HEAT PUMP OPERATION GUIDE

Introduction

This is a guide created by the technical team at Unico System UK to support our customers with the transition to renewable heat technologies and a superior indoor climate and air quality.

The UK is in the early stages of a technology shift motivated by climate change and the covid pandemic. Domestic heating accounts for 18% of UK carbon emissions and the government has identified electric heat pumps as an important tool in driving down the emissions from home heating. To that end, it has created drivers in the form of grant incentives to support the cost of installation and incentivise homeowners to remove fossil fuel boilers and switch to clean heat pump technology.

This guide will explain how clean heat pump technology works, its technological characteristics, its use with The Unico System small duct air distribution system, radiators, and under floor heating systems to provide superior, energy efficient indoor comfort.

What is a heat pump?

A heat pump (essentially, a refrigerator) is a machine that moves heat using mechanical work, as opposed to a boiler that ignites a fuel to release energy. In cold weather heat pumps move heat from the outdoors to warm a house and can also be designed to do the reverse: move heat from a house to the outdoors in warm weather. Since heat pumps transfer rather than generate heat, they are more energy-efficient than other methods of heating or cooling homes.

Heat pumps are a refrigeration technology. The earliest demonstration of the vapour compression cycle was in Edinburgh 1756, and the first working model was built in 1834 by an American expatriate to the UK. The first commercial home refrigerator was mass produced in 1913. The technology has been present for 190 years and has been re-engineered continuously since. [Source: American Society of Mechanical Engineers – ASME]

Today this technology is considered new in the UK, however, this “newness” is due to its late adoption compared to other countries. The application of heat pumps for home heating and cooling in Scandinavia has been prevalent since the fuel crisis of the early 1970s and has since been adopted globally as an energy efficient means to provide ‘Indoor Comfort’ in especially adverse weather conditions.

The UK heating, ventilation, and air conditioning (HVAC) industry needs to recognise and embrace the application principles of this technology so that our transition towards a low carbon future achieves the best outcomes.

Heat energy occurs naturally everywhere, and heat pumps enable us to use the free ambient heat in the air, ground, or water to cool or heat the internal envelope of a building. The heat pump’s vapour compression cycle allows a cold refrigerant to collect energy from outside (down to -25°C) and amplify the ambient energy temperature via a compressor to a usable 55°C. No ignition or burning takes place in this process, meaning this technology is clean. The heat pump’s vapour compression cycle can move more energy than it consumes, making it an extremely efficient machine for providing heat in contrast to a fossil fuel heat source.

