ELECTRICAL/ELECTRONICS EQUIPMENT SERVICING

Level – III Based on April 2022, Curriculum Version



Module Title: Installing, maintaining/repairing air conditioning systems

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Acronyms

AC	Alternating current
DC	Direct current
KV	Kilo Volt
OHS	Occupational health and safety
LAP	Learning Assistance Program
LED	light emitting diode
PCB	printed circuit board
ESD	Electro-Static Discharge
DMM	Digital Multi-Meter

Introduction to the Module

In Electrical/electronic equipment servicing filed; the: Install ,maintaining/repairing air conditioning systems project helps to require Install ,maintaining/repairing air conditioning systems includes constructing, diagnosing faults, dismantling, re-assembling, testing and preparing report. This module is designed to meet the industry requirement under the Electrical/electronic equipment servicing occupational standard, particularly for the unit of competency: Install maintaining/repairing air conditioning systems

Module units

- Overview of air conditioning systems
- Install and terminate low voltage (LV) and extra-low voltage (ELV) cables
- Fit non-ducted split air conditioning systems
- Install ducted split air conditioning systems
- Locate and rectify faults and carry out maintenance
- Commission air conditioning systems

- Complete work and report activities

Learning objectives of the Module

At the end of this session, the students will able to:

- Overview of air conditioning systems
- Install and terminate low voltage (LV) and extra-low voltage (ELV) cables
- Fit non-ducted split air conditioning systems
- Install ducted split air conditioning systems
- Locate and rectify faults and carry out maintenance
- Commission air conditioning systems
- Complete work and report activities

Module Learning Instructions:

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described below.
3. Read the information written in the information Sheets
4. Accomplish the Self-checks
5. Perform Operation Sheets
6. Do the “LAP test

Unit one: Overview of air conditioning systems

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

- Identifying basic concept of air condition
- Obtaining and implementing OHS and risk control measures
- Obtaining Tools, equipment and testing devices
- Determining Work details
- checking Components, piping, accessories, controls and consumables

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:

- Identify basic concept of air condition
- Obtain and implementing OHS and risk control measures
- Obtain Tools, equipment and testing devices
- Determine Work details
- Check components, piping, accessories, controls and consumables

1.1 Identify basic concept of air condition

Air conditioning is a system used to control the temperature, humidity, and air quality in indoor spaces. The basic concept of air conditioning involves removing heat and moisture from the air to create a cooler and more comfortable environment. Air conditioners have three main components: a compressor, a condenser coil, and an evaporator coil. The compressor pumps refrigerant gas between the coils to absorb heat from the indoor air and release it outside. The evaporator coil cools and dehumidifies the air, while the condenser coil releases the absorbed heat outside. Air conditioning systems can also be used for heating, dehumidifying, and humidifying. The components of an air conditioner used for commercial purposes include the compressor,condenser, evaporator, and expansion valve. The thermostat controls the system and allows users to set the desired temperature. The air pressure in a room is not changed by air conditioning, but the humidity and temperature are controlled to create a comfortable environment. A standard air conditioner or cooling system uses a specialized chemical called **refrigerant**, and has three **main mechanical components**: **a compressor**, **a condenser coil** and **an evaporator coil**. These componentswork together to quickly convert the refrigerant from gas to liquid and back again.

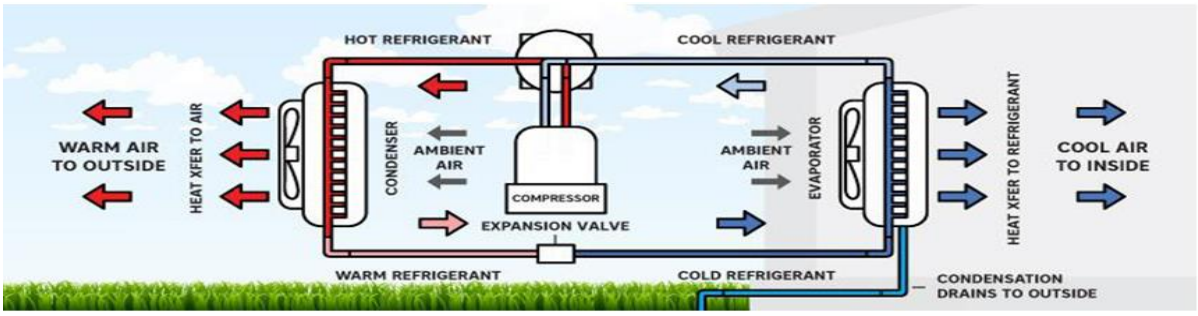


Figure 1•1 refrigerant cycle

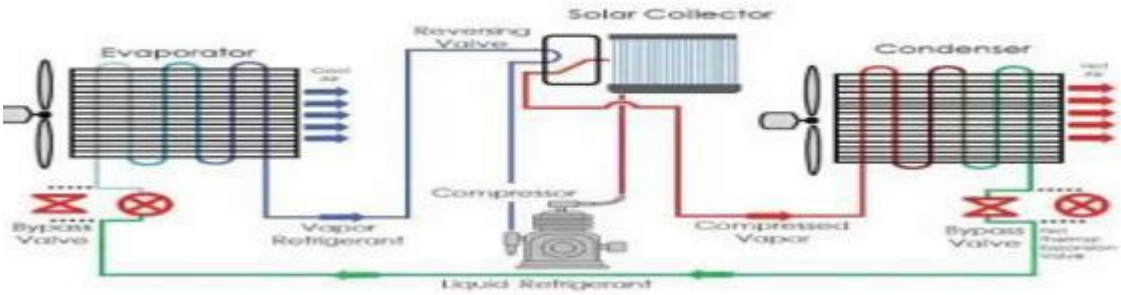


Figure 1.2.**The complete diagram of an air conditioning syst**em:



Figure 1.3. ductless split air condition

1.2. Obtaining and implementing OHS and risk control measures

1.2.1. Occupational Health and Safety (OHS) guidelines

To avoid injuries before, during and after working on electrical/ electronic equipment and/ or systems, remember the following safety procedures:

- Use the right tool for the job.
- Don't use broken or damaged tools, dull cutting tools, or screwdrivers with worn tips.
- Cut in a direction away from your body.
- Make sure your hand and footings are secure when using large tools.
- Pass a tool to another person by the handle
- Use the right personal protective equipment (PPE) for the job.
- Never carry sharp (blade type) or pointed tools such as a screwdriver in your pocket it causes an injuries.
- Always wear eye protection.
- Use tools that are the RIGHT SIZE & RIGHTTYPE for your job.
- Follow the correct procedure for using every tool.
- Don’t work with oily or greasy hands.
- Don’t use a file without a handle.

1.2.2. Safe work practices

The installer and service technician works in many areas: in the shop, in various types of buildings, in equipment rooms, on rooftops, under houses, and on the ground outside buildings. Each location requires different activities where safe performance is essential. In addition, the worker deals with many potentially dangerous conditions, such as handling pressurized liquids and gases, moving equipment and machines, working with electricity and chemicals, and being exposed to heat and cold. It is important, therefore, that the technician practice good safety procedures wherever or whatever the work is.

1.3. Obtain Tools, equipment and testing devices

- **Screwdrivers**

Screws are made in different sizes, and designed to be turned by screwdrivers of the corresponding sizes. The technician should have a good set of screwdrivers with both Philips and flat slotted heads.

Many people have the habit of trying to turn a screw with whichever screwdriver they have. Most screws can easily be turned if the right sized screwdriver is used.

A power screwdriver is also useful in electronic servicing because some equipment have numerous screws, which may be tiresome to get unscrewed by hand.



Figure1.4. Screwdrivers

- **Drill**

Drills are frequently used to both drill holes and drive screws. Cordless drills with interchangeable batteries are ideal for HVACR work.





Figure. electric drive drills

- **Long-Nose Pliers**

A long-nose plier is needed to remove components once they are desolder from the PCB board. They are very useful for reaching into tight spaces inside the equipment. For example, components located under the belly of the CRT are very difficult to remove without pliers.



Figure 1.5.Long-nose plier

- **Wire Cutters**

Wire cutters are useful for cutting wires, wire ties, and lead on large parts, such as resistors and capacitors.

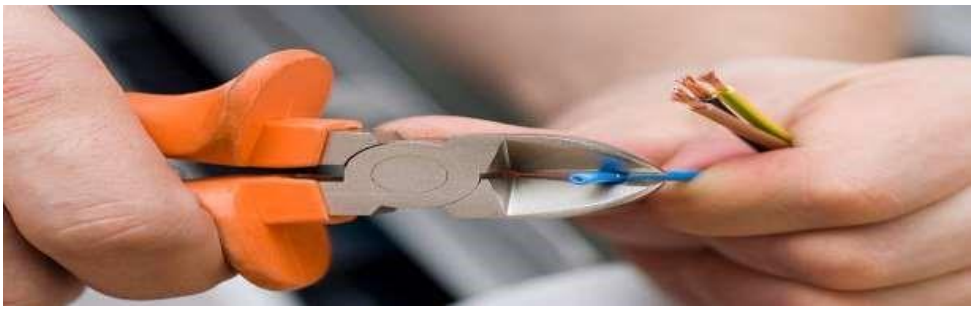


Figure 1.6. Wire cutters

- **Wire Strippers**

Before making connections with a piece of wire, anyone must “strip” away the plastic insulation on a wire using wire strippers. Sometimes insulation can be removed using wire cutters successfully but it

may often leave a nick or pinch in the conductor, which later might fatigue and break. So, it is advisable only to use wire stripper to remove insulation.



Figure 1. 7. Wire strippers

- **Magnifying Lamp**

A magnifying lamp not only provides light, but also makes it easier to read component marking especially the surface mounted components (SMD) and small resistor color code. A magnifying lamp can be used to check for cracks, broken solder joints or burnt components in a PCB board.



Figure . Magnifying lamp

- Toothbrush

A toothbrush is used to look for intermittent or bad connection in a PCB board. Simply run the toothbrush over the PCB board until the bad connections push into working.

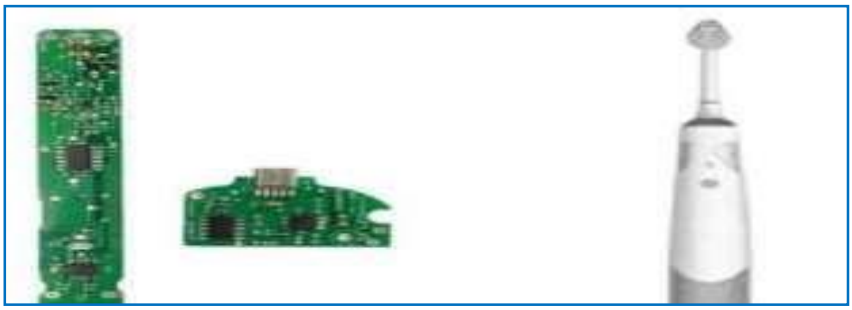


Figure 1.8. Toothbrush

- **Spark lighter**

Spark lighter is a tool suitable for lighting gas torches

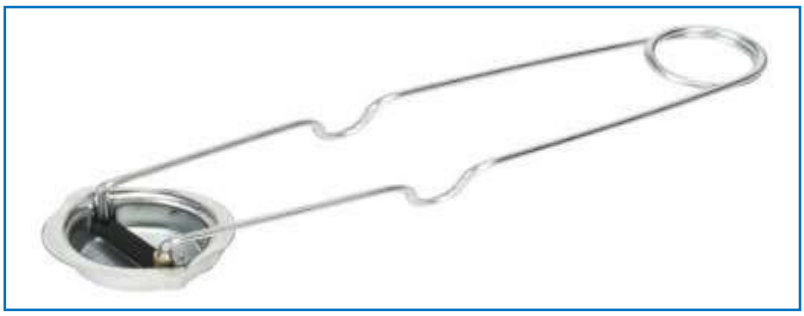


Figure Tube Cutter

- **Tube Cutter**

Tube Cutter is a type of tool used by plum ersto cut pipe. Besides producing a clean cut, the tool is often a faster, cleaner, and more convenient way of cutting pipe than using a hacksaw, although this depends on the metal of the pipe.



Figure 1. 9. Tube Cutter

- **Tube Bender** Tube Bender makes smooth, tight radius bends in soft copper and aluminum tubing up to 180°. Open side slips over tube at any point. No scoring or flattening of tubing.



Figure : 1.10. Tube Bender

- **Tube expander**

Tube Expander is a hand used expanding tool. It is a universal hand refrigeration tools for Copper Pipe Swaging Tool. It expand tubes of sizes: -inch, 5/16-inch, 3/8-inch, ½-inch, ⅝ inch, ¾ inch and ⅞ inch.



Figure 1.11. Tube Expander

- **Wire brush**

A wire brush is used for cleaning the welding surface, removal of slag, rust etc.



Figure 1.12. Wire brush

- **Leakage tester**

Leakage tester is the simplest refrigerant leak detection tester.



Figure 1.14… Leakage tester

- **Vacuum pump**

A vacuum pump is a device that simply draws in whatever the technician wants to vacuum, and discharge it to the surrounding atmosphere.



Figure 1.15 *Vacuum pump*

- **Digital scale**

A digital scale is a measuring device that reads and displays the weight of an object.



Figure1.1 1 *Digital scale*

- **Filler metal**

Probably the most widely used brazing filler metal is an alloy of copper and phosphorus, often with silver added as a third element. The role of silver in these alloys is often misunderstood.

Both phosphorus and silver have significant effects on the properties of these filler metals.

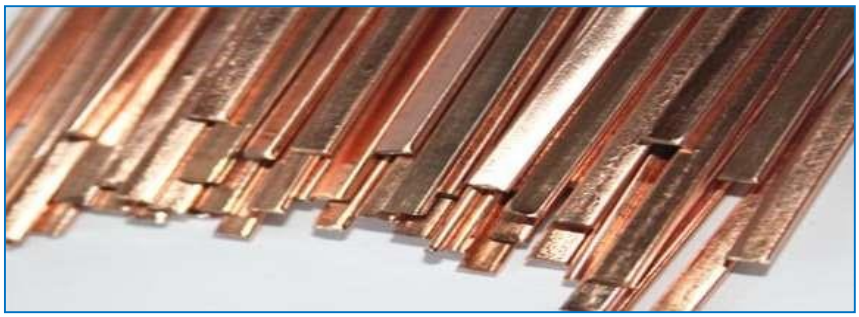


Figure1.17. filler metal

- **Test instrument**

This section highlights the general equipment for electronic servicing. Some equipment, such as a multi-meter, is an absolute necessity for the test bench while other equipment, such as a transistor tester, is useful but not imperative to have. In any case, the more equipment the technician has, the more his/her preparedness to troubleshoot of all kinds of electronic equipment problems.

- **Multi-meters**

There are two types of multi-meters in the market, the analog and the digital. The analog meter can measure ac and dc voltage, current, and resistance, and uses a meter to read out the test results. DMM are ranked by the number of digits they display. A "3½ digit" DMM will indicate three numbers for each reading. Digital meter really removed all the guess work! Not only that, many digital meter is auto range that means whatever value a technician wants to check it will automatically prompt the result without having to adjust to a suitable range in order to test the component.



Figure1.1 8 *Multimeter*

- **Oscilloscope**

An oscilloscope is a laboratory instrument commonly used to display and analyze the waveformof electronic signals. In effect, the device draws a graph of the instantaneous signal voltageas a function of time. A typical oscilloscope can display alternating current (AC) or pulsating direct current (DC) waveforms having a frequency as low as approximately 1 hertz (Hz) or as high as several megahertz (MHz).

Handling of electrical hand tools without damage means the way work of keeping something in proper condition. This would imply that maintenance should be actions taken to prevent a device or component from failing or to repair normal equipment degradation experienced with the operation of the device to keep it in proper working order. Properly maintained tools help improve efficiency of operation while

minimizing opportunities for injuries and extending tool life. Time spent in tool maintenance (sharpening, cleaning, lubrication etc.) is time well spent. Prior to use, always inspect the tools for defects or damage.

- Check for loose, bent, or cracked tool handles,
- mushroomed tool heads, s
- prung tool joints or worn teeth.

If a hand tool fails the initial inspection, inform the crew leader, tag the tool clearly as "defective", and remove it from service. Allow adequate time at the end of each work day to clean the tools and properly pack and secure for transportation or storage. Maintaining a safe and efficient work environment will help avoid injuries and unnecessary expenditures in the long run.

A. Handling of electrical hand tools /Maintenance/ should be:

- Keep metal blades of all tools sharp and well-oiled.
- Check for loose and worn out parts on tools regularly, and replace if necessary.
- Identify damaged tools and store them in a designated location to allow either the supervisor or maintenance person to arrange for their repair.
- Workers should know that the job is not complete until the tools are cleaned and stored in a designated location.

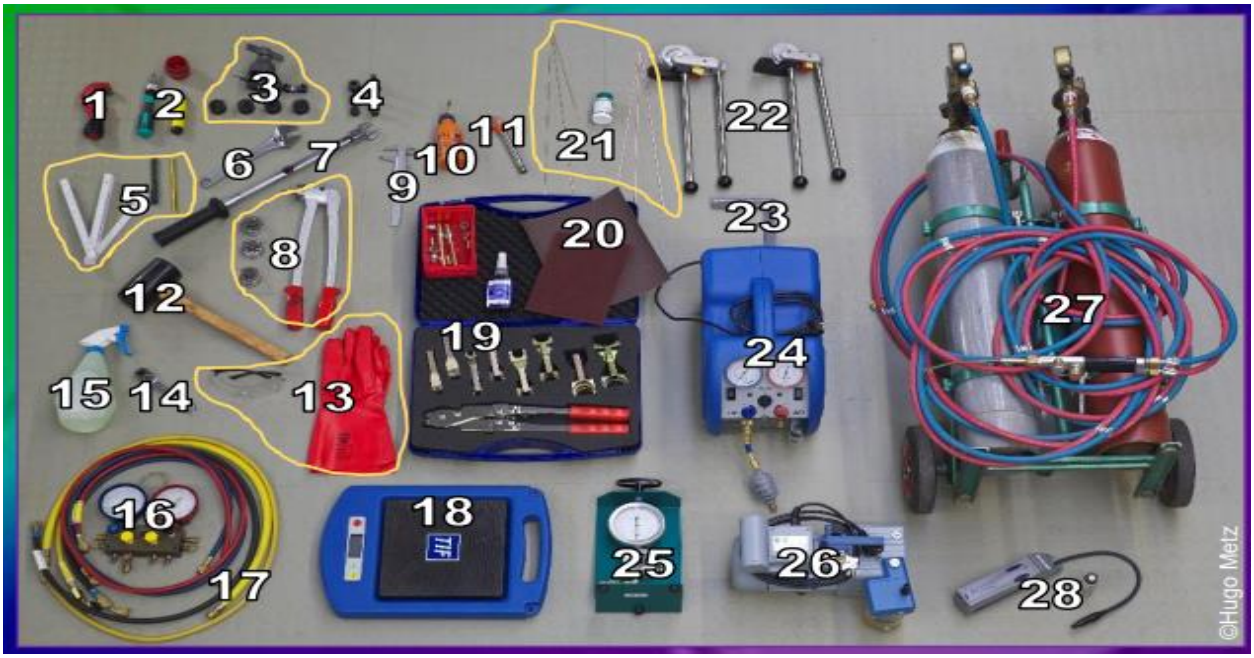
B. There are four principal causes of electrical failure:

- Dust and dirt accumulation; moisture.
- Loose connections; and friction of moving parts.
- An effective maintenance program should aim to minimize these effects by keeping equipment clean and dry, keeping connections tight and minimizing friction.

C. **Tools that are unsafe/faulty can be categorized in to two**:

- ✓ Those having minor faults such as loose handle, rusted hinges, damaged blade, bent ends & dirt edges, Dismantled casing, missing screws etc… & those fully damaged include broken teeth, broken blade, tool with missing parts, worn tools, burned elements, open circuits inside the tool, frayed or damaged flexible cords etc... The method of identifying faulty and functional tools is done either by visual inspection or by performing different tests using test instruments.
- ✓ Powered hand tools are visually inspected before use and electrically tested by a competent person as necessary

1.3.1. Air Conditioning Tools & Equipment for maintenance



A. Tools

1	Copper tube cutter	18	Weighing scale
2	Deburring tools	19	Tool kit for press fittings (*Lokring*)
3	Flaring tool (other types are available)	20	Non-metallic abrasive pad
4	Pipe calibration tools (internal/external)	21	Phosphorus brazing alloy, silver brazing alloy & flux
5	Ruler, pen & pencil	22	Pipe bending tools
6	Adjustable wrench	23	Engineer's square
7	Torque wrench	24	Recovery and recycling unit
8	Tube expander tool & expander heads	25	Vacuum gauge
9	Vernier calliper	26	Vacuum pump
10	Oil can	27	Oxy-acetylene torch set
		28	Electronic leak detector and calibrated leak test

11	Torch igniter
12	Rubber mallet
13	Safety glasses & insulating gloves
14	Refrigeration ratchet
15	Spray bottle (for leak detection)
16	Manifold gauge
17	Hoses

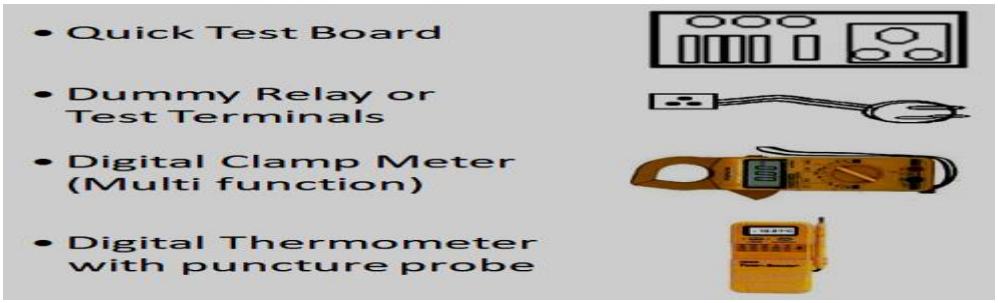




Fig 1.3.Gauge Manifold – 2 way

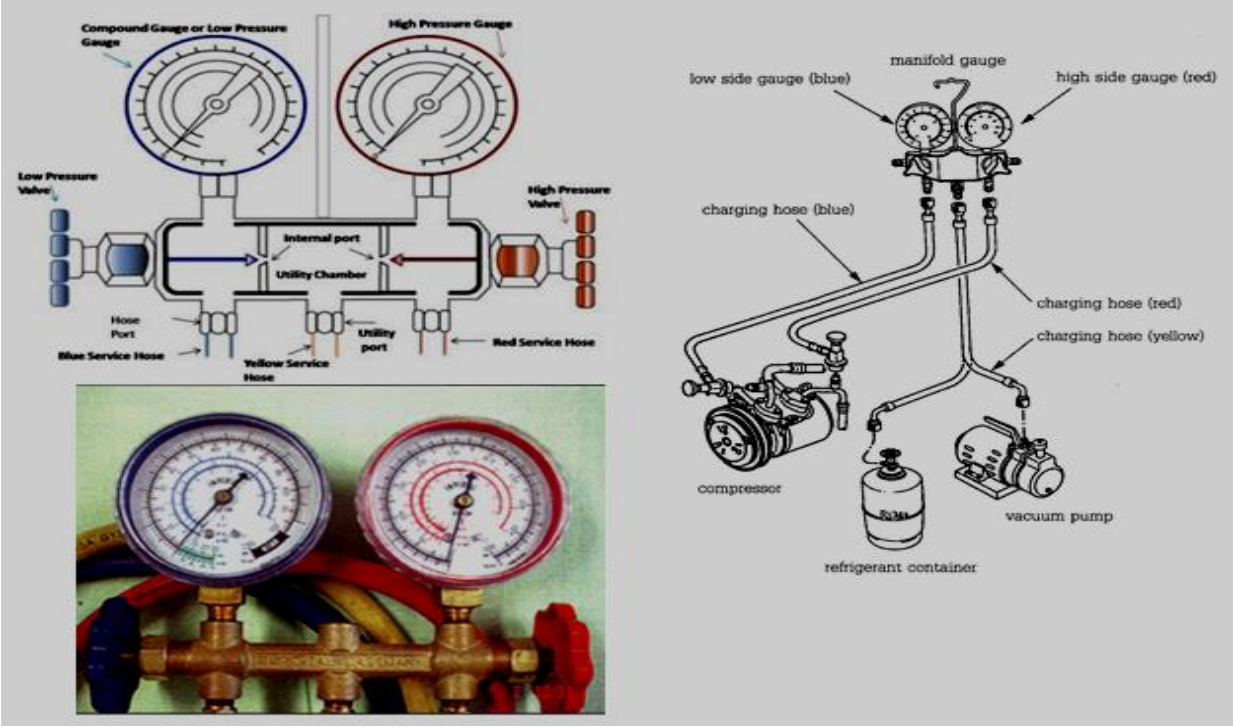


Figure 1.3. Manifold – 4 way

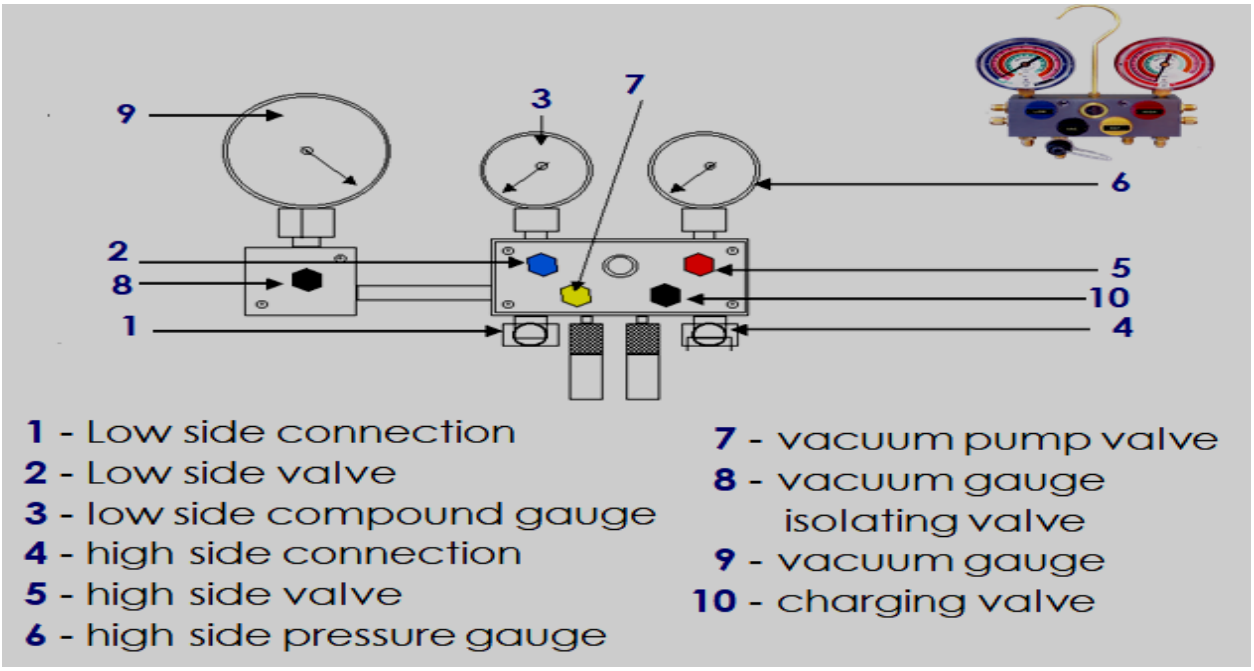


Figure 1.4. Brazing Equipment



Figure 1.5. **Refrigerant Recovery machine with a Recovery cylinder**

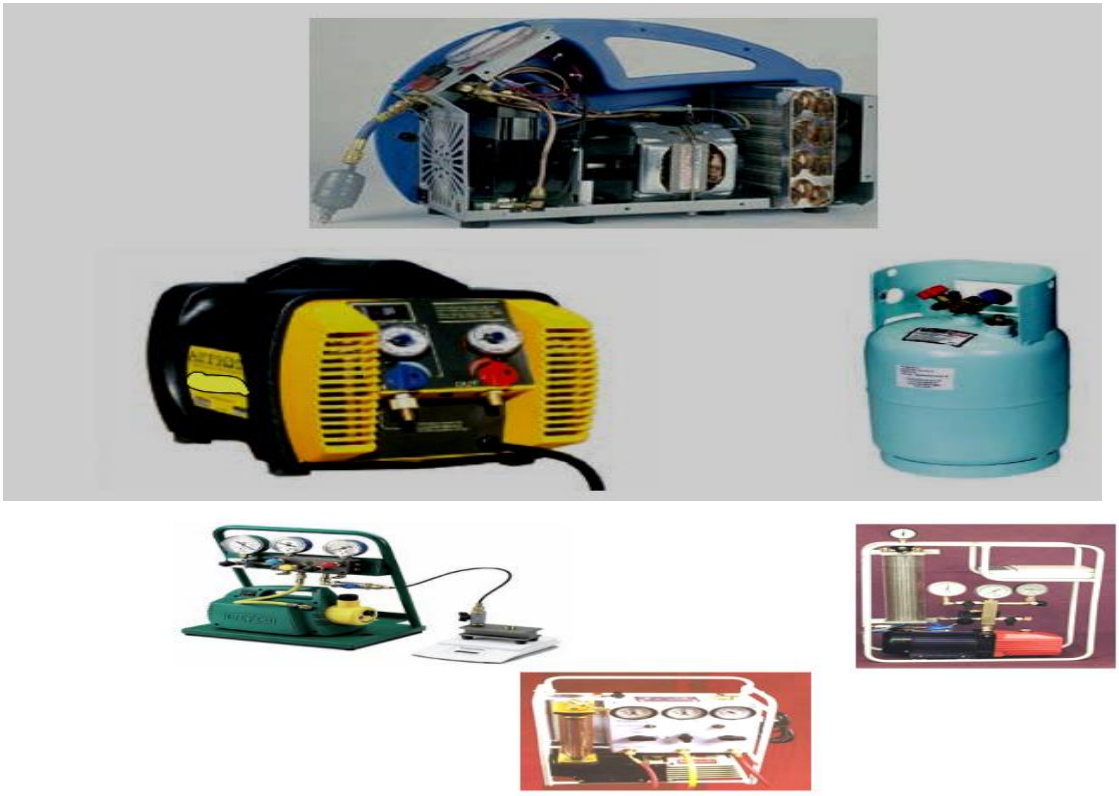


Figure 1.6. **Portable Evacuation & Gas Charging Station with weighing scale**



Figure A.

