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Participant Handbook

Sector
Electronics

Sub - Sector
Consumer Electronics &IT Hardware

Occupation
After sales support

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NSQF Level 4

HVAC Technician

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Shri Narendra Modi
Prime Minister of India

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Certificate

COMPLIANCE TO
QUALIFICATION PACK – NATIONAL OCCUPATIONAL STANDARDS

is hereby issued by the

ELECTRONICS SECTOR SKILLS COUNCIL OF INDIA

for

SKILLING CONTENT : PARTICIPANT HANDBOOK

Complying to National Occupational Standards of

Job Role/Qualification Pack **"HVAC Technician"** QP No.**"ELE/Q3112, NSQF Level 4"**

Date of Issuance: 27.01.2022
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The need for having a standard curriculum for the Job Role based Qualification Packs under the National Skills Qualification Framework was felt necessary for achieving a uniform skill-based training manual in the form of a participant handbook.

I would like to take the opportunity to thank everyone who contributed in developing this handbook for the HVAC Technician.

The handbook is the result of tireless pursuit to develop an effective tool for imparting the Skill Based training in the most effective manner.

I would like to thank the team for their support to develop the content, the SME and the team at the ESSCI along with the industry partners for the tireless effort in bringing the handbook in the current format.

About this Book

This Participant Handbook is designed to enable training for the Qualification Pack (QP) of HVAC Technician. The following National Occupational (NOS) are covered across Unit/s:

- ELE/N3101 - Engage with Customer for Service
- ELE/N3140 - Service, troubleshoot, and repair a HVAC system chillers
- ELE/N9905 - Work effectively at the work place
- ELE/N1002 - Apply health and safety practices at the workplace
- ELE/N3141 - (Optional) Service and repair of packaged type HVAC ducted system

Key Learning Objectives for the specific NOS mark the beginning of the Modules & Unit/s for that NOS.

Symbols Used


Key Learning Outcomes


Steps


Exercise


Tips


Notes


Unit Objectives


Activity


Practical

Table of Contents

The book on New Employability Skills is available at the following location:
https://www.skillindiadigital.gov.in/content/list
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1. Role and Responsibilities of an HVAC Technician

Key Learning Outcomes

At the end of this module, you will be able to:

1. Identify the work requirement, roles and responsibilities of an HVAC technician
2. Define the basic concepts of RAC and HVAC
3. Identify basics of electricity, magnetism and motor theory
4. List the tools and equipment used by HVAC technician
5. Classify different types of HVAC systems used
6. Identify the working of various components of an HVAC system

UNIT 1.1: Roles and Responsibilities of an HVAC Technician

Unit Objectives

At the end of this unit, you will be able to:

1. Interpret the working requirements of an HVAC technician
2. Analyse the role and responsibilities of an HVAC technician
3. Identify the career growth path for an HVAN technician

1.1.1 Who is an HVAC technician?

HVAC stands for heating, ventilation and air conditioning. It is a system used to control temperature, humidity, and air quality in indoor. It helps heating or cooling up the building and keeping it warm or cool (as required). It ventilates the dirty/old air out to bring in the fresh air, and giving the building the right amount of air conditioning under any environmental condition. It can be used both in commercial as well as residential buildings.

The HVAC system should be properly install and need timely maintenance and repair. To perform all these operation, we need an HVAC technician.

An HVAC technician's work involves installation, maintenance and repair of the following that controls the temperature and air quality in buildings:

- Heating
- Ventilation
- Air Conditioning
- Refrigeration

In addition, an HVAC technician also performs service; repair and performance check of a packaged type HVAC ducted system at a site.

Thus, as an HVAC technician, you are expected to install, maintain and repair heating, air conditioning and ventilation systems in commercial and industrial areas. You need to engage with the client to understand the work requirement and follows organizational norms to complete the work. Customer's satisfaction, safety and comfort should be among your top priorities. You should possess excellent customer handling and troubleshooting skills I adherence to organisational policy and procedures.

The following figure shows some of the attributes that an HVAC technician must possess:

Fig. 1.1.1: Attributes of an HVAC technician

Patience

Being patient helps an individual to work efficiently when a particular situation is solvable. An individual with patience proves to be:

- Efficient in work, especially in time of crisis.
- Adept in managing clients with high temper.

Integrity

Benefits of possessing integrity stretch to all aspects of an employee's job. An individual with integrity promotes:

- Trusting relationships with clients
- Good interaction with colleagues and supervisors

Punctuality

An individual should be punctual as it helps in:

- Being organized
- Being aware of the timelines
- Planning the day’s activities and the complete work plan for each installation

Critical Thinking

An individual must have critical thinking as it helps to:

- Analyse and evaluate the issue in order to form a judgment.
- Take decision wisely.

Good Interpersonal Relationship Building

Good interpersonal relationship building helps an individual to:

- Work as a team member for achieving a smooth workflow and a satisfied customer
- Communicate the constraints and quality requirements to the team
- Build team coordination

1.1.2 Role and Responsibilities

To be successful at workplace, you need to understand your role and responsibilities and be ready to accept workplace challenges. Following are the role and responsibilities of an HVAC technician:

Install, maintain and repair ventilation and air conditioning systems and equipment.
Identify maintenance risks on equipment.
Perform maintenance and service of the HVAC system
Diagnose electrical and mechanical faults for HVAC systems.
Clean, adjust and repair systems, and perform warranty services.
Perform emergency repairs promptly and efficiently.
Troubleshoot and repair HVAC system (chillers)
Use HVAC codes and standards to do technical calculations for optimum performance
Check the performance after service and repair
Keeping daily logs and records of all tasks performed
Comply with appliance standards and with Occupational Health and Safety Act.
Deal with workplace hazards
Follow fire safety practices
Follow emergencies, rescue and first-aid procedures
Comply with service standards, work instructions and customers' requirements.
Resolve customers' queries.
Communicate and manage work effectively at the workplace
Taking measures to enhance own competence
Follow workplace ethics and code of conduct
Interact with the client prior to initiating work
Understand the work requirement
Suggest possible solutions to the client
Achieve productivity and quality as per the company’s norms

Fig. 1.1.2: Roles and Responsibilities of an HVAC technician

In addition to the above role and responsibilities, it is expected by an HVAC technician to possess following skills and technical knowledge:

- Knowledge of advanced principles of air conditioning, refrigeration and heating and boiler system
- Proficient in balancing air and water treatment systems in line with HVAC protocols.
- Excellent written, verbal and interpersonal skills.
- Proficient in reading schematics and work plans.
- Ability to work after hours, over weekends and on public holidays with short or no notice.
- Ability to work in confined spaces.

1.1.3 Career Growth Path

Being an HVAC technician is just the first initial step of your professional journey. With experience and upgrading/enhancing your skills, you will keep stepping up. The following figure represents the career growth path for an HVAC technician.

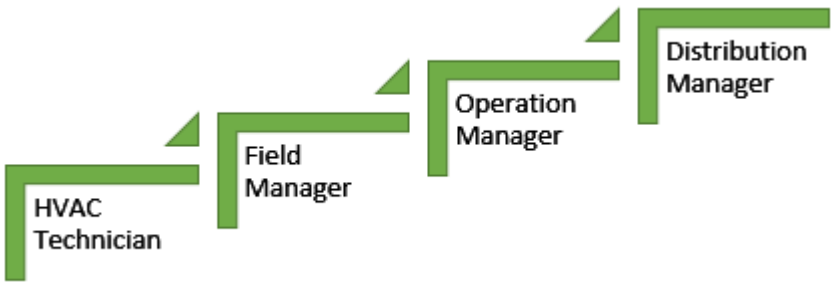


Fig. 1.1.3: Career Growth Path of an HVAC technician

Exercise

1. Who is an HVAC technician?
2. Explain the role and responsibilities of an HVAC technician.

UNIT 1.2: Basic Concepts of RAC and HVAC

Unit Objectives

At the end of this unit, you will be able to:

1. Explain the basic concept of RAC
2. Explain the basic terms used in Refrigeration
3. Explain the basic concept of HVAC
4. Identify the different components of HVAC system
5. Identify the different types of HVAC System

1.2.1 Basic Concept of RAC

RAC stands for Refrigeration and Air Conditioning. Air conditioning is the process of removing heat and moisture from an area to a place outside of the area, which makes the environment comfortable for the occupants. This basically works on the principle of refrigeration.

The basic principle behind the refrigeration process is that when a liquid expands into gas, it extracts heat from its surrounding area. A refrigerant is a chemical liquid which evaporates at a very low temperature enabling it to extract heat at a faster rate. This refrigerant is propelled through a closed system to ensure that it is not dispersed in the surroundings and can be used again and again. The following figure shows the refrigeration cycle:

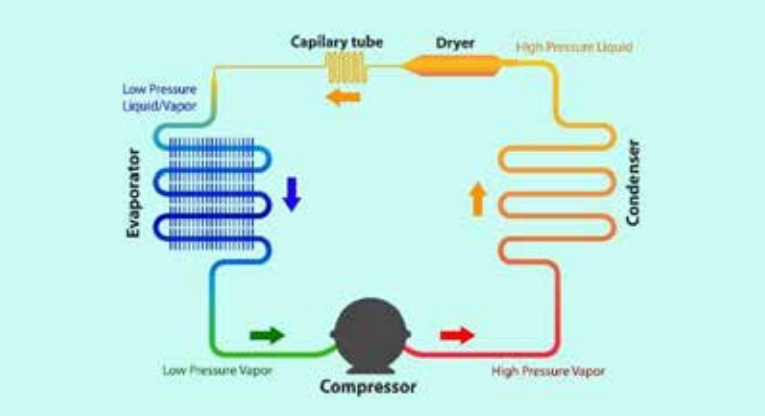


Fig. 1.2.1: Refrigeration cycle

A refrigeration cycle consists of two sides or pressure areas, the evaporating or low pressure side and the condensing or high pressure side. A metering device such as an expansion valve or a capillary tube separates the two areas on one side. On the other side, a compressor is placed between the two areas. The metering device controls the flow of refrigerant and the compressor compresses the refrigerant into high pressure gas. The low-pressure refrigerant passes through the evaporator causing it to evaporate. This low-pressure vapour then enters the compressor where it is compressed into a high temperature, high pressure vapour. It then goes into the condenser where it gives up its heat to the cooler air passing through the condenser. The refrigerant condenses back into high pressure liquid which travels to the metering device. It is made to pass through a small opening resulting in a drop of temperature and pressure. This low-pressure refrigerant then enters the evaporator again, thereby completing the refrigeration cycle.

Terms used in Refrigeration

- **Refrigerant:** Refrigerant is the main working fluid in any refrigeration system and it has a low boiling point. It vaporizes at low temperature and takes the heat away from the substance which has to be refrigerated.

  Examples: Freon 12 is used in domestic refrigerators and Freon 22 is used in ACs.

- **Cooling Capacity:** It is the rate at which heat is removed from a cold body or the rate of refrigeration produced.

  Unit of capacity of refrigeration is ton. One ton of refrigeration is the quantity of heat removed to freeze one ton of ice at a temperature of 0 °C in a time period of 24 hours.

- **British thermal unit (BTU):** Is defined as the amount of heat which is required to raise the temperature of one pound of water by one-degree Fahrenheit.

- **Cal or Watt:** The amount of energy which is required to raise the temperature of one gram of water by one degree Celsius at constant pressure of one atmosphere.

- **Refrigeration Effect:** It is the quantity of heat removed in unit time or the ratio of quantity of heat removed to the total time taken to remove that heat.

  $$\text{Refrigeration effect} = \frac{\text{Heat removed}}{\text{Time taken}}$$

- **Psychometry:** It is the study of the properties of moist air or mixture of air and water vapour.

- **Dry Air:** Dry air is the atmospheric air without the presence of water vapour.

- **Moist Air:** Air which contains water vapour is called as moist air.

- **Humidity:** The amount of water vapour present in air is called as its humidity. Humidity of air depends upon temperature and is independent of pressure.

- **Relative Humidity:** It is the ratio of mass of water vapour present in air to the mass of water vapour in fully saturated air at the same temperature and volume standards.

The air conditioning systems are basically of two types:

- **Window AC:** Window AC basically comprises of a single working unit which can be installed at a window. The condenser and the evaporator work on a single base. The following image shows the basic components of a window AC:

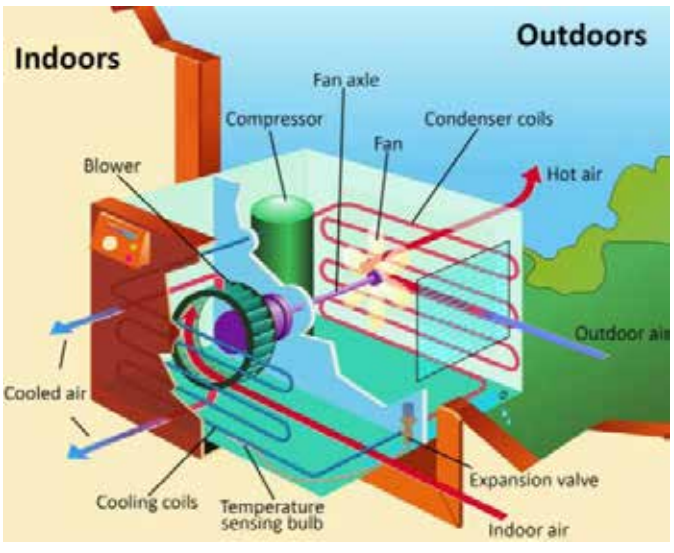


Fig. 1.2.2: Window AC diagram

- **Split AC:** A split AC is basically a two unit set. One is indoor unit (IDU) and the other one is outdoor unit (ODU). The IDU contains the evaporator, the basic air filter and the vents and the ODU contains the condenser coils, the fan motor and other compressor like parts. The following image shows the basic components of a split AC:

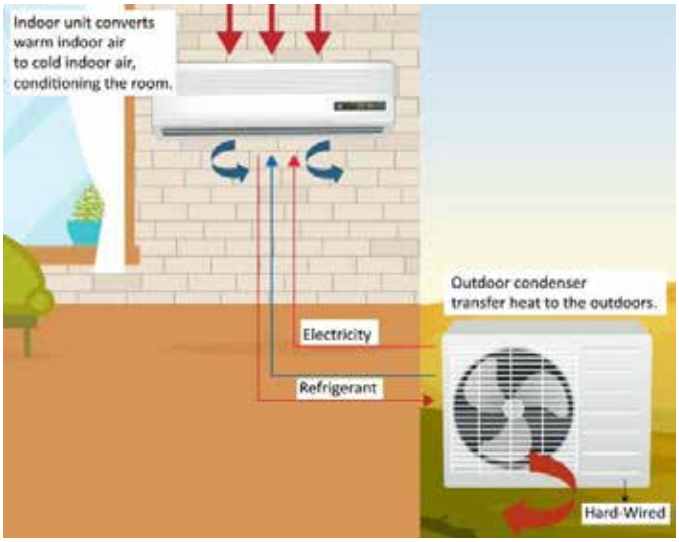


Fig. 1.2.3: Split AC diagram

Basic Wiring of ACs

- **Window AC:** As window AC comprises of only one unit in which all the components are connected, the wiring is done for a single unit. The following image shows the basic wiring diagram of the components of a window AC:

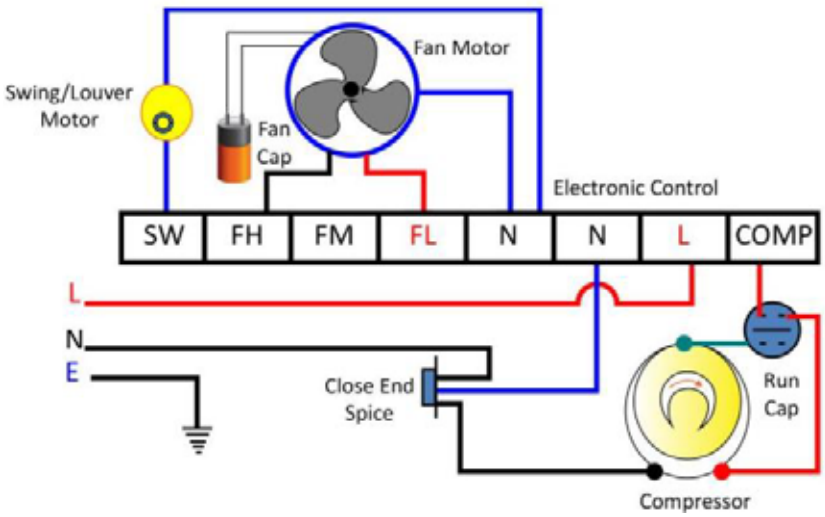


Fig. 1.2.4: Basic wiring of a window AC

- **Split AC:** A split AC contains two units, IDU and ODU. So, both the compartments have their different wiring connections. The following image shows the circuit diagram of both the units of a split AC:

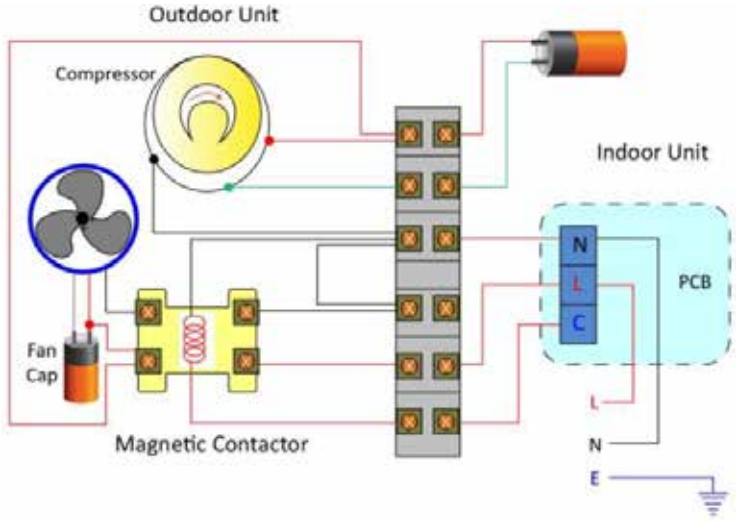


Fig. 1.2.5: Basic wiring of a split AC

The main power supply chord is split into ground wire, live wire and neutral wire. Ground wire is connected to the metal casing of the AC. Live wire is connected to the selector switch to supply power in the compressor, the motor and the other parts of the AC. The live wire from the selector switch is connected to the thermostat switch, then to the compressor of the AC and with the fan motor as well. The neutral wire is connected to the fan motor and the compressor and it goes directly without involving any switch. The connections are done at the backside of the selector switch. All the neutral wires are connected so that they become common to each other; this enables the connection to be connected at the same point.

1.2.2 Basic Concept of HVAC

HVAC is a climate control system for a confined space with respect to the specific requirements of the people, goods or machinery. An HVAC system can be installed in a home, commercial building (shopping malls, warehouses etc...), hotels, vehicles, passages.

Along with maintaining the air temperature (Heating/Cooling) as per the requirement, it also maintains the Indoor Air Quality (IAQ). IAQ refers to the quality of air inside the building. It is related to health and safety measures of the people or the goods placed. Specific gases are used to maintain the IAQ of the building/space where HVAC system is used.

Basic Components of HVAC System

A basic HVAC system consists of following components:

Thermostat	•It is helps in maintaing the temperature inside the building. The desired temperature it set in advanced and when the ambient temperature increases or descreases (beyond the set temperature value), the thermostat triggers the heat exchanger/ evaporator coil-condensing unit to circulate warm/cool air as required.
Furnace	•It is the key component of the HVAC system. Its function is to heat a supply of air distributed to various sections of the building. There are four different options available (depending on the model) for heat sources: combustion, heat pump, electric resistance or solar energy.
Heat exchanger	•It is placed inside the furnace unit. It's function is to pull cool air, heat it and then circulate the heated air. It starts operation only when the furnace is turned on by the thermostat to improve heating capabilitie. (Specifically during winter).
Evaporator Coil	•It is located in the metal enclosure on the furnance exterior. It operates just opposite to the heat exchanger. Evaporator coil cools the air when the thermostat is set to lower temperature. (Specifically in summer).
Condensing unit	•It is connected to the evaporator coil and is installed outside the building. It is packed with refrigerant gas and linked to the evaporator coil. When the refrigerant cools into a liquid by heat exchange with the outdoor air, the condensing unit sends it to the evaporator coil to vaporize it into gas again.
Refrigerant lines	•There are the narrow tubes made up of heat and cold resistant metal (copper /aluminium). It is responsible for carrying a refrigerant substance to the condensing unit in the form of a gas, and return it to the evaporator coil in liquid form.
Ductwork	•It refers to the system of ducts that transports air warmed or cooled to the various parts of the building. These ducts are made f leight weight metal such as aluminium.
Vents	•These are rectangular outlets responsible for delivering the air (heated/cooled) from the ducts into every room of the building. They are located on or near the ceiling and directs air downward.

Fig. 1.2.6: Basic Components of HVAC System

A basic HVAC system is an assembly of following units/subsystems:

Chiller	Air Handling Unit (AHU)	Cooling Tower	Pumps

Fig. 1.2.7: Subsystems of an HVAC System

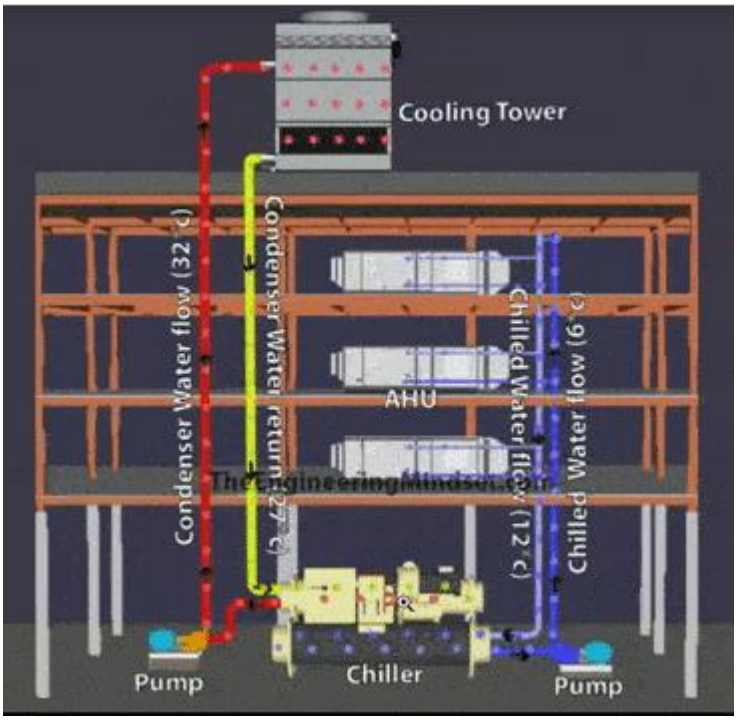


Fig. 1.2.8: HVAC System Assembly

Chiller

The purpose of chiller in an HVAC system is to remove heat through vapour compression or absorption. It is a type of heat exchanger in which, the heat is transferred from secondary refrigerant (water/air) to primary refrigerant (NH3) to produce chilled water. The essential components of chiller are evaporator, compressor, condenser and expansion valve.

The primary refrigerant (NH3) absorbs the heat from the secondary refrigerant (Water/air) and changes its (NH3) phase from liquid to vapour. The chilled water flows into AHU gets warm and return back into chiller

Based on the secondary refrigerant, Chiller can be categories as:

- **Air-Cooled Chiller:** These chillers uses motorized blower to blow the air across the refrigerant line. The purpose is to maintain ambient temperature.

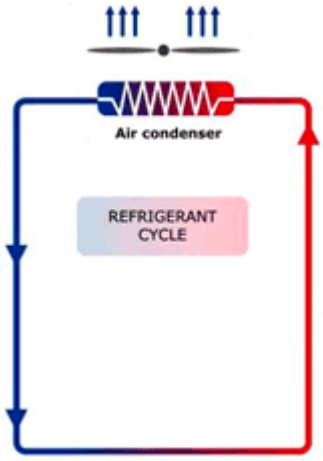


Fig. 1.2.9: Air-Cooled Chiller

- **Water – Cooled Chiller:** The purpose of these chillers is also to maintain the ambient temperature in the building. To solve the purpose, it involves two steps:
  - Move heat from refrigerant vapour into condenser water.
  - Pump the warm condenser water to the cooling tower where the heat is discharged to the atmosphere.

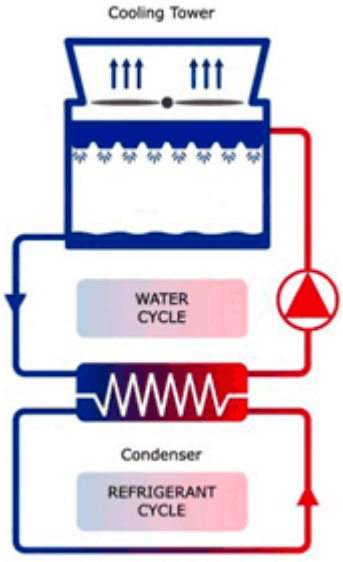


Fig. 1.2.10: Water-Cooled Chiller

Air Handling Unit (AHU)

AHU is basically a large metal box containing ventilators (for supply or exhaust the air), heating coil, cooling coil, air filters, mixing chambers and dampers.

It is used to re-condition and circulate/supply fresh air in the building. It takes in the outside air, re-conditions it and supplies fresh air to the building.

It removes all the exhaust air and creates acceptable quality and temperature of air. The outside air taken in by the AHU is either heated (in winters) by the heating coil or is cooled (in summers) by a cooling unit.

AHU is connected to the ducts that distributes the re-conditioned air in the diffract sections/zones of the building. The AHUs that are designed for roofs are also known as RTUs (Roof-Top Units).

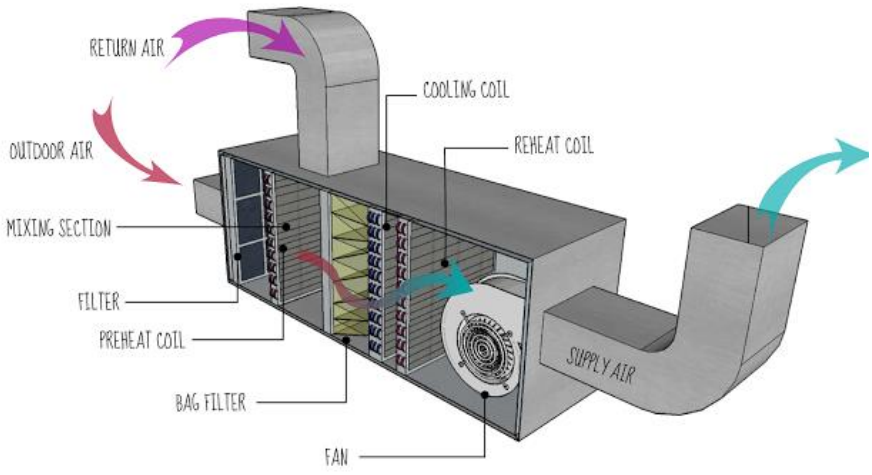


Fig. 1.2.11: Air Handling Unit

Cooling Tower

These are type of heat exchangers used to lower down the temperature of hot water. The warm water flows in the cooling tower, the evaporation process takes place using the large volume of air being blown through the large fans placed inside the tower. When the water cools down, it enters the tower sump placed at the bottom. The cool water is then sent back to cool the initial heat source. It is continuous loop that takes palaces in the cooling tower and the cycle repeats.

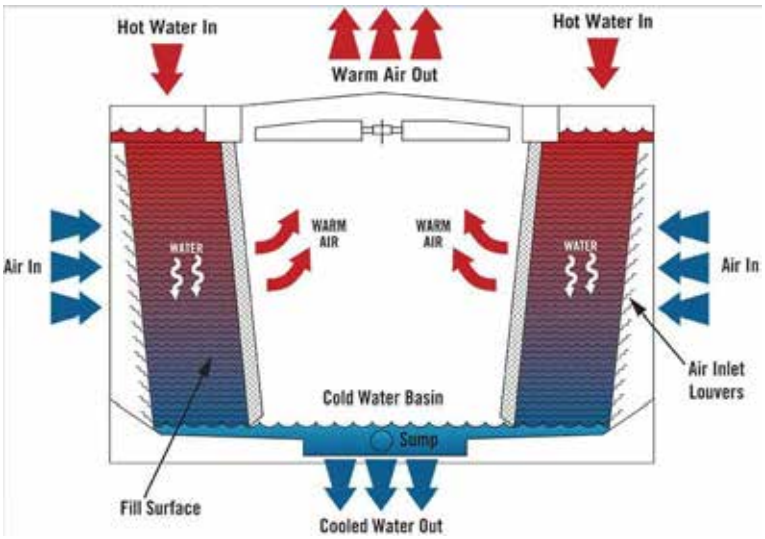


Fig. 1.2.12: Cooling Tower

Note: The functionality of HVAC system is controlled using a software program.

Pumps

Centrifugal pumps are the commonly used pumps in HVAC systems. Its purpose is to create a differential pressure between the inlet water and outlet water of the pump. Due to this pressure differential, the water flows through the pipes.

Fig. 1.2.13: Pump

1.2.3 Condenser

A condenser used in a HVAC system, is a device/unit used to transfer heat from a fluid/liquid into a gas/surrounding air by cooling it. The hot gas which is discharged from the compressor enters the condenser coil and gets condensed. The condensed air is than drained out of the condenser to a recipient located near the bottom.

A condensing unit comprised of condenser coil, compressor and controlling devices. The following schematic diagram represents the condenser unit of an air conditioning system.

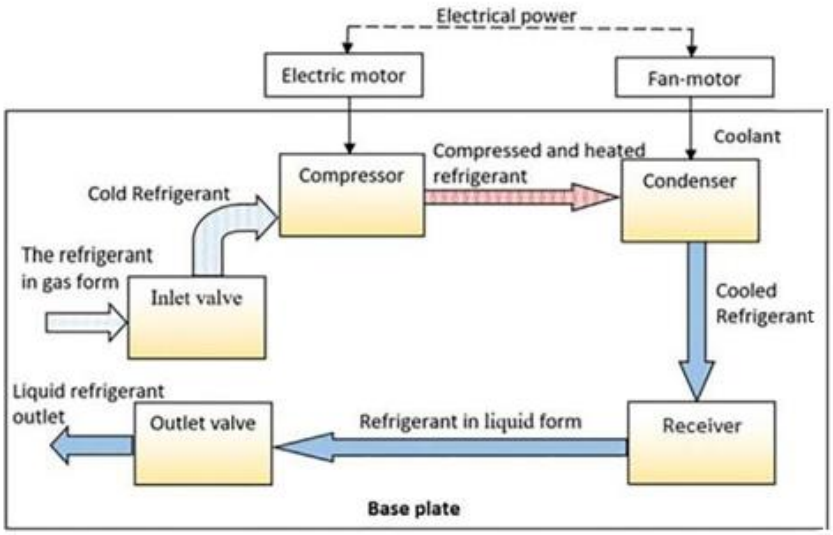


Fig. 1.2.14: Condenser Unit

Following are the various types of HVAC condensers:

- Air-cooled condensers
- Water-cooled condensers
- Evaporative

Air-Cooled Condensers

An air-cooled condenser consists of a coil of ample surface where a fan blows air, or is induced by natural draft. This type of condenser is used in small capacity refrigerating units. It is mostly designed for residential or small office air conditioners.

Timely and proper maintenance is required for air-cooled condensers. Any deposited dirt, lint, or other external materials act an obstacle and reduces the airflow around the tubes.

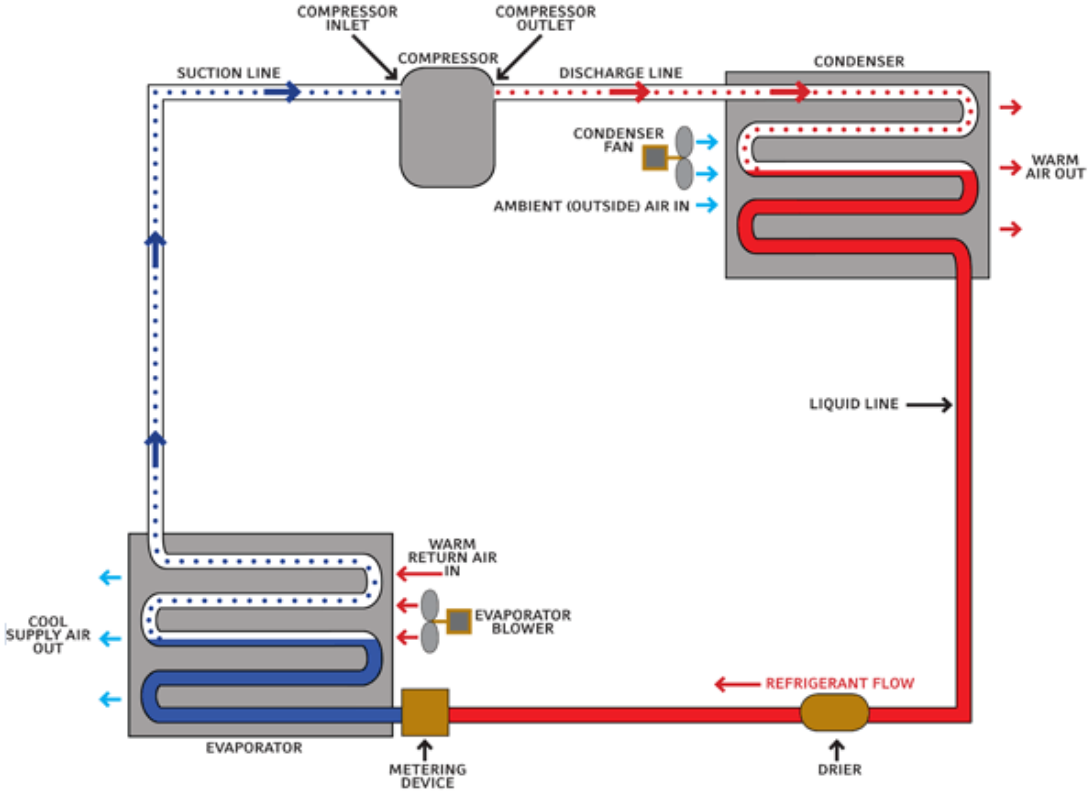


Fig. 1.2.15: Air-Cooled Condenser

Water-Cooled Condensers

In a water-cooled condenser the cooling is accomplished only by water, which circulates through tubes or coils enclosed within a shell. In these types of condensers, the refrigerant circulates throughout the annular space between the tubes/coils.

Due to its structure, it is also called double-pipe condenser.

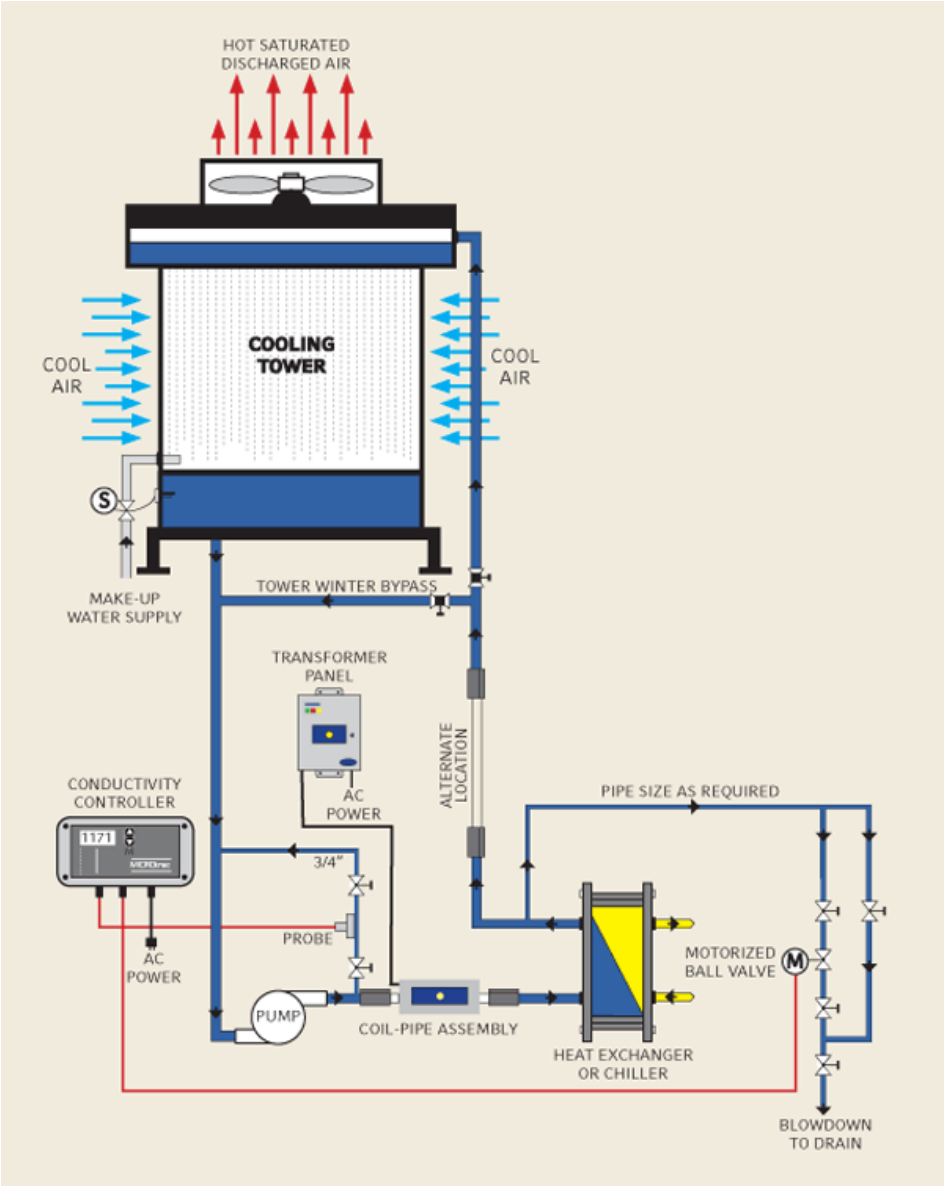


Fig. 1.2.16: Water-Cooled Condenser

Evaporative Condenser

The evaporative condenser consists of a coil. This coil is cooled by water sprayed from above and then cold air enters from the bottom and is blown across the coils. As water evaporates from the coil, it creates a cooling effect that condenses the refrigerant within the coil. The refrigerant gas in the coil is hot. It changed to the liquid state by just combining the sprayed water and the large column of moving air supplied by the fan. The water that does not evaporate is re-circulated using a pump. Because an evaporative condenser does not waste water, large compressor installations are possible in locations where water is scarce. Tests have proven that the amount of water required will not surpass the 0. 03 GPM per ton of the refrigeration. This is one of the eco-friendly reasons to use this type of condenser. Evaporative condensers also eliminate water disposal problems and provide one of the most economical means of cooling refrigerant gasses in standard air conditioners.

1.2.4 VAV Box

VAV box is also known as "Variable Air Volume" box. It is one of the essential components of an HVAC system. Its function is to control the air volume. It is installed at the opening of every duct.

Fig. 1.2.17: VAV Box

The different sections of a building may vary in size and thus varies the air intensity. The small sections of the building require less and large sections will require more. In such a situation, VAV boxes help controlling the air intensity according the section size.

VAV box contains sensors and controllers, which monitors the temperature of the particular section. These sensors are set to an ideal temperature. When the temperature level reaches that level, automatically the volume of air is minimised and controlled accordingly. Thus, it automatically adjust the air volume.

1.2.5 Types of HVAC Systems

There are different types of HVAC systems available. Based on the variation in the operations, HVAC systems can be categorised as follows:

1. **Split System HVAC:** In this HVAC system, the system is splited into:
    - **Outdoor unit:** It contains condenser and compressor.
    - **Indoor unit:** It contains the evaporation coil.
    - **Air Handler:** It sends the conditioned air through the duct system

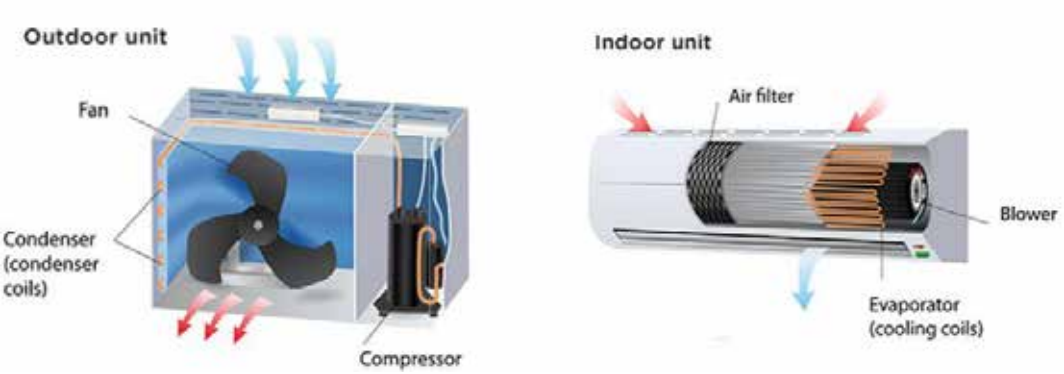


Fig. 1.2.18: Split System HVAC

There are two types of Split Systems HVAC; Mini Split also known as Ductless System and another type is Central System.

> **Note:** Central Systems are the ducted systems. In these systems, the heat-exchanger is placed inside the furnace of the air heating system. These systems has the ability of multi-zone temperature control.
>
> Ductless systems are the smallest HVAC system used for large single room or multiple small rooms. Commonly installed in houses.

2. **Packaged HVAC:** In these HVAC systems all the components such as evaporator coil, condenser, and compressor all packed/placed in one cabinet. These are big in size and are usually placed on the roof. A special concrete mount is built to keep the Packed HVAC cabinet. It is commonly used in small commercial buildings. The cabinet is connected with ducts through which the conditioned air is supplied to the building.

   These HVAC systems often include electric heating coils or a natural gas furnace due to which there is no need of a separate furnace.

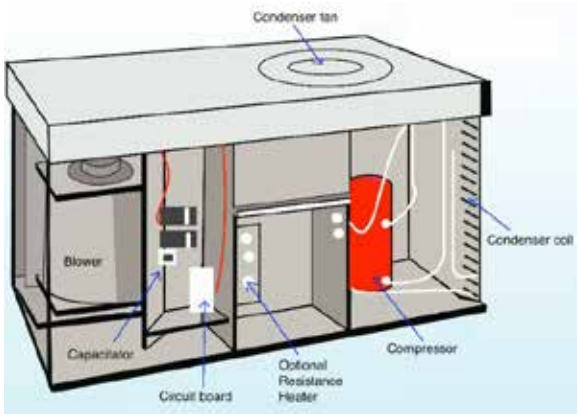


Fig. 1.2.19: Packaged HVAC

There are two types of packaged air conditioners:

- **Packaged air conditioners with water cooled condensers:** In these systems, the condenser is cooled by using water. Constant water is supplied to keep these systems working.
- **Packaged air conditioners with air cooled condensers:** In these systems, condensers are cooled by the atmospheric air. These are more like Air Handling units/Roof top units.

According to the zone (single or multiple) location and distribution, HVAC systems can be classified as:

- Central Air Conditioning System
- Local or Decentralised Air Conditioning System

1.2.5.1 Centralized Air Conditioning System

Central: It is a point or area that is in the middle of something.

Air Conditioning: It is a process for controlling the temperature, humidity (a quantity representing the amount of water vapour in the atmosphere), and ventilation (Ventilation is a fresh air circulation) in a building, to maintain a cool atmosphere in warm conditions.

System: A set of connected components that operate together to achieve a desired result.

Central air conditioning (or central A/C) is a system in which process of cooling can be achieved at a central location or middle location of building and supply this cooling to condition the various room or region in building to achieve desired temperature for comfort environment in the building.

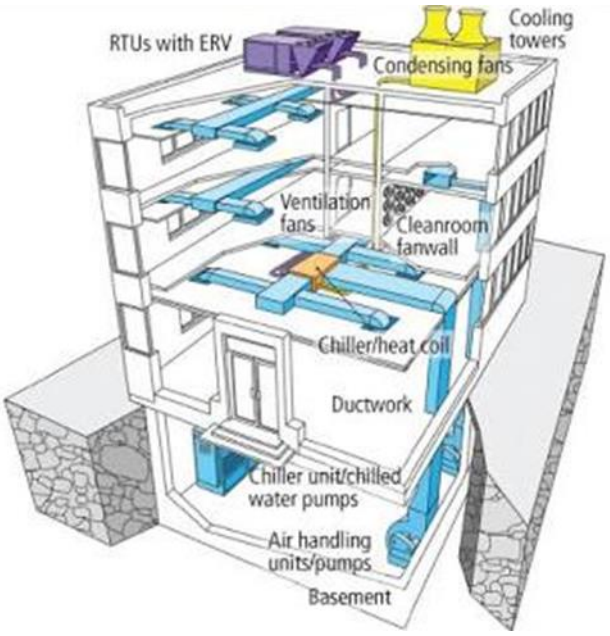


Fig. 1.2.20: Centralised Air Conditioning System

In today's modern Central Air Conditioning System, the cool air is supplied into large building according to cooling demand or load (100%, 75%, 50% etc.) into the building.

The cooling load of a building can be calculated by:

- Orientation of building
- No. of rooms
- No. of person living or working for hours
- Equipment load (light and fan)

If a Central AC system works on full load, it consume same amount of energy which is required to run the system according to specification. If the load is 50% then it runs at half load thus saving the energy.

Air conditioning can be done directly by passing air through evaporator coil which is fixed into air handling unit (AHU). The blower that is fixed in AHU takes air from surrounding which then passes through evaporator coil and gets cooled and then, this cold air is supplied into rooms through duct.

These ducts are connected between AHU and the different sections building where cooling is required. Such kind of system is known as **Direct Expansion (DX) air conditioning system**.

In another type, air conditioning can be done by secondary refrigerant (like water) which is first chilled by primary refrigerant (like NH_3) in **chiller**. Once the water is chilled, it is then supplied in chilled water coil of the Air Handling Unit (AHU). The blower fixed in AHU takes air from surrounding and cools it using chilled water. The cold air is supplied into the different sections of the building through ducts. These ducts are connected between AHU and the different sections building where cooling is required. Such kind of system is known as **Chilled Water (CHW) air conditioning system**.

Central air conditioning system has replaced decentralized air conditioning system in multi-storey building where there is problem to install outdoor unit. If we try to put number of split AC or Window AC (e.g. 20) and Put 20 outdoor in building. If these outdoor units are not placed properly, compressor consumes more electrical power.

Note: Central Air Conditioning Systems are widely used in Multi-Story Building because of the four major parameters; Temperature, Humidity, Air Movement and Air Quality.

