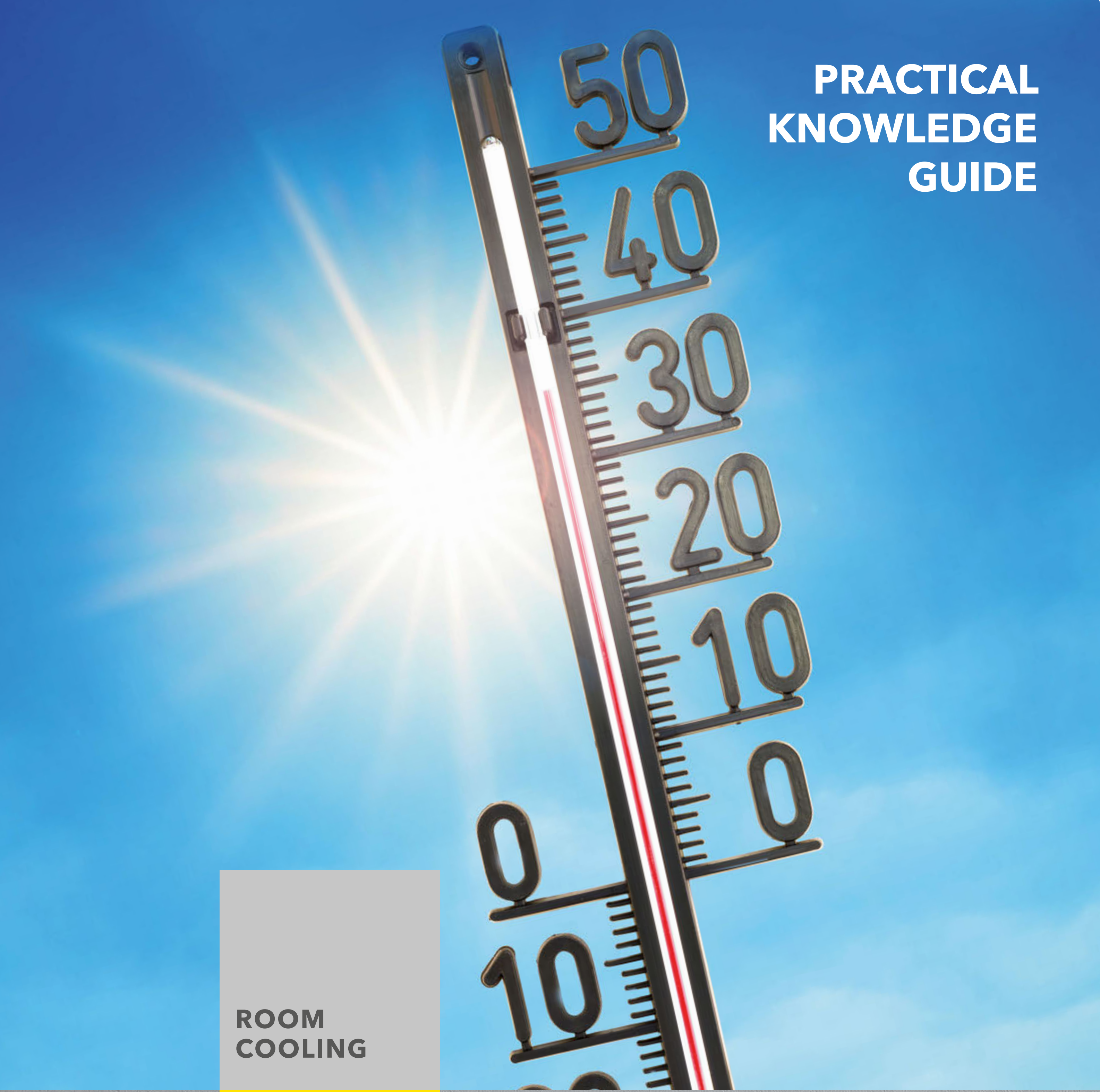
PRACTICAL KNOWLEDGE GUIDE



ROOM COOLING

EVERYTHING YOU NEED TO KNOW!

TROTEC

AT WORK.

THERE ARE MANY POSSIBILITIES FOR COOLING ROOMS.

WE WILL SHOW YOU WHAT TO WATCH OUT FOR SO YOU CAN ACHIEVE YOUR OBJECTIVE QUICKLY AND EFFICIENTLY.

