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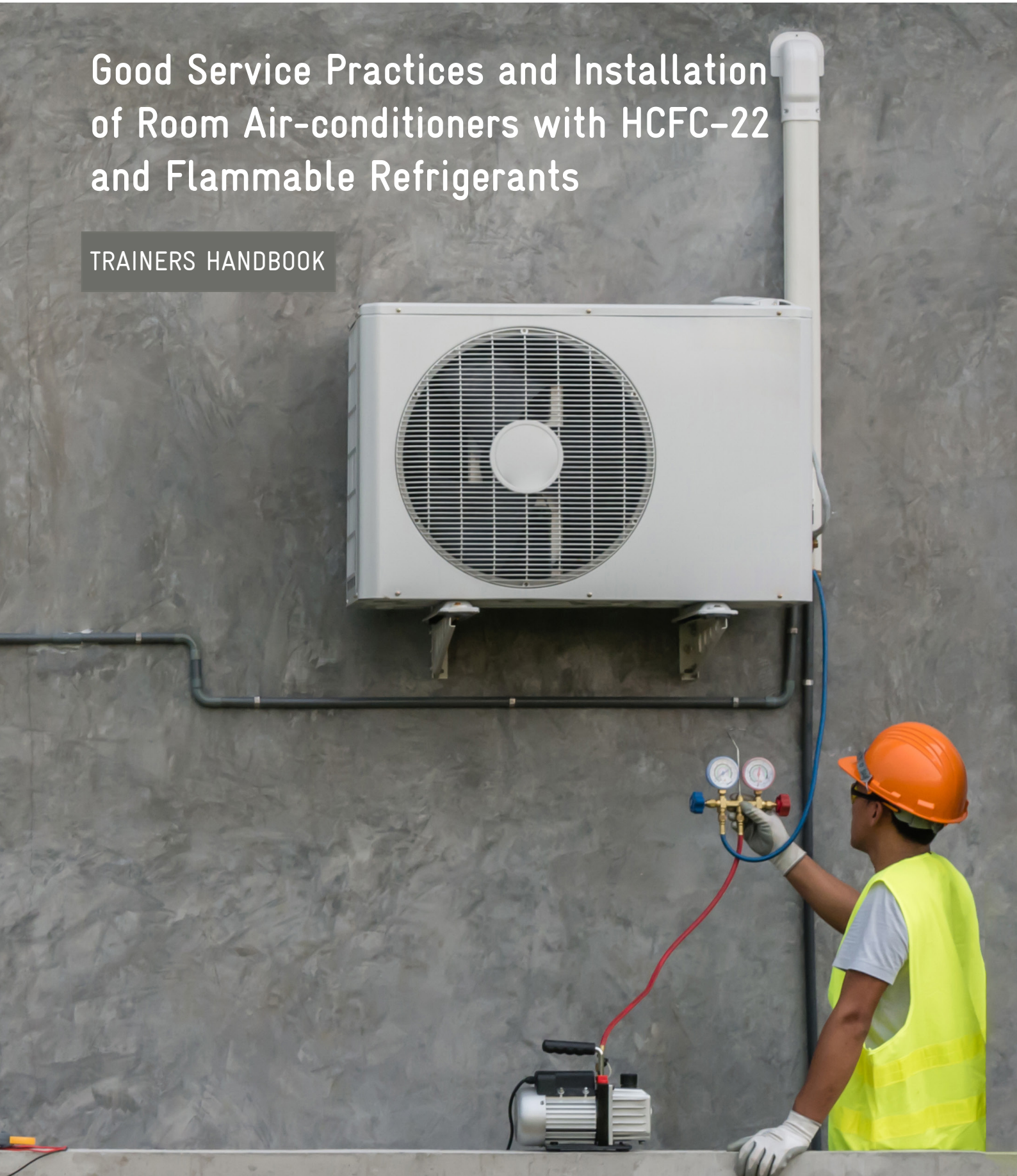
HPMP
HCFC Phase-Out Management Plan, Servicing Sector

Good Service Practices and Installation of Room Air-conditioners with HCFC-22 and Flammable Refrigerants

TRAINERS HANDBOOK



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New Delhi, India, September 2018

Good Service Practices and Installation of Room Air-conditioners with HCFC–22 and Flammable Refrigerants

TRAINERS HANDBOOK

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डॉ. हर्ष वर्धन
Dr. Harsh Vardhan

सत्यमेव जयते

भारत सरकार
पर्यावरण, वन एवं जलवायु परिवर्तन मंत्री
GOVERNMENT OF INDIA
MINISTER OF ENVIRONMENT, FOREST & CLIMATE CHANGE

FOREWORD

Refrigeration and air-conditioning (RAC) servicing sector is very important as refrigeration and air conditioning equipment remains in use for nearly 10 years leaving a significant population with Ozone Depleting Substances (ODS) based equipment likely to be in operation. The refrigerant consumption in the Servicing Sector not only depends on the installed base of RAC equipment, but also on quality of the product and the quality of servicing during product life cycle. There could be potentially significant savings in refrigerant use if good service practices are followed. The good service practice is important not only because of environment issue but also to maintain the design energy efficiency of the air-conditioners.

As per informal industry level estimates, the number of servicing technicians for the residential Refrigeration and Air-conditioning (RAC) sector is estimated to be 200,000 this number will be growing with the growing market of room air-conditioners. The consumption in the servicing sector will be reduced mainly through training on better servicing practices and leak prevention in the present scenario the service technicians also need to be prepared on the introduction of alternatives to HCFC-22 like HC-290, HFC-32 etc. The technicians will have to be trained to appropriately handle the low GWP flammable refrigerants.

The HCFC Phase out Management Plans (HPMPs) in India are being implemented under the direct supervision of the Ozone Cell, Ministry of Environment, Forest and Climate Change (MoEF&CC), Government of India. RAC servicing sector project under HPMP is being implemented by Government of Germany represented by Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH and United Nations Environment Programme (UNEP) under the guidance of Ozone Cell, MoEF&CC. The aim of HPMP is to minimize the emissions of ozone depleting substances into the environment and, thus, mitigate the ozone layer depletion

The Ministry is focussing on synergizing the training of RAC service technicians under HPMP Stage II with Skill India Mission in order to have wider positive impact on environment protection and livelihood of technicians. In this regard, the Technicians Handbook and the Trainers Handbook on Good Service Practices and Installation of Room Air-conditioners with HCFC 22 and flammable refrigerants will be a great help training of RAC service technicians.

I wish the trainings to be imparted under HPMP Stage II to RAC service technicians all success.

Date: 14.09.2018

(Dr. Harsh Vardhan)

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ABOUT PROKLIMA

Proklima is a programme of the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH. Since 2008 Proklima has been working successfully on behalf of the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) under its International Climate Initiative (ICI) to disseminate ozone-and climate-friendly technologies.

Proklima has been providing technical and financial support for developing countries since 1996, commissioned by the German Federal Ministry for Economic Cooperation and Development (BMZ) to implement the provisions of the Montreal Protocol on Substances that Deplete the Ozone Layer.

This publication has been prepared under the project HCFC Phase-Out Management Plan Service Sector under Multilateral Fund (MLF) to the Montreal Protocol.

ACKNOWLEDGEMENTS

This handbook is exclusively prepared for the Refrigeration and Air-conditioning (RAC) service technicians as a reference material for installation and servicing the air-conditioners charged with HCFC-22 and flammable refrigerant. We wish to thank Prof R.S. Agarwal, Mr. Ankur Khandelwal, Mr. C J Mathew and Mr. Ringkhang Muchahary for their valuable contributions to the handbook.

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Few pictures in this handbook were taken from the book 'Good Practices in Refrigeration', published by GIZ-Proklima in March/ April 2010.

SMITA VICHARE, GIZ – PROKLIMA

CONTENTS

IMPACT OF REFRIGERANTS ON ENVIRONMENT

Target Group
Trainers and Technicians

Duration of the Session
30 minutes

Purpose of the Session

To make the participants aware of the impact of refrigerants on environment, ozone depletion and global warming; and the imperative of moving towards HCFC-free refrigerants.

Terminal Performance Objectives

At the end of the session, the participants should know:

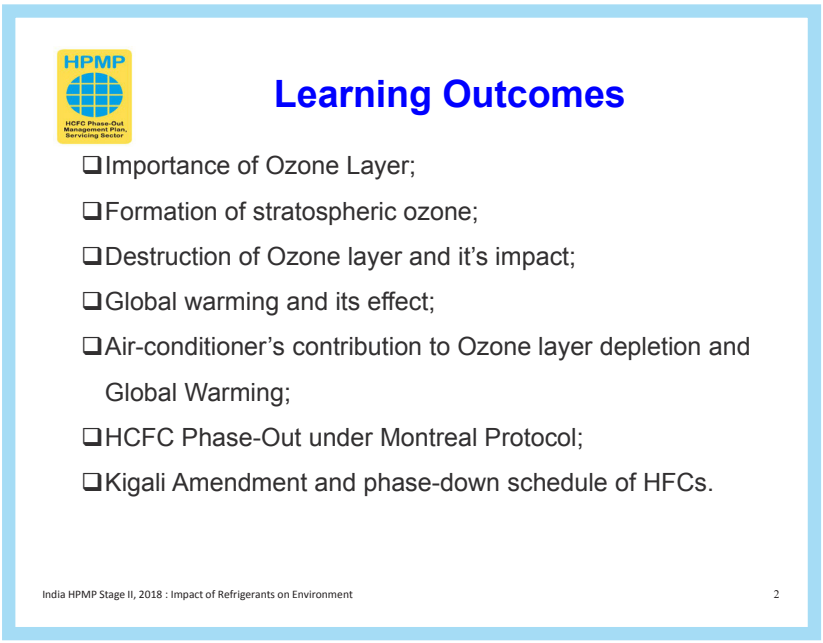
- Ozone Layer's importance and formation;
- Destruction of Ozone layer and its impact;
- Global warming and its effect;
- Air-conditioner's contribution to Ozone layer depletion and Global Warming;
- HCFC Phase-Out under Montreal Protocol;
- Kigali Amendment and phase-down schedule of HFCs

Key Message being delivered through this Session

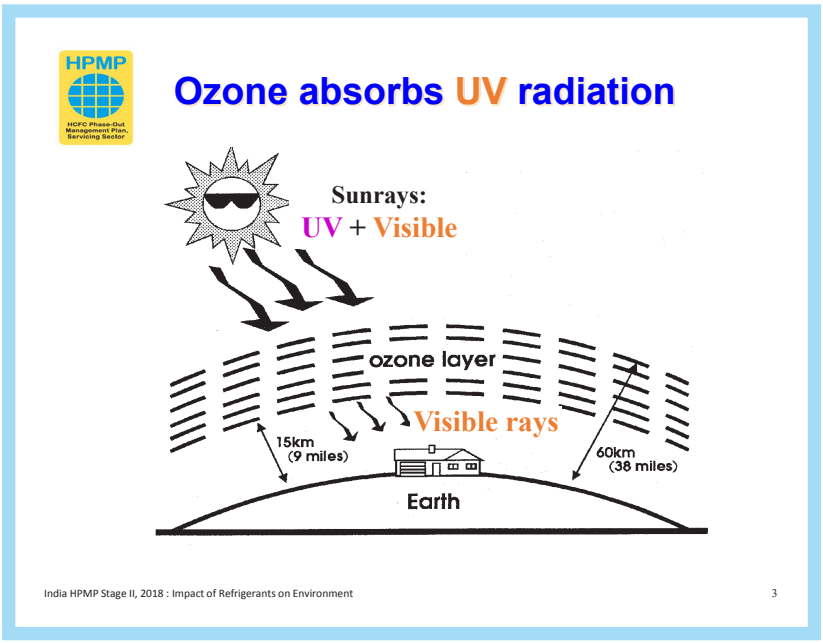
HCFCs have been widely used as refrigerants for the past several years, as it is having very good performance properties and commercially availability. HCFCs are not only ozone depleting substances, but also have high global warming potential. HFCs and HCs are alternative refrigerants to HCFCs. HFCs are not ozone depleting substances but are having global warming potential. As it is harmful to environment, Kigali amendment under the Montreal Protocol schedule to phase down the use of HFCs globally.

Tools & Equipment (if any) required for the session
None

SLIDE 1:
IMPACT OF REFRIGERANTS ON ENVIRONMENT



SLIDE 2:
LEARNING OUTCOMES



SLIDE 3:
OZONE ABSORBS UV RADIATION

The title slide shows the image of the earth showing the spreading ozone depletion caused by the chlorine and bromine components released by chemicals containing these components, including (Hydrochloroflourocarbons) HCFC-22. These compounds are also having high GWP that contributes the global warning.

The emissions of refrigerant occur during manufacturing and during servicing of air-conditioner, like charging refrigerant into the system, improper recovery of refrigerant and leakage from the air-conditioning system and lines.

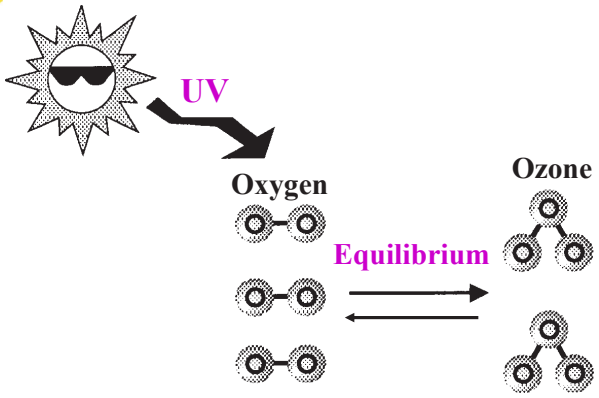
As HCFCs, including HCFC-22 are ozone depleting substances, it was agreed globally to phase-out the production and consumption of these chemicals and have the HCFC Phase-out Management Plan (HPMP) under the Montreal Protocol on Substances that Deplete the Ozone Layer.

As one of the Article 5 countries of the Montreal Protocol, India is phasing out the production and use of HCFCs in line with phase-out schedule of Article 5 countries. As most of the Room air-conditioners used currently are with HCFC-22, it is very important for the service technician to minimise the emission of HCFC-22 as much as possible during installing and servicing of air-conditioner. So, we need to learn and upgrade the good service practices of air-conditioner.

Participants will learn about how stratospheric ozone layer is formed above atmosphere and why it is important for the living beings on earth. They will also get aware how ozone layer is depleting and the impacts of the ozone layer depletion. It will also be delivered about the global warming and the contribution of air-conditioners on global warming and ozone layer depletion. Participants will also be awared about the Montreal Protocol and its HPMP and Kigali amendment and eventually how good servicing practice of Room Air-conditioner is important in mitigating ozone layer depletion and global warming.

Ozone layer is formed in the stratosphere, 15 to 60 kms (9 to 38 miles) above from the earth's surface. The Sun emits radiations of varying wavelengths in the form of electromagnetic spectrum. The UV ray is one form of radiant energy coming out from the Sun along with the visible rays. Of these, UV-B and UV-C being highly energetic, are harmful to life on Earth. UV-B radiation is absorbed only by the stratospheric ozone (ozone layer) and thus only 2-3% of it reaches the Earth's surface. Ozone layer, therefore, is essential for protection of life on the Earth by filtering out the dangerous part of Sun's radiation and allowing only the beneficial part to reach the Earth. Depletion of this layer would result in an increase of UV-B and UV-C radiation reaching the Earth's surface leading to dangerous consequences for the life on Earth. The ozone layer, therefore, acts as Earth's sunscreen.

Formation of Stratospheric Ozone



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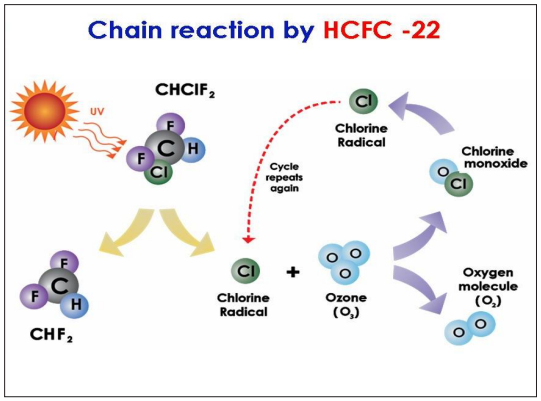
SLIDE 4:
FORMATION OF STRATOSPHERIC OZONE

Mechanism of Destruction of Stratospheric Ozone



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SLIDE 5:
MECHANISM OF DESTRUCTION OF STRATOSPHERIC OZONE

What happens if Ozone layer is damaged?

- Ozone layer filters UV-B portion of sun rays,
- If UV-B reaches earth, it causes:

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SLIDE 6:
WHAT HAPPENS IF OZONE LAYER IS DAMAGED?

Ozone (O_3) is a tri-atomic molecule of oxygen instead of normal two. It is formed from oxygen naturally in the upper levels of the Earth's atmosphere (stratospheric region) by high-energy ultraviolet (UV) radiation from the Sun. The radiation breaks down oxygen molecules, releasing free atoms, some of which bond with other oxygen molecules to form ozone.

The reverse is also true; some ozone is also decomposed into oxygen atoms, which join to become oxygen molecules. Thus, a continuous equilibrium is maintained between ozone and oxygen in that ozone layer.

In the ozone layer, ozone is present in very small quantities, its maximum concentration, at a height of about 17-25 km, is only ten parts per million.

When a HCFC molecule reaches to the ozone layer, it triggers a chain of reactions which initiate the ozone layer depletion. Firstly, in presence of sun's UV rays, HCFC molecule decomposes and releases chlorine radical. This chlorine radical reacts with a molecule of ozone, yielding an oxygen molecule and a chloro-mono-oxide molecule. The chloro-mono-oxide molecule is unstable which breaks and releases a free chlorine radical. This chlorine radical starts again another cycle of similar reaction with another ozone molecule, and once again returns to its chlorine radical state. Thus, through these repetitive cycles the ozone layer gets continually depleted in the presence of the HCFCs.

All the ODSs exhibit similar reactions, as HCFC-22 present in this slide, thus contributes depletion of ozone layer. The presence of chlorine and bromine atoms in the ODSs is what causes the ozone depletion. As the quantity of ozone in the stratosphere is limited, such reactions by chlorinated and brominated manmade chemicals have raised serious concerns.

Ultra Violet (UV) radiation is classified in three ranges: UV-A, UV-B, UV-C. Of these, UV-A is the least energetic and less harmful. UV-B is energetic enough to cause biological interactions. The component of UV-C in the solar spectrum itself is small, and that reaches the earth is practically nil. Because of the damage to the ozone layer, it is essentially the UV-B which reaches the earth's surface and cause a number of harmful effects, such as.

- It leads to an increase in the probability of the incidents of skin cancer amongst human beings.
- It can also induce eye damage since the UV radiation is known to damage the cornea and lens of the eye, leading to cataract.
- The UV radiation results in suppression of the immune systems of human bodies, making them prone to a number of infectious diseases.
- The UV radiation also has a harmful effect on fish and other ocean life, since it adversely influences the productivity of aquatic systems, leading to decreased reproductive capacity and impaired development.
- An increased level of UV radiation is also known to have adverse effects on synthetic polymers, naturally occurring biopolymers and some other materials of commercial interest.
- Material used in buildings, paints, packaging and countless other substances could be degraded by UV-B. UV-B radiation accelerates the photo-degradation rates of these materials thus limiting their lifetimes. Typical damages range from discoloration to loss of mechanical integrity.
- Increased UV-B radiation could also cause decreased crop yields and damage to forest as well as increased cases of cancer.

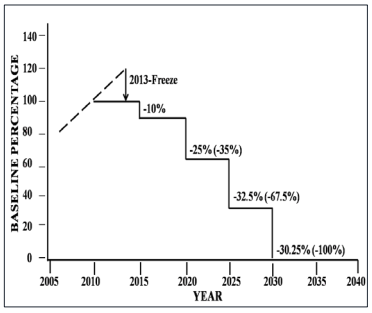
Environmental Regulations Related to Refrigerants

- Vienna Convention
  - Vienna Convention for Protection of Ozone Layer: A multilateral environmental agreement for the Protection of the Ozone Layer (1985)
- Montreal Protocol
  - Montreal Protocol on Substances that Deplete the Ozone Layer (agreement on 1987) - to phase-out Production and Consumption of Ozone Depleting Substances (ODSs) with a certain Agreed timeframe.

SLIDE 7:
ENVIRONMENTAL REGULATIONS RELATED TO REFRIGERANTS

HCFC Phase-Out under Montreal Protocol

- In September 2007 parties to the Montreal Protocol agreed to accelerate the phase-out of production and consumption of hydrochlorofluorocarbons (HCFCs);
- HCFC Phase-out schedule of Article 5 Parties including India:
  - Baseline : average of 2009 and 2010 production and consumption
  - Freeze : 2013
  - 10 % reduction of baseline in 2015
  - 35 % reduction of baseline in 2020
  - 67.5 % reduction of baseline in 2025
  - 100% phase-out in 2030



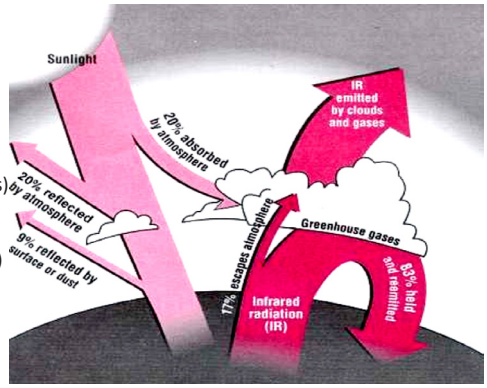
Allowing for servicing an annual average of 2.5% during the period 2030-2040

SLIDE 8:
HCFC PHASE-OUT UNDER MONTREAL PROTOCOL

Global Warming

Names of GHG

- Carbon dioxide (CO_2)
- Methane (CH_4),
- Nitrous Oxide(N_2O)
- Hydrofluorocarbons (HFCs)
- Perfluorocarbons (PFCs)
- Sulphur Hexafluoride (SF_6)
- Nitrogen Trifluoride (NF_3)



SLIDE 9:
GLOBAL WARMING

Vienna Convention for the Protection of Ozone Layer is a multilateral environmental agreement for the Protection of the Ozone Layer. It was agreed in 1985 in Vienna to protect human health and the environment against adverse effects resulting from modifications of the ozone layer.

Montreal Protocol on Substances that Deplete the Ozone Layer is an international treaty to phase-out Production and Consumption of Ozone Depleting Substances (ODSs) agreed in 1987 with a certain agreed timeframe. The objective of the Montreal Protocol was to reduce the atmospheric ozone depleting substances by implementing control measures to phase-out ODS.

In September 2007 parties to the Montreal Protocol agreed to accelerate the phase-out of production and consumption of HCFCs. This slide presents the accelerated phase-out schedule of HCFCs for Article 5 countries including India.

Another important environmental impact of refrigerants relates to the phenomenon of Global Warming.

The Greenhouse Effect is:

- The solar radiation interacts with earth's surface in several ways. Out of the total solar radiation, nearly 20% is reflected from the earth's atmosphere, 20% is dispersed into the atmosphere, and 9% is reflected from earth's surface or dust. The remaining, nearly 51%, penetrates the atmosphere and reaches the earth's surface.
- Most of the solar radiation reaching the earth's surface are reradiated to the atmosphere.
- As the reradiated radiation leaves the earth, it once again interacts with the atmosphere. Some of this manages to escape (about 17%), but majority of radiation is returned back to the earth's surface by the presence of greenhouse gases. This reflected energy further warms the surface of the earth,

leading to what we call the Greenhouse Effect.

Nature made greenhouse effect which is in limited amount of Global warming is necessary to sustain life on the earth. Absence of greenhouse effect would have rendered the earth temperatures so low that human life would not have existed on the earth.

However, some of the green-house gases, such as carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), Sulphur-hexafluorides (SF_6), Halocarbons (HFCs), perfluorocarbons (PFCs) and Nitrogen Trifluoride (NF_3) essentially emitted through the human activities, cause an increase in the level of greenhouse effect and thus, high global warming and this is harmful to mankind and the living beings on earth.

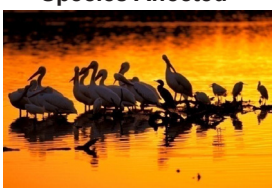
The effects of high global warming is presented in next slide

Effects of Global Warming

Rising Sea Level

Increase Temperature

Habitat Damage and Species Affected



Changes in Water supply

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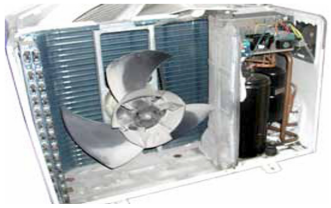
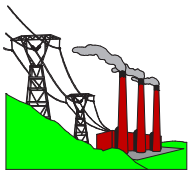
SLIDE 10:
EFFECTS OF GLOBAL WARMING

How ACs Contributes to Global Warming?

- Refrigerant emissions over the working life of AC (Direct emissions)
- Consumption of electricity over the entire working life of AC
- Electricity use contributes almost 90% of the CO2 emissions.





Refrigerant emissions: Installation /Servicing + Leaks + Failures + End of Life.
1 kg HCFC-22 = 1,820 kg CO_2

+

CO_2 emissions are due to energy generated to run Air Conditioning equipment

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SLIDE 11:
HOW ACS CONTRIBUTES TO GLOBAL WARMING?

Commonly used Refrigerants in Room AC Sector

- **Hydrochlorofluorocarbons (HCFCs)**
  - HCFC-22 - Ozone Depleting + Global Warming
- **Hydrofluorocarbon (HFCs)**
  - HFC-32 - Global warming
  - R-410A - Global warming
  - R-407C - Global warming
- **Hydrocarbons (HCs)**
  - R-290 - No Ozone depletion & negligible Global warming

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SLIDE 12:
COMMONLY USED REFRIGERANTS IN ROOM AC SECTOR

In the last hundred years, the mean global temperature has increased by 0.3 to 0.6°C. Because of this, the sea water thermally expands, and the icecaps melt, leading to rising sea levels. It destroys coastal towns making people homeless. An increase in global sea level of 4 to 10 inches has been observed over the last 100 years. This also affects rainfall pattern on the earth, leads to climate changes and thereby alters the bio-diversity.

It changes in water supply and water quality. Another effect of habitat damage and affect the plant and animal species. It also has a negative effect on human health, as evidenced by increase in cases of Malaria, Dengue and Yellow Fever. According to experts, the world will see a definite impact of global warming in the next few decades. Increase in global temperatures, coupled with rapid growth of population, will make society more vulnerable to climate change. It will lead to climatic disorders, droughts, famines, floods and longer heat waves spreading to newer areas. Tropical islands and low-lying coastal areas will face the threat of being submerged.

ACs contribute to global warming in two ways, called direct and indirect contribution.

Direct contribution is due to direct emission of refrigerant used in ACs. Refrigerant emits during installation and servicing, due to leakage, failure and at the end of life of ACs. As HCFCs and HFCs are having high global warming potential (e.g. GWP of HCFC-22 is 1820) small emission to environment contributes high global warming.

Indirect contribution is the energy-related contribution that is represented by the emissions of Green-house gases (mainly CO2) that arise from the production of electricity. Over the entire life cycle of air conditioning equipment, considerable amount of electricity is consumed. In most of the countries, electricity generation is by fossil fuel. Various experiments and calculations have shown that the indirect contribution of ACs to the greenhouse effect is significantly higher than the direct contribution associated with the emissions of HCFCs.

Commonly used refrigerant in Air-conditioning sector are presented in this slide. The refrigerants used are divided into three categories - HCFC, HFCs and HCs.

HCFCs, including HCFC-22 are ozone depleting substances which are being phased out under the HPMP of Montreal Protocol, in accelerated phase-out schedule. These are also having high global warming potential.

The next category refrigerants are HFCs and blend of HFCs. At present, HFC-32 and blends like R410A, R-404A and R407C are commercially available and used as refrigerant in Room air-conditioning sector. These chemicals are not having ozone depleting potential, but they are having high global warming potential. The Montreal Protocol is amended to phase-down HFCs as these chemicals have high GWP values.

The 3rd category refrigerant, HCs, like R-290 and R-600a are commercially available refrigerant which are not having ozone depleting potential and having negligible global warming potential compared to other two categories of refrigerants.

Kigali Agreement: Ozone and Climate

Montreal Protocol Successfully Phasing out ODS since, 1987

Kigali Amendment for Phase-down of HFCs, 2016

Ozone Layer Protection

Climate System Protection

All 197 countries of the world are working together to phase out ODSs

A dedicated Effort to reduce GHG emissions through Phase-down of HFCs and Energy Efficiency

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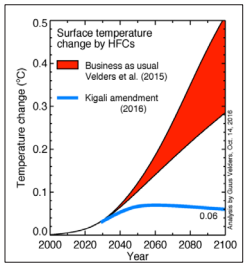
SLIDE 13:
KIGALI AMENDMENT: OZONE AND CLIMATE

Why Kigali Amendment?

- HFCs emerged as the main alternatives to Ozone Depleting Substances like CFCs, HCFCs, CTC etc.
- World Community recognized that the use of HFCs is growing with a very rapid rate;
- HFCs estimated production and consumption likely responsible for global temperature rise of 0.3°C to 0.5°C by the end of the century;



- HFC Phase-down will avoid the temperature rise by 0.3 to 0.5% by the end of century.

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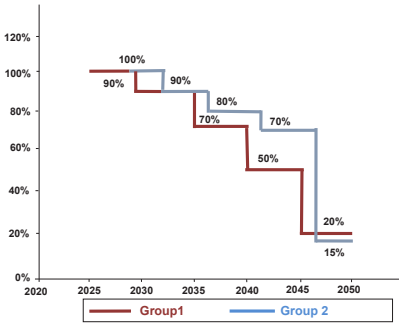
SLIDE 14:
WHY KIGALI AMENDMENT?

Phase-Down Schedule of HFCs for Article 5 Countries

Reduction Steps for Article 5 Countries



Group 1 * Schedule		Group 2 ** Schedule	
Base-line	HFC (Avg.2020 -2022)+ 65% of HCFC baseline	Base-line	HFC Avg. 2024-2026 + 65% of HCFC baseline
2024	100%	2028	100%
2029	90%	2032	90%
2035	70%	2037	80%
2040	50%	2042	70%
2045	20%	2047	15%

* China and other A5 countries.
** Bahrain, India , Iran, Iraq, Kuwait, Oman, Pakistan, Qatar, Saudi Arabia and UAE.

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SLIDE 15:
PHASE-DOWN SCHEDULE OF HFCS FOR ARTICLE 5 COUNTRIES

Montreal Protocol successfully phasing out the production and consumption of ODSs. All 197 countries of the world are working together to phase-out ODSs.

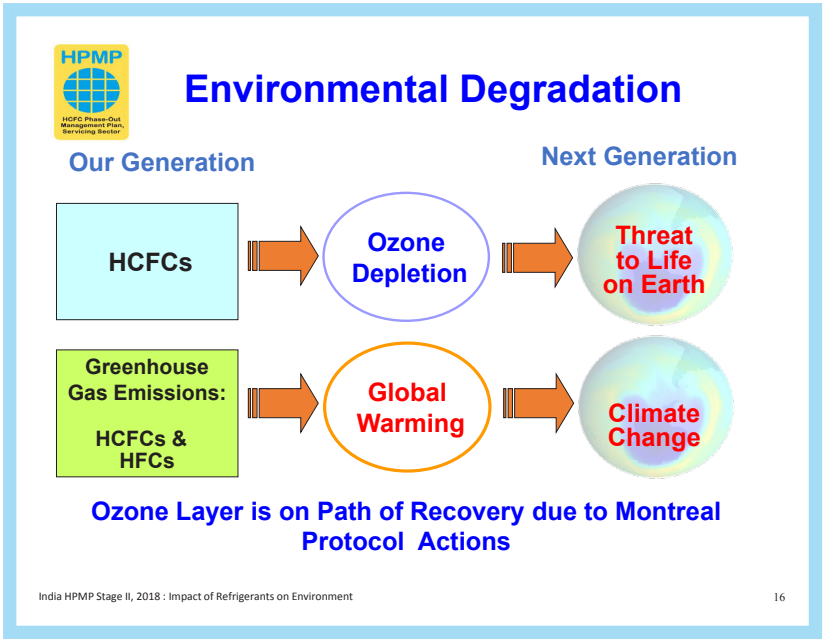
In Kigali, Montreal Protocol made amendment to phase-down the use of HFCs, in 2016, called Kigali amendment. It is a dedicated effort to reduce GHG emissions through phase-down of HFCs and improve energy efficiency.

Although, HFCs are not Ozone depleting substances, but have high global warming potential. These refrigerants are emerged as the main alternatives to ODSs which have been phased out under the Montreal Protocol. As ODSs are being phased out, there is a rapid growing of HFCs and it is estimated that by the end of century there will be temperature rise of 0.3 to 0.5°C because of HFCs production and consumption. So, the Parties to the Montreal Protocol on Substances that Deplete the Ozone Layer made agreement at their 28th Meeting of the Parties to the Montreal Protocol on 15 October 2016 in Kigali, Rwanda to phase-down hydrofluorocarbons (HFCs).

The HFCs phase-down schedule of Article 5 countries are presented in the next slide.

This slide presents the phase-down schedule of HFCs for Article 5 countries as per the Kigali amendment of the Montreal Protocol.

Article 5 countries are divided into two groups, Group-1 and Group-2. India is part of Group-2 countries; the Group -2, for those whose national circumstances were different and the manufacturing of HFCs and consumption in whose case was still rising in the absence of clear alternative technologies, for such countries the agreed baseline years are 2024, 2025 and 2026.



SLIDE 16:

ENVIRONMENTAL DEGRADATION

SLIDE 17:

BE THE PART OF SAVING OUR MOTHER EARTH

This slide pictorially summarizes the key environmental impacts of refrigerants. HCFC refrigerants are the source of ozone depletion, as they contain chlorine atoms. HCFCs and HFCs, both these refrigerants are a source of global warming, besides other greenhouse gases, namely, carbon dioxide, nitrous oxide methane gas (CH4) etc. Thus, use of these refrigerants is a heritage from our previous generations. The net result of this is environmental degradation through threat to life and climate change, which will adversely influence our future generations. So, we should switch over to HCFC -Free appliances and also to use more energy efficient appliances to save the environment.

This training is important because not only for professional upgradation but also to know our role in participating the global fight to mitigate ozone layer depletion and increased global warming and climate change.

The technician should give best service practices to maintain the designed energy efficiency of the operation of the Air-conditioner. There should be no leakage of HCFCs or HFCs to the environment while performing the servicing.

Be an ozone-friendly technician, trainer, consumer, company and thus, an ozone-friendly citizen.

FUNDAMENTALS OF AIR-CONDITIONING

Target Group
Trainers and Technicians

Duration of the Session
75 minutes

Purpose of the Session

Review of air-conditioning cycle (vapour compression cycle) and to make the participants understand the fundamentals of air conditioning, heat loads, parts and components and their functions. Make participants aware about the basics of electrical systems for air-conditioner and inverter technology.

Terminal Performance Objectives

At the end of session the participants should understand the following:

- Basics of Heat Loads
- Purpose of Air-conditioning
- Basics of vapor compression cycle
- Air-conditioning parts and components and their functions
- Working of Window and Split Air-conditioner
- Different Types of Air-conditioning
- Basics of Electrical System for Air-Conditioner
- Inverter Technology

Key Message being delivered through this Session

To understand air-conditioning system performance, first, we need to have knowledge of fundamentals of Air-conditioning. As a technician we should have an idea of defects and sources of degradation, and indication which part of the system is failing. Also, service technicians are expected to improve system efficiency. So, having knowledge of each and every component and their functions is very important.

Tools & Equipment (if any) required for the session
None

Fundamentals of Air-conditioning

SLIDE 1:
FUNDAMENTALS OF AIR-CONDITIONING

Learning Outcomes

- ❑ Basics of Heat Loads;
- ❑ Purpose of Air-conditioning;
- ❑ Basics of vapor compression cycle;
- ❑ Air-conditioning parts and components and their functions;
- ❑ Working of Window and Split Air-conditioner;
- ❑ Different Types of Air-conditioning systems;
- ❑ Fundamentals of Electricals for Air-Conditioner;
- ❑ Inverter Technology.

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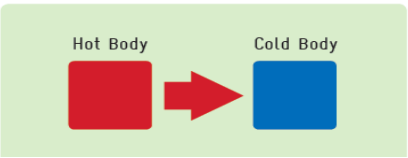
SLIDE 2:
LEARNING OUTCOMES

Heat Transfer and Refrigeration

Heat transfer takes place from a body at a higher temperature to a body at a lower temperature.



Refrigeration reduces the temperature of a space and maintain it at temperature lower than the ambient temperature. This is achieved by transferring heat from the air conditioned space to refrigerant and refrigerant to atmosphere.

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SLIDE 3:
HEAT TRANSFER AND REFRIGERATION

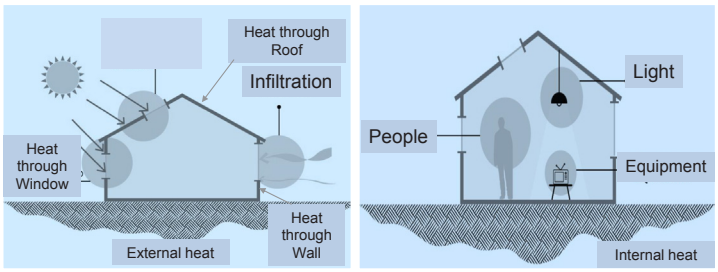
An air-conditioner technician should know the basics of air-conditioning and air-conditioning cycle before doing service or maintenance work. In this session participants will be understanding about fundamentals of air-conditioning, including each and every component of and their functions.

In this session participants will be understanding about heat transfer processes in air-conditioning. The basics of air-conditioning and air-conditioning cycle, vapour compression cycle will be discussed. The components of air-conditioning system and their functions will be reviewed. In this session, the different types of air-conditioner and the basics of electrical system in air-conditioning system are also be discussed. Also, inverter technology is a recent development in air-conditioning system and in this session, participants will learn about it.

Heat Transfer: Heat is a form of energy and always flows from a body at a higher temperature to a body at a lower temperature, as shown in figure. For example, when we heat one end of a long iron road, the temperature of that end will increase. After some time, the temperature at the other end will also increase due to flow of heat energy. Heat does not flow without the temperature difference. If the temperature difference is high, the faster the heat energy will flow.

Refrigeration: It is a process that reduces the temperature of a space and maintain them at a temperature lower than the ambient temperature. In air-conditioner, this is achieved by removing heat from the air-conditioned space to refrigerant and refrigerant to the atmosphere. Refrigeration works by changing the state of the refrigerant.

Removal of Heat by the Air-conditioner



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SLIDE 4:
REMOVAL OF HEAT BY THE AIR-CONDITIONER

Heat that to be Removed by the Air-conditioner

Air Conditioner Removes Heat Gained in the Space from following sources:

- Heat transfer through the wall and roof;
- Heat gain through windows;
- Outdoor air infiltration;
- Lights;
- Occupants;
- Electrical/electronic equipment.

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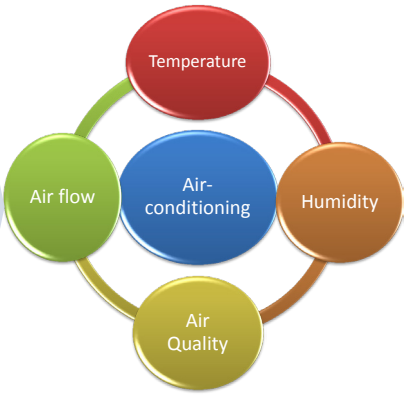
SLIDE 5:
HEAT THAT TO BE REMOVED BY THE AIR-CONDITIONER

Purpose of Air – conditioning (1)

Air-conditioning is a Process to control temperature, humidity, air circulation and purification of air in a confined space (room).



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SLIDE 6:
PURPOSE OF AIR-CONDITIONING (1)

The two figures depict the external and internal heat sources the air-conditioner needs to remove. These two types of heat to be removed by air-conditioner to cool the space to be air-conditioned to provide occupant comfort.

External heat source: Heat flows through the exterior walls and roof materials and windows and skylights. Hot or warm air from outside entering the space to be cooled through the window cracks is called infiltration. As low as the external heat energy entered inside the space, the cooling required by the air-conditioners will be low and thus consume less energy.

Internal heat Source: This includes electrical lighting, people (heat produced by metabolic activity in the human body) and appliances and equipment such as computers, elevators, servers, printers, refrigerator, kitchen equipment and so on. All these components throw heat into the space which is to be removed by the air-conditioner.

In this slide heat gained in the space from different sources that is to be removed by air-conditioner are listed.

Air-conditioning is a process to control temperature and humidity of air in a confined space as well as purification and filteration and circulation of air.

Air-conditioner is designed to control temperature and humidity. Good control of air movement is also needed to improve the thermal comfort. Air-conditioner purify the air supplied to the conditioned space through air filter. The comfort given by air-conditioner is measured by all these parameters.

Purpose of Air – conditioning (2)

To Maintain Comfort Conditions for Healthy Living and Working Environment by:

Temperature	Comfort range 22.1 - 26.7°C
Relative Humidity	Comfort range about 50-60%
Air movement	An airflow velocity of about 1 m/s

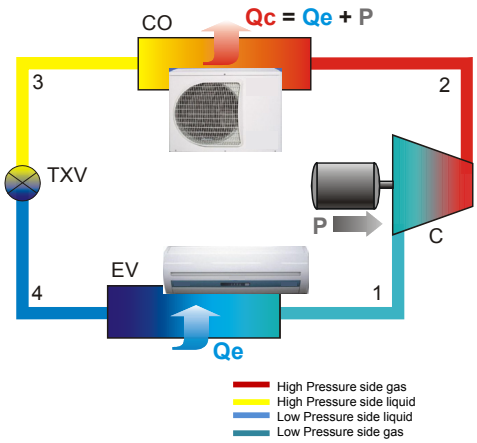
Advise the users to maintain temperature (25-27°C) to reduce energy consumption

SLIDE 7:
PURPOSE OF AIR-CONDITIONING (2)

Air Conditioning System

Main components:

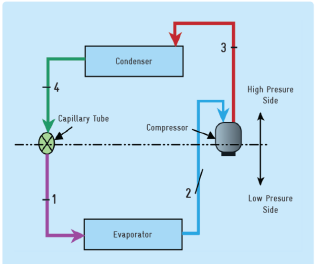
- Compressor
- Condenser
- Expansion Device/Capillary
- Evaporator or Cooling Coil.



SLIDE 8:
AIR-CONDITIONING SYSTEM

Vapour Compression Cycle

- **Two different pressures exist in the refrigeration cycle.**
  - Evaporator: "low pressure side"
  - Condenser: "high pressure side".
- **The two pressure areas are divided by the other two components.**
  - On one end, is the metering device capillary that reduces pressure to evaporator pressure & controls the refrigerant flow
  - On the other end, is the compressor which compresses refrigerant from evaporator to condenser pressure.



SLIDE 9:
VAPOUR COMPRESSION CYCLE

The range of the values of the parameters to maintain comfort conditions for healthy living and working environment are presented in this slide.

Human get comfort in the temperature range of 22.1 to 26.7°C depending on the activity and clothing. Relative humidity value of the air largely affects the thermal comfort, the comfort range of relative humidity is 50 to 60%. The relative humidity could be lower, but at very low humidity level there will be issues, such as skin drying, irritation of mucus membranes, dryness of the eyes.

Air movement or velocity of air circulating inside the conditioned space is also important factor to maintain the label of comfort. The velocity should be around 1 m/s for thermal comfort.

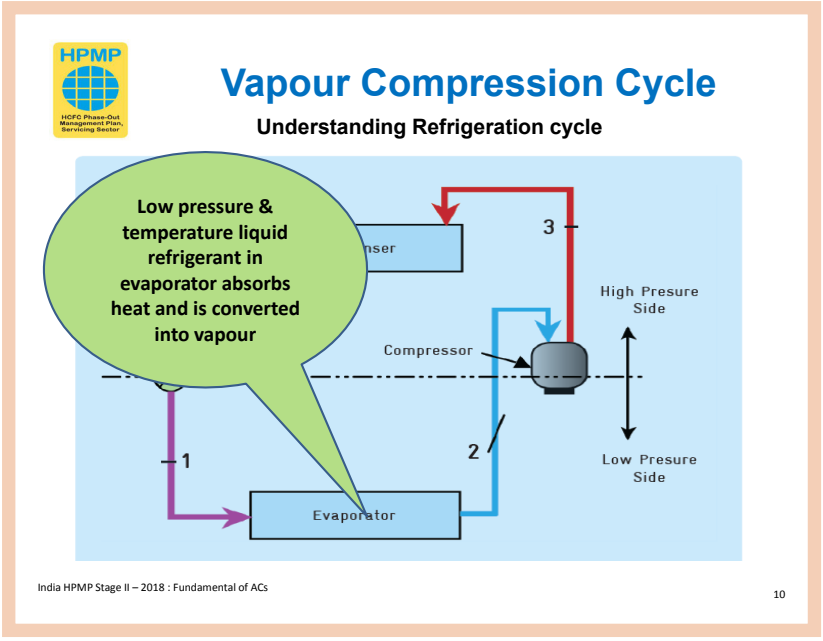
Room air-conditioner have four major parts:

- Compressor — changes a low-pressure vapor to a high-pressure vapor. The common types of room air-conditioners have small hermetic compressors of reciprocating or rotary type, and in select cases scroll compressors.
- Condenser — changes a high-pressure vapor to a high-pressure liquid by rejecting heat from the refrigerant causing the refrigerant to condense.
- Expansion device or Capillary — drops the pressure to lower the saturation temperature and allow the refrigerant to evaporate or boil in the evaporator, drawing heat into the refrigerant. In room air-conditioners it is capillary that acts as expansion valve.
- Evaporator — changes (boils) the low-pressure two-phase mixture of liquid and vapor refrigerant into an all-vapor stream of refrigerant, drawing heat into the refrigerant (thus providing cooling) during this evaporation.

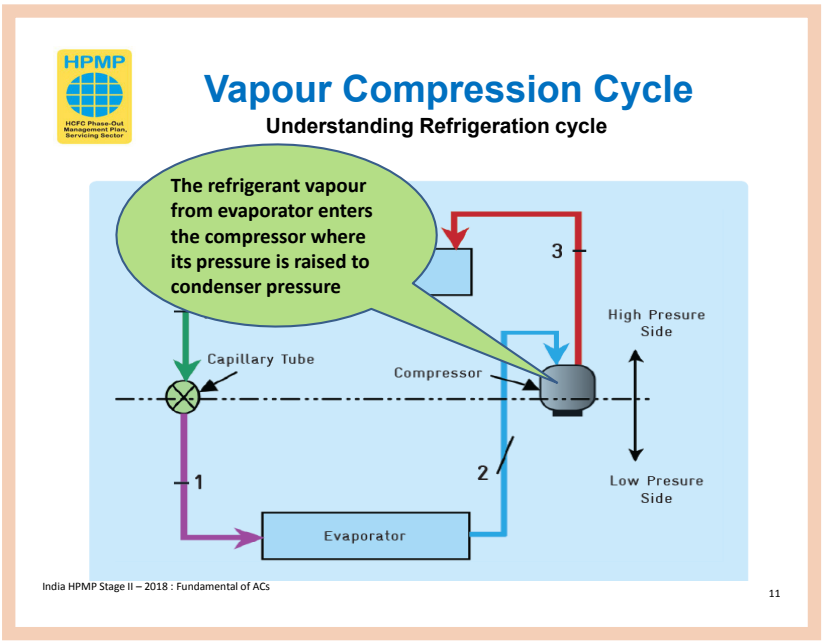
The figure in the slide shows the different component in the air-conditioning cycle with state of refrigerant with different colours. Refrigerant between compressor and condenser are in a high- pressure gaseous state. From condenser to expansion device is high pressure liquid state. Expansion device to evaporator is low pressure liquid state and evaporator to compressor is low pressure gaseous state.

Qe: Heat removed from the Space by the refrigerant in Evaporator.
P: Power consumed by the Compressor.
Qc: Heat removed to ambient by the refrigerant in Condenser, which is equivalent to sum of the Qe and P.

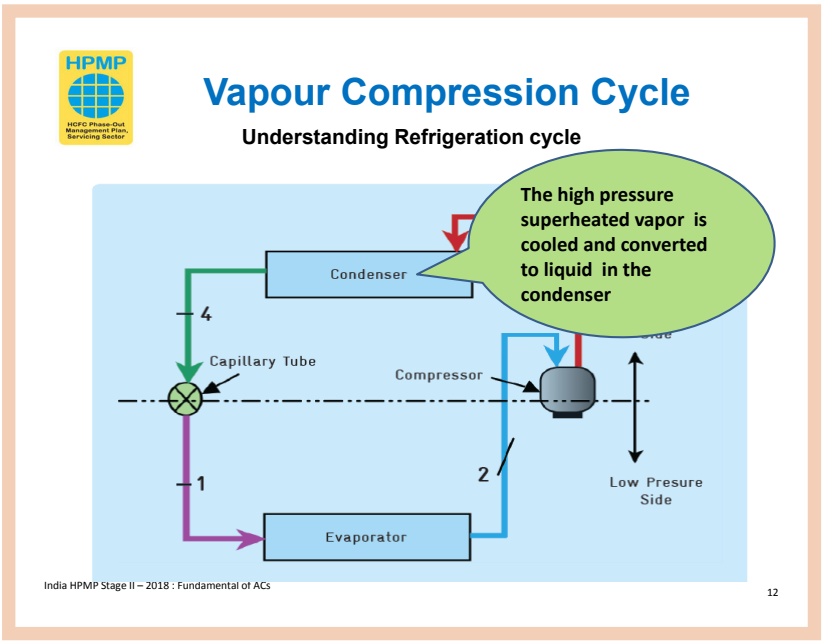
Two different pressures exist in air-conditioning cycle, high pressure and low pressure. Evaporator is in low pressure side and condenser in the high-pressure side. The two pressure areas are divided by other two components, one, expansion device or capillary that reduces pressure to evaporator pressure and controls the refrigerant flow. The other one is compressor, which increases the evaporator pressure to condenser pressure to reject heat in the condenser which is absorbed by the refrigerant in the evaporator.



SLIDE 10:
VAPOUR COMPRESSION CYCLE



SLIDE 11:
VAPOUR COMPRESSION CYCLE



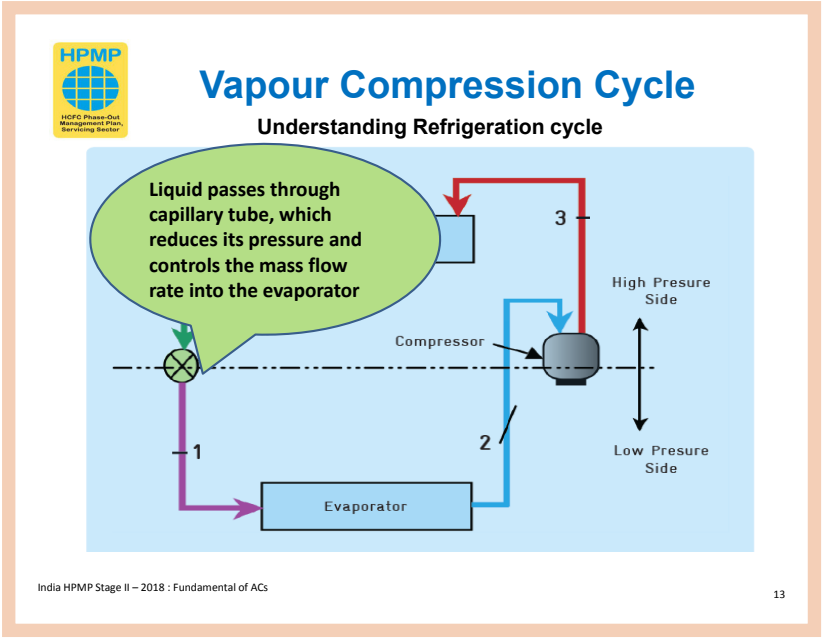
SLIDE 12:
VAPOUR COMPRESSION CYCLE

The process of evaporation is explained in this slide with the help of schematic of a refrigeration cycle. Evaporation takes place in a heat exchanger called evaporator. The liquid refrigerant in low pressure absorbs heat from the space changing its phase to vapour. The process of liquid refrigerant evaporating to vapour state is called evaporation. The component in which evaporation takes place is called evaporator. The design of evaporator should be such that refrigerant should become superheated state at its exit.

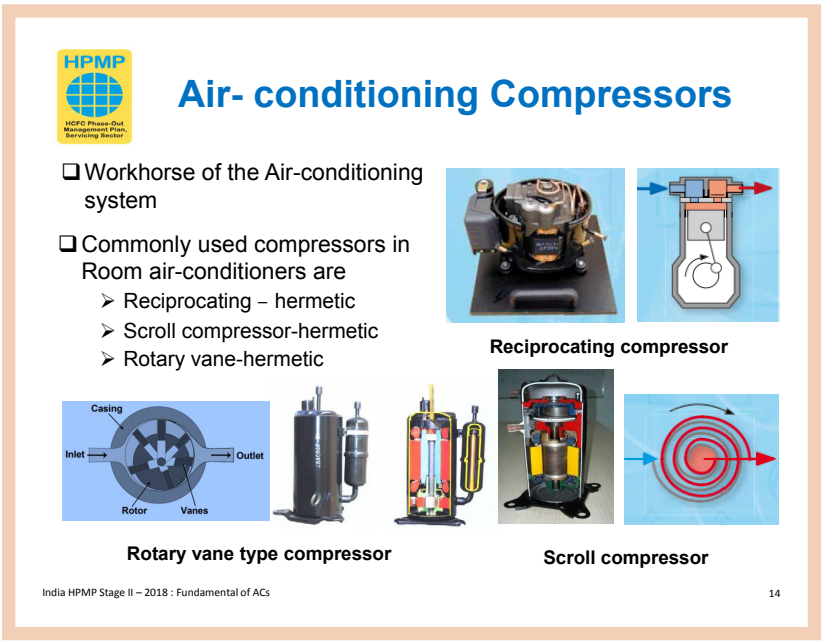
Since the capacity of a refrigerant to absorb heat energy is greatest when changing state from liquid to vapour, the heat exchanger (Evaporator) within the conditioned space is continuously supplied with liquid refrigerant, which vaporises in order to absorb heat energy from the conditioned space. Air is used to transport sensible and latent heat energy from products, lights, machinery and occupants to the Evaporator. In order for this to be effective and efficient, an Evaporator Fan is used to pass return air over the Evaporator Coil and to distribute conditioned air throughout the space.

This slide is about the compression process of refrigerant. The low pressure vapor refrigerant enters the compressor and it gets compressed in the compressor. In this process pressure and temperature of refrigerant increases substantially. The refrigerant entering the compressor should be dry only and not wet. The vapour at the outlet of the compressor is highly superheated.

High pressure superheated refrigerant after compression flows through heat exchanger where heat is rejected to atmosphere or air. The heat rejection in the first part of heat exchanger is de-superheating. The de-superheated refrigerant further rejects heat and it starts condensing in the heat exchanger. In the last part of heat exchanger, the condensed refrigerant is cooled and in liquid state.



