Work

Appendix B – General Terms and Conditions

Appendix A

Scope of Work

Scope of Services

You have instructed us to consider the valuation of a mobile crane effective as of 1 February 2021 (the "Valuation Date"). We understand the valuation is required regarding a potential sale of the Subject Asset and will be carried out in accordance with International Valuation Standards (IVS) issued by the International Valuation Standards Council (IVSC) and regulations and guidance published by the Saudi Authority for Accredited Valuers (TAQEEM).

We will:

- Collect the fixed asset data provided by ABC Company in relation to the Subject Asset.
- Conduct a site inspection in order to better understand the nature, condition and operation of the Subject Asset and to compare and contrast our site observations to the data provided.
- Conduct market research.
- Conduct valuation analysis of the Subject Asset. The Subject Asset reflects information provided by ABC Company and our observations during the site visits or in discussions with ABC Company.
- Hold interviews with ABC Company to discuss the replacement costs, age, existing market data and the condition of the Subject Asset including any factors that may impact the value of the Subject Asset.

Further explanation is provided below. Our role is to provide you with advice and recommendations for your consideration. We will not perform any management functions or make any management decisions.

As the engagement progresses, you may decide that you wish to vary the scope of work. We will discuss such matters with you and any changes to the scope of work will be agreed between us in writing.

Limitations to Scope

We will not, except to such extent as you request and we agree in writing, seek to verify the accuracy of the data, information and explanations provided by yourselves, and you are solely responsible for this data, information and explanations. We will therefore rely on the information provided by you to be accurate and complete in all material respects.

The valuation will be provided to you for the above purpose only and should not be used or relied upon for any other purpose, nor should it be disclosed to, or discussed with, any other party without our prior consent in writing, save as set out in Section 12 of the attached terms of business.

Purpose

We understand that ABC Company require assistance in considering and assessing offers made by third parties to potentially acquire the Subject Asset. Therefore, the results of our work will be used solely for the purpose of providing ABC Company's management with an opinion of Market Value of the Subject Asset (the Purpose).

Basis of Valuation

According to IVS 104, the standard/premise of value to be used is Market Value. The Standard defines Market Value as follows:

"Market Value is the estimated amount for which an asset or liability should exchange on the valuation date between a willing buyer and a willing seller in an arm's length transaction, after proper marketing and where the parties had each acted knowledgeably, prudently and without compulsion."

This will be the definition of value that we will apply in the provision of the Services.

Valuation

In the context of the valuation of an asset there are, broadly speaking, three different approaches, which are:

- Market-based approaches;
- Income-based approaches; and
- Cost-based approaches.

While each of these approaches is usually considered in the initial valuation of an asset, the nature and characteristics of the asset will determine the most applicable approach/approaches in a particular set of circumstances and in this context the basis is most likely to be market value.

Conduct of the Services

Assignment Team

This assignment will be conducted under the direction of [Name of Engagement Partner/Director] in the [XXX] team at [XXX]. They will be assisted by [Name of Engagement Manager] who is an [rank] in the [XXX] team at [XXX], who will have day-to-day responsibility for the intangible asset valuation work.

[Name of Review Partner], a Partner/Director in the [XXX] team at [XXX], will be Review Partner/Director on this assignment

Timetable

We will commence work [immediately / immediately on written confirmation from you that the terms of the assignment as set out in this letter are accepted / or on [Insert Date]] and we will aim to report our opinion of value no later than [X weeks from the receipt of all pertinent information or on [Insert Date]]. In order to meet this timetable, we will need timely access to management and the receipt from you of the necessary information. Receipt of information is expected within [14] days of acceptance of this letter. As you will appreciate, however, any such timetable is based on the assumption that we will receive the appropriate co-operation and assistance and be able to complete our market enquiries. If we do not, however, then we cannot be held responsible for any delays.

We will notify you as soon as practicable if it appears likely that there will be any significant delays in the above timetable.

Fees

I would refer you to the section 1 of the Fees – additional terms and conditions below for an explanation of our basis of charging and other matters related to our fees and invoicing arrangements. [If an estimate is supplied, include the following wording:] As this is an estimate, however, our fees may be more or less than this amount.

Fees – Additional Terms and Conditions

Our fees are subject to the provisions set out in the General Terms and Conditions contained in Appendix B and to the following additional terms and conditions.

1. Except to the extent that more specific fee arrangements are stated above, our fees will be based on:

- The number and seniority of staff required
- The degree of skill and responsibility involved
- The resources required to complete the Services
- The fee rates for the appropriate personnel

2. Any fee estimate agreed with you is necessarily based on the assumption that the information required for the Services is made available in accordance with agreed timetables and we have access to you and your key staff as required. If delays or other unanticipated problems which are beyond our control occur this may result in additional fees for which invoices will be raised, including where we need to carry out substantial further work due to changes in KSA law or tax authority practice.

3. If at any point you decide to terminate this engagement, we will be entitled to charge you for any unbilled work that we have undertaken up to the date of termination, in accordance with the General Terms and Conditions.

Invoicing Arrangements

We will issue an invoice every 30 days with our first invoice being issued as we commence work and our final invoice being issued on completion of the Services. Expenses and any applicable taxes will be added to each invoice as incurred.

Invoice amounts will be based on our best estimate of work undertaken in the next 30 days adjusted for variances in the previous month.

Payment

Invoices are payable immediately upon presentation.

Information Requirements

All information (which we reasonably request given our scope of work) will be provided to us within a mutually agreeable period of time. As we become aware of the need for further information, we will discuss this with you.

In respect of all our work we will be reliant on the accuracy and completeness of the underlying information that you supply to us. We will not verify this information and therefore will not check the accuracy of the information or any explanations provided

If you are not able to provide us with any of the information we have requested, this may affect our ability to conclude our valuation in the terms indicated above or at all. We will inform you of any restrictions to our valuation or the reliance which may be placed on it as a result of incomplete information.

In addition to the evidence supplied, our valuation will be based on discussions with management and our own research into the market and industry within which the Subject Asset operates.

Presentation of Results

The results of our work will be documented in a single narrative report ("Report") outlining the valuation methodologies and conclusions. The valuation and our recommendations will be provided to you for the Purpose only and must not be used or relied upon for any other purpose, and the Report must not be disclosed to, or discussed with, any other party without our prior written consent.

Appendix B

[Insert specific valuer's specific terms of business etc.]

Appendix B: Sample Mobile Crane Valuation Report

XYZ Company for Valuation Services

ABC Street,

ABC Dist.,

123456 Riyadh,

Saudi Arabia

ABC COMPANY

Valuation of A Mobile Crane on The Basis of Market Value

28 February 2021

XYZ Company for Valuation Services

XYZ Street,

XYZ Dist.,

123456 Riyadh,

Saudi Arabia

28 February 2021

ABC Company

ABC Street,

ABC Dist.

123456 Riyadh,

Saudi Arabia

Dear Sirs,

In accordance with your instructions, we have performed the work set out in our engagement agreement dated 15 January 2021(the Engagement Agreement) regarding the identification and valuation of a mobile crane located at ABC Company's Riyadh Cement Plant (the Subject Asset) as at 1 February 2021 (the Valuation Date).

Purpose of Our Report and Restrictions on Its Use

We understand that ABC Company require assistance in considering and assessing offers made by third parties to potentially acquire the Subject Asset. Therefore, this report (Report) was prepared solely for the purpose of providing ABC Company with an opinion of Market Value of the Subject Asset (the Purpose).

This Report and its contents may not be quoted, referred to or shown to any other parties except as provided in the Engagement Agreement. We accept no responsibility or liability to any person other than to ABC Company.

Nature and Scope of the Services

The nature and scope of the services, including the basis and limitations are detailed in the Engagement Agreement.

We performed our work considering applicable professional guidance, including International Valuation Standards (IVS) issued by the International Valuation Standards Council (IVSC) and regulations and guidance published by the Saudi Authority for Accredited Valuers (TAQEEM). When we were performing our work, we acted independently.

The contents of our Report have been reviewed by Management, who have confirmed to us their factual accuracy.