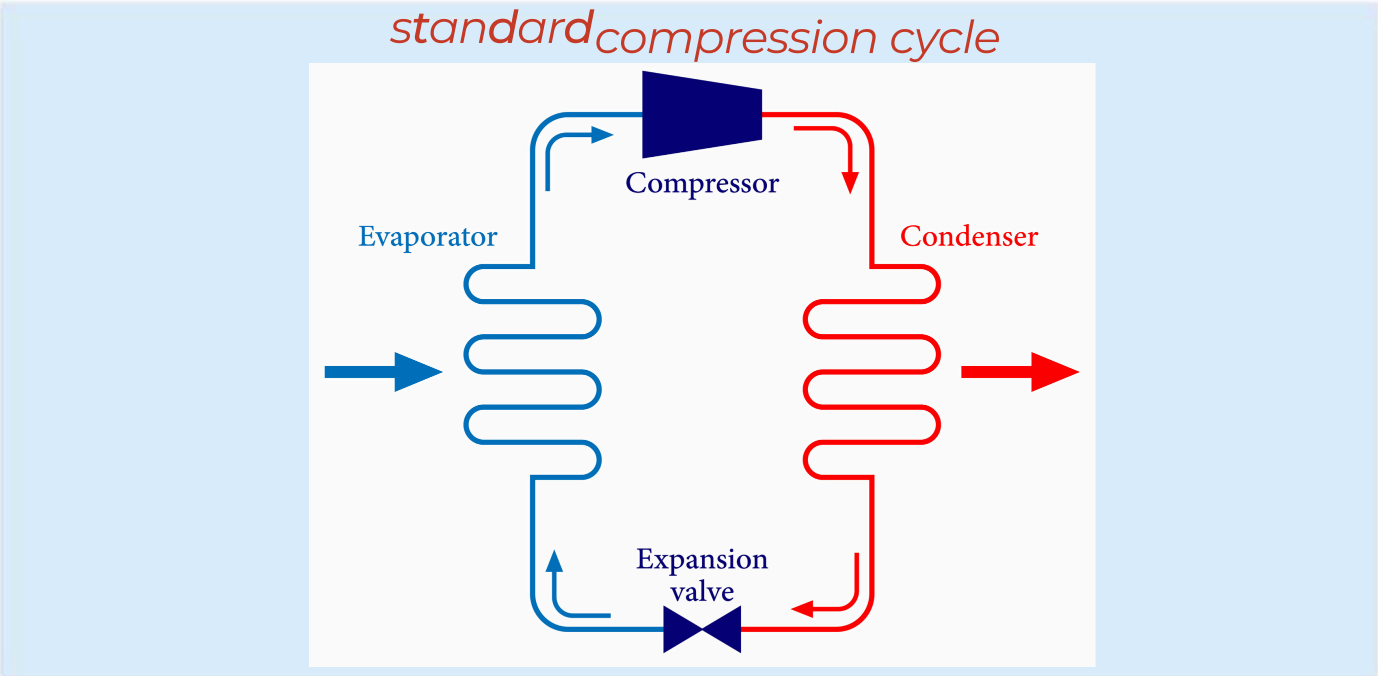
For example:

1. For every 1 kW of electricity consumed by a heat pump, the unit can move and reject 3-6 kW of heat energy, offering a coefficient of performance (CoP) of up to 6 to 1. *

2. By contrast, for every 1 kW of gas burned/consumed by a boiler, the unit can only move and reject 0.75-0.97 kW of heat energy, offering a coefficient of performance (CoP) only up to 0.97 to 1. **

Source: Estimated CoP based on various manufacturers published technical data for ground and air source heat pumps.
**Note: This is dependent on the type of heat pump and its source of energy and the system design*
Lorem Ipsum
***Note: This is dependent on the type of boiler and the operation mode set, flow management and overall system design*

Moving energy via a heat pump is a naturally slower process than burning a fuel source, but the laws of physics will always remain the same. We cannot change the laws of physics, so we need to understand them:



When moving energy, the system needs to maintain a constant and regular speed to ensure the correct amount of heat energy is delivered to the building envelope in order to maintain a comfortable internal temperature. In comparison to this process, a boiler would ignite a fuel releasing in excess of 200oC into a heat exchanger to be absorbed by water and delivered to an emitter circuit at 65-80oC. This is a rapid and high intensity heat delivery method.

These two heat sources are fundamentally different but often classified as the same because they use/share the

Understanding Energy Rejection

Heat energy is transferred when an a solid, gas, or liquid has a difference in temperature. The greater the difference in temperature, the faster the energy will move. From the second law of thermodynamics, we know that heat is attracted to the cold (or, conversely, cold is attracted to heat). This difference is referred to as the temperature delta or delta t (tit).

The energy rejection refers to the use of a surface area (or, emitter) to reject (or, radiate) the heat into the building envelope. This rejection happens faster the greater the flow temperature to the emitter is.

To heat a room to a "comfort set point" of 21oC, a value of energy will be required, and a heat loss rate coefficient will be calculated. As the temperature changes outside, the rate of heat loss is either increased or decreased, changing the value of energy needed to keep the room at 21oC.

So, a heat pump system will vary the energy delivered to the emitter by increasing or decreasing the heat energy temperature to maintain the room temperature at the "comfort set point." Or, to put it another way - changing the speed of energy transfer using temperature as the throttle.

