Siting of Hydrocarbon Heat Pumps

Introduction

The environmental impact of hydrocarbon refrigerants is a significant reason behind the expansion of this refrigerant class. The low global warming potential (GWP) and ozone depletion potential (ODP) associated with hydrocarbon refrigerants, emphasises their contribution to mitigating climate change and protecting the ozone layer. Hydrocarbons do not contain PFAS which contributes to toxic pollution unlike HFO refrigerants. They can also generate heat in excess of 60°C which makes them ideal for retrofit application of heat pumps.

The only drawback to the wider deployment of hydrocarbons is safety as they are flammable.

There are a number of interpretations across industry regarding the requirements for installation of hydrocarbon products, ranging from requiring full Atex zones around heat pumps to OEM products having no safety measures at all.

Regulations are yet to catch up with developments in the technology and market. In the absence of clear regulations Clade have issued this guidance.

Specific applications of different hydrocarbon products and the amount of gas charge will require different considerations by the principal designer and those undertaking the site risk assessments.

The Clade guidance for hydrocarbon product installation is general guidance for a range of products and installation scenarios. It is intended to raise the key considerations for designers and installing contractors when considering the application of hydrocarbon equipment. It is not intended to be definitive or to prescribe measures specific to an installation.

Given the right considerations it is very unlikely there are applications where hydrocarbon units cannot be installed safely.

Leak Detection

All Clade hydrocarbon products are fitted as standard with leak detection and safety shut down systems, unlike many other heat pumps on the market. This means that even with a small escape of gas the heat pump will shut down operation and engage ventilation fans to disperse any refrigerant. Safety systems on Clade units activate at a Lower Flammable Limit (LFL) of 20%. This means that the safety systems active when the concentration of a combustible material in air is 80% below at which ignition could occur. This low concentration is then ventilated from the heat pump by fans into atmosphere where this low concentration is dispersed.
The installation requirements are to consider where this low concentration of gas is dispersed.

Drains and gulleys

The Clade guidance raises considerations such as drain or gulley locations near the unit due to the refrigerant gas being denser than air. This should be then considered as a requirement dependant on the product and the gas charge. For example, the Aspen 280kW unit has a gas charge of 30-40kg of refrigerant, if a leak occurs there might be a potential that there is enough refrigerant to collect in a drain or gulley. For the same location, a Rowan heat pump would have different considerations. This is because the Rowan is a modular heat pump with several modules of refrigerant circuits with much smaller gas charges. It is very unlikely more than one circuit/module would form a leak and therefore the same considerations for a Rowan 300kW unit would be for around only 6kg of refrigerant not 30-40kg. This much smaller volume of refrigerant would likely change the approach taken during the design risk assessments or HAZID reviews. Putting this into context, a domestic patio heater or BBQ usually have 10kg of hydrocarbon connected to them.

Siting of Hydrocarbon Heat Pumps Guidance

This information is supplied to inform the site risk assessment. Each site is different and requires a site-specific risk assessment carried out by a competent person.

Risks with flammable refrigerant

Fires start when there is sufficient fuel, oxygen & heat for a chemical reaction (combustion); gas explosions occur when a source of ignition is introduced to a mixture of flammable gas and air, the impact of a gas explosion depends on the locations, type of gas and the amount present.

Flammable gas can mix with air and create a potentially explosive atmosphere, heat or a spark can then ignite this mixture of fuel & air. For the atmosphere to be flammable, the gas concentration in air must be above the Lower Flammability Limit (LFL) & below the Upper Flammability Limit (UFL). *The LFL of R290 is 2.1% & the LFL for R600a is 1.5%.*

The risk of flammable gas explosion if release occurred without any control measures and met an ignition source is high/critical.

Where risks are well managed with engineering design & administrative control. The likelihood of a leak occurring is sufficiently low & there are safeguards in place to deal with one should it occur. With all the control measures it is expected to be a Tolerable risk level

Hazardous Area Classification (HAC)

The dangerous substances & explosive atmospheres regulations require employers to conduct risk assessments on potential explosive atmospheres. Zones where flammable gas may be released are classified as Zone 0 – 2.

- Zone 0: An area in which an explosive gas atmosphere is present continuously or for long periods
- Zone 1: An area in which an explosive gas atmosphere is likely to occur in normal operation
- Zone 2: An area in which an explosive gas atmosphere is not likely to occur in normal operation and, if it occurs, will only exist for a short time.