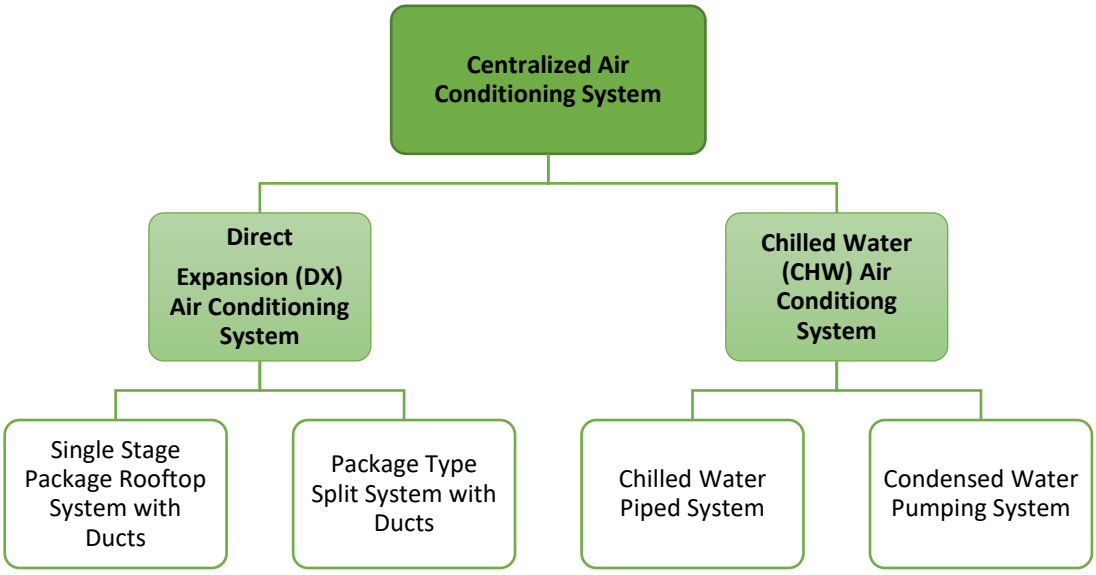


Fig. 1.2.21: Further Classification of Centralised Air Conditioning System

Direct Expansion Fresh Air Handling Unit (DX FAHU)

In such system, Direct Expansion of refrigerant to cool the Fresh Air from atmosphere is done in AHU (Air Handling Unit). That's why it is called DX-FAHU (Direct Expansion Fresh Air Handling Unit). It has two sections one is indoor unit (AHU) and another is outdoor unit (condensing unit).

In the following figure, the blue pipe from the indoor unit (AHU) acts as the inlet for liquid refrigerant into cooling coil. The red pipe is used to carry refrigerant vapour which returns after absorbing heat from fresh air.

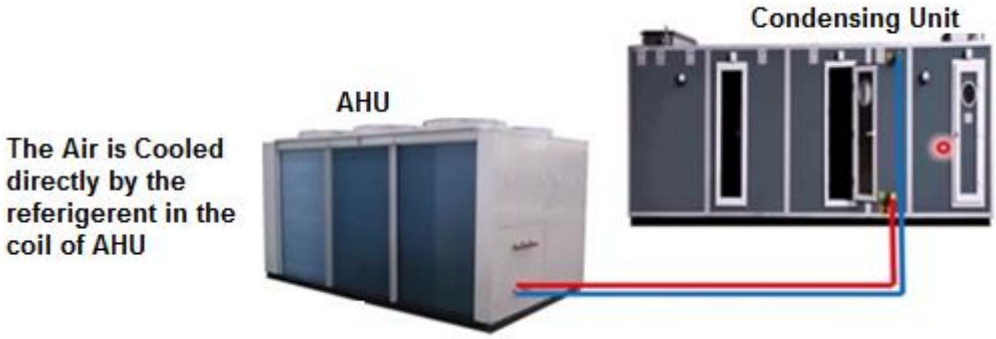


Fig. 1.2.22(a): Direct Expansion Fresh Air Handling unit (DX FAHU)

The AHU consists of following four sections as shown in the given figure:

1. Mixing box (mix fresh and return air)
2. Filter box
3. Cooling coil Box or DX-Coil Box
4. Fan Box

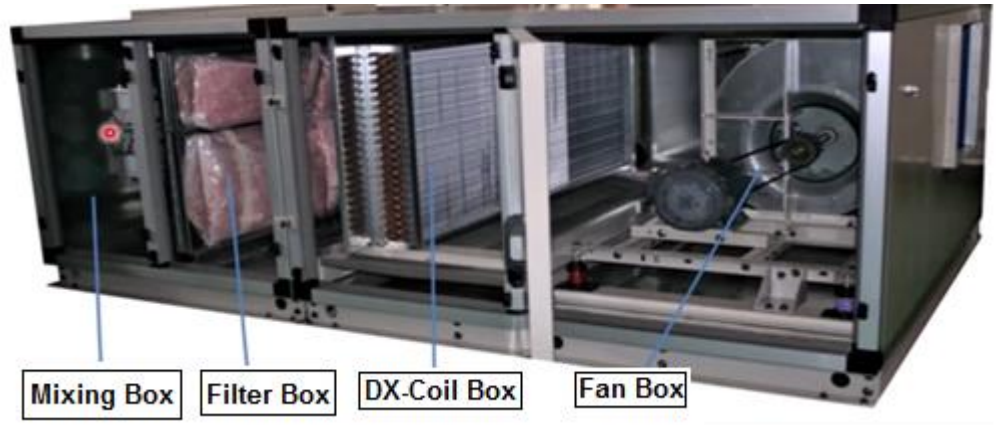


Fig. 1.2.22(b): Direct Expansion Fresh Air Handling unit (DX FAHU)

In AHU, warm air enters from mixing box and cool air exits from the fan box. In DX-FAHU, only fresh air flows and does not mixed with returning air.

In the outdoor unit, the vapour refrigerant enters the in to compressor (through red pipe). In the compressor, the vapour refrigerant pressure and temperature increases and then it passes into condenser. In the condenser, the refrigerant condenses by rejecting heat to atmosphere from the condenser coil. This condensed liquid refrigerant passes into cooling coil (through blue pipe) after expansion in AHU cooling coil.

Direct Expansion (DX) Air Refrigeration System is basically used in the following types of package units:

- **Single stage package rooftop system with ducts:** Single stage means the indoor and outdoor unit are in combined form. It is placed at rooftop because of its complex structure (both AHU and condensing unit is combined into single unit). This type of system is easy to install in building. We just have to connect the duct and power supply with motor and run the air conditioning system. It has cooling capacity from 5 TR to 130 TR (Tonne of refrigeration).

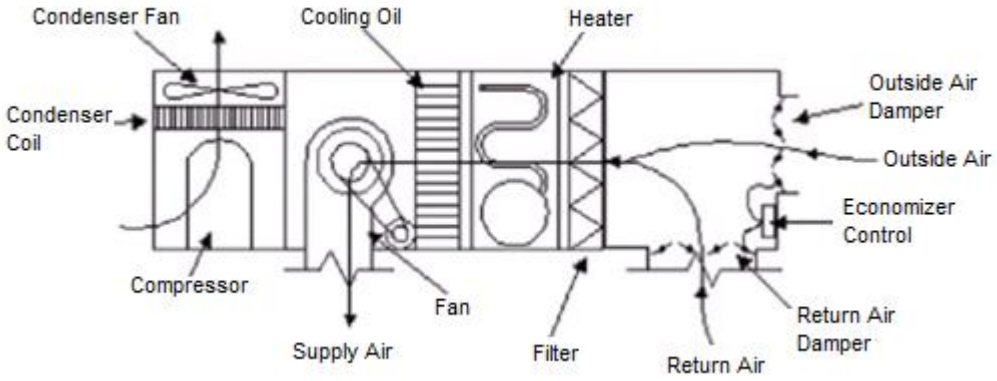


Fig. 1.2.23: Typical Single Packaged Rooftop System

- **Package type split system with duct:** Split system means both indoor and outdoor unit are separate. Indoor unit (AHU) is installed inside the building for cooling and the outdoor unit is installed outside the building for heat rejection to change vapour refrigerant into liquid phase. Such kind systems are preferable in small spaces where combined units cannot be installed. The cooling capacity of split system is 5 TR to 100 TR.

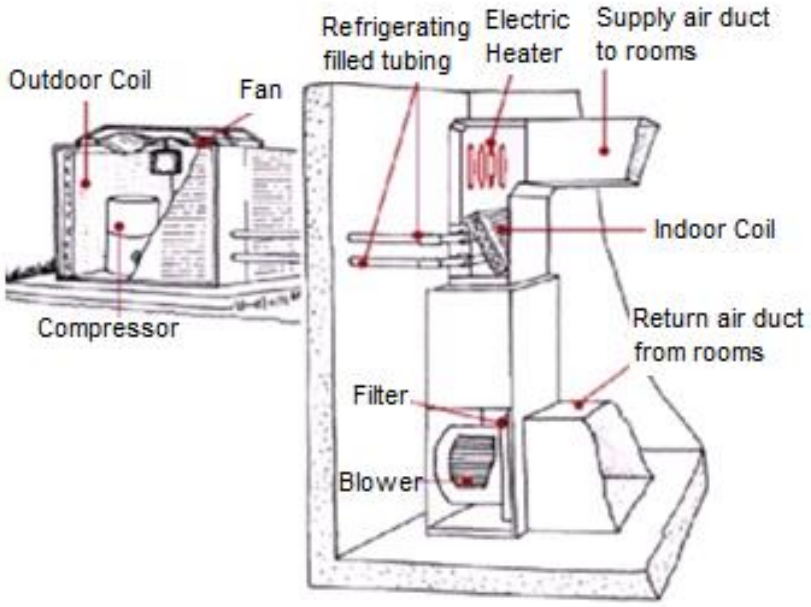


Fig. 1.2.24: Packaged Type Split System

Chilled Water (CHW) Air Conditioning System

In Chilled Water Air Conditioning System, the refrigerant is not directly expanded in AHU. This system is used to generate chilled water which acts as a secondary refrigerant. The chilled water used as refrigerant to condition air, is non-corrosive, has high specific heat value fluid, non-toxic and is cheap and thus, makes it an excellent choice compared to other secondary refrigerants such as sodium chloride brines, propylene glycols, ethylene, methanol or glycerine.

Following are the three important components of chilled water air conditioning system

1. Chilled water (Secondary Refrigerant)
2. Pipe Distribution(Between Chiller and Air Handling Unit)
3. Condensed water pipe distribution (Between Chiller and Condenser)

Fig. 1.2.25: Chilled Water Air Conditioning System

Chilled Water (Secondary Refrigerant)

The chilling process of secondary refrigerant (Water) takes place in chiller. In chiller (Heat exchanger), the primary refrigerant (i.e. NH_3) absorbs heat from the secondary refrigerant to reduce its temperature and lower down the water temperature to make it chilled water. This chilled water flows from chiller to cooling coil fixed in AHU with help of pump (as shown by blue line in Fig. 1.2.25). In Air Handling Unit (AHU), blower sucks air (fresh + return) from inlet section. When then inlet air cross the cooling coil, its temperature decreases and air becomes cooled. This cold air flows into different sections of building with the help of ducts. Subsequently, secondary refrigerant (water) temperature increases and it flows back to the chiller (as shown in by red line in Fig. 1.2.25).

Pipe Distribution (Between Chiller and Air Handling Unit)

The Pipe Distribution (Between Chiller and Air Handling Unit) is further divided in two types:

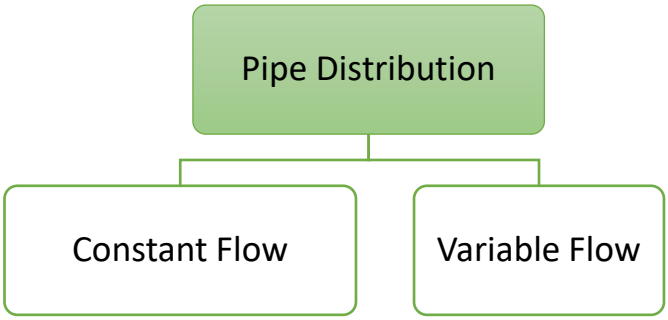


Fig. 1.2.26: Pipe Distribution

1. **Constant Flow Chilled Water System:** This system is divided in two sections:
   - **Chiller Plant/Production Load** where chilled water production takes place. Here, a constant speed pump operates and gives constant flow rate of chilled water.
   - **Distributed Load (Building Cooling Load):** Here, chilled water is distributed/supplied in cooling coil of AHU.

   In Constant primary flow chilled water system 3-way valve is used, which is operated according to cooling demand in the building. If cooling load is 100% then AHU is working on full load then 3-way valve is fully opened and total mass of water coming from chiller flows through AHU. If cooling load is 50% then 3-way valve regulate 50% of chilled water flow through AHU and remaining 50 % will by-pass before AHU.

   After the 3-way valve, balancing valve is used in to maintain the constant water flow after the exit from all AHU because the flow rate is different in different AHUs.

   Thus, a constant amount of water (Gallon per Minute) is supplied from supply valve (Chiller to Building) and returns from return valve (Building to chiller). Therefore it is called Constant flow chilled water system".

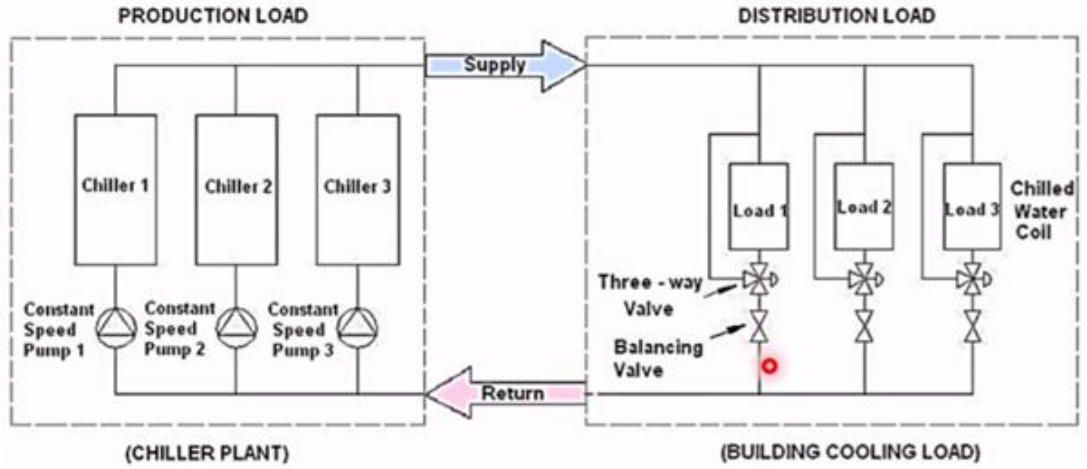


Fig. 1.2.27: Pipe Distribution: Constant Flow Chilled Water System

Advantages:

1. Lowest installed cost
2. Less space required
3. Easy to control and operate
4. Easy to commission or testing

Disadvantage

Highest Plant Energy Cost (pumps must run at full load at all low and high loads)

2. **Variable Primary Flow Chilled Water System:** This system is also divided into two sections; **Primary Loop (Production) and Secondary Loop (Distribution)**.The flow of water is controlled by variable speed drive(VSD) pump, in primary loop(Production) which is operated from secondary loop(Distribution).

   The 2-way valve senses the temperature of building rooms. When the comfortable temperature is achieved in building rooms then 2-way valve starts supplying chilled water as per different temperature in different rooms. When less opening is provided to the flowing water the water pressure increases in differential pressure line of the loop.

   Sensors senses the high pressure in differential pressure line of loop and send signals and the VSD pump controls the variable flow of chilled water supply.

   For example, If load is varies in rooms (i.e. 70%, 50%), VSD pump control the flow or variance in speed that controls flow of water so that differential pressure in the given section is high then VSD pump work at lower speed and similarly if differential pressure is low then VSD pump work at higher speed.

   The By-Pass Control Valve operates when flow in the loop is below 250 GPM (Gallon per Minute) by sensing the cooling load requirement.

> **Note:** The variable primary flow chilled water system is more energy saving, High efficient and cost effective as compare to both constant primary flow chilled water system and primary/secondary flow chilled water system.

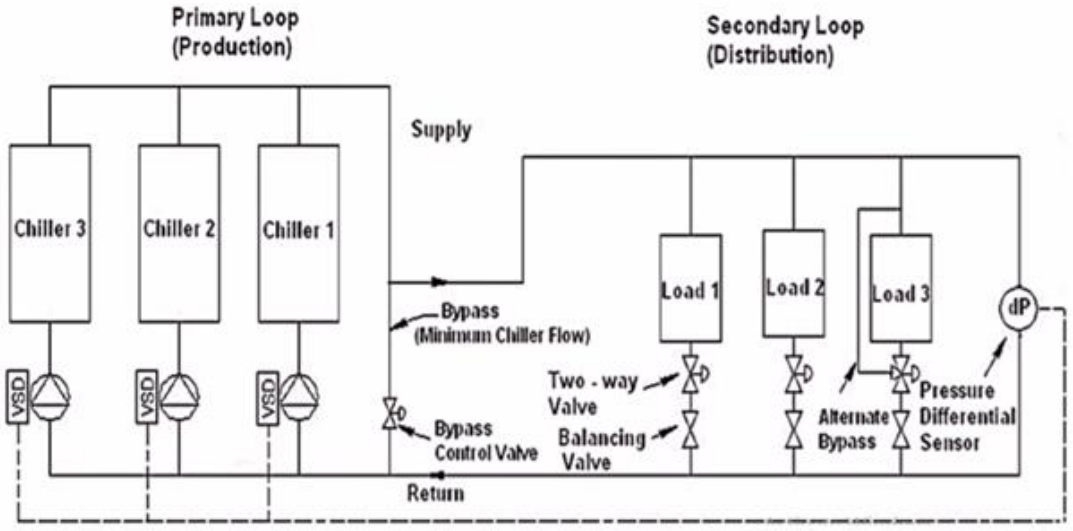


Fig. 1.2.28: Pipe Distribution: Variable Flow Chilled Water System

Advantages

1. Medium Installation Cost
   - No secondary pumps or piping, valves, electrical, installation etc.
   - Offset somewhat by added 2W Bypass Valve and more complex controls
2. Less Plant Space Needed
3. Best chilled water pump energy consumption
   - VSD energy saving
   - Lower pump design Head
   - Higher Pump Efficiency
4. Lower Potential impact from Low Delta

Disadvantages

1. Requires more robust (complex and properly calibrated) control system
2. Requires coordinated control of chillers, isolation valves and pumps
3. Potentially longer commissioning times to tune the system
4. Need experienced Facility manager to operate/maintain properly

All Air Distribution System (DUCT)

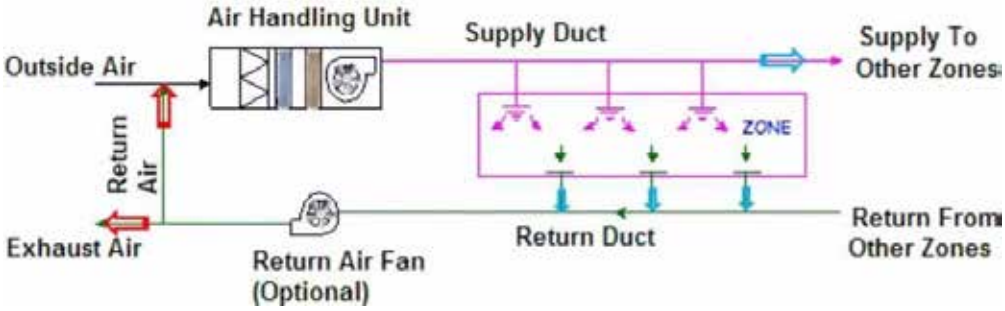


Fig. 1.2.29: All Air Distribution System (DUCT)

As you are aware of that in Central Air Conditioning System, air is supplied to different rooms/sections of the building with the help of AHU/FCU. For comfort zone, it is required to control temperature, humidity, air movement and air quality.

All air distribution system (DUCT) is used to supply air into duct and return some amount of air after circulated in condition room. It has been categorized as follows:

- Single Duct, Constant Volume, Single Zone System
- Single Duct, Constant Volume, Multi Zone System
- Single Duct, Variable Volume System
- Dual Duct, Constant Volume or VAV System

Where,

- **Single Duct** means supply air into condition room is done by duct and return air taken to AHU by plenum.
- **Constant Volume** means the volume is constant in duct with the help of fan, which is regulated by constant speed motor.
- **Single Zone System** means cool air supply in a single zone or in a single room only.

Components

The major components of All Air Distribution System are:

- **Damper:** Two Dumpers are used in this system. One damper for re-circulated air and another damper for exhaust air.
- **Mixing Box:** It is used to mix return air and fresh air before entering the cooling coil. For example, if 20% of air is exhaust in atmosphere and 80% of air returns to mixing chamber, than 80% return air mixes with another 20% return air and supplied again into conditioned room.
- **Cooling Coil:** It is used to cool the air.
- **Fan (Blower):** It is used to circulate air in the duct.
- **Humidifier:** It is used to control the humidity level in room after getting signal from humidity sensor (measure amount of moisture in air) fixed in room.

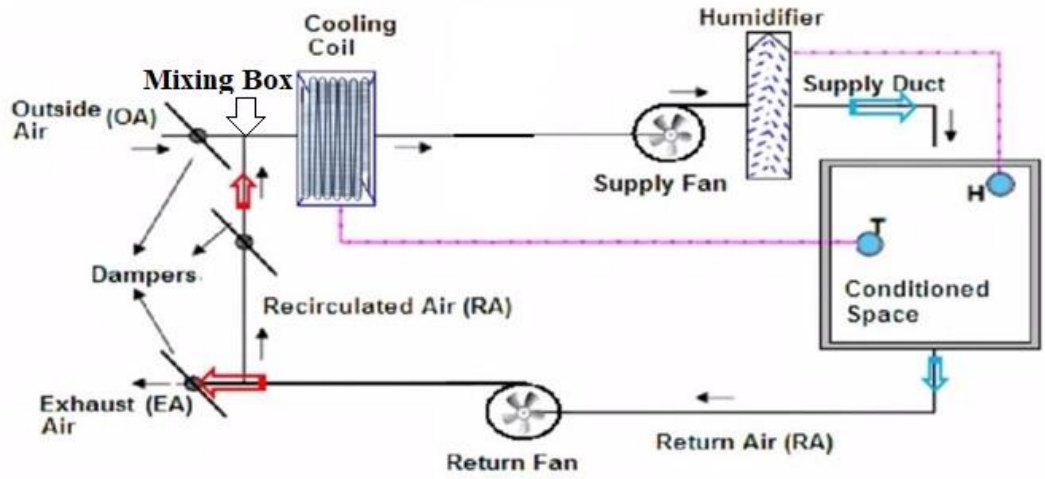


Fig. 1.2.30: Working of All Air Distribution System

Exercise

1. Differentiate between the following:
   a. Humidity and relative humidity.
   b. Condenser and Chiller (in HVAC System)
   c. Air-Cooled Chiller and Water Cooled Chiller
2. Explain VAV Box
3. What is AHU? Explain.
4. What is refrigerant?

UNIT 1.3: Basics of Electricity

Unit Objectives

At the end of this unit, you will be able to:

1. Explain basic electrical terms
2. Explain the measurement of electrical parameters
3. Describe the basics of electrical circuits
4. Describe the concept of magnetism and motor theory

1.3.1 Electricity

Electricity comes into existence whenever there is a flow of electric charge between any two components. The main parameters associated with electricity are as follows:

1. Voltage
2. Current
3. Resistance

Voltage

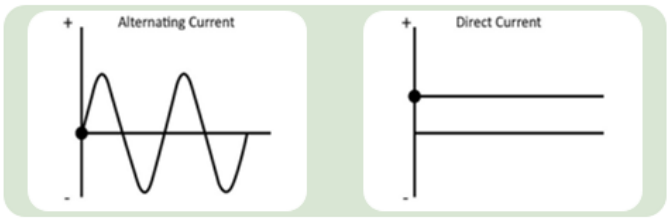
A force that causes electricity to move across a wire/cable is known as voltage. Volt is the unit of voltage and is denoted with letter V.

Current

Electric current, or simply current, is the flow of electric charge carried through electrons moving across wires. Ampere is the unit of current and is denoted with letter I.

AC and DC Current

The following figure lists the two types of current sources that are dependent on the direction in which the electrons flow:



AC can be defined as the flow of current in which electrons keep switching directions, going either forward or backward.

In this, the magnitude of induced current varies with time.

Types of AC are Sinusoidal, Trapezoidal, Triangular, Square.

DC can be defined as the flow of current in which the drift of electrons remains steady in a single direction.

In this the magnitude of induced current remains constant.

Types of DC are Pure and Pulsating.

Fig. 1.3.1: Difference between AC and DC current

Resistance

Resistance is an obstruction caused by a substance to the current flow. The unit of resistance is ohm and it is denoted with the symbol, Ω. According to Ohm's law, 1Ω resistance allows 1A of current to flow from one point to the other with a 1V voltage difference.

OMH's Law

According to Ohm's law, the flow of current through a conducting material is directly proportional to the conductor's voltage. The mathematical equation of Ohm's law is as follows:

I = V/R

Where,

I is the current

V is the potential difference

R is the resistance

Ohm's law states that R in the preceding relation is constant and independent of the current flowing through it as shown in the following image:

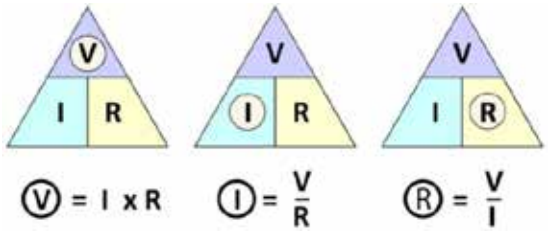


Fig. 1.3.2: Ohm's law triangle

Power Calculation and Energy Consumption

When electricity flows in an electric circuit, it results in some work done. For example, when it flows in a fan, the fan's blades rotate and when it flows in a refrigerator, it cools the things inside. Thus, when electricity flows through an appliance, it results in some work done. To calculate the electricity consumed, the following two parameters need to be considered:

1. Energy
2. Power

Energy

If the electric power is the rate or speed of work done, then electric energy is the total amount of work done in a given time period. It is a product of the power of an electrical appliance and the duration of its usage.

Power

Electric power is the rate of electrical energy transferred by any electrical circuit in a given time. The SI unit of power is watt which is represented by 'W', which is one joule per second.

The following equation shows the electrical power and energy calculation formula:

Electrical Energy (E) = Power (P) x Duration of Energy usage (T) = Power (Watt) x Time (hour)

E (Wh) = P (W) x T (h)

Power = Energy / Time

Example:

If 500W is used for a device for 4 hours, then consumption is = 0.5 kW * 4 Hrs. = 2 KWh.

1.3.2 Electric Circuit

An electric circuit is a path made by the interconnection of electrical components. Electrons from a voltage or current source flow along this path. The following figure lists the elements present in a basic electric circuit:

A source that provides electrical pressure known as voltage or Electromagnetic force (EMF) to electrical equipment to enable them to work.

Example: Battery

A device in a circuit which consumes electric power is called load.

Example: Bulb

A conductor that connects the supply source and the load.

Example: Wires

Fig. 1.3.3: Electric circuit constituents

An electric circuit consists of two paths/loops, as shown in the following image:

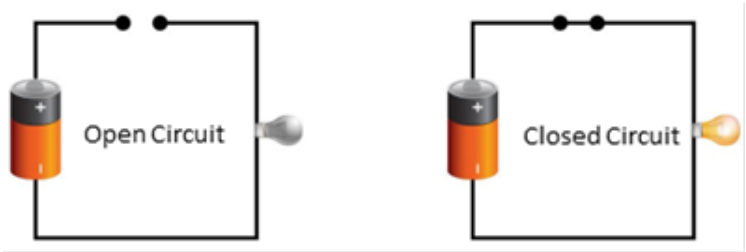


Fig. 1.3.4: Open and closed path

In a typical circuit, a battery provides voltage for the load through wires. For example, the required voltage for a bulb to glow is provided by a battery. The following image shows such an electric circuit:

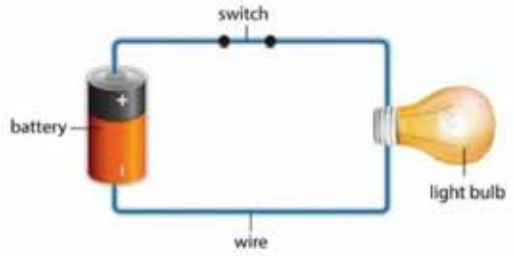


Fig. 1.3.5: An electric circuit

Types of Electric Circuit

An electric circuit is classified into two types:

- Series circuit
- Parallel circuit

Series Circuit

In this type of a circuit, all components are connected as a chain and the current flowing through each one of them is the same all over the circuit. There is a single route through which the current flows. So, the current passes through each and every component. Opening or breaking any point in a series circuit causes the whole circuit to stop functioning, which then needs to be replaced. The following image shows a series circuit:

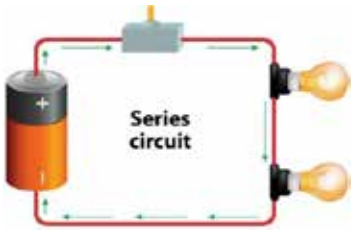


Fig. 1.3.6: A series circuit

Parallel Circuit

In this type of a circuit, two or more than two components are connected in parallel. In a parallel circuit, the components are of the same voltage. The current flow varies across the components. If any point of the circuit gets damaged, only that part needs to be replaced. The following image shows a parallel circuit:

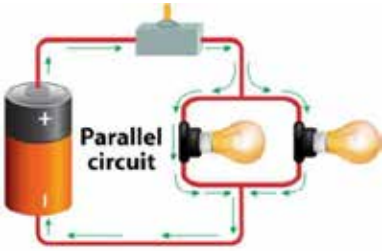


Fig. 1.3.7: A parallel circuit

Circuit Elements

A circuit consists of a number of components that may be electrical, electronic, and mechanical and so on. The following figure shows various types of circuit elements or components that are used in a control panel:

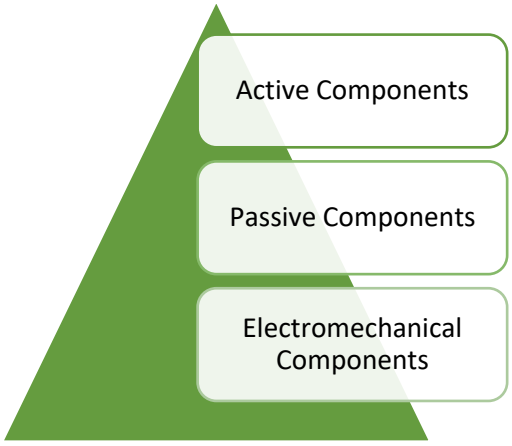


Fig. 1.3.8: Circuit elements

Active Components

Active components depend on a source of energy to perform their functions. These components can amplify current and can produce a power gain. The following figure lists the different types of active components in a circuit:

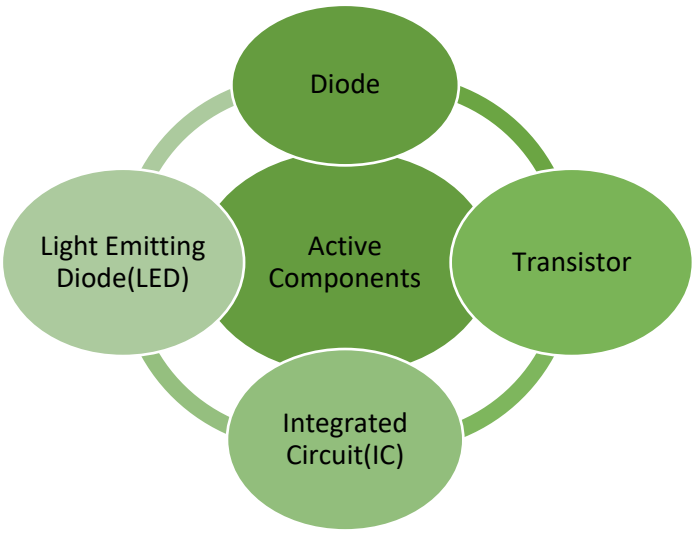


Fig. 1.3.9: Active components

Diode

A diode is a specialized electronic component with two terminals known as the anode and the cathode. It has very less resistance, ideally zero, to the flow of current in one direction whereas it has high resistance, ideally infinite, in the other direction. Diodes are usually made up of semiconductor materials such as germanium, silicon or selenium. Appliances such as refrigerators and ACs have this component in circuit boards.

The following image shows diodes:

Fig. 1.3.10: Diodes

Transistor

A transistor is an electronic device that is made up of a semiconductor material. Usually, it consists of three or more terminals for connecting to an external circuit. It is utilized to amplify or switch electrical power and electronic signals. Appliances such as refrigerators and ACs have this component in circuit boards. The following image shows a transistor:

Fig. 1.3.11: A transistor

IC

An IC, also known as a microchip, is a semiconductor wafer on which a number of small resistors, capacitors and transistors are fabricated. It can work as an oscillator, an amplifier, a timer, a counter, a microprocessor or as computer memory. Appliances such as refrigerators and ACs have this component in circuit boards. The following image shows an IC:

Fig. 1.3.12: An IC

LED

An LED is made of a p-n junction diode which releases light when it is activated. It is a two-lead semiconductor source of light. Appliances such as refrigerators and ACs have this component in their control panel display. The following image shows an LED:

Fig. 1.3.13: An LED

Passive Components

Passive components are those components which can perform their specific functions without any power source. These components are incapable of controlling current.

The following figure lists the different types of passive components in a circuit:

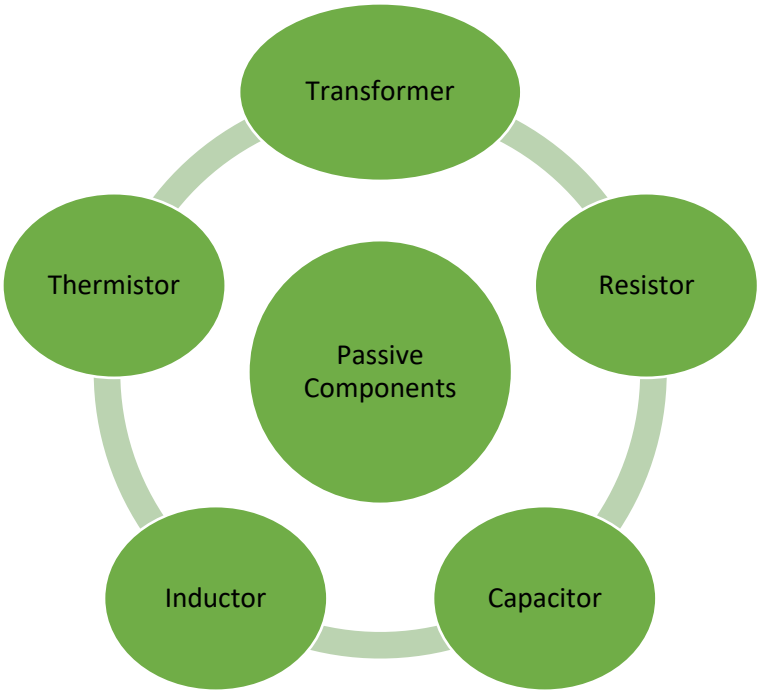


Fig. 1.3.14: Passive components

Transformer

A transformer consists of a metal core with coils of wire around it. It is a device used to convert AC to the required values by decreasing or increasing the alternating voltages in an electronic or electric system. Appliances such as refrigerators and ACs have this component in their power circuit board.

The following image shows a transformer:

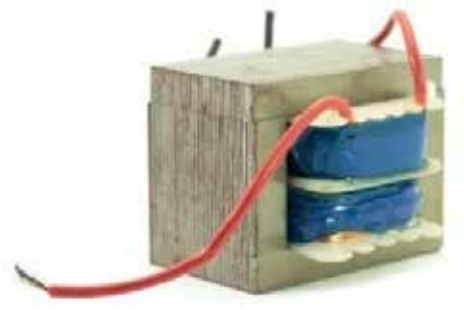


Fig. 1.3.15: A transformer

Resistor

A resistor is a component in an electronic circuit which is built to resist or limit the flow of current in that circuit. Its size varies in length from 5mm up to 300mm. Appliances such as refrigerators and ACs have this component in their circuit boards.

The following image shows resistors:

Fig. 1.3.16: Resistors

Colour Coding of Resistors

Colour coding was formulated to indicate the value of electronic resistance of a resistor.

In a resistor, colour coding is read as follows:

- Colour bands should be read from that end which has the bands nearest to it.
- The 1st and 2nd bands stand for the first two digits.
- The 3rd band represents the power-of-ten multiplier (the number of zeroes after the second digit).
- The 4th band represents the manufacturer's tolerance (accuracy of the resistor).

The following figure represents colour coding in a resistor:

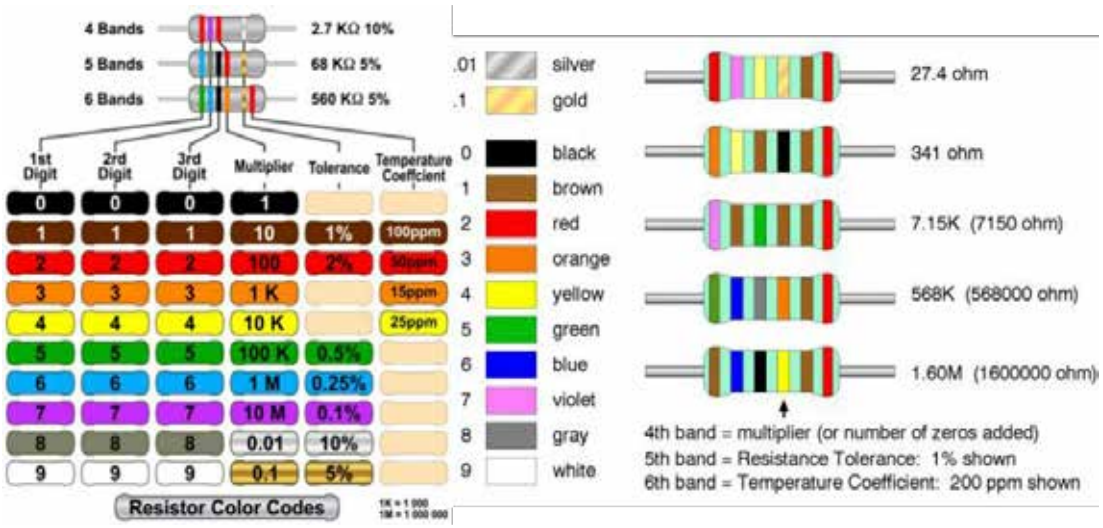


Fig. 1.3.17: Colour coding in a resistor

Capacitor

A capacitor is a device which is made up of one or more pairs of conductors and an insulator separating them. It is used to store electric charge. Appliances such as refrigerators and ACs have this component.

The following image shows capacitors:

Fig. 1.3.18: Capacitors

Inductor

An inductor consists of a coil or a wire loop. This component is used to store energy in the form of a magnetic field. The more the turns in the coil, the more will be the inductance. Appliances such as refrigerators and ACs have this component.

The following image shows inductors:

Fig. 1.3.19: Inductors

Thermistor

A thermistor is a kind of resistor which is more sensitive to temperature as compared to other resistors. It is extensively used as a temperature sensor, a self-regulating heating element and a self-resetting overcurrent protector. Appliances such as ACs have this component.

The following image shows a thermistor:

Fig. 1.3.20: A thermistor

Electromechanical components convert electric energy into mechanical energy (mechanical movement) or vice versa for carrying out electric operations.

The following figure lists various electromechanical components:

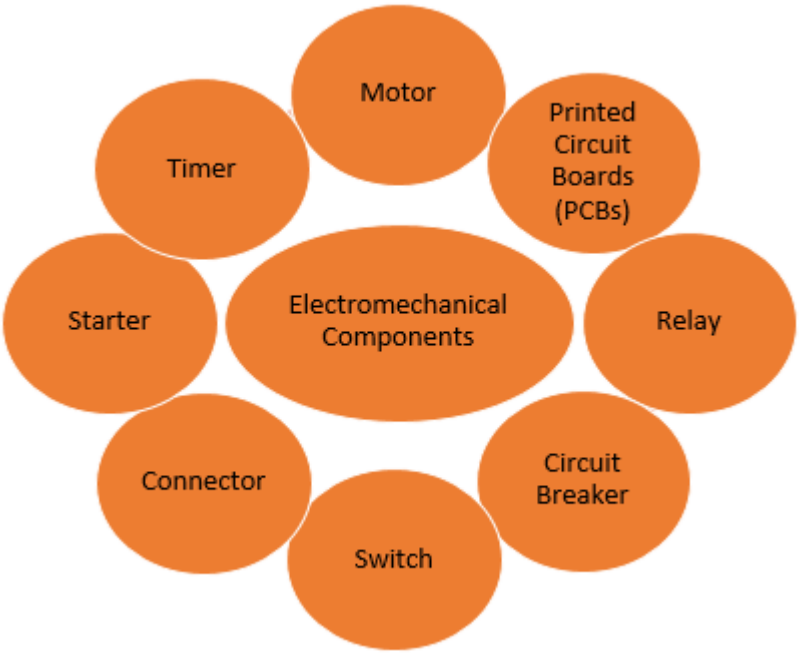


Fig. 1.3.21: Electromechanical components

Motor

A motor is an electrical component which is used to transform electrical energy into mechanical energy to produce linear or rotary force. These motors can be powered by using DC or AC motors.

The following image shows an electric motor which runs on AC power supply.

Fig. 1.3.22: A motor powered by AC current

PCB

A PCB acts as a base for the components that are mounted on its surface and are interconnected with wires, conductive tracks and so on. The components are generally fixed on the circuit board according to the specified design with the help of soldering.

Appliances such as refrigerators and ACs have this component. The following image shows a PCB:

Fig. 1.3.23: A PCB

Switch

A switch is a component used to make or break connections in an electrical circuit. It is used to divert the current from one conductor to another. It can be operated manually to control a circuit such as a light switch or can be operated by a moving object.

The following image shows a typical switch used in small appliances such as refrigerators and ACs:

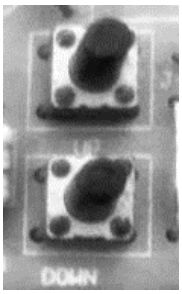


Fig. 1.3.24: Switch

Relay

A relay is a switch that controls an electrical circuit by opening and closing contacts in another circuit, electromechanically or electronically. In electromechanical relays, the opening and closing of contacts is done by a magnetic force. The electromechanical relays are operated by an electromagnet, which is a coil of wire wrapped round an iron core. In solid state relays, the switching is electronic as there are no contacts. Appliances such as refrigerators and ACs have this component. The following image shows both the relays:

Fig. 1.3.25: Solid state relay and electromagnetic relay

Circuit Breaker

A circuit breaker is a requisite component of an electrical power system required for its control and protection. It is a switching device which can be operated manually as well as automatically. Its main function is to shield an electric circuit from harm caused by overload or short circuit. It interrupts the current flow when protective relays find out a fault. Appliances such as refrigerators and ACs have this component.

The following image shows a circuit breaker:

Fig. 1.3.26: A circuit breaker

Starter

A starter in a refrigeration or air conditioning system helps start the motor. The starter is used since the motor windings installed in the system takes time to start as there is a previously maintained high pressure head in the system. This starter motor helps the main motor to start by decreasing the voltage and varying the value of frequency to the main motor start up.

The following image shows a starter:

Fig. 1.3.27: A starter

Timer

A timer or time switch is a type of circuit which is used for timing the refrigeration or air conditioning units. The timer operates as a switch which is controlled by a timing circuitry device. Air conditioning systems have timers which turns on/off the unit for certain period of time, set automatically or manually.

1.3.3 Magnetism and Motor Theory

A motor is an electrical component which is used to transform electrical energy into mechanical energy to produce linear or rotary force. Unlike magnetic solenoids, they generate usable mechanical powers. Following the air conditioner fan motor:

Fig. 1.3.28: Air Conditioner Fan Motor

In a normal motoring mode, force is generated inside the motor through the interaction between its winding currents and magnetic field.

Types of motors are:

1. Capacitor start motor
2. Relay start motor

Capacitor Start Motor

In a capacitor start motor, the capacitor is connected in series with the starter winding, which causes current in starter winding. When the motor reaches 75% of the rated speed, the capacitor and the starter winding is disconnected by a switch.

A capacitor start motor is used in air conditioners and washing machines. The following image shows a circuit diagram of a capacitor start motor:

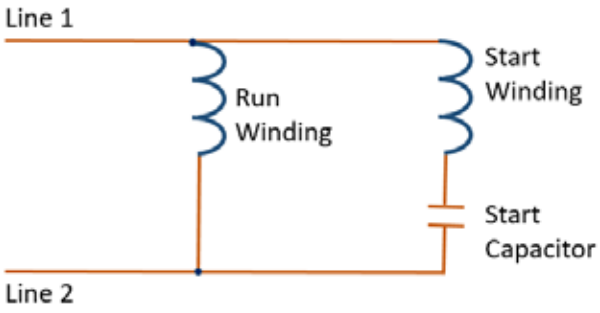


Fig. 1.3.29: Circuit diagram of capacitor start motor

Relay Start Motor

In a relay start motor a relay is connected between the starter and run winding, which causes current in starter winding. Then the resistance of motor increases with current, which cuts the start winding then the motor works only on run winding.

Relay start motor is used in refrigerators. The following image shows a circuit diagram of a relay start motor:

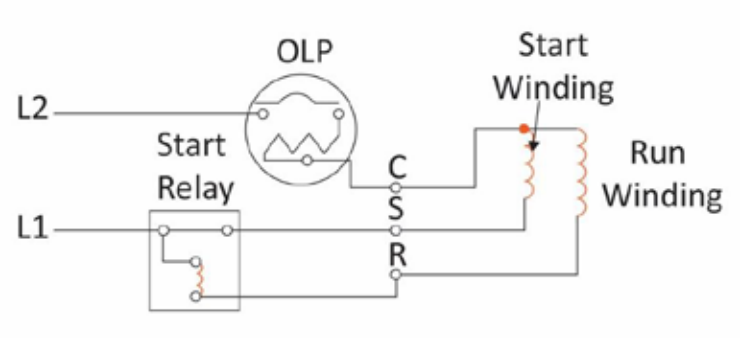
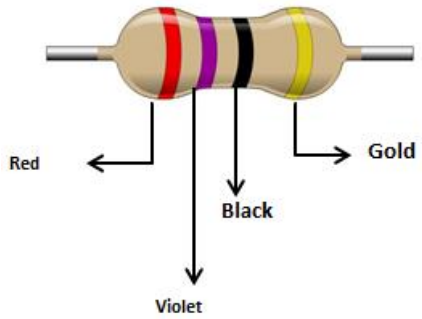


Fig. 1.3.30: Circuit diagram of relay start motor

Exercise

1. Differentiate between AC and DC current.
2. Calculate the resistance and tolerance of the following resistor.



3. If R1 = 8Ω, R2 = 8 Ω and R3 = 4 Ω
   Calculate the total resistance in:
   - Series circuit
   - Parallel circuit

Activity

Calculate resistance in a given circuit using Ohm's law. *(The aim of this activity is to analyse if the concept of Ohm's law used for calculating resistance is understood or not.)*

Equipment required:

1. Resistor
2. Multimeter
3. Power Source

Time required: 15-20 minutes

UNIT 1.4: Tools and Equipment

Unit Objectives

At the end of this unit, you will be able to:

1. Identify the types of tools used by an HVAC technician
2. Identify the equipment used by an HVAC technician
3. Identify the safety measures to be taken while handling tools

1.4.1 Tools and Equipment

Tools are non-consumable items that can be used in assembling RAC components. Tightening of bolts, stripping wires and measuring angles and length can be easily done with the help of specific tools. The tools can be divided into following categories based on the type of use:

- **Hand Tools:** These tools can be operated easily to perform tasks by using power and grip of hand. Some examples of hand tools are screw driver, hammer, measuring tape, wrenches and so on. The following image shows the basic hand tools used in the assembling of RAC components:

Fig. 1.4.1: Hand tools used in RAC components' assembling

- **Pneumatic Assembly Line Tools:** These tools are pneumatically powered tools used in the assembly line. They are handy and quick to operate. These tools are available on the line and thus easy to access and operate by the HVAC technician. The following image shows a pneumatic tool used in the assembly line:

Fig. 1.4.2: Pneumatic tool

Basic Hand Tools

The following tools are used for basic assembling of RAC components:

1. **Detachable Small Handle Screwdriver:** It is a screw driver which can be used from either end. One end has a plus '+' shape for '+' shaped screws and the other end is for minus '-' shaped screws.
2. **Detachable Long Handle Screw Driver:** It is a similar kind of a screw driver with a long stem. This also can be used from either end. One end has a plus '+' shape for '+' shaped screws and the other end is for minus'-' shaped screws.
3. **Slim Line Slot Head Screw Driver:** It is used where hands or fingers cannot reach. It has a long and thin stem and has a minus'-' shape.
4. **Round Screw Driver:** It is used to screw and un-screw the minus '-', plus '+', star '*', hexagonal or any other type of screw. It has a magnetic front socket which can hold bits of various shapes.
5. **Bit Pad:** It is a pad with eight-ten bits of varied shapes to be used with a round screw driver.
6. **Extension Bit/Rod:** It is a component that is attached to the front of the round screw driver to increase its length. Once attached, it increases the reach of the screw driver by an inch to three-four inches. The following image shows a screw driver set:

Fig. 1.4.3: A screw driver set with bits

7. **Tester:** It is used to check the presence of electric current in various sockets and wires during the assembling process. The following image shows a tester:

Fig. 1.4.4: A tester

8. **Double Ended Round Spanner:** It is a round spanner that can be used at either end. Each end has a different size. Generally, a set of spanners has a combination of sizes 10-11mm, 12-13 mm or 13-14mm.

