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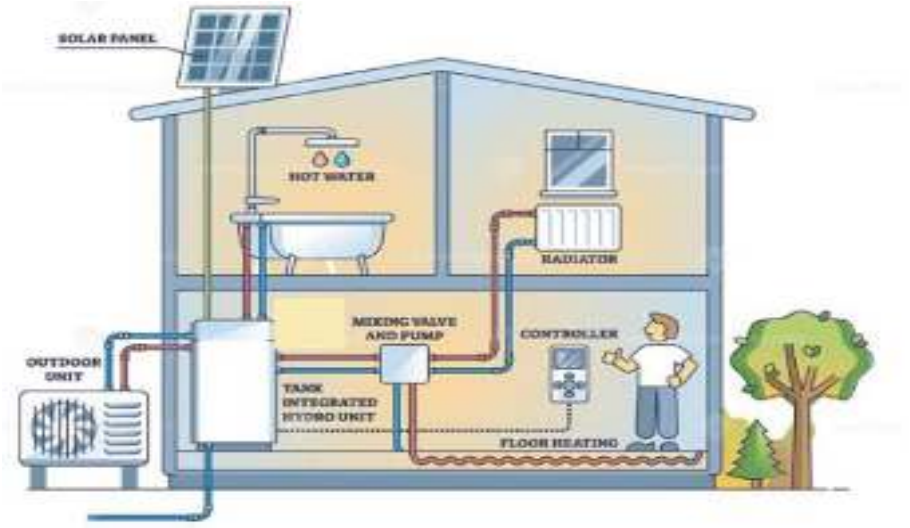
Ministry of Labor and Skills

BUILDING ELECTRICAL INSTALLATION LEVEL - III

Based on October, 2023 Curriculum Version - II



Module Title: Heating, ventilation and air conditioning system

Module code: EIS BEI3 M6 1023

Nominal duration: 112 Hours

Prepared by: Ministry of Labor and Skill

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Addis Ababa, Ethiopia

Table of Contents

Acknowledgment

Ministry of Labor and Skills wish to extend thanks and appreciation to the many representatives of TVET instructors and respective industry experts who donated their time and expertise to the development of this Teaching, Training and Learning Materials (TTLM).

Acronym

HVAC ---------- Heat, Ventilation and Air Conditioning

OSHA ---------- Occupational Safety and Health Administration

PPE ---------- Personnel protective equipment's

OHS ----------Occupational Healt & Safty

RTK ---------- Retrofit Test Kit

VRV ---------- Variable Refrigerant Volume

VRF ---------- Variable Refrigerant Flow

NEC ---------- National Electrical Code.

Introduction to the Module

In Building Electrical Installation field: heating, ventilation and air conditioning system installation. It helps to know the basic concepts, wiring system installation and maintain of heating, ventilation & air conditioning systems in order to creat a comfortable and healthy indoor environment in residential, commercial and industrial buildings.

This module is designed to meet the industry requirement under the Building Electrical Installation occupational standard, particularly for the unit of competency: Heating, ventilation and air conditioning system Installation

Module covers the units:

- Basic concepts of HVAC Systems
- HVAC Systems installation
- HVAC Systems maintenance

Learning Objective of the Module

- Understand Basic concepts of HVAC Systems
- Preform HVAC Systems installation
- Maintain HVAC System

Module Instruction

For effective use this modules trainees are expected to follow the following module instruction:

1. Read the information written in each unit
2. Accomplish the Self-checks at the end of each unit
3. Perform Operation Sheets which were provided at the end of units
4. Do the “LAP test” giver at the end of each unit and
5. Read the identified reference book for Examples and exercise

UNIT ONE: BASIC CONCEPTS OF HVAC SYSTEMS

This unit is developed to provide you the necessary information regarding the following content coverage and topics:

- Introduction of HVAC system
- Types of HVAC systems and their applications
- Components of HVAC systems
- Operation Principles
- Tools, equipment & materials
- OHS requirement

This unit will also assist you to attain the learning outcomes stated in the cover page.

Specifically, upon completion of this learning guide, you will be able to:

- Understand HVAC system
- Identify types of HVAC systems and their applications
- Identify components of HVAC systems
- Understand principles of heating, ventilation, and air conditionings
- Use tools, equipment & materials
- Identify and follow occupational health & safety requirement

1.1. Introduction of HVAC system

Defnition: HVAC stands for heating, ventilation, and air conditioning. It is a system that controls the temperature, humidity, and air quality in an indoor space. HVAC systems are used in a wide variety of buildings, including homes, offices, schools, hospitals, and commercial buildings.

A. Heating: It is the process of raising the temperature of indoor spaces during cold weather to provide comfort. The key concepts include:

- **Heat Generation:** Heating can be achieved through various methods such as furnaces, boilers, heat pumps, or electric heaters. These systems generate heat that is distributed throughout the building.
- **Heat Transfer:** Heat is transferred from the heat source to the indoor spaces through methods like forced air, radiant heat, or hydronic systems.
- **Temperature Control:** The heating system is equipped with a thermostat that monitors and controls the indoor temperature. It activates or deactivates the heating system based on the desired temperature set by the occupants.

B. Ventilation: It is the process of exchanging indoor air with fresh outdoor air to maintain air quality and remove pollutants. The key concepts include:

- **Air Exchange:** Ventilation systems bring in fresh outdoor air and exhaust stale indoor air to prevent the buildup of contaminants, odors, and excessive moisture.
- **Air Filters:** Ventilation systems often incorporate air filters that capture dust, allergens, and other particles, improving indoor air quality.
- **Ventilation Rate:** The ventilation system should be designed to provide an adequate amount of outdoor air based on the occupancy and activity level within the building.

C. Air Conditioning: Air conditioning is the process of cooling and dehumidifying indoor spaces during hot weather to provide comfort. The key concepts include:

- **Cooling Methods:** Air conditioning systems use refrigeration cycles to extract heat from indoor air and release it outside, cooling the indoor spaces.
- **Cooling Load Calculation:** The cooling system is sized based on factors such as the size of the space, insulation, occupancy, and heat-generating equipment to ensure proper cooling capacity.

- **Dehumidification:** Air conditioning systems remove excess humidity from the air, improving comfort and preventing moisture-related issues such as mold growth.
- **Temperature and Humidity Control:** Similar to heating, air conditioning systems are controlled by a thermostat that maintains a desired temperature and humidity level.

1.2. Components of HVAC systems

➢ The main components of an HVAC system are:

a. Thermostat: The thermostat is a device that controls the temperature of the air in a building. It does this by sending signals to the heating and cooling equipment to turn it on or off.

Fig 1.1: thermostat

b. Heat exchanger: The heat exchanger is a device that transfers heat from one medium to another. In an HVAC system, the heat exchanger is used to transfer heat from the air inside the building to the outside air in the winter, and from the outside air to the air inside the building in the summer.

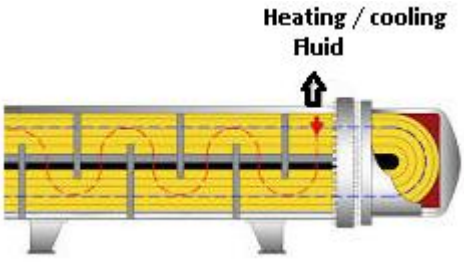


Fig 1.1: heat exchanger

c. Evaporator coil: The evaporator coil is a component of the air conditioning system. It is where the refrigerant absorbs heat from the air inside the building. The condenser coil is a component of the air conditioning system. It is where the refrigerant releases heat to the outside air.

Fig.1.3 : Evaporator coil

d. Blower motor: The blower motor is a fan that circulates the air through the heating and cooling equipment and the ductwork.

Fig.1.4 : blower motor

e. **Ductwork:** The ductwork is a system of pipes that distribute the conditioned air throughout the building.

Fig.1.5 : ductwork

f. **Air filter:** The air filter removes dust, pollen, and other allergens from the air.

Fig.1.6 : air filter

g. **Humidifier**: The humidifier adds moisture to the air, which can be helpful in dry climates.

Fig.1.7 : humidifier

h. **Dehumidifier:** The dehumidifier removes moisture from the air, which can be helpful in humid climates.

Fig.1.8 : dehumidifier

i. **Air purifier**: The air purifier removes pollutants from the air, such as smoke, dust, and bacteria.

Fig.1.9 : air purifier

Note: HVAC systems can be complex, but it is important to understand the basic components of the system in order to maintain it properly. By regularly cleaning and inspecting the components of your HVAC system, you can help to ensure that it operates efficiently and effectively

1.3. Types of HVAC systems and their applications

There are many different types of HVAC systems, each with its own advantages and disadvantages. The type of HVAC system that is best for a particular application depends on a number of factors, including the size and type of building, the climate, and the budget.

Most common types of HVAC systems and their applications are:

A. Split system

It is the most common type of HVAC system in residential and commercial buildings. They consist of two main components: an ***outdoor unit*** and ***an indoor*** unit. The outdoor unit contains the compressor and condenser coil, while the indoor unit contains the evaporator coil and blower motor.

Split system is relatively easy to install and maintain and they offer good energy efficiency. They are also relatively quiet compared to other types of HVAC systems.

Indoor Unit

Outdoor unit

Fig.1.10 : Split system

Typical applications:

- Residential homes
- Small commercial buildings
- Multi-family homes

B. Ductless mini-split systems

Ductless mini-split systems are a good option for ***homes and businesses*** without ductwork. They consist of an outdoor unit and one or more indoor units. The indoor units can be mounted on the wall, ceiling, or floor.

Ductless mini-split systems are very energy efficient and can be used to heat and cool individual rooms or zones. They are also relatively quiet and easy to install and maintain.

Typical applications:

- Residential homes without ductwork
- Small commercial buildings without ductwork
- Multi-family homes without ductwork
- Additions and renovations to existing buildings

C. Packaged heating and cooling systems

Packaged heating and cooling systems are a good option for small commercial buildings and multi-family homes. They consist of a single unit that contains both the heating and cooling components.

Fig 1.11: Packaged heating and cooling systems

It is relatively easy to install and maintain, and they can be very energy efficient. However, they can be more expensive than other types of HVAC systems.

Types of Packaged Units

- **Packaged Air Conditioners:** The compressor, coils, air handler are all housed in a single boxed cabinet. The packaged air conditioner can also provide limited warmth by using an electrical strip heating.
- **Packaged Heat Pumps:** A packaged heat pump uses heat pump technology to cool and heat your home.
- **Packaged Gas-Electric:** The packaged gas-electric unit combines an air conditioner with gas-powered furnace performance.
- **Packaged Dual-Fuel:** The packaged dual fuel system contains a heat pump, capable of heating and cooling, as well as a gas furnace. This type of packaged system optimizes the heating source for the conditions.

Typical applications:

- Small commercial buildings
- Multi-family homes
- Office buildings
- Retail stores

D. Heat pumps

Heat pumps are a type of HVAC system that can be used to heat and cool a building. They work by transferring heat from one place to another, using a refrigerant. Heat pumps can be very energy efficient, especially in climates with mild winters. However, they can be more expensive to install than other types of HVAC systems.

How Does a Heat Pump Work

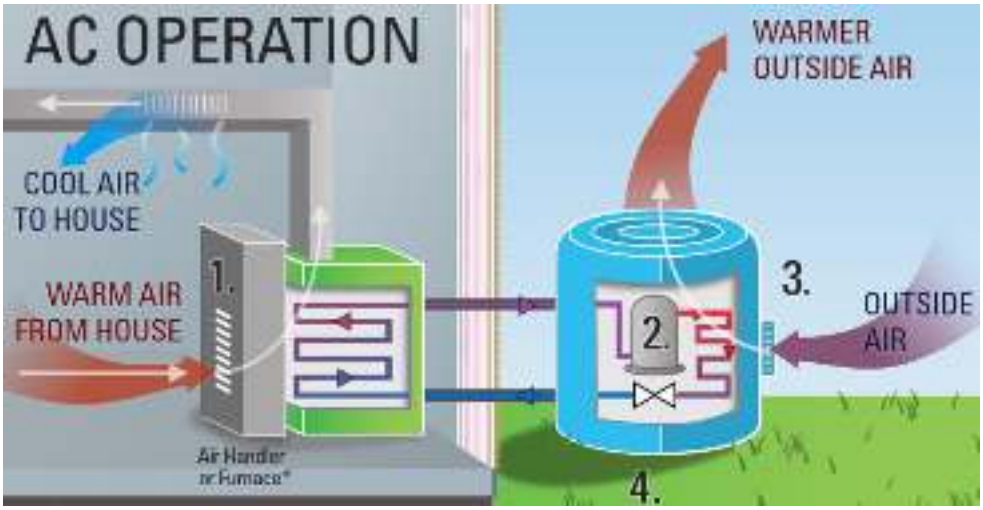


Fig 1.12: AC operation

- Warm air from inside the home is passed across a cool refrigerant coil and the heat is absorbed by the liquid refrigerant, which evaporates into a low temperature gas and the cooled air is ducted back through the home.
- The low temperature gas refrigerant goes through a compressor, which raises its temperature and pressure.
- Hot, high pressurerefrigerant gas is passed through the out door coil. The refrigerant passes heat to the outdoor air and condenses to a high temperature liquid.
- Warm liquid refrigerant is passed through an expansion valve, which relieves pressure. As the pressure is reduced, the temperature of the liquid is reduced. The low temperature, low pressure liquid refrigerant is then piped back into the house.