SLIDE 13:
VAPOUR COMPRESSION CYCLE



SLIDE 14:
AIR-CONDITIONING COMPRESSORS

When the high-pressure liquid refrigerant flows through the capillary, its pressure decreases. The capillary also controls the refrigerant flow or quantity into the evaporator. Hence, appropriate capillary diameter and length should be used, else performance will change.

Compressor acts as the heart of the air-conditioning system. Its main function is drawing in the cool vaporized refrigerant that carries the heat energy from the evaporator coils, compressing it from a low pressure and temperature to a high pressure and temperature, and pushing it around the refrigeration loop for the purpose of heat rejection.

The commonly used compressor in the Room air-conditioners are

Reciprocating – hermetic: A reciprocating compressor is also called a piston compressor which adopts the back and forth piston motion in a cylinder synchronized with suction and discharge valves to compress the vaporized refrigerant from a low pressure and temperature to a high pressure and temperature. The motion of the piston is achieved via a crankshaft which converts motor rotations to piston reciprocations. Each operation cycle includes three actions: suction, compression and discharge. Each crankshaft rotation can achieve these three actions in sequence.

In hermetic compressors, the motor and the compressor are enclosed in the same housing to prevent refrigerant leakage. The housing has welded connections for refrigerant inlet and outlet and for power input socket. As a result of this, there is virtually no possibility of refrigerant leakage from the compressor.

Scroll Compressor: A rotary-scroll compressor is used to compress gaseous refrigerant to a higher pressure and temperature via a fixed and orbital scroll. The cool vapor refrigerant is drawn in from outside the fixed scroll, then compressed in between the fixed and the orbital scroll, and finally the compressed refrigerant is discharged from the centre of the fixed scroll with a continuous displacement. Each operation cycle includes three actions: suction, compression, and discharge.

Compared with the reciprocating and rotary-vane compressors, a rotary-scroll compressor has the following benefits:

- Higher reliability due to simpler structure and less components
- Higher efficiency due to less losses because it requires neither suction nor discharge valves, meanwhile there is no clearance volume.
- Less vibration and less surging due to continuous gas displacement through the sweeping motion of the rotors.

Rotary-vane compressor: A rotary-vane compressor is also known as a rotary piston compressor because the function of the vane is similar to that of a piston. The fixed casing is known as a cylinder. The vane splits the space between the cylinder and the rolling piston into two sections (suction and discharge). As the rolling piston rotates, these two volumes are increased and decreased to achieve gas suction, compression and discharge. Each operation cycle includes five actions: start, suction, compression, discharge and end. Compared with the reciprocating compressor, the rotary-vane compressor has:

- Higher efficiency due to less losses from clearance volume and discharge valve resistance.
- Smaller dimensions and lighter weight per unit capacity (40%-50% savings).
- Less vibration, less components, and higher reliability because there is no conversion from rotations to reciprocations.

Air- conditioning Expansion Devices

Constant restriction Type - Capillary Tube

- A narrow diameter tube connecting the condenser to the evaporator

- The Pressure of Refrigerant drop through the capillary tube from condenser pressure to evaporator pressure resulting corresponding temperature drop

Variable-restriction Type

- **Automatic Expansion Valve**
  - It maintain constant pressure in the evaporator. It works in response to the pressure changes in the evaporator due to changes in heat load,

- **Thermostatic Expansion Valve**
  - Controls the flow of refrigerant by sensing the degree of superheat temperature at the outlet of the evaporator

Refrigerant must be free from moisture and dirt otherwise it will choke the Expansion device and stop the flow of refrigerant

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SLIDE 15:

AIR-CONDITIONING EXPANSION DEVICES

Expansion devices reduce the pressure & temperature of the refrigerant coming from the condenser as per the requirement of the system. It also regulates the flow (metering) of refrigerant as per the load on the evaporator. Expansion device is essentially a restriction offering resistance to flow so that the pressure drops, resulting in a throttling process.

Basically, there are two types of expansion devices.

- Constant restriction type – Capillary tube
- Variable-restriction type – Expansion Valve

Constant restriction type – Capillary tube:

The capillary tube is a fixed restriction type expansion device. It is a long and narrow tube connecting the condenser directly to the evaporator. Its resistance to flow permits the capillary to be used as a pressure reducing device to meter the flow of refrigerant given to the evaporator.

The Pressure drop through the capillary tube is due to the following:

- Friction due to fluid viscosity, resulting in frictional pressure drop.
- Acceleration due to the flashing of the liquid refrigerant into vapour resulting in momentum pressure drop.

The cumulative pressure drop must be equal to the difference in pressure at the two ends of the tube. For a given state of refrigerant, the pressure drop is directly proportional to the length and inversely proportional to the bore diameter of the tube. Capillary tube is the most commonly used expansion device in Room air conditioners. The advantage of a capillary tube is its simplicity, low cost and the absence of any moving parts. The disadvantage is that the refrigerant must be free from moisture and dirt otherwise it will choke the tube and stop the flow of refrigerant. It cannot be used with high fluctuating load conditions.

Variable Restriction Type:

In this, the extent of opening area of flow keeps on changing depending on the type of control.

Two common types are:

- Automatic Expansion Valve (Pressure Control)
- Thermostatic Expansion Valve

Automatic Expansion Valve

This works in response to the pressure changes in the evaporator due to increase in load (pressure increase) or due to decrease in load (pressure decreases). This valve maintains a constant pressure throughout the varying load on the evaporator controlling the quantity of refrigerant flowing into evaporator. This consists of a needle valve, a seat, a diaphragm and a spring. The opening of the valve in the seat is controlled by the two opposing forces, the tension in the spring, the pressure in the evaporator acting on diaphragm. Once the spring is adjusted for a desired evaporator pressure and given load, the valve operates, automatically with changing load conditions in the evaporator.

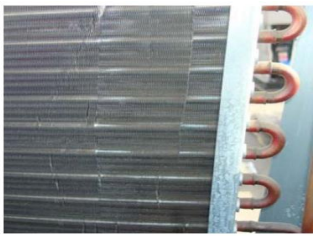
Thermostatic Expansion Valve

Thermostatic expansion valve controls the flow of refrigerant through the evaporator such a way that the quality of the vapour leaving the evaporator will always in superheated condition. Its operation is used for maintaining a constant degree of superheat at the evaporator outlet.

Air- conditioning Heat Exchangers

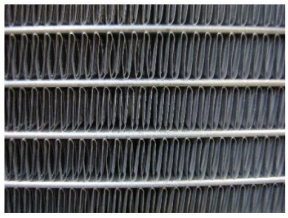
Fin and Tube Condenser/Evaporator

Coiled copper tubing with one or more rows depending on the size of the air conditioning unit covered with the aluminum fins



Microchannel Condenser/Evaporator

Microchannel condenser coils are all aluminum coils with multiple flat tubes containing small channels (microchannels) through which refrigerant flows.



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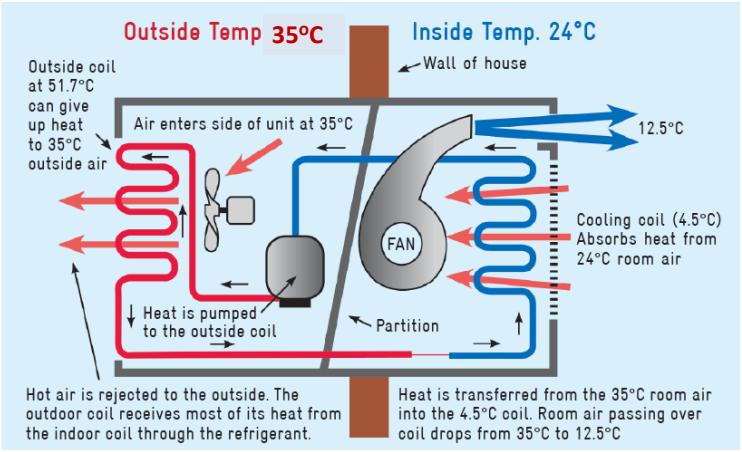
SLIDE 16:

AIR-CONDITIONING HEAT EXCHANGERS

Working of Room Air-conditioner: Window



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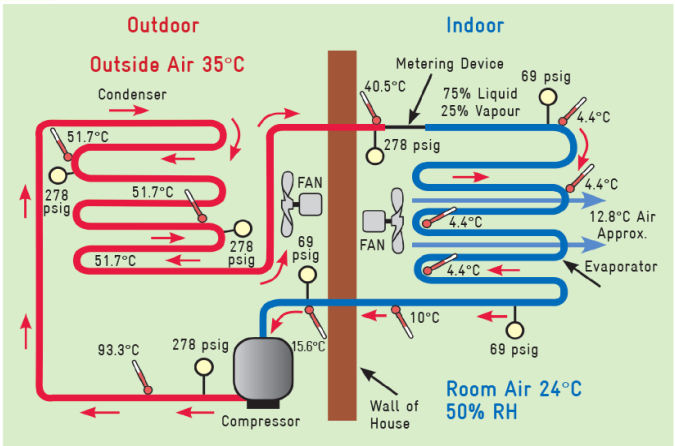
SLIDE 17:

WORKING OF ROOM AIR-CONDITIONER: WINDOW

Working of Room Air- conditioner: Split



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SLIDE 18:

WORKING OF ROOM AIR-CONDITIONER: SPLIT

Fin and Tube Condenser/Evaporator

It is made of copper tubes coiled with one or more number of rows depending on the size of the air-conditioning unit. The copper tubing coils are covered by aluminium fins.

Microchannel Condenser/Evaporator

The Microchannel coil is constructed of parallel flow aluminum coils with multiple flat tubes containing small channels (microchannels) that are mechanically brazed to enhanced aluminum fins, resulting in better heat transfer and a smaller, lighter, corrosion resistant coil.

Microchannel coils are smaller, more efficient, and use less refrigerant than standard tube and fin coils. Microchannel coils are much sturdier and harder to damage. The Microchannel coils can be washed with a high-pressure sprayer without bending the fins – with a tube and fin coil that would bend all the fins flat.

This slide presents the schematic for functioning of window air conditioner with approximate temperatures and air-flow at various locations. The colours indicate the temperature of hot or cold air and refrigerant. Various components of window air conditioner namely compressor, condenser, capillary, evaporator and fans, are shown. The difference between supply & return air should be around 12.5°C

This slide presents the schematic of functioning of split air conditioner. In this figure air temperatures, relative humidity and movements are shown. Various components of split air conditioner; like compressor, condenser, capillary, evaporator, and fans are shown.

Air – conditioner Performance Parameters

Cooling Capacity	Amount of Cooling Produced
Power Consumption (kW)	Electrical Power Consumed (Compressor + Fan Motors)
Units of refrigeration	❑ Ton of Refrigeration (TR)
Ton of Refrigeration	▪ 1 TR = 12,000 Btu /h ▪ 1 TR = 3,000 kcal/h ▪ 1 TR = 3.517 kW

$$Cofficeint\ of\ perfromance(COP)/Energy\ Efficiency\ Ratio\ (EER) = \frac{\text{Refrigeration Effect (Watt)}}{\text{Electrical Power Input (Watt)}}$$

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SLIDE 19:
AIR-CONDITIONER PERFORMANCE PARAMETERS

Types of Air Conditioners

➢ **Room air conditioners** – Window & Split



➢ **Central air conditioning systems**

– Chillers

➢ **Heat pumps** – Cooling & Heating

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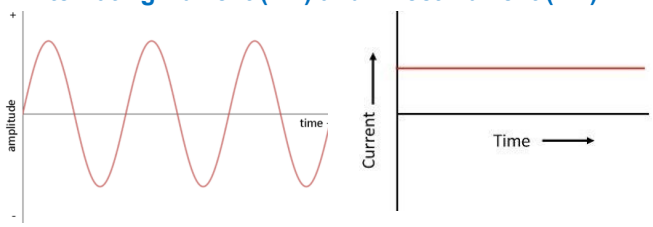
SLIDE 20:
TYPES OF AIR-CONDITIONERS

Fundamentals of Electricity (1)

Alternating Current (AC) and Direct Current (DC)



- Flow of current in which electrons keep switching directions, going either forward or backward
- Magnitude of induced current varies with time
- Types of AC are Sinusoidal, Trapezoidal, Triangular, Square

- Flow of current in which the drift of electrons remains steady either in a single direction, or forward;
- Magnitude of induced current remains constant;
- Types of DC are Pure and Pulsating

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SLIDE 21:
FUNDAMENTALS OF ELECTRICITY (1)

Cooling capacity of air conditioner is the amount of cooling produced by the air-conditioner unit used. Cooling capacity of air-conditioner is represented by several units, like, ton of refrigeration (TR), Btu/hr, kW etc.

Ton of Refrigeration is defined as the amount of heat required absorbed by 1 ton (2000 lbs) of ice at 32°F to convert to water of 32°F in 24 hours

1 TR = 2000×144/24 = 12,000 Btu/hr

Coefficient of Performance (COP) or Energy Efficiency Ratio (EER) is defined as the ratio of Refrigeration Effect or cooling capacity in watt to the Electrical Power Input watt. Electrical Power input is the power consumed by equipment used in AC, such as compressor + fan motors.

Air conditioners are classified on the basis of type of use. Room air-conditioners are commonly used in residential home. Mostly, Room air conditioners are either split type or window. For large building, central air conditioning systems are applicable. They are called as chillers. If the air conditioners are designed and used for both cooling and heating, then they are called as a heat pump which is reversible cycle. It comes with extra parts. We shall restrict our discussion to only room air conditioners mainly unitary or window type and split air conditioners.

Alternating Current (AC):

It is the flow of current in which electrons keep switching directions, going either forward or backward. The magnitude of induced current varies with time. Types of AC are Sinusoidal, Trapezoidal, Triangular, Square.

Direct Current (DC):

The flow of current in which the drift of electrons remains steady either in a single direction, or forward is called direct Current. In case of DC, magnitude of induced current remains constant. Types of DC are Pure and Pulsating

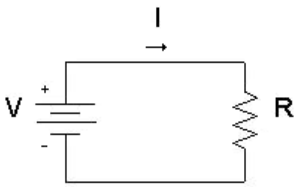
Fundamentals of Electricity (2)

Ohm's Law

Flow of current through a conducting material is directly proportional to the conductor's voltage:

$$I = \frac{V}{R}$$

I = current
V = Potential difference
R= Resistance

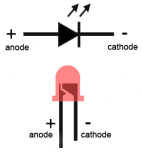


SLIDE 22:
FUNDAMENTALS OF ELECTRICITY (2)

Electrical Circuit Components

Active Component

LED

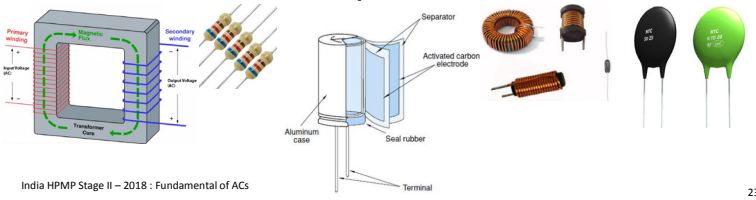


Transistor

Integrated Circuit (microchip)

Passive Component

Transformer **Resistor** **Capacitor** **Inductor** **Thermistor**



SLIDE 23:
ELECTRICAL CIRCUIT COMPONENTS

Ohms Law:

Flow of current through a conducting material is directly proportional to the conductor's voltage.

I=V/R

I = current

V = Potential difference

R= Resistance

Active Component:

LED: It is made of a p-n junction diode which releases light when it is oscillated. Energy is released as photons when a suitable voltage is applied to the leads.

Transistor: To amplify or switch electrical power and electronic signal consisting three or more terminals for connecting to an external circuit. It is made of semiconductor materials.

Integrated Circuit (microchips): A semiconductor wafer on which a number of small resistors, capacitors and transistors are fabricated. It works as an oscillator, an amplifier, a timer, a counter, a microprocessor or a computer memory.

Passive Component:

Transformer: It consists of metal core with coils of wire around it. It converts alternating current to the required values by decreasing or increasing the alternating voltages in an electronic or electric circuit.

Resistor: Resistor can be a small carbon device or big wire-wound power resistor, resist or limit the flow of current in the circuit.

Capacitor: It is made of one or more pairs of conductors and an insulator separating them. It is used to store electric charge.

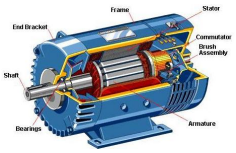
Inductor: It consists of a coil or a wire loop. It is used to store energy in the form of a magnetic field. More the turns in the coil, the more will be the inductance.

Thermistor: It is a kind of resistor which is more sensitive to temperature as compared to other resistors. It is used as an inrush current limiter, temperature sensor, self regulating heating element and self-resetting overcurrent protector.

Electrical Circuit Components

Electromechanical Component

Motor



Printed Circuit Board (PCB)

Relay

Switch

Contactor

Connector

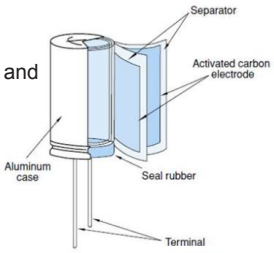
Circuit Breaker

SLIDE 24:
ELECTRICAL CIRCUIT COMPONENTS

Electrical Circuit Components

❑ Capacitor

- Made of one or more pairs of conductors and an insulator separating them
- Used to store electric charge



❑ Relay

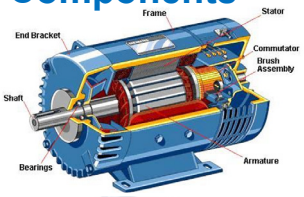
- It is a switch that controls an electrical circuit by make and break the circuit or switching ON/OFF

SLIDE 25:
ELECTRICAL CIRCUIT COMPONENTS

Electrical Circuit Components

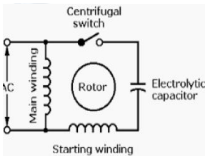
❑ Motor

- Used to transform electrical energy into mechanical energy, produces linear or rotary force



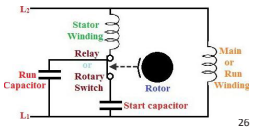
❑ Capacitor Starts Motor

- The capacitor is connected in series with the starter winding, which causes current in starter winding.



❑ Relay Start Motor

- Relay is connected between the Start and run winding, which causes current in starter winding



SLIDE 26:
ELECTRICAL CIRCUIT COMPONENTS

Electromechanical Components

Motor: Used to transform electrical energy into mechanical energy, produces linear or rotary force.

Printed Circuit Board (PCB): A PCB acts as a base for the components that are mounted on its surface and are interconnected with wires, conductive tracks and so on.

Relay: It is a switch that controls an electrical circuit by opening and closing contacts in another circuit, electromechanically by a magnetic force or electronically.

Switch: It is used to make or break connections in an electric circuit. A switch is used to divert the current from one conductor to another.

Connector: A device which is used to join two circuit together. The connector may be a port, a plug, a cable connector etc.

Contactor: An electrically-controlled switch used for switching an electrical power circuit.

Circuit Breaker: A control and protection device of electrical power system. A switching device which can be operated manually as well as automatically. Its main function is to shield an electric circuit from harm caused by overload or short circuit. It interrupts the current flow when protective relays find out a fault.

Capacitor: It is made of one or more pairs of conductors and an insulator separating them. It is used to store electric charge.

Relays: It is a switch that controls an electrical circuit by opening and closing contacts in another circuit, electromechanically by a magnetic force or electronically

---

Motor: It is used to transform electrical energy into mechanical energy, produces linear or rotary force. Force is generated inside the motor through the interaction between its winding currents and magnetic field.

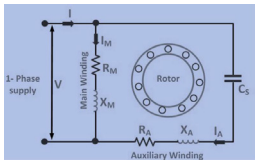
Capacitor Starts Motor: The capacitor is connected in series with the starter winding, which causes current in starter winding. When motor reaches 75% of the rated speed, the capacitor and the starter winding is disconnected by a switch.

Relay Start Motor: Relay is connected between the start and run winding, which causes current in starter winding. Resistance of motor increases with current, which cuts the start winding then the motor works only on run winding.

Electrical Circuit Components

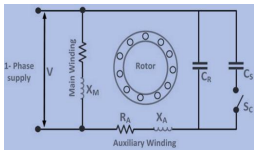
❑ Permanent Split Capacitor (PSC) Motor

- It has a cage rotor and the two windings - main and auxiliary windings
- It has only one capacitor connected in series with the starting winding. The capacitor is permanently connected in the circuit both at the starting and the running conditions.



❑ Capacitor Start Capacitor Run (CSR) Motor

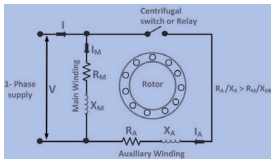
- It has a cage rotor, and its stator- two windings - Main and Auxiliary.
- Two capacitors - one is used at the time of the starting known as starting capacitor; other one is used for continuous running of the motor and is known as RUN capacitor.



Electrical Circuit Components

❑ Split Phase Induction Motor

- It is also known as a Resistance Start Motor. It has a single cage rotor, and stator - two windings main winding and starting winding.
- The main winding has very low resistance and a high inductive reactance whereas the starting winding has high resistance and low inductive reactance.



Electrical Circuit Components

❑ Printed Circuit Board (PCB)

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

SLIDE 27 AND 28:
ELECTRICAL CIRCUIT COMPONENTS

SLIDE 29:
ELECTRICAL CIRCUIT COMPONENTS

In these two slides types of motors used in Room Air-conditioners are presented

Printed Circuit Board: A PCB acts as a base for the components that are mounted on its surface and are interconnected with wires, conductive tracks and so on. The components are generally soldered on the circuit board according to the specified design

Fixed Speed ACs

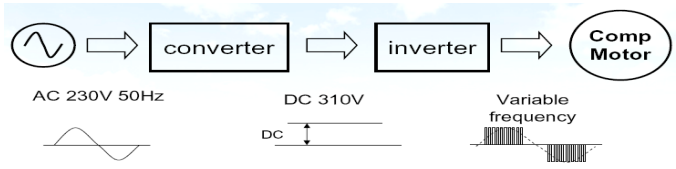
Why are Fixed Speed ACs Less efficient?

- System operation with ON-OFF Control;
- Most of the time AC operates at part-load
- Capillary is used as expansion Devise; starting power is higher;
- Limitation of efficiency of AC motors compared to DC motors:
  - Compressor motor
  - Condenser motor
  - Evaporator motor

SLIDE 30:
FIXED SPEED ACS

Principle of Inverter Technology

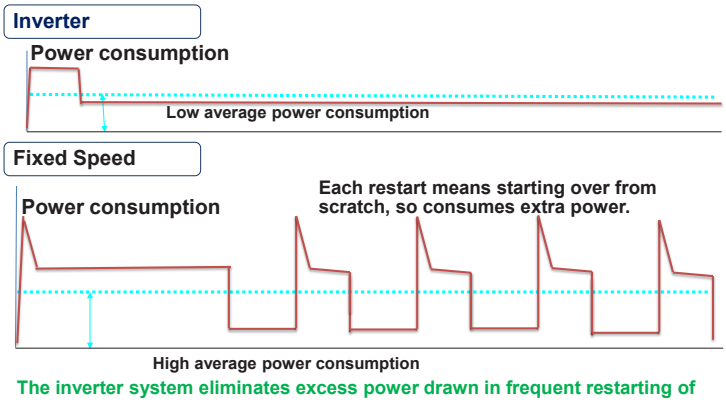
- Inverter is a device which supplies variable frequency power to the DC motor of the compressor which can operate the compressor at variable speed;
- Motor speed is varied by the inverter according to the cooling load and therefore energy consumption is proportional to cooling load.



Inverter output frequency ➡ Compressor RPM ➡ Refrigerant flow rate ➡ Cooling Capacity

SLIDE 31:
PRINCIPLE OF INVERTER TECHNOLOGY

Power Consumption in Inverter and Fixed Speed ACs



The inverter system eliminates excess power drawn in frequent restarting of compressor and re-cooling hot fluid entered in the evaporator from condenser;

SLIDE 32:
POWER CONSUMPTION IN INVERTER AND FIXED SPEED ACS

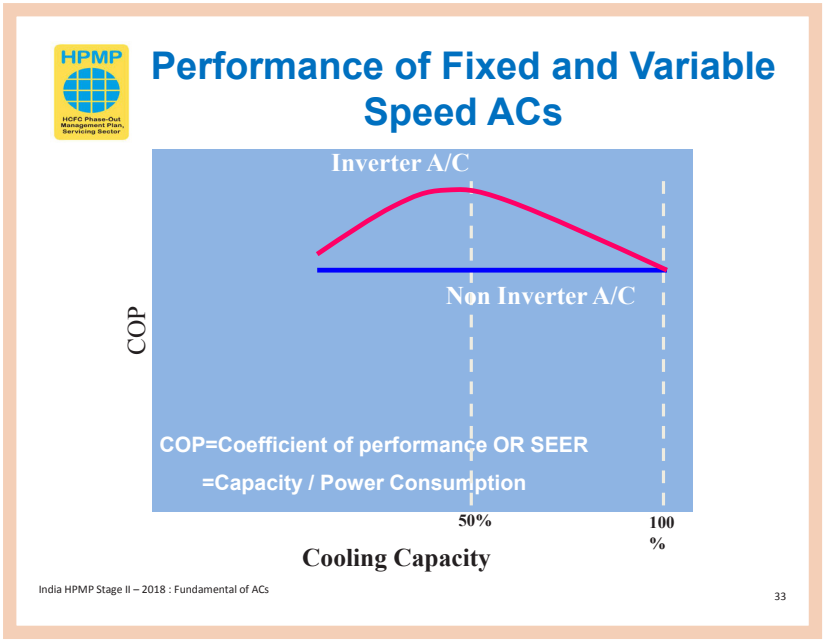
Fixed speed ACs are less efficient, especially at part load because the system operates with ON-OFF control. Capillary, the constant restriction type is used as expansion device for fixed speed ACs. The starting power is higher in case of fixed speed ACs. Limitation of efficiency of AC motors like compressor motor, condenser motor and evaporator motor compared to DC motors.

The Inverter technology is the latest evolution of technology, it controls the speed of the compressor motor, by monitoring the indoor temperature. The DC Inverter units have a variable-frequency drive that comprises an inverter to control the speed of the motor, thus the compressor and the cooling. The drive converts the incoming AC current to DC and then through a modulation in an inverter produces current of desired frequency. Through microcontroller adjust the speed of the compressor according to the ambient air temperature..

In this slide the power consumption of Inverter and non-inverter ACs are compared.

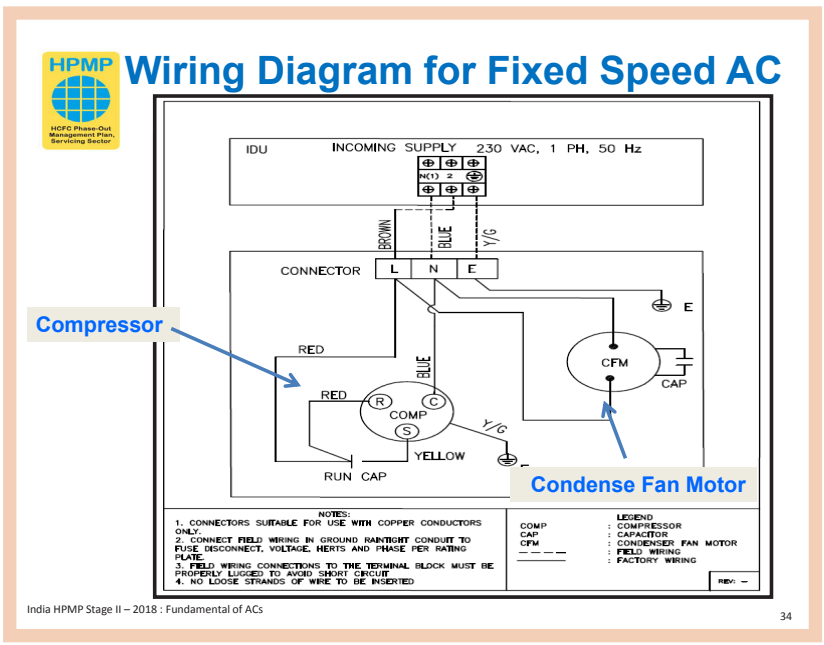
Air conditioners without inverters consumes high energy during starting the system. It runs to cool a room to a set temperature, then turn OFF once the temperature is reached, then turn back ON again when the temperature rises above or falls below the set temperature, repeating this process during operation. As a result, room temperature fluctuates, and energy is wasted. Thus, the average power consumption is higher.

In case of inverter technology, the temperature is adjusted quickly by high motor speed so initial energy consumption is higher and motor speed is slowed to maintain set temperature once reached, so average energy consumption is lower compared to non-inverter AC.



SLIDE 33:

PERFORMANCE OF FIXED AND VARIABLE SPEED ACS



SLIDE 34:

WIRING DIAGRAM FOR FIXED SPEED AC

The figure shows the comparison of COP of inverter and non-inverter AC with cooling capacity. COP of the non-inverter AC is constant because it always runs at its maximum capacity. In case of inverter AC, COP is almost same at 100% cooling capacity, but as the required cooling capacity decreases, the COP is higher as compared to fixed speed at 50% cooling capacity required.

Here wiring diagram of fixed speed AC is presented

ALTERNATIVE REFRIGERANTS TO HCFC-22

Target Group
Trainers and Technicians

Duration of the Session
30 minutes

Purpose of the Session

To make the participants gain information and knowledge about the alternative refrigerants to HCFC-22.

Terminal Performance Objectives

At the end of session the participants should understand the following:

- Why alternative refrigerants to HCFC-22;
- Desirable characteristics for selection of future refrigerants;
- Safety classifications of refrigerants;
- Characteristics and merit and demerits of available refrigerants;
- Comparison of properties of R-290 and HFC-32 refrigerants with HCFC-22;
- Lubricants suitable for different refrigerants.

Key Message being delivered through this Session

As HCFC-22 is having ODP and high GWP and this chemical is being phased out globally, we need alternative to this chemical which is having likely similar properties suitable for room air-conditioner, considering the zero-ozone depleting potential and low or negligible global warming potential. There are some new refrigerants already available in the market. As a technician it is very important to know the characteristics of these refrigerants.

Tools & Equipment (if any) required for the session
None

Alternative Refrigerants to HCFC-22

SLIDE 1:
ALTERNATIVE REFRIGERANTS TO HCFC-22

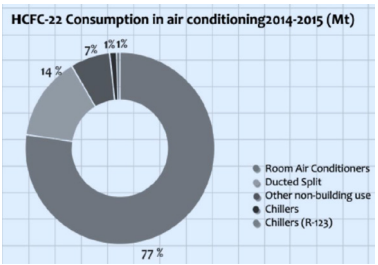
Learning Outcomes

- ❑ Why alternative refrigerants to HCFC-22;
- ❑ Desirable characteristics for selection of future refrigerants;
- ❑ Safety classifications of refrigerants;
- ❑ Characteristics and merit and demerits of available refrigerants;
- ❑ Comparison of properties of R-290 and HFC-32 refrigerants with HCFC-22;
- ❑ Lubricants suitable for different refrigerants.

SLIDE 2:
LEARNING OUTCOMES

Why Alternative Refrigerants to HCFC-22?

- ❑ HCFC-22 is one of the Ozone Depleting Substances (ODS);
- ❑ It also has high global warming potential (GWP);
- ❑ HCFC-22 is widely used refrigerants for Room Air-conditioner because of its properties.
- ❑ HCFC-22 is being phased-out globally under the Montreal Protocol due to ozone depleting property;



SLIDE 3:
WHY ALTERNATIVE REFRIGERANTS TO HCFC-22?

Refrigerant is a very important single substance or mixture fluids used in Air-conditioning working cycle. It is used to absorb heat from the air to be cooled from the conditioned space. Refrigerant should have the certain properties to run the Air-conditioning system to get the desired cooling and comfort to the space to be air-conditioned and meet the safety and environment issues.

Presently, HCFC-22 is most suitable and commonly used refrigerant in the Room Air-conditioner. But, it is an ozone depleting substance, it is also having a high global warming potential. As it is an ozone depleting substance, HCFC-22 is being phased-out globally. Therefore, we need alternative to this chemical which is having likely similar properties suitable for room air-conditioner, considering the zero-ozone depleting potential and low or negligible global warming potential. There are some new refrigerants already available in the market. Although these refrigerants are suitable for Air-conditioner, they have some different characteristics compared to HCFC-22 and some refrigerants have safety issues. So, as a technician it is very important to know the characteristics of these refrigerants.

In this slide the learning outcomes in this session is presented. As said earlier, we will be learning here why alternative to HCFC-22. It is very important to know what desirable characteristics the future refrigerant should have. ASHRAE classified refrigerants based on safety issues like flammability and toxicity limit, whihc will be learnt in this session. Participants will learn the merits and demerits of the alternative refrigerant in their characteristics. The comparison of properties of R-290 and HFC-32 with HCFC-22 will be discussed. Suitable Lubricant for the refrigerants will also be discussed.

Presently, HCFC-22 is most suitable and commonly used refrigerant in the Room Air-conditioner, as it has very good properties and it is widely used refrigerant for Room ACs, 77% of its consumption are in Room ACs. But, it is an ozone depleting substance, although the ozone depleting potential is lower than that of CFCs, and also having high global warming potential. Because of ozone depleting substances, HCFC-22 is being phased-out globally under the Montreal Protocol.

Important Considerations for Selection of Future Refrigerants

Emissions ↓

Energy Efficiency ↑

Focusing on Emissions of Refrigerants & Energy Efficiency is essential to do what's good to environment

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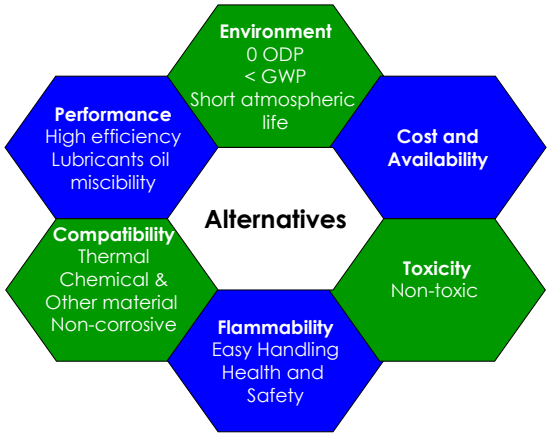
SLIDE 4:
IMPORTANT CONSIDERATIONS FOR SELECTION OF FUTURE REFRIGERANTS

Desirable Characteristics of Refrigerant



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SLIDE 5:
DESIRABLE CHARACTERISTICS OF REFRIGERANT

ASHRAE 34: Safety Classification of Refrigerant

American Society of Heating, Refrigerating and Air-conditioning Engineers (ASHRAE) 34 – Designation and Safety Classification of Refrigerants for toxicity and flammability

❑**Flammability**
- "1" – No flammability
- "2" – Flammable
- "2L"– Mildly Flammable
- "3" – Higher Flammability

❑**Toxicity**
- "A" – Lower toxicity
- "B" – Higher toxicity

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SLIDE 6:
ASHRAE 34: SAFETY CLASSIFICATION OF REFRIGERANT

RAC technicians should perform the services such that the environmental effect due to Room AC system is as much low as possible. This can be achieved when Room AC system consumes less energy (high energy efficient) and refrigerant leakages are minimum/negligible. Whether manufacturers, an engineer/technician, or an owner, the focus of achieving the best possible energy efficiency, with the lowest possible emissions is the key to being both environmentally and economically responsible.

This slide shows that the alternative refrigerant to HCFC-22 must have some desirable characteristics. The system with new refrigerant should have similar or higher efficiency as compared with HCFC-22. The alternative refrigerant must be having a good lubricant oil miscibility characteristic. It must have zero ODP and minimum GWP, preferably negligible GWP. It must be available in the market and cost must not be too high. It should be preferably non-toxic and non-flammable. It must be compatible to all the materials used in air-conditioning system. The stability of a refrigerant is linked to the way it behaves in the presence of other substances, particularly within the refrigerating system. It is important that the refrigerant will not react with, or act as a solvent with, any of the materials within the system. These include tubes and other components, compressor oils and associated additives. This should also be considered with respect to the small quantities of contaminants such as moisture and air. There are many refrigerant available, but none have all the characteristics as desired. So, except zero ODP, we have to select the one nearest to the desired.

The standard ASHRAE 34 specifies the safety class of refrigerant and also gives designation to refrigerant. Under the safety, all refrigerants are categorized for toxicity and flammability.

The flammability of refrigerant is referred with numbers. This classification includes '1" for No flammability, "2" for flammable, "2L' for mildly flammable and "3" for higher flammability. The lower toxicity is denoted by "A" and higher by "B".

The flammability of refrigerant higher or lower is defined on the basis of flammability limits and heat of combustion when tested in air at 21°C and 101 kPa. If there is no flame propagation, then that refrigerant comes under "A1" category. When flammability limit is more than 0.10 kg/m3 and heat of combustion is less than 19 kJ/kg then that refrigerant comes under category "A2". For "A2L" the limits are flame propagation velocity is less than 10 m/s under category "A2". The category "A3" refrigerant is considered as highly flammable when flammability limit is less than or equal to 0.10 kg/m3 and heat of combustion is more than or equal to 19 kJ/kg.

ASHRAE 34: Safety Classification of Refrigerant

	Lower (Chronic) Toxicity		Higher (chronic) Toxicity	
Non-flammable	**A1**	HCFC-22 R-744 HFC-134a R-410A, R-407C,R-404A	**B1**	HCFC-123
Mildly Flammable	**A2L**	HFC-1234ze HFC-1234yf HFC-32	**B2L**	R-717
Flammable	**A2**	HFC-152a	**B2**	
Higher Flammability	**A3**	HC-290 HC-600a	**B3**	

Increasing safety requirement

Increasing safety requirement

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SLIDE 7:
ASHRAE 34: SAFETY CLASSIFICATION OF REFRIGERANT

Low-GWP Single Component Refrigerants

Natural Refrigerants

R-290, R-600a, CO2, Ammonia

Fluorocarbon Refrigerants

High Pressure
HCFC-22 Replacements - HFC-32

Medium Pressure
HFC-134a Replacements- HFO-1234yf, HFO-1234ze (E), HFC-152a

Low Pressure
HCFC-123 Replacements- HFO-1233zd (E), HFO-1336mzz

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HFO - Hydrofluoroolefin 8

SLIDE 8:
LOW-GWP SINGLE COMPONENT REFRIGERANTS

Potential Single Component Refrigerant Alternatives for Room AC

HC-290:			
An excellent alternative to HCFC-22 with negligible GWP	New systems have higher efficiency	Safety issues related to flammability to be addressed adequately	Already in commercial use in many countries including India
HFC-32:			
Moderate GWP (675) but higher than R-290	Higher Pressure than HCFC-22 and it is mildly flammability.	New systems have higher efficiency.	Already widely used in several countries including India

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SLIDE 9:
POTENTIAL SINGLE COMPONENT REFRIGERANT ALTERNATIVES FOR ROOM AC

In this slide a list of available refrigerants with their flammability and toxicity class are presented. HCFC-22 is non-flammable and low toxic. Likewise, R-744, R-410A, R-407C, R-404A are also non-flammable and lower toxic. HFC-32 is mildly flammable and low toxic. R-290 is highly flammable and low toxic. There are some refrigerants which are higher toxic, like HCFC-123 and R-717.

In this slide two different classification of refrigerants having low GWP single component are presented. One is natural Refrigerant and the other is Fluorocarbon Refrigerant.

Available Natural refrigerants are:

- HCs (e.g. HC-290, HC-600a) contain Hydrogen and Carbon.
- CO_2 contains one atom of Carbon and two of Oxygen
- Ammonia contains one atom of Nitrogen and three atoms of Hydrogen

Low-GWP single component Fluorocarbon refrigerants are:

HFC-32: It is high pressure refrigerant replacement for HCFC-22

HFC-1234yf, HFO-1234ze(E), HFC-152a: These are medium pressure refrigerants can replace HFC-134a.

HFO-1233zd(E), HFO-1336mzz: These are low pressure refrigerants for the replacement of HCFC-123.

The refrigerants like ammonia, CO_2, HFCs and HCs are in use from long years, but the Trainer can now focus on switching over from HCFC to promoting low GWP or negligible GWP refrigerants. With the continued attention on replacement refrigerants, coupled with the ever-growing market for Room AC, there are now many refrigerants that are currently commercially available. Such a diversity of refrigerants and their variety of different characteristics can create difficulties in handling and servicing practices for many RAC technicians.

R-290: New system have higher efficiency. It is an excellent alternative to HCFC-22 in the current situation, as it has zero ozone depleting potential and negligible global warming potential. It is a highly flammable refrigerant, so safety issues to be addressed adequately. It is commercially available and used by many countries including India.

HFC-32: It is a high-pressure refrigerant; the pressure is higher than that of HCFC-22. It is mildly flammable. The new system with HFC-32 have high efficiency. But, this refrigerant has moderate global warming potential (=675) which is much higher compared to R-290. It is also used in many countries including in India.

Potential HFC Blends for Room AC (High GWP)

R-410A (HFC-32/125):			
For new systems	Not a long term refrigerant due to its high GWP	Higher Pressure than HCFC-22	Widely used HFC blend all over the globe, including India
R-407C (HFC-32/125/134a) :			
Lower Cooling Capacity as well as energy efficiency	Not a long term candidate due to its High GWP	Pressure a little higher than HCFC-22	

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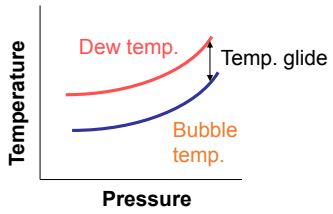
SLIDE 10:
POTENTIAL HFC BLENDS FOR ROOM AC (HIGH GWP)

Issues with HFC Blends

- ❑ Many alternatives are zeotropic blends
- ❑ Do not behave as single substance
  - ➢ have temperature glide
  - ➢ different behaviour in system
  - ➢ different charging procedure
  - ➢ leakages are more problematic



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SLIDE 11:
ISSUES WITH HFC BLENDS

Characteristics of Commercialized Alternative Refrigerants in Room AC

Property	HCFC-22	HFC-32	R-290	R-410A
Chemical formula	$CHClF_2$	CH_2F_2	C_3H_8	CH_2F_2/C_2HF_5 (50% HFC-32+ 50% HFC-125)
Cooling capacity relative to HCFC-22	100	160	94	140
Ozone Depleting Potential (ODP)	0.055	0	0	0
Global Warming Potential (GWP)	1810	675	3	2100
Flammability*	Non-flammable (A1)	Mild-flammable (A2L)	Flammable (A3)	Non-flammable (A1)
Toxicity	Low	Low	Low	Low

Properties of Refrigerants *ASHRAE Std. 34 designation (ASHRAE, 2013)

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SLIDE 12:
CHARACTERISTICS OF COMMERCIALIZED ALTERNATIVE REFRIGERANTS IN ROOM AC

R-410A (HFC-32/HFC-125): It is also high-pressure refrigerant like HFC-32, higher pressure than HCFC-22. It can be used for new system designed for high pressure refrigerant. It is not flammable, but having high global warming potential, so, it cannot be selected for long term solution alternative. It is also widely used all over the world, including in India.

R-407C (HFC-32/125/134a): Low cooling capacity as well as energy efficiency as compared to HCFC-22. Pressure is a little higher than HCFC-22. But, it is having high global warming potential, so, not a long-term candidate.

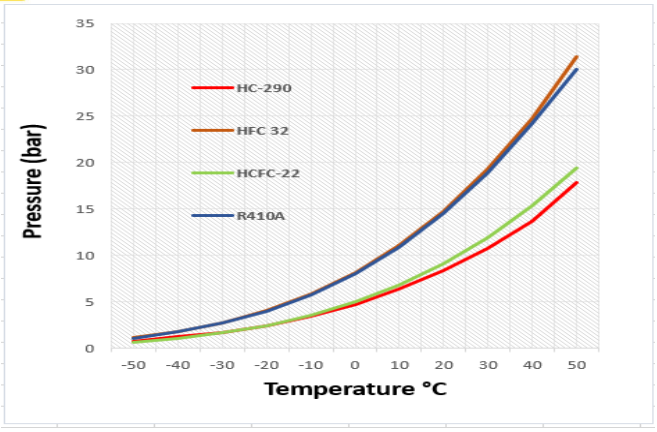
Zeotropic blends: A zeotropic blend is a mixture of refrigerants whose different volatilities are seen when observing the performance of a refrigeration cycle. There is change in the molar composition and/or a change in saturation temperature during boiling or condensation; in this way, it does not behave like a single refrigerant when condensing or evaporating. Two different situations arise, depending upon the type of system.

The figure shows zeotropic mixture of refrigerant components, as it flows through a heat exchanger tube. In the case of a pure fluid, the temperature of the refrigerant remains the same as the liquid vaporises, or the vapour condenses. However, with a zeotropic blend, as the refrigerant vaporises, the saturation temperature rises (or as the vapour condenses, the saturation temperature falls). The refrigerant is at the bubble temperature when it is just a pure liquid (e.g. when it is just evaporating) and is at the dew temperature when it is just a pure gas (e.g. when it is just condensing).

Temperature glide: The characteristic called “temperature glide” occurs when the refrigerant blend has various temperatures as it evaporates or condenses at a single given pressure.

In this slide some important characteristics of alternative refrigerants to HCFC-22 in Room AC is tabulated. Cooling capacity of R-290 is little lower than HCFC-22 but it has no ODP and negligible GWP (=3). Cooling capacity of HFC-32 and R-410A are relatively high, but they are having high GWP compared to R-290, which is environmental issue. Although R-290 is more preferable concerning the environmental issue, it is having safety issues because it is a highly flammable substance. R-410A is non-flammable like HCFC-22 and HFC-32 is mildly flammable. All these refrigerants are low toxic.

Characteristics of Commercialized Alternative Refrigerants for Room AC



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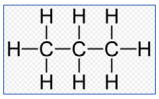
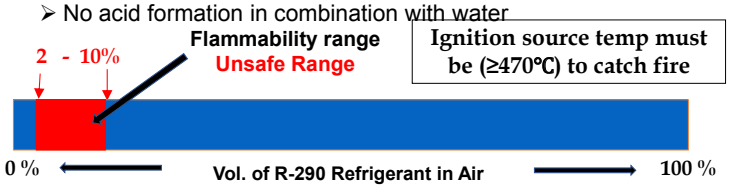
SLIDE 13:
CHARACTERISTICS OF COMMERCIALIZED ALTERNATIVE REFRIGERANTS FOR ROOM AC

Characteristics of R-290

- Single Fluid
- Boiling point -42.1°C
- Compatible with mineral oil with viscosity correction
- Hydrocarbons purity class 99.95% as refrigerant
- No acid formation in combination with water



C3H8
Propane



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SLIDE 14:
CHARACTERISTICS OF R-290

Refrigerants Charge Limits of R-290

As per EN378 Standard

- Sealed systems with R-290 charge of 150 g or less may be used in any location or category of occupancy.
- Systems containing more than 150 g, refrigerant charge is governed by the area of the room.
- For wall mounted Air Conditioners, IDU must be installed at a height of minimum 2.1 m.
- **Heavier than air**

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SLIDE 15:
REFRIGERANTS CHARGE LIMITS OF R-290

The pressure vs. temperature graph is plotted for HCFC-22, R-290, HFC-32 and R-410A. The vapour pressure curves for HCFC-22 and R-290 are very similar. However, for HFC-32 and R-410A, the pressures are higher than HCFC-22.

R-290 is a single fluid hydrocarbon refrigerant which can be long term solutions due to their zero ODP and negligible GWP. Boiling point temperature of R-290 is -42.1°C which is slightly lower than HCFC-22. It is miscible with mineral oil and some other commonly used refrigeration oils with appropriate viscosities. The system capacities with R-290 are close to with HCFC-22, with hydrocarbons purity class 99.5%. Although R-290 is not applicable for retrofitting for system with HCFC-22, it can only be used in properly designed. The main disadvantage of R-290 is that they are flammable. R-290 is flammable in the range of 2 to 10% volume present in air. At above 470°C and above it will be self-ignited. This safety issue needs to be addressed, by adequate changes in some electrical components and adequate ventilation surrounding the system/equipment.

European Union regulation, EN378 Standard has restricted the refrigerant charge limit of R-290 in air-conditioning systems. There is no restriction for the equipment with R-290 charge quantity of 150g or lower. But the equipment with charge quantity above 150g must follow charge limit as per the area of the space or room. R-290 vapour density at 20°C and at atmospheric pressure is higher than that of air, so when leakage it flows downward. So, for wall mounted air-conditioners, IDU must be installed at a height of minimum 2.1m.

Summary of Properties of R-290

- Zero ODP and Negligible GWP compared to HCFC-22;
- R-290 is like HCFC-22 a single-component refrigerant, easy to handle;
- Lower refrigerant charge for the same cooling capacity than HCFC-22;
- Higher heat transfer coefficient;
- Reduction of electrical power consumption;
- Easily available;
- Very good compatibility with lubricants and materials.

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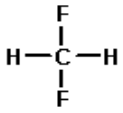
SLIDE 16:
SUMMARY OF PROPERTIES OF R-290

HFC-32 - Characteristics

- Single component fluid;
- Boiling point: -51.7°C;
- Sensitive to contamination;
- Miscible with Polyol Easter oils;



CH_2F_2
Difluoromethane

Flammability range :
14 - 31 by Vol. % in air

Ignition source temp must be (≥648℃) to catch fire

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SLIDE 17:
HFC-32 – CHARACTERISTICS

Characteristics of HFC-32

- Lower GWP, almost 37% GWP of the HCFC-22;
- Single-component refrigerant, easy to handle (recovery/recycle, recovery/reclaim and reuse);
- Refrigerating capacity (per unit mass of circulated refrigerant) is about 1.6 times than that of HCFC-22;
- Lower refrigerant charge for the same cooling capacity than HCFC-22;
- Lower size of compressor than HCFC-22;
- Cost of refrigerant is lower than HCFC-22;
- Overall reduced environmental impact on climate due to the cumulative effect of lower GWP, lower charge and improved COP.

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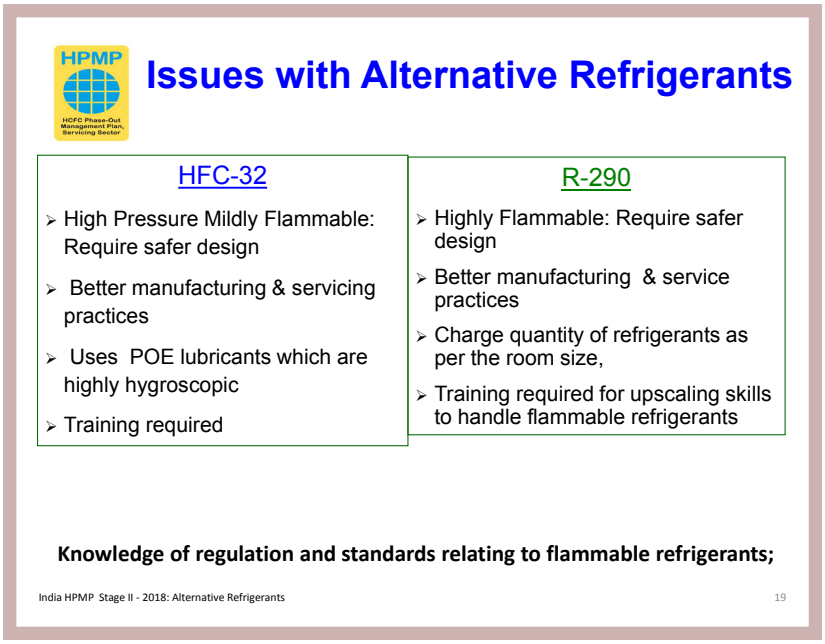
SLIDE 18:
CHARACTERISTICS OF HFC-32

R-290 has no ODP and negligible GWP compared to HCFC-22. It is a single-component refrigerant, easy to handle. Requires lower refrigerant charge for the same cooling capacity than HCFC-22. It has higher heat transfer coefficient. Reduction of electrical power consumption due to lower pressure ratio and lower density than HCFC-22. It is easily available in the market and having very good compatibility with lubricants and materials.

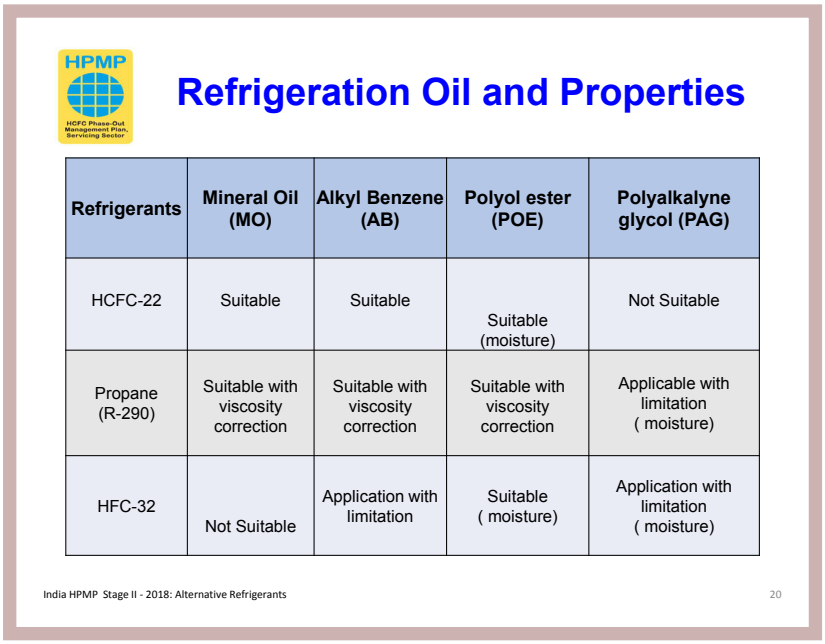
HFC-32 (Difluoromethane) is an organic compound of the dihalogenoalkane variety. It is based on methane, except that two of the four hydrogen atoms have been replaced by fluorine atoms. Hence the formula is CH2F2. HFC-32 is a refrigerant that has zero ozone depletion potential. As a refrigerant HFC-32 is classified as A2L - slightly flammable. Although it has zero ozone depletion potential, it has global warming potential of 675, little lower than other blends of HFC available refrigerants. The refrigerant HFC-32 is primarily seen as a replacement for HCFC-22 refrigerant. HFC-32 is a single component refrigerant, there is no temperature glide. It is a high-pressure refrigerant, boiling point is -51.7°C, lower than HCFC-22. This refrigerant is miscible with Polyol Easter oils, the most suitable lubricant for system with this refrigerant. HFC-32 is mildly flammable, flammability range of 14 to 31% volume present in air. Its ignition temperature is higher (648°C) compared to R-290.

Although HFC-32 has high GWP compared to R-290, but it is 37% lower than HCFC-22 refrigerant. It is a single component substance, so easy to handle by technicians, in case of recovery, recycle or for reuse. It has very high refrigerating capacity, about 1.6 times, as compared to HCFC-22, as it has high latent heat of vaporization. Refrigerating charge quantity required is lower than the HCFC-22 and so lower refrigerant circulating rate, thus require lower size of compressor.

