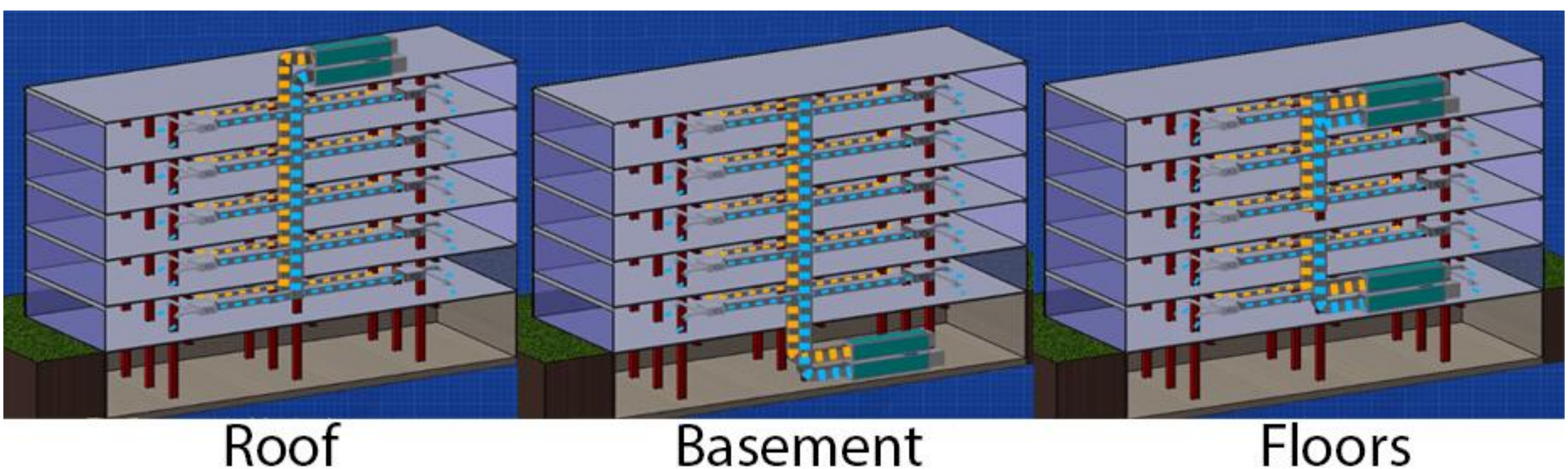
Materials and components of Air Handling Units (AHUs)

AHUs

What is an AHU?

It is a box which contains all the sub-systems which allow the air to enter in certain conditions (design conditions) inside of a building. Also to extract the polluted air and pull it out of the building.

Position of an AHU

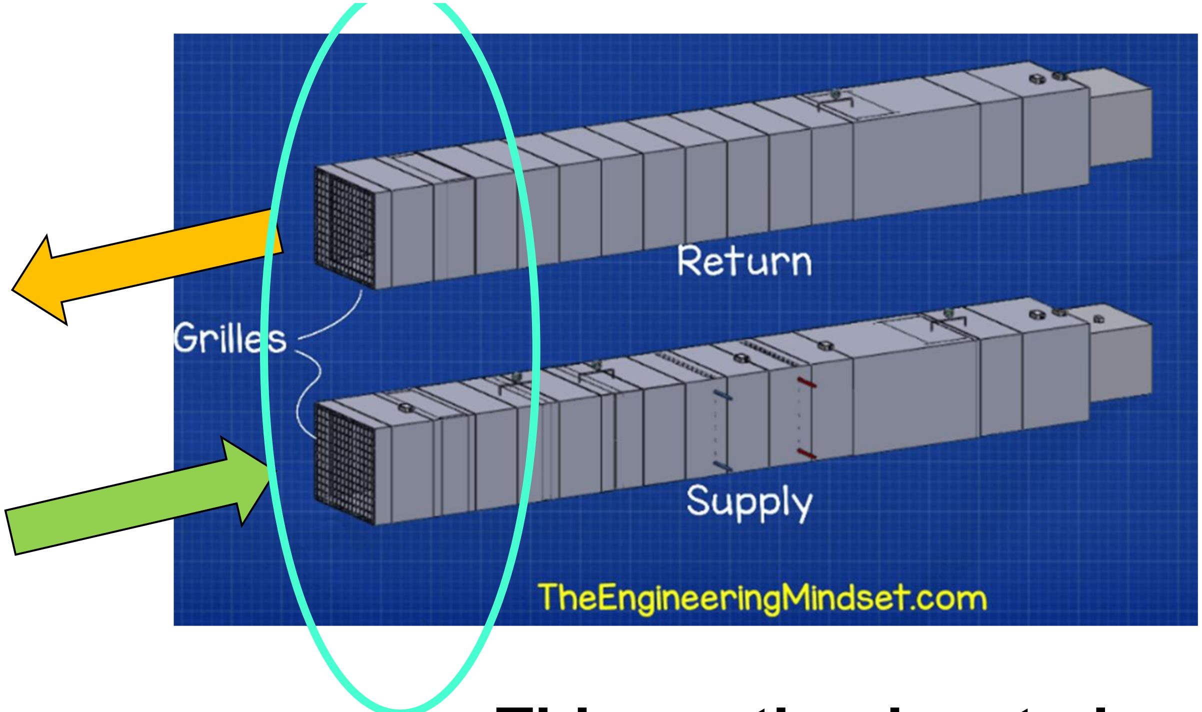


https://theengineeringmindset.com/air-handling-units-explained/

External sections and grilles:

Exhaust air

Fresh air

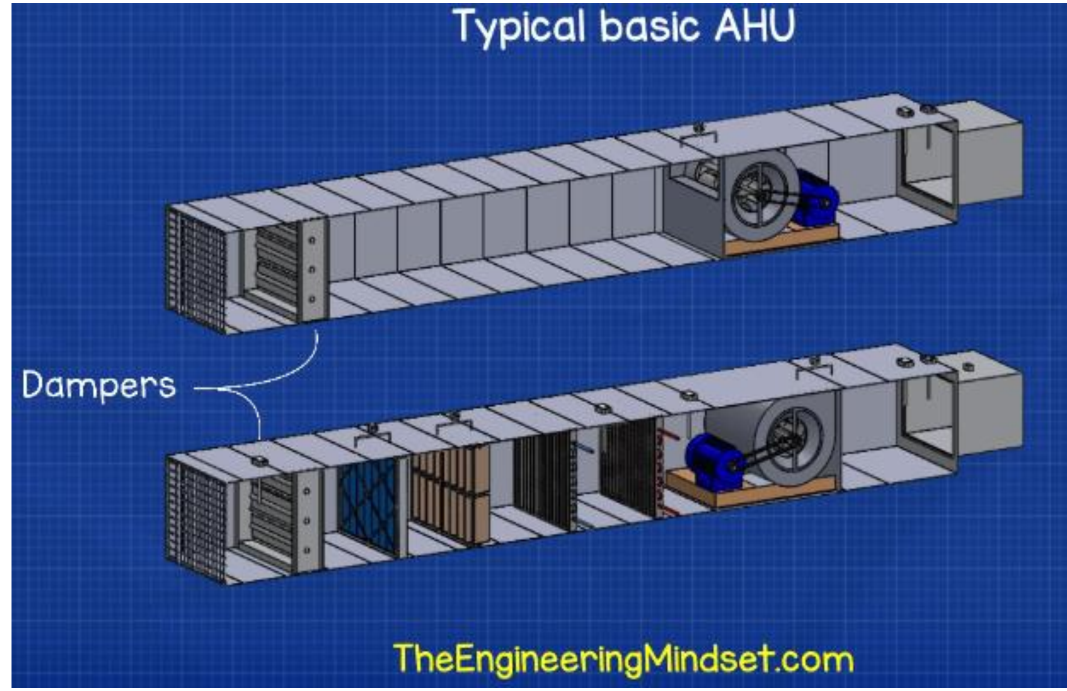


This section has to be outside

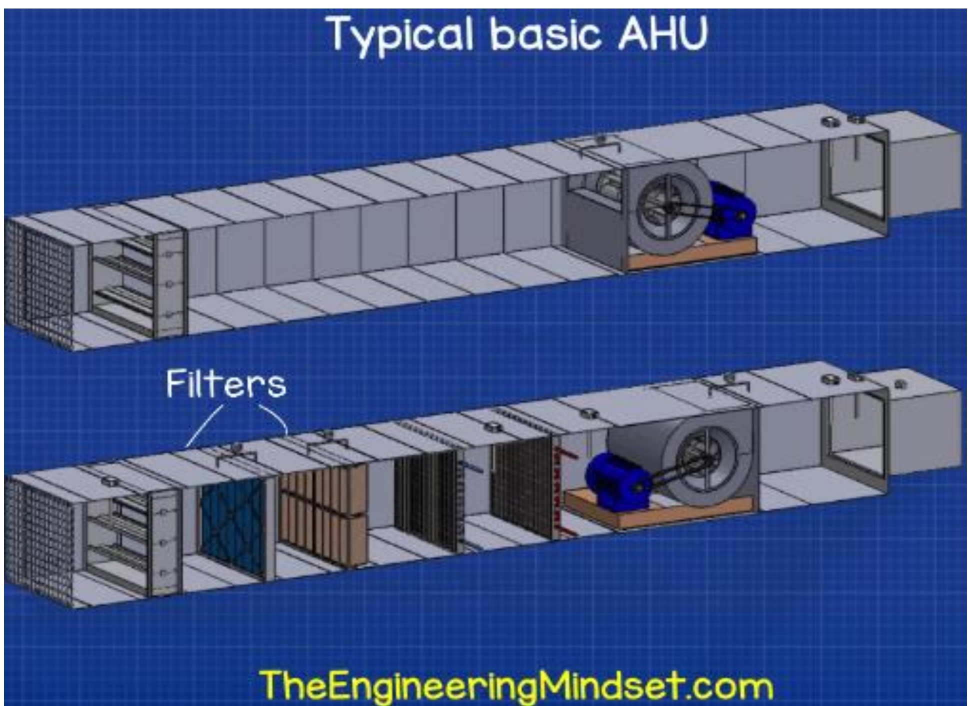
At the very front on the inlet and outlet of each housing we have a grille to prevent objects and wild life entering into the mechanical components inside the AHU

Dampers

The dampers are multiple sheets of metal which can rotate, controlling the amount of air entering