Whilst each part of our Report addresses different aspects of our work, the entire Report should be read for a full understanding of the basis for our valuation conclusions.

We appreciate the opportunity to provide our services to ABC Company. Please do not hesitate to contact us if you have any questions about this engagement or if we may be of any further assistance.

Yours faithfully,

[VALUER NAME]

Machinery Equipment Valuer – (100000000) Machinery & Equipment Division

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Valuation Overview

1.0 Purpose and Objective

At the request of ABC Company, XYZ Company for Valuation Services performed a valuation of a certain tangible asset (the Subject Asset) as at the 1 February 2021 (the Valuation Date). We understand that the purpose of the valuation was to provide ABC Company with an opinion of Market Value of the Subject Asset. Consequently, the results of our analysis will be used solely for the purposes of assisting Management with their internal decision-making purposes.

We understand that ABC Company require assistance in considering and assessing offers made by third parties to potentially acquire the Subject Asset. Therefore, the purpose of our work was to provide recommendations of Market Value of the Subject Asset of ABC Company in accordance with International Valuation Standards (the Purpose).

2.0 Basis of Value

The proposed sale of the Subject Asset involves the sale for removal from the present location and therefore the appropriate basis of value will most likely be market value assuming an ex-situ valuation premise.

The standard/premise of value adopted in this Report is Market Value, which is defined as follows:

*Market Value is the estimated amount for which an asset or liability should exchange on the valuation date between a willing buyer and a willing seller in an arm's length transaction, after proper marketing and where the parties had each acted knowledgeably, prudently and without compulsion. (*IVS 104 *Bases of Value).*

Such market valuations will generally exclude any costs/benefits of installation. Potential purchasers will also most likely take into consideration any costs associated with removal, relocation (including tax/duties, etc.), installation and re-commissioning. As the Subject Asset is a mobile crane, these costs are not significant. Ex-situ defined as follows:

Valuation based on the assumption of subject assets being removed from their current location on basis of piecemeal (breakup) disposal (e.g. auction) or removal of entire asset base as single package

Title to the Subject Asset is assumed to be good and marketable unless otherwise stated. The Subject Asset is further assumed to be free and clear of any or all liens, easements or encumbrances unless otherwise stated.

3.0 Subject Asset

This valuation is in respect of a Liebherr LTM 1095-5.1 mobile crane located at ABC Company, Riyadh Cement Plant. Please refer to **Appendix I** for a detailed description of the Subject Asset. Photographs of the Subject Asset are provided at **Appendix II.**

4.0 Scope of Work

The scope of our engagement included:

- Collection of the fixed asset data provided by ABC Company in relation to the Subject Asset.
- Site inspection in order to better understand the nature, condition and operation of the Subject Asset and to compare and contrast our site observations to the data provided.

- Interviews with ABC Company to to understand the nature of Subject Asset, including their type, configuration, usage, operational capabilities, and maintenance; amongst other aspects considered.
- Market research.
- Valuation analysis of the Subject Asset. The Subject Asset reflects information provided by ABC Company and our observations during the site visits or in discussions with ABC Company.

5.0 Limitations

In accordance with our Engagement Agreement and the transmittal letter that accompanies this Report, our analysis is subject to the limiting conditions contained in this Report.

6.0 Currency

Unless otherwise noted, all currency amounts are quoted in Saudi Riyal (SAR).

Valuation

7.0 Valuation Procedures

In order to value the Subject Asset, we undertook the following procedures:

- Data collection and reconciliation
- Site inspection
- Engineering meetings and interviews
- Cost and market research
- Valuation methodology selection and analysis

The first phase of our analysis began with our data collection procedures. We worked in conjunction with ABC Company to identify what information was critical to the analysis and to also identify what information was readily available.

We held discussions with ABC Company to develop a comprehensive list of the data required for the valuation analysis including financial and operating data for the Subject Asset. We independently developed and collected additional data to aid in deriving our value conclusions.

Initially, ABC Company provided us with an electronic copy of the fixed asset register (FAR). The FAR contained descriptive information including ownership company, asset type, location, asset code, asset description, purchase date, purchase price, accumulated depreciation and net book value.

The following list details additional data items collected and utilised in our valuation analysis:

- Balance sheet information
- Equipment maintenance records with descriptive information on the Subject Asset's manufacturer, model, serial number, capacity and model year
- Facility drawings illustrating the plant layout

8.0 Site Inspection

A site inspection in relation to the Subject Asset was completed on 1 February 2021 as presented below.

NAME	DESIGNATION
Valuer Name 1	ME Valuer, Machinery and Equipment Division, TAQEEM
Valuer Name 2	ME Valuer, Machinery and Equipment Division, TAQEEM

The site inspection allowed us to better understand the nature, condition and operation of the Subject Asset and to compare and contrast our observations to the information provided. During our site inspection, we noted and gathered supplementary information such as make, model, size, design capacity, materials of construction, age, observed physical condition and current use for the Subject Asset.

9.0 Engineering Meetings and Interviews

In addition to the site inspection, we consulted with ABC Company management and gathered additional detailed information necessary to perform the valuation of the Subject Asset. This included meetings with the engineering personnel involved in the construction and purchasing of new equipment to:

- Understand the processes being employed.
- Develop replacement cost estimates.
- Understand the overhaul and maintenance history of the Subject Asset.
- Gather technical data and cost trends.

10.0 Cost and Market Research

In conducting our valuation, where possible, we have undertaken independent research by contacting a limited number of original vendors and new and used suppliers of the Subject Asset. During these conversations, we discussed the current market demand for the types of assets being valued as well as replacement costs for new equipment and potential Market Values for refurbished or used equipment. We also researched various publicly available sources of information regarding cost trends and sector specific inflationary indices. These suppliers and publicly available sources of information included, but were not limited to:

- Industry journals & publications, including:
- XXX Journal
- Various auctioneers

Subsequent to the procedures described previously, we used the data provided in conjunction with information gathered as the basis for our valuation analysis.

11.0 Methodology Selection and Analysis

The methods and procedures used to perform the valuation of the Subject Assets are intended to conform to standards promulgated by the IVSC and TAQEEM.

We considered the three main approaches to value (market, income and cost approaches) and the methods that comprise these approaches. Based on the nature of the Subject Asset and information available, we concluded on the market approach as being the most appropriate to value the Subject Asset.

At its simplest, the *market approach* requires the *valuer* to make comparisons with other *assets*, directly or indirectly, to derive, extract or corroborate relevant inputs. The *market approach* relies on sales of comparable *assets* to provide an indication of value for the Subject Asset.

12.0 Application of the Market Approach

In conducting our valuation, we have undertaken independent research by holding discussions with Management and contacting original equipment manufacturers and auctioneers/suppliers related to the Subject Assets. During these conversations we discussed the current the market environment in which mobile cranes are bought/sold, to better understand asset demand, potential purchasers, disposal channels/markets and trends. We also held discussions to obtain sales comparison data such as comparable transactions, which help to quantify value.

In order to meaningfully analyse the data, we undertook the following procedures:

- Independent used equipment market research
- Converted all market data into base currency
- Plotted a scatter graph of the market data on the basis of age against market data as a percentage of current replacement cost new (RCN) value
- Adjusted the secondary market data set for any obvious outliers

- Inserted a best fit regression line into the scatter chart in order to estimate a value for each asset based on age

In assessing Market Value, no further adjustments for physical deterioration and functional and economic obsolescence were required because the Market Approach typically reflects all forms of obsolescence and deterioration.

13.0 Valuation Opinion

After taking into considerations of all the relevant data and the principles stipulated, we are of the opinion the market value of the specified machinery and equipment at the date of valuation is **SAR2,650,000 (TWO MILLION SIX HUNDRED AND FIFTY THOUSAND SAUDI RIYAL).**

Limitations

Our Report may be relied upon by ABC Company for the purposes stated in the Engagement Agreement only. You must maintain the Report in strictest confidence and must not disclose the Report to any other party or use the Report for any other purpose without our prior written consent, except that you may provide a copy of the Report to your officers and employees, and your professional advisors (financial, accounting and legal), who are assisting or advising you, provided that, in each case, you must first notify the recipient, and ensure that the recipient understands and agrees that:

The Report and its contents are confidential and may not be disclosed without our written consent.