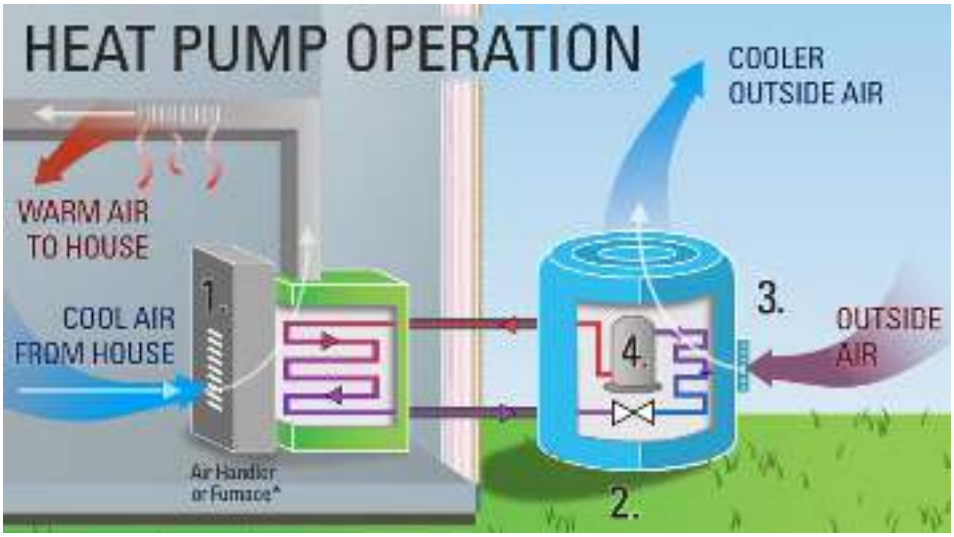


Fig 1.12: Operations of Heat pump

- Cold air inside the home is passed across the high temperature, high pressure gas in the indoor coil which transfers heat to the cold air. The refrigerant condense to a liquid and the warm air is circulatd through the home.
- Warm liquid refrigerant is passed through an expansion valve, which relieves pressure. As the pressure is reduced the temperature of the liquid is reduced and the cold refrigerant passes through the outdoor coile.
- Heat energy transfers from the outside air to the low-pressure, low-temperature liquid refrigerant.
- The low-temperature gas refrigerant goes through a compressor, which raises its temperature, pressure and passes it back to the indoor coil.

Typical applications:

- Residential homes
- Small commercial buildings
- Multi-family homes

E. Geothermal heat pumps

Geothermal heat pumps are a type of heat pump that uses the earth's constant temperature to heat and cool a building. They are very energy efficient and can provide year-round comfort. However, they are also the most expensive type of HVAC system to install.

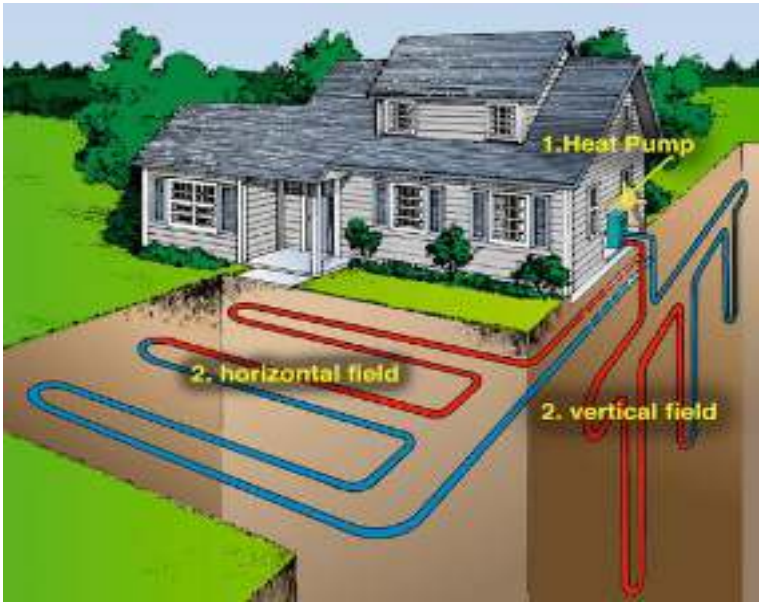


Fig 1.13: Geothermal heating and cooling system

Geothermal heating and cooling system operation

- **Winter Operation:** The underground pipes called a ground loop circulate water which absorbs the heat from the earth and returns it to the indoor heat pump. The heat pump extracts the heat from the liquid then distributes it throughout the home as warm air. With the heat removed, the water is re-circulated to collect more heat from the ground. In this case, the loop water is warmer when it comes into the home than when it goes back into the earth since the heat is being removed.
- **Summer Operation**: The indoor heat pump takes the hot air from your home and removes the heat. This leaves behind cool air to be distributed through vents as air-conditioning. The removed heat from the air is re-injected into the earth through the ground loop. In this case, the water is warmer leaving the home than when it returns since heat is rejected into it.

Typical applications:

- Residential homes
- Small commercial buildings
- Multi-family homes

F. Central heating and cooling systems

Central heating and cooling systems are typically used in commercial buildings. They consist of a central heating and cooling plant that distributes conditioned air throughout the building through a network of ducts.

Central heating and cooling systems can be very energy efficient and can provide year-round comfort. However, they can be more expensive to install and maintain than other types of HVAC systems.

How a Central Air Conditioner Works

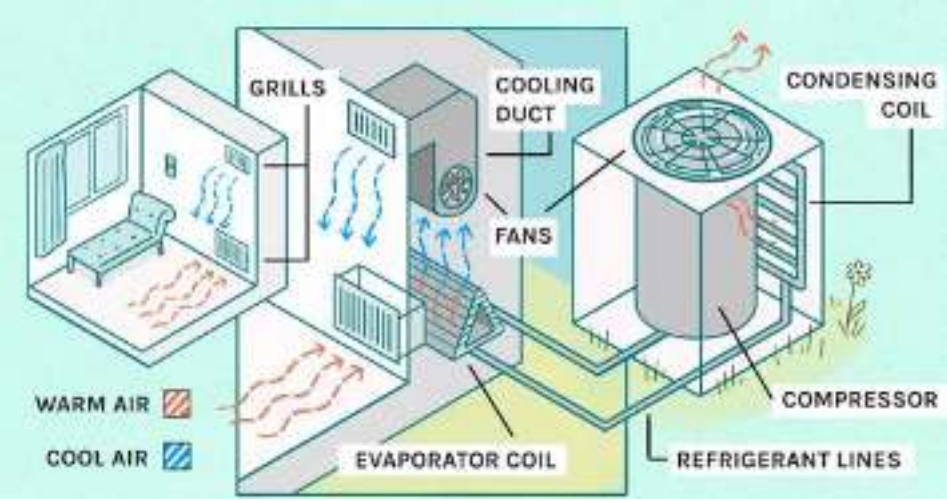


Fig 1.15: Central heating and cooling operation

It incorporate two different coils. The cooling compressor is set outside the home, separate from the fan unit used to blow the cool air throughout the home on the central air unit. The central air unit can cool the entire home evenly by using the existing heating and cooling ducts throughout the home.

The coil outside of your home is called the condensing coil. It consists of a compressor, condensing coil condenser fan and a grill to protect persons from coming into contact with the fan blade, a case built around all of the components, controls, and two refrigerant lines that run into the home to the evaporator coil.

The refrigerant inside the compressor is pumped through the evaporator coil inside, which cools the air as the furnace fan blows air through the coil. The coil absorbs the heat from the air. Then the refrigerant flows back outside to the condenser coil, and this is where the heat that was absorbed is released. The refrigerant returns to a liquid form as it is cooled, and the cycle continues until the home reaches the desired temperature.

Typical applications:

- Large commercial buildings
- Office buildings
- Retail stores
- Hospitals
- Schools

1.4. Principles of heating, ventilation, and air conditionings

The basic principles of HVAC systems are

A. Heating Principles

- Heat Generation: Heat is produced through combustion, resistance heating, or heat pump operation.
- Heat Transfer: Heat is transferred from the heat source (such as a furnace or heat pump) to the air or water circulating through the system.
- Distribution: The heated air or water is distributed throughout the building via ductwork or piping.
- Control: Thermostats and control systems regulate the heating process to maintain the desired temperature.

B. Ventilation Principles

- Air Exchange: Ventilation systems bring in fresh outdoor air and remove stale indoor air to maintain air quality.
- Filtration: Air filters remove dust, pollutants, and allergens from the incoming air.
- Distribution: The fresh air is distributed throughout the building using a network of ducts or natural ventilation methods.
- Control: Ventilation rates can be adjusted based on occupancy, air quality, and energy efficiency requirements.

C. Air Conditioning Principles

- Cooling: Air conditioning systems remove heat from indoor air through refrigeration cycles.
- Refrigerant Circulation: Refrigerant absorbs heat from the indoor air, is compressed, and releases heat outdoors.
- Dehumidification: Air conditioners remove moisture from the air, reducing humidity levels for comfort.
- Distribution: The cooled and dehumidified air is distributed through ductwork or air handling units.
- Control: Temperature and humidity levels are controlled using thermostats and control systems.

1.5. Tools, equipment & materials

The following are some of the tools, equipment, and materials that you will need to install heat, ventilation, and air conditioning (HVAC) systems:

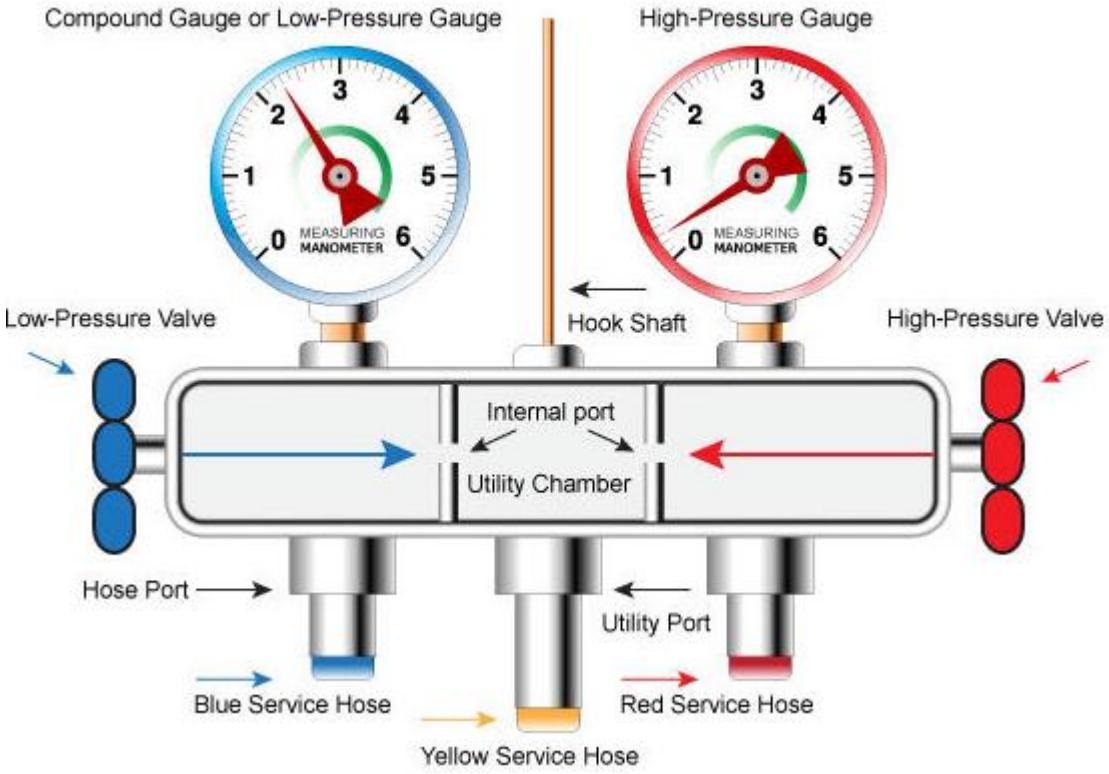
Table 1.1.: Tools, equipment & materials

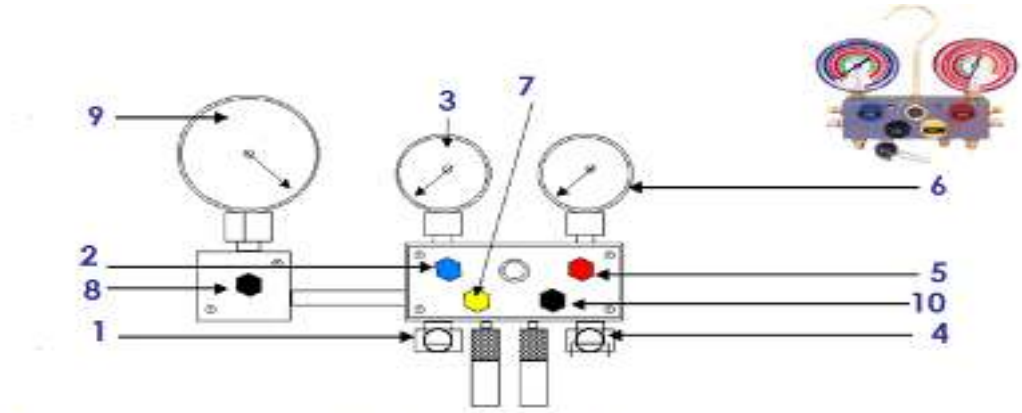
Name	
1. Quick Test Board 	2. Dummy Relay or Test terminals 
3. Digital Clamp Meter 	4. Digital Thermometer with Puncture Probe 
5. Line Tester (500V) 	6. Wire Stripper 
7. Ratchet Wrench/Service Valve Wrench	8. Igniter

	
9. Tube Cutter 	10. Deburring tools 
11. Capillary Tube  	12. Tube Bender • Lever type - Spring Type  
13. Flaring 	14. Combination 
15. Expander 	16. Scrubbed cum wire brus 
17. Sprit level 	18. Cable Ties 

- **HVAC gauges** are used by refrigeration HVAC specialists for a variety of pressure readings and other purposes. Vacuuming, testing, refilling, and recovering are all part of the job. People who work with refrigerators, air conditioners, and other similar appliances know all too well the value of HVAC gauges.