Clade do not assign a hazardous area classification to heat pumps, an explosive atmosphere is possible but only under critical failure of the system.

Principle of control

A gas explosion will not happen if leaks are detected & the gas exhausted safely from the area so that a flammable atmosphere does not occur. Control of ignition sources in the vicinity of potential leaking equipment further reduces the probability of a gas explosion occurring.

Control Measures

Control measures by Clade

Limited charge size

Amount of refrigerant present within systems is limited by BS:EN 378, depending on the location classification of the room charge size may be limited. Refer to BS:EN 378 1. Considerations must be made on locating the equipment.

Leak detection & ventilation

System installed with gas detection, if it's detected at 20% of the LFL then it will completely shut off power to the system. This will stop the circulation & subsequent release of refrigerant, allowing refrigerant gas to disperse. Leak detection triggers a ventilation system, facilitating the safe removal of flammable gases & a return to below the LFL. A competent person would then need to repair leaks.

Strength testing & leak checks

Systems are all pressure tested prior to them being commissioned, this confirms that the vessels and associated pipework can contain refrigerant above the operating pressure. Pressure relief valves are fitted & vent to an external point, compliant with relevant legislation (Pressure System Safety Regulations) & a UK Conformity Assessment mark.
UKCA marks are replacing CE marks, now that the UK has left the EU.

Quality assurance & commissioning

All units go through a thorough QA process, pre-commissioning checks, before they finally signed off by a commissioning engineer at the customer's site. These checks include:

- Pressure relief valve pipe work
- Plant room extract system integrity and operation
- Electrical shutdown integrity and operation
- Gas detection integrity and operation.

Safe charging of refrigerant

Heat pumps are not in scope for the Gas Safe Register, commissioning engineers are suitably trained to work with Hydrocarbon refrigerants, holding City & Guilds qualification: Safe Handling of Hydrocarbon Refrigerants. All relevant Clade personnel are trained and qualified.

Control measures suggested for consideration by installation Principal Designer

Hazard	Harm / How harm will come about	Siting Considerations
Leaked Refrigerant – flammable gas	Potential for gas to leak & form vapor cloud above LFL. A source of ignition would initiate gas explosion.	2.5 metre zone around exhaust vent to be clear of sources of ignition, vehicle parking bays, smoking areas. Handover of equipment to customer, O&M manual to state risks & prohibition of ignition sources.
Leaked Refrigerant – flammable gas	R290 & R600a are heavier than air. Potential for gas to settle in drains, or area of low airflow around exhaust vent, leaving flammable gas cloud at low level. Risk of explosion if ignition source is met.	Drains to be 2.5 metres away from emergency exhaust ventilation. If the area the vent exhausts to is not clear of obstructions that could allow gas to accumulate, consider increasing this distance. (Site specific: Install Ducting to move further from Drains)
Leaked Refrigerant – flammable gas	R290 & R600a are heavier than air. Potential for flammable gas to be drawn into air inlet. Windows or other openings potentially able to allow flammable gas inside building. Risk of gas explosion if ignition source is met.	3 metre zone around exhaust ventilation to be clear of air inlets. Customer to be informed of risks associated with flammable gas being drawn into air inlet. (Site specific: Install ducting to move further from air inlet)
Leaked Refrigerant – flammable gas	Severe impact from large or sharp objects could rupture refrigerant pipework causing a release of flammable gas.	Heat pumps must be protected from significant risk of collision.
Fire - heat	The flammable gas contained within the heat pump would add load to any fire that had started in the area.	Combustibles to be kept clear of heat pump, reducing chance of an external fire exposing the unit to heat & compromising the containment of flammable gas. Customer to include existence of heat pump in their emergency manual – share with fire brigade on arrival. Fire risk assessment to be updated when heat pump is installed.
Lightning	The flammable gas contained within the heat pump would add load to any fire that had started in the area.	Consider whether lightning protection is installed on buildings. If no lightning protection is present, customer to consider risk & seek guidance from lightning protection consultancy.
Unauthorized access	Those attempting to access the unit for maintenance could fall if it's positioned too close to the edge of a roof.	Adequate security measures to be in place to prevent unauthorized access to equipment. Unit to be located in area not easily accessed by persons out of hours. Keys for access into unit retained by authorized persons only.