The Valuation Date is 1 February 2020. Therefore, the Report does not provide any guidance for the value of the assets at any other date.

The appraisal Report is subject to the following general assumptions and limiting conditions as applicable:

No investigation has been made of, and no responsibility is assumed for, the legal description of the property being valued or legal matters, including title or encumbrances. Title to the property is assumed to be good and marketable unless otherwise stated. The property is assumed to be free and clear of any liens, easements, encroachments, or other encumbrances unless otherwise stated.

Information furnished by others, upon which all or portions of this appraisal are based, is believed to be reliable but has not been verified in all cases. No warranty is given as to the accuracy of such information.

It is assumed that all required licences, certificates of occupancy, consents, or other legislative or administrative authority from any local, state, or national government or private entity or organisation has been or can readily be obtained or renewed for any use on which the value estimates contained in this Report are based.

No responsibility is taken for changes in market conditions, and no obligation is assumed to revise this Report to reflect events or conditions, which occur subsequent to the date hereof.

Neither XYZ Company nor any individual signing or associated with this Report shall be required by reason of this Report to give further consultation, provide testimony, or appear in court or at other legal proceedings unless specified arrangements therefore have been made.

This Report has been made only for the purpose stated and shall not be used for any other purpose. Neither this Report nor any portions thereof (including, without limitation, any conclusions as to value or the identity of XYZ Company or any individual signing or associated with this Report or the professional associations or organisations with which they are affiliated) shall be disseminated to third parties except federal and state taxing authorities by any means without the prior written consent and approval of XYZ Company.

The date of value to which the opinions expressed in this Report apply is set forth in the letter of transmittal. Our recommendation of value is based on the purchasing power of the local currency, as of that date.

Prepared by:

[VALUER NAME]
Machinery Equipment Valuer – (100000000) Machinery & Equipment Division

Appendix I

MICRO DESCRIPTION AND VALUATION ANALYSIS

Micro description	Qty	Manufacturer	Model	Capacity	Size	Year Built	Number	Useful Life (years)	Age (years)	Market Value (SAR)
Mobile Crane, Rough Terrain	1	Liebherr	LTM1095-5.1	95 tons	58.0 m boom	2012	12345678	25	8	2,650,000
Total Market Value										**2,650,000**

Appendix II

PHOTOGRAPHS

PHOTOGRAPHS

Appendix C : Sample Substation Valuation Engagement Letter

Private and Confidential

1 January 2020

Your ref: [INSERT]

Our ref: [INSERT]

Direct Line: xxxx:

Email: xxx

ABC Company

Attention: [Insert name of individual and title]

ABC Company
ABC Street,
ABC Dist.
123456 Riyadh,
Saudi Arabia

Dear Sirs,

Valuation of A Certain Substation and Associated Electrical Equipment Assets for Financial Reporting Purposes

Thank you for choosing XYZ Company for Valuation Services ("we") to perform certain professional services (the "Services") for ABC company ("you" or "Client"), relating to the valuation of certain identifiable tangible assets in relation to the acquisition of DEF Company effective as of 3 February 2020 (the "Valuation Date"). The valuation will be carried out in accordance with IFRS 3 *Business Combinations* and IFRS 13 *Fair Value Measurement,* International Valuation Standards (IVS) issued by the International Valuation Standards Council (IVSC) and guidance published by the Saudi Authority for Accredited Valuers (TAQEEM). We appreciate the opportunity to assist you and look forward to working with you.

This cover letter, together with all of its appendices, exhibits, schedules and other attachments (collectively, this "Agreement"), describes and documents the arrangements between us, including our respective obligations. The scope of the Services is set out in the Statement of Work at Appendix A, together with details of our fees and billing arrangements. Any additional terms and conditions specific to the Services are set out in Appendix B, including restrictions on the disclosure and use of our advice and reports.

Please sign and return the enclosed copy of this Agreement to confirm your agreement with these arrangements and return it to me at your earliest convenience. If you have any questions about these arrangements, please contact [insert contact person's name and telephone number].

Yours faithfully

[Name]

Machinery Equipment Valuer – (100000000) Machinery & Equipment Division

AGREED

ABC Company
By (Authorised Representative):

Signature: ____

By: [Name and Title] ______________________________________

Date: ____

Appendix A – Statement of Work

Appendix B – General Terms and Conditions

Appendix A

Scope of Work

Scope of Services

You have instructed us to consider the valuation of certain substation and associated electrical equipment assets (the "Subject Assets") effective as of 3 February 2020 (the "Valuation Date"). We understand the valuation is required regarding the acquisition of the Subject Assets and will be carried out in accordance with IFRS 3 *Business Combinations* and IFRS 13 *Fair Value Measurement,* International Valuation Standards (IVS) issued by the International Valuation Standards Council (IVSC) and guidance published by the Saudi Authority for Accredited Valuers (TAQEEM).

We will:

- Collect the fixed asset data provided by ABC Company in relation to the Subject Assets.
- Conduct a site inspection in order to better understand the nature, condition and operation of the Subject Assets and to compare and contrast our site observations to the data provided.
- Conduct market research.
- Conduct valuation analysis of the Subject Assets. The Subject Asset reflects information provided by ABC Company and our observations during the site visits or in discussions with ABC Company.
- Hold interviews with ABC Company to discuss the replacement costs, age, existing market data and the condition of the Subject Assets including any factors that may impact the value of the Subject Assets.

Further explanation is provided below. Our role is to provide you with advice and recommendations for your consideration. We will not perform any management functions or make any management decisions.

As the engagement progresses, you may decide that you wish to vary the scope of work. We will discuss such matters with you and any changes to the scope of work will be agreed between us in writing.

Limitations to Scope

We will not, except to such extent as you request and we agree in writing, seek to verify the accuracy of the data, information and explanations provided by yourselves, and you are solely responsible for this data, information and explanations. We will therefore rely on the information provided by you to be accurate and complete in all material respects.

The valuation will be provided to you for the above purpose only and should not be used or relied upon for any other purpose, nor should it be disclosed to, or discussed with, any other party without our prior consent in writing, save as set out in Section 12 of the attached terms of business.

Purpose

The results of our work will be used solely for the purposes of assisting ABC Company's management in the valuation of the Subject Assets in connection of the acquisition of DEF Company's GHI plant for financial statement reporting purposes according to IFRS 3.

Basis of Valuation

According to IFRS 13, the standard/premise of value to be used in the application of purchase accounting rules is Fair Value. The Standard defines Fair Value as:

'*The price that would be received to sell an asset or paid to transfer a liability in an orderly transaction between market participants at the measurement date'*

This will be the definition of value that we will apply in the provision of the Services.

Valuation

In the context of the valuation of an asset there are, broadly speaking, three different approaches, which are:

- Market-based approaches;
- Income-based approaches; and
- Cost-based approaches.

While each of these approaches is usually considered in the initial valuation of an asset, the nature and characteristics of the asset will determine the most applicable approach/approaches in a particular set of circumstances.

Conduct of the Services

Assignment team

This assignment will be conducted under the direction of [Name of Engagement Partner/Director] in the [XXX] team at [XXX]. They will be assisted by [Name of Engagement Manager] who is an [rank] in the [XXX] team at [XXX], who will have day-to-day responsibility for the intangible asset valuation work.

[Name of Review Partner], a Partner/Director in the [XXX] team at [XXX], will be Review Partner/Director on this assignment

Timetable

We will commence work [immediately / immediately on written confirmation from you that the terms of the assignment as set out in this letter are accepted / or on [Insert Date]] and we will aim to report our opinion of value no later than [X weeks from the receipt of all pertinent information or on [Insert Date]]. In order to meet this timetable, we will need timely access to management and the receipt from you of the necessary information. Receipt of information is expected within [14] days of acceptance of this letter. As you will appreciate, however, any such timetable is based on the assumption that we will receive the appropriate co-operation and assistance and be able to complete our market enquiries. If we do not, however, then we cannot be held responsible for any delays.

