

The Ingenious Air® Small Duct System

Design Guide



Air Conditioning Redefined

✓ Draught Free

✓ Low Carbon Footprint

✓ Improves Indoor Air Quality

Contact Us Today For Your Free Quotation

T: +44 1268 544 530 | E: info@ingenious-air.com | W: www.ingenious-air.com

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“We had ceiling cassettes installed during an office refurbishment. Apart from the draughts they weren’t too bad in the summer. In the winter the staff complained bitterly of being too cold. The heat from the cassettes was not reaching their feet and they were uncomfortable. We had two Ingenious Air® Small Duct Systems installed and straight away the problem was resolved to everyone’s satisfaction.”

Mr. Alun Lewis, the Millennium Stadium, Cardiff

System Overview

The award winning Ingenious Air® Small Duct System is an energy efficient, draught-free, ducted air conditioning system. The system won 'Air Conditioning Product of the Year' at the UK's prestigious RAC Industry Cooling Awards in 2015.



It is suitable for residential, commercial, industrial, medical, laboratory and heritage applications - both new build and retrofit.

Optional modules provide an array of functions in order to create the desired indoor environment:

- Cooling
- Heating
- High specification air purification
- Humidity control
- Outside air ventilation

Modules can easily be added post installation.

The system is **kind to the environment** and has multiple 'green' credentials for sustainability. Just one system can provide precise individual temperature and time control for up to eight rooms. One air handling unit (AHU) can therefore replace up to eight fan coils, which significantly reduces carbon footprint.

Reducing the number of components in this way simplifies installation and lowers whole-life costs and environmental impact. It has also passed US Energy Star testing.

The system uses the energy efficient **induction method of air delivery**, which has a natural **de-stratification effect**. The air movement pattern is imperceptible to human skin and creates a comfortable indoor environment. There are virtually **NO draughts**.

Treated air is continuously and gently distributed via **stylish and unobtrusive air outlets**. The outlets are discreetly positioned in 'out of traffic' areas in the ceilings, walls, bulkheads, pillars and floors.

A **natural de-humidification** effect removes excess humidity from the air in cooling mode and further improves comfort levels. Achieving lower relative humidity allows occupants to feel more comfortable at higher temperatures in cooling mode. The same cooling or heating performance can therefore be achieved using up to 50% less air than other systems

The system therefore achieves **thermal comfort**. This enables employers to meet their legal workplace requirements regarding temperature and draughts.

Multiple outlet colour and composition choices complement any interior design. There are no large ceiling grilles or wall mounted units, freeing up floor and wall space.

A **straightforward static regain design** increases flexibility and simplifies design and installation processes, which saves valuable time and money. A choice of plenum ductwork shapes and sizes allow the installer to avoid obstacles without affecting air delivery rates. Plug and play fittings make installation easier. Pre-cut, known resistance assembled flex lengths of patented small duct and built-in sound attenuator save time and materials.

The optional high specification air purification achieves superior indoor air quality and creates a healthier environment. It cleans the air of all three types of serious indoor air pollution:

1. Airborne, disease causing micro-organisms (viruses and bacteria),
2. Allergens, dust and the conditions that promote mould and mildew
3. Harmful Volatile Organic Compounds (VOCs)

Multiple control options are compatible with the newest intelligent controls and easily connect to building management systems (BMS).

An ingenious design allows all serviceable parts to be installed outside of sensitive or occupied areas. This provides **easier maintenance access** during normal working hours, keeping businesses running.

The system can **easily be adapted** to future building layout changes as air outlets can be quickly re-sited. Upgrading to additional modules post-installation is also straightforward.

How the System Works

A modular air handling unit (AHU) is at the core of the system. Each AHU is paired with a renewable technology heating /cooling source, such as an air conditioning heat pump or boiler.

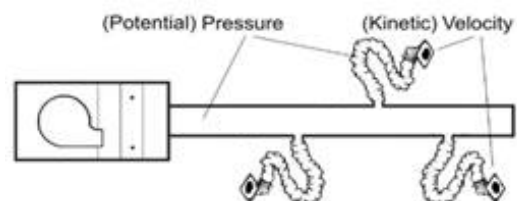
The AHU also connects to the main **plenum ductwork**. The plenum ductwork is connected to a series of 3m flexible small diameter, sound attenuated ducts called mini ducts. These versatile smaller sized mini ducts fit into areas that are too restrictive for standard system ducting. They terminate in stylish and discreet air outlets.

Three model sizes and speed control inverter fan motors allow sizing to suit your project size and airflow required.

The AHU contains a high efficiency variable frequency drive fan motor. The fan motor creates an even, static pressure (potential energy), of up to 300Pa, throughout the whole plenum ductwork. This is known as static regain.

The static regain ensures that the ductwork plenum is evenly pressurised and delivers the same amount of treated air to every mini duct. This in turn ensures that the mini ducts deliver the treated air evenly to where it is required, without the need for post installation balancing.

The static pressure (potential energy) is converted to velocity pressure (kinetic energy) as it is released through the mini ducts.



The smaller sizing of the mini ducts increases the speed at which the treated air leaves the system via the air outlets (The Venturi Effect). The increased speed delivers the small amounts of treated air into the room at low pressure (Bernoulli's Theorem).

The low pressure of the treated air stream draws room air continuously and imperceptibly back towards the air outlets. Air is slowly drawn from all corners of the room and gently mixed with the treated air stream.

The interaction with the room air creates a 200mm 'cone of influence' from the outlet. Outside of this cone, no draughts are felt.

De-stratification occurs naturally as a result of the induction method of air delivery. In heating mode, heat that normally rises and is lost at ceiling level is re-distributed downwards to mix with cooler floor level air.

In cooling mode, de-stratification prevents 'cold toes warm nose' syndrome. Cold air does not sit at low level and become stagnant.

Room coverage is equal. Occupants are warmed or cooled at the same rate and feel comfortable. All points of the room are heated, cooled or purified efficiently and effectively, regardless of room size.

The constant fan option maintains a continuous, imperceptible movement of air even when the system is not heating or cooling. Room temperatures stay stable for longer. This reduces the operating time of the heating and cooling sources, in turn minimising costs.

Before

Traditional air conditioning systems often blow air directly onto some occupants. This creates uneven temperatures and draughts