PRACTICAL KNOWLEDGE CONCERNING AIR CONDITIONING

INFORMATION REGARDING THE PRACTICE-ORIENTED CALCULATION OF THE REQUIRED DEVICE PERFORMANCE AND THE TECHNOLOGY EMPLOYED BY DIFFERENT COOLING SYSTEMS

Which cooling technique?

Monobloc or split unit, one-hose or two-hose technology, evaporation cooler or refrigeration system? If you are looking for the ideal device to provide refreshingly cold air in rooms with high temperatures, you may easily lose track of things in view of the manifold options and techniques.

First of all: there is no such thing as one and only one optimal technique. As diverse as the parameters such as room size, cooling method, degree of comfort, installation work and, of course, budget may be, as particular can the individual perfect solution be.

It is for this very reason that Trotec has numerous high-quality devices working on different cooling techniques available for you.

This way you will always find the device suitable for your personal requirements and benefit from the best value-for-money ratio offered by a leading brand supplier!

We have compiled detailed information regarding the functional principle of different methods on the following pages.

Online capacity calculation:

Calculating the cooling load in a way to meet specific requirements is a very complex affair. It is no coincidence that projects of larger dimensions are calculated by qualified air-conditioning technicians. If our rules of thumb are not quite sufficient for your individual requirements, simply make use of our online calculator for a more detailed calculation:

https://uk.trotec.com/climate_calculator

Quick calculation of the required cooling capacity for living and office spaces

How much power is required to cool a room? The rule of thumb: Every cubic metre of room volume requires a cooling capacity of 30 watts.

According to this rule of thumb, the required cooling capacity can quickly and easily be determined, as can be seen from the following example calculation with a room's floor space of 35 m^2 and a ceiling height of 2.5 m:

35 m^2 x 2.5 m height =
87.5 m^3 cubature x 30 watts =
2,625 watts

This is only a rough calculation formula for living and office spaces with modern insulation (passive house standard), though.

The required cooling capacity further depends on the room's "thermal load": For selecting an appropriate air conditioner, the factors of insolation, insulation, window dimensions, the number of persons as well as the heat sources play an equally important role.

No rule without exception

No one really has 1.47 children.
And yet that is the German statistical average.

Reality also does not usually offer an ideal-typical standard room on which the room-size-dependent rule of 30 watts for the cooling capacity calculation is based. Still, it is a room that – according to the statistics – you are most likely to find and hence serves as basis of calculation.

This principle is well-known from the manufacturer's specifications regarding the fuel consumption of your car. One will never fully attain the values in practice, but all manufacturers adhere to the same evaluation procedures regulated by law to permit a comparison of the different vehicles. The situation is not so very different for air conditioners.

The recommendations for room size suitability are based on ideal-typical conditions to be found indeed on a statistical average, but hardly ever in real life.

We as individual producer cannot single-handedly adjust the equipment labelling for this would eradicate any chance of comparing the devices with competition models.

One thing is certain: A device marked as suitable for 30 square metres has more or less the same cooling capacity regardless of the manufacturer. Possible room size recommendations are usually based on the rule of 30 watts per cubic metre.

Important note: This calculation is based on the unit "watt" and only applies to compressor air conditioners. It cannot be applied to air coolers, as air coolers do not cool down the room air by means of a compression refrigeration system, but adiabatically – according to the principle of water evaporation.

Rough calculation of the required cooling capacity in due consideration of the room type and how it is used*:

- **30 watts per cubic metre**
  for ideal-typical standard rooms provided with passive house insulation, normal sized window area and little frequented
- **Additional 10 watts per cubic metre**
  in case of poor insulation
- **Additional 10 watts per cubic metre**
  if there are more than 3 individuals in the room
- **Additional 10 watts per cubic metre**
  if the size of the window area exceeds the average
- **Additional 10 watts per cubic metre**
  if the windows and/or outer walls are facing south
- **50 watts per cubic metre**
  for rooms in attic flats

  Especially in case of attic flats in old buildings determining the required cooling capacity remains a difficult task due to the lack of knowledge regarding the roof's thermal insulation. To be on the safe side, one should calculate with 60 watts per cubic metre or even more if the roofs are poorly insulated or there are plenty of skylights.
- **55 watts per cubic metre**
  when using air conditioners in construction site trailers

* see "Important note", page 2

Important information on the cooling of entire flats:

As their name suggests, room air conditioners are designed for the air conditioning of one room – not several.

Even in case of a larger room of say 70 m² – the cooling capacity calculated for this room cannot simply be used for a flat of the same size that is divided into several rooms. The air conditioner's capacity may be suitable for this room size, but the desired cooling effect can only be achieved on the condition of unrestricted air circulation within the room – or in all rooms in case of a flat.