We will notify you as soon as practicable if it appears likely that there will be any significant delays in the above timetable.

Fees

I would refer you to the section 1 of the Fees – additional terms and conditions below for an explanation of our basis of charging and other matters related to our fees and invoicing arrangements. [If an estimate is supplied, include the following wording:] *As* this is an estimate, however, our fees may be more or less than this amount.

Fees – Additional Terms and Conditions

Our fees are subject to the provisions set out in the General Terms and Conditions contained in Appendix B and to the following additional terms and conditions.

1. Except to the extent that more specific fee arrangements are stated above, our fees will be based on:

- The number and seniority of staff required
- The degree of skill and responsibility involved
- The resources required to complete the Services
- The fee rates for the appropriate personnel

2. Any fee estimate agreed with you is necessarily based on the assumption that the information required for the Services is made available in accordance with agreed timetables and we have access to you and your key staff as required. If delays or other unanticipated problems which are beyond our control occur this may result in additional fees for which invoices will be raised, including where we need to carry out substantial further work due to changes in law or tax authority practice.

3. If at any point you decide to terminate this engagement, we will be entitled to charge you for any unbilled work that we have undertaken up to the date of termination, in accordance with the General Terms and Conditions.

Invoicing Arrangements

We will issue an invoice every 30 days with our first invoice being issued as we commence work and our final invoice being issued on completion of the Services. Expenses and any applicable taxes will be added to each invoice as incurred.

Invoice amounts will be based on our best estimate of work undertaken in the next 30 days adjusted for variances in the previous month.

Payment

Invoices are payable immediately upon presentation.

Information Requirements

All information (which we reasonably request given our scope of work) will be provided to us within a mutually agreeable period of time. As we become aware of the need for further information, we will discuss this with you.

In respect of all our work we will be reliant on the accuracy and completeness of the underlying information that you supply to us. We will not verify this information and therefore will not check the accuracy of the information or any explanations provided.

If you are not able to provide us with any of the information we have requested, this may affect our ability to conclude our valuation in the terms indicated above or at all. We will inform you of any restrictions to our valuation or the reliance which may be placed on it as a result of incomplete information.

In addition to the evidence supplied, our valuation will be based on discussions with management and our own research into the market and industry within which the Subject Assets operate.

Presentation of Results

The results of our work will be documented in a single narrative report ("Report") outlining the valuation methodologies and conclusions. The valuation and our recommendations will be provided to you for the Purpose only and must not be used or relied upon for any other purpose, and the Report must not be disclosed to, or discussed with, any other party without our prior written consent.

Appendix B

[Insert specific valuer's specific terms of business etc.]

Appendix D: Sample Substation Valuation Report

Company for Valuation Services

XYZ St.,

XYZ Dist,

123456 Riyadh,

Saudi Arabia

ABC COMPANY

Valuation of Substation and Associated Electrical Equipment Located at DEF Plant, Riyadh,

For Financial Reporting Purposes

28 February 2020

XYZ Company for Valuation Services
XYZ Street,
XYZ Dist.,
123456 Riyadh,
Saudi Arabia
28 February 2020

ABC Company
ABC Street,
ABC Dist.,
123456 Riyadh,
Saudi Arabia

Dear Sirs,

In accordance with your instructions, we have performed the work set out in our engagement agreement dated 1 January 2020 (the Engagement Agreement) regarding the identification and valuation of substation and associated electrical equipment located at DEF Company's GHI Plant, Riyadh (the Subject Assets) as at 3 February 2020 (the Valuation Date).

Purpose of Our Report and Restrictions On Its Use

This report (Report) was prepared on the specific instructions of ABC Company for the purpose of assisting ABC Company in addressing matters in relation to acquisition accounting in accordance with accounts to be prepared under International Financial Reporting Standards (IFRS) 3 *Business Combinations* and IFRS 13 *Fair Value Measurement* (the Purpose).

This Report and its contents may not be quoted, referred to or shown to any other parties except as provided in the Engagement Agreement. We accept no responsibility or liability to any person other than to ABC Company.

Nature and Scope of the Services

The nature and scope of the services, including the basis and limitations are detailed in the Engagement Agreement.

We performed our work considering applicable professional guidance, including IFRS 3 *Business Combinations* and IFRS 13 *Fair Value Measurement,* International Valuation Standards (IVS) issued by the International Valuation Standards Council (IVSC) and guidance published by the Saudi Authority for Accredited Valuers (TAQEEM). When we were performing our work, we acted independently.

The contents of our Report have been reviewed by Management, who have confirmed to us their factual accuracy.

Whilst each part of our Report addresses different aspects of our work, the entire Report should be read for a full understanding of the basis for our valuation conclusions.

We appreciate the opportunity to provide our services to ABC Company. Please do not hesitate to contact us if you have any questions about this engagement or if we may be of any further assistance.

Yours faithfully,

[VALUER NAME]
Machinery Equipment Valuer – (100000000) Machinery & Equipment Division

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Valuation Overview

1.0 Purpose and Objective

At the request of ABC Company, XYZ Company for Valuation Services performed a valuation of certain tangible asset (the Subject Assets) as at the 3 February 2020 (the Valuation Date). We understand that the purpose of the valuation was to assist ABC Company in addressing matters in relation to acquisition accounting in accordance with accounts to be prepared under International Financial Reporting Standards (IFRS) 3 *Business Combinations* and IFRS 13 *Fair Value Measurement* (the Purpose).

ABC Company acquired the business and assets comprising the substation located at DEF Company's GHI Plant, Riyadh, Saudi Arabia for a total consideration of SAR1,800,000 (the Transaction). In accordance with our engagement letter dated 1 January 2020, we have valued certain identified tangible assets in relation to the Transaction as at the Valuation Date.

2.0 Basis of Value

The standard/premise of value adopted in this Report is Fair Value, which is defined as follows:

The price that would be received to sell an asset or paid to transfer a liability in an orderly transaction between market participants at the measurement date. (IFRS 13 Fair Value Measurement)

In addition, IFRS 3 specifies that fair value should reflect market expectations about the probability that the future economic benefits associated with the asset will flow to an acquirer. Therefore, any analysis should generally reflect assumptions which would be common to any market participant if it were to buy or sell each identified asset on an individual basis.

Thus, the fair value should be estimated with reference to 'market participants' in general but exclude synergistic values that are unique to a particular buyer. In this context, market participants would include potential buyers that have an ability to acquire and would take an active part in managing the acquired company. Such ability would be evaluated in the context of financial ability as well as a plausible post-combination operating strategy.

For an operating business, the definition further assumes profitable continuation of existing use, subject to highest and best use.

Title to the Subject Assets is assumed to be good and marketable unless otherwise stated. The Subject Assets are further assumed to be free and clear of any or all liens, easements or encumbrances unless otherwise stated.

3.0 Subject Assets

This valuation is in respect of Substation and associated electrical equipment located at DEF Company's GHI Plant, Riyadh, Saudi Arabia, The Subject Assets comprised the following:

i. Transformer.
ii. Circuit breakers
iii. MV & LV switchgear.
iv. Power factor correction equipment.
v. PLC and control gear.
vi. Stand-by generator.

In performing the valuation of the tangible assets, we considered the primary functions of the assets as part of our procedural due diligence and noted and considered related key value drivers.

- As outlined in the scope of work, we have reviewed the technical list of assets supplied by [XXX] from the [XXX] data room and the PME information in the [XXX] presentation dated [XXX] (the "Subject Assets"), as well as supplementary data supplied by [XXX] Management.
- We have also carried out a one day, site inspection of the subject Machinery and Equipment (M&E) assets at [XXX].
- We made calculations in order to determine current IFRS related fair value ranges for the subject assets, based upon IVS and TAQEEM valuation principles and guidance. We have indicated a likely value range relative to underlying cost and *market value* data obtained through our research and discussions with market sector parties (insofar as is possible.)
- The primary valuation approach was the *cost approach*, utilising the Depreciated Replacement Cost method. For the [XXX] element we adopted a *market approach*.
- Intangible assets, real estate and wider *business valuation* considerations were excluded from this valuation.
- The following sections of the draft interim *report* provides an overview of the plant as well as the assumptions.
- Key assumptions and limitations are documented in the Appendices.