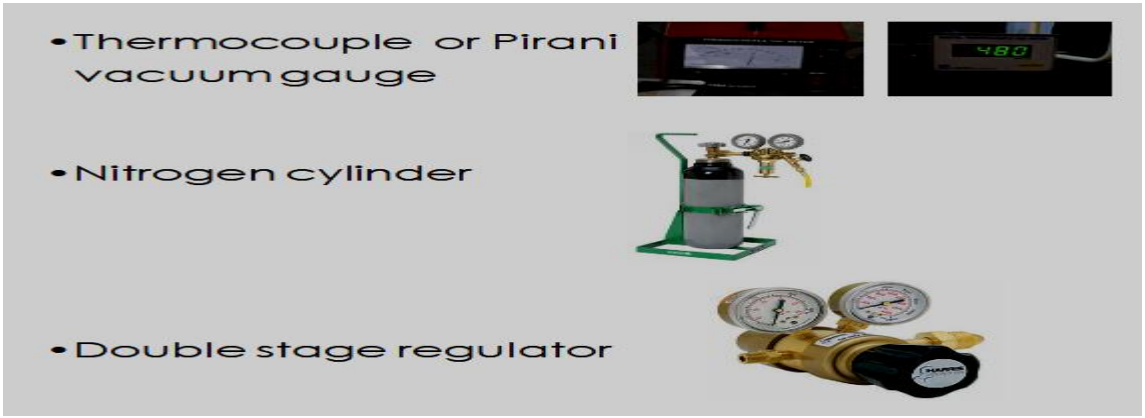


Figure B.

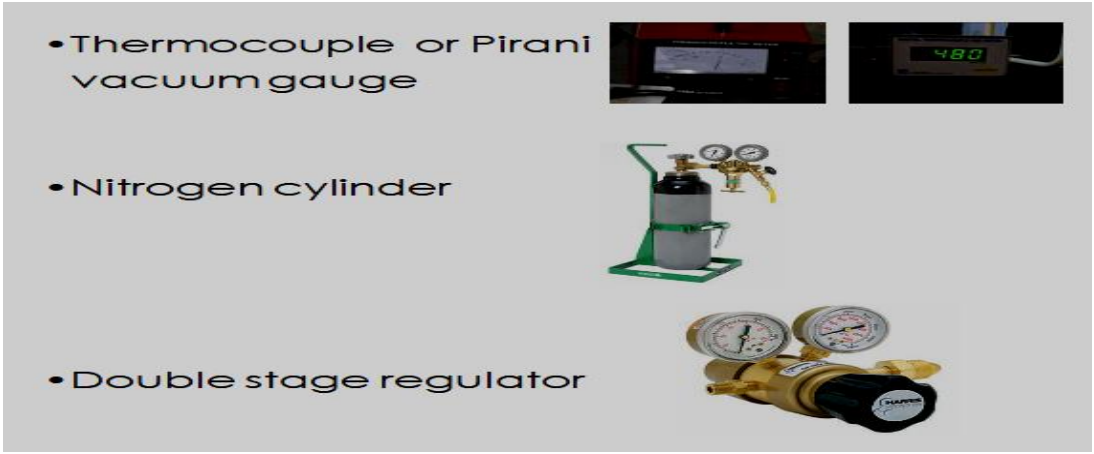
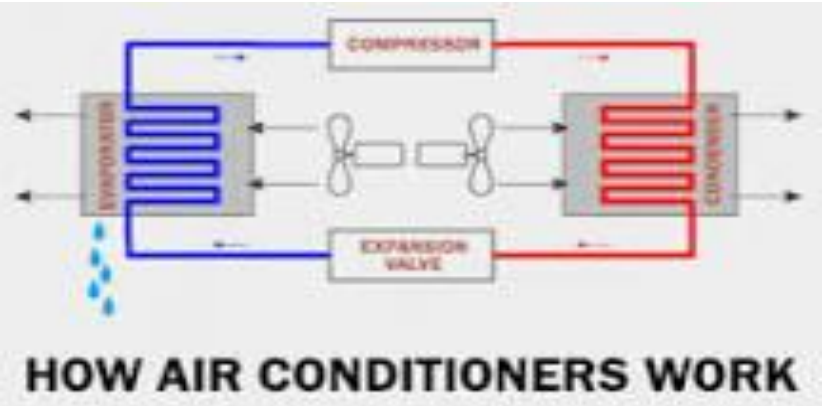


Figure C.

Figure: A, B, and C: Important test instrument and level gauge indictors Equipment

1.4. Determining Work details

A. Basic details of air conditioner



An air conditioner cools your home with a cold indoor coil called the evaporator. The condenser, a hot outdoor coil, releases the collected heat outside. The evaporator and condenser coils are serpentine tubing surrounded by aluminum fins. This tubing is usually made of copper the construction of the air conditioner? The outdoor unit has a coil, compressor, fan, filter drier, electrical panel in a stamped louver metal box that varies with manufacturers. The indoor unit has a coil, fan, electrical panel, expansion valve and often a furnace. These systems require a condensate drain as well.

B. Detailed Job Description

Heating and Air Conditioning Mechanics and Installers HVACR technicians install, maintain, and repair heating, cooling, and refrigeration systems. Heating, air conditioning, and refrigeration mechanics and installers—often called HVACR technicians—work on heating, ventilation, cooling, and refrigeration systems that control the temperature and air quality in buildings.

C. Duties Heating, air conditioning, and refrigeration mechanics and installers

- Install, clean, and maintain HVACR systems
- Install electrical components and wiring
- Inspect and test HVACR systems and components
- Discuss system malfunctions with customers
- Repair or replace worn or defective parts
- Recommend maintenance to improve system performance

Keep records of work performed Heating and air conditioning systems control the temperature, humidity, and overall air quality in homes, businesses, and other buildings. By providing a climate-controlled environment, refrigeration systems make it possible to store and transport food, medicine, and other perishable items. Some HVACR technicians specialize in one or more specific aspects of HVACR, such as radiant heating systems, solar panels, testing and balancing, or commercial refrigeration.

When installing or repairing air conditioning and refrigeration systems, technicians must follow government regulations regarding the conservation, recovery, and recycling of refrigerants. The regulations include those concerning the proper handling and disposal of fluids and pressurized gases. Some HVACR technicians sell service contracts to their clients, providing periodic maintenance of heating and cooling systems.

The service usually includes inspecting the system, cleaning ducts, replacing filters, and checking refrigerant levels. Other workers sometimes help HVACR technicians install or repair cooling and heating systems. For example, on a large air conditioning installation job, especially one in which workers are covered by union contracts, ductwork may be installed by sheet metal workers, electrical work by electricians, and pipe work by plumbers, pipefitters, and steamfitters. Boiler systems are sometimes installed by a boilermaker. Home appliance repairers usually service window air conditioners and household refrigerator

1.5. Obtaining and checking Components

When obtaining and checking components for ductless and duct air conditioning systems, it is important to consult the manufacturer's documentation or seek professional assistance for accurate and safe procedures. Components:

- **Ductless air conditioning systems typically consist of two main components**:
  - ✓ An outdoor compressor/condenser unit
  - ✓ An indoor air-handling unit.
- **Ductless air conditioner** systems use the same process for cooling as a typical central air conditioning system. However, while central air conditioning uses one centrally located indoor unit that delivers cool air to the entire home through a series of ducts and vents, a ductless indoor unit blows cooled air directly into one living space.

At the minimum, a complete ductless system includes an indoor unit with an evaporator coil and blower fan; and it has an outdoor unit with a compressor, condenser coil and fan. The two units are connected with copper refrigerant tubing and electrical wiring.

- **Ductless AC units** are effective for any space in the home:
  - ✓ No matter the room's ceiling height, high wall units can be mounted directly to an interior wall
  - ✓ Console units work for rooms where wall mounting isn't possible or desirable
  - ✓ In-ceiling units are an example of a ducted unit which is hidden from view if ceiling space
- **Condensing units (CDUs)** are the outdoor HVAC/R units. Their main function is to condense refrigerant or other substances from their gaseous state to liquid state. The latent heat is then transferred to the condenser coolant. Condensing units can either be an air conditioning unit, refrigeration unit, or part of a heat pump.
- **A typical HVAC/R condensing unit has:**
  - ✓ A compressor to increase the pressure of refrigerant to keep the liquid refrigerant moving along
  - ✓ A fan for blowing the outside air through the heat exchanger to help cool the refrigerant
  - ✓ A condensing coil to help send the heat carried by the refrigerant to the outside

It is very important to make sure the Condensing Unit is always clean and clear of any debris (leaves, tree branches, etc.) to prevent blockages and to prevent your HVAC unit from working harder than is necessary. It is also recommended that your Condensing Unit be placed in a shady area so it does not overheat as easily with the hot summer temperatures.

Self Check 1.1.

TEST I. Say True Or False For The Following Questions

1. Air conditioning systems can also be used for heating, dehumidifying, and humidifying.
2. A complete ductless system includes an indoor unit with an evaporator coil and blower fan
3. Ductless air conditioner systems use the same process for cooling as a typical central air conditioning system.
4. Spark lighter is a tool suitable for lighting gas torches
5. Tube Bender is a hand used expanding tool.

.

TEST II. Choose The Best Answer

1. Air conditioning system used to control

A. Temperature, B. Humidity, C. Air quality D. All

2. A standard air conditioner or cooling system uses a specialized chemical called

A. Refrigerant B. Evaporator C. Condenser D. All

3. Which is incorrect about main mechanical components of air conditioner

A. Compressor C. Evaporator coil

B. Fan motor D. Condenser coil

TEST II: Write Correct Answer At Blank Space provided Below

1._____ is used to condense refrigerant or other substances from their gaseous state to liquid state.

2. _____is a laboratory instrument commonly used to display and analyzes the waveformof electronic signals.

Unit Two: Install and terminate low and extra-low voltage (ELV) cables

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

- Selecting and terminating cables and conductors
- Installing cables
- Inspecting of installed cables and testing
- Selecting cables/wiring AC installation

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:

- Select and terminate cables and conductors
- Install cables
- Inspecting of installed cables and testing
- Selecting cables/wiring AC installation

2.1. Selecting and terminating cables and conductors

This Electrical Inspection Checklist: Air-Conditioning and Refrigerating is engineered to provide an NEC compliant process to guide you in your safety inspections Air-conditioning and refrigerating equipment is commonplace within both residential and commercial spaces and requires regular inspection. This process is geared to you can add or remove steps as you please. Each inspection-specific task contains the relevant NEC section reference which applies to the action. It is recommended that you Throughout the checklist, you will find form fields where you can record relevant information. This data will be stored in the template overview which you can view on the left-hand tab for the template

A. Electrical Terminations Information

Electrical Connector for Terminations



Electrical terminations are installed at the end of a bus or transmission line to prevent signals from reflecting back. Sometimes called electrical terminators, these electrical devices are used to prevent electrical interference.

2.1.1. Types of Electrical Terminations

There are four basic types of electrical terminations: chip, coaxial, SCSI, and waveguide.

- **Chip terminations** have a form factor of an integrated circuit (IC) chip. They are manufactured using thin-film technology.
- **Coaxial terminations** terminate coaxial ports.
- **SCSI terminations** are electrical circuits placed at each end of a small computer system interface (SCSI) cable for impedance matching.
- **Waveguide terminations** are devices that terminate waveguide ports.

Other unlisted or proprietary electrical terminations are also available.

- Specifications

Electrical terminations differ in terms of performance specifications and category or application. Power rating, voltage standing wave ratio (VSWR), return loss are the most important performance specifications to consider. VSWR, a unit-less ratio ranging from 1 to infinity, expresses the amount of reflected energy at the input of the device. A value of 1 indicates that all the energy passes through. Any other value indicates that a portion of the energy is reflected. In terms of category or application, there are four choices for electrical terminations:

- General-purpose termination
- RF termination
- Telecommunications or telecom terminations
- Audio / video cable termination

A. methods of cable termination



The two typical methods of cable termination are crimping, which involves compressing a metal sleeve around the cable, and soldering, which uses melted solder to secure the cable's wires

B. Methods of cable laying and termination?

There are five different methods of laying cables eg (a) Laying directly in ground, (b) Drawing in ducts, (c) Laying on racks in air, (d) Laying on racks inside a cable tunnel and (e) Laying along buildings. or structures

2.2. Installing cables

A. Types of Cables Are Used to Power Air Conditioners

Air conditioners require specific types of cables to ensure a safe and reliable power supply. Here are the main types of cables used to power air conditioners:

- **NM-B Romex**: NM-B Romex cables are commonly used in residential and commercial applications. These cables consist of multiple conductors encased in a non-metallic sheath. They are designed to handle the electrical load required by air conditioners efficiently. NM-B Romex cables are known for their durability,

flexibility, and ease of installation, making them the primary choice for powering air conditioning units in residential and commercial buildings.

- **THHN**: THHN cables are also widely used in residential and commercial applications. These cables are made of thermoplastic insulation and a nylon jacket, providing excellent heat, moisture, and abrasion resistance. THHN cables have high ampacity ratings and are suitable for powering air conditioners efficiently.
- **MICC** Mineral Insulated Copper Clad Fireproof Cable: MICC cables are specifically designed for industrial air conditioner systems. These cables have a unique construction, consisting of a copper-clad conductor surrounded by mineral insulation. MICC cables are highly fire-resistant, providing enhanced safety in industrial settings. When choosing the appropriate cable, consider the application (residential, commercial, or industrial), electrical load requirements, and safety regulations. When it comes to wiring air conditioners, choosing the right wire size is crucial. In the case of 10/2 or 10/3 wire for air conditioners, the better choice is 10/2 wire. However, understanding the differences between these wire types and their applications is essential for making an informed decision This article will explore the distinctions, factors affecting wire sizing, and other important considerations

2.2.1. Cable used for ac installation

Most air conditioners ranging from 1.5 to 5 tons require wire sizes ranging from 18 AWG to 10 AWG. These wire sizes are determined by considering factors such as the AC unit's tonnage, voltage, maximum wattage, and the 80% NEC (National Electric Code) rule

A single core cable refers to a cable that has only one insulated conductor with its own cable sheath and a multi core cable refer a cable with multiple cores within one common sheath. A conductor may be defined as the conducting portion of a cable, which consists of a single wire or group of wires in contact with each others. The ability of a material to be a good or bad conductor of electricity depends on the composition of that material,

A. Cable running or termination operations

- **The following precautions shall be taken in these operations:**
  - ✓ Care shall be taken not to breach the cable’s protective sheath.
  - ✓ Cables shall not be forced through openings that are too narrow or have sharp or rough edges. c) Cables shall not be bent more than the manufacturer’s recommended minimum bend radius.

- ✓ All building entry and cable pathway entry points shall be suitably sealed against water ingress in a manner aligned with the New Zealand Building Code Document E2, with drip loops provided on cables where necessary.

Use of gel-filled cables Termination of gel filled cables into telecommunications cabinets shall be directed by the recommendations and warranty requirements of the system manufacturer. The installation of gel filled copper or fiber cables shall not be permitted in a riser as this, negates any manufacturer's warranty. **Cables shall be:**

A. Rated for the environment in which they are installed

B. Certified by the manufacturer for the environment in which they are installed. External cables installed underground shall be gel-filled water-resistant cables

C. Installed in a manner that does not expose them to the elements and that protects them from risk of damage or vandalism. Refer to 0 for more information on conduit sizing, fill rates and installation.

Cabling within enclosures All cables shall terminate at the patch panels in the communications enclosures with an excess length of five (5) metres for optical fiber and not less than half (0.5) metres for other cables neatly placed out of sight prior to terminating. Excess cable shall not be stored in "coils" but shall be formed into a "loop back" generally contained at one side of the cabinet up against a wall. Any excess length cabling must be properly supported. Cables terminating at the enclosures shall be neatly loomed within the enclosure, utilizing the cable management system specified in 7.5. Cables shall be loomed between the space on the outside of the mounting rails and the removable door. Cables loomed inside wall mounted cabinets shall be loomed in groups of a maximum of 12, to allow enough space for mounting active network equipment.

2.3. Undertaking safety inspection of installed cables and testing

A. Visual Inspection

Visual inspection can be completed on energized installations. However, if cables are touched or moved they should be de-energized. Cables in vaults, substations rooms, manholes, and at other areas need to be inspected on a **yearly basis.**

- **This inspection needs to include:**
  - ✓ Oil leaks, soft spots, and insulation swelling
  - ✓ Physical damage, sharp bends, and excessive and prolonged tension
  - ✓ Cracked jackets of non-leaded cables

- ✓ Poor earth connections, metallic-sheath bonding deterioration, corroded cable supports, and continuity of main earthing system
- ✓ Soft spots in terminations and splices
- ✓ Corona tracking
- ✓ Potheads should be inspected for oil or compound leaks

Inspect the manhole for spalling concrete and standing water Aerial cables need to be inspected for mechanical damage that is made by vibration or deterioration of support and suspension mechanism. Inspection needs to be made of cables for insulation abrasion and cable being bent or pinched.

Self Check 2.1.

TEST I. Say True Or False For The Following Questions

1. Most air conditioners ranging from 1.5 to 5 tons require wire sizes ranging from 18 AWG to 10 AWG.

2. The thermostat controls the system and allows users to set the desired temperature.

3. Installing cables shall not be forced through openings that are too narrow or have sharp or rough edges.

4. Electrical terminations differ in terms of performance specifications and category or application.

TEST. II. Choose The Best Answer

1. Wich one of the following is correct length about cables terminate for optical fiber.

A. five (5) metres , B. half (0.5) metres C. Four (4) metres D. None

2. Wich one of the following is the better choice wire for air conditioners

A. 10/2 wire B. 10/3 wire C. 10/4 wire D. All

3. Which is incorrect about main mechanical components of air conditioner?

A. Compressor C. Evaporator coil

B. Fan motor D. Condenser coil

Unit Three: Fit non-ducted split air conditioning systems

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

- Identifying all required major components
- Installing refrigerant pipe work and associated components
- Conducting pressure testing of the installed components and pipe
- Evacuating air conditioning system
- Carrying vacuum drop test
- Checking power and control circuit wiring

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:

- Identify all required major components
- Install refrigerant pipe work and associated components
- Conduct pressure testing of the installed components and pipe
- Evacuate air conditioning system
- Carry vacuum drop test
- Check power and control circuit wiring

3.1. Identifying all required major components

3.1.1. Components of an air conditioner

Below are the components of the air conditioner used for commercial purposes:

A. **Compressor:**

The compressor is the engine of the system as it works with a fluid that easily transforms the gas into a liquid. Its primary function is to convert low-pressure gas into high-pressure gas, which has a high temperature. in its working, the gap regions between molecules get narrowed down with a produced energized gas. This energized gas which is also known as a refrigerant is released from the compressor and enters the condenser.

B. **Condenser Coil:**

The condenser coil contains a fan that cools the high-pressure gas and converts it into a liquid. The product obtained is used by the evaporator to do the work. The compressor and condenser are ones placed outside of the house.

C. **Thermostat:**

The thermostat maintains the temperature of an air conditioning system as it regulates the heat energy inside and outside of it. depending on the design, a thermostat can be set manually or automatically.

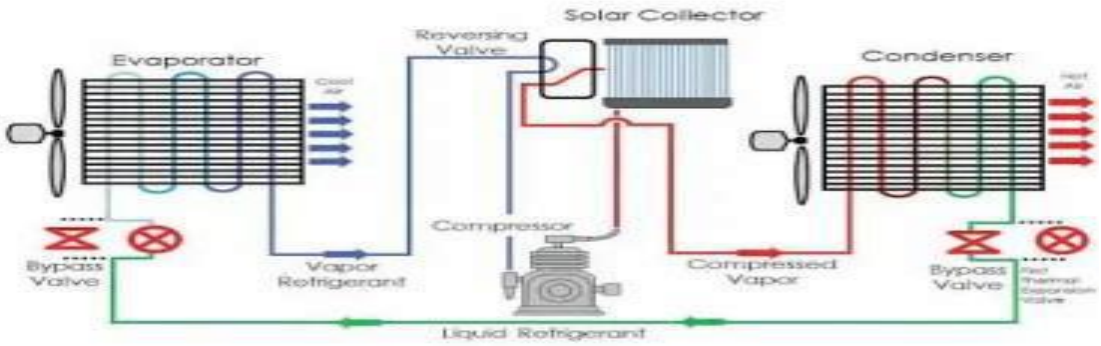
D. **Evaporator:**

Evaporators are air conditioning components found inside the house near the furnace. It's connected to the condenser with an extremely thin pipe. The high-pressure gas is transformed into a low-pressure liquid of the air conditioner. The liquid is then converted to gas due to the decreasing pressure. The fluid or refrigerant is what takes away the heat from the and cools it off. The evaporator releases the fluid in the form of a gas in order to get compressed again by the compressor. All of these happen in a cyclic fashion.

E. **Air Handler and Blowing Unit:**

These air conditioner components work together to draw the air to the evaporator and distribute cool air over the room. A duct system facilitates the passage of airflow in the room

The complete diagram of an air conditioning system:



3.1.2. Working principle of Air Conditioner

Compress	Condenser	Capillary Tube	Evaporator
			
Coolant that evaporated from the evaporator is sucked into the condenser through pipe. Coolant sucked into the condenser is compressed by a piston in the cylinder to have high pressure to become gas with high pressure and high temperature. Condenser can be categorized into three types based on compression method: piston compressor, scroll compressor, and rotary compressor are commonly used. Compressors are like hearts in humans. It compresses coolant and drops coolant pressure in the evaporator.	Coolant gas with high temperature and high pressure from the compressor is sent to condenser. It is cooled by air and gives up heat of condensation to become liquid. The amount of heat emitted from the condenser is the sum of heat absorbed from the surroundings and applied heat to compress. Condenser cooling method can be categorized in two types: water cooling and air cooling	High pressure coolant that became liquid in the condenser changes to have low pressure as it passes capillary tube and can easily evaporated. Capillary tube is 1 m in length (one or many) and a narrow tube with diameter of Φ 0.8~2.0mm. It throttles by system resistance and also decompresses. Diameter and length is selected based on experiments on cooling device capacity, operation condition coolant charge. If internal diameter is large or length is short, coolant flows in large amount, resulting in degraded cooling and coolant noise.	Liquid coolant with low pressure and low temperature that passed the capillary tube is sent to the evaporator. It absorbs heat from the surroundings and evaporates to become gas. It is changed into low pressure gas and again sent to compressor.

3.1.3. Cooling Cycle principle of Wall- mounted Air Conditioner

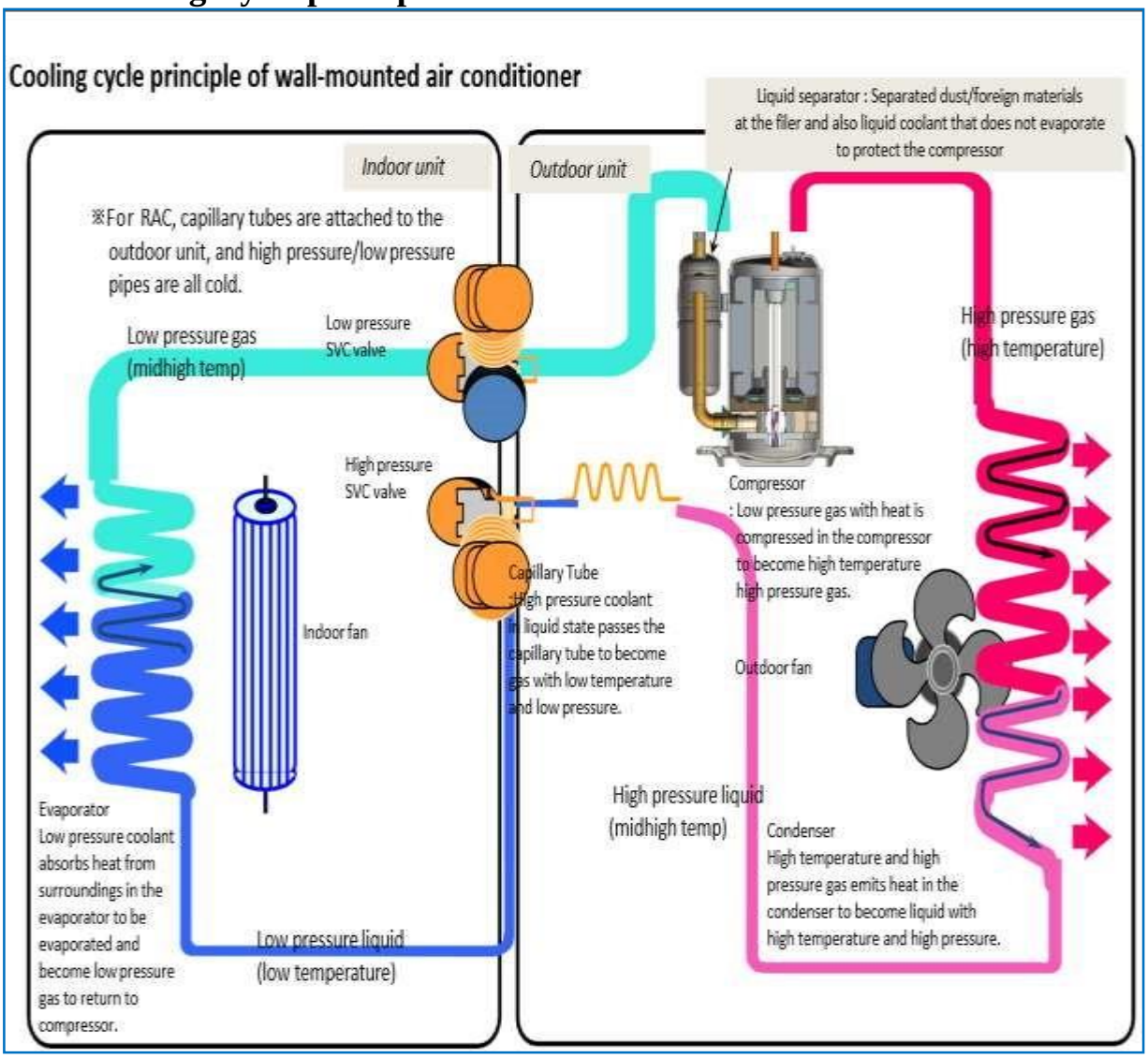


Figure 3. 6 Process of refrigeration cycle

3.1.4. Classification of the air conditioning system

We classify the air conditioning system in order to distinguish one type from another. This provides a background for selecting the optimum air conditioning system depending on the building's requirements. An air conditioner can be classified into three categories which include:

A. Classification based on major function:

- Comfort air conditioning e.g. hotels, homes, offices, etc.
- Commercial air conditioning e.g. malls, supermarkets, etc.

- Industrial air-conditioning e.g. processing, laboratories, etc.

B. Classification based on the season in the year:

- A summer air conditioner that controls all four atmospheric conditions for summer comfort.
- Winter air conditioner is designed for comfort in the winter.
- A year-round air conditioner that consists of heating and cooling tools with an automatic control that could serve in any weather condition in the year.

C. Classification based on equipment arrangement:

- These types include a unitary system and a central system.

1.3.5. Types of the air conditioning system

Below are the various types of air conditioning systems available in our modern world:

A. Central Air Conditioning:

The central conditioning is the most common type of cooling system. It's preferably used in larger homes because of its efficient cooling. the conditioning system circulates cool air through the supply and returns ducts. The supply ducts and registers are located on the wall or floors of the house supplying the air inside. Once the air becomes warm, it circulates back into the supply ducts and registers when it will be transferred back to the air conditioner. Installing these types of air conditioning systems requires deep thinking, planning, and preparation. The sizing is crucial to the functionality of the system, installing a system that's of the wrong size, even if efficient, the utility costs will be more than they should.



B. Ductless, Mini-Split Air Conditioner:

The ductless, mini-split air conditioning system is also common but it's modified with new parts. Just like the central conditioning type, these systems have an indoor handling unit and an outdoor compressor/condenser.

These types of air conditioning systems are effective in cooling individual rooms because the system can have as many as four indoor handling units. The handling unit is connected to the outdoor unit. Also, each handling unit has its own thermostat, which allows each of them to work at a different temperature. A particular part can be cooled in the system



C. Window Air Conditioner:

A window air conditioner is a compact unit, ideal for cooling one particular room. The system is also known as a "unitary unit", it's installed in the window of a room. In its working, warm air is sent out through the back of the conditioning system and blows cool air through the front part. It's perfect for those who secure small spaces and won't be perfect for larger homes as it doesn't cool effectively in such a kind of environment.