Though the air conditioners of the PAC series are already fitted with powerful radial fans (the design of which promotes an extensive air transport), a homogenous air distribution across several rooms using only one air conditioner is still a physical impossibility.

> **Our recommendation:** Provided the cooling capacity of the air conditioner is dimensioned for the total area of two adjoining rooms and using an additional well-suited fan, the air current can be directed in a way to distribute the cold air in the adjoining room as well.

Planning with practical aspects in mind and allowing for reserves as well

If you want to achieve a more distinct cooling effect, proceed with your capacity planning on the assumption that not all parts of your room will correspond to the statistical standard and therefore factor in some spare capacity for good measure. Not least because the number of occupants may vary and now and then there can be spells of particularly hot weather. If nothing else, this is due to the individual requirements that go hand in hand with bringing about and maintaining an agreeable room climate under changeable circumstances.

As the figure indicates, there can be various factors influencing the room size recommendation – as a result the basic value for the calculation is no longer 30 watts per cubic metre but 60 or more still.

Accordingly, an air conditioner recommended for a room size of 40 m² can only effectively cool rooms of 20 m² in these changes conditions.

A well thought-out mission plan is half the battle

To "just quickly" use the air conditioner for a little cooling is what most people do wrong at first and often the source of annoyance regarding an allegedly insufficient device performance. For instance: in order to have the bedroom reasonably cool overnight, the air conditioner is operated merely for a few hours during the evening and then switched off. Momentary observation: Everything has been cooled down perceptibly to an agreeable level – just perfect.

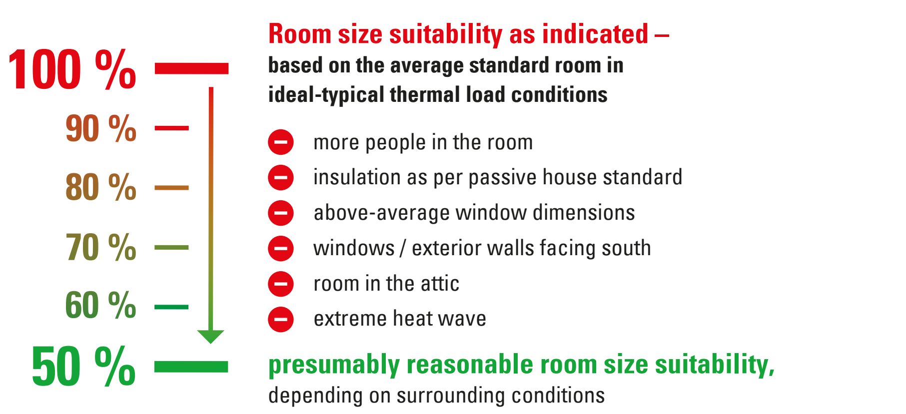
Only it will not last – not for long, because the air conditioner only cools the air presently in the room.

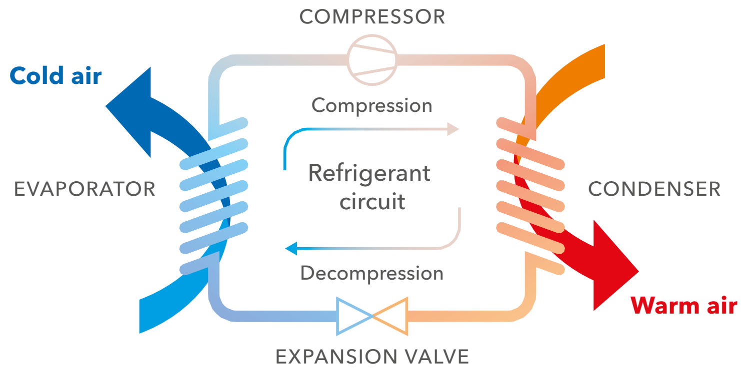
But 95 % of the thermal energy that has accumulated throughout the day is not stored on the air, but in walls, floors, ceilings and furniture. And they emit this heat during the night to the room air, the temperature of which then – with the air conditioner being deactivated – again increases.

It would be better to allow an uninterrupted operation of the devices during the day so that walls, floors, ceilings and furniture store less heat which is constantly conveyed to the air and then cooled by the air conditioner. Employing this method, the rooms remain agreeably cool until late at night despite the air conditioners having been switched off in the evening.

Having said this, though, it is not possible to attain a "cold storage" as the walls are continuously "charged" with heat from outside.