Please refer to Appendix I for a detailed description of the Subject Assets.

4.0 Scope of Work

The scope of our engagement included:

- Collection of the fixed asset data provided by ABC Company, representing all of the plant and equipment acquired by ABC Company.
- Site inspections in order to better understand the nature, condition and operation of the assets at the site and to compare and contrast major assets observed to the data provided.
- Interviews with ABC Company to understand the nature of the Subject Assets, including their type, configuration, usage, operational capabilities, and maintenance; amongst other aspects considered.
- Market research.
- Valuation analysis of the Subject Assets. The Subject Assets valued reflects information provided in the Fixed Asset Registers (FAR) and our observations during the site visits or in discussions with ABC Company.

5.0 Exclusions

The following items were excluded from the scope of this Report:

- Real property
- Intangible assets
- Any cashflow/profitability analysis or related adjustments
- Inventory
- Any other assets & liabilities.

6.0 Limitations

In accordance with our Engagement Agreement and the transmittal letter that accompanies this Report, our analysis is subject to the limiting conditions contained in this Report.

7.0 Currency

Unless otherwise noted, all currency amounts are quoted in Saudi Riyal (SAR).

Valuation

8.0 Valuation Procedures

In order to value the Subject Assets, we undertook the following procedures:

- Data collection and reconciliation
- Site inspection
- Engineering meetings and interviews
- Cost and market research
- Valuation methodology selection and analysis

The first phase of our analysis began with our data collection procedures. We worked in conjunction with ABC Company to identify what information was critical to the analysis and to also identify what information was readily available.

We held discussions with ABC Company to develop a comprehensive list of the data required for the valuation analysis including financial and operating data for the Subject Asset. We independently developed and collected additional data to aid in deriving our value conclusions.

Initially, ABC Company provided us with an electronic copy of the fixed asset register (FAR). The FAR contained descriptive information including ownership company, asset type, location, asset code, asset description, purchase date, purchase price, accumulated depreciation and net book value.

The following list details additional data items collected and utilised in our valuation analysis:

- Balance sheet information
- Equipment maintenance records with descriptive information on the Subject Assets' manufacturer, model, serial number, capacity and model year
- Facility drawings illustrating the plant layout

9.0 Site Inspection

A site inspection in relation to the Subject Assets was completed on 3 February 2020 as presented below.

NAME	DESIGNATION
Value Name 1	ME Valuer, Machinery and Equipment Division, TAQEEM
Valuer Name 2	ME Valuer, Machinery and Equipment Division, TAQEEM

The site inspection allowed us to better understand the nature, condition and operation of the Subject Assets and to compare and contrast our observations to the information provided. During our site inspection, we noted and gathered supplementary information such as make, model, size, design capacity, materials of construction, age, observed physical condition and current use for the Subject Assets.

10.0 Engineering Meetings and Interviews

In addition to the site inspection, we consulted with ABC Company management and gathered additional detailed information necessary to perform the valuation of the Subject Assets. This included meetings with the engineering personnel involved in the construction and purchasing of new equipment to:

- Understand the processes being employed.
- Develop replacement cost estimates.
- Understand the overhaul and maintenance history of the Subject Assets.
- Gather technical data and cost trends.
- Discuss functional and/or non-cashflow related economic obsolescence issues and develop an understanding of the maintenance and retirement policies related to the Subject Assets.

11.0 Cost and Market Research

In conducting our valuation, where possible, we have undertaken independent research by contacting a limited number of original vendors and suppliers of the Subject Asset. During these conversations, we discussed the current market demand for the types of assets being valued as well as replacement costs for new equipment and potential Market Values for refurbished or used equipment. We also researched various publicly available sources of information regarding cost trends and sector specific inflationary indices. These suppliers and publicly available sources of information included, but were not limited to:

- Industry journals & publications, including:
- [XXX] Journal
- Various auctioneers

Subsequent to the procedures described previously, we used the data provided in conjunction with information gathered as the basis for our valuation analysis.

12.0 Methodology Selection and Analysis

The methods and procedures used to perform the valuation of the Subject Assets are intended to conform to standards promulgated by the IVSC and TAQEEM.

We considered the three main approaches to value (market, income and approaches) and the methods that comprise these approaches. Based on the nature of the Subject Assets and information available, we concluded on the cost approach as being the most appropriate to value the Subject Assets.

For the valuation of the Subject Assets, the income approach was considered to be inappropriate and was not used as individual income streams could not be allocated reasonably and effectively to each of the Subject Assets. In the event that income streams could be allocated, they would likely, by default, correspond to both tangible and intangible assets.

We concluded that the market approach was also inappropriate due to the specialised nature of the Subject Assets and the lack of comparable sales information.

For the purpose of this analysis, the cost approach was used to value the Subject Assets. By using this approach, we recognised the contributory value associated with the necessary installation, engineering, and set-up costs related to the installed complement of assets.

13.0 Application of the Cost Approach

In conducting our valuation, we have undertaken independent research by contacting vendors, industry experts and suppliers related to the Subject Assets. During these conversations we discussed the current market demand for the types of assets being valued as well as replacement costs for new assets and market values for refurbished or used assets.

We also researched various publicly available sources of information regarding cost trends, normal useful lives, and technological changes in the industries in which the Subject Assets operate.

Subsequent to the procedures described previously, we used the data provided in conjunction with information gathered as the basis for our valuation analysis.

In applying the cost approach, we first identified current reproduction or replacement cost estimates for the Subject Assets using both direct and indirect (trending) methods.

14.0 Calculation of the Replacement Cost New under the Direct Method

Direct calculation of the replacement cost new (RCN) is based on physical and technical parameters of the Subject Asset. In our application of the direct method of the cost approach, we primarily relied on information contained in the Assets register, data gathered during our site visits and detailed information supplied in response to our requests for information.

Estimates of RCN, by definition, include both direct and indirect costs associated with each Assets including engineering, procurement and construction management, materials, equipment, freight, installation and commissioning labour.

We considered the following sources of data in determining our estimated replacement cost new:

- Historical cost data
- Discussions with project engineers, manufacturers and suppliers of the Subject Assets

15.0 Calculation of the Replacement Cost New under the Indirect Method

Under the indirect method of the cost approach, the reproduction cost new for the Subject Assets was estimated by indexing the historical cost recorded in the FAR based on Assets type and acquisition date. Historical costs generally included the base cost of the asset, any additional considerations regarding freight, duty, local delivery, installation and commissioning, and indirect costs such as engineering, procurement, construction management and borrowing costs as appropriate and applicable.

16.0 Physical Deterioration and Obsolescence

As the Subject Assets has been in use for a number of years, it is reasonable to assume that its market value is something less than its RCN. Therefore, allowances were made for physical deterioration as well as functional and economic obsolescence as they might apply. The following key factors were considered:

- Effective life – The life, usually expressed in terms of years, that an Assets will be used before it deteriorates to an unusable condition or is retired from service
- Chronological age – The portion of an asset's life elapsed since it was originally placed into service
- Effective age – The age of an Assets indicated by its actual condition, which may or may be not equal to the chronological age
- Remaining useful life – The period over which an Assets will remain in use before it is retired from service

17.0 Effective Lives

The effective life estimation used in the valuation of the Subject Assets were based on discussions with relevant engineering personnel, reference information, various published sources, and our experience valuing similar assets.

We have also considered whether any external factors may exist that could have an impact on the effective lives of the Subject Asset. We have not identified any such factors. The effective lives adopted for the Subject Assets are provided in **Appendix I.**

18.0 Depreciation Profiles

Different physical depreciation profiles are known and widely used in practice that operate under the basic concepts outlined previously. In the cost approach analysis, we considered the following physical deterioration curves:

- Straight-line depreciation profile - A linear consumption of utility of an Assets over its useful life.
- Diminishing value depreciation profile - Decline in value each year is a constant proportion of the remaining value and produces a progressively smaller value decline over time.