Fig1.16 HVAC Guage





1 - Low side connection
2 - Low side valve
3 - low side compound gauge
4 - high side connection
5 - high side valve
6 - high side pressure gauge
7 - vacuum pump valve
8 - vacuum gauge isolating valve
9 - vacuum gauge
10 - charging valve

Fig1.16 HVAC Guage parts

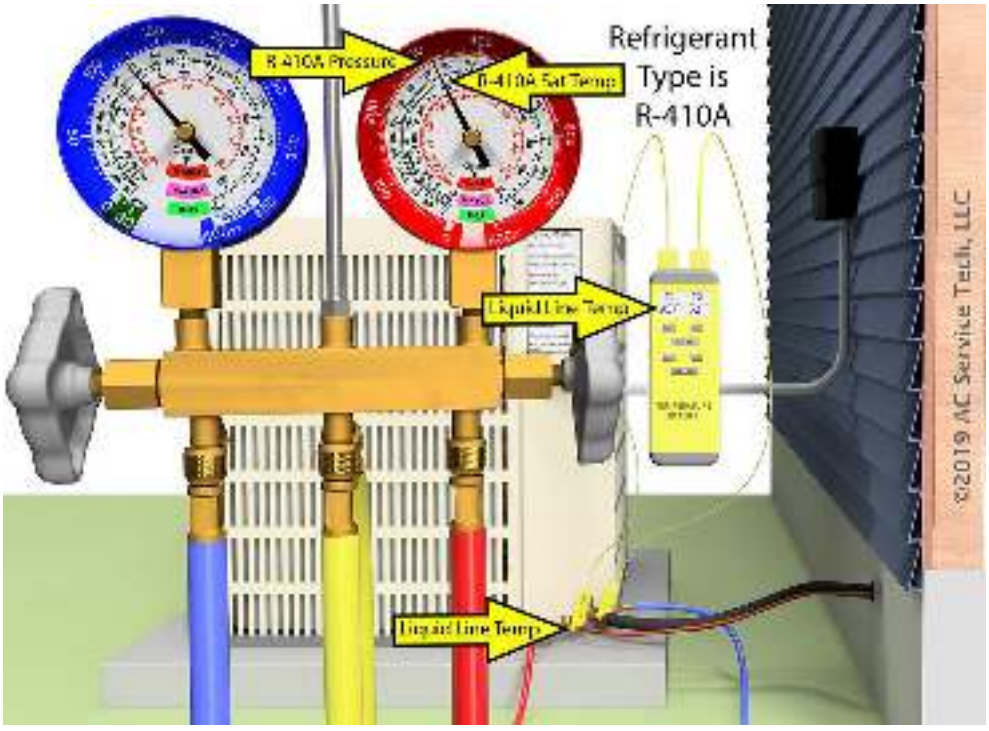


Fig1.17 HVAC Guage parts

Fig1.18 HVAC Guage parts

- **Float Switches** For Refrigerant Recovery Tanks

No matter which method you use, the unit continues to recover until the switch shuts down; then, the tank indicates that with a lamp. Once you go to purge the recovery unit, essential at the end of every service, the switch gets activated again and won't turn off until the tank has been fully cleared. While this sounds simple enough, the procedure itself has some inherent safety issues. The switch only turns off the recovery machine but doesn't stop the flow of refrigerant, which can potentially result in an overfilled tank, which then becomes a hazard to the technician.

Fig1.18 Float Switches

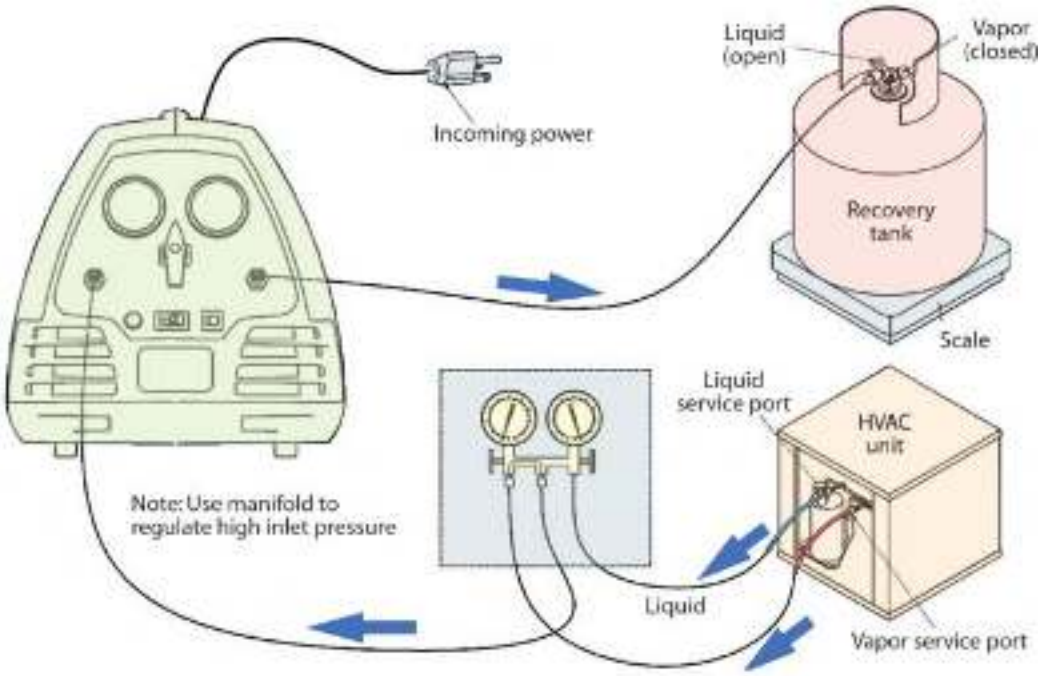


Fig1.20: Float Switches connection

- **Portable Evacuation & Gas Charging Station with weighing scale**

Evacuating and refrigerant charging station, consist of a Rotary two stage vacuum pump and motor (with gas ballast and anti such back). manifold with gauges and valves and capable of pulling vacuum up to 50 microns of Hg and with provision of connecting to a microns level vacuum gauge). Graduated charging cylinder with provision for temperature correction and all necessary isolating valves II)

Fig1.21: Portable Gas Charging Station

- **Electronic Leak Detector:** It is an electronic device whose basic function is to monitor for leaks in the piping system and shut down the pump when a leak is detected.

Fig1.22: Leak Detector

- Sound Level Meter (DB meter): Is device for measuring the intensity of noise, music, and other sounds. A typical meter consists of a microphone for picking up the sound and converting it into an electrical signal, followed by electronic circuitry for operating on this signal so that the desired characteristics can be measured.

Fig1.23: DB meter

- **Nitrogen Cylinder:** commonly used in the Air Conditioning / Refrigeration industry to purge moisture while repairing pipes.

Fig1.24: Nitrogen Cylinder

- **Double stage regulator:** designed to lower the high pressure in two stages. They require less readjustment and provide a more constant delivery pressure despite changes in inlet pressure. They are exceptionally well suited for high pressure cylinder applications.

Fig1.24: Double stage regulator

1.6. OHS requirement

OHS procedures for the installation of heat, ventilation and air conditioning (HVAC) systems vary depending on the specific job, but there are some general principles that should always be followed:

- Before starting any work, identify all potential hazards and implement appropriate controls techniques.
- Use appropriate PPEs
- Always use the correct tools and equipment for the job.
- If any work is required on refrigeration systems, you must be trained in the safe handling of refrigerants.
- If any work is required at heights, the trainee's must be trained in safe work practices and must use appropriate fall protection equipment.

- All workers should be familiar with the emergency procedures in place in case of an accident.
- Be aware of your surroundings and take precautions to avoid hazards, such as electrical wires, sharp edges, and tripping hazards.
- Communicate effectively with other workers, especially when working in teams.
- Take breaks and stay hydrated.
- If you are not confidential about any aspect of HVAC installation, always ask for help from a qualified professional.

Some specific examples of OHS procedures for common HVAC installation are:

- Always wear safety glasses and gloves when working with HVAC system.
- Be careful not to overtighten the refrigerant lines, as this can damage the unit.
- Make sure that the air conditioning unit is properly grounded.
- Be careful not to overtighten the gas lines, as this can damage the system.
- Make sure that the heating system is properly vented
- Test the HVAC system for leaks before putting it into operation.

Self-Check 1

I. Choice the best answer from the given alternatives

1. Which of the following is NOT a component of an HVAC system?
   A. Thermostat B. Heat exchanger C. Evaporator coil D. Compressor
2. Which type of HVAC system is the most common in residential and commercial buildings?
   A. Split system C. Packaged heating and cooling system
   B. Ductless mini-split system D. Heat pump
3. What is the purpose of the condenser coil in an HVAC system?
   A. To transfer heat from the air inside the building to the outside air
   B. To absorb heat from the air inside the building
   C. To release heat to the outside air
   D. To circulate the air through the heating and cooling equipment and the ductwork

4. What does HVAC stand for?
   A. Heating and Ventilation Control C. Heating, Ventilation, and Air Conditioning
   B. Heat and Ventilation Conditioning D. Heat and Ventilation Control
5. Which type of HVAC system is commonly used in residential buildings?
   A. Split system B. Packaged system C. Central system D. Geothermal system

II. <u>Explaine the following short answer questions short & presizily</u>

1. What is the purpose of an HVAC system?
2. What are the common types of HVAC systems and their applications?
3. What are the main components of an HVAC system?
4. What are the principles of heating, ventilation, and air conditioning?
5. What are some common tools, equipment, and materials used in HVAC installations?
6. What are some important OHS (Occupational Health and Safety) requirements for HVAC installations?

Operation sheet #1

Operation Title: <u>Identification of tools, equpments & materials with their application</u>

Instruction: Using white paper list the reqired materials, tools & equipments with their functions for installing HVAC system.

Purpose: When you have completed this Unit, the trainee should be able to identify materials, tools & equipments with their functions for installing HVAC system.

Required tools and equipment: unit one of this module, tools from workshops like Electrical boiler screwdrivers, wrenches, drills, saws, pipe, fittings, valves and measuring instrument,

Precautions:

- Safe handling of hand tools, testing instruments and components

Procedures:

Step 1: Properly identify Tools & equipments used to HVAC installation.

Step 2: Properly identify materials used to HVAC installation

Quality criteria: Reading the circuit properly, safety procedures were followed & all hand tools were cleaned

LAP Test # 1

Name: _____ Date: _____

Time started: _____ Time finished: _____

Instruction I: Given necessary templates, tools and materials you are required to perform the following tasks within 5 hours.

Task 1: Identification of tools, equpments & materials with their application

UNIT TWO: HVAC SYSTEMS INSTALLATION

This unit to provide you the necessary information regarding the following content coverage and topics:

- Selection wiring systems.
- Heating System Installation
- Ventilation System Installation
- Air Conditioning System Installation

This guide will also assist you to attain the learning outcomes stated in the cover page. Specifically, upon completion of this learning guide, you will be able to:

- Select wiring systems.
- Install Heating System
- Install Ventilation System
- Install Air Conditioning System

2.1. Selection of Wiring System for HVAC Systems

- A process of connecting various accessories for distribution of electrical energy from supplier's meter board to home appliances is known as Electrical Wiring. The wiring system selected will depend to a large extent on the types of service required. **Some common factors to be considered while choosing a particular Electrical Wiring System are:**
  - Cost of the Wiring System.
  - Type of Wires / Cables used.
  - Quality of the Wires.
  - Type of load (light, HVAC, motors etc.)
  - Safety of the Wiring System.
  - Possibility of future modifications / extensions.
  - Life of installation.
  - Construction of the building (wooden, concrete, brick and mortar, etc.)
  - Fire safety

- **Types of wiring system**
  - **Low-Voltage Control Wiring**: HVAC systems often require low-voltage control wiring to connect various components and enable communication between them. This wiring system typically uses low-voltage wires, usually 18-22 gauge, to transmit signals and control commands. The most commonly used wiring standard for low-voltage control is the thermostat wire, which consists of multiple color-coded conductors.
  - **Thermostat Wiring**: The thermostat wire connects the thermostat to the heating and cooling equipment. It carries signals such as temperature settings, mode selection (heating or cooling), and fan control. The standard thermostat wire consists of at least four conductors, each with its own color (commonly red, green, yellow, and white).