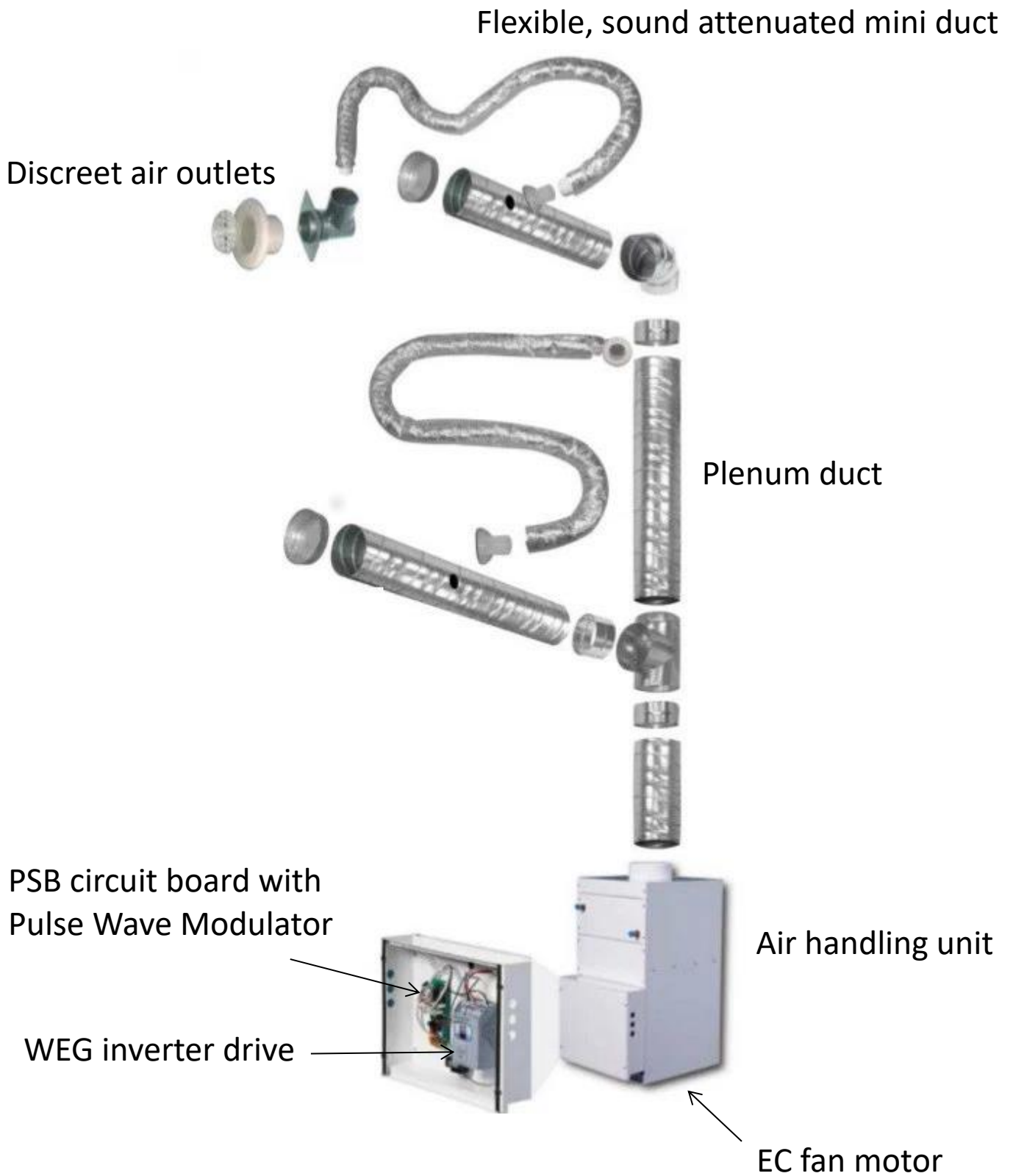


After

The Ingenious Air® System creates a comfortable even temperature throughout the room. There are no draughts



System Exploded Diagram



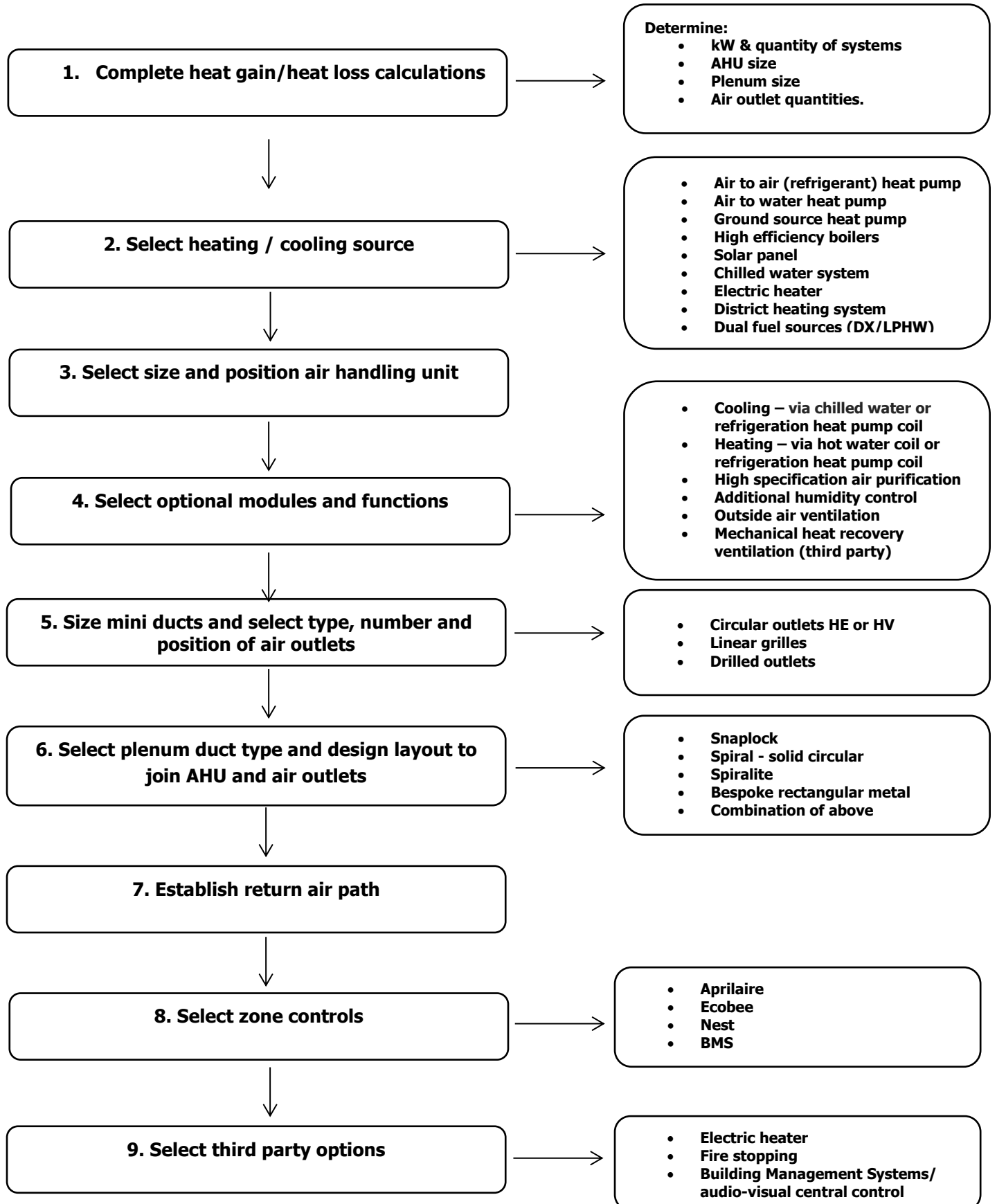
Three Model Sizes

MODEL NUMBER	HE 101	HE 70/71	HE 50/51
Cooling & Heating Requirement	Higher e.g. 100 – 150m ² office space	Average e.g. 50 – 100m ² office space	Small e.g. up to 50m ² office space
Application Size	12.5- 19.5kW heat pump cooling	5 - 10kW heat pump cooling	3.5 - 6.5kW heat pump cooling
Maximum Heating With 71°C hot water supply With 88°C hot water supply <i>See Table p19 for further details</i>	29.5kW 39.3kW	19.7Kw 26.1kW	13.1kW 17.4kW
Maximum Cooling Powered by heat pump With 6°C chilled water supply <i>See table p19 for further details</i>	12.5 – 19.5kW 8.6kW	7- 10kW 5.4kW	3.5 – 6.4kW 3.6kW
Heating - Electric	5 - 23kW	5 - 18kW	5 - 15kW
Guide No. of Outlets 50mm/HV 72mm/HE	40 - 64 20– 32	20 - 40 10 - 20	12 - 26 6 - 13
Maximum Air Flow	595 litres/sec	365 litres/sec	220 litres/sec
Dimensions - AHU Only Weight L x W x H (mm)	52.2kg 813 x 635 x 457	43.1kg 813 x 483 x 457	36.3kg 813 x 356 x 457
Dimensions - AHU, HEPS, Heat Pump, Cooling Coil & Return Air Mix Box L x W x H (mm)	1950 x 750 x 457	1950 x 580 x 457	1950 x 450 x 457

All three models share the same features:

- Cooling and heating options
- Direct drive EC fan motor
- Digital display WEG inverter drive with pulse wave modulator
- PSB circuit board
- Single side access panel

Design Process



Design Process Steps

Step 1: Complete Heat Gain/Heat Loss Calculations

Overview

Heat gain/heat loss calculations determine the heating or cooling load and the size of system required for each area. This information is used to work out the quantity of duct, mini duct and controllers and specify and supply the heat pump if one is necessary.