9. **Simple Spanner:** It is a normal spanner (wrench) which can be used at either end. These are also two in number. One is a combination of 10-11mm and the other is a combination of 12-13mm and 14-15mm. The following image shows a spanner set:

Fig. 1.4.5: Spanner with wrench heads

10. **Adjustable Wrench:** It is a spanner that can be adjusted as per the head size of a nut/bolt. It is helpful in situations where the HVAC technician encounters a head which is either bigger or smaller than the limited sized spanner they otherwise carry along with them.
11. **Measuring Tape:** It is a self-retracting pocket tape measure which is used to measure the lengths and other parameters of objects while carrying out assembling. The following image shows a measuring tape:

Fig. 1.4.6: A measuring tape

12. **Spirit Level Meter:** It is an ideal tool for precise determination of horizontals, inclines and angles of a surface. The following image shows a spirit level meter:

Fig. 1.4.7: A spirit level meter

13. **Heavy Duty Hammer:** It is used for driving nails, fitting parts, and breaking objects. It has a handle and a head, with most of the weight in the head. One side of the head has a little slit that is used to pull out nails from brackets. The following image shows a heavy-duty hammer:

Fig. 1.4.8: A heavy duty hammer

14. **Pliers:** Pliers are hand tools that are designed primarily for gripping objects by using leverage. Three types of pliers are used by an assembling operator. They are as follows:
    a. **Combination Pliers:** These are used for gripping small objects, to cut and bend wire and cable and to hammer other small tools such as a chisel, a screwdriver and small nails. These pliers have a gripping joint at their snub nose and cutting edge in their craw. They also have insulated handle grips that reduce (but do not eliminate) the risk of an electric shock due to contact with live wires.
    b. **Side Cutter or Heavy Duty Cutter:** These are used to cut wires and nails.
    c. **Wire Stripper/Cutter:** It is used for stripping electric wires to remove insulation from the wires while leaving them intact. It is an adjustable plier which can be adjusted using a screw driver to enable its usage on a thicker wire as well. The following image shows pliers and cutters:

Fig. 1.4.9: Cutters and pliers

15. **Component Box:** It is a small box to keep small spare parts like screws, nuts, bolts, p-clips and so on.

16. **Digital Multimeter:** It is an electronic device which is capable of taking various electronic measures such as current, voltage or resistance. The basic measurements that are normally made include voltage, current (both AC and DC) as well as resistance. Advanced multimeters have a variety of other functions such as measurement of frequency (not up to a high level of precision), capacitance and temperature. The following image shows a digital multimeter:

Fig. 1.4.10: A digital multimeter

17. **Hacksaw:** It is used by the installer to cut a plastic pipe or a plastic conduit. It is a hand saw with a C shaped frame which holds a blade. The following image shows a hacksaw:

Fig. 1.4.11: A hacksaw

18. **Cutting Knife:** It is used at a workplace to cut the tape of sealed packages without damaging the packaging content. It is also known as a utility knife. The following is an image of a cutting knife:

Fig. 1.4.12: A cutting knife

19. **Tube Cutter:** This tool is used to cut a copper or a plastic pipe in a clean, convenient and fast manner. It is also known as a pipe cutter. The following image shows a tube cutter:

Fig. 1.4.13: A tube cutter

20. **Torque Wrench:** It is used to measure the torque in nuts or bolts. It is mainly used in prevention of over tightening of bolts. The following image shows a torque wrench:

Fig. 1.4.14: A torque wrench

21. **Wrench:** This tool is used to turn fasteners such as nuts and bolts by applying torque and tightening the screw. The following image shows a wrench:

Fig. 1.4.15: A wrench

22. **Refrigerant Gas Detector:** This tool is used to detect a gas leak around the appliance or in the surrounding. The following image shows a gas detector:

Fig. 1.4.16: A gas detector

Digital Clamp Meter: An electrical tester which combines a multimeter with a current sensor is known as a clamp meter. The probes in the device measure voltage whereas the clamps measure the current. The clamps are the hinged jaws joined to an electric meter that allows users to clamp around the cable/wire anytime for measuring the current without disturbing any other element. While using a clamp meter, the wire/cable to be measured is not disconnected. The following image shows a clamp meter:

Fig. 1.4.17: A clamp Meter

Pneumatic Tools

These tools as discussed earlier are powered by compressed air and are easy to operate. The tools are quick to work with and thus increase the work efficiency on the assembly line.

1. **Drill Machine:** It is used to create holes and through-holes in concrete and masonry (max. diameter 20 mm). It is also used for drilling metal sheets, wood, drywall and driving screws. It operates at 600 W. It can be operated in two modes, normal as well as hammer. The normal motion is a rotatory motion whereas hammer motion is a combination of rotatory and hammer motion.

   There are separate bits for both the modes. The following image shows a drill machine and drill bits:

Fig. 1.4.18: A drill machine and drill bits

Bits: The way a drill machine has two modes, normal and hammer, bits are also of two types. One set of bits is used for normal drilling whereas the other set is used for hammer drilling. A hammer drilling bit has got a different shape and also has grooves for better grip. It is generally used for concrete and comes in varied sizes such as 6mm, 8mm, 10mm, 12mm and 47mm in length.

2. **Pneumatic Screw Drivers:** Pneumatic screw drivers are used to tighten or loosen the screws that are mounted with a measurable amount of strength, which is required for a good mounting. It is a multipurpose tool as only by changing the head of the tool, multiple types of screws can be mounted and removed. The following image shows a pneumatic screw driver:

Fig. 1.4.19: A pneumatic screw driver

1.4.2 Maintenance and Housekeeping of Tools

As tools are essential for an HVAC technician, regular maintenance and checks needs to be done to maintain the tools in good condition. Using or working with a damaged, broken or unsuitable tool is hazardous.

To keep the tools in good condition, the following practices should be adhered:

- The tools should be taken from the store as per the requirement and returned in good condition after completion of work.
- A regular routine check of the tools should be done to examine their condition.
- The damaged and worn out tools should be fixed, else the tools should be replaced.
- Before and after completion of the work, the tools should be cleaned properly.
- The edges of sharp edged tools should be maintained sharp.
- The tools should be kept in the store department in an ordered way in proper toolboxes.
- The sharp tools should be kept with protective guard over the sharp edges.
- The broken tools should be discarded with care.
- Regular examination, repair and maintenance of the tools should be carried out only by a competent person.
- Any issue related to damage or faulty tool/equipment should be reported to the store supervisor or senior.

Safety While Working

While working at a site, an HVAC technician should ensure to follow the safety regulations to avoid any accident. Safety is the primary concern as per any company's policy and standards.

Safety should be followed:

- While handling tools/equipment
- Working around machines and electrical components.

The following safety points should be considered while working:

- **Overloading –** While using tools/equipment, make sure that they are not overloaded or operated beyond working limits. The ladder or structure over which work has to be done should not be overloaded as well.
- **Overreach –** Do not try to reach beyond a point while working on an elevated surface. Keep the safety line tied with the safety belt while working.
- **Resting Tools –** Avoid resting or hanging of tools over the assembly line.
- **Carrying Tools –** Always carry tools safely or use tool belts for carrying them.
- **Stability –** Always ensure to make a stable point of contact on the ground, especially while working around automated machines or assembly lines. Ensure making three points of contact rule for stable position before starting the work.
- **Standardised Equipment –** Ensure the use of standardised equipment like tools, ladders and safety equipment.
- **Maintenance –** Always maintain tools and equipment in good condition and clean them before using.

First Aid

While working on an assembly line and handling tools and equipment, a person might suffer some injury. So, to handle such a situation the operator should know how to use the first aid kit, which can provide the necessary first aid. The first aid box may contain:

- Instructions to provide first aid
- Sterile and antiseptic liquids
- Bandages of appropriate sizes and cotton
- Scissors, clippers and tweezers
- Cold pads
- Disposable gloves

The operator should have the required basic knowledge to provide first aid. Also, in case of any accident, the person should contact emergency services as soon as possible via the available communication methods.

Exercise

1. Look at the picture. Pick any 6 tools and write about them in the following table:

Name of the tool	Function/Usage of the tool

2. List 5 points that can help an HVAC technician to keep his/her tools in a good working condition:

_____

_____

_____

_____

_____

Activity 

HVAC system functioning is controlled using software. Browse about such software and create a presentation. Highlight its features, interface and usage.

(The aim of this activity is to help you understand various software available and their usage for HVAC systems monitoring and functioning.)

Equipment required:

1. Laptop/desktop with Internet connection
2. MS Office for PowerPoint presentation
3. Notepad & pen

Time required: 30-40 minutes

QR Code

Scan the QR code below to access the ebook

https://www.youtube.com/watch?v=ScVBPAitibQ

1.1.1 Who is an HVAC technician

https://www.youtube.com/watch?v=LU4rc1mBcYA

1.1.2 Role and Responsibilities

https://www.youtube.com/watch?v=RRY902AmAWY

1.1.3 Career Growth Path

https://www.youtube.com/watch?v=22M09sEHYIg

1.2.1 Basic Concept of RAC

https://www.youtube.com/watch?v=GzEMdQk1QTk

1.2.2 Basic Components of HVAC System

https://www.youtube.com/watch?v=p-HFH1-pTNs

1.2.3 Condenser

https://www.youtube.com/watch?v=vw-bAbjPTd8

1.2.4 VAV Box

https://www.youtube.com/watch?v=TyTQTe-jEqA

1.2.5 Types of HVAC Systems

https://www.youtube.com/watch?v=It6hjeI4JcI

1.2.5.1 Centralized Air Conditioning System

Skill India
कौशल भारत - कुशल भारत

सत्यमेव जयते
GOVERNMENT OF INDIA
MINISTRY OF SKILL DEVELOPMENT
& ENTREPRENEURSHIP

N·S·D·C
National
Skill Development
Corporation
Transforming the skill landscape

2. Pre-requisites of Work

Unit 2.1 – Interacting with Supervisor

Unit 2.2 – Interacting with Colleagues

Unit 2.3 – Identify the Possible Solutions and Suggest to Client

Unit 2.4 – Plan Work Schedule

Unit 2.5 – Analyse the Drawings and Layouts

Key Learning Outcomes

At the end of this module, you will be able to:

1. Demonstrate effective communication while interacting with the customer supervisor to get work requirement and work schedule
2. Identify the requirement of service and repair by interacting with the client and supervisors
3. Analyse the drawings and layouts of site
4. Identify the possible solutions and suggest to client
5. Plan work schedule and collect tools equipment from store
6. Deliver quality work to get client satisfaction and positive feedback

UNIT 2.1: Interacting with Supervisor

Unit Objectives

At the end of this unit, you will be able to:

1. Identify work requirements and targets
2. List the ways to ensure quality and timely completion of work
3. List the points to understand the work plan
4. Explain the principles of work ethics

2.1.1 Understand the Work Requirement

For a person to work, it is important to understand the work requirements. The work requirements for an HVAC technician include certain responsibilities as shown in the following figure:

- Take work order from the supervisor about the work assigned
- Understand the work requirements
- Follow the line of authority
- Issue on time the tools and the equipment and use appropriate drawings
- Keep upto date with new products and developments
- Plan, organize and control work for efficiency
- Report on the shortage of components such as screw, nut and other tools
- Find solutions to work related issues and queries or escalate issues of concern to the supervisor
- Highlight and resolve the issues occurring during assembling process

Fig. 2.1.1: Meaning of work requirement

Work requirement is also a document which has the date, location and the details of a particular task, which has to be done. It is the record of the task which is to be performed. The HVAC technician should be able to understand the task assigned and its requirement.

2.1.2 Quality and Timely Completion of Work

A few simple principles, if adhered to, can ensure production of quality work. As an HVAC technician, maintenance of quality and timely completion of work can be done in the following ways:

1. Ensure that work is done is as per the guidelines and standard of the company.
2. Plan and organize the day to day activities of production depending upon the instruction given by supervisor.
3. Follow the proposed plan of action.
4. Inform the supervisor in case of any potential hazards.
5. Follow guidelines of job instructions or work manuals.
6. Work to ensure quality of finished product.

The HVAC technician would get a job sheet or work allocation from the supervisor. The supervisor would also share a plan of action with the HVAC technician to ensure adherence to timelines and quality for the work assigned and an explanation if the target is not met. The following figure highlights the points which help an HVAC technician in understanding the plan to achieve 100 percent quality standards and timely completion of work:

Fig. 2.1.2: Achieving quality and timely completion of work

2.1.3 Work Ethics

Work ethics mean differentiating between the right and the wrong way of doing a job and adopting the right conduct. Work ethics involve certain principles as shown in the following figure:

Fig. 2.1.3: Work ethics

Resolve Personnel Issues

Resolving personnel issues involves the followings:

- Communicating effectively with the personnel ensures positive feedback in the organization. Two-way communication within and beyond the facility is also advised for an HVAC technician in any organization.
- All conflicts of interest, misunderstandings and personnel grievances need to be understood and then reported to the higher authority.
- Suggestions on resolving the problems is important as it helps the facility staff to concentrate on the job at hand.

Any personal issue or grievance also needs to be attended by the HVAC technician himself/herself before pushing the issue through to the supervisors. Managing the personnel is the most important part of team effort towards a unified goal.

Deliver Work of Expected Quality

Delivery of work as per expected quality should be maintained in the following ways:

- Ensure the work done is as per the guidelines and standard of the company.
- Plan and organize work for the day.
- Follow the plan.
- Inform supervisor in case of any deviation or emergency.

Inform Superior about Potential Hazards

Understanding all the possible hazards that can happen in a work place are the responsibilities of an HVAC technician. One possible cause of hazard could be the lack of clear understanding about the company's code of conduct or reference handbook which puts constraints on the use of equipment for purpose that is against the code of conduct. An HVAC technician can handle the hazard by:

- Communicating any such hazard to the supervisor to prevent unaffordable downtimes which could hamper critical functioning of the organization.
- Having clear communication with the other staff members and getting in place early warning systems for potential threats in another dimension.

- Making risk assessment which is an integral part of his/her job description. Potential hazards should be assessed with precision and supported with practical evidence.
- Adopting a systematic approach which is another dimension of communicating potential hazards.

The following figure shows a systematic approach for handling hazards:

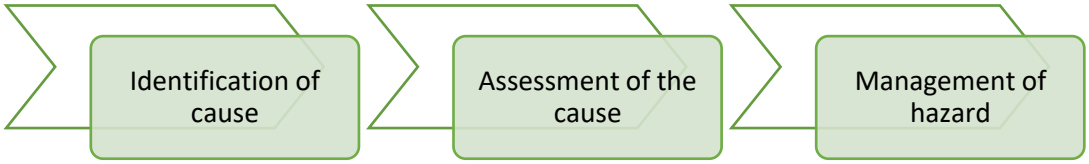


Fig. 2.1.4: Systematic approach for handling hazards

Exercise

1. Explain what you mean by “Code of Conduct”.
2. Why is it important to inform your supervisor about any hazard?

UNIT 2.2: Interacting with Colleagues

Unit Objectives

At the end of this unit, you will be able to:

1. Explain the importance of healthy interpersonal relationship
2. List the ways to establish better communication among co workers
3. Explain the importance of informal communication

2.2.1 Interpersonal Relationship

Every worker works towards a common goal in an organization, still all of them are divided by certain roles and activities and the way they accomplish that objective. Interpersonal communication – whether formal or informal - is the most common and important key to accomplish productivity and perform social functions in an organization.

The primary objective of an HVAC technician is to understand the process and the health of the communication taking place among the co-workers in order to improve its quality. A healthy interpersonal relationship enables carrying out the tasks as shown in the following figure:

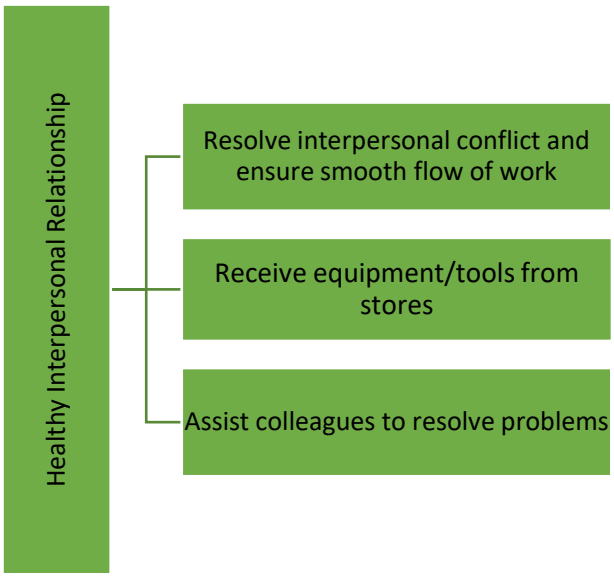


Fig. 2.2.1: Healthy interpersonal relationship

Resolve Conflicts

As discussed earlier, individuals are divided by roles and responsibilities in an organization despite working towards a common goal. Hence possibility of conflicts is nearly unavoidable.

A few tips to reinstate better communication among co-workers in such a quandary are as follows:

- **Clarify Role and Responsibilities:**

  Going to basics is the best way to resolve a problem. Role of an HVAC technician is to ensure a glitch-free workflow in an organization. The entire team should participate in

addressing issues, whether small or big. Providing a more rounded perspective of job roles and responsibilities offers inculcation of a positive and resolute approach for problems among co-workers. Also, this enables people with less job experience to take up things in a more constructive manner.

- **Plan Strategically:**

  In most organizations, conflicts between co-workers occur due to tight schedules and deadlines. Employees working on deadlines are required to work on short turnaround times, resulting in causing frustration and stress. Strategic planning in advance is the best way to avoid such circumstances. Irrespective of the team size, this can be achieved by deploying tools like calendar to communicate deadlines. The following image shows planning using a calendar:

Fig. 2.2.2: Planning using a calendar

Receive Equipment/Tools from Stores

Getting the job done in a process depends on information communication. Furthermore, accuracy of the end result entirely depends on effective inter-personal communication. For example, an electronic appliances company wants to replace old appliances with the new ones, accurately and smoothly. The entire exchange process depends on how effectively the electronic company communicated with the person in charge at the store, the requirement for infrastructure upgrade.

Assist Colleagues

Be it work allocation, manpower distribution or identification of areas of high responsiveness, healthy communication is the key to improve service quality. Informal communication is what is usually seen to be dominant in most workplaces. People asking for help from the person sitting at the adjacent desk to troubleshoot a module issue, rather than consulting an HVAC technician, is one of the most common examples of informal communication.

The communication is spontaneous and successful in achieving the goal, paving the way to formal interpersonal communication. Despite having established communication procedures, the informal communications occur in every organization and help in resolving problems and conflicts in real time.

Hence, the role of an HVAC technician is to make proper communication with colleagues regarding errors occurring in any step of the assembly process.

The following image shows colleagues assisting each other:

Fig. 2.2.3: Colleagues assisting each other

2.2.2 Team Coordination

An HVAC technician needs to be able to work in a team. To work in a team, an operator should be able to get along with fellow operators, respect others and show a cooperative behaviour always.

Working in and as a team enables some positive aspects as listed in the following figure:

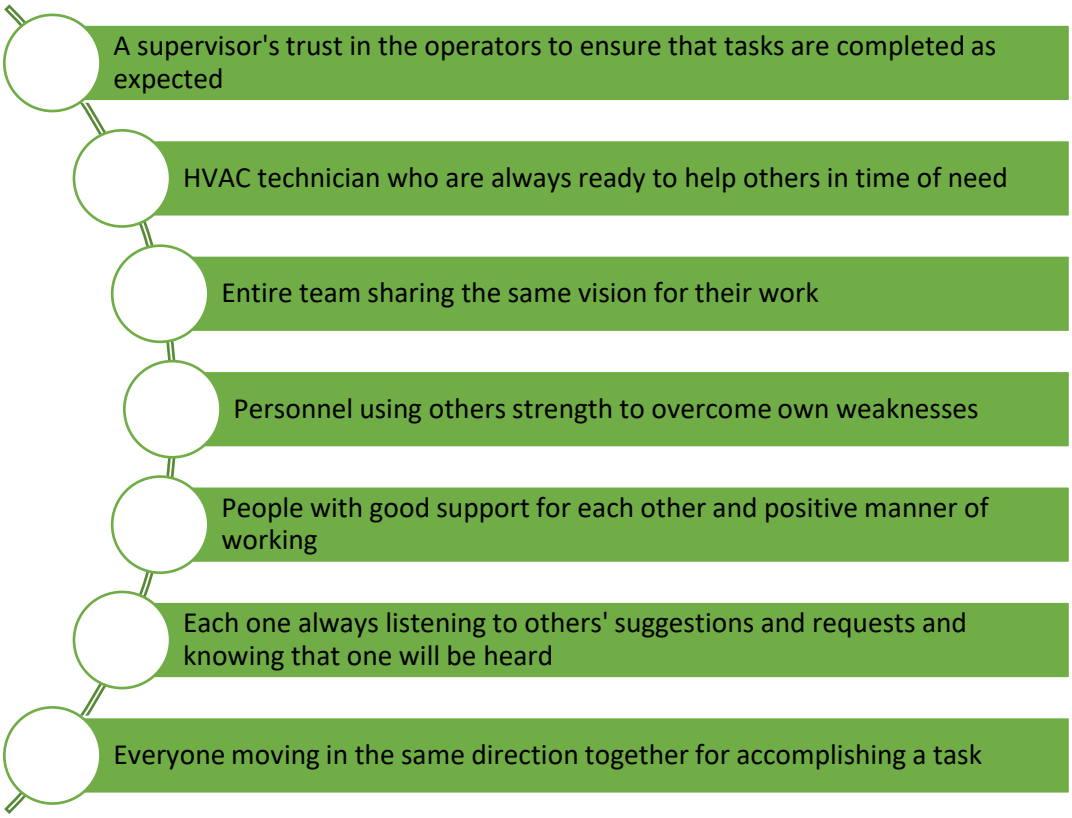


Fig. 2.2.4: Team coordination

To make teamwork effective at workplace, the following points need to be considered:

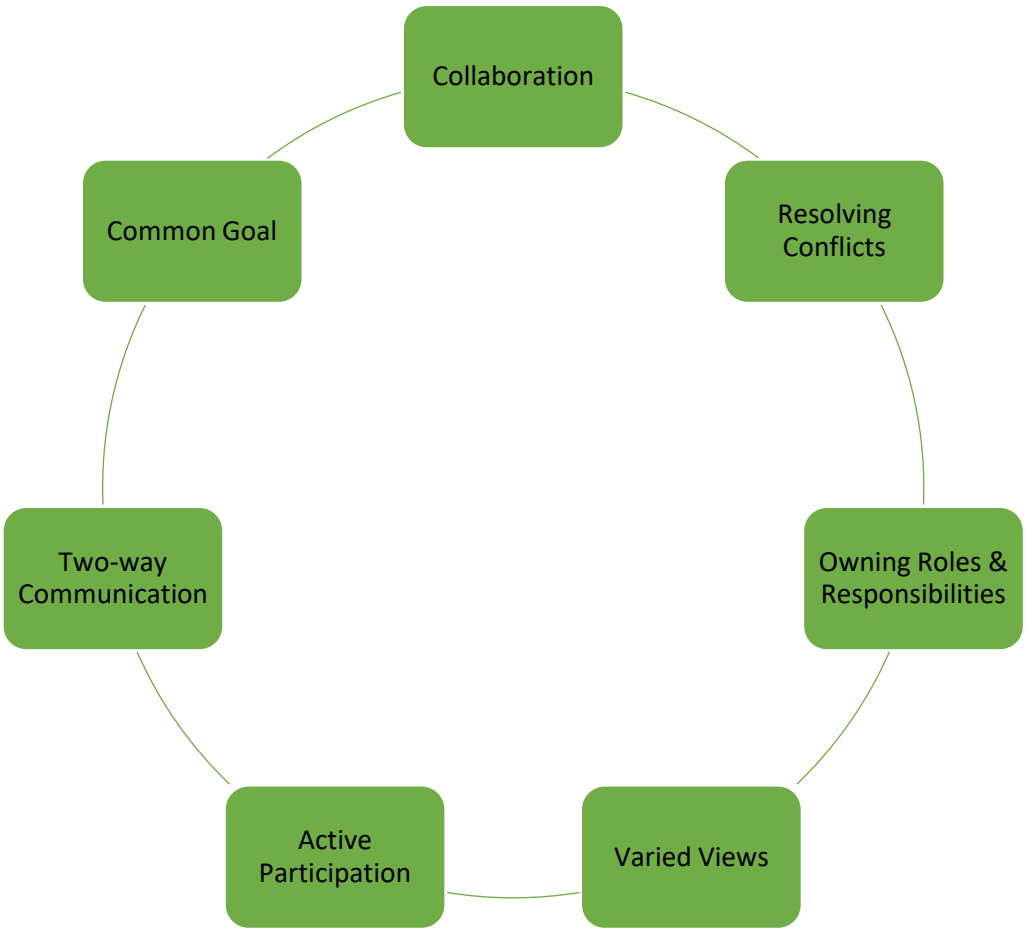


Fig. 2.2.5: Points to be considered for effective teamwork

Role Play

There is an argument going on between two of your colleagues. You found that the situation is getting worse. How will you handle the situation?

UNIT 2.3: Identify the Possible Solutions and Suggest to Client

Unit Objectives

At the end of this unit, you will be able to:

1. Inspect and communicate the issue
2. Diagnose and Identify the issue
3. Explain the solution
4. List the dos and don'ts
5. Perform documentation

2.3.1 Understand Customers' Requirements

Understanding the needs of a customer is one of the foremost parts of an HVAC technician's job role. This includes the following practices:

- Call the customer
- Check time of visiting the location
- Greet the customer and talk politely
- Understand the customer's requirement
- Provide the best possible and cost-effective solution to the customer
- Ensure that the customer is satisfied with the service
- Address the queries and issues raised by the customer

An HVAC technician's job is a customer facing role. The following figure shows the characteristics which every electrician should reflect:

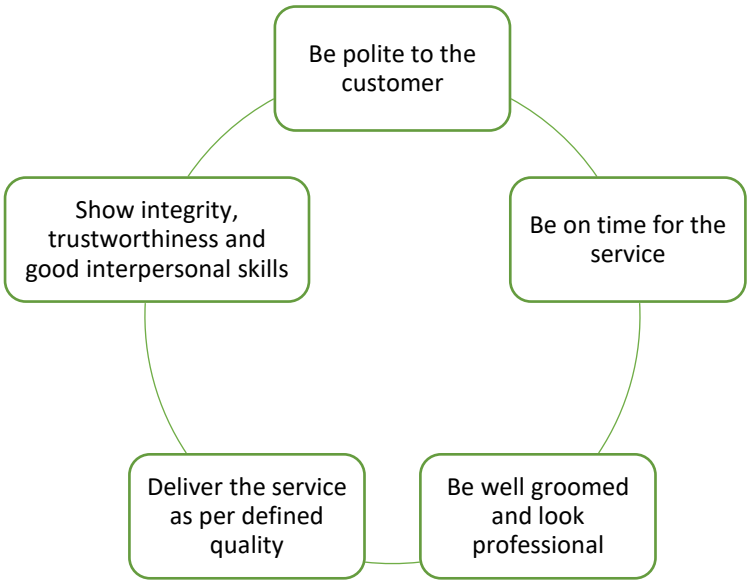


Fig. 2.3.1: Characteristics of HVAC technician

When on a visit to a customer's site, to ensure good service, the customer's requirement should be understood, and a solution should be suggested. The following figure shows the points to be taken care of while communicating with a customer:

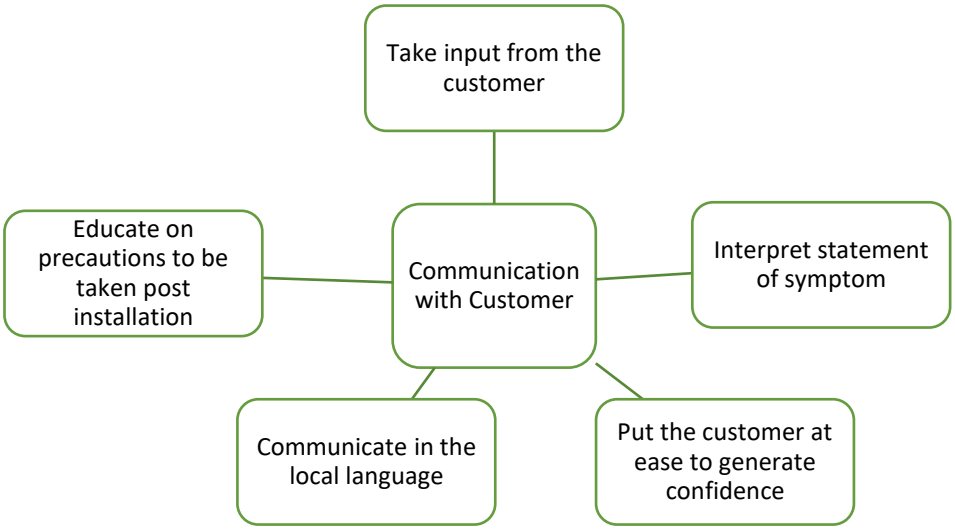


Fig. 2.3.2: Communicating with a customer

Educating and Informing the Customer

Educating a customer about the wiring process is an important aspect of an HVAC technician's job. For the satisfaction of the customer, an HVAC technician should inform the customer about the installation process and other information about material and fittings installed by him/her at the customer's site or premises.

The following figure shows a list of information to be given to the customer:

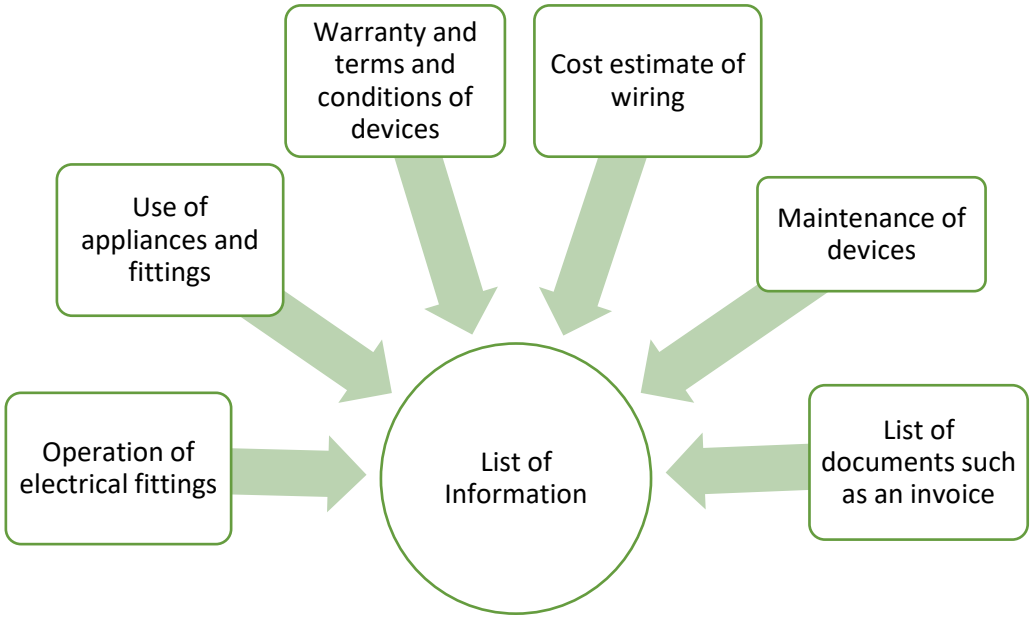


Fig. 2.3.3: List of information

Asking Questions

Asking questions is also a skill required for the role of an HVAC technician. Questions may be asked to the customer to get more details or to be sure of something. An HVAC technician should also ask a customer appropriate questions to analyse the problems faced and seek inputs from them to understand the symptoms.

Warranty Coverage

Warranty coverage is an agreement between the manufacturer and the buyer which assures the customer of getting a free repair service till the mentioned date of warranty.

An HVAC technician is responsible for informing the customer about the replacement or repairing procedure of appliances and he/she should tell the customer about the estimated cost of the repairing or whether the repairing will take place at the service centre.

Suggest a Solution to the Customer

After identifying the issue, an HVAC technician needs to offer solutions to the customer. The HVAC technician should explain all the possible solutions along with the cost associated. The person should then propose the best solution and let the customer decide whether to go ahead with the given solution or not.

The following figure shows the steps involved in offering solutions to a customer:

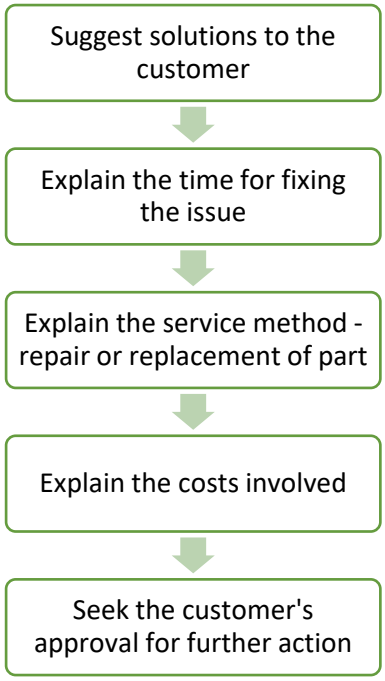


Fig. 2.3.4: Suggesting a solution to the customer for an issue

Escalating Issues

Often, there can be certain issues that need to be resolved at the earliest. The first step in resolving issues is their escalation. HVAC technicians need to communicate with their supervisor/s regarding process issues that might be affecting their performance. The following figure lists some of the issues that need to be escalated to the supervisor as soon as possible:

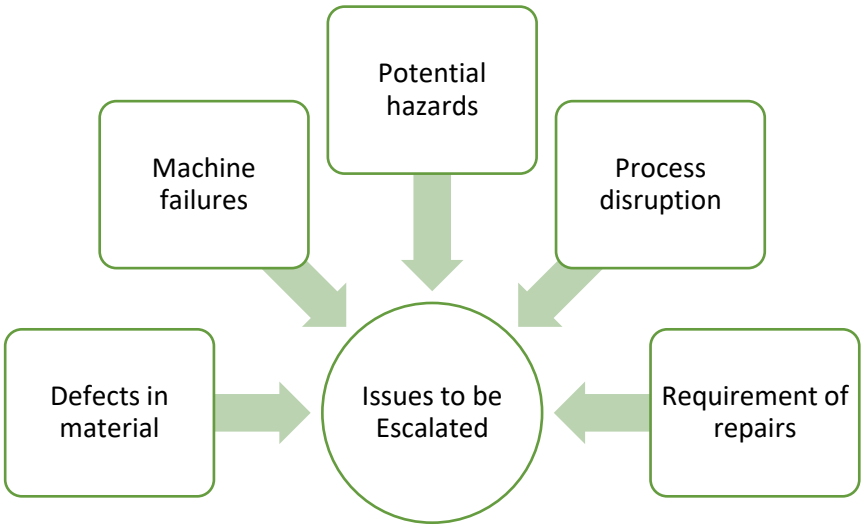


Fig. 2.3.5: Some of the issues that need to be escalated

Personnel issues that are directly related to the job description as well as ones that are not related to work need to be attended by the supervisors. Also, maintenance issues need to be communicated to the maintenance personnel.

The following figure shows process of issue escalation:

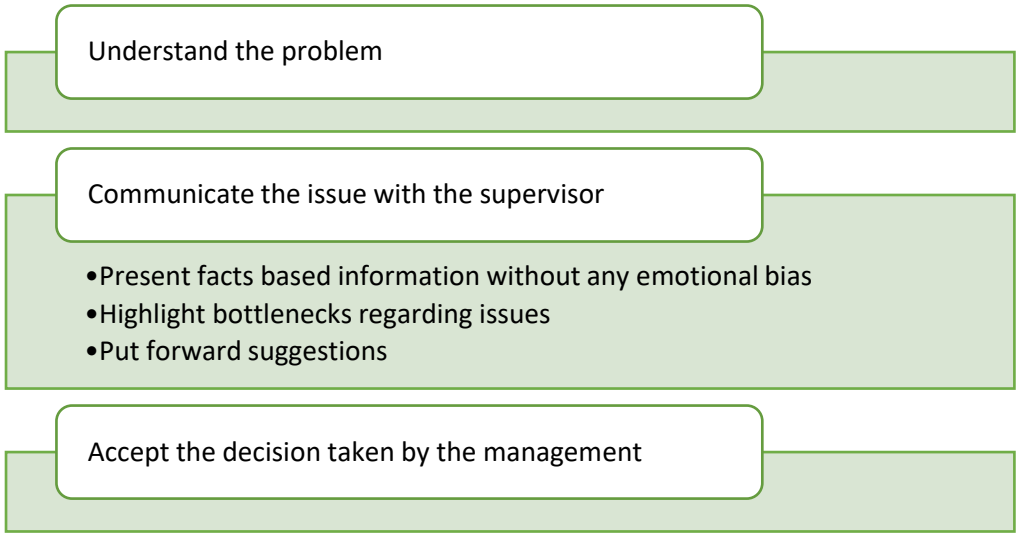


Fig. 2.3.6: Process of issue escalation

The following figure lists some key considerations regarding issue escalation that must be kept in mind while communicating with supervisors:

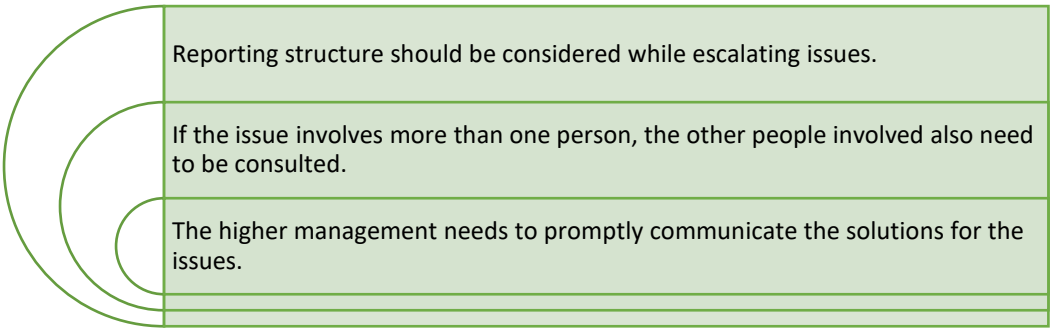


Fig. 2.3.7: Some key considerations regarding issue escalation

Escalating Customer Queries

There may be cases where a customer's request is not closed within the agreed time frame. In such a situation, the electrician should escalate the matter to his superior/ back line support and the escalation manager. The supervisor is responsible for ensuring that all escalated enquiries are dealt with and resolved promptly. However, the electrician should try to exhaust all the options at his/her level before escalating any enquiry to the supervisor.

A customer enquiry should reach the supervisor only if there is a need to oversee the issue from a holistic viewpoint. The supervisor will evaluate the situation, facilitate the issue resolution and act as an advocate on behalf of the customer.

Complaints Escalation Process

An HVAC technician should do everything to resolve an issue at the first instance. To facilitate a fast and efficient resolution of the issues at the first point of contact, a complaint process needs to be designed and followed.

If an issue is unresolved and needs expert guidance, the HVAC technician should clearly explain the escalation options to the customer before proceeding. The following figure shows the steps of a complaint resolution process:

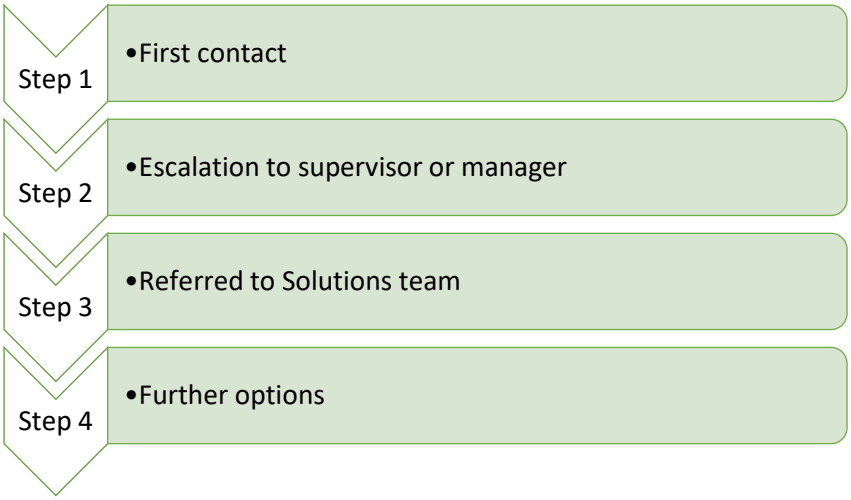


Fig. 2.3.8: A complaint resolution process

Step 1: First Contact

An HVAC technician needs to be empowered to resolve first level complaints and complex issues and make rational customer service decisions.

Step 2: Escalation to a Supervisor or Manager

If an HVAC technician is not able to resolve a complaint, it can be escalated to a supervisor or a manager. The manager will review the problem, respond to the complainant and attempt to resolve the issue to the customer's satisfaction.

In circumstances where the manager is unable to resolve the complaint to the customer's satisfaction, the complaint will be referred to the Solutions team.

Step 3: Referred to Solutions team

The Solutions team will review and try to resolve the issue to the customer's satisfaction in accordance with the industry's code and regulation.

Step 4: Further Options

Most of the complaints can be handled internally by utilizing all possible avenues of resolving the complaint. However, if a customer is still not satisfied with the handling of the complaint, then as a last resort an HVAC technician may seek complaint mediation or further assistance from the supervisor.

2.3.2 Take Feedback from Customer

The last step of understanding customer's concerns is to take feedback from the customer as this is the most important thing for an organization. The procedure as shown in the following figure should be followed:

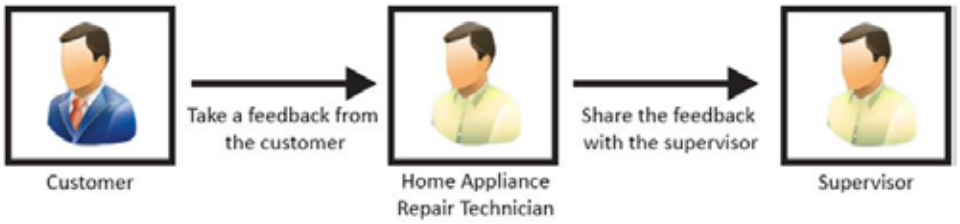


Fig. 2.3.9: Procedure to be followed for taking customer feedback

The time taken to resolve an issue and the difficulties that a customer encountered while communicating the problem should be understood. The misunderstandings observed during the interaction should be clearly documented.

The methods of interaction and behavioral aspects also need to be considered in drawing conclusions after each task or problem handling routine. Getting honest feedback from the clients helps to improve the organizational functioning.

The HVAC technician can get a feedback form filled by the customer at the facility. The following figure shows a typical template for a customer feedback form:

Customer Feedback Form

Please fill the form. We value your feedback.

Date: _____ Location: _____

Service: Complaint ☐ New Connection ☐

1. How would you rate our service?

☐ Very Good

☐ Good

☐ Poor

2. Did the technician come with all the necessary tools and equipment to do the job?

☐ Yes ☐ No

3. Did the technician behave politely with you?

☐ Yes ☐ No

4. Did the wireman have knowledge of the work to be done?

☐ Yes ☐ No

5. Any suggestion which you would like to share.

Fig. 2.3.10: A sample customer feedback form

Role Play

You are an HVAC technician. You just received a phone call from customer reporting to escalate the issue directly to the supervisor as the HVAC system is not working properly post 1 hour of installation. How should the situation be handled?

UNIT 2.4: Plan Work Schedule

Unit Objectives

At the end of this unit, you will be able to:

1. List the points to understand the work plan
2. List the ways to ensure quality and timely completion of work
3. Describe how to achieve targets
4. Identify safety standards to be followed at workplace
5. Achieve zero defect as per company's standards

2.4.1 Quality and Timely Completion of Work

A technician can maintain quality and achieve timely completion of work in the following ways:

- Ensure whatever work is done is as per the guidelines and standard of the company
- Plan and organize the work for the day
- Follow the plan
- Inform the supervisor in case of any deviation or emergency

A few simple principles, if adhered to, can ensure production of quality work. As an HVAC technician, maintenance of quality and timely completion of work can be done in the following ways:

- Ensure that work is done is as per the guidelines and standard of the company.
- Plan and organize the day to day activities of production depending upon the instruction given by supervisor.
- Follow the proposed plan of action.
- Inform the supervisor in case of any potential hazards.
- Follow guidelines of job instructions or work manuals.
- Work to ensure quality of finished product.

The HVAC technician would get a job sheet or work allocation from the supervisor. The supervisor would also share a plan of action with the HVAC technician to ensure adherence to timelines and quality for the work assigned and an explanation if the target is not met.