Creating the Energy Balance

The heat pump system needs to be in equilibrium, or balance, to ensure it delivers the correct amount of heat into the building as the temperature changes outside. The heat pumps emitter system has to effectively reject heat into the building at the same rate the heat pump is collecting it. It is important that the system designer understands exactly how much energy is to be rejected to enable the heat pump to efficiently collect the needed energy.

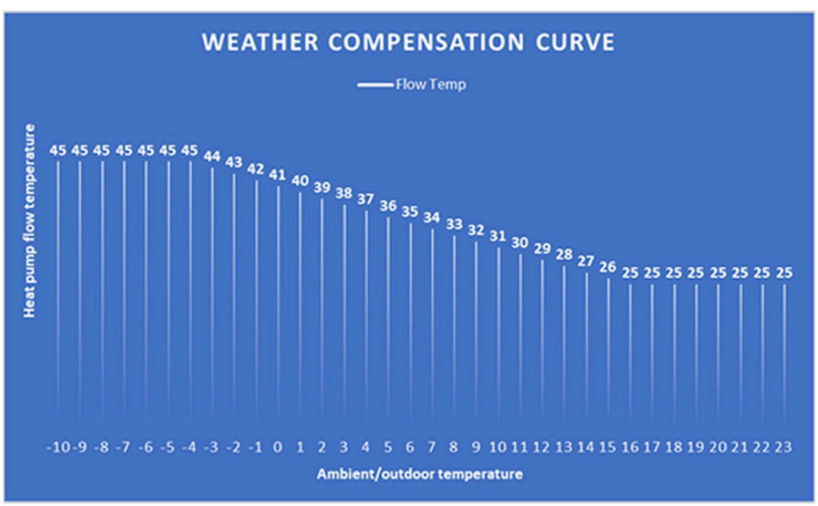
A building heat loss calculation informs the designer of the value of heat loss to correctly size the heat pump's collection capacity. This also informs the correct size of emitters to ensure proper energy rejection.

It is important to state that the heat pump should not be expected to deliver more heat energy than is needed into the building at a given outdoor temperature, as this will overheat the building envelope. This means the system needs to ideally provide continuous operation to maintain the correct energy value being delivered into the building. Continuous heat pump operation delivers optimal energy efficiency and performance throughout the heating and season.

Controlling the balance

The heat pump should always be in full control of the energy balancing and provide governance – that is, the rate of energy collection and rejection with a correctly sized and balanced emitter system.

We established earlier that the value of energy required to heat a room to 21oC changes as the outside temperature changes. To compensate for the increased heat loss, we can increase the flow temperature to speed up the transfer process. We call this control "weather compensation," and it is the most accurate way of ensuring the heat source can deliver the correct amount of energy into the building. To do this, the heat pump must measure the outside temperature and use the heat pump's control logic to set parameters to calculate the correct amount of energy to be collected based on the change rate of heat loss within the building.



This graph shows that as the ambient temperature decreases the flow temperature is increased to speed up the heat energy transfer.

The weather compensation control also must ensure the correct amount of energy delivered to the emitters is governed to ensure the energy balance. As the temperature decreases outside, the speed of the water delivering the heat energy to the emitters has to increase. If this does not occur the heat pump will be using electricity to raise the temperature but will not be able to deliver the correct amount of energy to released. Proper flow rates and pipe sizing are needed to ensure the correct amount of energy delivery and are a critical component to the system's efficient operation.

Upsetting the Balance

Since most UK homes are fitted with boilers, retrofitting them with heat pumps is likely to adopt the air-to- water type systems. If a heat pump is using water as the medium to carry the energy to an emitter, it is important that the total volume of water is available to the heat pump. If the water is closed off or trapped by valves (zone and thermostatic) within the emitter system, then that part of the system is no longer carrying the correct amount of energy and, therefore, no longer maintaining the heat to that area of the building envelope.