Design Process

- Follow an appropriate methodology/procedure to perform building heat load calculations OR confirm that the calculations were performed by a qualified third party.
 - AHU
 - Plenum size
 - Outlet quantities.

Step 2: Select Heating/Cooling Source to Suit Heat Load/Loss Calculations

Overview

The Ingenious Air® System is connected to a heating/cooling source. It works with all current renewable technologies for a lower environmental impact than conventional energy technologies.

Heating/cooling source options include:

- Air to air heat pumps (refrigerant heat pumps)
- Air to water heat pumps
- Ground source heat pumps
- High efficiency boilers (gas, oil fired, electric, bio-mass etc.)
- Solar panels
- Chilled water systems
- Electric heater
- District heating systems.
- Dual fuel sources (DX and LPHW).

Design Notes

- The Ingenious Air® System is usually paired with an air source heat pump (from all the major manufacturers) for both heating and cooling.
- The type of heating/cooling source will depend on:
 - The services you want the system to perform.
 - The heating / cooling requirement from each Ingenious Air® System air handling unit.
- You can connect to more than one heating source e.g. a heat/cool heat pump plus hot water supply.
- Projects requiring air purification only may not require a heating/cooling source.



Step 3: Select and Position Air handling Unit (AHU)

Overview

The modular air handling unit (AHU) is at the core of the system. It connects to the sustainable heating/cooling source and the main plenum ductwork.

Air is treated as programmed to:

- Heat
- Cool
- Purify
- Mix with up to 100% fresh air – directly or via a heat recovery system
- De-humidify
- Humidify

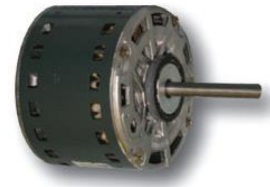


The AHU can be conveniently hidden in a choice of locations, with no impact on the working of the system. Positioning the AHU away from the conditioned area allows maintenance to be completed away from occupied areas, reducing costs and disruption for the client.

AHU Components

Electrically Commutated Fan Motor

A high efficiency, variable frequency direct drive (VFD), permanently lubricated, electronically commutated (EC) fan motor is housed within the AHU. All three model sizes have the same motor.



The motor uses less energy than standard motors:

- Increases energy efficiency with constant fan option. The continuous, imperceptible movement of air is maintained even when the system is not heating or cooling. This helps keep room temperatures stable for longer, which reduces the operating time of the heating and cooling source and running costs.
- Only uses the amount of power needed to achieve the desired speed. It adjusts its speed to suit requirements.
- Runs cold to the touch – does not generate excess heat.
- Converts the single phase supply to a three phase for extra efficiency.
- Is brushless.
- Provides a wide range of speeds.

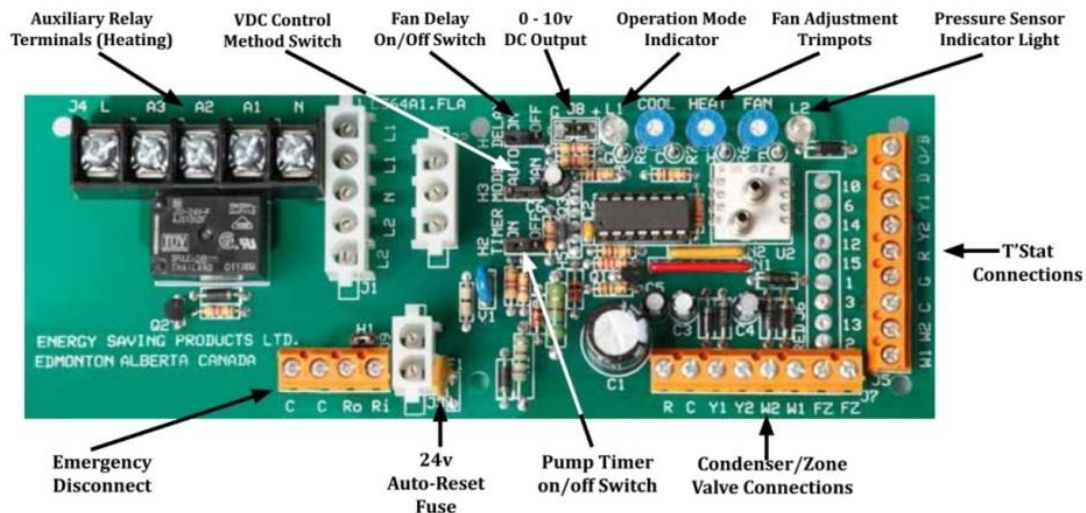
PSB Circuit Board with Pulse Wave Modulator (PWM)

The dual function pressure sensing circuit board (PSB) makes zoning simple and easy. It eliminates the need for by-pass dampers. The PSB sends control signals to the heating/cooling source. When used with inverter heat pump air conditioning DX outdoor units, it is connected to an interface panel supplied by the heat pump manufacturer.

Two different control methods provide a 0 - 10vdc output signal to the variable frequency drive (VFD):

1. **Automatic Mode** – the recommended method of fan speed control and the standard factory setting. It makes zoning simple. A pressure sensor measures the air pressure in the plenum duct. It modulates fan speed and makes automatic airflow adjustments to maintain a constant supply air static pressure.
2. **Manual Mode** - allows for direct speed control of the fan anywhere from 0 - 100% capability, by manually selecting the output value of the WEG

inverter drive. It by-passes the pressure sensor used in automatic mode and can be used in single zone applications. It does not compensate for dirty filter or closed outlets.



Duct pressure is individually set for cooling, heating and constant fan. The fan adjusts its speed to maintain this set static pressure. Airflow can easily be adjusted for all modes using the trim pots (COOL, HEAT and FAN).

If a zone damper or outlet is switched off, the pressure will increase in the duct. The PWM will automatically react and slow the fan down.

If the filters get dirty the fan automatically increases speed to maintain the required duct pressure.

WEG Inverter Drive

The digital display WEG inverter drive is a reliable and robust motor control. It is housed within the air handling unit and provides many years of issue-free operation.



The WEG is sized to ensure increased reliability and higher efficiencies at peak load. It allows for minimum power consumption at reduced loads (<100w average for constant fan speed).

It allows the setting of minimum and maximum fan speeds. Fan speed is determined by the PSB circuit board. The PSB converts the pressure in the duct to a 0 - 10vdc output to control the WEG.

Design Process

1. Select AHU size. Match the AHU size from the sizing table to the heat gain/loss requirement.
2. Select plenum size, and outlet quantities based on required airflow or kW cooling / heating.
3. Use capacity tables to determine air flow requirements.
4. Select AHU position.

DESIGN NOTES

- The AHU comes in three model sizes depending on project size and air flow required (See **Three Model Sizes** chart).
- Supply plenum ducts for more than one unit can be joined for larger capacities if required.
- Use water temperature and flow details to size system when working with heated or cooled water.
- Check the heat pump manufacturer's recommendations for minimum kW cooling/heating requirements.
- You have flexibility to produce a quieter performance by lowering the fan speed and/or adding extra air outlets. Contact The Ingenious Air® Company to discuss.