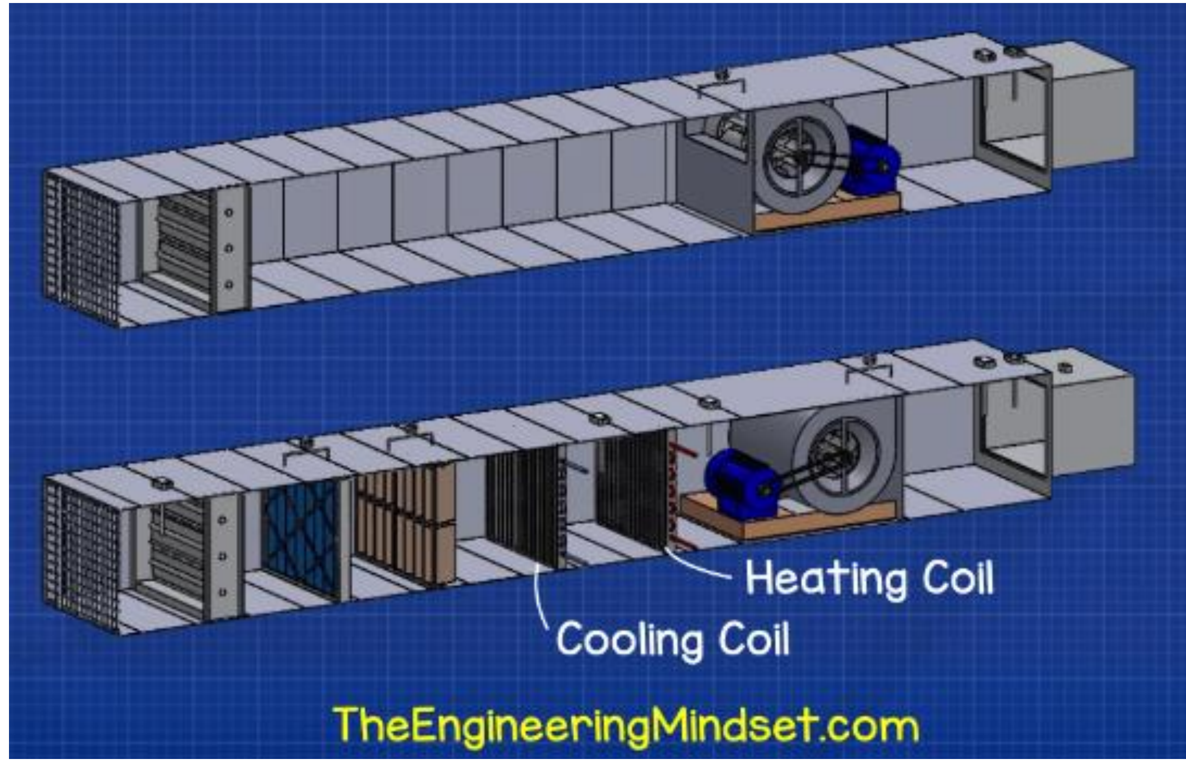
Filters



After the dampers there are some filters. These are there to try and catch all the dirt and dust etc.
from entering the AHU and the building. Typically, we have some panel filters or pre-filters to catch the largest dust particles. Then we have some bag filters to catch the smaller dust particles

Cooling coil and heating coil

The next thing we find are the cooling and heating coils. These are there to heat or cool the air. This needs to be at a designed temperature to keep the people inside the building comfortable. Inside a hot or cold fluid, usually heated or chilled water, refrigerant or steam.



Depending on the type of plant (full-air or air and water based solution) the coils have to heat, cool and dehumidify the air

Adiabatic humidifier

Source: Condair

Adiabatic/evaporative humidification systems which use mechanical energy to generate water particles and/or evaporate water to/from media

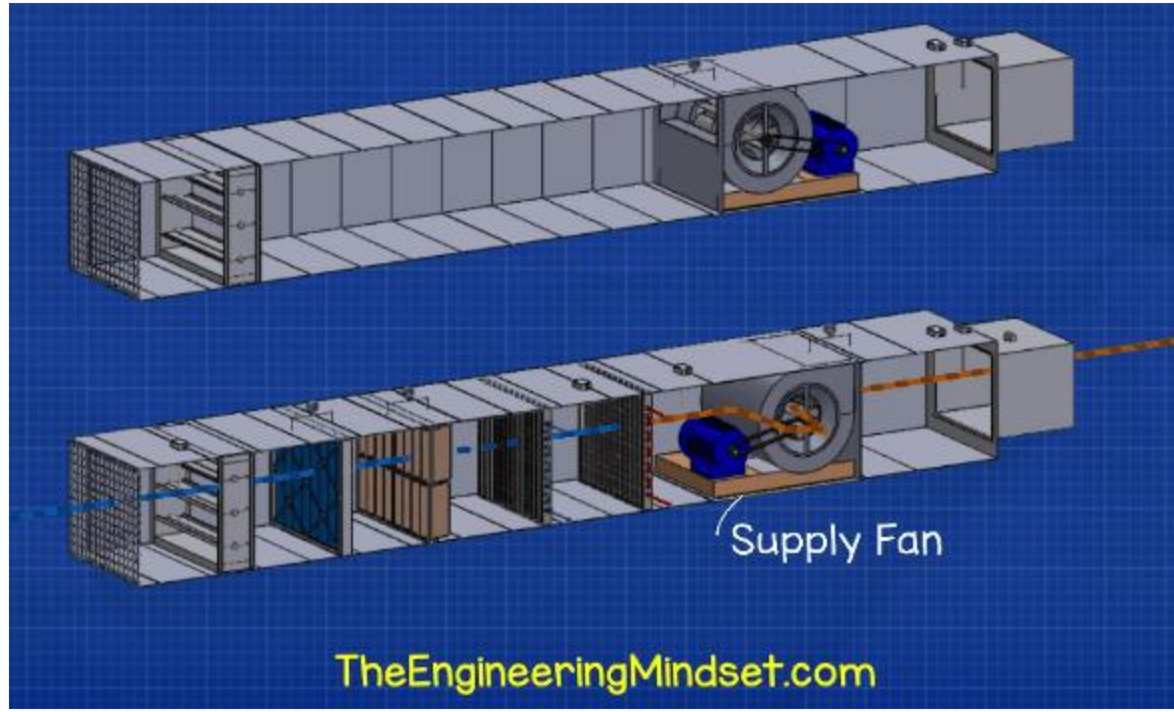
Isothermal humidifier

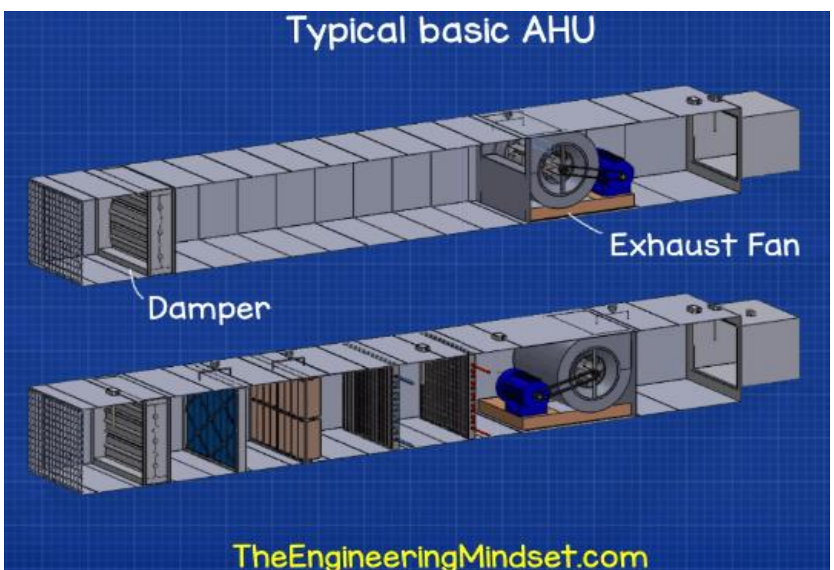
Source: Carel

Isothermal/steam humidification systems which use electricity or fuel as an external heat source to change water to steam.

Supply Fan

This is going to pull the air in from outside and then through the dampers, filters and coils and then push this out into the ductwork around the building. Centrifugal fans are very common in old and existing AHU's but EC fans are now being installed and also retrofitted for increased energy efficiency.

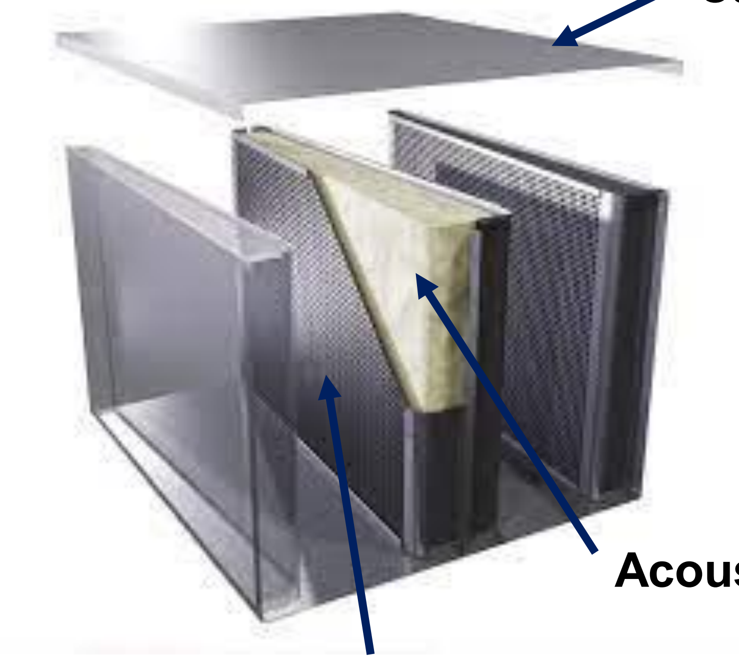




Exhaust Fan

The return AHU in its simplest form has just a fan and damper inside. The fan is pulling the air in from around the building and then pushing it out of the building.

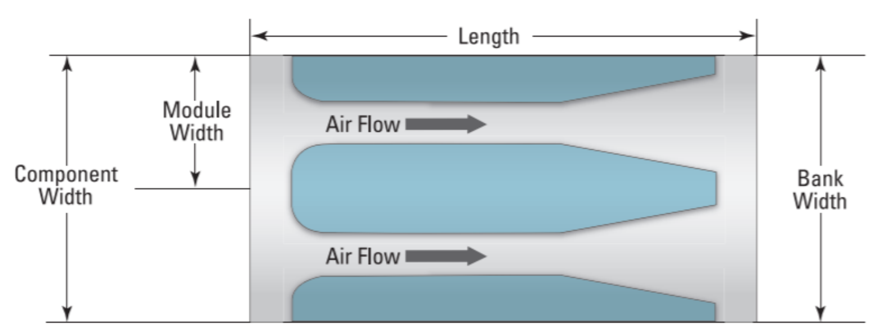
Rectangular silencers



Circular silencers

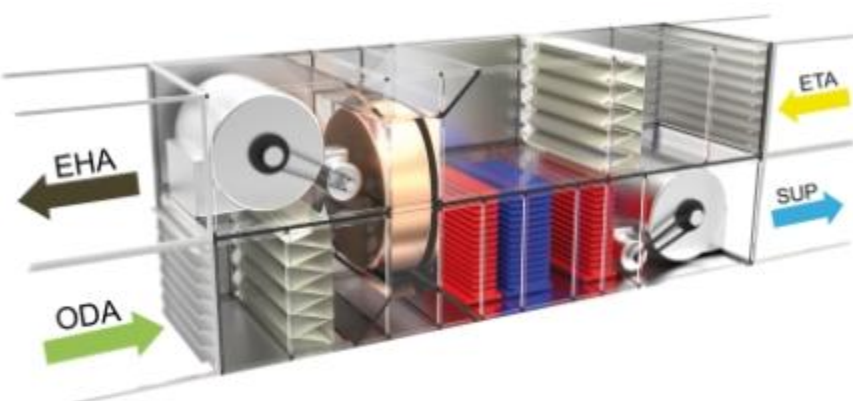
Source: Price Industries

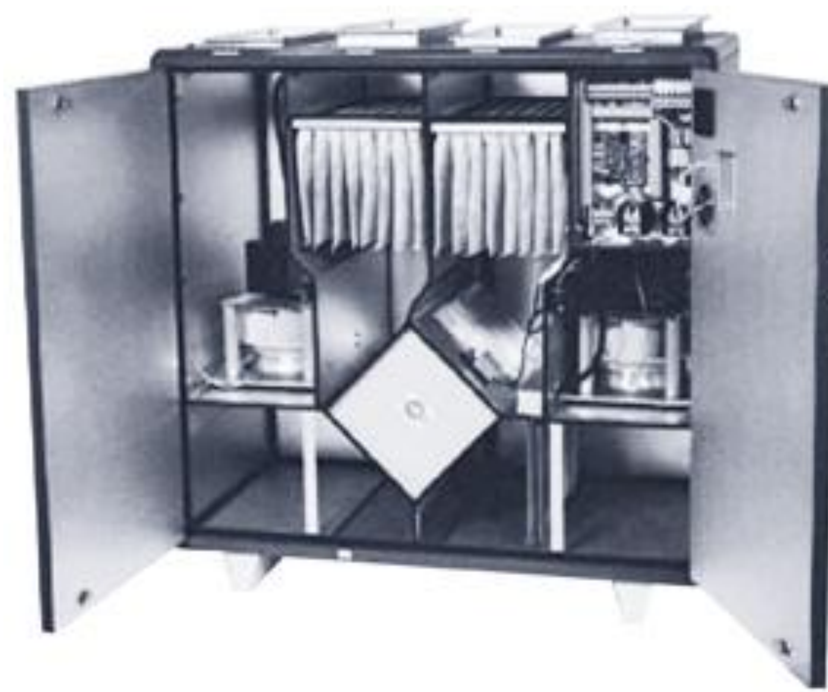
Multiple Module, Single Component Silencer



A very common configuration uses a duct sit in between the exhaust and the fresh air intake. This allows some of the exhaust air to be recirculated back into the fresh air intake, to offset the heating or cooling demand. This may be done when the required air flow rate in the building is high compared to the fresh air.