- **Line-Voltage Wiring/ Single-phase:** In addition to low-voltage control wiring, HVAC systems also require line-voltage wiring to power certain components. Line-voltage wiring carries higher voltage levels, typically 120 or 240 volts, and requires proper safety precautions during installation.
- **Power Supply Wiring:** This wiring connects the HVAC equipment to the electrical panel, delivering the necessary power to run the system. It typically involves larger gauge wires and may require the use of junction boxes, circuit breakers, and disconnect switches.
- **Motor Wiring:** HVAC systems often include motors for components such as fans, blowers, and compressors. Motor wiring connects these motors to the power supply and control devices, following specific wiring diagrams provided by the manufacturer.
- **Control Wiring:** Control wiring is used to connect control devices, such as relays, contactors, and switches, to the HVAC system. These devices help regulate the operation of various components and ensure proper sequencing and safety.

➢ To select the wiring systems for HVAC you shoud consider

- Types of HVAC system
- The size the home
- The energy efficiency needs
- The location of the system.

2.2. Heating System Installation

The installation of a heating system is a complex process that should be carried out by a qualified HVAC technician. However, here is a general overview of the steps involved

➢ **Plan the system**. The first step is to create a plan for the heating system. This will involve determining the type of system that is best suited for your home, as well as the size and location of the various components.

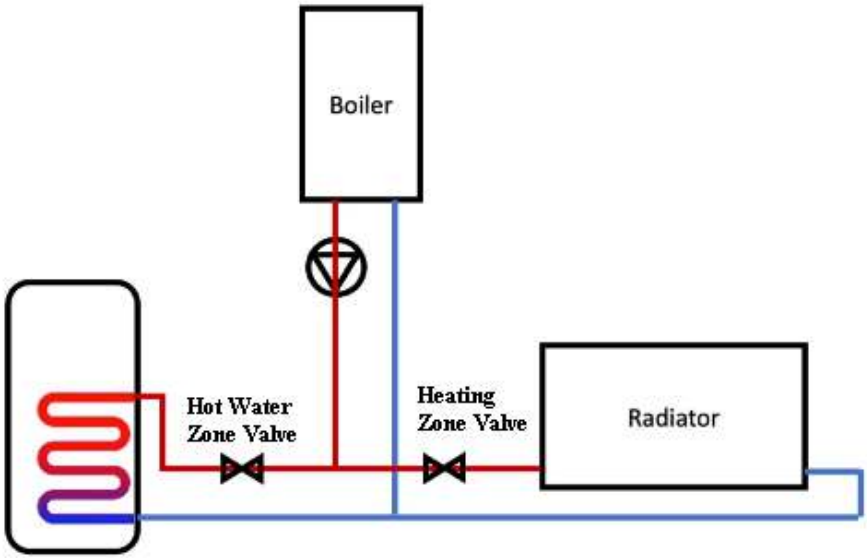


Fig 2.1: Plan system

- **Install the boiler.** The boiler is the heart of the heating system, and it is responsible for generating heat. If you are considering a new heating system for your home, a boiler installation may be just what you need. With so many options available, it's important to understand the process and what to expect.

Example

Electric Boiler: To connect an electric boiler, you will need to follow the wiring diagram that is provided with the boiler. The wiring diagram will show you how to connect the boiler to the electricity supply, as well as to the central heating system and any other components, such as a thermostat or a hot water cylinder. Understand the following procedures

1. Disconnect the electricity supply to the circuit that you will be connecting the boiler to.
2. Remove the cover from the boiler's terminal box.
3. Connect the wires from the electricity supply to the corresponding terminals on the boiler.
4. Connect the wires from the central heating system to the corresponding terminals on the boiler.
5. Connect any other wires, such as the thermostat wires or the hot water cylinder wires, to the corresponding terminals on the boiler.
6. Replace the cover on the boiler's terminal box.
7. Reconnect the electricity supply to the circuit.

8. Test the boiler to make sure that it is working properly.

240V & 120V AC Single Phase Single Element Thermostat Wiring Connection

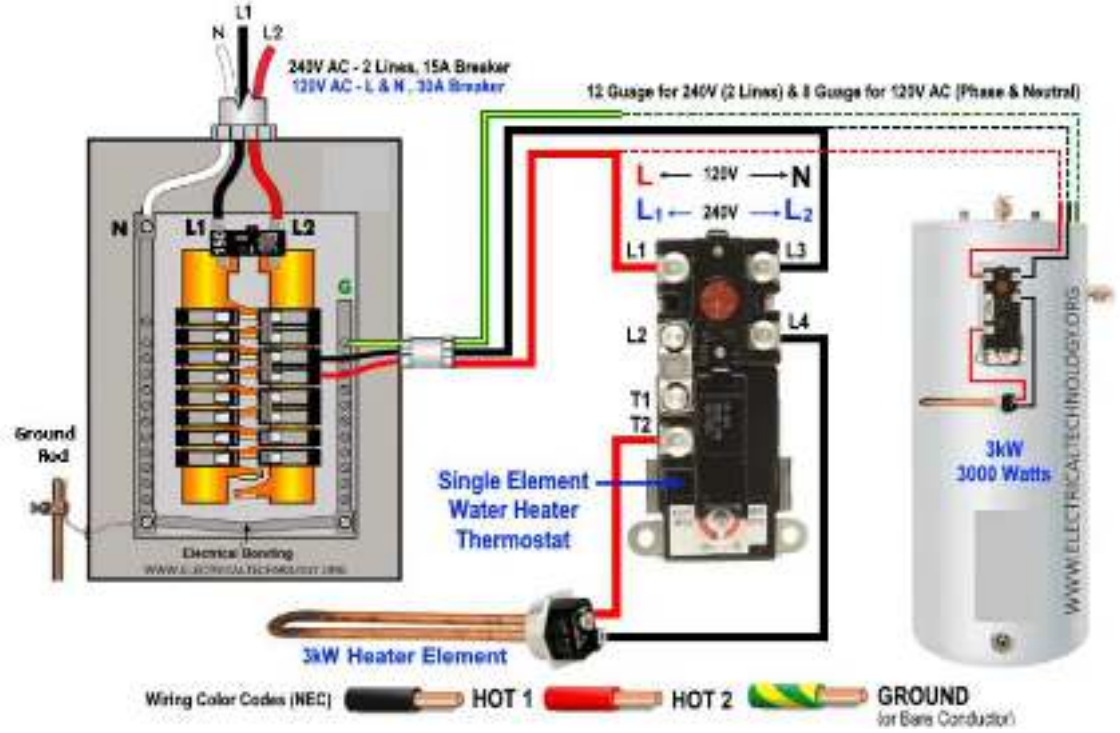


Fig 2.2: Single phase electric Boiler wiring connections

The same thermostat can be wired for both 120V AC (Line and Neutral) and 240V AC (two lines or phase wires). In the following water heater wiring diagram, a 3000 Watts single heating element is shown connected to 120V AC as well as 240V AC.

The wiring connections for both single phase 120V and 240V are the same i.e. the Line is connected to the L_1 terminal while neutral or second line is connected to the L_3 terminal. The water heater element is connected to the thermostat via T_2 as hot and L_4 as neutral. Black color is "Neutral" while red is "Phase or Line" and the yellow/green wire is used for ground / earth. The colors are used for showing the wiring connection purposes and it may vary according to the different areas and location. Please follow your own codes and regulations. For more details, see the footer note for wiring color codes and voltage levels of NEC and IEC.

In a 120V connection, the 3000 watts heating element draws 25A current, so 8 gauge wires for neutral and line have been used with a 30A breaker or fuse.

In 240V connection, the 3kW heater element draws 12.5A current, thus a 12 gauge wire for both lines and 15A over current protection circuit breakers can be used.

- **Install the radiators**. Radiators are the devices that distribute heat throughout the home. They are typically installed in each room of the home, and they are connected to the boiler by pipes.

Gravity hot water controlled by a 6 wire valve (not your standard 5 wire valve) and a pumped central heating circuit controlled by a thermostat.

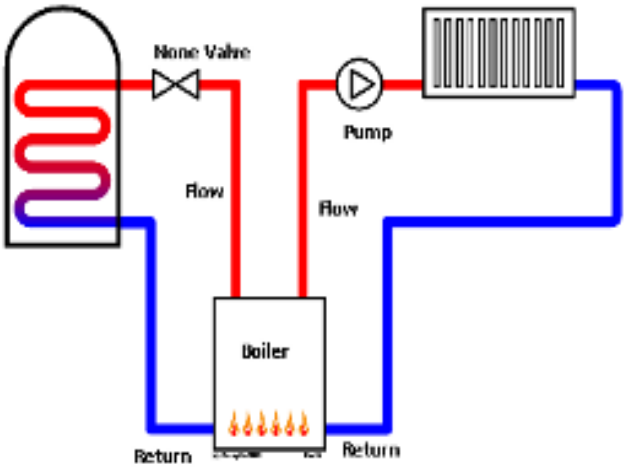


Fig 2.2: Schematic diagram

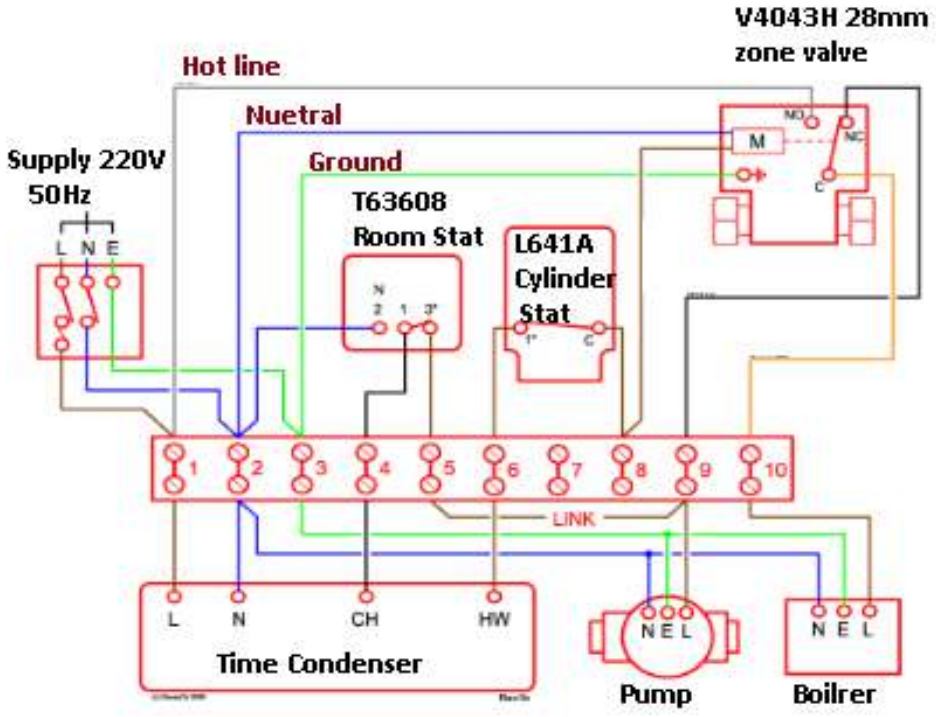


Fig 2.2: Wiring diagram

- **Lay the pipes**. The pipes that connect the boiler to the radiators are typically laid in the walls or floors of the home

- **Install the controls.** The heating system is controlled by a thermostat, which allows you to set the desired temperature for your home. The thermostat is typically installed on a wall in a central location.

230V, 240V & 120V AC Single Element Thermostat Wiring Diagram

The following water heater diagram shows different connections i.e. single phase 120V AC and 240V two phases in USA (NEC) while single phase 230V AC in UK and EU (IEC).

In the first case, a 2.8kW single element water heater is connected to the 120V AC (Line and Neutral) which draws 23.33 amp current.

In case of 120V AC single phase (Line and Neutral), 8 gauge wires are used with a 30 amp circuit breaker and a single way (SPST = Single Pole Single Throw) switch having 30A rated current and the safe limit of current is 24A (30A x 80%). In other words, 23A x 1.25 = 28.75. The nearest rating is 30A breaker which is suitable to use in a 120V, 2800 Watts water heater.