Energy Star Testing – Energy Use

TEST	LOAD %	FAN DRAW W	AIR FLOW L/S	WATTS L/S	NET EFF. %	CSHE %	TPR
HE-Z-50H & NPE-180A c/w external pump @ 100 Pa diff. pres.	100	179	198	0.90	89.40	90	0.9
	40	141	181	0.78	93.90		
	15	141	181	0.78	79		
HE-Z-70H & NPE-180A c/w external pump @ 100 Pa diff. pres.	100	242	305	0.79	86.90	91	0.92
	40	184	282	0.65	95.30		
	15	184	282	0.65	84		
HE-B-50H & NPE-180A w/o external pump @ 200 Pa diff. pres.	100	327	227	1.44	88.40	89	0.9
	40	220	198	1.11	94		
	15	220	198	1.11	79		
HE-B-70H & NPE-180A w/o external pump @ 200 Pa diff. pres.	100	267	273	0.98	86.30	88	0.89
	40	196	244	0.80	92.70		
	15	196	244	0.80	80		
HE-B-70H & NPE-180A w/o external pump @ 300 Pa diff. pres.	100	519	350	1.48	85.60	89	0.9
	40	291	288	1.01	91.60		
	15	291	288	1.01	84.90		
HE-B-50H & NPE-180A w/o external pump @ 300 Pa diff. pres.	100	288	196	1.47	81.80	81	0.83
	40	240	184	1.30	85.70		
	15	241	184	1.30	72		
HE-Z-100H & NPE-240A c/w external pump @ 100 Pa diff. pres.	100	409	469	0.87	87.50	93	0.94
	40	323	439	0.74	95.60		
	15	323	439	0.74	90		
LV-Z 1050H & NPE-240A c/w external pump @ 100 Pa diff. pres.	100	254	367	0.69	90.90	0.93	
	40	212	337	0.63	97.10		
	15	212	337	0.63	85		

Positioning

- Multiple mounting configurations are available with over 32 viable configurations per model.
- Take into account the location of the heating /cooling source to the AHU.
- Position AHU in the least sensitive area for best results:
 - Attic space
 - Basement
 - Utility room
 - Plant room
 - Store areas
 - Above ceilings
 - Externally, in insulated weatherproof housing.

- Commercial – warehouse, in corridor etc.
- In residential applications, position away from the main bedrooms e.g. the loft or over the bathrooms.
- Suspend the AHU.
- Keep a small space between AHU and any other surface to prevent vibration transfer.
- Use anti-vibration mounts if in a sensitive area.

Maintenance Access

- To minimise access requirements, ensure all modules are installed to allow access from the same side. All three models have single side access panels.
- Ensure minimum clearances are met for maintenance access:

MODEL	MINIMUM CLEARANCE (MM)
HE-Z 51	457
HE-Z 71	559
HE-Z 101	737

Design Rules

One Ingenious Air® System:

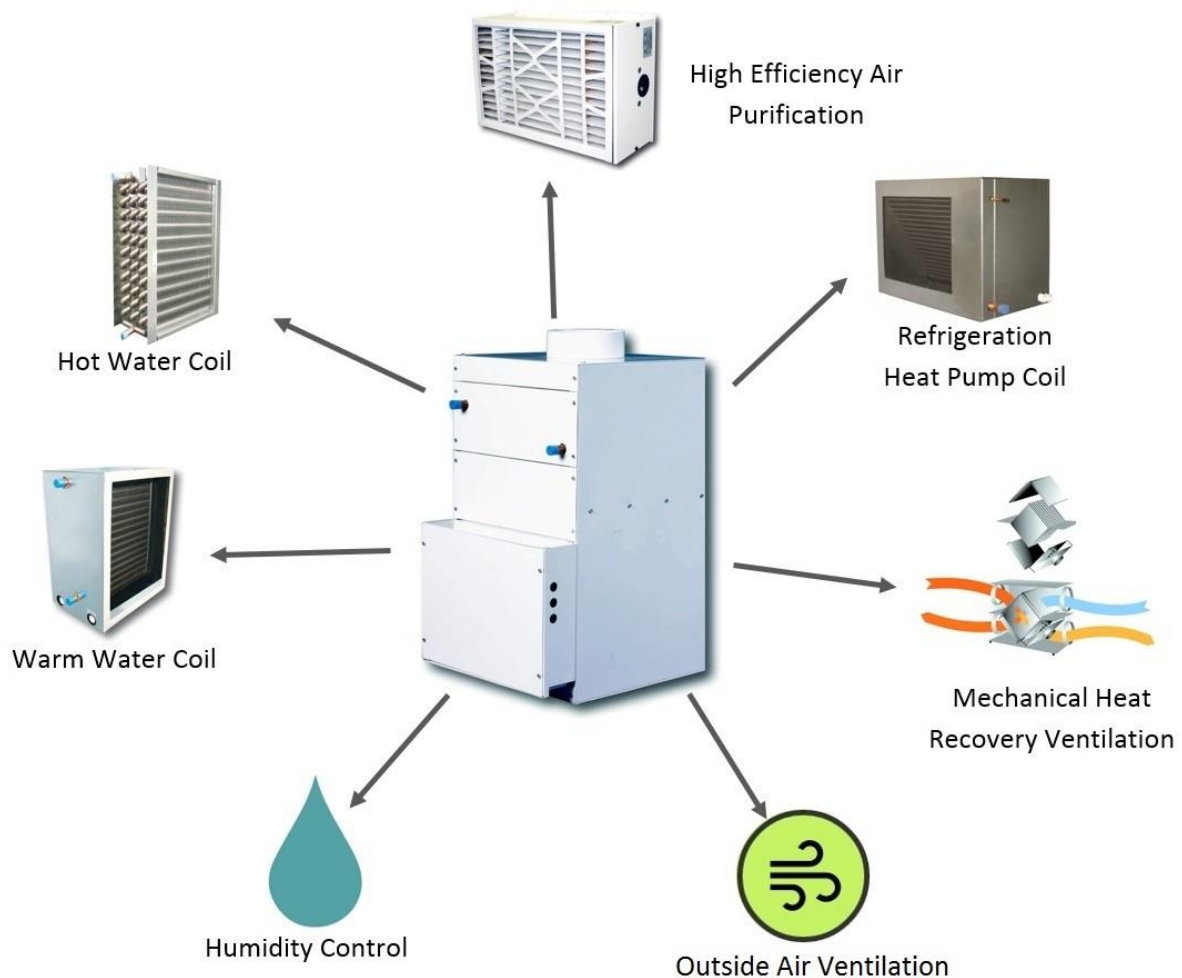
- Provides 4 –30kW of heat and 3.5 -19.5kW of cooling depending on the cooling/heating source.
- Covers a large area, with a heating capacity up to 36kW and a cooling capacity up to 19.5kW.
- Can maintain a difference of up to 4°C between two adjoining rooms.
- Maximum watts per outlet = kW of heating/cooling source ÷ no. of outlet.
- Avoid under-sizing. This will ensure best performance and sound levels.
- Always design with the orientation of the building in mind.
 - **Residential projects**
 - Approx. 8 litres/sec of air per HV outlet
 - Approx. 16 litres/sec of air per HE outlet
 - **Commercial projects** can be higher.

Step 4: Select Optional Modules

You can add up to seven optional functions to the air handling unit (AHU) to create the required environment:

1. Cooling – via a chilled water coil or refrigeration heat pump coil
2. Heating – via a hot water coil
3. Heating – via a refrigeration heat pump coil
4. High specification air purification
5. Additional humidity control – via a humidistat
6. Outside air ventilation
7. Mechanical heat recovery ventilation.

You can choose any combination, depending on what you want the system to do. They can also easily be added years after the initial installation.



Chilled Water Coil Module (WCM)

The chilled water based module is mainly used in chilled water applications for cooling, but can be used for heating with water temperatures up to 65°C.



Design Rules

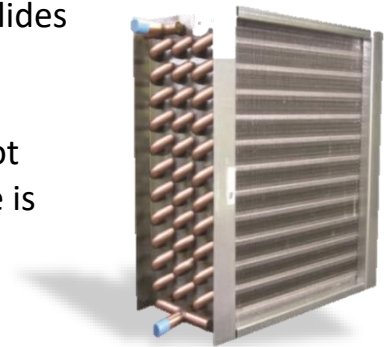
- The WCM comes complete with 2 built-in 19mm primary and secondary drain lines.
- It connects to the chilled or warm water supply. The coil bolts on to the return air side of the air handling unit and must be installed in a vertical position for condensate drain off.
- The preferred water temperature is 4°C for maximum duty from the AHU.
- The coil bolts on to the return air side of the air handling unit and must be installed in a vertical position for condensate drain off.
- Ensure the primary drain line is vented and P-trapped.
- The use of a mixture of glycol will reduce capacities; refer to glycol manufacture reduction charts.
- When the potential for gravity flow of the hot water exists, check valves may be needed on both the supply and return lines.
- All lines should be piped so as not to restrict access to the front panels, filter section, or electrical enclosure.
- Size supply and return lines according to table:

WCM kW CAPACITY AND SHR AT 23.9 °C Room Temperature								
Coil Model		50	50	70	70	100	100	100
Airflow in L/S		177	236	295	354	413	472	590
Supply Water Temp.	8.889°C	3.40/77	4.07/80	5.43/78	6.11/80	7.68/78	8.39/79	9.58/81
	7.778°C	3.77/73	4.51/76	6.04/74	6.77/76	8.54/74	9.30/75	10.61/78
	6.667°C	4.14/71	4.94/73	6.64/72	7.44/73	9.39/71	10.23/72	11.64/75
	5.556°C	4.50/69	5.38/71	7.23/69	8.11/71	10.23/69	11.14/70	12.68/72
	4.44°C	4.86/67	5.81/69	7.81/67	8.76/69	11.05/67	12.04/68	13.71/70

Hot Water Coil (HWC)

The module is a high capacity hydronic water coil, which slides into a readymade space inside the air handling unit.