Possible AHU configurations





Technical figures for a heating/cooling coil:

BATTERIE DI RISCALDAMENTO AD ACQUA

Tubi in rame, alette in alluminio, 2 ranghi, passo alette non inferiore a 2 mm.
Attacchi filettati Gas. Telaio in lamiera zincata.
Flangia da 30 mm su entrambe le facce per il collegamento ai canali.
Condizioni nominali: aria entrante +5 °C - acqua 80-70 °C

MODELLO	PORTATA m3/h	POTENZA Kw	H x L mm	DP aria Pa	Peso Kg
BAAC 1319	1200	8,9	300 x 500	15	8
BAAC30	1800	13,0	360 x 600	16	10
BAAC41	2600	17,3	420 x 600	24	12
BAAC36	3600	27,6	480 x 700	41	13
BAAC50	5000	41,8	540 x 800	56	15

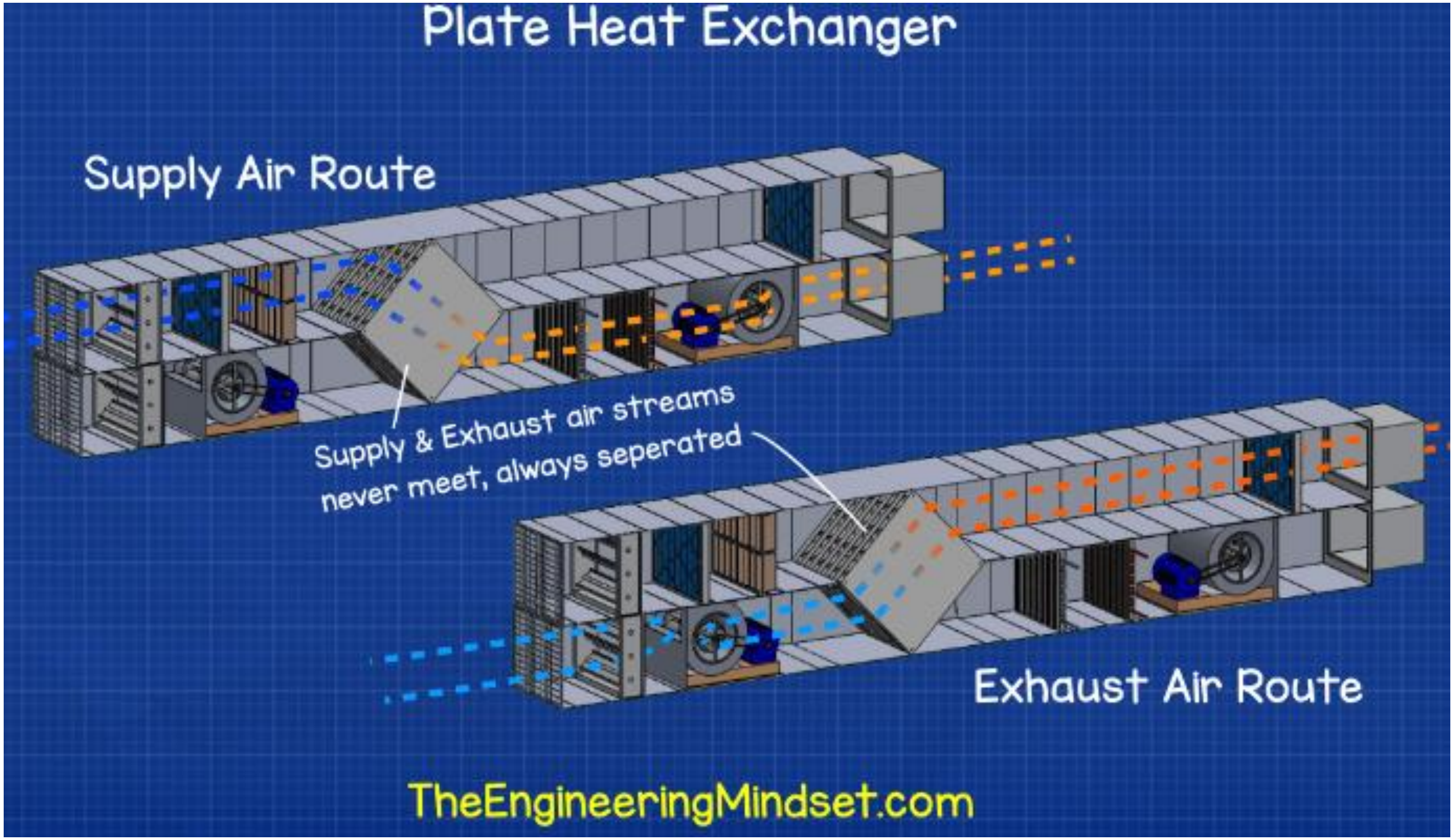
BATTERIE DI RAFFREDDAMENTO AD ACQUA

Tubi in rame diametro 6 mm, alette in alluminio, 6 ranghi, passo alette non inferiore a 2,5 mm. Attacchi filettati Gas. Telaio in lamiera zincata. Flangia da 30 mm su entrambe le facce per il collegamento ai canali. Condizioni nominali: aria entrante 32 °C - 50% U.R. Acqua 7 - 12 °C

MODELLO	PORTATA m3/h	POTENZA Kw	H x L mm	DP aria Pa	Peso Kg
BAAF12	1200	12,7	300 x 500	110	16
BAAF18	1800	17,5	360 x 600	115	20
BAAF26	2600	23,6	420 x 600	160	22
BAAF36	3600	33,2	480 x 700	170	27
BAAF50	5000	47,6	540 x 800	190	32

Heat recovery units

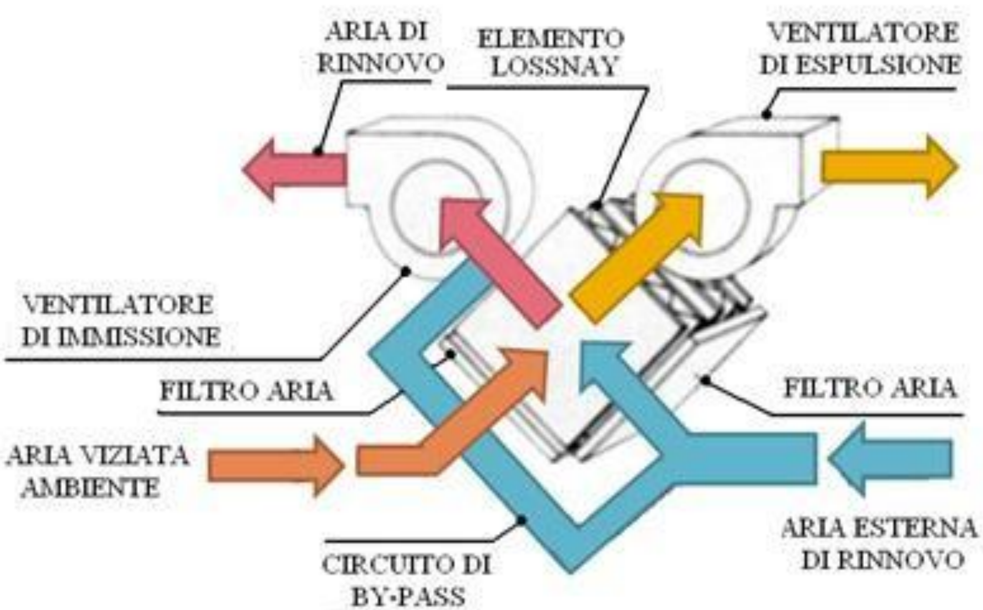
Plate heat exchanger

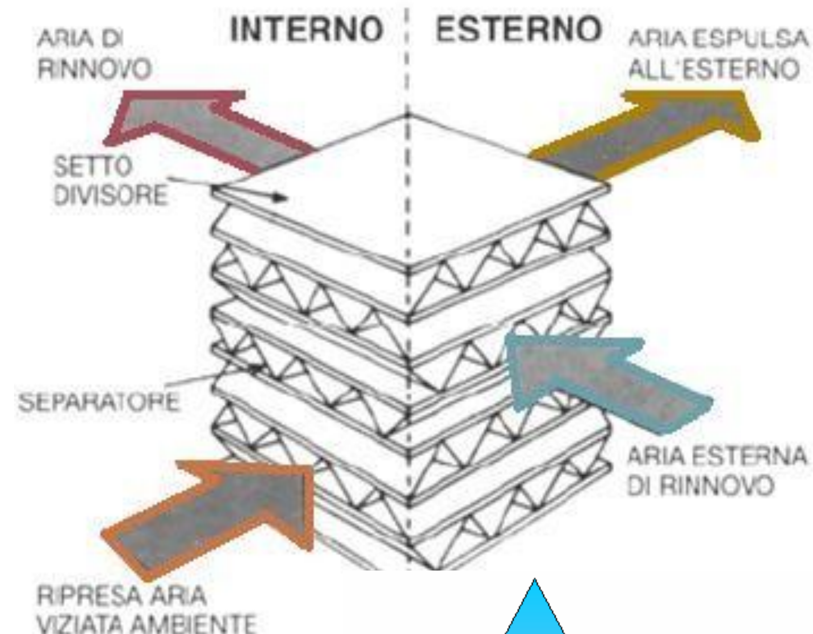


The most common and widely used system (efficiency around 50%)

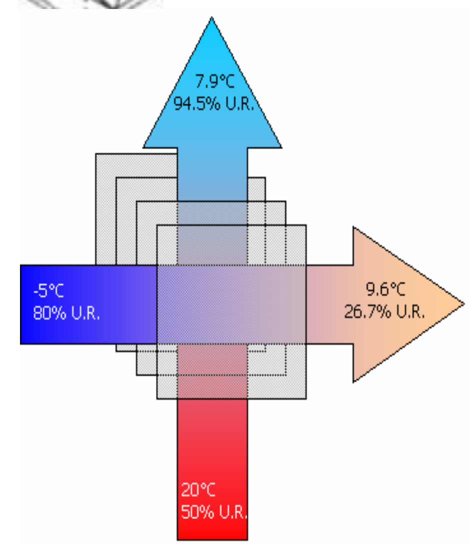
Heat recovery unit

Through heat exchangers it is possible to recover part of the thermal energy of the outgoing exhaust air flow (stale air) in favour of the incoming fresh air flow, which is preheated without additional energy costs.