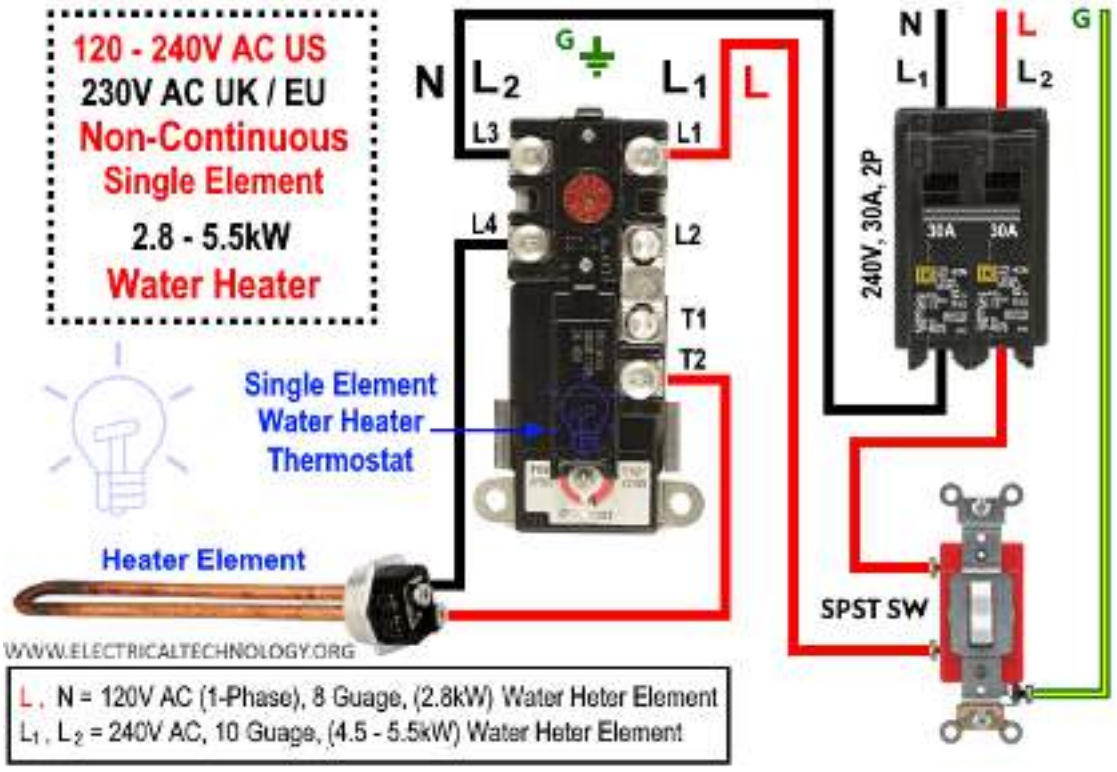


Fig 2.3: Single element water heator & Thermostat

In case of 240V AC (US) or 230V AC (EU / UK), a 5.5kW single element water heater is connected to the supply voltage through a 30A breaker and single way switch where the element circuit draws 22.91A in 240V two lines and 23.91A in 230V line and neutral.

The wiring connection is the same despite both wires connected to the L_1 and L_3 are two hot lines in case of 240V AC while the L_1 is Hot and L_3 is Neutral in case of 230V AC. For 22.91A or 23.91A, a 10 gauge wire is suitable with a 30A switch and protection circuit breaker as shown in the wiring diagram.

- **Test the system**. Once the system is installed, it is important to test it to make sure that it is working properly. This involves turning on the boiler and checking the radiators to make sure that they are getting hot.

Importante Notes

- A dual element thermostat can be used for a single element water heater.
- A single element thermostat can't be used for a double element water heater.
- A single element thermostat can only be used for dual elements in case of simultaneous (continuous) operation of redundant elements which need different wiring connections (we will show in the next posts of this series).
- A 240V AC water heater element can be connected to the 120V AC.
- A 120V AC water heater element can't be used for 240 or 230V.
- An upper thermostat of 240V can't be used with a single element water heater as the single element thermostat looks similar to the upper thermostat of dual element thermostat. Care must be taken for replacing the appropriate thermostat.
- 30A Breaker and 10 gauge wire can be used on 240V AC water heater
- A switch rated for 15A, 120V can be used on 20A, 120V circuit.
- A switch rated for 20A, 120V can't be used on household 15A, 120V circuits.
- A switch rated for 120V can't be used on 240V circuits and vice versa.
- A 240V switch can be used on a 120V circuit if the ampere rating is the same.
- A 120V switch can't be used on 240V circuit even if current rating in amperes are the same.

- An oversized breaker used for protection can damage the water heater or other connected appliances and even lead to the fire due to overheat.
- An oversized switch is OK but lower rating than the load current can melt the switch contacts.
- An undersized breaker or same rating with load current breaker can trip and reset the circuit again and again. Use the correct size breaker.

2.3. Ventilation System Installation

To connect an electric ventilation system, you will need to follow the wiring diagram that is provided with the system. The wiring diagram will show you how to connect the system to the electricity supply, as well as to the ventilation fans and any other components, such as a thermostat or a humidity sensor.

➢ **Main components of Vantilation**

- **Ventilation fan**: It is the main component of the system and is responsible for moving air through the ducts.
- **Ductwork:** It is the system of pipes that carry the air from the ventilation fan to the different rooms in the house.
- **Thermostat:** It controls the operation of the ventilation fan.
- **Humidity sensor:** It controls the operation of the ventilation fan. It turns the fan on when the humidity in the house rises above a certain set point and turns it off when the humidity drops below the set point.
- **Electrical panel**: It contains the circuit breakers that protect the ventilation system from electrical overload.

➢ **Procedures to install Ventilation systems**

- Disconnect the electricity supply to the circuit that you will be connecting the system to.
- Remove the cover from the ventilation system's terminal box.
- Connect the wires from the electricity supply to the corresponding terminals on the ventilation system.
- Connect the wires from the ventilation fans to the corresponding terminals on the ventilation system.

- Connect any other wires, such as the thermostat wires or the humidity sensor wires, to the corresponding terminals on the ventilation system.
- Replace the cover on the ventilation system's terminal box.
- Reconnect the electricity supply to the circuit.
- Test the ventilation system to make sure that it is working properly.

Example

a. Exhaust Fan Installation:

Fig 2.4: exhaust Fan

Instructions

- Choose a location for the exhaust fan. The fan should be installed in a high location, such as on the ceiling or in the upper wall. It should also be located near a window or door so that the exhaust air can be vented outside.

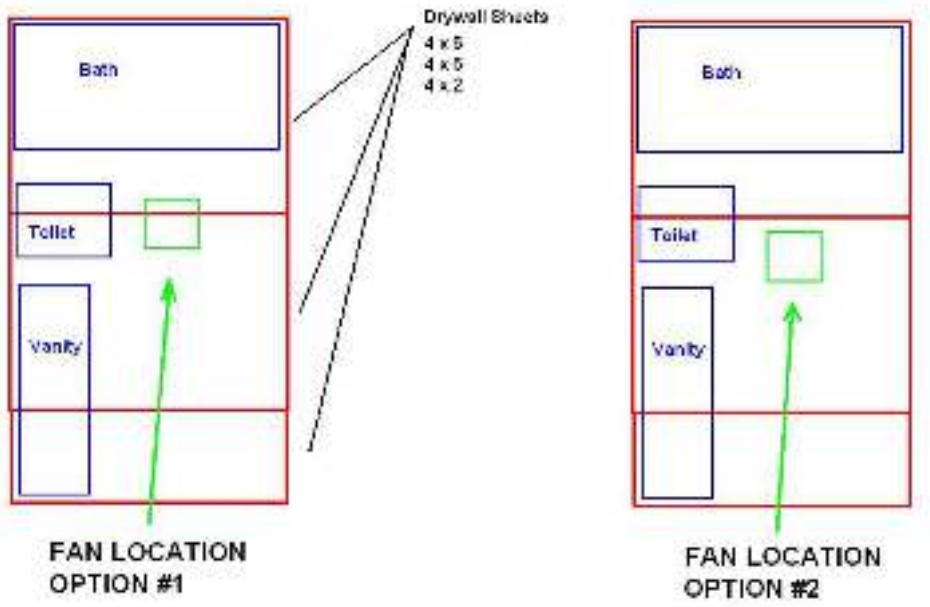


Fig 2.5: select exhaust Fan location

- Mark the location of the exhaust fan on the ceiling or wall. Use a level to make sure that the fan will be installed straight.
- Cut a hole in the ceiling or wall for the exhaust fan. The hole should be slightly larger than the fan so that there is room for the ductwork.
- Install the exhaust fan in the hole. Secure the fan to the ceiling or wall using screws.

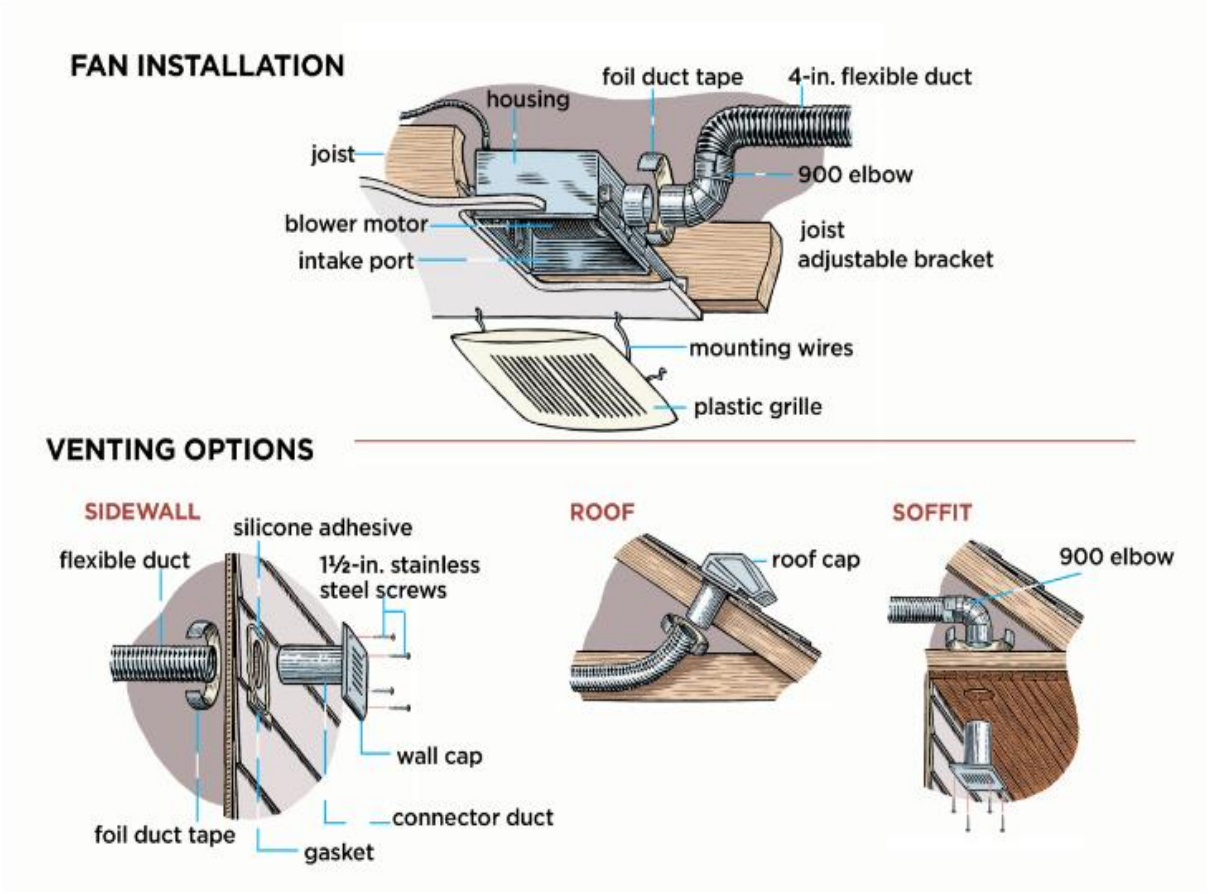


Fig 2.5: installations 0f exhaust Fan location

- Attach the ductwork to the exhaust fan. Use duct tape to seal the joints between the ductwork and the fan.

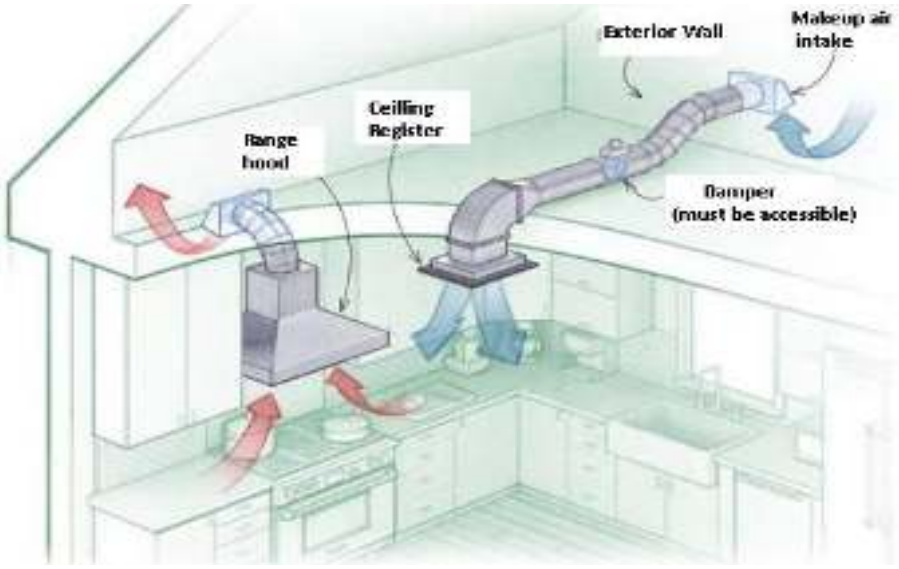


Fig 2.6: Attach the ductwork

- Run the ductwork to a window or door. Use duct tape to seal the joints between the ductwork and the window or door.
- Connect the exhaust fan to the electrical supply. Be sure to follow the manufacturer's instructions for wiring the fan.