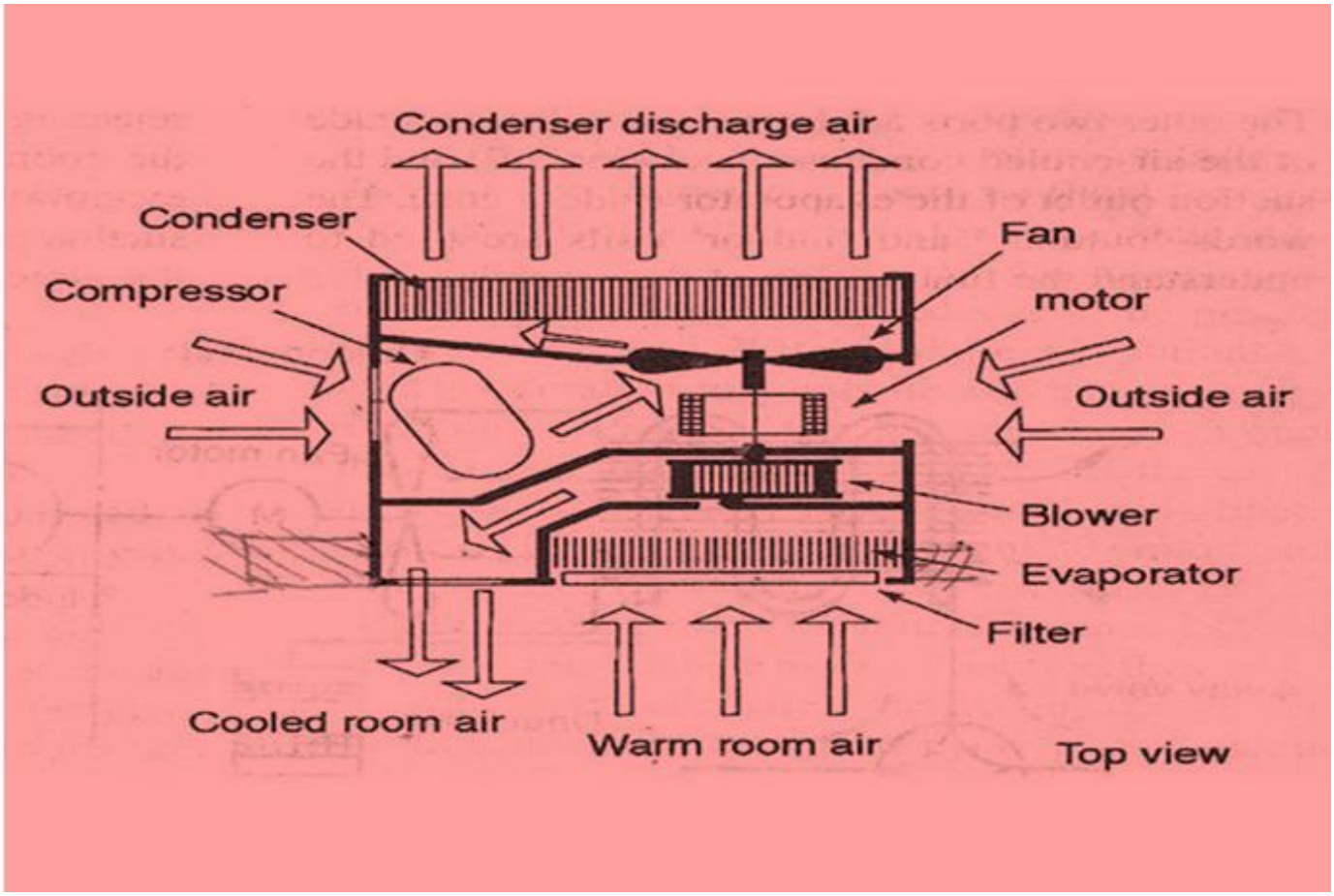


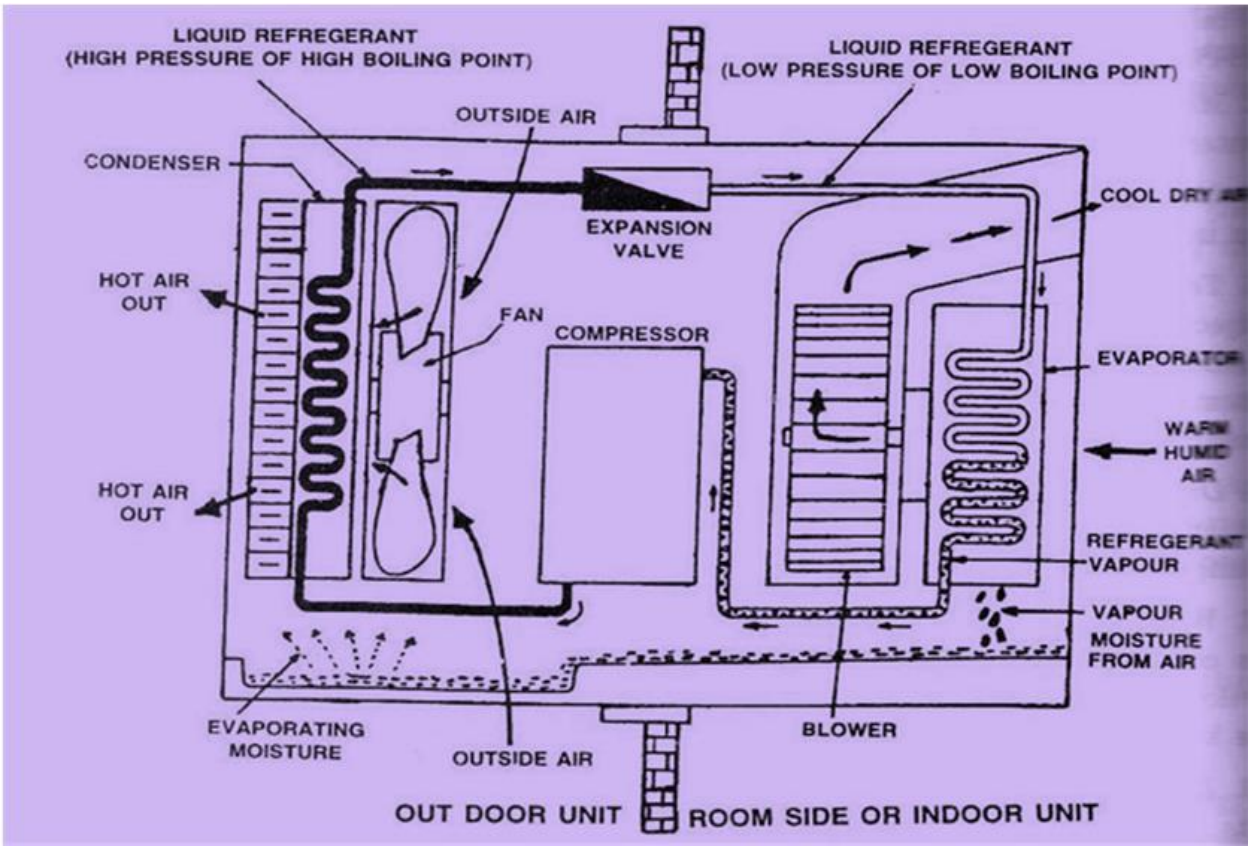
1.3.6. Various Parts of the Window Air Conditioner

The various parts of the window air conditioner can be divided into following 4 categories:

- The refrigeration system,
- Air circulation system,
- Ventilation system, control system, and
- The electrical protection system.

Air Circulation system





Indoor Unit and outdoor Unit of window air conditioner

1.3.7. Window Type Air Conditioner Working

The low pressure vapour refigerant from the evaporator is sucked by compressor through the open inlet valve.

- The compressor compresses the vapour refrigerant.
- The high pressure and high temperature vapour refrigerant then flows to the condenser through the open outlet valve.
- In the condenser, the outside atmospheric temperature in summer being around 42o C, air is circulated by fan.
- After condensation, the high pressure liquid refrigerant formed passes through an expansion valve which reduces its pressure,

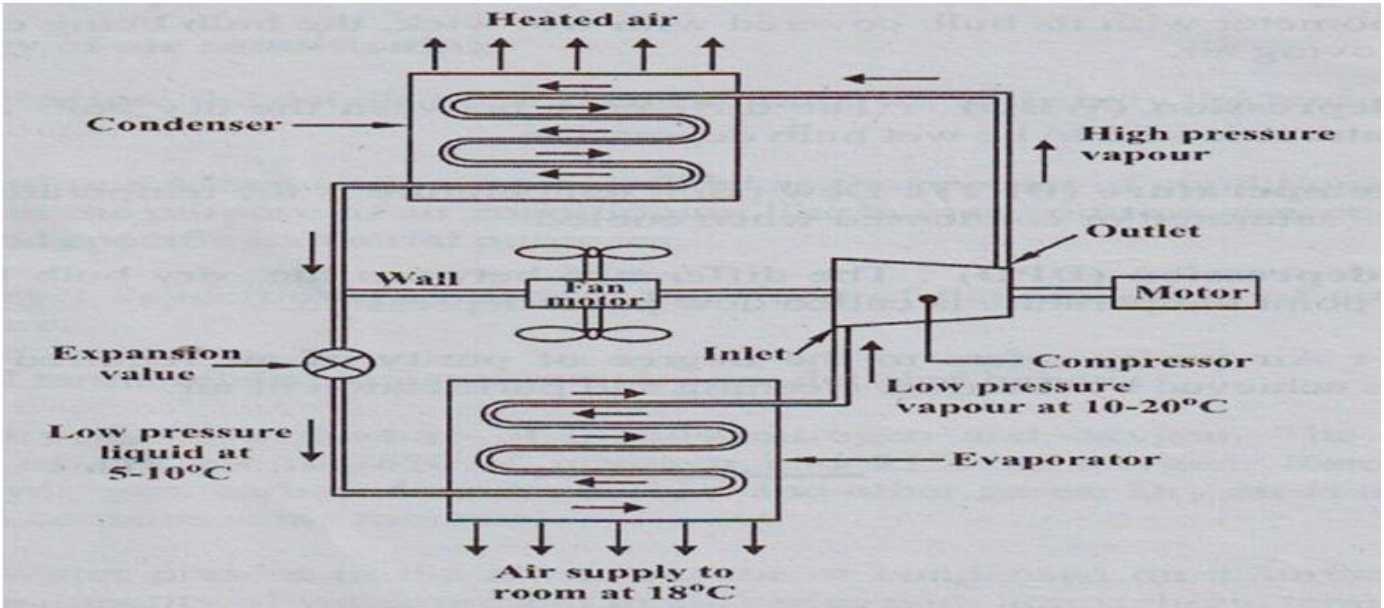


Fig.1 Window room air conditioner

The low pressure refrigerant then enters the evaporator and evaporates, thus absorbing latent heat of vapourisation from the room air.

- The equipment which is used for evaporating the refrigerant is called evaporator.
- After evaporation, the refrigerant becomes vapour.
- The low pressure vapour is again passed to the compressor. Thus the cycle is repeated.
- A partition separates high temperature side of condenser, compressor and low temperature side of evaporator
- The quantity of air circulated can be controlled by the dampers.
- The moisture in the air passing over the evaporator coil is dehumidified and drips into the trays.
- The unit automatically stops when the required temperature is reached in the room. This is accomplished by the thermostat and control panel. Generally, the refrigerant monochloro difluro methane (CHCLF2) is used in air conditioner. It is called Freon 22

D. Portable Air Conditioner:

These types of air conditioning systems are specified as next-generation window unit cooling systems. It takes air from the room and cools it then send it back into the room. It also vents warm

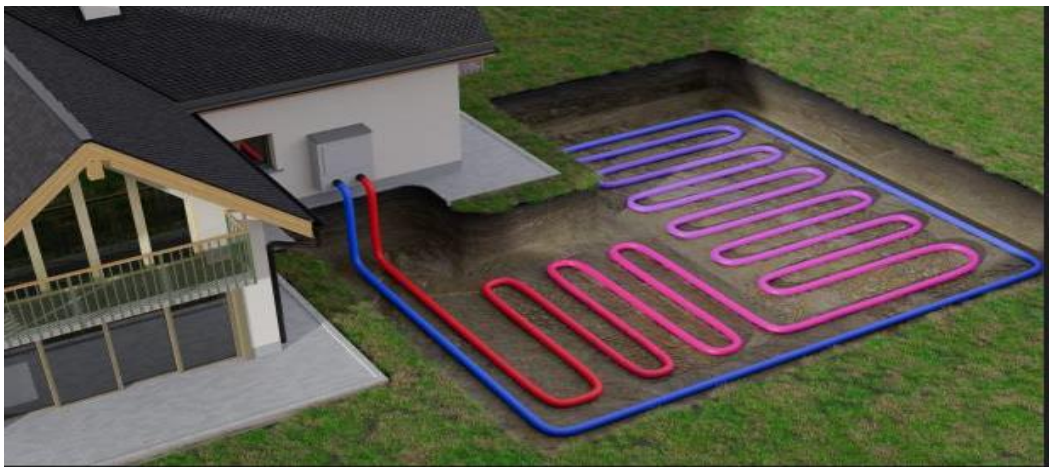
air from outside, through an exhaust hose that's installed in a window. Just like the window air conditioning units, these types of systems are also designed to cool only one room.

They're affordable, versatile, and also easy to install. Its portability makes it even more ideal



E. Geothermal Heating and Cooling:

Geothermal energy is sustainable, energy-efficient, and has a long lifespan. These cooling and heating process is possible because the ground temperature always remains 55 degrees. It does not change no matter how hot or cold the temperature is. Geothermal technology extracts heat from the ground and uses it inside the house. The system contains a geothermal coil (loops or wells) installed deep into the ground, it's what cools and heats the house and then distributes it back into the ground.



F. Hybrid Air Conditioners

Hybrid air conditioners are heat pump systems powered either by burning fossil fuels or electricity. Manufacturers intelligently choose a suitable source of energy in order to save money and energy.

The system works as it will normally do in the summer by pulling heat from the indoors and distribute it outdoors. It works reverse in the winter by pulling heat from the outside to discharge it into the house. The hybrid pump system works with the second law of thermodynamics, which stated that heat gets transferred from a hot object to a cold object. So, when the refrigerant drops below the

outside temperature, the heat obtained from the outside environment is transferred to the system heat pump's coils and into the refrigerant. The extracted heat is what turns into warm, conditioned air for the room.



3.2. Installing refrigerant pipe work and associated components

3.2.1. Installation procedure of air conditioner Window & Split

A. Types of Installation

I. **Window Mounting**

A. Wooden frames

B. Section frames

- Iron section
- Aluminum section

II. **Opening in Wall**

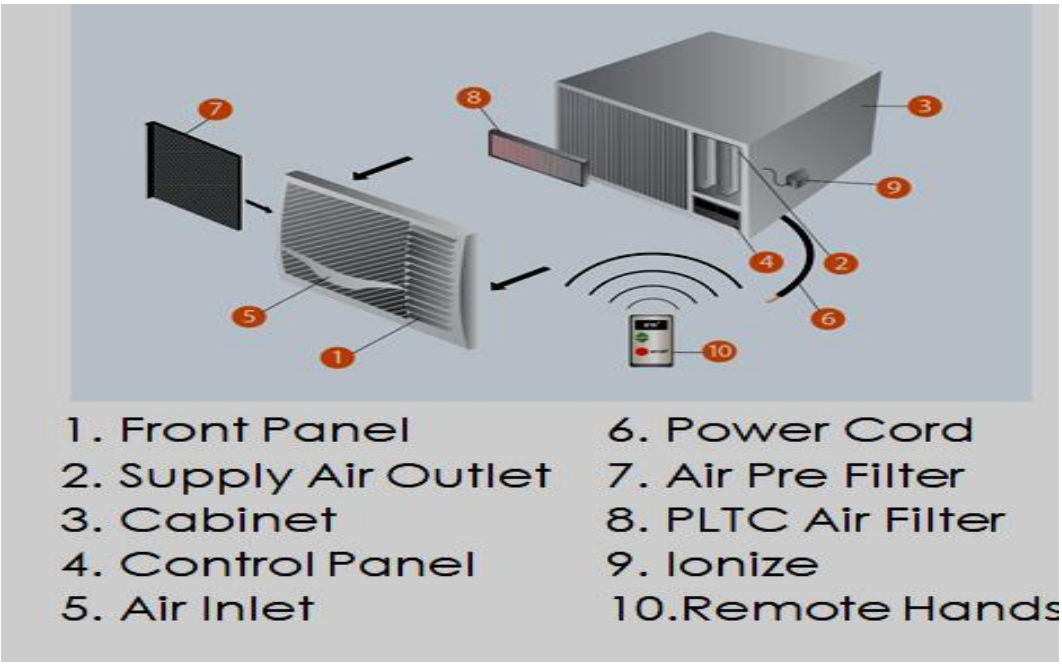
- Light wall - 4" Thick
- Heavy wall - more than 9 " thick .

III. **Special Installations**

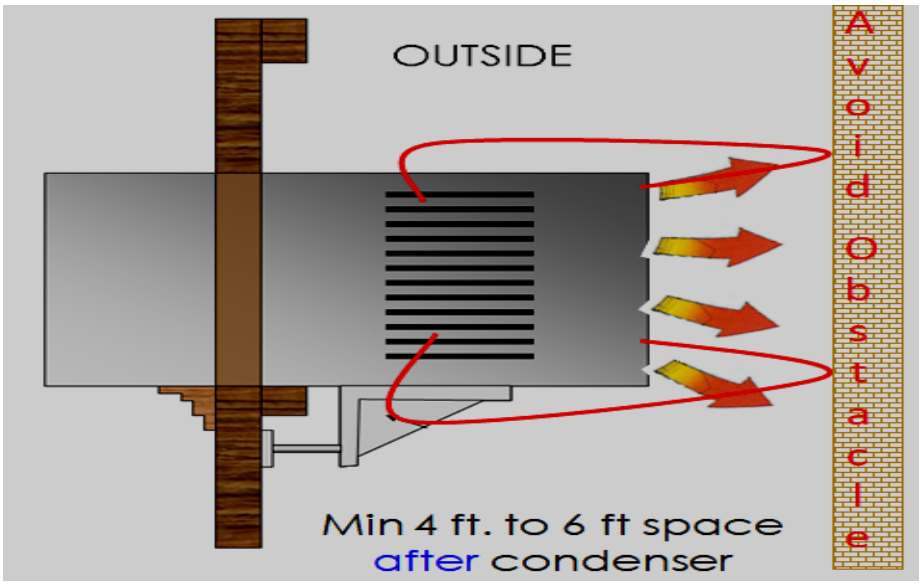
- Wooden Partition
- Glass Partition

3.2.2. Installing refrigerant pipe work procedure

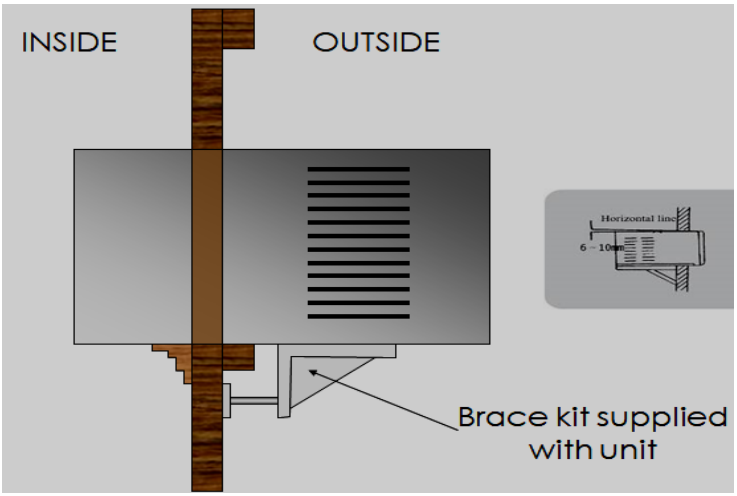
A. Know the Air conditioner Window Type



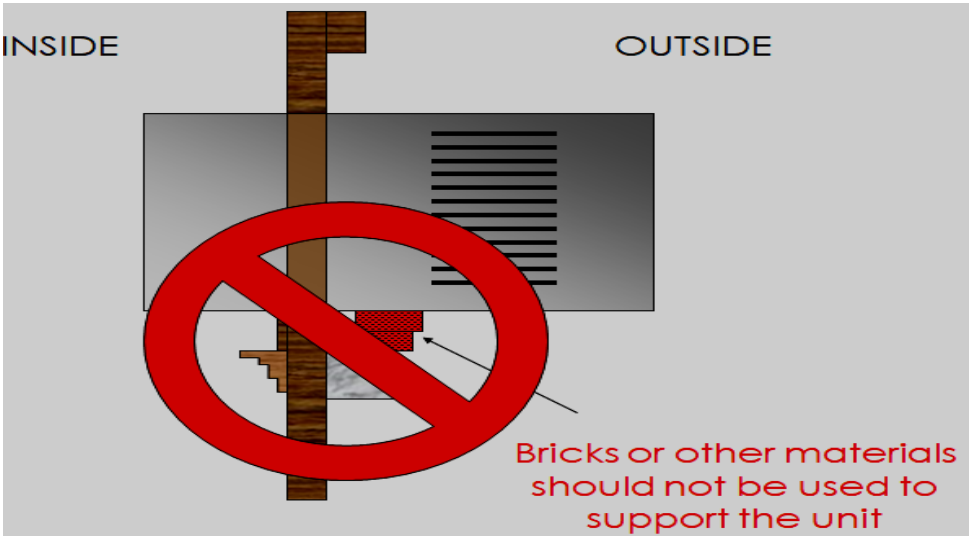
B. Determine Air Conditioner Location



C. Preparation of window



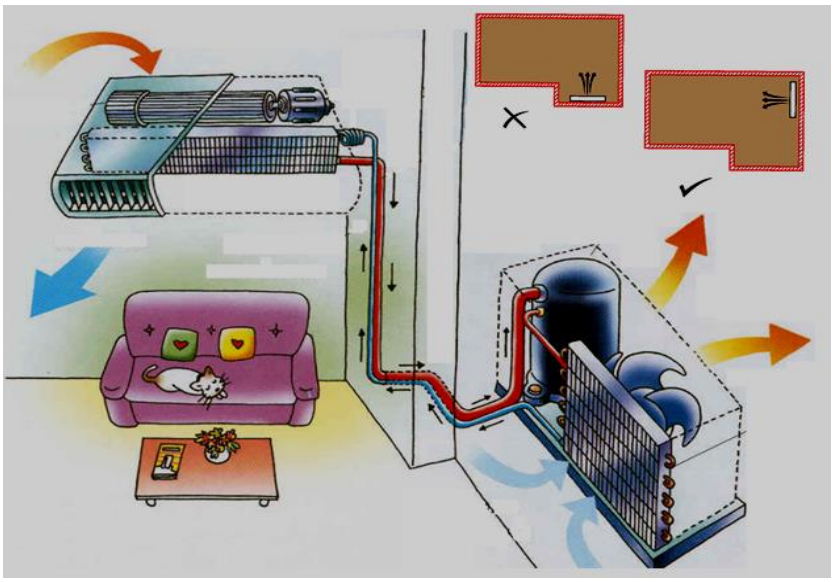
D. Installation inside and outside bracket supply unit



E. Test Run Before Sliding the unit to Cabinet

- Compressor functioning
- Fan mounting
- Motor
- Blower
- Alignment
- Operation of control panel and remote control
- Cooling
- Check current

F. Determine Split Air Conditioner Location



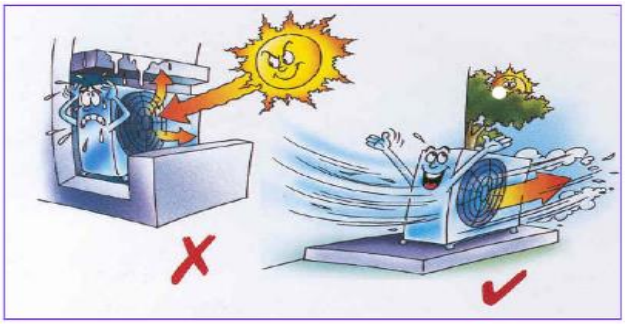
G. Indoor Unit

At a distance 1m or more away from TV and radio etc

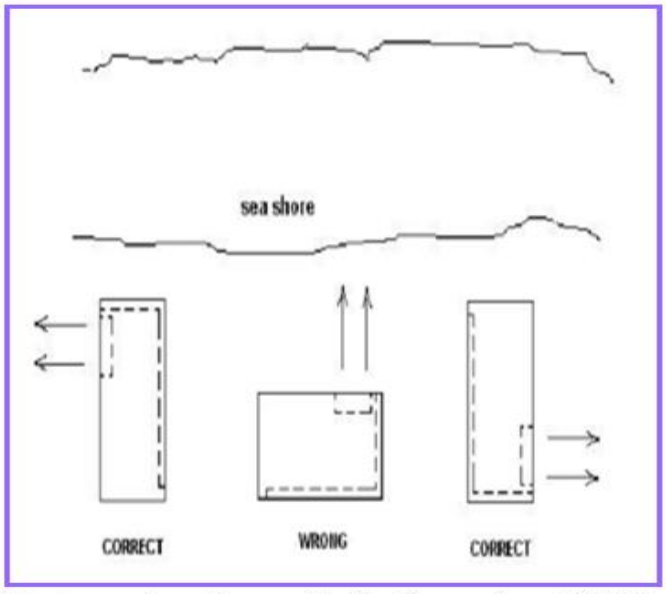


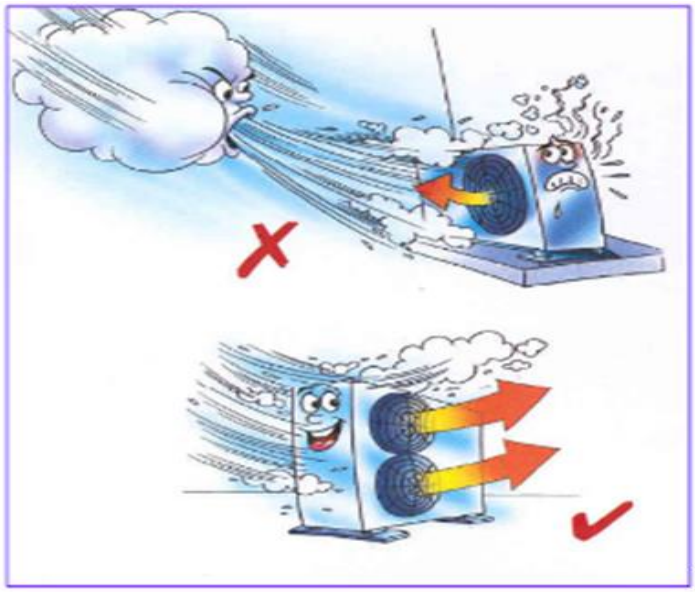
I. Possible Troubles:

- Malfunction by noise and Harmon's generate due to the high voltage

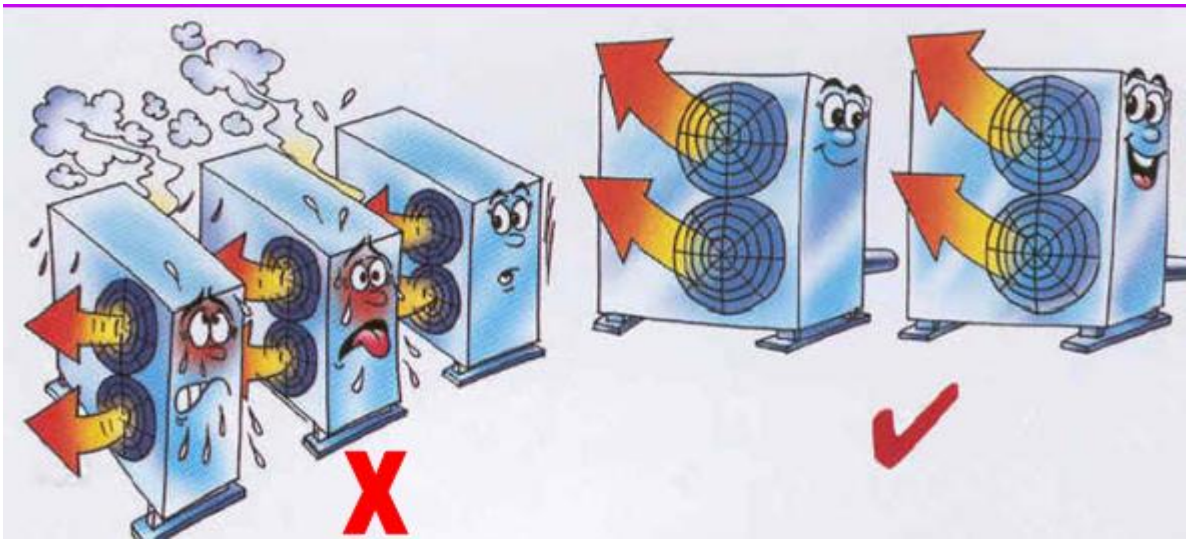


H. Condenser location



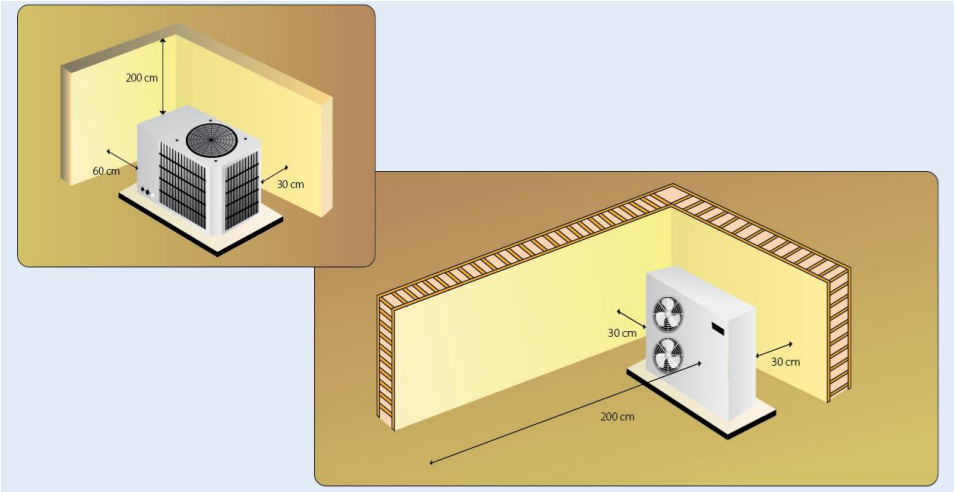


I. Determination of air flow for CDU



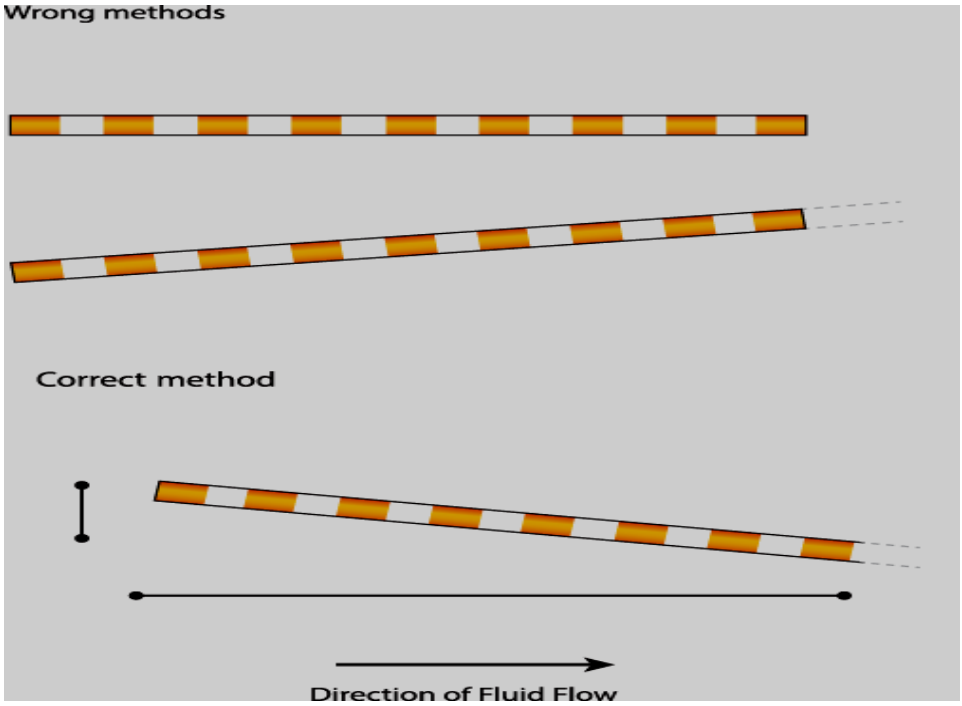
Hot air must not be allowed to flow freely through the adjacent CDU to maintain good efficiency.