The following figure highlights the points which help an HVAC technician in understanding the plan to achieve 100 percent quality standards and timely completion of work:

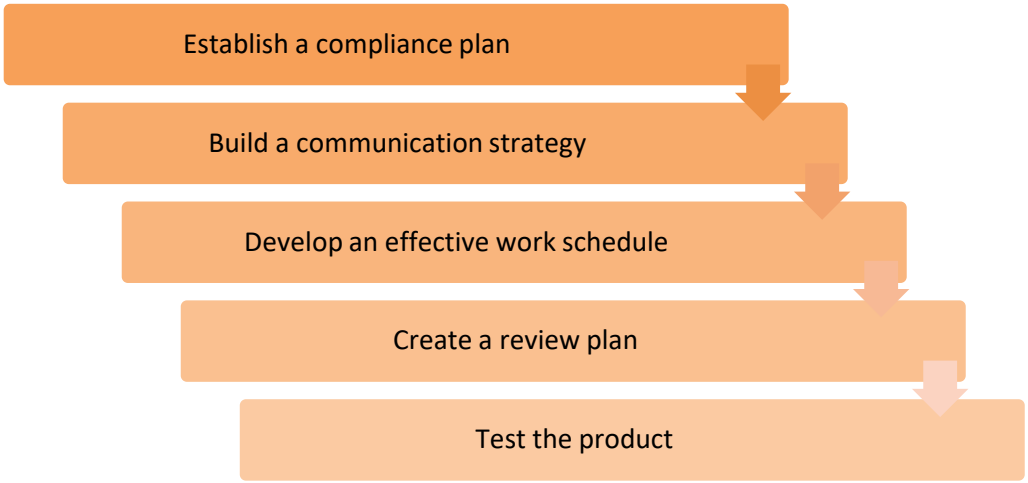


Fig. 2.4.1: Achieving quality and timely completion of work

2.4.2 Meet the Targets

Just like any other employee of an organization, meeting the targets set by the supervisor is very important. An HVAC technician needs to be clear about the goals and visions of the organization to achieve targets and quality in work. The following figure shows the key points which will help an HVAC technician to meet the expected targets and quality:

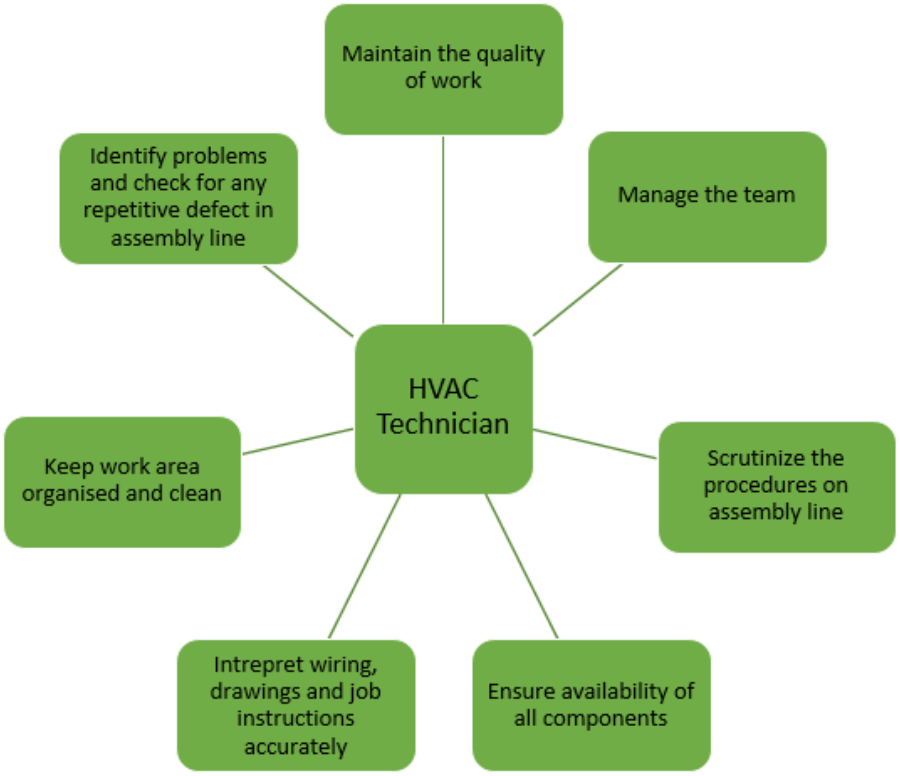


Fig. 2.4.2: Key points to remember for meeting targets

The quality of work needs to be maintained at all times in compliance with the referral handbook of the company. Making sure that individual roles and responsibilities are understood by the personnel is vital. Timely check of the machinery and software systems needs to be done to avoid any bottlenecks in achieving weekly or monthly targets.

2.4.3 Achieving Zero Defects

Zero defects in components can be achieved in the ways as listed in the following figure:

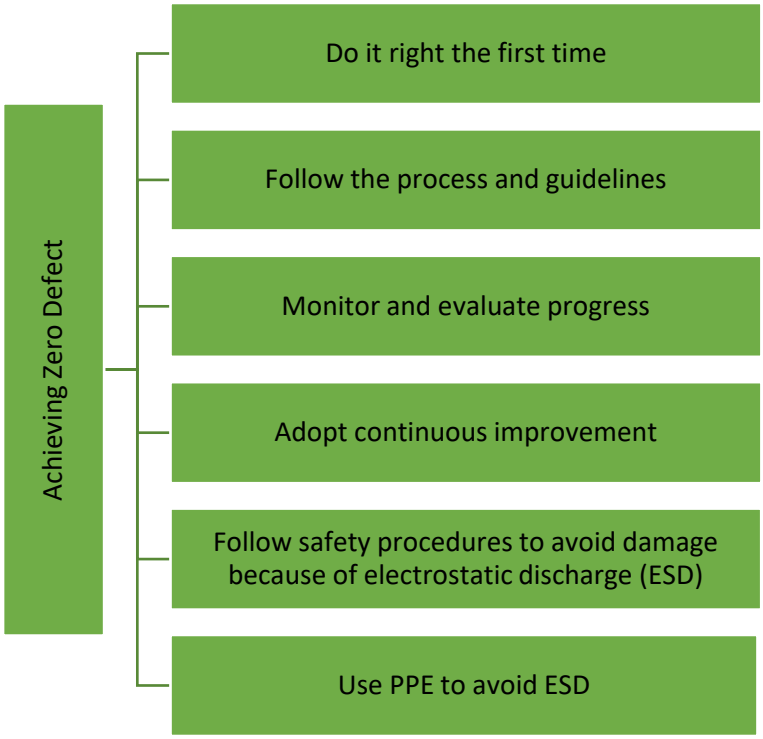


Fig. 2.4.3: Measures to achieve zero defect in components

2.4.4 Take Feedback from Customer

The supervisor shares a plan of action with the technicians to ensure adherence to timelines and quality for the work assigned. Therefore, a supervisor's responsibilities includes the following:

- Planning the task
- Getting the task done from others
- Organizing and controlling work for efficiency
- Looking after interpersonal issues

The following figure highlights the points which help the technician in understanding the plan to achieve 100% quality and timely completion of work:

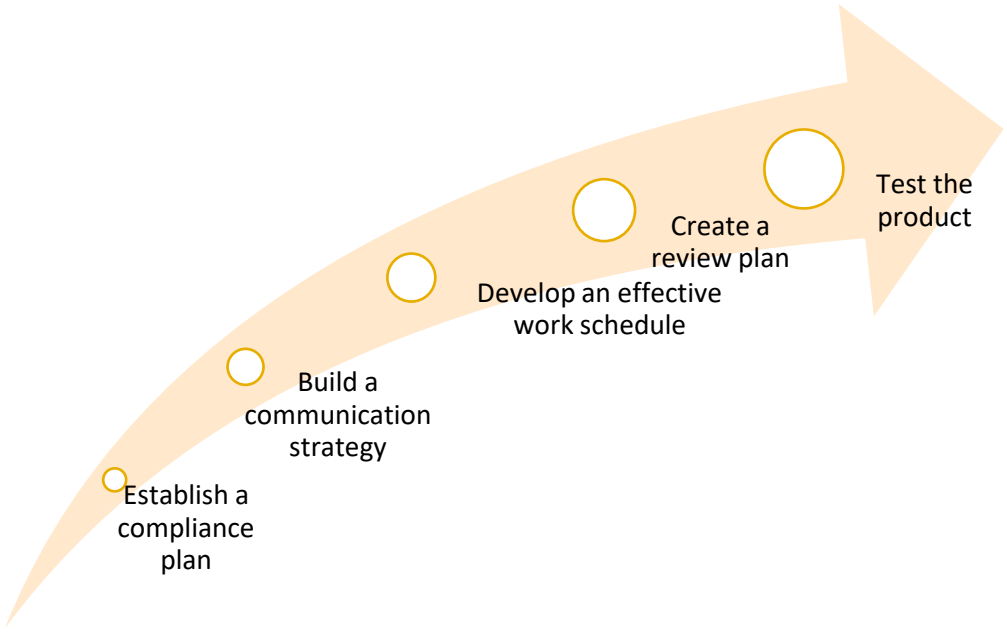


Fig. 2.4.4: Achieving quality and timely completion of work

2.4.5 Spot Process Disruptions and Delays

Delays and disruptions are common while working as a technician. Certain guidelines must be followed to resolve issues in case of disruptions and delays. The following figure lists the general guidelines to follow in such cases:

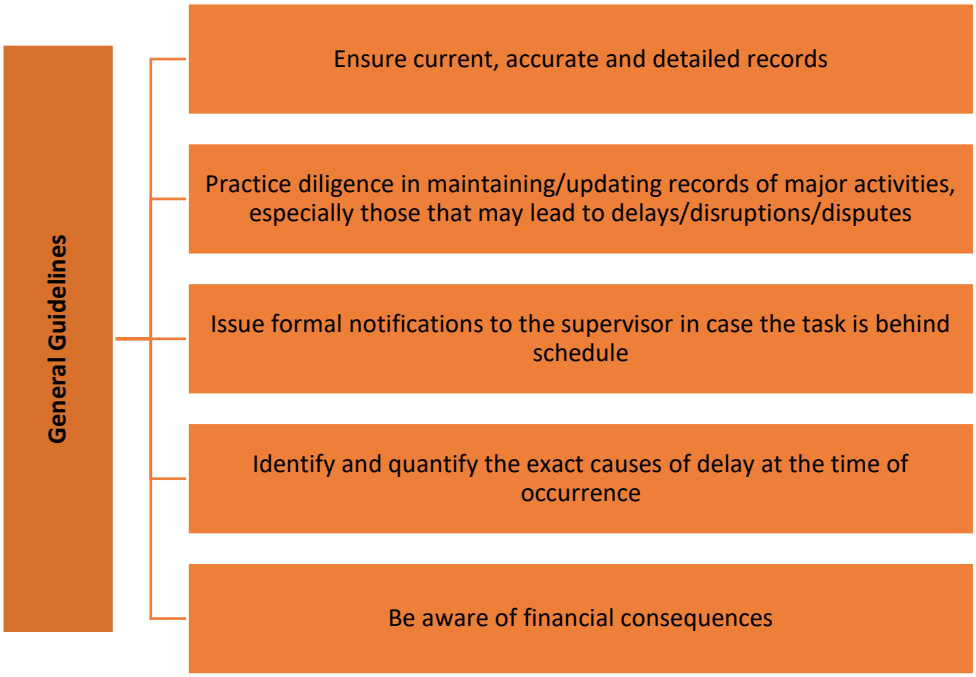


Fig. 2.4.5: General guidelines to follow in case of disruptions and delays

The following figure highlights the points which an employee, a technician, must abide by while interacting with the supervisor:

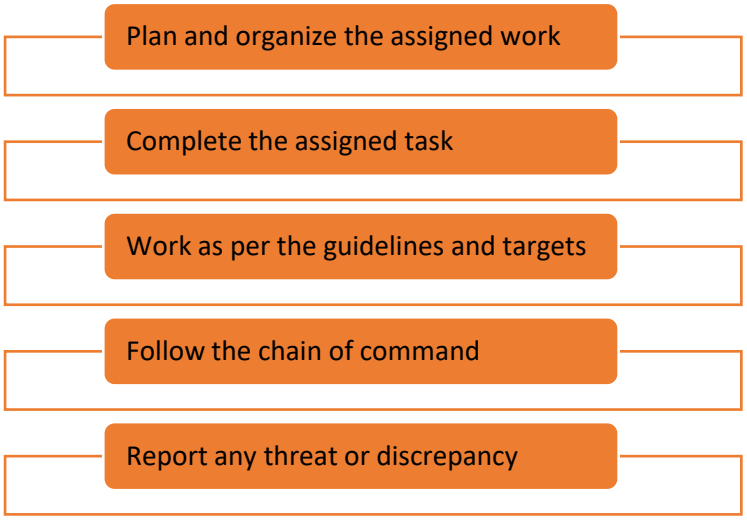


Fig. 2.4.6: Points to adhere to while interacting with a supervisor

UNIT 2.5: Analyse the Drawings and Layouts

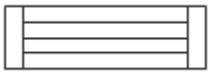
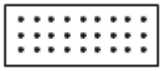
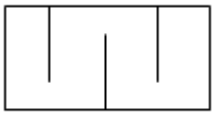
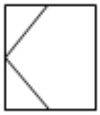
Unit Objectives

At the end of this unit, you will be able to:

1. Identify the HVAC plan symbols
2. Analyse the HVAC plan drawings and layout of site

2.5.1 HVAC plan Symbols

The following table represents the various HVAC Equipment Symbols:

Symbol	Equipment it Represents
	The **Pump** is a mechanical device using suction or pressure to raise or move liquids, compress gases, or force air into inflatable objects such as tires.
	The **Silencer** is a device fixed to the exhaust of a motor vehicle to reduce engine noise.
	The **Condenser** is an apparatus or container for condensing vapour into liquid. It is also known as Heat transfer.
	The **Drier** is a kind of substance or device to accelerate drying or extract moisture.
	The **Muffler** is a device used to reduce the noise of an engine or deaden the sound of an instrument.
	The **Filter** is a porous device for removing impurities or solid particles from a liquid or gas that passes through it.
	The **Nozzle** is a cylindrical or round spout at the end of a pipe, hose, or tube used to control the direction or the velocity of gas or liquid flow.

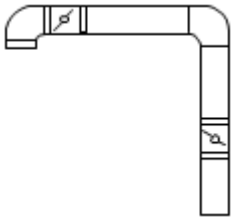
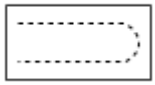
Symbol	Equipment it Represents
	The **Pipeline** is a long pipe, typically underground, for transporting oil, gas, etc.
	The **Chiller** is a machine for removing heat from a liquid through a circle of vapour compression, absorption and refrigeration.

Table 2.5.1: Symbols and their representation

The following table represents the various HVAC Ductwork Symbols:

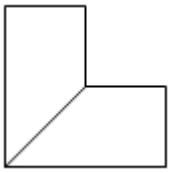
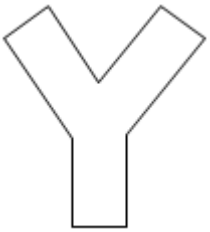
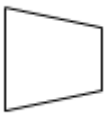
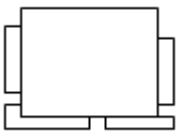
Symbol	Description
	The **Bend** is a curve part in a road, river, path, or racing circuit.
	The **Y junction** generally has 2 arms of equal size.
	The **Transition** is the process or a period of changing from one state or condition to another.
	The **VAV box** is short for Variable Air Volume box, which is a type of HVAC system.

Table 2.5.2: Ductwork symbols and their description

The following table represents the various HVAC Sensor Symbols:

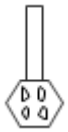
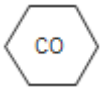
Symbol	Description
	The **Temperature** shape shows a kind of device to measure temperature.
	The **Humidity** shape shows a kind of device to measure humidity.
	The **Timer** shape shows a device to count time.
	The **Air quality** is a device to detecting air quality.

Table 2.5.3: Sensor symbols and their description

2.5.2 HVAC Layout

HVAC layout are deigned and created by HVAC Engineers. You as an HVAC technician, you should be able to under the drawings and layout of the site where the HVAC system are being installed. Following is an example of a HVAC layout of an auditorium.

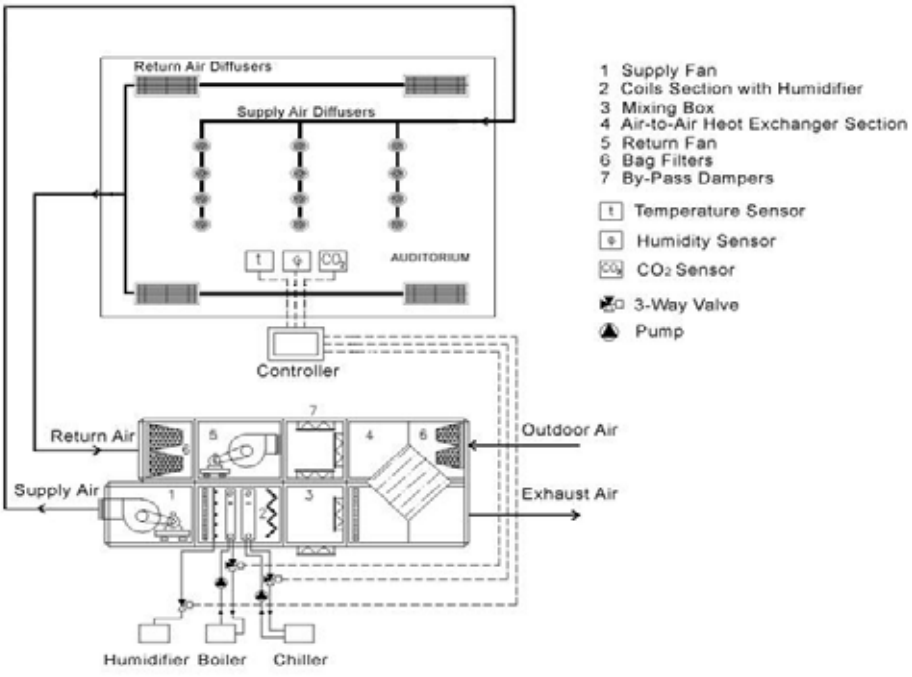
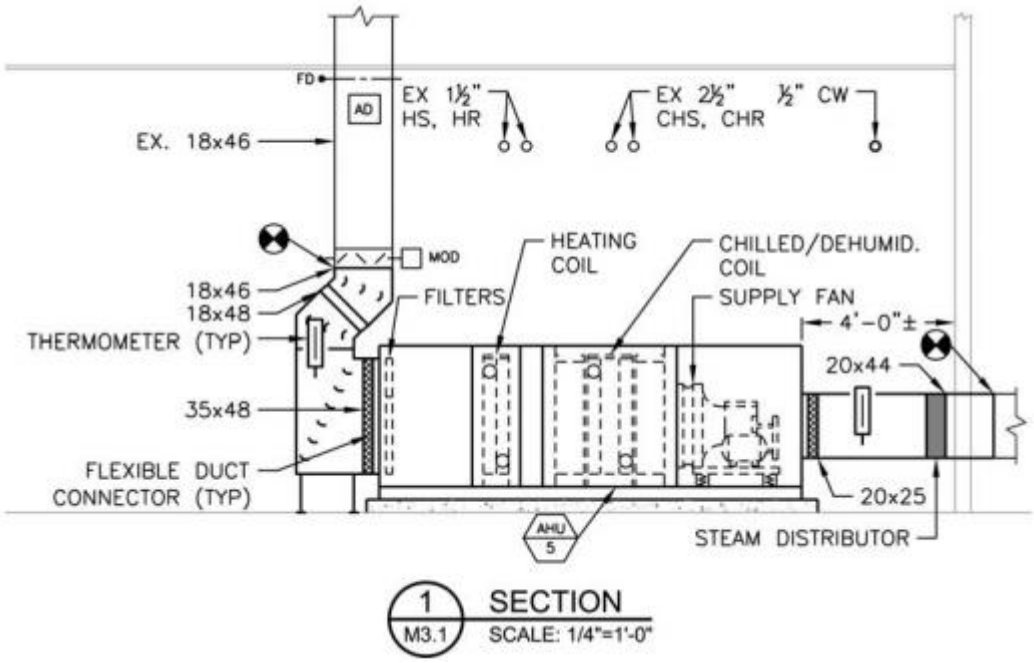


Fig. 2.5.1: HVAC layout of an auditorium

The space reflected in the above layout is an, located at the ground floor of a 5 storied office. The auditorium is air conditioned by using a single-duct, single-zone, constant volume, all-air HVAC system. The general layout of the HVAC system's components is shown in the Fig. 2.5.1.

Exercise

Explain the following section drawing of an AHU.



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Corporation
Transforming the skill landscape

ESSCI

3. Service of an HVAC System

Unit 3.1 – Service and Maintenance of HVAC System

Unit 3.2 – Cleaning Equipment

Unit 3.3 – Check Water Pipelines and Pumps for any Damage

Unit 3.4 – Fix Faults in Electrical Control Panels and Supply Boxes

Unit 3.5 – Prepare Maintenance and Service Records

Key Learning Outcomes

At the end of this module, you will be able to:

1. Comply with the service and maintenance documents of HVAC system
2. Prepare maintenance and service records
3. Perform maintenance of a cooling tower and chiller
4. Use appropriate tools and equipment for maintenance and service
5. Use proper equipment to clean duct work, AHU and FCU
6. Analyse and check water pipelines and pumps for any damage
7. Devise solutions to fix faults in electrical control panels and supply boxes

UNIT 3.1: Service and Maintenance of HVAC System

Unit Objectives

At the end of this unit, you will be able to:

1. Explain the importance of servicing and maintaining HVAC system
2. Identify the importance of complying with service and maintenance documents
3. Identify the best practices of servicing and maintaining an HVAC system
4. Identify and update the various maintenance and service records

3.1.1 Importance of Servicing and Maintaining an HVAC System

Regular servicing and maintenance of any electronic component increases its performance and efficiency. Similarly, an HVAC system also requires regular servicing and maintenance. In not only increases the its efficiency but also increases the life-span of its components and can also save from any bid faulty disaster. A well-maintained HVAC system has the following advantages:

- Improves Air Circulation
- Enhance Air Quality
- Long life of spare parts/components used
- Reduce chances of HVAC system breakdown

Maintenance of an HVAC system involves the following tasks:

Visual Inspection of complete system
Inspect and Change Filters (If required)
Clean and Remove Dust and Debris
Check and Condensate Drains (pipes)
Check Thermostat Setting
Check Electric Connections and Voltage
Lubricate Moving Parts
Inspect Exhaust Outlets
Check all Connections
Check Refrigerant Levels
Check all Compoents for Any Rust /Damage
Check for Any Leakage
Check for Air Flow and Quality
Clean Ducts and Vents
Clean Cooling Towers, Chillers, Air Handling Units (AHU)and Fan Coil Unit (FCU)

Fig. 3.1.1: Task list for HVAC Maintenance

3.1.2 Maintenance of a Cooling Tower

The cooling towers are more prone to pollutants like dirt, pollen, dust, insects and other debris. These pollutants can lead to corrosion and premature basin failure or growth of microorganisms like algae which can lead to health risks. Therefore, the occupational safety and health administration technical manual states that the cleaning and chlorination of the cooling tower should be conducted twice a year. Following figure represents the cooling tower cleaning protocol:

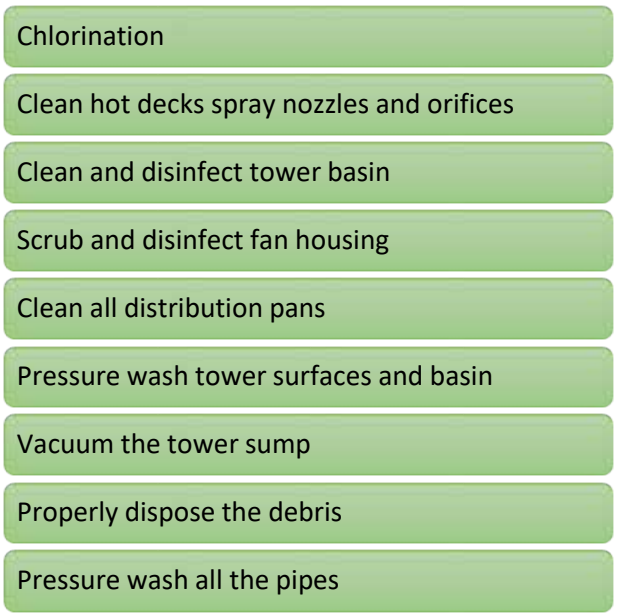

Fig. 3.1.2: Cooling Tower Cleaning Protocol

The inside environment of a functional cooling tower is like a hurricane. The regular inspection and maintenance result in best HVAC system performance.

- **Water Treatment:** An effective water treatment removes harmful bacteria and controls biological contamination. A regular chemical treatment/chlorination is recommended, which controls biological organisms, scale, and corrosion.
- **Prevent scale deposits:** The water that evaporates from the cooling tower leaves behind the minerals dissolved in it as scale deposits on the surface. These scale deposits obstructs the heat transfer from the water to the air thus reducing the effectiveness. To prevent scale deposit, adequate water treatment is recommended.
- **Clean clogged spray nozzles:** There is a chance that the micro-organisms like algae and sediment collects in the water basin and excess solid gets clog in the spray nozzles that can cause uneven water distribution and a result reduces evaporation. Proper water treatment can resolve this problem of clogged strainers. Professional Kits are available that can be used to replace older distribution nozzles.
- **Ensure Adequate Airflow:** Inadequate airflow through the cooling tower reduces the transfer of heat from the water to the air. Inadequate airflow can be caused due to the following reasons:
    - Debris at the inlets/outlets of the tower
    - Loose fan and motor mountings
    - Poor motor and fan alignment

- Poor gearbox maintenance
- Improper fan pitch

This can finally lead to failure of the fan motor. Thus it is important to ensure adequate airflow in the cooling tower. Regular cleaning helps avoiding such system failure.

- **Ensure Adequate Pump Performance:** A cooling tower use pumps to transport water over the tubes for evaporative cooling. Thus, proper water flow is important to achieve optimum heat transfer. Any kind of fault such as loose connection, damage, faulty bearings, cavitation, clogged strainers, excessive vibration can result in reduced water flow, and finally reducing the efficiency, and premature equipment failure.

Maintenance Schedule for Cooling Tower

Description	Comments	Maintenance Frequency
Cooling tower use/ sequencing	Turn on/sequence unnecessary cooling towers	Daily
Overall visual inspection	Complete overall visual inspection to be sure all equipment is operating and safety systems are in place	Daily
Fan motor condition	Check the condition of the fan motor through temperature or vibration analysis and compare to baseline values	Weekly
Clean suction screen	Physically clean screen of all debris	Weekly
Operate make-up water float switch	Operate switch manually to ensure proper operation	Weekly
Vibration	Check for excessive vibration in motors, fans, and pumps	Weekly
Check tower structure	Check for loose fill, connections, leaks, etc.	Weekly
Check belts and pulleys	Adjust all belts and pulleys	Weekly
Test water samples	Test for proper concentrations of dissolved solids, and chemistry. Adjust blowdown and chemicals as necessary. Perform weekly for open towers and monthly for closed systems.	Weekly (Open) Monthly (Closed)
Check lubrication	Assure that all bearings are lubricated per the manufacture's recommendation	Monthly
Check motor supports and fan blades	Check for excessive wear and secure fastening	Monthly
Motor alignment	Aligning the motor coupling allows for efficient torque transfer	Monthly
Check drift eliminators, louvers, and fill	Look for proper positioning and scale build up	Monthly
Inspect nozzles for clogging	Make sure water is flowing through nozzles in the hot well	Annually
Clean tower	Remove all dust, scale, and algae from tower basin, fill, and spray nozzles	Annually
Check bearings	Inspect bearings and drive belts for wear. Adjust, repair, or replace as necessary.	Annually
Motor condition	Checking the condition of the motor through temperature or vibration analysis assures long life	Annually

Source: OHSA (Occupational Health and Safety Association)

Table 3.1.1: Maintenance schedule

3.1.3 Maintenance of a Chiller

To improve the performance and reducing the operating cost of chiller, the following maintenance tasks should be followed:

- **Operate multiple chillers for peak efficiency:** The HVAC system with two or more chillers can save energy by meeting the building loads to the most efficient combination.
- **Raise chilled-water temperature:** An increase in the temperature of the chilled water supplied to the building's air handlers improves its efficiency. Establish A chilled-water reset schedule should be establish in such a way that it can adjust the chilled-water temperature automatically with the change in outside-air temperature.
- **Reduce condenser water temperature:** Reducing the temperature of the water returning from the cooling tower to the chiller condenser by 2-3°F reduces chiller energy use by 2-3%. The temperature set point for the water leaving the cooling tower should be as low as the chiller manufacturer will allow for water entering the condenser.
- **Purge air from refrigerant:** Air trapped in the refrigerant loop increases pressure at the compressor discharge. This increases the work required from the compressor. Newer chillers have automatic air purgers that have run-time meters. Daily or weekly tracking of run time helps tracking any leakage.
- **Verify Performance of hot-gas bypass and unloader:** These are most commonly found on reciprocating compressors to control capacity. Make sure they operate properly.
- **Maintain refrigerant level:** To maintain a chiller's efficiency, regular perform the following checks:
    - Check the refrigerant sight-glass
    - Check Superheat and sub-cooling temperature readings and maintain as per manufacturer’s guidelines

  By performing these checks, you can detect the low-level and high-level refrigerant conditions. Both these conditions are not good for chiller as they reduce the capacity and efficiency of the chiller.
- **Maintain a daily log:** It is best practice to maintain a daily log of temperatures, fluid levels, pressures, flow rates, and motor amperage. These readings help understanding the functioning of chiller and troubleshooting problems. Now-a-days, chillers comes with an automatically save logs of these measurements in their on-board control system, which may be able to communicate directly with the DDC.

Maintenance Schedule for Chiller

DESCRIPTION	COMMENTS	MAINTENANCE FREQUENCY
Fill out daily log	Check all setpoints for proper setting and function. Make sure there are no unusual sounds and the space temperature is acceptable.	Daily (4x)
Chiller use/sequencing	Turn off or sequence unnecessary chillers	Daily
Check chilled water reset settings and function	Check settings for approved sequence of operation at the beginning of each cooling season	Annually
Check chiller lockout setpoint	Check settings for approved sequence of operation at the beginning of each cooling season	Annually
Clean evaporator and condenser tubes	Indicated when pressure drop across the barrel (tube bundle) exceeds manufacturer's recommendations, but at least annually.	Annually
Verify motor amperage load limit	Motor amperage should not exceed manufacturer's specification	Annually
Compressor motor and assembly	Conduct vibration analysis: Check all alignments to specifications. Check all seals. Lubricate where necessary.	Annually
Compressor oil system	Perform analysis on oil and filter. Change if necessary. Check oil pump and seals Check oil heater and thermostat Check all strainers, valves, etc.	Annually
Electrical connections	Check all electrical connections and terminals for full contact and tightness	Annually
Check refrigerant condition	Add refrigerant if low. Record amounts and address leakage problems.	Annually
Check for condenser and evaporator tube corrosion and clean as needed.	Indications include: poor water quality, excessive fouling, and age of chiller. Eddy current testing may be done to assess tube condition.	As needed

Table 3.1.2: Maintenance schedule for chiller

Activity

Create your own HVAC service and maintenance checklist and submit it for evaluation.

(The aim of this activity is to analyse if the tasks and activities needed for maintenance of an HVAC system is well understood or not.)

Equipment required:

1. HVAC equipment/system, if available
2. Notepad & pen

Time required: 15-20 minutes

UNIT 3.2: Cleaning Equipment

Unit Objectives

At the end of this unit, you will be able to:

1. Identify the various cleaning equipment
2. Identify how to clean AHU

3.2.1 Equipment used for cleaning and maintaining

The following table represents the equipment to clean duct:

Equipment	Image	Description
Chemical Fogger		It is used for disinfectant application.
Duct Cleaning Vacuum	 	It is used to clean the ducts and vents. It has two-directional rotating brush that safely removes the debris. The dual vacuum motor pulls the hose into disposable vacuum bag. These come in different models.

Equipment	Image	Description
Disinfectant and Low Toxicity Duct Fungicide		These are sprayed into the ducts to kill any residual mold, fungi, bacteria, algae etc.
Rotatory Duct Cleaner		These are used to remove any harmful deposits in the duct. These can be easily used in round, rectangular or spiral ducts.

Table 3.2.1: Equipment and their use

The following figure represents the steps involved in cleaning the ducts and vents:

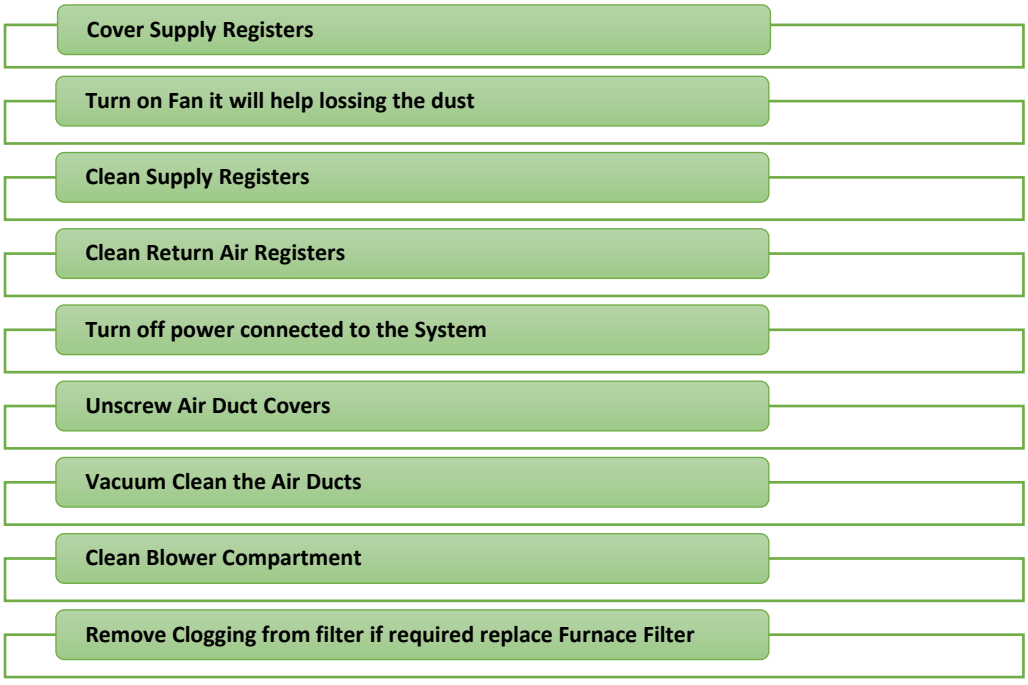

Fig. 3.2.1 Steps to clean duct and vent

3.2.2 Cleaning/Servicing AHU

It is recommended to clean and take preventive maintenance of Air Handling Units. Following are some simple cleaning/servicing steps:

- Clean all the filters using spray shower or in case of big unit specialised AHU Filter cleaning machines are available which cleans 4-5 filters in one time.
- Clean and Drain condenser. Use any disinfectant if required.
- Lubricate the motor, blower bearing, pumps by grease
- Clean the AHU coils and straighten coils with a fine comb
- Check and clean the motor belt and pulley. If required replace them.
- Inspect all the wiring and electric connections for damage or loose connections
- Check all the unit's bypass valves

Activity

Activity 1 – The aim is to help you analyse the requirement of the equipment and their usage for cleaning and maintenance of an HVAC system.

Task 1: Trainer will demonstrate the usage of various cleaning equipment available in lab. Note down the observation.

Task 2: Demonstrate the usage of any equipment as directed by the trainer.

Equipment required:

1. Cleaning equipment
2. HVAC system
3. Notepad & pen

Time required: 30-40 minutes

Activity 2 – The aim is to fix/troubleshoot a fault in the pipeline.

Trainer will demonstrate the procedure to fix leakage in water pipeline.

Equipment required:

1. HVAC pipe with a fault/leakage
2. Cleaning equipment
3. HVAC system

Time required: 60 minutes

UNIT 3.3: Check Water Pipelines and Pumps for any Damage

Unit Objectives

At the end of this unit, you will be able to:

1. Perform Pressure test to check pipelines.
2. Check pumps for any damage

3.3.1 Pressure Test

For efficient working and high performance of the HVAC system, as a HVAC technician it is your responsibility to strive for NO LEAKAGE in pipes or any other component of the HVAC system.

Pressure Test is the most recommended test for piping system. This test helps avoiding any failure due to improper/inadequate joining/fitting of piping. Also, it helps in detecting any leakage in the pipe lines.

Checking the Process pipes

1. Ensure all the piping loops are closed
2. Air pump the system slowly starting with 60 psi.
3. Let it stand for fifteen minutes or as recommended by the manufacturer's guidelines.
4. Start increasing the pressure upto 125 psi.
5. Once the buildings main sections have been tested, individual coils should be pressurized with air at 125 psi.

Once the process pipes are check then pressure testing is performed to check all the water distribution, supply system including the gas pipes.

All such test are done under the supervision of the senior authorities and are properly documented and signed by the signatory authorities.

Following is the format to record the pressure testing result:

Name of Piping Systems' Team Member performing test_____

Date test was performed:_____ Job #_____ Job Name: _____

Duration of testing time: _____ Job Location: _____

SYSTEM TYPE	COMPONENT	TEST MEDIUM AND PRESSURE RATING	DURATION
HVAC, process piping	All piping	Air @ 125 psi ☐ Hydro (water) @ 125 psi ☐	One hour minimum Two hours minimum
Gas, low pressure	All piping	3 psi ☐	10 minutes minimum
Gas, high pressure	All Piping	*Determined by Inspector:* Recorded on: (check off) Gauge ☐ Graph ☐ Tested at _____psi	*Determined by pressure available on job-site:* ____ hours (not less than one hour for each 100 ft. of pipe)
Plumbing	Underground	10 feet head pressure ☐	15 minute minimum
	In wall rough	10 feet head pressure ☐	15 minute minimum
	FINISH PLUMBING:		
	Water piping, hot	Air @ 125 psi ☐	15 minute minimum
	Water piping, cold	Air@ 125 psi ☐	15 minute minimum

Description of piping and/or components tested including location:

_____

_____

_____

PRINT CLIENT/INSPECTOR NAME: _____

Sign Name and Date of client's representative who witnessed test:

_____

If system was tested in sections, what is the status of any blanks or valves used?

	Installed	Removed		Closed	Opened
Pan Blanks Location:			Valves Location:		

Fig. 3.3.1 Format for Pressure Testing Form

3.3.2 Checking Pumps for Damage

Pumps are one the most important part of an HVAC system as they keep functioning the system efficiently. To keep them running properly, it is advised to do keep checking the pumps regularly and do the needful maintenance as and when required.

Following are few pump maintenance checkpoints that should be followed:

1. Create Maintenance Schedule: Every pump comes with a manufacturer's maintenance and cleaning guidelines. Accordingly, a maintenance schedule should be created. While creating a maintenance schedule do keep in mind the time at which maintenance work can be done so that it does not impact much to the people inside the building. As the HVAC system will be shut down during maintenance work. Secondly, decide the frequency i.e. after how much interval the next maintenance should be schedule. All these should be recorded in Maintenance Log as per prescribed format.

2. Keep track of pump during operation hours also. When the pumps are running check for any leakage, unusual sound or vibration/odour. Note all the observation in Maintenance Log.
3. While inspecting the pumps for maintenance, do the following mechanical checks:
   a. Mounting Points
   b. Leakage
   c. Loose Connections
   d. Rust/Corrosion nearby inlet or outlet pipes attached to the pumps.
4. Lubricate bearings as per manufacturer's guideline. Do not over grease it, it may damage the bearing.
5. Check for damaged hoses or seals and replace immediately.

Example: Trouble Shooting Heat Pump

Problem	Possible Reason	Possible Solutions
Heat Pump: Icing up in Winter	Defrost Mode not working	Solution 1: Check for Fan Motor Solution 2: Check for Refrigerant Solution 3: Check for any blockage in outdoor unit. Solution 4: Check for water leakage

Activity

Create a presentation of various possible problems that may occur in a heat pump. Write the possible reasons and solutions. Present your presentation in the class.

(The aim of this activity is to analyse if you have understood the issues, and their possible resolutions, for an HVAC system.)

Equipment required:

1. Laptop/desktop with Internet connection
2. MS Office for PowerPoint presentation
3. HVAC system with a working heat pump (or a faulty one)

Time required: 60 minutes

UNIT 3.4: Fix Faults in Electrical Control Panels and Supply Boxes

Unit Objectives

At the end of this unit, you will be able to:

1. Repair faults in electrical control panels and supply boxes

3.4.1 Troubleshooting Electrical Control Panels

Electrical control panels are designed and used to control mechanical equipment. Each one is designed for a specific equipment arrangement and includes devices that allow an operator to control specified equipment.

HVAC control panels are the system that controls temperature and air in the given environment. An HVAC control panel has the following components:

1. **Terminal block assembly:** It is used to connect PLC modules to ventilation equipment
2. **PLC (Programmable logic controller):** It adjusts the temperature by triggering relays installed in the HVAC machinery.
3. **24 VAC Transformer:** It provides the power for the relay modules.
4. **24 VDC Power supply:** It provides power to the Analog Input and Analog Output Modules, the HVAC Control Panel Touch Screen, and the humidity, pressure and temperature sensors.
5. **Main Circuit Breaker (MCB):** It breaks/interrupt the current flow of electricity as a fault is detected.

Possible Faults	Possible Reason	Possible Solution
Switch Disconnect or Fuse Burning	Over Current and Short Circuit	Check the fuses continuity with a Multi Meter. Replace the Fuse with same rated Current and Voltage
MCB tripping	Short Circuited Current	Rectify the cause that produced the tripping. Once the cause is rectified Switch on the MCB and check.
Relays not working	Faulty Coil or No Power Supply or got disconnected	Check the power Supply voltage, Continuity between contacts, wiring faulty.

Table 3.4.1: Possible faults, their reasons and solutions

Repairing a Thermostat

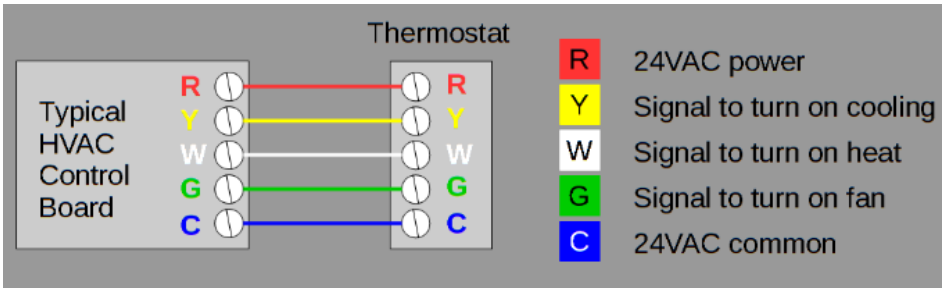

Fig. 3.4.1: Thermostat

Thermostat, located behind the control panel, has a special sensing bulb connected to it to sense temperature controlled by thermostat. It extends from the thermostat to area of the evaporator coil. A field technician should follow the steps shown in the following figure to service a thermostat:

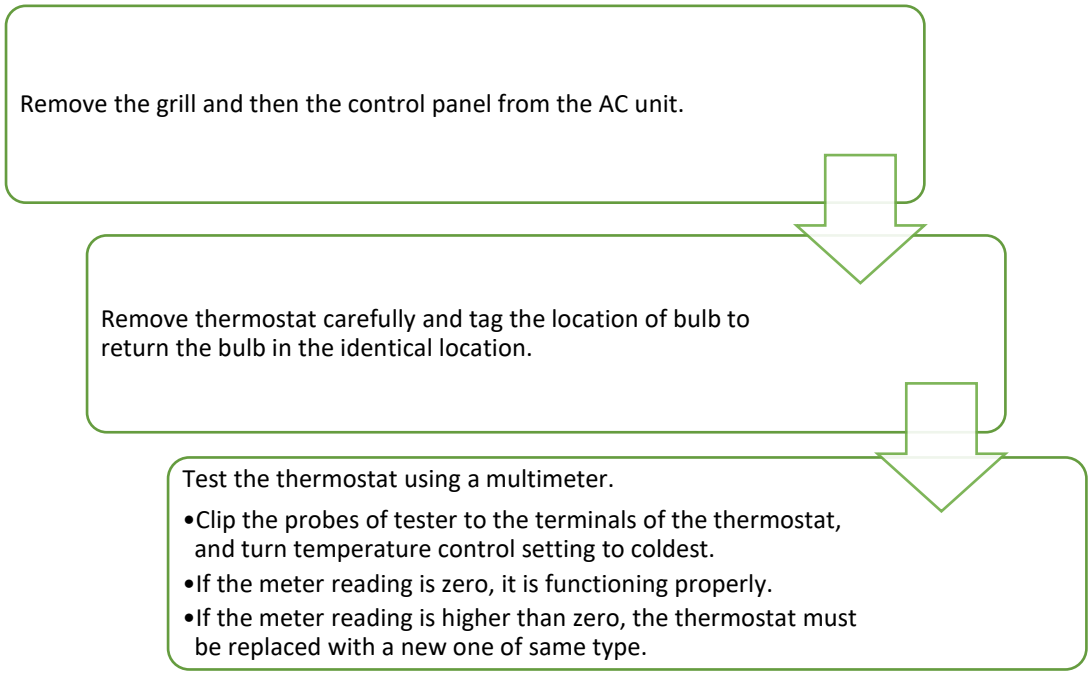

Fig. 3.4.2: Steps for servicing a thermostat

Demonstration

Trainer will demonstrate the functioning of electrical control panel using a video. Note down your observations.

Activity

You will be provided a non-working electrical control panel by the trainer. You need to perform the following tasks:

- Identify its different components.
- Draw, label and explain all the components of electrical control panel in your notebook.

(The aim of this activity is to analyse if you have understood the issues, and their possible resolutions, for the electrical control panel of an HVAC system.)

Equipment required:

1. Dysfunctional Electrical control panel
2. Notepad and pen
3. HVAC system

Time required: 60 minutes

UNIT 3.5: Prepare Maintenance and Service Records

Unit Objectives

At the end of this unit, you will be able to:

1. Explain maintenance schedules
2. Recognize importance of documentation

3.5.1 Maintenance Schedule

Maintenance schedule is vital for keeping records of servicing, repairing and performing preventive maintenance. The HVAC technician should maintain service records and next servicing schedules to be inform the customer about the maintenance of the components at the facility. The HVAC technician needs to perform hardware and software maintenance.

The following image shows a sample maintenance schedule report:

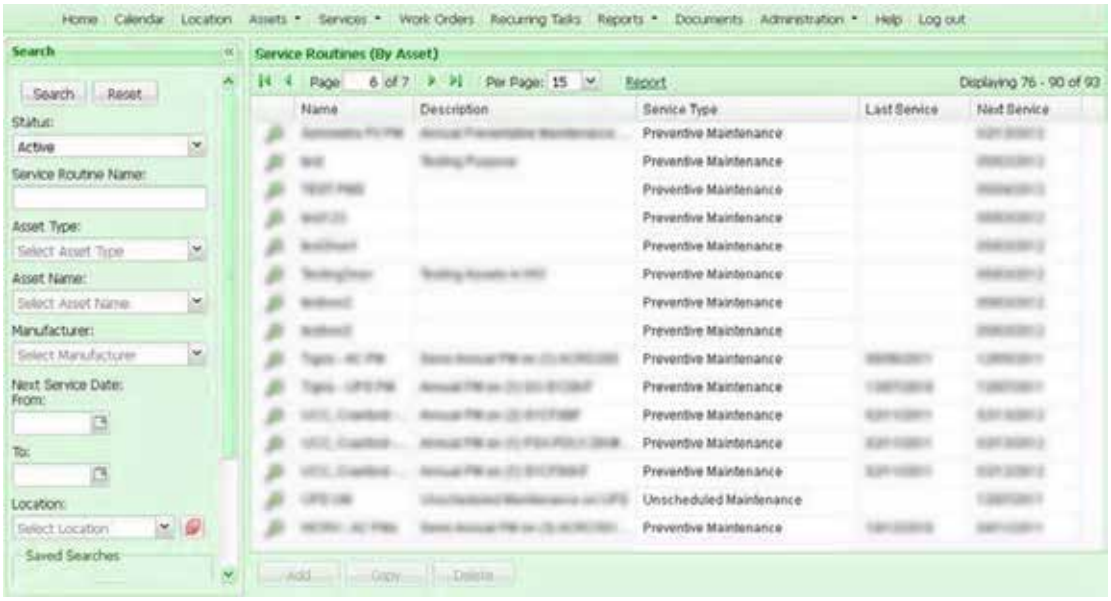

Fig. 3.5.1: Sample maintenance schedule report

Software Maintenance

A HVAC technician needs to update the software version. He/she should record the expiry date of software and after expiry date install new one with proper licence agreement.

Hardware Maintenance

The HVAC technician should assess the condition of hardware components and upgrade it if required. He/she should be aware of the compatibility issue. The HVAC technician also needs to maintain the warranty details of the components. If the warranty period is going to expire, he/she should communicate that with the customer and ask for any extended warranty he needs.

In this case, there are two ways:

- The customer can ask for extending the warranty period.
- The customer doesn't want to extend it. If there is any problem, he will buy a new one.

The HVAC technician needs to communicate about the above two ways and then tell the details of further procedure.