The high capacity hydronic water coil is mainly used for hot water only, not cooling. The maximum water temperature is 88°C.



The coil is factory tested at 500 psi for leaks, and is designed to have a low water pressure drop through the coil reducing pump head loss. It is designed with ¾" copper connections with 6 internal rows of 3/8" copper tubing. This provides high heat transfer ratings even when using low water temperature sources.

A timer incorporated within the circuit board will 'duty cycle' the circulation pump for five minutes every 24 hours, if required. This ensures there is no stagnant water within the water coil and helps to prevent pipe freezing.

All controls must be site fitted.

HOT WATER HEATING	HE - 50/51	HE - 70/71	HE - 100/101
COIL TYPE	6 ROW/10 FPI	6 ROW/10 FPI	6 ROW/10 FPI
EWT 88°C	17.4kW	26.1kW	39.3 kW
EWT 82°C	16.0kW	24.0kW	36.0 kW
EWT 77°C	14.5kW	21.8kW	32.8 kW
EWT 71°C	13.1kW	19.7kW	29.5 kW
EWT 66°C	11.6kW	17.5kW	26.3 kW
EWT 60°C	10.2kW	15.2kW	23.0 kW
EWT 54°C	8.7kW	13.1kW	19.7 kW
EWT 49°C	7.3kW	11.0kW	16.5 kW
EWT 43°C	5.9kW	8.9kW	13.3 kW
GPM Flow Rating (L/s)	5 (0.32 L/s)	7 (0.44 L/s)	10 (0.63 L/s)
Pressure Drop in FT (m) H ₂ O	3 (9.15 KPa)	6.5 (19.8 KPa)	6.8 (20.7 KPa)
CFM @ 68°F EAT (L/s @ 20°C EAT)	470 (221 L/s)	700 (300 L/s)	1120 (528 L/s)

Refrigerant Cooling / Heating Module (RPM-E)

This is a complete module that provides heating and/or cooling.

Design Rules

- Connects to heat pump / energy source
- Complete module.
- Draw-through unit only.
- Multi-position airflow configurations for horizontal, vertical or counter-flow configurations.
- Can be left or right handed.
- The module bolts on to the air-on side of the air handling unit (AHU) and connects to the outdoor heat pump via refrigerant pipework.
- Must be installed in the vertical position on the return air side of the AHU to allow for condensate drain off. Cannot be turned on its side.



Design Notes

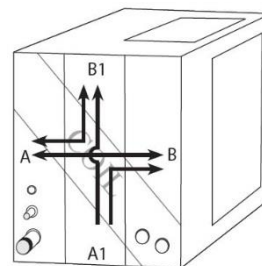
- A secondary drain pan is recommended for any installation that has the potential of property damage due to condensate.

RPM-E Rough Opening Sizes

ROUGH OPENING SIZES	A OR B	A1 OR B1
RM – 50	298mm (L) x 337mm (H)	298mm (L) x 229mm (H)
RM – 70	425mm (L) x 337mm (H)	425mm (L) x 229mm (H)
RPM – 100	578mm (L) x 337mm (H)	578mm (L) x 229mm (H)

Airflow Through Coil

RIGHT	WRONG
A to B	B1 to A1
A to B1	B to A1
A1 to B	A to A1
A1 to B1	B to B1
B to A	
B1 to A	



Air Purification Module

The high specification air purification module is also known as the High Efficiency Purification System (HEPS purifier). It is designed specifically for use with the Ingenious Air® System.

Dramatically reduces all three types of serious indoor air pollutants:

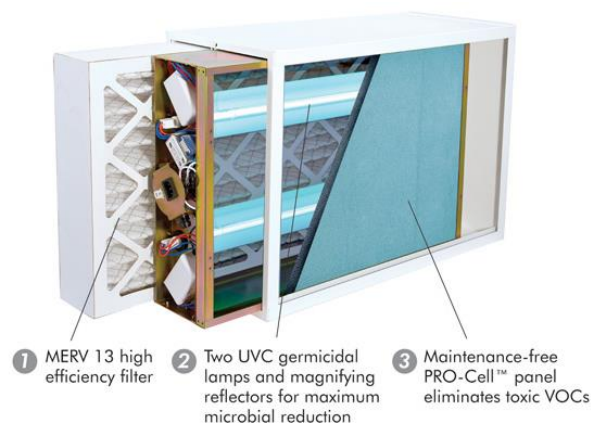
1. Airborne disease-causing microscopic particles – that cause infectious diseases including influenza, common colds, tuberculosis, legionella and c.difficile.
2. Airborne primary sources of allergy - that cause symptoms such as fatigue, headaches, coughing, sneezing, runny, itchy eyes, stuffy nose, wheezing and shortness of breath.
3. Airborne toxic volatile organic compounds (VOCs) - including nitrous oxide, carbon monoxide, fumes and unpleasant odours from paint solvents, car exhausts, pesticides, cleaning fluids and alcohol. VOCs can cause short and long-term ill-health.



Dust Mites, Spores, Dust, Influenza, Bacteria, Pet Dander, Viruses, Pollen, Colds, Vehicle Exhaust

Combines three powerful technologies

1. High efficiency electrostatic particle filtration - reduces microscopic allergens as small as 0.3microns. The average human hair is 80 microns in size and a bacterium is 1 micron.
2. Titanium photo-catalytic oxidation (PCO) - reduces VOC chemical fumes and odours.
3. Ultraviolet germicidal air disinfection - destroys airborne bacteria and viruses and VOCs too small to be caught by HEPA filters.



Design Notes

- Fits all three Ingenious Air® System models.
- Fits straight on to the HE101, but needs an adaptor kit to connect to the HE51 and HE71.
- Can be fitted retrospectively, even years after installation.
- Standard filters should always be provided if air purification is not added.

Humidistat Optional Component

The humidistat is available as an optional component to the Ingenious Air® System. It controls the system to operate as a de-humidifier and can also be connected to as humidifier.

The system naturally takes excess moisture out of the air, but can also be set to actively humidify or de-humidify a conditioned area.

Lower off coil temperatures lead to reduced sensible heat ratios. This is designed for improved comfort.

A humidistat can be added to make the system de-humidify through cooling and to control a separate humidifier. That humidifier can be added to the supply ductwork or be stand-alone as required. It controls the system to operate as a de-humidifier.

Outside Air Make-Up

The Ingenious Air® System can reduce outside air ventilation ductwork compared with other ventilation systems.

Any mix of 0 – 100% outside air or 100% recirculated air can be introduced directly through the small duct system or with or without mechanical heat recovery ventilation. This is dictated by project requirements.

The outside air is mixed with re-circulating air from inside the building at the return air (mixing) box.

A motorised damper can be connected to a CO₂ monitor so that it only opens when required. This reduces heating/cooling costs.

The Ingenious Air® System can reduce ventilation ductwork (compared with other ventilation systems). It delivers outside air to the 'air on' side of the AHU, through a heat recovery unit if required. This reduces the supply side ducting of the vent systems. Please contact The Ingenious Air® Company for further information.