J. Determine Split Air Conditioner Location



Do not install CDU too close to the wall. It will trip due to high head pressure, as heat dissipation can't happen

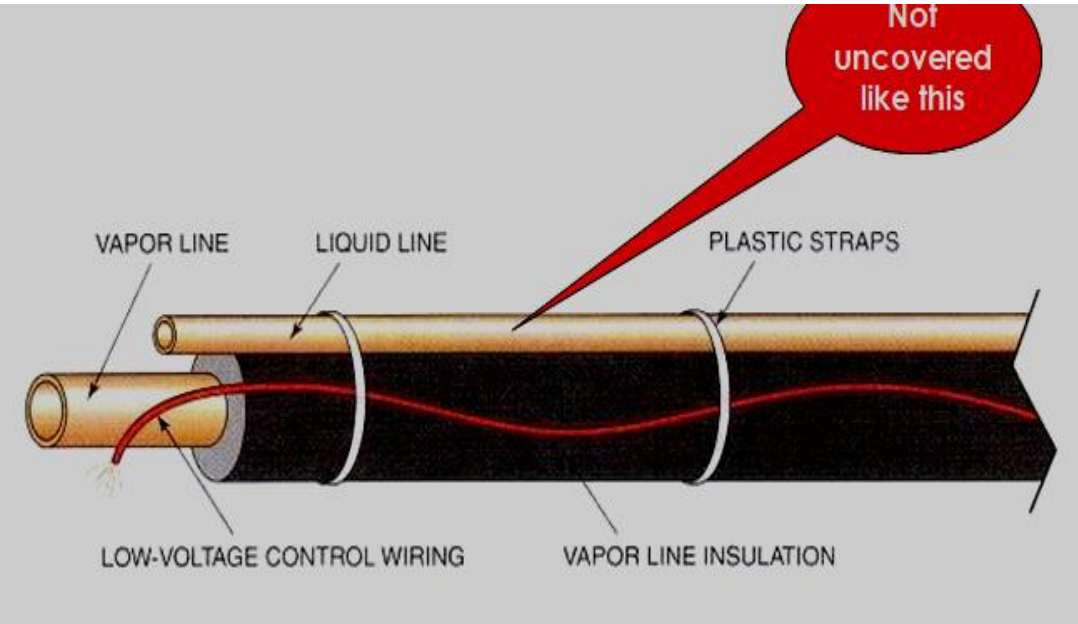
K. **Piping layout for split air-conditioner**



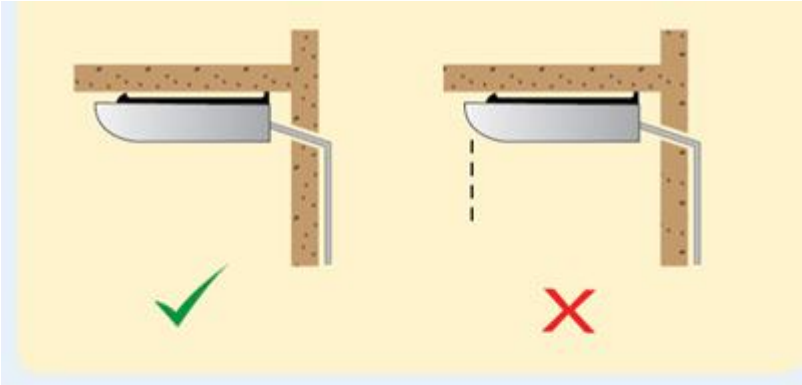
1/8 inch per foot (10.4 mm/m) in the direction of refrigerant flow

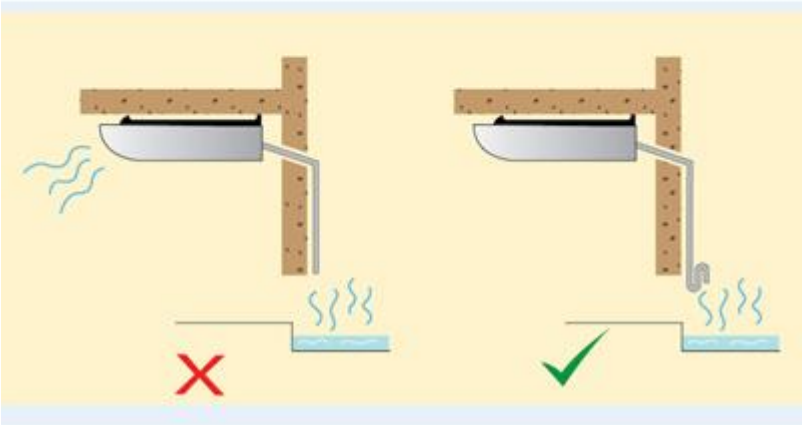
Insulation

Insulate both the pipes separately with proper size of insulation sleeve



L. Drainage



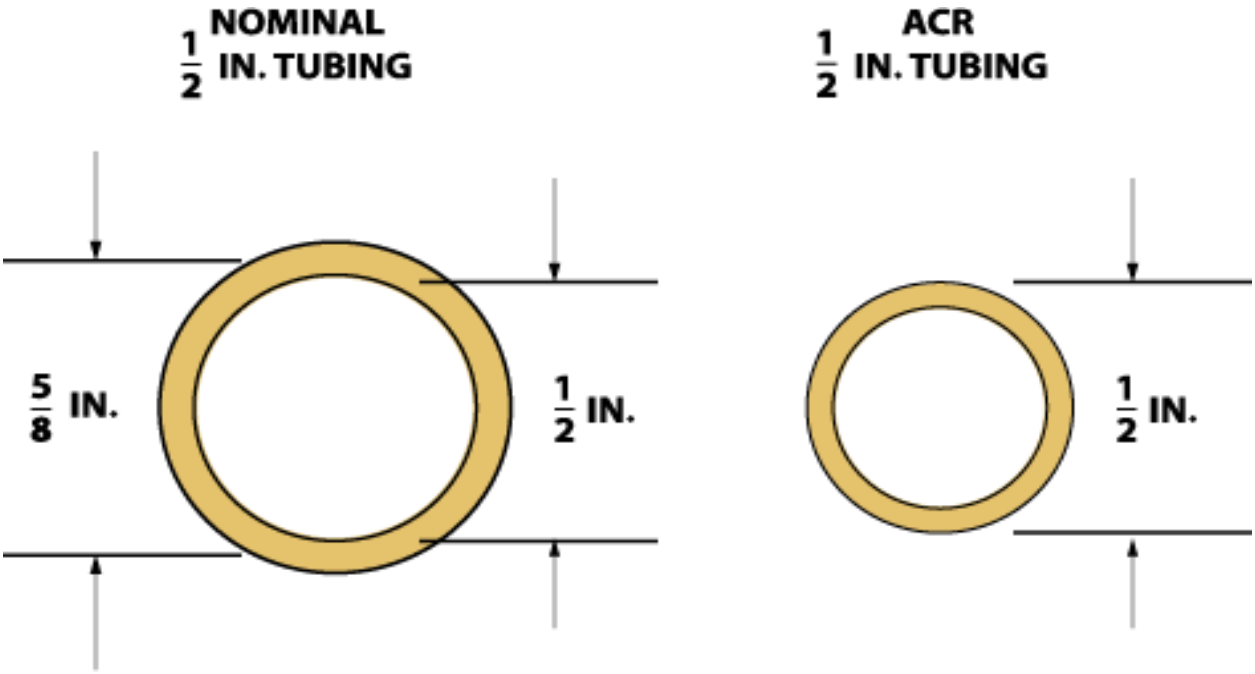


M. Indoor test for dipping of water



N. Airconditioning tubing v/s. plumbing tubing

Some Common Grades of Copper	
K	Thick-walled copper piping used for heavy duty applications
L	Medium-walled copper piping is the most frequently used
M	Thin-walled copper piping is rarely used in the HVAC industry



O. Copper tube data

Nominal Dia.	Type	Wall Dia.	Diameter		Surface Area		Cross Section		Weight	Working Pressure ASTM B88 To 250°F	
		(in)	Outside D, (in)	Inside D (in)	Outside (ft^2/ft)	Inside (ft^2/ft)	Metal Area (in^2)	Flow Area (in^2)	Tube (lb/ft)	Annealed (PSIG)	Drawn (PSIG)
1/2	K	0.049	0.500	0.402	0.131	0.105	0.069	0.127	0.269	894	1676
	L	0.035	0.500	0.430	0.131	0.113	0.051	0.145	0.198	638	1197
5/8	K	0.049	0.625	0.527	0.164	0.138	0.089	0.218	0.344	715	1341
	L	0.040	0.625	0.545	0.164	0.143	0.074	0.233	0.285	584	1094
3/4	K	0.049	0.750	0.652	0.196	0.171	0.108	0.334	0.418	596	1117
	L	0.042	0.750	0.666	0.196	0.174	0.093	0.348	0.362	511	958
7/8	K	0.065	0.875	0.745	0.229	0.195	0.165	0.436	0.641	677	1270
	L	0.045	0.875	0.785	0.229	0.206	0.117	0.484	0.455	469	879
1 1/8	K	0.065	1.125	0.995	0.295	0.260	0.216	0.778	0.839	527	988
	L	0.050	1.125	1.025	0.295	0.268	0.169	0.825	0.654	405	760
1 3/8	K	0.065	1.375	1.245	0.360	0.326	0.268	1.217	1.037	431	808
	L	0.055	1.375	1.265	0.360	0.331	0.228	1.257	0.884	365	684
1 5/8	K	0.072	1.625	1.481	0.425	0.388	0.351	1.723	1.361	404	758
	L	0.060	1.625	1.505	0.425	0.394	0.295	1.779	1.143	337	631
2 1/8	K	0.083	2.125	1.959	0.556	0.513	0.532	3.014	2.063	356	668
	L	0.070	2.125	1.985	0.556	0.520	0.452	3.095	1.751	300	573
2 5/8	K	0.095	2.625	2.435	0.687	0.637	0.775	4.657	2.926	330	619
	L	0.080	2.625	2.465	0.687	0.637	0.640	4.772	2.479	278	521
3 1/8	K	0.109	3.125	2.907	0.818	0.761	1.033	6.637	4.002	318	596
	L	0.090	3.125	2.945	0.818	0.771	0.858	6.812	3.325	263	492
3 5/8	K	0.120	3.625	3.385	0.949	0.886	1.321	8.999	5.120	302	566
	L	0.100	3.625	3.425	0.949	0.897	1.107	9.213	4.291	252	472
4 1/8	K	0.134	4.125	3.857	1.080	1.010	1.680	11.684	6.510	296	555
	L	0.110	4.125	3.905	1.080	1.022	1.387	11.977	5.377	243	456
5 1/8	K	0.160	5.125	4.805	1.342	1.258	2.496	18.133	9.674	285	534
	L	0.125	5.125	4.875	1.342	1.276	1.963	18.665	7.609	222	417
6 1/8	K	0.192	6.125	5.741	1.603	1.503	3.579	25.886	13.867	286	536
	L	0.140	6.125	5.845	1.603	1.530	2.632	26.832	10.200	208	391
8 1/8	K	0.271	8.125	7.583	2.127	1.985	6.687	45.162	25.911	304	570
	L	0.200	8.125	7.725	2.127	2.022	4.979	46.869	19.295	224	421

P. Un-rolling tube rolls

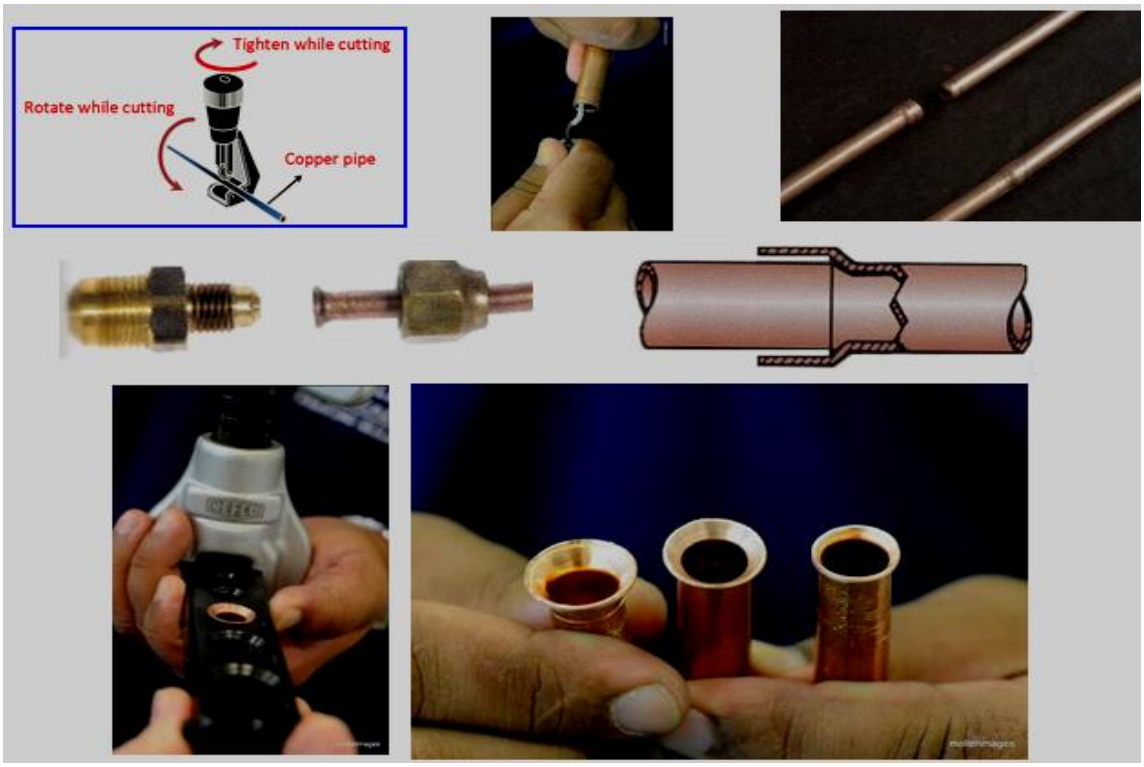


Keep the both end close until actual brazing/connection takes place

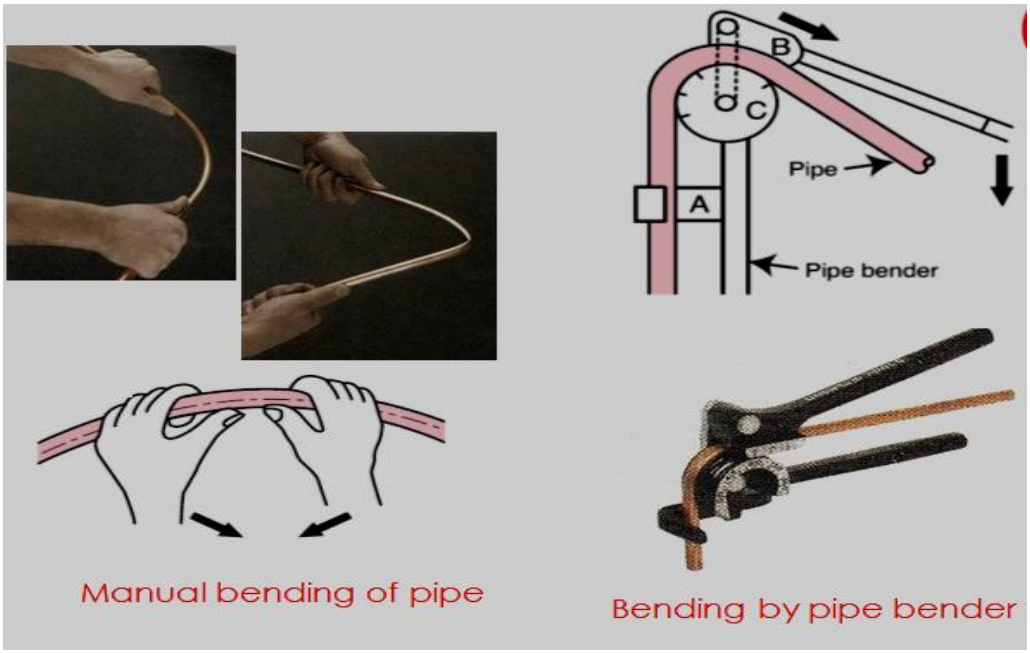
Tubing should be unrolled carefully to avoid kinking the pipes



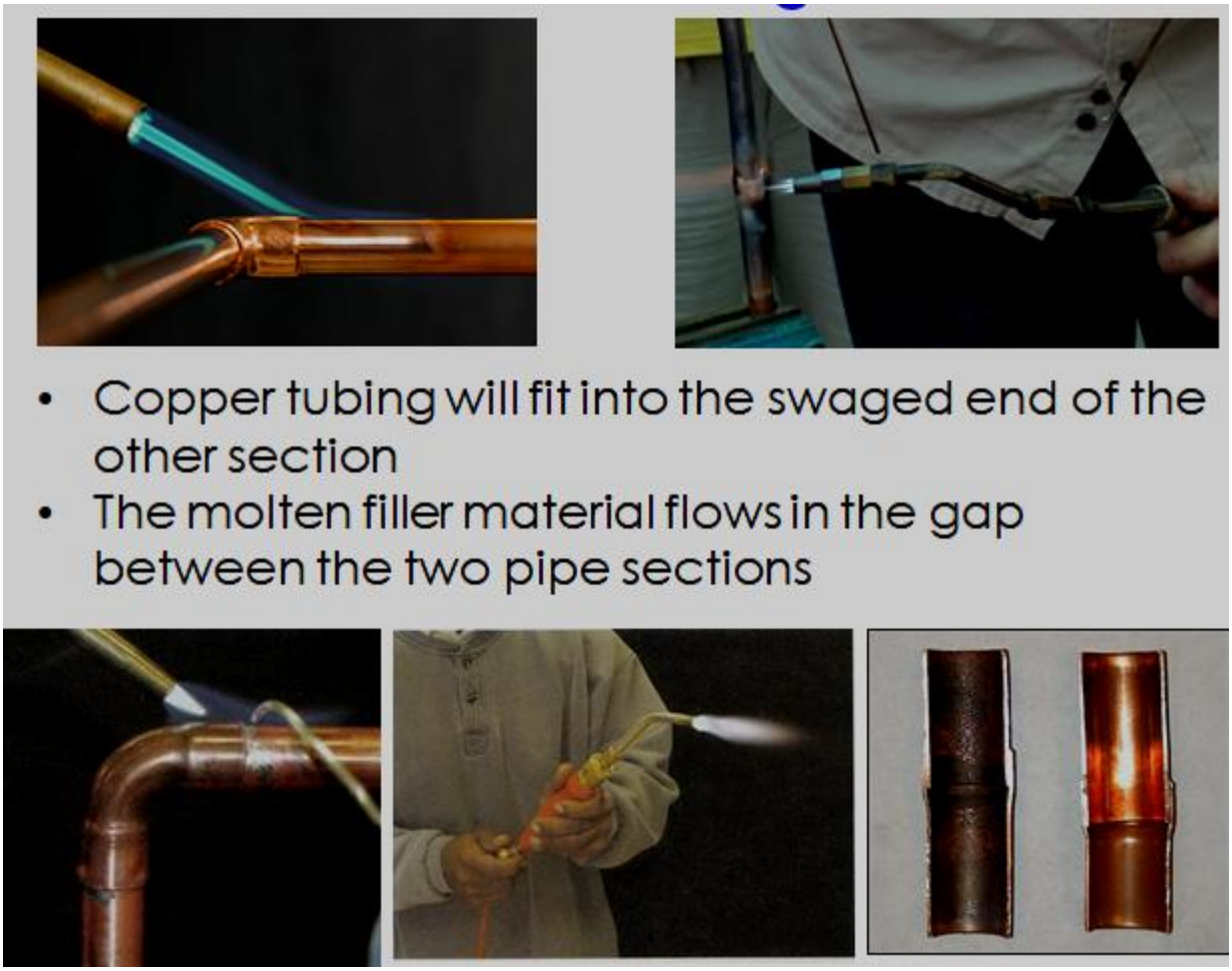
Q. Tubes cutting, swaging and Flaring



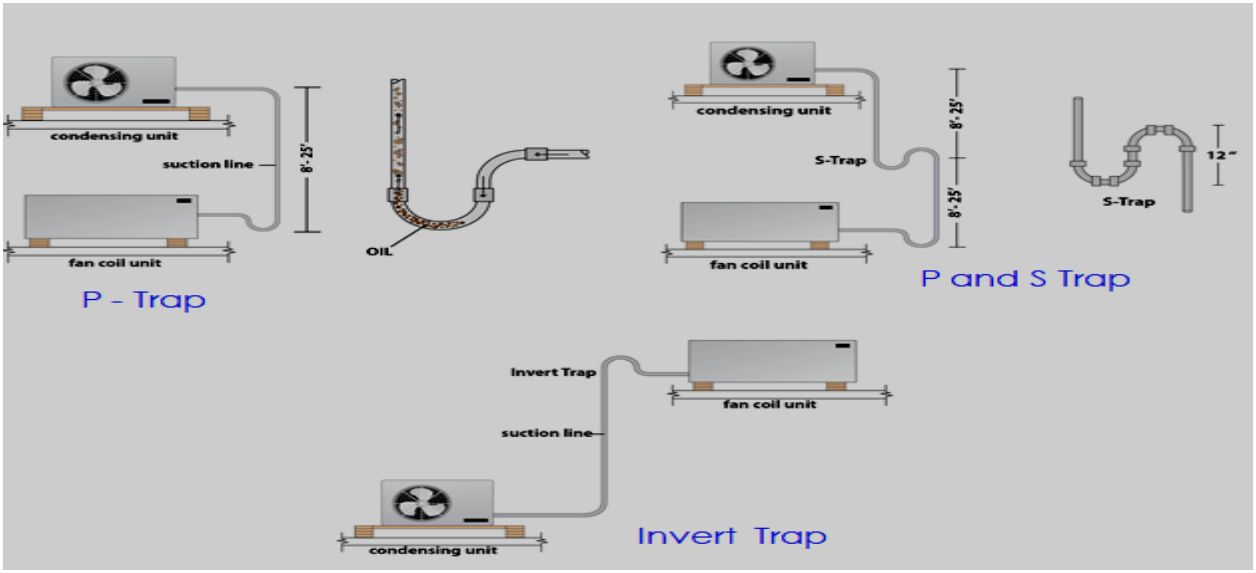
- **Tubes bending**



R. Tubes Brazing



S. P-Trap, P - Trap and S – Trap & Invert Trap



3.3. Conducting pressure testing of the installed components and pipe

3.3.1. Pressure Testing for Strength and Leak Tightness

Systems are pressure tested to ensure they are:

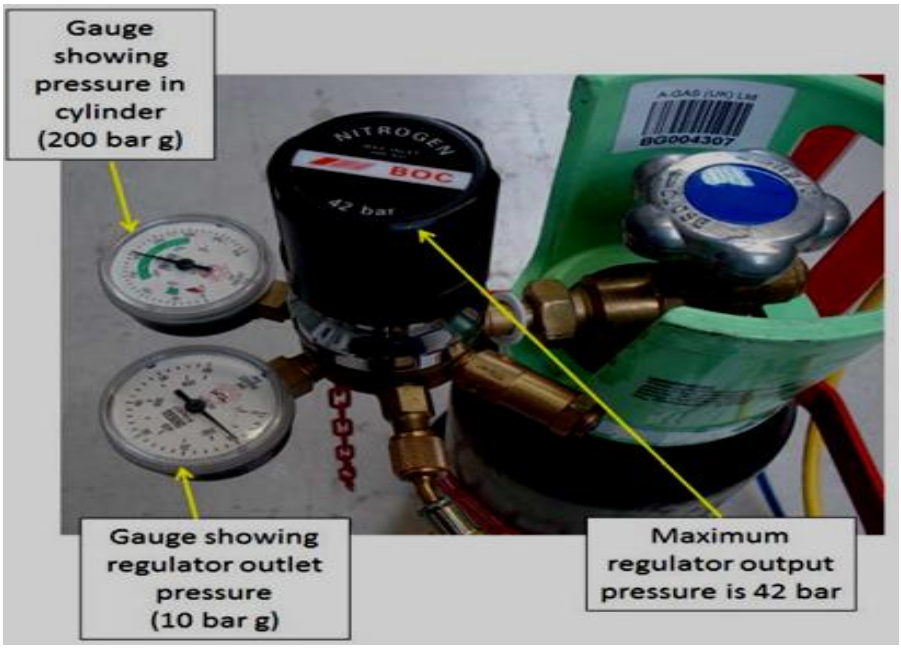
- **Safe** – for this test a pressure above the system's maximum allowable
- pressure (PS) is used;
- **Leak tight** – this test is at PS

Pressure testing is hazardous and should be carried out carefully:

- The nitrogen used for pressure testing is an a sphyxiant, so the area around the system should be well-ventilated;
- High pressures are used, so all non-essential personal should be evacuated from the area;
- Anyone carrying out the pressure testing should wear safety goggles.

I. Nitrogen and regulation

Dry (oxygen free) nitrogen (OFN) is used to achieve the pressures required for the pressure tests because it is inert. You must **never** use oxygen for pressure testing - pure oxygen at high pressure reacts violently with oil and will explode.



A. Using the nitrogen regulator

- Ensure the regulator is closed (wound fully anti clockwise);
- Open the cylinder valve;
- Slowly open the regulator to the pressure required.
- Do not use a regulator with an output pressure

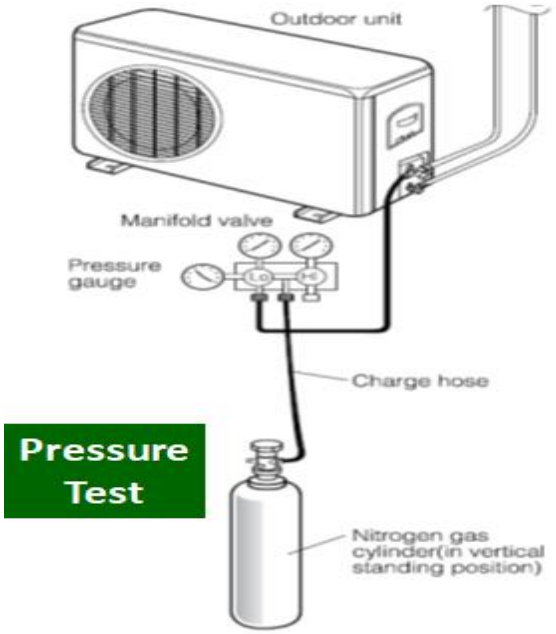
B. Pressure test equipment



- The nitrogen cylinder should be connected to the system using a suitable pressure testing assembly with gauges and hoses suitable for the test pressure. The photo shows a suitable pressure testing gauge / regulator assembly.
- If you are using a manifold ensure it is suitable for the pressure and does not have a sight glass.
- You should use the gauge on the manifold to monitor the test pressure (the gauge on the regulator has a very small scale).
- Ensure the manifold valve is open before opening the nitrogen regulator.

3.3.2. Pressure test, Evacuation & Gas Charging

- **Leak Test with electronic leak detector**







D. Leak Test with electronic leak detector





E. Measure recommended Current of OEM



3.3.3. Pressure testing in any HVAC System

When it comes to installing or repairing piping in any HVAC system, pressure testing is an essential procedure that must be conducted to ensure that the system is free from any leaks. Cyril Air Inc understands the importance of pressure testing in HVAC systems, and we offer pressure testing services to our clients in the Bronx, Manhattan, Brooklyn, and Queens. Our pressure testing service is an effective way to detect leaks in piping before the system is put into operation.

A. Pressure testing is a crucial procedure that is carried out after the installation or repair of piping in HVAC systems. It is a process in which a specific amount of pressure is applied to the piping system to detect any leaks in the system. The amount of pressure applied to the system is usually based on the manufacturer's recommendations. The purpose of pressure testing is to ensure that the system is leak-free before it is put into operation.

There are three common types of pressure testing used in HVAC systems: hydrostatic pressure testing, pneumatic pressure testing, and duct pressure testing.

B. Hydrostatic pressure testing is the most common type of pressure testing used in HVAC systems. It involves filling the piping system with water and pressurizing it to a specific pressure. The system is then checked for any leaks, and the pressure is maintained for a specific period to ensure that there are no leaks.

Pneumatic pressure testing deploys the same concept as hydrostatic pressure testing, but instead of water, air is used to pressurize the piping system. This method is used in situations where the risk of freezing is present.

Duct pressure testing is a specific type of pressure testing used to detect air leaks in the ductwork of HVAC systems. In this method, the airflow through the fan is measured, and the results are used to interpret duct leakage. If any leaks are detected, the ducts are repaired and retested until optimal results are achieved.

At Cyril Air Inc, we offer all three types of pressure testing to our clients in the Bronx, Manhattan, Brooklyn, and Queens. Our team of experts uses advanced equipment and techniques to conduct pressure testing, ensuring that your HVAC system is free from leaks and operates efficiently.

We understand that HVAC systems are essential for the comfort and safety of your home or business. A faulty system can lead to a significant decrease in indoor air quality, increased energy bills, and potential safety hazards. That’s why we take pressure testing seriously and make sure that our clients receive top-quality service from us.

Our pressure testing services are designed to ensure that your HVAC system is leak-free, energy-efficient, and safe. By detecting any leaks in your piping system, we can help you avoid potential safety hazards and reduce your energy bills. Our team of experts is dedicated to providing you with reliable and efficient pressure testing services that meet your needs and budget. We believe that prevention is better than cure. That’s why we recommend that you get your HVAC system pressure tested regularly to ensure that it operates efficiently and

safely. Regular pressure testing can help you avoid costly repairs and replacements and ensure that your HVAC system lasts longer.

