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Contents

1 INTRODUCTION

The installation, operation and maintenance of heat pump systems do not normally present excessive health and safety requirements and should normally have a low or medium risk.

Notice should be taken for the following with standard protocols adopted.

1.1 Electrical supplies safety

Work with electrical supplies - care should be taken with any appliance that utilises electricity.

1.2 Refriregant safety

Extra risks contain the works with the refrigerants; anti- freeze should be handled according to the manufacturers/suppliers' instructions and with due caution.

1.3 Working at height

Working at height - due care should be taken when working at height.

1.4 Working in confined spaces

Working in confined spaces - due care should be taken when working in confined spaces such as small plant-rooms, lofts or under-floors.

1.5 Working below the ground level

Working below ground level – due care should be taken not to enter any excavations below ground level without adequate protection, e.g. such as temporary or permanent shoring of the sides of the excavation.

Installers should also be familiar with all relevant health and safety legal requirements and information from responsible bodies.

2 LECTURE NOTES

2.1 Electrical supplies safety

This section covers electrical requirements for heat pump installations. All electrical work must be carried out by a registered electrician. An Electrical Certificate of Compliance (CoC) must be issued on completion.

Depending on the heat pumps power input rating and the buildings existing electrical installation, the heat pump may either be connected to an existing electrical circuit with sufficient spare capacity (e.g. looped off an existing power socket), or to a separate dedicated circuit (wired back to the main switchboard).

- Select a circuit for the main power supply.
- For installations in new buildings, use a dedicated circuit.
- Refer to the manufacturer's specifications for:
  - rated voltage
  - input capacity/fuse size
  - electrical cable size
  - wiring diagram for electrical installation.
- All hard wiring must be carried out by a registered electrician.

Outdoor unit connections:

- Remove service cover from outdoor unit.
- Fix indoor/outdoor connecting cable correctly to the terminal block in the outdoor unit.
- Tighten terminal screws to ensure that wires are firmly secured.
- Connect power supply cable to terminal block in outdoor unit.
- Install a lockable isolating switch.
- Install the switch so that it can be reached for servicing
- Attach the isolating switch to the house – not the outdoor unit.
- Provide waterproof protection to the connection as required, such as:
  - cable gland
  - lexible conduit.

- Replace service cover to outdoor unit when all connections are completed.

NOTE:

- DO NOT connect the isolating switch to the outdoor unit. Otherwise the unit cannot be isolated from power.
- DO NOT allow contact between wiring and refrigerant pipework.
- DO NOT run the main power cable and heat pump system power cable together.
- DO NOT allow electrical work to be carried out by an unlicensed tradesperson or without an Electrical Certificate of Compliance (CoC). Otherwise, the owner's house insurance may be voided.

2.2 Refrigerant safety

The dangers of refrigerant gas leaks are two-fold; they can pose a risk to human health and contribute to environmental damage. Refrigerant gases can displace oxygen, leading to oxygen deficiency and asphyxiation. They can be flammable and toxic to varying degrees, and can also cause chemical burns and irritation to the eyes, skin, and respiratory system. These risks can be especially prominent in confined spaces where there is no ventilation and gases can accumulate. Additionally, refrigerant gases contribute to ozone depletion and global warming, which can have severe consequences for the environment. This is particularly of concern in refrigerants such as CFCs and HCFCs which are being phased out due to their high GWP and ozone depleting properties, however even HFCs which were initially used widely as a non-ozone depleting replacement can still have high GWP, and hence need to be used in moderation.

Common refrigerant gases used in heat pumps include:

- Hydrofluorocarbons (HFCs), such as R-134a, R-404A, R-407C, R-410A, and R-507A.
- Chlorofluorocarbons (CFCs), such as R-11 and R-12. However, their usage has been phased out globally under the Montreal Protocol.
- Hydrochlorofluorocarbons (HCFCs), such as R-22 and R-123. Their usage is also being phased out globally due to their high global warming potential (GWP).
- Ammonia (NH3), which is commonly used in industrial refrigeration systems.

- Carbon dioxide (CO2), which is gaining popularity as a natural refrigerant due to its low GWP.
- Propane (R-290), which is also being used as a natural refrigerant in some applications.