We have adopted straight line depreciation for transformers and switchgear and diminishing value depreciation for generators.

19.0 Residual Values

Additionally, the residual value of an asset must be estimated to perform a depreciation calculation. The residual value of an item is the estimated amount that an entity could currently obtain from disposal of the asset, after deducting the estimated costs of disposal, if the assets was already of the age and in the condition expected at the end of its useful life.

We have adopted residual values of between 2% and 5% depending on the nature of the individual Subject Assets.

20.0 Functional Obsolescence

To consider functional obsolescence we sought to identify the existence of either excess capital costs or excess operating costs associated with the Subject Assets.

We understand from discussions with ABC Company management and the major equipment suppliers, that the Subject Assets reflect the most up to date technology for this type of facility, and that the capital and operating costs are considered consistent with other available equipment. Accordingly, we concluded that no adjustment was required in respect of functional obsolescence.

21.0 Economic Obsolescence

There are two broad methods commonly used to identify and quantify economic obsolescence:

- The enterprise value (EV) comparison method: A comparison between the EV and the indicated values of relevant assets and liabilities to identify and quantify EO as part of the cost approach
- The in-utility method: A method which focusses on identifying and eliminating excess capacity compared to market demand

Given the Subject Assets transacted at the valuation date as part of an arm's length transaction involving the sale of an operating business enterprise, we adopted the EV comparison method.

In discussions with ABC Company management we determined the following:

Transaction completion date:	3-Feb-19
Total consideration paid:	SAR 1,800,000
Assets included in transaction:	Tangible assets (which are the Subject Assets) Inventory Goodwill
Tenure:	Leasehold tenure, remaining lease term 10 years

ABC Company management further advised that the fair value of inventory acquired in the transaction was SAR 100,000 and that no liabilities were acquired as part of the transaction. They further advised that no real property was acquired in the transaction and tenure is by way of a 10-year lease at market rents.

Having regard to the above information it is apparent that the indicated fair value of the business, including all assets, inventory and goodwill, is SAR 1,800,000. After deducting the fair value of acquired inventory (SAR 100,000), the indicated fair value available to be attributed to tangible assets and goodwill is SAR 1,700,000. Our cost approach indicates a fair value for the Subject Assets of SAR 1,596,000 which is less than the balance available for tangible assets and goodwill.

This indicates that:

a) no adjustment is required for economic obsolescence and

b) the implied value of goodwill is SAR 104,000.

An indicative balance sheet summarising this information is presented below:

Category	Fair value (SAR)	Source
Tangible assets (Subject Assets)	1,596,000	XYZ Company cost approach
Inventory	100,000	ABC Company
Goodwill	104,000	Implied from above and transaction value
Total enterprise value	1,800,000	Transaction value

Having regard to the above we concluded that no adjustment was required for economic obsolescence.

22.0 Valuation Opinion

After taking into consideration all the relevant data and the principles stipulated, we are of the opinion the fair value of the Subject Assets as at the Valuation Date is:

SAR 1,596,000 (ONE MILLION FIVE HUNDRED AND NINETY-SIX THOUSAND SAUDI RIYAL).

Limitations

Our Report may be relied upon by ABC Company for the purposes stated in the Engagement Agreement only. You must maintain the Report in strictest confidence and must not disclose the Report to any other party or use the Report for any other purpose without our prior written consent, except that you may provide a copy of the Report to your officers and employees, and your professional advisors (financial, accounting and legal), who are assisting or advising you, provided that, in each case, you must first notify the recipient, and ensure that the recipient understands and agrees that:

The Report and its contents are confidential and may not be disclosed without our written consent.

The Valuation Date is 3 February 2020. Therefore, the Report does not provide any guidance for the value of the assets at any other date.

The appraisal Report is subject to the following general assumptions and limiting conditions as applicable:

No investigation has been made of, and no responsibility is assumed for, the legal description of the property being valued or legal matters, including title or encumbrances. Title to the property is assumed to be good and marketable unless otherwise stated. The property is assumed to be free and clear of any liens, easements, encroachments, or other encumbrances unless otherwise stated.

Information furnished by others, upon which all or portions of this appraisal are based, is believed to be reliable but has not been verified in all cases. No warranty is given as to the accuracy of such information.

It is assumed that all required licences, certificates of occupancy, consents, or other legislative or administrative authority from any local, state, or national government or private entity or organisation has been or can readily be obtained or renewed for any use on which the value estimates contained in this Report are based.

No responsibility is taken for changes in market conditions, and no obligation is assumed to revise this Report to reflect events or conditions, which occur subsequent to the date hereof.

Neither XYZ Company nor any individual signing or associated with this Report shall be required by reason of this Report to give further consultation, provide testimony, or appear in court or at other legal proceedings unless specified arrangements therefore have been made.

This Report has been made only for the purpose stated and shall not be used for any other purpose. Neither this Report nor any portions thereof (including, without limitation, any conclusions as to value or the identity of XYZ Company or any individual signing or associated with this Report or the professional associations or organisations with which they are affiliated) shall be disseminated to third parties except federal and state taxing authorities by any means without the prior written consent and approval of XYZ Company.

The date of value to which the opinions expressed in this Report apply is set forth in the letter of transmittal. Our recommendation of value is based on the purchasing power of the local currency, as of that date. Prepared by:

[VALUER NAME]
Machinery Equipment Valuer – (100000000) Machinery & Equipment Division

Appendix I

MICRO DESCRIPTION AND VALUATION ANALYSIS

Qty	Description General	Description Technical	Manufacturer	Model	Cap	Cap Units	Build year	RCN SAR	Adopted Effective Age	Useful Economic Life	Depn Profile	Residual value	Depn Factor	Fair value SAR
1	TRANSFORMER	22 kV-433 V	SCHNEIDER		1.5	MVA	2002	210,000	17	25	SL	2.0%	33.4%	70,000
1	SWITCHGEAR	SF6 AIR BREAKER	MERLIN GERIN	SM6	22	kV	2002	460,000	17	25	SL	2.0%	33.4%	150,000
1	MOTOR CONTROL CENTRE	MAIN MCC	METALCLAD		415	V	2002	2,530,000	17	25	SL	2.0%	33.4%	840,000
2	POWER FACTOR CORRECTOR		ABB	ABBACUS	200	kVAr	2002	780,000	17	25	SL	2.0%	33.4%	260,000
1	SWITCHGEAR	PLC PANEL	ALLEN BRADLEY				2002	200,000	17	25	SL	2.0%	33.4%	67,000
1	SWITCHGEAR	PROCESSOR & POWER SUPPLY	LOGIX				2002	390,000	17	25	SL	2.0%	33.4%	130,000
1	SWITCHGEAR	415 V SWITCHBOARD	METALCLAD		415	V	2002	200,000	17	25	SL	2.0%	33.4%	67,000
1	GENERATOR	PACKAGED, DIESEL	KOHLER	350RE02V	375	kVA	2004	110,000	15	20	DV	5.0%	10.6%	12,000
	Total Fair Value							**4,880,000**						**1,596,000**

EXERCISE QUESTIONS

1. Which of the following is the name given to the process used in thermal power plants?
   A. Erskine cycle
   B. Rankine cycle
   C. Thermal cycle
   D. Condensate cycle

2. What is the function of a distribution substation?
   A. transfers power from the transformer to the high voltage consumer switchboard system
   B. transfers power from the transmission system to the distribution system
   C. transfers power from the transmission system to direct consumers
   D. transfers power from the transmission system to the transformer system

3. Which of the following is **TRUE** regarding Geothermal power plants?
   I. They use steam naturally generated and stored in the earth
   II. They use impulse & reaction turbines
   III. They are a form of thermal power plant
   IV. They are very similar to solar photo-voltaic plants

   A. I and II only
   B. II, III and IV only
   C. I and III only
   D. All of the above

4. Combined cycle gas turbine (CCGT) power plants capture ___________ to produce steam.
   A. sunlight
   B. exhaust gas from the gas turbine
   C. electricity from the generator
   D. CO_2 from the atmosphere