The following image shows a sample maintenance requirement form:

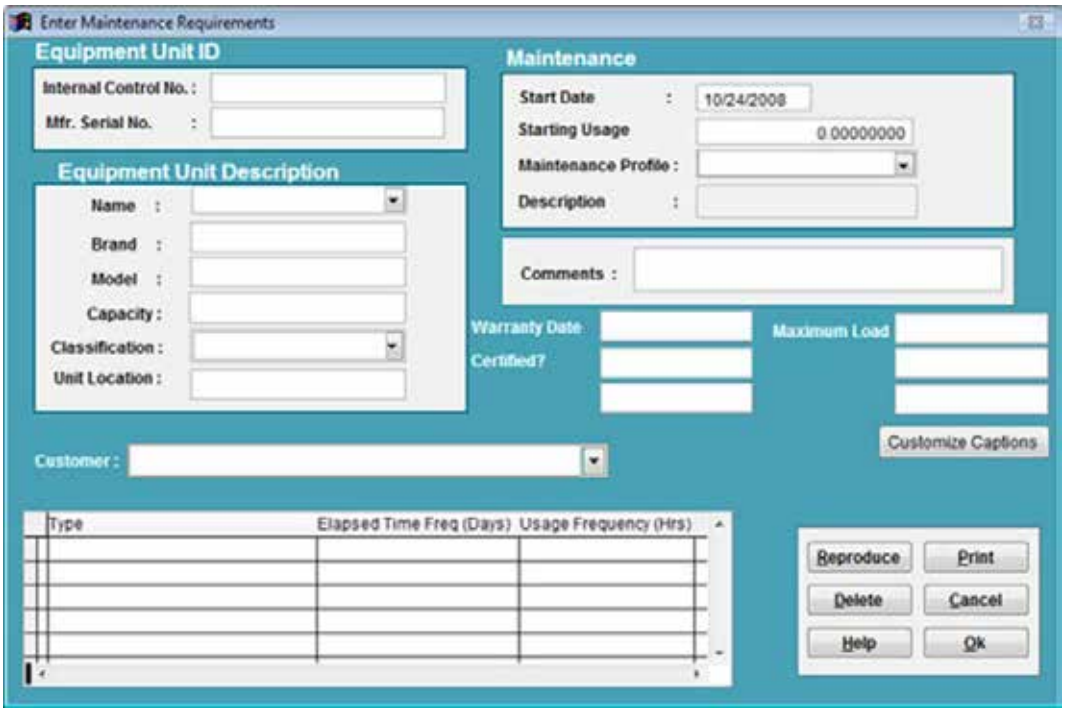

Fig. 3.5.2: Sample maintenance requirement form

3.5.2 Importance of Documentation

After repairing, the technician must provide documents about the appliance worked upon, the information can include:

- Existing service contracts, guarantees and warranties
- Information about the replacement cycles for the faulty modules
- Records of repairs and replacements
- Records of items added, replaced, or removed
- Equipment and supplies inventory
- Maintenance service agreements; routine inspections, periodic maintenance and eventual renewal services
- Safety and test certificates
- Maintenance cost involved

Documentation

Right documentation can make a lot of the difference in getting quick resolutions. To achieve this, certain steps need to be taken as shown in the following figure:

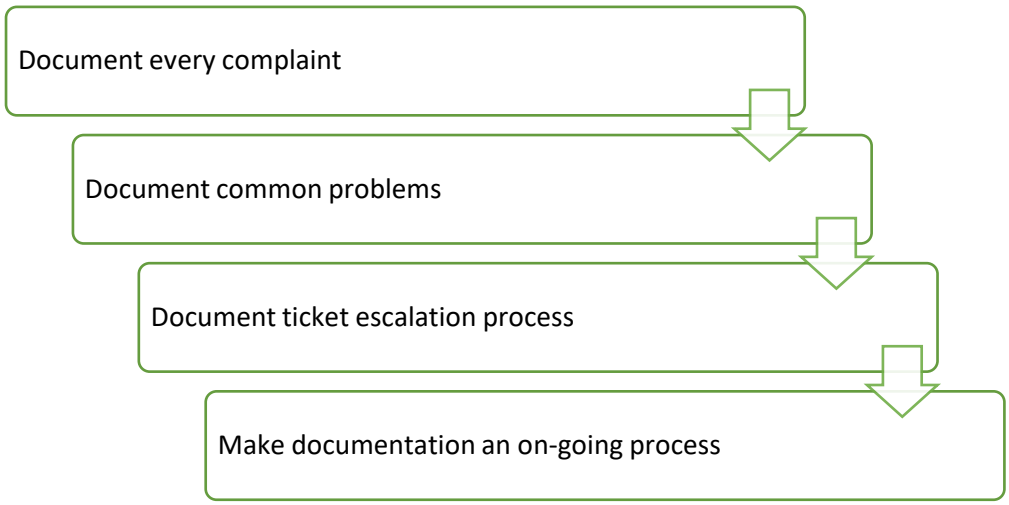

Fig. 3.5.3: Steps for documentation

Document Every Complaint

A field technician needs to document issues as they come in. In addition to recording the symptoms described by the customers, they should probe for the right symptoms. For example, if a customer says that the computer is running slow, the technician needs to differentiate whether the problem is caused by a virus or a malfunctioning part or some other system.

The field technician should know how to ask the right questions to try and resolve an issue within the first call.

Document Common Problems

Majority of the issues can be reduced to a handful of common problems. If there is a good documentation process that has resolution paths for all common problems, then the field technician does not have to reinvent the wheel for every ticket. The technician can use internal technician knowledge base and time tested processes to resolve the issues quickly.

A well organised process enables the field technician to respond to a ticket quickly and resolve most of the customers' problems immediately.

Document Ticket Escalation Process

A good escalation process makes sure that when the field technician is not able to resolve a problem, the technician addresses ticket escalation promptly. The ticket gets send to the next level of customer support and the customer does not have to wait for days for it to get resolved.

Documentation should be an On-going Effort

Documentation is not a onetime effort; it needs to be an on-going process. The field technicians should regularly optimize the issue resolution procedures and processes. This ensures that the customer issues are resolved promptly.

Activity 

During your field visit, collect information and formats (if possible) that are used by HVAC technician.

(The aim of this activity is to analyse the importance of maintaining records during a field visit for maintenance or repair of an HVAC system.)

Equipment required:

1. Notepad and pen
2. HVAC system

Time required: 60-90 minutes

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4. Repair of the System and Performance Check

Unit 4.1 – Complaint Handling

Unit 4.2 – Identify Faulty Parts and Troubleshooting

Unit 4.3 – Evaluating and Repairing Electrical Connections, Earthing and Motor Issues

Unit 4.4 – Achieving Delivery Standards

Key Learning Outcomes

At the end of this module, you will be able to:

1. Analyse customer input or complain to identify the issue
2. Perform basic troubleshooting steps to identify issues in chiller and cooling tower
3. Identify and fix the faulty units in chiller and cooling tower
4. Identify and fix faults in the AHU, FCU and ducts for faults
5. Evaluate and repair the electrical connections, Earthing and motor issues
6. Examine the air flow through ducts and temperature range in different regions
7. Identify the fault and perform replacement of faulty modules such as condenser, evaporator, filter and so on
8. Examine the air flow and electrical parameters to calculate efficiency of the system
9. Examine the system performance as per ISHRAE/ASHRAE and contract standards.
10. Record and report the repair work done

UNIT 4.1: Complaint Handling

Unit Objectives

At the end of this unit, you will be able to:

1. Identify customer's concern
2. Identify the symptoms and faults
3. Propose solution to the customer

4.1.1 Identify the Concerns of the Customer

An HVAC technician is responsible for the maintenance and repair of HVAC systems installed at customer's premises. It is very important for him/her to clearly understand the concerns of the customer. The following figure represents the various activities which should be done before scheduling a visit to the customers' premises:

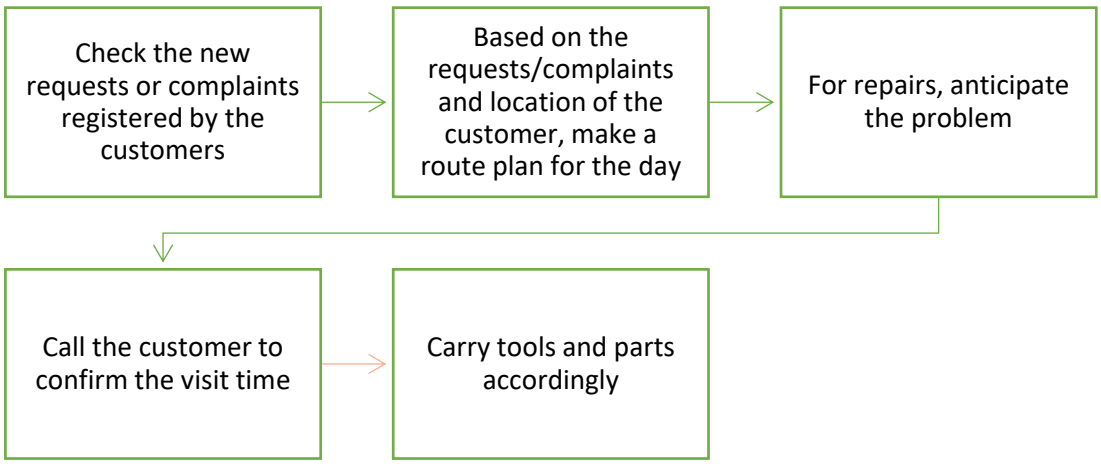

Fig. 4.1.1: To-do list for an HVAC technician

Interact with the Customers on Phone

Prior to visiting a customer's premises for repairing/servicing, it is important to call the customer and ask about the problem in detail.

The following figure highlights the to-do list to be followed when on a call with a customer before visiting the premises:

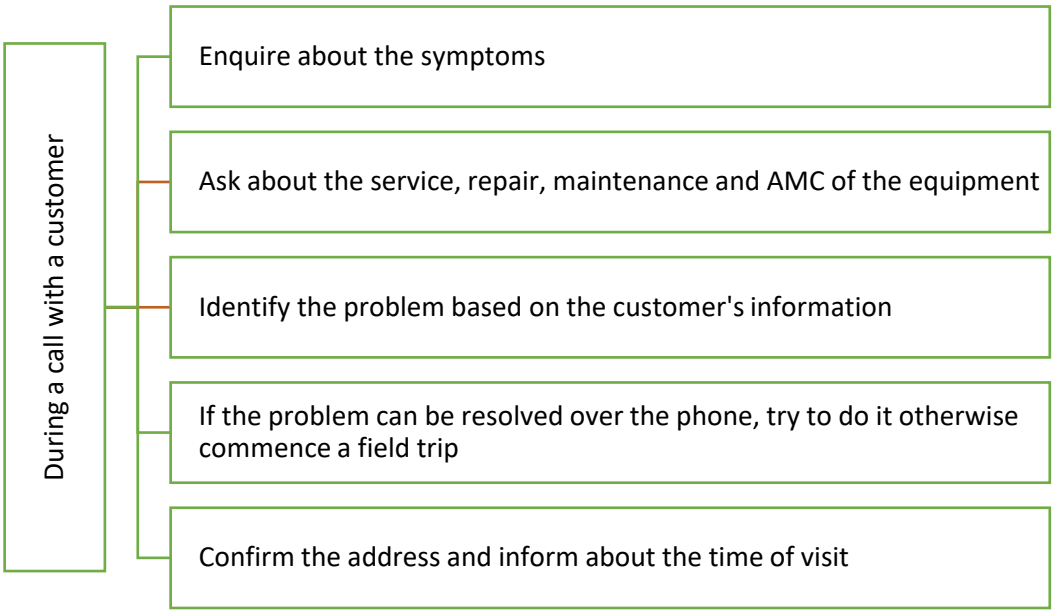

Fig. 4.1.2: Interacting with customer on Phone

Interact with the Customer at their Premises

It is a good practice to be humble and respectful towards the customer. The following figure represents how to interact with a customer when visiting the premises for service/repair:

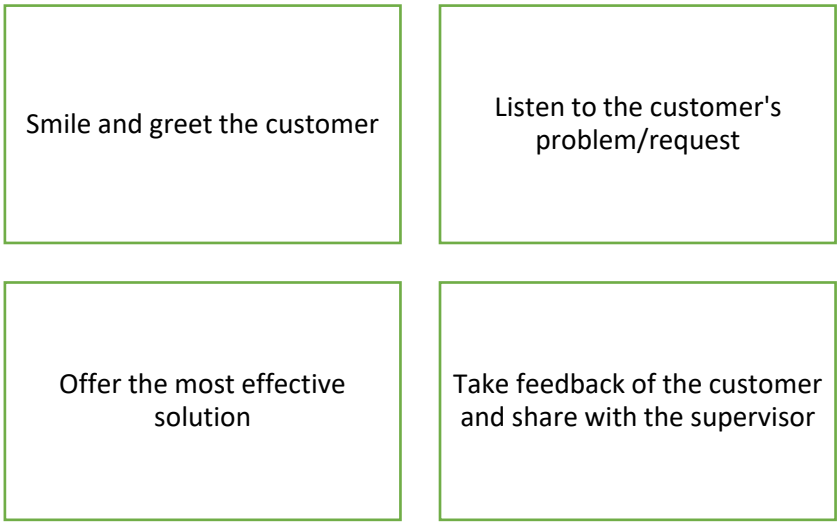

Fig. 4.1.3: Interacting with customer

4.1.2 Understand the Symptoms and Identify the Fault

It is very important for a technician to identify the fault correctly. Wrong identification of fault will lead to wrong solution which will be waste of time and money and can also cause damage to the appliance.

Fig. 4.1.4 Understanding Customer's Requirement:

When visiting a customer for a repair/servicing request, it is important to know the details of the problem and accordingly suggest a corrective measure. The customer should be satisfied with the suggested solution. The following figure highlights the to-do list to be followed at a customer's premises:

At customer's premises	Enquire about the symptoms and history of problem
	Ask about the year of purchase, service and warranty
	Identify the problem based on customer's information and examination
	Communicate the problem identified to the customer and inform about possible reasons
	Inform the customer regarding the costs involved and hand over the invoice after task is completed
	Ensure service is provided to achieve 100% customer satisfaction

Fig. 4.1.5: To-do list to be followed at a customer's premises

An HVAC technician should know how to identify faults and symptoms related to that. The following figure shows steps required to understand symptoms and identify the fault:

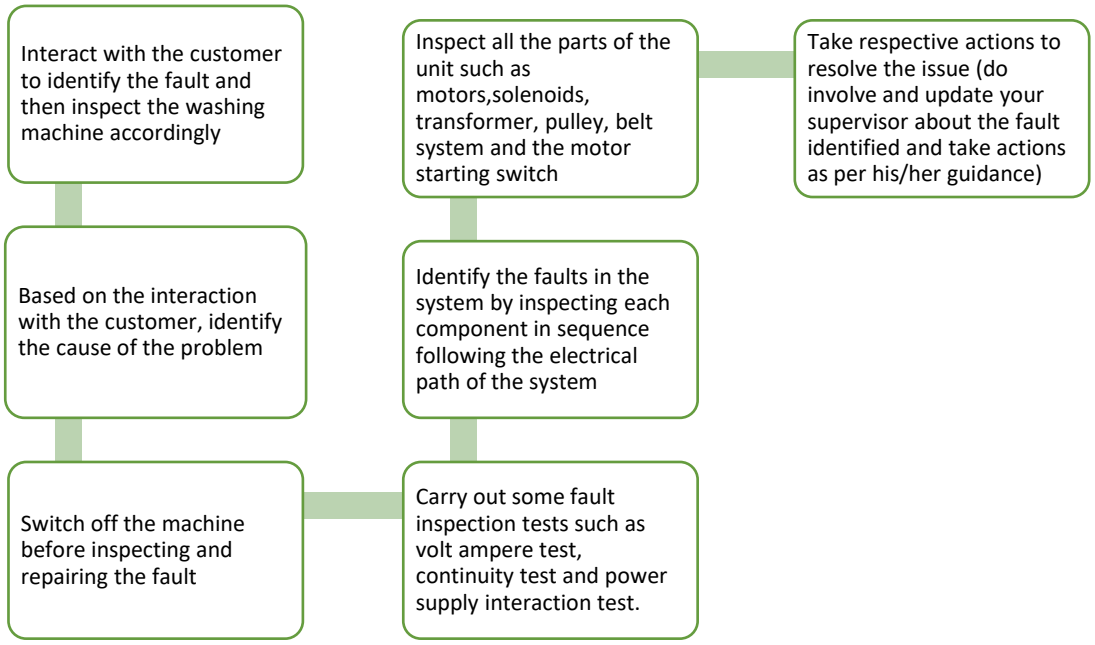

Fig. 4.1.6: Steps required to understand the symptoms and identify the fault

4.1.3 Suggest a Solution to the Customer

After identifying the issue, the HVAC technician needs to offer solutions. He should explain all the possible solutions along with the cost associated. He should then propose the best solution and let the customer decide whether to go ahead with the given solution or not. The following figure shows the steps involved in offering solutions to a customer:

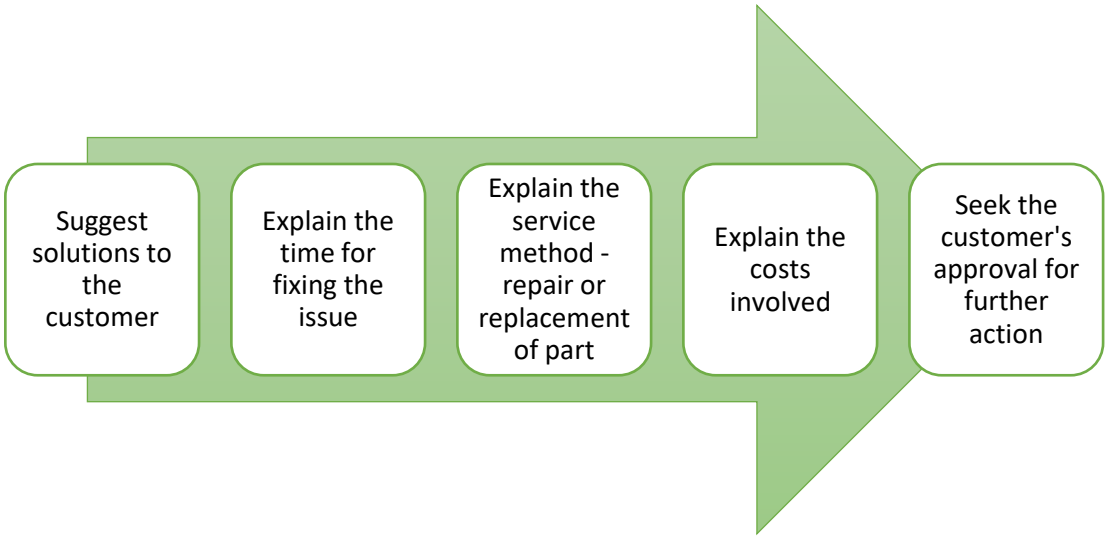

Fig. 4.1.7: Suggesting a solution to the customer for an issue

4.1.4 Confirmation of Functionality of the Repaired Module

Once the HVAC system has been repaired, ensure that the unit is functioning properly with the repaired or replaced parts. The following figure lists the checks that should be performed after repairs are complete:

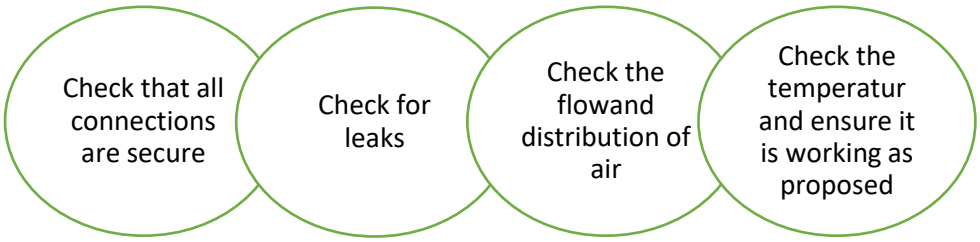

Fig. 4.1.8: Checks performed after repairs

UNIT 4.2: Identify Faulty Parts and Troubleshooting

Unit Objectives

At the end of this unit, you will be able to:

1. Identify the various fault that may occur in cooling tower
2. Troubleshoot cooling tower issues
3. Troubleshoot AHU faults
4. Troubleshoot a compressor
5. Identify various repairing methods for sealed systems

4.2.1 Troubleshooting

Troubleshooting refers to repair of faulty products or processes. It begins with searching for the source of a problem and ends with finding the solution for that problem to ensure that the product or process functions properly. Good troubleshooting consists of the following four steps:

- Identification of the symptoms
- Elimination of the causes of a problem
- Verification of the solution
- Restoration of the product or process

In other words, the first thing to do is to identify the symptoms that are causing a failure in the system. The next step is to diagnose the cause of that malfunction, till a solution is reached. This is followed by returning the product to its original state.

Troubleshooting Some Common Faults in Cooling Tower

Following are some common faults that may occur in cooling towers.

S.No.	Problems	Potential Cause	Troubleshooting Tips
1.	Unexpected Rise in Temperature	Less Air Flow	Adjust the blade level
		Water flow above the recommended level	Correct the level of water flow
		Obstruction in Sprinkler Output	Clear the obstruction, check for other faults in sprinkler and if required repair or replace the sprinkler
		Water Flow below the recommended level	Check for any leakage or obstruction in supply of water
		Obstruction in flow of external air around the cooling tower Or the exhaust air is not being recycled	Check for air obstruction or exhausts

S.No.	Problems	Potential Cause	Troubleshooting Tips
2.	Excessive Vibration or Noise	Fault in motor bearing	Lubricate it or replace it (if damaged)
		Loose fan mount/fan block	Tighten the loosen parts
		One part getting rubbed with another	Check for proper tolerance
		Loosen motor shaft hub mounting	Tighten them back using shrims
3.	Unexpected Fall in Cooling Capacity	Motor not working properly	Perform the following tasks: • Check the fuse • Check the switch capacity • Check the flow of current to motor • Check the switch contact • Service the motor and check for any faulty part and if require replace it
		Fan not working	• Check for jammed bearing • Check for proper flow of current and voltage • Check for all connected wires and switches
		Check Motor RPM (Revolutions Per Minute)	If Motor RPM is less: • Check for defects in starter • Check the electrical load and ensure it is not beyond the capacity of motor • Check the voltage supply • Check for all connections and switches • Check the manufacture's guidelines for any other cause and troubleshoot accordingly

S.No.	Problems	Potential Cause	Troubleshooting Tips
4.	Overflow of Water	Blockage in filter	Clear all the blockage Follow all necessary guidelines (manufacturer's guidelines) while cleaning the filters
		High Speed of Sprinkler	Check the angle of sprinkler and adjust accordingly Adjust the sprinkler's speed
		Incorrect placement of Sprinkler	Ensure that the sprinkler is not to above the rage of filters. Adjust as recommended
5.	Water Conductivity Beyond its Range	Faulty controller	Clean it with a clean dry cloth also check for other electrical faults like loose connection, voltage supply as recommended
		Blockage in solenoid	Check for any debris or any other deposits around it
		Water Leakage	Check for all water leakage possibilities and act accordingly
		Faulty Chemical Feed Pump	• Ensure that Chemical Feed Pump is properly primed • Adjust the chemical feed pump settings is recommended • Check for faults in chemical feed pump as recommended by manufacturer's guidelines
6.	Rise in Motor Temperature	Drop in Voltage Supply	Check and adjust the voltage supply as recommended
7.	Corrosion	Caused due to combination and reaction of air, sodium, and any other chemical components found in the water	To avoid Corrosion: • Apply polymeric coating solutions • Perform regular inspections • Once Corrosion occurs • Replace the damaged part immediately

S.No.	Problems	Potential Cause	Troubleshooting Tips
8.	Scaling	Occurs during heat exchange process	• Use conductive tubes coatings • Monitor and maintain calcium level of water
9.	Fouling	Clogging of pipes or cooling surface	• Use chlorine for fouling treatment • For excessive clogging the respective hardware such as fill, nozzle needs to be replaced with a new one.

Table 4.2.1: Troubleshooting tips

Troubleshooting Some Common Faults in Chillers

Following are some common faults that may occur in chillers.

S.No.	Problems	Potential Cause	Troubleshooting Tips
1.	No Power Supply	Improper Voltage Supply	Check for voltage supply as recommended
		Fault in MCB	Check MCB and correct flow of electric current in the circuit
2.	High Pressure Discharge in Water Cooled Chillers	Bad water treatment	Ensure proper water treatment as per Health and Safety guidelines
		Insulation in condenser	Clean all the external and internal surfaces and components attached to the condenser
		Reduction of water flow	• Check the system valves • Check the strainers • Check the pumps • Check the voltage supply to the pumps
3.	Reduction in Airflow (In Air Cooled Chillers)	Dust and other deposits on Condensers	Clean all the external and internal surfaces and components attached to the condenser
4.	Low Pressure Discharge (In Air Cooled Chillers)	Suction Valve Closed partially	Check for any obstacle
		Undercharge Refrigerant	Check for leakage in pipelines

		Very low air temperature	
5.	Thermostat not Working	Electrical Defect	Check the manufacturer's manual and rectify the error. If required replace it with a new one.
6.	Insufficient Cooling	Leakage in Refrigerant	Check for leakage and resolve it
		Blocked Filter or condenser	Clean filter as per manufacturer's guidelines

Table 4.2.2: Troubleshooting tips for chillers

Troubleshooting some common faults in Refrigerant

Following are some common faults that may occur in refrigerant.

S.No.	Problems	Potential Cause	Troubleshooting Tips
1.	Excess frost	Defective bi-metal or thermal fuse or defrost heater	1. Check the continuity of each component 2. Replace defective component
2.	Temperature not maintained	Improper installation	1. Check installation 2. Check ventilation
3.	Condensation in compartment	Air leakage	1. Check for leakage 2. Do proper insulation
4.	Improper cooling	Gas leakage	1. Check for gas leakage 2. Repair the leakage 3. Refill refrigerant
5.	Frequent compressor tripping	Defective condenser fan motor	1. Check condenser fan motor 2. Replace defective motor
6.	Fan runs even when door is open	Defective door switch	1. Check door switch 2. Replace if defective
7.	No cooling in refrigerator	Defective sealed system	1. Refer to unit on sealed system
8.	Refrigeration unit not working	Fuse blown	• Check fuse • Replace if defective

		Defective thermostat	1. Short thermostat connection 2. Check if refrigerator working 3. If yes, repair/replace thermostat

Table 4.2.3: Troubleshooting tips for refrigerant

Troubleshooting Some Common Faults in AHU/FCU

Following are some common faults that may occur in an air handling unit/fan coil unit.

S.No.	Problems	Potential Cause	Troubleshooting Tips
1.	Fan Motor Not Working	Electric Power Failure	• Check for voltage and loose connections • Check for electric power supply
		Control Panel Fault	Check for MCBs, Fuse and other component connections
		Isolation Switches Fault	Check for time switch error
		Duct Blockage	Clean all the blockages in ducts/filters/coil
		Impeller(rotating part of a pump/motor) jammed	Lubricate and check bearing. If required replace the faulty part
2.	Insufficient Air Flow	Blockage	Clean all the components of AHU as per manufacturer's guidelines
		Leakage	Check for leakages in all the joints, fitting and ductwork fittings
		Excessive Pressure Loss	Check air flow against fan static pressure. If fault is found in fan's static pressure rectify it else check damper position.
		High Resistance	Check main branch damper
		Extract Fan not working properly	Check Fan motor and check for other electrical faults
3.	Boilers not meeting the desired load	Boiler Thermostat not set properly	Check thermostat settings
		Poor Combustion	Check the quality of excess combustion

4.	Boiler Overheating	Fault in System Controls	Check for all electrical faults, voltage supply and safety switches
5.	The AC unit does not turn on		• Check the fuses or the breaker. • Check the wiring and the selector switch.
6.	Air coming out from the unit is not cold enough but the temperature is set to low	Thermostat failure Exhaust Vent Problem Obstruction in Coil	• Check whether the thermostat is set at high warm position. • Keep the exhaust vent control in "Open" position. • Ensure that the location of the thermostat sensing bulb is correct. • Check the cleanliness of the coils.

Table 4.2.4: Troubleshooting tips for AHU/FCU

Repairing a Fan

Generally loose or dirty blades of a fan lead to malfunctioning. Cleaning and tightening the fan blades usually fixes the problems with fan. The following figure lists the steps to repair the fan of an AC unit:

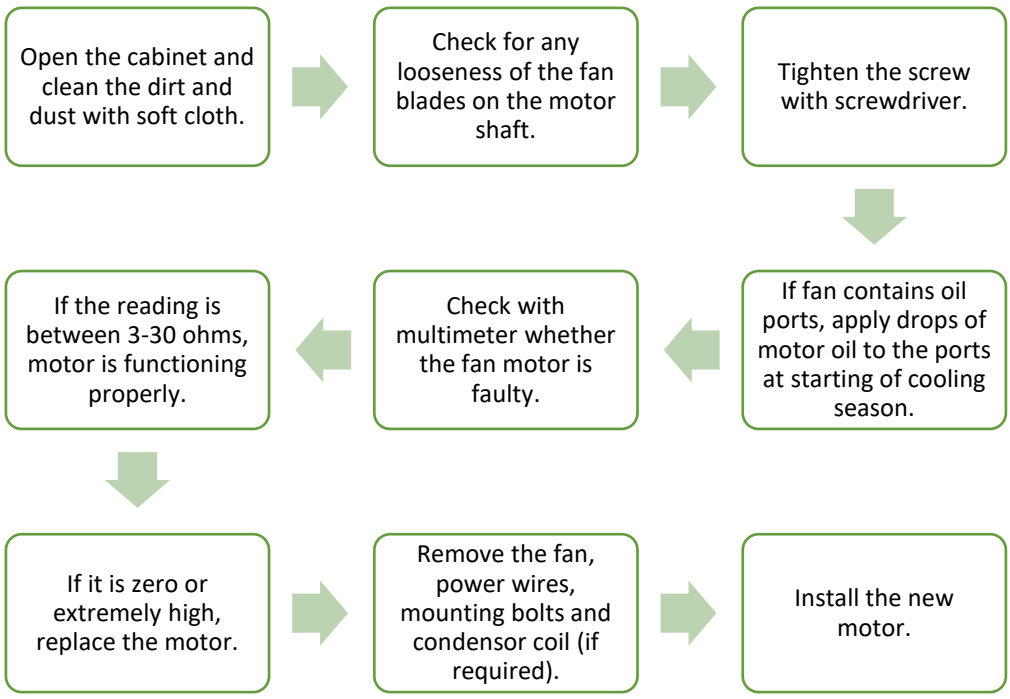

Fig. 4.2.1: Steps for repairing the fan of the Air Conditioning Unit

4.2.2 Repairing Methods for Sealed Systems

Proper repair of sealed system is dependent foremost upon a thorough understanding of the normal operating procedures, the types of failures that can occur in a sealed system and the correct diagnosis of the problem.

The following figure shows the types of failures that can necessitate repairs:

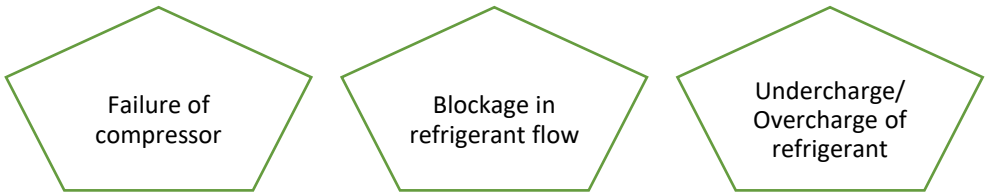

Fig. 4.2.2: Types of failures

Failure of Compressor

The inflow and outflow of refrigerant in a compressor is regulated by two valves. A defective valve leads to inefficiency and subsequently a failure of compressor. The compressor is unable to maintain correct pressure differential needed for proper evaporation and condensation of refrigerant.

Blockage in Refrigerant Flow

The system must be free of any contaminants or moisture. Moisture is especially very harmful to the system. Water mixes with the refrigerant and forms salt and sludge. These salts and debris block the flow of refrigerant through the capillary tube.

Undercharge/Overcharge of Refrigerant

The system should be charged properly with the factory recommended refrigerant. It is highly unlikely for a unit to leave the factory with incorrect charge. Undercharge or overcharge of refrigerant is usually a result of poor system processing after repairs. It occurs when a unit is incorrectly charged after performing repair. Undercharge reduces the system's ability to absorb heat and overcharge has an adverse impact on the cooling efficiency as well as on power consumption.

Once the problem has been isolated, appropriate repairs can be undertaken.

The following figure shows the prerequisites for a successful repair:

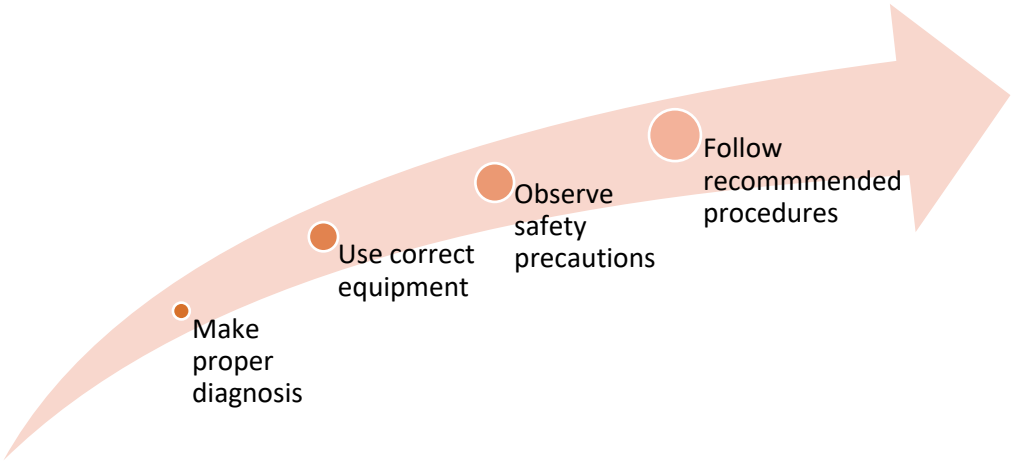

Fig. 4.2.3: Prerequisites for successful repair

Sealed system repair consists of specific steps that need to be followed.

The following figure shows the steps of sealed system repair:

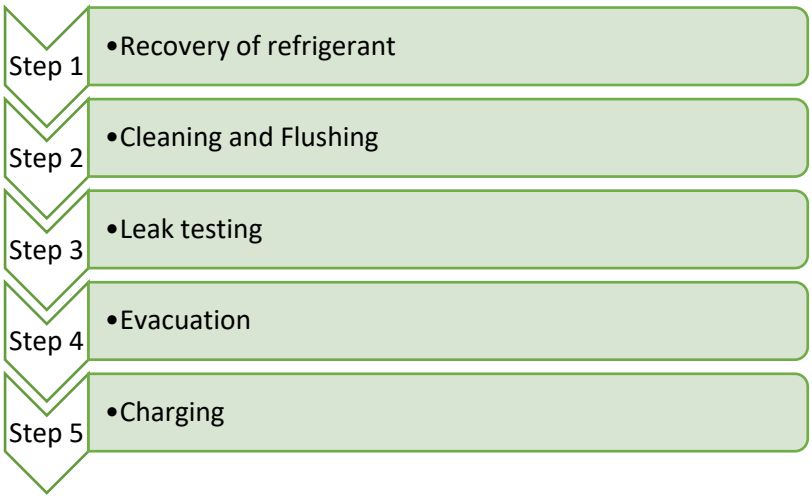

Fig. 4.2.4: Steps of sealed system repair

Recovery of Refrigerant

Recovery of a refrigerant refers to the process of removing a refrigerant from a system and storing it in a recovery cylinder. A recovery cylinder is different from the conventional cylinder in two ways. First, the cylinder valve has the refrigerant filling port enabled and secondly, its upper part is painted yellow to mark it as a recovery cylinder.

There are three different methods of recovering a refrigerant, as shown in the following figure:

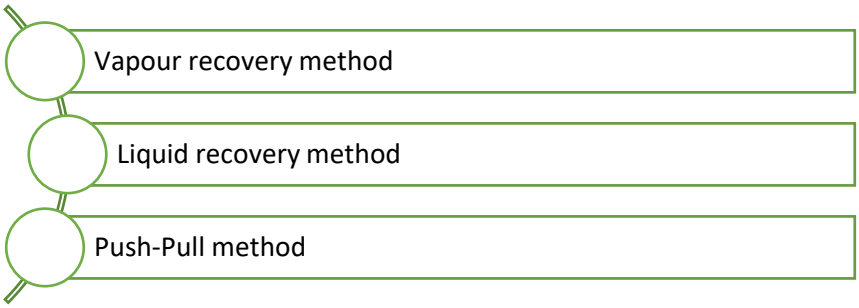

Fig. 4.2.5: Methods of refrigerant recovery

Vapour Recovery Method

It is the most common method of refrigerant recovery. The refrigerant which is in vapour form is drawn into the recovery system from the refrigeration unit. It passes through the compressor to the condenser. The gas cools down to liquid and is stored in the recovery cylinder. The following figure shows the steps of the vapour recovery method:

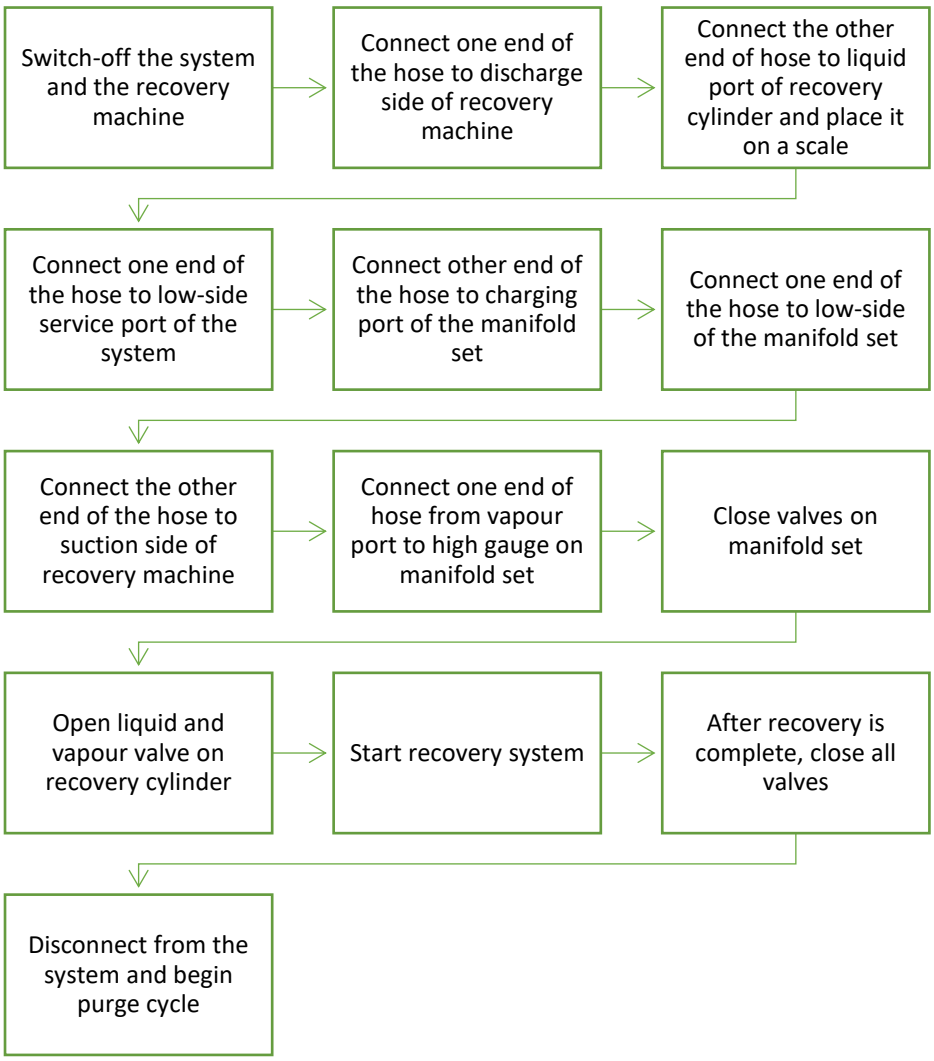

Fig. 4.2.6: Vapour recovery method

Liquid recovery Method

This method is preferred when the refrigerant has to be recovered from oil-less compressors having constant-pressure valves. The recovery method is similar to the vapour recovery method with the difference that it enables liquid refrigerant to be recovered.

The following figure shows the steps of the liquid recovery method:

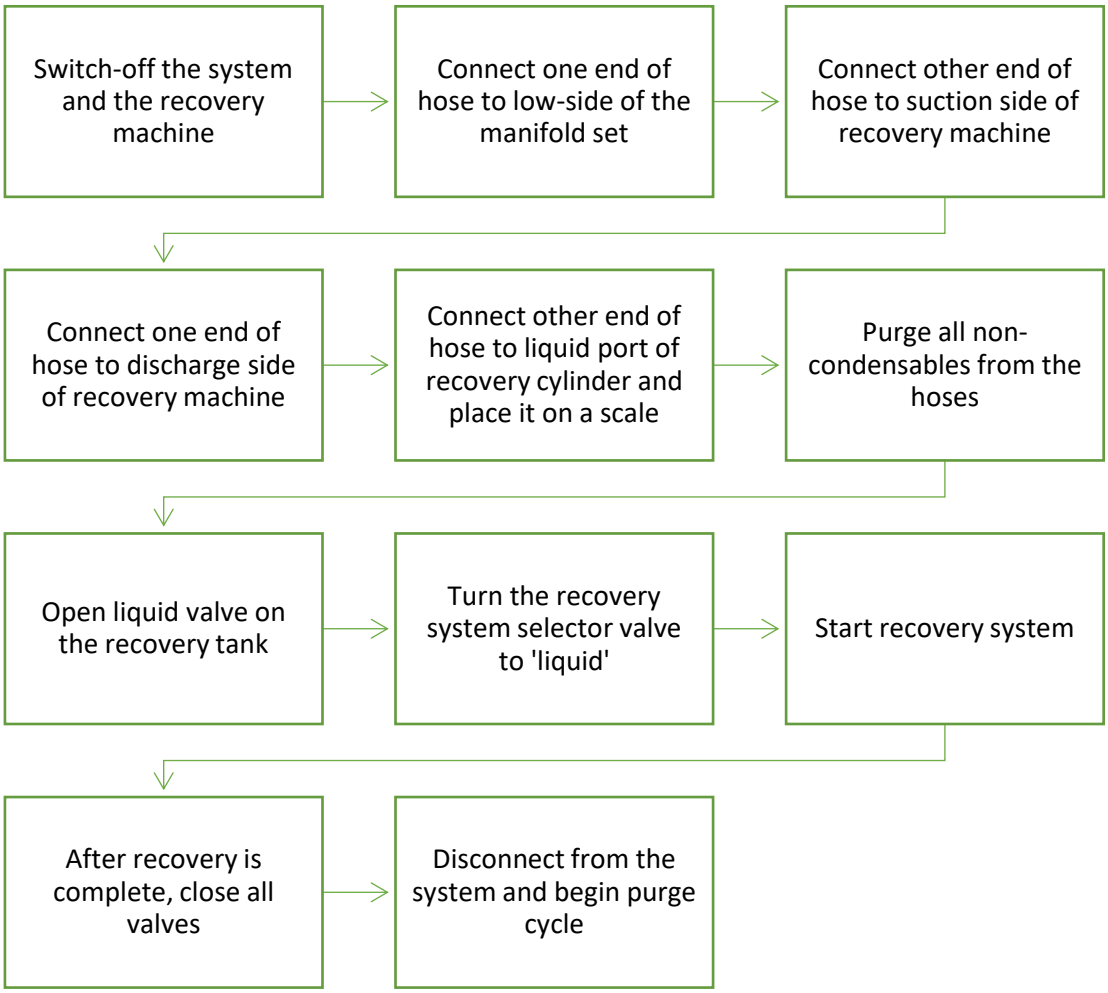

Fig. 4.2.7: Liquid recovery method

Push-Pull Method

This method is used to recover bulk liquid from a system. The recovery machine creates potential difference to siphon the refrigerant from one tank to another. The recovery unit pulls vapour from the recovery cylinder. This produces a high-pressure gas that pushes the liquid out of the system into the recovery cylinder.

The following figure shows the steps of the push-pull method:

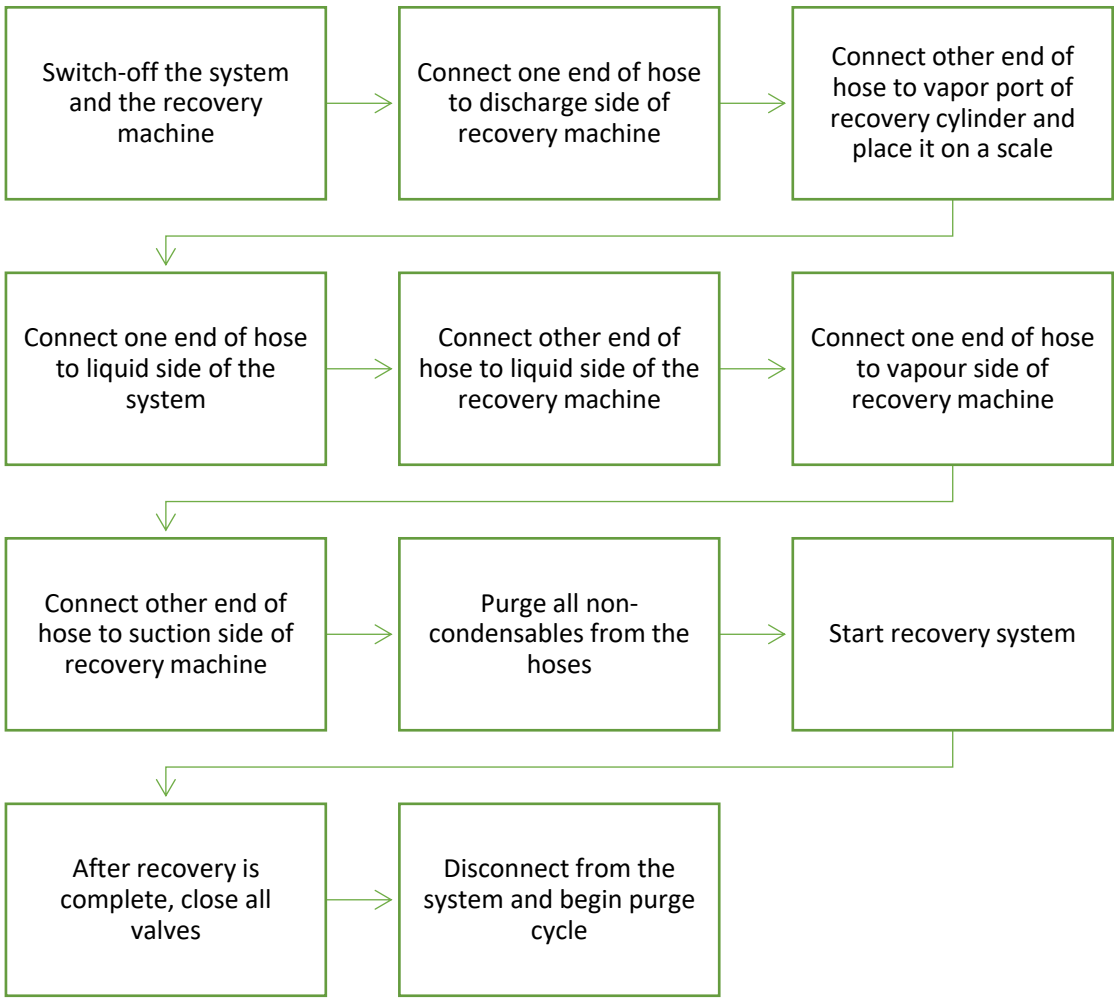

Fig. 4.2.8: Push-pull method

Cleaning and Flushing

When a refrigeration system suffers a failure, it becomes contaminated with disintegrated particulate, sludge, acids, carbon residues, and moisture. These contaminants need to be cleaned and flushed out of the system. The most common cause of contamination is compressor failure.