The heat transfer coefficient of HFC-32 is 20 to 40% higher than HCFC-22. The cooling capacity and COP are high. This refrigerant is available in the market at lower cost compared to HCFC-22. Although high GWP, the overall environmental impact is lower due to lower charge required and better COP.



SLIDE 19:
ISSUES WITH ALTERNATIVE REFRIGERANTS



Refrigerants	Mineral Oil (MO)	Alkyl Benzene (AB)	Polyol ester (POE)	Polyalkalyne glycol (PAG)
HCFC-22	Suitable	Suitable	Suitable (moisture)	Not Suitable
Propane (R-290)	Suitable with viscosity correction	Suitable with viscosity correction	Suitable with viscosity correction	Applicable with limitation (moisture)
HFC-32	Not Suitable	Application with limitation	Suitable (moisture)	Application with limitation (moisture)

SLIDE 20:
REFRIGERATION OIL AND PROPERTIES

Issues of HFC-32 and R-290 refrigerants:

HFC-32 is a high pressure and mildly flammable refrigerant. Although R-290 is low pressure, it is highly flammable and thus require safer design. Therefore, to handle R-290 and charge quantity the technician should have knowledge of regulation and standards relating to flammable refrigerant. HFC-32 is miscible with POE lubricants which is highly hygroscopic.

On the part of manufacturer safer design is required, but at the same time technicians must follow good service practices considering safety. It must be recommended that technicians handling R-290 and HFC-32 refrigerant is well trained and always use the PPE.

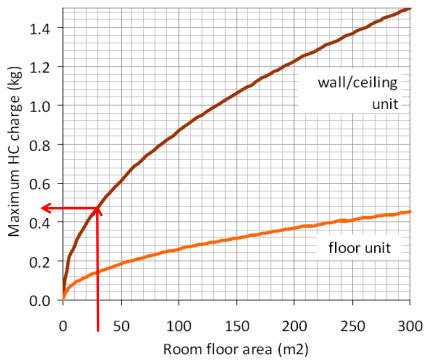
Compressor manufacturers always specify oil type and fill each model of compressor accordingly. In hermetic systems, the lubricant is in intimate contact with the electrical motor windings. The oil must therefore provide good, material compatibility and have high thermal stability properties. Although the majority of the lubricant remains in the compressor, a small amount will be circulated into the rest of the refrigerant circuit. The lubricant must be able to resist both the high temperatures at the compressor discharge valves and the low temperatures at the expansion device. It must be sufficiently soluble with the refrigerant itself in order for it to be returned back to the compressor, so that over time, it does not become starved of oil, which could lead to mechanical failure.

In this slide a table has been shown which describes that to what refrigerant what lubricants suits better.

The properties of a good refrigeration lubricant are:

- Low wax content. Separation of wax from the refrigeration oil mixture may plug refrigerant control orifices
- Good thermal stability. It should not form hard carbon deposits and spots in the compressor, such as in the valves of the discharge port
- Good chemical stability. There should be little or no chemical reaction with the refrigerant or materials normally found in systems
- Low pour point. This is the ability of the oil to remain in a fluid state at the lowest temperature in the system
- Good miscibility and solubility. Good miscibility ensures that the oil will be returned to the compressor, although a too high solubility may result in lubricant being washed off the moving parts
- Low viscosity index. This is the ability of the lubricant to maintain good oiling properties at high temperatures and good fluidity at low temperatures and to provide a good lubricating film at all times.

Charge Quantity Limits for R-290



- The Charge quantity should be based on as per the IEC 60335-2-40 for a given room size. Maximum R-290,
- Max Charge in kg: 2.5 x $(LFL)^{5/4}$ x h (m) x (room area $(m^2))^{1/2}$

LFL = 0.038 kg/m^3

- For Example:
  Room Area: 6 m × 5 m = 30 m^2 installation height 2.1 m,

Max charge quantity= 480g.

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SLIDE 21:

CHARGE QUANTITY LIMITS FOR R-290

The figure shows the charge limit with respect to room floor area. In the figure, at 30 m2 area installed indoor at a height of 2.1 m the maximum charge limit is 0.48 kg.

INTRODUCTION TO RAC TOOLS AND EQUIPMENT & COPPER TUBE PROCESSING

Target Group
Trainers and Technicians

Duration of the Session
30 minutes

Purpose of the Session

To familiarize the participants about the tools and equipment required for good quality servicing by service technician leading to customer satisfaction, in RAC servicing sector and to understand the copper tube processing for Air-conditioning.

Terminal Performance Objectives

At the end of this session, the participants should know:

- Various tools and equipment that are used for installation and servicing of room air conditioners;
- Steps for Copper Tube Processing and explanation for workshop exercise on Copper Tube Processing.

Key Message being delivered through this Session

Use of proper tools and equipment would lead to accuracy, reliability, responsiveness and credibility, which are select elements of quality service. In order to have a set of correct tools & equipment each technician must understand the importance & benefits derived from them. Technician should learn that the selection of correct tools delivers quality service as well as saves the time. Since HCFC refrigerants are under phaseout, it is very essential to understand the actual need of each tool & equipment; as level of accuracy and safety required in alternative refrigerants is relatively very high.

Tools & Equipment (if any) required for the session

One complete set of RAC tool kit. Special tools must be shown to them in the class along with teaching.

Introduction to RAC Tools and Equipment & Copper Tube Processing

SLIDE 1:
INTRODUCTION TO RAC TOOLS AND EQUIPMENT & COPPER TUBE PROCESSING

Learning Outcomes

- ❑ Introduction of tool and equipment used in Room Air-conditioning (AC) servicing;
- ❑ Steps for Copper Tube Processing;
- ❑ Explanation for workshop exercise on Copper Tube Processing.

SLIDE 2:
LEARNING OUTCOMES

RAC Tools & Equipment


Screw Driver


Crimping pliers


Piercing Pliers / Valve


Torque Wrenches


Line Tester


Hand Drill Machine


Ratchet wrench / Service valve wrench

SLIDE 3:
RAC TOOLS & EQUIPMENT

Air-conditioner service technicians work mainly with hand tools and equipment. Technicians must select quality tools, take good care of them and be skilled in their use. The technicians should always use the right-hand tools and equipment for the right job and as recommended by the manufacturer of the air-conditioner. Using improper equipment and tools for a specific job may be unsafe and unproductive. Use of appropriate equipment and tools helps in improving the quality of installation as also repairs and servicing and satisfied customer.

For Air-conditioner technicians, the copper tube processing work is very important and must be carried out in a perfect clean and proper manner. The ability to properly perform quality copper tubing processes is a basic requirement for the RAC technician.

The participants will get familiar with the important tools and equipment required to a service technician. They will learn how to use these tools properly.

Technicians will learn the steps for copper tube processing and will get familiar with the workshop exercise for copper tube processing which to be done during the practical session.

The items showed in this slide are:

Screw driver: The various types of screw driver bits e.g. flat bladed key stone/cabinet, Phillips type, Allen type, Bristol, etc. can be used as per the requirement. Sturdy screw drive size 8 x 200 mm with firmly bonded plastic handle can be used to remove/fit screws while servicing and installation of systems. Never pound the screw driver with hammer.

Crimping Pliers: Crimping pliers are necessary for crimping closed end splice & fixing fastener clips to wire's end. These can be used to cut wire and strip wire. These can be also used for crimping solderless connectors onto wires. They can be used to cuts small bolts also.

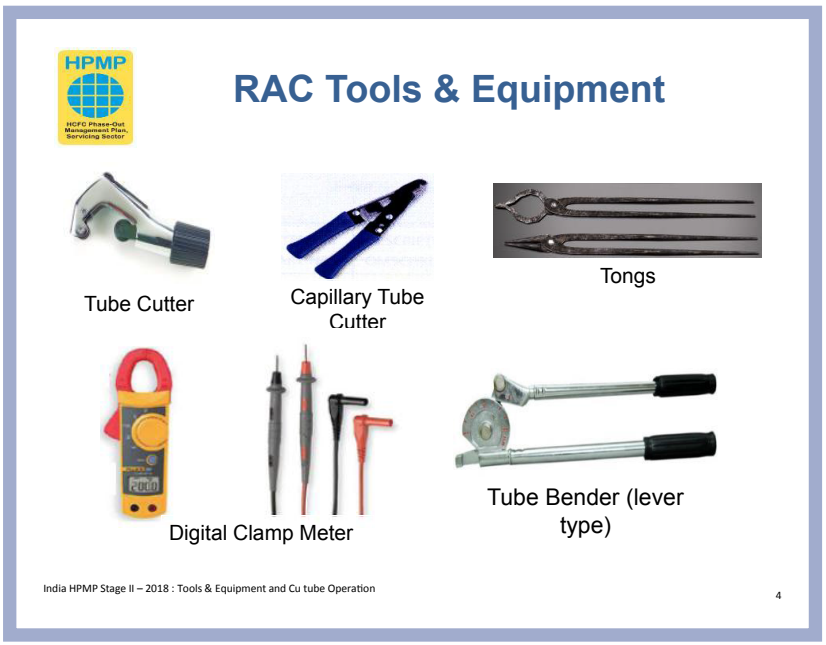
Piercing Pliers / Valve: For recovering refrigerant from defective refrigeration circuits without service ports, it is necessary to create a temporary access port on the system. A piercing plier is used for this purpose. It simultaneously pierces tubing as it locks into place to create a temporary 1/4" access port on system.

For piercing tubes, quick piercing pliers / valves can be applied, e.g. quick tube piercing valve fits 1/4" tube fitted with 1/4" SAE threads. Use connectors to control the flow of fluid by raising and lowering a needle that fits into a matching seat.

Line Tester (500 V): Insulated electric tester (500 V) should be used before start of electric work to test live electric supply in wires and sockets. It also helps to check polarity in the electric socket.

Torque Wrench: A torque wrench is used to apply a specific torque to a fastener such as nut and bolt or flare nut and union, in order to ensure that it is tightened sufficiently and prevent over tightening of the same. A

SLIDE 3 (CONTINUED)



SLIDE 4:

RAC TOOLS & EQUIPMENT

set of torque wrenches (several heads) for up to 200 Nm (2039 kgfcm) and hardware (springs, screws, washers, nuts, bolts, bearings, rivets etc.) are required for the servicing of air-conditioners.

Hand Drill Machine: A tool used for drilling holes on various materials for different purposes such as fastening materials together or for passing tubes and other materials through. Used to drill the holes to sheet metal spare for fitting of screws, even drill holes at the time of installation. With this the attachment for making larger hole in brick wall too is good to use for good work instead of cracking the wall.

Ratchet Wrench/Service Valve Wrench: This is also one of the important tools. This is used to open and close cylinder valves. By design it will not damage the valve stem and ensure proper sealing of the valve. To open or close the service, cylinder valve which can rotate clock wise or anti clock wise. In case of this tool lot of field technicians have been seen using wrong tool i.e. plier. After few openings with a plier the cylinder valve forms the circular shape and slippery goes on. This causes the loss of refrigerant because of unable to open valve any more on the cylinder. Improper handling of any cylinder valve may cause uncontrollable leakage or worse may be the chances of the accident.

Tube cutter: Tube cutters are available in different design and sizes. Tubing cutters make an accurate 90° cut on copper tubing. It should be taken care of during the cutting process, tube cutter is to rotate once around copper tube and then rotate the handle wheel slightly to the level of tightness and then again rotate around the tube. The instruction must be passed on that do not rotate handle wheel to too tight otherwise the blade will get damage and one cannot cut the tube nicely.

Keep the wheel shaft, rollers and sliding parts lubricated always. A well-oiled tool will operate easier, function better and last longer. Replace worn parts promptly. A worn component will eventually lead to failure of other tool parts. Remove chips, dirt and other foreign matter from working parts periodically.

Capillary tube cutter: Very important tool for RAC technicians. It can cut the capillary at an angle and with no burs. It consumes very less time, without burs cutting and trainer is supposed to show them how to cut the capillary. One can make at an angle of 45 degrees with respect to capillary and apply the capillary cutter. Trainers must tell not to use wire cutters instead of capillary cutter as the wire cutter do not have angle inside the cutter. Capillary cutter must not be put on where the brazing material is otherwise the blade will get damage.

Tube bender (lever type): Bending of soft copper tubing greater than 1/4" diameter by hand can result in kinks or flats. Hence it is important to use tube benders to make short radius bends. Lever type tube benders can make short bends up to 180. No technician is perfect in bending the tubes with his hand. Some lining comes inside the tube. So always best to use the lever type tube benders for better practices during installation of air-conditioners. Some technicians use spring bender also as they are cheaper.

Tongs: Tongs shall be used to lift the objects that are too hot to handle.

Digital Clamp Meter: The multifunctional digital clamp meter aids to check the resistance, AC/DC voltage and current. It measures resistance in the range 0-200kΩ, DC voltage upto 1000V, AC voltage upto 750V and AC current 0-300amp. This can be used for checking earthing in wall socket where the appliance will be connected but the most ideal equipment is Megger or Resistance Tester.

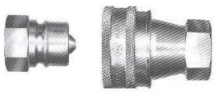
RAC Tools & Equipment

Flaring tool

Swaging tool

Scrubber cum wire brush

Deburring tool



Male & Female Quick Coupler

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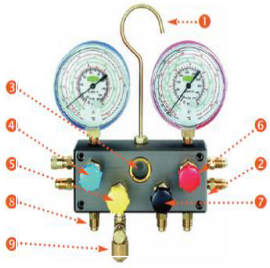
SLIDE 5:
RAC TOOLS & EQUIPMENT

RAC Tools & Equipment



1 – Support bar
2- Manifold body
3- Sight glass for refrigerant flow
4- Low Pressure valve
5- Vacuum pump valve
6- High Pressure valve
7- Valve Connection - charging cylinder
8- Hose connection ¼" male flare
9- Vacuum hose connection 3/8"

4-way gauge manifold

2-way gauge manifold

India HPMP Stage II – 2018 : Tools & Equipment and Cu tube Operation

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SLIDE 6:
RAC TOOLS & EQUIPMENT

Flaring tool with swaging kit: Flaring tools consists of a tube holding device the so-called flaring bar or flaring block and a yoke assembly comprised of a feed screw and a smooth surfaced flare compression cone. The tubing is clamped in the flaring bar, yoke is engaged and feed screw advanced until a moderate resistance is encountered.

Deburring tool: Using this tool the inside as well as outside of the copper tube can be deburred or reamed and keep the tube wall surface smooth and clean. While deburring, keep the tool at the bottom hand and tube on the upper hand, so that all the burs can be collected within the deburring tool otherwise all the burs will enter the copper tube.

Male and female quick coupler: Male & Female couplers are used for joining tubes that eliminate need for flaring of tubes and save time, avoid leakages that can occur through ordinary valves during servicing. They are suitable for 1/4" copper tubes.

Scrubber cum wire brush: Use scrubber to clean outside of copper tubes joints after brazing.

2 Way Gauge Manifold:

Very important to diagnose trouble in air-conditioning systems. This is mainly used during evacuation or charging operations. It contains two shut-off valves, three external connections, and two pressure gauges. The gauges and the flexible hoses that connect to the manifold to connect it to the system are colour coded; blue is the low side of the system, red is the high side. The left-hand gauge is called a compound or suction pressure gauge. The right-hand gauge is called the high pressure or discharge pressure gauge.

The right side shut-off valve will control the flow through the centre port and the port on the left side (blue low side), with left shut-off valve (hand-knob) is in the open position. To allow flow only through the center port (yellow line) close the low side blue label shut-off valve.

The gauges will indicate either vacuum or pressure depending whether hand-knobs are in the open or closed position.

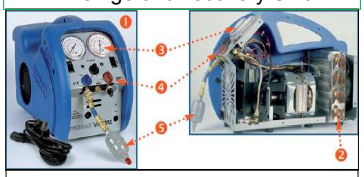
4-way Gauge Manifold:

A 4-way gauge manifold is an essential tool for air-conditioning technicians. This reads pressures on both high and low sides of the system. This can also be applied to read vacuum on the low-pressure side of the system.

A 4-way manifold saves time because there is no need to switch hoses for different processes. The low and high sides, the vacuum pump and the charging device can be hooked up right at the beginning of the job. The manifold is a central control for service. One needs to just operate the appropriate valve.

RAC Tools & Equipment

Refrigerant Recovery Unit



1. Recovery unit
2. Condenser and ventilator
3. High and low pressure gauges
4. Refrigerant inlet & outlet valves
5. Inline filter-drier

1,3&4 – Refrigerant Recovery Cylinder
2 – Liquid level float
5 – Cylinder cut
6 – Liquid/Vapour valve
7 – Transfer line for gaseous refrigerant
8 – Transfer line for liquid refrigerant

India HPMP Stage II – 2018 : Tools & Equipment and Cu tube Operation

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SLIDE 7:
RAC TOOLS & EQUIPMENT

RAC Tools & Equipment

Brazing tool kit

Brazing Nozzle

Brazing tool kit

Filler Material

Heat Deflector

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SLIDE 8:
RAC TOOLS & EQUIPMENT

RAC Tools & Equipment

Portable Gas Charging Station with fittings

Vacuum Gauge

Weighing Scale

Vacuum Pump

Control Valve

Electronic Leak Detector

India HPMP Stage II – 2018 : Tools & Equipment and Cu tube Operation

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SLIDE 9:
RAC TOOLS & EQUIPMENT

Refrigerant recovery machine with a recovery cylinder:

Since it is important to reduce HCFCs emission and in line with HCFC phase-out - it is important to recover as much HCFCs as possible. Likewise, HFCs should also be recovered as they have high GWP. For such recovery of refrigerants, a recovery machine is required.

The image illustrates the recovery machine with oil-less compressor. Having drier at the entry port of refrigerant. One more mesh filter is fitted inside the inlet valve through which the refrigerant passes on to the system. Oil less recovery machine does not have the risk of addition of any oil from the compressor.

Separate recovery cylinders should be used for recovery of different refrigerants. Recovery process will be discussed in detail in good service practice session.

Brazing tool kit: For proper brazing using adequate temperature, the minimum requirement is oxy-acetylene brazing kit or an LPG brazing kit. One example is the swirl jet or spit fire which can reach higher temperatures than the ordinary LPG torches. It is still better to have oxy-acetylene brazing torch – but economic consideration may not allow this.

Brazing filler metal: Brazing filler metals can join similar and dissimilar metals at brazing temperature. Brazing filler metals melt at temperature range of 538 to 816 C. Some filler material used for brazing copper tubing are of two categories, alloys containing silver, others are copper alloys which contain some phosphorous. These two classes vary in melting, flowing and fluxing characteristics. Strong joints can be made with either class of filler metal.

Heat deflector: An asbestos-lined heat deflector should be used to reflect the heat on to the joints while brazing.

Brazing Nozzle: Torch attachments different sizes with tips made of hard copper.

Portable Gas Charging Station with fittings: Portable Gas Charging Station with hoses with female quick couplers. This helps to charge the correct amount refrigerant to air conditioners. Small refrigerant disposable cans /cylinders usually come with 1 to 2.5 kg. Dispose these cylinders properly after use. Once the refrigerant gas is charged to the system, it must be checked for leakage.

Vacuum Pump: Double stage vacuum pump 40 L/ min (1.44 CFM) to 280 L/min (9.64 CFM), ultimate vacuum down to 12 microns, gas-balast valve equipped. It is very important for evacuating the system before charging the refrigerant into the system.

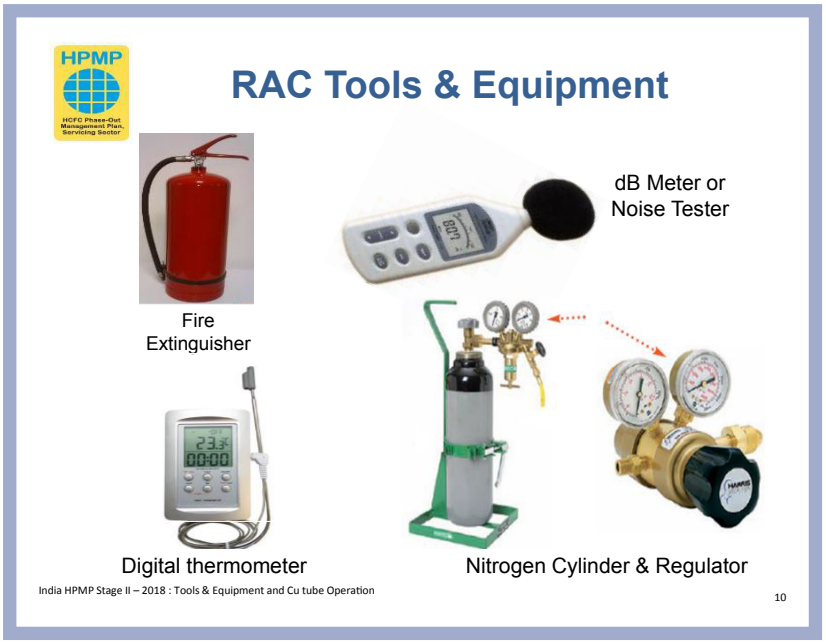
Vacuum Gauge: Also called micron gauge to measure the vacuum while evacuating the system accurately.

Weighing Scale: Digital weighing scale/balance for accurate quantity of charge; this is a must for charging for good working of the air-conditioner.

Electronic Leak Detector: Leaks in the air-conditioning system will cause the system to lose its refrigerant charge. In many cases, it is difficult to determine the exact location of the leak as well as how severe it is. Leak detectors are needed to accurately locate leaks. It is having audio/visual indications, sensitivity up to 0.5 g /Year, lockout and clear facility (switches) are also provided. Separate leak detectors are required for each type of refrigerant.

To check leakage, turn on the detector switch and adjust the sensitivity to produce an occasional ticking. Position the detector probe end under the suspected refrigerant leak areas. Since refrigerant is heavier than air, it will flow downward from a leak. If refrigerant is leaking, the detector rate of ticking will increase.

Control Valve: Ideal for using it during refrigerant charging. Eliminates the need for frequent purging of hoses with refrigerant and prevents refrigerant, oil, or dye from spraying during connections.



SLIDE 10:
RAC TOOLS & EQUIPMENT

SLIDE 11:
RAC TOOLS & EQUIPMENT

Fire Extinguisher: This is most important, do not forget to have a powder type (ABC) fire extinguisher as only this can be used on any type of fire (oil, electricity, papers etc.). It should be placed in a safe but rapidly accessible location to make use of it in case of any eventuality. It is better to display the location near the entrance of any workshop or keep it close to brazing kit. The label of the extinguisher must be checked for its status.

Sound Level Meter (dB meter): This is used to measure the noise & vibrations produced by compressor/ Air-conditioner. It has a point at the top, which is the microphone that samples and measures the sound. Inside the box at the bottom of the meter, electronic circuits measure the sound detected by the microphone and amplify and filter it in various ways before showing a readout on a digital LCD display. Use of this is reliable when noise levels are concerned. However, the surrounding noise level must be at least 12 dB levels lower than that of object under test, otherwise reading becomes incorrect.

Nitrogen cylinder with 2 stage regulator & hose: Nitrogen gas being inert, non-oxidizing, is recommended for flushing & leak testing of a refrigeration system. The pressure of nitrogen in the cylinder is above 2000 psi, and such pressure can cause serious accident. To avoid any unpleasant event, a 2-stage regulator must be used for regulating its output pressure to safe working limits of about 15-20 bar (220-294 psig).

Dual Stage Regulators reduce the source pressure down to the desired delivery pressure in two steps. The advantage of a dual stage regulator is its ability to deliver a constant pressure, even with a decrease in inlet pressure. If the cylinder pressure drops, in case of single stage regulator, the delivery pressure increases because of the decrease in inlet pressure. In a dual stage regulator, the second stage compensates for this increase, providing a constant delivery pressure regardless of inlet pressure.

Refrigerant Identifier: With the introduction of new refrigerants, it is difficult to identify refrigerants by their saturation pressure and temperature. The Refrigerant Identifier will provide a fast, easy and accurate means to identify the refrigerant and also determine the purity of recycled or reclaimed refrigerant. Refrigerant identifier for HCFC-22 can help for ascertaining presence of refrigerant like HCFC-22 in just 5 minutes.

Oil Can: Oil can is required for Oiling the Fan Motor for better lubrication which is necessary at the time of Service.

Air Velocity meter (Anemometer): Anemometer is an apparatus for measuring the speed of air. The commonest kind of anemometer is a fan blades fixed in the circular ring. When placed in an airflow direction, the lightweight metal vanes present in the devise rotate due to the flow of air through it. This rotation speed of the vanes is proportional to the speed of air flow through the anemometer. A gearing and clutch mechanism that exists in the device records the number of rotations of the vanes and thus the speed of the air is displayed on the screen.

Hand electrical air blower: Used at the time of servicing the AC to remove the dust particles from the Evaporator or Condenser Coil & from exterior parts of air-conditioner. The high velocity air jet blow to remove dust and other contaminants from coils and exterior of the system.

Copper Tube Processing

India HPMP Stage II – 2018 : Tools & Equipment and Cu tube Operation

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SLIDE 12:
COPPER TUBE PROCESSING

Copper Tubes

Copper tubes to be as per IS 10773 or ASTM standards for purity, design, fittings & liquid/gas compatibility for safety and quality.

3 types of copper tubes for Air-conditioner

- K - Thick-walled copper tubing for heavy duty applications
- L - Medium-walled copper tubing, most frequently used
- M - Thin-walled copper tubing, rarely used in RAC industry

Measured by their outside diameter (OD).

Outside Diameter	Wall Thickness
1/4	.030
3/8	.032
1/2	.032
5/8	.035
3/4	.035
7/8	.045
1 1/8	.050
1 3/8	.050

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SLIDE 13:
COPPER TUBES

Copper Tubing Operations

- Proper copper tube processing is necessary to make strong, durable and gas tight joints that can withstand vibration, temperature and thermal cycling stress,
- Steps of Copper tube operations are:
  - Straightening and measuring
  - Cutting
  - Reaming
  - Bending
  - Cleaning/Polishing
  - Swaging soft-drawn copper tubing
  - Flaring soft-drawn copper tubing
  - Brazing

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SLIDE 14:
COPPER TUBING OPERATIONS

This presentation is about the copper tubing operations in servicing of air conditioners. The quality of copper tube operations is very important in RAC. This section is about to identify types and sizes of copper tubing, select and properly use copper tubing tools, to understand the different steps needed for copper tubing, like bending, flared connections, brazed joints and to explain what will be doing in practical session of copper tubing operation.

ASTM or ISI standard tubes offer desired design, purity, size, compatibility with refrigerants, and safety of copper tubes.

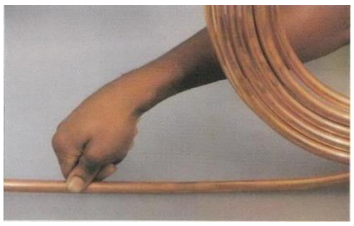
When copper tube for Air-conditioning is manufactured, the inside of the tubing is dehydrated to remove all moisture. The tubing is then charged (filled) with low-pressure nitrogen gas and sealed with a cap at each end to keep the tubing safe from contamination by oxygen and moisture in the air. Oxygen atoms combine with copper atoms (a process called oxidation), a layer of copper oxide would form inside the tube. The caps also keep out dirt and other foreign matter that could contaminate a refrigeration system. Caps or plugs should be replaced after cutting a length of tubing.

The tubes used in air conditioners are measured based on outside diameter. Air conditioning and refrigeration tubes are classified based on thickness of tubes. Three types are available in the market. Thick walled K class tubes are used for heavy duty applications and where corrosion might occur. Medium thick-walled L- class tubes are used widely in almost all applications including residential and commercial applications. L and K are suitable for room air-conditioners. Type M is a thin-walled tubing; it is not used in air-conditioning systems because it does not meet safety code requirements. Do not think of saving few rupees but consider quality of your work and customer relation in long term apart from successful practice under HPMP. While thin walled L class tubes are to be rarely used in ACR industry. They are not good for Room AC as leaks are possible due to thin walls.

Various copper tubing operations are listed in this slide. The operations with copper tubing are straightening and measuring, cutting, reaming, bending, cleaning/polishing, swaging soft-drawn copper tubing, flaring soft-drawn copper tubing, and brazing. All these operations need to be done carefully in good service practicing. It must be remembered that correct sizes give good fit.

Tube Straightening and Measuring

- To ensure square and accurate cut, the tube must be straightened properly. It is impossible to straighten cupper tube end after cutting



- Always measure the length with proper scale or measuring tape and cut the tube, inaccuracy can compromise joint quality

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SLIDE 15:
TUBE STRAIGHTENING AND MEASURING

Copper tube cutting

- Use a wheel cutter instead of a hacksaw in order to prevent burr entering the tube.
- Always tighten the cutter wheel gradually while rotating the tool around the tubing.
- To cut capillary tubes, capillary cuter is recommended

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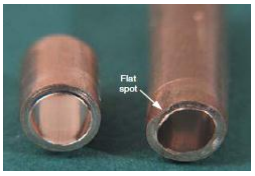
SLIDE 16:
COPPER TUBE CUTTING

Reaming

- A de-burrer, reamer or round file can be used to remove internal burrs.

- Excess pressure leaves burr



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SLIDE 17:
REAMING

A photograph of straightening operation of copper tubing used in air conditioners is shown. This is first step-in copper tube processing. The straightening must be done from head to tail of tube.

Straightening is done by supporting the coil upright with one hand and holding the free end of the tubing stationary on a flat surface with the other hand (or a foot). The coil is then rolled in a straight line to the desired length. Do not make straighten an excessive amount because it is difficult to recoil the tubing without bends.

Before cutting, marking is important. The part marked to be placed on flat surface safely, free from damage. The correct dimensions must be made and incorporated while working on copper tubes.

In air conditioners servicing, cutting of copper tube must be done precisely. Although, cutting copper tubing is a simple task, but it must be performed properly. Care must be exercised not to damage the ends being cut. The cutting of tube should be done using tube cutter. Copper tubing cutters make an accurate 90°. The surface of cut part should not be rough or slanted. It should be at right angle to the axis of tube and smooth. Avoid excessive blade pressure; because of more pressure on cutter, the tube gets cut like pinched and leaves some burr. Do not twist the tube and let cutting edge reach bottom or other side. Select cutter as per size; not to use hacksaw or any other tool. Keep the cutter blade sharp.

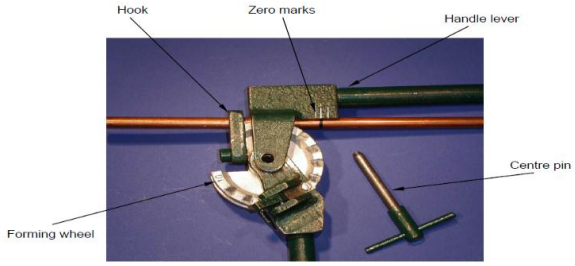
After cutting off the desired length, replace the cap or plug on the end of the coil to prevent contamination.

After cutting operation the tube ends must be reamed. Reaming is a process of removing burrs and scraping the ends to a flat surface. Tube face and reamer should be facing each other w/o deviation. To remove the burr, the tool reamer is positioned at the tube to be reamed and rotated gently. Both the outer and inner burr is to be removed with the help of tool reamer.

Care must be taken that copper chips or burrs will not enter inside the tubing. Hold the tubing upside down or at an angle during the reaming process so the chips will fall to the floor. It is important to have proper dimension of the cut tubing end. Burrs or ridges on the inside of the tube will cause problems in assembly. The thickness of the tubing at the cut should match the thickness of the rest of the tubing.

Bending

- For bending of tube, use of a calibrated lever type bending tool is recommended.
- To minimize the pressure drop do not allow the tubing to kink or flatten.



SLIDE 18:
BENDING

Bending Steps

1. Positioning

2. Bending Start Positioning

3. Bending the tube

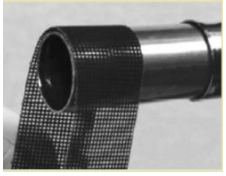
4. Removal of the tool

SLIDE 19:
BENDING STEPS

Cleaning and Polishing

- Dirt, debris & foreign materials must be removed from the tube end;
- For surface cleaning use a abrasive or Emery cloth.
- For interior fitting cleaning use a properly sized fitting brush
- Prevent cleaning particles or swarf from entering the tube.





SLIDE 20:
CLEANING AND POLISHING

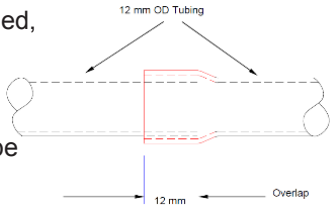
Bending is one of the most important process in copper tubing in air-conditioning system. This operation helps to avoid many joints in the air conditioning servicing. Smooth copper tube should be bent. While bending the care must be taken in for the entire tube surface remains round at bend. Do not flatten the tube. Calibrated lever type bending tool should be used as recommended one for bending of tube. Lever-type tubing benders are easy to operate and are calibrated to allow accurate short radius bends up to 180°. Some benders are designed to fit only one size of tubing, while others can be used with a range of sizes..

1. *Positioning:* The bending tool diameter must match the copper tube diameter. With the handles at 180° and the tube holding clip raised out of the way, insert the tube in the forming wheel groove.
2. *Bending Start Positioning:* Place the tube-holding clip over the tube and bring the handle into an approximately right-angle position, engaging the forming shoe over the tube. The zero mark on the forming wheel should then be even with the front edge of the forming shoe.
3. *Bending the tube:* Bend by pulling the handles towards each other in a smooth, continuous motion. The desired angle of the bend will be indicated by the calibrations on the forming wheel.
4. *Removal of the tool:* Remove the bent tube by pivoting the handle to a right angle with the tube, disengaging the forming shoe. Then release the tube holding clip.

Always the copper tubes must be kept clean using abrasives like polish or emery cloth, wire brush etc. For surface cleaning use an abrasive plastic scouring pad. Prevent cleaning particles or swarf from entering the tube. For interior fitting cleaning use a properly sized fitting brush.

Swaging

- Enlarging one end of a tube for making joint with another tube of same size.
- Place the tube in correct size hole of swaging /flaring block
- Position the tubing to be swaged, the size equal to OD +3mm above the block
- The length of overlap should be equal the OD of the tubing



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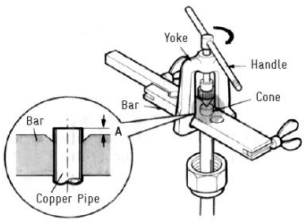
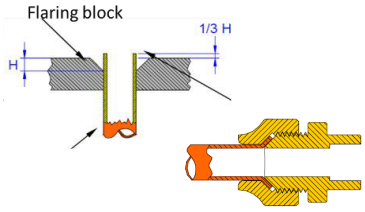
SLIDE 21:
SWAGING

Flaring

- Flaring is a mechanical way of joining tubes.
- Flare nut compresses the flare against fitting to obtain a tight, leak proof, metal-to-metal contact.
- Prepare the tube well before flaring
- Extended portion should be about one third the height of the flare





Correctly made flare

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SLIDE 22:
FLARING

Flaring Steps

1. Assemble the flaring tool with tube

2. Fabricate the flare

3. Inspect your work

4. Assembling

5. Tightening

6. Final result

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SLIDE 23:
FLARING STEPS

The swaging operation helps to join the two tubes of same diameter. Swaging is the process of enlarging the diameter of one end of a length of soft copper tubing, so the end of another length can be slipped into it. For this operation only, soft copper tube should be used. The swaged copper tube connection is then brazed. To perform swage, the flaring block, hammer, and proper size swaging tool are required.

Selection of correct size hole to place the tube is very important. The position of the tube above the flaring block should be OD+3 mm of the tube. The length of the overlap of the two copper tubes to be swaged should be equal to OD of the tubing.

To join the copper tube with male threaded flare fitting in air conditioner servicing perfectly, flaring operation must be performed. The end of soft copper tube is flared at 45° angle. The flared end of tubing rests against the male portion of the fitting being connected. For flaring operation, a flare block and a flaring yoke are required. The point to be noted that in this connection metal to metal contact without gasket is involved and pressure in system are about 30 bars. Therefore, proper attention very much required while doing the flaring process. The detailed step by step procedure is explained in next slide. Flared joint must be done carefully to avoid emission of refrigerants.

After cutting, reaming and cleaning process do the following steps

Assemble the flaring tool with tube: Place the flare-nut over the end of the tube with the threads close to the end being flared. Insert the tube between the flaring bars of the flaring tool. Opening of the flaring bars must match the diameter of the tube being flared.

Fabricate the flare: Align the compression cone on the tubing's end and tighten the screw. As you turn the handle, the cone flares the tubing's end.

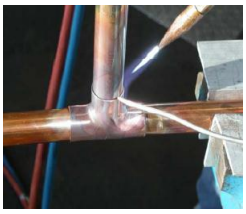
Inspect your work: Inspect your work after removing the tubing from the flaring tool. If the tube end has splits, cut off the flared portion and repeat the process. It is essential to examine the tight position of male flare union, female flare-nut flared copper tube. Tight and clean fitting is requested.

Assembling: Position the flare union against the flared end of the tubing and slide down the nut. The fitting should be easily tightened by hand if done properly. Additional pipe jointing or sealing compound (e.g. oil) is not necessary.

Tightening: Tighten the joint by placing one wrench on the union and one on the nut. Do not over-tighten a flare joint. Once the parts fit by hand, give them a half turn on each nut/wrench to create a gas tight join.

Brazing

- Brazing is an important part of RAC trade for producing strong joints to withstand vibrations, temperature, tension etc.
- If the temperature required to melt the filler metal is above 450^{0}C and below the melting point of the base metal then it is referred to as brazing



- Filler metals used for brazing are of two categories:
  - Copper to Copper - Copper alloys which contains some phosphorous
  - Copper to Steel - Alloys containing 30 % to 60% silver.

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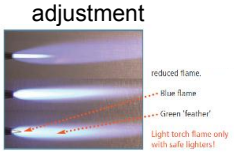
SLIDE 24:
BRAZING

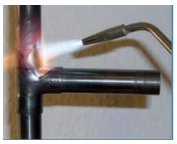
Brazing Steps

1. Assembling

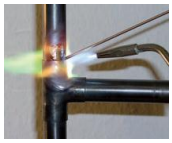
2. Torch (flame) adjustment



3. Apply heat



4. Apply filler



5. Complete joint

6. Remove the heat

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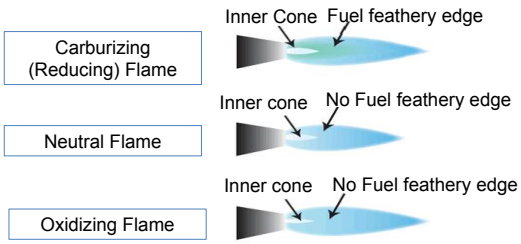
SLIDE 25:
BRAZING STEPS

Brazing



Brazing equipment	Temperature range
Oxygen-Acetylene	3000°C
Oxygen LPG	2200°C
Air LPG	1900°C
Air Butane	1900

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SLIDE 26:
BRAZING

The brazing is a hot process operation for joining two metal or alloy pipes in refrigeration and air conditioning.

To perform the brazing process a striker, air-conditioning service wrench, brazing rods, and an acetylene-oxygen cylinder and torch are required. Heat source depend upon the size of tubes to be brazed. For air conditioning application normally heat source should produce temperature above 450°C. The brazing rod should melt on contact with the heated copper tubes and should never be heated directly by the torch flame and melted. This can happen only if the copper tubes have been heated to the appropriate temperatures. The filler rod that has melted on contacting the heated base metals (copper tubes) flows into the clearance between the overlapping copper tubes that must be joined, by capillary action. This capillary action will take place only when the clearances are maintained within certain limits.

Assembly: Put the pipe and fitting or expanded pipes together and make sure you maintain the right joint depth. in the system.

Torch (flame) adjustment: Adjust the torch for a slightly reduced flame. Slowly pass nitrogen into the tube work to prevent oxide formation on the inner surface of the tubes. Once the refrigerant is circulating, oxide scale on the inside of the tubes can lead to serious problems. Flow rate should be about 1 to 2 liters per minute. Flow rate sensitively can be felt easily on the back of a moistened hand.

Apply heat: Apply heat uniformly to both, tube and fitting, by moving the torch around to ensure even heating before adding the filler material (rod).

Apply filler: As the heated area gradually changes color to red (a cherry red but not a bright red), apply filler material (rod) by lightly brushing the tip of the stick into the shoulder of the fitting. Care should be taken not to over-heat the tube.

Remove the heat: Remove the heat until the molten brazing alloy solidifies to a tan black color (approx. 10 to 15 seconds).

At the end of brazing torch, flame gets developed when we burn acetylene and oxygen together. The flame formed are of 3 types; neutral, reducing and oxidizing. The sketches are presented in this slide. In the case of neutral flame, Inner cone gives 2/3rd of heat whereas the outer envelope provides 1/3rd of the energy. In the mixture of acetylene and oxygen, when excess acetylene is present then combustion of acetylene is incomplete. This type of flame is good for aluminum alloys and high carbon steels. In burning mixture due to excess oxygen, oxidizing flame gets formed. For brass welding this flame is good. It is recommended to use neutral or reducing flame for brazing of Air-conditioning joints.

The temperature range of different brazing equipment are also presented in the slide. The flame out of Oxygen-LPG reaches over 2200°C temperature. Use of correct flame is important else the metal tubes may burn or melt, or carbon will deposit at the jointed portion of tubes leading to chokes in future. It is suggested to use neutral or reducing or carburizing flame and not oxidizing flame.

Insulating Tubes

- Proper insulation is must to avoid heat transfer from Copper (refrigeration) tubes
- Insulate both - gas and liquid tubes separately
- Start insulation by wrapping or roles slipping over tubes from one end continually without gaps, else on a humid days, sweating may appear.

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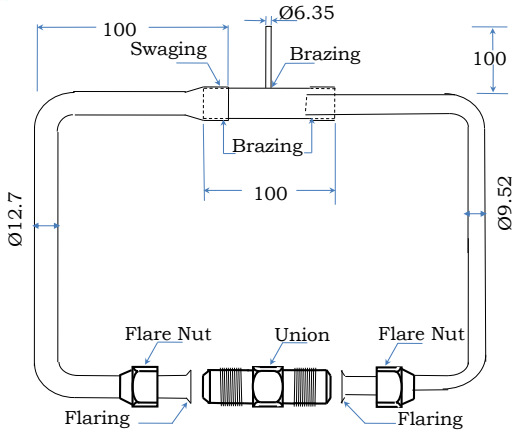
SLIDE 27:
INSULATION TUBES

Workshop Practice
Copper Tubing Processes



Sr. No	Description	Size	Qty
	Specifications		
5	Union	12.7	01
4	Flare Nut	12.7	02
3	Copper Tube	6.35 Dia 100 Long	01
2	Copper Tube	12.7 Dia 100 Long	01
1	Copper Tube	12.7 Dia 483 Long	02

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SLIDE 28:
WORKSHOP PRACTICE COPPER TUBE PROCESSING

Air-conditioning tubing is normally insulated both on low pressure and high-pressure side. The insulation prevents the condensation around tubing. Before applying the insulation over tubing, the ID of insulation is normally powdered for better slippage around bends and tube surface. In many cases the insulation is provided by wrapping insulation material around tubing. In this case, the care must be taken that there are no gaps while wrapping the material. Proper insulation and right method cum care ensures satisfactory performance of tubing. Both the tubes must be wrapped using good quality insulation material to avoid loss of heat transfer.

This slide presents the drawing of copper tube processing to be done during the workshop practice.

BRAZING

Target Group
Trainers and Technicians

Duration of the Session
30 minutes

Purpose of the Session

To understand the importance of brazing in refrigeration and air conditioning applications. Longer life of air conditioner without frequent servicing depends on the quality of brazed joints. To make understand that better skills are required for quality brazing.

Terminal Performance Objectives

At the end of session the participants should understand the following:

- Importance of Brazing in Room Air-conditioner;
- Safety precaution while doing Brazing
- Brazing material
- Brazing joints
- Brazing tools and equipment
- Brazing process and temperatures
- Advantages of Brazed joint

Key Message being delivered through this Session

The brazing is very important operation in joints while servicing of air conditioners. Quality brazing helps to avoid frequent servicing and minimize leaks. The participants need to give attention to develop better skills in brazing.

Tools & Equipment (if any) required for the session

Two pieces of pipes, Filler material, Brazing torch, Gas Cylinders with caps, Two-stage Pr. Regulators with Gauges, Hoses with crocodile clips, Key for cylinder valves, Gas lighter

Brazing

SLIDE 1:
BRAZING

Learning Outcomes

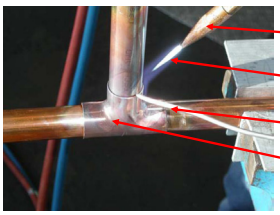
- ❑Importance of Brazing in Room Air-conditioner;
- ❑Safety precaution while doing Brazing;
- ❑Brazing material;
- ❑Brazing joints;
- ❑Brazing tools and equipment;
- ❑Brazing process and temperatures;
- ❑Advantages of Brazed joint.

India HPMP Stage II, 2018 : Brazing 2

SLIDE 2:
LEARNING OUTCOMES

Importance of Brazing

- Brazing is a non-detachable joining process most common in Air-Conditioner parts or lines for producing strong and tough joints
- Brazing can be done between Copper to Copper, Copper to Aluminum and Copper to Steel tubes to withstand vibrations, shocks and tension etc.



India HPMP Stage II, 2018 : Brazing 3

SLIDE 3:
IMPORTANCE OF BRAZING

It signifies the brazing operation for joining two metal or alloy pipes in refrigeration and air conditioning. Technicians should be careful that the environmental effect due to AC system is as much low as possible. It is very important that brazing is done properly and accurately, so that there is no leakage of refrigerant into the environment. Brazing is a hot non-attachable process using flame, so safety precaution while doing brazing is very important.

In this slide what the participants will learn in this session are presented. In this session participants will get awareness about the importance of brazing in Room AC and safety precaution while doing Brazing. The technicians will also learn about brazing process, material, joints, tools and equipment, brazing temperature. Participants will also learn the advantage of brazing joint.

Brazing is a non-detachable joining process most common in air-conditioner parts or lines for producing strong and tough joints. Brazing can be done between Copper to Copper, Copper to Aluminum and Copper to Steel tubes to withstand vibrations, shocks and tension etc.

To perform the brazing process a striker, air-conditioning service wrench, brazing rods or filler material, and an acetylene-oxygen cylinder and torch are required, as shown in the figure.

Brazing

- If the temperature required to melt the alloy used to join copper tubing is above 450°C it is considered brazing, if less than 450°C, then soldering
- Necessary to avoid refrigerant leakage at joints.

India HPMP Stage II, 2018 : Brazing 4

SLIDE 4:
BRAZING

Safety Precaution while doing Brazing

During Brazing ALWAYS !

• Always wear safety goggles!

• Always wear safety shoes!

• Always wear working clothes!

• Always wear safety gloves!

India HPMP Stage II, 2018 : Brazing 5

SLIDE 5:
SAFETY PRECAUTION WHILE DOING BRAZING

Safety Precaution while doing Brazing

There is a strict smoking ban in all work areas!

India HPMP Stage II, 2018 : Brazing 6

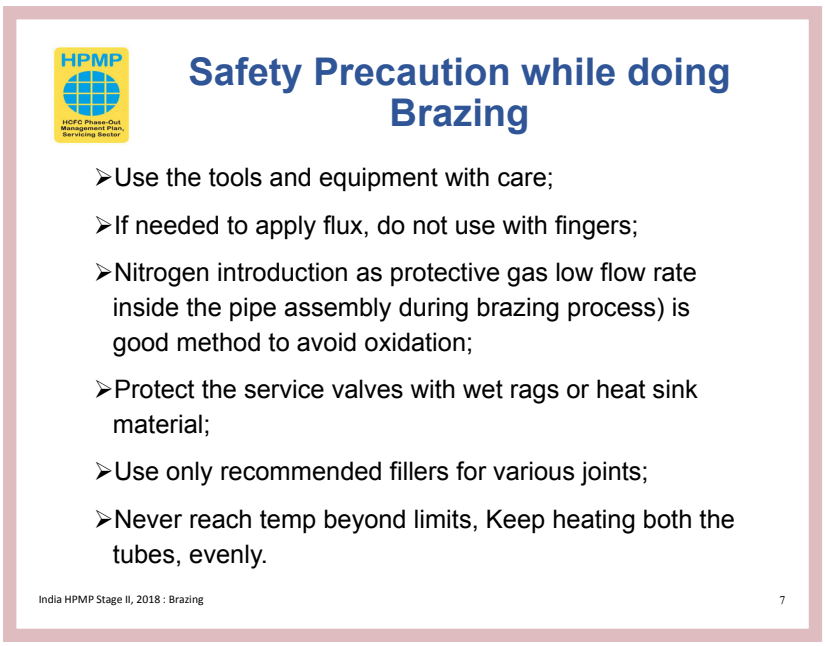
SLIDE 6:
SAFETY PRECAUTION WHILE DOING BRAZING

If the temperature required to melt the alloy used to join copper tubing is above 450°C it is considered brazing, if less than 450°C, then soldering. Heat source depend upon the size of tubes to be brazed. For air conditioning application normally heat source should produce temperature above 450°C. The brazing rod should melt on contact with the heated copper tubes and should never be heated directly by the torch flame and melted. This can happen only if the copper tubes have been heated to the appropriate temperatures. The filler rod that has melted on contacting the heated base metals (copper tubes) flows into the clearance between the overlapping copper tubes that have to be joined, by capillary action. This capillary action will take place only when the clearances are maintained within certain limits.

RAC technicians should be careful that the environmental effect due to RAC system is as much low as possible. This can be achieved when RAC system consumes less energy (high energy efficient) and refrigerant leakages are minimum/negligible. Whether manufacturers, an engineer/technician, or an owner, the focus of achieving the best possible energy efficiency, with the lowest possible emissions is the key to being both environmentally and economically responsible.

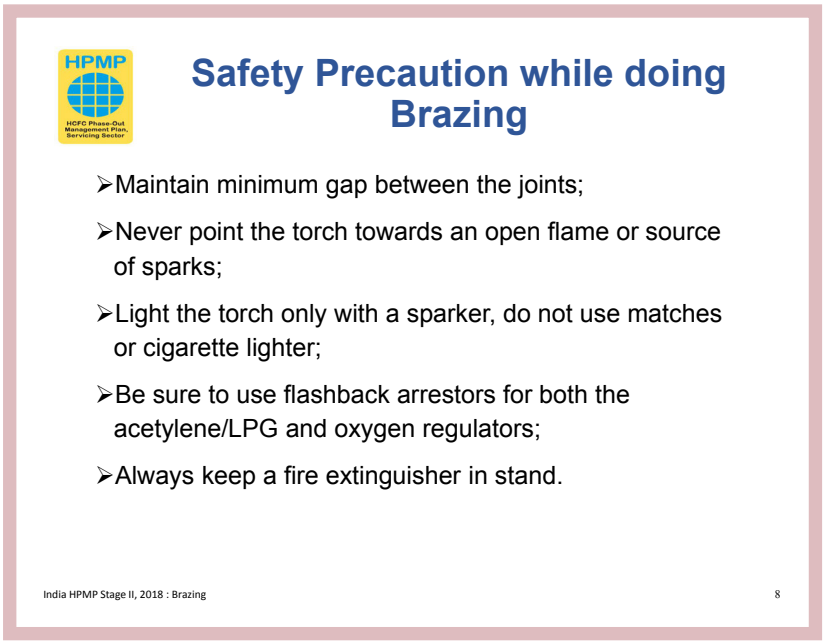
This slide presents safety- “Safety First and Everywhere”. During brazing, always wear Personal Protective Equipment (PPE) like goggles, shoes, apron/lab coat and gloves exclusively designed for safety. Remember safety is for you, your property and customer’s property too. Never take short cuts.

Safety has one more vital issue of smoking. Never smoke in work area or laboratory or work place. Always make a practice to work in safe working environment and to remind the same install the safety signs apart from First-aid kit and fire extinguisher at a convenient place. This is for self and property.



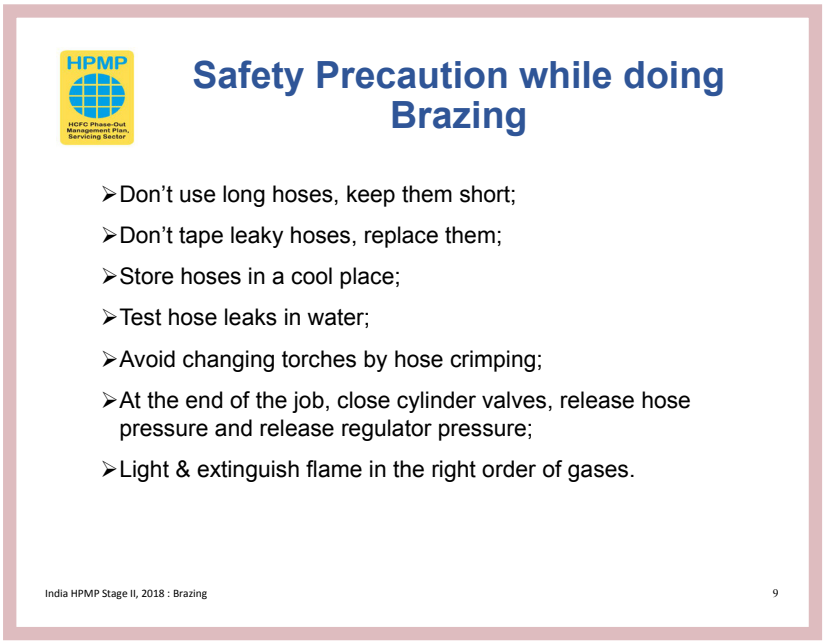
SLIDE 7:

SAFETY PRECAUTION WHILE DOING BRAZING



SLIDE 8:

SAFETY PRECAUTION WHILE DOING BRAZING



SLIDE 9:

SAFETY PRECAUTION WHILE DOING BRAZING

This slide explains about safety and precaution while doing brazing. Brazing is also called as hard soldering. To perform the brazing process a striker, refrigeration service wrench, brazing rods, and air-acetylene torch are required. Heat source depend upon the size of tubes to be brazed. It needs to use the tools and equipment with care. If needed to apply flux, do not use with fingers.

Nitrogen introduction as protective gas low flow rate inside the pipe assembly during brazing process is good method to avoid oxidation. Service valves should be protected with wet rags or heat sink material while doing brazing. Use only recommended fillers for various joints.

The brazing rod should melt on contact with the heated Cu tubes and should never be heated directly by the torch flame and melted. This can happen only if the Cu tubes have been heated to the appropriate temperatures.