5. Which of the following statements is **FALSE** in relation to electrical power transformers?

   A. Transformers are generally used to step up or step down the voltage levels of a system for transmission and generation purpose

   B. Transformers are rated by kVA or MVA

   C. Transformers are static electrical machines used for transforming power from one circuit to another circuit without changing frequency

   D. Transformers generate power from the transmission system to the distribution system

6. The advantages of high voltage transmission are:

   I. Reduces volume of conductor material

   II. Transmission of electric power by a three-phase line

   III. Increases transmission efficiency

   IV. Decreases percentage line drop

   A. I and II only

   B. II and III only

   C. I and IV only

   D. All of the above

7. Which of the following voltage ranges is typically classified as extra-high voltage (EHV):

   A. 2.4 kV to 69 kV

   B. 100 kV to 275 kV

   C. 345 kV to 745 kV

   D. >800 kV

8. The three main types of pump found in process plants are:

   A. Positive disposition, centrifugal and axial flow

   B. Centrifugal, positive distribution and axial displacement

   C. Positive displacement, axial flow and centrifugal

   D. Negative displacement, centrifugal and axial flow

9. Which of the following is **NOT** one of the three (3) main categories of water pipe?

   A. Metallic pipes
   B. Cement pipes
   C. Fiber optic pipes
   D. Plastic pipes

10. Which of the following are common components of a compressed air system?

   I. Air compressor
   II. Air humidifier
   III. Air receiver
   IV. Piping and valves

   A. I, II and III only
   B. I, III and IV only
   C. II, III and IV only
   D. All of the above

11. The two most common types of boiler found in process plants are:

   A. Fire-tube and steam-tube
   B. Air-tube and steam-tube
   C. Fire-tube and air-tube
   D. Water-tube and fire-tube

12. Cellular manufacturing is ______________.

   A. Typical of projects in which the product produced is too fragile, bulky, or heavy to move
   B. A type of layout where machines are grouped according to the process requirement for a set of similar items (part families) that require similar processing
   C. Flow shops (repetitive assembly and process or continuous flow industries)
   D. Primarily in job shops, or firms that produce customized, low-volume products that may require different processing requirements and sequences of operations

13. Mobile cranes include which of the following?

    I. Monorails
    II. Carry deck or pick and carry cranes
    III. Rough or all-terrain cranes
    IV. Jib cranes

    A. I, II and III only
    B. II and III only
    C. I and IV only
    D. All of the above

14. Fixed position layouts are best for:

    A. Electrical goods manufacturing
    B. Footwear manufacturing
    C. Ship building
    D. All of the above

15. Which of the following are appropriate ways to describe and record assets in an asset listing (select all that apply):

    I. Process flow order
    II. Newest machines first
    III. Walk-round order
    IV. By physical location

    A. I, II, III only
    B. I, III, IV only
    C. II, III, IV only
    D. All of the above

16. Which of the following statements is **NOT TRUE** about the combination layout?

    A. Combines the advantages of both the process and product layouts
    B. It is used when the same item is being manufactured in different types or sizes
    C. It increases inventory holdings due to the uncommon production regime between assembly lines
    D. Commonly called combination or hybrid layout

17. Which of the following statements **DOES NOT** apply to fixed position layouts?

A. The resources are arranged sequentially based on the routing of the products

B. Equipment and parts moved in and out of work area

C. Large projects too big to move

D. Suitable for building static structures

18. Which of the following statements is **CORRECT** for a motor control center (MCC)?

A. MCC panels consist of starters are used to start or control motors, water pumps, compressors, fans, conveyor belts etc.

B. An MCC is an assembly of one or more enclosed sections having a common bus bar and principally containing motor control units

C. MCCs can be identified by voltage, the number of sections and/or the load measured in Amperes

D. All of the above

19. Which of the following statements best describes a distributed control system (DCS)?

A. A DCS is a computerized control system consisting of computer-software packages communicating with autonomous control hardware providing a centralized human-machine interface (HMI) for controlled equipment

B. A DCS allows different nodes (a network point, typically a computer) of a network to communicate directly with one another

C. A DCS modulates signals so that the digital information is encoded and transmitted over a phone line and then demodulated

D. A DCS connects multiple networks and routes network traffic.

20. Which of the following statements best describes the pre-treatment stage of wastewater treatment plant?

A. Pre-treatment consists of large sedimentation tanks, commonly called pre-settling basins, primary sedimentation tanks or primary clarifiers

B. Pre-treatment typically consists of screens, chambers, equalization basins and skimmers to remove large debris, grit, oils and fats from the input stream

C. Pre-treatment systems include fluoridation and chlorination facilities

D. Pre-treatment systems are classified as fixed-film or suspended-growth systems

21. Which of the following are components that supervisory control and data acquisition (SCADA) systems might utilize?

    A. Programmable logic controllers (PLCs)
    B. Field instruments
    C. Remote terminal units (RTUs)
    D. All of the above

22. A substation may contain which of the equipment listed below.

    I. High voltage consumer switchboard and switchgear
    II. Low voltage switchgear
    III. Grounding (earthing) system
    IV. Medium voltage switchgear

    A. I, II and III only
    B. II, III and IV only
    C. I, II and IV only
    D. All of the above

23. Which of the following statements is correct?

    A. A substation is a system of electrical conductors in a generating or receiving station on which power is concentrated for distribution
    B. A substation is a system that converts different energy sources into electric power
    C. A substation uses transformers to transform voltage from high to low, or vice versa
    D. A substation is a facility where heat energy is converted to electrical power

24. Insulators are often made of which material:

    A. Lead
    B. Copper
    C. Ceramic
    D. Aluminum

25. A generator set, also known as a genset, operates by which of the following methods?

A. the switchgear driven by an internal combustion engine generates electrical power

B. an alternator driven by an internal combustion engine generates electrical power

C. the transformer driven by an internal combustion engine generates electrical power

D. the distribution board driven by an internal combustion engine generates electrical power

26. A comprehensive, structured and well written valuation report is characterized by:

I. Clear and logical relay of all relevant information and reasoning

II. Thorough research that is convincingly and accurately presented and summarized

III. Short, concise and simple sentences

IV. Clear from of any misrepresentations, omission of importance facts and hearsay evidences

A. I, II and III only

B. II, III and IV only

C. I, II and IV only

D. All of the above

27. The macro description of machinery and equipment includes which of the following?

I. business operation

II. identify the roles and functions of plant and machinery

III. the level of maintenance and usage

IV. suitability of plant and machinery on site

A. I, II and III only

B. II, III and IV only

C. I, II and IV only

D. All of the above

28. Which of the following statements **DO NOT** apply to a Valuation Report?

A. Valuation Report is a detailed document, which provides background data, substantiation of information, and an explanation why certain conclusions were reached

B. The Valuation Report must be able to express the valuation task performed by the valuer and clearly describe the interest valued

C. The Valuation Report can be used by the client to check their maintenance schedule of machinery and equipment

D. The Valuation Report is an extension of the valuer's professional work, and must be concise, structured and prepared in line with professional valuation standards

29. Which of the following should be included in the main body of the Valuation Report?

I. Scope of work

II. Description of Machinery & Equipment

III. Details of the valuation approach and assumptions adopted

IV. Date of valuation

A. I, II and III only

B. II, III and IV only

C. I, II and IV only

D. All of the above

30. Which of the following is **NOT** typically included in the micro description of Machinery & Equipment?

A. Name of manufacturer

B. Model or type number

C. Functional description

D. Causes of obsolescence

31. Which of the following is **NOT** a defined basis of value in the IVSC glossary?

A. Market Value

B. Fair Value

C. Liquidation Value

D. Going Concern Value

32. Which of the following are bases of value appropriate for insurance purposes and which are methods of valuation appropriate for insurance purposes?