In conclusion, pressure testing is an essential procedure that must be conducted after piping installation or repair in any HVAC system. It helps detect any leaks in the system before it is put into operation, ensuring that the system is safe, energy-efficient, and leak-free. Cyril Air Inc provides top-quality pressure testing services to our clients in the Bronx, Manhattan, Brooklyn, and Queens. Our team of experts uses advanced equipment and techniques to conduct pressure testing, ensuring that your HVAC system operates efficiently and safely. Contact us today to schedule a pressure testing service for your HVAC system.

3.4. Evacuating air conditioning system

A. Removal and evacuation

When breaking into the refrigerant circuit to make repairs – or for any other purpose –conventional procedures shall be used. However, it is important that best practice is followed since flammability is a consideration.

- **The following procedure shall be adhered to:**
  - ✓ Remove refrigerant
  - ✓ Clean the circuit with inert gas
  - ✓ Evacuate
  - ✓ Purge again with inert gas
  - ✓ Open the circuit by cutting or brazing
  - ✓ The refrigerant charge shall be recovered into the correct recovery cylinders.
  - ✓ The system shall be “flushed” with OFN to render the unit safe.

This process may need to be repeated several times.

B, Compressed air or oxygen shall not be used for this task.

Flushing shall be achieved by breaking the vacuum in the system with OFN and continuing to fill until the working pressure is achieved, then venting to atmosphere, and finally pulling down to a vacuum. This process shall be repeated until no refrigerant is within the system. When the final OFN charge is used,

the system shall be vented down to atmospheric pressure to enable work to take place. This operation is absolutely vital if brazing operations on the pipe work are to take place. Ensure that the outlet for the vacuum pump is not close to any ignition sources and there is ventilation available

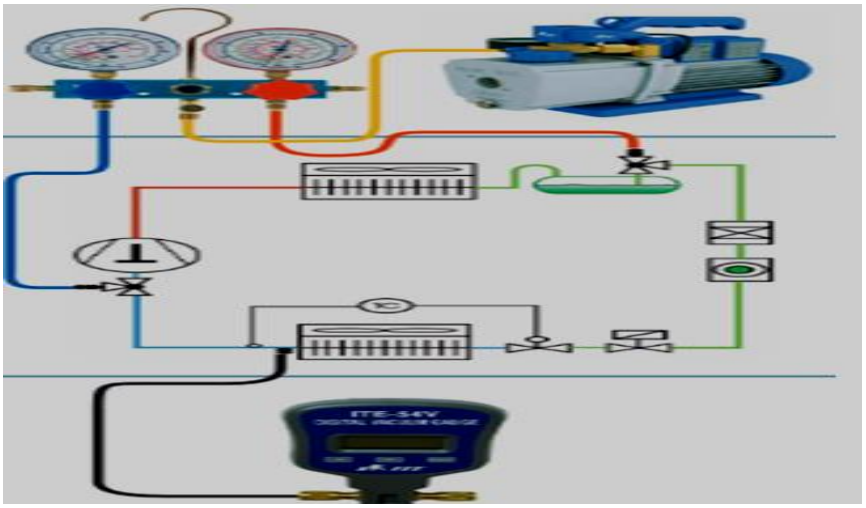
3.4.1. Evacuation & Vacuum holding

- To remove non-condensable gases (e.g. air) & moisture
- Deep vacuum important due to hygroscopic nature of polyolester oil
- Two stage rotary vacuum pump - capable of developing blank off pressure of 20-50 microns, minimum capacity 2cfm
- Micron gauge capable of reading pressures in microns or other scales

Step1. Connect the vacuum pump to the manifold gauge set to the centre port.

Step2. Connect the vacuum gauge to the service port at the evaporator's outlet service port

Step3. Run the vacuum pump and read the vacuum indicated at the vacuum gauge.



3.5. Carrying vacuum drop test

3.5.1. Vacuum Drop Test of Air-Cooled Condensers in Operation

Vacuum tightness is critical for air-cooled condensers operating at low absolute pressure. Low vacuum is aimed for because vacuum dominates the power plant efficiency. To verify vacuum tightness usually a vacuum drop test is made with the system empty at normal atmospheric temperature and free of any liquids. This test is done before commissioning of the power unit and generally follows the recommendations of the Heat Exchanger Institute (HEI) as outlined as "Standards for Steam Jet Vacuum

Systems". However, over time of operation the power plant may develop leakages, which were not present at the time of the original drop test.

This calls for a tightness test at operating conditions where pre-conditions for the standard vacuum drop test are not fulfilled. The report describes a vacuum drop test without interfering too much into normal power plant operation. The test is suitable for stationary operating conditions using standard operation readings. The assessment of leakage flow is based on the measured vacuum decay rate. It is shown that vacuum decay rates taken from tests before and after commissioning are different. Contractual fixing of acceptable vacuum decay rates should therefore be treated with care.

A. Conduct the Vacuum Test

- Connect a tachometer and vacuum gauge to a none regulated vacuum source on the engine.
- Disconnect and plug fuel vapor canister vacuum lines.
- Start engine and run the engine until it reaches normal operating temperature.
- Note the vacuum gauge reading and any variations in the pointer movement at idle and 2000 RPM.
- If the vacuum reading is steady and between 18 and 22 in Hg. the vacuum test indicates that the vacuum system and the basic engine is in good condition
- If the vacuum reading is below 18 in Hg. at idle (at sea level – less if corrected for altitude), the engine is NOT developing sufficient vacuum.
- If the vacuum gauge fluctuates at idle, possible causes are sticking/leaking valves and/or ignition misfire
- If the vacuum gauge fluctuates at idle but steadies as engine speed is increased, check for leaky valves or a faulty camshaft the is holding the valves open.
- If the vacuum gauge fluctuates more as engine speed increases, possible causes are a leaking head gasket, leaking valves, weak or broken valve springs, and/or ignition miss.
- If the vacuum gauge seems to fluctuate regularly each engine cycle, the possible causes are a burnt, leaking valve or improper valve clearance. The faulty valve will cause the vacuum gauge to fluctuate when it operates
- If the vacuum reading drops steadily as engine speed increased, there is excessive backpressure due to restriction in the catalytic converter or the exhaust system.
- If the vacuum gauge seems to drift lazily at idle, possible causes are an extremely lean air/fuel mixture or a minor vacuum leak.

3.6. Checking power and control circuit wiring

3.6.1. The Electrical wiring diagrams for Air conditioning equipment

- **The main types and equipment's in common Air conditioning systems were:**
  - ✓ Window air conditioning units,
  - ✓ Split air conditioning units,
  - ✓ Multi-Split air conditioning units,
  - ✓ Mini-heat pumps,
  - ✓ Split Packaged units,
  - ✓ Unitary Packaged units,
  - ✓ Chillers,
  - ✓ Air Handling Units,
  - ✓ Fan Coil Units,
  - ✓ Pumps,
  - ✓ VAV boxes,
  - ✓ Dampers.

3.6.1. Window Air Conditioning Units Construction



B. Window air conditioning unit casing houses the following components:

- Condenser (outdoor coil),
- Condenser fan,
- Hermetic compressor,
- Evaporator (indoor conditioning coil),
- Evaporator fan (blower),

- Controls: The controls for window units are simple and in-built it includes: (see **Fig A)**



Fig.A: Window Air Conditioning Units Controls

- A rotating selector/Mode switch marked with a hot-cold scale of five positions
- Cool, high fan, low fan) with no temperature settings.
- A rotating Thermostat switch work as on/off switch for the compressor, its status is depending on what temperature degree you set it at (usually there are 8 positions for cooling degree).
- Louvers swing switch: it is on/off switch which controls the swing motor responsible for controlling the movement and direction angle in which the air be supplied from the louvers to the room.

3.6.2. The power flow in Branch circuit of a Window air conditioning unit

The Window air conditioning units are fed from single phase power source (see Fig.B), so its branch circuit and its main power cord consisting of 3 wires (The ground wire, hot wire and neutral wire).

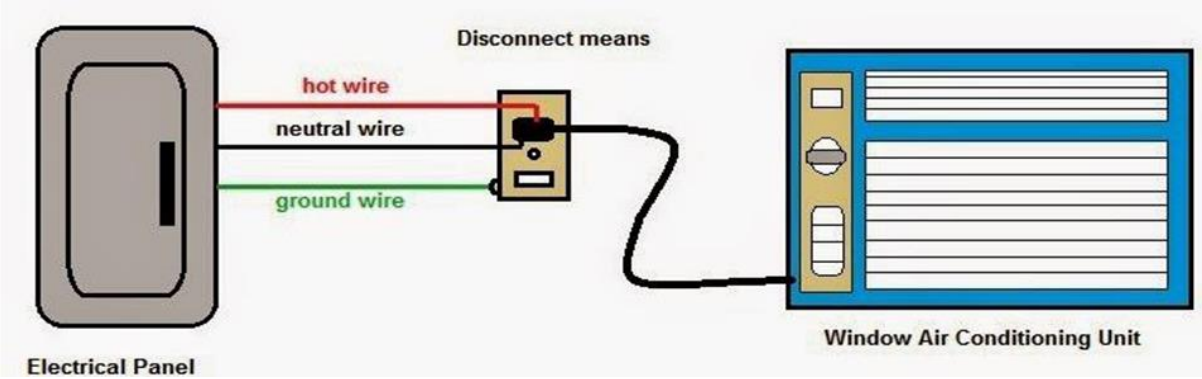
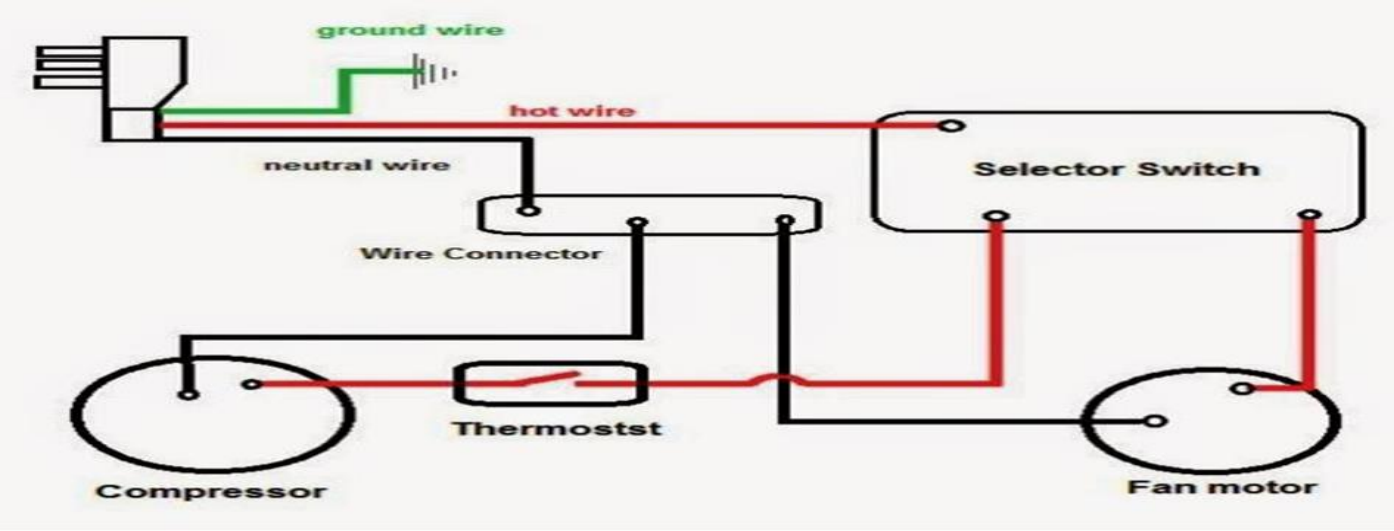


Fig.C: Window Air Conditioning Unit Power Circuit

The branch circuit will originate from one of the single pole Overcurrent protective device OCPD included in an electrical panel.

- Then go through raceway system (conduits, ducts, …) to a disconnect means of some type suitable for the application .
- Finally, the main power cord of the Window air conditioning unit is connected to this disconnecting means from one side, the other side enters the casing of the unit to be connected to the unit's terminal box.

A. Electrical wiring connections inside The Window air conditioning units



Here we are interested on how the main power cord is connected inside the unit and this can be explained as From the figure above.

B. **Window Air Conditioning Unit Internal Electrical Wiring**

I. Inside the unit the main power cord is split to:

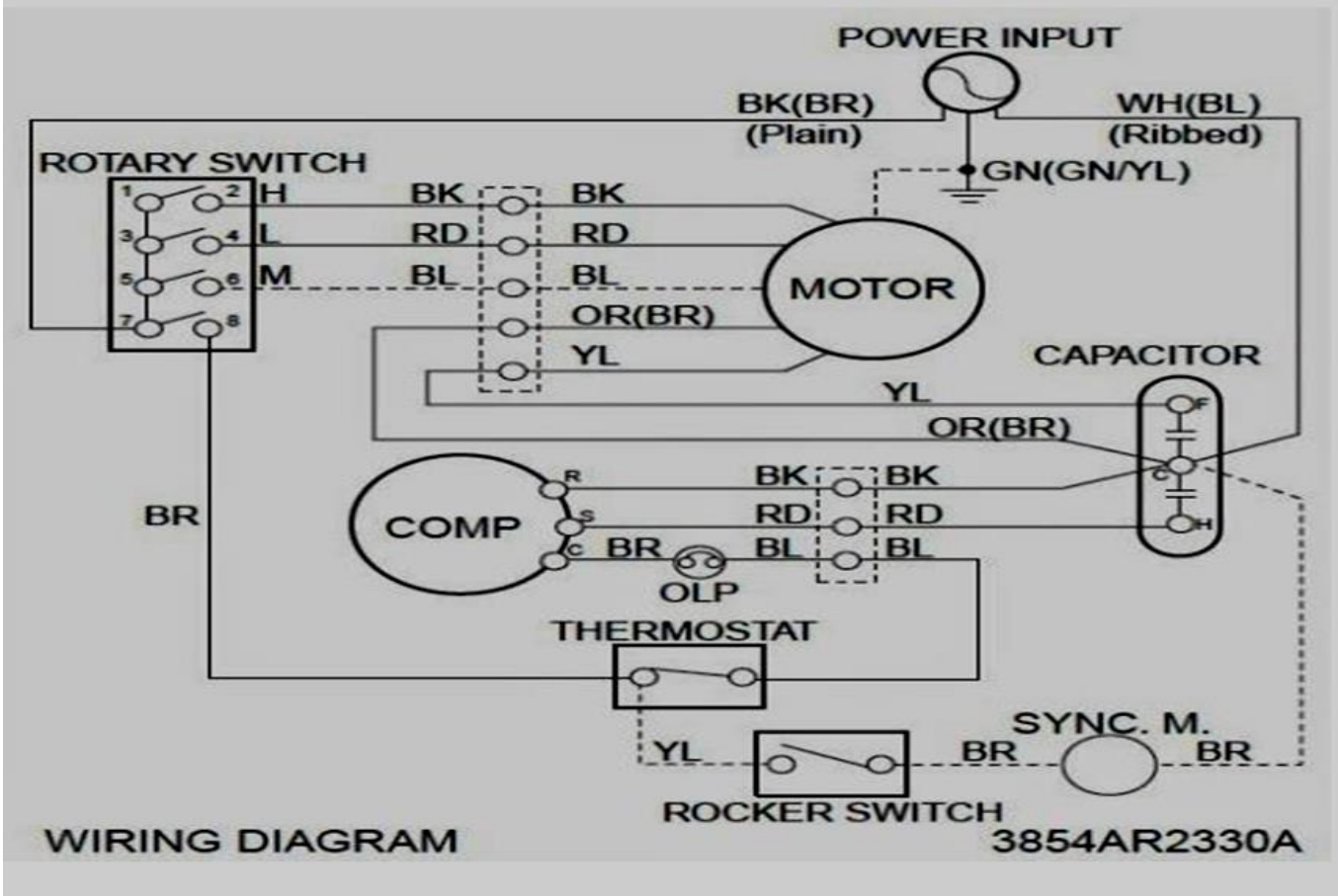
- ✓ The ground wire (either green or a bare wire) is screwed to the metal casing of the unit.
- ✓ Hot wire
- ✓ Neutral wire.

II- Hot wire goes to the selector switch on a window unit to feed power to the vital parts, compressor and

fan motor as follows:

- ✓ Hot wire to selector switch to thermostat switch to compressor
- ✓ Hot wire to selector switch to fan motor.

III - Neutral wire will be connected to fan motor and compressor without goes through any switch. These connections are made on the wire connector in the back of the selector switch so, all neutral wires are common to each other because they are connected to the same point. some examples for the complete electrical wiring diagrams for Window Air Conditioning Unit given below**.**



C. Split Air-Cooling Units

- **Split air-Cooling Units Construction**

The split systems are individual systems in which the two heat exchangers are separated (one outside, one inside) . There are two main parts of the split air conditioner which are:

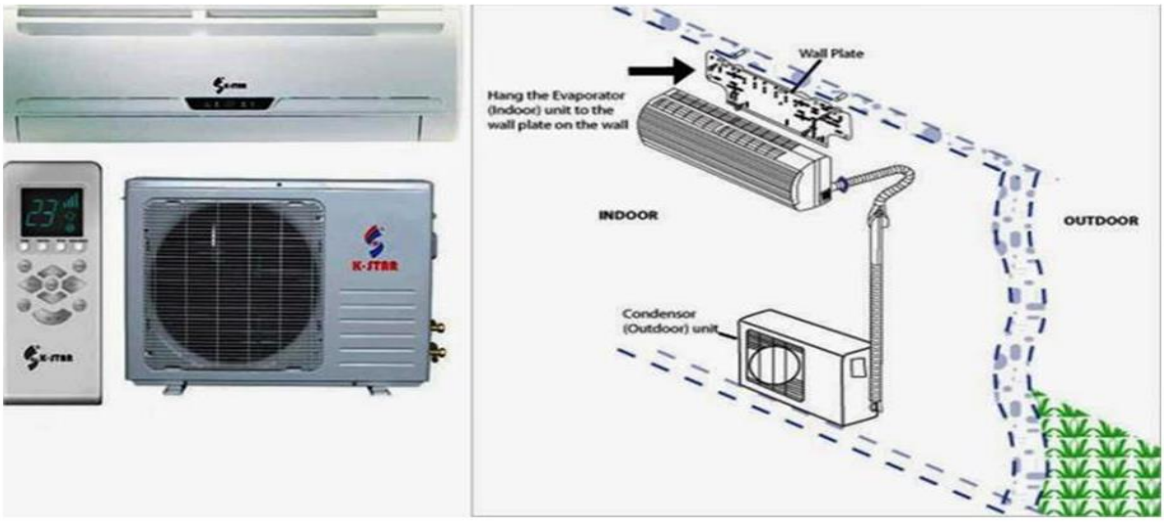


Figure : Split air Cooling Units Construction

A. There are two unit parts

- Outdoor unit,
- Indoor unit.

I- Outdoor unit This unit is installed outside the room or office space which is to becooled and houses important components of the air conditioner like:

- The compressor,
- Condenser Cooling Fan,
- Expansion Valve.

II-Indoor unit: The most common type of the indoor unit is the wall mounted type though other types like ceiling mounted and floor mounted are also used.

- The indoor unit produces the cooling effect inside the room or the office and houses the following components:
  - ✓ The evaporator coil or the cooling coil,
  - ✓ Cooling Fan or Blower,
  - ✓ The drain pipe,
  - ✓ Louvers or Fins,
  - ✓ Air filter,
  - ✓ Controls.

B. The power flow in Branch circuit of a Typical split air conditioning unit

I. The split air conditioning units are fed from either:

- Single phase power source (so its branch circuit and its main power cord consisting of 3 wires (The ground wire, hot wire and neutral wire). **OR**
- Three phase power source ,so its branch circuit and its main power cord consisting of 5 wires (The ground wire, 3 hot wires and neutral wire).

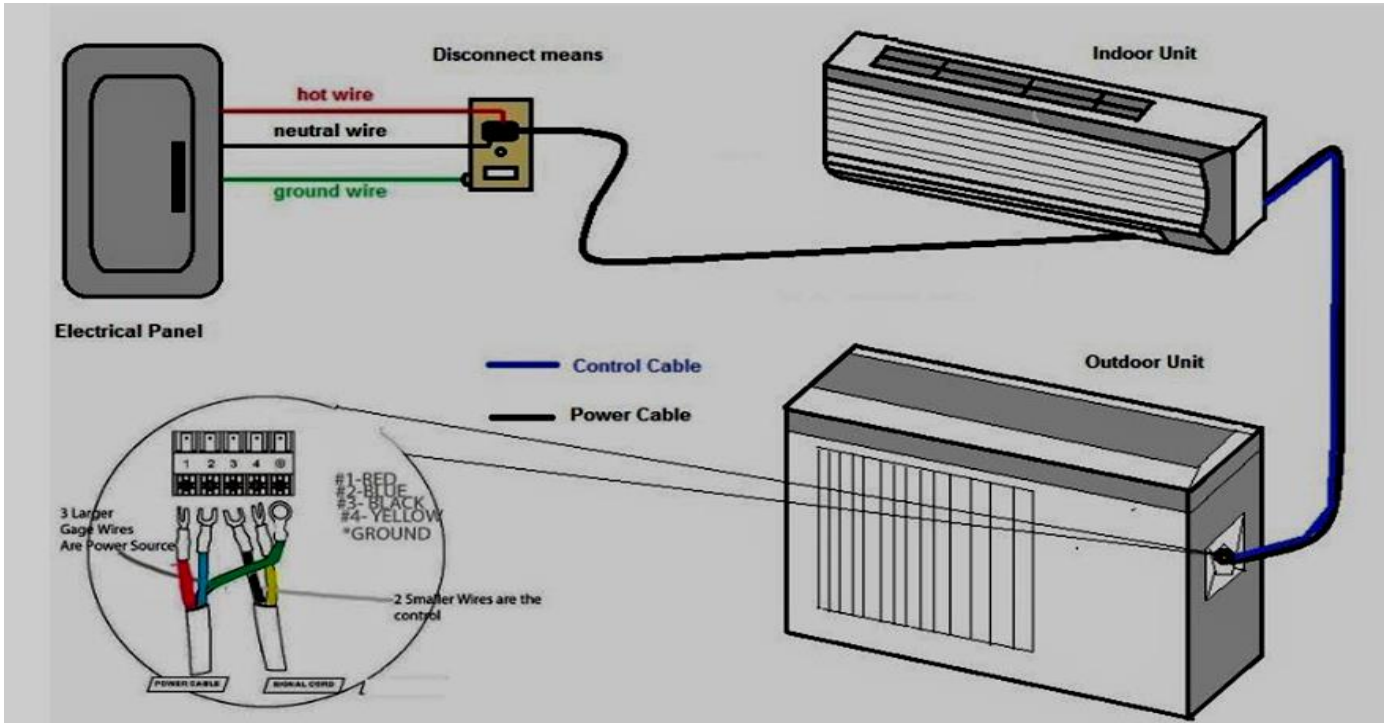


Figure: Split air Cooling Units - Single Phase - Indoor feed Outdoor

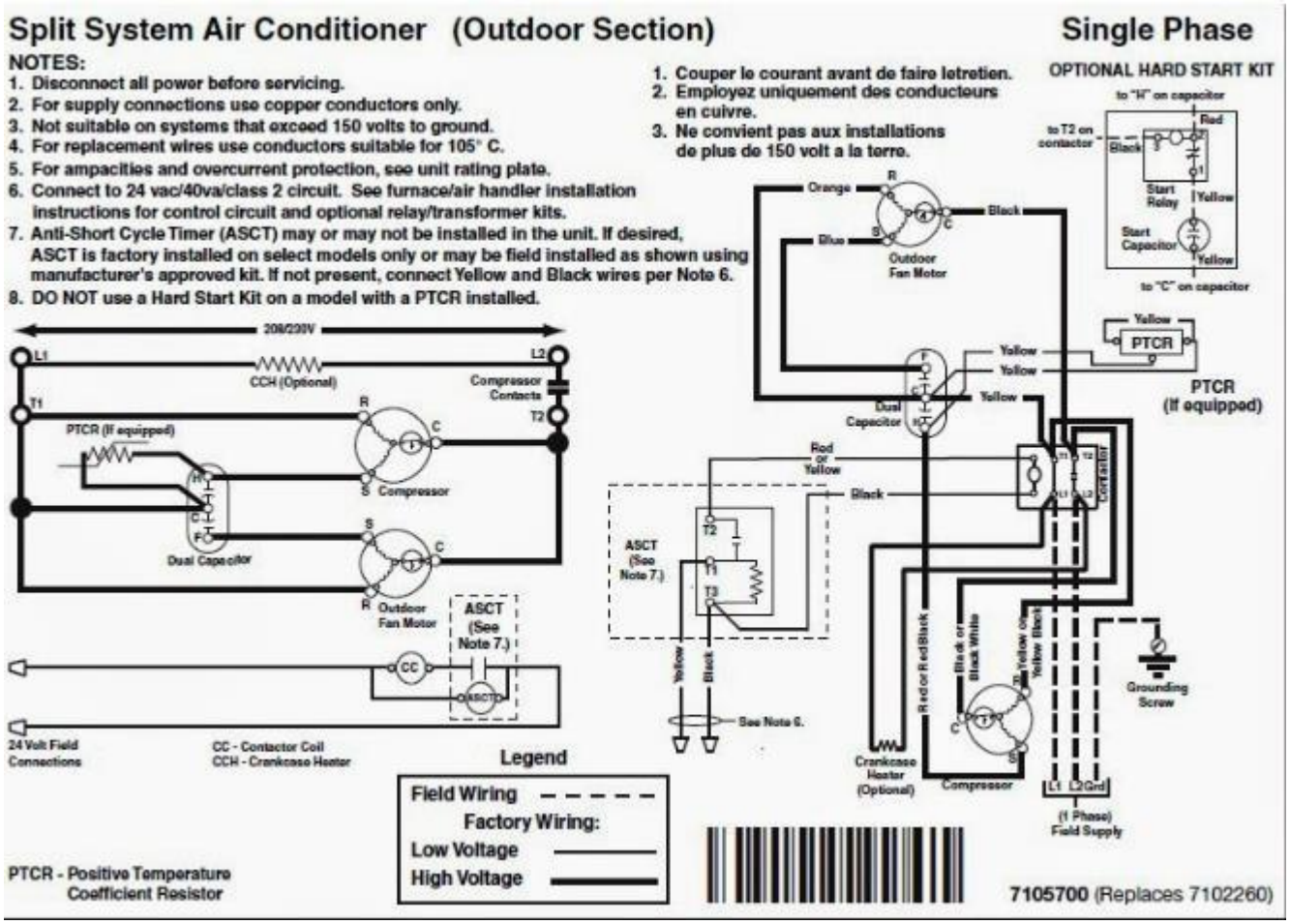


Figure : Split air Cooling Units - Single Phase - Electrical Wiring Diagram

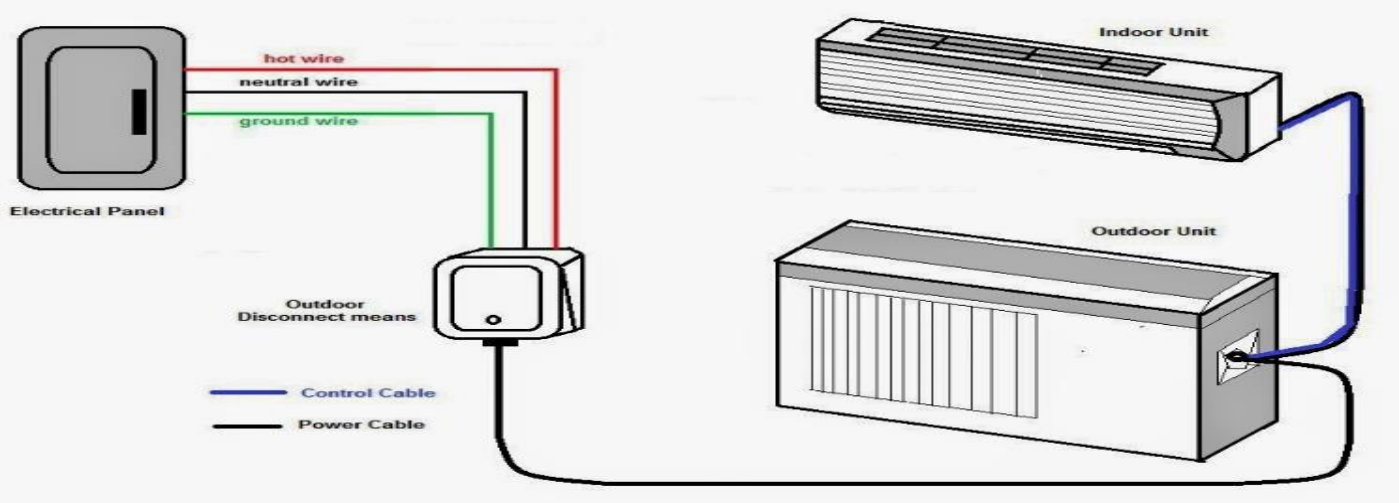


Figure : Split air Cooling Units - Single Phase - Outdoor feed Indoor

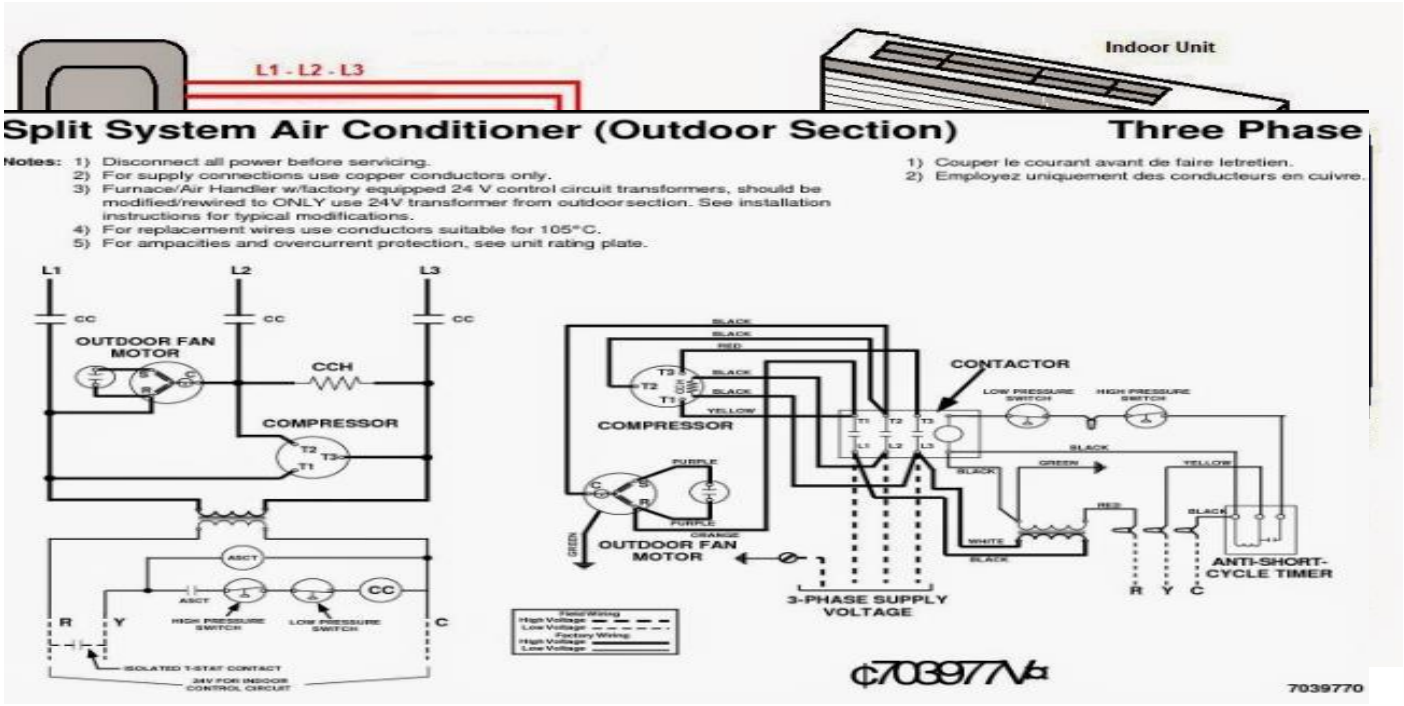


Figure:D. Split air Cooling Units - Three Phase

The branch circuit will originate from one of the single pole/three pole Overcurrent protective device OCPD included in an electrical panel.