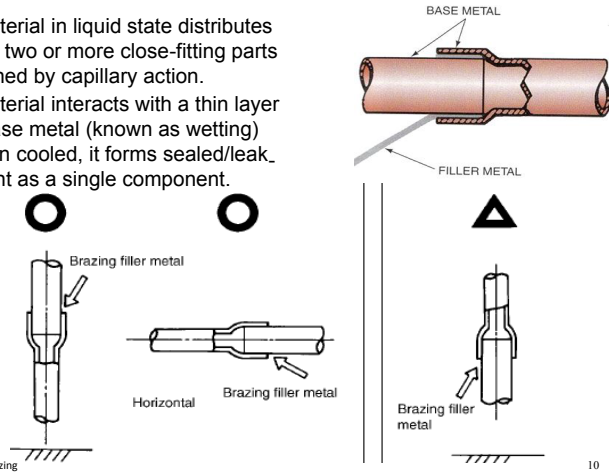
The filler rod that has melted on contacting the heated base metals (Cu tubes) flows into the clearance between the overlapping Cu tubes that have to be joined, by capillary action. This capillary action will take place only when the clearances are maintained within certain limits.

Torch should never be pointed towards an open flame or source of sparks. It is recommended that always use sparker to light the torch, not to use matches or cigarette lighter. Be sure to use flashback arrestors for both the acetylene and oxygen regulators. Always keep a fire extinguisher in stand safety precaution.

In this slide some more safety precaution while doing brazing is presented

Brazing Filler Material

- Filler material in liquid state distributes between two or more close-fitting parts to be joined by capillary action.
- Filler material interacts with a thin layer of the base metal (known as wetting) and when cooled, it forms sealed/leak_ proof joint as a single component.



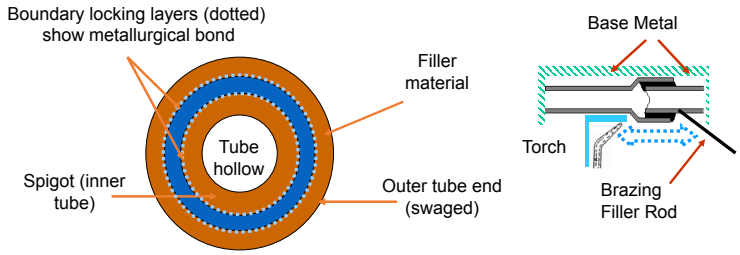
SLIDE 10:
BRAZING FILLER MATERIAL

Brazing Filler Material

- Brazed joint is stronger than the filler metals used because of the geometry of the joint and the metallurgical bonding that occurs.
- For brazing Steel base metal + copper filler material normally with Ag 35%
- Fluxes made of sodium, potassium. Lithium & borax. added as paste, powder to brazed metal to remove oxides
- Should use at least 2% silver alloy for copper to copper joints.

SLIDE 11:
BRAZING FILLER MATERIAL

Brazing joint



Melted Filler material wets base metal and penetrates surface & forms metallurgical bond.

SLIDE 12:
BRAZING JOINT

Filler material in liquid state distributes between two or more close-fitting parts to be joined by capillary action. Filler material interacts with a thin layer of the base metal (known as wetting) and when cooled, it forms sealed/leak-proof joint as a single component.

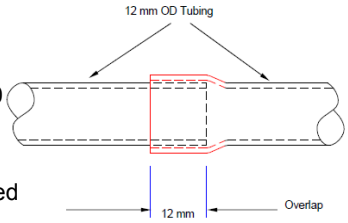
Brazed joint is stronger than the filler metals used because of the geometry of the joint and the metallurgical bonding that occurs. For brazing Steel base metal + copper filler material normally with Ag 35%. Fluxes made of sodium, potassium, Lithium & borax. added as paste, powder to brazed metal to remove oxides. At least 2% silver alloy to be used for filler material for copper to copper joints.

In the brazing process melted filler metal joins the base surface irregular voids such that metallurgical bonding occurs between the filler material and base material. In a pictorial form a cross-section of the inner and outer tubes being brazed, along with the molten filler material. The melted filler rod as a liquid wets the surface of the Cu tubes and penetrates superficially into the surface of the Cu tubes to form a strong metallurgical bond between the outer surface of one tube and the inner surface of the other tube that overlaps this tube at the joint. The boundary-locking layers in the diagram show the metallurgical bond.

Joint Preparation

For joining same size tubes

- Swage end of one/male tube
- Clearances to be within 0.05 to 0.50 mm and length of lap joint to be at least equal to tube diameter
- Correct distortion in the soft annealed Cu tubes, before making the joint (Taken care by using a proper swaging tool)



For joining tubes of adjacent sizes (1/4 to 3/8")

- The length of smaller tube inside the larger tube should be at least 1.5 times the diameter of smaller tube

SLIDE 13:
JOINT PREPARATION

Joint Preparation

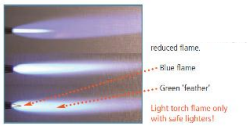
- Clean external & internal surfaces to be brazed, remove dirt/grease, using abrasive cloth/spiral wire brushes (Grease /oil may be removed by appropriate solvents)
- Insert the spigot end into the swaged end/ bigger tube end/ fitting end
- Provide support to the tubes being brazed to retain uniform clearances and prevent slipping, disorientation etc.

SLIDE 14:
JOINT PREPARATION

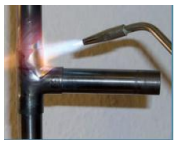
Brazing Process

1. Assembling

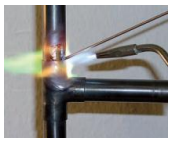
2. Torch (flame) adjustment



3. Apply heat



4. Apply filler



5. Complete joint

6. Remove the heat

SLIDE 15:
BRAZING PROCESS

Before start of brazing process, the tubes are to be prepared. First swage one pipe end in the case of same size pipes. Clearance between two tubes should be in the range 0.05 mm to 0.5 mm. Length of joint should be at least equivalent to the diameter of tubes in the case of same size tubes. Clean the surfaces of tubes and ends of tubes with proper materials. While inserting the smaller diameter end into larger diameter end, the tubes must be straight and aligned with each other.

There may be brazing of the two dissimilar tubes like ¼" to 3/8". In such case length of joint should at least equivalent to the 1.5 times diameter of smaller tube.

The swaging operation helps to join the two tubes of same diameter. Swaging is the process of enlarging the diameter of one end of a length of soft copper tubing, so the end of another length can be slipped into it. For this operation only soft copper tube should be used. The swaged copper tube connection is then brazed. To perform swage, the flaring block, hammer, and proper size swaging tool are required.

Selection of correct size hole to place the tube is very important. The size should be OD+3 mm of the tube. The length of the overlap of the two copper tubes to be swaged should be equal to OD of the tubing.

The first thing to be done before the commencement of brazing is to ensure that the joints are prepared correctly. This involves thorough cleaning of the surfaces to be joined using emery or wire brush to leave a clean and bright surface. This will ensure removal of all dirt, greases, oils and other impurities that will otherwise be present on the surfaces and prevent proper wetting of the surfaces. Insert the spigot end into the swaged end/ bigger tube end/ fitting end. Provide support to the tubes being brazed to retain uniform clearances and prevent slipping, disorientation etc.

Assembly: Put the pipe and fitting or expanded pipes together and make sure you maintain the right joint depth. in the system.

Torch (flame) adjustment: Adjust the torch for a slightly reduced flame. Slowly pass nitrogen into the tube work to prevent oxide formation on the inner surface of the tubes. Once the refrigerant is circulating, oxide scale on the inside of the tubes can lead to serious problems. Flow rate should be about 1 to 2 liters per minute. Flow rate sensitively can be felt easily on the back of a moistened hand.

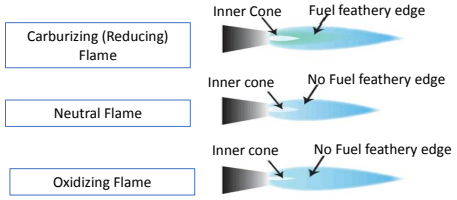
Apply heat: Apply heat uniformly to both, tube and fitting, by moving the torch around to ensure even heating before adding the filler material (rod).

Apply filler: As the heated area gradually changes color to red (a cherry red but not a bright red), apply filler material (rod) by lightly brushing the tip of the stick into the shoulder of the fitting. Care should be taken not to over-heat the tube.

Remove the heat: Remove the heat until the molten brazing alloy solidifies to a tan black color (approx. 10 to 15 seconds).

Types of Flame in Oxy-Acetylene/ LPG Brazing

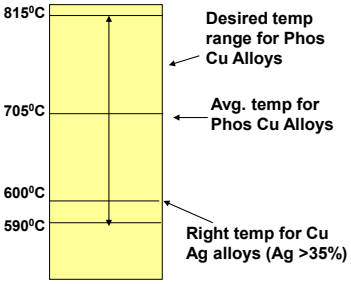
- **Neutral flame (3200°C):** Acetylene (C_2H_2) and O_2 are mixed in equal amounts and burn at the tip of the welding torch. Inner cone gives 2/3rd of heat whereas the outer envelope provides 1/3rd of the energy.
- **Reducing flame (3000°C):** Excess amount of acetylene is used, giving a reducing flame. Combustion of acetylene is incomplete (greenish) between the inner cone and the outer envelope. Good for brazing aluminum alloys, high carbon steels.
- **Oxidizing flame (3400°C):** Excess amount of O_2 is used, giving an oxidizing flame. Good for welding brass.



SLIDE 16:
TYPES OF FLAME IN OXY-ACETYLENE/LPG BRAZING

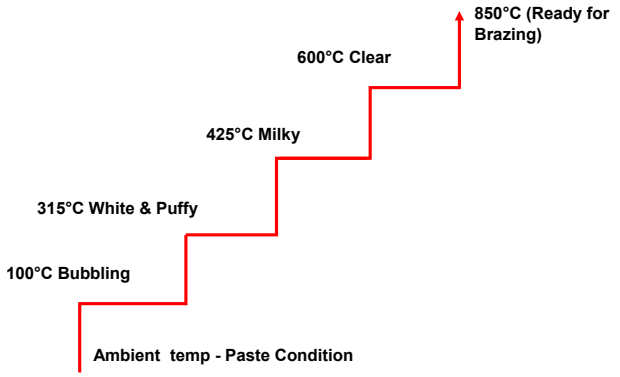
Brazing Temperatures

Metal / Filler Material	Melts at ^{0}C	Flows at ^{0}C
Copper	1083	
Silver	950	
Cu-Phos (w/o Ag)	710	732
(5% Ag)	643	732
(15% Ag)	643	705
Cu-Ag (35%Ag)	607	703



SLIDE 17:
BRAZING TEMPERATURES

Status of Flux at Different Temperatures



SLIDE 18:
STATUS OF FLUX AT DIFFERENT TEMPERATURES

At the end of welding torch flame gets developed when we burn C2H2 and O2 together. The flame formed are of 3 types; neutral, reducing and oxidizing. The sketches are presented in this slide. In the case of neutral flame, Inner cone gives 2/3rd of heat whereas the outer envelope provides 1/3rd of the energy.

In the mixture of acetylene, C2H2 and O2, when excess C2H2 is present then combustion of acetylene is incomplete. This type of flame is good for aluminum alloys and high carbon steels. In burning mixture due to excess O2 oxidizing flame gets formed. For brass welding this flame is good. It is recommended to use neutral or reducing flame for brazing of RAC joints.

The flame out of Oxy-LPG too reaches over 2800°C temperature like Oxy-acetylene flame. Use of correct flame is important else the metal tubes may burn or melt, or carbon will deposit at the joint portion of tubes leading to chokes in future. It is suggested to use neutral or reducing or carburizing flame and not oxidizing flame.

For proper brazing, the process should be conducted at desired temperature. This slide presents the correct temperatures for various filler materials. If the temperature exceeds the desired temperature then filler starts flowing.

This refers to the temperature range at which Phosphorus Cu brazing rods start melting. The temperature should be in the range of 600°C to 815°C, considering all brazing alloys for Cu. The average temperature for such brazing rods is around 705°C.

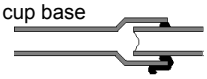
The addition of Ag lowers the melting point of the rods; and rods with 35% Ag start melting at around 600°C. Phosphorus Cu rods with 5% Ag start melting at around 643°C.

The drawing clearly says use of brazing or filler material with silver content is ideal and it avoids chances of burning or melting copper tubes.

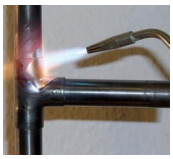
The figure shows status of brazing flux at different temperature. The flux starts bubbling at about 100°C, becomes white at 315°C, milky at 425°C, and clear at 600°C. It becomes ready for brazing at 850°C. Since all this is possible without thermometer but due to application of flux powder, it is necessary that technician uses it carefully and always, especially when dissimilar metals like steel are under brazing. So, the flux helps brazer to understand when to touch filler material or when the metals are ready to accept filler material through capillary action.

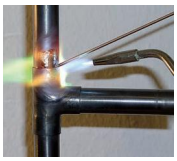
Quality of Brazed Joint

- Under-heating is the principal cause of inferior joints
- Maintain proper temperature range from brazing mouth to cup base



- Excessive clearances between joints can cause voids inside
- Advisable to provide fillets at the joints to compensate for voids





India HPMP Stage II, 2018 : Brazing 19

SLIDE 19:
QUALITY OF BRAZED JOINT

Brazing Tools & Equipment

Brazing tool kit

Brazing Nozzle

Brazing tool kit

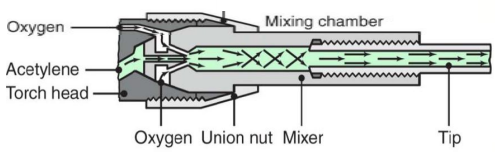
Filler Material

Heat Deflector

India HPMP Stage II, 2018 : Brazing 20

SLIDE 20:
BRAZING TOOLS AND EQUIPMENT

Brazing torch



India HPMP Stage II, 2018 : Brazing 21

SLIDE 21:
BRAZING TORCH

For longer life of brazed joints, the heating should be uniform for entire portion of brazing. The joint should not be under heated. There should not be excessive clearance otherwise the voids will be formed in filler material. Then joint becomes the weak. It is advisable to keep some fillets at the joints to compensate the voids. Always filler material should melt on its own and no attempt should be made to drop the filler material. This makes good/strong joint.

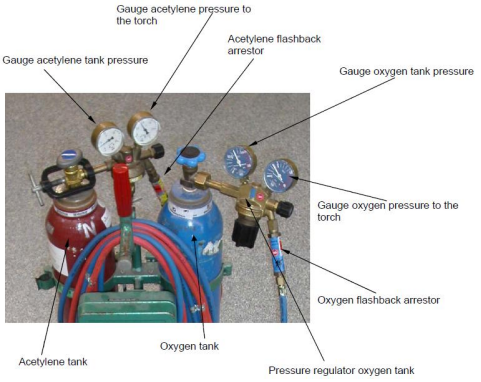
Brazing tool kit: In this slide the tools and equipment for brazing copper tube is presented. For proper brazing using adequate temperature, the minimum requirement is an LPG brazing kit. One example is the swirl jet or spit fire which can reach higher temperatures than the ordinary LPG torches. It is still better to have oxy-acetylene brazing torch – but economic consideration may not allow this.

Brazing filler metal: Brazing filler metals can join similar and dissimilar metals at brazing temperature. Brazing filler metals melt at temperature range of 538 to 816 C. Some filler material used for brazing copper tubing are of two categories, alloys containing silver, others are copper alloys which contain some phosphorous. These two classes vary in melting, flowing and fluxing characteristics. Strong joints can be made with either class of filler metal.

Heat deflector: An asbestos-lined heat deflector should be used to reflect the heat on to the joints while brazing.

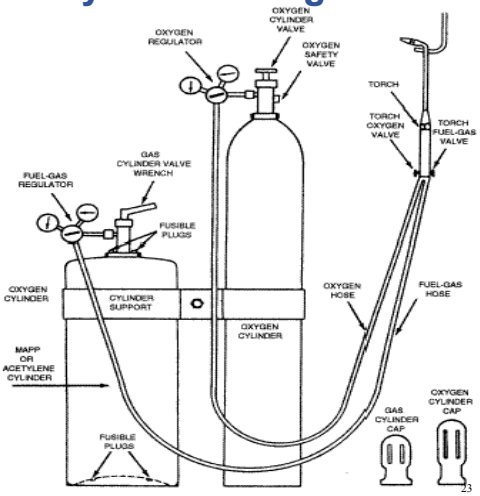
This slide shows the schematic of brazing torch. It consists of components valves to regulate Acetylene and Oxygen, mixing chamber, and tip. Mixer is very critical and its tip or nozzle must be kept clean.

Brazing Set



India HPMP Stage II, 2018 : Brazing 22

Oxy-Acetylene Brazing Set



India HPMP Stage II, 2018 : Brazing 23

Set of Equipment for Brazing

1. Gas cylinders with caps
   Pressure Oxygen – 125 kg/cm^2 (1777.9 psi)
   Acetylene – 16 kg/cm^2 (227.5 psi) or LPG
2. Two-stage Pr. regulators with gauges
   Working pressure of oxygen 1 kg/cm^2 (14.2 psi)
   Working pressure of acetylene/LPG 0.15 kg/cm^2 (2.1 psi)
   Working pressure varies depends upon the thickness of the metal pieces brazed.
3. Hoses with crocodile clips
   Red and Green or Blue
4. Welding torch – with various tips
5. Key for cylinder valves
6. Gas lighter

Oxygen = threads-right-handed hoses-green or blue
Acetylene = threads-left handed hoses-red

India HPMP Stage II, 2018 : Brazing 24

SLIDE 22 & 23:
BRAZING SET

SLIDE 24:
SET OF EQUIPMENT FOR BRAZING

The slide presents the photograph and schematic of Oxy-Acetylene brazing set. The set consists of Oxygen and Acetylene cylinders. For regulating valves with pressure gauges are fitted on cylinders. The cylinders should be placed properly with required support. In the case of brazing torch is connected, the cylinders should be caped. Once brazing is complete, put-off regulators and cylinders using proper keys and then do cap the cylinders without fail.

For brazing operation, the tools and equipment required are filler material, brazing torch, gas cylinders with caps, two-stage pressure regulators with gauges, hoses with crocodile clips, key for cylinder valves, and gas lighter.

The flame of an Air LPG torch made in India and using cooking gas LPG as the fuel attains a temperature of 900°C (straight flame) to 1030°C (swirl jet or cyclone). This does heat the tubes to temperatures necessary to completely melt the rods for small tubing of 1/4" to 3/8". Against this, an oxy-acetylene flame attains a temperature of 3000°C, heats the tubes to the necessary temperatures very fast, and the brazing operation is over very quickly. In fact, in this case one has to watch out against overheating.

Advantages of Brazing

- Dissimilar metals can be joined;
- Good for very thin metal joints;
- Metals with different thickness can be joined easily;
- Thermal stresses not produced in the work piece - no warping;
- Using this process, carbides tips are brazed on the steel tool holders.

SLIDE 25:

ADVANTAGES OF BRAZING

The advantages of brazing are given in this slide.

PRESSURE MEASUREMENT AND EFFECTS OF ALTITUDE

Target Group
Trainers and Technicians

Duration of the Session
30 minutes

Purpose of the Session

To provide the participants clear understanding of the term pressure, their equivalent units, measuring instruments, and devices to obtain vacuum. The participants should understand the effect of elevation on atmospheric pressure.

Terminal Performance Objectives

At the end of session the participants should understand the following:

- Concept of Pressure
- Units of Pressure
- Atmospheric Pressure and Pressure equivalent
- How Pressure is defined
- Pressure Gauge and measurement
- Measurement of Vacuum
- Rotary Vacuum Pump Mechanism
- Gas-Ballast Valve Operation

Key Message being delivered through this Session

Pressure is one of the key parameters in refrigeration and air conditioning systems. It needs to be understood and measured, not only to evaluate its performance, but also to ensure proper servicing and operation of the appliances. It is useful to understand the concept of pressure measurements, including the concept of absolute pressure, vacuum pressure and gauze pressure. A number of systems of units are used to record pressure such as S.I. units, M.K.S. units and British Units. In India, S.I. units are officially recognized, but in practice, British units are still commonly used, especially in RAC industry. Participants must also learn conversion from one system of units of pressure to another, as it is commonly required in practice. Effective use of Vacuum pump is very important, the rotary vacuum pump mechanism and gas-ballast valve operation are discussed in details.

Tools & Equipment (if any) required for the session
Bourdon tube pressure gauge, micron gauge and Vacuum pump.

Pressure Measurement and Effects of Altitude

SLIDE 1:
PRESSURE MEASUREMENT AND EFFECTS OF ALTITUDE

Learning Outcomes

- ❑Definition of Pressure;
- ❑Units of Pressure;
- ❑Atmospheric Pressure and Pressure equivalent;
- ❑Concept of Pressure and its Measurement;
- ❑Pressure Gauge;
- ❑Rotary Vacuum Pump Mechanism;
- ❑Gas-Ballast Valve Operation.

SLIDE 2:
LEARNING OUTCOMES

Definition of Pressure

- ❑ **Pressure** (symbol: ***p***) - the force applied over an area in a direction perpendicular to the surface of the area.
- ❑ Mathematically, pressure $p = F/A$ where:
  - ***F*** = Force = mass * Acceleration = m*a = newton (1 newton = 1 $kg.m/s^2$)
  - ***A*** = Area
- ❑ Unit of pressure are
  - ➢ N/m^2 (SI Unit)
  - ➢ kgf/cm^2 (MKS Units)
  - ➢ lbf/in^2 (psi) (British Unit)
- ❑ Pressure is a natural physical phenomenon that is a scalar quantity and a fundamental parameter in thermodynamics.

SLIDE 3:
DEFINITION OF PRESSURE

Pressure is defined as the force applied over an area in a direction perpendicular to the surface of the area. Pressure is an important parameter in refrigeration and air conditioning systems. A number of systems of units are used to record pressure such as S.I. units, M.K.S. units and British Units. In India S.I. units are officially recognized, but in practice, British units are still commonly used in RAC industry. As a service technician, should know about pressure and pressure measurement tools and procedures to ensure proper servicing and operation of the appliances.

This session will start with review of the concept of pressure as pressure is one of the key parameters in refrigeration and air conditioning systems. Units of pressure must be known taking into account how pressure is defined, including the concept of absolute pressure, vacuum pressure and gauge pressure. It is useful to understand the atmospheric pressure and pressure equivalent concept of pressure measurements, pressure gauge, measurement of vacuum. We are also learning here about rotary vacuum pump mechanism and gas-ballast valve operation.

Pressure is the force applied over an area in a direction perpendicular to the surface of the area. It is denoted by the symbol p.

Mathematically it is expressed as

$$p = F/A$$

Where, p = the pressure in psi (or kPa)

F = the force in pounds (or Newton)

A = the area in square inch (or m^2)

Force is proportional to mass 'm' and acceleration 'a'.

Force = mass * acceleration (m*a)

Unit of pressure are

S.I. Unit -	N/m^2
MKS Units -	kgf/cm^2
British Unit lbf/ln2 -	psi

The average atmospheric pressure at sea level is 14.7 psi or 1.013 bar or 1013 millibars or 101.3 kilo-pascals.

Pressure is a natural physical phenomenon. This is scalar quantity and fundamental parameter in thermodynamics.

Units of Pressure

Pressure P	**= F/A = N/m^2**
1 N/m^2	**= 1 Pascal (Pa)**
1 bar	**= 10^5 N/m^2 = 10^5 Pa**
	= 1.02 kgf/cm^2
	= 14.5 lbf/in^2

1 torr	**= 1 mm Hg or**
	= 1/760 atm or
	= 133 N/m^2
1 in of Hg	**= 0.0339 bar**
	= 33.9 millibar
1 mm H_2O	**= 9.81 N/m^2**
	= 10 N/m^2
	= 10 Pa
1 millibar	**= 100 Pa**

India HPMP Stage II - 2018: Pressure Measurement 4

SLIDE 4:
UNITS OF PRESSURE

Atmospheric Pressure

- Atmospheric pressure - measure of force pressing down on the Earth's surface from overlying gases in the atmosphere.
- Atmospheric Pressure - normally measured in units like
  - atmospheres (1 atmosphere - average atmospheric pr. at sea level),
  - millibars (1 atmosphere = 1013.25 millibars),
  - psi (1 atmosphere = 14.7 pounds per square inch),
  - mm or inches of Hg (1 atmosphere = 760 mm or 29.92 inches)
- Low air density results in upward air & low surface pressure
- High air density results in downward air & high surface pressure

For every 100 meters of elevation change, atmospheric pressure reduces by about 10 millibars.

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SLIDE 5:
ATMOSPHERIC PRESSURE

Pressure Equivalents

Atmospheric Pressure (Standard) =	
0	**gauge pressure (psig)**
14.7	**pounds per square inch (psia)**
29.9	**inches of mercury**
760	**millimeter of mercury**
760	**torr**
760,000	**millitorr or microns**
101,325	**pascal**
1.013	**bar**
1013	**millibar**

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SLIDE 6:
PRESSURE EQUIVALENTS

Measurement of pressure is required to assure that refrigeration system operates at design pressure. The unit of Force is Newton and area is square-meter implies the unit of pressure is N/m2 is also known as Pascal. The equivalence units of pressure are given in this slide.

Atmospheric pressure is the measure of force applied due to air column on the Earth's surface. Pressure is measured in different units like atmosphere, psi, in of Hg, mm of WC, etc. One atmosphere pressure is the average pressure applied at sea level. The equivalence of 1 atmosphere to other unit is

1 atmosphere = 1013.25 millibars

1 atmosphere = 14.7 pounds per square inch

1 atmosphere = 760 mm or 29.92 inch of Hg

The pressure difference at two different locations in the atmosphere results the wind. If the air is hotter, its density is lower, this results upward air motion and lower surface pressure. Whereas if the air is colder, its density is higher, this results downward air motion and higher surface pressure.

For every 100 meters of elevation change, atmospheric pressure reduces by about 10 millibars. Therefore, in a city like Pune, which is 559 meters above sea level, the atmospheric pressure will be 1013 – 56 = 957 millibars.

This slide presents the relation between the standard atmospheric (barometric) pressure, gauge pressure, vacuum pressure and absolute pressure as discussed in previous slide.

Standard atmospheric pressure is the pressure measured at zero feet altitude i.e. at sea level. The approximate value is 14.7 psia. This is mentioned in equivalent unit as 29.92 inches Hga at 0oC or 1013 milibars or 760 mm Hga or 760 torr or 101.325 kilopascals or 33.96 feet H2O at 20oC.

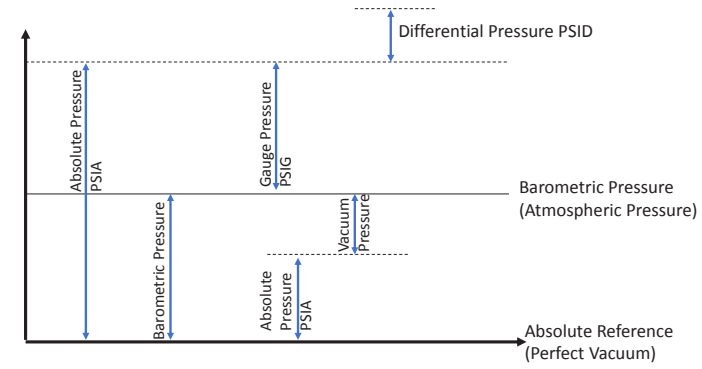
Zero gauge pressure (psig) = 14.7 pounds per square inch (psia) = 29.9 inches of mercury = 760 millimeter of mercury = 760 torr = 760000 millitorr or microns =101325 pascals =1.013 bar =1013 milibar (NTP)

Concept of Pressure and Its Measurement

- **Absolute pressure:** Pressure referenced to zero absolute pressure and has units of psia. Absolute pressure can only have positive value.
- **Gauge pressure:** Pressure is referenced to atmospheric pressure and by convention measured in positive direction, i.e. 7 psig.
- **Vacuum pressure:** Pressure is referenced to atmospheric pressure and by convention measured in negative direction, i.e. - 5mm Hg.

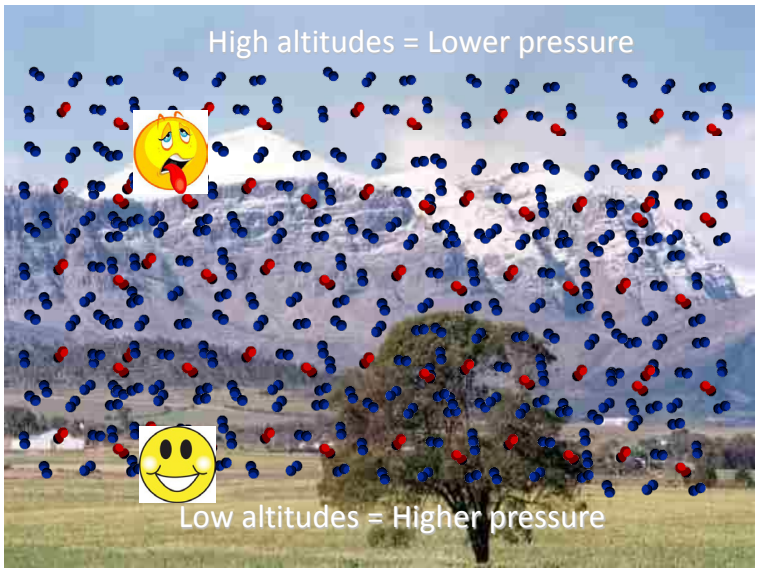
SLIDE 7:
CONCEPT OF PRESSURE AND ITS MEASUREMENT

Concept of Pressure and Its Measurement



Absolute Pressure= Atmospheric Pressure + Gauge Pressure

SLIDE 8:
CONCEPT OF PRESSURE AND ITS MEASUREMENT



SLIDE 9:
IMAGE OF PRESSURE VARIATION WITH ALTITUDE

Pressure is defined differently

Absolute pressure

Pressure mentioned with respect to zero absolute pressure (including the atmospheric pressure) is absolute pressure. The unit of absolute pressure is Pisa. Absolute pressure cannot be negative, and its value is always positive.

Absolute Pressure = Atmospheric Pressure + Gauge Pressure

Gauge pressure

Pressure mentioned with respect to atmospheric pressure is gauge pressure. By convention it is measured in positive direction like 7 psig, 100 psig, etc. g denoted gauge.

Vacuum pressure

Pressure mentioned with respect to atmospheric pressure and measured in negative direction like -5mm Hg is vacuum pressure.

In this slide the three defined pressure mentioned in slide 7 is presented figuratively.

Absolute Pressure is sum of Atmospheric and Gauge Pressure.

Difference of any two levels of pressure is called Differential Pressure.

At high altitude, pressure is lower and at lower altitude the pressure is higher. This means the pressure decreases as one move away from sea level. This has to be noted while evacuating the system. Its animated image.

Atmospheric Pressure at Site Elevation

Feet	Meters	psia	Atm	Bar	kPa	kg/cm2	In Hg	Mm Hg
0	0	14.7	1.00	1.013	101	1.03	29.9	760
328	100	14.5	0.99	1.000	100	1.02	29.5	752
500	150	14.4	0.98	0.994	99.4	1.01	29.4	747
656	200	14.3	0.97	0.988	98.8	1.01	29.2	743
1000	300	14.2	0.96	0.976	97.6	1.00	28.9	734
1312	400	14.0	0.95	0.964	96.4	0.98	28.5	725
1500	450	13.9	0.94	0.956	95.6	0.98	28.3	719
2000	600	13.7	0.93	0.939	93.9	0.96	27.8	706
2500	750	13.4	0.91	0.923	92.3	0.94	27.3	694
3000	900	13.2	0.89	0.906	90.6	0.92	26.8	681
3500	1070	12.9	0.88	0.888	88.8	0.91	26.3	668
4000	1220	12.7	0.86	0.871	87.1	0.89	25.8	655
4500	1370	12.4	0.85	0.858	85.8	0.87	25.4	645
5000	1520	12.2	0.83	0.842	84.2	0.86	24.9	633
5500	1680	12.0	0.81	0.825	82.5	0.84	24.4	620
6000	1830	11.8	0.80	0.811	81.1	0.83	24.0	610
6500	1980	11.5	0.78	0.794	79.4	0.81	23.5	597
7000	2130	11.3	0.77	0.781	78.1	0.80	23.1	587
7500	2290	11.1	0.76	0.767	76.7	0.78	22.7	577
8000	2440	10.9	0.74	0.750	75.0	0.76	22.2	564
8500	2590	10.7	0.73	0.737	73.7	0.75	21.8	554

SLIDE 10:
ATMOSPHERIC PRESSURE AT SITE ELEVATION

Measurement of Vacuum

- 1 micron = 1/1,000 of a millimeter Hg
- 1,000 microns = 1 mm Hg
- 1 micron = 1/25,400 in.
- Correct methods to measure
  - Electronic (thermistor) vacuum gauge
  - Analog, digital, or light-emitting diode (LED)
  - U-tube manometer

SLIDE 11:
MEASUREMENT OF VACUUM

Pressure Measurement

Thermo Couple Vacuum Gauge

Use to measure the fine vacuum which is difficult to measure on Compound gauge.

1 Micron = 0.001mm

i. e. 1/1000mm Hg.

Can be used to check leakage by pressure rise test.

Compound Gauge

Useful to measure the pressure at Low Side & High Side present in the Sealed System.

SLIDE 12:
PRESSURE MEASUREMENT

The table presents atmospheric pressure at site elevation. At higher elevation e.g. 1520 mtrs above sea level, atm pressure is 0.86kg/cm2 or 12.2 psia (29.4 in Hg) whereas at lower elevation e.g.150 mtrs above sea level, atm pressure is 1.01 kg/cm2 or 14.4 psia (24.9 in Hg).

At negative elevation e.g. -3000 feet downhill sea level, atm pressure is 16.4 psia (33.3 in Hg). The table has the figures for atmospheric pressures for different locations in India along with Millibar & PSI gauge reading at 0 vacuum. Therefore, the pressure gauge needle is to set at zero (Gauge Pressure) , if the gauge is moved to a higher altitude like Srinagar.

Refrigeration systems are always tested for leakage. The systems are evacuated using vacuum pump and vacuum is usually specified in microns. It should reach at least 500 microns if there are no leaks in the system.

1 micron = 1/1,000 of a millimeter Hg

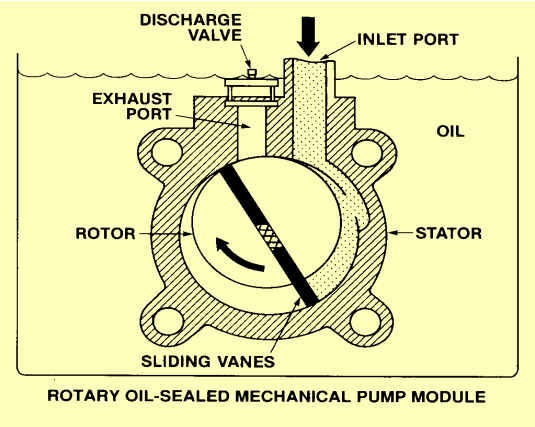
1,000 microns = 1 mm Hg

1 micron = 1/25.400 in

It is advised to use correct method to measure the vacuum. You can use Electronic (thermistor) vacuum gauge or analog, digital, or light-emitting diode (LED) or U-tube manometer for measurement of precise vacuum. The system of air-conditioner must reach below 500 microns vacuum.

In this slide Vacuum gauge and compound gauge for measuring pressure is presented. Vacuum gauge is used to measure the fine vacuum which is difficult to measure on compound gauge. This should be used to measure vacuum while evacuating process in servicing Room AC.

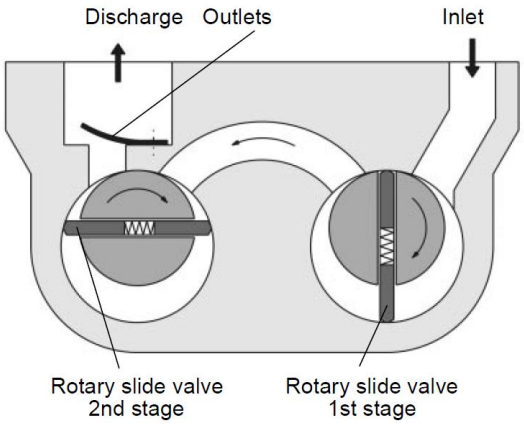
Rotary Vacuum Pump Mechanism



ROTARY OIL-SEALED MECHANICAL PUMP MODULE

SLIDE 13:
ROTARY VACUUM PUMP MECHANISM

How the 2-Stage Pump Works



SLIDE 14 TO 19:
HOW THE 2-STAGE PUMP WORKS

SLIDE 14

Gas-Ballast Valve Operation

- ❑ Water vapour sucked off from the system condenses in the pump housing and affect the sealing of vacuum ports and thus results in poor quality of vacuum.
- ❑ This results in corrosion and possibly in a decomposition of the vacuum pump oil.
- ❑ The gas ballast allows filtered fresh air in to the first stage of the vacuum pump and purges out condensate.
- ❑ During the evacuation operation, the pump should first be operated with gas ballast open to achieve better vacuum levels and enhances life of vacuum pump oil. This prevents any damage to pump due to moisture.

SLIDE 15

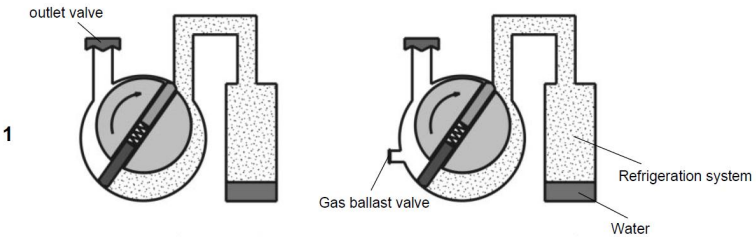
The rotary vacuum pump can be used to evacuate the refrigeration system for obtaining the high vacuum around 500 microns. This vacuum pump consist a rotor eccentrically mounted inside the stator. The rotor contains slots in which the spring loaded sliding vanes are fitted. When rotor rotates fluid volume enters from the suction port and is compressed and delivered to the discharge port through the discharge valve. The continuous operation creates the vacuum on the suction port.

Two stage pumps can be used to create the vacuum. The delivery of the first stage pump is the suction of the second stage. The fluid compressed and delivered with the help of vanes and rotor arrangement through the discharge valve.

Gas-Ballast Valve Operation

Without Gas-Ballast

With Gas-Ballast



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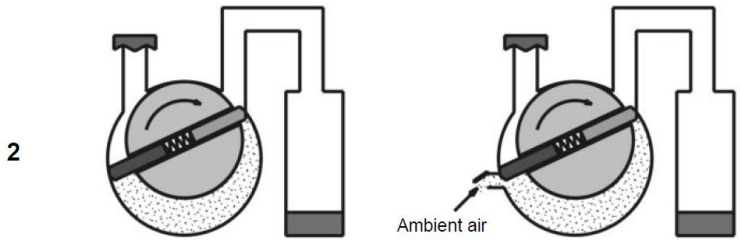
SLIDE 16

Gas-Ballast Valve Operation

Without Gas-Ballast

With Gas-Ballast



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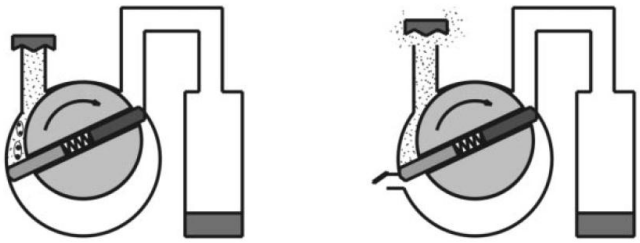
SLIDE 17

Gas-Ballast Valve Operation

Without Gas-Ballast

With Gas-Ballast

3



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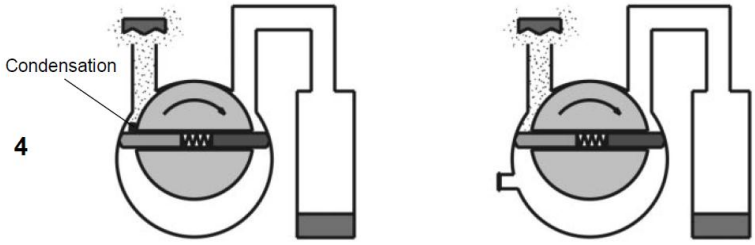
SLIDE 18

Gas-Ballast Valve Operation

Without Gas-Ballast

With Gas-Ballast



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SLIDE 19

INSTALLATION OF SPLIT AIR-CONDITIONERS WITH FLAMMABLE REFRIGERANTS

Target Group
Trainers and Technicians

Duration of the Session
30 minutes

Purpose of the Session

To make the participants aware of the safety measures to be taken and Good Service Practices to be followed while installing Split Air-conditioners with Flammable refrigerants.

Terminal Performance Objectives

At the end of this session, the participants should know:

- Importance of selecting proper location for installing Indoor and Outdoor units of split type air-conditioners
- Steps for installation of split type Room air conditioners
- Piping work involved in installation.
- Pressure Testing of the system.
- System evacuation and charging of additional refrigerant if required.
- Performance testing and customer education
- Report writing

Key Message being delivered through this Session

Knowledge and skills acquired for proper installation of SAC. Safety measures to be taken while handling flammable and higher-pressure refrigerants. Importance of proper leak testing and evacuation of system while installing. Proper use of recommended tools for installation of SAC.

Tools & Equipment (if any) required for the session
One complete set of RAC tool kit. Special tools must be shown to them in the class along with teaching.

Installation of Split Air-Conditioners

SLIDE 1:
INSTALLATION OF SPLIT AIR-CONDITIONERS:

Learning Outcomes

- ❑ Importance of selecting proper location for installing Indoor and Out door units of split type air-conditioners
- ❑ Steps for installation of split type Room air conditioners
- ❑ Piping work involved in installation.
- ❑ Pressure Testing of the system.
- ❑ System evacuation and charging of additional refrigerant if required.
- ❑ Performance testing and customer education
- ❑ Report writing

India HPMP Stage II - 2018: Installation of Split Air-Conditioners 2

SLIDE 2:
LEARNING OUTCOMES

General Steps in Installation

1	Selection of site for IDU
2	Selection of site for ODU
3	Ensure that the working area is safe
4	Check that all tools are present
5	Install ODU
6	Install IDU
7	Install Refrigeration tubes, Insulation, cabling and drain pipe
8	Connect Refrigeration tubes to ODU service valves
9	Leak test the IDU and refrigerant tubes with Nitrogen
10	Evacuate IDU and refrigeration tubes
11	Open ODU service valves and get pressure equalization
12	Depending on installation situation charge additional refrigerant
13	Routine Check
14	Report writing

India HPMP Stage II - 2018: Installation of Split Air-Conditioners 3

SLIDE 3:
GENERAL STEPS IN INSTALLATION

Quality installation of ACs is an important element required to ensure energy efficiency and prevent refrigerant leakage. If a system is installed improperly, irrespective of the certified star rating it will never work the way it was designed and it will not have the expected life.

There is a need to improve the core competencies of installers to ensure that Split air-conditioners are installed properly. This is beneficial not only as a process improvement for AC businesses, but, more importantly, ensure refrigerant containment and meet the target for HCFC phase-out.

Correct installation is very important, as it has quite a bearing on the actual effect of the air conditioner. Incorrect installation can lead to high electricity bills, poor conditioned air circulation, as well as maintenance problems. Many studies have proven that air conditioners that are improperly installed reduce its capacity and efficiency by more than twenty percent. Incorrect airflow problems are another common problem with improper AC installations. In fact, proper installation of airconditioning system is one of the key elements needed for economical and efficient operation of the system.

This slide is the summary of what the trainees will learn during the session.

The participants will get familiar with:

Importance of selecting proper location for installing Indoor and Outdoor units of split type air-conditioners. Steps for installation of split type Room air conditioners. Piping work involved in installation. Pressure Testing of the system. System evacuation and charging of additional refrigerant if required. Performance testing, customer education and Report writing.

For quality installation of Split air-conditioner following the right steps is very important. This slide presents the main steps to be followed during installation of air conditioner.

All steps presented in this slide are necessary and must follow by one after other.

Factors Affecting Performance of Air-Conditioners

- **Ambient Temperature**
- **Compressor - Type & Capacity**
- **Condenser & Evaporator Design**
- **Air-flow over Compressor, Condenser, Evaporator**
- **Liquid Control/Capillary Design**
- **Refrigerant - Type & Quantity**
- **Refrigeration Tubing & Insulation**
- **Quality Installation**

SLIDE 4:
FACTORS AFFECTING PERFORMANCE OF AIR-CONDITIONERS

Location for installation

Select the locations for IDU and ODU based on the following criteria:

- Follow manufacturers guidelines for AC selection for room size and refrigerant charge size which is utmost important because of safety considerations in case of flammable refrigerants
- Most suitable positioning of indoor unit
- Most suitable positioning of outdoor unit
- Appropriate path for interconnecting pipework
- Layout scheme for water drain piping

SLIDE 5:
LOCATION FOR INSTALLATION

Location for installation

Select the location where:

- Free air-circulation is possible for supply & return air
- Wall/panel is strong to bear the weight of the unit
- Cold supply of air reaches all the corners of the room as far as possible
- Arrangement for drainage water line from indoor unit is convenient
- Shorter length of refrigerant piping and Minimal bends are used.

SLIDE 6:
LOCATION FOR INSTALLATION

The performance of air conditioner depends on parameters like ambient temperature, type of compressor, design of condenser, evaporator, air flow quantity over the condenser and evaporator, capillary dimensions, refrigerant type and quality, tubing and insulation. At high ambient the air conditioner loses its capacity leading to lower energy efficiency. If condenser and evaporator are oversized or undersized, the air conditioner demands more power or losses capacity respectively. For better refrigerant control the capillary has to be optimized.

Normally issues listed at 1 is with nature and 2 to 7 are under manufacturer's control but issue 8 is strictly under the control of technicians and it is more important than all other. Good and bad performance depends on installation and hence the room air-conditioners must be installed carefully using right and/or recommended methods, right tools, right materials by trained / qualified technicians.

For air-conditioners with flammable refrigerants selection of location for installation is very critical. It should be based on the following considerations.

Ensure that the room size is in relation to the refrigerant charge as specified by the manufacturer.

This depends upon the type of refrigerant (Like R-290 or HFC-32) and the height at which the indoor unit is to be installed. This calculation is made in such a way that even if the entire charge quantity of refrigerant leaks in to the room the concentration will be less than the lower flammable limit.

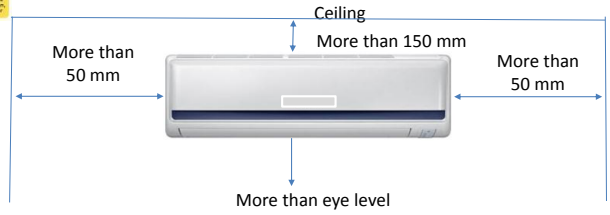
Select the most suitable positioning of indoor and outdoor unit and appropriate path for interconnecting refrigerant tubes.

Quality installation of IDU demands strong wall to bear the weight of the unit. It should be away from direct heat and breeze. There should be no obstruction for air circulation so that the cold air reaches all corners of the room.

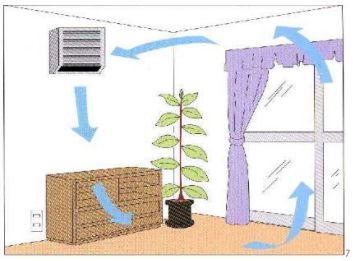
Exclusive electrical power point (phase line on the right) with circuit breaker; neither common power point, nor extension to original cable/wire.

Ensure that it is convenient to make arrangement for draining of water from indoor unit and the refrigerant tubing has shorter length and minimal bends.

Installation of indoor unit



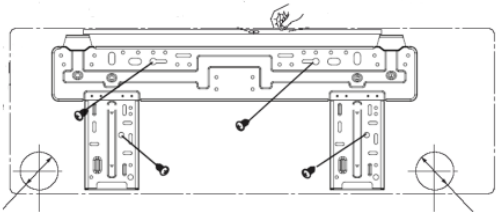
- Provide sufficient space around the unit.
- For air-conditioners with flammable refrigerant no spark points must be near to the unit
- No flare fittings for flammable refrigerants inside the room.



India HPMP Stage II - 2018: Installation of Split Air-Conditioners

SLIDE 7:
INSTALLATION OF INDOOR UNIT

Installation of indoor unit



- Mount the installation plate horizontally aligning with a sprit level.
- Drill the piping hole on right or left side as required
- Hang IDU on the installation plate
- Insert the Drain pipe through the hole drilled for piping
- Remove air filters & pour some water into drain tray to confirm smooth flow of water
- Reseal unused portion of hole around tubing's using putty

India HPMP Stage II - 2018: Installation of Split Air-Conditioners 8

SLIDE 8:
INSTALLATION OF INDOOR UNIT

Installation of Outdoor unit

- The location should be easily accessible
- Ensure that there is no source of ignition near the unit
- Foundation should be strong enough to bear the Weight & Vibration of the Unit
- Ensure that adequate space for ventilation around the Unit is available

SLIDE 9:
INSTALLATION OF OUTDOOR UNIT

Provide sufficient space around the unit (more than 50 mm on sides), sufficient distance between ceiling and unit (more than 50 mm in case of front suction or grille design and more than 150 mm in case of top suction or flat front panel design), access for drain pipe with slope towards outside,

Ensure that there is no source of ignition near the unit. For flammable refrigerants avoid flare connections inside the room. This is to prevent any leakage of refrigerant in to the rooms as flare connections, over time can develop leak due to vibration or poor workmanship.

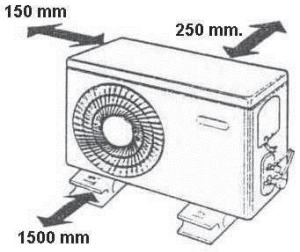
Make necessary arrangements so that the walls and surrounding areas does not get dirty during the installation. Check for the distance form top and sides as specified by the manufacturer. Mount the installation plate with one screw at the centre. Align it horizontally with a spirit level. Mark the position of other screws and fix the plate firmly. Mark the piping hole on the left or right side as required and drill a 70 to 100 mm hole slightly sloping towards outside for smooth flow of drain water. To do the terminal wiring of the indoor unit, first remove the cover and securely connect the wires to the terminals. Unroll the pipes of the indoor unit. Attach the drainage tube. Keep the drain pipe lower to facilitate water flow. Tie the pipes and the wire, then wrap it with piping tape. Insert the refrigerant pipes, electrical wire and the drain pipes through the hole made on the wall carefully without damaging them. Fix the upper part of the indoor unit to the upper part of the installation plate and press the lower part of the unit until it is securely fixed to the plate. Make sure that the unit is fixed properly.

The location should be easily accessible so that it is convenient to work on it during installation and servicing. Ensure that there is no source of ignition near the unit. The mounting wall must be strong enough to bear the weight and vibration of the unit. Install the rubber grommets and Place the unit with proper padding.

Make sure that adequate space for ventilation around the unit is available. If thre unit is mounted on support bracket the wall and the support bracket should be strong enough to take the load of the ODU.

Installation of outdoor unit

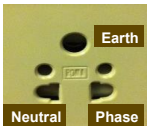
- A Wing / Shed above the Unit is desirable
- Site is not Exposed to Salty Atmosphere
- Running Noise and hot air exhaust from condenser do not disturb the neighbours
- Areas where water is likely to get accumulated, place the ODU on the concrete block or raised platform.
- Ensure that adequate space for ventilation around the unit is available:



SLIDE 10:
INSTALLATION OF OUTDOOR UNIT

Electrical connections

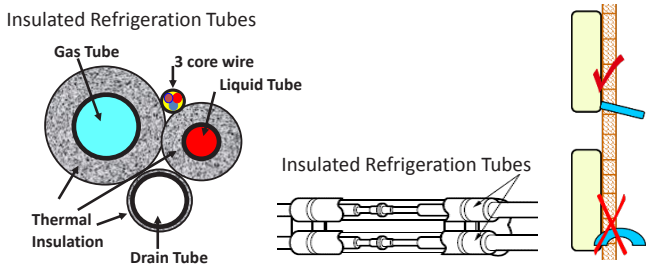
- Pass the electrical wires through the same hole drilled for the refrigerant tubing.
- Make all electrical connections as shown in wiring diagram
- Ensure adhering to the colour codes of the wires and use of only specified wires
- Ensure grounding is provided at the appropriate place
- Use always crimping connectors for wire connections
- Ensure that all electrical terminals are properly connected
- Check power supply and earth connection



SLIDE 11:
ELECTRICAL CONNECTIONS

Connecting the Tubes

- Prepare the tubes and connect the suction and liquid lines to the outdoor and Indoor unit by fastening the flare nuts.
- Do not over tighten a flare joint, use a torque wrench.



SLIDE 12:
CONNECTING THE TUBES

It is always advisable to make some arrangements to prevent direct exposure of the unit to sunlight. Direct exposure will increase the load on the compressor. The site should not be exposed to salty atmosphere. This will lead to corrosion of condenser and other aluminium parts. Install in such a way that the running noise and hot air exhaust do not disturb the neighbours.

At locations where water is likely to get accumluated, place the ODU on concrete blocks or raised platform. the clearnace of the unit at back and sides should be more than 150mm, space in front of the unit to be more than 1500mm.

This slide explains detailed procedure of installation of power connection of SAC. Technician must follow the instructions and procedure given by original manufacturer. All colour codes to be followed strictly so that technician will work on the equipment in future will not face difficulties. Always use crimping connections for all wire connections. Any loose connection is a source of ignition. Different types of wires to be used for SAC is as follows

SAC	Size of wire
0.8 / 1.0/1.5 TR	1.5 mm2
2 TR	2.5 mm2

For connecting IDU & ODU, copper tubing is necessary. When height between IDU and ODU is about 3 m then length of tube should be 5 m and when height is 7 m then length should be 10 m. Connect the piping to the Indoor Unit. Align the centres of both flares (IDU & piping) and tighten the flare nuts connecting the piping to the outdoor unit. Apply torque that is just right for flare nuts, over tightening shears the tubes, ultimately resulting into leak.

Insulate all tubing's for better performance. This slide also shows the various colour codes for tubes carrying liquid and gaseous refrigerant, drain, and 3 core electrical wires. It is must that the drain pipe should be inclined so that condensate drains. In the case of drain pipe placed like siphon the condensate will not flow.

Tightening torque required for different size flare nuts

Flare size			Min. tube thickness (mm) (For HCFC-22, R-290, HFC-32, R-410A)	Torque (Nm)
Metric (mm)	Imperial Series			
	mm	inch		
6			0.8	14 to 18
	6.35	1/4	0.8	14 to 18
	7.94	5/16	0.8	33 to 42
8			0.8	33 to 42
	9.52	3/8	0.8	33 to 42
10			0.8	33 to 42
12			0.8	50 to 62
	12.7	½	0.8	50 to 62
15			0.8	63 to 77
	15.88	5/8	0.95	63 to 77
18			1.0	90 to 110
	19.06	4/4	1.0	90 to 110

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SLIDE 13:
TIGHTENING TORQUE REQUIRED FOR DIFFERENT SIZE FLARE NUTS

Leak testing

- Do not purge the refrigeration system with the refrigerant:
  - Flammability and GWP
- Fill the IDU and connecting pipes with Oxygen free dry Nitrogen (OFDN)
- Apply soap solution to joints, connections and fittings and check for leaks.
- Keep the system under pressure for 15 min (pressure holding).
- Never start system when pressurized with OFDN.