Fig 2.7: connection

- Test the exhaust fan to make sure that it is working properly. Turn on the fan and check to make sure that the air is being vented outside.

- Install any necessary control switches or timers, wiring them according to the manufacturer's instructions.

b. Mechanical Ventilation System Installation:

- Determine the most suitable location for the ventilation unit, which is often placed in an attic, basement, or dedicated mechanical room.
- Install the unit by securing it to the wall or ceiling, following the manufacturer's guidelines.
- Connect the fresh air intake duct to an outdoor opening, ensuring proper sealing and protection from weather elements.
- Install the supply ducts to distribute fresh air throughout the space, and install the exhaust ducts to remove stale air.
- Connect the ventilation unit to the electrical supply and install any control switches or panels as required.

c. Test and Inspect: Once the installation is complete, it's essential to test and inspect the ventilation system to ensure proper operation and safety. This includes checking fan functionality, verifying airflow, and ensuring control switches are working correctly.

2.4. Air Conditioning System Installation

Air conditioning system installation is the process of putting in a system that cools and dehumidifies the air in a building. Air conditioning systems are important because they help to keep people comfortable and healthy in hot and humid climates.

1. Assess Cooling Needs.
2. Choose the Air Conditioning System: Based on your assessment, select the most suitable air conditioning system for the space.
    - Split System Air Conditioners: is suitable for cooling individual rooms or small spaces.
    - Central Air Conditioning Systems: a central unit to connects to a network of ducts to distribute cool air.
    - Ductless Mini-Split Systems: Ductless systems are similar to split systems but do not require ductwork.

3. Gather Tools and Materials
4. Prepare the Installation Area
5. Install the Air Conditioning System Components:

➢ **Split System Air Conditioner Installation:**

- Position the outdoor unit (condenser) in a suitable location outside, considering noise, airflow, and accessibility.
- Connect the refrigerant lines between the indoor and outdoor units, ensuring proper insulation and leak-free connections.
- Install the necessary electrical wiring, following safety guidelines and the manufacturer's instructions.
- Connect the indoor and outdoor units according to the provided diagrams and secure all connections.
- Install the necessary control switches or panels, wiring them appropriately

Example

1. Setting up the Indoor Unit

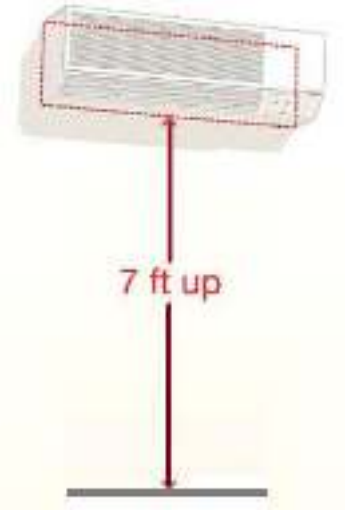


Fig 2.8: Setting up the Indoor Unit

➢ Select an unobstructed location on your interior wall to mount the indoor unit.

Mount the unit 7 feet (2.1 m) off the floor and ensure there’s at least 6–12 inches (15–30 cm) of open space on every side of the unit to allow for proper airflow.[1]

- Choose a location with studs to ensure the wall is strong enough to hold the weight of the unit.
- Install the unit at least 3.3 feet (1.0 m) away from antennas and power or connecting lines that are used for television, radio, home security systems, intercoms, or telephones. The electrical noise from these sources could cause operational problems for your air conditioner.
- Avoid locations where gas may leak or where oil mist or sulfur exists.
- Most of these units have remote controls so that you can easily turn them on or off and adjust the temperature even if they're mounted high on the wall.

Fig 2.9.: Select an unobstructed location

➢ **Secure the mounting plate to the interior wall.**

Hold the mounting plate against the wall where you want to install the indoor unit. Use a level to make sure it is both horizontally and vertically level. Use a pencil to mark the locations of the screw holes, remove the plate, then drill a hole into the wall where each screw will go.

- Position the plate so it matches up with the holes, insert plastic anchors into the holes, and secure the plate to the wall with tapping screws.

➢ **Drill a 3 in (7.6 cm) hole through the wall so you can feed the pipes outside.**

Make a mark in the center of the hole in the mounting plate. Use a keyhole saw or a drill with a hole-cutting attachment to create a circular 3 in (7.6 cm) opening through the wall that slopes slightly downward toward the ground to ensure adequate drainage.

- Make sure there are no pipes or wires behind the wall before drilling or cutting the hole.

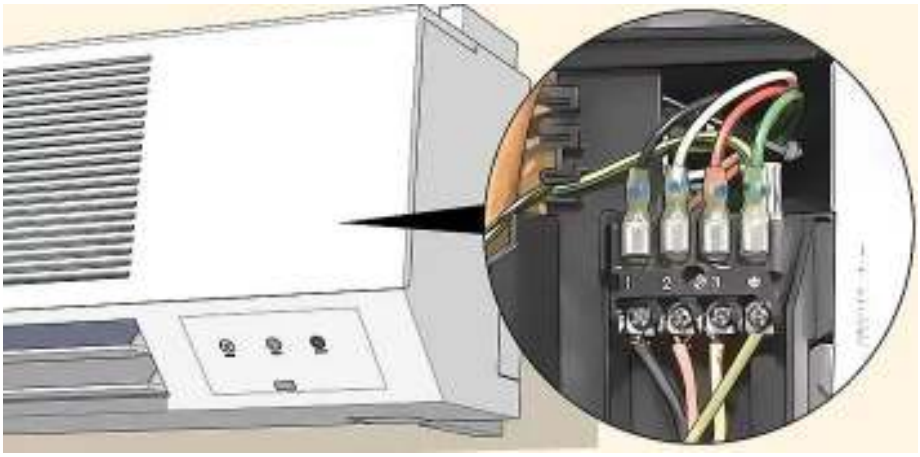


Fig 2.10.: connection terminals to outdoor

- **Check the electrical connections on the indoor unit.** Lift the A/C unit's front panel and remove the cover. Make sure the cable wires are connected to the screw terminals and that the wiring matches the diagram that came with the unit.

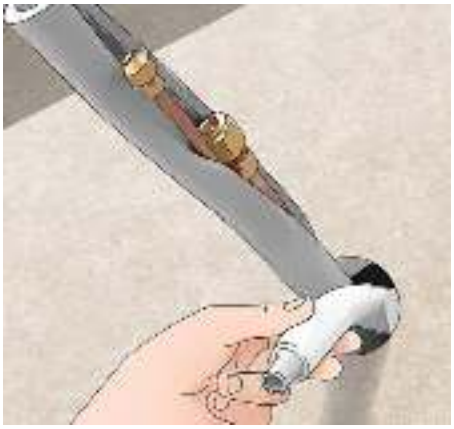


Fig 2.11.: Checking the electrical connections

- **Run the pipes and cables through the hole in the wall, then connect them to the unit.** Secure the included copper pipes, power cable, and drain pipe together with electrical tape. Place the drain pipe on the bottom to ensure a free flow of water. Run the pipes and cable through the hole in the wall, then secure them to the designated spots on the indoor unit as directed by the instruction manual.
  - Each line comes pre-insulated, so you don't have to worry about adding extra insulation.
  - Do your best to minimize how much the pipes and cable bend to ensure that the unit performs well.

- Make sure that the drainage pipe allows water to drain in an appropriate place. See the instruction manual included with your kit for more information.

Fig 2.12.: Run the pipes and cables

➢ **Secure the indoor unit to the mounting plate.**

To attach the air conditioner to the wall, simply align the female connections on the back of the unit with the male connections on the mounting plate and press firmly to secure the unit in place. Make sure the unit tilts backward 2-3 degrees so that water can flow out of the drain pipe. It may help to have a friend hold the unit in place while you secure the connections.

2. Installing the Outdoor Condenser

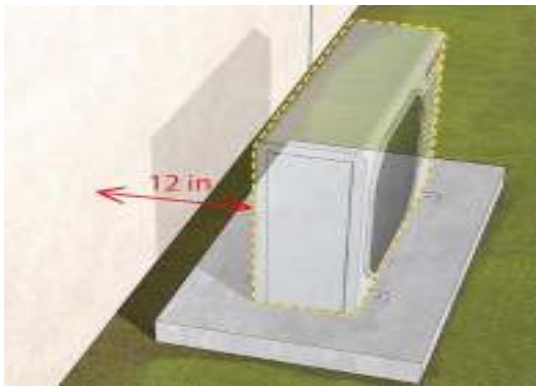


Fig 2.13.: outdoor condencer installation

➢ **Position the outdoor unit away from any heavily trafficked, dusty, or hot areas.**

Find the hole you drilled through the mounting plate for the interior unit and position the exterior unit within 50 feet (15 m) so the piping and cable can easily be attached. Choose a location with at least 12 inches (30 cm) of space surrounding its perimeter to ensure proper functioning. If possible, select a shady location that's sheltered from the wind in addition to dust and traffic to keep your unit functioning at its best.

Make sure that no antenna of a radio or television is within 10 feet (3.0 m) of the outdoor condenser.

- **Lay a concrete pad on the ground.**

Don't place the outdoor unit directly on the wall as it's heavy and can shift around on dirt or rocks. It's necessary to install the condenser on a concrete pad, which you can find at home improvement stores. Position the pad where you want to install the unit and use a level to make sure it's flat and even

Fig 2.14.: Laying aconcrete pad

- **Secure the outdoor unit on top of the concrete pad.** Lay a rubber cushion on top of the pad to minimize vibration, then set the outdoor condenser unit on top of the pad. Secure the unit to the concrete with anchor bolts.

Fig 2.15.: Laying aconcrete pad

Split Air Conditioner Connection: Indoor fed Outdoor

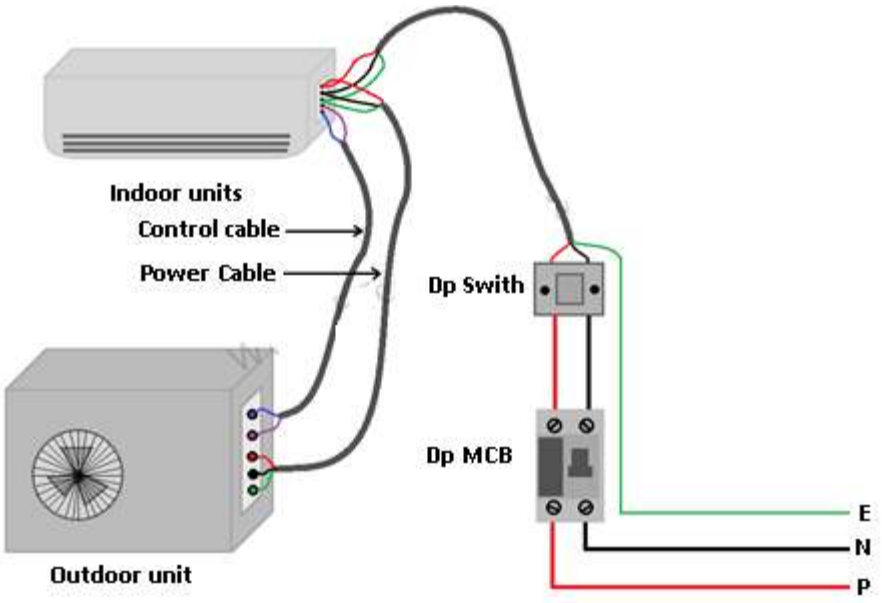


Fig 2.16.: Indoor fed Outdoor

As you see in the above figure, first the power supply comes from the main distribution board and goes to the double pole MCB. After MCB, the supply goes to the double pole switch. After the switch, the power cable of the Air Conditioner starts.

The power cable of the Air Conditioner contains three wires that are Phase wire, Neutral wire, and Earth Wire.

There are two cables are connected between the outdoor unit and indoor unit of Split A/C. The control cable contains two wires and the power cable contains three wires. Here as the power lines first goes to the indoor unit and the power supply is given to the outdoor unit from the indoor unit that is why it is called indoor fed outdoor.