Then go through raceway system (conduits, ducts, …) to a disconnect means of some type suitable for the application. After that, the main power cord of the split air conditioning unit is connected to this disconnecting means from one side, the other side is connected to the terminal box in the indoor unit or in the outdoor unit according to the manufacturer's recommendations and wiring diagrams.

Note:If power source connections made in indoor unit, an indoor disconnecting means is used and if power source connections made in outdoor unit, an outdoor disconnecting meanswith suitable identity of protection (IP) is used (review the manufacturer's recommendations and wiring diagrams).

Self Check 3.1.

TEST I. Say True Or False For The Following Questions

1. A duct system facilitates the passage of airflow in the room
2. You must never use oxygen for pressure testing
3. Anyone carrying out the pressure testing should wear safety goggles.
4. Pressure testing is used to ensure that the system is leak-free before it is put into operation
5. The condenser coil contains a fan that cools the high-pressure gas and converts it into a liquid

TEST II. Choose The Best Answer from the given alternative

1. _____is the engine of the system as it works with a fluid that easily transforms the gas into a liquid.

A. The central conditioning B. window air conditioner

C. The condenser coil D. The compressor

2._____ contains a fan that cools the high-pressure gas and converts it into a liquid.

A. The compressor B. window air conditioner

C. Hydrostatic pressure testing D. Electronic leak detector Test

3._____is the most common type of pressure testing used in HVAC systems.

A. pressure testing B. window air conditioner

C. Hydrostatic pressure testing D. Electronic leak detector Test

4 _____is the most common type of cooling system.

A. split type air conditioning B. window air conditioner

C. The evaporator coil D. The compressor

5. _____ is heat pump systems powered either by burning fossil fuels or electricity.

A. window air conditioner B. Hybrid air conditioners C. split type air conditioning D.None

Operation Sheeet 3.1.

Operation Title: Installing air conditioning pipe work and associated components

Purpose:-To practice and demonstrate the knowledge and skill To Installing air conditioning pipe work and associated components.

Instruction: - Utilize the tools and components provided. Within 3 hours, Installing air conditioning pipe work and associated components ,also locate any problematic components.

- **Procedures to do the task**

Step 1: Know the air-conditioner

Step 2: Determine Air Conditioner Location

Step 3: Build Out the Frame

Step 4: Transfer the Interior Opening to the Exterior
& Cut Through the Outside of the House

Step 5: Install the Chassis

Step 6: Install the Air Conditioner

Step 7: Finish the Inside and Outside Wall

Step 8: Plug In the Unit and Test

- **Tools and equipment needed**

✓ screwdriver set, - PVC drainage pipe,
hex-head nut drivers, - refrigerant piping or tubing,
✓ pipe wrenches, - wire,
✓ cordless drill, hole saw, - air filter housing bracket kit,
✓ Allen wrenches, - bracket installation kit,
✓ flare tool, - discharge hose,
✓ torque wrench,
✓ manifold gauge set,
✓ vacuum pump,
✓ R410a adapter,
✓ plastic anchors,
✓ apping screws,
✓ and more.

LAP Test 3.1.

Instructions: Given the necessary templates, tools, materials, and equipment you are required to use to perform Installing air conditioning pipe work and associated components. you have to complete this task within 5 hours.

Task – 1: Identify Air Conditioner Location area.

Task – 2: Cut Interior Opening to the Exterior through the Outside of the House

Task – 3: Install the Air Conditioner

Unit Four: Install ducted split air conditioning systems

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

- Mounting major components
- Installing flexible ductwork
- Locating and rectifying Leaks
- Checking power and control circuit wiring

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:

- Mounting major components
- Installing flexible ductwork
- Locating and rectifying Leaks
- **C**heck power and control circuit wiring

4.1. Mounting major component

Some best practices for mounting major components in an air conditioning system include:

- **Proper Location:** Choose a suitable location for each major component, considering factors such as accessibility for maintenance, proper airflow, and protection from heat sources or moisture.
- **Secure Mounting Surface:** Ensure that the mounting surface is sturdy, level, and capable of supporting the weight of the component. Use appropriate mounting hardware, such as bolts or brackets, to securely fasten the component to the surface.
- **Adequate Clearance**: Provide sufficient clearance around the major components to allow for proper airflow and ventilation. This helps prevent overheating and ensures optimal performance.
- **Proper Wiring:** Follow the manufacturer's instructions and local electrical codes when making electrical connections. Use appropriate wiring techniques, such as proper grounding and protection from damage, to ensure safe and reliable operation.
- **Insulation:** Properly insulate refrigerant lines to prevent condensation and maintain efficient cooling. Insulation helps prevent energy loss and ensures the effectiveness of the air conditioning system.
- **Safety Considerations:** Adhere to safety guidelines and regulations when mounting major components. Use appropriate personal protective equipment (PPE) and consult with a licensed professional if needed.

When mounting major components in an air conditioning system, it is essential to prioritize safety to prevent injury and property damage. Here are some of the most important safety considerations to keep in mind:

- **Wear Proper Protective Equipment:** When dealing with electrical work, it is crucial to wear protective gear such as gloves, goggles, and a face mask.
- **Turn Off Power**: Before working on any electrical components, turn off the power source and unplug the unit from the wall outlet to reduce the risk of electric shock.
- **Proper Ventilation:** Ensure that the area where you are working has proper ventilation to prevent the buildup of hazardous fumes or gases.
- **Avoid Contact with Live Electrical Components:** Always avoid contact with live electrical components to prevent electric shock or injury.
- **Refrigerant Hazards:** Be aware of refrigerant hazards and avoid contact with refrigerant or mixtures of

refrigerant and oil. If refrigerant comes in contact with skin or eyes, flush the exposed area with water and seek medical attention immediately.

- **Proper Charging Techniques:** Overcharging a refrigeration or air conditioning system can result in an explosion. Always use proper charging techniques and limit charge amounts to those specified on the system equipment serial label or in the original equipment.
- **Installing a non-ducted split or ducted split air conditioning system** involves several steps and requires specific tools and materials. Here are some general steps involved in the installation process:
- **Select the appropriate system:** Choose a system that is appropriately sized for the cooling needs of the home or building. The cost of the system will depend on the size and features of the unit.
- **Choose the installation area:** Select an appropriate location for the indoor and outdoor units, ensuring that there is enough space for installation and maintenance.
- **Install the mounting plate:** Fix the mounting plate on the wall using plastic anchors, tapping screws, and a level.
- **Drill the outlet hole:** Drill an outlet hole in the wall for the copper pipes, drainage pipe, and wire.
- **Mount the indoor unit:** Mount the indoor unit on the mounting plate and connect the copper pipes, drainage pipe, and wire to the unit.
- **Mount the outdoor unit:** Lift the outdoor unit onto the bracket and bolt it up firmly.
- **Connect the wires:** Open the cover over the electrical ports and connect the wires.
- **Run the piping and wiring:** Run the piping and wiring from the indoor unit through the hole in the wall and attach a PVC drainage pipe to the unit.
- **Test the system:** Test the system to ensure that it is functioning properly and efficiently.

4.2. Installing flexible ductwork

Unlike central HVAC units, **ductless systems** don't have ducts. They move refrigerant between the indoor and outdoor units using small tubing that runs through the walls or ceiling cavities, and cool air blows out of the indoor units, rather than out of vents connected to ducts

Ducts are conduits or passages used in heating, ventilation, and air conditioning (HVAC) to deliver and remove air. The needed air flows include, for example, supply air, return air, and exhaust air. Ducts commonly also deliver ventilation air as part of the supply air. As such, air ducts are one method of ensuring acceptable indoor air quality as well as thermal comfort. A duct system is also called ductwork. Planning (laying out), sizing, optimizing, detailing, and finding the pressure losses through a duct system is called duct design

4.2.1. Fiberglass duct board (pre insulated non-metallic ductwork)

Fiberglass duct board panels provide built-in thermal insulation and the interior surface absorbs [sound], helping to provide quiet operation of the HVAC system. The duct board is formed by sliding a specially-designed knife along the board using a straightedge as a guide.

The knife automatically trims out a groove with 45° sides which does not quite penetrate the entire depth of the duct board, thus providing a thin section acting as a hinge. The duct board can then be folded along the groove to produce 90° folds, making the rectangular duct shape in the fabricator's desired size. The duct is then closed with outward-clinching staples and special aluminum or similar metal-backed tape.

A. Flexible ducting

- **Flexible ducts** (also known as flex) are typically made of flexible plastic over a metal wire coil to shape a tube. They have a variety of configurations. In the United States, the insulation is usually glass wool, but other markets such as Australia, use both polyester fiber and glass wool for thermal insulation.

A protective layer surrounds the insulation, and is usually composed of polyethylene or metalized PET. It is commonly sold as boxes containing 25' (7.5 m) of duct compressed into a 5' (1.5 m) length. It is available in diameters ranging from as small as 4" (10 cm) to as big as 18" (45 cm), but the most commonly used are even sizes ranging from 6" to 12" (15 to 30 cm).

Flexible duct is very convenient for attaching supply air outlets to the rigid ductwork. It is commonly attached with long zip ties or metal band claps. However, the pressure loss is higher than for most other types of ducts. As such, designers and installers attempt to keep their installed lengths (runs) short, e.g. less than 15 feet (5 m) or so,

and try to minimize turns. Kinks in flexible ducting must be avoided. Some flexible duct markets prefer to avoid using flexible duct on the return air portions of HVAC systems, however flexible duct can tolerate moderate negative pressures. To use flexible ducting in a system, make sure to pull the duct tight so you get the full internal diameter. This reduces resistance and improves airflow, as well as ventilation efficiency. Minimize bends and kinks as much as possible, since they can affect how well the airstream flows through the ductwork.

There are a few types of flexible ducting - Polyurethane (PU), Aluminium & Aluminium insulated, Acoustic and Rectangular flexible ducting, as well as semi- and combi-flex.

B. Fabric ducting

This is actually an air distribution device and is not intended as a conduit for conditioned air. The term fabric duct is therefore somewhat misleading; fabric air dispersion system would be the more definitive name. However, as it often replaces hard ductwork, it is easy to perceive it simply as a duct. Usually made of polyester material, fabric ducts can provide a more even distribution and blending of the conditioned air in a given space than a conventional duct system. They may also be manufactured with vents or orifices.

Fabric ducts are available in various colors, with options for silk screening or other forms of decoration, or in porous (air-permeable) and non-porous fabric. The determination which fabric is appropriate (i.e. air-permeable or not) can be made by considering if the application would require an insulated metal duct. If so, an air-permeable fabric is recommended because it will not commonly create condensation on its surface and can therefore be used where air is supplied below the dew point.

Material that eliminates moisture may be healthier for the occupants. It can also be treated with an anti-microbial agent to inhibit bacterial growth. Porous material also tends to require less maintenance as it repels dust and other airborne contaminants. Fabric made of more than 50% recycled material is also available, allowing it to be certified as green product. The material can also be fire retardant, which means that the fabric can still burn, but will extinguish when the heat source is removed.

Fabric ducts are not rated for use in ceilings or concealed attic spaces. However, products for use in raised floor applications are available. Fabric ducting usually weighs less than other conventional ducting and will therefore put less stress on the building's structure. The lower weight allows for easier installation.

Fabric ducts require a minimum of certain range of airflow and static pressure in order for it to work.

C. PVC low-profile ducting

PVC low-profile ducting has been developed as a cost-effective alternative to steel low-profile ducting. Low-profile ducting has been used extensively in apartment and hotel ventilation since 2005. The growth of low-profile ducting has grown significantly due to the reduction of available space in ceiling cavities in an effort to

reduce cost. Since the Grenfell Tower fire in 2017 there has been a rise in the discovery of non-compliant building materials; many PVC low-profile ducting manufacturers have struggled to gain or maintain compliance, and some building projects have had to resort back to using the more expensive steel option.

4.3. Locating and rectifying Leaks

Start by locating the refrigerant lines, and then use a soapy water mixture or an electronic device to figure out where the leak is. You can use a similar procedure to test your vehicle's A/C system for leaks

4.3.1. Types of Leak Tests for an Air Conditioner

A. Electronic Leak Detector Test

Most HVAC service technicians keep an electronic leak detector or sniffer in their toolkits. As the name suggests, the HVAC tech runs this tool along the refrigeration components to detect any R22 or R410a outside of the system. Most HVAC technicians will start a leak test by using this device, as it can be more cost effective in finding a leak. The limitation to an electronic leak detector test is that it can only scan the components it can touch. With an evaporator coil leak, for example, it can be quite difficult to position the electronic leak detector in all places a potential leak might be. So while this can be the most cost effective leak test, it is also the most prone to inaccuracy.

B. Nitrogen Leak Detector Test and Bubble Test

- **An AC leak test with nitrogen**—the preferred test by Home sense technicians—adds a greater degree of clarity to leak detection, though for slightly more cost. With this nitrogen leak test procedure, the HVAC technician first removes any remaining Freon or Puron and pumps compressed nitrogen into the refrigeration system. The leaks become audible because the nitrogen is held at a higher pressure than the refrigerant can operate under normal conditions. Imagine when you pump air into your bicycle tire, and you can hear the air coming out. It's the same concept here.

  In addition to listening for audible signs of a leak, HVAC technicians will also be watching the gauges to see if pressure changes. In a system without leaks, pressure will remain constant. A system with a leak will show fluctuations. Also, the technician will many times take the additional step of "bubbling" the system. The technician will mix up soap bubbles, run it along components of the refrigeration system, and look for air **bubbles.**

C. Dye Testing for a Freon Leak

A dye test for freon or Puron leaks can also be applied. Here, an HVAC technician adds ultraviolet dye to the system, looking for both constant and intermittent leaks. The UV dye mixes with lubricants within the system and finds its way to even the smallest leaks. The technician uses a blue/black light to see the dye as it leaks out.

It's important to note that not all dyes are recommended by manufacturers and can have negative consequences on the air conditioning system if the dye is not supported. If you think you may have a freon leak and are still unsure, please don't hesitate to contact us. We know how to detect freon leak and can help!

D. Detect a Refrigerant Leak

One of the more common problems that an air conditioning system can encounter is a leak along the refrigerant lines. As refrigerant leaks out, it drops the set "charge" in the system, which must remain at this level for the AC to work correctly. A loss of refrigerant will mean a loss in cooling ability for the system, and it will also cause problems such as a frozen coil and even serious, irreparable damage to the compressor when it starts to overheat. When leaks begin, they need immediate repair from specialists, followed by a recharging of the system to the correct refrigerant level. You cannot fix this problem on your own: although signs of leaks are often obvious (loss of cooling, iced evaporator coil, hissing sounds), locating the often tiny leaks themselves can be tricky.

Here are three ways that our Pensacola Beach, FL air conditioning repair specialists at Kool Breeze handle finding refrigerant leaks.

I. Electronic detectors: In the HVAC world, these are usually called "sniffers," and are the most common device used to pinpoint refrigerant leaks. Sniffers generate a high voltage spark that will drop in voltage when it encounters an insulating gas—such as R-410A, the refrigerant blend used in most modern air conditioners. The technicians run the sniffer along the refrigerant line until registering a large drop in voltage.

II. Fluorescent detection: Fluorescent lights are helpful in picking out the otherwise hard to see escaping refrigerant gas. The technicians first add a fluorescent dye into the air conditioners system, and then scan UV lights over the AC. The leaking gas will appear as green.

III. Bubble solution: This is an old technique that was around long before using UV lights and high voltage detectors. It doesn't work for very small leaks, but technicians may use it if they suspect a large leak. Using squeeze bottles, the technicians apply a soapy solution along the area of the refrigerant lines where they think leaks may be. The escaping gas should create bubbles from the soap.

4.4. Checking power and control circuit wiring

4.4.1. Electrical wiring system for indoor unit and outdoor unit

Electrical work must be performed in accordance with this Manual by a person certified under the national or regional regulations. Be sure to use a dedicated circuit for the unit.

- **An insufficient power supply circuit or improperly performed electrical work can cause serious accidents such as electric shock or fire**.
  - ✓ **Before starting work**, check that power is not being supplied to the indoor unit and outdoor unit.
  - ✓ **For wiring,** use the prescribed type of cables, connect them securely, making sure that there are no external forces of the cables applied to the terminal connections. Improperly connected or secured cables can cause serious accidents such as overheating the terminals, electric shock, or fire.
  - ✓ **Securely install the electrical box cover on the unit.** An improperly installed electrical box cover can cause serious accidents such as electric shock or fi re through exposure to dust or water.
  - ✓ **Install sleeves into any holes made in the walls for wiring.** Otherwise, a short circuit could result.
  - ✓ Use the included connection cables and power cables or ones specified by the manufacturer. Improper connections, insufficient insulation, or exceeding the allowable current can cause electric shock or fire.
  - ✓ **Do not modify the power cables**, use extension cables, or use any branches in the wiring. Improper connections, insufficient insulation, or exceeding the allowable current can cause electric shock or fi re. • Match the terminal block numbers and connection cable colors with those of the outdoor unit or branch box. Erroneous wiring may cause burning of the electric parts.
  - ✓ **Securely connect the connection cables to the terminal board**. In addition, secure the cables with wiring holders. Improper connections, either in the wiring or at the ends of the wiring, can cause a malfunction, electric shock, or fire.
  - ✓ **Always fasten the outside covering of the connection cable with the cable clamp**. (If the insulator is chafed, electric leakage may occur.)
  - ✓ **Install a earth leakage breaker.** In addition, install the earth leakage breaker so that the entire AC main power supply is cut off at the same time. Otherwise, electric shock or fi re could result.
  - ✓ **Always connect the earth cable**. Improper grounding work can cause electric shocks.
  - ✓ **Install the remote controller cables** so as not to be direct touched with your hand.
  - ✓ **Perform wiring work** in accordance with standards so that the air conditioner can be operated safely and positively.
  - ✓ **Connect the connection cable firmly to the terminal board.** Imperfect installation may Cause a fire.

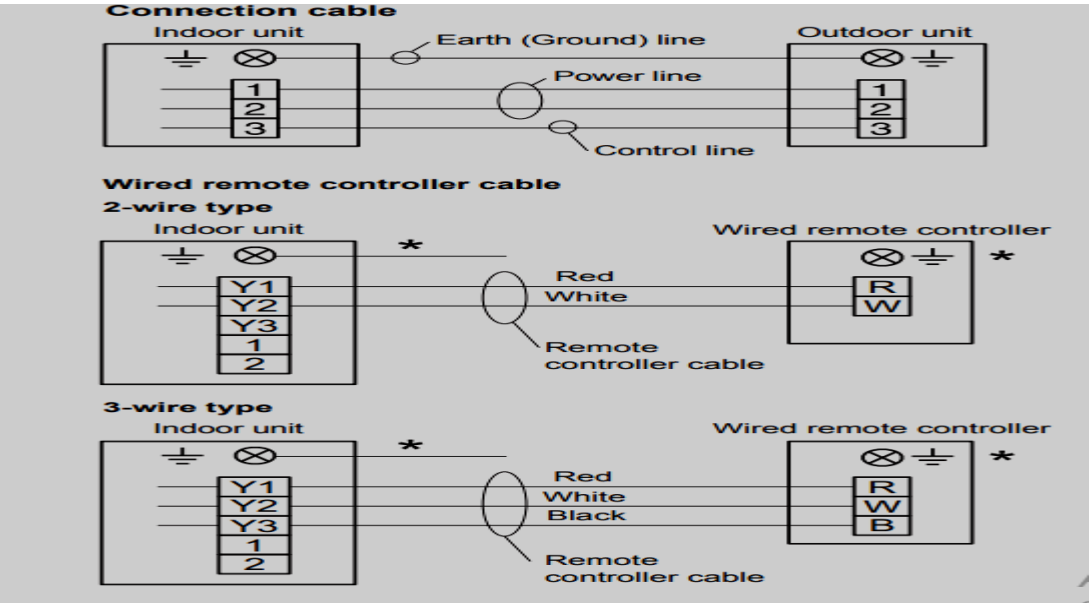
A. Ground the unit.

Do not connect the earth cable to a gas pipe, water pipe, lightning rod, or a telephone earth cable.

- **Improper grounding may cause electric shock.**
  - ✓ Do not connect power supply cables to the transmission or remote controller terminals, as this will damage the product.
  - ✓ Never bundle the power supply cable and transmission cable, remote controller cable together. Separate these cable by 50 mm or more. Bundling these cables together will cause miss operation or breakdown.
  - ✓ When handling PCB, static electricity charged in the body may cause malfunction of the PCB.
    - ➢ **Follow the cautions below:**
      - Establish a ground for the indoor and outdoor units and peripheral devices.
      - Cut power (breaker) off.
      - Touch metal part of the indoor and outdoor units for more than 10 seconds to discharge static electricity charged in the body.
      - Do not touch terminals of parts and patterns implemented on PCB.

B. Wiring system diagram

Connection diagrams and Standard pair:



C. Wired remote controller cable 3-wire type only

- **Earth (Ground) the remote controller if it has a earth (ground) line**.

✓ Connect the remote controller cable to the primary unit Wired remote controller is recommended using simultaneous twin or triple connection.

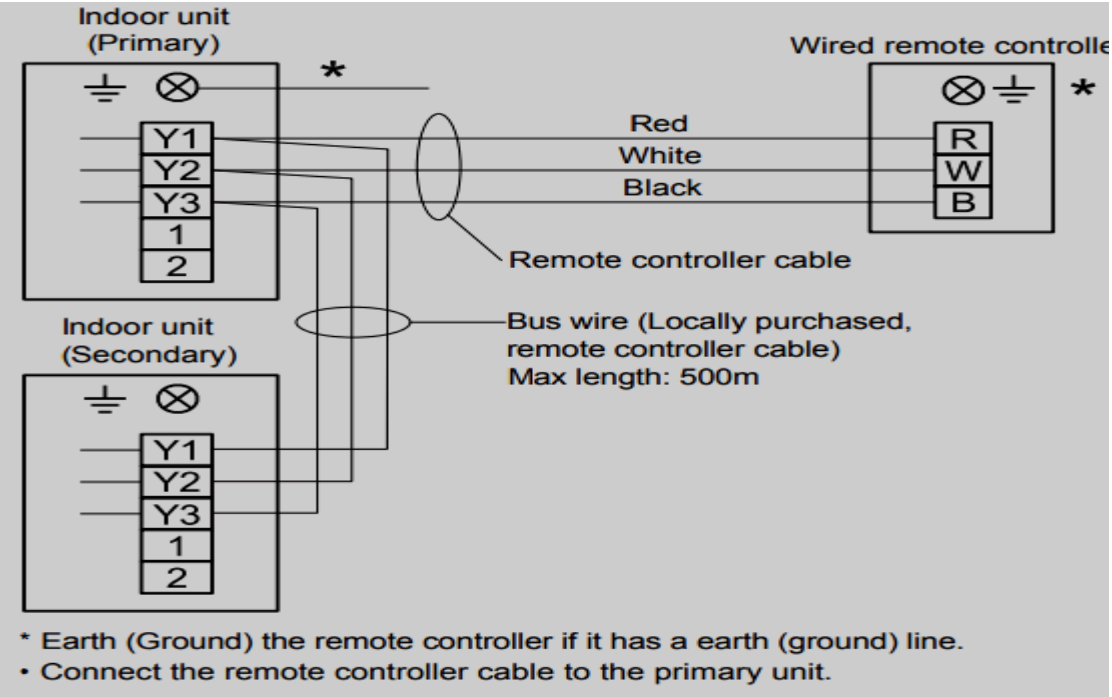
CAUTION: Tighten the indoor unit connection cable and power supply indoor and outdoor unit, branch box terminal board connections fi rmly with the terminal board screws. Faulty connection may cause a fire.

✓ If the indoor unit connection cable and power supply are wired incorrectly, the air conditioner may be damaged.

✓ Connect the indoor unit connection cable by matching the numbers of the outdoor and indoor units terminal board numbers as shown in terminal label.

✓ Earth (Ground) both the indoor and outdoor, units by attaching a earth (ground) cable.

✓ Unit shall be grounded in compliance with the country or region's regulations.

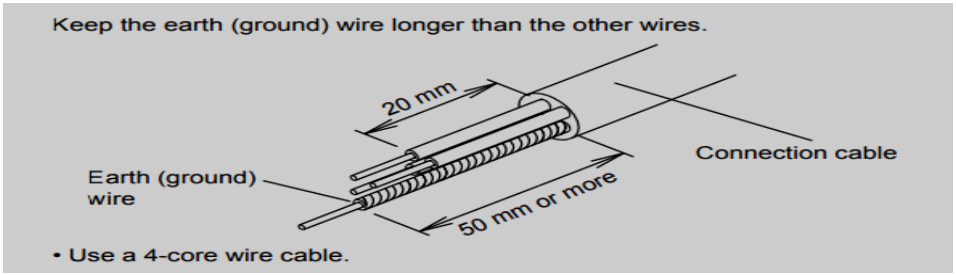


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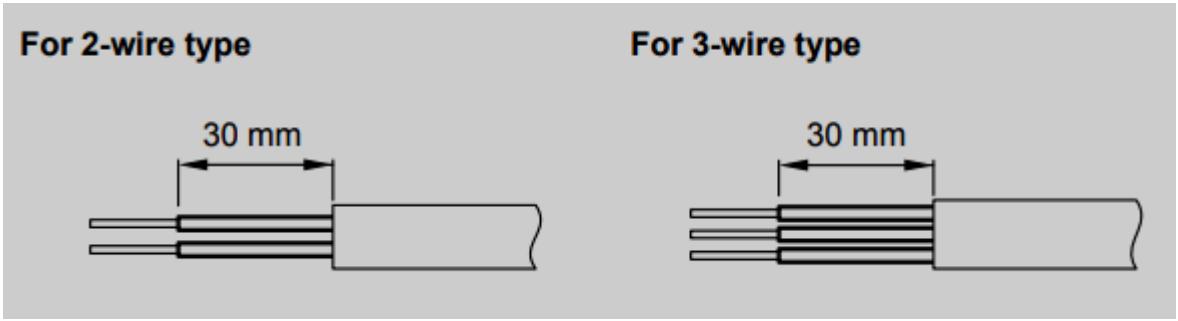
D. Connection cable preparation

■ Connection cable

Earth (ground) wire Keep the earth (ground) wire longer than the other wires.



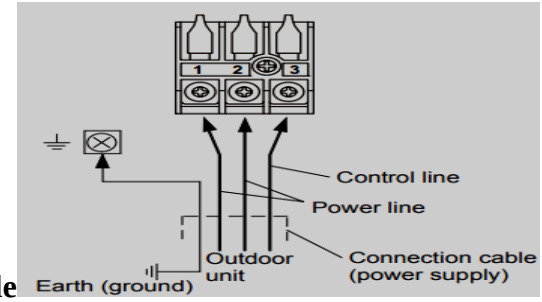
E. Remote controller cable



4.4.2. System of connect wiring to the terminals.

A. Use ring terminals with insulating sleeves as shown in the figure below to connect to the terminal block.
B. Securely crimp the ring terminals to the wires using an appropriate tool so that the wires do not come loose.
C. Use the specified wires, connect them securely, and fasten them so that there is no stress placed on the terminals.
D. Use an appropriate screwdriver to tighten the terminal screws. Do not use a screwdriver that is too small, otherwise, the screw heads may be damaged and prevent the screws from being properly tightened.
E. Do not tighten the terminal screws too much; otherwise, the screws may break.
F. See the table below for the terminal screw tightening torques.
G. Please do not fix 2 power supply cables with 1 screw

- **Connection cable**



Self Check 4.1.

TEST I. Say True Or False For The Following Questions

6. A duct system facilitates the passage of airflow in the room
7. You must never use oxygen for pressure testing
8. Anyone carrying out the pressure testing should wear safety goggles.
9. Pressure testing is used to ensure that the system is leak-free before it is put into operation
10. The condenser coil contains a fan that cools the high-pressure gas and converts it into a liquid

TEST II. Choose The Best Answer from the given alternative

1. _____is the engine of the system as it works with a fluid that easily transforms the gas into a liquid.

A. The central conditioning B. window air conditioner

C. The condenser coil D. The compressor

2._____ contains a fan that cools the high-pressure gas and converts it into a liquid.