In addition to these, there are many other refrigerant gases used in specific applications or industries. For example, some refrigerants used in automotive air conditioning systems include R-1234yf and R-744 (carbon dioxide). Other refrigerants used in specialty refrigeration applications include R-508B, R-600a, and R-1270. The development and use of new refrigerants is ongoing, as the industry seeks to find alternatives with lower environmental impact and better performance.

The dangers of refrigerant gas leaks are two-fold; they can pose a risk to human health and contribute to environmental damage. Refrigerant gases can displace oxygen, leading to oxygen deficiency and asphyxiation. They can be flammable and toxic to varying degrees, and can also cause chemical burns and irritation to the eyes, skin, and respiratory system. These risks can be especially prominent in confined spaces where there is no ventilation and gases can accumulate. Additionally, refrigerant gases contribute to ozone depletion and global warming, which can have severe consequences for the environment.

Early refrigerants used were chlorofluorocarbons (CFCs), but the ozone-depleting nature of these compounds has led to them being phased out and replaced with hydrochlorofluorocarbon (HCFC) compounds such as R-22. For environmental reasons HCFCs have also been phased out and replaced with blended hydrofluorocarbon (HFC) compounds. Hydrofluorocarbons (HFCs) such as R410A and R32 are currently widely used in refrigeration and air conditioning systems. However, HFCs are greenhouse gases with high global warming potential.

The switch from HFCs to more environmentally acceptable alternatives will help combat climate change, but will also present increased risks to health and safety in some circumstances because of the higher toxicity, flammability or pressure of common alternatives.

When purchasing a heat pump, ensure you understand which refrigerant is suitable for the system. The installation and technical guide supplied by the manufacturer will provide this information and must be observed at all times.

NOTE: DO NOT use the incorrect refrigerant in a heat pump as this could void the warranty and can create the risk of an accident.

Essential requirements:

- heat pump systems must be able to be installed, operated, serviced and decommissioned without loss of refrigerant.
- heat pump systems must be installed by an appropriately qualified person with Approved Filler Compliance Certificate for refrigerant handling.
- refrigerant must not be intentionally released into the atmosphere. Releasing refrigerants into the atmosphere can incur hefty fines.

The outdoor unit is factory-charged with sufficient refrigerant to allow for the indoor unit and a specific pipe run. Refer to the manufacturer's installation instructions for the pre-charge pipe length. You will need to add extra refrigerant where pipe runs exceed the manufacturer's parameters for the factory-charged amount of refrigerant.

Procedure safety:

- Only use the refrigerant specified by the manufacturer for charging.
- Measure the additional pipe run length.
- Accurately calculate the amount of refrigerant required according to the manufacturer's instructions.
- Measure the required amount of refrigerant (where additional charge is required) by mass, using electronic scales.
- Keep the charge lines as short as possible.
- Leak test the pipework before charging, by partially opening, then closing the cylinder valve to pressurise the connecting pipework.
- Charge using liquid refrigerant from the cylinder.
- Check for leaks using the bubble test solution.
- Ensure that the cylinder and unit are at the same height to prevent gravity transfer of the refrigerant.

NOTE:

- DO NOT release refrigerant into the atmosphere. Releasing refrigerants into the atmosphere can incur hefty fines
- DO NOT use ultraviolet dye.
- DO NOT use reclaimed refrigerant to add additional charge.

The possible hazards when working with refrigerant, which are:

- Inhalation of refrigerant: Refrigerant does not contain any oxygen. This means that if the air in the workplace is replaced by refrigerant vapor due to refrigerant release the danger exists that asphyxiation occurs. This will cause paralysis and, if the person is not removed from the workplace in time, death.
- Spillage of refrigerant on the skin or the eyes: At atmospheric pressure almost, all refrigerants boil at a very low temperature. Spillage of this very cold refrigerant can cause frostbite. Ingestion: Refrigerant, if swallowed can cause injury to a person's stomach or lungs.
- Explosions: Excessive system / cylinder pressures. Ammonia is explosive at concentrations between 16 and 27%.
- Fire: We have R290 and R600a, which are flammable and under certain conditions can even be explosive. In the automotive sector we have 1234YF, also a flammable refrigerant being introduced.