Inside the recuperators the outgoing and incoming air flows cross each other (without mixing), so that the hot air flow cools down while the other one heats up.



Heat recovery unit

Heat recuperators used in air conditioning systems are exchangers that allow the transfer of heat and/or humidity between a flow of exhaust air and a flow of supply air, under the action of a difference in temperature (or humidity).

A distinction is made between heat recuperators and heat recovery units; the latter are made up of, in addition to the recuperator itself, a series of accessories such as filters, pre-heating devices, dampers, regulation equipment, assembled in a box with flanges for connection to the ducts.

Heat recovery unit: efficiency

The efficiency of a heat exchanger, according to ASHRAE Standard 84, is defined as the ratio of the energy or moisture actually transmitted to the maximum transmissible values

$$\varepsilon = W_i (X_{iu}-X_{ii}) / W_{min} (X_{ei}-X_{ii}) = W_e (X_{ei}-X_{eu}) / W_{min} (X_{ei}-X_{ii})$$

where:

ε = efficiency (sensible, latent ot total)

X_{ii} = supply inlet temperature or humidity or entalpy

X_{iu} = supply outlet temperature or humidity or entalpy

X_{ei} = exit inlet temperature or humidity or entalpy

X_{eu} = exit outlet temperature or humidity or entalpy

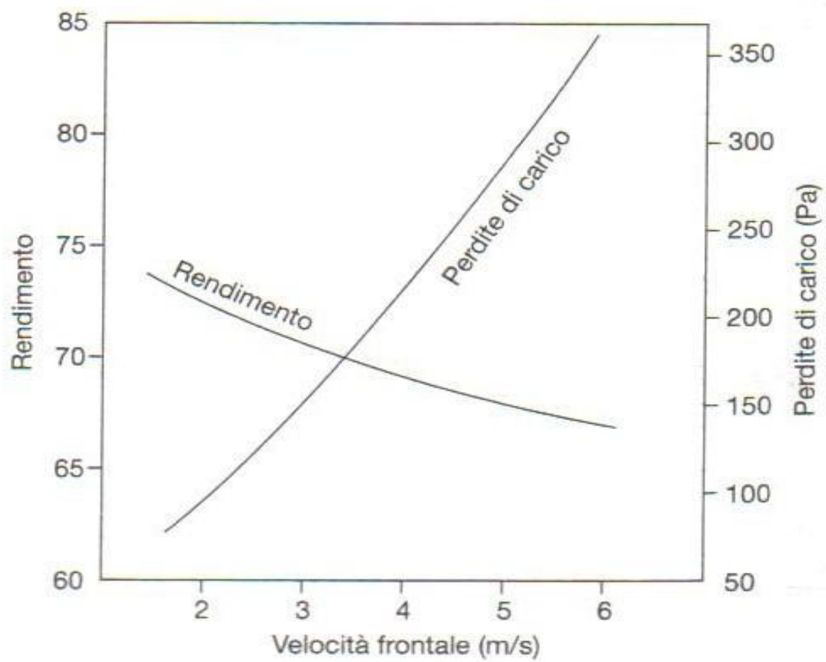
W_i = supply flow rate

W_e = exit flow rate

W_{min} = the lesser of W_i and W_e

In the case of temperature efficiency, the flow rates should be multiplied by the specific heat of the dry air.

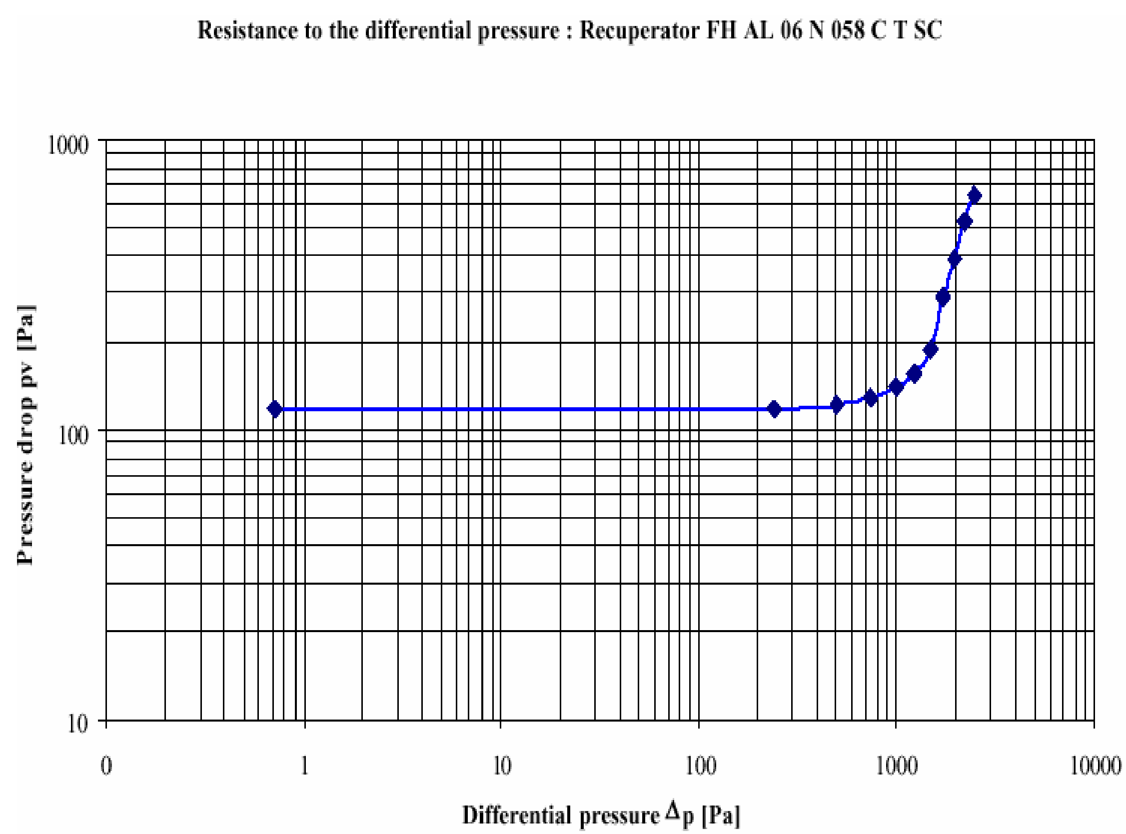
Heat recovery unit: pressure loss



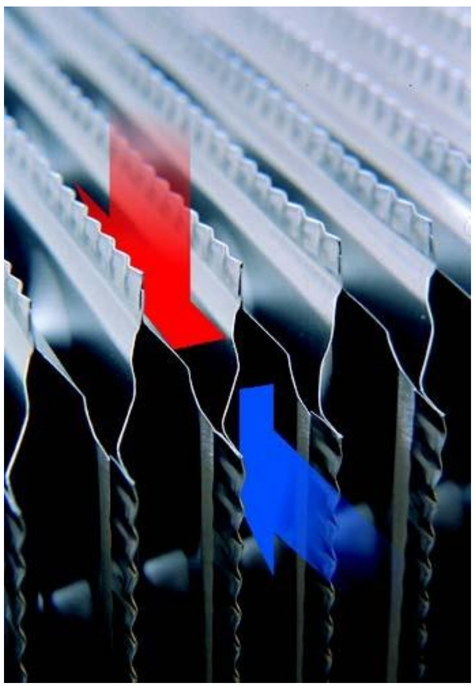
The pressure drop of a recuperator is defined as the total pressure difference, measured on each of the two flows, between the inlet and the outlet of the recuperator. This pressure drop must be compensated for the head of the fan.

Heat recovery unit: differential pressure

The two flows crossing the recuperator can have a different pressure. This pressure difference (differential pressure) affects the flow rate leakage from the unit. In addition, the mechanical structure of the unit must be adequate to resist the deformation generated by the differential pressure.



Static plate heat exchangers



They are made up of flat layers, with variable spacing depending on the type of use. The exhaust and inlet flows are kept separate by special seals. The heat is transferred directly from the flow at warmer temperature to the one at colder temperature.

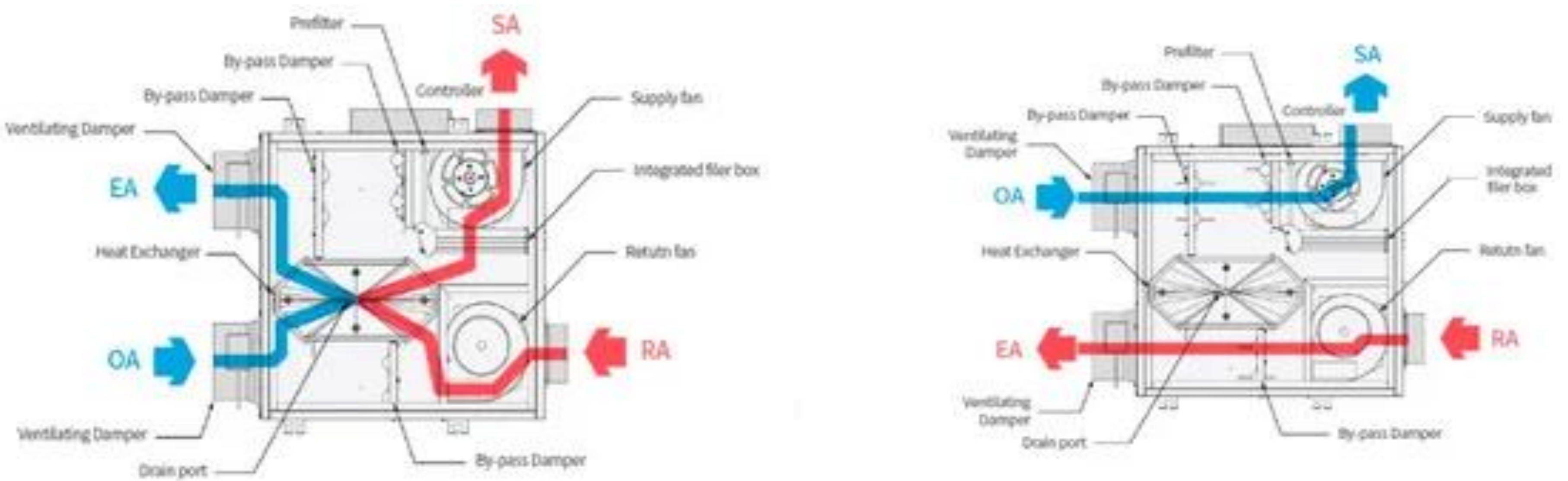
The overall resistance to heat transfer of the recuperator is composed of convection on both faces of the plate and conduction through the thickness of the plate.

Static plate heat exchangers

The material from which plates are commonly made is aluminum because of its corrosion resistance, ease of fabrication, flammability and durability.
In more corrosive environments, aluminum can be protected with an acrylic paint. In the presence of high temperatures (over 200°C) and where cost is not a key factor, stainless steel alloys are used.
For low cost requirements combined with corrosion resistance, plastic or even glass materials are used.