A. The compressor B. window air conditioner

C. Hydrostatic pressure testing D. Electronic leak detector Test

3._____is the most common type of pressure testing used in HVAC systems.

A. pressure testing B. window air conditioner

C. Hydrostatic pressure testing D. Electronic leak detector Test

4 _____is the most common type of cooling system.

A. split type air conditioning B. window air conditioner

C. The evaporator coil D. The compressor

5. _____ is heat pump systems powered either by burning fossil fuels or electricity.

A. window air conditioner B. Hybrid air conditioners C. split type air conditioning D.None

Operation Sheeet 4.1.

Operation Title: Install split type air conditioning work and associated components

Purpose:-To practice and demonstrate the knowledge and skill To Install split type air conditioning work and associated components.

Instruction: - Utilize the tools and components provided. Within 3 hours, Install split type air conditioning work and associated components ,also locate any problematic components.

- **Procedures to do the task**

  Step -1: Choose a suitable location for each major component.

  Step -2: Prepare the mounting components and installation of indoor unit on wall.

  Step -3: Drill the hole for tubing place to connect the Outdoor unit with the Indoor unit.

  Step -4: Laying of interconnection the copper pipes line for installing with the two unites.

  Step -5: Hang the air conditioning properly.

  Step -6: Install the condenser part of air conditioner

  Step -7: Make the connection is correct with manufacturing standards.

  Step - 8: Test and complete the installation works.

- **Tools and equipment needed**

✓ screwdriver set, - Copper drainage pipe,
hex-head nut drivers, - refrigerant piping or tubing,
✓ pipe wrenches, - wire,
✓ cordless drill, hole saw, - air filter housing bracket kit,
✓ Allen wrenches, - bracket installation kit,
✓ Stud Finders. .
✓ Electrical Multi-meter. ...
✓ Wrenches. ...
✓ Tape Measure. ...
✓ Screwdriver. ...
✓ Pliers.

LAP Test 4.1.

Instructions: Given the necessary templates, tools, materials, and equipment you are required to use to perform Install split type air conditioning work and associated components. you have to complete this task within 5 hours.

Task – 1: Identify suitable location area to split type Air Conditioner

Task – 2: Prepare impotrant tools needed to install

Task – 3: Install split type air conditioning work and associated components



Figure split type air conditioning

Unit Five: Locate and rectify faults and carry out maintenance

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

- Carrying out Fault diagnosis
- Carrying fault-finding and rectification processes
- Returning System
- Identifying and regularizing components that require routine maintenance

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:

- Carry out Fault diagnosis
- Take fault-finding and rectification processes
- Return System
- Identify and regularize components that require routine maintenance

5.1. Carrying out Fault diagnosis

5.1.1. Carry out Fault Diagnosis with an Air Conditioning System

Carrying out fault diagnosis is an essential step in identifying and resolving issues with an air conditioning system. Here are some key points to consider when identifying and carrying out fault diagnosis:

Symptoms: Identify the symptoms of the problem, such as unusual noises, insufficient cooling, or poor airflow. This can help narrow down the potential causes of the issue.

Visual Inspection: Conduct a visual inspection of the system to look for any obvious signs of damage, such as leaks, loose connections, or worn components.

Electrical Testing: Use a multimeter or other electrical testing equipment to check for proper voltage, current, and resistance in the electrical components of the system.

Refrigerant Testing: Use a refrigerant gauge or other testing equipment to check the pressure and temperature of the refrigerant in the system.

Component Testing: Test individual components, such as the compressor, condenser, and evaporator, to determine if they are functioning properly.

System Performance Testing: Test the overall performance of the system, such as the cooling capacity and airflow, to determine if the system is operating efficiently.

Repair or Replacement: Based on the results of the fault diagnosis, determine if any components need to be repaired or replaced. It is recommended to consult with a licensed professional for any repairs or replacements.

5.2. Carrying fault-finding and rectification processes

5.2.1. Identifying defect faults

Some common air conditioner problems and defects to look for:

Refrigerant Leaks: If the refrigerant charge does not match the manufacturer's specifications, the performance and efficiency of the unit can be impaired. Refrigerant leaks can also be harmful to the environment.

Inadequate Maintenance: Many common problems with air conditioners result from faulty installation, poor service procedures, and inadequate maintenance. Corrosion of wire and terminals is a problem in many systems, so electrical connections and contacts should be checked during a professional service call.

Electric Control Failure: The compressor and fan controls can wear out, especially when the air conditioner turns on and off frequently, as is common when a system is oversized. Faulty electrical components can

produce a buzzing sound.

Sensor Problems: If the thermostat sensor is knocked out of position, the air conditioner could cycle constantly or behave erratically.

Drainage Problems: If the condensate drain becomes clogged, water can back up into the air conditioner and cause it to shut down.

Frozen Evaporator Coil: The evaporator coil can freeze if the air filter is dirty or if there is a problem with the refrigerant flow.

Air Conditioner Leaking Water Outside: This can be caused by a clogged condensate drain line, a dirty air filter, or a damaged condensate pan.

Air Conditioner Is Not Turning On: This could be due to a tripped circuit breaker, a blown fuse, or a faulty thermostat.

Unusual Noises: Different sounds can indicate different problems. For example, a refrigerant leak can produce a hissing sound, while thumping, rattling, or banging noises could mean there is a problem with a blower or motor assembly. **Poor Airflow:** This could be caused by a dirty air filter, a blocked duct system, or a problem with the blower motor.

5.2. Carrying fault-finding and rectification processes

5.2.1. Assembling and disassembling of Air Conditioner

A. Window type Air conditioner

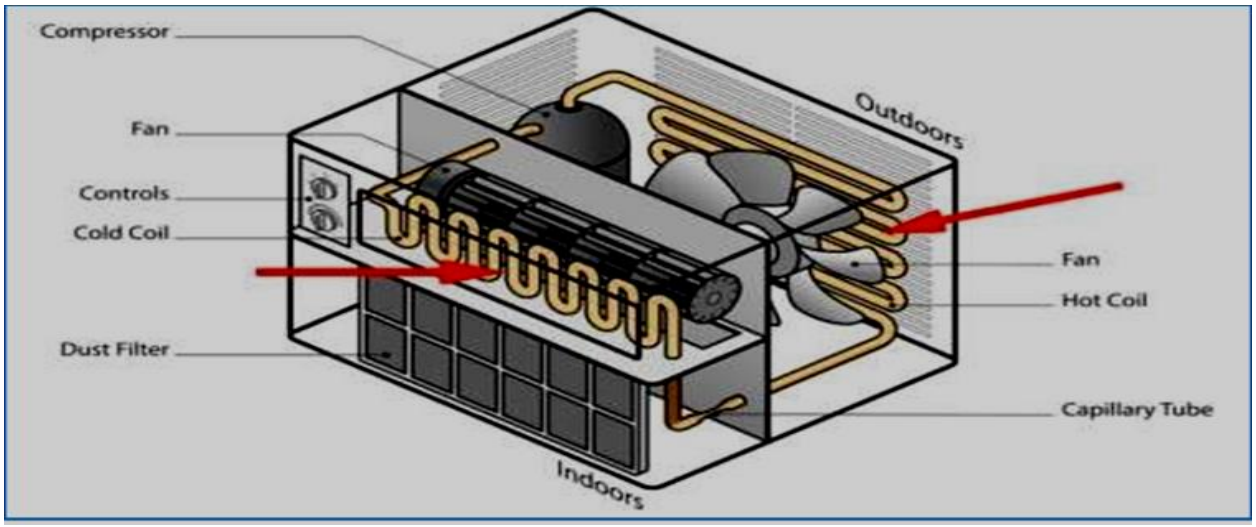


Figure 5.1.Components of window type Air conditioner

To disassemble the air conditioner, the following steps can be used [use service manual]:

Step - 1: Disconnect the air conditioner from the electric supply, and remove the cabinet.

Step – 2: Remove the electric control boxes, then the screws that secure each box to the partition.

Step -3: Remove the control-box covers, and disconnect the motor leads.

Step – 4: Remove the control box assemblies from the unit.

Step – 5: Remove the fan motor and fans, and loosen both fans, and remove them from the shaft.

Step – 6: Remove the access panel that fits down over the cooling-unit fan shaft.

Step – 7: Loosen and remove the motor cradle supports at each end of the motor.

Step – 8: Lift the motor up and out.

Split type Air conditioner

For effective and safe operation of the air conditioner, regular cleaning of the internal elements of the system is required, and in addition to the external, it is mandatory to disassemble and clean the indoor unit.

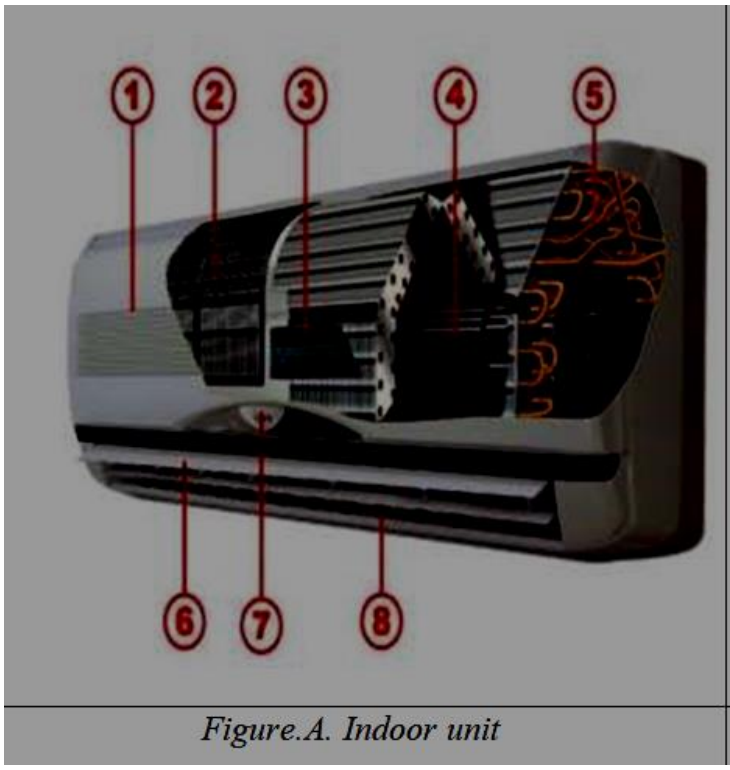


Figure.A. Indoor unit



Figure B Outdoor unit

According to figure. A above, the indoor elements of Air conditioner indicated by the numbers are as follow.

1. Front (front) panel 2. Coarse filter	3. Fine filter 4. Fan	5. Evaporator 6. Horizontal blinds	7. Indicator panel 8. Vertical blinds

Disassemble Steps of Air Conditioner

Using an adjustable wrench and a set of hex wrenches.

Step –1: Disconnect air conditioner line from outdoor unit

Step –2: Remove the two large brass valve caps facing outside in figure 2.19 (**NOT** the small caps on the left). Instead close the valve on the small (upper) line.

Step - 3: Turn the unit on, COLD cycle, and listen carefully to the outer unit.

After a minute or two, the motor sound will change slightly. This is when all the refrigerant has been pulled into the power unit and the air handler + pipes are empty

(of anything - they will be near-vacuum).

Step - 4: Close the valve on the lower (large) line, and the turn the unit off and unplug it.

Step - 5: Crack/ open the nut on the large line, then hear if the gas is hissing.

It helps to check that air going in to the system and it will stop soon. If anything comes **OUT**, close the nut immediately and repeat the above.

Step – 6: Once the hissing stops, proceed to disconnect both lines. Put the valve caps back on and cover both the exposed valve ends and the pipes with electrical tape. Then, the unit can be moved to anywhere.

Note: It is advisable to use company's disassemble procedure for further.

Assembling/ Installation steps of Air conditioner

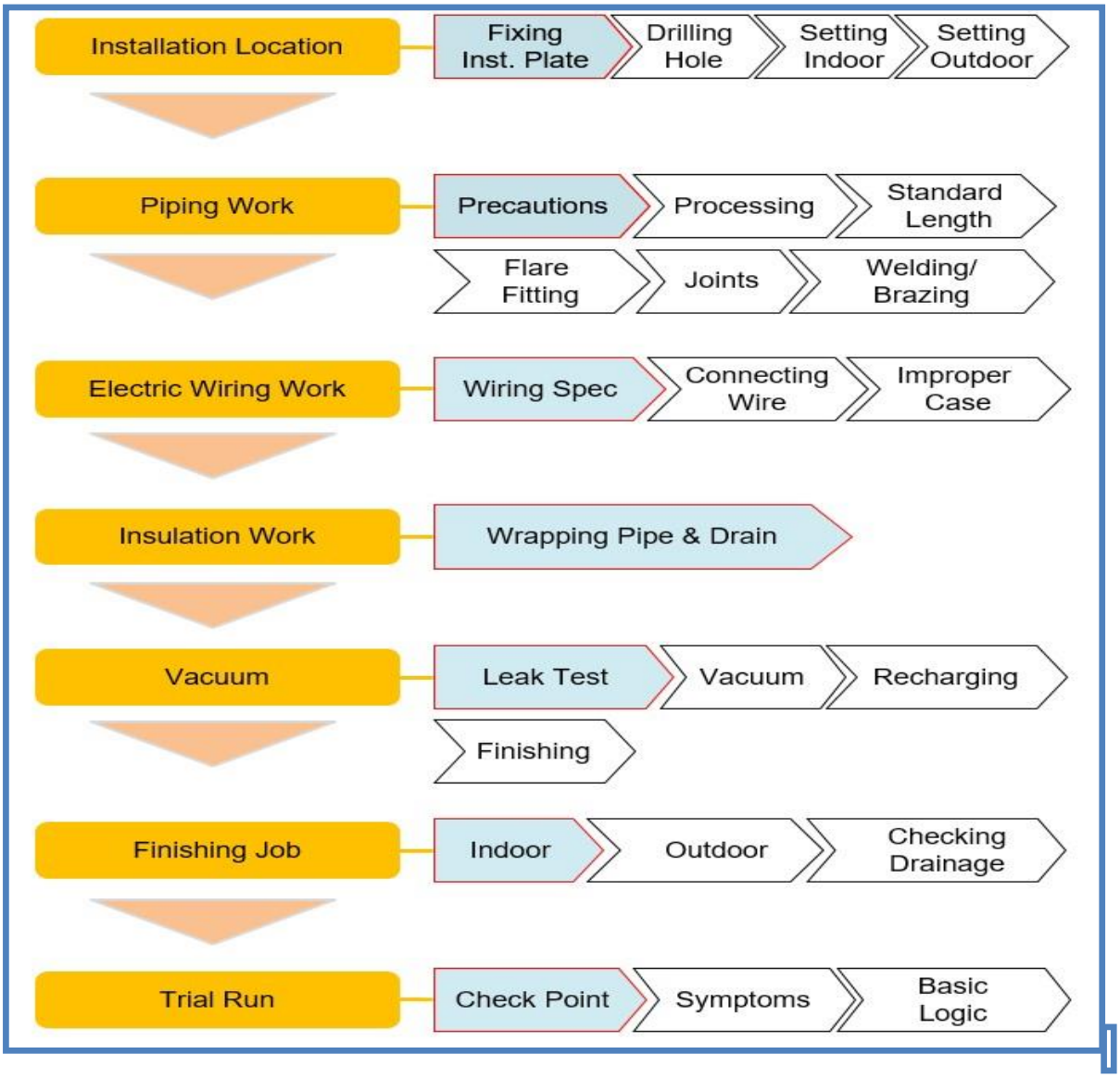


Figure 5 .2. Installation/Assembling Flow Chart

Assembling/ Installation procedures of Air conditioner

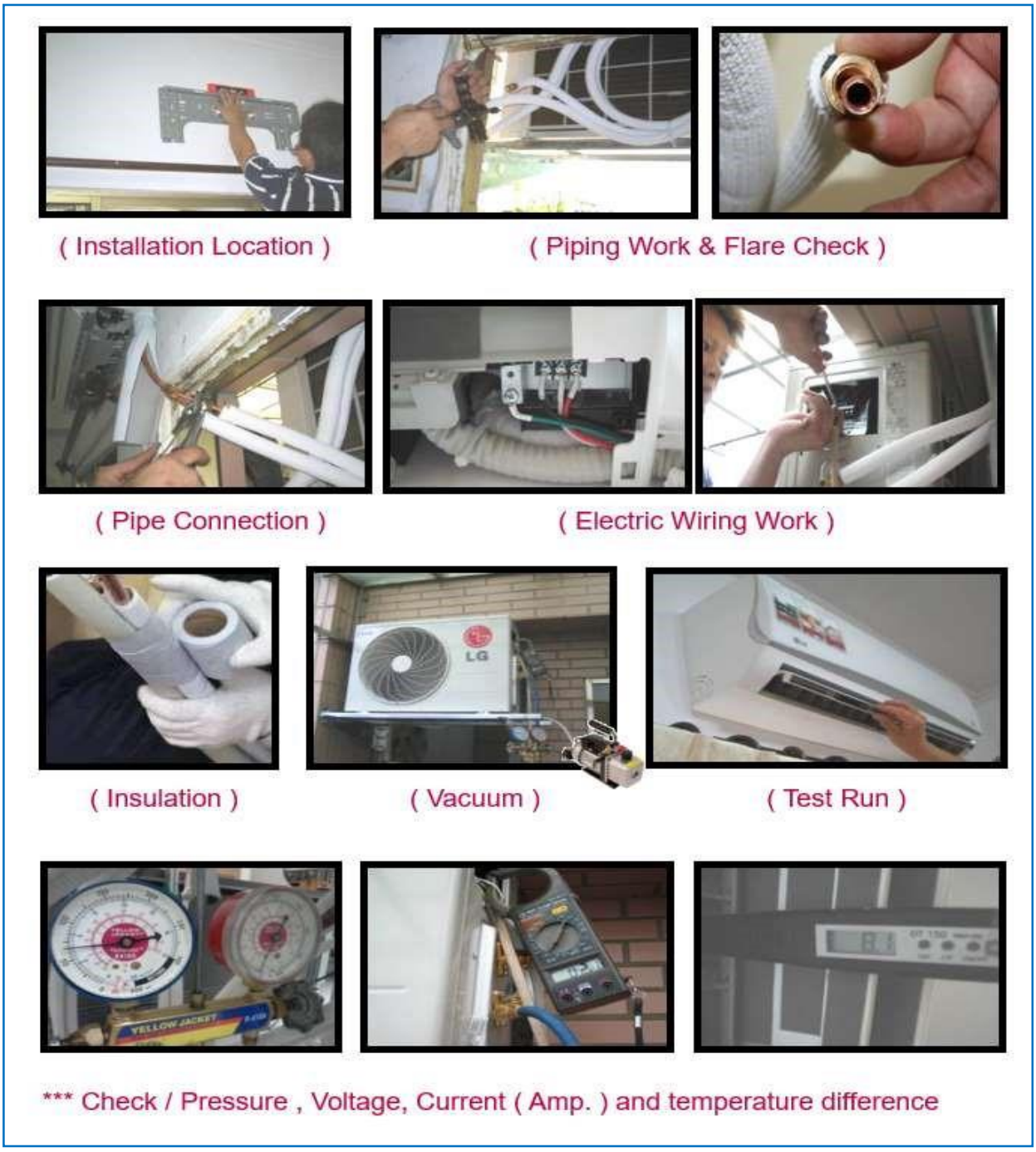


Figure5 .3. Installation/Assembling Procedures

A. Common problems, causes and possible solutions to Air-Conditioning (Cooling)

Problem	Possible Cause	Possible Repair
No cooling, Outdoor unit not running,Indoor fan running	**Open outdoor disconnect switch, Open fuse or breaker, Faulty wiring**	**Close disconnect switch. Replace fuse, reset breaker, and determine problem, Repair or replace faulty wiring or connections.**
No cooling; indoor fan and outdoor unit will not run	**Low-voltage control problem Thermostat Interconnecting wiring or connections C. Transformer**	**Repair loose connections or replace thermostat and/or sub base, Repair or replace wiring or connections, Replace if defective,** ***Safety Precaution*****: Look out for too much current, draw due to a ground circuit or shorted coil.**
No cooling; indoor and outdoor, fan running, but compressor not running	**Tripped compressor internal overload** A. **Low line voltage** B. **high head pressure Dirty outdoor (condenser) Condenser fan not running all the time Condenser air recirculating Overcharge of refrigerant C. Low charge, motor not being properly cooled**	**Correct low voltage, call power company, repair loose connections, Clean condenser, Check condenser fan motor and capacitor, Correct recirculation problem, Correct charge, Correct charge; if due to leak, repair leak.**
Indoor coil freezing	**Restricted airflow, Low charge, Metering device, Restricted filter drier, Operating unit during low ambient conditions without proper head pressure control**	**Change filters, Open all supply register dampers, Clear return air blockage, Clean fan blades, Speed fan up to higher speed, Adjust unit charge—repair leak if refrigerant has been lost, Change or clean metering device, Change filter drier, Add proper low-ambient head pressure control.**

Refrigerant shortage

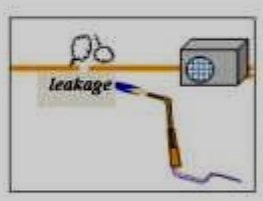
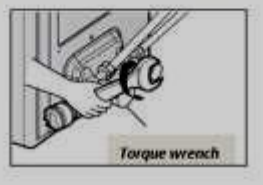
Failure	Refrigerant shortage
Symptom and reason	Weak cool air

Failure details	Correct Installation
• When extending pipes during reinstallation due to relocation, appropriate refrigerant pressure should be reached. If pressure is lower than It should be, cooling power is impeded. • Symptoms when refrigerant is short Temperature difference between sucked and discharged air is less than 8°C. Operating current is below rated, and pressure on the low pressure side is also low. 	• How to determine whether refrigerant is short 1) Frost is formed from the exit if the capillary tube to the entrance of the evaporator. 2) Suction pipe of the compressor is not cold. (Suction pipe temperature is similar to ambient temperature.) 3) Pressure on the low pressure side is low when cooling is used (There may be difference based on outside temperature). 4) Compressor oil leaks from indoor and outdoor unit joints and welds.

Refrigerant Leak

5.2.1. Some Problems on Air Conditioner

Failure	Refrigerant leakage
Symptom and reason	Weak cool air

Failure details	Correct Installation
• When extending pipes during relocation, refrigerant leakage may occur due to connection failures Impedes cooling power • Symptoms when refrigerant is short Temperature difference between sucked and discharged air is less than 8°C. Operating current is below rated, and pressure on the low pressure side is also low. 	• Check and repair refrigerant leaking area   

Over charging refrigerant

Failure	Overcharged refrigerant
Symptom and reason	Weak cool air

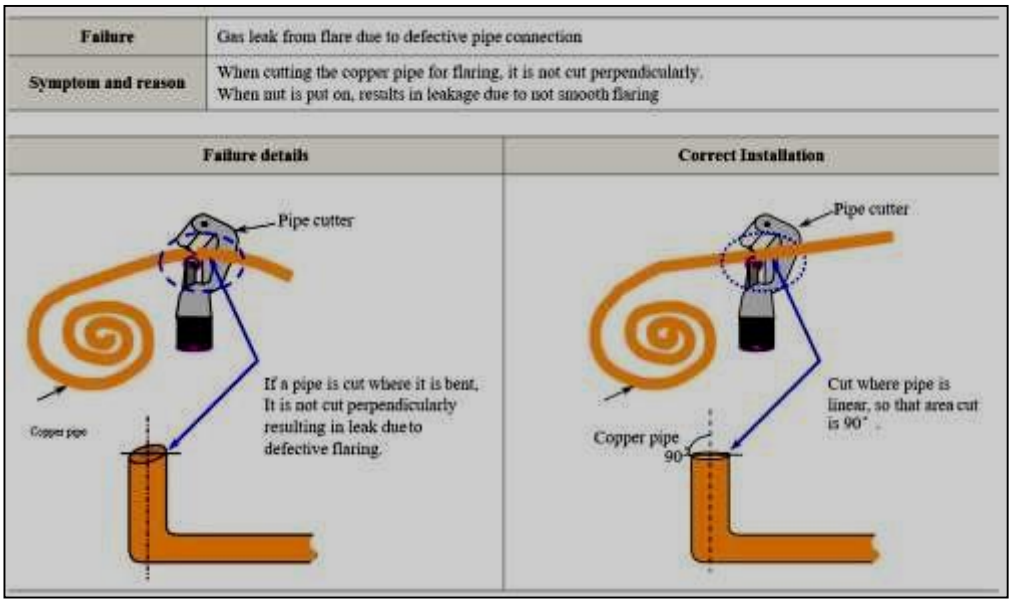
Failure details	Correct Installation
• When extending pipes during relocation, if refrigerant is overcharged, cooling power is impeded. • Symptoms when refrigerant is short Temperature difference between sucked and discharged air is about 10°C. Operating current is higher than rated. Pressure on the low pressure side is also high.	• How to determine whether refrigerant is overcharged If user continues to use the product, overload pressure switch is activated. Continuous use of the product will be unavailable and it will be difficult to activate the compressor. Fuse or circuit breaker is easily blown. ☞When symptoms above appear, set refrigerant to have the appropriate and rated pressure.

2.11.4.4. Refrigerant Clogged

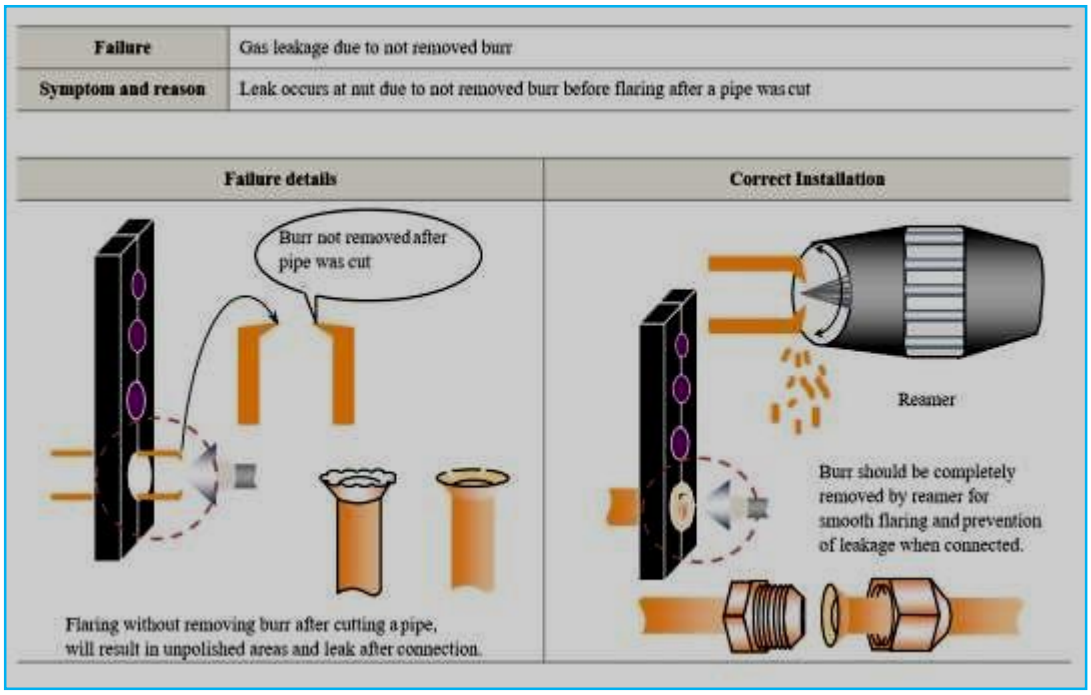
Failure	Refrigerant clogged
Symptom and reason	Weak cool air

Failure details	Correct Installation
• If pipe is clogged or bent, while extending pipe during relocation, cooling power is impeded. • Symptoms when refrigerant is overcharged When strainer and capillary tube are clogged, pressure drops at the exit. Refrigerant evaporates to form dews or frost. Operating current is below rated and pressure on the low pressure side will be below normal. If completely clogged, pressure on the low pressure side will eventually reach 0kgf/cm.	• How to determine 1) Same symptoms as those for refrigerant shortage appear. Same symptoms occur when refrigerant is charged. 2) Refrigerant balancing time can take more than 3 minutes. ☞If user continues to use the product, temperature of the gas discharged from the compressor gets higher to make refrigeration oil depleted, affecting product lifetime.

Gas Leak from Flare Due to Pipe Connection Defective

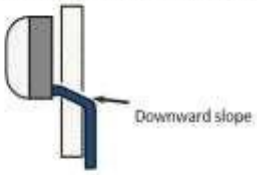


Gas Leak due to unmoved burr



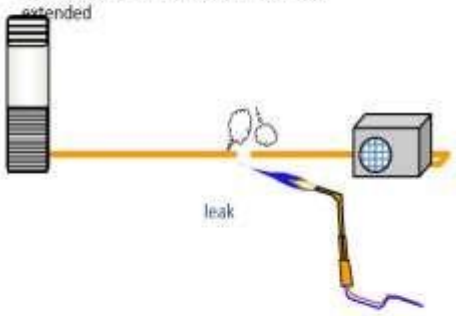
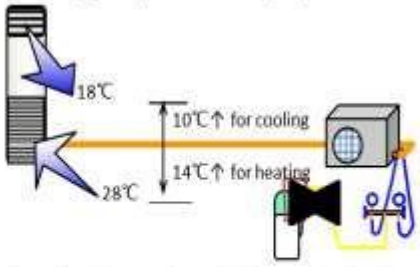
Water Leak due to Wrong Pipe Connection through Wall

Failure	1. Water leakage due to upward connection through the wall and drain hose under water 2. Water leaks as drain hose is dipped in ditch
Symptom and reason	Pipe is connected upward through a wall making drain flow difficult causing water leakage. Drain hose end is dipped in the water to cause water leakage

Failure details	Correct Installation
1. Pipe is installed upward through a wall causing water leakage 	☞ should be installed downward when connected through wall 
2. Drain hose is dipped in the water making drain flow difficult. Water leakage occurs. 	☞ Drain hose should not be sank under water. 