While working with refrigerants (particularly in the liquid phase) personnel should wear the following appropriate safety equipment:

- Safety goggles to protect the eyes;
- Gloves made from non-absorbent material to protect the hands;
- Clothing (overalls) to cover the body, arms and legs to protect against liquid splashes;
- Safety shoes;
- A gas mask, when working with ammonia.

Refrigerant gases do not contain any oxygen and if refrigerant is leaking from a plant there is a danger of an excessive build-up of refrigerant vapor, which can cause asphyxiation. For this reason, there are work situations in which it is essential that two competent persons are required to be present. They are, as follows:

- When working in an enclosed area.
- When working in a basement.
- When working in a badly ventilated area.

The procedures to be followed in the event of an accident or fire when working with refrigerants.

Inhalation of refrigerant:

- Remove patient to fresh air, keep warm and at rest.
- Apply artificial respiration if breathing has ceased or shows signs of failing.
- If breathing is difficult, give oxygen.
- In the event of cardiac arrest apply external cardiac massage.
- Obtain immediate medical attention.

Spillage of refrigerant on the skin:

- Remove contaminated clothing.
- Wash areas of skin that were in contact with refrigerant with plenty of water for fifteen (15) minutes.
- If irritation or blistering occurs obtain immediate medical attention.

Eye contact:

- Immediately irrigate eyes with eyewash solution or clean water, holding the eyelids apart for at least ten (10) minutes.
- Obtain immediate medical attention.

Ingestion (swallowing):

- If the person is conscious, wash out the mouth with water and give 200 to 300 ml of water to drink.
- Do not induce vomiting because the hazard of the refrigerant getting into the lungs is greater than swallowing it.
- Obtain immediate medical attention.

In case of fires:

- Locate fire-fighting equipment and extinguish.
- Inform if necessary the fire department immediately.
- Evacuate other people working in the area.

2.3 Working at height

Working at height remains one of the biggest causes of fatalities and major injuries. Common cases include falls from roofs, ladders, and through fragile surfaces. ‘Work at

height' means work in any place where, if there were no precautions in place, a person could fall a distance liable to cause personal injury.

Employers should first assess the risks. Before working at height they should work through these simple steps:

- avoid work at height where it's reasonably practicable to do so;
- where work at height cannot be easily avoided, prevent falls using either an existing place of work that is already safe or the right type of equipment
- minimize the distance and consequences of a fall, by using the right type of equipment where the risk cannot be eliminated.

Working at height the workers should to do:

- work off scaffolding in preference to working off ladders
- ensure workers can get safely to and from where they work at height;
- ensure equipment is suitable, stable and strong enough for the job, maintained and checked regularly;
- take precautions when working on or near fragile surfaces;
- provide protection from falling objects;
- consider emergency evacuation and rescue procedures.
- as much work as possible from the ground;

Working at height the workers should not to do:

- overload ladders – consider the equipment or materials workers are carrying before working at height. Check the pictogram or label on the ladder for information
- overreach on ladders or stepladders;
- rest a ladder against weak upper surfaces, e.g. glazing or plastic gutters;
- use ladders or stepladders for strenuous or heavy tasks, only use them for light work of short duration (for example a maximum of 30 minutes at a time);
- let anyone who is not competent (who doesn't have the skills, knowledge and experience to do the job) work at height.

2.4 Working in confined spaces

Working in a confined space is dangerous because of the risks from noxious fumes, reduced oxygen levels, or a risk of fire. Other dangers may include flooding/drowning or asphyxiation from some other source such as dust, grain or other contaminant.

Working in confined spaces the workers should to do:

- be aware of the risks that may occur within a confined space;
- make sure the person doing the work is capable and trained in both the work and the use of any emergency equipment.

Working in confined spaces the workers should not to do:

- work in confined spaces unless it's essential to do so;
- ignore the risks – just because a confined space is safe one day doesn't mean it will always be;
- let others enter a confined space until you are sure it's safe to do so.