The effects this has on an air-to-water heat pump system are:

01 Reducing the volume of water available to the heat pump changes the rate of energy collection and can force the heat pump to cycle off as there is now too much energy for the emitter system to reject. This is problematic because heat pumps are not designed to switch on and off in rapid succession and are limited to 3-4 compressor starts per hour to protect the product. Therefore, when the heat pump starts back up again the energy deficit is now larger and requires the heat pump to work harder to cover the shortfall, thus increasing the cost of energy consumption and increased heat recovery time.

02 Holding the water within a closed zone and allowing that water to cool longer than the main volume of water in motion will reduce the overall water temperature going back to the heat pump. When this happens the heat pump has to use more energy to build additional pressure in the vapor compression cycle, meaning the heat pump is using more electricity and increasing the running cost.

03 Incorrectly sized emitters will prevent the correct amount of energy the system can reject entering the room, thereby preventing the room from reaching desired temperature and not delivering the 'indoor comfort' the system should be able to deliver

04 Cooler areas or zones within the building envelope will induce heat transfer from the warmer rooms where thermal bridging is not present. This will reduce the overall mean temperature from 21oC and marginally increase running cost of the system.

05 When the external temperature is below 4°C and the humidity is high, and especially when it is foggy and misty, the heat pump unit will need to perform a defrost. A heat pump will recover some of the heated water within the emitter circuit to enable the heat pump to charge the refrigerant temperature to 80-90oC to melt the ice formation on the unit to maintain an efficient heating operation during the colder months of the heating season.

06 Using thermostats in the conventional way to switch a heat pump on and off will increase running costs and provide false information to the owner of the system.

Pairing Heat Pumps with The Unico System

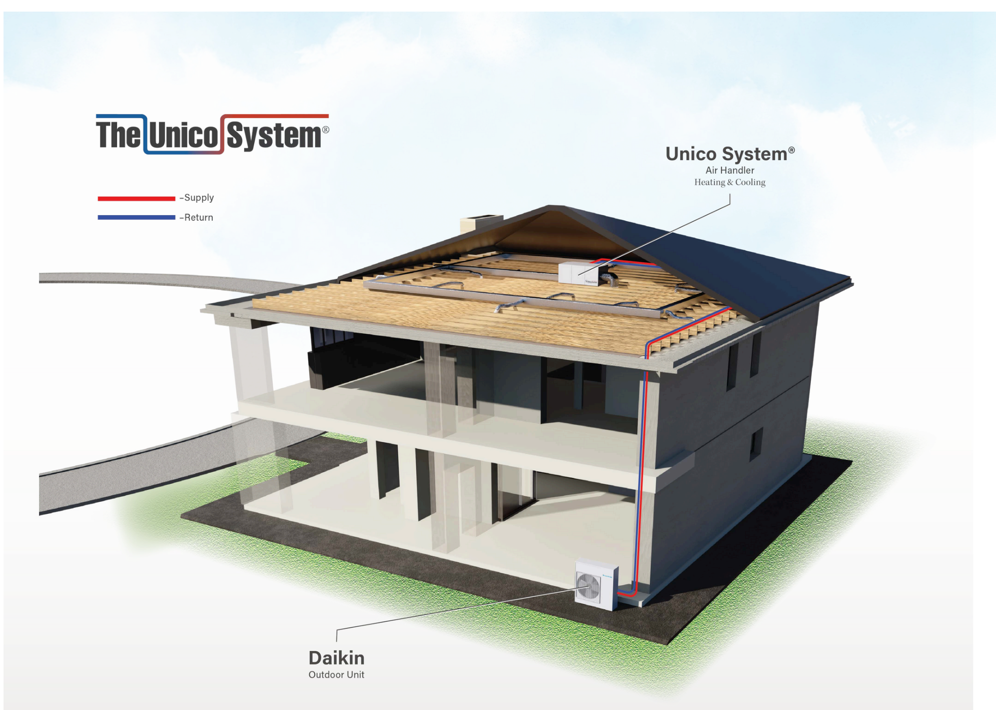
What is The Unico System?

The Unico System is a Small Duct High Velocity HVAC system with an option for a fan coil unit with the ability to transfer thermal energy from an outdoor heat pump to a building via an interior central air duct. This also enables the complete ventilation of a building providing filtration and conditioned air within the same system.