Refrigerant shortage after pipe extension

Failure	1. Refrigerant shortage due to not supplemented refrigerant after pipe was extended. 2. Refrigerant shortage due to gas leakage at welds
Symptom and reason	Impeded cooling power due to refrigerant shortage by leakages after pipe extension

Failure details	Correct Installation
1. Impeded cooling power due to not supplemented refrigerant after pipe was extended 	☞ Refrigerant should be charged after pipe was extended. (After operating on strong cooling for about 15 minutes, when refrigerant pressure becomes parallel, check the pressure with Manifold gage, and inject appropriate amount of refrigerant. ◑ *Refer to refrigerant pressure table by temperature*  ☞ Leak test should be done for welded areas before insulating.
2. Refrigerant shortage due to small leak in welds	

5.3. Returning System

5.3.1. Air Conditioning Return system

- **What is an air conditioner return?**

Return vents: What is a return vent? These vents suck the air from each room and send it back to the air conditioning or heating system. Return vents tend to be bigger than supply vents, and you won't feel any air coming from them

A.The Difference between Supply Air Vents and Return Air Vents

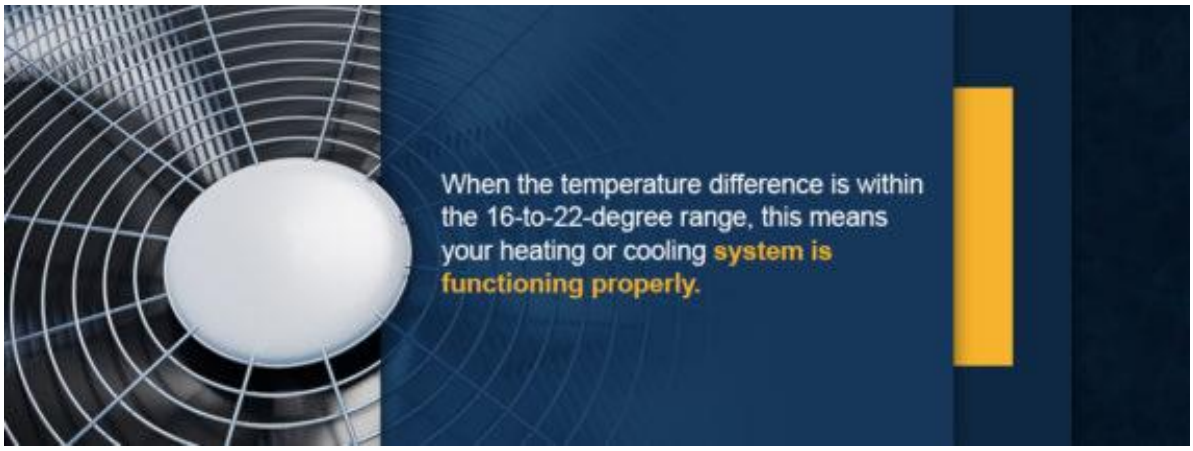
If your home has central heating and cooling, you'll notice two types of vents on your walls.

- **Supply vents**: These are the vents that blow air into each room. The conditioned air goes from your air conditioner or furnace, travels through the ductwork and exits out the supply vents. These vents are easy to identify, as they're the only vents from which you can feel conditioned air blowing out.
- **Return vents**: What is a return vent? These vents suck the air from each room and send it back to the air conditioning or heating system. Return vents tend to be bigger than supply vents, and you won't feel any air coming from them. When an HVAC system delivers air to a room, it increases that room's air pressure. Return vents exist to remove the extra air.

- **How Many Return Air Vents Do I Need?**

Homes constructed before the advent of central air often have retrofitted HVAC systems. The earliest HVAC systems featured a large, single return vent placed somewhere in the middle of the home, but this is not the most effective system. Instead, there should be at least one return vent in every room, with two or three being ideal.

If your house has only one return vent, this is not a problem — make sure to keep the doors open in every room so the air can circulate properly. Make sure there are no furniture, draperies, rugs, etc. blocking return vents. If you ever need to replace portions of the ducts in your home, this may be a good opportunity to install a few additional return vents. What Should the Temperature Difference Be Between the Supply and Return Vents?



While there isn't any perfect temperature you should set your HVAC system to, there is an ideal temperature difference between the supply and return air, which should be between 16 and 22 degrees Fahrenheit. This difference in temperature is the evaporator Delta T.

When the temperature difference is within the 16-to-22-degree range, this means your heating or cooling system is functioning properly. If it is outside of this range, however, this means your system has a few problems.

In the case of air conditioning, the evaporator Delta T will tell you about the performance of your AC's evaporator coil, which is the component responsible for cooling the warm air in your home. Here's how you go about determining the Delta T for your system measurement.

1. **Obtain a temperature probe**: This device will provide a quick and accurate measurement of the surrounding air temperature.
2. **Record the return vent temperature**: Take your temperature probe and record the return vent's temperature.
3. **Record supply vent temperatures**: Go to three supply vents and measure their temperatures.
4. **Determine the supply vent average temperature**: Add the three recorded temperatures together and divide by three to get the average temperature of the supply vents.
5. **Determine Delta T**: To figure out Delta T, subtract the temperature of the return air from the average temperature of the supply vents.

B. If the Delta T Is Too High

If the Delta T you calculated doesn't fall within the 16-to-22-degree range, something about your AC system isn't working correctly.

C. **If your Delta T is above 22 degrees**, chances are that the airflow across your coil is too low, which can result from:

- A dirty air filter or evaporator that needs cleaning

- Ductwork that isn't big enough
- A fan set to the wrong speed

D. To fix an AC system with a high Delta T, try one of the two following solutions.

- **Replace the air filter**: Doing so can often reduce the difference in temperature.
- **Hire an expert:** You can have a professional increase the speed of your blower motor, clean your coil and look for other potential issues with your system.

E. If the Delta T Is Too Low

If your Delta is less than 16 degrees Fahrenheit, the difference between your incoming and outgoing temperature is not high enough.

- **This problem can result due to the following**.
  - ✓ Insufficient levels of refrigerant
  - ✓ Leaky reverse valves
  - ✓ Leaky AC return air ducts
  - ✓ Weakening compressor valves

When it comes to the above issues, it's best not to attempt to fix them yourself. Instead, hire an expert to check your system for leaky refrigerant and inspect your ductwork and valves.

Should I Put a Filter in My Return Vent?

Your HVAC system, just like any other piece of machinery, works best when free of dust and other debris. Debris can accumulate inside an HVAC system, like your AC unit's evaporator coils.

While routine maintenance is a good idea, installing a return vent filter can help prevent this debris from entering your return vents and ensure the air entering your HVAC system is clean.

Your AC system also comes with a filter that purifies the air before it enters your equipment. A filter on your return duct, therefore, serves more like an additional precaution that helps further clean the air and extend the life of your HVAC system.

5.4. Identifying and regularizing components that require routine maintenance

5.4.1. Air Conditioners, Maintenance and Basic Troubleshooting

Some basic troubleshooting tips for common air conditioner problems. Central air conditioning is a system with multiple components. And sometimes when it's not cooling adequately your first instinct is to call an HVAC technician for air conditioner repair

A. Check the Thermostat Settings

Knowing how to troubleshoot an air conditioner often starts with the main control – its thermostat. Thermostats come in a variety of options, starting with very basic models that simply control heating and cooling temperatures and fan operation. More sophisticated programmable versions can be set to automatically change temperatures throughout the day for better comfort when you are home and higher efficiency when you are at work or asleep at night. Wi-Fi® models can be controlled from a mobile device or computer anywhere you have access to the internet.

Considering all of the options available, there are a number of ways your **thermostat settings** can make it appear that your air conditioner is not running correctly.

- **Symptoms you might notice include:**

✓ Lukewarm air blowing from the registers/vents at times, and cold air blowing at other times

✓ Higher than expected temperature reading on the thermostat

✓ No air blowing from the registers/vents.

If you experience any of the above symptoms in your home, be sure to check the thermostat before calling an HVAC repair service.

✓ Is the thermostat set for heating instead of cooling the air? If it is, simply adjust the thermostat so it is set to cool, or change the setting to auto so it will automatically change between cooling and heating as temperatures change.

✓ Is the fan set on "auto", "on", or "off"? If the setting is "on", the fan will run constantly, even when the system isn't cooling the air. This could result in warmer air blowing from the registers when the AC unit isn't operating. Changing the fan setting to "auto" will resolve the issue by turning off the blower when the system is not actively cooling. If it's set to "off", simply select "on" or "auto".

- ✓ Check the temperature setting to make sure somebody else didn't change it to a higher setting.
- ✓ If you have a programmable thermostat, review your "comfort schedule" for any issues, and make sure your programmed settings still match the times and temperatures you expect when you are home, away and asleep.
- ✓ If you have made some of the described adjustments and your system does not respond, it may be time to contact your local Carrier® HVAC expert for a professional AC troubleshooting appointment.

B. Air Filter Is Dirty

The next most common step in AC troubleshooting is checking for a dirty air filter. Your AC system is more than just the outdoor unit sitting by the side of your home. Most systems also include an indoor air handler unit, usually a furnace or fan coil.

The indoor unit should include an air filter that traps dust, dirt and other airborne particles. Whether you have a basic, 1-inch furnace filter or a more sophisticated electronic air cleaner or purifier, maintenance is the key to effective indoor air filtration and proper cooling system operation. Lack of maintenance can lead to a clogged filter and blocked air flow. These can lead to loss of efficiency, discomfort, or in more extreme cases, system failure.

- **Symptoms of a dirty filter include:**
  - ✓ The air temperature in your home is warmer than normal
  - ✓ Airflow from your cooling registers seems to be less than usual
  - ✓ The AC runs for short periods of time before shutting down and re-starting (short cycling)

Before checking your air filter, be sure the thermostat is set for cooling and that the temperature setting is correct. If you still suspect the problem is a dirty air filter, consult your owner's manual for instructions on removing and cleaning or replacing your air filter or check out our page on how to change air conditioner filters.

Basic filters are often inside the furnace cabinet, but larger, 4-inch media filters, electronic air cleaners, and whole-home air purifiers are likely mounted outside the furnace between the cabinet and the return air duct. If cleaning or replacing the filter doesn't solve the problem, contact your local Carrier® dealer for assistance.

C. Refrigerant Level Is Low

Your air conditioning system uses a chemical called refrigerant to help cool your home. The refrigerant is pumped through copper tubing, the indoor evaporator coil and outdoor condensing unit, in a continuous loop. As it flows through your AC system, the refrigerant pulls heat from your home and deposits it outside, leaving indoor air cooler, less humid and more comfortable.

- **If refrigerant levels get low, you might experience the following air conditioner problems**:
  - ✓ House not staying cool enough

- ✓ System running continuously or for longer than normal cycles
- ✓ AC turning on, then off quickly, several times in a row (short cycling)

If your thermostat settings are correct and your air filter is clean, you may have a leak or other issue that is causing the refrigerant levels to drop. If you suspect low refrigerant levels, contact your local Carrier dealer. A qualified HVAC technician will have the tools and will know how to troubleshoot an air conditioner for refrigerant-based issues. Do not attempt to troubleshoot refrigerant issues yourself.

D. Electrical Panel Issues

If there is no air coming from the registers, the house is too warm, and the system isn't running at all, you might have lost power to the system. Your air conditioner runs on electricity, so if it won't power on, locate your home's electrical panel (breaker box). Look for a blown fuse or a tripped circuit breaker that isn't in the ON position. Keep in mind that your air conditioner outdoor unit will be connected to a dedicated 220 or 240 volt disconnects or circuit breaker located near the air conditioner unit. The air conditioner also is connected to a circuit breaker or fuse at the electrical panel (breaker box).

Remember that electricity can be dangerous – even deadly. If it is a blown fuse or a tripped circuit breaker, make sure you are comfortable and competent to safely replace the fuse and/or reset the breaker – if not, consult a qualified professional. Do not attempt to troubleshoot electrical issues yourself. If the circuit breaker trips again (or the fuse blows again) it's time to call a technician who knows how to troubleshoot an air conditioner with electrical issues.

E. Evaporator Coil Is Frozen

With a typical split-system central air conditioner, the evaporator coil is often located inside the home or garage, as a part of the air handler unit. If the indoor unit is a furnace, the evaporator coil is typically mounted where the outgoing air flows. If it's a fan coil, the evaporator coil is typically located inside the fan coil cabinet.

- **You may have a frozen evaporator coil if you notice**:
  - ✓ Higher utility bills
  - ✓ Inadequate cooling
  - ✓ Excessive condensate drainage near your indoor unit
  - ✓ Frost or ice forming on the copper refrigerant lines coming from your evaporator coil cabinet
  - ✓ Frost forming on exterior refrigerant tubing or the outdoor unit
- **Issues that can lead to a frozen evaporator coil include:**
  - ✓ Excessive buildup of dust, dirt or other pollutants on the evaporator coil
  - ✓ Excessively dirty or clogged air filter

- ✓ Excessive buildup of dust, dirt or debris on the outdoor condensing unit
- ✓ Low refrigerant levels

Continuing to operate the system with a frozen evaporator coil can cause serious damage to the coil and a potentially costly repair. Because the evaporator coil is typically not easily accessible and troubleshooting an air conditioners refrigerant levels should be handled by a professional contractor, we recommend you shut down the system and contact your local Carrier dealer when you have a frozen evaporator coil. Do not attempt to troubleshoot refrigerant or electrical issues yourself.

F. Condensing Unit Is Faulty or Broken

With a typical split-system central air conditioner, the condensing unit sits outside your home and includes the outdoor coil, the compressor, the condenser fan and its electronic controls.

- **To troubleshoot an air conditioner for a faulty or broken condensing the issues like:**
  - ✓ No cooling or inadequate cooling
  - ✓ System turning on and off rapidly (short cycling)
  - ✓ System running continuously or for unusually long periods of time
  - ✓ Frost or ice on the coil or copper refrigerant tubing
  - ✓ Condensing unit not turning on at all

As was the case with evaporator coil issues, a condensing unit might have an excessively dirty coil or refrigerant leakage. Additional issues with the outdoor condensing unit might include a faulty compressor, a failing condenser fan motor, or a faulty run capacitor. Most of these air conditioner problems require a professional. Do not attempt to troubleshoot refrigerant or electrical issues yourself. You may also want to check out our mini split ac repair and troubleshooting guide.

5.5. Checking power and control circuit wiring

Self Check 5.1.

TEST I. Say True Or False For The Following Questions

1. Return vents suck the air from each room and send it back to the air conditioning or heating system.
2. Return vents tend to be bigger than supply vents
3. Supply vents are the vents that blow air into each room.
4. Temperature probe is a device wich provide a quick and accurate measurement of the surrounding air temperature
5. If cleaning or replacing the filter doesn't solve the problem.

TEST II. Choose The Best Answer from the given alternative

1. Which one of the following are not the symptoms of a dirty filter problem in air conditioner.

A. The air temperature in your home is warmer than normal

B. Airflow from your cooling registers seems to be less than usual

C. the AC runs for short periods of time before shutting down D. none

2. Which one of the following are the symptoms of a condensing unit Is faulty or broken for an air conditioner except ____

A.There are adequate cooling C. System running continuously
B. System turning on and off rapidly D. Condensing unit not turning on at all

3. Which one of the following are the symptoms of refrigerant levels get low during working time.

A. System running continuously C. House not staying cools enough

B. AC turning on, then off quickly D.All

Unit Six: Commission air conditioning systems

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

- Charging air conditioning system
- Obtaining and recording measurements
- Adjusting control devices installed in the air stream

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:

- Charging air conditioning system
- Obtaining and recording measurements
- Adjusting control devices installed in the air stream

6.1. Charging air conditioning system

A. Charging

The compressor must never be operated without refrigerant or under vacuum. A damage of the compressor would result. If the filling capacity of the plant is known, liquid charging of the refrigerant into the high side of the system can be carried out with the plant at rest, against vacuum, using a charging cylinder or scales.

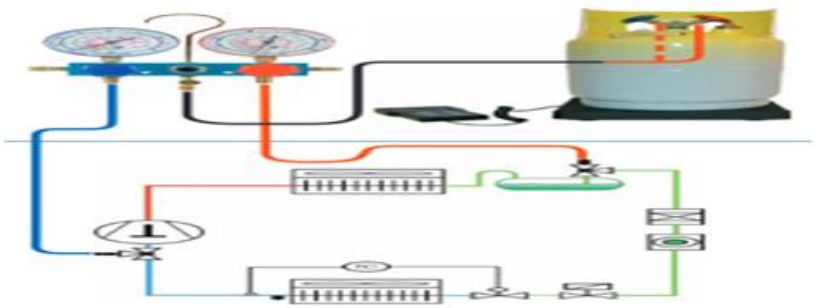


Fig Air conditioning charging

B. charge a ductless AC system, follow these steps:

- **Shut down the AC unit:** Before starting the charging process, make sure to turn off the AC unit.
- **Attach the hoses**: Connect the hoses from the gauge manifold to the pressure ports of the AC system. The low-pressure hose is typically blue and connects to the suction line, while the high-pressure hose is usually red and connects to the liquid line.
- **Connect the refrigerant container:** Attach the supply hose from the manifold to the refrigerant container. Ensure that the container remains in an upright position.
- **Add refrigerant:** Slowly add the refrigerant to the system, allowing 5-10 minutes for the system to stabilize between additions. It is important to follow the manufacturer's guidelines for the correct amount of refrigerant to add.

- **Monitor the system:** Once the refrigerant has been added, monitor the system to ensure it is functioningproperly. Check for any leaks or abnormalities in the cooling performance.

It is worth noting that charging a ductless AC system may require the assistance of a licensed professional. If you are unsure or uncomfortable with the process, it is recommended to seek professional help to avoid any potential damage or safety hazards.

6.2. Obtaining and recording measurements

In the case of air conditioning, the evaporator Delta T will tell you about the performance of your AC's evaporator coil, which is the component responsible for cooling the warm air in your home. Here's how you go about determining the Delta T for your system measurement.

1. **Obtain a temperature probe**: This device will provide a quick and accurate measurement of the surrounding air temperature.
2. **Record the return vent temperature**: Take your temperature probe and record the return vent's temperature.
3. **Record supply vent temperatures**: Go to three supply vents and measure their temperatures.
4. **Determine the supply vent average temperature**: Add the three recorded temperatures together and divide by three to get the average temperature of the supply vents.
5. **Determine Delta T**: To figure out Delta T, subtract the temperature of the return air from the average temperature of the supply vents.

6.3. Adjusting control devices installed in the air stream

Ductless and duct AC systems have built-in control panels on the air handler to adjust settings and temperatures. Most models also include a remote control with each air handler, allowing you to adjust the unit's settings remotely. These systems do not use traditional thermostats like a central air conditioning system

does The perfect ductless mini-split controls not only mean that your system will run at optimum efficiency

but also that you can easily meet the needs of your family's preferences.

2. A controller is a ductless accessory meant for communicating with your cooling and heating system. Most controllers are a simple, handheld remote control. But, there are also newer, sophisticated ones that allow you to control your system from your smartphone

3. The control devices installed in the air stream of ductless and duct AC systems can be djusted using the built-in control panel, remote control, or a controller accessory. These devices allow you to turn the unit on or off, set the specific temperature, and choose between different modes such as AUTO, DRY, COOL, and HEAT.

Here are some best practices for adjusting control devices in the air stream:

Familiarize Yourself with the System: Before making any adjustments, familiarize yourself with the air conditioning system and the control devices installed. Refer to the manufacturer's documentation or user guides for specific instructions.

Use Appropriate Tools: Use the appropriate tools and equipment to make adjustments to the control devices. This may include manual tools or electronic controls, depending on the system.

Monitor Performance: After making adjustments, monitor the system's performance to ensure that the desired changes have been achieved. This may involve observing the airflow and temperature changes in the air conditioning system.

Document Changes: Keep a record of any adjustments made to the control devices for future reference and troubleshooting purposes.

Seek Professional Help: If you are unsure about how to adjust the control devices or if the adjustments require specialized knowledge, seek guidance from a qualified professional.

By following these best practices, you can ensure that the adjustments made to the control devices are accurate and safe, promoting efficient operation and longevity of the air conditioning system.

Self-check: 6.1.

TEST I: Say True or False

1. The compressor must never be operated without refrigerant or under
2. Before starting the charging process, make sure to turn off the AC unit
3. The low-pressure hose is typically red and connects to the suction line.
4. The high-pressure hose is usually blue and connects to the liquid line.

TEST. II:. Give short answer

1. What are HVAC Gauges?
2. Write main types of refrigerants and manifold gauges?
3. Define Air conditioner Charging ?
4. Write steps that follow to charge a ductless AC system

Operation sheet 6.1.

Operation sheet title: **-charging of refrigerant gas.**

Purpose: - To charging of refrigerant gas.

Instruction: To apply refrigerant, recover, evacuate, vacuum, and replace gas, use the provided tools and materials. 5 hours to do

- **Tools and requirements**
  - ✓ Recover machine
  - ✓ Vacuum pump
  - ✓ Gauge manifold
  - ✓ Nitrogen Cylinders
  - ✓ Refrigerant
  - ✓ Refrigerator
  - ✓ Recovery cylinder
- **Procedures to do the task**

Step .1: Connect hose 2 and 3 connection to C and D, respectively.

Step .2: Both the gauges must be zeroed.

Step .3: Evacuate the system into a recovery bottle by connecting the vacuum pump to charging hose 1, open both valves A and valve B till the evacuation process is complete (vacuum gauge reading showing 500 microns as final reading).

Step .4: Stop the vacuum pump after the system has evacuated, close the charging hose (1) valve going to the recovery bottle, check the pressure drop in the gauge for around 20 min to know if there is any leakage in the system.

Step .5: Disconnect the charging hose 1 from the vacuum pump and connect it to the blue connection of the charging cylinder for a **gas charge**.

Step .6: Open valve A, slightly open the connection at C and purge the whole hose line from 1 to 2 by crack opening the gas valve of the refrigerant charging bottle; try not to avoid any excess leak directly into the environment.

Step .7: Same way, purge the high-pressure liquid side hoses from 1 to 3 to remove any air/moisture inside the hose.

Step .8: Now tight both the low and high-pressure side hose at position C & D, respectively as shown in the image.

Step .9: Start charging the gas refrigerant from the refrigerant bottle to the low-pressure side of the system at connection C by opening valve A and the refrigerant valve of the charging bottle until the vacuum comes to zero.

Step .10: Now start the compressor as the suction pressure goes above zero.

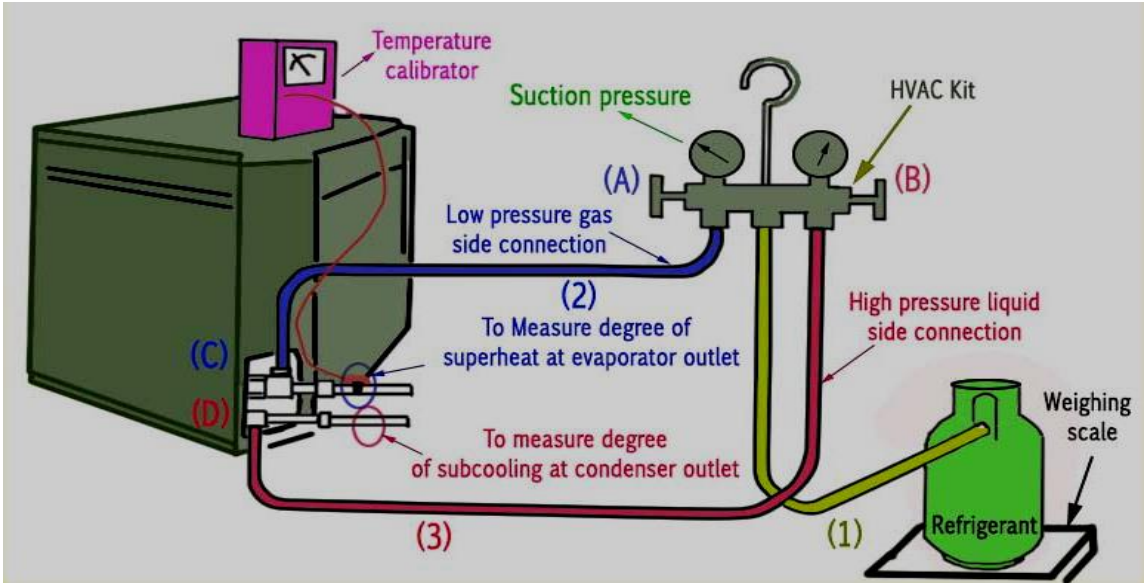
Step .11: After about 30 – 40 seconds of charging, close valve A and check the suction gauge pressure for a rise in pressure.

Step .12: Keep monitoring the degree of superheat by the temperature calibrator to ensure the liquid is not entering into compressor suction also; we can calculate how much charge present in the system by the pressure chart.

Step .13: If the superheat temperature is high, then it means the system is running low in refrigerant, whereas a lower superheat temperature than the desired reading means the system is overcharged.

Step .14: Repeat the procedure 10 to 11 until the suction pressure reaches 60 psi (as per maker). This avoids the risk of overcharging of the system also keeps measuring the refrigerant by the weighing scale.

Step .15: Once the refrigerant has charged, close the refrigerant valve, valve A and B and disconnect all the hoses, and secure everything.



Lap Test 6.1.

Instructions: Given the necessary templates, tools, materials, and equipment you are required to use to perform recovery, evacuation, vacuuming, and gas charging, you have to complete this task within 5 hours.

Task – 1: Tube brazing

Task –2: Refrigerant recovery.

Task - 3: Evacuate the system

Task - 4: Vacuum the system

Task - 5: Recharge the refrigerant

Unit Seven: Complete work and report activities

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

- Cleaning and made worksite and equipment
- Recording refrigerant usage
- Notifying completion of task

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:

- Clean and made worksite and equipment
- Record refrigerant usage
- Notify completion of task

7.1. Cleaning and made worksite and equipment

- **Work Environment**
  - ✓ Ensure that the floor of a work place is clean to avoid tripping or other possible instances that could lead to a worker losing his or her balance.
  - ✓ Keep the workspace clean and tidy to avoid clutter, which may cause accidents.
  - ✓ Use clamps to secure a work piece, which is liable to move, into a stable position.
  - ✓ Do not carry a sharp or pointed tool in your pocket. Carry tools securely and safely.
  - ✓ Keep close track of tools when working at heights. A falling tool can cause serious injury. 6. Pass a tool to another person by the handle; never throw it to them.

    Store tools properly when not in use

7.1.1. Cleaning work area

Housekeeping is not limited to keeping the place clean; it is also concerned with keeping equipment and materials in good repair and in their proper place. Good housekeeping is essential to preventing losses or injuries. Every injury caused by housekeeping can be prevented if everyone helps to keep the work area clean.

Cleanliness gives rise to a good character by keeping body, mind, and soul clean and peaceful. Maintaining cleanliness is the essential part of healthy living because it is the cleanliness only which helps to improve our personality by keeping clean externally and internally

- **Classification of cleaning methods**
  - ✓ Mechanical-by machine or human action or both
  - ✓ Chemical
  - ✓ Combination of both mechanical and chemical
  - ✓ Heat and Steam (sterilization).
- **Purpose/useCleaning work area**

Experts recommend that you work on educating your workers on the importance of maintaining a clean and hygienic office space. An unclean work environment is an excellent breeding ground for various germs and allergens, which only emphasizes the need to keep it clean at all times

- **Necessary tools and equipmentfor Cleaning work area**

  Selection of cleaning equipment Cleaning equipment covers a wide range of products and items. The following information is to help you decide which machine you may need to use.

- **Vacuum cleaners:** the vacuum cleaner is the most used piece of electrical cleaning equipment. If it is properly cared for it will become your best friend!



Figure7.1:- Vacuum cleaners

- **Barrel style:**the barrel vacuum cleaner is named because of its appearance. They are usually on wheels with a flexible hose and have extension tubes with a nozzle attached. The nozzles can be interchanged for different surfaces e.g. a brush nozzle would be used on hard floor, where a flat nozzle would be used on carpet.



Figure 7.2:- Barrel style

- **Backpack:** this is a vacuum cleaner where the body of the machine is carried on the back. It is worn like a backpack and is strapped to the operator by straps and buckles. They are designed to be used in areas where access is difficult e.g.in cinemas and theatres between all the seats or in restaurants where there is a large amount of tables and chairs. They can be heavy and hot if worn for an extended period. They are

designed to be used on curtains and air vents and periodically on carpets. The size of the machine limits the amount of suction that is generated. They should not be used by people who have bad backs.



Figure 7.3:- Barrel style

- **Floor scrubbing machines**: a floor scrubbing machine is used for wet scrubbing on hard floors. They vary in sizes and the machine can be either manually operated or automatic.



Figure 7.4:-Floor scrubbing machines

7.2. Recording refrigerant usage

7.3. Notifying completion of task

A.Define notify work

Notification work is a term used to describe particular types of work that are subject to compliance with Building Regulations notification or approval.
Work that needs to be notified should be signed off by your local authority building control body. Alternatively, you could use a registered competent person who can self-certify that the work is compliant.

There is further guidance in a leaflet about Building Regulations and notification work available from Communities and Local Government.

7.3.1. Follows rules to notify work

All notification work must be notified using one of the three routes

- **Route 1: Direct notification through Local Authority Building Control**

The homeowner must contact Building Control directly to ensure that a Building Control Officer visits the installation and issues a compliance certificate. The cost for this can vary depending on area.

- **Route 2: Self-certification through a recognized scheme such as ELECSA(ELE Ctrical Self Assessment)**Companies registered with the ELECSA Part P scheme can self-certify all notification work themselves via the ELECSA website, by phone or fax. Notification of work must take place within 20 days of it being completed. There is no need to contact the Local Building Control directly as we will notify the work on your behalf.
- **Route 3: Certification by a registered Third Party In the latest Approved** Document, a provision has been made for an alternative route for installers who are not registered competent persons (Route 2)and wish to appoint a registered third-party certifier to inspect and test the work as necessary. Note that there is no process as yet to facilitate this route for building regulations notification

The notification process the core principle of ELECSA is to keep the additional paperwork and hassle that you have to endure to an absolute minimum. To this end, we have implemented a system whereby all the responsibility of notifying the homeowner and the relevant Local Authority of the installation is handled by us all you need to do is inform us once you have completed the installation.

Who needs to be notified?

It is a legal requirement that each notification air condition installation carried out by a registered contractor needs to be notified to three separate bodies:

- ✓ The relevant self-certifying scheme –done by you and notified to ELECSA
- ✓ The relevant Local Authority –done by ELECSA
- ✓ The householder –done by ELECSA

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