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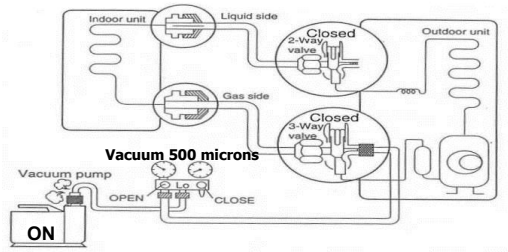
SLIDE 14:
LEAK TESTING

Evacuation

- To remove all traces of oxygen and non condensable gases it is important to evacuate the system
- Evacuate IDU and connecting tube to 500 microns or below.
- Close valves and check for vacuum holding.



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SLIDE 15:
EVACUATION

This slide explains the torque required for tightening different tube sizes. Apply torque that is just right for flare nuts, over tightening shears the tubes, ultimately resulting into leak. If a flare joint leaks even after tightening to the required torque, the reason for leakage may be due to bad flare, burrs on tube and wrong size flare. Then cut the tube and make new flare.

For reliability and environment protection the system must be pressure and leak tested. Do not purge the system with refrigerant or use it for leak testing. This is due to flammability and GWP concerns. The system should be checked for leakage using OFDN.

Nitrogen required in refrigeration and air conditioning applications should be 99.995% pure free from oxygen, air dust etc. and dew point at least -40°C. If not available, connect 25g drier-filter to the cylinder hose prior to inlet valve of hose to be connected to air-conditioner system. The test pressure of OFDN should be higher than operating pressure. Procedure for leak testing is similar for HCs & HFCs. Keep the system under pressure for 15 minutes and observe for any drop in pressure. If there is any drop in pressure identify the leak and rectify it. Use of soap solution for leak testing is permitted when the system is under positive pressure. Apply soap solution on each joint with the help of a brush and look for leakage, if any.

For better performance of air-conditioner the system should be free from air, moisture, and non-condensable gases. Therefore, it is important to evacuate the IDU during installation of air-conditioner. For deep vacuum, a suitable 2-stage rotary vane vacuum pump should be deployed (100-120 lpm. & blank-off 20 microns). Use micron gauge to measure evacuation pressure. The evacuation must reach 500 or lower microns level. A Bourdon type vacuum gauge cannot read vacuum in microns – hence actual vacuum reached cannot be known.

However, in the absence of a micron vacuum gauge, the vacuum pump should be run for about 15 minutes after the Bourdon type vacuum gauge reading shows -30" / -760 mm / 0 milli bar (at sea level).

Additional Refrigerant Quantity

- If additional tube is required contact dealer to know the additional refrigerant quantities to be charged;
- Correct quantity of extra charge be determined as under:

  For a system using 6.35mm (1/4") liquid tube and 12.7mm (1/2") gas tube with a total measured length of 15 mtr (On split air-conditioner 4mtr of tube is included on original charge.) Refer following chart to calculate charge quantity.

For –R-22

Liquid tube (15 – 4) mtr x 21.38 g/mtr = 235 g
Gas tube (15 – 4) mtr x 1.87 g/mtr = 20.57 g
Add charge of refrigerant to interconnecting tubing = 255.57g ~ 256g

Gas Tube dia	g/mtr	Liquid Tube dia	g/mtr
12.7 (1/2")	1.87	6.35 (1/4")	21.38
15.87 (5/8")	3.71	7.94 (5/16")	37.16
19.05 (3/4")	5.58	9.52 (3/8")	57.66

SLIDE 16:
ADDITIONAL REFRIGERANT QUANTITY

Performance testing

- Open service valves and allow refrigerant to equalise in the system
- If additional tube length was added in case of split unit due to positioning of IDU and ODU, charge refrigerant as per manufacturer's guidelines
- Connect power cord to electrical point and switch-on the unit
- Set control panel as desired and start the air-conditioner
- Permit air-conditioner to run for about 20-25 minutes.
- Give demonstration for effective use

SLIDE 17:
PERFORMANCE TESTING

Post Installation Check-up

- Are indoor & outdoor units installed securely?
- Is enough space provided around the units for better performance? Is anything obstructing air circulation?
- Are tubings insulated sufficiently and properly ?
- Are all gaps around unit and tubes hole filled with thermal insulation?
- Is care taken to avoid neighbor's complaints about vibration & dripping?
- Is earthing wire connected to the units properly?
- Are line voltage and current as specified?
- Do final leak testing of Refrigerant
- Check operations of electronic/electrical control panel.

SLIDE 18 & 19:
POST INSTALLATION CHECK-UP

If the distance between IDU and ODU are longer than OEM suggested one, quantity of refrigerant specified by manufacturer may not be sufficient and additional refrigerant will have to be charged.

Usually the standard length of tubing is 4 mtrs only. Additional gas charge quantity varies with the length and diameter of refrigerant tubing.

For calculation of additional charge, table is given in this slide. For 6.35mm (1/4") liquid tube and 12.7mm (1/2") gas tube with a total measured length of 15 mtr, the additional charge will be approximately 256 g of HCFC-22. Technician must use table given in this slide. OEMs need to be contacted or their service manuals must be referred for this purpose.

For air-conditioners with flammable refrigerants the selection of air-condioner has to be based on the room size and refrgerant charge quantity therefore it is essential to consult the manufacturer before extending refrigerant tubes or charging additional refrigerants.

Open the lock nuts on the service valves, then by using an Allan key to open the service valves on both vapour and liquid lines. Wait for the refrigerant to get equalized in the system. Switch on the air-conditioner and run it for 20 to 25 minutes. Observe suction pressure and supply and return air temperature. Reinstall the locknuts on the service valves. Do the final leak testing. Ensure that there are no leaks.

Give demonstration for effective use.

Do post installation check-up as explained in these slides.

Post Installation Check-up

- Does drain flow out smoothly? Is drain pipe extended with commercial rigid?
- Note temperatures of supply and return air? (Difference to be 10-12°C)
- Does drain flow out smoothly?
- Is customer educated? (Features/Benefits, filter cleaning, front grille panel, regular maintenance etc.)

Report writing
Installation Report

Installation Company's Name			
Address			
Tel #			
Technician's Name			
Customer's Name			
Address			
Tel #			
Installation / Appliance Data			
Model #		Sr. No.	
Date of Installation / Repairs		Time:	
Refrigerant's name/type		Refrigerant qty in g	
Suction pressure		Discharge pressure	
Air temp entering condenser		Air temp leaving condenser	
Air temp entering evaporator		Air temp leaving evaporator	
Total length of copper tubing		Elevation of installation	

SLIDE 20:
INSTALLATION REPORT

Installation Report

Electrical Data	
Power Supply (Voltage)	
Overall Ampere Reading	
Current draw Compressor	

Other executions for system commissioning! Tick box for completion	
Only use correct and reliable tools / equipment for system commissioning!	
Functional AC system check including performance test!	
Check the AC system for refrigerant leakage!	
Check that electrical connections are tight!	
Check that condensate drain is tight and with down-grade!	
Check insulation of refrigerant transfer tubes and quick-coupler!	
Check free run of condenser and evaporator fans!	
Check system operation (indoor/outdoor) on abnormal operational noise!	
Clean system components including air filter (if indicated)	
Check display of the remote controller!	
Execute briefing of the AC system user!	

Technician's Initials and date	Customer's Initials and date

SLIDE 21:
INSTALLATION REPORT

Sample installation report.

Sample installation report.

GOOD SERVICE PRACTICES FOR ROOM AIR-CONDITIONERS WITH NON-FLAMMABLE REFRIGERANTS

Target Group
Trainers and Technicians

Duration of the Session
45 minutes

Purpose of the Session

To train the participants for systematic servicing procedures for air conditioners.

Terminal Performance Objectives

At the end of session the participants should understand the following:

- Steps for Services for the split Room air conditioners;
- Refrigerant recovery process;
- Refrigerant handling and piping work involved in installation, repair, relocation and removal;
- Cleaning, Flushing and Pressure Testing of the Room ACs;
- System evacuation and Refrigerant charging methods;
- Refrigerants contamination and its effect;

Key Message being delivered through this Session

Currently, HCFC-22 is most commonly used refrigerants in various appliances including Room air-conditioners. As HCFCs are having Ozone depleting potential and high Global Warming Potential we need to recover the refrigerants instead of releasing the same in the environment. The good service practice is important not only because of environment issue but also to maintain the design energy efficiency of the air-conditioners. Thus, there is a need to upgrade the servicing procedure and facilities.

Tools & Equipment (if any) required for the session

HCFC-22 refrigeration system, repair tools, pressure gauges, recovery system, charging system, HCFC-22 leak detectors, filter/drier, Nitrogen cylinder, soap solution, pliers, brazing torch, temperature measuring devices etc.

HPMP

HCFC Phase-Out Management Plan, Servicing Sector

giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

Good Service Practices for Room Air-Conditioners with Non-flammable Refrigerants

SLIDE 1:

GOOD SERVICE PRACTICES FOR ROOM AIR-CONDITIONERS WITH NON-FLAMMABLE REFRIGERANTS

HPMP

HCFC Phase-Out Management Plan, Servicing Sector

Learning Outcomes

- ❑ Steps for Services for the split Room air conditioners;
- ❑ Refrigerant recovery process;
- ❑ Refrigerant handling and piping work involved in installation, repair, relocation and removal;
- ❑ Cleaning, Flushing and Pressure Testing of the Room ACs;
- ❑ System evacuation and Refrigerant charging methods;
- ❑ Refrigerants contamination and its effect.

India HPMP Stage II – 2018 : GSP for Room AC with Non-flammable Refrigerants 2

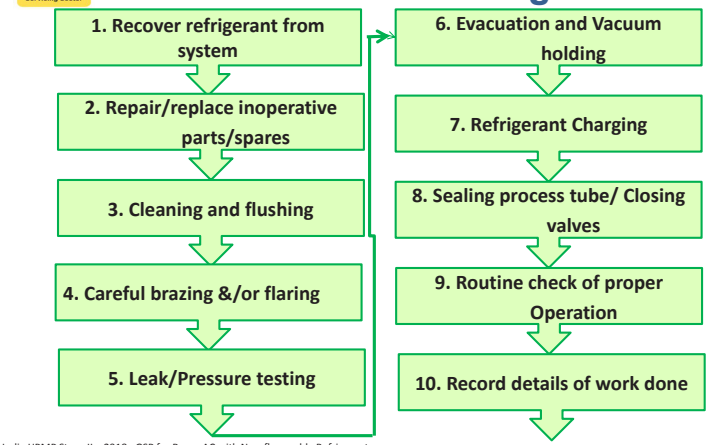
SLIDE 2:

LEARNING OUTCOMES

HPMP

HCFC Phase-Out Management Plan, Servicing Sector

Steps for Servicing of ACs with Non-flammable refrigerants



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SLIDE 3:

STEPS FOR SERVICING OF ACS WITH NON-FLAMMABLE REFRIGERANTS

Title of the presentation. This session is to learn and upgrade to quality service practice of air-conditioning system. The aim of the HPMP is to minimize the emissions of ozone depleting substances into the environment and, thus, mitigate the ozone layer depletion. The servicing must be done carefully, so that refrigerants do not emit into the atmosphere and maintain the energy efficiency of the air-conditioner.

This slide is about what the trainees will learn during the session. The trainees will learn and upgrade about importance of refrigerant recovery process, steps for installation and services for the split room air conditioners, refrigerant handling and piping work involved in the installation, repair, relocation and removal. Cleaning, flushing and pressure testing of the room ACs to be discussed. System evacuation and refrigerant charging methods will be explained. Refrigerants contamination and its effect will be presented to the trainees.

For quality servicing, selecting right steps is very important. This slide presents 10 main steps to be followed during servicing of air conditioner.

All steps presented in this slide are necessary and they must follow by one after other. The technician must have knowledge of recovery process, cleaning and flushing, copper tube operation, leak and pressure testing, evacuating, charging, sealing, which are most common practices to be done by the technician while servicing. Routine check of proper operation is important to optimise energy consumption and emission of refrigerant to the atmosphere. The details of work done to be recorded by the technician once work is finished.

Recover Refrigerant from System

- Quality service should avoid loss of refrigerant from the system, recover the refrigerant before servicing;
- Standard liquid/vapor recovery is good method for room ACs;
- Ensure availability of recovery unit and cylinder suitable for specific refrigerant;
- Use piercing plier or piercing valve;
- Use 3/8" or ¼" hose of short length to make an efficient recovery;
- Replace the filter-dryer or particulate filter on recovery unit when required.

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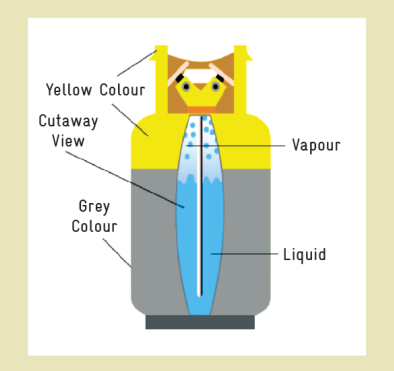
SLIDE 4:
RECOVER REFRIGERANT FROM SYSTEM

Recover Refrigerant from System

Recovery Cylinder



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SLIDE 5:
RECOVER REFRIGERANT FROM SYSTEM

Before starting the service work on the refrigerant circuit, the existing refrigerant must be removed. Considering the environmental impact of refrigerants, recovery of HCFC-22 is very important in servicing/repairing of HCFC-22 air conditioner systems, the recovered refrigerant must be stored in an external container without necessarily testing or processing it. Standard liquid and vapour recovery of HCFC-22 is good method.

Before recovery work, first you need to identify the refrigerant type and quantity in the system you are servicing. Then, it is to be checked that recovery unit and cylinder is available. Also, keep all the required tools such as safety gloves, 3/8" or ¼" diameter short length hose pipe. It is advised to have at least one cylinder for every refrigerant type serviced so that the recovered refrigerant can be put back into the same system after finishing the service, plus an extra cylinder for burnouts and other unknowns.

Always pump liquid out of the system first, and then recover the remaining vapours. This will significantly speed up recovery rates. Use an approved in-line filter to prevent contaminants from entering the recovery unit and recovered refrigerant.

In this slide, the refrigerant recovery cylinder is depicted. The image of recovery cylinder explains the internal parts and system for recovery in vapor as also liquid state of refrigerant. One should be careful in selecting the cylinder for different types of refrigerant.

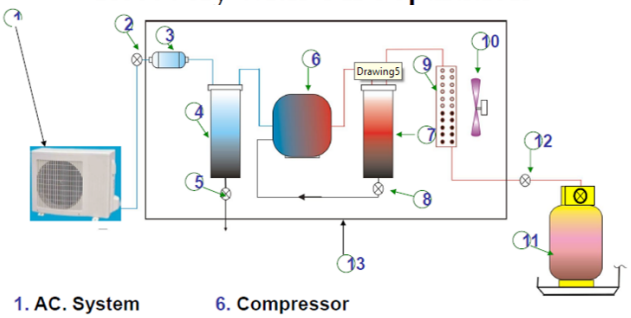
Disposable cylinders are not safe for refilling. Use only clean cylinders, free from contamination by oil, acid and moisture etc. It is also advised that only certified cylinders should be used, and they should be checked visually before using.

Do not exceed 80% of the rated capacity of the cylinder by volume. Never mix different refrigerants or recover one refrigerant into a cylinder meant for some other refrigerant. It is always good to label the recovery cylinder putting the refrigerant number, name and the weight of the cylinder and the total weight with date.

It is important to evacuate the recovery cylinders and purge the hoses to avoid contamination or introduce non-condensable gases that would increase the discharge pressure.

Recover Refrigerant from System

Recovery with Oil Separation



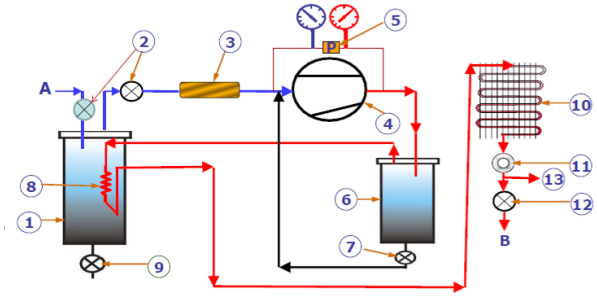
1. AC. System
2. Inlet Valve
3. Filter drier
4. Oil Separator
5. Oil drain valve
6. Compressor
7. Oil Separator
8. Oil return valve
9. Condenser
10. Fan
11. Recovery Cylinder
12. Outlet Valve
13. Recovery Unit

SLIDE 6 / 7:

RECOVER REFRIGERANT FROM SYSTEM

Recover Refrigerant from System

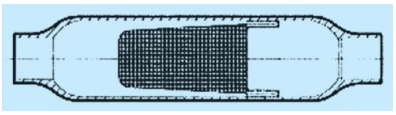
Recovery Unit



1. Distillator
2. Valves
3. Filter
4. Compressor
5. Pressure control
6. Oil separator
7. Oil drain valve
8. Heat exchanger
9. Oil drain valve
10. Condensing unit
11. Sight glass
12. Valve
13. Access valve
A. Entry-suction

Repair or Replace In-operative Spares

- Replace with genuine and recommended spares if necessary
- Each time the system is being repaired, install a new strainer and filter. This will desiccate and purify refrigerant.



Cut section of strainer

SLIDE 8:

REPAIR OR REPLACE IN-OPERATIVE SPARES

There are few steps for proper use of the vapor recovery method as under:

However, remember, your system configuration may vary. Check your operation manual to find the proper configuration for your unit.

1. Connect a hose, with a low-loss fitting on both ends, to the discharge side of the recovery equipment.
2. Connect the other end of this hose to the tank liquid port on the recovery cylinder.
3. Place the recovery cylinder on a weighing scale.
4. Connect a hose from the low-side service port of the AC system.
5. Connect the other end of this hose to the center (charging) port of your manifold set.
6. Connect a hose to the low-side of your manifold set.
7. Connect the other end of this hose to the suction side of the recovery equipment.
8. Connect a hose from the tank vapor port to the high gauge on the manifold set. This will allow you to monitor the tank pressure.
9. Close valves on manifold set.
10. Open vapor and liquid valves on the recovery cylinder.
11. Start the recovery system.
12. Allow unit to pull into the appropriate vacuum based on refrigerant type.
13. Close all valves and disconnect from the AC system or begin purge cycle.

Use approved hoses. Use approved refrigerant recovery tank made for use with the type of refrigerant being recovered. A scale must be used to indicate when the recovery tank is 80% full when it does not have the 80% Shutoff Kit option installed. Use with sufficient ventilation to keep operator exposure below recommended limits, especially in enclosed and low-lying areas. Do not operate the unit with a defective part. Wear safety goggles and protective gloves

Air conditioner system servicing is required most of the time due to some spare parts not working. It is necessary to repair these parts and if it can't be repaired needs to have replaced them.

Install fresh strainer/filter each time system is repaired to desiccate, purify and improve refrigeration effect. However, in most room air-conditioner systems the desiccants are not included in driers, but all systems are fitted with drier/strainer.

There should be very less chances of capillary getting choked due to internal frost formation. The selection of drier/strainer depends on the basis of two system characteristics, 1) type and amount of contaminants that can be expected to develop in the system and 2) maximum operating pressure of the system. A strainer having adequate screen area to catch and hold foreign particles that accumulate during the life of the unit and yet permit the refrigerant flow to continue without excessive pressure drop, it is necessary to consider the size and quantity of the contaminants. Strainer wire mesh is normally made of stainless steel, brass or phosphor bronze and sizes are from 100 x 90 to 150 x 140 etc.

In fact, in AC systems, the refrigerant and lubricant need to be kept free of moisture. Drier/filters filled with moisture-adsorbing desiccant are usually used to prevent moisture accumulation. Desiccant is a material that removes moisture from the air left out in the refrigeration system through a process called adsorption. Desiccation refers to the status of powerful drying and not absorption. There is little difference between the materials that absorb water plainly take it into themselves and the materials that adsorb water - just have the water molecules stick to the surface.

Cleaning and Flushing

- Dismantle the system parts;
- Clean the tube ends;
- Clean the spares using emery cloth/paper;
- Use cleaning agents like Haxane or Perchloro ethylene for cleaning;

- Use Oxygen-Free Dry Nitrogen (OFDN) with two stage pressure Regulator;
- Never start system when pressurized with OFDN.

India HPMP Stage II – 2018 : GSP for Room AC with Non-flammable Refrigerants

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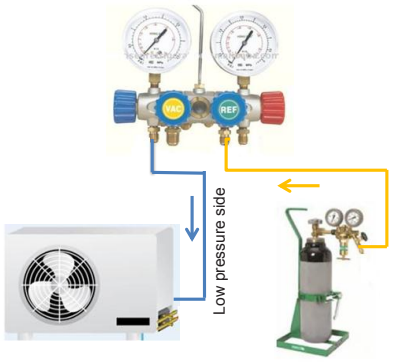
SLIDE 9:
CLEANING AND FLUSHING

Leak & Pressure Testing

- For reliability and environment protection, all systems must be pressure and leak tested
- Use only Oxygen Free Dry Nitrogen (OFDN) for pressurizing the system
- Do not pressurize the system with pressures that are above the system's test pressures. (1.1 x operating pressure)
- keep system under pressure for 15 min (pressure holding)



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SLIDE 10:
LEAK & PRESSURE TESTING

Leak & Pressure Testing

❑ **Soap Solution**

- Applying soap solution to joints, connections and fittings while under a standing pressure of dry nitrogen helps to identify leak points when bubbles appear.

❑ **Electronic refrigerant detector**

- Electronic refrigerant detectors contain sensitive element to a particular chemical component in a refrigerant.

- Audible "ticking" signal &/or visible flashing indicating lamp increases frequency and intensity as sensor analyses higher concentrations of refrigerant, which hints source of leak to be nearer/around

India HPMP Stage II – 2018 : GSP for Room AC with Non-flammable Refrigerants

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SLIDE 11:
LEAK & PRESSURE TESTING

Cleaning/ flushing is an important step of proper servicing practice. After dismantling the system, system parts where spares are to be located, both spare and system parts have to be cleaned and polished. Once the old filter drier is removed, the system needs to be properly flushed and cleaned of micro-particles and dirt present in the system.

It is suggested to flush the system using OFDN at a pressure of about 150 psi. The Nitrogen cylinder must be fitted with two stages regulator. It is a must to have proper regulator. Atmospheric air contains moisture, which is detrimental to the system. Use of air should be totally avoided. Use of petrol is to be avoided totally, Petrol contains impurities that can destroy the compressor. Refrigerants and lubricants are very sensitive to contaminants and moisture.

It is must that after joining the spares with system, entire system has to be tested for leakage. For reliability and environment protection the system must be pressure and leak tested. Joints in entire system should be checked for leakage using OFDN.

Nitrogen required in refrigeration and air conditioning applications should be 99.995% pure free from oxygen, air dust etc. and dew point at least -40°C. If not available, connect 25g drier-filter to the cylinder hose prior to inlet valve of hose to be connected to air-conditioner system.

The test pressure of OFDN should be higher than operating pressure. Duration of leak test under high pressure should be minimum 15 minutes. Never start the system when system is under OFDN.

Procedure for leak testing is similar for HCs & HFCs. Use of soap solution for leak testing is permitted when the system is under positive pressure. Apply soap solution on each joint with the help of a brush and look for leakage, if any.

This slide gives information about different leak testing methods. The cheapest and most effective system is soap solution. This must be applied only when there is positive pressure inside. When soap solution applied on fittings, joints, connections with system under pressure of nitrogen, bubbles appear on surface if system has leakage at that point.

Electronic leak detectors are also used for leak tests. The instrument has sensitive element which detects particular chemical part of refrigerant. The audible signal indicates the leakage of refrigerant from the system.

Common Leak Spots

- Flare-nuts;
- Service valve: O-rings, access fitting, mounting;
- Cracked brazed joint in tubing;
- Deteriorated evaporator / condenser end bends;
- Tubes rubbing with one another or with other materials.

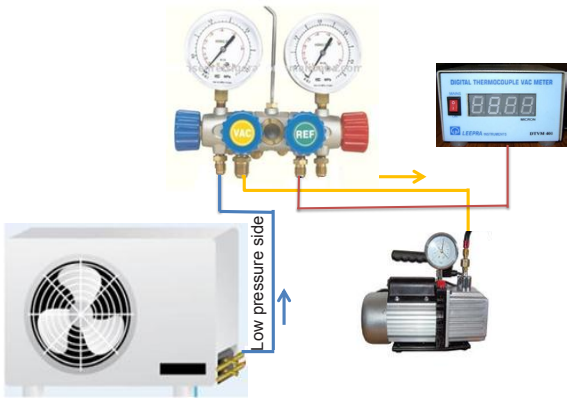
SLIDE 12:
COMMON LEAK SPOTS

System Evacuation

- Removal of moisture and non-condensable gases from the system .
- Evacuation is normally carried out by a specific vacuum pump and is ideally drawn to an absolute pressure of (500 micron) or lower. (100 lpm & blank-off about 20 microns) is a must.
- If possible, a system should be evacuated on both, high and low pressure sides
- Not to operate compressor while system is in vacuum
- Short hose with large dia. (3/8") is good for evacuating as it reduces time required for evacuation.

SLIDE 13:
SYSTEM EVACUATION

System Evacuation –1st Step



SLIDE 14:
SYSTEM EVACUATION – 1ST STEP

Usually the leak of refrigerant from sealed system is possible through mainly joints due to

- Incorrect Flare-nut joints
- Service valve: O-rings, access fitting, mounting
- Cracked brazed joint in piping
- Deteriorated evaporator / condenser end bends
- Pipes rubbing together or with other materials.

For better performance of air-conditioner the system should be free from air, moisture, and non-condensable gases. Freezing of moisture leads to choking of capillary, strainers, and filter/drier. Therefore, accurate evacuation of system is important process in servicing of air-conditioner. For deep vacuum, a suitable 2-stage rotary vane vacuum pump should be deployed (100-120 lpm. & blank-off 20 microns). Use micron gauge to measure evacuation pressure. The evacuation must reach 500 or lower microns level. The evacuation with full knowledge of the vacuum levels attained, gives assurance and knowledge of the quality of the work done. A Bourdon type vacuum gauge cannot read vacuum in microns – hence actual vacuum reached cannot be known.

However, in the absence of a micron vacuum gauge, the vacuum pump should be run at least half an hour after the Bourdon type vacuum gauge reading shows -30" / -760 mm / 0 milli bar (at sea level). Neither the vacuum level nor vacuum holding can be known from this. Therefore, superior quality of evacuation, and assurance is not as of using micron gauge.

The vacuum pump must be examined half yearly for its blank-off pressure to be between 5-20 microns. Check the Yellow hose used for evacuation and other hoses connected to manifold gauge. This makes sure that all the hoses or set-up is adequately evacuated and no chance of atmospheric air to enter during the quality repairs procedure.

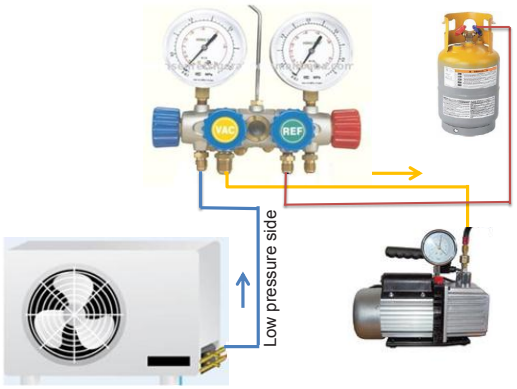
This slide presents the process of evacuation.

Make proper connections to the vacuum pump (having 4-way manifold) using adequate hose (3/8" dia.) connected to the system.

Switch on the vacuum pump and open the valves. Run the pump and evacuate till the gauge shows the lowest vacuum at which it holds steady. This level should be around 500 microns or lower, close the valve to isolate the vacuum pump from the manifold and observe the rise in pressure (vacuum holding). For measurement of vacuum, use good calibrated quality micron gauge. A micron gauge capable of reading between 5 to 5000 microns is required to make accurate measurement of the vacuum.

After reaching desired vacuum, pump to be disconnected and system should hold vacuum (should not raise above 1500 microns after 5 minutes). In case the pressure increase is greater, then the system should be evacuated once again and the vacuum holding repeated. But it may be remembered that not to heat the compressor by external heat source. This results in non-uniform heating.

System Evacuation-2nd Step



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SLIDE 15:

SYSTEM EVACUATION – 2ND STEP

Boiling Point of Water at Various Vacuum Levels

Microns	Temp. in C
7,59,968	100
5,35,000	96.11
5,25,526	90
3,55,092	80
2,33,680	70
1,49,352	60
92,456	50
55,118	40
31,750	30
25,400	26.67
22,860	24.44
20,320	22.22
17,780	20.56
15,240	17.78
12,700	15
10,160	11.67
7,620	7.22
4,572	0
2,540	-6.11
1,270	-14.44
500	-23
254	-31.11

Our aim 500 microns

Water boils even at below 0°C temp. as pressure reduces

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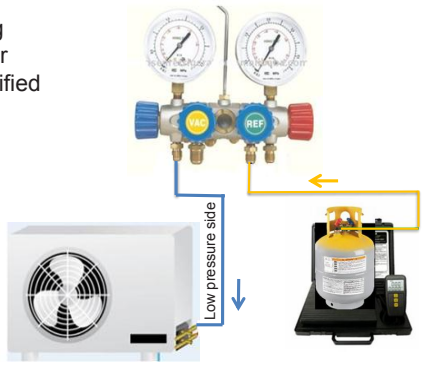
SLIDE 16:

BOILING POINT OF WATER AT VARIOUS VACUUM LEVELS

Refrigerant Charging

- Charging is transferring refrigerant from cylinder into a system in a specified quantity by weight.
- Charging should be done using a cylinder connected to the system via manifold/hoses.



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SLIDE 17:

REFRIGERANT CHARGING

After the vacuum gauge shows the vacuum, then close the valve as shown in the figure and remove the micron gauge. Then attach the charging cylinder with valve in close position. Run the vacuum pump for two minutes with high side valve in open position to remove the non-condensable gases from the charging hose. By doing this there will be no need to purge the refrigerant from the charging hose.

All liquids, at any temperature, exert a certain vapor pressure. The vapor pressure can be thought of as the degree to which the liquid molecules are escaping into the vapor phase. The vapor pressure increases with temperature, because at higher temperature the molecules are moving faster and able to overcome the attractive intermolecular forces that tend to bind them together. Boiling occurs when the vapor pressure reaches or exceeds the surrounding pressure from the atmosphere or whatever else is in contact with the liquid.

In atmospheric pressure, water boils at 100°C. As pressure decreases, the boiling temperature of water also decreases. At vacuum or much negative pressure, it boils at -20°C too. Recall the Boyles and Charles Laws for this purpose. This is why must use double stage rotary vane vacuum pump for pulling deep vacuum so that no traces of moisture can remain inside system.

For better performance of air-conditioner a correct quantity of refrigerant is important.

In case of single substance refrigerant, the charging can take place in gaseous or liquid state. Since there is no effect of atmosphere (pressure-temperature) on mass or weight of the refrigerant, weight system must be deployed for measuring amount of refrigerant while gas charging. Hence always use digital weighing scale/balance for accurate quantity of charge; this is a must for good working of the air-conditioner.

- After evacuation and off the system, arrange your tools and equipment connections as presented on the slide. Charging should be done using a cylinder connected to the system via manifold and hoses.
- Initially, manifold gauge valves should be closed, stop valves at condensing unit are open.
- Open the refrigerant cylinder valve and record the weighing scales
- Open the low-pressure valve at the manifold gauge.
- Open the refrigerant valve at the manifold gauge.
- Charge refrigerant vapour slowly into the suction side of the condensing unit
- Charge (50% of total charge) refrigerant measuring the weighing scale and close the refrigerant charging valve of the manifold gauge set.
- Switch on the unit to cooling mode, there is a time delay of 3 minutes until the compressor starts.
- Open the refrigerant charging valve of the manifold gauge set and slowly charge accurately the remaining refrigerant amount.
- Close the refrigerant cylinder valve, remove Manifold and install end-caps.
- Final leak check with soapy water or electronic leak detector.
- Do general functional test of the system

Refrigerant Charging

- Ensure system charge as per recommended in ODU
- Reconfirm airflow through the condenser and evaporator.
- In compressor, refrigerant should enter as a vapor only.
- Charging by known weight is the most accurate method, use weighing balance.
- Charging by pressure measurement or suction temperature measurement will not result in accurate charging
- Run the system and check suction pressure, temperatures & leaks, if any
- After disconnection of gauges and hoses a leak test must be carried out.

SLIDE 18:
REFRIGERANT CHARGING

Refrigerant Charging

- High operating pressures and temperatures indicate overcharge. These systems have greater leakage potential. In extreme cases, over charging will increase head pressure and reduce performance and efficiency.
- Low operating pressures indicate undercharge. making systems less efficient, with higher running costs and unable to meet the load.

SLIDE 19:
REFRIGERANT CHARGING

Charging with Blends

- Blends have different refrigerant component's concentrations in liquid and vapour at any temperature;
- Vapour-charging will result in the wrong refrigerant blend composition and would result in improper system performance.
- Refrigerant to be charged as liquid form only
- Charge gradually from the suction side of the system using a short length capillary

SLIDE 20:
CHARGING WITH BLENDS

Following to be considered while charging:

Before charging ensure the amount to be charged recommended by manufacturer. Reconfirm airflow through the condenser and evaporator. In compressor refrigerant should enter as a vapour only. Charge always in a well evacuated system. Charging should be done slowly and gradually, so that no liquid goes into the compressor. Charging should be done by weighing accurate mass of charge; this is essential for good working of the appliance. Charging by pressure measurement or suction temperature measurement will not result in accurate charging. After charging must check if there is any leakage and check the pressure and temperature.

High operating pressures/temperatures indicate that system is overcharged. There is more chance of leakage from overcharged system. It also reduces the air-conditioner performances and efficiency.

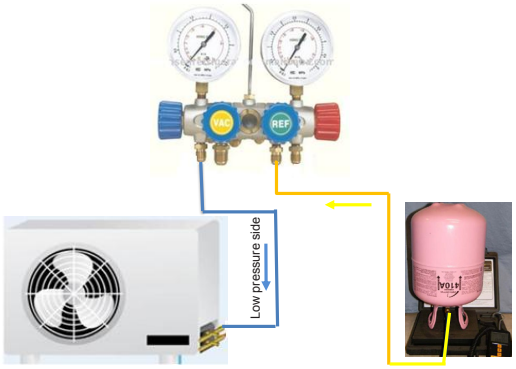
Undercharge will cause low operating pressure making system less efficient and thus cost of running system will increase and unable to meet the load required.

In case of over-charged system, the excess charge of HCFC-22 should not be vented out into atmosphere but recovered as mentioned earlier. Therefore, the technician must use weighing scale for charging of refrigerant, in addition to manifold gauge kit.

Refrigerant blends are a mixture of different refrigerant components. If the blend is a zeotropic mixture (i.e. R4xx) and it is charged as vapour, the refrigerant with the highest vapour pressure will be charged at a higher proportion than the other component(s). Charging as a liquid is the only way to guarantee that the blend is charged within its intended composition.

Fractionation of a refrigerant blend (separation of the individual components) can occur by removing the refrigerant from the cylinder as a vapour instead of a liquid. This can potentially lead to both safety and performance issues. As such, it is recommended charging all blends in liquid phase only. But one care must be taken that after charge do not start the machine immediately. Charge gradually from the suction side of the system using a short length capillary. Give sometime to refrigerant to settle in the system.

Charging with Blends



SLIDE 21:
CHARGING WITH BLENDS

Sealing Tube / Closing Valve

Split AC:

1. Close the 3-way service valve properly
2. Check for leaks
3. Put lock-nut
4. Final leak test must be done.

Window AC:

1. Crimp/Pinch (twice)
2. Do not remove pinching tool until tube is sealed
3. Braze/seal tube
4. Remove pinching/crimping tool
5. Final leak test must be done.

SLIDE 22:
SEALING TUBE / CLOSING VALVE

Contamination and Cross Contamination

- Contaminants:
  - Other refrigerants, other lubricant oils, from other systems;
  - Moisture;
  - Non – condensable gases;
  - Chemical residues;
  - Dirt, dust and metal particles;
  - Organic.

SLIDE 23:
CONTAMINATION AND CROSS CONTAMINATION

When a blended refrigerant passes through a sight-glass it will tend to flash inside the larger capacity of the glass. However, it does re-integrate as a blended liquid after passing through. This ensures you have full stream of liquid to the expansion device (TEC).

Do not over charge the HFC blends. It is better to charge the refrigerant by weight.

After correct charging of refrigerant, charging tube should be sealed or valve should be closed properly. For this follow the steps given in this slide. In any case the leak detection is a must.

Refrigerant systems can be contaminated by moisture, non-condensable (mainly if evacuation is not done thoroughly), chemical residues, dirt or dust, if care is not taken during servicing

Therefore, as a part of quality repairs to sealed system the technician must use right tools/equipment and pull the vacuum to the level of 500 microns.

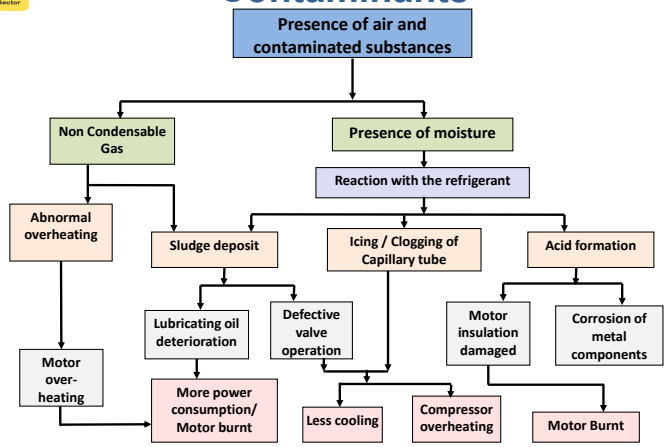
The common contaminants likely to be present are listed in this slide.

Contamination and Cross Contamination

- Probable Places for Refrigerant Cross-Contamination:
  - Recovery, Recycling and Reclamation machines used for multiple refrigerants
  - Recovery cylinders
  - Hoses and manifolds
- Avoiding Refrigerant Cross-Contamination :
  - Ensure that all traces of the previous refrigerants are removed from the charging cylinder / can / recovery unit and system is evacuated to desired vacuum (500 microns) before charging with new refrigerant
  - Use separate recovery units and cylinders for each type of refrigerant.

SLIDE 24:
CONTAMINATION AND CROSS CONTAMINATION

Effect of Presence of Contaminants



SLIDE 25:
EFFECT OF PRESENCE OF CONTAMINANTS

Routine Check-up of Performance

- Check air temperature – both supply and return air.
- Check current drawn by AC and other parameters as per name plate for quality repairs and servicing.
- Record all observations.

SLIDE 26:
ROUTINE CHECK-UP OF PERFORMANCE

In addition to the above sources of contamination, there is also the risk of cross contamination, which is the introduction or import of contaminants into a refrigeration system from another system or equipment used in servicing.

Most common examples of cross-contamination are:

- contamination of HFC by HCFC-22 or vice-versa
- contamination of HFC systems by mineral oil from HCFC-22 system
- contamination of HFC systems by chemical residues like copper or Fe chlorides from HCFC-22 systems.
- The most common sites where refrigerants can remain as substantial residuals are Gas charging stations or E&C units and the condensers of recovery or recovery & recycling machines, and also, hoses and manifolds. In both these cases, where an E&C unit or an R&R machine is used for more than one refrigerant, there are potential sites of cross-contamination, which need careful handling.
- The following action is recommended:
- Empty out all the residual refrigerant before using a different refrigerant and evacuate the E&C unit / R&R machine preferably to 500 microns before reuse. This ensures removal of almost all traces of the residual refrigerant.
- It is better however, if separate machines are used for separate refrigerants
- Recovery cylinders are other potential sources. It is absolutely necessary to use separate cylinders for each & every type of refrigerant.

In this slide effect of presence of contaminants are presented. Non-condensable gases, which have low boiling points, remain in gaseous phase under operating conditions, and will remain trapped in the condenser tubing. These gases accumulate in the condenser and blanket heat transfer surfaces, which impacts condenser coil performance and efficiency. Excessive non-condensable gases can all affect cooling capacity. Non-condensable contaminants in the system can lead to a false diagnosis of refrigerant charge. Evaporator saturation temperature can provide clues about defects due to the presence of non-condensable.

Excess moisture in refrigeration systems may lead to freeze-up of the capillary tube or expansion device. Contaminants can cause valve breakage, motor burnout, and bearing and seal failure, more power consumption, less cooling, decrease the life of compressor.

Therefore, as a part of quality repairs to sealed system the technician must use right tools/equipment and pull the vacuum to the level of 500 microns.

As part of routine check-up, measure temperatures of supply and return air after 20 minutes. Measure the current drawn by air conditioner. Keep record in job cards.

Required maintenance of the indoor unit

- Examine the fan for functionality and smooth running.
- Carefully clean the air-filter, if necessary use a shower bath with hand-warm water.
- Check the heat-exchanger (evaporator) for contamination, if necessary clean the evaporator
- Check the alignment of the evaporators fins, if necessary carefully adjust the alignment by the use of a fin-comb
- Check and clean the condensate pan and drain hose
- Check the control board (mode and temperature indicators)
- Check the connection cables, wires are free of damage and screws are tight.
- Clean the housing of the indoor unit.
- Verify the specific condition according the provided checklist

SLIDE 27:
REQUIRED MAINTENANCE OF THE INDOOR UNIT

Servicing the outdoor unit

- Examine the fan for functionality and smooth running.
- Examine the compressor for functionality and smooth running.
- Check that the fixings and vibration dampers of the compressor are in good condition.
- Check the heat-exchanger (condenser) for contamination, if necessary clean the condenser
- Check the alignment of the condensers fins, if necessary carefully adjust the alignment by the use of a fin-comb.
- Check the connection cables, wires are free of damage and screws are tight.
- Check the operational conditions of the refrigeration system.
- Clean the housing of the outdoor unit.
- Verify the specific condition according the provided checklist with page.

SLIDE 28:
SERVICING THE OUTDOOR UNIT

Servicing Refrigerant circuit

- Examine the refrigerant circuit and check that it is free of leaks by using a gas detector or soap bubbles etc., which is reliable and safe for use with the refrigerant used.
- Pay particular attention to the connections of the pipe-set between the indoor and outdoor unit, as well as to the brazed joints and mechanical connections.
- Verify that all refrigerant transferring pipes are free of vibration and do not touch each other (friction).

SLIDE 29:
SERVICING REFRIGERANT CIRCUIT

This slide presents the list of required maintenance of the Indoor unit

This slide presents the list of required maintenance of the outdoor unit

This slide presents the list of required maintenance of the Refrigerant circuit

SLIDE 30:

JOB CARD FOR QUALITY REPAIRS

This slide presents job card to be maintained for quality repairs. Every technician must keep record in job card for future reference or analysis.

GOOD SERVICE PRACTICES FOR ROOM AIR-CONDITIONERS WITH FLAMMABLE REFRIGERANTS

Target Group
Trainers and Technicians

Duration of the Session
30 minutes

Purpose of the Session

To make the participants aware of the good practices and safety measures to be taken during servicing of Split Air-conditioners with flammable refrigerant.

Terminal Performance Objectives

At the end of this session, the participants should know:

- Various tools and equipment that are used for servicing of Split air conditioners with flammable refrigerant.
- Steps for servicing of air-conditioners with flammable refrigerants.
- Safety measures to be taken during servicing of SAC with flammable refrigerants.
- Understand and acquire required skills for servicing of SAC.

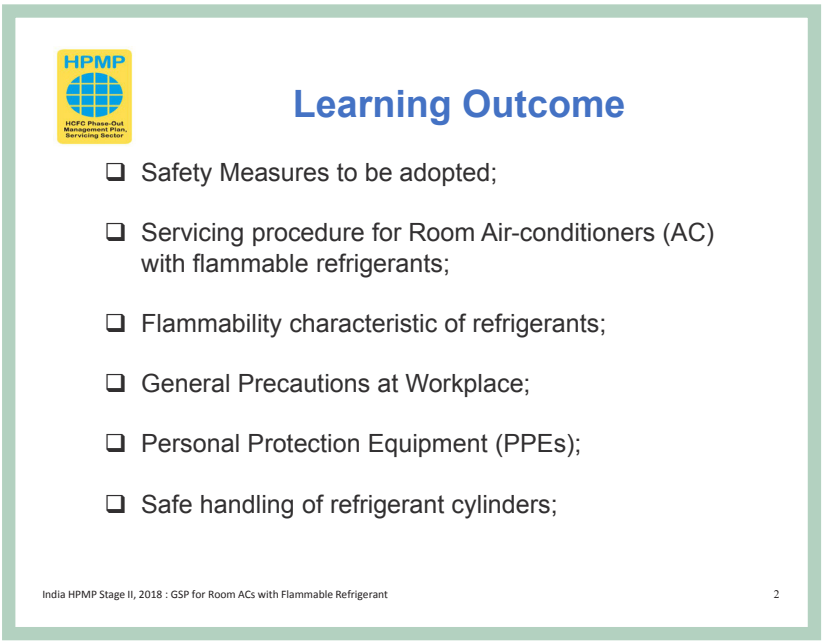
Key Message being delivered through this Session

Knowledge and skills acquired for servicing of air-conditioners with flammable refrigerants and Safety measures to be taken while handling flammable and higher-pressure refrigerants.

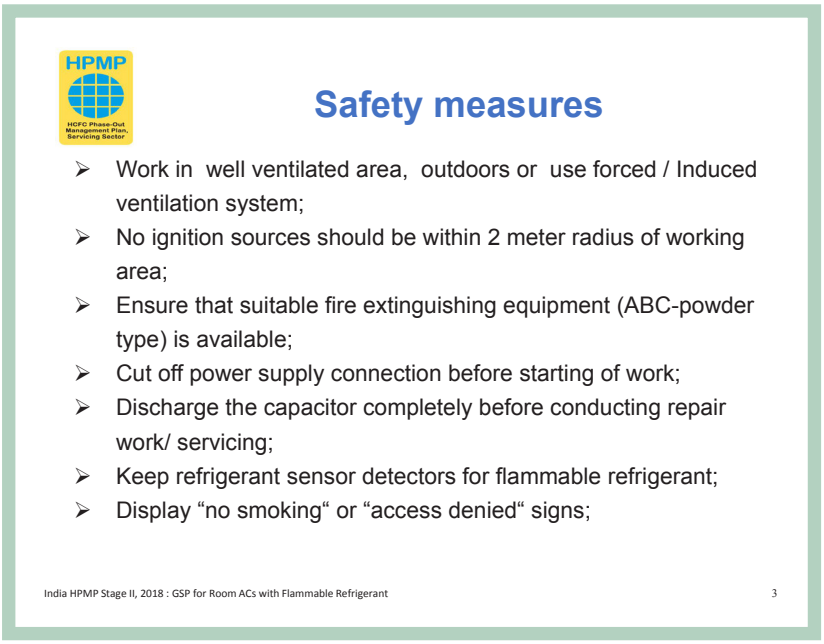
Tools & Equipment (if any) required for the session

Split air-conditioner charged with R-290 or HFC-32, repair tools, pressure gauges, long hose for venting of refrigerant, Evacuation and charging unit, R-290 leak detector, filter/drier, Nitrogen cylinder, soap solution, pliers, brazing torch, temperature measuring devices etc.

SLIDE 1:
GOOD SERVICE PRACTICES FOR ROOM AIR-CONDITIONERS WITH FLAMMABLE REFRIGERANTS:



SLIDE 2:
LEARNING OUTCOMES



SLIDE 3:
SAFETY MEASURES

This session is to learn quality service practice of air-conditioners with flammable refrigerants. The aim of the HPMP is to minimize the emissions of ozone depleting and global warming substances into the environment and, thus, mitigate the ozone layer depletion. The servicing must be done carefully, so that refrigerants do not emit into the atmosphere and maintain the energy efficiency of the air-conditioner. Because of growing concern for environment industries have started using alternative refrigerants that are eco-friendly but require safer work practices.

The participants will get familiar with:

The safety measures to be taken while servicing of Room air conditioners with flammable refrigerants. Safe venting of refrigerants, refrigerant handling, Cleaning, Flushing and leak Testing, System evacuation and Refrigerant charging methods.

They will also learn about general precautions at work place and use of PPEs and safe handling of refrigerant cylinders.

This slide presents the safety measures to be taken during servicing of air conditioners with flammable refrigerants.

Servicing Procedure for ACs with flammable refrigerants

1. Safe venting / Recovery of refrigerant;
2. Removal of left over refrigerant by vacuum pump;
3. Repair/replace defective parts;
4. Cleaning and flushing;
5. Brazing /connecting tubes;
6. Leak testing & pressure holding;
7. Evacuation & Vacuum holding;
8. Refrigerant Charging;
9. Closing of valves;
10. Checking for Proper Operation.

SLIDE 4:
SERVICING PROCEDURE FOR ACS WITH FLAMMABLE REFRIGERANTS.

Safe venting of R-290

- R-290 has zero ODP and negligible GWP, it can be released in a safe open area.
- Connect a long hose to the service valve of the AC and vent the refrigerant gradually to a safe area outside.
- Use piercing plier/valve for appliances without service valve.
- Evacuate the system to about -20" hg to remove residual refrigerant in order to eliminate the risk of flash-fire.
- To break the vacuum, fill the system with Oxygen Free Dry Nitrogen (OFDN) to a pressure of about 5 psig.

SLIDE 5:
SAFE VENTING OF R-290

Recovery of Refrigerant for HFC-32

- In case of HFC-32 recover the refrigerant before start of servicing the equipment;
- Follow the same recovery steps as for HCFC-22;
- Use recovery cylinder and recovery machine suitable for the specific flammable refrigerant.
- Recover the refrigerant to levels of -20" Hg.
- Make sure recovery cylinder is not over filled, it should be filled up only up to 80% of cylinder capacity in volume at 25℃
- Mark cylinder: weight and the type of refrigerant recovered.
- Fill the system with OFDN to a pressure of about 5 psig after recovery.

SLIDE 6:
RECOVERY OF REFRIGERANT FOR HFC-32

This slide presents 10 main steps to be followed during servicing of air conditioner with flammable refrigerants.

All steps presented in this slide are necessary and they must follow by one after other. The technician must know the importance of venting of refrigerant in to an open outside area, removal of left over refrigerant by evacuation, cleaning and flushing, leak and pressure testing, evacuating, gas charging, sealing, which are most common practices to be done by the technician while servicing. Routine check of proper operation is important for optimise energy consumption and emission of refrigerant to the atmosphere. The details of work done to be recorded by the technician once work is finished.

R-290 is non-ODS and has negligible Global warming potential. Hence it need not be recovered and can be released in to the atmosphere. It is highly flammable therefore it should be vented to safe outside open area and not to be released indoors, working area and near sources of ignition. Connect a long hose to the service valve of the AC and vent the refrigerant gradually. Use piercing plier/valve for appliances without service valve. After venting the refrigerant, it is necessary to remove the residual refrigerant remaining in the system. This is to prevent the risk of flash fire during de-brazing of system lines. Using a vacuum pump, evacuate the system to about -20" of Mercury and break the vacuum by filling the system with Dry Nitrogen to a pressure of about 5 psig. It is important to break the vacuum with dry nitrogen or else air will enter the system and contaminate the circuit.

If the air-conditioner is charged with HFC-32, the refrigerant should be recovered before starting the service work on the system. Recovery of HFC-32 is very important during servicing/repairing of HFC-32 air conditioner systems because it has a Global warming potential of 675. HFC-32 is mildly flammable and has higher pressure. Therefore, it is important to ensure that the recovery unit and recovery cylinders are suitable for HFC-32.

Always wear goggles and safety gloves while handling refrigerants. Use 3/8" or ¼" diameter short length hose pipe for recovery. Do not exceed 80% of the rated capacity of the recovery cylinder by volume. It is advised to have at least one cylinder for every refrigerant type serviced so that the recovered refrigerant can be put back into the same system after you have finished the service. Recover the refrigerant until the pressure in the system drops to about -20" of Mercury. This is to prevent the risk of flash fire during de-brazing of system lines. Put off the recovery machine and break the vacuum in the system by filling OFDN to a pressure of about 5 psig.

Repair or Replace Defective Parts

- Release the OFDN from the system
- Dismantle the system by disconnecting tubes
- Replace all defective parts without using source of flame.

Cleaning and Flushing

- Clean the tube ends by using an abrasive or emery cloth.
- Flush the system with OFDN at a pressure of about 150 psig

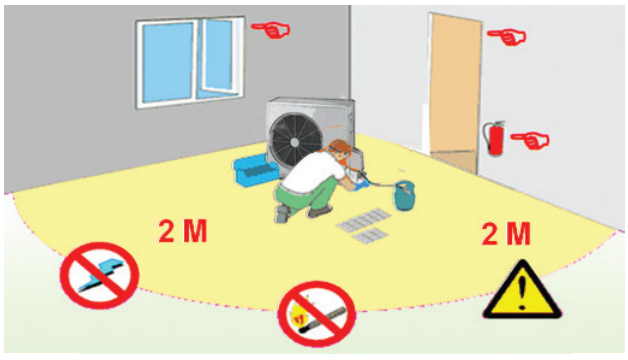
SLIDE 7:
REPAIR OR REPLACE DEFECTIVE PARTS

Safe Servicing of R-290 Room ACs

- Examine the Servicing site before starting servicing in term of safety requirements of R-290.
- The safety checklist should include the following:
  - No fire or heat source within 2 meters of installation/maintenance of the unit;
  - Shut-off the power supply to the RAC unit.
  - No smoking;
  - No entry of other than servicing technicians in the installation/maintenance site ;
  - Ensure adequate ventilation. Keep windows and doors opened ;
  - Ensure fire extinguisher equipment is available at site.

SLIDE 8:
SAFE SERVICING OF R-290 ROOM ACS

Safe Servicing of Flammable Refrigerant AC



SLIDE 9:
SAFE SERVICING OF FLAMMABLE REFRIGERANT AC

Air conditioner system servicing is required mainly due to failure of some parts. It is necessary to either repair or replace them. Release the nitrogen from the system and dismantle or de-braze the joints or the parts to be replaced. Install fresh strainer/filter without fail each time system is repaired.

Cleaning/ flushing is an important step of proper servicing practice. After dismantling the system, tube ends need to be cleaned and polished and the system needs to be properly flushed and cleaned with dry nitrogen.

It is suggested to flush the system using OFDN at a pressure of about 150 psig. The Nitrogen cylinder must be fitted with two stages regulator. Oxygen and compressed air should not be used as atmospheric air contains moisture, which is detrimental to the system. Petrol should not be used as a solvent for cleaning as it contains impurities that can destroy the compressor. Instead Perchloro Ethelene or Hexane should be used.