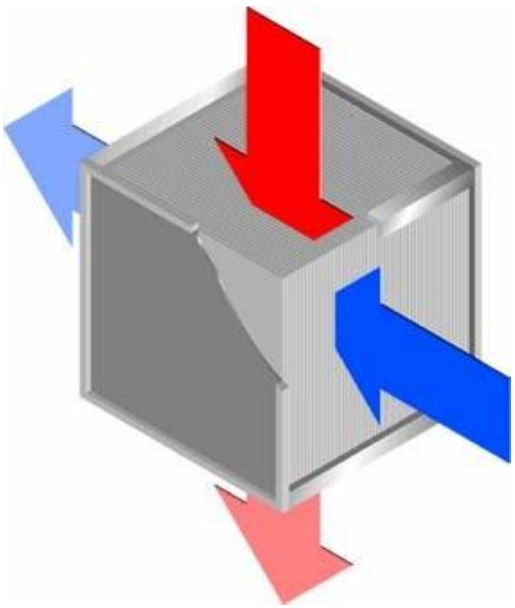
Heat recovery unit: control

Under certain conditions, overheating may occur, due to internal gains.
In these conditions the power of the recuperator must be reduced.
A bypass damper is used to exclude a part or all of the external air to go through the recuperator.
This method of reducing the flow rate, by means of the bypass damper, is also used when there is a risk of frost in the winter period.



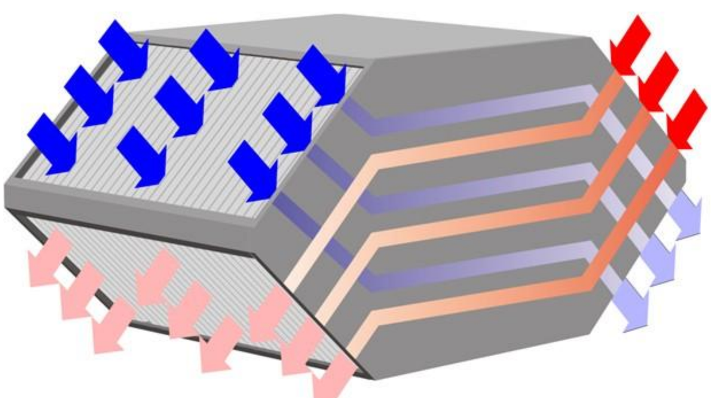
(a) (b)

Static plate heat exchangers



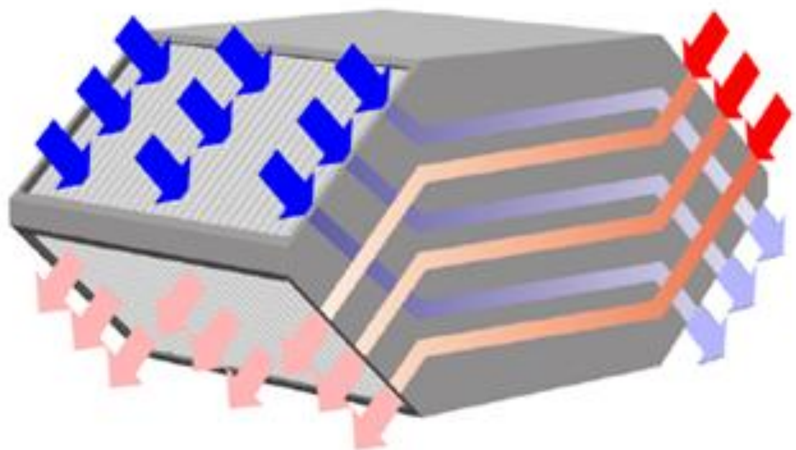
They have the possibility of recovering both sensible and latent heat.

In fact, when the walls of the exchanger are colder than the dew temperature of the extracted air, the steam contained in it condenses and the condensation heat is transferred to the fresh air. In case of condensation it is advisable that the fins are arranged vertically.



Normally the air movement is cross-flow and the efficiency has values between 40 and 70%.
Counterflow models are also available with efficiencies of over 80%, but with a higher unit cost.

Counter-flow plate heat exchanger



- High efficiency (nominally up to 93%)
- Solution for small and medium air volumes (residential or commercial applications)
- It could be made of plastic or aluminium

Static plate heat exchangers

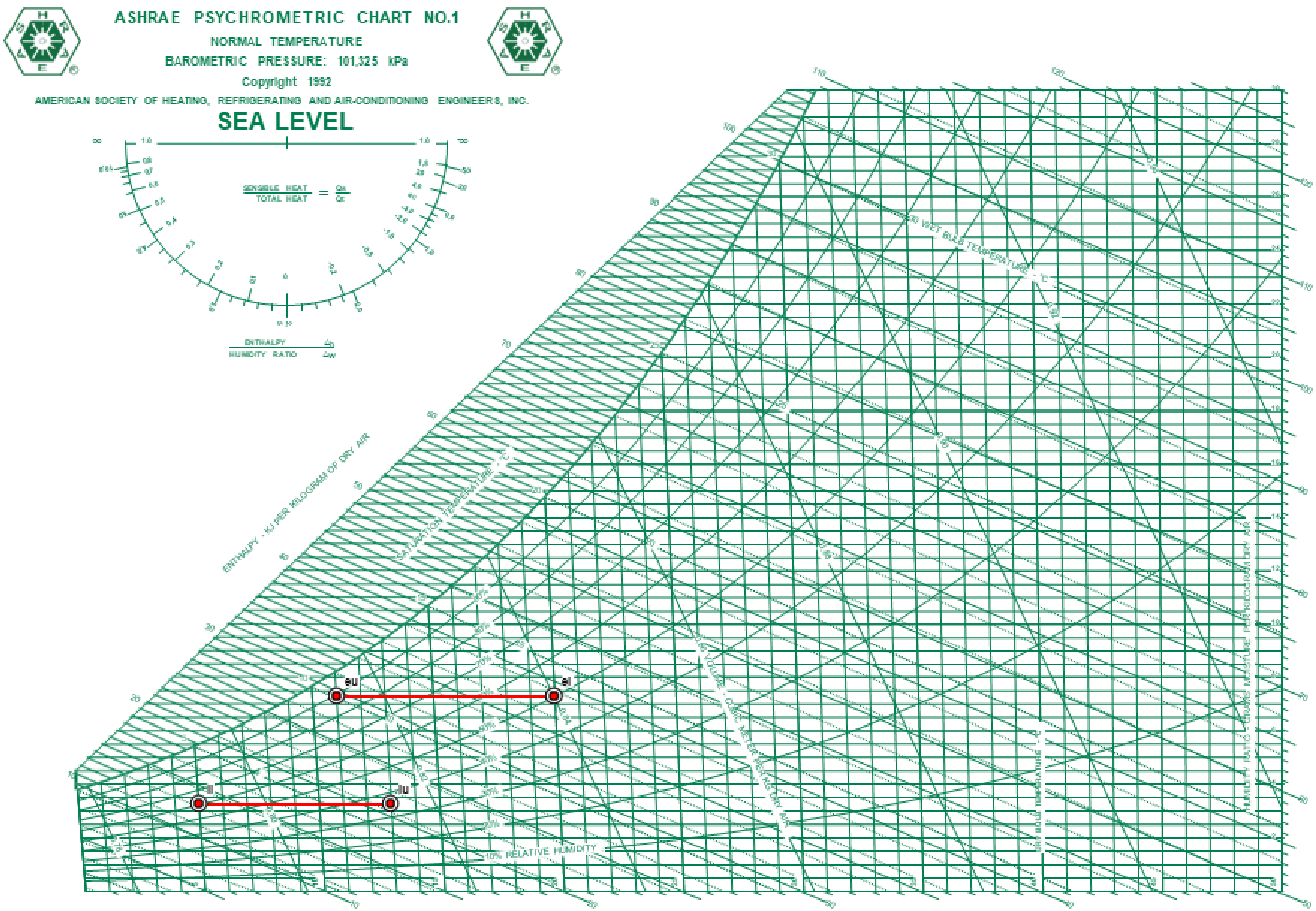
Pros

- little or no contamination between streams
- no moving parts
- flexibility of construction with different materials suitable for any characteristic of different environments
- low pressure drops
- easy cleaning
- effective noise dampening action

Cons

- The latent heat transfer occurs only on condition that the surface temperature of the recuperator falls below the dew point of one of the two air streams, condensing the actual humidity.
- The two air flows, exhaust and fresh air, must be contiguous.

Example



ASHRAE PSYCHROMETRIC CHART NO.1
NORMAL TEMPERATURE
BAROMETRIC PRESSURE: 101.325 kPa
Copyright 1992
AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR-CONDITIONING ENGINEERS, INC.
SEA LEVEL
SENSIBLE HEAT / TOTAL HEAT = Qs / Qt
ENTHALPY / HUMIDITY RATIO = Δh / ΔW
ENTHALPY - KJ PER KILOGRAM OF DRY AIR
SATURATION TEMPERATURE - °C
10% RELATIVE HUMIDITY
eu
el
ll
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Example