Room size suitability in theory and practice:





MOBILE AIR CONDITIONING SYSTEMS – CONVENIENT REFRIGERATION SYSTEMS

Some basics about cooling technology for a better understanding:

Unlike air coolers, all air conditioners of our PAC series cool the room air with the help of a powerful compression refrigeration system. A refrigerant is led through two heat exchangers – a condenser and an evaporator.

By means of a compressor and an expansion valve, the refrigerant is exposed to changing pressures within this closed circuit, which results in the gas heating up during compression and cooling down during decompression. The heat is discharged to the outside at the condenser, and the cold is blown into the room at the evaporator.

Dehumidification at the same time

Since the air can cool down to below its dew point at the evaporator, humidity contained in the air condenses simultaneously. This means that the air is not only cooled but also dehumidified, which generally promotes personal well-being and creates a more pleasant room climate, since stuffy humid air is generally perceived as oppressive and disagreeable.

Depending on the construction, these refrigeration systems are available from Trotec as split or monobloc air conditioners, the latter with either one-hose or two-hose technology.

MOBILE SPLIT UNITS

Condenser (external unit) and evaporator (internal unit) of split devices such as the PAC 4600 are constructively divided.

The external unit positioned on a balcony, terrace, window sill or elsewhere out of doors is connected to the air conditioner by a connection line.

Since the waste heat arising from the cooling process is discharged by the external unit and via the connection line (hot refrigerant), split units – unlike conventional monobloc air conditioners – do not need an exhaust air hose to emit the warm air.

Compared to monobloc devices, split air conditioners are characterized by a distinctly better energy efficiency as the waste heat is produced outside in the external unit rather than by the basic device set up indoors.

Hence the warmth withdrawn from the room air does not need to be conducted to the outside through an exhaust air hose as is necessary in case of monobloc air conditioners.

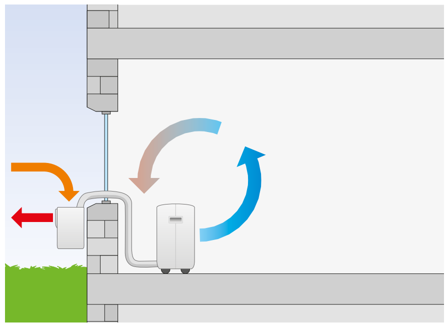
As another consequence of this no vacuum is created and so none of the warm outside air is trailing back into the room to be cooled.

The better energy efficiency is however opposed by a poorer oxygen balance.

The best comparison for split air conditioners is the recirculation operation of a car's air conditioning system. Time and time again the same air is conducted through the unit, that way the sucked-in air becomes colder and colder and in doing so less energy is required for cooling.

But cooling exclusively in recirculation mode means that at some point the oxygen in the room is depleted. The same holds true for split units. The same air is cooled down over and over and at some point the people present in the room will have used up all the oxygen. Then one needs to ventilate the room to let in new oxygen, which in turn reduces the energetic advantage as compared to monobloc devices. The advantage is put into perspective depending on the oxygen demand within the room.

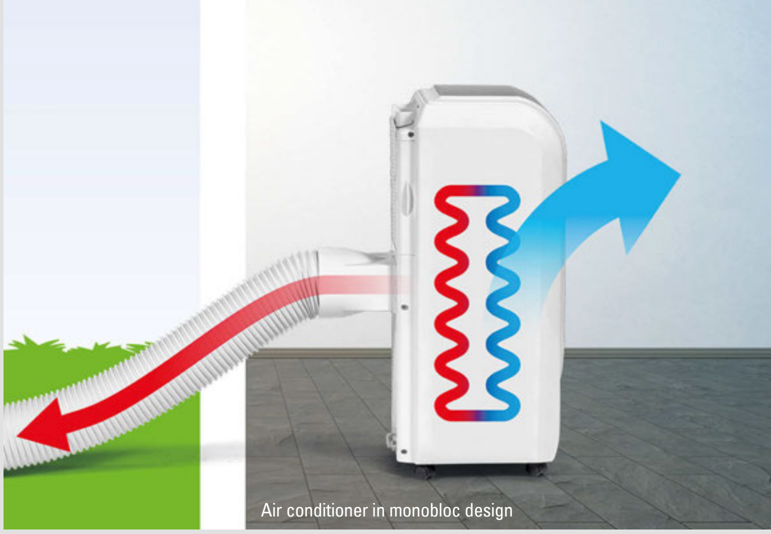
Conclusion: The more people there are in the room, the more will the energy balance of split and monobloc devices assimilate due to the required ventilation cycles.