2.5 Working below the ground level

Common hazards by working at or below ground level:

- Earthworks collapse or cave in
- Exposure to 'unexpected' risks in excavations
- Vehicles fall into excavations
- Loads fall from vehicles
- Crushing due to impact of moving or toppling plant and equipment
- Impact from release of pressure
- Falling from plant and equipment
- Falls caused by swinging loads, plant and equipment
- Limbs or bodies caught in machinery
- Poor ergonomics
- Physiological and psychological damage through repetitive work
- Physiological and psychological damage caused by poor environment (wet conditions, noise, heat, poor ventilation, chemicals, noxious gases)

Specific hazards of excavations include:

- Persons becoming trapped and buried in an excavation owing to the collapse of the sides
- Persons being struck and injured by material and other items falling into the excavation
- Persons falling into the excavation
- Unsafe means of access and insufficient means of escape in case of flooding
- Vehicles driven into or too close to the edge of an excavation, particularly while reversing, causing the sides to collapse
- Asphyxiation or poisoning caused by fumes heavier than air entering the excavation, e.g. exhaust fumes from diesel and petrol engines.

Working below the ground level the workers should to do:

- be aware of the risks;
- make sure the person doing the work is capable and trained in both the work and the use of any emergency equipment.

Working below the ground level the workers should not to do:

- ignore the risks;

let others to work below the ground level until you are sure it’s safe to do so.

3 . QUESTIONS & ANSWERS

3.1 Question & Answer 1

Question: Is the refrigerant ammonia explosive?

Answer: Ammonia is explosive at concentrations between 16 and 27%.

3.2 Question & Answer 2

Question: Are the refrigerants R290 and R600a flammable?

Answer: Yes, the refrigerants R290 and R600a are flammable and under certain conditions can even be explosive.

3.3 Question & Answer 3

Question: Why can refrigerant, if swallowed cause injury to a person's stomach or lungs?

Answer: At atmospheric pressure almost all refrigerants boil at a very low temperature and spillage of this very cold refrigerant can cause frostbite.

3.4 Question & Answer 4

Question: What was the reason of phasing out refrigerants including chlorofluorocarbons (CFCs)?

Answer: Early refrigerants used were chlorofluorocarbons (CFCs), but the ozone-depleting nature of these compounds has led to them being phased out.

3.5 Question & Answer 5

Question: What was the reason of phasing out several refrigerants including hydrofluorocarbons (HFCs) and hydrochlorofluorocarbons (HCFCs)?

Answer: Their usage is being phased out globally due to their high global warming potential (GWP).

3.6 Question & Answer 6

Question: What to do, if breathing is difficult?

Answer: Give oxygen.

3.7 Question & Answer 7

Question: Wha to do in the event of cardiac arrest?

Answer: Apply external cardiac massage.

3.8 Question & Answer 8

Question: What to do in spillage of refrigerant on the skin?

Answer: Remove contaminated clothing. Wash areas of skin that were in contact with refrigerant with plenty of water for fifteen (15) minutes. If irritation or blistering occurs obtain immediate medical attention.

3.9 Question & Answer 9

Question: What to do in refrigerant eye contact?

Answer: Immediately irrigate eyes with eyewash solution or clean water, holding the eyelids apart for at least ten (10) minutes. Obtain immediate medical attention.

3.10 Question & Answer 10

Question: What to do in case of ingestion refrigerant?

Answer: If the person is conscious, wash out the mouth with water and give 200 to 300 ml of water to drink. Do not induce vomiting because the hazard of the refrigerant getting into the lungs is greater than swallowing it. Obtain immediate medical attention.

3.11 Question & Answer 11

Question: What to do in case of fires?

Answer: Locate fire-fighting equipment and extinguish. Inform if necessary the fire department immediately. Evacuate other people working in the area.

3.12 Question & Answer 12

Question: The work situations in which it is essential that two competent persons are required to be present?

Answer: When working in an enclosed area. When working in a basement. When working in a badly ventilated area.

3.13 Question & Answer 13

Question: Which refrigerant can use for charging?

Answer: Only use the refrigerant specified by the manufacturer for charging.

3.14 Question & Answer 14

Question: How can measure the amount of refrigerant for charging?

Answer: Measure the required amount of refrigerant (where additional charge is required) by mass, using electronic scales.

3.15 Question & Answer 15

Question: For charging using liquid or gas phase refrigerant from the cylinder?

Answer: Charge using liquid refrigerant from the cylinder.

4 PRACTICAL EXERCISES

4.1 Exercise 1

Question:

While working with refrigerants (particularly in the liquid phase) personnel should wear the following appropriate safety equipment: (say it!)