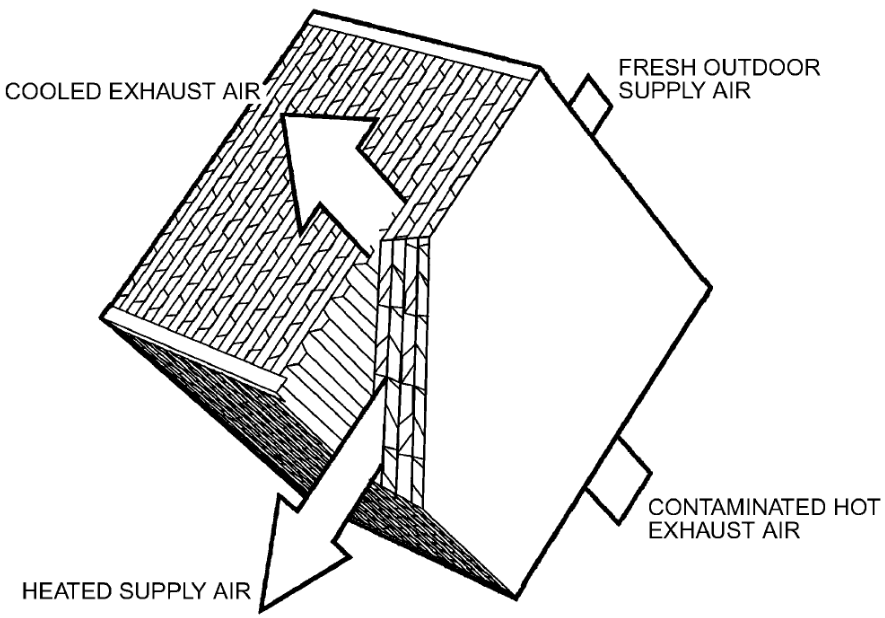


Fig. 2 Fixed-Plate Cross-Flow Heat Exchanger

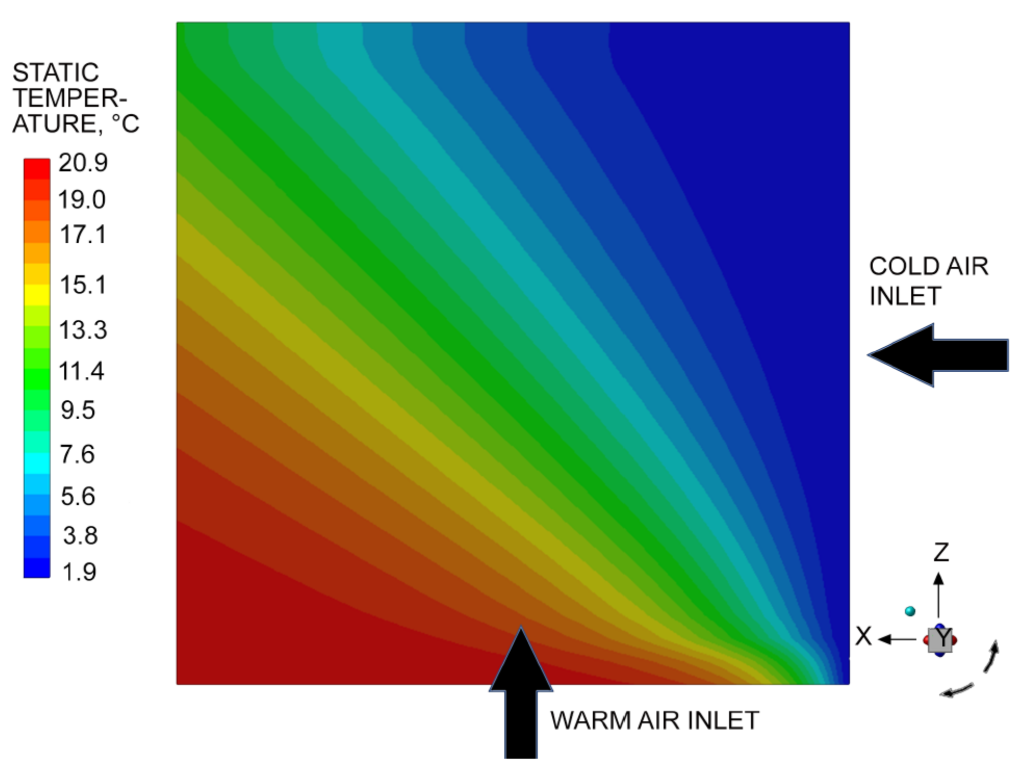
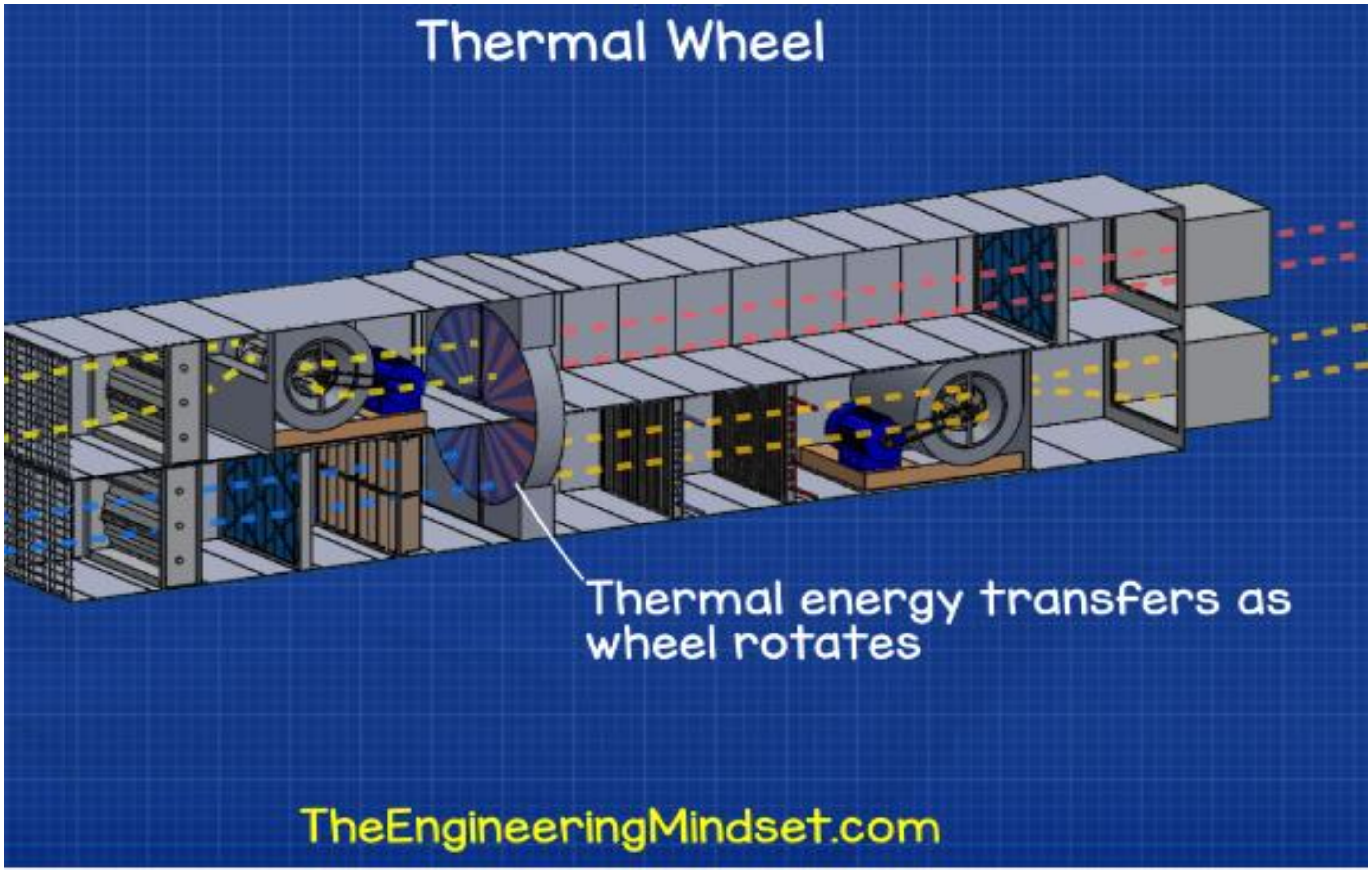
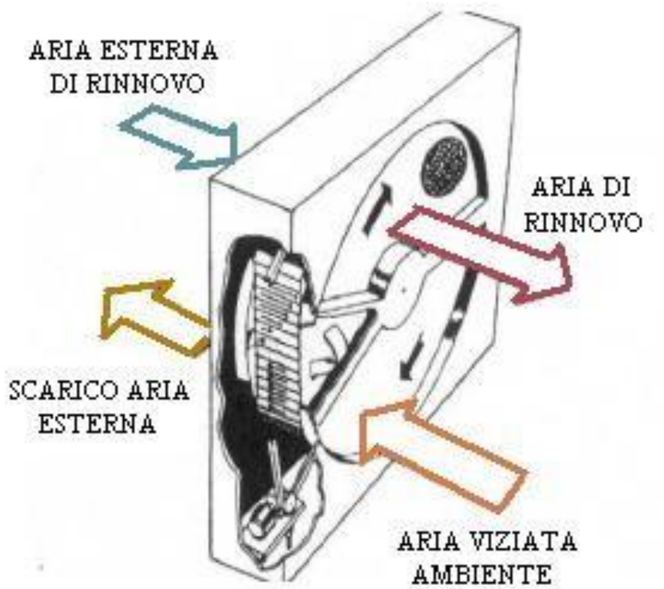


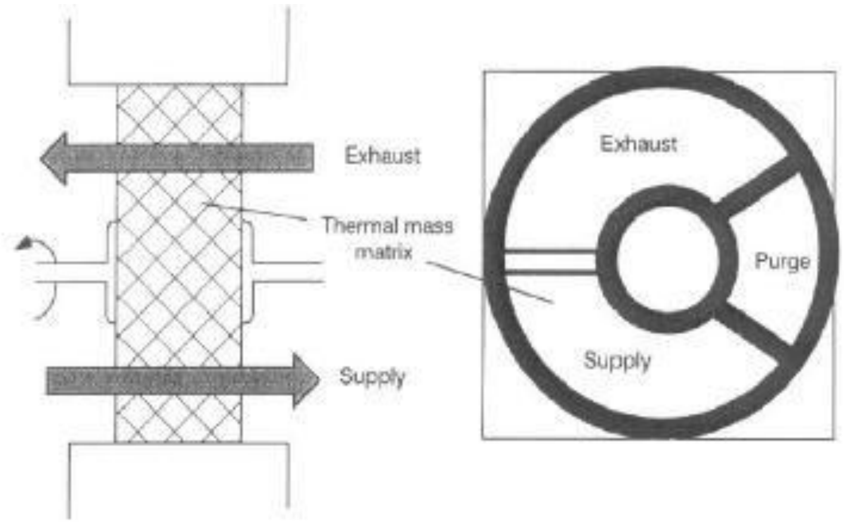
Fig. 4 Typical Temperature Stratification at Outlets of Cross-Flow Heat Exchanger

Thermal wheel



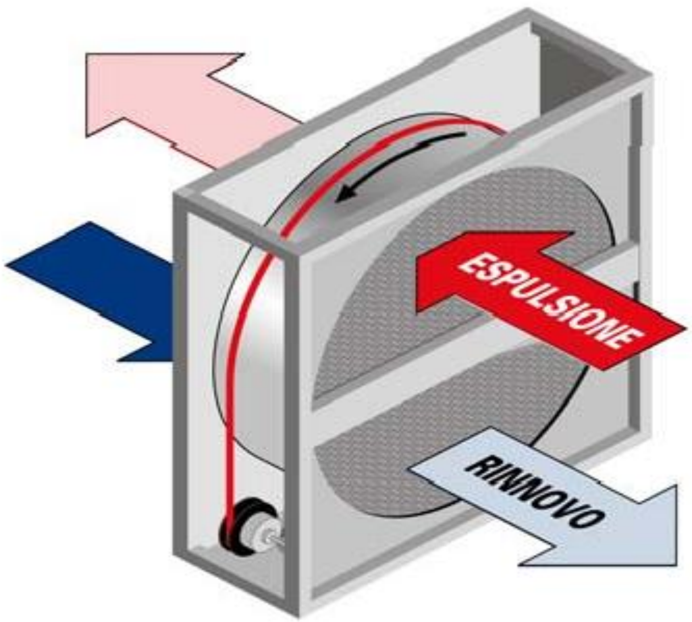
Heat recovery wheel





The heat recovery wheel consists of a cylindrical rotor built in such a way as to be permeable to air, characterized by a very high heat exchange area; the fresh air and the exhaust air each cross one half of the heat exchanger, flowing in countercurrent.

Heat recovery wheel

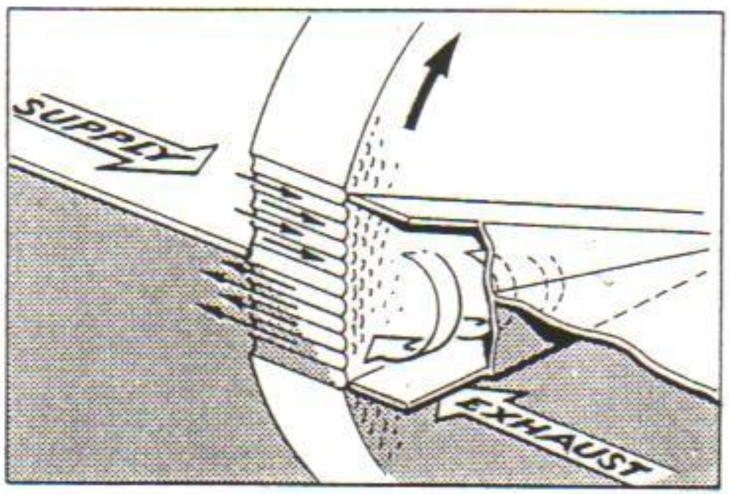


The heat exchange in these recuperators is by storage: while the cylinder rotates slowly, the exhaust air crosses one half of the casing and releases heat to the rotor matrix that accumulates it. The fresh air, which crosses the other half, absorbs the accumulated heat.

As the rotation continues, the heat-absorbing and heat-delivering parts are continuously reversed, and the process can continue indefinitely.

In summertime it is the outside air that is cooled and dehumidified; in wintertime the incoming air, cold and dry, absorbs heat from the rotor and, if necessary, humidity, in appliances with hygroscopic surfaces..

Heat recovery wheel



There is the possibility of contamination between the two airstreams by entrainment.

Air that is trapped inside the ducts is transferred to the other flow due to rotation. To eliminate this, the recuperator is equipped with a cleaning sector.