The earliest known HVAC system was the "windcatcher" system found in the ancient Egypt, where a system of ducts was used to cool homes by drawing cool air in from outside and circulating it throughout the home. The first modern residential HVAC system was installed by 1914, driven by the Coyne College, the first school to introduce HVAC training courses in 1899. In 1946 a jet engine pioneer named Calvin McCracken built a system called "Jet Heet" in New Jersey. This first small duct system consisted of small, insulated ducts delivering air at a high velocity. Over the years, engineers perfected this method of air delivery, including the ability to provide cooling, into what The Unico System is today.

When pairing an indoor air delivery method such as The Unico System with an outdoor heat pump, the air mass used to transfer thermal energy greatly increases the surface area compared to that of a radiant heat panel and allows the transfer of the thermal energy to occur at a lower temperature. This enhances the performance of the heat pump since the lower the flow temperature, the lower the running cost to move that energy, thereby improving the overall performance of the system. A further benefit of HVAC systems -and, specifically, that of The Unico System -is the ability to reduce humidity at the point of treatment, thereby enhancing indoor comfort and health benefits.

Pairing The Unico System central air with a heat pump is not only an extremely efficient method that lowers operational costs, but it provides a number of benefits when it comes to superior comfort and indoor air quality.



Single Unico System® air handler, single Daikin outdoor unit

Understanding energy rejection with The Unico System

The Unico System provides a great way to release heat energy at low temperatures because the surface area of air in comparison to a radiator and under floor heating is significantly greater. This means all the air within the building envelope is in contact with The Unico System, thereby releasing energy faster in comparison to radiant heating methods. Heat pumps combined with The Unico System provide an excellent solution for rejecting the correct amount of heat at lower flow temperatures in order to gain the heat pump's efficiency.

When combining a heat pump and The Unico System it is important to know how much energy you need the system to release. The total amount of fan coil surface area, fan speed, and flow temperature will dictate how much energy can be released.

When designing a Unico System heating and cooling circuit, it is important to make sure the correct amount of duct is installed as errors can occur if the air mass (i.e., emitter surface) is too small for the design flow temperature, which will result in lower energy output into the building envelope leading to an increase in the system's operating costs, a failure to deliver the correct desired indoor comfort temperature, and increased system noise. Conversely, if the air mass is too large, this will result in a higher energy input that can overheat the property beyond healthy or comfortable levels, force excessive ventilation needed to cool the property, and an unnecessary increase in operating costs.

Creating an energy balance with The Unico System

The heat pump and The Unico System and should be in equilibrium, or balance, to ensure it delivers the correct amount of heat into the building as the ambient temperature changes. The Unico air handler has to effectively reject heat into the building envelope at the same rate the outdoor heat pump is collecting it.

It is important to state that the Unico System and the heat pump should not be expected to deliver more heat energy than is needed into the building envelope as this will overheat the environment and contravene building regulations Part L. The ideal approach to heating with heat pumps is to provide continuous operation to maintain the correct energy value being delivered into the building, thereby ensuring optimal energy efficiency and performance throughout the heating season.

Controlling the balance with The Unico System

Pairing The Unico System with a heat pump works very differently to the traditional boiler set up. The significant difference is you no longer need zoning with individual room thermostats as a control method.

The heat pump is in full control of the energy balance and is governing the rate of energy collection and rejection. To maintain this control, the heat pump is measuring the outside temperature to calculate the correct amount of energy to collect based on the change of heat loss rate within the building. This is no coincidence as it has been established that the value of energy changes as the outside temperature changes.

This is how the heat pump manages "weather compensation" - the most accurate way of ensuring the heat source can deliver the correct amount of energy into the building. The water flow carrying the energy to The Unico System is regulated by a variable speed pump located within the heat pump. The flow rate of the water provides a critical method of control when delivering the energy from the heat pump to the Unico air handling unit.