There is no universal rule as to which system can be said to be more advantageous, it depends on the individual usage behaviour. If there are no persons in the room (server room, cold storage cell etc.), the energetic advantage as compared to monobloc air conditioners is the greatest.

Another difference can be perceived in the noise emission. Split air conditioners are generally more silent than monobloc devices, because part of the ventilation system is accommodated in the external unit, whereas in case of monobloc air conditioners all fans for cooling and warm air discharge are integrated entirely in the basic device, which inherently leads to an increased noise generation.

Similar appearance, different technology: Air cooler PAE 25,
monobloc air conditioner PAC 2010 E and split air conditioner PAC 4600 (FLTR).



Air conditioner in monobloc design

Practical tip: Even if it were possible with the device used, the room temperature still should not be cooled down excessively. This would not just unnecessarily increase the energy consumption, common colds during the summertime are in part also attributed to a "cold-shock response" upon entering a chilled room. We therefore recommend to adjust the room temperature to a level of about 3 °C below the outside temperature – however by no more than 5 °C.

MONOBLOC AIR CONDITIONERS

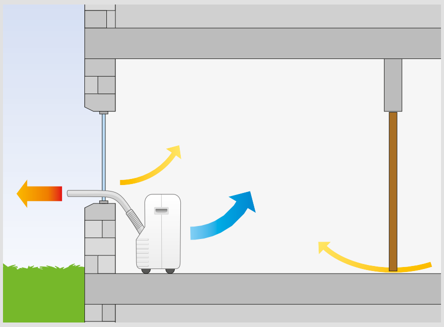
WITH ONE-HOSE TECHNOLOGY

This is the most common type of construction of Trotec's PAC air conditioners. The entire technology is integrated space-savingly into the housing and the process-related hot air is discharged to the outside by means of a central exhaust air hose through a window or door gap – that's why it is referred to as one-hose technology.

The permanent discharge of warm air creates a slight underpressure, which evens out by trailing warm air from outside and adjacent rooms.

The positive effect is that this way the room is continuously supplied with fresh air. This also means, though, that approx. 20 to 30 % of the energy will be lost owing to the warm air sucked in from outside.

However, for the most part this energetic disadvantage is only negative at first. For if the room is occupied by people, oxygen is indispensable which would not be able to enter the room in the recirculation mode of split units.



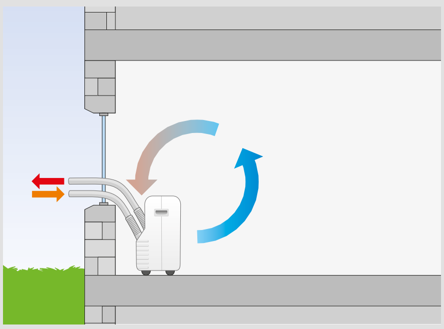
Monobloc devices with one-hose technology score in particular with their advantageous combination of powerful cooling, permanent supply of fresh air and extremely easy handling. They can be conveniently and flexibly put into operation in different rooms.

Monobloc air conditioners are also the least expensive alternative for room cooling.

WITH TWO-HOSE TECHNOLOGY

As with one-hose devices, the process-related hot air is discharged to the outside through an exhaust air hose, but additionally, the device is supplied with the same amount of fresh air via a second hose.

In contrast to one-hose devices, this allows for pressure-tolerant recirculation operation without trailing warm air from outside, which makes these devices more efficient but also requires slightly more installation work. For rather than just one hose one needs to install two hoses for this procedure.



These devices are more energy-efficient than monobloc devices with one-hose technology, but on the downside – just like with the split units – the room is again supplied with hardly any fresh air (oxygen).

NO HOSE, NO COOLING!

There is absolutely no need to be unsettled by illustrations of air conditioners that suggest the task can be accomplished without hoses – the use of at least one hose is inevitable, even though it may not always be apparent from the picture! Why? It's quite simple:

Air conditioners are compression cooling devices. And they generate cold and warmth in equal measure – due to the unalterable laws of physics. The generated cold is wanted in the room, the warmth is not. Which is why it has to go – outside.

Split units automatically discharge the warmth to the condenser set up outside. All the same, these devices, too, need a connection line for the circulating refrigerant which ensures the heat removal.

In case of the monobloc design (see fig. above) the heat is produced centrally within the device and must therefore be conducted to the outside in a way that prevents it from being mixed with the just cooled room air.