The following figure shows the guidelines that must be followed when flushing a system:

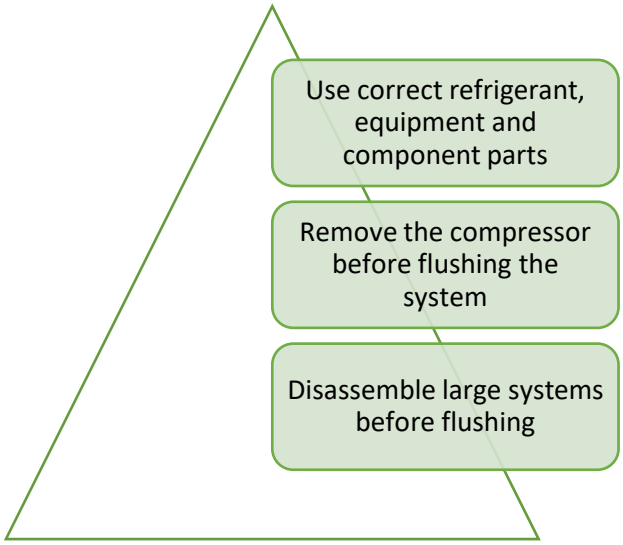

Fig. 4.2.9: Guidelines for flushing system

It is very important to use correct equipment, ensure that it is in good working condition and undertake periodic and regular maintenance of the tools.

The following figure shows the equipment required for flushing a system:

Flushing solvent canister	Injection tool	Charging hose	Waste container
Nitrogen tank	Vacuum pump	Clean wipes	Safety equipment

Fig. 4.2.10: Equipment for flushing system

Before starting the flushing operation, confirm the availability of all required tools and equipment.

The following figure shows the steps of flushing a system:

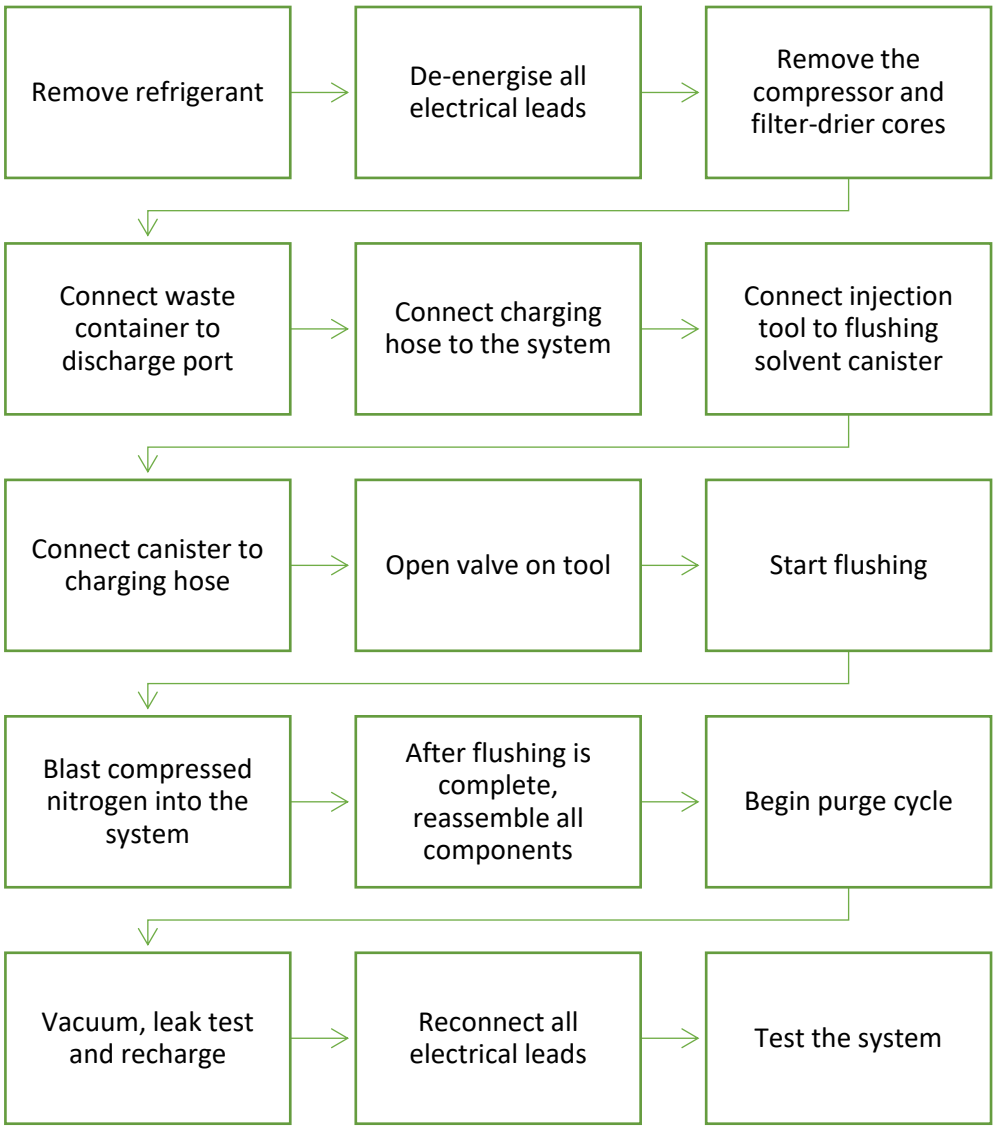

Fig. 4.2.11: Steps for flushing system

Leak Testing

The refrigerators can operate properly only with a fixed charge of refrigerant. If it is diagnosed during troubleshooting that the refrigerant is insufficient, then the system needs to be checked for leaks. Theses leaks are then repaired, and the system is recharged with refrigerant.

The following figure lists the various causes of refrigerant leaks:

Vibration	•Leads to misalignment of eals and loosening of bolts
Frequent temperature changes	•Leads to expansion and contracrtion in metal parts
Frequent pressure changes	•Leads to difference in material stress
Incorrect material used	•Fail under pressure or temperature changes
Poor connections	•Result in leakage from joints, connections or caps on valves
Corrosion	•Decays the materials creating holes
Accidental damage	•Leads to impact on refrigerant containing parts

Fig. 4.2.12: Causes of refrigerant leaks

Once the possibility of leak is diagnosed, it is critical to check the whole system for multiple leaks and mark them for repair. Leak detection is carried out manually by the technician to identify possible leaks.

The following figure shows the methods for leak detection:

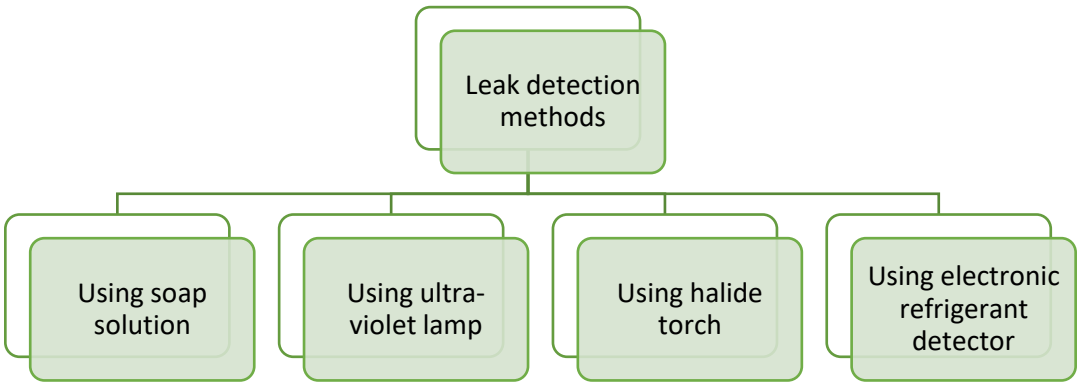

Fig. 4.2.13: Methods of leak detection

Using Soap Solution

It is the most effective and economical method used by technicians to detect leakage.

A soap solution is applied to joints, connections and fittings while the system is running. The appearance of bubbles confirms leakage.

The following image shows leak detection using soap solution:

Fig. 4.2.14: Leak detection using soap solution

Using Ultra-Violet Lamp

In case of large refrigeration systems, it is difficult to access all joints and connections. So, it is not possible to use soap solution or electronic detector to check for leakage. In such situations, ultra-violet lamp is used. An additive dye is added to the refrigerant. When a ultra-violet lamp is pointed, the leak glows in yellow-green colour.

The following image shows leak detection using ultra-violet lamp:

Fig. 4.2.15: Leak detection using ultra-violet lamp

Using Halide Torch

The halide torch is used to detect leakage of CFCs and HCFCs. It contains a copper catalyst over which the refrigerant is drawn with the help of a blue flame. When the refrigerant burns over the copper catalyst, the chlorine in it reacts and the colour of the flame changes to green. It does not work in case of refrigerants such as HFCs which do not contain chlorine.

The following image shows a halide torch:

Fig. 4.2.16: A halide torch

Using Electronic Refrigerant Detector

An electronic refrigerant detector is a battery or AC powered device containing an element sensitive to a particular chemical component in the refrigerant. As it approaches the source of leak, the audible or visible signal increases in frequency and intensity.

The following image shows leak detection using electronic refrigerant detector:

Fig. 4.2.17: Leak detection using electronic refrigerant detector

Evacuation

Evacuation refers to the process of removing vapours, fluids and non-condensable gases such as air and nitrogen from the refrigeration system.

The following figure shows the equipment needed for evacuating a system:

Fig. 4.2.18: Equipment for evacuating a system

The following figure shows the steps of evacuating a system:

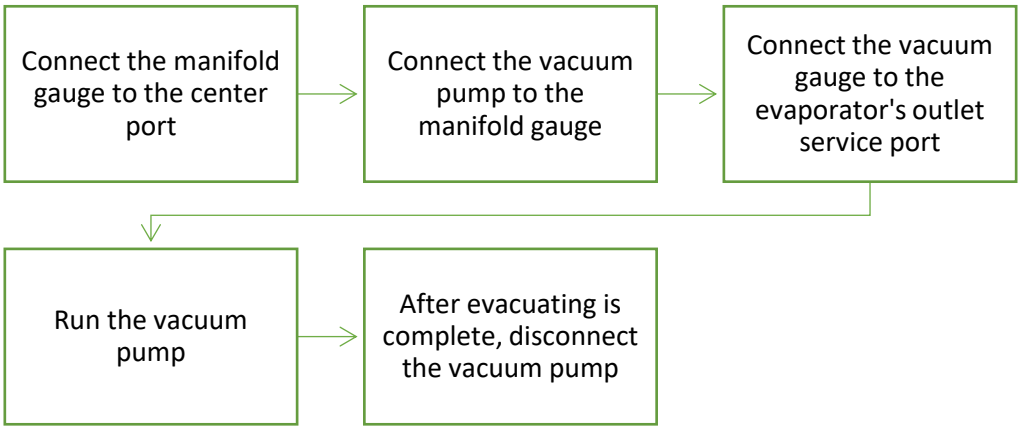

Fig. 4.2.19: Steps for evacuating a system

Charging

Every refrigeration system needs an optimum level of refrigerant to function efficiently. When the level of refrigerant drops, it needs to be filled-up. Charging refers to the process of adding the refrigerant in proper quantity to a refrigeration system.

The following figure shows the steps of charging a system:

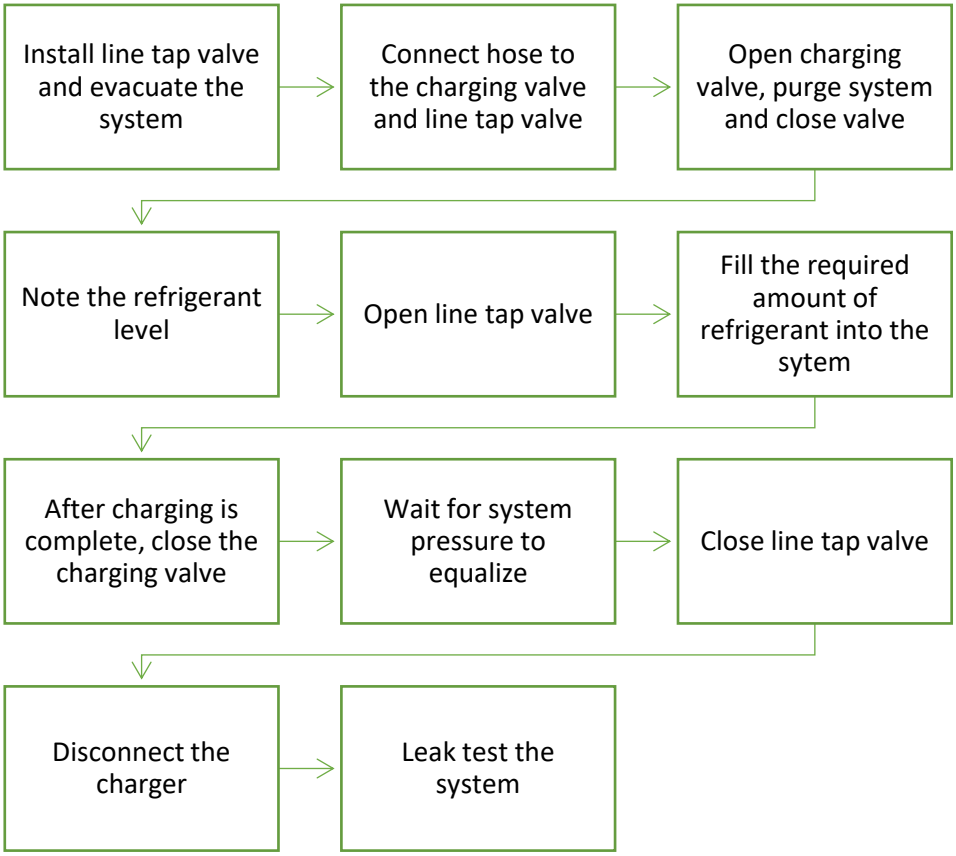

Fig. 4.2.20: Steps for charging a system

Testing a compressor

Step 1: Check the power outlet to make sure it is working well.

Step 2: Turn the power off and take out the unit's terminal cover by removing the mounting screws located at the four corners of the front of the air conditioner unit. Ensure that the terminals and wires are not damaged.

Step 3: Check the compressor to make sure that there is no cracked valve inside it.

Step 4: Test the electrical terminals using a multimeter. A typical unit has three terminals; C, R, and S. The continuity between every two terminals (C - R, C - S, and R - S) should be tested.

- Check the wire connections and if the wire is found faulty, replace it.
- If the resistance is higher (higher than 30 ohms), check if the compressor is hot. If so, it may be that the internal overload is open and wait for the compressor to cool down.
- If the resistance is high but the unit is cool, it indicates that the compressor motor is bad.

Step 5: Check the resistance of each of the terminals to the compressor's body. If the resistance reading is low, it signifies that the motor is grounded and the compressor needs a replacement.

UNIT 4.3: Evaluating and Repairing Electrical Connections, Earthing and Motor Issues

Unit Objectives

At the end of this unit, you will be able to:

1. Identify the electrical faults in an HVAC system

4.3.1 Evaluating and Repairing Electrical Connections

All electrical systems should be subjected to thorough testing and inspections after the completion of installation. Faulty wiring can lead to potential life-threatening situations. The inspection and testing ensure that all the wiring and appliances are installed in perfect order.

Visual Inspection

Visual inspection of the installation is carried out prior to conducting any tests. This ensures that the system is safe to test. The following figure lists the checks that a domestic electrician should perform and ensure as a part of visual inspection:

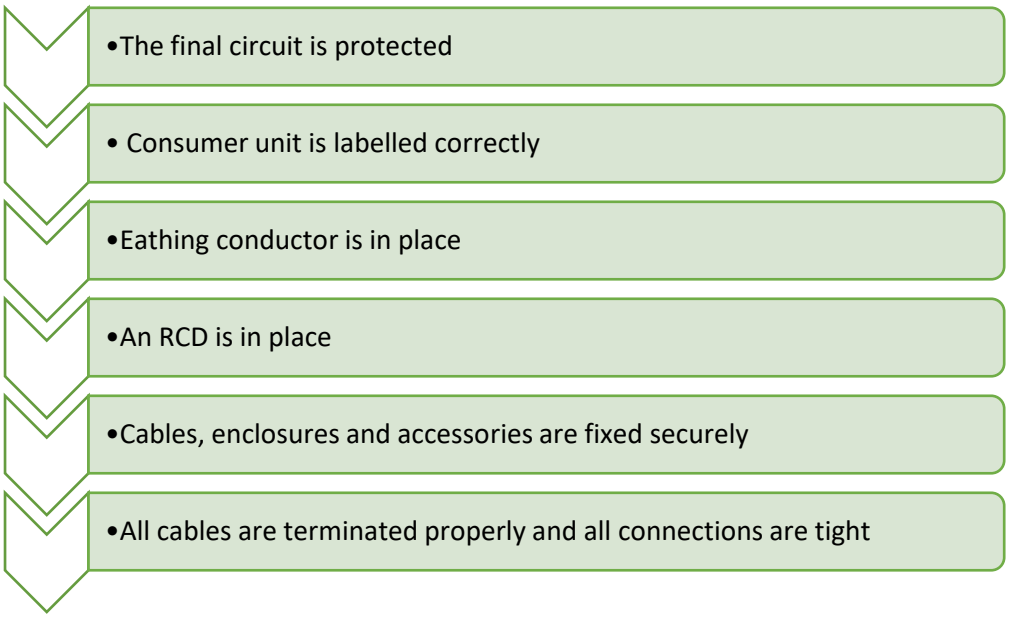

Fig. 4.3.1: Visual inspection

Charging the Circuit

The first step of testing the wiring system is to charge the circuit by performing the following steps:

- Connect the main supply line
- Ensure that all the circuits are switched off
- Switch on the circuits one by one
- Check all parameters such as voltage and earthing at each termination point

Applying Load and Checking if it Works

Once the electric circuit is charged and all the parameters have been checked, apply loads one at a time and check if they are working. Load refers to any appliance or fixture that draws power and puts a load on the circuit such as light, fan, refrigerator, air conditioner (AC) and so on.

Perform the following steps, to check if a load is working:

1. Turn on the switch connected to the appliance
2. Check if it is working
3. If not, turn off the switch
4. Check if the circuit breaker has tripped
5. If not, check the wiring and the connections

Keep on switching one appliance after another. Repeat the steps after adding each load.

Performing Simple Wiring Tests

A lot of tests can be performed using simple handheld instruments such as neon –tester, continuity tester, mini multimeter and 3-prong analyzer.

Using a Neon Circuit Tester

A neon circuit tester is an inexpensive, versatile and simple electrical testing tool. It has two probes and a neon indicator light that glows when power is connected. It is generally used to test if a circuit is energized. The red test lead is connected to the “hot” side/wire and the black lead is connected to the “neutral” side/wire. If the circuit is live, the lamp lights up.

The following image shows a typical neon circuit tester:

Fig. 4.3.2: A typical neon circuit tester

Perform the following steps to test a ground wire:

1. Switch off the power to the concerned circuit
2. Disconnect and separate the wires
3. Switch on the circuit
4. Touch the hot wire with one lead and the ground wire with the other lead
5. If the ground wire is good, the lamp will glow

Perform the following steps to test that a metal box is grounded:

1. Switch off the power to the concerned circuit
2. Disconnect and separate the wires
3. Switch on the circuit
4. Touch the hot wire with one lead and the metal box with the other lead
5. If the metal box is grounded, the lamp will glow

Using a Continuity Tester

A continuity tester is an inexpensive, versatile and simple electrical testing tool for tracing wiring and testing switches. It has a wire lead, a probe and a light bulb. When the probe and the lead are touched to a wire, the bulb glows if the circuit is complete. This helps in tracing the route of a wire even when the circuit is switched off.

The following image shows a typical continuity tester:

Fig. 4.3.3: Continuity tester

Perform the following steps to identify the route of a wire:

1. Switch off the power to the concerned circuit
2. Connect the test wire to a circuit wire inside one of the electric boxes
3. Attach the lead to the test wire
4. Touch the probe to the ends of wires inside the other electric box
5. When the right wire is found, the lamp will glow

Perform the following steps to test a switch:

1. Switch off the power to the concerned circuit
2. Remove the switch
3. Attach the lead to one terminal of the switch
4. Touch the probe to the other terminal
5. Flip the switch on and off
6. If the switch is good, the lamp will also glow on and off

Wiring Systems Tests

The wiring systems tests are of two types:

- Dead Testing
- Live Testing

Dead Testing

Dead testing forms the initial testing of the circuits. They are performed when the circuits are not energized. Dead Tests include:

- Leakage Test
- Insulation Test
- Ring Circuit Test

Live Testing

Live testing on circuits is performed after dead testing. After the results of dead testing are found satisfactory, the electric installation is put back into place. The next step is to perform the following live tests:

- Polarity test
- Earth loop impedance test
- Prospective short circuit test
- Residual current device test

Verifying Polarity

The polarity test is conducted to ensure that the polarity at the main supply point is correct. It checks that the live and the neutral have not been crossed over. It verifies that the fixed equipment, sockets and switches in the system are connected in the current carrying conductor and not in the neutral. There are two methods of verifying polarity:

- Continuity Testing
- Live Testing

Continuity Testing

The following steps are performed to test the polarity by continuity testing:

1. Switch off the circuit breaker for the circuit under test
2. Connect a temporary link between the line conductor and the circuit protective conductor (CPC) or any equipotential bonding conductors.
3. Place the test leads of an ohmmeter across the line conductor and the nearest CPC
4. If the switch is connected properly to the line conductor, the instrument will show zero reading
5. If the switch is not connected to the line conductor, the instrument will show some osmic value
6. Interchange the connections to fix the problem

The process of troubleshooting electrical faults consists of the following steps:

- Inspect and locate potential hazards
- identify and rectify faults in domestic electrical wiring
- disassemble and replace faulty electrical components

Inspect and Locate Potential Hazards

Potential hazards refer to situations which are not dangerous at present but can be a risk in the near future. It is critical to be able to identify such situations, inspect the cause of the problem and rectify it. The following table lists some common potential hazards and their solutions:

Symptom	Cause	Solution
Power outages	A safety trigger is tripped	• Open the main breaker panel • Switch on the tripped circuit breaker • Inspect the circuit and outlets controlled by the tripped breaker for defect
Dimming/flickering lights	• Loose bulb • Faulty light switch • Loose wiring	Loose bulb • Switch off the light • Tighten the bulb in its socket Faulty light switch • Replace the switch Loose wiring • Switch off the concerned circuit breaker • Remove the light fixture • Inspect the wiring • If defective, replace wiring
Sparking in any part of the electrical system	• Wear and tear • Overloaded circuit • Loose wiring • Damaged wiring	Wear and tear of component • Replace the component Overloaded circuit • Switch off the circuit breaker • Switch off all lights, fixtures and appliances • Switch on the circuit breaker • Switch on the fittings one by one • Locate the defective fitting • Shift it to another circuit

Symptom	Cause	Solution
		Loose wiring • Switch off all lights, fixtures and appliances • Switch off the circuit breaker • Inspect the wiring • Tighten loose connections Damaged wiring Replace wiring
Overheating of appliances or sockets or plugs	• Frayed wiring • Loose wiring • Defective appliance • Defective plug/socket • Incorrect fuse	• Unplug the appliance • Inspect the plug and socket • Replace the defective part • Inspect the appliance • Replace if defective • Inspect the wiring for wear and tear • Replace if defective • Inspect connections • Tighten loose connections • Inspect the fuse • Replace with a higher rating fuse
Unusual sounds from any part of the electrical system	• Loose wire • Short circuit • Damaged motor of an appliance	• Switch off the circuit breaker of the affected part • Inspect the wiring • Tighten loose connections • Inspect the appliance on that circuit • If defective, repair the motor
Burning odour	• Loose connections • Overheated wires • Damaged insulation	• Switch off all lights, fixtures and appliances • Switch off the circuit breaker • Inspect the wiring • Tighten loose connections • Replace the damaged wires

Table 4.3.1: Causes of potential hazards and their solutions

Burnt Wire in Electrical Box

The following figure lists the steps to repair a burned wire in an electrical box:

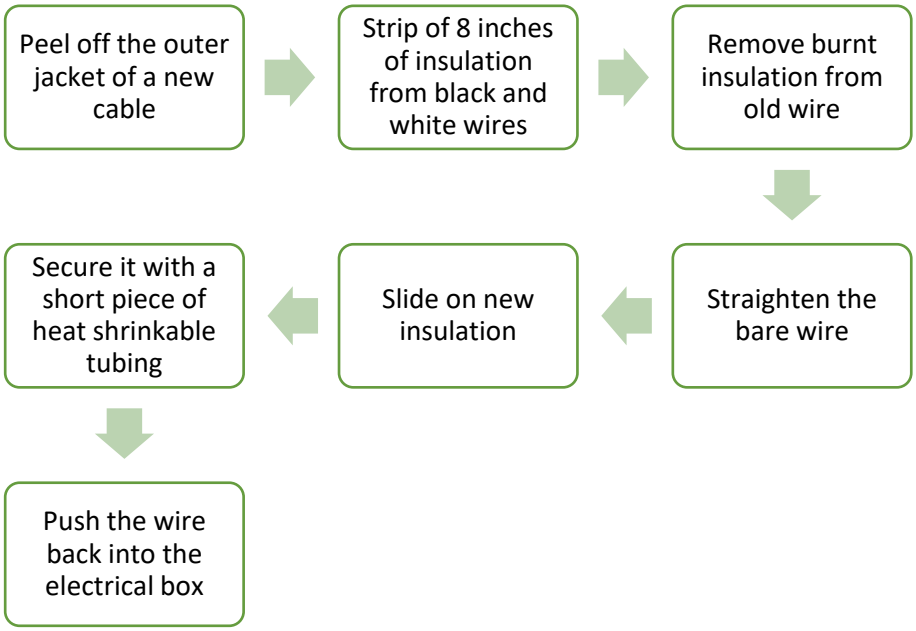

Fig. 4.3.4: Repairing a burned wire in an electrical box

Fix Underground Wiring

The following figure lists the steps to fix underground wiring:

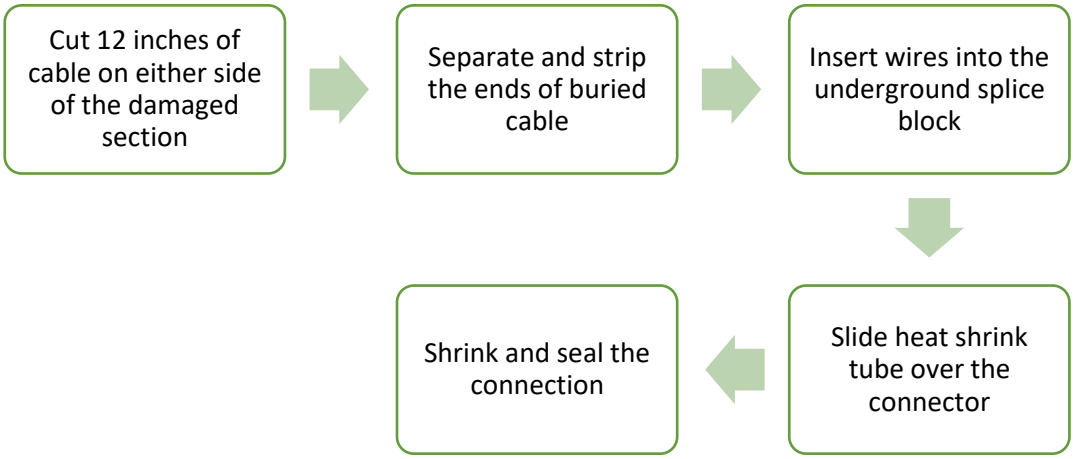

Fig. 4.3.5: Fixing underground wiring

4.3.2 Evaluating and Repairing Earthing Issues

Earth leakage or ground leakage refers to the flow of current from a live conductor to earth through an insulator. It is hazardous and should be controlled. To control such earthing issues Earth Leakage Circuit Breaker (ELCB) are used.

How to check earth leakage?

Check the resistance of each terminal by using a multimeter. If it is close to zero, this means it is causing an earth leakage. You need to immediately find the cause and rectify it accordingly. Some of the possible reasons that may cause earth leakage are:

- Any wire connected to electric circuit touching the grounded metal field.
- Loose Wire Connection
- Neutral conductor touching the earth conductor

Performing Leakage Test

- Every electric conductor is enclosed in a protective insulation for protection. Ideally, the insulation should be perfect and should not allow any current to pass through it. But, in real world this is not the case and some current will flow through the insulation or the protective ground conductor to ground.

Leakage Current

- Leakage current is the small amount of current that is present through and over the insulation. Over time, a build-up of leakage current can prove to be dangerous and is an indication of deterioration in insulation. It is, therefore, very important to test and identify the source of the leakage current. Leakage current can be measured with the help of a clamp meter.

Measuring Leakage Current

Disconnect the load before measuring the leakage current. To test single phase circuits, perform the following steps:

- Clamp the jaws of the clamp meter around the phase and the neutral conductor as shown in the following image:

Fig. 4.3.6: Testing a single-phase circuit

- If the meter records any current value, this indicates leakage of current to the ground.

To test three phase circuits, perform the following steps:

- Clamp the jaws of the clamp meter around all the three conductors as shown in the following image:

Fig. 4.3.7: Testing a three-phase circuit

- If the meter records any current value, this indicates leakage of current to the ground.

To test the ground conductors, perform the following steps:

- Clamp the jaws of the clamp meter around the ground conductors as shown in the following image:

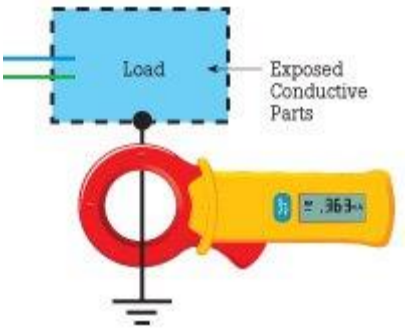

Fig. 4.3.8: Testing ground conductor

If the meter records any current value, this indicates leakage of current to the ground.

Circuit Breaker Fuse

The following figure lists the steps to dissemble and replace a faulty circuit breaker fuse:

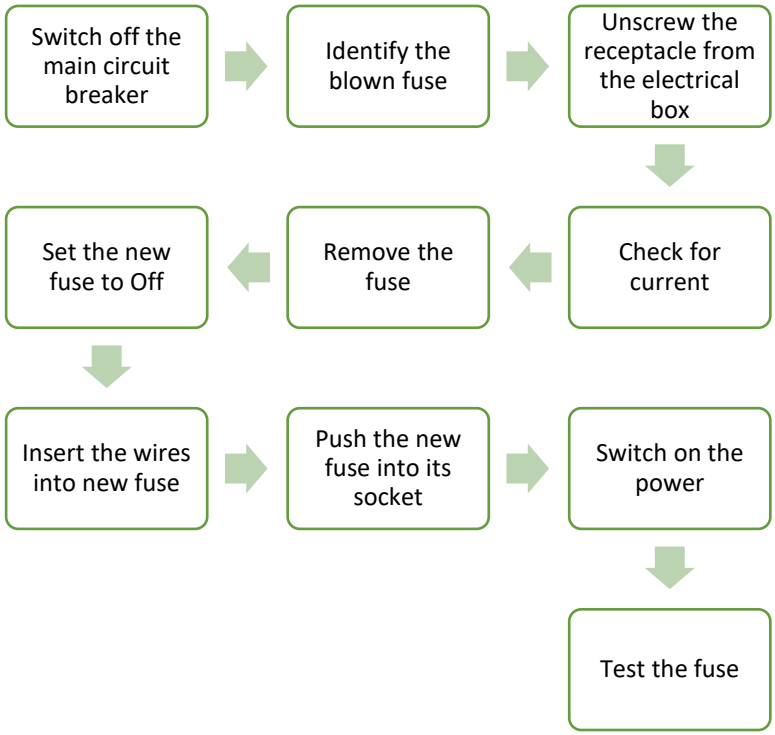

Fig. 4.3.9: Replacing a faulty circuit breaker fuse

4.3.3 Evaluating and Repairing Motor Issues

The blower motor fitted in HVAC system is responsible to blow conditioned air through duct/vents. The following factors can help evaluating the performance of a blower motor:

- Less/ No Air Flow
- Overheating
- High Sound

Note:

Some of the factors that can affect HVAC electric motors are:

Dirty Condenser Coils	Frequent Tripping of MCBs

Dirty condenser coil may not directly impact the working of motor but with regular deposits of debris and stucking the airflow will put lot of load on motor. This may result in lowering down the HVAC system energy efficiency and increases the motor problems.

Such as overheating of motor or may lead to any other physical or electric damage to the motor. So, it recommended to regularly clean the condenser coils.

There can be any reason for tripping of MCBs. Every time the MCB trips the system gets off and again it is started as required. Such Frequent on-off cycle can impact the motor too. Such trippings should not be ignored, the root cause should be find and rectified immediately

If the motor is not working properly, you need to perform the following tasks:

Task 1: Check for physical damage of the motor parts:

1. Check for broken mounting or any other part
2. Check for deposition of dust or debris from surroundings
3. Check for rust/corrosion
4. Check for damaged wire

If any of the above issues are identified rectify as per the instruction manual. If required replace the broken, rusted part.

Task 2: Check the bearings of motor:

1. Ensure that the rotation is free and it is spinning quietly without making any noise
2. Check shaft by pulling out and pushing in with slight movements

If the movements are not smooth, there is need for lubrication. If still the problem is not resolved change the faulty parts.

Task 3: Check the Windings

1. Check the windings that may get damage due to short circuit in electrical supply.
2. Check its resistance value using a ohmmeter

Task 4: Check for other possible issues

1. Check the capacitor used to run the motor
2. Check the fan
3. Check for proper voltage supply
4. Check for continuous flow of electric current

All the tasks performed to evaluate and repair the motor should be well documented and approved by the supervisor.

UNIT 4.4: Achieving Delivery Standards

Unit Objectives

At the end of this unit, you will be able to:

1. Adhere 100% to contracted standards of work
2. Achieve downtime of less than 1% or as contracted
3. Escalate problems in time and as per criticality of work process
4. Maintain 100% records of activity

4.4.1 Adhere 100% to Contracted Standards of Work

A customer service department must own a measurable set of standards so that the helpdesk technicians can be aware of what expected from them. These standards ensure that the customer service and satisfaction is consistently at the highest possible level.

The standards for customer service should also reflect the organizational values. For example, hospitality industry may have different customer service standards in comparison with a corporate service that provides technology tools to a wide range of commercial customers. To make sure that the service levels are consistent throughout the organization, a clear and measurable set of standards need to be designed and followed.

The following figure shows the features of customer service standards:

Fig. 4.4.1: Features of customer service standards

- **Timeliness –** The IT helpdesk technician should aim for a timely resolution of customer issues.
- **Accuracy –** Customer service must be accurate. The focus should be on solving the issue with right set of methods and standards.
- **Appropriateness –** Appropriateness refers to how effectively the expectations of the customers are met. The helpdesk technician should ensure that the best possible solution is selected to resolve an issue.

- **Measurability –** To be effective, the standards need to be measurable. Along with setting standards, guidelines should also be created to be aware of how to monitor them and evaluate the results. The helpdesk technician should use these guidelines to point out the problem areas and maintain the service standards consistently.

Benefits of Implementing Standards

Once the service standards are defined, they need to be followed by the customer service team. The helpdesk technicians should have a clear understanding of the benefits of following such standards. Some benefits of these standards are as shown in the following figure:

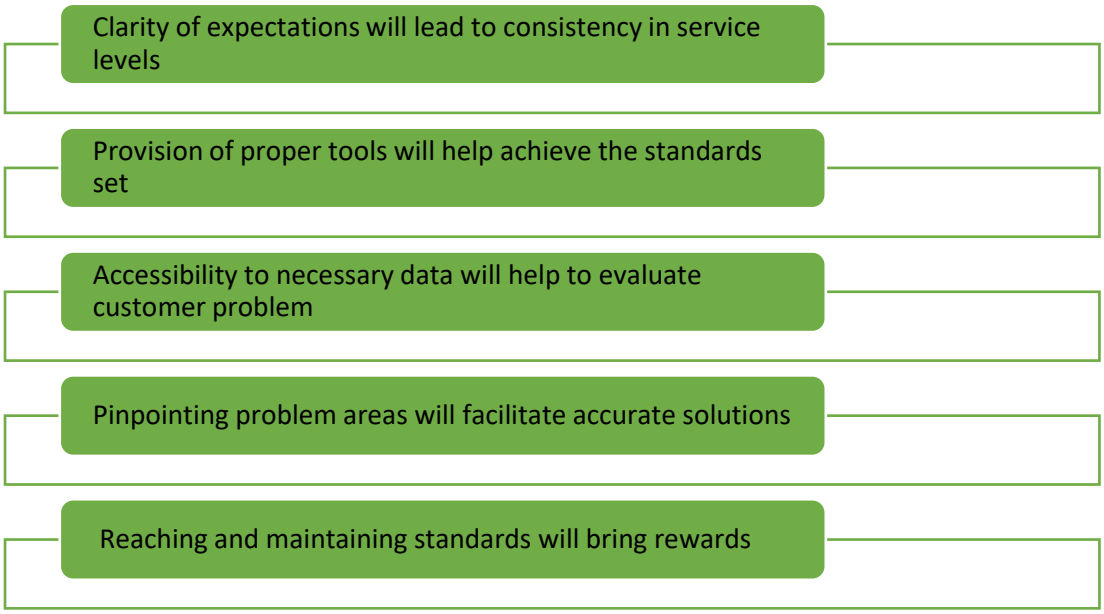

Fig. 4.4.2: Benefits of customer service standards

4.4.2 Achieve Downtime of Less Than 1% or as Contracted

Downtime or outage duration refers to the period when a system becomes unavailable and is not able to perform its primary function. When this happens, it raises questions on the availability, reliability and recovery of the system. The unavailability is the proportion of a time-span that a system is not available because of the system failing to function due to an unplanned event, or as a result routine maintenance.

As depicted in the following figure, downtime occurs in two ways:

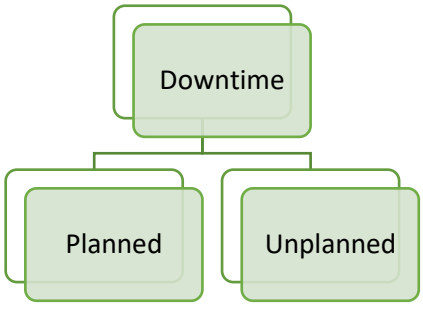

Fig. 4.4.3: Occurrence of downtime

Planned downtime

Planned downtime is the result of scheduled system maintenance work. This includes upgrading a system or replacing aged hardware from time to time, which requires rebooting a machine. Planned and scheduled downtime in service windows has minimal impact but is difficult to avoid.

Unplanned downtime

Unplanned downtime is beyond the control of the organization and is unforeseeable. It, therefore, has more impact on the business. Examples of unplanned downtime are infrastructure failures, human mistakes or even geographical catastrophes.

4.4.3 Maintain 100% Record Activity

Good customer service also involves maintaining accurate records, managing details of dealings with the customers. Customer records can help in gathering information about how best it is to market a company's services and help to ensure that the organisation is running smoothly. Most records are stored electronically on a database.

Objectives of Documentation

- To record all the problems reported by users.
- To record the timing of the corrective action.
- To record the issues that are escalated and to whom.
- To record what action has been taken by whom.
- To record when the outstanding requests get cleared.

Right documentation can make a lot of the difference in getting quick resolutions.

To achieve this, certain steps need to be taken as shown in the following figure:

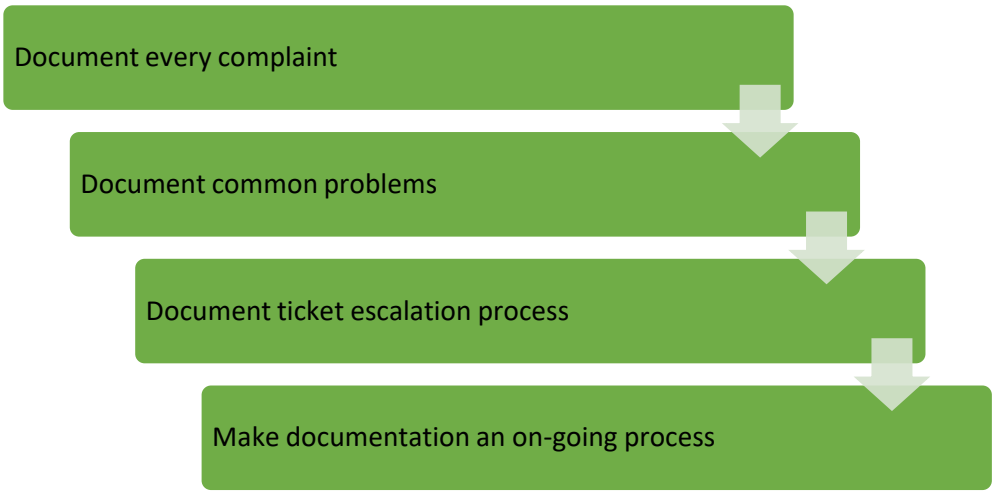

Fig. 4.4.4: Steps for right documentation

Document Every Complaint

The help desk technicians need to document issues as they come in. In addition to recording the symptoms described by the customers, they should probe for the right symptoms. For example, if a customer says that his computer is running slow, the help desk needs to differentiate whether the problem is caused by a virus or a malfunctioning hardware or an unpatched system.

The help desk technician should know how to ask the right questions to try and resolve an issue within the first call.

Document Common Problems

Majority of the help desk issues can be reduced to a handful of common problems. If there is a good documentation process that has resolution paths for all common problems, then the help desk technician does not have to reinvent the wheel for every ticket. He can use the internal help desk knowledge base and time tested processes to resolve the issues quickly.

A well organised process enables the help desk technician to respond to a ticket quickly and resolve most of the customers' problems immediately.

Document Ticket Escalation Process

A good escalation process makes sure that when the helpdesk technician is not able to resolve a problem, he addresses ticket escalation promptly. The ticket gets send to the next level of customer support and the customer does not have to wait for days for it to get resolved.

Documentation should be an on-going effort

Documentation is not a onetime effort; it needs to be an on-going process. The help desk technicians should regularly optimize the issue resolution procedures and processes. This ensures that the customer issues are resolved promptly.

Note:

ISAHRE and ASHARE are two Societies for HVAC engineers.

ISHARE the Indian Society of Heating, Refrigerating and Air Conditioning Engineers, was founded in 1981. **ASHRAE** was formed as the American Society of Heating, Refrigerating and Air-Conditioning Engineers

These bodies not only have set standards for the HVAC engineers but also provide relevant certified training, which helps in professional growth at global level.

To know more about the these bodies, you may refer the following links:

https://ishrae.in/Home/about_ishrae

https://www.ashrae.org/

Skill India
कौशल भारत-कुशल भारत

सत्यमेव जयते
GOVERNMENT OF INDIA
MINISTRY OF SKILL DEVELOPMENT
& ENTREPRENEURSHIP

N·S·D·C
National
Skill Development
Corporation
Transforming the skill landscape

ESSCI
Skilling India in Electronics

5. Soft Skills and Work Ethics

Unit 5.1 – Effective Communication and Coordination at Work

Unit 5.2 – Working Effectively and Maintaining Discipline at Work

Unit 5.3 – Maintaining Social Diversity at Work

ELE/N9905

Key Learning Outcomes

By the end of this unit, participants will be able to:

1. State the importance of work ethics and workplace etiquette
2. State the importance of effective communication and interpersonal skills
3. Explain ways to maintain discipline in the workplace
4. Discuss the common reasons for interpersonal conflict and ways of managing them effectively.

UNIT 5.1: Efffecte Communicacation aCoordinainati t Work

Unit Objectives

By the end of this unit, participants will be able to:

1. Work efffectely at the workplace.
2. Demonstrate practicesrelated to gender and PwD sensitazation.

5.1.1 Importance of Work Ethics and Workplace Etiquette

Workplace ethics are a set of moral and legal guidelines that organizations follow. These guidelines influence the way customers and employees interact with an organization. Workplace ethics essentially guide how an organization serves its clients and treats its employees.

For example, if a company seeks to fulfil the promises it makes, it may develop processes and set up a robust support system to address this policy and build customer/client loyalty. To achieve this goal, the company may implement specific incentive programs for employees to encourage them to produce high-quality work and ensure the organization fulfils the promises it makes to its clients/ customers.

Many organizations, often the large ones, set detailed ethical codes to guide their operations and control how the organizational processes impact the stakeholders. These ethics usually help organizations maintain certain standards of responsibility, accountability, professionalism and among others, as they navigate through different challenges and day-to-day circumstances. By following these guidelines, organizations often experience several benefits that improve the lives of stakeholders, such as customers, employees, leaders, etc.

Examples of Common Workplace Ethics

Fig. 5.1.1 Examples of Common Workplace Ethics

Workplace ethics are essential for a successful organization with a satisfied and loyal team. High ethical standards help in ensuring all stakeholders, such as customers, investors, employees, and other individuals involved in the workplace operations, feel the organization is safeguarding their interests. By creating and implementing ethical guidelines, organizations can keep the best interests of their employees in mind while maintaining a positive influence on those they impact through their processes.

As a result, employees maintain the organization's best interests by being ethical in their daily work duties. For example, fairly-treated employees of an organization who understand the organization's commitments to environmental sustainability are usually less likely to behave in a manner that causes harm to the environment. Thus, they help maintain a positive public image of the organization. It means that workplace ethics help in maintaining reciprocal relationships that benefit organizations at large and the individuals associated with and influenced by the organizational policies.

Benefits of Workplace Ethics

There are various benefits of implementing workplace ethics. When organizations hold themselves to high ethical standards, leaders, stakeholders, and the general public can experience significant improvements. Following are some of the key benefits of employing ethics in the workplace:

Fig. 5.1.2 Benefits of Workplace Ethics

5.1.2 Interpersonal Communication

Interpersonal communication is a process that involves sharing ideas and emotions with another person, both - verbally and non-verbally. It is essential to interact effectively with others in both personal and professional lives. In professional life or the workplace, strong interpersonal skills play a crucial role in achieving effective collaboration with colleagues.

Interpersonal Skills

Interpersonal skills, in other terms, are known as people skills, which are used to communicate and interact with others effectively. These are soft skills one uses to communicate with others and understand them. One uses these skills in daily life while interacting with people

Examples of Interpersonal Skills

Fig 5.1.3 Examples of Interpersonal Skills

Numerous interpersonal skills involve communication. Communication can be verbal, such as persuasion or tone of voice — or non-verbal, such as listening and body language.

Importance of Interpersonal Skills

Interpersonal skills are essential for communicating and collaborating with groups and individuals in both personal and professional life. People with strong interpersonal skills often are able to build good relationships and also tend to work well with others. Most people often enjoy working with co-workers who have good interpersonal skills.

Among other benefits of good interpersonal skills is the ability to solve problems and make the best decisions. One can use the ability to understand others and good interpersonal communication skills to find the best solution or make the best decisions in the interest of everyone involved. Strong interpersonal skills help individuals work well in teams and collaborate effectively. Usually, people who possess good interpersonal skills also tend to be good leaders, owing to their ability to communicate well with others and motivate the people around them.

Interpersonal communicationis the key to working in a team environment and working ccollectely to achieve shared goals. Following are the interperso

Verbal Communication

The ability to speak clearly, appropriately and confidently can help one communicate effectively with others. It is vital to select the appropriate vocabulary and tone for the target audience.

For example – one should speak formally and professionally in the work environment, while informal language is acceptable in an intimate environment with close friends and family. Also, one should avoid using complex or technical language while communicating with an audience that may not be familiar with it. Using simple language in a courteous tone helps achieve better communication, irrespective of the audience.