I. Reinstatement
II. Depreciated replacement cost
III. Sales comparison
IV. Indemnity

a) Bases of value – Circle the correct answer(s) from I, II, III, IV
b) Valuation methods – Circle the correct answer(s) from I, II, III, IV

33. Which of the following is **NOT** a function of a Valuation Report?

A. Acts as a legal document in defending a valuation
B. May be a comparable for future valuations
C. Acts as a legal document to increase production of industries
D. As a source of future reference in updating valuations

34. Which of the following could be considered a purpose for a valuation of Machinery and Equipment?

I. Market Value
II. Financial reporting
III. Insurance
IV. Disposal by private treaty sale

A. I, II and III only
B. II, III and IV only
C. I, II and IV only
D. All of the above

35. Which of the following should be included in a Valuation Report for Machinery & Equipment?

I. Identification of which assets have been valued using the depreciated replacement cost (DRC) method of the cost approach and which have been valued using the comparable sales method of the market approach

II. Details regarding key inputs adopted in applying the depreciated replacement cost (DRC) method of the cost approach, e.g. replacement costs new, ages, effective lives, depreciation method(s), residual value, etc.

III. Comparable sales evidence or discussion of market conditions

IV. Inventory

A. I, II and III only

B. II, III and IV only

C. I, II and IV only

D. All of the above

Questions 36 – 40. Select the appropriate words from the table below to fill in the blanks

Fair Value	Financial reporting	Market
Insurance	Client and/or intended user	Marketing period
Cost	Ex-situ	Date of valuation

36. Among the bases of value commonly required for Machinery & Equipment valuations are Market Value and ________________

37. Special assumptions relating to valuations of Machinery & Equipment on the basis of Market Value include the ____________ and whether the assets are value in-situ or ____________

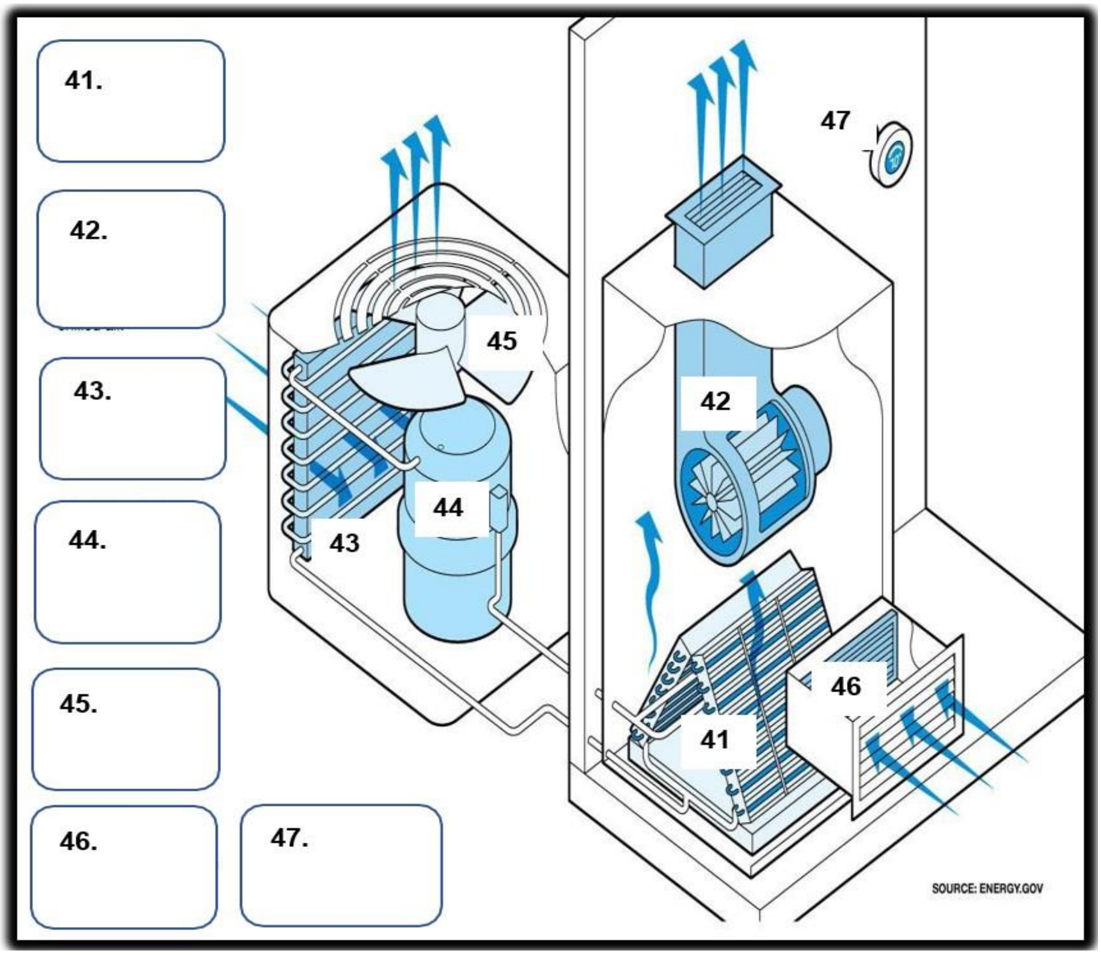
38. Loan security, ________________, and ________________ are three common purposes for Machinery & Equipment valuations

39. The three main approaches to value identified by the IVS are income, ________________ and _______________

40. A Machinery & Equipment Valuation Report must identify the basis of value, ___________________ and ____________________

Fill in the blanks. Match the correct answers for Questions 41 – 47

Fan	Blower	Condenser	Compressor
Evaporator	Filter	Thermostat	



Fill in the blanks. Match the correct statement for Questions 48 – 50

Busbars	Transformer	Insulators

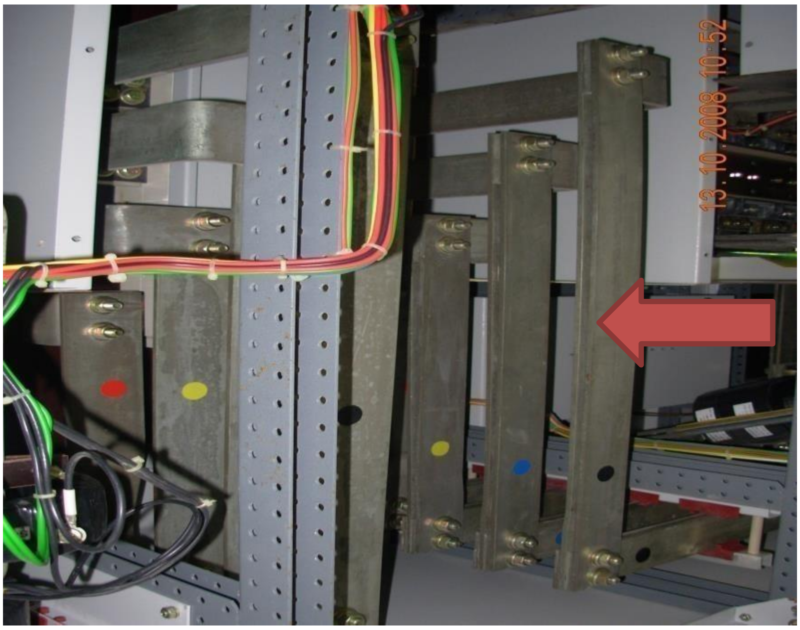
48.

Answer:

49.

Answer:

50.



Answer:

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THIS IS THE END OF THE EXERCISE QUESTION PAPER

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EMBARGO

EXERCISE ANSWERS

1	B	26	D
2	B	27	D
3	C	28	C
4	B	29	D
5	D	30	D
6	D	31	D
7	C	32	a) I and IV, b) II and III
8	C	33	C
9	C	34	B
10	B	35	A
11	D	36	Fair Value
12	D	37	Marketing period, Ex-situ
13	B	38	Financial Reporting, Insurance
14	C	39	Market, Cost
15	B	40	Client and/or end user, Date of valuation
16	C	41	Evaporator
17	A	42	Blower
18	D	43	Condenser
19	A	44	Compressor
20	B	45	Fan
21	D	46	Filter
22	D	47	Thermostat
23	C	48	Transformer
24	C	49	Insulators
25	B	50	Busbars