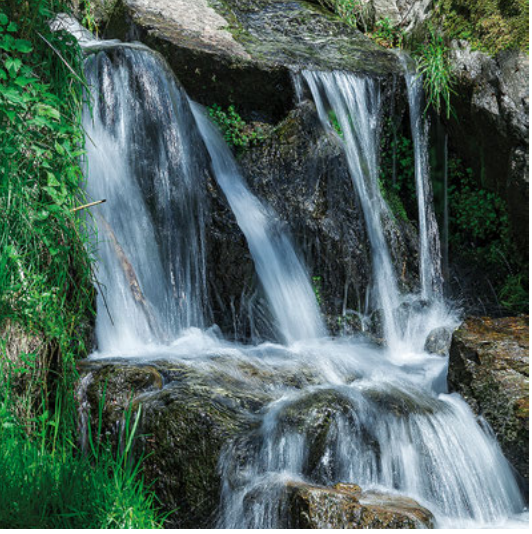
One exhaust air hose is the mandatory minimum and hence always included in the delivery scope of monobloc air conditioners available on the market, even though that may not be immediately apparent from the respective illustration.

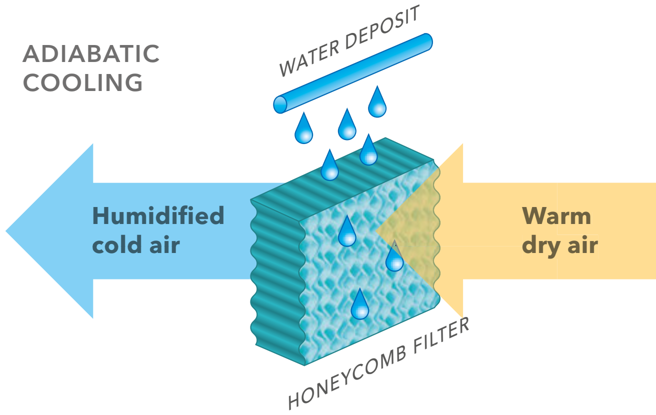
In short: air conditioners without an exhaust hose are never "proper (compression) air conditioners", instead, they are always air coolers that cool adiabatically by means of water evaporation! (see page 6)

Would you have known?

Humans are at their most productive in ambient temperatures of 20 °C, whereas at 28 °C the productivity is reduced to about 70 % and in temperatures of 33 °C it even falls to 50 %.

The German workplace regulation ASR A3.5 on indoor temperature thus stipulates that the temperature at office workplaces must not exceed 26 °C.





ADIABATIC COOLING WITH MOBILE AIR COOLERS

The devices of the PAE series from Trotec are air coolers and, unlike PAC air conditioners, do not have a compressor-operated cooling unit but cool the room air using the natural principle of water evaporation, which is also referred to as adiabatic cooling. Everyone knows this cooling effect, for example from sweat evaporation or cooler air in the vicinity of water falls, rivers and lakes.

The physical principle in short: In order to evaporate, the water requires energy. This energy is extracted from the ambient air in the form of heat, which makes the air cooler.

It is important to note that the energy stored in our room air can be divided into sensible (or perceptible) heat and latent (i.e. hidden) heat.

The highlight: only the sensible heat is temperature-relevant and can be measured with a thermometer. Since this sensible heat is consumed during evaporation and then stored as latent energy in the water vapour contained in the air, the adiabatic cooling method is an entirely natural and moreover cost-effective cooling method requiring no external energy for the cooling process of a compressor-operated air conditioning system such as with the PAC devices. In practice, however, it is more suitable for smaller rooms and temperature differences.

The effective radius of adiabatic cooling units cannot be increased as easily as in case of high-performance compression refrigeration systems.

Almost all air coolers for private use operate based on the principle of direct cooling, i.e. they supply the incoming air directly with moisture from evaporation.

Therefore, in contrast to monobloc air conditioners, no additional process air discharge is required, which on the one hand makes the devices extremely easy to handle since they only have to be set up and switched on, but on the other hand also increases the room humidity level.

Air coolers only operate efficiently in rooms containing rather dry air (less than 40 % RH) and they can only reduce the temperature until reaching the air saturation limit, for example from 25 °C/50 % RH to a theoretical value of maximally 18 °C/98 % RH. Albeit, this temperature difference is a mere theory and not relevant in practice, for with a relative humidity level of 98 % in the room the perceived climate would be extremely muggy and sweltering (see comfort chart on the right).

Ordinarily, the mobile air coolers of the PAE series can be used to achieve temperature differences of 1 - 2 °C in smaller rooms without increasing the humidity to a disagreeably high level – depending on initial humidity level and temperature.