Active Listening

Active listening is defined as the ability to pay complete or undivided attention to someone when they speak and understand what they are saying. It is important for effective communication because without understanding what the speaker is saying, it becomes difficult to carry forward a conversation. One should ensure to use appropriate verbal and non-verbal responses, e.g. eye contact, nodding, or smiling, to show interest in what the speaker says. Active listening is also about paying attention to the speaker's body language and visual cues. Asking and answering questions is one of the best ways to demonstrate an interest in conversing with the other person.

Active listening is critical for communicating effectively without ambiguity. It helps one understand the information or instructions being shared. It may also encourage co-workers to share their ideas, which ultimately helps achieve collaboration.

Body Language

One's expression, posture, and gestures are as important as verbal communication. One should practice open body language to encourage positivity and trust while communicating. Open body language includes - maintaining eye contact, nodding, smiling and being comfortable. On the other hand, one should avoid closed body language, e.g. crossed arms, shifting eyes and restless behaviour.

Empathy

Empathy is the ability to understand the emotions, ideas and needs of others from their point of view. Empathy is also known as emotional intelligence. Empathetic people are good at being aware of others' emotions and compassionate when communicating with them. Being empathetic in the workplace can be good to boost the morale of employees and improve productivity. By showing empathy, one can gain the trust and respect of others.

Conflict Resolution

One can use interpersonal communication skills to help resolve disagreements and conflicts in the workplace. This involves the application of negotiation and persuasion skills to resolve arguments between conflicting parties. It is also important to evaluate and understand both sides of the argument by listening closely to everyone involved and finding an amicable solution acceptable to all.

Good conflict resolution skills can help one contribute to creating a collaborative and positive work environment. With the ability to resolve conflicts, one can earn the trust and respect of co-workers.nal communicationskills that vital for success at work:

Teamwork

Employees who communicate and work well in a team often have better chances of achieving success and common goals. Being a team player can help one avoid conflicts and improve productivity. One can do this by offering to help co-workers when required and asking for their feedback and ideas. When team members give their opinions or advice, one should positively receive and react to the opinions/advice. One should be optimistic and encouraging when working in groups.

Improving Interpersonal Skills

One can develop interpersonal skills by practising good communication and setting goals for improvement. One should consider the following tips to improve their interpersonal skills:

- One should ask for feedback from co-workers, managers, family or friends to figure out what needs improvement concerning their interpersonal skills.
- One can identify the areas of interpersonal communication to strengthen by watching others.
- One can learn and improve interpersonal skills by observing co-workers, company leaders and professionals who possess good interpersonal skills. This includes watching and listening to them to note how they communicate and the body language used by them. It is vital to note their speed of speaking, tone of voice, and the way they engage with others. One should practice and apply such traits in their own interactions and relationships.
- One should learn to control their emotions. If stressed or upset, one should wait until being calm to have a conversation. One is more likely to communicate effectively and confidently when not under stress.
- One can reflect on their personal and professional conversations to identify the scope of improvement and learn how to handle conversations better or communicate more clearly. It helps to consider whether one could have reacted differently in a particular situation or used specific words or positive body language more effectively. It is also vital to note the successful and positive interactions to understand why they are successful.
- One should practice interpersonal skills by putting oneself in positions where one can build relationships and use interpersonal skills. For example, one can join groups that have organized meetings or social events. These could be industry-specific groups or groups with members who share an interest or hobby.
- Paying attention to family, friends and co-workers and making efforts to interact with them helps a lot. One should complement their family, friends and co-workers on their good ideas, hard work and achievements. Trying to understand someone's interests and showing interest in knowing them can help one build strong interpersonal skills. Offering to help someone, especially in difficult situations, helps build stronger and positive workplace relationships.
- One should avoid distractions, such as a mobile phone, while interacting with someone. Giving someone full attention while avoiding distractions helps achieve a clear exchange of ideas. By listening with focus, one can understand and respond effectively.

- One can attend appropriate courses on interpersonal skills or sign up for workshops at work to improve interpersonal skills. One can find many resources online also, such as online videos.
- For personal mentoring, one can approach a trusted family member, friend, co-worker, or current/ former employer. A person one looks up to with respect and admires is often a good choice to be selected as a mentor. One can even hire a professional career or communication coach.

Interpersonal communication skills often help one boost their morale, be more productive in the workplace, complete team projects smoothly and build positive and strong relationships with co-workers.

Notes

UNIT 5.2: Working Efffectely and Maintaining Discipline at Work

Unit Objectives

By the end of this unit, participants will be able to:

- Discuss the importance of following organizational guidelines for dress code, time schedules, language usage and other behavioural aspects
- Explain the importance of working as per the workflow of the organization to receive instructions and report problems
- Explain the importance of conveying information/instructions as per defined protocols to the authorised persons/team members
- Explain the common workplace guidelines and legal requirements on non-disclosure and confidentiality of business-sensitive information
- Describe the process of reporting grievances and unethical conduct such as data breaches, sexual harassment at the workplace, etc.
- Discuss ways of dealing with heightened emotions of self and others.

5.2.1 Discipline at Work

Discipline is essential for organizational success. It helps improve productivity, reduce conflict and prevent misconduct in the workplace. It is important to have rules concerning workplace discipline and ensure that all employees comply with them. In the absence of discipline, a workplace may experience conflicts, bullying, unethical behaviour and poor employee performance. An efficient workplace disciplinary process helps create transparency in the organization. Benefits of disciplinary standards:

All employees follow the same rules which helps establish uniformity and equality in the workplace

Managers and supervisors have defined guidelines on what accon to take while initi atg disciplinary y aon

With well-defined and enforced disciplinary rules, an organiizaon can avoid various safety, security, rupati nal risks

Fig 5.2.1 Benefits of Disciplinary Standards

Maintaining an organized and cohesive workforce requires maintaining discipline in both personal and professional behaviour. It is important to follow the appropriate measures to keep employees in line without affecting their morale.

Defining Discipline

The first and crucial step in maintaining workplace discipline is to define what is meant by discipline. It helps to evaluate common discipline problems and devise guidelines for handling them effectively.

Among a number of areas, discipline usually covers:

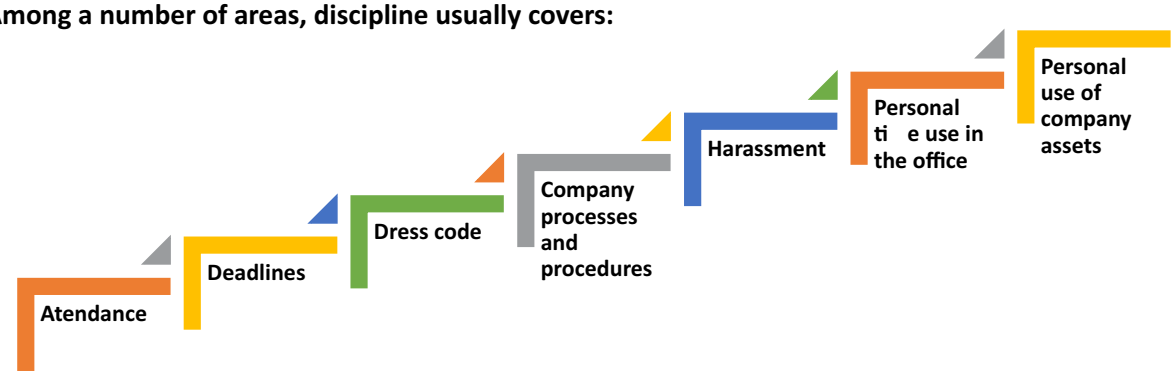

Fig 5.2.2 Examples of Workplace Discipline

According to demography and local issues, it may also include substance use and related issues.

It is vital for a workplace to have an employee handbook or company policy guide, to serve as a rulebook for employees to follow. The employee handbook/ company policy guide should be reviewed and updated periodically according to any issues or areas, or concerns identified concerning workplace discipline. Such manuals should also cover all the laws and regulations governing workplace behaviour.

Defining and documenting workplace rules aids in their implementation, ensuring little or no ambiguity. All employees in a workplace should also have easy access to the workplace guidelines so that they can refer to them to get clarity whenever required. To maintain discipline at work, it is also critical to ensure uniform application of workplace guidelines to all employees without exception.

5.2.2 Employee Code of Conduct

The employee code of conduct manual serves as a guide for employees to inform them regarding the behaviour expected from them at work. It helps create a good work environment with consistent behaviour from employees. The manual should list examples of acceptable and not acceptable behaviours at work. The code of conduct should be discussed with employees so that they have the clarifications required.

For example, an organization may create guidelines concerning the conduct with clients to ensure no contact is made with them except for business purposes, also prescribing the use of appropriate means of communication.

Employees should have a clear understanding concerning their job responsibilities and the behaviour expected from them with all stakeholders, e.g. company personnel, clients and associated third parties. It is critical to have documented guidelines for employees to follow concerning all aspects of work. It should also document the disciplinary action to be followed in case of non-compliance, e.g. verbal and

then written warning, temporary suspension or eventual termination of service in case of repeated non-compliance with the employee code of conduct. Employees should know what the company rules are and what will happen if they break the rules. However, disciplinary action should be initiated only when reasonably required to avoid its misuse for employee harassment.

There should also be an effective mechanism for employees to raise their concerns/ grievances and have them addressed while maintaining privacy, as required, e.g. raising concerns regarding the behaviour of a co-worker.

The employee code of conduct manual must be duly reviewed and approved by the concerned stakeholders, such as the Human Resources (HR) department and company executives.

5.2.3 Interpersonal Conflicts

Interpersonal conflict is any type of conflict between two or more people. These are found in both - personal and professional relationships - among friends, family, and co-workers. In the workplace, interpersonal conflict is often observed when a person or group of people interfere with another person's attempts at completing assignments and achieving goals. It is critical to resolve conflicts in the workplace to boost the morale of employees, repair working relationships among them, and improve customer satisfaction.

Reasons for Workplace Conflicts

Workplace conflicts are often observed when two or more people have different points of view. This can happen between managers, co-workers, or clients and customers. In general, interpersonal conflicts are caused by a lack of communication or unclear communication.

Some of the leading reasons for workplace conflicts are:

- Difference in values
- Personality clashes
- Poor communication

Example of poor communication – if a manager reassigns a task to another employee without communicating with the employee to whom it was originally assigned, interpersonal conflict can arise among them. This may potentially make the first employee, i.e. who was originally assigned the task, feel slighted and mistrusted by the manager. It may even cause animosity in the first employee toward the employee who has now been assigned the task.

Types of Interpersonal Conflict

Following are the four types of interpersonal conflicts:

a. **Policy-related interpersonal conflict**

When a conflict relates to a decision or situation that involves both parties, it can be called a policy-related interpersonal conflict. Example – two people or groups working on the same project, trying to adopt different approaches. To resolve policy-related interpersonal conflicts, the parties involved should try to look for a win-win situation or make a compromise. This is especially critical to resolve trivial issues so that work is not affected and common goals are achieved.

b. **Pseudo-conflicts**

Pseudo-conflict arises when two people or groups want different things and cannot reach an agreement. Pseudo-conflicts usually involve trivial disagreements that tend to hide the root of the issue.

c. **Ego-related interpersonal conflicts**

In ego conflicts, losing the argument may hurt or damage a person's pride. Sometimes ego conflicts arise when a number of small conflicts pile up on being left unresolved. To resolve ego-related conflicts, it's best to find the root of the issue and work towards a resolution.

d. **Value-related interpersonal conflicts**

Sometimes conflicts may occur between people when they have different value systems. Such conflicts can be difficult to identify initially, making the people involved think the other party is being disagreeable or stubborn, wherein they just have different values. Some co-workers may highly value their personal/ family time after office that they may be unreachable to clients during non-office hours, while others may place a high value on client satisfaction and may still be available for clients during non-office hours. Conflict may arise among such people when they may be required to coordinate to help a client during after-office hours. Value-related interpersonal conflicts are often difficult to settle since neither party likes to compromise.

Resolving Interpersonal Conflicts

Conflicts are usually likely in the workplace; they can, however, be prevented. Often resolving interpersonal conflicts through open communication helps build a stronger relationship, paving the way for effective coordination and success. Some ways to resolve interpersonal conflict:

- **Communication -** A great way to resolve interpersonal conflicts is for the opposing parties to listen to one another's opinions and understand their viewpoints. Meeting in person and keeping the conversation goal-oriented is important. One can have effective communication by following some measures, e.g. staying on the topic, listening actively, being mindful of the body language, maintaining eye contact, etc.

- **Active Listening -** One should patiently listen to what the other person is saying without interrupting or talking over them. It helps one display empathy and get to the root of the issue. Asking questions to seek clarification when required helps in clear communication and conveys to the other person that one is listening to them. Practising active listening is a great way to improve one's communication skills.
- **Displaying Empathy -** Listening attentively and identifying the anxieties/ issues of co-workers is a great way to show empathy and concern. It is essential to understand their feelings and actions to encourage honesty and avoid future conflict.
- **Not Holding Grudges -** With different types of people and personalities in a workplace, it is common for co-workers to have conflicts. It is best to accept the difference in opinions and move on. Being forgiving and letting go of grudges allows one to focus on the positive side of things and perform better at work.

Work-related interpersonal conflicts can be complicated because different people have different leadership styles, personality characteristics, job responsibilities and ways in which they interact. One should learn to look above interpersonal conflicts, resolving them to ensure work goals and environment are not affected.

5.2.4 Importance of Following Organizational Guidelines

Policies and procedures or organizational guidelines are essential for any organization. These provide a road map for the operations of the organization. These are also critical in ensuring compliance with the applicable laws and regulations by guiding the decision-making process and business operations.

Organizational guidelines help bring uniformity to the operations of an organization, which helps reduce the risk of unwanted and unexpected events. These determine how employees are supposed to behave at work, which ultimately helps the business achieve its objectives efficiently.

However, organizational guidelines are ineffective and fail to serve their purpose if they are not followed. Many people don't like the idea of following and abiding by specific guidelines. Such people should be made to understand the benefits of following the organizational guidelines. Some of the key benefits are given below:

With well-defined organizational guidelines in place, no individual can act arbitrarily, irrespective of their position in the organization. All individuals will know the pros and cons of taking certain actions and what to expect in case of unacceptable behaviour. Benefits of following organizational guidelines:

- Consistent processes and structures - Organization guidelines help maintain consistency in operations, avoiding any disorder. When all employees follow the organizational guidelines, an organization can run smoothly. These ensure that people in different job roles operate as they are supposed to, knowing what they are responsible for, what is expected of them, and what they can expect from their supervisors and co-workers. With clarity in mind, they can do their jobs with confidence and excellence. With every person working the way intended, it's easy to minimise errors.

  With all the staff following organizational guidelines, the organization has a better scope of using time and resources more effectively and efficiently. This allows the organization to grow and achieve its objectives.
- **Better quality service -** By following organizational guidelines, employees perform their duties correctly as per the defined job responsibilities. It helps enhance the quality of the organization's products and services, helping improve the organization's reputation. Working with a reputable organization, employees can take pride in their work and know they are contributing to the reputation.
- **A safer workplace -** When all employees follow organizational guidelines, it becomes easy to minimise workplace incidents and accidents. It reduces the liabilities associated with risks for the organization and limits the interruptions in operations. Employees also feel comfortable and safe in the workplace, knowing their co-workers are ensuring safety at work by following the applicable guidelines.

Different organizations may have different guidelines on dress code, time schedules, language usage, etc. For example – certain organizations in a client-dealing business requiring employees to meet clients personally follow a strict dress code asking their employees to wear formal business attire. Similarly, organizations operating in specific regions may require their employees to use the dominant regional language of the particular region to build rapport with customers and serve them better. Certain organizations, such as banks, often give preference to candidates with knowledge of the regional language during hiring.

Working hours may also differ from one organization to another, with some requiring employees to work extra compared to others. One should follow the organizational guidelines concerning all the aspects of the employment to ensure a cohesive work environment.

5.2.5 Workflow

Workflow is the order of steps from the beginning to the end of a task or work process. In other words, it is the way a particular type of work is organised or the order of stages in a particular work process.

Workflows can help simplify and automate repeatable business tasks, helping improve efficiency and minimise the room for errors. With workflows in place, managers can make quick and smart decisions while employees can collaborate more productively.

Other than the order that workflows create in a business, these have several other benefits, such as:

- Identifying Redundancies - Mapping out work processes in a workflow allows one to get a clear, top-level view of a business. It allows one to identify and remove redundant or unproductive processes.

  Workflow gives greater insights into business processes. Utilizing such useful insights, one can improve work processes and the bottom line of the business. In many businesses, there are many unnecessary and redundant tasks that take place daily. Once an organization has insight into its processes while preparing workflow, it can determine which activities are really necessary.

  Identifying and eliminating redundant tasks creates value for a business. With redundant tasks and processes eliminated, an organization can focus on what's important to the business.

- Increase in Accountability and Reduction in Micromanagement - Micromanagement often causes problems in a business setting as most employees don't like being micromanaged, and even many managers don't like the practice. Micromanagement is often identified as one of the reasons why people quit their job.

  However, the need for micromanagement can be minimized by clearly mapping out the workflow. This way, every individual in a team knows what tasks need to be completed and by when and who is responsible for completing them. This makes employees more accountable also.

  With clearly defined workflow processes, managers don't have to spend much time micromanaging their employees, who don't have to approach the manager to know what the further steps are. Following a workflow, employees know what is going on and what needs to be done. This, in turn, may help increase the job satisfaction of everyone involved while improving the relationships between management and employees.

- Improved Communication - Communication at work is critical because it affects all aspects of an organization. There are instances when the main conflict in an organization originates from miscommunication, e.g. the management and employees disagreeing on an aspect, despite pursuing the same objectives. Poor communication is a common workplace issue that is often not dealt with.

- This highlights why workflow is important. Workplace communication dramatically can increase with the visibility of processes and accountability. It helps make the daily operations smoother overall.

- Better Customer Service - Customers or clients are central to a business. Therefore, it is imperative to find and improve ways to improve customer experience. Relying on outdated manual systems may cause customer requests or complaints to be overlooked, with dissatisfied customers taking their business elsewhere. However, following a well-researched and defined workflow can help improve the quality of customer service.

By automating workflows and processes, an organization can also reduce the likelihood of human error. This also helps improve the quality of products or services over time, resulting in a better customer experience.

5.2.6 Following Instructions and Reporting Problems

All organizations follow a hierarchy, with most employees reporting to a manager or supervisor. For organizational success, it is vital for employees to follow the instructions of their manager or supervisor. They should ensure they perform their duties as per the given instructions to help achieve the common objectives of the organization and deliver quality service or products. This consequently helps maintain the reputation of the organization.

It is also important to be vigilant and identify problems at work or with the organizational work processes. One should deal with the identified within their limits of authority and report out of authority problems to the manager/ supervisor or the concerned person for a prompt resolution to minimise the impact on customers/clients and business.

5.2.7 Information or D ta Sharing

Information or data is critical to all organizations. Depending on the nature of its business, an organization may hold different types of data, e.g. personal data of customers or client data concerning their business operations and contacts. It is vital to effective measures for the appropriate handling of different types of data, ensuring its protection from unauthorized access and consequent misuse.

One should access certain data only if authorised to do so. The same is applicable when sharing data which must be shared only with the people authorised to receive it to use it for a specific purpose as per their job role and organizational guidelines. For example – one should be extra cautious while sharing business data with any third parties to ensure they get access only to the limited data they need as per any agreements with them. It is also critical to monitor how the recipient of the data uses it, which should strictly be as per the organizational guidelines. It is a best practice to share appropriate instructions with the recipient of data to ensure they are aware of the purpose with which data is being shared with them and how they are supposed to use and handle it. Any misuse of data must be identified and reported promptly to the appropriate person to minimise any damage arising out of data misuse.

These days most organizations require their employees and business partners or associated third parties to sign and accept the relevant agreement on the non-disclosure of business-sensitive information. In simple terms, business-sensitive information is confidential information. It is proprietary business information collected or created during the course of conducting business, including information about the business, e.g. proposed investments, intellectual property, trade secrets, or plans for a merger and information related to its clients. Business-sensitive information may sometimes also include information regarding a business's competitors in an industry.

The release of business-sensitive information to competitors or the general public poses a risk to a business. For example, information regarding plans for a merger could be harmful to a business if a competitor gets access to it.

5.2.8 Reporting Issues at Work

Most organizations have defined guidelines on appropriate reporting processes to be followed for reporting different types of issues. For example – one can report any grievances or dissatisfaction concerning co-workers to their manager/supervisor, e.g. data breaches or unethical conduct. If the concern is not addressed, then the employee should follow the organizational guidelines and hierarchy for the escalation of such issues that are not addressed appropriately.

For example – any concern related to sexual harassment at the workplace should be escalated to the concerned spokesperson, such as Human Resources (HR) representative, and if not satisfied with the action taken, it should be reported to the senior management for their consideration and prompt action.

5.2.9 Dealing with Heightened Emotions

Humans are emotional beings. There may be occasions when one is overwhelmed by emotions and is unable to suppress them. However, there may be situations when one must manage emotions well, particularly at work.

Stress in one's personal and professional life may often cause emotional outbursts at work. Managing one's emotions well, particularly the negative ones, is often seen as a measure of one's professionalism. Anger, dislike, frustration, worry, and unhappiness are the most common negative emotions experienced at work.

Ways to manage negative emotions at work:

- **Compartmentalisation –** It's about not confining emotions to different aspects of one's life. For example, not letting negative emotions from personal life affect work-life and vice versa. One should try to leave personal matters and issues at home. One should train their mind to let go of personal matters before reaching work. Similarly, one can compartmentalise work-related stresses so that negative emotions from work don't affect one's personal life.

- **Deep breathing and relaxation –** Deep breathing helps with anxiety, worry, frustration and anger. One should take deep breaths, slowly count to ten - inhaling and exhaling until one calms down. One can also take a walk to calm down or listen to relaxing music. Talking to someone and sharing concerns also helps one calm down.

- **The 10-second rule -** This is particularly helpful in controlling anger and frustration. When one feels their temper rising, they should count to 10 to calm down and recompose. If possible, one should move away to allow temper to come down.

- **Clarify -** It is always good to clarify before reacting, as it may be a simple case of misunderstanding or miscommunication.

- **Physical activity -** Instead of losing temper, one should plan to exercise, such as running or going to the gym, to let the anger out. Exercise is also a great way to enhance mood and release any physical tension in the body.

- **Practising restraint -** One should avoid replying or making a decision when angry, not allowing anger or unhappiness to cloud one's judgement. It may be best to pause any communication while one is angry, e.g. not communicating over email when angry or upset.

- **Knowing one's triggers -** It helps when one is able to recognise what upsets or angers them. This way, one can prepare to remain calm and plan their reaction should a situation occur. One may even be able to anticipate the other party's reaction.

- **Be respectful -** One should treat their colleagues the same way one would like to be treated. If the other person is rude, one need not reciprocate. It is possible to stay gracious, firm and assertive without being aggressive. Sometimes, rude people back away when they don't get a reaction from the person they are arguing with.

- **Apologise for any emotional outburst –** Sometimes, one can get overwhelmed by emotions, reacting with an emotional outburst. In such a case, one should accept responsibility and apologise immediately to the affected persons without being defensive.

- **Doing away with negative emotions -** It is recommended to let go of anger, frustration and unhappiness at the end of every workday. Harbouring negative emotions affects one emotionally, affecting their job performance also. Engaging in enjoyable activities after work is a good stress reliever.

Notes

UNIT 5.3: Maintaining Social Diversity at Work

Unit Objectives

By the end of this unit, participants will be able to:

1. Explain the concept and importance of gender sensitivityand equality.
2. Discuss ways to create sensitivityfor different genders and Persons with h Disabiliti(PwD).

5.3.1 Gender Sensitivity

Gender sensitivity is the act of being sensitive towards people and their thoughts regarding gender. It ensures that people know the accurate meaning of gender equality, and one's gender should not be given priority over their capabilities.

Fig 5.3.1 Gender Equality

Women are an important source of labour in many sectors, yet they have limited access to resources and benefits. Women should receive the same benefits and access to resources as men. A business can improve its productivity and quality of work by providing better support and opportunities to women.

Important Terms

- **Gender Sensitivity-** Gender sensitivity is the act of being sensitive to the ways people think about gender.
- **Gender Equality -** It means persons of any gender enjoy equal opportunities, responsibilities, and rights in all areas of life.
- **Gender Discrimination –** It means treating an individual unequally or disadvantageously based on their gender, e.g. paying different wages to men and women for similar or equal job positions.

Strategies for Enhancing Gender Equity

To enhance gender equity, one should:

- Follow gender-neutral practices at all levels at work.
- Participate together in decision-making.
- Help in promoting women's participation in different forums.
- Assist women in getting exposure to relevant skills and practices.
- Assist women in capacity building by mentoring, coaching or motivating them, as appropriate.
- Assist in the formation and operation of women support groups.
- Assist in the implementation of women-centric programmes.
- Combine technical training with reproductive health and nutrition for coffee farming households.
- Assist in making a work environment that is healthy, safe, and free from discrimination.

Bridging Gender Differences

Men and women react and communicate very differently. Thus, there are some work differences as both genders have their style and method of handling a situation.

Although, understanding and maturity vary from person to person, even between these genders, based on their knowledge, education, experience, culture, age, and upbringing, as well as how one's brain functions over a thought or problem.

In order to bridge the gap, one should:

- Not categorize all men and women in one way.
- Be aware of the verbal and non-verbal styles of communication of every gender to avoid any miscommunication and work better.
- Be aware of partial behaviour and avoid it.
- Encourage co-workers of different genders to make room by providing space to others.

Ways to reduce Gender Discrimination

- Effective steps against sexual harassment by the concerned authorities and general public.
- Gender stereotypes are how society expects people to act based on their gender. This can only be reduced by adopting appropriate behaviour and the right attitude.
- Objectification of females must be abolished.

Ways to Promote Gender Sensitivity in the Workplace

Practices that promote gender diversity should be adopted and promoted.

- All genders should receive equal responsibilities, rights, and privileges.
- All genders should have equal pay for similar or the same job roles/ positions.
- Strict and effective workplace harassment policies should be developed and implemented.
- An open-minded and stress-free work environment should be available to all the employees, irrespective of their gender.
- Women should be encouraged to go ahead in every field of work and assume leadership roles.
- Follow appropriate measures for women's empowerment.
- Men should be taught to be sensitive to women and mindful of their rights.

5.3.2 PwD Sensitivity

Some individuals are born with a disability, while others may become disabled due to an accident, illness or as they get old. People with Disabilities (PwD) may have one or more areas in which their functioning is affected. A disability can affect hearing, sight, communication, breathing, understanding, mobility, balance, and concentration or may include the loss of a limb. A disability may contribute to how a person feels and affect their mental health

Important Terms

·**Persons with Disabilities (PwD) –** Persons with Disabilities means a person suffering from not less than 40% of any disability as certified by a medical authority.

·**Types of Disability:**

a. Blindness – Visually impaired
b. Low Vision
c. Leprosy Cured
d. Hearing impairment
e. Locomotor disability
f. Mental retardation
g. Mental illness

PwD Sensitivity

PwD sensitivity promotes empathy, etiquette and equal participation of individuals and organizations while working with individuals with a disability, e.g. sensory, physical or intellectual.

Ways to be PwD Sensitive

To be sensitive to PwD, one should:

- Be respectful to all Persons with Disabilities (PwD) and communicate in a way that reflects PwD sensitivity.
- Always be supportive and kind towards a PwD with their daily chores.
- Be ready to assist a PwD to help them avail of any benefit/ livelihood opportunity/ training or any kind that helps them grow.
- Encourage and try to make things easier and accessible to PwD so that they can work without or with minimum help.
- Protest where feasible and report any wrong act/behaviour against any PwD to the appropriate authority.
- Learn and follow the laws, acts, and policies relevant to PwD.

Appropriate Verbal Communication

As part of appropriate verbal communication with all genders and PwD, one should:

- Talk to all genders and PwD respectfully, maintaining a normal tone of voice with appropriate politeness. It is important to ensure one's tone of voice does not have hints of sarcasm, anger, or unwelcome affection.
- Avoid being too self-conscious concerning the words to use while also ensuring not to use words that imply one's superiority over the other.
- Make no difference between a PwD and their caretaker. Treat PwD like adults and talk to them directly.
- Ask a PwD if they need any assistance instead of assuming they need it and offering assistance spontaneously.

Appropriate Non-verbal Communication

Non-verbal communication is essentially the way someone communicates through their body language. These include:

- **Facial expressions -** The human face is quite expressive, capable of conveying many emotions without using words. Facial expressions must usually be maintained neutral and should change according to the situation, e.g. smile as a gesture of greeting.
- **Body posture and movement -** One should be mindful of how to sit, stand, walk, or hold their head. For example - one should sit and walk straight in a composed manner. The way one moves and carries self, communicates a lot to others. This type of non-verbal communication includes one's posture, bearing, stance, and subtle movements.

- **Gestures -** One should be very careful with their gestures, e.g. waving, pointing, beckoning, or using one's hands while speaking. One should use appropriate and positive gestures to maintain respect for the other person while being aware that a gesture may have different meanings in different cultures.

- **Eye contact -** Eye contact is particularly significant in non-verbal communication. The way someone looks at someone else may communicate many things, such as interest, hostility, affection or attraction. Eye contact is vital for maintaining the flow of conversation and for understanding the other person's interest and response. One should maintain appropriate eye contact, ensuring not to stare or look over the shoulders. To maintain respect, one should sit or stand at the other person's eye level to make eye contact.
- **Touch -** Touch is a very sensitive type of non-verbal communication. Examples are - handshakes, hugs, pat on the back or head, gripping the arm, etc. A firm handshake indicates interest, while a weak handshake indicates the opposite. One should be extra cautious not to touch others inappropriately and avoid touching them inadvertently by maintaining a safe distance.

Rights of PwD

PwD have the right to respect and human dignity. Irrespective of the nature and seriousness of their disabilities, PwD have the same fundamental rights as others, such as:

- Disabled persons have the same civil and political rights as other people
- Disabled persons are entitled to the measures designed to enable them to become as self-dependent as possible
- Disabled persons have the right to economic and social security
- Disabled persons have the right to live with their families or foster parents and participate in all social and creative activities.
- Disabled persons are protected against all exploitation and treatment of discriminatory and abusive nature.

Making Workplace PwD Friendly

- One should not make PwD feel uncomfortable by giving too little or too much attention
- One should use a normal tone while communicating with a PwD and treat them as all others keeping in mind their limitations and type of disability
- Any help should be provided only when asked for by a PwD
- One should help in ensuring the health and well-being of PwD.

Expected Employer Behaviour

Some of the common behavioural traits that employees expect from their employers are:

- Cooperation: No work is successful without cooperation from the employer's side. Cooperation helps to understand the job role better and complete it within the given timeline.
- Polite language: Polite language is always welcomed at work. This is a basic aspect that everybody expects.
- Positive Attitude: Employers with a positive attitude can supervise the work of the employees and act as a helping hand to accomplish the given task. A person with a positive attitude looks at the best qualities in others and helps them gain success.
- Unbiased behaviour: Employers should always remain fair towards all their employees. One should not adopt practices to favour one employee while neglecting or ignoring the other. This might create animosity among co-workers.
- Decent behaviour: The employer should never improperly present oneself before the employee. One should always respect each other's presence and behave accordingly. The employer should not speak or act in a manner that may make the employee feel uneasy, insulted, and insecure.

Exercise

1. List down three examples of workplace ethics.
2. List down three examples of interpersonal skills.
3. Identify two reasons for workplace conflicts.
4. Identify two ways of resolving interpersonal conflicts
5. List down two ways of dealing with heightened emotions at work.
6. List down two types of non-verbal communication.

Notes

Skill India
कौशल भारत-कुशल भारत

सत्यमेव जयते
GOVERNMENT OF INDIA
MINISTRY OF SKILL DEVELOPMENT
& ENTREPRENEURSHIP

N·S·D·C
National
Skill Development
Corporation
Transforming the skill landscape

ESSCI
Skilling India in Electronics

6. Basic Health and Safety Practices

Unit 6.1 - Workplace Hazards

Unit 6.2 - Fire Safety

Unit 6.3 - First Aid

Unit 6.4 - Waste Management

ELE/N1002

Key Learning Outcomes

By the end of this module, participa ts will be able to:

1. Discuss job-site hazards, risks and accidents
2. Explain the organizational safety procedures for maintaining electrical safety, handling tools and hazardous materials
3. Describe how to interpret warning signs while accessing sensitive work areas
4. Explain the importance of good housekeeping
5. Describe the importance of maintaining appropriate postures while lifting heavy objects
6. List the types of fire and fire extinguishers
7. Describe the concept of waste management and methods of disposing of hazardous waste
8. List the common sources of pollution and ways to minimize them
9. Elaborate on electronic waste disposal procedures
10. Explain how the administer appropriate first aid to victims in case of bleeding, burns, choking, electric shock, poisoning and also administer first aid to victims in case of a heart attack or cardiac arrest due to electric shock

UNIT 6.1: Workplace Hazards

Unit Objectives

By the end of this unit, participants will be able to:

- Discuss job-site hazards, risks and accidents
- Explain the organizational safety procedures for maintaining electrical safety, handling tools and hazardous materials
- Describe how to interpret warning signs while accessing sensitive work areas
- Explain the importance of good housekeeping
- Describe the importance of maintaining appropriate postures while lifting heavy objects
- Explain safe handling of tools and Personal Protective Equipment to be used.

6.1.1 Workplace Safety

Workplace safety is important to be established for creating a safe and secure working for the workers. The workplace has to be administered as per the rules of the Occupational Safety and Health Administration (OSHA). It refers to monitoring the working environment and all hazardous factors that impact employees' safety, health, and well-being. It is important to provide a safe working environment to the employees to increase their productivity, wellness, skills, etc.

The benefits of workplace safety are:

- Employee retention increases if they are provided with a safe working environment.
- Failure to follow OSHA's laws and guidelines can result in significant legal and financial consequences.
- A safe environment enables employees to stay invested in their work and increases productivity.
- Employer branding and company reputation can both benefit from a safe working environment.

6.1.2 Workplace Hazards

A workplace is a situation that has the potential to cause harm or injury to the workers and damage the tools or property of the workplace. Hazards exist in every workplace and can come from a variety of sources. Finding and removing them is an important component of making a safe workplace.

Common Workplace Hazards

The common workplace hazards are:

·Biological: The threats caused by biological agents like viruses, bacteria, animals, plants, insects and also humans, are known as biological hazards.

- **Chemical:** Chemical hazard is the hazard of inhaling various chemicals, liquids and solvents. Skin irritation, respiratory system irritation, blindness, corrosion, and explosions are all possible health and physical consequences of these dangers.
- **Mechanical:** Mechanical Hazards comprise the injuries that can be caused by the moving parts of machinery, plant or equipment.
- **Psychological:** Psychological hazards are occupational hazards caused by stress, harassment, and violence.
- **Physical:** The threats that can cause physical damage to people is called physical hazard. These include unsafe conditions that can cause injury, illness and death.
- **Ergonomic:** Ergonomic Hazards are the hazards of the workplace caused due to awkward posture, forceful motion, stationary position, direct pressure, vibration, extreme temperature, noise, work stress, etc.

Workplace Hazards Analysis

A workplace hazard analysis is a method of identifying risks before they occur by focusing on occupational tasks. It focuses on the worker's relationship with the task, the tools, and the work environment. After identifying the hazards of the workplace, organisations shall try to eliminate or minimize them to an acceptable level of risk.

Control Measures of Workplace Hazards

Control measures are actions that can be taken to reduce the risk of being exposed to the hazard. Elimination, Substitution, Engineering Controls, Administrative Controls, and Personal Protective Equipment are the five general categories of control measures.

- **Elimination:** The most successful control technique is to eliminate a specific hazard or hazardous work procedure or prevent it from entering the workplace.

- **Substitution:** Substitution is the process of replacing something harmful with something less hazardous. While substituting the hazard may not eliminate all of the risks associated with the process or activity, it will reduce the overall harm or health impacts.

- **Engineering Controls:** Engineered controls protect workers by eliminating hazardous situations or creating a barrier between the worker and the hazard, or removing the hazard from the person.

- **Administrative Controls:** To reduce exposure to hazards, administrative controls limit the length of time spent working on a hazardous task that might be used in combination with other measures of control.

- **Personal Protective Equipment:** Personal protective equipment protects users from health and safety hazards at work. It includes items like safety helmets, gloves, eye protection, etc.

6.1.3 Risk for a Drone Technician

A drone technician may require to repair the propeller, motor and its mount, battery, mainboards, processor, booms, avionics, camera, sensors, chassis, wiring and landing gear. A technician may face some risks while repairing the drones' equipment.

- The technician is susceptible to being physically harmed by propellers.
- Direct contact with exposed electrical circuits can injure the person.
- If the skin gets in touch with the heat generated from electric arcs, it burns the internal tissues.
- Major electrical injuries can occur due to poorly installed electrical equipment, faulty wiring, overloaded or overheated outlets, use of extension cables, incorrect use of replacement fuses, use of equipment with wet hands, etc.

6.1.4 Workplace Warning Signs

A Hazard sign is defined as 'information or instruction about health and safety at work on a signboard, an illuminated sign or sound signal, a verbal communication or hand signal.'

There are four different types of safety signs:

- Prohibition / Danger Alarm Signs
- Mandatory Signs
- Warning Signs
- And Emergency

1. Prohibition Signs: A "prohibition sign" is a safety sign that prohibits behaviour that is likely to endanger one's health or safety. The colour red is necessary for these health and safety signs. Only what or who is forbidden should be displayed on a restriction sign.

Fig. 6.1.1. Prohibition arning Signs

2. Mandatory Signs:

Mandatory signs give clear directions that must be followed. The icons are white circles that have been reversed out of a blue circle. On a white background, the text is black.

Fig. 6.1.2. Mandatory Signs

3. Warning Signs

Warning signs are the safety informationcommunicaatiosigns. They are shown as a 'yellow colour triangle'.

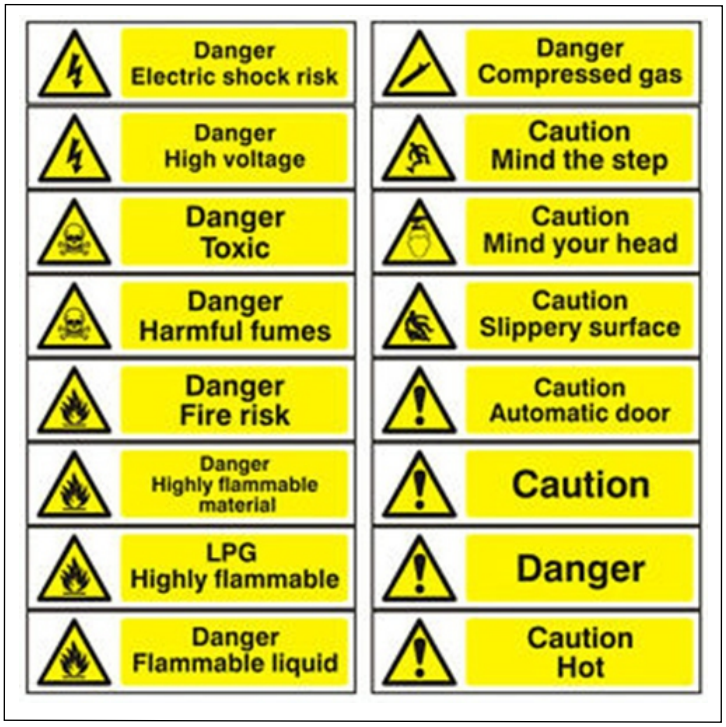

Fig. 6.1.3. Warning Signs

4. Emergency Signs

The locationor routes to emergency ffacilitieare indicated by emergency signs. These signs have a green backdrop with a white emblem or writing.These signs convey basic informaatioand frequently refer to housekeeping, company procedures, or logistics.

Fig. 6.1.4. Emergency Signs

6.1.5 Cleanliness in the Workplace

Workplace cleanliness maintenance creates a healthy, efficient and productive environment for the employees. Cleanliness at the workplace is hindered by some elements like cluttered desks, leftover food, waste paper, etc. A tidy workplace is said to improve employee professionalism and enthusiasm while also encouraging a healthy working environment.

Benefits of cleanliness in the workplace:

1. Productivity: Cleanliness in the workplace can bring a sense of belonging to the employees, also motivating and boosting the morale of the employees. This results in increasing their productivity.
2. Employee Well-being: Employee well-being can be improved by providing a clean work environment. Employees use fewer sick days in a workplace where litter and waste are properly disposed of, and surfaces are cleaned regularly, resulting in increased overall productivity.
3. Positive Impression: Cleanliness and orderliness in the workplace provide a positive impression on both employees and visitors.
4. Cost saving: By maintaining acceptable levels of cleanliness in the workplace, businesses can save money on cleaning bills and renovations, which may become necessary if the premises are not properly kept.

Reasons for Cleaning the Workplace

- Cleaning of dry floors, mostly to prevent workplace slips and falls.
- Disinfectants stop bacteria in their tracks, preventing the spread of infections and illness.
- Proper air filtration decreases hazardous substance exposures such as dust and fumes.
- Light fixture cleaning improves lighting efficiency.
- Using environmentally friendly cleaning chemicals that are safer for both personnel and the environment.
- Work environments are kept clean by properly disposing of garbage and recyclable items.

6.1.6 Lifting and Handling of Heavy Loads

Musculoskeletal Injuries (MSIs), such as sprains and strains, can occur while lifting, handling, or carrying objects at work. When bending, twisting, uncomfortable postures and lifting heavy objects are involved, the risk of injury increases. Ergonomic controls can help to lower the risk of injury and potentially prevent it.

Types of injuries caused while lifting heavy objects:

- Cuts and abrasions are caused by rough surfaces.
- Crushing of feet or hands.
- Strain to muscles and joints

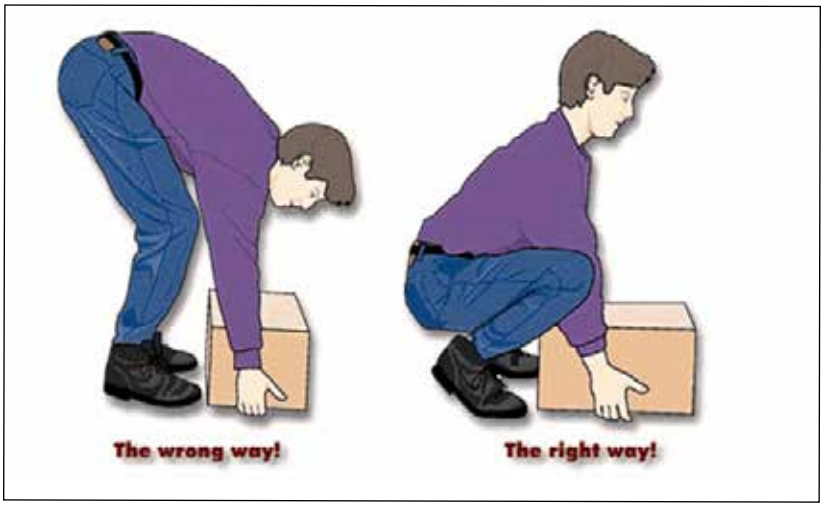

Fig. 6.1.5. Lifting loads echnique

Preparing to lift

A load that appears light enough to bear at first will grow increasingly heavier as one carries it further. The person carrying the weight should be able to see over or around it at all times.

The amount of weight a person can lift, depends on their age, physique, and health

It also depends on whether or not the person is used to lifting and moving hefty objects.

Common Causes of Back Injuries

The Most Common Causes of Back Injuries are:

1) **Inadequate Training:** The individual raising the load receives no sufficient training or guidance.
2) **Lack of awareness of technique:** The most common cause of back pain is incorrect twisting and posture, which causes back strain.
3) **Load size:** The load size to consider before lifting. If the burden is too much for one's capacity or handling, their back may be strained and damaged.
4) **Physical Strength:** Depending on their muscle power, various persons have varied physical strengths. One must be aware of their limitations.
5) **Teamwork:** The operation of a workplace is all about working together. When opposed to a single person lifting a load, two people can lift it more easily and without difficulty. If one of two people isn't lifting it properly, the other or both of them will suffer back injuries as a result of the extra strain.

Techniques for Lifting Heavy Objects

Technique	Demonstraton
1. Ensure one has a wide base of support before lifting the heavy object. Ensure one's feet are shoulder-width apart, and one foot is slightly ahead of the other at all times. This will help one maintain a good balance during the lifting of heavy objects. This is known as the Karate Stance.	
2. Squat down as near to the object as possible when one is ready to lift it, bending at the hips and knees with the buttocks out. If the object is really heavy, one may wish to place one leg on the floor and the other bent at a straight angle in front of them.	

3. Maintain proper posture as one begin to lift upward. To do so, one should keep their back straight, chest out, and shoulders back while gazing straight ahead.	
4. By straightening one's hips and knees, slowly elevate the thing (not the back). As one rises, they should extend their legs and exhale. Lift the heavy object without twisting the body or bending forward.	
5. Do not lift bending forward.	
6. Hold the load close to the body.	

7. Never lift heavy objects above the shoulder	
8. Use the feet (not the body) to change direction, taking slow, small steps.	
9. Set down the heavy object carefully, squatting with the knees and hips only.	

Table 6.1.1 Techniques for lifting he vy objects

[3]*Source:https://ww .braceability.ccom/blogs/articles/7-prop-heavavy-liftinechniques*

6.1.7 Safe Handling of Tools

Workers should be trained on how to use tools safely. When tools are misplaced or handled incorrectly by workers, they can be dangerous. The following are some suggestions from the National Safety Council for safe tool handling when they are not in use:

- Never carry tools up or down a ladder in a way that makes it difficult to grip them. Instead of being carried by the worker, tools should be lifted up and down using a bucket or strong bag.
- Tools should never be tossed but should be properly passed from one employee to the next. Pointed tools should be passed with the handles facing the receiver or in their carrier.
- When turning and moving around the workplace, workers carrying large tools or equipment on their shoulders should pay particular attention to clearances.
- Pointed tools such as chisels and screwdrivers should never be kept in a worker's pocket. They can be carried in a toolbox, pointing down in a tool belt or pocket tool bag, or in hand with the tip always held away from the body.
- Tools should always be stored while not in use. People below are put in danger when tools are left sitting around on an elevated structure, such as a scaffold. In situations when there is a lot of vibration, this risk increases.

6.1.8 Personal Protective Equipment

Personal protective equipment, or "PPE," is equipment worn to reduce exposure to risks that might result in significant occupational injuries or illnesses. Chemical, radiological, physical, electrical, mechanical, and other job dangers may cause these injuries and diseases.

PPE used for protection fom the following injuries are:

Injury Protecton	Protecton	PPE
Head Injury Protecton	Falling or flying objects, stationary objects, or contact with electrical wires can cause impact, penetration, and electrical injuries. Hard hats can protect one's head from these injuries. A common electrician's hard hat is shown in the figure below. This hard hat is made of nonconductive plastic and comes with a set of safety goggles.	
Foot and Leg Injury Protecton	In addition to foot protection and safety shoes, leggings (e.g., leather) can guard against risks such as falling or rolling objects, sharp objects, wet and slippery surfaces, molten metals, hot surfaces, and electrical hazards.	
Eye and Face Injury Protecton	Spectacles, goggles, special helmets or shields, and spectacles with side shields and face shields can protect against the hazards of flying fragments, large chips, hot sparks, radiation, and splashes from molten metals. They also offer protection from particles, sand, dirt, mists, dust, and glare.	