The system also has the potential to revolutionise fresh air ventilation requirements: Adding air purification reduces smells, pollutants and bio-pathogens. The system allows you to design below the 10lts/sec per person in some commercial applications. Please contact The Ingenious Air® Company for further information.

Step 5 - Size Mini Ducts and Select Air Outlet Type, Number and Position

Overview

Mini Ducts

The plenum connects to small diameter, 3m long flexible ducts called mini ducts. The mini ducts terminate in discreet air outlets positioned discreetly in the walls, floors and ceilings.



Mini duct is supplied in pre-cut, known resistance assembled standard 3m lengths, with built in sound attenuation. It is pre-packaged with the corresponding size take off, dust cap, rough in boot and air outlets. Fittings are straightforward 'plug and play'.

The **rough-in boot** is connected to the mini duct and is used to position the mini duct and the air outlet vent plate in the room. The insulation and vapour barrier that is around the mini duct can be used for the rough in boot.



The **take-off** connects the main plenum ductwork to the flexible mini ducts.

Air Outlets

The induction method of air delivery allows the air outlets to be positioned in 'out of traffic' areas in walls, ceilings, bulkheads, kick spaces and floors. This frees up floor and wall space as there is no need for radiators, large grilles and wall mounted units.

There are three types of air outlet, depending on the finish and style required.

1. Circular Outlets

Circular outlets are stylish and discreet. Multiple design, colour and composition choices including plastic, metal and wood, mean they complement any interior design. They can be mixed and matched, depending on the finish and style you require.



They blend beautifully into your client's interior design and layout, whether modern or traditional. White outlets can be painted to perfectly match your client's colour scheme.

Circular outlets are highly versatile and ideal for buildings needing a more sensitive solution, such as listed buildings. If your client changes room layout after the initial installation, re-siting the position of the air outlets is quick and easy.

Bespoke circular outlets can be designed specifically to match your requirements. This is useful for unusual projects, such as anti-ligature applications. Please contact us for more information.

Circular outlets come in two sizes and are available with standard and directional, louvered inserts:



HV Outlet



HE Outlet

2. Linear Grilles

Linear grilles give clean straight lines for a modern look and work equally well positioned in high side walls, ceilings or floors. They come in a range of sizes and can be as thin as 20mm. Multiple grilles or single long grilles can be used to complement the interior design.

Rectangular slot rough-in boots are available on special order for thinner linear slots.



3. Drilled Outlets

Drilled outlets create a more industrial look. They supply large areas with heating and cooling. They can also create a pressurized air curtain for bay doors, or large openings to the outside environment.



Design Process

1. Use the heat gain/heat loss calculations to select AHU, plenum size, and outlet quantities.
2. Select mini duct size – either 50mm or 72mm diameter (see below)
3. Select air outlet design
4. Size number of air outlets required
5. Mark up positioning.
6. Select position and orientation of modules and plenum duct work:
 - RM/RPME coil
 - HEPS
 - Return air box.

Design Notes

- The air outlet and mini duct size are the same.
- Outlet requirements can vary depending on what is taking place through the rest of the system.
- Any combination of HV ducting, HE ducting, and drilled outlets can be used, following the minimum and maximum outlets as per the unit selection.
- There are two sizes of mini duct, which correspond to the two sizes of circular air outlet, HV and HE:

Two Sizes Of Mini Duct

Sizing	HV Mini Duct	HE Mini Duct
Air outlet internal diameter	50mm	72mm
Outside diameter of mini duct	114mm	125mm
Minimum radius of bends	152mm	178mm
Minimum length	3m	3m

- Allow enough outlets per room to match the heat gain/ heat loss calculations.
- Commercial projects usually require fewer outlets than residential due to higher sound tolerances.
- Use the larger (HE) size outlet where possible for best cost, installation speed and visual results use.
- Contact The Ingenious Air® Company if the ceiling is above 5m. The system has been installed in ceilings up to 13m with <1°C difference floor to ceiling.

Positioning

- Position air outlets discreetly in 'out of traffic' areas in walls, ceilings, floors and bulkheads.
- Correct positioning is essential to ensure heating and cooling is virtually draught-free, responsive and achieves an even temperature throughout the area. Positioning also dictates:
 - Airflow pattern
 - Final position of the plenum duct
 - Position of take offs in the plenum duct.
- Place outlets in out of traffic areas. Air is evenly and gently circulated throughout the room at all times. This constant circulation is vital to maintain comfort.

- Do NOT position under/beside/on-top of objects that may hamper the cone of influence from circulating the room air.
 - Locate HV outlets 150mm on centre from any possible obstruction.
 - Locate HE outlets 180mm on centre from any possible obstruction.

Design Rules

Mini duct

- Allow a minimum of 300mm between every mini duct take off on the plenum.
- Do NOT run the mini duct in the outside walls as it may be subject to heat loss or gain and can result in higher operating costs while delivering inferior air quality.
- Do NOT reduce the mini duct length. (Mini ducts are supplied in 3m lengths).
- If a shorter length is required, the installer will fold the mini ducts to keep the 3m standard. In this way, with the equal as pressure throughout the supply plenum duct, each mini duct outlet will supply approx. the same air flow and this same KW of cooling/ heating.
- Mini duct can be extended by using a smooth bore tube supplied by The Ingenious Air® Company. Please contact us to discuss.

Airflow requirements

- The air flow from one HE duct is equal to two HV ducts of the same length i.e. 1 x HE duct = 2 x HV ducts of the same length.
- As the pressure is equal throughout the supply plenum duct, each mini duct outlet will supply approx. the same air flow and this same KW of cooling/heating.

Airflow – circular outlets

- Max Watts per outlet = kW of heating/cooling source ÷ no. of outlets.
- Do NOT use a single outlet on its own in one on a DX system.
- Do NOT use HE outlets for 51mm x 102mm partition wall applications.
- For the best results allow 25 x HE (50 x HV) outlets on a HE101 and 15 x HE (30 x HV) outlets on a HE71.

Drilled outlet sizes for airflow:

- 1 x 50mm drilled outlet aperture = 1 x 72mm HE circular outlet
- 1 x 35mm drilled outlet aperture = 1 x 50mm HV circular outlet.

Quantity Of Circular Air Outlets Required (Guide Only):

SYSTEM	APPLICATION	No. HE OUTLETS	No. HV OUTLETS
HE101	Commercial	25	50
HE101	Residential	27	54
HE71	Commercial	15	30
HE71	Residential	17	34
HE51	Commercial	10	20
HE51	Residential	12	14

DUCT SIZE (mm)	Maximum No. HE OUTLETS (72mm internal diameter)	Maximum No. HV OUTLETS (50mm internal diameter)
100	N/A	4
125	3	6
150	6	12
175	9	18
200	20	40
250	30	60

EXAMPLES

14kW cooling requirement

- Select 1 x HE101 with suitable heat pump.
- $14\text{kW} \div 24 \text{ outlets} = 583 \text{ watts per HE outlet or } 291 \text{ watts per HV outlet.}$
- E.G. Allow 7 x HE (4.08kW) or 14 x HV outlets for a 4kW room requirement.

10kW cooling requirement

- Select 1 x HE71 with suitable heat pump.
- $10\text{kW} \div 15 \text{ outlets} = 0.667 \text{ watts/ outlet as } 338 \text{ watts/outlet.}$

4kW individual room requirement (as part of overall system)

- Allow 6 x HE (0.667 watts/outlet) or 12 x HV outlets

If a system requires 24 outlets of HV 50mm flex duct you can change to:

- 12 x HE x 72mm duct outlets *or*
- 8 x HE duct and 8 x 50mm duct outlets *or*
- Any combination to give you the equivalent.

Step 6 - Select Plenum Duct Type and Design Layout to Join AHU and Air Outlets

Plenum Duct

Overview

The plenum duct sizes are smaller for two reasons:

- The wider Delta T of air over the coil allows for a lower air requirement to provide the same kW of cooling and heating when compared with other systems.
- Because it is a plenum not a duct, the air can travel quicker with no ill effects. Therefore the plenum can be smaller than other systems without a noise penalty.