The efficiency of air coolers depends on various factors such as the fan performance and the surface area of the evaporation filter. As can be seen from the theoretical example values, the use of direct coolers simultaneously causes the humidity level in the room to rise perceptibly for process-related reasons, which is not always desirable.

An increasing humidity level also reduces the devices' cooling capacity.

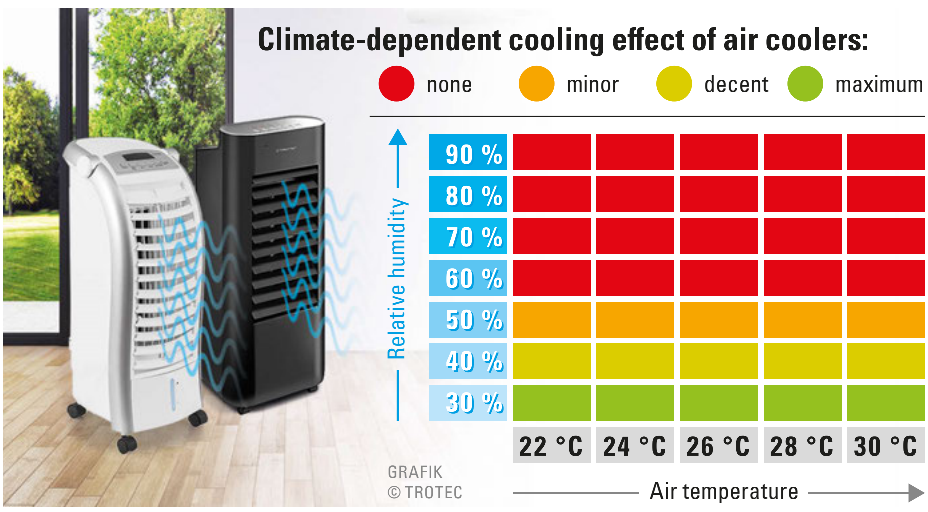
Consequently, the cooling efficiency of air coolers is directly dependent on the overall weather conditions:

Air coolers accomplish maximum efficiency in hot and dry air.

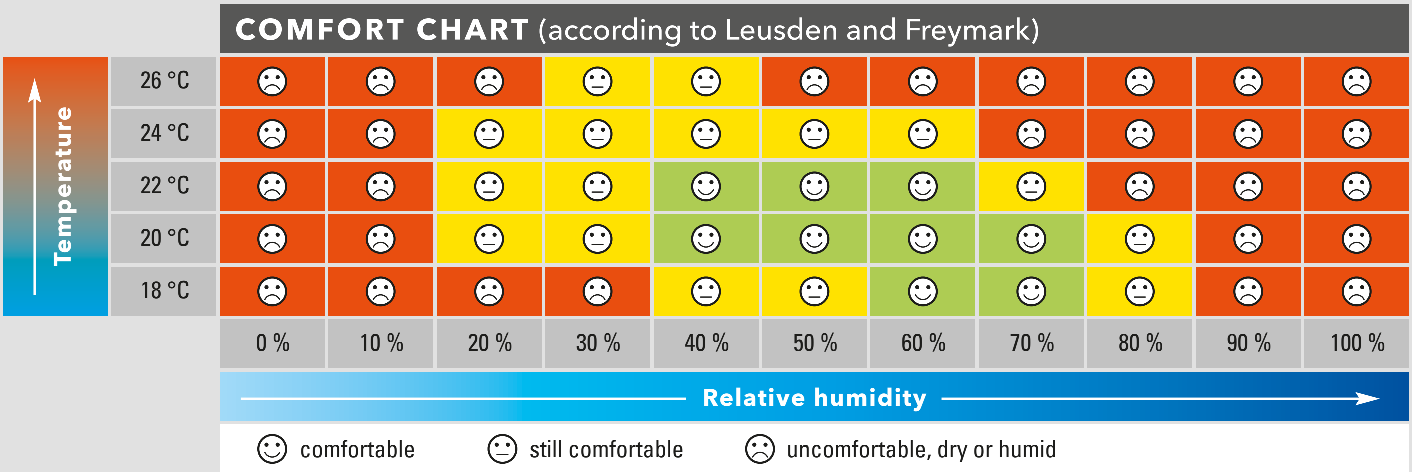
Sticky hot conditions on the other hand allow for hardly any cooling.

Yet worse: Owing to the additional humidification of the already very humid air, the room climate is perceived as even more unpleasant.

Seeing as this circumstance is caused by the process, it concerns all air coolers on the market, although some competitors' offers suggest otherwise.