Top Tips to deliver maximum efficiency and performance

01 Crunch the numbers

02 Choose your weapon

03 Choose your ride

04 Calculate your route

05 Consult with the power source

06 Invest in you and your team

The heat pump flow rate controls the amount of energy delivered to the Unico System. Changing the flow rate is effectively controlling the temperature in the building. Therefore, TRV's and thermostats within the building that were normally used for controlling a fossil fuel boiler are no longer required for the control of a heat pump, or they are no longer the primary control for temperature within the

Upsetting the Balance

The heat pump and The Unico System transfer heat to the air handler to heat the building. If the air is closed off or trapped by valves within the duct circuit, then that zone or emitter is no longer carrying the correct amount of energy to that part of the building and is no longer maintaining the energy input. The effect this has on a HVAC system is the following:

01 Reducing the volume of air within a room will reduce the amount of energy to maintain its comfort temperature as well as the filtering and humidification of the air within it. When the zone opens up, the heat pump and Unico System will need to work a little harder to re-heat and condition the air that was contained within.

02 Introducing cooler air to the overall air entering The Unico System will increase the overall energy demand, making the heat pump and The Unico System work harder to cover the shortfall, increasing operating costs.

03 Where additional controlled heating circuits are installed, holding the water within a closed zone and allowing that water to cool longer than the main volume of water in motion will reduce the overall water temperature going back to the heat pump. When this happens the heat pump has to use more energy to build additional pressure in the refrigeration circuit meaning the heat pump is using more electricity and increasing the running cost.

Delivering efficiency and performance

01 *Crunch the numbers*

Calculate the heat loss to the regional weather profile used within the Microgeneration Certification Scheme standards MIS3005D or heating design guide produced by CIBSE. New buildings should also have a calculation for heat gains to prevent overheating by solar and extreme weather conditions for highly insulated buildings.

When you know the value of energy the system is required to deliver at the peak temperature of the buildings region you can correctly size the capacity and size of the heat pump. And decide if the system needs to heat only or if there is a requirement for heating and cooling. There are many options and types of heat pump and emitter systems. **For a more in-depth guide from [Unico System UK] or [Bell Solutions] see the following guides [insert list of document references]**

02 *Choose your weapon*

Select the type of technology you wish to use to harvest the renewable energy. There are many options and types of heat pump and emitter systems. Make sure the units can deliver 100% capacity of heat for the region the building is located in. **For a more in-depth guide from [Unico System UK] or [Bell Solutions] see the following guides [insert list of document references]**

03 *Choose your ride*

Select the type of emitter system you want to operate with the heat pump system. There are many options and types of heat pump and emitter systems from under floor heating, radiators, and fan coils to central air handling units. **For a more in-depth guide from [Unico System UK] or [Bell Solutions] see the following guides [insert list of document references]**

04 *Calculate your route*

Design the heat pump system considering the system temperatures to be used with the selected heat emitters, the overall system flow rates, and the functions or heating and/or cooling to be operated. Knowing the energy delivery flow is the most important factor in your design. **For a more in-depth guide from [Unico System UK] or [Bell Solutions] see the following guides [insert list of document references]**

05 *Consult with the power source*

Because typical UK homes are limited on the amount of power they can draw down, you will need to apply to the energy network operators to get permission to connect a heat pump or pumps to the electricity network. If a heat pump and the installed appliances within the property exceed this load huge damage can be caused to the network sub-stations. **For a more in-depth guide from [Unico System UK] or [Bell Solutions] see the following guides [insert list of document references]**

06 *Invest in you and your team*

Training and continuous professional development (CPD) will be required when embarking on becoming a heat pump installer or HVAC engineer. The amount of information and the overall process of designing and installing heat pumps is far more technical than fitting a fossil fuel heat source. Gone are the days where a rule of thumb could be applied to design principles. Professional heating engineers are now required to understand mechanical, electrical, and ventilation principles just to decide on a heat pump application. **For a more in-depth guide from [Unico System UK] or [Bell Solutions] see the following guides [insert list of document references]**

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The Unico System®