Answer:

- Safety goggles to protect the eyes;
- Gloves made from non-absorbent material to protect the hands;
- Clothing (overalls) to cover the body, arms and legs to protect against liquid splashes;
- Safety shoes;
- A gas mask, when working with ammonia.

4.2 Exercise 2

Question:

Find right refrigerants to the CFCs, HFCs and HCFCs: R-11, R12, R-22, R123, R134a, R-404A, R 407C, R-410A, R-507A.

Answer:

Hydrofluorocarbons (HFCs): R-134a, R-404A, R-407C, R-410A, R-507A.

Chlorofluorocarbons (CFCs): R-11, R-12.

Hydrochlorofluorocarbons (HCFCs): R-22, R-123.

5 MULTIPLE CHOICE QUESTIONS

5.1 Multiple choice question 1

Working in confined spaces the workers should to do:

- **be aware of the risks that may occur within a confined space;**
- work in confined spaces unless it's essential to do so;
- ignore the risks – just because a confined space is safe one day doesn't mean it will always be;
- let others enter a confined space until you are sure it's safe to do so.

5.2 Multiple choice question 2

Working in confined spaces the workers should not to do:

- be aware of the risks that may occur within a confined space;
- work in confined spaces least by four persons in team;
- **ignore the risks – just because a confined space is safe one day doesn't mean it will always be;**
- make sure the person doing the work is capable and trained in both the work and the use of any emergency equipment.

5.3 Multiple choice question 3

Common hazards by working at or below ground level:

- earthworks collapse or cave in;
- exposure to 'unexpected' risks in excavations;
- vehicles fall into excavations;
- **all risks in the list.**

5.4 Multiple choice question 4

Working at height the workers should not to do:

- ensure workers can get safely to and from where they work at height;
- ensure equipment is suitable, stable and strong enough for the job, maintained and checked regularly;
- take precautions when working on or near fragile surfaces;
- **overload ladders – consider the equipment or materials workers are carrying before working at height**.

5.5 Multiple choice question 5

Working at height the workers should to do:

- **as much work as possible from the ground;**
- overreach on ladders or stepladders;
- use ladders or stepladders for strenuous or heavy tasks, only use them for light work of short duration;
- let anyone who is not competent work at height.

5.6 Multiple choice question 6

A work situation with in working with refrigerants in which is essential that two competent persons are required to be present:

- when working in an enclosed area;
- when working in a basement;
- when working in a badly ventilated area;
- **all cases in the list.**

5.7 Multiple choice question 7

Actions by spillage of refrigerant on the skin:

- remove contaminated clothing;
- wash areas of skin that were in contact with refrigerant with plenty of water for fifteen (15) minutes;
- if irritation or blistering occurs obtain immediate medical attention;
- **all actions in the list.**

5.8 Multiple choice question 8

Actions by eye contact of refrigerant:

- **immediately irrigate eyes with eyewash solution or clean water, holding the eyelids apart for at least ten (10) minutes;**

- remove all clothing;
- not to obtain immediate medical attention;
- all actions in the list.

5.9 Multiple choice question 9

Actions by ingestion (swallowing) of refrigerant:

- **if the person is conscious, wash out the mouth with water and give 200 to 300 ml of water to drink;**
- induce vomiting;
- not to obtain immediate medical attention;
- all actions in the list.

5.10 Multiple choice question 10

Actions in case of fires:

- **locate fire-fighting equipment and extinguish;**
- inform the fire department before starting of the work;
- not to evacuate other people working in the area;
- all actions in the list.

5.11 Multiple choice question 11

Hydrochlorofluorocarbons (HCFCs) are:

- R-11
- R-12
- **R-22**
- All above mentioned

5.12 Multiple choice question 12

Chlorofluorocarbons (CFCs) are:

R-22

R-123

R-11

R-120

5.13 Multiple choice question 13

Hydrofluorocarbons (HFCs) are:

R-134a

R-404A

R-407C

R-All above mentioned

5.14 Multiple choice question 14

Hydrofluorocarbons (HFCs) are:

R-11

R-500A

R-407C

R-22

5.15 Multiple choice question 15

Hydrochlorofluorocarbons (HCFCs) are:

R-22

R-134A

R-11

R-407C

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