Protecton against Hearing Loss	Hearing protection can be obtained by wearing earplugs or earmuffs. High noise levels can result in permanent hearing loss or damage, as well as physical and mental stress. Self-forming earplugs composed of foam, waxed cotton, or fibreglass wool usually fit well. Workers should be fitted for moulded or prefabricated earplugs by a specialist.	
Hand Injury Protecton	Hand protection will aid workers who are exposed to dangerous substances by skin absorption, serious wounds, or thermal burns. Gloves are a frequent protective clothing item. When working on electrified circuits, electricians frequently use leather gloves with rubber inserts. When stripping cable with a sharp blade, Kevlar gloves are used to prevent cuts.	
Whole Body Protecton	Workers must protect their entire bodies from risks such as heat and radiation. Rubber, leather, synthetics, and plastic are among the materials used in whole-body PPE, in addition to fire-retardant wool and cotton. Maintenance staff who operate with high-power sources such as transformer installations and motor-control centres are frequently obliged to wear fire-resistant clothes.	

Table 6.1.2. Personal protective equipment

Notes

UNIT 6.2: Fire Safety

Unit Objectives

By the end of this unit, participants will be able to:

1. List the types of fire and fire e extinguiss.

6.2.1 Fire Safety

Fire safety is a set of actions aimed at reducing the amount of damage caused by fire. Fire safety procedures include both those that are used to prevent an uncontrolled fire from starting and those that are used to minimise the spread and impact of a fire after it has started. Developing and implementing fire safety measures in the workplace is not only mandated by law but is also essential for the protection of everyone who may be present in the building during a fire emergency.

The basic Fire Safety Responsibilities are:

- To identify risks on the premises, a fire risk assessment must be carried out.
- Ascertain that fire safety measures are properly installed.
- Prepare for unexpected events.
- Fire safety instructions and training should be provided to the employees.

6.2.2 Respond to a Workplace Fire

- Workplace fire drills should be conducted on a regular basis.
- If one has a manual alarm, they should raise it.
- Close the doors and leave the fire-stricken area as soon as possible. Ensure that the evacuation is quick and painless.
- Turn off dangerous machines and don't stop to get personal items.
- Assemble at a central location. Ascertain that the assembly point is easily accessible to the employees.
- If one's clothing catches fire, one shouldn't rush about it. They should stop and descend on the ground and roll to smother the flames if their clothes catch fire.

6.2.3 Fire Extinguisher

Fire extinguishers are portable devices used to put out small flames or minimise their damage until fire-fighters arrive. These are maintained on hand in locations such as fire stations, buildings, workplaces, public transit, and so on. The types and quantity of extinguishers that are legally necessary for a given region are determined by the applicable safety standards.

Types of fire extinguishers are:

There are five main types of fire extinguishers:

1. Water.
2. Powder.
3. Foam.
4. Carbon Dioxide (CO2).
5. Wet chemical.

1. **Water:** Water fire extinguishers are one of the most common commercial and residential fire extinguishers on the market. They're meant to be used on class-A flames.

2. **Powder:** The L2 powder fire extinguisher is the most commonly recommended fire extinguisher in the Class D Specialist Powder category, and is designed to put out burning lithium metal fires.

3. **Foam:** Foam extinguishers are identified by a cream rectangle with the word "foam" printed on it. They're mostly water-based, but they also contain a foaming component that provides a quick knock-down and blanketing effect on flames. It suffocates the flames and seals the vapours, preventing re-ignition.

4. **Carbon Dioxide (CO2):** Class B and electrical fires are extinguished with carbon dioxide extinguishers, which suffocate the flames by removing oxygen from the air. They are particularly beneficial for workplaces and workshops where electrical fires may occur since, unlike conventional extinguishers, they do not leave any toxins behind and hence minimise equipment damage.

5. **Wet Chemical:** Wet chemical extinguishers are designed to put out fires that are classified as class F. They are successful because they can put out extremely high-temperature fires, such as those caused by cooking oils and fats.

Notes

UNIT 6.3: First Aid

Unit Objectives

By the end of this unit, participants will be able to:

1. Explain how the administer appropriate first aid to victims in case of bleeding, burns, choking, electric shock, poisoning
2. Explain how to administer first aid to victims in case of a heart attack or cardiac arrest due to electric shock.

6.3.1 First Aid

First aid is the treatment or care given to someone who has sustained an injury or disease until more advanced care can be obtained or the person recovers.

The aim of first aid is to:

- Preserve life
- Prevent the worsening of a sickness or injury
- If at all possible, relieve pain
- Encourage recovery
- Keep the unconscious safe.

First aid can help to lessen the severity of an injury or disease, and in some situations, it can even save a person's life.

6.3.2 Need for First Aid at the Workplace

- In the workplace, first aid refers to providing immediate care and life support to persons who have been injured or become unwell at work.
- Many times, first aid can help to lessen the severity of an accident or disease.
- It can also help an injured or sick person relax. In life-or-death situations, prompt and appropriate first aid can make all the difference.

6.3.2 Need for First Aid at the Workplace

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6.3.3 Treating Minor Cuts and Scapes

Steps to keep cuts clean and prevent infectionsand scars:

- **Wash Hands:** Wash hands first with soap and water to avoid introducing bacteria into the cut and causing an infection. One should use the hand sanitiser if one is on the go.
- **Stop the bleeding:** Using a gauze pad or a clean towel, apply pressure to the wound. For a few minutes, keep the pressure on.
- **Clean Wounds:** Once the bleeding has stopped, clean the wound by rinsing it under cool running water or using a saline wound wash. Use soap and a moist washcloth to clean the area around the wound. Soap should not be used on the cut since it may irritate the skin. Also, avoid using hydrogen peroxide or iodine, as these may aggravate the wound.
- **Remove Dirt:** Remove any dirt or debris from the area. Pick out any dirt, gravel, glass, or other material in the cut with a pair of tweezers cleaned with alcohol.

6.3.4 Heart Atack

When the blood flow carrying oxygen to the heart is blocked, a heart attack occurs. The heart muscle runs out of oxygen and starts to die.

Symptoms of a heart attack can vary from person to person. They may be mild or severe. Women, older adults, and people with diabetes are more likely to have subtle or unusual symptoms.

Symptoms in adults may include:

- Changes in mental status, especially in older adults.
- Chest pain that feels like pressure, squeezing, or fullness. The pain is most often in the centre of the chest. It may also be felt in the jaw, shoulder, arms, back, and stomach. It can last for more than a few minutes or come and go.
- Cold sweat.
- Light-headedness.
- Nausea (more common in women).
- Indigestion.

- Vomiting.
- Numbness, aching or tingling in the arm (usually the left arm, but the right arm may be affected alone, or along with the left).
- Shortness of breath
- Weakness or fatigue, especially in older adults and in women.

First Aid for Heart Attack

If one thinks someone is experiencing a heart attack, they should:

- Have the person sit down, rest, and try to keep calm.
- Loosen any tight clothing.
- Ask if the person takes any chest pain medicine, such as nitro-glycerine for a known heart condition, and help them take it.
- If the pain does not go away promptly with rest or within 3 minutes of taking nitro-glycerine, call for emergency medical help.
- If the person is unconscious and unresponsive, call 911 or the local emergency number, then begin CPR.
- If an infant or child is unconscious and unresponsive, perform 1 minute of CPR, then call 911 or the local emergency number.

Notes

UNIT 6.4: Waste Management

Unit Objectives

By the end of this unit, participants will be able to:

1. Describe the concept of waste management and methods of disposing of hazardous waste.
2. List the common sources of pollutionand ways to minimize them.
3. Elaborate on electronic waste disposal procedures.

6.4.1. Waste Management and Methods of Waste Disposal

The collection, disposal, monitoring, and processing of waste materials is known as waste management. These wastes affect living beings' health and the environment. For reducing their effects, they have to be managed properly. The waste is usually in solid, liquid or gaseous form.

The importance of waste management is:

Waste management is important because it decreases waste's impact on the environment, health, and other factors. It can also assist in the reuse or recycling of resources like paper, cans, and glass. The disposal of solid, liquid, gaseous, or dangerous substances is the example of waste management.

When it comes to trash management, there are numerous factors to consider, including waste disposal, recycling, waste avoidance and reduction, and garbage transportation. Treatment of solid and liquid wastes is part of the waste management process. It also provides a number of recycling options for goods that aren't classified as garbage during the process.

6.4.2 Methods of Waste Management

Non-biodegradable and toxic wastes, such as radioactive remains, can cause irreversible damage to the environment and human health if they are not properly disposed of. Waste disposal has long been a source of worry, with population increase and industrialisation being the primary causes. Here are a few garbage disposal options.

1. **Landfills:** The most common way of trash disposal today is to throw daily waste/garbage into landfills. This garbage disposal method relies on burying the material in the ground.
2. **Recycling:** Recycling is the process of transforming waste items into new products in order to reduce energy consumption and the use of fresh raw materials. Recycling reduces energy consumption, landfill volume, air and water pollution, greenhouse gas emissions, and the preservation of natural resources for future use.

3. **Composting:** Composting is a simple and natural bio-degradation process that converts organic wastes, such as plant remnants, garden garbage, and kitchen waste, into nutrient-rich food for plants.
4. **Incineration:** Incineration is the process of combusting garbage. The waste material is cooked to extremely high temperatures and turned into materials such as heat, gas, steam, and ash using this technology.

6.4.3 Recyclable, Non-Recyclable and Hazardous Waste

1. **Recyclable Waste:** The waste which can be reused or recycled further is known as recyclable waste.
2. **Non-recyclable Waste:** The waste which cannot be reused or recycled is known as non-recyclable waste. Polythene bags are a great example of non-recyclable waste.
3. **Hazardous Waste:** The waste which can create serious harm to the people and the environment is known as hazardous waste.

6.4.4 Sources of Pollution

Pollution is defined as the harm caused by the presence of a material or substances in places where they would not normally be found or at levels greater than normal. Polluting substances might be in the form of a solid, a liquid, or a gas.

- **Point source of pollution:** Pollution from a point source enters a water body at a precise location and can usually be identified. Effluent discharges from sewage treatment plants and industrial sites, power plants, landfill sites, fish farms, and oil leakage via a pipeline from industrial sites are all potential point sources of contamination.

  Point source pollution is often easy to prevent since it is feasible to identify where it originates, and once identified, individuals responsible for the pollution can take rapid corrective action or invest in longer-term treatment and control facilities.
- **Diffuse source of pollution:** As a result of land-use activities such as urban development, amenity, farming, and forestry, diffuse pollution occurs when pollutants are widely used and diffused over a large region. These activities could have occurred recently or in the past. It might be difficult to pinpoint specific sources of pollution and, as a result, take rapid action to prevent it because prevention often necessitates significant changes in land use and management methods.

Pollution Prevention

Pollution prevention entails acting at the source of pollutants to prevent or minimise their production. It saves natural resources, like water, by using materials and energy more efficiently.

Pollution prevention includes any practice that:

- Reduces the amount of any hazardous substance, pollutant, or contaminant entering any waste stream or otherwise released into the environment (including fugitive emissions) prior to recycling, treatment, or disposal;
- Reduces the hazards to public health and the environment associated with the release of such substances, pollutants, or contaminants (these practices are known as "source reduction");
- Improved efficiency in the use of raw materials, energy, water, or other resources, or Conservation is a method of safeguarding natural resources.
- Improvements in housekeeping, maintenance, training, or inventory management; equipment or technology adjustments; process or method modifications; product reformulation or redesign; raw material substitution; or improvements in housekeeping, maintenance, training, or inventory control.

6.4.5 Electronic Waste

Lead, cadmium, beryllium, mercury, and brominated flame retardants are found in every piece of electronic waste. When gadgets and devices are disposed of illegally, these hazardous compounds are more likely to contaminate the earth, pollute the air, and leak into water bodies.

When e-waste is dumped in a landfill, it tends to leach trace metals as water runs through it. The contaminated landfill water then reaches natural groundwater with elevated toxic levels, which can be dangerous if it reaches any drinking water bodies. Despite having an environmentally benign approach, recycling generally results in international shipment and dumping of the gadgets in pits.

Some eco-friendly ways of disposing of e-waste are:

- Giving back the e-waste to the electronic companies and drop-off points
- Following guidelines issued by the government
- Selling or donating the outdated technology-based equipment
- Giving e-waste to a certified e-waste recycler

Exercise

1. Name all five types of fire extinguishers.
2. Explain PPE in brief.
3. List the common workplace hazards.
4. Fill in the blacks:
   i. A "_____ sign" is a safety sign that prohibits behaviour that is likely to endanger one's health or safety.
   ii. _____ entails acting at the source of pollutants to prevent or minimise their production.
   iii. _____ is the treatment or care given to someone who has sustained an injury or disease until more advanced care can be obtained or the person recovers.
   iv. The threats caused by biological agents like viruses, bacteria, animals, plants, insects and also humans, are known as _____.
   v. The workplace has to be administered as per the rules of the _____.

Notes

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7. Service and Repair of Packaged Type HVAC Ducted Systems - Optional

Unit 7.1 – Packaged Air Conditioners

Unit 7.2 – Installation and Repair of Ductwork

Key Learning Outcomes

At the end of this module, you will be able to:

1. Explain about a packaged air conditioner.
2. List the types of packaged air conditioners.
3. Elaborate about compressor and cooling system of packaged air conditioner.
4. Describe the components of a packaged air conditioner.
5. Distinguish between packaged air conditioned with water cooled condenser and air cooled condenser.
6. Install the ductwork unit.
7. Check the working of installed ductwork.
8. Service and repair the ductwork unit.
9. Elaborate about cooling tower and its types.

UNIT 7.1: Packaged Air Conditioners

Unit Objectives

At the end of this unit, you will be able to:

1. Explain about a packaged air conditioner.
2. List the types of packaged air conditioners.
3. Elaborate about compressor and cooling system of packaged air conditioner.
4. Describe the components of a packaged air conditioner.
5. Distinguish between packaged air conditioned with water cooled condenser and air cooled condenser.

7.1.1 Introduction

An HVAC designer will suggest this type of air conditioner if you want to cool more than two rooms or a larger space at your home or office. A package unit is the all-in-one heating and cooling system for homes that don't have a lot of room indoors for either a furnace and coil, or an air handler. Package units will contain all of their parts in one outdoor unit. It is installed outside the home (either on the roof or the side) where it produces conditioned air that is forced into a series of ducts running throughout the house.

The window and split air conditioners are usually used for the small air conditioning capacities up to 5 tons. The central air conditioning systems are used for where the cooling loads extend beyond 20 tons. The packaged air conditioners are used for the cooling capacities in between these two extremes. The packaged air conditioners are available in the fixed rated capacities like 3, 5, 7, 10 and 15 tons etc. These units are used commonly in places like restaurants, telephone exchanges, homes, small halls, etc.

As the name implies, in the packaged air conditioners all the important components of the air conditioners are enclosed in a single casing like window AC. Thus, the compressor, cooling coil, air handling unit and the air filter are all housed in a single casing and assembled at the factory location.

Depending on the type of the cooling system used in these systems, the packaged air conditioners are divided into two types:

- Packaged air conditioners with water cooled condenser
- Packaged air conditioners with air cooled condenser

7.1.2 Types of Packaged Air Conditioners

Packaged air conditioners with water cooled condenser

In the packaged water conditioners, the condenser is cooled by the water. The condenser is of shell and tube type, with refrigerant flowing along the tube side and the cooling water flowing along the shell side. The water has to be supplied continuously in these systems to maintain functioning of the air conditioning system.

The shell and tube type of condenser is compact in shape and it is enclosed in a single casing along with the compressor, expansion valve, and the air handling unit including the cooling coil or the evaporator. This whole packaged air conditioning unit externally looks like a box with the control panel located externally.

In the packaged units with the water-cooled condenser, the compressor is located at the bottom along with the condenser. Above these components the evaporator or the cooling coil is located. The air handling unit comprising of the centrifugal blower and the air filter is located above the cooling coil. The centrifugal blower has the capacity to handle large volume of air required for cooling a number of rooms. From the top of the package air conditioners the duct comes out that extends to the various rooms that are to be cooled.

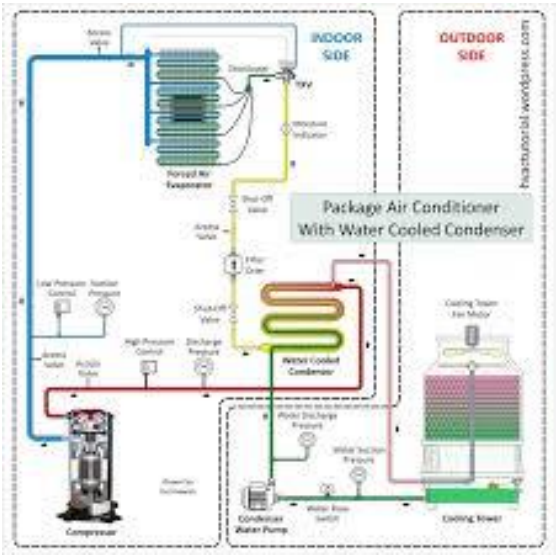

Fig 7.1.1: Packaged air conditioner with water cooled condenser

Packaged Air Conditioners with Water Cooled Condenser

In this packaged air conditioners, the condenser of the refrigeration system is cooled by the atmospheric air. There is an outdoor unit that comprises of the important components like the compressor, condenser and in some cases the expansion valve. The outdoor unit can be kept on the terrace or any other open place where the free flow of the atmospheric air is available. The fan located inside this unit sucks the outside air and blows it over the condenser coil cooling it in the process. The condenser coil is made up of several turns of the copper tubing and it is finned externally. The packaged ACs with the air-cooled condensers are used more commonly than the ones with water cooled condensers since air is freely available it is difficult maintain continuous flow of the water.

The cooling unit comprising of the expansion valve, evaporator, the air handling blower and the filter are located on the floor or hanged to the ceiling. The ducts coming from the cooling unit are connected to the various rooms that are to be cooled.

Fig. 7.1.2: Packaged air conditioners with air cooled condenser

7.1.3 Packaged Air Conditioner: Capacity Control System

Compressors and Control System in the Packaged Air Conditioners

The packaged air conditioners are used for the low to medium tonnage of air conditioning load ranging from 5 to 20 tons also higher. For smaller loads up to 5 tons single compressor is used. For the higher load of more than 5 tons two compressor are used in the package air conditioning system forming two independent refrigeration systems. Though the two systems are independent they are housed in the same supporting framework. The evaporator systems of these two systems are entwined together.

With the two compressors installed in the system there is facility for the capacity control of the air conditioning plant thus one can run the plant fully or partially as per the heating load or as per the number of rooms to be cooled. At full capacity both the compressors can be kept running, while at the partial load one of the compressors can be kept off. The capacity control can also be done automatically by thermostat. The two compressors also ensure that the air conditioning plant won't stop completely when one of the compressors break down, for the system can still keep on running though on partial capacity.

The water-cooled condenser used with the two-compressor system can be single shell but partitioned inside it for different passages for the refrigerant from the two compressors. There can also be two different water-cooled condensers for two different systems. If the condenser is of air cooled type, there would be two condensers either placed side-by-side or entwined together just like the evaporator of the system.

Thermostat Setting for Two Compressor Systems

For controlling the operation of the two-compressor packaged air conditioning system, two different thermostats can be connected to the two cooling systems. This will allow for the capacity control of both the compressors to ensure optimum running of the plant.

In many cases the thermostat is connected to the compressor of one cooling system only. In this case one compressor keeps on running at full capacity and the other compressor remains shut or runs at partial or full capacity depending on the cooling load. To ensure that one compressor won't wear and tear at the fast rate, the compressor running at the full capacity is interchanged from time-to-time.

The two-compressor system is used for the cooling loads between 5 to tons 15 tons, for higher loads more than two units can be installed as per the requirements. There can be multiple air handling units in these systems sending the chilled air to different parts of the building. The compressor and the condenser units are housed in the same location of the building thus there is one common place for the return air. If these units have water cooled condenser, the hot water coming out from them is cooled in the single cooling tower.

During the full load all the compressors run at the full capacity, and when the load reduces one or more compressors are stopped automatically, which makes the other compressors to run at the full load. When the compressor runs at full capacity it runs more efficiently. Whether the packaged air conditioner consists of single compressor or the multiple compressors, most of the components are assembled at the factory site, so the installation of the package AC is quite easy.

7.1.4 Ductwork in Package AC

Ductwork installation is one of the important aspects people overlook. For instance, room additions have a great impact on the ductwork, including the general cooling and heating of your home or commercial building. Even 200 square feet of addition may require significant changes to your ductwork system. Therefore, it's important to understand what ductwork is, the role it plays and its key components.

Fig. 7.1.3: Ductwork in package AC unit

The Basic Function of the Duct System

A ductwork system is designed to distribute airflow from your HVAC equipment to your entire home or commercial building. This encompasses the air that is sucked from the whole building into the air conditioner /heater where it gets cooled or heated and then pushed back via the ducts into your living space.

The intake and output of the air are determined by how efficient a duct system is. If you do not have properly designed return vents, the equilibrium of the cooling and heating system and air pressure will be off. This makes your climate control and home's efficiency suffer invariably.

You should know that pipes used to transfer gas, water or refrigerant are not ductwork. Only air is moved via ductwork. What's more, there are many ductwork constructions and shapes you can choose from. It may come in oval, round or rectangular shapes. It might be fashioned from a wide range of materials like flexible plastics, fiberglass or different metals.

Fig 7.1.4: Exposure of air diffuser

Another problem home owner who install replacement windows or upgrade their insulation face is enhanced ventilation. Usually, this is a minor fix, but it needs to be evaluated and handled by a heating, ventilation and air conditioning expert. Small changes in ductwork or other aspects of your system can help give you the most comfortable and energy-efficient experience possible.

Proper Installation of duct

Properly-installed ductwork helps to keep the home comfortable because it effectively regulates the temperature in the entire home. However, poor installation creates numerous problems. Seams between duct pieces are sealed using an aluminium tape while ductwork is separated from areas like crawl spaces and attics with insulation. If any of these issues is not appropriately handled, air leakage occurs. This makes the system inefficient, and the quality of air will be poor. It could also lead to the failure of the entire air conditioning or heating equipment, which is even more costly.

Did you notice that we said ductwork is sealed with aluminium tape? Despite the misleading name, duct tape isn't suitable for sealing ducts. Instead, special aluminium tape or sometimes mastic is used to create the proper seal on ductwork to provide long-lasting protection and efficiency.

Another aspect that needs to be considered when installing ductwork is the sizing. The ductwork's size should match the size of the air conditioner and/or heater so as to ensure the operation is very efficient. Ductwork installation experts should be capable of matching the equipment you are using to the duct system for a solid fit.

The pros can also fine-tune the ductwork for comfort, longevity and optimal efficiency. This is known as balancing; a process where the dampers located in the ducts are adjusted to make sure that the required amount of air flows into each room.

Ductwork Should Be Kept Clean

The quality of air in your home or commercial building is essential. Keeping dust, pet dander or other types of irritants from the air you breathe in encompasses more than simply changing your equipment's air filter.

Did you know that contaminants can also collect in your duct system and regular cleaning is required? Cleaning the air ducts is a vital part of ensuring that your family is healthy and the residence is clean. So why should you clean your ducts? Listed below are some reasons.

- **Clogging of the ducts** – dust and other particles can clog your ducts, causing your HVAC equipment to work less effectively. This can also cause health issues.
- **You may be losing efficiency** – if you have clogged air ducts, your unit will be forced to work harder to sustain the required temperatures in your residence. This results in an inefficient unit and high utility bills.

7.1.5 Materials used in Ductwork

Ducts are fabricated from different materials, namely:

- **Galvanized steel** – this is a standard and most popular material used to fabricate ductwork. The zinc coating found in the metal hinders rust and helps you avoid painting costs. The metal ducts are lined using faced fiberglass blankets (also known as duct liner) or externally wrapped with duct wrap. If need be, a double-walled duct can be used.
- **Aluminium** – this ductwork is light and very easy to install. You can easily get custom-made or special shapes fabricated on site or in the shop, depending on your needs. Aluminium ducts are less common compared to galvanized steel.
- **Polyurethane and phenolic panels** – these foam panels are crafted with factory-applied aluminium finishes on both sides. The aluminium foil's thickness varies depending on whether it's meant to be used indoors or externally.
- **Flexible ducting** – these ducts are made with flexible plastic over a metallic wire coil in order to shape a tube. The flex ducts came in a wide range of configurations, and are convenient for attaching the outlets that supply air to the rigid ductwork.

Parts of the System

A duct system has other components other than the ducts, which help the system to operate as required to offer quality air in your entire home or commercial building. Listed below are some key components you should know and their functions:

Vibration isolators

Vibration isolators are flexible sections usually inserted in the duct after or before the air handler to minimize the vibration that occurs when a duct system is operating. Duct systems

start at the air handler, which contains blowers. Blowers create substantial vibration, making the duct system transmit the vibration and noise throughout the building. This is avoided by using vibration isolators made with a rubberized material.

Fig. 7.1.5: Exposure of ductwork

Volume Control Dampers

Your duct system needs to have a way to adjust the airflow volume to different sections of the ducting unit. Volume control dampers help with this function and can be automatic or manual. Automatic control in a simple system is provided by zone dampers while the VAR (variable air volume) helps control the complex systems.

Smoke and Fire Dampers

These components are found in the duct system if a duct is passing through a fire curtain or firewall. They are designed to seal off a duct immediately if they detect fire or smoke. They then stay sealed until a technician manually reopens them.

Turning Vanes

Turning vanes are designed to be installed in the ductwork to reduce resistance and turbulence to the flow of air. The air is guided by the vanes, helping it change the direction easily.

Plenums

These are the central collection and distribution units in an HVAC system. The return plenums carry air from numerous return vents into the centralized air handler. The supply plenum, on the other hand, directs air from the system's central unit into the rooms that need cooling or heating.

Terminal Units

Terminal units are often found in the branch ducts in a multi-zone HVAC system. Normally, each thermal zone has one terminal unit. Some of them are fan-powered mixing boxes, induction terminal units and VAV boxes. Sometimes they contain a cooling or heating coil.

Air Terminals

These are the outlets that supply air or are exhaust or return air inlets. When it comes to supplying air, diffusers are commonly found in smaller HVAC systems used in residences. Exhaust grilles are used for appearance reasons, although some also have an air filter.

Conclusion

To get quality air in your home or commercial building, it's important to have an efficient duct system. Proper installation is key and should always be done by a professional who can evaluate your needs and ensure you get a system that's efficient and effective.

You should make sure your duct system is cleaned by specialists to ensure that you and your family breathe quality air. You can always choose the material you prefer for your ductwork, but a professional should be in a better position to advise you accordingly.

UNIT 7.2: Installation and Repair of Ductwork

Unit Objectives

At the end of this unit, you will be able to:

1. Install the ductwork unit.
2. Check the working of installed ductwork.
3. Service and repair the ductwork unit.
4. Elaborate about cooling tower and its types.

7.2.1 Installation of Ductwork

Step 1 — Check Equipment
IDENTIFY UNIT—The unit model number and serial number are stamped on the unit identification plate. Check this information against shipping papers.

INSPECT SHIPMENT—Inspect for shipping damage while unit is still on shipping pallet. If unit appears to be damaged or is torn loose from its securing points, have it examined by transportation inspectors before removal. Forward claim papers directly to transportation company. Manufacturer is not responsible for any damage incurred in transit. Check all items against shipping list.

Step 2 — Provide Unit Support
SLAB MOUNT — Place the unit on a rigid, level surface, suitable to support the unit weight. The flat surface should extend approximately 2-in. beyond the unit casing on the 2 sides. The duct connection side and condensate drain connection sides should be flush with the edge of the flat surface. A concrete pad or a suitable fiberglass mounting pad is recommended. The unit should be level to within 1⁄4 inch. This is necessary for the unit drain to function properly.

Step 3—Provide Clearances— The required minimum service clearances and clearances to adequate ventilation and condenser air must be provided. The condenser fan pulls air through the condenser coil and discharges it through the fan on the top cover. Be sure that the fan discharge does not recirculate to the condenser coil. Do not locate the unit in either a corner or under an overhead obstruction. Do not restrict condenser airflow. An air restriction at either the outdoor-air inlet or the fan discharge can be harmful to compressor life.

Step 4 — Place Unit — Unit can be moved with the handholds. Use extreme caution to prevent damage when moving the unit. Unit must remain in an upright position during all moving operations. The unit must be level for proper condensate drainage; the ground-level pad must be level before setting the unit in place. When a field fabricated support is used, be sure that the support is level and that it properly supports the unit.

Step 5—Select and Install Ductwork— The design and installation of the duct system must be in accordance with the standards of air conditioning and ventilating systems. Select and size ductwork, supply-air registers and return-air grilles according to ASHRAE (American Society of Heating, Refrigeration, and Air Conditioning Engineers) recommendations. Use the duct flanges provided on the supply- and return air openings on the side of the unit.

7.2.2 Initial Start up

PRE-START-UP

TO CHECK

Failure to observe the following warnings could result in serious personal injury:

1. Follow recognized safety practices and wear protective goggles when checking or servicing refrigerant system.
2. Do not operate compressor or provide any electric power to unit unless compressor terminal cover is in place and secured.
3. Do not remove compressor terminal cover until all electrical sources are disconnected.
4. Relieve all pressure from both high- and low-pressure sides of the system before touching or disturbing anything inside terminal box if refrigerant leak is suspected around compressor terminals. Use accepted methods to recover refrigerant.
5. Never attempt to repair soldered connection while refrigerant system is under pressure.
6. Do not use torch to remove any component. System contains oil and refrigerant under pressure. To remove a component, wear protective goggles and proceed as follows:
   a. Shut off electrical power to unit.
   b. Relieve all pressure from system using both high and low-pressure ports. Use accepted methods to recover refrigerant.
   c. Cut component connecting tubing with tubing cutter and remove component from unit.
   d. Carefully dismantle remaining tubing stubs when necessary. Oil can ignite when exposed to torch flame.

Prepare the unit for initial start-up:

1. Remove all access panels.
2. Read and follow instructions on all WARNING, CAUTION, and INFORMATION labels attached to, or shipped with, unit. Make the following inspections:
   a. Inspect for shipping and handling damages such as broken lines, loose parts, disconnected wires, etc.
   b. Inspect for oil at all refrigerant tubing connections and on unit base. Detecting oil generally indicates a refrigerant leak. Leak-test all refrigerant tubing connections using electronic leak detector, or liquid-soap solution.
   c. Inspect all field- and factory-wiring connections. Be sure that connections are completed and tight.
   d. Inspect coil fins. If damaged during shipping and handling, carefully straighten fins with a fin comb.
3. Verify the following conditions:
   a. Make sure that outdoor-fan blade is correctly positioned in fan orifice.
   b. Make sure that air filter is in place.
   c. Make sure that condensate drain pan and trap are filled with water to ensure proper drainage.
   d. Make sure that all tools and miscellaneous loose parts have been removed.

START-UP

Use the Start-Up Checklist supplied product Supplier Company.
Check for Refrigerant Leaks — Locate and repair refrigerant leaks and charge the unit if necessary. Evacuate refrigerant system and reclaim refrigerant if no additional leaks are found.

Start-Up Cooling Section and Make Adjustments
Checking Cooling Control Operation—Start and check the unit for proper cooling control operation as follows:
1. Place room thermostat SYSTEM switch in OFF position. Observe that blower motor starts when FAN switch is placed in ON position and shuts down when FAN switch is placed in AUTO. Position (Functioning tab may depend on company).
2. Place SYSTEM switch in COOL position and FAN switch in AUTO. position. Set cooling control below room temperature. Observe that compressor, condenser fan, and evaporator blower motors start. Observe that cooling cycle shuts down when control setting is satisfied. Functioning tab may depend on company.
3. When using an automatic changeover room thermostat, place both SYSTEM and FAN switches in AUTO. positions. Observe that unit operates in Cooling mode when temperature control is set to ‘‘call for cooling’’ (below room temperature).

Indoor Airflow and Airflow Adjustments

FAN OPERATION — The FAN switch on the thermostat controls indoor fan operation. When the FAN switch is placed in the ON position, the IFR (indoor-fan relay) is energized. The normally-open contacts close, which then provide power to the indoor (evaporator) fan motor (IFM). The IFM will run continuously when the FAN switch is set to ON. When the FAN switch is set to AUTO, the thermostat deenergizes the IFR (provided there is not a call for cooling). The contacts open and the IFM is deenergized. The IFM will be energized only when there is a call for cooling.
COOLING — On a call for cooling, the compressor contactor and the IFR are energized through the terminals of the thermostat. On units with a compressor time delay relay, there is a 5-minute (± 45 sec) delay between compressor starts. Energizing the compressor contactor supplies power to the compressor and the outdoor (condenser) fan motor (OFM). Energizing the IFR provides power to the IFM. When the need for cooling has been satisfied, the OFM, compressor, and IFM (FAN on AUTO) are deenergized. If the unit is equipped with a 30-second delay, the indoor fan will remain energized for 30 seconds after the compressor is deenergized.
HEATING — If accessory electric heaters are installed, on a call for heat the thermostat energized the relay which energizes the electric heaters. The IFR is energized which starts the indoor-fan motor. If the heaters are staged. When, the need for heating is satisfied, the heater and IFM are deenergized.

7.2.3 Servicing and Repairing

To ensure continuing high performance, and to reduce the possibility of premature equipment failure, periodic Servicing must be performed on this equipment. This cooling unit should be inspected at least once each year by a qualified service person.

The minimum Servicing requirements for this equipment are as follows:

1. Inspect air filter(s) each month. Clean or replace when necessary.
2. Inspect indoor coil, outdoor coil, drain pan, and condensate drain each cooling season for cleanliness. Clean when necessary.
3. Inspect blower motor and wheel for cleanliness each cooling season. Clean when necessary. For first heating season, inspect blower wheel bimonthly to determine proper cleaning frequency.
4. Check electrical connections for tightness and controls for proper operation each cooling season. Service when necessary.
5. Check the drain channel in the top cover periodically for blockage (leaves, insects). Clean as needed.

Air Filter

Inspect air filter(s) at least once each month and replace (throwaway-type) or clean (cleanable-type) at least twice during each cooling season or whenever the filters become clogged with dust and lint. Replace filters with the same dimensional size and type as originally provided, when necessary.

Unit Top Removal (Condenser-Coil Side)

When performing service procedures that require removal of the unit top, be sure to perform all of the routine service procedures that require top removal, including coil inspection and cleaning, and condensate drain pan inspection and cleaning.

Only qualified service personnel should perform service and service procedures that require unit top removal.

Evaporator Blower and Motor — For longer life, operating economy, and continuing efficiency, clean accumulated dirt and grease from the blower wheel and motor annually.

To clean the blower wheel:

1. Access the blower assembly as follows:
   a. Remove top access panel.
   b. Remove screws that hold blower orifice ring to blower housing. Save screws.
   c. Loosen setscrew(s) which secure wheel to motor shaft.
2. Remove and clean blower wheel as follows:
   a. Lift wheel from housing. When handling and/or cleaning blower wheel, be sure not to disturb balance weights (clips) on blower wheel vanes.
   b. Remove caked-on dirt from wheel and housing with a brush. Remove dirt accumulations from wheel and housing with vacuum cleaner, using a soft brush attachment. Remove grease and oil with a mild solvent.
   c. Reassemble blower into housing. Place upper orifice ring on blower to judge location of the blower wheel. Be sure setscrews are tightened on motor and are not on round part of shaft.
   d. Replace top access panel.

Condensate Drain Pan — Inspect the condenser coil, evaporator coil, and condensate drain pan at least once each year. Proper inspection and cleaning require the removal of the unit top. The coils are easily cleaned when dry; therefore, inspect and clean the coils either before

or after each cooling season. Remove all obstructions (including weeds and shrubs) that interfere with the airflow through the condenser coil. Straighten bent fins with a fin comb. If coated with dirt or lint, clean the coils with a vacuum cleaner, using a soft brush
Clean the drain pan and condensate drain by removing all foreign matter from the pan. Flush the pan and drain tube with clear water. Do not splash water on the insulation, motor, wiring, or air filter(s).

Condenser Fan

1. Shut off unit power supply.

2. Remove condenser-fan assembly (grille, motor, motor cover, and fan) by removing screws and flipping assembly onto unit top cover.

3. Loosen fan hub setscrews.

4. Adjust fan height.

5. Tighten setscrews.

6. Replace condenser-fan assembly.

Electrical Controls and Wiring— Inspect and check the electrical controls and wiring annually. Be sure to turn off the electrical power to the unit. Remove the top panel to locate all the electrical controls and wiring. Check all electrical connections for tightness. Tighten all screw connections. If any smoky or burned connections are noticed, disassemble the connection, clean all the parts, restrip the wire end and reassemble the connection properly and securely. After inspecting the electrical controls and wiring, replace all the panels.

Refrigerant Circuit— Inspect all refrigerant tubing connections and the unit base for oil accumulations annually. Detecting oil generally indicates a refrigerant leak. If oil is detected or if low cooling performance is suspected, leak-test all refrigerant tubing using an electronic leak detector, or liquid-soap solution.

Evaporator Airflow — The cooling airflow does not require checking unless improper performance is suspected. If a problem exists, be sure that all supply- and return-air grilles are open and free from obstructions, and that the air filter is clean.

Metering Devices— Refrigerant metering devices are fixed orifices and are located in the inlet header to the evaporator coil.

Repairing

Symptom	Cause	Solution
Compressor and condenser fan will not start.	Power failure	Call power company.
	Fuse blown or circuit breaker tripped	Replace fuse or reset circuit breaker.
	Defective thermostat, contactor, transformer, or control relay	Replace component.
	Insufficient line voltage	Determine cause and correct.

	Incorrect or faulty wiring	Check wiring diagram and rewire correctly.
	Thermostat setting too high	Lower thermostat setting below room temperature.
Compressor will not start but condenser fan runs.	Faulty wiring or loose connections in compressor circuit	Check wiring and repair or replace.
	Compressor motor burned out, seized, or internal overload open	Determine cause. Replace compressor.
	Defective run/start capacitor, overload, or start relay	Determine cause and replace.
	One leg of 3-phase power dead	Replace fuse or reset circuit breaker. Determine cause.
Compressor cycles (other than normally satisfying thermostat).	Refrigerant overcharge or undercharge	Recover refrigerant, evacuate system, and recharge to capacities shown on nameplate.
	Defective compressor	Replace and determine cause.
	Insufficient line voltage	Determine cause and correct.
	Blocked condenser	Determine cause and correct.
	Defective run/start capacitor, overload or start relay	Determine cause and replace.
	Defective thermostat	Replace thermostat.
	Faulty condenser-fan motor or capacitor	Replace.
	Restriction in refrigerant system	Locate restriction and remove.
Compressor operates continuously.	Dirty air filter	Replace filter.
	Unit undersized for load	Decrease load or increase unit size.
	Thermostat set too low	Reset thermostat.
	Low refrigerant charge	Locate leak, repair and recharge.
	Leaking valves in compressor	Replace compressor.
	Condenser coil dirty or restricted	Clean coil or remove restriction.
Excessive head pressure.	Dirty air filter	Replace filter.
	Dirty condenser coil	Clean coil.
	Refrigerant overcharged	Recover/Remove excess refrigerant.
	Air in system	Recover refrigerant, evacuate system, and recharge.

	Condenser air restricted or air short-cycling	Determine cause and correct.
Head pressure too low.	Low refrigerant charge	Check for leaks, repair, and recharge.
	Compressor valves leaking	Replace compressor.
	Restriction in liquid tube	Remove restriction.
Excessive suction pressure.	High heat load	Check for source and eliminate.
	Compressor valves leaking	Replace compressor.
	Refrigerant overcharged	Recover/Remove excess refrigerant.
Suction pressure too low.	Dirty air filter	Replace filter.
	Low refrigerant charge	Check for leaks, repair, and recharge.
Suction pressure too low.	Metering device or low side restricted	Remove source of restriction.
	Insufficient evaporator airflow	Increase air quantity. Check filter — replace if necessary. Check for other evaporator coil obstructions.
	Temperature too low in conditioned area	Reset thermostat.
	Field-installed filter-drier restricted	Replace.

Table 7.2.1: Causes and solution of different symptoms in ductwork

7.2.4 Cooling Tower

Introduction

A cooling tower is a **specialized heat exchanger** in which air and water are brought into direct contact with each other in order to **reduce the water's temperature**. As this occurs, a small volume of water is evaporated, reducing the temperature of the water being circulated through the tower.

Water, which has been heated by an air-conditioning condenser, is pumped to the cooling tower through pipes. The water sprays through nozzles onto banks of material called "fill," which slows the flow of water through the cooling tower, and exposes as much water surface area as possible for maximum air-water contact. As the water flows through the cooling tower, it is exposed to air, which is being pulled through the tower by the electric motor-driven fan.

When the water and air meet, a small amount of water is evaporated, creating a cooling action. The cooled water is then pumped back to the condenser or process equipment where it absorbs heat. It will then be pumped back to the cooling tower to be cooled once again.

Cooling Tower Fundamentals provides a level of basic cooling tower knowledge and is a great resource for those wanting to learn more.

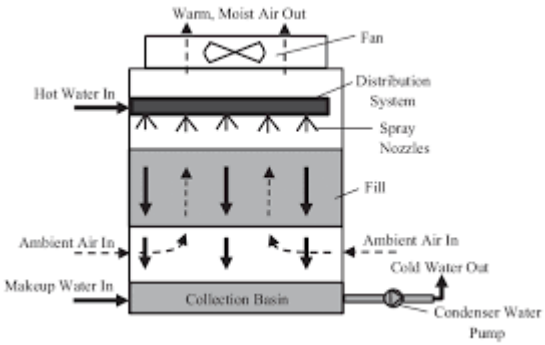

Fig. 7.2.1: Cooling Tower

Types of Cooling Towers

1. Crossflow Cooling Towers

In crossflow towers the water flows vertically through the fill while the air flows horizontally, across the flow of the falling water.
Because of this, air does not have to pass through the distribution system, permitting the use of gravity flow hot water distribution basins mounted at the top of the unit above the fill. These basins are universally applied on all crossflow towers.

2. Counterflow Cooling Towers

Counterflow towers are designed so that air flows vertically upward, counter to the flow of falling water in the fill. Because of this vertical airflow, it is not possible to use the open, gravity-flow basins typical in crossflow designs. Instead, counterflow towers use pressurized, pipe-type spray systems to spray water onto the top of the fill.
Since air must be able to pass through the spray system, the pipes and nozzles must be farther apart so as not to restrict airflow.

Induced Draft vs. Forced Draft Cooling Towers

Induced draft cooling towers have fans that are typically mounted on top of the unit and pull air through the fill media. Conversely, air is pushed by blowers located at the base of the air inlet face on forced draft towers.

Factory Assembled (FAP) vs. Field Erected (FEP) Cooling Towers

Factory-assembled towers (FAP) are built and shipped in as few sections as the mode of transportation will permit. A relatively small tower will ship essentially intact. A larger, multi-cell cooling tower is manufactured as modules at the factory, and shipped ready for final assembly. Factory-assembled towers are also known as “packaged” or “FAP” (factory-assembled product). Factory-assembled cooling towers can be crossflow or counterflow, induced draft or forced draft, depending on the application. Induced draft tower is widely used for HVAC and light industrial applications.
Field-erected cooling towers (FEP) Field-erected towers are primarily constructed at the site of ultimate use. All large cooling towers, and many of the smaller towers, are prefabricated, piece-marked, and shipped to the site for final assembly. The manufacturer usually provides labour and supervision for final assembly. Field-erected towers can be crossflow or counterflow, depending on the application.

Performance Drivers

Using a total system approach, every cooling tower and component is designed and engineered to work together as an integrated system for efficient performance and long life.

Variable Flow – There may be significant energy savings opportunities if the cooling tower can be operated under variable flow in off-peak conditions. Variable flow is a way to maximize the effectiveness of the installed tower capacity for whatever flow the process has.

Fill – One of the single most important components of a cooling tower is the fill. Its ability to promote both the maximum contact surface and the maximum contact time between air and water determines the efficiency of the cooling tower. The two basic fill classifications are splash type fill (breaks up the water) and film type fill (spreads the water into a thin layer).

Drift eliminators – Designed to remove water droplets from the discharged air and reduce loss of process water, drift eliminators cause the air and droplets to make sudden changes in direction. This causes the drops of water to be separated from the air and deposited back into the tower.

Nozzles – Crossflow configuration permits the use of a gravity-flow distribution system with a nozzle. With this system, the supply water is elevated to hot water distribution basins above the fill and then flows over the fill (by gravity) through nozzles located in the distribution basin floor. Counterflow configuration necessitates the use of a pressure type system of closed pipe and spray nozzles.

Fans – Cooling tower fans must move large volumes of air efficiently, and with minimum vibration. The materials of manufacture must not only be compatible with their design, but must also be capable of withstanding the corrosive effects of the environment in which the fans are required to operate.

Driveshafts – The driveshaft transmits power from the output shaft of the motor to the input shaft of motor. Because the driveshaft operates within the tower, it must be highly corrosion resistant. Turning at full motor speed, it must be well balanced and capable of being re-balanced.

Air Conditioner Pumps

Air conditioner pumps that are commonly used in HVAC industry are the centrifugal pumps. It basically consists of a pump impeller which is connected to the shaft of a motor. The centrifugal force created when the motor turns causes the liquid to be drawn towards it and discharged to the opening of the volute.

The pump creates a differential pressure between the water inlet and outlet of the pump. This pressure differential enables the water to flow through the pipes.

The motor used can be single speed, dual speed or variable speed. The more complicated variable speed motor which can vary its speed and connected to the building management system is increasingly being used due to its better efficiency and control. By varying the speed of the pump motor, the impeller speed can be optimized to the load of the system.

The moving parts of the pumps are usually made of non-ferrous material to prevent corrosion. The body is made from cast-iron for stability and durability.

These pumps are used in:

- **Condenser water system** where the hot water from the condenser is pumped to the cooling tower which is located a distance away from the condenser. The hot water is then cooled at the cooling tower before being circulated back to the condenser. This process is done repeatedly.

- **Chilled water system** where the chilled water from the chillers are being pumped and circulated to the various sections of a building before being used to cooled the space.

- **Hot water system** where the hot water from the boiler is circulated to the heat transfer units and back.

In-Line Pumps and the Closed Coupled Pump

There are two main design of the air conditioner pumps. They are the In-Line Pumps and the Closed Coupled Pump.

- The **in-line type** is smaller which is used for a lower head application. It is also known as booster pumps. The suction and discharge are connected in a straight line making it light in weight and hence can be supported directly by the piping. It is also less costly and simpler to install.
- The **closed coupled pump** has its impeller mounted on and supported by the motor shaft. It has mounting flange with base that supports the motor and pump. There is also an end suction connection. It is available from small to medium capacities and is not too costly.

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9. Annexure

Annexure - QR Code

Chapter No.	Unit No.	Topic Name	Page No.	QR Code(s)	URL
1. Role and Responsibilities of an HVAC Technician	1.1 – Roles and Responsibilities of an HVAC Technician	1.1.1 Who is an HVAC technician	54		https://www.youtube.com/watch?v=ScVBPAitibQ
		1.1.2 Role and Responsibilities			https://www.youtube.com/watch?v=LU4rc1mBcYA
		1.1.3 Career Growth Path			https://www.youtube.com/watch?v=RRY902AmAWY
		1.2.1 Basic Concept of RAC			https://www.youtube.com/watch?v=22M09sEHYIg
		1.2.2 Basic Components of HVAC System			https://www.youtube.com/watch?v=GzEMdQk1QTk
		1.2.3 Condenser			https://www.youtube.com/watch?v=p-HFH1-pTNs
		1.2.4 VAV Box			https://www.youtube.com/watch?v=vw-bAbjPTd8
		1.2.5 Types of HVAC Systems			https://www.youtube.com/watch?v=TyTQTe-jEqA
		1.2.5.1 Centralized Air Conditioning System			https://www.youtube.com/watch?v=lt6hjeI4JcI
8. Employability and Entrepreneurship Skills			219		https://www.skillindiadigital.gov.in/content/list

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