In contrast to compressor-operated air conditioners, the efficiency of air coolers is – for process-related reasons – liable to considerable fluctuations relating to the prevailing climate conditions: from the max. possible cooling effect (temperature reduction of 1 to 3 °C) in hot and dry air to no noticeable improvement when the room air is muggy.



AIR CONDITIONERS OR AIR COOLERS – AN AID FOR DECISION MAKING

With a difference of 10 to 18 °C between the incoming and exiting air at the device, air conditioners of the PAC and PT series produce far greater temperature differences than air coolers which generally can attain no more than 1 to 3 °C difference.

Seeing as the room is constantly supplied with warmth at the same time – be it through walls or door gaps – the room air can, on balance, be cooled down by approx. 4 to 15 °C using compressor-operated air conditioners – as usual depending on the applied model as well as on the climatic conditions in the room (temperature and relative humidity).

Having said this, except for very few special refrigeration systems customary air conditioners cannot achieve a room temperature lower than 16 °C, because the devices usually switch off at that temperature level. What this means in practice is that even if the air conditioner is technically capable of cooling the room by 15 °C, a room of 24 °C would be cooled down to no more than the level of 16 °C!

After all, the temperature difference in the room that can be attained by air conditioner or air cooler always depends on the room size and the cooling capacity of the respective device. Please always observe the recommended maximum room sizes provided in the technical data and all of the above-mentioned influencing factors!

In conclusion one can say that whether air conditioning system or air cooler is to be the proper choice depends largely on the intended use, usage behaviour, personal requirements and – if nothing else – the individual willingness to invest.

Air coolers are very reasonably priced, both in terms of purchase costs and later power consumption, quickly and easily installed and do not require warm air to be discharged to the outside by means of a refrigerant line or exhaust hose for hot air. On the other hand, the cooling capacity is heavily dependent on the relative humidity and limited to only a few degrees Celsius.

The cooling ability of air coolers further depends on the overall weather conditions. Air coolers attain their maximum efficiency in a hot and dry climate. In hot and sticky climate conditions, however, the cooling capacity is reduced to virtually zero.

By contrast, air conditioners of the PAC and PT series are genuine chillers – to be sure, their cooling capacity also depends on air temperature and humidity, but not nearly as much as that of the air coolers.

Unlike air coolers, air conditioners dehumidify the room air which is particularly advantageous at high humidity levels. Air conditioners of the PAC and PT series are fitted with both a compressor and a complete cooling unit, which is why their purchase price as well as the costs for power consumption are considerably higher than those for air coolers.

In contrast to air coolers, the resulting waste heat is not retained by the damper exhaust air, but discharged to the outside. As a consequence, every compressor-operated air conditioning system needs either an exhaust hose for hot air (monobloc air conditioners) or a refrigerant connection line to the external cooling unit (split units). For this reason the installation of air conditioners is more time-consuming.

Overview: Quick comparison of procedural differences	**Air coolers**	**Air conditioners** (compressor-operated)
Can be used without exhaust air hose or refrigerant connection line	yes	no
Temperature difference* (ΔT) between intake air and blown out cooling air at the device	1 to 3 °C	10 to 18 °C
Room temperature can be reduced by approx.	max. 2 °C	max. 15 °C
Air temperature to which rooms can be cooled down to at most	-	18 °C
Acquisition costs in direct comparison	lower	higher
Energy consumption in direct comparison	lower	higher
Effective cooling capacity despite high humidity level	no	yes
Influence of climate conditions on the cooling capacity	high	low
Process-related humidity behaviour	Humidification	Dehumidification
Cooling effect noticeable even in hot and humid climate conditions**	no	yes
Cooling effect noticeable even in hot and dry climate conditions**	yes	yes

* depending on the relative humidity level; ** depending on air temperature and humidity as well as the correct dimensioning

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Practical knowledge concerning air conditioning

Monobloc or split unit, one-hose or two-hose technology, evaporation cooler or refrigeration system? If you are looking for the ideal device to provide refreshingly cold air in rooms with high temperatures, you may easily lose track of things in view of the manifold options and techniques.

Benefit from the comprehensive overview of the device differences, functional principles and possible applications provided in this brochure.

After all, the Trotec Group is one of the prime international addresses for professional complete solutions regarding climate control and measuring technology for building diagnostics. We step up to both industrial customers and private end users.

We can offer our industry expertise acquired over many years, products of a high quality and a comprehensive range of services – all from a single source!

You have questions? We will be pleased to advise you personally and in detail. Feel free to contact us by phone or e-mail – we look forward to your inquiry.

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