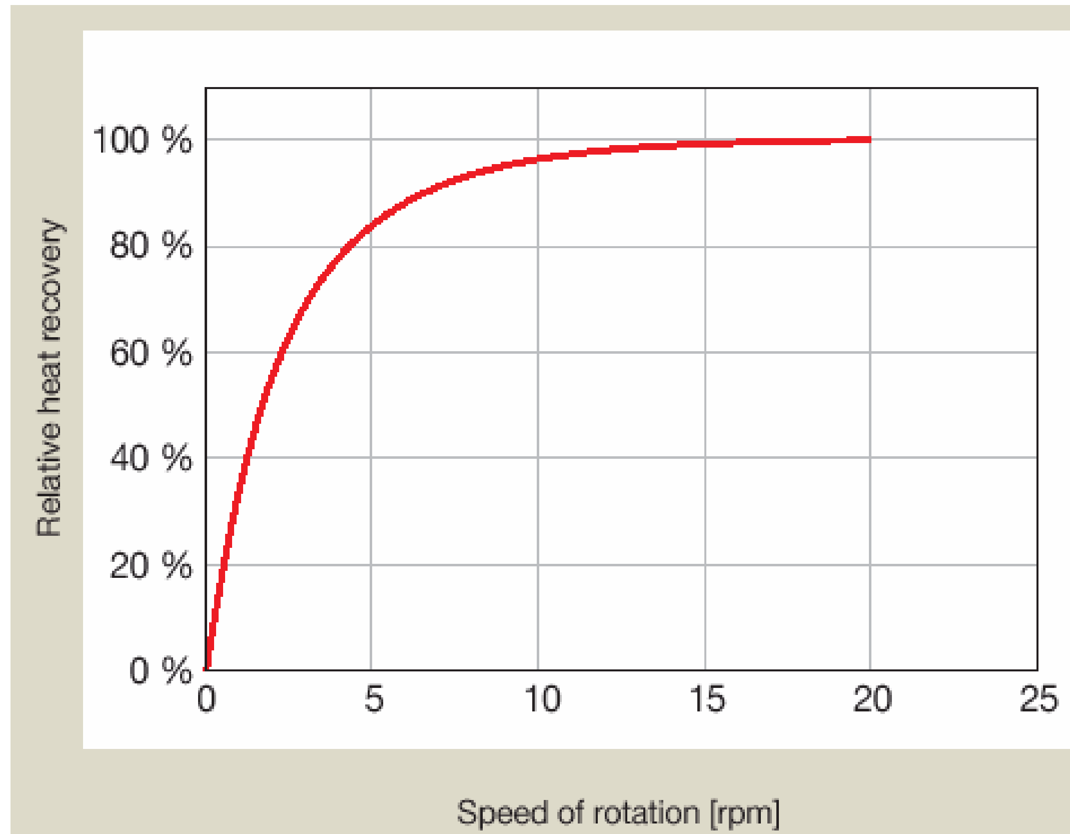
The cleaning sector is located downstream of the rotor, at the point where the rotor passes from the expulsion side to the inlet side.
In this way, a small amount of the supply air will be transferred into the exhaust air ducts allowing it to be cleaned.

Heat recovery wheel

In order to exclude overheating, especially in the intermediate seasons (spring and autumn), a control on the delivery temperature is carried out, according to the needs of the plant, by means of a regulation of the rotation speed.

A variable speed drive motor is used and it is therefore possible to modulate the efficiency between a minimum and a maximum value.

The amount of heat recovered increases as the speed of rotation increases. Usually, therefore, the rotation speed of the recuperator is enslaved to the required temperature.