A list of safe servicing of R-290 Room AC is presented here. There should not be any fire or heat source within 2 meters of installation/maintenance of the unit. Shut-off the power supply to the Room AC unit. Smoking is strictly prohibited while doing servicing. No entry of other than servicing technicians in the installation/maintenance site. Ensure adequate ventilation and keep windows and doors opened. Ensure fire extinguisher equipment is available at site.

Here some pictorial view of safe servicing practice of Flammable Refrigerant AC is presented.

Brazing

- Braze in a well ventilated area.
- Do not braze with flammable refrigerant in or around the system
- While brazing, to prevent oxide formation inside the tubes, slowly pass Nitrogen through the tube, without building up pressure
- Do not over heat the tubes.
- No smoking .

SLIDE 10:
BRAZING

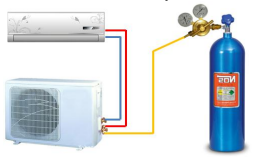
Ignition Sources

- Flames
  - brazing torches
  - match, etc.
- Sparks
  - unsealed electrical switches
  - loose wires
  - damaged/broken sockets
  - loose joints and terminals
- Static electricity

SLIDE 11:
IGNITION SOURCES

Leak testing & Pressure holding to ensure system is leak-tight

- Pressurize the system with OFDN with a maximum pressure of 1.1 times the operating pressure



- Observe the changes in system pressure, if any, to determine whether there is the leak.
- Apply soap solution to joints, connections and fittings to identify leak points
- Check the leak by keeping system under pressure for about 15 min (pressure holding).

SLIDE 12:
LEAK TESTING AND PRESSURE HOLDING TO ENSURE SYSTEM IS LEAK-TIGHT

Brazing is an important process in servicing of air-conditioners for containment of refrigerant. Brazing should be done in a well-ventilated area. Do not braze with flammable refrigerant in or around the system. To prevent oxidation inside the system components, it is recommended to pass nitrogen through the tubes at very low pressure without building up any pressure inside the system.

Heat should be applied uniformly by moving the torch around and across the joint. The filler rod should melt only on contact with the heated base metal. Do not over heat the joints. Smoking is strictly prohibited where brazing is done and especially while servicing appliances with flammable refrigerants.

This slide illustrates different sources of ignition. These include flames due to brazing torches, match or cigarette lighter or sparks from unsealed components such as electrical switches (door switches), relays, OLPs or loose wires or even static electricity.

The basic safety logic is that in order to have an explosion, there should be a combustible mixture of gas and air (Oxygen) within the flammable limits, and simultaneously, there should be an ignition source with sufficient intensity to initiate and sustain the explosion. Therefore, the first step is to avoid the possibility of any leak. Even if there is a leak, make sure that a combustible mixture is not formed. In addition to this, the area should be controlled in such a way that the sources of ignition are eliminated or avoided.

For reliability and environment protection the system must be pressure and leak tested. The entire system should be checked for leakage using OFDN with a maximum pressure of 1.1 times the operating pressure.

Nitrogen required in refrigeration and air conditioning applications should be 99.995% pure free from oxygen, air dust etc. and dew point at least -40°C. If not available, connect 25g drier-filter to the cylinder hose prior to inlet valve of hose to be connected to air-conditioner system. Procedure for leak testing is similar for HCs & HFCs. Keep the system under pressure for 15 minutes and observe for any drop in pressure. If there is any drop in pressure identify the leak and rectify it.

The cheapest and most effective method of identifying leak is by use of soap solution. This must be applied only when there is positive pressure inside. When soap solution is applied on fittings, joints, connections with system pressurised with nitrogen, bubbles appear on surface if system has leakage at that point. Refrigerant leaks can occur from anywhere through out the system. Look for wet oily spots along the refrigerant tubes and components. Most of the time that may be an indication of leak.

Evacuation

- Evacuate the system to ensure no traces of air and moisture left in the system;
- A two stage vacuum pump designed for flammable refrigerant should only be used for vacuuming the system.
- The vacuum pump outlet should be connected to a long pipe and kept outside the building/workshop in an open area;
- Vacuum pump power lead should be at least 1.5 meters long and should be kept away from the refrigerant charging point;
- Vacuum pump oil level should not be less than full scale 2/3.
- Use a digital micron gauge to measure level of evacuation.
- Evacuate the system to 500 microns or below
- Once desired vacuum is achieved, disconnect pump and check vacuum holding (Should not raise above 1500 microns after 5 minutes)

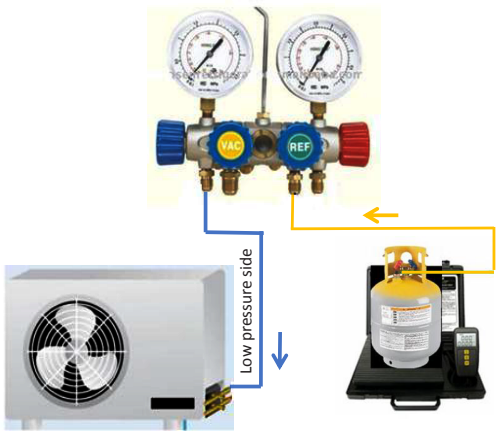
SLIDE 13:
EVACUATION

Charging R-290 Room AC

- Charging of AC with flammable refrigerant is similar to those using HCFC-22 refrigerants;
- Charging should be carried out in safe and well ventilated area,
- Ensure system has been adequately evacuated (500 microns), refrigerant
- Charging should be by weight using electronic scale of accuracy of 5g;
- Never charge more than the recommended by the manufacturer (as written on the AC unit),
- Charging speed should be slow, ,
- The refrigerant charging hose should not be too long.
- Label the system when charging is completes with flammable sign. if it is not already labeled.

SLIDE 14:
CHARGING R-290 ROOM AC

Charging of R-290 Room AC



SLIDE 15:
CHARGING OF R-290 ROOM AC

For better performance of air-conditioner the system should be free from air, moisture, and non-condensable gases. Therefore, it is important to evacuate the system during servicing of air-conditioner. For deep vacuum, a suitable 2-stage rotary vane vacuum pump should be deployed (100-120 lpm. & blank-off 20 microns). Use micron gauge to measure evacuation pressure. The evacuation must reach 500 or lower microns level. A Bourdon type vacuum gauge cannot read vacuum in microns – hence actual vacuum reached cannot be known. The vacuum pump outlet should be connected to a long pipe and kept outside the building/workshop in an open area. Vacuum pump power lead should be at least 1.5 meters long and should be kept away from the refrigerant charging point. Vacuum pump oil level should not be less than full scale 2/3.

After the desired vacuum is achieved, close the valve and isolate the vacuum pump to check the system for vacuum holding. (should not raise above 1500 microns after 5 minutes). In case the pressure increase is greater, then the system should be evacuated once again and the vacuum holding repeated. A certain amount of refrigerant remains mixed with the lubricant. Warming by running the compressor before evacuation helps in evacuation process. But it may be remembered that not to heat the compressor by external heat source. This results in non-uniform heating.

For better performance of air-conditioner the refrigerant charge quantity should be accurate. Therefore, always use a digital weighing scale for charging with an accuracy of 5g. Before charging ensure the system has been adequately evacuated, about 500 microns.

Since both R-290 and HFC-32 are single substance refrigerants, the charging can take place in gaseous or liquid state. Both under charging and overcharging will reduce the system performance and efficiency. Over charging may lead to refrigerant circuit burst. This is dangerous as both R-290 and HFC-32 are flammable. Charging speed should be slow and refrigerant charging hose should not be too long.

Label the system when charging is completed with flammable sign, if it is not already labelled.

This slide shows how refrigerant charging cylinder is connected to the system using a four-way gauge manifold to charge the refrigerant into the system.

Sealing of System and performance checking

- Close the 3-way service valve properly
- Check for leaks
- Put lock-nut
- Final leak test must be done.
- Check air temperature – both supply and return air.
- Check voltage and current drawn by AC
- Record all observations.
- Labelling.

SLIDE 16:
SEALING OF SYSTEM AND PERFORMANCE CHECKING

Higher Pressure Refrigerants

- Some of the refrigerants like R-32 & R-410A have higher operating pressures
- Important to understand the danger from pressure explosion
- Use cylinders with the right pressure rating and frequently check the condition of cylinders.

Refrigerant	Cylinder service pressure PSIG
R-22	260
R-134a	260
R- 404A	300
R-407C	300
R-410A	400
R-32	400

Source: The Refrigeration Service Engineers Society, USA

Typical test pressure is 2 to 2.5 times the service pressure.

SLIDE 17:
HIGHER PRESSURE REFRIGERANTS

Safe Handling and Storage of Flammable Refrigerant Cylinders

- The servicing technicians should strictly comply the following to ensure safe storage, handling and use of R-290 cylinders:
  - No direct exposure of cylinders to sun light;
  - Store R-290 refrigerant cylinder in upright position;
  - R-290 cylinders storage should be in well ventilated;
  - R-290 cylinders storage should be away from opened-flame or heat source;
  - Regularly check valve of R-290 cylinder making sure that there is no leakage;
  - No refilling of R-290 disposable cylinders.

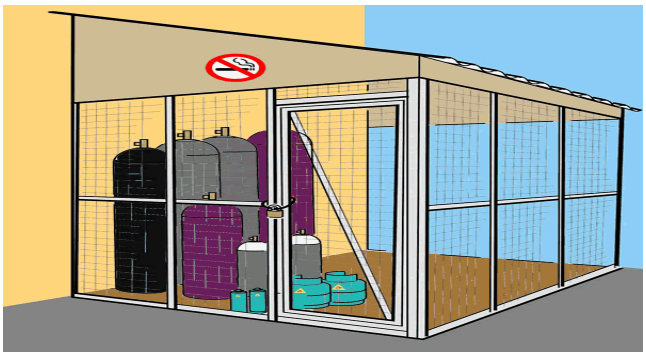
SLIDE 18:
SAFE HANDLING AND STORAGE OF FLAMMABLE REFRIGERANT CYLINDERS

Close the 3-way service valve properly, Check for leaks and put lock-nut. Do final leak test. Check air temperature – both supply and return air. Check voltage and current drawn by AC. Record all observations. Do labelling.

Refrigerants like HFC-32 and R-410A have higher operating pressures. These refrigerants should not be stored in cylinders rated for refrigerants like HCFC-22. Always check the pressure rating of the cylinder before filling the cylinder with any refrigerant. The table given in the slide shows the pressure rating recommended for different refrigerants. The test pressure of any cylinder is 2 to 2.5 times the service pressure.

The servicing technicians should strictly follow safe storage process, handling and use of R-290 cylinders. Do not allow direct exposure of cylinders to sun light. Store R-290 refrigerant cylinder in upright position. R-290 cylinders storage should be in well ventilated. R-290 cylinders storage should be away from opened-flame or heat source. Regularly check valve of R-290 cylinder making sure that there is no leakage. R-290 disposable cylinders should not be refilled.

Safe Storage of HC and other Pressurized gas Cylinders



India HPMP Stage II, 2018 : GSP for Room ACs with Flammable Refrigerant 19

SLIDE 19:
SAFE STORAGE OF HC AND OTHER PRESSURIZED GAS CYLINDERS

General Precautions

- Follow the Petroleum and Explosive Safety Organization (PESO) Regulations for transport of flammable and high pressure refrigerants;
- Do not transport refrigerant in the passenger compartment of a vehicle.
- Always keep First - Aid box
- Use dry powder fire extinguisher

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SLIDE 20:
GENERAL PRECAUTIONS

This slide explains pictorially how to store the flammable refrigerants. It should be handled and stored in the same way as LPG or any other flammable gases. Cylinders should be stored in dry and ventilated areas away from fire. Any build-up of static electricity should be avoided. It is ideal to store the cylinders outside in a secure and locked compound, protected from weather and direct sun light. The cylinders should be kept upright with valves closed and capped. There should be no ignition sources in the proximity of the storage area.

Cylinders can also be kept inside provided all safety measures are implemented. However, they should not be stored inside, if the premises are residential. A flammable gas alarm should be fitted in the bulk storage area. Cylinders should preferably be stored on the ground floor and never in basements. If stored in a basement, in case of any leakage the refrigerants will accumulate there and will not be easily dispersed. This can eventually lead to an explosion, if there is any spark in the room. HC cylinders should not be stored with other flammable substances, particularly flammable gases. Storage of empty cylinders should be segregated from that of the filled-up cylinders

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Follow the Petroleum and Explosive Safety Organization (PESO) Regulations for transport of flammable and high-pressure refrigerants. Do not transport refrigerant in the passenger compartment of a vehicle. Always keep First - Aid box. Use dry powder fire extinguisher.

GOOD SERVICE PRACTICES FOR ENERGY EFFICIENT OPERATION OF ROOM AIR-CONDITIONERS

Target Group
Trainers and Technicians

Duration of the Session
30 minutes

Purpose of the Session

To make the participants aware of the Good Service Practices for Energy Efficient Operation of Room Air-conditioner and advices to educate the customer for energy efficient operation and preventive maintenance and checklist for good service practices for energy efficient operation.

Terminal Performance Objectives

At the end of the session, the participants should know:

- Importance of adopting Good Service Practices for Energy Efficient Operation of Room AC
- Good Service Practices for Energy Efficient Operation
- Advices to educate customer for energy efficient operation
- Preventive Maintenance;
- BEE, Energy star labeling and why it is important;
- Checklist for Good Service Practices for Energy Efficient Operation

Key Message being delivered through this Session

Good service practices those technicians should follow while performing servicing. The energy consumption can also be lowered by periodic preventive maintenance, using BEE energy star labelled Room Air-conditioner and energy efficient operation. The technician will learn in this presentation the advices that they should provide the AC users for operating the systems efficiently.

Tools & Equipment (if any) required for the session
None.

Good Service Practices for Energy Efficient Operation of Room Air-conditioners

SLIDE 1:
GOOD SERVICE PRACTICES FOR ENERGY EFFICIENT OPERATION OF ROOM AIR-CONDITIONERS

Learning Outcomes

- ❑ Importance of adopting Good Service Practices for Energy Efficient Operation of Room AC;
- ❑ Good Service Practices for Energy Efficient Operation;
- ❑ Advices to educate customer for energy efficient operation;
- ❑ Preventive Maintenance;
- ❑ Bureau of Energy Efficiency (BEE) Energy star labeling;
- ❑ Checklist for Good Service Practices for Energy Efficient Operation.

SLIDE 2:
LEARNING OUTCOMES

Importance of Good Services Practices

Minimize the emission of refrigerants from air conditioners	The potential release/leakage of refrigerants from air-conditioners during installation, servicing, operation has a significant impact on the energy, environment and climate.
Maintain the original performance of the Air-conditioner	Maintain the system efficiency as designed and do not deteriorate the performance of AC while performing service and repair
Costumer Satisfaction	- Save energy bill - Improved occupant comfort and Achieve job satisfaction - Better working relationships and Win repeat business

SLIDE 3:
IMPORTANCE OF GOOD SERVICES PRACTICES

Room air-conditioner consumes high energy as compared to other household appliances. The efficiency of the Room Air-conditioner decreases due to age, defects and poor service practices. To maintain the designed energy efficiency of Room Air-conditioner it is necessary to follow good service practices and periodic preventive maintenance. With proper maintenance of air-conditioner, there will be significant saving of energy use. The household energy consumption can be lowered by energy efficient operation and adopting high BEE energy star labeled Room Air-conditioner. This presentation discusses about the service practices that should be followed while servicing for energy efficient operation of Room Air-conditioners.

These are the list what participants will learn in this session. Participants will know the importance of adopting Good Service Practices for energy efficient operation of room AC. It is important for the customer to know how to operate the air-conditioner efficiently and this session specifies the advices that service technician can give to the customer. Periodic maintenance is needed to maintain the designed efficiency of the room AC and desired comfort. BEE energy star labelling and it's importance will also be discussed. At the end the checklist for Good Service Practices for energy efficient operation will be presented.

Minimize the emission of refrigerants from air-conditioners:

Most of the refrigerants have harmful impact on the environment, so during installation and/or servicing care should be taken to avoid release of refrigerants to the environment.

There should not be any leakage in the system and lines, so that the system will run at the designed optimal efficiency. It is very important to examine the leak source, determining the reason for the leak and carry out repair/servicing the air-conditioning system properly.

Maintain the original performance of the Air-conditioner:

The efficiency or performance of the air-conditioner degrades due to the age of the equipment and poor servicing. It would result in high energy consumption for the same cooling required.

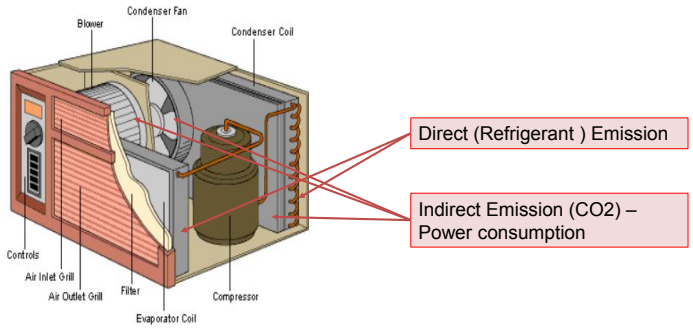
The service technician should follow the good service practices to achieve the original/designed performance of the air-conditioner.

Customer Satisfaction:

Service technician can help customer to save the energy bill with improved occupant comfort by quality installation of the air-conditioner and suggesting right way of operating the system.

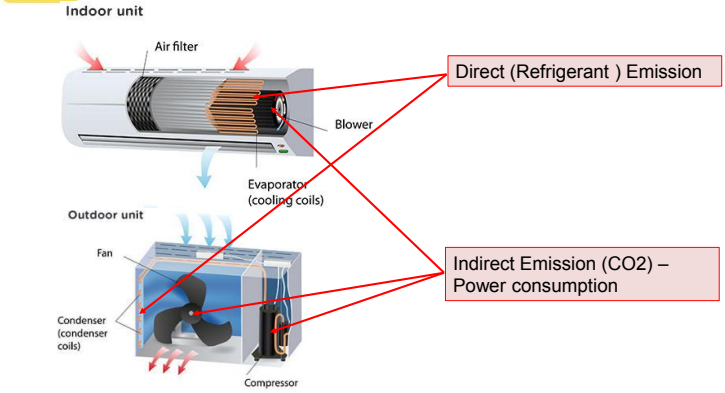
Service technician should always make sure that the customer is satisfied with the job, which will make good relationship with the customer, and will help in getting enhanced/repeated business.

Sources of Emissions



Window Room Air-conditioner

Sources of Emissions



Split Room Air-conditioner

Preventive Maintenance

- Periodically inspecting, servicing, cleaning, or replacing defective parts to prevent high energy consumption/ sudden failure;
- Preventive maintenance helps the system to maintain original energy efficiency and minimizes the chances of leakage and emission of refrigerant;
- Follow manufacturer's recommended schedule for Preventive Maintenance.

SLIDE 4 AND 5:
SOURCES OF EMISSIONS

SLIDE 6:
PREVENTIVE MAINTENANCE

In these two slides emissions of global warming substances using room air-conditioners are presented.

There are direct emissions of refrigerant used in ACs during installation, servicing during working life due to leakage of refrigerant and disposal of ACs, at the end of life. As HCFCs and HFCs are having high global warming potential (e.g. GWP of HCFC-22 is 1820, R-410A is 2080), such emissions to environment contribute towards global warming.

Indirect emission is due to electricity consumption during the working life time of the equipment. Generation of electricity in the power plants results in CO_2 production and its emission to the environment, which is one of the Greenhouse Gases (GHGs). The indirect emissions are 4 times that of refrigerant emissions. The emission of CO_2 causes global warming.

This slide shows some importance of preventive maintenance. To prevent chance of sudden failure of the system, it is good to have periodic inspection, cleaning and replacing the defective parts. Preventive maintenance is important to maintain the original energy efficiency of the system and for the environmental perspective, so that there would be no leakage of refrigerant to the environment. Also, due to poor functioning of some parts of the system, it is good to replace that.

Manufacturers recommend the schedule for the preventive maintenance. It should be done according to the schedule given.

Good Services Practices for Energy Efficient Operation

❑ Cleaning of condenser and evaporator coils

- Make sure condenser and evaporator coil surfaces are free from dust, debris and other contaminants;
- Clean the condenser and evaporator coils periodically, clean with cleaning agent to avoid coil choking and poor performance of the system.

SLIDE 7:

GOOD SERVICES PRACTICES FOR ENERGY EFFICIENT OPERATION

Good Services Practices for Energy Efficient Operation

❑ Energy Efficiency Consideration on Electrical components

- Connect all the wires/cables properly and durably. Loose cables may lead to energy loss and also overheating or sparking;
- Select correct value of capacitor;
- Use the relay specified by the manufacturer of the AC.

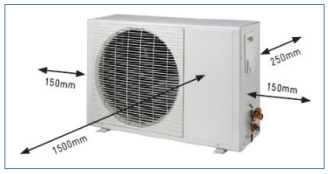
SLIDE 8:

GOOD SERVICES PRACTICES FOR ENERGY EFFICIENT OPERATION

Good Services Practices for Energy Efficient Operation

❑ Avoid restrictions of Airflow over

- Condenser Coil – Place the outdoor unit such that the air flow over the condenser is not restricted.
- Evaporator/cooling Coil – Perform periodic proper cleaning of air filter.



SLIDE 9:

GOOD SERVICES PRACTICES FOR ENERGY EFFICIENT OPERATION

Dust debris or contaminant creates fouling on evaporator surfaces, which reduce airflow and poor heat transfer in condenser and evaporator resulting in less cooling and reduction in overall performance and efficiency of AC. The excessive accumulation of dirt on the evaporator may have ice formation on coil surface.

Dust, debris can be sucked into the fins of a condensing unit coil as air is drawn through them by the fan. These obstructions will lower the effectiveness of the coil, elevate condensing temperature, and reduce cooling efficiency. A visual inspection is generally adequate to determine whether the coil must be cleaned, though cleaning a relatively unobstructed coil will likely improve efficiency.

Both the evaporator and condensers coil should be cleaned at least twice in a year. The filters of ACs should be cleaned frequently.

While servicing it is to be checked that all wires/cables are properly connected, any loose connections should be avoided completely. There will be energy loss due to loose connections of wires and also chances of overheating and sparking which is a heavy danger in case of flammable refrigerant.

When replacing electrical parts like running capacitor and starting fan motor capacitor, only select the parts recommended by the manufacturer. A wrong size capacitor could cause the compressor/fan motor to overheat, decrease the efficiency and shorten its life. Also, use the relay specified by the manufacturer.

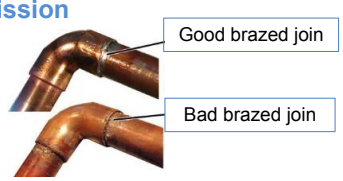
Avoid restriction of Airflow over condensing coil and evaporator coil:

There should not be any obstruction to the circulation of air, restriction on air flow will reduce the AC performance. The space around the ODU must be more than 150-250 mm (6”–9.8”) in the rear and more than 1500 mm (59”) in front of the unit. There should be adequate space, more than 150 mm (6”), around the IDU. The distance between the ceiling and the IDU should be more than 50 mm (2”) in the case of front suction or grille design and more than 150 mm (6”) in the case of top suction or flat front panel design.

Good Services Practices for Energy Efficient Operation

❑ **Aim for Zero refrigerant emission**

- Follow the correct method/procedures/good services practices for copper tubing operation.



❑ **Replace with only clean and correct size of Copper Tubes**

- Use clean copper tubes and always close the cap of copper tubes to avoid entering of moisture, dust and other contaminants;
- Always select the correct sizes of copper tubes and minimize the number of bends.

SLIDE 10:
GOOD SERVICES PRACTICES FOR ENERGY EFFICIENT OPERATION

Good Services Practices for Energy Efficient Operation

❑ **Leak and Pressure Testing**

- All systems must be pressure and leak tested for reliability and environment protection. For leak-proofing the system, joints must be pressure tested.

❑ **Use Oxygen-Free Dry Nitrogen**

- Oxygen-Free Dry Nitrogen (OFDN) should be used for pressure testing and flushing of the system.

SLIDE 11:
GOOD SERVICES PRACTICES FOR ENERGY EFFICIENT OPERATION

Good Services Practices for Energy Efficient Operation

❑ **Avoid Sludge and Oxide formation**

- Sludge and oxide formation can reduce the thermal conductivity of copper tubes and reduce cooling capacity.
  - Clean the condenser and evaporator coil with solvents like Haxane or Perchloro ethylene and flush the system thoroughly with OFDN;
  - While brazing, to prevent oxide formation on the inside of the tubes, slowly pass Nitrogen through the tube at a regulator pressure of about 0.5 bar to 1 bar.

SLIDE 12:
GOOD SERVICES PRACTICES FOR ENERGY EFFICIENT OPERATION

Aim for zero refrigerant emissions

Leakage of refrigerant is harmful to environment. The reduction of refrigerant charge in the system due to leakage results in decrease in system performance and efficiency.

It is important to follow the correct method of copper tube operation to ensure no leakage from copper tubing joints.

Replace with only clean and correct size of copper tubes

The copper tubes coils are filled with low-pressure nitrogen gas and sealed with a cap at each end to keep the tubing safe from contamination by oxygen, dust and moisture in the air.

Oxygen reacts with copper and creates a layer of copper-oxide inside the tube. These may cause contamination in the system so always close the remaining parts of the copper tubes with caps after cutting as well as the system if it is opened for servicing.

Ensure the use of proper size of the copper tubes. Incorrect size and more number of bends results in pressure drop in the refrigeration circuit which increases energy consumption of the AC. This changes the performance characteristics, so maintain right size of tubes and try minimum bends.

Leak and Pressure Testing

Air-conditioners are designed to operate with a fixed amount of refrigerant charge. If it has been deducted that a system has insufficient refrigerant, the system must be checked for leaks, then repaired and recharged. Leak test is important for reliability and environmental protection. Apply soap solution to joints, connections and fittings while system is running or under a standing pressure of nitrogen to identify leak points through appearance of bubbles. Electronic leak detector can also be used for leak detection.

Use Oxygen-Free Dry Nitrogen (OFDN)

After repairing and joining processes the system must be tightness and pressure tested. This is to be done by pressurizing the system with OFDN.

Avoid Sludge and Oxide formation

After long operation and due to some contaminants, there may be sludge and oxide formation inside the system that can reduce the heat transfer rate and thus cooling capacity.

So, it is required to clean the condenser and evaporator coil with solvents and flush the system thoroughly with OFDN when system is opened for servicing. Slowly pass low pressure OFDN through the tubes.

Good Services Practices for Energy Efficient Operation

❑ **Proper evacuation of system**

- Ideal vacuum should be about 500 micron or lower; If non condensable gases, Air, N_2, O_2, and moisture are left in refrigerant line, these decrease the energy efficiency of the system-
  - Contribute to higher than normal pressures and discharge temperatures – result in more power consumption;
  - Reduce the cooling capacity of the system.

❑ **Use Quality Refrigerants**

- Impurities in refrigerant cause non-condensable gases/ moisture in system, choking of capillary, cross contamination of refrigerants, pressure variation; thus affecting the performance.

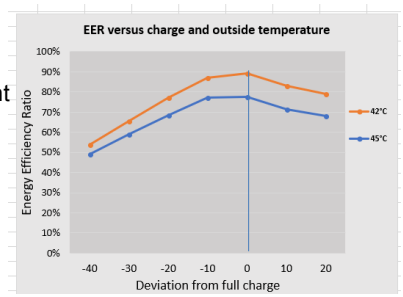
SLIDE 13:

GOOD SERVICES PRACTICES FOR ENERGY EFFICIENT OPERATION

Good Services Practices for Energy Efficient Operation

❑ **Refrigerant Charge Quantity as specified on the outdoor unit of the Air-conditioner**

- Over charge of refrigerant increases the compressor power consumption
- Under charge of refrigerant decreases the cooling capacity
- Therefore, Less and more charge both decrease the efficiency of the system
- Charging by weight is the best method for proper functioning of Room ACs;

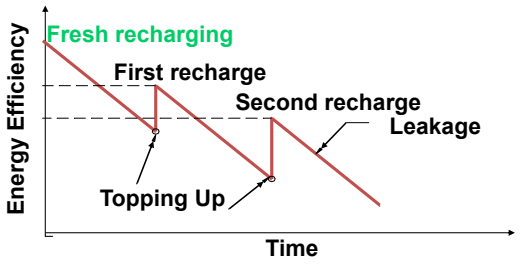


SLIDE 14:

GOOD SERVICES PRACTICES FOR ENERGY EFFICIENT OPERATION

Energy Efficiency Degradation with successive topping up

- **Topping up will lead to energy penalty**
- **Fresh recharging is preferable**



SLIDE 15:

ENERGY EFFICIENCY DEGRADATION WITH SUCCESSIVE TOPPING UP.

Proper evacuation of the system:

For better performance of air-conditioner the system should be free from air, moisture, and non-condensable gases. Presence of moisture leads to choking of capillary, strainers, and filter/drier. The non-condensable gases decrease the energy efficiency of the system by contributing to higher condenser and discharge pressure than normal pressure. This results in increased power consumption and, also, lesser cooling capacity of the system. Therefore, accurate evacuation (proper vacuum) of system is important before charging the refrigerant. The evacuation must be carried out to 500 or lower microns level. Evacuate the system at least for 30 minutes to ensure adequate vacuum, if micron gauge is not available.

Use Quality Refrigerants

Impurities in refrigerant cause non-condensable gases and moisture in system that creates chocking of capillary. Ensure the use of proper quality of refrigerants, cross contamination of refrigerants may result in reduced performance and even failure of the system.

The capillary systems like ACs are very sensitive to charge quantity. Charge the quantity of refrigerant as per the manufacturer recommendation (specified on the outdoor unit). The graph depicts the changes of energy efficiency ratio with quantity of refrigerant charge in the system.

Overcharge of refrigerant increases the compressor power consumption. High operating pressures/temperatures indicate that system is overcharged. There is more chance of leakage from overcharged system.

Undercharged will cause less cooling effect thus decreases the system efficiency and unable to meet the load required.

Charging of refrigerant by weight is the right procedure for room ACs.

Figure shows the decrease of energy efficiency of the system with time. With fresh recharge the original efficiency of the air-conditioner will be obtained. There is a decrease in charge quantity with time due to leakage and thus efficiency goes down with time gradually. For first time recharge (Top-up) the system without removing the full charge from the system there will be increase of efficiency but will be lower than the original efficiency. Again, due to leakage the efficiency comes down. In second recharge the efficiency will increase but not to the level of even first recharge. The decrease of efficiency is due to continued leakage of refrigerant. So, topping up of the refrigerant is not preferable, fresh charging after evacuating the system should be done. In case of refrigerant blends, it is more predominant.

Good Services Practices for Energy Efficient Operation

❑ **Use Clean and Recommended Lubrication**

- If not, this results to improper miscibility of refrigerant and lubricant, and choking of capillary.

❑ **Replace the Strainer/Filter**

- Each time the system is being serviced/repaired, install a new strainer/filter. This will minimize possibility of moisture and other contaminants in the system.

❑ **Strictly follow the installation procedure as per the manual**

SLIDE 16:
GOOD SERVICES PRACTICES FOR ENERGY EFFICIENT OPERATION

Education to Customer on Energy Saving

- Close doors and windows to separate air conditioned space from unconditioned spaces.

- Use ceiling fans at low speed, it would help distribute/ circulate. air

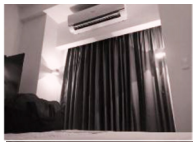
- Use energy efficient lightings (LEDs) to reduce cooling loads.

- Savings in electricity bill choosing higher energy efficient appliances rated (5 or 4 star).

SLIDE 17:
EDUCATION TO CUSTOMER ON ENERGY SAVING

Education to Customer on Energy Saving

- Draw curtains, drapes and blinds as far as possible when air-conditioner is in use.



- Use remote to maintain indoor temperature between 24 - 27ºC.

- Clean indoor Air filter periodically

- Turn off air-conditioner when space is not occupied.

SLIDE 18:
EDUCATION TO CUSTOMER ON ENERGY SAVING

Lubrication of moving parts is very important in room air-conditioning system. Always use good quality recommended lubricating oil. The change in oil may result in improper miscibility of refrigerant and lubricant. This would result in separation of oil in the cooling coil.

While doing servicing, replace strainer/filter so that there will be minimum possibility of moisture and other contaminants in the system.

The technician should always follow strictly the installation procedure as per the manual. Technician should read properly the installation manual provided by the manufacturer, it is very important for system with flammable refrigerants.

The next three slides present the advices that the technicians should provide the AC users for operating the systems efficiently.

Doors and windows of air-conditioned spaces should be closed so that there will be no exchange of air from outside the space. The cooling energy required will increase as it has to cool the hot air entering from outside continuously.

Run ceiling fan, it helps proper circulation of the air inside the room. Also, due to a little higher speed of air using ceiling fan, the temperature set point can be increased, by which we can lower energy consumption of room AC.

LED lights consume less energy and also generate less heat for same output lumens. So, selecting LED lights will consume less both lighting and air-conditioner energy.

While buying new air-conditioner, opt higher BEE Star rating system, which consumes less energy as compared to low star rating system. 5 Star rated Room AC consume about 20 to 25% lower energy than 1 Star AC.

Draw curtains, drapes and blinds if possible, this helps lower the heat transfer through windows and walls, lowering the cooling energy required and thus less energy consumption.

Run the system at higher temperature set in a range 24-27°C. At lower temperature setting, it will consume more power. Running at higher temperature it can reduce energy consumption of room AC by upto 15 to 20%.

Air-filter gets dirt due to dust and due to that there will be restriction of air circulation which cause less cooling. Air filter can be cleaned by customer periodically.

Energy is scares and we should help in conserving it. The majority of the energy consumption and thus electricity bill is due to operating air-conditioner, so, turn off air-conditioner when space is not occupied.

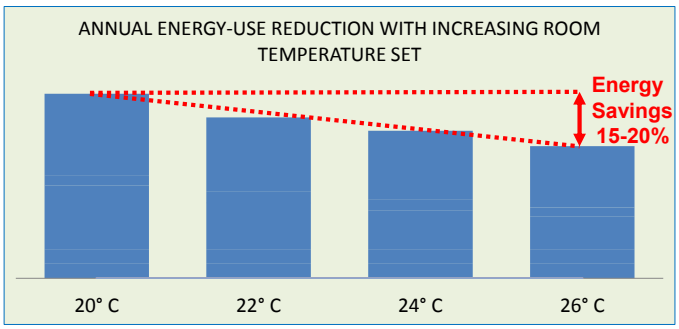
Education to Customer on Energy Saving

- Get AC serviced at least twice in a year.

- Ask for certified AC technician to perform AC servicing.

SLIDE 19:
EDUCATION TO CUSTOMER ON ENERGY SAVING

The impact of Indoor Temperature settings on Energy Consumption



SLIDE 20:
THE IMPACT OF INDOOR TEMPERATURE SETTINGS ON ENERGY CONSUMPTION

Air-conditioner Energy Labeling Standard

Room Air Conditioners

- BEE started mandatory energy efficiency rating Star rating from 2010 for Room Air-conditioner up to a rated cooling capacity of 10.4 kW
- Test Standard: **IS: 1391 Part 1 and Part 2 with all amendments, as applicable.**
- The labelling program is a dynamic system, every two years BEE revise and enhance energy efficiency values..
- 5 Star ACs have the highest energy efficiency and offer largest energy savings to users.

SLIDE 21:
AIR-CONDITIONER ENERGY LABELLING STANDARD

The customer should be educated to always keep the air-conditioners filters clean and get serviced at least twice in a year. Make aware to the customer that air-conditioner servicing should be get it done by certified technicians.

The setting of temperature plays a critical role in cooling capacity requirement of the space to be air-conditioned, lower the set point temperature, more is the cooling requirement and more energy consumption for the space. Setting the room temperate to 26°C the energy savings will be around 15 to 20% lower than the room temperature set of 20°C.

The room air conditioner of the vapour compression type which are of unitary air conditioner and split air-conditioner up to a rated cooling capacity of 10,465 Watts (9,000 kcal/hour) being manufactured, commercially purchased or sold in India shall –

- meet the compliance requirements of the maximum operating conditions test in accordance with IS 1391(Part1) for unitary air conditioner and IS 1391(Part2) for split air conditioner.
- be certified against IS/ISO 9000 or above.

The label to room air conditioner is maximum of five stars with an interval of one star, and the room air conditioner is rated from star one to star five based on their relative energy efficiencies.

Standards and labelling program when launched few important requirements were specified for reporting which is essential.

Apart from many small and big issues following must be done by each OEM before going for putting Star labels on the products.

1. Rated power (input).
2. Rated capacity (output).
3. EIndian Seasonal Energy Efficiency Ratio (ISEER).
4. Star rating. (Number of Star derived)
5. Some requirements for energy label validity.
6. Performance criteria for energy labelling validity.
7. Test report format.
8. Printing requirements for air conditioner appliance energy labels.

Air-conditioner Energy Labeling Standard

Inverter Air Conditioners

- Indian Seasonal Energy Efficiency Ratio (ISEER) is used for the star labelling

$$\text{ISEER} = \frac{\text{Total annual amount of heat that the equipment can remove from the indoor air when operated for cooling in active mode}}{\text{Total annual amount of energy consumed by the equipment during the same period}}$$

- Testing standard – IS 1391 Part II
- Calculation procedure – ISO 16358

SLIDE 22:
AIR-CONDITIONER ENERGY LABELLING STANDARD

Air-conditioner Energy Labeling Standard

Star level up-gradation for Split AC

2009-2011	2012-2013	2014-2015	2016-2017	2018-2019
Star 1				
Star 2	Star 1			
Star 3	Star 2	Star 1	Star 1	
Star 4	Star 3	Star 2	Star 2	
Star 5	Star 4	Star 3	Star 3	Star 1
	Star 5	Star 4	Star 4	Star 2
		Star 5	Star 5	Star 3
				Star 4
				Star 5

2016 - 2017			2018 - 2019		
Star Level	Min EER	Max EER	Star Level	Min ISEER	Max ISEER
Star 1	2.70	2.89	Star 1	3.10	3.29
Star 2	2.90	2.99	Star 2	3.30	3.49
Star 3	3.10	3.29	Star 3	3.50	3.99
Star 4	3.30	3.49	Star 4	4.00	4.49
Star 5	3.50	-	Star 5	4.50	-

SLIDE 23:
AIR-CONDITIONER ENERGY LABELLING STANDARD

Checklist for Good Service Practices

	Action
☐	Check air filter and perform cleaning
☐	Check Condenser coil, wash outdoor unit condenser coil annually at least once a year to maximize efficiency and enhance AC working life;
☐	Check Evaporator coil and clean it at least once a year;
☐	Perform leak and pressure testing
☐	Use Oxygen Free Dry Nitrogen to remove contaminants from the system
☐	Ensure correct Refrigerant Charge as recommended by the manufacturer
☐	Treat AC drain pans to prevent its clogging may be due to algae growth
☐	Check compressor amps
☐	Check condenser fan amps
☐	Tighten electrical connections
☐	Check capacitance of Capacitors
☐	Educate customer on Energy Efficient operations

SLIDE 24:
CHECKLIST FOR GOOD SERVICE PRACTICES

Energy Efficiency Ratio means the ratio of capacity (in Watts) to the power consumption at nominal voltage and frequency;

Indian Seasonal Energy Efficiency Ratio (ISEER) means the ratio of the total annual amount of heat that the equipment may remove from the indoor air when operated for cooling in active mode to the total annual amount of energy consumed by the equipment during the same period;

Every room air conditioner shall be tested in accordance with the IS 1391(Part 1) for unitary air conditioners and IS 1391(Part 2) for split air conditioners

The methodology for calculating the cooling seasonal total load, cooling seasonal energy consumption and Indian seasonal energy efficiency ratio shall be in accordance with the ISO 16358

The star level or star rating of the room air conditioner shall be determined by energy efficiency ratio or Indian seasonal energy efficiency ratio depending on the year of manufacturing or commercial purchase or sale, whichever is applicable as following year.

- From 12th January 2009 to 31st December 2011
- From 1st January 2012 to 31st December 2013
- From 1st January 2014 to 31st December 2015
- From 1st January 2016 to 31st December 2017
- From 1st January 2018 to 31st December 2019

From figure it can be seen that 1 star of air-conditioners for the year 2009-2011 was not permitted from 2012-2013 and similarly 2 star for the year 2016-2017 shall not be permitted from 2018 omwards.

In this slide checklist for Good Service Practices for energy efficient operations are listed.

SOFT SKILLS & PERSONAL PROTECTIVE EQUIPMENT

Target Group
Trainers and Technicians

Duration of the Session
30 minutes

Purpose of the Session

To make the participants aware of the behavioural and work ethics, communicate effectively with customers and co-workers.

Importance of working with professionalism and use of PPEs

Terminal Performance Objectives

At the end of this session, the participants should know:

- Work and Behavioral ethics.
- To work with professionalism.
- Understand the importance of using PPEs during installation and servicing of ACs.

Key Message being delivered through this Session

Knowledge and skills acquired for Communicating effectively with customers and co-workers, Work with professionalism and importance of using PPEs.

Tools & Equipment (if any) required for the session
An open mind and a receptive heart.

Soft Skills

&

Personal Protective Equipment

SLIDE 1:
SOFT SKILLS & PERSONAL PROTECTIVE EQUIPMENT:

Learning Outcomes

- Work and behavioural ethics;
- Communicate effectively with customers;
- Communicate with Co-workers & Other Staff;
- Different types of communication skills;
- Professionalism;
- Work safely;
- Use PPEs.

SLIDE 2:
LEARNING OUTCOMES

Role of RAC Technicians


Installation


Preventive Maintenance


Attending Service Calls


Attending Breakdown Calls

Customers are those who need your assistance and they are the reason you have a job.


Documentation

SLIDE 3:
ROLE OF RAC TECHNICIAN

Customers are the backbone of any business and for any company to survive, the customers should be satisfied with the products and services the company offers. In the case of air-conditioning service, the technician who visits the customer becomes the face or image of the company. Therefore, it is important that the technician understand the need and expectation of the customer. Customer expectation varies according to income, race, geography and culture. So, the technician should know not only to repair and service the equipment but also communicate to the customer in a proper way and understand that customer satisfaction depends highly on the behavior of frontline service providers.

The presentation is prepared based on the QP "Qualification Pack" of Skill India Technician Certification requirement.

The participants will get familiar with importance of work and behavioural ethics, communicate with customers effectively, effective communication with co-workers. Participants will learn different types of communication skills, how to work and interact with customers in a professional manner.

Work safely and in a systematic way so that it creates a good impression for the customer and does not damage or mess up the customers premises. Participants will get introduced to the importance of using PPEs.

When a customer purchases an air-conditioner from the show room and make the payment the role of the sales person ends there but for the service technician, it is the beginning of long term relationship. His/her role starts with identification of proper location for installation, Installing the AC, educating the customer on proper usage, giving energy saving tips, doing preventive maintenance, attending breakdown calls etc.

The customers need the services of the technician, but we need to be aware of the fact that they are the reason the dealer was able to make a sale and the staff in the organisation have their job.

Behavioural and Work Ethics

Service technicians to know Good Service is all about:

- Attitude
- Communication skill
- Work Ethics
- Language skills
- Time management

Good customer service is taking that extra step to help without being asked!

SLIDE 4:
BEHAVIORAL AND WORK ETHICS

Communication with Customers

❑ Introduction to Customer

Introduce yourself and your company

Greet the customer

Ask permission before entering the house

Show your ID Card

Friendliness - the most basic and associated with courtesy and politeness.

SLIDE 5:
COMMUNICATION WITH CUSTOMERS

Communication with Customers

❑ Before Service Work

Check customer location and take time for visit

Understand the problem faced by the customer and Enquire about the symptoms and history of problems in the appliance

Ask customer about warranty status of appliance and annual maintenance contract

Inform customer about visiting charges

SLIDE 6:
COMMUNICATION WITH CUSTOMERS

The technicians must understand what is "Good service" all about. It is not just knowing all about the equipment and serving technics but a combination of many factors with work ethics at the core of it. It includes:

Attitude: An effective customer relationship starts with the attitudes of the customer service representatives. Maintaining a positive attitude is about putting oneself in the customer's position and viewing the problem from their point of view. This would help the service technician to make better decisions and know how to deal with different customers. Attitude of the technician should be that of **"Help and Support".**

Communication skills: Communication is the key component of an excellent service, as it is the art of conveying the message. As to how the technician can steer the conversation toward a positive outcome this is possible thorough effective communication. Being cheerful and calm even in a tough situation helps to win the customer.

Language skills: Politely communicating in the language that can be understood by the customers and peer group enhances the ability to explain and execute the work appropriately.

Time management: Visiting and /or completing the tasks in time as specified is one of the important characteristics necessary for a technician to be successful.

While visiting customers keeping appointment is important. That is going to be your first chance of impressing the customer. Ring the bell and wait, introduce yourself and your company, greet the customer formally. Use customer title and surname, if someone does not have a professional title, use the title "Sir" or "Madam". Show your ID card. Ask permission before entering the house.

The smile on your face and the tone of your voice can make a huge difference.

Ask customer about the warranty status of the equipment or whether they have taken any annual maintenance contract for that appliance. Request to show the relevant document and inform customer about visiting charges if any.

The ability to really listen to customers is so crucial for providing great service. Pay attention to their needs; make a special effort to hear what they're saying. Don't start the work even if you are aware of the problem.

Communication with Customers

❑ During Service Work

Identify the problem based on customer's information using standards checks and tests and discuss with customer

Explain the time required and methodology for servicing necessary

Suggest possible solutions and approx. costs to be involved after investigation / prior check

SLIDE 7:
COMMUNICATION WITH CUSTOMERS

Communication with Customers

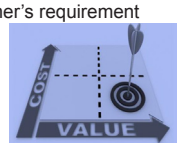
❑ During Service Work

Seek customer's approval on further action before starting servicing

Replace with genuine company specified spare parts with consent of the customer.

For replacing any spare parts seek confirmation from the customer;

Assess the necessary problem and solution(s) accurately and offer most appropriate and cost-effective service as per customer's requirement



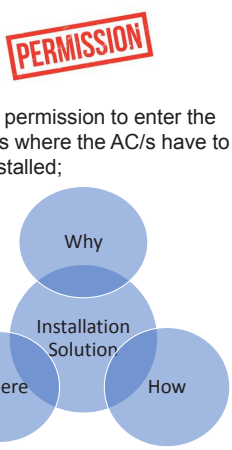
SLIDE 8:
COMMUNICATION WITH CUSTOMERS

Communication with Customers

❑ During Installation

Before installation work inform customer pre-installations/ masonry/ electrical work to be carried out

Know from customer where the air conditioner is to be installed, and check the location and explain the best possible solution to install



Seek permission to enter the rooms where the AC/s have to be installed;

SLIDE 9:
COMMUNICATION WITH CUSTOMERS

Examine appliance and ask questions in sequence, to correctly ascertain the problem. Customer may not be familiar with technical terminologies and hence talk in simple language that could be understood by customer. Suggest possible solutions and approximate cost involved and the time required for completion of the job.

Before replacing any part or doing any service, seek customers approval. Don't take things for granted. This can prevent the possibility of any confrontational situation.

Before installation inform the customer about pre-installation masonry, electrical and other related work to be carried out and whether the cost of these are included in the installation charges or not. Though you have taken permission to enter the house it does not mean that you can walk in to room where AC is to be installed. So, seek permission before entering the room.

Know from customer where the air-conditioner is to be installed. Check the location and explain the best possible option. Remember, customer is always right, explain the advantages and disadvantages of different locations and let the customer decide.

Communication with Customers

❑ During Installation

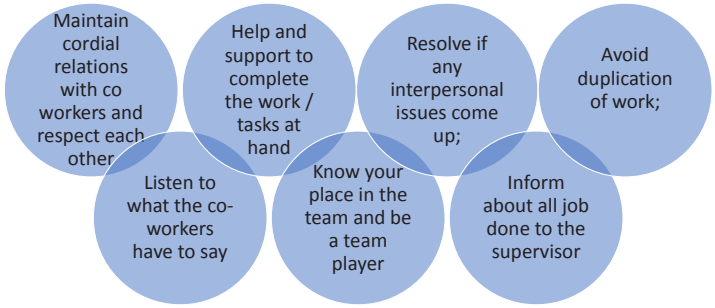
Check that all supporting accessories purchased have are there in the package of Air-conditioner and inform to customer;

Inform to the customer the precautions and good practices to be taken while using the air conditioner

Fill in customer acknowledgement form

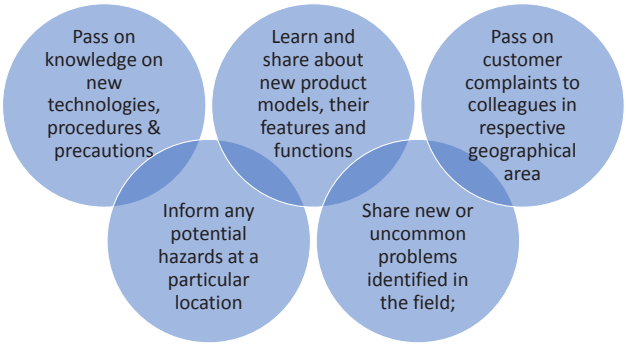
SLIDE 10:
COMMUNICATION WITH CUSTOMERS

Communication with Co-workers



SLIDE 11:
COMMUNICATION WITH CO-WORKERS

Communication with Co-workers



SLIDE 12:
COMMUNICATION WITH CO-WORKERS

At the time of installation, while opening the package of the air conditioner check and ensure that all the supporting accessories are available in the pack and inform the customer about it.

Educate the customer about the precautions to be taken, good practices to be followed, energy saving tips and proper temperature settings.

Ensure that Everything is done diligently but write it down in black and white get it acknowledged by the customer. If the customer was very happy with your service, encourage them to write their feedback in the acknowledgement form.

Whatever occupation or industry you're in, your team matters the most. They are your partners and not competitors so it's important to create a happy environment amongst your teams. This will result in heightened confidence and excellent service delivery.

Listen to what coworkers have to say and help and support each other to complete the task at hand. Through a positive attitude in customer service everyone would feel more accountable, everyone would be more resourceful in searching for solutions, ensure regular follow-up to show customers that everyone in the company cares. The quality of products and services would become better, as everyone would strive for excellence and fairness while dealing with customers.

It is important to resolve any interpersonal issues among team members. Managers need to recognize the signs of team effectiveness and early indications of problems and resolve it at the earliest.

Pass on knowledge on new technologies, procedures and precautions to team members. We know that all our customers are different and therefore no two problems are the same. We need to learn from other members of our team. What goes a long way toward making it great is the fact that, unlike a computer-based automated service, people have the ability to analyse a situation, think innovatively and come up with solutions that will suit the customer and make them happy. So, discussing the problems that you came across in the field with your colleagues will help you to come up with better solutions.

Pass on customer complaints to colleagues in respective geographical area. Working together produces good customer service. Strong teams, for example, assure consistency of communication with the customer, deadlines are more likely to be met and everyone takes responsibility for their actions.

Telephone Skills

Speak clearly and slowly

Smile (you can hear it in your voice!)

State your name and organisation

Write down the caller's name and use it

SLIDE 13:
TELEPHONE SKILLS

Telephone Skills

- Don't say rude things while someone's on hold

If caller is explaining something use words to show you're listening (umm, yes, no …)

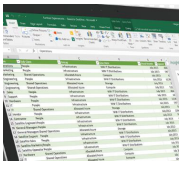
- Have writing pad and pencil ready to take notes or messages

Don't eat or drink while on the phone

SLIDE 14:
TELEPHONE SKILLS

Writing Skills

Note problems on job sheet and details of work done



Document the completed work on computer and paper

Activity logs, attendance sheets as per organizational format in English and/or local language

Employee Attendance Sheet in Excel

Sl#		Employee Name	Total Present	Total Absent
			P	A
1	0	0	0	0
2	0	0	0	0

Fill forms such as work orders, invoices, maintenance records

Incident Report Template

Write basic accident or incident report as witnessed in appropriate format to relevant authority

SLIDE 15:
WRITING SKILLS

Before you answer a call relax your mind because an agitated mood will affect your tone and voice. Answer the call with a smile. The customer can actually hear it in your voice.

Speak clearly. Your tone and voice must be vibrant as you deliver your words. Practice your speaking skills at home, with friends or colleagues. State your name and organization while answering the call. Write down the caller's name and use it during the conversation. Make sure you greet the customer with the right words before providing the required information.

Always take the customer's permission before putting him/her on hold. Customers hate being put on hold just as much as you do. Inform the customer how long they will have to be on hold for. Never say rude words while somebody is on hold. Have a writing pad and pencil ready to take notes or messages. Never answer a call while eating food or chewing gum.

During installation or attending service complaints we communicate a lot of information like the nature of complaint, corrective actions taken, type of work done, precautions to be taken and payment received from customers etc. write it down in black and white get it acknowledged by the customer. Clear writing minimises issues with customers, cuts complaints and promotes loyalty. Ensure to fill up all required format immediately on completion of work. This will help us to keep the maintenance records properly.

Reading Skills

Job sheet for installation as registered by customer care/ company's ERP system

The standard operating procedures for different types of air conditioner

Basic electro-mechanical structure and functionality of features

Job sheet and complaints

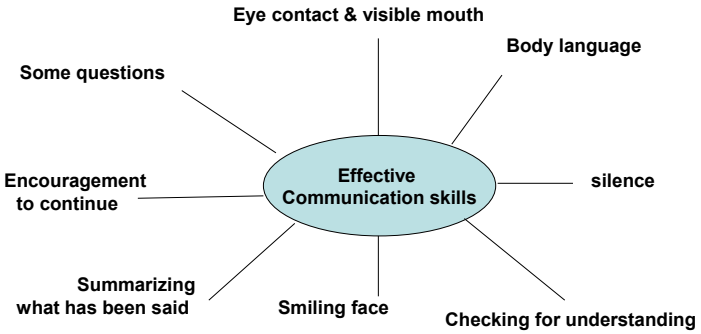
Product operating manuals

Electrical and electronic symbols, multiples and SI units

Warnings, instructions and other text material on product labels, and components

SLIDE 16:
READING SKILLS

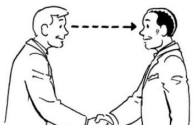
Effective Communication Skills



SLIDE 17:
EFFECTIVE COMMUNICATION SKILLS

Body Language

Eye Contact – the eyes communicate more than any other part of the human anatomy



Smiling – this shows customers that you enjoy helping them

Tone of Voice – this is especially important on the phone when visual cues are missing

Posture – an alert posture tells the customer that you are interested in the work you are doing

SLIDE 18:
BODY LANGUAGE

It is important to acquire good reading skills as it allows you to understand written sentences and paragraphs in work related documents. Make it a habit to read all product operating manuals, Standard operating procedures, MSDS of different types of solvents and refrigerants used in your work places.

Eye contact – Eye contact is a really important form of non-verbal communication and can creates an instant connection between you and your customer and provides a positive step towards building a successful human connection with a customer.