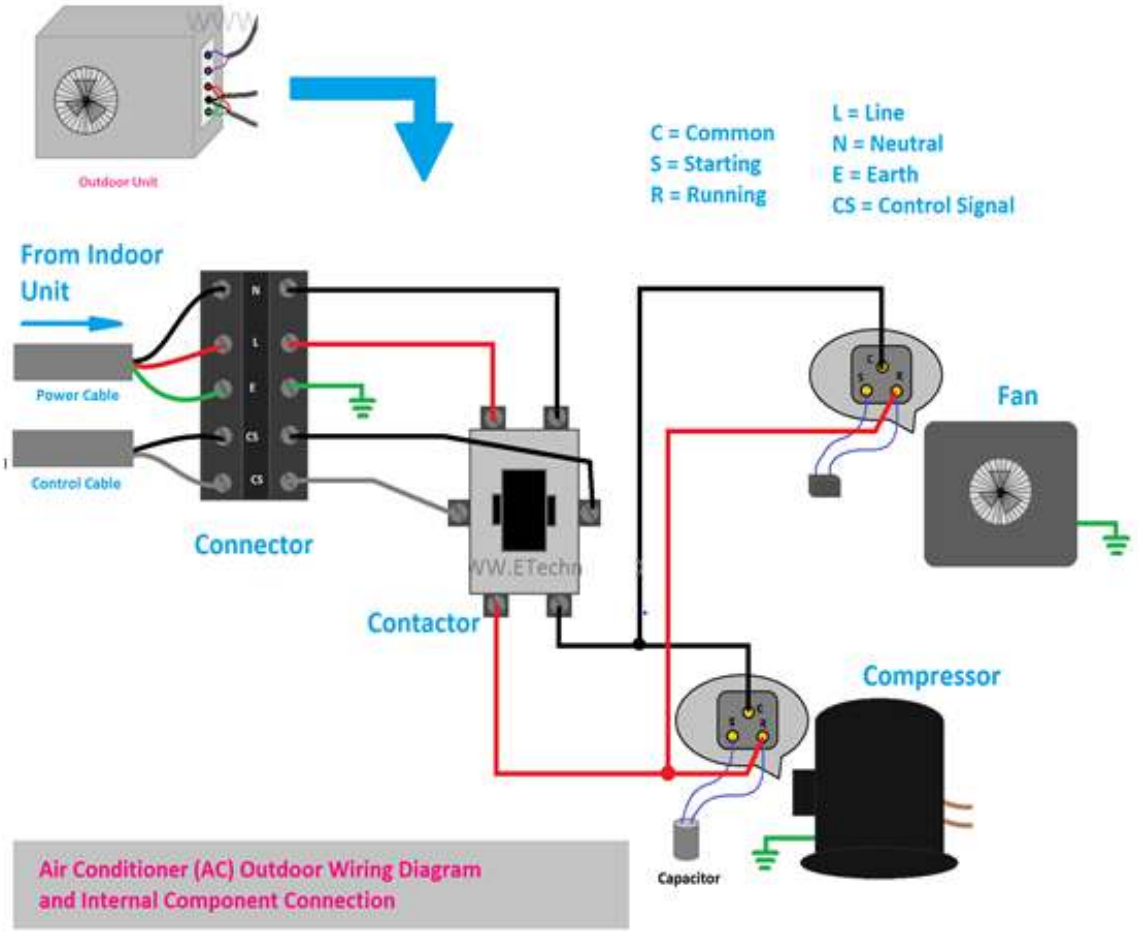


Fig 2.17.: Indoor fed Outdoor

Connection of Air Conditioner: Outdoor fed Indoor

Here the power lines from the double pole switch first go to the outdoor unit and then the power supply is given to the indoor unit from the outdoor unit.

Window Air Conditioner Wiring

Window air conditioner wiring is very simple. The power cable contains three wires(Phase wire, Neutral wire, Earth wire) which are going to the window A/C from the double pole switch.

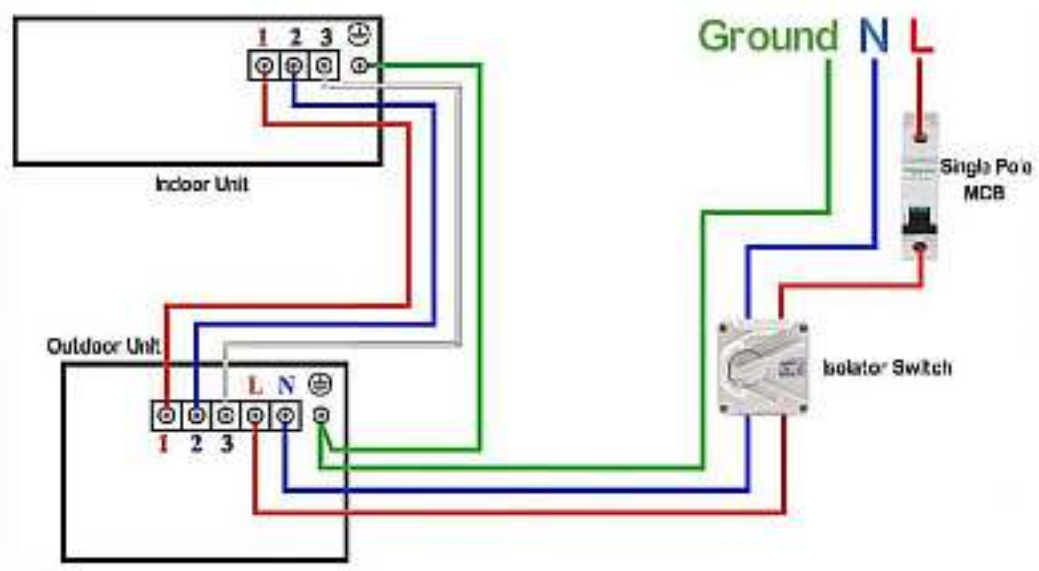


Fig 2.18: Wiring diagrams of Split System Air Conditioner

Self-Check # 2

I. Choice the best answer from the given alternatives

1. Which of the following is NOT a type of wiring system?
   A. Cleat wiring system B. Conduit wiring system
   C. Sheathed cable wiring system D. Central heating system
2. What is the purpose of a heating system?
   A. To provide hot water for domestic use
   B. B. To provide warm air for heating a building
   C. To provide cool air for cooling a building D. All of the above
3. What is the purpose of a ventilation system?
   A.To provide fresh air to a building
   B. To remove stale air from a building
   C. To control the temperature and humidity in a building D. All of the above
4. What is the purpose of an air conditioning system?
   A. To provide cool air for cooling a building
   B. To control the humidity in a building
   C. To improve indoor air quality D. All of the above
5. Which of the following is NOT a type of heating system?
   A. Central heating system C. Space heating system
   B. Solar heating system D Ventilation system

II. Match column "B" to Column "A"

A	B
1. _____Split system	A. Uses a network of pipes under the floor to heat the space
2. _____ Packaged system	B. Utilizes a heat pump to transfer heat from the air or ground
3. _____ Radiant floor heating	C. Uses an outdoor unit and indoor unit connected by refrigerant lines

4. _____ Heat pump system
5. _____ Ventilation fan

D. Transports air between the HVAC system and different spaces
E. Contains all components in a single unit installed outside the building
F. Extracts stale air and brings in fresh air

III Explaine the following short answer questions short & presizily

1. What are the factors to consider when choosing a wiring system for a building?
2. What is a common method used for heating system installation?
3. What role does an air handler play in a ventilation system installation?
4. What is a split system in the context of air conditioning system installation?

Operation Sheet # 2

Operation Title: **Install Heating system**

Instruction: Using flip chart draw the wiring diagrams of heating system

Purpose: When you have completed this Unit, the trainee should be able to install the heating systems.

Required tools and equipment: unit one of this module, tools from workshops like Electrical boiler screwdrivers, wrenches, drills, saws, pipe, fittings, valves and measuring instrument,

Precautions:

- Before starting the installation, make sure to turn off the power supply.
- Wear appropriate PPES & use the appropriate tools and equipment for the installation.
- Follow Manufacturer's Instructions and Handl the fuel properly because the heating system uses fuel, such as natural gas, oil, or propane, handle it with care

Procedures:

1. Select the required tools, equipments and materials.
2. Determine the right heating Location based on EBCS standards.
3. Prepare the Installation Area
4. Calculate Heating Load based on EBCS standards
5. Shut Off Power and Water Supply.
6. Mount Heating System Components.
7. Install Electrical Wiring systems based on EBCS standards.
8. Connect Water Supply.
9. Install Controls and Thermostats
10. Perform Inspection and Testing its functionalities

Quality criteria: Reading the circuit properly, follow safety procedures & installation procedures

Operation Sheet # 3

Operation Title: Install Ventilation system

Instruction: Using flip chart draw the wiring diagrams of ventilation system

Purpose: When you have completed this Unit, the trainee should be able to install the ventilation systems.

Required tools and equipment: unit one of this module, tools from workshops like Electrical boiler screwdrivers, wrenches, drills, saws, pipe, fittings, valves and measuring instrument,

Precautions:

- Before starting the installation, make sure to turn off the power supply.
- Wear appropriate PPES & use the appropriate tools and equipment for the installation.
- Follow Manufacturer's Instructions

Procedures:

1. Select the required tools, equipments and materials.
2. Determine the right heating Location based on EBCS standards.
3. Prepare the Installation Area
4. Shut off the power to the area where the ventilator will be installedMount Heating System Components.
5. Install Electrical Wiring systems based on EBCS standards.
6. Install Ductwork
7. Connect Intake and Exhaust Vents
8. Install Controls and Switches
9. Perform Inspection and Testing its functionalities

Quality criteria: Reading the circuit properly, follow safety procedures & installation procedures

Operation Sheet # 4

Operation Title: Install air conditioning system

Instruction: Using flip chart draw the wiring diagrams of air conditioning system

Purpose: When you have completed this Unit, the trainee should be able to install the air conditioning systems.

Required tools and equipment: unit one of this module, tools from workshops like Electrical boiler screwdrivers, wrenches, drills, saws, pipe, fittings, valves and measuring instrument,

Precautions:

- Before starting the installation, make sure to turn off the power supply.
- Wear appropriate PPES & use the appropriate tools and equipment for the installation.
- Follow Manufacturer's Instructions

Procedures:

1. Select the required tools, equipments and materials.
2. Determine the right heating Location based on EBCS standards.
3. Prepare the Installation Area
4. Install Mounting Brackets (for Window or Through-the-Wall Units).
5. Install Electrical Wiring systems based on EBCS standards.
6. Install the Air Conditioner
7. Connect the Refrigerant Lines (for Split Systems)
8. Connect the Thermostat and Controls
9. Perform Inspection and Testing its functionalities

Quality criteria: Reading the circuit properly, follow safety procedures & installation procedures

LAP Test # 2

Name: _____ Date: _____

Time started: _____ Time finished: _____

Instruction I: Given necessary templates, tools and materials you are required to perform the following tasks within 15 hours.

Task 1: Install an electrical heating system

Task 1: Install an electrical Ventilation system

Task 1: Install an electrical air conditioning system

UNIT THREE: HVAC SYSTEMS MAINTENANCE

This unit is developed to provide you the necessary information regarding the following content coverage and topics:

- Maintenance schedule
- Common HVAC problems
- Maintenance procedure
- Electrical systems commissioning and inspection.
- Cleaning and storing tools, equipment and surplus materials

This unit will also assist you to attain the learning outcomes stated in the cover page.

Specifically, upon completion of this learning guide, you will be able to:

- Prepare maintenance schedule
- Identify common HVAC problems
- Apply maintenance procedure
- Apply electrical systems commissioning and inspection.
- Cleaning and storing tools, equipment and surplus materials

3.1. Maintenance schedule

- Maintenance scheduling is planned work that includes the who, what, when, and where of tasks. Maintenance planning is a process that helps you identify and solve potential problems before they get out of hand.
- HVAC maintenance is a critical part of keeping your heating, ventilation, and air conditioning system running efficiently and effectively. It can help to:
  - Extend the life of your HVAC system
  - Reduce energy costs
  - Improve indoor air quality
  - Prevent costly repairs
- The specific maintenance schedule for HVAC system will vary depending on the type of system you have and how often you use it. However, there are some general guidelines that you can follow:

a. Monthly:

- Check and replace air filters.

  Example: if you have a central HVAC system with disposable filters, you might use 1-inch pleated filters that need replacement when they become visibly dirty or every 1-3 months.
- Inspect and clean outdoor condenser unit
- Inspect indoor vents and registers
- Test the thermostat to ensure proper operation.

b. Quarterly:

- Inspect and clean blower assembly

  Example: clean the blower fan, motor and assembly using a soft brush or vacuum cleaner to ensure proper airflow and efficiency.
- Check and clean evaporator and condenser coils:
- Inspect and clean condensate drain
- Clean the drain lines and pans.
- Lubricate moving parts.

c. Bi-Annual

- Schedule professional maintenance
- Check and adjust thermostat settings

d. Annually:

- Ductwork inspection
- Lubricate moving parts
- Test system performance
- Carbon monoxide (CO) detector check

3.2. Common HVAC problems

Common HVAC problems can vary depending on the specific system and its age, but some issues tend to occur more frequently. Here are a few common problems:

A. **Airflow issues**: Restricted or inadequate airflow can result in poor cooling or heating performance. This can be caused by clogged filters, blocked vents, or malfunctioning fans.

B. **Thermostat problems**: Faulty thermostats can lead to inaccurate temperature readings or improper system operation. This can result in discomfort and energy inefficiency.

C. **Refrigerant leaks:** Leaking refrigerant can cause your HVAC system to lose cooling capacity and may lead to increased energy consumption. It's important to address refrigerant leaks promptly to prevent further damage.