Plenum Shape

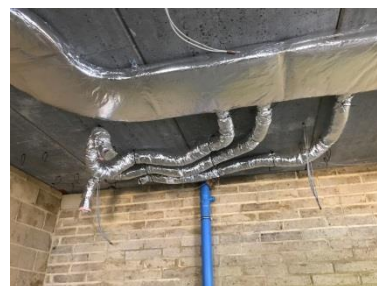
There is a choice of plenum shape, depending on the type of installation.

- **Snaplock** - site assembly ductwork with adjustable elbows, supplied in 1.5m lengths. Best for residential projects.
- **Spiral** - solid circular ductwork supplied in 3m lengths. Best for commercial projects.
- **Spiralite** - lightweight phenolic foam duct with excellent thermal properties and external and internal foil lining. Best for when drilled outlets are used and the duct is on show.
- **Bespoke rectangular metal ductwork** - the cross sectional area is the same as the round duct that would have been used. The shape can vary on the same system to suit site conditions, providing the cross sectional area is maintained where required. Best for constricted void spaces.

Circular Plenum Duct:



Rectangular Plenum Duct:



Design Process

1. Select plenum type:
 - a. Snaplock
 - b. Spiral
 - c. Spiralite
 - d. Bespoke rectangular metal ductwork
2. Decide the supply plenum duct route based on air outlet position requirements and quantity.

Design Notes

- The Ingenious Air® System is a static regain system, which gives increased design and positioning flexibility for the AHU and air outlets. There is:
 - NO requirement to reduce the plenum size to maintain duct velocity. Static regain means the pressure is maintained throughout the entire plenum*.
 - NO requirement for post-installation balancing.
 - NO requirement for air outlets to be located on outside walls in central locations. Designing duct layouts is therefore substantially easier.
- The plenum can change shape e.g. from round to rectangular to navigate an obstruction then revert back to round.
- The route of the plenum ductwork is dictated by the required position of the air outlets.

Design Rules

- Use a maximum of 70m of total plenum duct per system.
- Keep the number of bends to a minimum for best system performance.
- For the best fan motor performance:
 - Use 250mm plenum duct (plus insulation) for the HE-Z 101.
 - Use 200mm plenum duct (plus insulation) for the HE-Z 71 & 51.
- The plenum must be insulated if used for cooling or for heating passing through an un-insulated space.
- Use solid duct only for plenum.
- If rectangular duct is required, keep the cross section area the same as the circular and keep duct height at least 100mm internal diameter.
- Plenum branch ducts can be reduced in size if required e.g. if access issues make using the same size plenum duct are impractical.
- Maintain smooth radius bends.

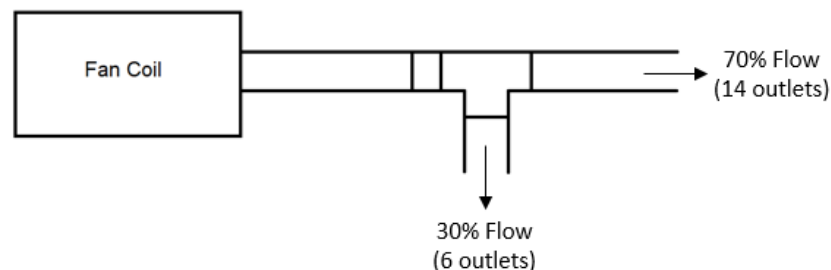
Branch Rule For Plenum Duct

- Maximum 30% of outlets on a branch (i.e. 30% of outlets available at that point on the plenum)

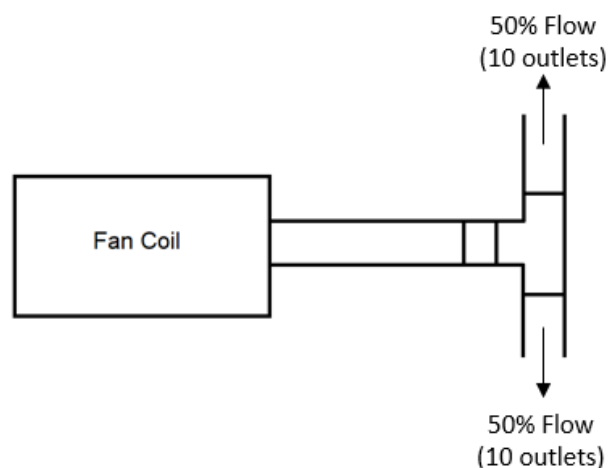
Elbows And Tees

- Keep elbows and tees to a minimum for the best system performance.
- In a tee design, allow for 50% of the outlets on the system after that tee to be on either side (max 60/40%). (Ignoring outlets connected to the system prior).
- For tee reductions, keep the tee to the full duct size and reduce only after the tee.
- Allow 300mm after tees/bends, before the next bend, tee or mini duct take-off.
- Do not place elbows and tees closer than 450mm from the supply outlet on the AHU. Up to 30% of the airflow can be lost if elbows or tees are installed closer than 450mm.

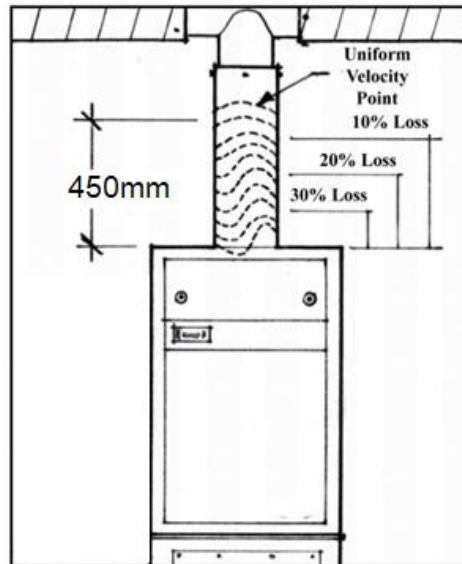
Example: Branch tee, 20 outlets:



Example: Bullhead tee, 20 outlets:



Sigma velocity profile of the first 450mm of the main plenum and why it's important to allow the system to equalize air flow:



Step 7: Establish Return Air Path

Overview

When designing, you must allow for room air to be drawn back to the air handling unit so the air can be continually conditioned. Options are:

- A return air grille and sound attenuated return air duct.
- A shadow gap or ceiling void.
- Air transfer to allow the air to escape the room and flow back to a centralised return air.

Sound attenuated flexible duct or solid duct with baffle is used for solid return air duct. If a shadow gap or ceiling void plenum is used, a return air duct is still recommended for sound attenuation.

Return Air Box

The return air box is an optional component for the return air plenum, which is connected to the air handling unit (AHU). It is acoustically lined with half-inch sound absorbing insulation. It can also be used as a transition and mixing box for the return air. It has a 25mm filter (if not using the optional air purification module).



Return Air Grille

A single central return air grille is positioned discreetly in a central location e.g. in the corridor of an office complex. The grille size matches the return air duct and air speed requirements.

The shape of the grille is not important providing the free air dimensions are at least equivalent to the cross section of the return air duct.

You can design your own return air grille. It can be any size, shape or design as long as it meets the minimum requirements for return air flow.

Design Notes

The Ingenious Air® System can use as little as 50% of air compared with other systems.

Multiple returns can be used if required. Mechanical heat recovery ventilation can be added to the return air path.

Closed rooms should have air transfer to allow the air to escape the room and flow back to a centralised return air. A closed room will slightly pressurise, and air will escape through the undercut of a door back to a centralized return air. I.e. a bedroom with 3 x 50mm outlets will deliver 30litres/sec into the space. A 12mm undercut door will provide 9600mm² return air from the space at a transfer velocity $\geq 3.2\text{m/s}$. This is sufficient to provide comfortable return air.

In larger buildings a return air plenum/path can be integrated in the structure of the building between joists.

Areas that cannot be tied into the return air should have air transfer to allow the air to escape the room and flow back to a centralised return air.