Body language – Your body language can communicate a lot to the customers. When a positive attitude in customer service exists, the service staff will appear more amenable, amicable, responsive, and attuned to the needs and expectations of customers. This in turn would reflect in their behaviour towards customers, who would feel heard, respected, and cared for by the company.

Silence- Though silence is not golden in customer service, sometimes it is better to keep silent, especially when there is situation of arguments and if you feel your response is going to make him/her more angry.

A Smiling face- The smile on your face and the tone of your voice can make a huge difference.

Summarise what was discussed, listen to what they have to say about the quality of work, so we can do better next time. Pay attention to their needs; make a special effort to hear what they're saying. Encourage them to continue and ask questions.

Your body language can communicate a lot to the customers. When a positive attitude in customer service exists, the service staff will appear more amenable, amicable, responsive, and attuned to the needs and expectations of customers. This in turn would reflect in their behaviour towards customers, who would feel heard, respected, and cared for by the company.

Eye contact often determines the level of trust and trustworthiness;

Smile- This shows that you enjoy being there and enjoy your work.

Posture- An alert posture conveys to the customer that you are interested in the work what you are doing.

Body Language

Gestures – using gestures contributes to how your total message is interpreted

Nonverbal cues are more immediate, instinctive, and uncontrolled than verbal expressions.

Keep appropriate physical distance with customer during conversation

Be aware of cultural differences

SLIDE 19:
BODY LANGUAGE

Professionalism

Competency

Punctual

Polite

Be confident

Follow up (don't just say you'll do something, do it)

Always upgrade knowledge and skills;

SLIDE 20:
PROFESSIONALISM

Professionalism

Do not forget to carry all required tools;

Always follow the right work procedure;

Keep the work area neat and organized (Handling of appliance and tools)

Ensure zero accidents at work;

Leave a positive impression, smile, that leads to repeat orders;

Say goodbye

SLIDE 21:
PROFESSIONALISM

Gestures- Using gestures contributes to how your total message is interpreted. When we interact with others, we continuously give and receive wordless signals. All of our nonverbal behaviors—the gestures we make, the way we sit, how fast or how loud we talk, how close we stand, how much eye contact we make—send strong messages. These messages don't stop when you stop speaking either. Even when you're silent, you're still communicating nonverbally. In many instances, what comes out of your mouth and what you communicate through your body language are two totally different things. When faced with these mixed signals, the listener has to choose whether to believe your verbal or nonverbal message. Invariably, they're going to choose the nonverbal because it's a natural, unconscious language that broadcasts your true feelings and intentions.

Professionalism is particularly important for those who work in customer service since job skills, good judgement and polite behavior can leave consumers feeling satisfied and encourage them to remain loyal customers.

Competency is the sum total of the skills, knowledge, practical behaviors and attitudes.

Punctuality - A skill that a customer service representative should have is the ability to effectively manage time.

Follow up- As far as possible don't keep work pending. Like the NIKE tag line "Just Do It" Follow it up and keep the customer informed about the progress.

It's a fact that passion in the workplace creates excitement.

Always upgrade Knowledge and skills - Customer expectations are always changing, and new technologies and products are being introduced in to the market. To manage them it is necessary to constantly upgrade the skills and knowledge of service technicians.

This slide is self-explanatory

Personal hygiene

The first contact leaves a powerful impression.

Wear clean and neatly ironed cloths

Wear polished shoes and clean socks

Take bath regularly and

wash hands properly

Accessories – avoid wearing heavy jewelry, earrings, tattoos to work.

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SLIDE 22:
PERSONAL HYGIENE

Personal Protective Equipment (PPE)

- When hazards can not be eliminated through engineering and / or administrative controls, PPE must be used to protect the eyes, face, head, feet, hands, arms, body, ears, and lungs from:
  - Falling objects
  - Refrigerants/Chemicals
  - Heat hazard
  - Harmful dust
  - Optical radiation
  - Electrical hazard
  - Noise Hazard

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SLIDE 23:
PERSONAL PROTECTIVE EQUIPMENT (PPE)

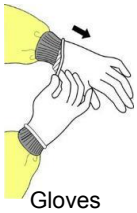
Personal Protective Equipment (PPE)

hard hat

Safety Goggles

Face shields

Masks



Gloves

Safety shoes

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SLIDE 24:
PERSONAL PROTECTIVE EQUIPMENT (PPE)

Maintaining good hygiene helps you to reduce the risks of ill health, but equally important affects how we and others perceive ourselves and can influence our levels of confidence and self-esteem which can affect many aspects of our lives.

Wear clean and neatly ironed cloths. Wear polished shoes and clean socks. Take bath regularly and wash hands properly. While working on appliances don't touch the appliances and walls with dirty hands. Some stains caused by greasy hands may not be able to remove easily. Avoid wearing heavy jewellery to work.

Personal safety is very important while servicing the air conditioners. Technicians must wear personal protective equipment like lab coat, safety goggles/glasses, protective shoes, gloves, mask during welding/brazing, while handling refrigerants and safety belts and helmet during installation of air-conditioners. Each person working in and around workshop must advice colleagues to be careful.

Different types of personal protective equipment exist.

Masks: Masks can help to filter the vapours to a limited extent.

Goggles: Goggles protect the eyes against inadvertent splashes of solvents.

Face Shields: Protect the whole face against inadvertent splashes.

Gloves: Most solvents remove the fat content of the skin and refrigerants can cause frost burns. Gloves can protect the skin adequately.

Care should be taken in selecting gloves and other protective clothing as different solvents, oils and refrigerants affect the materials from which they are made in different ways. For example, leather gloves should not be used for handling refrigerants. Viton, Neoprene and PVA gloves are most suited for RAC servicing

Personal Protective Equipment (PPE)

- whenever installation is taking place at heights, safety belts and harnesses must be used
- Leather gloves should **not** be used while handling refrigerants
- Use Nitrile, PVA, Neoprene or Viton gloves
- PPEs should be provided, used, and maintained in a clean and reliable condition.
- Use Ear Plugs or Ear Muffs for protection from noise

SLIDE 25:

PERSONAL PROTECTIVE EQUIPMENT (PPE)

This slide is self-explanatory

INTRODUCTION TO CERTIFICATION PROCESS FOR FIELD TECHNICIAN: AIR CONDITIONER

Target Group
Trainers and Technicians

Duration of the Session
30 minutes

Purpose of the Session

To make the trainer-participants familiar with the Certification – needs and benefits for quality servicing and get awareness on roles and responsibility and examination and assessment for certification process and material for preparation for the exam.

Terminal Performance Objectives

At the end of session the participants should understand the following:

- Needs of Certification;
- Benefits of Certification;
- International Scenario;
- Certification: Roles and Responsibility;
- How to prepare for Exam;
- Examination and Assessment

Key Message being delivered through this Session

Most of the countries in the world have certification process for Room air-conditioner service technicians. Only certified service technicians are allowed to work in this area. India now has a technician certification program, initially in voluntarily. It may become mandatory in coming future. Government of India is working to give certification to service technicians for Room Air-conditioner through assessment process. In this session participants will be given awareness about the certification process, its needs and benefits, roles & responsibility of certification process and information on exam preparation and examination and assessment process.

Tools & Equipment (if any) required for the session
None

HPMP

HCFC Phase-Out Management Plan, Servicing Sector

giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

Introduction to Certification process for Field Technician: Air Conditioner

India HPMP Stage II – 2018 : Certification Process

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SLIDE 1:

INTRODUCTION TO CERTIFICATION PROCESS FOR FIELD TECHNICIAN: AIR CONDITIONER

HPMP

HCFC Phase-Out Management Plan, Servicing Sector

Learning Outcomes

- ❑Needs of Certification;
- ❑Benefits of Certification;
- ❑International Scenario;
- ❑Certification: Roles and Responsibility;
- ❑How to prepare for Exam
- ❑Examination and Assessment

India HPMP Stage II – 2018 : Certification Process

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SLIDE 2:

LEARNING OUTCOMES

HPMP

HCFC Phase-Out Management Plan, Servicing Sector

Why Certification

- The introduction of alternative refrigerants is associated with a number of challenges, as these require handling of
  - Flammability
  - Toxicity
  - High Pressure Systems
  - Environmental impacts
- It is an approval process to ensure that technician is competent to
  - complete the installation and servicing of AC successfully;
  - work with RAC tools & equipment and refrigerants;
  - safely work / handle flammable refrigerants;

India HPMP Stage II – 2018 : Certification Process

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SLIDE 3 & 4:

WHY CERTIFICATION

Certification for room air-conditioner service technicians is important which will help reducing refrigerant emissions and increasing energy efficiency thus conservation of energy. Government of India has a certification program for service technicians for room air-conditioner through assessment process.

In this session participants will learn about needs of certification, benefits of certification, international scenario of certification to room air-conditioner service technicians, roles and responsibility of certification process. The participants will also get awareness about how to prepare for exam and examination and assessment process for the certification.

HCFCs, including HCFC-22 are being phased-out under Montreal Protocol, globally, as these chemicals are having ozone depleting potential. Many of the refrigerants alternative to HCFC-22 have flammable and/or toxic properties or high working pressures. Most technicians are not familiar for servicing of ACs with these alternative refrigerants. The installation and servicing of air-conditioning equipment operating with such refrigerants need to be handled carefully and considered in the context of safety issues. It is therefore essential to have training followed with a certificate based on the assessment theory and practical of the technician.

Certification is an approval process to ensure that technician is competent to complete the installation and servicing of AC successfully and safely, work with RAC tools & equipment and flammable and high pressure refrigerants. Training, assessment and certification also give enhance assurance that servicing will be performed according to applicable standards.

In India there is a high demand for certified technicians, currently the estimated number of ACs in operation is about 35 million and expected to grow to 100 million by 2030. It will also support in protecting environment from improper handling of refrigerants and RAC equipment.

Why Certification

- High demand for certified technicians, currently the estimated number of ACs in operation is about 35 million and expected to grow to 100 million by 2030;
- Support in protecting environment from improper handling of refrigerants and RAC equipment.

India HPMP Stage II – 2018 : Certification Process 4

Benefits of Certification

- Certification is a measure undertaken voluntarily for enhancement of professional skills;
- Opening of global opportunities for certified RAC technicians;
- Enhance skills of the existing manpower in the RAC sector/ industry;
- Enrichment of skills viz. further education, training, behavioral and professional based on review and assessment;
- Health & safety awareness for the technicians working in the field;
- Value addition for technicians leading to better quality of life.

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SLIDE 5:
BENEFITS OF CERTIFICATION

Overview National Qualification & Certification Network

National Qualification & Certification Partner	HPMP	National RAC Training Network	National RAC Certification
Aims / Services	Capacitating of RAC Sector Conformity →	Training education courses →	Examination of Competence Requirements
Achievements	Awareness Competence Requirements & Self-evaluation of Technicians	Qualification Upgrade to Required Certification Level	Certification

India HPMP Stage II – 2018 : Certification Process 6

SLIDE 6:
OVERVIEW NATIONAL QUALIFICATION & CERTIFICATION NETWORK

Certification is a measure undertaken voluntarily for enhancement of professional skills of RAC servicing personnel. It will help the service technicians in a number of ways, the social status and identity, safety, increased employability within the country and abroad and increaed earnings. Certification has been one of the requirements for taking any such employment especially abroad as skilled peronnel for Indian certified room AC technicians. The certification process will enhance skills of the RAC technicians through further education and training, required for preparation for the assessment/exam. The education and skill enhancement in addition to the upgrading the skills will create health & safety awareness and significant value addition for technicians leading to better quality of life.

Technicians participating in the two day technicians training programs conducted by GIZ under HPMP in the country will receive a Certificate of Participation. In addition will allow the technicians to make himself aware of his competence requirements and do self-evaluation leading to identify the gaps in what they know and what is required for acquiring the certificate. Slide shows the role of various elements of process of certification.

The National Training Network will provide training and education courses making qualification upgrade to the required certification level. Certification will be provided through examination, which will be based on the competence required for the service technicians.

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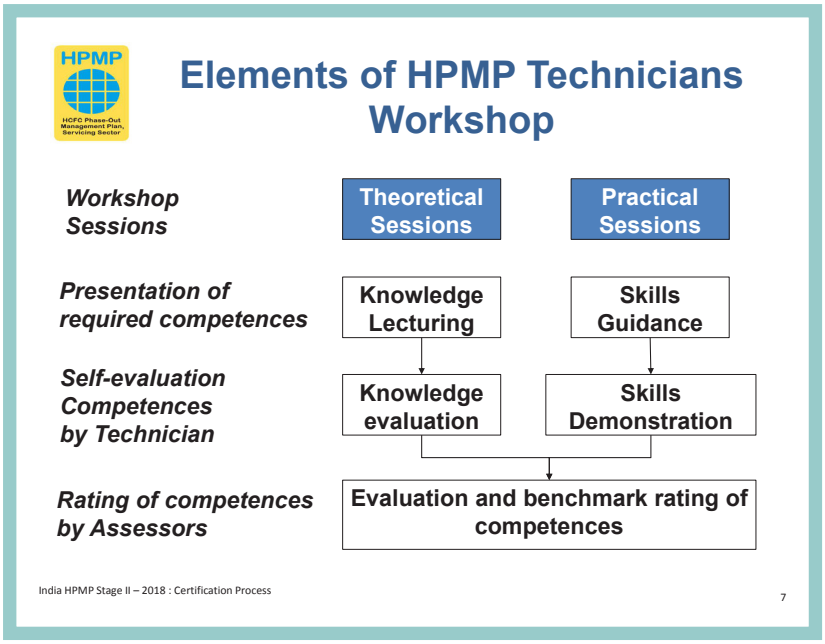
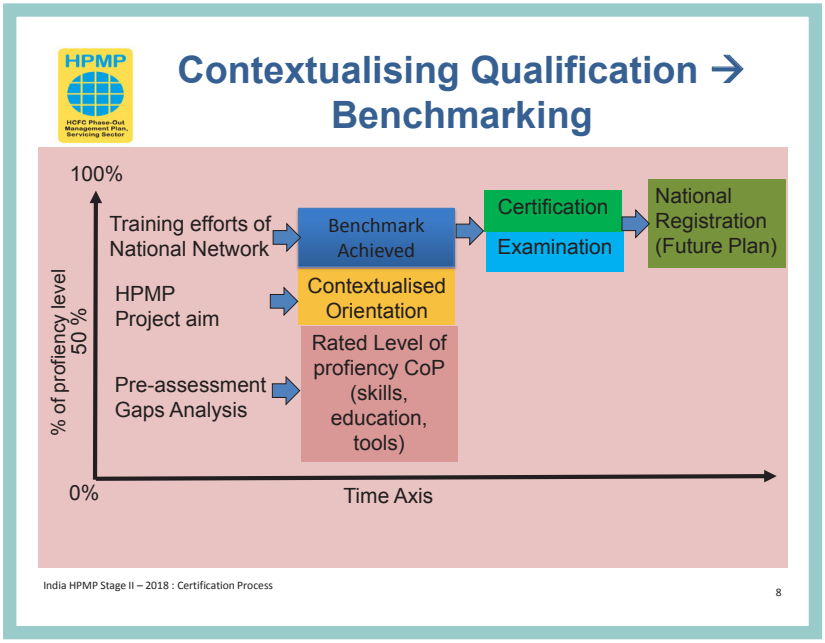


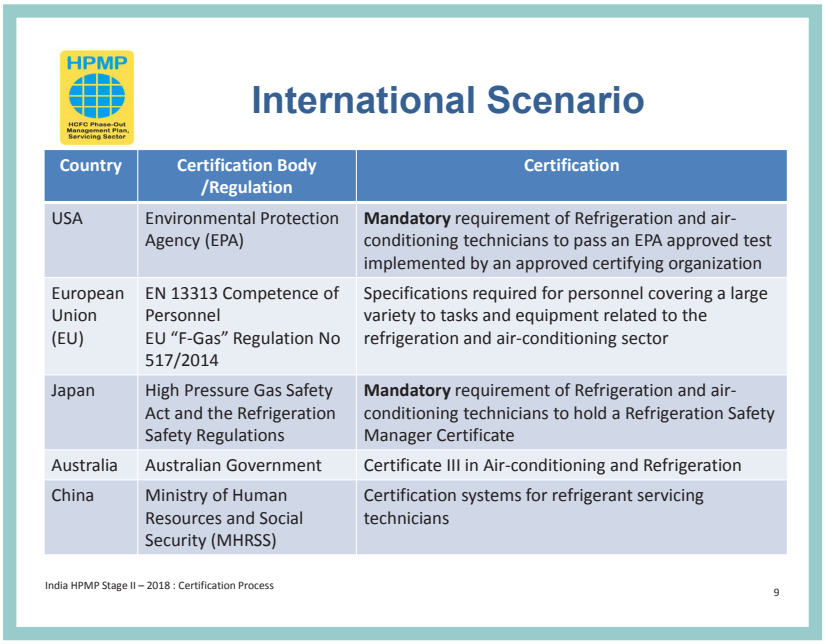
SLIDE 7:

ELEMENTS OF HPMP TECHNICIANS WORKSHOP



SLIDE 8:

CONTEXTUALISING QUALIFICATION → BENCHMARKING



Country	Certification Body /Regulation	Certification
USA	Environmental Protection Agency (EPA)	**Mandatory** requirement of Refrigeration and air-conditioning technicians to pass an EPA approved test implemented by an approved certifying organization
European Union (EU)	EN 13313 Competence of Personnel EU "F-Gas" Regulation No 517/2014	Specifications required for personnel covering a large variety to tasks and equipment related to the refrigeration and air-conditioning sector
Japan	High Pressure Gas Safety Act and the Refrigeration Safety Regulations	**Mandatory** requirement of Refrigeration and air-conditioning technicians to hold a Refrigeration Safety Manager Certificate
Australia	Australian Government	Certificate III in Air-conditioning and Refrigeration
China	Ministry of Human Resources and Social Security (MHRSS)	Certification systems for refrigerant servicing technicians

SLIDE 9:

INTERNATIONAL SCENARIO

Technicians training under HPMP is of two day duration which includes theory through classroom training and practical – hand on training.

During the training the topics covered will be primarily on good service practices and installation of room air-conditioners with HCFC–22 and flammable refrigerants, energy efficiency and soft skills. These contents of the training provided for example form the syllabus / topics of the proposed national certification

This slide shows a graph of the percentage of proficiency along with time. By training efforts of a national network, the achievement of technician's performance level can be benchmarked.

Technicians training program under HPMP is prepared through gaps analysis/pre-assessment and the required skills/education/tools. On undergoing the training under HPMP the service technician can achieve a benchmark for planning to write the examination for the certification. Upon the successful completion of the certification exam, technician can be registered as a nationally certified technician for servicing room air-conditioner.

Many countries have certification system for Room Air-conditioners service technician and it mandatory to have for installation and servicing of Room ACs.

In USA Environmental Protection Agency (EPA) gives certificate to qualified service technicians. It is Mandatory requirement of Refrigeration and air-conditioning technicians to pass an EPA approved test implemented by an approved certifying organization.

In European Union the technicians are required to follow regulation 'EN 13313 Competence of Personnel and EU "F-Gas" Regulation No 517/2014'. According to the EN 13313, persons responsible for installation, inspection, testing, maintenance, repair, commissioning, and disposal of refrigerating sys¬tems and their parts, must have the competencies to be certified by an approved national organization. The "F-gas" Regulation requires all personnel and companies to have a certification proving their ability to manipulate systems using "F-gases". The personnel certification is obtained after a theoretical and practical assessment (EC No 303 & 304/2008 for examination requirements).

Japan has certification body - High Pressure Gas Safety Act and the Refrigeration Safety Regulations. It is mandatory requirement of Refrigeration and air-conditioning technicians to hold a Refrigeration Safety Manager Certificate.

Ministry of Human Resources and Social Security (MHRSS), Australian Government give certificate III in Air-conditioning and Refrigeration to perform servicing work. In China Ministry of Human Resources and Social Security (MHRSS) gives certification systems for refrigerant servicing technicians.

Certification – Roles and Responsibility

Certification Standards

- National Skills Qualification Framework (NSQF) Standard : One standard framework across the Nation.
- Qualification Packs (QPs) & National Occupational Standards (NOSs)

Assessment & Certification

- NSQF Certification with Skill India logo

Affiliation

- Adjoined industry and Govt certificate e.g. (ESSCI)
- Training Partner (TP) & Trainer
- Assessment Partner (AP) & Assessor
- Master Trainer

SLIDE 10:

CERTIFICATION – ROLES AND RESPONSIBILITY

Preparations for Exam

Refer / study the :

- training material prepared under HPMP for RAC technicians viz. the Technicians Handbook
  - Good Practices in Installation and Servicing of Room Air-conditioners with HCFC – 22 and flammable refrigerants (technicians receive it as reference material on undergoing the technicians training programs – HPMP Stage –II)
- participant Handbook – Field Technical Air Conditioner, published by ESSCI
- other relevant reading / reference material prepared by experts from RAC Industry Experts and other experts

SLIDE 11 & 12:

PREPARATION FOR EXAM

Preparations for Exam

For example exams conducted by ESSCI

- Follow “Qualifications Pack- Field Technician: Air Conditioner” Published by ESSCI, Skill India for Electronics
- The Qualification Pack consists of the following topics :
  - Installation of room air conditioner
  - Repair of dysfunctional air conditioner
  - Interaction with colleagues
  - Maintaining of health and safety
  - Engagement with customer for service
- E- learning contents in student section of ESSCI website, www.essc-india.org

The roles and responsibility of certification system in India is as follows:

Certification Standards is one standard framework across the Nation as per National Skills Qualification Framework (NSQF) Standard. The technicians must be qualified as per Qualification Packs (QPs) & National Occupational Standards (NOSs). A NSQF Certification with Skill India logo is provided to the certified technicians.

NOSs – National Occupational Standards (NOSs) specify the standard of performance, knowledge and understanding when carrying out a particular activity in the workplace. Each NOS defines one key function in a job role.

QPs – A set of NOSs, aligned to a job role, called Qualification Packs (QPs), would be available for every job role in each industry sector. This drive both the creation of curriculum, and assessments.

The affiliation of certification are:

- Adjoined industry and Govt certificate e.g. (ESSCI)
- Training Partner (TP) & Trainer
- Assessment Partner (AP) & Assessor
- Master Trainer

Following are the material the technicians should follow to prepare for exam to get certification:

Training material prepared under HPMP for RAC technicians viz. the Technicians Handbook - Good Practices in Installation and Servicing of Room Air-conditioners with HCFC – 22 and flammable refrigerants (technicians receive it as reference material on undergoing the technicians training programs – HPMP Stage –II).

Participant Handbook – Field Technical Air Conditioner, published by ESSCI and some other relevant reading / reference material prepared by experts from RAC Industry Experts and other experts.

Follow "Qualifications Pack- Field Technician: Air Conditioner" Published by ESSCI, Skill India for Electronics. Participants must go through the Qualification Pack that consists of the following topics:

- Installation of room air conditioner
- Repair of dysfunctional air conditioner
- Interaction with colleagues
- Maintaining of health and safety
- Engagement with customer for service

Participants may also refer E- learning contents in student section of ESSCI website, www.essc-india.org

Examination and Assessment

- Assessment procedures

The independent accredited body in cooperation with the certifying body and the board of examiners will set out assessment rules and documents for the general assessment procedure.

- The test can contain two sections, theory and practical.
  - Theoretical Assessment e.g. online
  - Practical Assessment e.g. by the Industry person
- Test will be PAN India and can support most of the languages in the country
- Re-evaluation and Renewal of Competence Certificates

Competence certificates should be valid for a particular duration e.g. four (4) years,

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SLIDE 13:
EXAMINATION AND ASSESSMENT

Certificate - Sample

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SLIDE 14:
CERTIFICATE SAMPLE

The independent accredited body in cooperation with the certifying body and the board of examiners will set out assessment rules and documents for the general assessment procedure.

The test can contain two sections, theory and practical. Theoretical Assessment e.g. online and Practical Assessment e.g. by the Industry person. Test will be PAN India and can support most of the languages in the country. There will be re-evaluation and renewal of Competence Certificate. Competence certificates may be valid for a particular duration e.g. four (4) years (it is not yet decided).

In this slide the sample of certificate is presented.

PROFESSIONAL STANDARDS

Target Group
Trainers

Duration of the Session
30 minutes

Purpose of the Session

To make the trainer-participants familiar with the existence and use of correct standards for quality servicing, leading to customer satisfaction, including adoption of Good Servicing Practices (GSP) in Room Air-Conditioner servicing sector in our country. The trainer-participants are expected to recognize the significance of the standards and the agencies issuing them.

Terminal Performance Objectives

At the end of session the participants should understand the following:

- Importance of Standards
- List of Selected Organizations for Development of Standards
- IS Standards for Air-conditioner
- Standards on Room Air-conditioner
- Important International Standards
- Air-conditioner Energy Star labeling Standards
- ASHRAE 34: Designation of Refrigerants
- ASHRAE 34: Safety Classifications of refrigerants
- Relevant Safety Standards for Flammable Refrigerants
- Environmental Impact - ODP, GWP and TEWI

Key Message being delivered through this Session

In our country, majority of the service technicians have very limited knowledge of the standards necessary for servicing of room air-conditioners, as applicable. The various countries have their own service standards, however there are few international standards that works globally. The organizations or manufacturers which are successful in national and international know that product quality is extreme important; standards are an important means of accurately quantifying the quality rating of a manufacturer and its products. Each trainer-participant in the AC service field must be aware of the standards, because they are intended to serve as a model for quality production and services. As HCFCs are being phased out and some alternative refrigerants are highly flammable we should also need to know relevant safety standards for flammable refrigerant and importance of ODP, GWP, TEWI and labelling on appliances. Trainers will also get information of air-conditioner energy star labelling, and ASHRAE standards for designation of refrigerants and safety classifications and some relevant safety standards for flammable refrigerant.

Tools & Equipment (if any) required for the session
Not in particular but it is advisable to have copies of select standards for demonstration.

Professional Standards

SLIDE 1:
PROFESSIONAL STANDARDS

Learning Outcomes

- ❑Importance of Standards;
- ❑List of Selected Organizations for Development of Standards;
- ❑IS Standards for Air-conditioner;
- ❑Standards on Room Air-conditioner;
- ❑Important International Standards;
- ❑Air-conditioner Energy Star labeling;
- ❑ASHRAE 34: Designation of Refrigerants;
- ❑ASHRAE 34:Saftey Classifications of refrigerants;
- ❑Relevant Safety Standards for Flammable Refrigerants;
- ❑ODP, GWP and TEWI;

SLIDE 2:
LEARNING OUTCOMES

Importance of Standards

- ➢Standards are a formalised set of criteria developed by experts to ensure a certain product quality, safety consideration in work/handling and equipment/system performances.
- ➢Standardisation of servicing provides to service technicians a set of basic performance criteria to be followed during servicing.
- ➢Indian industry manufacture the products as per the professional standards.

SLIDE 3:
IMPORTANCE OF STANDARDS

Standards are based on the consolidated results of science, technology and experience, and aimed at the promotion of optimum community benefits. Standards can be made mandatory by either trade practices regulation or Gazette notice. A gazette notice refers to a published Indian Standard like ODS rules 2000, various acts etc. and could detail variations to that standard. You as trainer or promoter of technology, check both the gazette notices and the Indian Standards as applicable.

Participants in this session will learn about the importance of standards, will discuss about some selected organizations who develops standards. There are IS standards for Room AC and some important international standards. In this session, participants will get aware of air-conditioner energy star labelling, and ASHRAE standards for designation of refrigerants and safety classifications and some relevant safety standards for flammable refrigerant. Participants will also get aware of ODP, GWP and TEWI.

Standard is a document, established by consensus and approved by a recognized body having experts that provides, for common and repeated use, rules, guidelines/codes or characteristics for activities or their results, aimed at the achievement of the optimum degree of order in a given context. Standards can ensure a certain product quality, safety consideration in work/handling and equipment or system performances. Standardization of servicing can provide both technicians and training institutes with a set of basic performance criteria to follow during and actual servicing. Indian industry manufactures the products as per the professional standards.

Standards are needed because they make life easier by increasing the reliability and effectiveness of products and services that people use. Standards are published documents that are also designed to ensure the reliability of the materials, products, methods, and/or services people use every day. Standards address variety of issues, including but not limited to various protocols that help ensure product functionality & compatibility, facilitate interoperability and support consumer safety & public health.

SLIDE 4: SELECTED ORGANIZATIONS FOR DEVELOPMENT OF STANDARDS

In this slide, information about various organizations engaged in formulating the standards relating to Room Air-Conditioner sector (especially in refrigerated product group) has been provided. The most common and popular institutions or agencies are:

BIS:

Bureau of Indian Standards (BIS) is the national Standards Body of India working under the aegis of

Ministry of Consumer Affairs, Food & Public Distribution, Government of India. It is established by the Bureau of Indian Standards Act, 1986 which came into effect on 23 December 1986. This organization was formerly the Indian Standards Institution (ISI), set up under the Resolution of the then Department of Industries and Supplies No. 1 Std.(4)/45, dated 3 September 1946. The ISI was registered under the Societies Registration Act, 1860. As a corporate body, it has 25 members drawn from Central or State Governments, industry, scientific and research institutions, and consumer organizations. Its headquarters are in New Delhi, with regional offices in Kolkata, Chennai, Mumbai, Chandigarh and Delhi, and 20 branch offices. BIS represents India in ISO, the International Electrotechnical Commission (IEC), the International Telecommunication Union (ITU) and the World

Standards Service Network (WSSN) etc.

BSI

British Standards Institution (BSI) is the national standards body of the United Kingdom. BSI produces technical standards on a wide range of products and services, and also supplies certification and standards-related services to businesses.

ISO

The International Organization for Standardization (ISO), Geneva too issues the globally used standards. ISO develops International Standards. They were founded in 1947, and since then have published over 19000 International Standards covering almost all aspects of technology and business. From food safety to computers, and agriculture to healthcare, ISO International Standards impact all our lives. ISO standards contribute to making the development, manufacturing and supply of products and services more efficient, safer and cleaner. ISO International Standards provide practical tools for tackling many of today's global challenges.

In general, there are two types of product standards (mandatory):

- Safety standards - goods must comply with particular performance, composition, contents, methods of manufacture or processing, design, construction, finish or packaging rules.
- Information standards - prescribed information must be given to consumers when they purchase specified goods (e.g. labeling for products & safety labeling for refrigerants/lubricants/chemicals, energy labeling for RAC appliances etc.).

UL

Underwriter Laboratories, USA. UL certifies, validates tests, inspects, audits, and advises and trains. They provide the knowledge and expertise to help customers navigate growing complexities across the supply chain from compliance and regulatory issues to trade challenges and market access. They facilitate global trade and deliver peace of mind. Their five businesses, Product Safety, Verification Services, Life & Health, Knowledge Services and Environment, demonstrate their expanding breadth of expertise and growing range of services to offer solutions needed in a constantly evolving world.

IEC

International Electrotechnical Commission (IEC) prepares and publishes International Standards for all electrical, electronic and related technologies. The IEC is one of three global sister organizations (IEC, ISO, ITU) that develop International Standards for the world. More than 10,000 experts from industry, commerce, government, test and research labs, academia and consumer groups participate in IEC Standardization work.

AHRI

Air-conditioning, Heating and Refrigeration Institute, (AHRI) is the trade association representing manufacturers of air conditioning, heating and commercial refrigeration equipment. An internationally recognized advocate for the industry, AHRI develops standards for and certifies the performance of many of these products. AHRI also publishes more than 80 standards and guidelines, the majority of which are accredited as American National Standards by the American National Standards Institute.

ASHRAE

ASHRAE develops standards for both its members and others professionally concerned with refrigeration processes and the design and maintenance of indoor environments. ASHRAE writes standards for the purpose of establishing consensus for:

1) methods of test for use in commerce and
2) performance criteria for use as facilitators with which to guide the industry.

ASHRAE publishes the three types of voluntary consensus standards: Method of Measurement or Test, Standard Design and Standard Practice. ASHRAE does not write rating standards unless a suitable rating standard will not otherwise be available. Consensus standards are developed and published to define minimum values or acceptable performance, whereas other documents, such as design guides, may be developed and published to encourage enhanced performance.

IS Standards for Air-Conditioners

IS 1391(PT 1) :1992	Room air conditioners specification Part 1 Unitary air conditioners (second revision) (9000kcal/h)
IS 1391(PT 2):1992	Room air conditioners specification Part 2 Split air conditioners) (second revision) (9000kcal/h)
IS 659:1964	Safety code for air conditioning (first revision)
IS 660 : 1963	Safety code for mechanical refrigeration
IS 3615:2007	Glossary of terms used in refrigeration and air conditioning (1st revision)
IS 302-1 (2008)	Safety of household and similar electrical appliances, Part 1: General Requirements (6th Revision)
IS: 732-1989	Code of practice for electrical wiring installations.
IS: 996 -2009	Single phase AC induction motors for general purpose (3rd revision)

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SLIDE 5:

IS STANDARDS FOR AIR-CONDITIONERS

Standard on Room Air Conditioner in India

Indian Standard

ROOM AIR CONDITIONERS- SPECIFICATION

IS:1391 – 1992

(2nd revision)

Part 1 : Unitary Room Air Conditioner

Part 2: Split Air Conditioners

- Limited to Room air-conditioners only
- Covers - Reference, Terminology, Classification, Construction, Dimensions, Rating, Performance, Test Conditions, Performance Calculations, Specifications on Label, Noise limits and Safety etc.
- Cooling and Heating modes

India HPMP Stage II - 2018: Professional Standards 6

SLIDE 6:

STANDARD ON ROOM AIR CONDITIONER IN INDIA

Types of Standards issued normally come under following categories:

- **Basic/Fundamental standard -** standard that covers a wide range of services or establishes a general provision for a specific field. A basic standard may function as a standard for direct application or as a basis for other standards.
- **Terminology standard -** standard that deals with terms used, which often includes their definitions, and sometimes by explanatory notes, illustrations, examples, etc.
- **Testing standard -** standard that deals with test methods, sometimes supplemented with other provisions related to testing, such as sampling, use of statistical methods, sequence of tests.
- **Product standard -** standard that lays down the requirements to be accomplished by a product or a group of products, to certify its fitness for use.
- **Process standard -** standard that lays down the requirements to be accomplished by a process, to establish its fitness for use.
- **Service standard -** standard that lays down the requirements to be accomplished by a service, to establish its fitness for use. Service standards may be prepared in fields such as laundering, hotelkeeping, transport, car-servicing, telecommunications, insurance, banking, trading.

There are various Standards issued in India by Bureau of Indian Standards (BIS), the erstwhile ISI, for room air-conditioners wherein all the following are inter-dependent and need to refer together. The Standard IS 1391, originally issued in 1992, has been revised from time to time to make it stringent.

- **IS 1391(PT 1):1992** Room air conditioners specification Part 1 Unitary or window air conditioners (second revision)
- **IS 1391(PT 2):1 992** Room air conditioners specification Part 2 Split air conditioners) (second revision)
- **IS 659: 1964** Safety code for air conditioning (first revision)
- **IS 3615: 2007** Glossary of terms used in refrigeration and air conditioning (first revision)
- **IS 302-1 (2008)** Safety of household and similar electrical appliances, Part 1: General Requirements (6th Revision)
- **IS: 732-1989** Code of practice for electrical wiring installations.
- **IS: 996 -2009** Single phase AC induction motors for general purpose (3rd revision)

IS 1391(PT 1):1992 (second revision) Room air conditioners specification consists of two parts:

- Part 1 Unitary air conditioner
- Part 2 Split air conditioners

This standard is limited to Room ACs only. It covers references, terminology, classification, construction, dimensions, rating performance, test conditions, performance calculations, specifications on label, noise limits and safety etc. It is for both cooling and heating modes.

Testing of Air-Conditioners Cooling Mode Only

IS-1391 Part 1 for WACs		IS-1391 Part 2 for SACs	
Capacity Rating Test	High load Test	Capacity Rating Test	High load Test
Room side DBT 27°C WBT 19°C	DBT 35°C WBT 24°C	Room Side DBT 27°C WBT 19°C	DBT 35°C WBT 24°C
Outdoor side DBT 35°C WBT 24°C	DBT 46°C WBT 27°C	Outdoor Side DBT 35°C WBT 24°C	DBT 46°C WBT 27°C

Only for high load test voltages are 90% and 110% of ratings

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SLIDE 7:

TESTING OF AIR-CONDITIONERS COOLING MODE ONLY

Testing of Air-Conditioners Heating Mode Only

IS-1391 Part 1 for WACs		IS-1391 Part 2 for SACs	
Capacity Rating Test	Over load Test	Capacity Rating Test	Over load Test
Room side DBT 21°C WBT 19°C	DBT 24°C WBT n s	Room Side DBT 21°C WBT 19°C	DBT 24°C WBT n s
Outdoor side DBT 7°C WBT 6°C	DBT 21°C WBT n s	Outdoor Side DBT 7°C WBT 6°C	DBT 21°C WBT n s

Only for high load test voltages are 90% and 110% of ratings

India HPMP Stage II - 2018: Professional Standards 8

SLIDE 8:

TESTING OF AIR-CONDITIONERS HEATING MODE ONLY

Important other International Standards

ISO 5149: 2014	Mechanical refrigerating systems used for cooling and heating – Safety requirements
ISO 11650:1999	Performance of refrigerant recovery and/or recycling equipment
AHRI Guideline - N:2017	Assignment of Refrigerant Container Colors
IS/ISO 817:2014	Refrigerants -- Designation and safety classification
BS 5643:1984	Glossary of refrigeration, heating, ventilating and air-conditioning terms
BS EN 378-4:2016	Refrigerating systems and heat pumps. Safety and environmental requirements. Operation, maintenance, repair and recovery
ASTM B280-18	Seamless copper tube for air conditioning and refrigeration field service

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SLIDE 9:

IMPORTANT OTHER INTERNATIONAL STANDARDS

Here we shall learn the various conditions that need to be created for testing a designed air-conditioner. These conditions can be created only under certain conditions for a long duration of entire test like testing laboratories. The conditions are for capacity rating (cooling) calculation and under high load conditions. You will note that there are 2 sides of temperatures and humidity stated for room side (evaporating coil side) and outside (condensing coil side). This slide is for testing of Air-conditioner for cooling mode. In the next slide, the heating mode is presented

This slide is for testing of Air-conditioner for heating mode.

The International Organization for Standardization (ISO) Geneva develops the globally used standards. ISO standards contribute to making the development, manufacturing and supply of products and services more efficient, safer and cleaner. They make trade between countries easier and fairer. The relevant standards are

- ISO5149:2014 Mechanical refrigerating systems used for cooling and heating – Safety requirements.
- ISO 11650:1999 Performance of refrigerant recovery and / or recycling equipment.
- IS/ISO 817:2014 Refrigerants – Designation and safety classification.

Similarly, other standards issued by other organizations like AHRI, BS Standards have issued following useful standards.

- BS 5643: 1984 Glossary of refrigeration, heating, ventilating and air-conditioning terms.
- BS EN 378 -4:2016 Refrigerating systems and heat pumps, safety and environmental requirements, operation, maintenance, repair and recovery.
- AHRI Guidelines - N: 2017 Assignment of Refrigerant Container Colors.

ASTM International is one of the largest voluntary standards development organizations in the world-a trusted source for technical standards for materials, products, systems, and services. Known for their high technical quality and market relevancy, ASTM International standards have an important role in the information infrastructure that guides design, manufacturing and trade in the global economy.

- ASTM B280-18 Seamless copper tube for air conditioning and refrigeration field service

Standards & Labeling

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SLIDE 10:
STANDARDS & LABELLING

Why Energy Efficiency Labelling for Appliances?

- Create consumer awareness about cost of operation.
- Create a demand for more efficient products.
- Provide a new avenue for competition.
- Reduction in energy use and lower operating cost.
- Prevent “dumping” of inefficient products.

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SLIDE 11:
WHY ENERGY EFFICIENCY LABELLING FOR APPLIANCES?

Why Energy Efficiency Labelling for Appliances?

Conserve Energy

- Energy - scarce & expensive.
- Ineffective operating procedures further push up costs.
- Energy efficient technologies helps to protect global climate, as fossil fuels are responsible for the greenhouse effect.
- Energy efficiency/conservation measures can reduce peak and average demand.
- Considering above factors & to provide a policy guidance, GoI enacted the Energy Conservation Act, 2001.
- BEE is established to implement & monitor the Energy Conservation Act, 2001
- Standards & Labeling Program launched on 18th May 2006

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SLIDE 12:
WHY ENERGY EFFICIENCY LABELLING FOR APPLIANCES?

Like what we have learnt about BIS who operates for product design related standards, to make energy efficient products, the Bureau of Energy Efficiency was established by Ministry of Power,

- BEE is established to implement & monitor the Energy Conservation Act, 2001
- One of the key thrust areas of EC Act, 2001 is Standards & Labelling Program launched on 18th May 2006

In our country, like in many other countries, consumers need to be made aware about the quality and cost of operating the products apart from cost of product alone. So, product awareness was created that resulted in a demand for more efficient products, new avenue for competition, reduction in energy usage and lower operating cost. This standardization ensures energy efficiency of the products and prevents the "dumping" of inefficient products to customers.

As we all know energy is scarce and expensive so need to conserve energy. Energy should be conserved since we are consuming disproportionate amount of energy. A technician's efficiency and quality of work is essential to improve the energy efficiency of the air conditioners. Energy Efficiency can be improved by optimization or better designs. Also, the ineffective production procedures further increase cost. With use of more energy efficient technologies, many businesses could cut their energy consumption upto 20%. Energy efficient technologies helps to protect global climate, especially when fossil fuels that are responsible for the greenhouse effect. The electricity that we use comes mostly from burning fossil fuels, that emits carbon-dioxide which is harmful to humans and the environment. Apart from these it also helps us to save money, mitigates the numerous adverse environmental and social impacts associated with energy production and consumption. Energy conservation also extends the lifetime of equipment and reduces the maintenance cost by operating less hours and at less than maximum capacity.

Energy conservation measures can reduce peak and average energy demand. Investment in energy efficiency or energy conservation is highly cost effective. It also avoids investment in fuel, mining, transportation etc.

Considering above factors & to provide a policy guidance, Government of India enacted the Energy Conservation Act, 2001. Bureau of Energy Efficiency (BEE) is established to implement & monitor the Energy Conservation Act, 2001 Standards & Labelling Program launched on 18th May 2006.

BEE Air-conditioner Energy Labeling Standard

Standards & Labeling scheme specifies:

1. Rated power (input).
2. Rated capacity (output).
3. Indian Seasonal Energy Efficiency Ratio (ISEER)
4. Star rating.
5. Requirements for energy label validity.
6. Performance criteria for energy labelling validity.
7. Test report format.
8. Printing requirements for air conditioner appliance energy labels.

SLIDE 13:

BEE AIR-CONDITIONER ENERGY LABELING STANDARD

Energy Efficiency Standards and Labeling – Worldwide

- 1960 - Russia introduced the efficiency information labels and performance standards.
- 1962 - First mandatory minimum energy-efficiency standard launched in Poland.
- 1968 - French government introduced standards for refrigerator and for freezers (1978).
- 1976 - California, U.S introduced energy-efficiency standards
- 43 governments of world introduced standards and labeling in 2000. Increased to 65 in 2007.
- Recently, many countries initiated programs - voluntary endorsement labeling for energy efficient products.
- Many other countries including Australia, Canada, China, Brazil, Thailand, Japan and United Kingdom (U.K.) have then implemented national programs.

SLIDE 14:

ENERGY EFFICIENCY STANDARDS AND LABELING – WORLDWIDE

Standards and labelling program when launched few important requirements were specified for reporting which is essential. Apart from many small and big issues following must be done by each OEM before going for putting Star labels on the products.

1. Rated power (input).
2. Rated capacity (output).
3. Indian Seasonal Energy Efficiency Ratio (ISEER).
4. Star rating. (Number of Star derived)
5. Some requirements for energy label validity.
6. Performance criteria for energy labelling validity.
7. Test report format.
8. Printing requirements for air conditioner appliance energy labels.

In this slide we have made attempt to inform you the similar actions taken by various countries of the globe. You will note that similar activity had begun in Russia in 1960; almost 40 years before us. In any case the energy labelling is essential and will become more stringent as discussed in other presentation too, when you have seen how progressively the bar for ISEER (earlier EER) is raised for a single star from 2.3 in 2010-11 to 3.10 current (2018-19)) or 3.1 to 4.5 for five stars. In short, each country tries to save the electrical energy and thereby produce quality products and save energy for other applications. This act also helps towards environmental protection. Therefore, all technicians too need to work considering all these aspects for the nation and world as a whole. The earth provides enough to satisfy every man's needs but not every man's greed. – Mahatma Gandhi. To summarize, consumption on Non-Renewable Sources must be reduced as much as possible:

1. Resource Depletion: By using these resources in excess, they are going to deplete one day and will take another millions of years to form again.
2. Save Money: Usage of fluorescent bulbs, solar electricity may cost expensive initially but prove to be cost-effective in the long run. Many energy efficiency and conservation measures are better investments than the stock market or bank interest.
3. Reduce Carbon-dioxide: If Non-Renewable resources are used up to the limit they may also help in reducing the carbon-dioxide. Pollution from nuclear and coal power plants cause diseases like asthma, emphysema etc.
4. Climate Change: Due to increase int the rate of these resources it also affects the climate greatly, Drought, Severe storms, floods, land loss, erosion of soil and heat deaths are few examples of climate change.
5. Ozone Layer Depletion: Ozone layer in the atmosphere protect us from ultraviolet rays from reaching the earth thus, making life on the earth possible.
6. Adverse effect on humans and the environment: Extraction of Uranium and Coal from beneath the earth cause huge effect to the lives of coal miners. These people have high cancer death rates. They also harm the environment and agricultural lands.
7. Acid Rain : Coal power plants and vehicles emit sulfur dioxide (SO2) and nitrous oxides (NOx). These travel beyond the local area and are harmful to the health throughout whole regions. When SO2/NOx and water vapor mix under certain conditions, sulfuric acid and nitric acid, known as acid rain, are formed. This is very harmful to the lungs. It kills fish in lakes, corrodes property (buildings, monuments, cars), harms the soil (releasing toxins), and harms trees and crops.
8. Global Warming : With so much dependence on Nonrenewable sources, global warming is taking place all over the world and the result which is glaciers are melting which is causing the rise in the sea level.

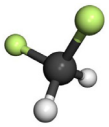
ASHRAE-34: Designation of Refrigerants

1. Fully Saturated Halogenated Compounds → R_{XYZ}

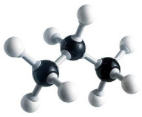
X	Y-1	Z
No. of carbon atoms (C) – 1 (omitted if the digit is zero)	No. of Hydrogen Atoms (H)	No. of Fluorine atoms (F)

e.g.

HCFC-22 ($CHClF_2$)



HFC-32 (CH_2F_2)



R-290 (C_3H_8)

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SLIDE 15:

ASHRAE-34: DESIGNATION OF REFRIGERANTS

ASHRAE-34: Designation of Refrigerants

2. Inorganic Refrigerants → Designated by "7" followed by molecular wt.

e.g.
R717 –NH_3 (Ammonia);
R718-Water;
R744- CO_2

3. Mixtures → Azeotropic Mixtures are designated by 500 series; Zeotropic mixtures are designated by 400 series

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SLIDE 16:

ASHRAE-34: DESIGNATION OF REFRIGERANTS

ASHRAE 34: Safety Classification of Refrigerant

American Society of Heating, Refrigerating and Air-conditioning Engineers (ASHRAE) 34 – Designation and Safety Classification of Refrigerants for toxicity and flammability

❑Toxicity
- "A" – Lower toxicity
- "B" – Higher toxicity

❑Flammability
- "1" – No flammability
- "2" – Flammable
- "2L"– Mildly Flammable
- "3" – Higher Flammability

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SLIDE 17:

ASHRAE 34: SAFETY CLASSIFICATION OF REFRIGERANT

In this slide ASHRAE-34 designation of refrigerants are given.

Fully saturated halogenated compounds are designated with formula

R XYZ

Where, R indicates refrigerant

X indicates no. of Carbon atoms (C) – 1, is omitted if the digit is zero

Y-1 indicates no. of Hydrogen atoms (H)

Z Indicates no. of Fluorine atoms (F)

For example

HCFC-22- ($CHClF_2$)

HFC-32 – (CH_2F_2)

R-290 – (C_3H_8)

Inorganic refrigerants are designated by "7" followed by molecular weight. For Carbon Dioxide the designation works out to be R-744. Other examples are R-717 (Ammonia) and R-718 (Water).

In the case of mixtures, azeotropic mixtures are designated by 500 series e. g. R-502 and zeotropic mixtures are designated by 400 series e. g. R-410A, R-407C, R-417A etc.

All hydrocarbons are designated as per formula **R-XYZ** e. g. Propane (C3H8) - HC290, n-Butane – R-600, isobutane – R-600a.

The standard ASHRAE-34 specifies the safety class of refrigerant and also gives designation to refrigerant. Under the safety, all refrigerants are categorized for toxicity and flammability. The lower toxicity is denoted by "A" and higher by "B". The flammability of refrigerant is referred with numbers. This classification includes '1" for No flammability, "2' for Lower flammability, "3" for higher flammability and "2L" for subset of "2". For example, Propane is classified by A3, Isobutane by A3, Ammonia by B2L and Carbon Dioxide by A1.

The flammability of refrigerant higher or lower is defined on the basis of flammability limits and heat of combustion when tested in air at 21°C and 101 kPa. If there is no flame propagation, then that refrigerant comes under "A1" category. When flammability limit is more than 0.10 kg/m3 and heat of combustion is less than 19 kJ/kg then that refrigerant comes under category "A2". For "A2L" the limits are flame propagation velocity is less than 10/s under category "A2". The category "A3" refrigerant is considered as highly flammable when flammability limit is less than or equal to 0.10 kg/m3 and heat of combustion is more than or equal to 19 kJ/kg.

The toxicity lower or higher denoted by "A" and "B" respectively.

ASHRAE 34: Safety Classification of Refrigerant

	Lower (Chronic) Toxicity		Higher (chronic) Toxicity	
No flame propagation	**A1**	HCFC-22 R-744 HFC-134a R-410A, R-407C,R-404A	**B1**	HCFC-123
Mildly Flammable	**A2L**	HFC-1234ze HFC-1234yf HFC-32	**B2L**	R-717
Flammable	**A2**	HFC-152a	**B2**	
Higher Flammability	**A3**	HC-290 HC-600a	**B3**	

Increasing safety requirement

Increasing safety requirement

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SLIDE 18:

ASHRAE 34: SAFETY CLASSIFICATION OF REFRIGERANT

Relevant Safety Standards for Flammable Refrigerants

Field	US	Europe	International
Classification	ASHRAE 34 UL 2182	-NA- (based on ISO)	ISO817
Refrigerant charge limits and Safety requirements	ASHRAE 15 UL 207 UL 250 UL 471 UL 474 UL 484 UL 984 UL 1995 UL 60335-2-40	EN378 EN60335-2-40 EN60335-2-89	ISO5149 IEC60335-2-40 IEC60335-2-89

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SLIDE 19:

RELEVANT SAFETY STANDARDS FOR FLAMMABLE REFRIGERANTS

Relevant Safety Standards for Flammable Refrigerants

ISO Standards

- **ISO 817: 2014: Refrigerant Designation and Safety Classification Standard**
  - Nomenclature / Designation;
  - Safety Classification A / B:
    - Category: A1, A2L, A2 and A3
    - Category: B1, B2L, B2 and B3
- **ISO 5149-1 : 2014 - Refrigerating Systems and Heat Pumps**
  - Allows the use of flammable refrigerants for comfort air-conditioning;
  - Toxicity and flammability characteristics are used to determine refrigerant charge limits;
  - Requirements for A2L refrigerants for ACs and multi-indoor units included.

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SLIDE 20:

RELEVANT SAFETY STANDARDS FOR FLAMMABLE REFRIGERANTS

In this slide ASHRAE 34 safety classification of the most common refrigerant used in Room ACs are presented.

In this slide the standards for refrigerant classification, refrigerant charge limit and safety classifications are presented.

ISO 817:2014: Refrigerant Designation and Safety Classification Standards

It provides system for assigning designations to refrigerants. It also establishes a system for assigning a safety classification to refrigerants based on toxicity and flammability data and provides a means of determining the refrigerant concentration limit. This standard is similar to ASHRAE-34 Standard. The letters 'A' and 'B' are used to classify toxicity. Flammability is classified by the categories: '1', '2', '2L' and '3'

ISO 5149-1:2014: Refrigerating System and Heat Pumps

It also specifies the requirements relating to the safety of persons and property for the design, construction, installation and operation of refrigerating systems and puts an emphasis on minimising the leakage of refrigerant to the atmosphere. This standard allows the use of flammable refrigerants for comfort air-conditioning. Toxicity and flammability characteristics are used to determine refrigerant charge limits. Requirements for A2L refrigerants for ACs and multi-indoor units included.

Relevant Safety Standards for Flammable Refrigerants

IEC Standards: **IEC 60335-2-40 : 2013**

- ❑ IEC Standards are Product Specific
- ❑ IEC 60335-2-2013 deals with "Air-conditioners & Heat Pumps":
  - ➢ Flammable refrigerants requirements being addressed
  - ➢ Product Safety addressed including the following:
    - Safety markings
    - Electrical Safety
    - Construction: Ignition sources in the product, charge limits
    - Abnormal operations
    - Mechanical strength

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SLIDE 21:
RELEVANT SAFETY STANDARDS FOR FLAMMABLE REFRIGERANTS

Relevant Safety Standards for Flammable Refrigerants

Refrigerant Charge Limit as per IEC Standards

- ❑ Refrigerant Charge limit
  - ➢ $m_{max} = 2.5 \times LFL^{5/4} \times h_0 \times A^{1/2}$

Where:

m_{max} : allowable maximum charge in a room in kg;
A : room area in m^2;
LFL : lower flammable limit in kg/m^3;
h_0 : installation height of the appliance in m.

For a typical 5kW R-290 split AC:

$m_{max} = 2.5 \times 0.038^{5/4} \times 2.3 \times 14^{1/2} = 360$ g.

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SLIDE 22:
RELEVANT SAFETY STANDARDS FOR FLAMMABLE REFRIGERANTS

ODP and GWP

- ➢ Montreal Protocol has tabulated the ozone depleting substances and their Ozone Depleting Potential (ODP) values.
- ➢ Intergovernmental Panel on Climate Change (IPCC) defines the value of the Global Warming Potential (GWP) values.
- ➢ ODP values and GWP values for 100 years of horizon of some chemicals are given in the table

Compound	ODP	GWP*
CO2	0	1
CFC-11	1	4750
HCFC-22	0.055	1810
Propane (R-290)	0	3
Propene /Propylene	0	3
HFC-32	0	675
R-407C	0	1700
R-404A	0	4200
R-410A	0	2100

*Values are taken from Technology and Economic Assessment Panel Report

India HPMP Stage II, 2018 : Impact of Refrigerants on Environment 23

SLIDE 23:
ODP AND GWP

IEC 60335-2-40:2013 deals with the safety of electric heat pumps and air conditioners.