D. **Electrical malfunctions**: Electrical issues, such as faulty wiring or blown fuses, can disrupt the operation of your HVAC system. These problems may require professional assistance to diagnose and repair.

E. **Compressor failures**: The compressor is a vital component of an HVAC system, and its failure can result in a complete system breakdown. Compressor issues can be caused by electrical problems, refrigerant leaks, or general wear and tear.

3.3. Maintenance procedure

A maintenance procedure is a set of steps or actions that need to be followed in order to properly maintain and care for a particular item, system, or equipment. The purpose of a maintenance procedure is to ensure that the item or equipment remains in good working condition, prevent breakdowns or malfunctions, and extend its lifespan.

- General maintenance procedure:
  - Identify the item or equipment: Clearly identify the specific item or equipment that requires maintenance.
  - Determine the maintenance schedule: Determine how often the maintenance should be performed. This can be based on manufacturer recommendations, industry standards, or specific requirements.
  - Gather necessary tools and materials: Identify and gather all the tools, materials, and resources needed to perform the maintenance procedure. This may include specialized tools, lubricants, cleaning agents, replacement parts, etc.
  - Prepare the work area: Ensure that the work area is clean, organized, and safe for performing the maintenance procedure. Remove any obstacles or hazards that may interfere with the process.
  - Follow safety protocols: Before starting any maintenance procedure, it is important to follow all safety protocols and guidelines. This may include wearing personal protective equipment (PPE), shutting off power sources, locking out machinery, etc.
  - Perform visual inspection: Conduct a visual inspection of the item or equipment to identify any visible signs of damage, wear and tear, leaks, loose connections, etc.
  - Clean and lubricate: Clean all accessible parts of the item or equipment using appropriate cleaning agents and methods. Lubricate moving parts as per manufacturer recommendations.
  - Check fluid levels: Check fluid levels such as oil, coolant, hydraulic fluid, etc., and top up if necessary.

- Test functionality: Test the functionality of the item or equipment by operating it according to its intended use. Check for any abnormal noises, vibrations, leaks, or other issues.
- Record observations: Document any observations, findings, or issues encountered during the maintenance procedure. This information can be used for future reference and to track the item's condition over time.
- Replace or repair parts: If any damaged or worn-out parts are identified during the maintenance procedure, they should be replaced or repaired as necessary.
- Reassemble and restore: Once the maintenance procedure is complete, reassemble any disassembled parts and restore the item or equipment to its normal operating condition.
- Clean up: Clean up the work area, dispose of any waste materials properly, and return tools and

3.4. Electrical systems commissioning and inspection.

Electrical systems commissioning and inspection is the process of ensuring that electrical systems in a building or facility are installed, tested, and functioning correctly. This process involves various steps to verify that the electrical systems meet safety standards, comply with regulations, and perform as intended.

Commissioning typically begins during the design phase of a project and continues through construction and into the operational phase. It involves a series of inspections, tests, and documentation to ensure that all electrical components are properly installed, connected, and functioning as per design specifications.

A. Pre-commissioning preparation:

Review design documents and specifications to understand the intended functionality of the electrical system.

- Verify that all necessary permits and approvals are obtained.
- Gather relevant documentation, including equipment manuals, test reports, and as-built drawings.

B. Visual inspection

- Inspect the electrical system components, such as panels, switches, breakers, transformers, wiring, grounding systems, etc., for proper installation and compliance with codes and standards.
- Check for any visible signs of damage or defects.

C. Functional testing

- Test the operation of individual electrical components to ensure they function as intended.
- Verify proper functioning of circuit breakers, switches, relays, motor control centers (MCCs), emergency power systems, etc.
- Conduct load testing to ensure that the system can handle expected electrical loads.

D. Grounding and bonding verification

- Inspect grounding electrodes and connections to ensure proper grounding and bonding practices are followed.
- Measure ground resistance to confirm compliance with requirements.

E. Protection device testing

- Test protective devices such as circuit breakers, fuses, ground fault circuit interrupters (GFCIs), surge protectors, etc., to verify their correct operation.
- Ensure that protection devices are set at appropriate levels for overcurrent protection.

F. Power quality analysis

- Conduct power quality measurements to assess voltage levels, harmonics, power factor, etc., and compare them against acceptable limits.
- Identify any issues affecting power quality and recommend corrective actions if necessary.

G. Documentation and reporting

- Document all findings, observations, and test results during the commissioning and inspection process.
- Prepare a comprehensive report summarizing the condition of the electrical system, any deficiencies found, and recommendations for corrective actions.

H. Corrective actions

- Address any identified deficiencies or non-compliance issues promptly.
- Coordinate with contractors or electricians to rectify problems and ensure compliance with codes and standards.

I. Final verification

- Conduct a final inspection to verify that all corrective actions have been completed satisfactor

3.5. Cleaning and storing tools, equipment and surplus materials

The proper cleaning and storage of tools, equipment, and surplus materials is essential for maintaining their condition, extending their lifespan, and ensuring safety in the workplace. Here are some professional tips:

Cleaning

- Clean tools and equipment immediately after use. This will remove dirt, dust, and other debris that can cause corrosion or damage.
- Use the appropriate cleaning products for the type of tool or equipment you are cleaning. For example, you may need to use a degreaser to clean oily tools or a disinfectant to clean tools that have been used to handle food.
- Pay attention to detail. Be sure to clean all parts of the tool or equipment, including the handles, cords, and attachments.
- Dry tools and equipment thoroughly before storing them. This will help to prevent rust and corrosion.

Storage

- Store tools and equipment in a dry, well-ventilated area. Avoid storing tools and equipment in damp areas or in direct sunlight.
- Organize tools and equipment so that they are easy to find and use. This will help to prevent accidents and injuries.
- Store tools and equipment in a secure location. This will help to prevent theft and damage.
- Use appropriate storage containers for tools and equipment. For example, store sharp tools in a sheath or scabbard to prevent accidental injuries.
- Store surplus materials in a way that prevents them from becoming damaged or lost. This may involve storing them in a secure location or labeling them clearly.

Self-Check # 3

I. Choice the best answer from the given alternatives

1. What is the most common HVAC problem?
   A. Dirty air filter C. Clogged condensate line
   B. Refrigerant leak D. Broken fan E. All of the above
2. What is the best way to clean an HVAC air filter?
   A. Vacuum it C. Replace it with a new one
   B. Wash it with water and soap D. All of the above
3. What is the best way to store surplus HVAC materials?
   A. In a dry, cool place C. Away from direct sunlight
   B. In a well-ventilated area D. All of the above

II. Match column "B" to Column "A"

A	B
1. _____ Dirty air filter	A. Warm air coming from the vents
2. _____ Refrigerant leak	B. Reduced airflow
3. _____Broken fan	C. Increased energy bills
4. _____ Testing of circuit breakers	D. Safety inspection
5. _____ Visual inspection of wiring	E. Functional testing
6. _____ Measurement of voltage and current	
7. _____Operation of switches and outlets	

III Explaine the following short answer questions short & presizily

1. What are the benefits of having a regular HVAC maintenance schedule?
2. What are the benefits of having a regular HVAC maintenance schedule?
3. What are the benefits of having a regular HVAC maintenance schedule?

Operation Sheet # 5

Operation Title: maintain Heating system installation problem

Instruction:

Purpose: When you have completed this Unit, the trainee should be able to maintain the heating systems.

Required tools and equipment: unit one of this module, tools from workshops like screwdrivers, wrenches, , Flashlight, Wire brush,Vacuum cleane and measuring instrument

Precautions:

- Always turn off the heating system and disconnect the power before inspecting or cleaning the heating element.
- Be careful not to touch the heating element with your bare hands, as it may be hot even after the system has been turned off.
- Wear safety glasses when inspecting or cleaning the heating element.

Procedures:

1. Select the required tools, equipments and materials.
2. Locate the heating element.
3. Remove the access panel to the heating element.
4. Inspect & carefully clean the heating element form dirt, debris and corrosion. If it is damaged, replaced by normal one.
5. Use the wire brush to clean the heating element.
6. Vacuum up any loose dirt or debris.
7. Measure the resistance of the heating element using a digital multimeter.
8. Once the heating element is clean, replace the access panel and reconnect the power.
9. Finally Turn on the heating system and verify that it is operating properly.

Quality criteria: Reading the circuit properly, follow safety procedures & installation procedures

Operation Sheet # 6

Operation Title: maintain Ventilation system installation problem

Instruction:

Purpose: When you have completed this Unit, the trainee should be able to maintain the ventilation systems.

Required tools and equipment: unit one of this module, tools from workshops like screwdrivers, wrenches, Flashlight, Wire brush, Vacuum cleane and Digital multimeter

Precautions:

- Always turn off the ventilation system and disconnect the power before inspecting or cleaning the fan.
- Be careful not to touch the fan blades with your bare hands, as they may be sharp.
- Wear safety glasses when inspecting or cleaning the fan.

Procedures:

1. Select the required tools, equipments and materials.
2. Locate the ventilation fan.
3. Remove the access panel to the ventilation fan
4. Inspect & carefully clean the ventilation fan blades form dirt, debris and corrosion. If it is damaged, replaced by normal one.
5. Use the wire brush to clean ventilation fan blades.
6. Vacuum up any loose dirt or debris.
7. Measure the resistance of the resistance of the fan motor using a digital multimeter.
8. nce the fan is clean, replace the access panel and reconnect the power..
9. Finally nce the fan is clean, replace the access panel and reconnect the power.

Quality criteria: Reading the circuit properly, follow safety procedures & installation procedures

Operation Sheet # 7

Operation Title: maintain the air conditioner installation problem

Instruction: in this operation sheet the maintenance is only electrical parts

Purpose: When you have completed this Unit, the trainee should be able to maintain the air conditioning systems.

Required tools and equipment: unit one of this module, tools from workshops like screwdrivers, wrenches, Flashlight, Wire brush, Refrigerant pressure gauge, Refrigerant manifold, Non-conductive voltage tester and Digital multimeter

Precautions:

- Always disconnect the power to the air conditioner before working on it.
- Be careful when handling electrical components, as they can be dangerous if not handled properly.
- Wear safety glasses and gloves when working on the air conditioner.

Procedures:

1. Select the required tools, equipments and materials.
2. Inspect the air conditioner's electrical wiring system for any loose connections, damaged wires, or burned insulation.
3. check the air conditioner's circuit breaker
4. Use a multimeter to check the voltage & current at the air conditioner's electrical terminals
5. If you have a non-conductive voltage tester, you can use it to check for voltage at the air conditioner's electrical terminals.

6. **Quality criteria:** Reading the circuit properly, follow safety procedures & installation procedures

Operation Sheet # 8

Operation Title: maintain the air conditioner installation problem (faulty thermostat)

Instruction: in this operation sheet the maintenance is only electrical parts

Purpose: When you have completed this Unit, the trainee should be able to maintain the air conditioning systems.

Required tools and equipment: unit one of this module, tools from workshops like screwdrivers, wrenches, Flashlight, Wire brush, Refrigerant pressure gauge, Refrigerant manifold, Non-conductive voltage tester and Digital multimeter

Precautions:

- Always disconnect the power to the air conditioner before working on it.
- Be careful when handling electrical components, as they can be dangerous if not handled properly.

Procedures:

1. Select the required tools, equipments and materials.
2. Remove the thermostat cover.
3. Use a multimeter to check the voltage and current at the thermostat terminals.
4. If the voltage and current are outside of the manufacturer's specifications, the thermostat is faulty and needs to be replaced.
5. If the voltage and current are within the manufacturer's specifications, check the thermostat connections to make sure that they are tight.
6. If the thermostat connections are tight, the thermostat is faulty and needs to be replaced.

Quality criteria: Reading the circuit properly, follow safety procedures & installation procedures

Operation Sheet # 9

Operation Title: maintain the air conditioner installation problem (fan motor)

Instruction: in this operation sheet the maintenance is only electrical parts

Purpose: When you have completed this Unit, the trainee should be able to maintain the air conditioning systems.

Required tools and equipment: unit one of this module, tools from workshops like screwdrivers, wrenches, Flashlight, Wire brush, Refrigerant pressure gauge, Refrigerant manifold, Non-conductive voltage tester and Digital multimeter

Precautions:

- Always disconnect the power to the air conditioner before working on it.
- Be careful when handling electrical components, as they can be dangerous if not handled properly.

Procedures:

1. Select the required tools, equipments and materials.
2. Locate the fan motor.
3. Use a multimeter to check the voltage and current at the fan motor terminals.
4. If the voltage and current are outside of the manufacturer's specifications, the fan motor is faulty and needs to be replaced.
5. If the voltage and current are within the manufacturer's specifications, check the fan motor connections to make sure that they are tight.
6. If the fan motor connections are tight, the fan motor is faulty and needs to be replaced.

Quality criteria: Reading the circuit properly, follow safety procedures & installation procedures

LAP Test # 3

Name: _____ Date: _____

Time started: _____ Time finished: _____

Instruction I: Given necessary templates, tools and materials you are required to perform the following tasks within 25 hours.

Task 1: maintain Heating system installation problem

Task 2: maintain ventilation system installation problem

Task 3: maintain air conditioning wiring system problem

Task 4: maintain thermostat problem

Task 5: maintain fan motor problem

Reference

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