Design Rules

Return Air Duct Sizing

- Size return air on a 37pa static pressure (compared with 25pa static pressure for conventional forced air systems). See Return Air Table below.
- Do NOT undersize the return air, as this will create noise, increase motor power consumption and reduce airflow.

- The minimum of free air area of the return air grille must be equal to or greater than return air duct cross-section.
- Multiple return air ducts can be used if required.

Return Air Box Dimensions

AHU	LENGTH (mm)	HEIGHT (mm)	WIDTH (mm)
HE/HE-Z 50/51	610	470	370
HE/HE-Z 70/71	610	470	495
HE/HE-Z 101	610	470	648

RECOMMENDED RETURN AIR SIZES FOR ROUND AND RECTANGULAR DUCTS

AHU	ROUND DUCT (mm)	RECTANGULAR DUCT EQUIVALENT (cm ²)	FLEX DUCT (mm)
HE/HE-Z 50/51	300	774	355
HE/HE-Z 70/71	300	774	355
HE/HE-Z 101	350	1084	405

STEP 8: Select Zone Control

Overview

Time And Temperature Control - Technical Aspects

The Ingenious Air® System houses an inverter, speed control, fan motor in the air handling unit. Each system can be zoned to provide individual time and temperature control for up to eight rooms per AHU. One system can therefore replace up to eight fan coils. This means less pipework, less hot works, less refrigerant gas, less Nitrogen required when brazing DX systems and less valves when using chilled water.

Zoning keeps use of the fan motor to a minimum as the system only heats / cools the areas in use, rather than the entire floor space. The fan automatically slows/speeds up as required.

The fan motor speed control is based on duct pressure. The commissioning engineer will adjust the pressure setting requirement individually for fan only mode, heat mode and cool mode through twist pots on the control board at commissioning stage. This can be re-adjusted at any time in the future.

The duct pressure is converted to a signal to the digital display inverter (WEG), which in turn controls the fan motor speed to maintain the required pressure. The digital display makes commissioning and future adjustment easier.

For individual control, there is a 24v thermostat or BMS control in each room. There is also an air control damper in the relevant plenum duct branch (see dampers shown in yellow below).

Each thermostat or the BMS is connected to a zone control panel, usually located adjacent to the air handling unit.

The zone control panel opens/closes the required dampers. It also controls the run/heat/cool signals to the air handling unit and heat pump outdoor unit.

As a damper closes, the pressure in the plenum begins to rise. The fan speed is reduced to the point where it is maintaining the required constant pressure in the duct. This keeps energy use to a minimum by only using the air required.

The pipe sensors connected to the heat pump interface panel register a reduced delta T on the liquid/suction temperatures from the reduced air flow over the coil. They instruct the inverter outdoor unit to throttle back accordingly. Chilled water or LTHW applications do not require this.

When a valve opens, the duct pressure begins to fall and the fan speed is increased to maintain the required constant duct pressure. The required duct pressure is set by the engineer on the twist pots and as shown on the digital display of the inverter.

If there is a heat requirement from one thermostat and a cooling requirement from another thermostat at the same time, the system will switch between heat/cool and open/close the appropriate damper valves. Factory tests show a constant 4°C temperature difference maintained in to adjacent commercial offices with one set to heating and one set to cooling.

If the thermostat is set to fan “on” to circulate/purify air when neither heating nor cooling is required, all damper valves will open. The fan will run at the speed required to maintain the pressure requirement set by the commissioning engineer via the “fan” twist pot.

Damper valves can be adjusted to allow a small amount of air to bleed through, if required, into a room/zone even when the thermostat is satisfied.

Controls Options

The system works with a range of 24V controls and can also be connected to third party central control systems, including:

- Smart controls
 - Aprilaire with Wi-Fi capability
 - Google's NEST Learning Thermostat
 - The Ecobee
- Simple controls
- Building management systems (BMS)

Design Notes

- There is flexibility on zone design.
- The zone control panel is usually positioned on or near the AHU (only required for zoning).
- The system has a 24v control circuit.
- If higher temperature differences are needed, separate systems can be utilised to service a number of rooms. E.g. one system can service individual rooms on the warmer south side of the building, while rooms in the shaded north side could be serviced by another system. This still offers significant carbon footprint savings compared with individual fan coils.

Transformer

- When zoning an additional transformer is required, provided by The Ingenious Air® Company.
- Usually standardise 100va (see manufacturer's instructions).

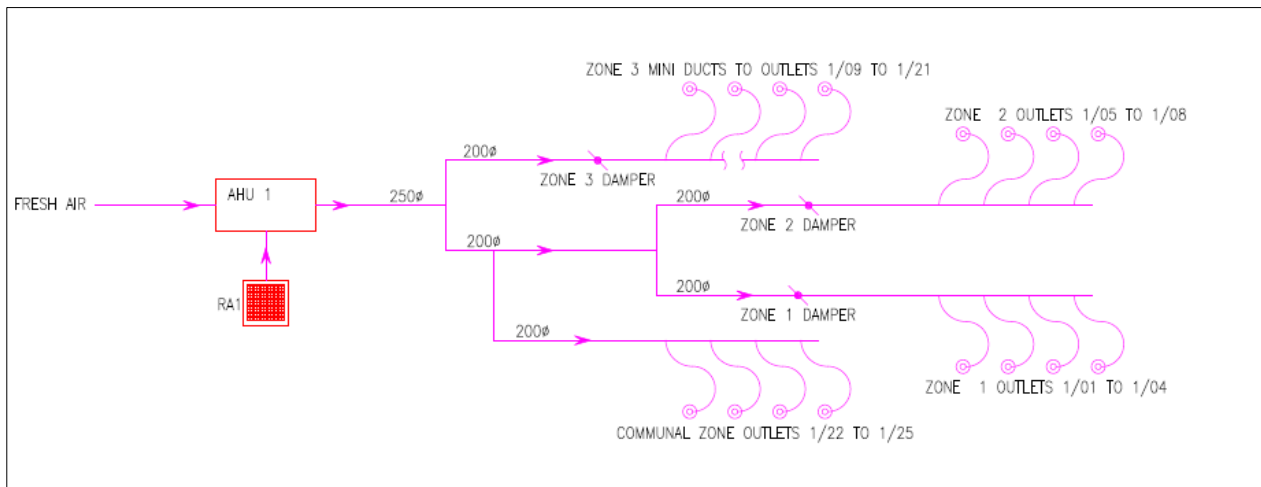
Zone Damper Valves

- Can be adjusted on site to allow for air bleed in the closed position.
- The factory setting allows approx. 8% of the airflow to bleed through. This can be easily adjusted using an adjustment screw under the motor cover lid.

Design Rules

- A maximum of 8 zones per system, with separate control, can be connected to each AHU.
- Ensure that air flow corresponds to the condensing unit manufacturer's minimum air flow requirements.

Sample Duct Schematic with Dampers for Zoned System:



Step 9 – Select Third Party Options

- Mechanical heat recovery ventilation
- Electric heater
- Fire stopping
- Heat pumps
- Water chiller
- Gas / oil fired / electric boiler
- Air to water or ground source heat pump
- Solar panels

Electric Heater

If required, a duct heater can be fitted either to the supply plenum duct or inside the AHU.

Design Rules

- For high outside air intake designs where refrigerant heat pumps are used, it is advisable to fit a pre-heater as per the requirements of the heat pump manufacturer.

Fire Stopping

Some areas require a Fire Stopping device to stop the spread of a fire and/or prevent the duct system from supplying oxygen to the fire.

A signal from a fire alarm can be used to stop the systems running via a connection on the PCB. Fire dampers will be used as per normal practice. Fire suppression collars can be used for the mini-duct.

– END OF DESIGN GUIDE –

Contact Details

Call **+44 1268 544530**

or email **info@ingenious-air.com**

To discuss how the system will benefit your project
or for your **FREE** Quotation



The Ingenious Air Company is a trading name of Hi-Velocity UK Ltd

The Ingenious Air Company, The Laindon Barn, Dunton Road, Laindon, Essex, SS15 4DB, UK.