This standard does not take into account refrigerants other than group A1, A2L, A2 and A3 as defined by ISO 817 classification. This standard specifies particular requirements for the use of flammable refrigerants.

Product Safety addressed including the following:

- Safety markings
- Electrical Safety
- Construction: Ignition sources in the product, charge limits
- Abnormal operations
- Mechanical strength

In this slide the formula to calculate maximum charge limit as per IEC standards are presented.

Refrigerant Charge limit

$$m_{max} = 2.5 \times LFL^{5/4} \times h_0 \times A^{1/2}$$

Where:

m_{max} : allowable maximum charge in a room in kg;

A : room area in m^2;

LFL : lower flammable limit in kg/m^3;

h_0 : installation height of the appliance in m.

For a typical 5kW R-290 split AC:

Assuming Area A = 14 m2 and height h0 = 2.3 m

LFL = 0.038 kg/m^3

Refrigerant Charge Limit: $m_{max} = 2.5 \times 0.038^{5/4} \times 2.3 \times 14^{1/2} = 360$ g.

Montreal Protocol has tabulated the ozone depleting substances and their Ozone Depleting Potential (ODP) values based on the research data. Intergovernmental Panel on Climate Change (IPCC) defines the value of the Global Warming Potential (GWP) values. ODP and GWP values of the available and developing refrigerants are listed in the Technology and Economic Assessment Panel reports. ODP values and GWP values for 100 years of horizon of some chemicals are given in the table

Total Equivalent Warming Impact (TEWI)

- Warming or environmental impacts are due to direct and indirect emissions of greenhouse gases
- TEWI combines the effects of:
  - Direct emissions of refrigerants from Air-conditioners during its life time
  - Indirect emission of CO_2 from the combustion of fossil fuels for generation of electricity used by the Air-conditioner throughout its lifetime.
- Provides a measure of the environmental impact of Refrigerant and all other greenhouse gases from manufacture, operation, service and end-of-life disposal of equipment.

SLIDE 24:
TOTAL EQUIVALENT WARMING IMPACT (TEWI)

TEWI Calculations

Reflects lifetime contribution of an appliance to the global warming

$$TEWI = \underbrace{m_{ref}.GWP_{ref}.z + m_{ba}.GWP_{ba}}_{\text{Direct}} + \underbrace{t.E.f}_{\text{Indirect}}$$

TEWI	:	Total Equivalent Warming Impact in kg CO_2
m_{ref}	:	Mass of refrigerant in kg
GWP_{ref}	:	Global Warming Potential of refrigerant in kg CO_2
z	:	Number of charges of refrigerant during service life
m_{ba}	:	Mass of blowing agent in kg
GWP_{ba}	:	Global Warming Potential of blowing agent in kg CO_2
t	:	Service life of appliance in years
E	:	Annual energy consumption of appliance in kWh/yr
f	:	CO_2-factor of energy conversion in kg CO_2/kWh_{el}

SLIDE 25:
TEWI CALCULATIONS

Warming or environmental impacts are due to direct and indirect emissions of greenhouse gases. GWP of refrigerant is the global warming impact of the direct emission of a greenhouse gas in relation to the impact from the emission of similar amount of CO2. The impact is estimated during a time horizon, a time horizon of 100 years is most adopted value. In addition to the direct impact due to emission of the refrigerant estimated by GWP, air-conditioning system while operating requires energy input, which indirectly affects the environment. This impact is originated from CO2 emissions from the energy production processes.

TEWI combines the effects of:

- Direct emissions of refrigerants from Air-conditioners during its life time
- Indirect emission of CO2 from the combustion of fossil fuels for generation of electricity used by the Air-conditioner throughout its lifetime.

TEWI provides a measure of the environmental impact of Refrigerant and all other greenhouse gases from manufacture, operation, service and end-of-life disposal of equipment.

In this slide TEWI Calculation is presented

Total Equivalent Warming Impact in kg CO2

TEWI = m_{ref}.GWP_{ref}.z + m_{ba}.GWPba + t.E.f

Where,

m_{ref}	:	Mass of refrigerant in kg
GWP_{ref}	:	Global Warming Potential of refrigerant in kg CO_2
z	:	Number of charges of refrigerant during service life
m_{ba}	:	Mass of blowing agent in kg
GWP_{ba}	:	Global Warming Potential of blowing agent in kg CO_2
t	:	Service life of appliance in years
E	:	Annual energy consumption of appliance in kWh/yr
f	:	CO_2-factor of energy conversion in kg CO_2/kWh_{el}

TRAINING METHODOLOGY

Target Group
Trainers

Duration of the Session
60 minutes

Purpose of the Session

To make the prospective trainers understand the factors which influence training effectiveness in general, so that they are better prepared in planning and delivery of training to AC service technicians under HPMP project.

Terminal Performance Objectives

At the end of the session, the participants should know/ understand:

- Components of a training cycle, namely, training needs analysis, training design, delivery and evaluation.
- Importance of focusing on critical information and skill needs of the trainees while designing a training programme
- Difference between pedagogy and androgogy
- Need for prior preparation before embarking upon a training programme
- Suggested measures to enhance their individual effectiveness in training delivery

Key Message being delivered through this Session

The key message is that effective training doesn't take place on its own; it has to be planned for. Conceptual understanding of the purpose of training and factors influencing training effectiveness is essential for this purpose. Considerable effort has been gone into by HPMP experts in designing training content. Careful preparation in terms of ensuring a proper well-equipped training venue and planning the details of a training session is equally important to make the training programme a success. Evaluation of training at various levels is also necessary to assess its effectiveness and take corrective actions. The ultimate test of training effectiveness is whether it has resulted in adoption of improved practices by the trainees of any technician training programme, after they go back to work.

Tools & Equipment (if any) required for the session
None

HPMP

giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

Training Methodology

SLIDE 1:

TRAINING METHODOLOGY

HPMP

Learning Outcomes

- ❑Help trainers in becoming a more effective technical trainer
- ❑Understand the factors influencing training effectiveness
- ❑Understand the difference between adult learning & child learning
- ❑Enhance trainer's confidence

India HPMP Stage II - 2018 : Training Methodology 2

SLIDE 2:

LEARNING OUTCOMES

HPMP

Purpose of Training

- ❑To develop <u>competence</u> of trainees;
- ❑To meet the development needs of individuals;
- ❑To enhance their productivity, quality & customer service orientation;
- ❑To facilitate them make a change in their working methods.

India HPMP Stage II - 2018 : Training Methodology 3

SLIDE 3:

PURPOSE OF TRAINING

This is the title slide. The trainer should explain why a session on training methodology has been added into the ToT programme outline.

In this session, the learning outcomes of this session on training methodology have been stated. These are to (a) help the participants in becoming more effective technical trainers; (b) make them understand the factors influencing training effectiveness; (c) enable them to differentiate between the principles of adult and child learning; and (d) enhance their confidence in conducting technical training under HPMP.

Training, in general, is concerned with developing competence of trainees. The term 'competence' has been elaborated in the next slide. Training also serves to meet the development needs of individuals. It is useful to enhance their productivity, quality and customer orientation. Lastly, it facilitates the trainees in making a deliberate change in the work methods adopted by them in their day-to-day jobs.

Competence

- Competence is the sum total of knowledge, skills and attitudes (KSAs) of a person, which provides him/her the ability to:
  - handle the specific job effectively;
  - transfer skills to new work situations;
  - learn new skills on his / her own initiative.

India HPMP Stage II - 2018 : Training Methodology 4

SLIDE 4:
COMPETENCE

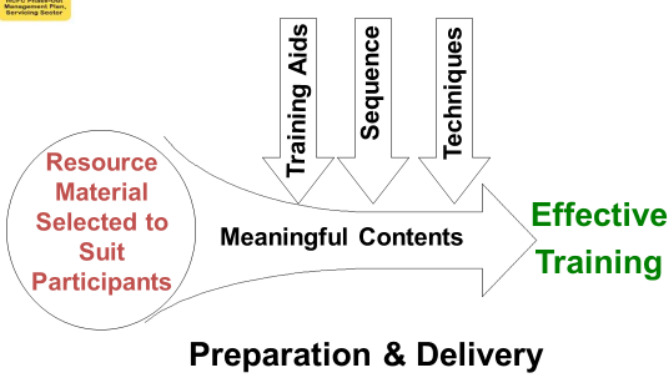
Purpose of Technical Training

- Technical training is focused on specific work- related situations
- It aims at reducing the:
  - learning time for change in the method of working;
  - fire-fighting in work situation;

India HPMP Stage II - 2018 : Training Methodology 5

SLIDE 5:
PURPOSE OF TECHNICAL TRAINING

Elements of Technical Training



India HPMP Stage II - 2018 : Training Methodology 6

SLIDE 6:
ELEMENTS OF TECHNICAL TRAINING

In this slide, the term "competence" has been elaborated. Competence is the sum total of knowledge, skills and attitudes (KSAs) of a person, which provides him/her the ability to: (a) handle the specific job effectively; (b) transfer skills to new work situations; and (c) learn new skills on his/ her own initiative. All the three ingredients of learning (KSAs) are important, and they go together. Providing knowledge without an effort to develop the requisite skills will not lead to any change in work methods. Developing new skills amongst the trainees is easier and better sustained if the knowledge behind the skill (namely the rationale for changing the work methods/ practices) is shared with the trainees. However, there is a risk that the learnt skills may not be put to use if the accompanying mindset is not geared towards utilizing the new skills. This change in mindset can be achieved by inculcating relevant attitudes through training.

A person is truly competent in his sphere if he or she can not only perform his current job confidently but can also transfer his existing skills to new and unfamiliar work situations by virtue of his understanding of the basic principles. Not only that, a competent person has the capability of autonomous learning, i.e., learning new skills as and when demanded by a future job, based on his/ her own initiative.

This slide focuses on technical training as one form of training. The purpose of technical training is primarily to develop skills relevant to a specific work-related situation. For example, training imparted to service technicians under HPMP project is a technical training. A person, even if not given technical training, may still learn proper working methods in due course, but that learning will usually take place through a long-drawn process, with trial and error. However, with the help of systematic technical training, the learning time can be expected to substantially reduce. Similarly, if a person has been imparted technical training, there will be less need for fire-fighting or need to solve emergency situations. Thus, technical training is extremely important in bringing about a change in the working methods and streamlining various activities.

This slide pictorially represents various factors which have to be considered with regard to technical training. For ensuring effective technical training, it is important to ensure that resource materials are selected to suit the participants, so that the contents of training are meaningful to them. Use of proper training aids, sequence of presentation of training content and appropriate training techniques are the other important factors to be considered. Preparation and delivery of training are, therefore, critical for technical training to achieve its purpose.

Training under HPMP

❑Purpose :

Make service technicians aware of the need for

- ➢ adopting better practices
- ➢ developing requisite skills to service appliances using alternative refrigerants

❑Falls under the category of technical training

India HPMP Stage II - 2018 : Training Methodology 7

SLIDE 7:
TRAINING UNDER HPMP

Training Cycle

Training Needs Analysis (Need identification + Intimation)

↓

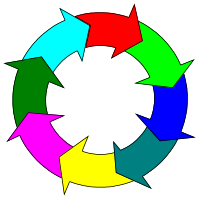
Design of Training (Contents & Sequence)

↓

Delivery of Training (Training Calendar & Methodology)

↓

Evaluation of Training (Study of retention by participant)



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SLIDE 8:
TRAINING CYCLE

Training Needs Analysis

❑Identify the gap between required and possessed knowledge, skills & attitudes

❑Prioritize the identified needs

❑Identify the key parameters of design of training

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SLIDE 9:
TRAINING NEEDS ANALYSIS

This slide discusses the technician training programmes in the context of purpose of technical training mentioned earlier. As the participants are aware, training under HPMP has been planned with a view to make the service technicians aware of the need for adopting better practices and developing requisite skills to service appliances using alternative refrigerants. The purpose of this training is very specific and skills-oriented, and therefore, it falls under the category of technical training. However, imparting skills under HPMP technicians training is also accompanied by providing the requisite background knowledge behind the skills to be developed. It also includes conscious efforts to change the attitudes of service technicians and make them amenable to adoption of correct service practices.

Development of technical training delivery system requires adoption of a systematic training cycle. This is a sequence of steps starting with training needs analysis, which involves identification of training needs and their intimation. The next logical step is that of design of training, which is concerned with finalising the contents and sequence of training. After the training design is finalised, delivery of training is the next logical step. Planning for training delivery also covers deciding about training calendar, which is essentially a schedule of proposed training programmes with dates and locations finalised and announced beforehand. In addition, aspects related to training methodology and techniques to be adopted need to be considered under this step. The fourth and final step is that of evaluation of training. This will be discussed in detail in a subsequent slide, but its basic purpose is to assess the effectiveness of training being imparted. One aspect of evaluation is how much of new knowledge is being retained by the trainees of any training programme.

An important aspect of a standard training cycle is that there is a feedback loop from every stage to the previous stages. This means that results of evaluation of training can be used to influence, not only the delivery of training (which is often done in practice), but also even training design and training needs analysis. Similarly, issues with training delivery can sometimes necessitate reviewing the training design; and this along with a review of training design, can point towards the need for re-examining the training needs analysis, which was the starting point.

This slide further elaborates the first step of a typical training cycle, namely, training needs analysis. The purpose of training needs analysis is to identify the gap between required and possessed knowledge, skills and attitudes (KSAs) of the participants. For this purpose, the KSAs of an average trainee are considered, and not the exceptional cases. Once this gap is known, it is likely that a large number of training needs get identified. However, these identified needs have to be prioritised so that training design, which is the next step of the training cycle, can focus on more critical training needs. Based on this prioritisation of training needs, the key parameters of training design can be identified. This slide also points out that design of technicians training programmes under HPMP has been essentially based on training needs analysis done by a team of experts by examining the current practices followed by technicians and determining the changes in practices considered essential to cope with the requirements imposed by alternative refrigerants.

Design of Training

- Training design should focus on what learners should do differently from what they are doing now
- Priority should be given to those areas of knowledge which are more critical for the trainers to understand

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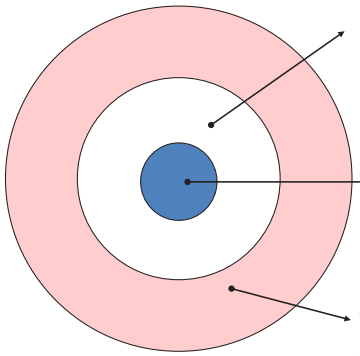
SLIDE 10:
DESIGN OF TRAINING

Criticality of Information



Should Know
Other processes, Depts., Eqpts, Matl etc.

Must Know
Sequence, Safety, Key Issues, etc..

Could Know
Background, Future trends etc..

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SLIDE 11:
CRITICALITY OF INFORMATION

Training Design for HPMP

- For training under HPMP, brainstorming amongst experts was carried out to arrive at the training design
- Theory and practical topics were identified, considering
  - appropriate theory practical mix
  - optimum two -days duration

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SLIDE 12:
TRAINING DESIGN FOR HPMP

This slide describes two very important principles of training design. The first principle is that training design should focus on what learners should do differently from what they are doing now. In other words, the most important criterion for designing training is the change in practices or work methods, which are sought after through training. Secondly, even though providing comprehensive background knowledge can be useful, priority should be given to those areas of knowledge which are more critical for the trainers to understand. This has been explained in greater detail in the next slide.

This slide elaborates the concept of criticality of information, which should be the basis of deciding what information/ knowledge must form part of the training design. The innermost circle represents the "Must Know" segment of information, i.e., the knowledge which is indeed critical for the trainees to possess. The training programme design should ensure that the "must know" information is indeed shared with the trainees. Examples of "must know" include information on safety, sequence of operations and key issues etc. The middle circle represents the "Should Know" segment. The information or knowledge falling under this segment is not the most critical but is still very important. As far as possible, training design should endeavour to share this kind of information also with the trainees. Examples of this may include information related to other processes, departments, equipment & material etc. The outermost circle represents the "Could Know" segment of information. Examples of this kind of information are historical background and future trends etc. As the name indicates, provision of this kind of information should be deemed as optional. It may be good to share such information, as it provides additional perspectives, but if it can't be shared because of time constraints, it still does not affect the training design.

[A decision on what information falls under the segment of "Must Know", "Should Know" and "Could Know" has to be made at the stage of training design. In HPMP technicians training programme design, these considerations have been kept in mind while designing the training programme. However, on many occasions, a decision on what is critical and what is not, has to be taken by the trainer on the spot if he or she faces a time constraint.]

In this slide, a brief overview has been given of the approach used in HPMP project to design a standard technician training programme. This was done through a series of brainstorming sessions amongst a group of experts. For arriving at the training design, various theory and practical topics were identified, which, in the opinion of experts, are critical for trainees. Based on prior experience of conducting such training programmes under HPMP pilot phase, assessment of the desirable sequence of topics and the time duration required for delivery of each was made. As the feedback from participants of earlier programmes had clearly indicated that a two-days duration is most preferred by the target group, this factor was duly considered for preparing the training programme outline. Care was also taken that there is an appropriate mix of theory and practical topics so that adequate weightage is given to learning of new skills as well as knowing the theoretical concepts behind them.

Delivery of Training

- This requires consideration of
  - Finalization of training calendar
  - Recruitment of trainees
  - Preparation of training venue
  - Identification of trainers
  - Preparation by the designated trainers
  - Actual training delivery

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SLIDE 13:
DELIVERY OF TRAINING

Preparation of Training Venue

- Whereabouts & how to reach?
- Seating arrangement
- Teaching aids available
- Arrangement for giving demos
- Lighting arrangements & stand-by power supply

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SLIDE 14:
PREPARATION OF TRAINING VENUE

Attributes of a Trainer

- Possessing Content Knowledge
- Belief in the theme of training
- Open to new inputs
- Encourages information sharing
- Responsive to the feedback
- Flexible in delivery

<u>These factors need to be considered while identifying trainers</u>

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SLIDE 15:
ATTRIBUTES OF A TRAINER

Delivery of training is the next step of a standard training cycle after training needs analysis and training design. This step requires consideration of various related issues, which would enable implementation of training design. Finalization of training calendar is one such issue, which involves preplanning a series of training programmes in terms of the organizer, venue and the specific dates of the training programme. The approach to be adopted for recruitment of trainees and allocation of responsibility for the same is another important aspect to be taken care of. Identification of the most appropriate training venue in terms of its suitability is another important consideration. For example, an exhaustive institutional assessment study was carried out under HPMP project to shortlist various training institutes in the selected geo-focus States of the project. Once the training venue has been identified, actions have to be initiated to ensure that the requisite infrastructure and training equipment is available at the selected training venue at the time of training. An equally important consideration is that of proper identification of trainers for a specific training programme to ensure that the requisite expertise in imparting theory as well as practical sessions is indeed available. The designated trainers need to gear themselves up for conducting the training programme well in advance. Last, but not least, the actual training delivery on the scheduled training dates is the final aspect of training delivery step of the training cycle.

Though it may appear obvious, preparation of training venue is a very important activity to ensure success of a training programme. Firstly, the whereabouts of the training venue and how to reach there should be explicitly stated. Secondly, it should be ensured that a proper seating arrangement has been provided for. It should also be ensured that all teaching aids such as overhead projector, white board/ black board etc. are available at the training venue. At the same time, there should be complete tools and equipment arrangement for giving demos. In the case of technicians training under HPMP, this includes requisite Split Room AC charged with HCFC-22 and R-290, charging-cum-evacuation units and cylinders, tools such as pinching pliers, piercing valves, copper tube cutter, flaring swaging tools and other equipment such as brazing facility and nitrogen cylinder etc. It has also to be ensured that lighting arrangements are proper, both in the classroom for theory sessions and in the workshop area for practical work. If the venue is likely to face power breakdowns, it should be made sure that arrangement for stand-by power supply is made beforehand.

The trainer is one of the most critical resources for a training programme. Even if some of the training equipments are not available, it might be still possible to conduct a training programme, though not of the best quality. But no training programme can be conducted in the absence of trainers. A trainer not possessing the desirable attributes may be a single most important cause of the failure of a training programme; therefore, it is essential that the selected trainers should possess some key attributes. In this slide, six such important attributes have been identified. Firstly, the trainer should possess the complete content knowledge, i.e., he should have the complete technical knowledge of the subject matter. Secondly, he should have belief in and be committed to the theme of training. He should be open to new inputs, such as newly emerging scientific knowledge and viewpoints expressed by the participants from their experience. He should be amenable to an interactive approach of training and should encourage information sharing with the trainees. He should also be responsive to the feedback from the participants; as such a feedback is likely to be based on field level experience of the participants. The trainer should not follow a rigid programme-driven approach in conducting training but should be amenable to adapt training delivery according to the situation at hand; in other words, he should be flexible in delivery. These factors should be consciously considered while identifying trainers for training programmes being planned in the future.

Prior preparation by the designated trainer

- ❑What is the context & overall design?
- ❑What is the objective of the session?
- ❑What is the no. and profile of participants? *(Background, experience, qualifications, age, sex, etc.)*
- ❑What would have been covered before the session?
- ❑What is the time allotted (& available?)

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SLIDE 16:
PRIOR PREPARATION BY THE DESIGNATED TRAINER

Contents & Structure of Lecture

- ❑Provide authentic & verifiable information
- ❑Develop a minimum / core content
- ❑Design a logical sequence of the session
- ❑Prepare bullet points
- ❑Keep it short & sweet (KISS)
- ❑Make sure to summarize at the end

HPMP Training Material for technicians training has been prepared keeping in view the above considerations

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SLIDE 17:
CONTENTS AND STRUCTURE OF LECTURE

Considerations for Actual Training Delivery

- ❑Awareness of the difference between Pedagogy and Androgogy
- ❑Qualities of Good Speaking
- ❑Combating nervousness
- ❑Enhancing delivery effectiveness
- ❑Platform tricks

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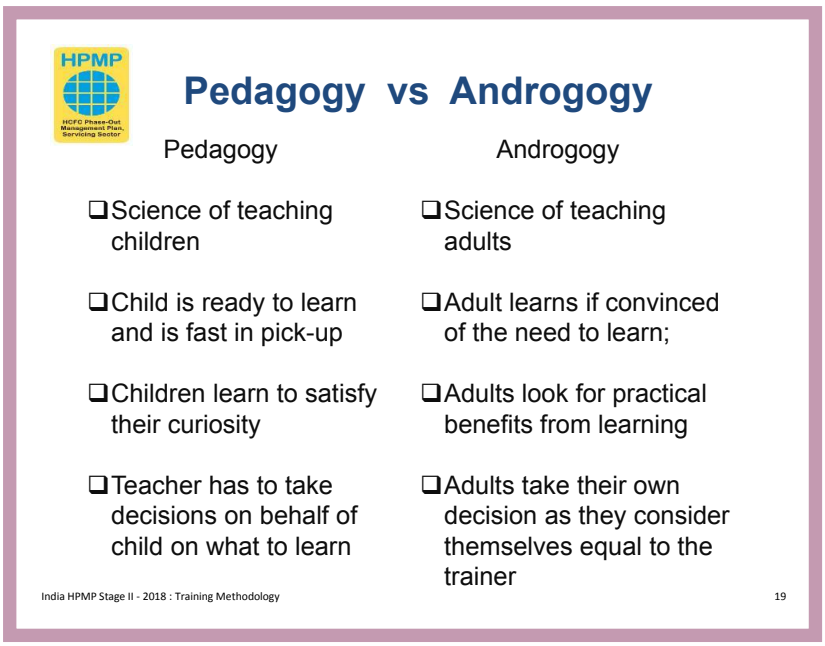
SLIDE 18:
CONSIDERATIONS FOR ACTUAL TRAINING DELIVERY

The designated trainer of a training programme should take preparatory steps well in advance of a scheduled training programme. If he is one amongst several trainers for the programme, he should be fully familiar with the context and overall design of the programme. He should be clear about the objectives of the training session assigned to him. He should be aware of the number of participants in the training programme and their profile in terms of background, experience, qualifications, age and sex etc. It will be very useful if he has a clear picture of what would have been covered in the training programme before his session and should know the time for training delivery allotted to him and time actually available (as some differences may arise during training).

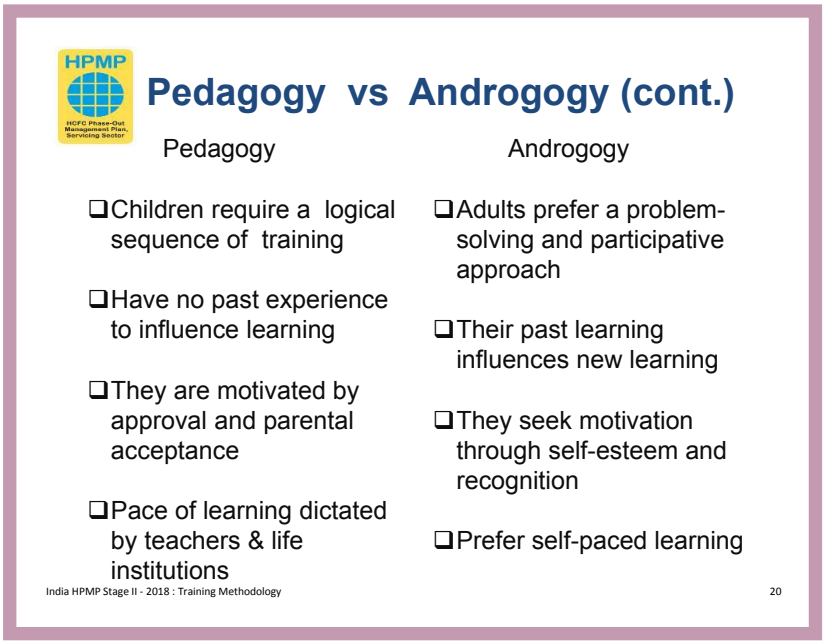
While developing the contents and structure of a particular lecture, the trainer should ensure that authentic and verifiable information is provided to the trainees. He must develop a minimum/ core content which has to be delivered through that lecture, and then design a logical sequence of the session. The information to be shared should be summarised in the form of bullet points for easy reference. Throughout this exercise, attempt should be to keep the content and structure of the lecture short and sweet. A summary of all the points made during the lecture should be given at the end.

It also needs to be highlighted that in the process of standardisation of training material for technicians training, all these factors have been duly considered.

The trainer should know the differences between pedagogy, the science of learning by a child and androgogy, the science of adult learning. These differences have been elaborated in the next two slides. Besides, the trainer should understand the important qualities of good speaking; should know how to combat nervousness in an actual training situation; and should be aware of the methods for enhancing effectiveness of training delivery. Many well-known platform tricks can be helpful to the trainer in making his training delivery interesting for the trainees.



SLIDE 19:
PEDAGOGY VS. ANDROGOGY



SLIDE 20:
PEDAGOGY VS. ANDROGOGY (CONTD)

SLIDE 21:
QUALITIES OF GOOD SPEAKING

In this slide, some important differences between pedagogy and androgogy have been highlighted. Firstly, while pedagogy is the science of learning by a child, androgogy is the science of adult learning. A child is always ready to learn and is fast in pick-up; on the other hand, an adult learns if convinced of the need to learn. Children learn basically to satisfy their curiosity; whereas, adults look for practical benefits. In the case of children, a teacher has to take decisions on behalf of the child on what to learn; whereas, the adults usually take their own decision on what to learn as they consider themselves equal to the trainer.

In this slide, the differences between pedagogy and androgogy have been further explained. Pedagogy is based on the belief that typically, children require a logical sequence of training, whereas adults prefer a problem solving and participative approach. Children have no past experience to influence their learning; whereas, in the case of adults, their past learning influences new learning. Children are motivated to learn for approval and acceptance by the parents (or other substitutes). For adults, motivation for learning is through self-esteem and recognition from their close network of family, friends and professional colleagues. Lastly, in the case of children, the pace of learning is guided by the teachers and various other life institutions; whereas, adults typically prefer a pace of learning, which they can control themselves.

This slide highlights four most important requirements of good speaking, which any trainer should try to imbibe in the process of training delivery. The trainer should be clear, concrete concise and consistent. All these four terms are self-explanatory. It is recommended that before taking up a training session, the trainer should do some rehearsal, so as to imbibe these qualities as closely as possible.

Combating Nervousness

- Reasons:
  - Lack of confidence
  - Difficulty of Articulation
  - Fear of cross-questioning
- How to combat?
  - Relax for a while
  - Smile
  - Drink water
  - Reassure yourself that you know the subject

SLIDE 22:
COMBATING NERVOUSNESS

Some tips for enhancing effect

- **Attitude**: Modest, not arrogant or nervous
- **Mood**: Cheerful, not depressed
- **Humour**: Yes, but not for the sake of it
- **Voice**: Firm
- **Body Language**: Positive & Supportive of Verbal Communication
- **Ending**: Logical, not sudden

SLIDE 23:
SOME TIPS FOR ENHANCING EFFECT

Some Platform Tricks

- Use ice-breakers to kick-off
  - Greeting
  - Brief introductions
  - Some background

- Maintain eye contact
- Watch the attention level & make on-line changes
- Make the session interactive
- Be enthusiastic & non-monotonous
- Don't loose track

SLIDE 24:
SOME PLATFORM TRICKS

This slide gives some advice on how the trainers can get over the problem of nervousness, which they may sometimes face while delivering training. Some of the common reasons for a trainer becoming nervous have also been stated. A trainer may sometimes get nervous due to lack of confidence, or due to a difficulty in articulating. He/ she may also get nervous out of a fear of cross-questioning from the participants. To combat these difficulties, it is suggested that on sensing the first signs of nervousness, he/she should try to relax for a while, and, may be, smile. Sometimes, drinking a glass of water helps. While using these diversions to relax, the trainer should also, at the same time, reassure himself/ herself that he/she knows the subject being covered.

This slide gives some further tips for the benefit of a trainer, which can help him make the training delivery more effective. Firstly, the trainer should begin with a modest attitude, rather than an arrogant, know-it-all attitude. However, this should not reflect nervousness. The trainer should display a cheerful, rather than a depressed mood. A sense of humor can do wonders to make the delivery of training interesting and absorbing; however, care should be taken that humor in training delivery does not become an end in itself. The voice delivery of the trainer during training should be firm, reflecting the confidence of knowing the subject. His/her body language should be positive; and it should be in tandem with the verbal communication from him. Very often, the body language betrays the spoken word, resulting in confusing signals being received by the trainees; that should be avoided. Finally, the ending of the session should be logical, and not sudden.

In this slide, some additional tips for making the training delivery effective have been suggested. Firstly, it is advisable for a trainer to begin the session with some "ice-breakers", i.e., starting words to initiate the communication between him and the trainees. This can be in the form of greetings, a brief introduction of self and the participants, and/or sharing of some background information. Communication is most effective when the trainer maintains a continual eye contact with the trainees. Besides, the trainer should keep on watching the attention level of trainees during the training session and should be prepared to make on-line changes on what messages have to be delivered based on the observed attention level of the trainees. The trainer should make all efforts to make the session interactive and should actively seek participation of the trainees. He/ she should continue to remain enthusiastic and non-monotonous in delivery. Finally, while using various platform tricks to hold attention of the trainees, he should not lose track of the objective of the training session.

Evaluation of Training Effectiveness

There can be four levels of effectiveness:

- **Satisfaction**

(Evaluation through Participants Feedback)

- **Learning**

(Evaluation through tests/ examination)

- **Behavior**

(Evaluation through peers, supervisor, juniors)

- **Results/ Improvement in performance at work**

(Evaluation through observation)

SLIDE 25:
EVALUATION OF TRAINING EFFECTIVENESS

When is training effective?

- Pull by individuals rather than push by the organization
- Driven by the need for learning
- This happens when:
  - learner is faced with a problem
  - learner is motivated
  - learner sees the relevance
  - learner feels it is profitable to get trained
  - learner finds the training interesting

SLIDE 26:
WHEN IS TRAINING EFFECTIVE?

3 I's of Learning

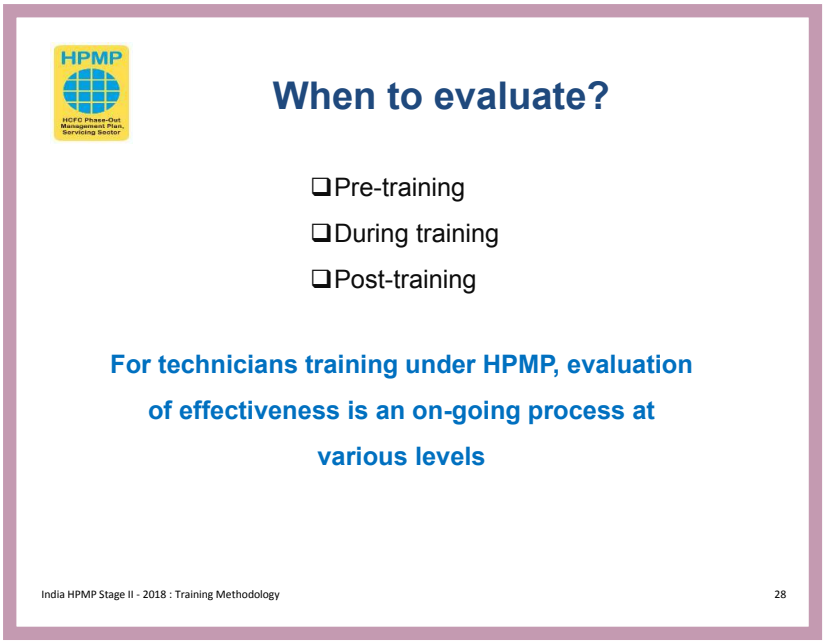
- I hear ..... I forget
- I see - - - I remember
- I do ——— I understand

SLIDE 27:
3 I'S OF LEARNING

Evaluation of training effectiveness is the final stage of a training cycle. Effectiveness of training can conceptually be evaluated at four levels. First is the level of participant satisfaction from training. This evaluation is typically done by collecting participants' feedback immediately after the training has been completed. The second level of evaluation is that of actual learning by the participants. This can be usually done by conducting tests/ quizzes of the trainees after completion of training. The third level is that of evaluating a change in behaviour of the trainees after training. If a positive change in behaviour of the trainees is visible, it reflects that training has succeeded in inculcating desirable attitudes amongst them. This kind of evaluation can also be done with the help of peers, supervisor or juniors of the trainee, by ascertaining their opinion on any observed behavioural change on the part of the trainee. The last level is that of evaluation of actual results or improvement in performance at work. This is the ultimate test of whether training has been successful in making the trainees start using the new skills learnt through the training programme. Evaluation of results is feasible only through observation, not immediately after training, but after giving sufficient time interval in which the trainees can take steps to implement new skills acquired through training.

Since the stage of evaluation in the standard training cycle is concerned with assessing the effectiveness of training, this slide drives home certain important messages on what makes training effective. Firstly, it is the pull (towards training) by individuals (trainees), rather than push by the organization (i.e., those who are interested in imparting training), which makes training effective. In other words, the trainees should exhibit some demand or need for getting trained, rather than giving the impression that training is being thrust upon them. In other words, training should be driven by a demonstrated need for learning on the part of trainees. However, this does not always happen, and very often training is organised because there is a budget provision. The motivation to learn (and therefore demand for training) arises only in situations in which the learner (a) is faced with a problem; (b) is well motivated; (c) sees the relevance of training; (d) feels it is profitable to get trained; and (e) finds the training interesting. These factors are closely related to the principles of adult learning discussed through two earlier slides.

This slide tries to reinforce the message that training can increasingly become more effective if practical hands-on content is added. If training is primarily catered to delivering a message through speech, this has the risk of poor retention by the trainees. If training delivery is enhanced to also incorporate a visual effect, say by adding audio-visuals or showing videos or by exhibiting a piece of equipment, the chances of training becoming more effective increase, because the trainees are likely to remember what they see. However, training effectiveness is the highest when the trainees also get an opportunity to do something with their own hands. In that case, trainees can be expected to more clearly understand the concepts being highlighted through actual hands-on work.



SLIDE 28:

WHEN TO EVALUATE?

This slide depicts three possible stages at which training evaluation can be designed (though it is not necessary that every training should be evaluated at each of these three stages). The first stage of evaluation can be called, pre-training evaluation, i.e., evaluation even before the training has commenced. This, strictly speaking, is not an evaluation of training; it is an evaluation aimed at understanding the target group profile, so that training design can keep the results of this evaluation into consideration. The second stage of evaluation is during training itself; usually, it takes the form of formal and informal feedback from the participants. Formal feedback is usually taken through specially designed feedback forms immediately at the end of training. Informal feedback can be taken at any time during the training and can be helpful in taking corrective actions in training design, if necessary. Evaluation during training can also relate to evaluation of learning gained, and for that purpose, quizzes or evaluation questions can be posed to the participants. The third stage is that of post-training, i.e., evaluation conducted after some time interval of completion of training. This is usually done with a view to ascertain whether the learning acquired by the trainees has been internalised by them, and whether this has translated into a successful change-over to desirable work methods or practices. If not, this evaluation can also help in determining whether training has resulted in a change in mindset or attitudes on the part of trainees.

It also needs to be stressed here that for technicians training under HPMP project, evaluation of training effectiveness at various levels is an on-going process. A pre-training evaluation has taken place through survey of the typical profile and other characteristics, which has been covered in a separate training session. Evaluation of participant feedback is being collected through feedback sheets circulated to all the participants of a training programme. Also, informal feedback is being regularly obtained through hand-held training programmes and through monitoring of a sample of training programmes.

Good service practices for servicing of Room Air conditioners

Target Group: Trainers

Duration of the Practical: 120 minutes

PURPOSE OF THE PRACTICAL:

- To make the technicians aware about quality service procedures of HCFC-22 Air-conditioners.
- To demonstrate and to give them hands on training on step by step operations/procedures for quality servicing of R22 air conditioners and thereby reduce the emission of HCFCs into the atmosphere and to maintain energy efficiency.

LEARNING OUTCOME:

At the end of the practical, the participants should learn Good servicing practices of R22 room air conditioners. Hands on training for processes such as:

- Recovery of R22,
- Repairs and replacement of parts,
- Cleaning and flushing of system,
- Brazing/connecting of tubes,
- Leak testing,
- Evacuation of system,
- Charging of refrigerant.
- Closing of valves/Sealing of tubes,
- Performance testing etc.

TOOLS & EQUIPMENT (IF ANY) REQUIRED FOR THE PRACTICAL:

Screw driver set, Phillips head screw driver, Tube cutter, Tube flaring tool, Tube bender, Torque wrench, Adjustable wrench, Reamer (for deburring), Digital clamp meter, digital thermometer, combination plier, Electronic weighing scale, Nitrogen Cylinder with regulator, Brazing torch, HCFC-22 leak detector, soap solution, Evacuation and charging unit, gauge manifold, Recovery machine, Recovery cylinder

STEPS FOR PRACTICAL:

All the steps discussed during the class are necessary and they must be followed one after other. These include:

- Recovery of HCFC-22,
- Repairs,
- Cleaning and flushing,
- Brazing or connecting of tubes,
- Leak test,
- Evacuation,

- Refrigerant charging,
- Closing of valves/sealing of tube,
- Performance checking,
- Report writing,

Ensure that all the tools and equipment are available.

Step 1: Recovery of refrigerant

I. Confirm that the recovery unit was not used for recovering any other refrigerant other than HCFC-22. If so it needs to be evacuated properly.

II. Use only certified recovery cylinders.

III. Use safety gloves and goggles while recovering.

IV. Start the system and run it for 5 minutes to warm up the compressor. This will release the oil mixed with the compressor oil.

V. Turn off the system.

VI. Connect a hose from the service port of the vapor line valve to the gauge manifold (Low side). Connect another hose from the gauge manifold to the inlet of the Recovery unit and from the recovery unit outlet to the recovery cylinder.

VII. Open the service valve of the system and carefully purge the lines upto the inlet of the recovery machine from service valve.

VIII. Open the inlet valve of the Recovery machine.

IX. Turn the selection knob to recovery mode.

X. Open the outlet valve of the recovery unit and purge the line connected to the recovery cylinder.

XI. Place the recovery cylinder on a weighing scale and record the initial weight.

XII. Open the cylinder valve.

XIII. Start the recovery unit and run it until the suction pressure drops to -20" Hg.

XIV. Wait for a while, if the pressure increases, start the recovery unit and recover until the pressure drops to -20" Hg. Record the final weight. Never fill a cylinder more than 80% of its capacity.

XV. Fill the system with OFDN to break the vacuum and maintain a positive pressure of 2 to 5 psig.

XVI. Close the service valve on the ODU.

Step 2: Repair/Replace inoperative parts

Open the service valve and release the OFDN from the system. Disconnect suction and liquid lines, repair/replace parts if required. Once a flare connection is opened, the same should not be reused. Cut the flare end and make new flare.

Step 3: Cleaning and flushing

After due repairs, Flush the system using OFDN at a pressure of about 150 psi

Step 4: Brazing/ connecting tubes

I. Install fresh strainer/filter

II. Connect the lines properly. Use torque wrench and tighten the nuts. Do not over tighten the flare nuts

Step 5: Leak testing & pressure holding

I. Pressurize the system using OFDN at a pressure of about 150 psi. (The recommended test pressure of OFDN is 10% more than operating pressure of the system.)

II. Apply soap solution to joints, connections and fittings and check for leaks.

III. Refrigerant leaks can occur anywhere throughout the system. Look for wet, oily spots along refrigerant lines and components

IV. Wait for about 15 minutes and observe for any drop in pressure. If there is no drop in pressure then the system is ready for evacuation. If not locate and rectify the leak.

Step 6: Evacuation & Vacuum holding

I. Open the service valve and release the Nitrogen pressure from the system.

II. Connect the system to an evacuation and charging unit using a 4-way gauge manifold. (Use a double stage vacuum pump with gas ballast and digital micron meter.)

III. Before connecting the system, check the vacuum pump and ensure that the blank off pressure is below 100 microns.

IV. Open the valve and start evacuating the system.

V. Evacuate the system to 500 microns or below

VI. Once desired vacuum is achieved, disconnect pump and check vacuum holding (Should not raise above 1500 microns after 5 minutes)

VII. If the vacuum levels increase more than 1500 microns repeat the evacuation and vacuum holding process.

Step 7: Charging of Refrigerant

I. Isolate the vacuum pump by closing the valve.

II. Connect the refrigerant cylinder to the manifold. The connecting line should either be evacuated or purged with refrigerant.

III. Place it on a weighing scale and note down the initial weight

IV. Open the valve on the manifold and charge the system with specified quantity of refrigerant using a digital weighing scale.

V. Charging should be done slowly and gradually,

Step 8: Performance checking

I. Switch on the AC and check the suction pressure.

II. Measure temperatures of supply and return air after 10 minutes, 20 minutes and 30 minutes start of the system.

III. Measure the current drawn by air conditioner. It should be about 80% to 90% of the rated Amp.

Step 9: Sealing process tube/closing valves

I. Close the 3-way service valve properly

II. Check for leaks

III. Put lock-nut

IV. Do final leak test

Step 8: Report writing

Prepare report in given format.

Quality Installation of Split Air-conditioner with Flammable refrigerants

Target Group: Trainers

Duration of the Practical: 120 minutes

PURPOSE OF THE PRACTICAL:

To learn about the Quality Installation of Split Air-conditioner with Flammable refrigerants.

LEARNING OUTCOME:

At the end of the practical, the participants should learn:

- Safety measures to be taken during installation of SAC with flammable refrigerants.
- Knowledge about the tools for installation of SAC with flammable refrigerants.
- Understand and acquire required skills for installation of SAC with flammable refrigerants.

TOOLS & EQUIPMENT (IF ANY) REQUIRED FOR THE PRACTICAL:

Screw driver set, Phillips head screw driver, Knife or wire stripper, Steel tape measure, Spirit level, Hacksaw, Core bits for drilling, Hammer, Drilling machine, Tube cutter, Tube flaring tool, Tube bender, Torque wrench, Adjustable wrench, Reamer (for deburring), Refrigeration (thermal) insulation tape, Insulated staples for connecting wire, Putty, Clamps or saddles to protect refrigerant tubes, Fire extinguisher, Digital clamp meter, digital thermometer, combination plier, Nose plier, Propane/LP Gas alarm etc.

STEPS FOR PRACTICAL:

Step 1: Selection of location for IDU and ODU

The trainer will briefly explain the process for selecting the location for indoor and outdoor unit of the air conditioner, tools required for doing a proper installation of AC and need for a suitable fire extinguisher and propane gas alarm.

Step 2: Install IDU

I. Mark the position for the installation plate and explain about providing space around the unit as required.

II. Fix the installation plate on the wall or wooden panel with one center screw.

III. Align the plate with a spirit level, mark the position and fix the remaining screws of the plate.

IV. Refer the installation manual and mark the position for the connecting pipes and drill the piping hole.

V. The trainer must ensure that the person who drills the hole must wear the goggles.

VI. Fix the drain pipe to the IDU.

VII. Connect the wire to the indoor unit. (Use always crimping connectors).

VIII. Fasten together the connecting tube, drain hose and cable and insert it through the hole drilled for piping.

IX. Hang IDU on the installation plate.

Step 3: Install ODU

I. Explain about the location for ODU and requirement of space around the unit.

II. Place the ODU properly.

Step 4: Connect the Refrigeration tubes

I. Connect the vapour and liquid lines to both IDU and ODU. To reduce tension on the flare joint, align the tubes with the fitting before connecting the flare nuts.

II. Demonstrate the use torque wrench while tightening the flare nuts.

Step 5: Leak test the IDU and refrigerant tubes

I. Fill the IDU and connecting tubes with Oxygen free dry Nitrogen (OFDN) with 150 psi pressure.

II. Check leak by applying soap solution to joints, connections and fittings.

III. Keep the system under pressure for 15 min (pressure holding) check for any drop in pressure. If there is any drop in pressure, identify the leakage, rectify and perform pressure test again with OFDN.

IV. Never start system when pressurized with OFDN. (Ensure that no electrical switches be operated without the permission of the trainer).

Step 6: Evacuate IDU and connecting tubes

I. Connect a hose from the service port of the vapor line valve to the gauge manifold (Low side). Connect another hose from the gauge manifold to the inlet of the vacuum pump. Connect the digital vacuum meter to the manifold. Check the blank off pressure of the vacuum pump and ensure that it is below 100 microns.

II. Open the valve on the manifold and evacuate IDU and connecting tube to 500 microns or below.

III. Once desired vacuum (500 microns or below) is achieved, disconnect pump and check vacuum holding (Should not raise above 1500 microns after 5 minutes).

Step 7: Start the system

I. Open service valves and allow refrigerant to equalize in the system.

II. Connect power cord to electrical point and switch-on unit.

III. Set control panel as desired and start the air-conditioner.

Step 8: Performance check

I. Permit air-conditioner to run for about 20-25 minutes and check the performance of the system.

II. Check temperature and suction pressure.

III. Close the 3-way service valve properly.

IV. Check for leaks.

V. Put lock-nut.

VI. Do final leak test.

Step 9: Report writing

Prepare post-installation report of SAC in given format.

Servicing Split Air-conditioner with Flammable Refrigerants

Target Group: Trainers

Duration of the Practical: 120 minutes

PURPOSE OF THE PRACTICAL:

- To make technicians aware about quality repair procedures of air conditioners with flammable refrigerants.
- To demonstrate and to give them hands on training on step by step operations/procedures for quality repairs of air conditioners with flammable refrigerants.

LEARNING OUTCOME:

At the end of the practical, the participants should learn how to service a Room Air-conditioners with flammable refrigerants by taking required safety measures and following good servicing practices such as:

- Venting or Recovery of refrigerant,
- Removing left over refrigerant by evacuation,
- Repairs and replacement of parts,
- Cleaning and flushing of system,
- Brazing/connecting of tubes,
- Leak testing,
- Evacuation of system,
- Charging of refrigerant,
- Closing of valves/Sealing of tubes,
- Performance checking.

TOOLS & EQUIPMENT (IF ANY) REQUIRED FOR THE PRACTICAL:

Screw driver set, Phillips head screw driver, Tube cutter, Tube flaring tool, Tube bender, Torque wrench, Adjustable wrench, Reamer (for deburring), Digital clamp meter, digital thermometer, combination plier, Electronic weighing scale, Nitrogen Cylinder with regulator, Brazing torch, leak detector for HFC Refrigerants, leak detector for HC Refrigerants, soap solution, Evacuation and charging unit, gauge manifold, Recovery machine, Recovery cylinder**, Fire extinguisher, long hose for venting of refrigerant to safe area and propane gas alarm.**

STEPS FOR PRACTICAL:

Step 1: Safety measures

I. Smoking is strictly prohibited.

II. Ensure that there is no source of ignition near (2 meter radius area) the work area. Check the electrical extension boards for any loose wires. Always use plug tops and NEVER insert wires directly into the socket.

III. Ensure that the place is well ventilated, all the tools, equipment and **Suitable fire extinguishers** are available.

IV. All the steps that were explained during the class are necessary and they must be followed one after the other. These include safe venting/recovery of refrigerant, removal of left over refrigerant by vacuum pump, repairs, cleaning and flushing, brazing/connecting of tubes, leak test, evacuation, Refrigerant charging, closing of system valves, performance checking and recording of work completed.

Step 2a: Safe venting of R-290

I. Start the system, it must run at least for five minutes to warm up the compressor. This will release the oil mixed with the compressor oil.

II. Switch off the compressor.

III. Connect a hose from the service port of the vapor line valve to the gauge manifold (Low side). Connect a long hose to the manifold and place the other end of the long hose in a safe open outside area. Open the valve and release the refrigerant.

Step 2b: Recovery of refrigerant (HFC-32) (Step 2b is only for information)

I. Confirm that the recovery cylinder and recovery unit are suitable for flammable refrigerants like HFC-32.

II. Use safety gloves and goggles while recovering.

III. Start the system and run it for about five minutes to warm up the compressor. This will release the oil mixed with the compressor oil.

IV. Connect a hose from the service port of the system to the inlet of the Recovery unit with a gauge manifold. Connect another hose from the recovery unit outlet to the recovery cylinder.

V. Open the service valve on the system and carefully purge all the lines.

VI. Open the inlet valve of the Recovery machine

VII. Turn the selection knob to recovery mode

VIII. Open the outlet valve and purge the line connected to the cylinder.

IX. Place the recovery cylinder on a weighing scale and record the initial weight.

X. Open the cylinder valve

XI. Start the recovery unit and run it until the suction pressure drops to -20" Hg.

XII. Wait for a while, if the pressure increases, start the recovery unit and recover until the pressure drops to -20" Hg. Record the final weight. Never fill a cylinder more than 80% of its capacity.

XIII. Fill the system with OFDN to break the vacuum and maintain a positive pressure of 2 to 5 psig.

Step 3: Removal of left over refrigerant by vacuum pump (Only for R-290)

To eliminate the risk of flash fire during un-brazing of tubes, it is important to remove the left over refrigerant (R-290) from the system. (As a measure of safety, it is recommended to use a tube cutter and cut the tube instead of un-brazing).

I. Connect a vacuum pump to the service port of the system with the help of gauge manifold and charging lines.

II. Ensure that the place is well ventilated and the discharge from the vacuum pump does not get accumulated near the work area. If not connect a long hose to the outlet of vacuum pump with the other end of the tube left in an open outside area so that the flammable refrigerant is not released in the working area.

III. Evacuate the system to about -20" Hg.

IV. Fill the system with OFDN to break the vacuum and to maintain a positive pressure (Recommended 2 to 5 psig.)

Step 4: Repair/replace inoperative parts

I. Open the service valve and release the OFDN from the system.

II. Open/disconnect the tubes.

III. Repair/replace parts if required. Once a flare connection is opened, the same should not be reused. Cut the flare end and make new flare.

Step 5: Cleaning and flushing

After due repairs, flush the system using OFDN at a pressure of about 150 psi.

Step 6: Brazing /connecting of tubes

I. Install fresh strainer/filter.

II. Connect/braze the lines properly. Use torque wrench, do not over tighten the flare joint.

Step 7: Leak testing and pressure holding

I. Pressurize the system using OFDN at a pressure of about 150 psi.

II. (The recommended test pressure of OFDN is 10% more than operating pressure of the system).

III. Apply soap solution to joints, connections and fittings to identify leak points when bubbles appear.

IV. Wait for about 15 minutes (Pressure holding) and observe for any drop in pressure. If there is no drop in pressure then the system is ready for evacuation. If not locate and rectify the leak.

Step 8: Evacuation & Vacuum holding

I. Open the service valve and release the Nitrogen pressure from the system.

II. Connect the system to an evacuation and charging unit using a gauge manifold (4-way manifold). Use a double stage vacuum pump with gas ballast. Use a digital micron gauge to measure level of vacuum.

III. Before connecting the system, check the vacuum pump and ensure that the blank off pressure is below 100 microns.

IV. Open the valve and start evacuating the system.

V. Evacuate the system to 500 microns or below

VI. Once desired vacuum is achieved, close the valve disconnect pump and check vacuum holding (Should not raise above 1500 microns after 5 minutes)

VII. If the vacuum levels increase more than 1500 microns repeat the evacuation and vacuum holding process.

Step 9: Charging of refrigerant

Isolate the vacuum pump and gas charge the system using a digital weighing scale. For better system performance, correct quantity of refrigerant is important. Charging should be done slowly and gradually,

Step 10: Checking of proper operation

I. Switch on the AC and check the suction and discharge pressure (if port is provided on discharge side).

II. After 20 minutes, measure temperatures of supply and return air.

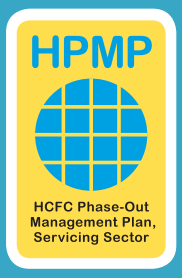
III. Measure the current drawn by air conditioner.

Step 11: Closing of valves/sealing of process tube

I. Close the 3-way service valve properly.
II. Check for leaks.
III. Put lock-nut.
IV. Do final leak test.

Step 11: Report writing

Prepare report in given format.



HCFC Phase-Out Management Plan (HPMP) for Service Sector in India: The Government of India has planned to reduce consumption of HCFC in the servicing sector during Phase 1 (2012 – 2014) in order to meet its compliance targets in 2013 (freeze) and 2015 (10% reduction) in line with the accelerated phase-out schedule of the Montreal Protocol. In the servicing sector HCFC-123, HCFC-124, HCFC-142b and HCFC-22 are consumed, however, during Phase I only the consumption of HCFC-22 will be addressed. Awareness raising, early adoption of better servicing practices and recovery would have an immediate phase-out impact and could significantly reduce the consumption of HCFC in the country

The Refrigeration and Air Conditioning (RAC) servicing sector contributes to a large extent to the consumption of HCFCs, in particular in the room air-conditioner segment. GIZ-Proklima on behalf of the Government of Germany and in close co-operation with the Ozone Cell in the Ministry of Environment and Forests will implement phase-out activities in the Indian RAC servicing sector. The consumption will be reduced mainly through training on better servicing practices and leak prevention but service technicians also need to be prepared on the introduction of alternatives like HC-290, HFC-410a and HFC-32. There are already 15 training partners in the country which will reach out to train as many technicians as possible and to address all the identified sub-sectors in metros and towns all over India.

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