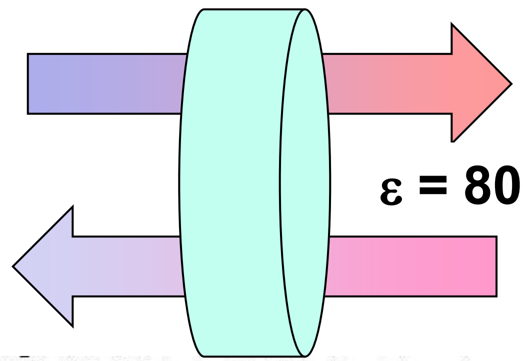


Enthalpy wheel: Winter operation

Outdoor →

0°C / 50%
4 kJ/kg / 1.8 g_v/kg

1°C / 65%
11 kJ/kg / 3 g_v/kg

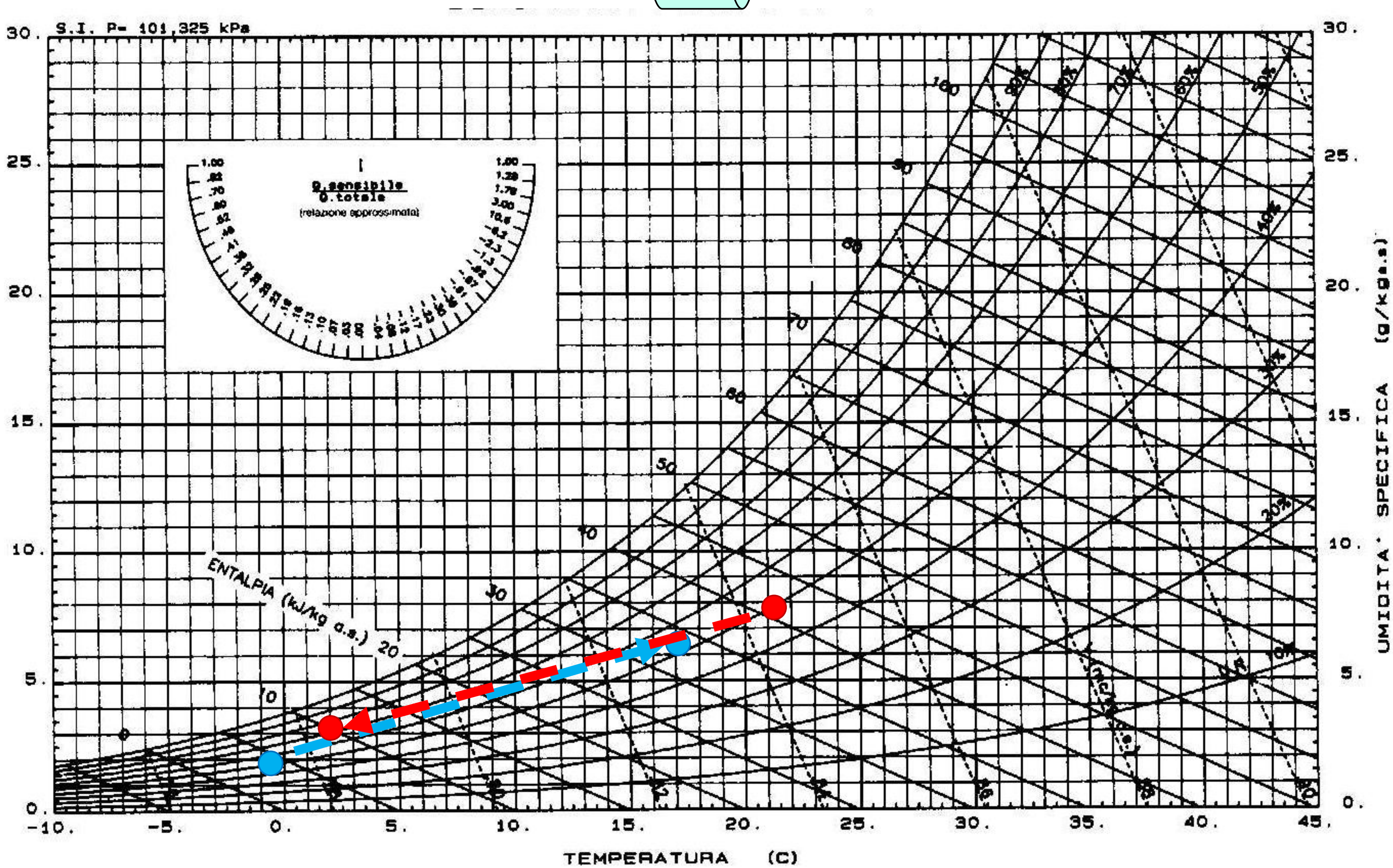


ε = 80%

17°C / 50%
33.5 kJ/kg / 6.5 g_v/kg

21°C / 50%
41 kJ/kg / 7.7 g_v/kg

← **Indoor**

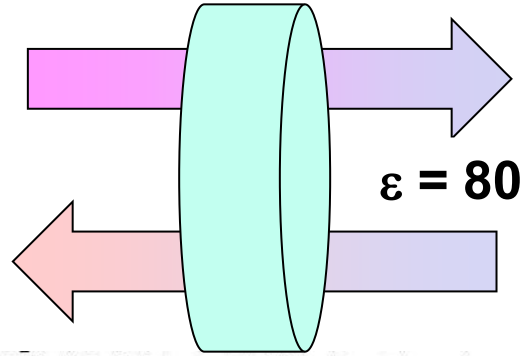


Enthalpy wheel: Summer operation

Outdoor

32°C / 65%
81 kJ/kg / 19 g_v/kg

30°C / 65%
75 kJ/kg / 17.5 g_v/kg

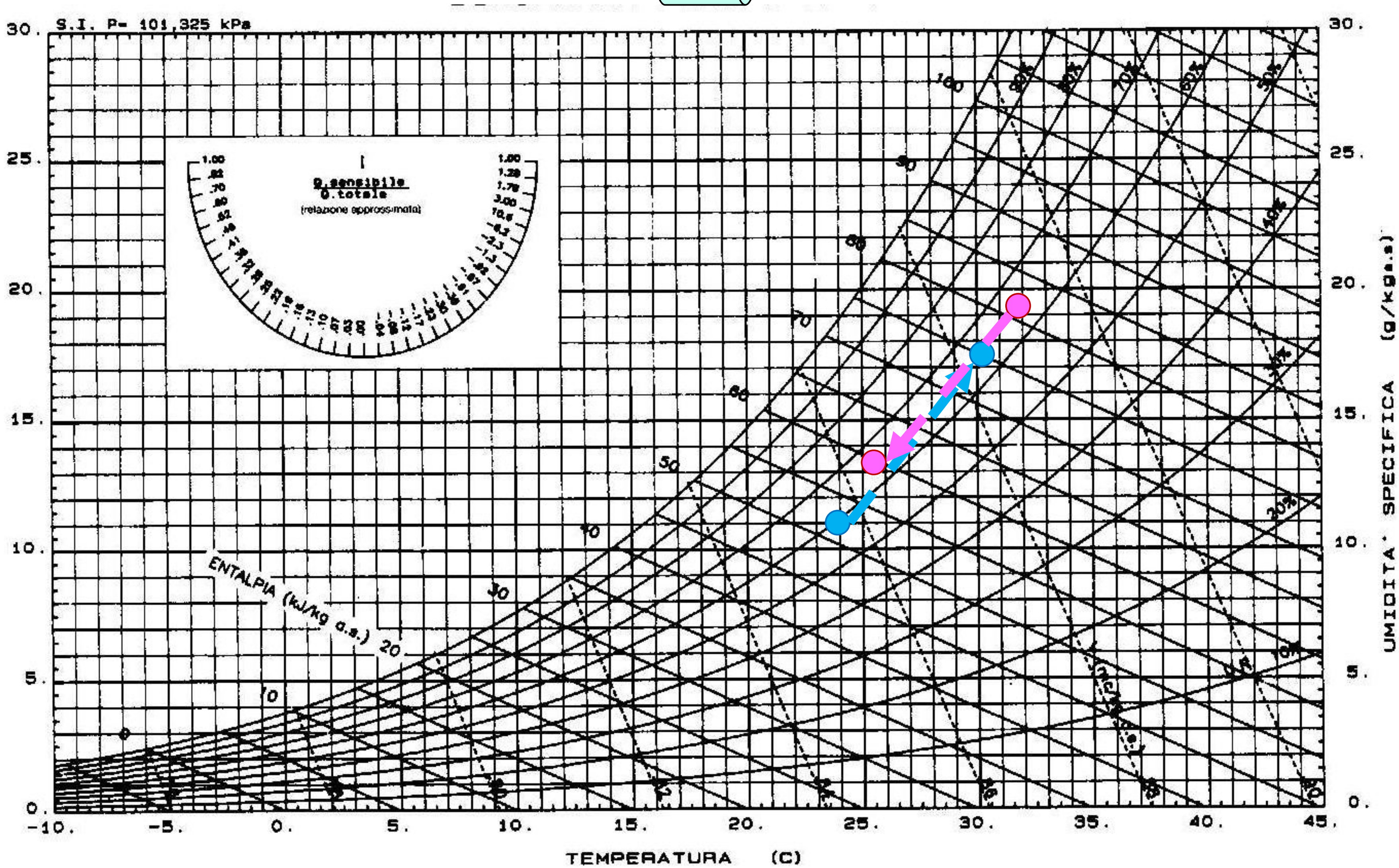


ε = 80%

25.5°C / 65%
58 kJ/kg / 13 g_v/kg

24°C / 60%
53 kJ/kg / 11 g_v/kg

Indoor



Heat recovery wheel

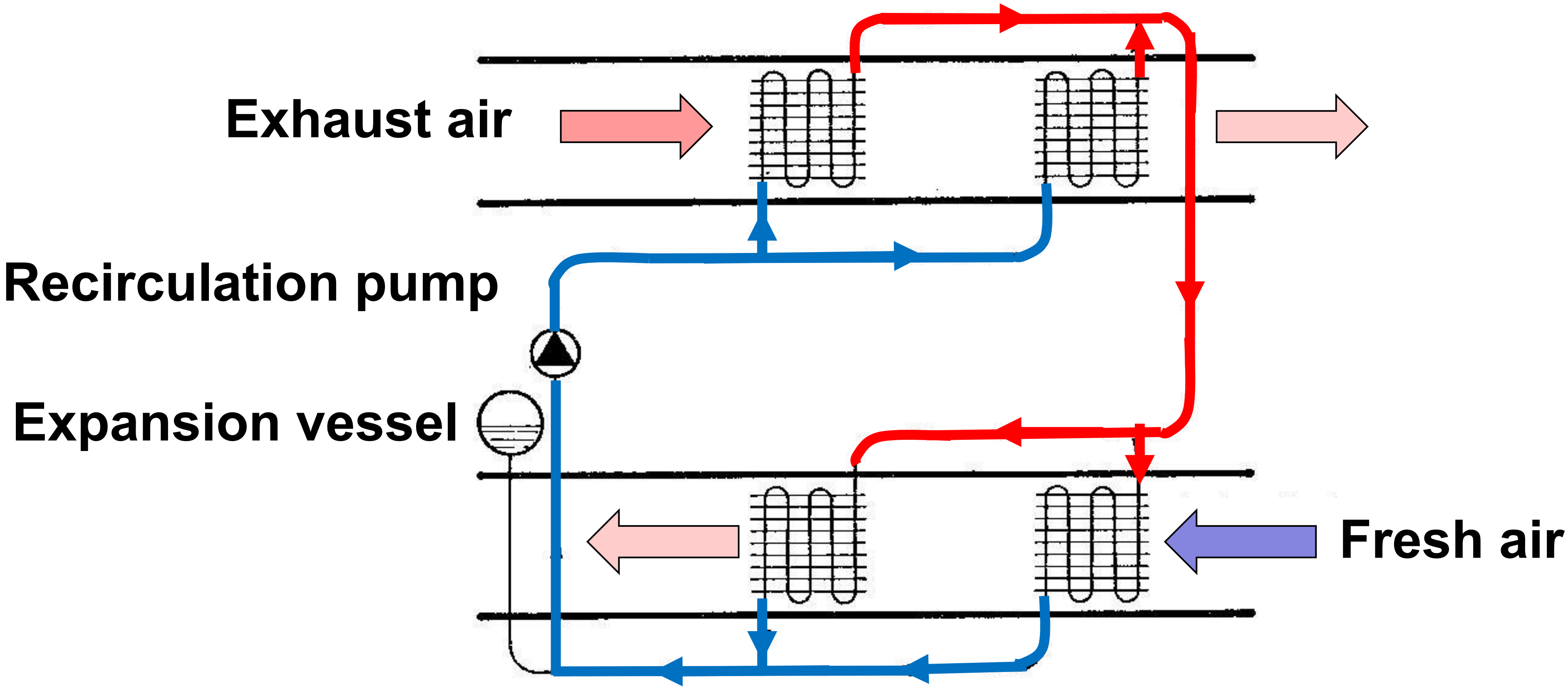
Pros

- The exchange surface, very high in relation to the volume, allows higher yields than other types of recuperators.
- The high efficiency and the possibility of recovering humidity as well as heat make it possible to significantly reduce the installed capacity of a system.
- The possibility of recovering humidity makes it possible to reduce humidification devices.

Cons

- Contamination between the two flows by entrainment and leakage
- In entrainment, air trapped inside the volume can be transferred to the other flow.
- Critical applications, such as hospitals, operating rooms and clean rooms require strict control of entrainment flows to prevent any risk of contamination.

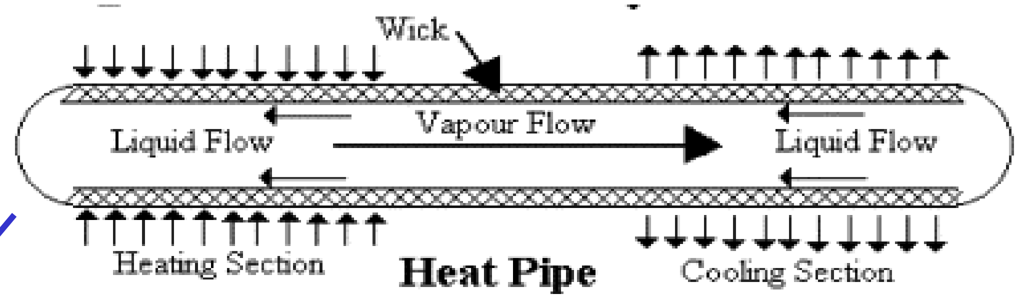
Run around coil

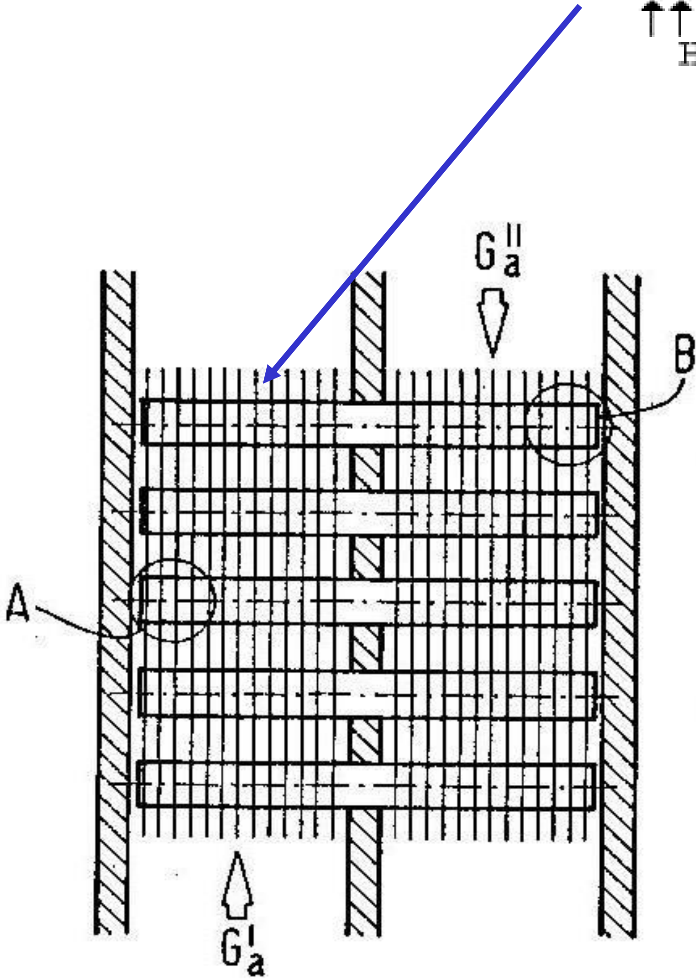


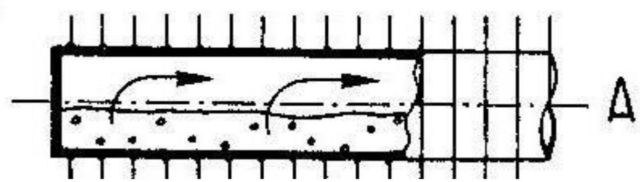
Commonly used:

- when exhaust and fresh ari are distant
- pump for water or glycol-water mixture
- to avoid cross contamination odf air streams (operating theatres)
- heat recovery from exhaust from WCs

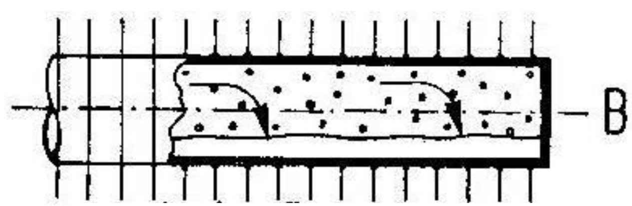
Heat pipe





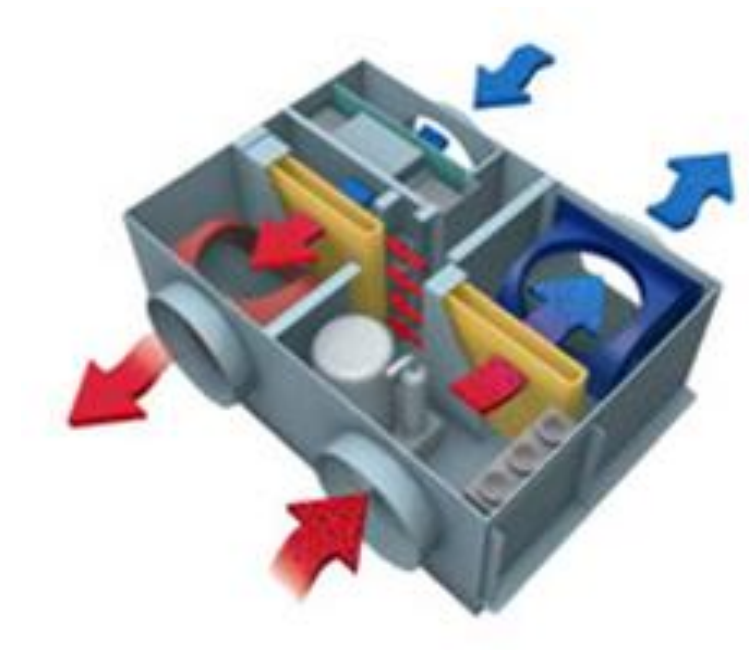


Warm air stream



Cold air stream

Heat recovery via a heat pump (thermodynamic heat recovery)



- It is basically a heat pump
- The heat moves from the exhaust to the fresh air via compression
- No cross contamination
- Without a plate heat exchanger the heat can be used for heat recovery and supply air at temperature > 20°C. Considering just the heat recovery (from outdoor air to 20°C the efficiency is about 50%
- Originally it has been proposed as solution without the heat recovery. Today a plate heat exchanger is also proposed by some manufacturers