Whitepaper

Clean indoor air – the guide

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Technology for intelligent buildings

Table of Contents

Introduction

Especially in times of COVID-19, people have become increasingly aware of room air quality and its significance. However, the issue was no less important before the pandemic; unfortunately, many saw no need for action. Because an optimal indoor air climate promotes the ability to concentrate as well as productivity and helps prevent illnesses such as colds, headaches or the like.

But how exactly can you ensure good room air quality? A lot of discussion on this topic is currently taking place and solutions such as air filter devices or indoor air quality indicators (CO_2 indicators) are mentioned most frequently. In many countries incentive programmes are also launched at short notice for this purpose. Especially for public buildings or places of assembly, incentive funds are being made available more and more frequently. For detailed information, it is best to contact the state-specific authority for public funding. In Germany, for example, many cities prefer the use of indoor air quality indicators in schools, day-care centres and places of assembly. So what makes the most sense?

This guide provides you with comprehensive information on the subject of "clean room air". We explain typical terms that are on everyone's lips, compare products and solutions such as air filter devices and indoor air quality indicators, and explain what is essential to look out for when buying.

An overview of room air quality

What is meant by good room air or room air quality?

Nowadays, people spend an average of 90% of their entire life in closed indoor spaces Therefore, a good indoor climate plays an increasingly significant role. Particularly, the room air quality has an enormous influence on people's well-being and health. But what exactly is meant by good room air quality? Due to the corona pandemic, one could think that the room air quality is synonymous with the carbon dioxide (CO_2) content of the room air. This is partly true, but other parameters are also decisive for the quality of the room air. The most relevant parameters are:

- CO_2 content
- Relative humidity
- Temperature

These values are also used to design ventilation and air-conditioning systems for functional buildings such as offices, hotels, schools, etc. Some rules of thumb should be considered: the CO_2 content should not exceed 1000 ppm (parts per million), the room air temperature should be between 20°C in winter and 26°C in summer and the relative humidity should be between 40 % and 60 %.

How is room air related to Corona?

The room air quality has a direct impact on the spread of viruses such as the COVID-19 virus. The virus spreads much easier in a poor indoor climate than in a good room air quality. The effects of the parameters are described below:

CO_2 content and aerosols

The carbon dioxide content is a good indicator of fresh or "stale" air in a room. Especially in closed rooms with a large number of people, such as classrooms, CO_2 spreads quickly in the room air through breathing, talking, coughing, etc. A high CO_2 concentration does not directly indicate the viral load in the air, but it does show that it has not been aired for too long and an increased risk of infection may exist as a result. In addition to CO_2, aerosols are also exhaled during breathing. These are tiny droplets or moisture particles that float in the air for a certain time and may contain virus particles that remain infectious in the air. Fresh air supply reduces the CO_2 content and therefore the density of the aerosols and ultimately the risk of infection.

In short: the lower the CO_2 content, the lower the risk of infection!

Relative humidity and room air temperature

The relative humidity in a room is crucial for the survival of aerosols and thus the ability to transmit viruses such as COVID-19. When the relative humidity is low (dry air), the aerosols absorb less water and quickly become smaller and lighter - the particles with the pathogens remain in the air longer and harbour an increased risk of infection. Scientific studies have already shown that at a humidity of 40% or more, the survival time of virus-contaminated aerosols in the air is the shortest. High temperatures increase this effect as the air can absorb more moisture. For this reason, the infection rate is lower in summer than in winter.

In short: relative humidity of 40% or more and high temperatures reduce the risk of infection!

How to ensure good room air?

The magic word for good indoor air is ventilation. Therefore, ventilation was added to the well-known rules “social distancing”, “wash your Hands often” and “wear a mask” for combating the coronavirus. But how exactly should you ventilate?

Ventilate, ventilate, and ventilate again

Good room air quality can be achieved through ventilation by opening windows. This mixes the stale room air with fresh air. The CO_2 concentration and the aerosol density in the room are reduced. However, this has some disadvantages that affect the well-being of the people in the room. For example, classrooms get hot in summer due to the supply of warm outside air. In winter, however, rooms cool down and the relative humidity drops increasing the risk of infection. Large temperature differences between outside air and indoor air therefore often cause excessive costs for cooling the rooms in summer or heating in winter.

Automatic ventilation control using ventilation and air-conditioning systems

These problems do not arise when operating a central ventilation system. Ventilation and air-conditioning systems supply rooms with filtered, heated or cooled air (outside or inside air) and ensure stable room air parameters such as CO_2 content, relative humidity and temperature. Polluted air is also removed from the rooms. For automatic control, the ventilation and air-conditioning system accesses room sensors to continuously adjust the actual values to the target values.

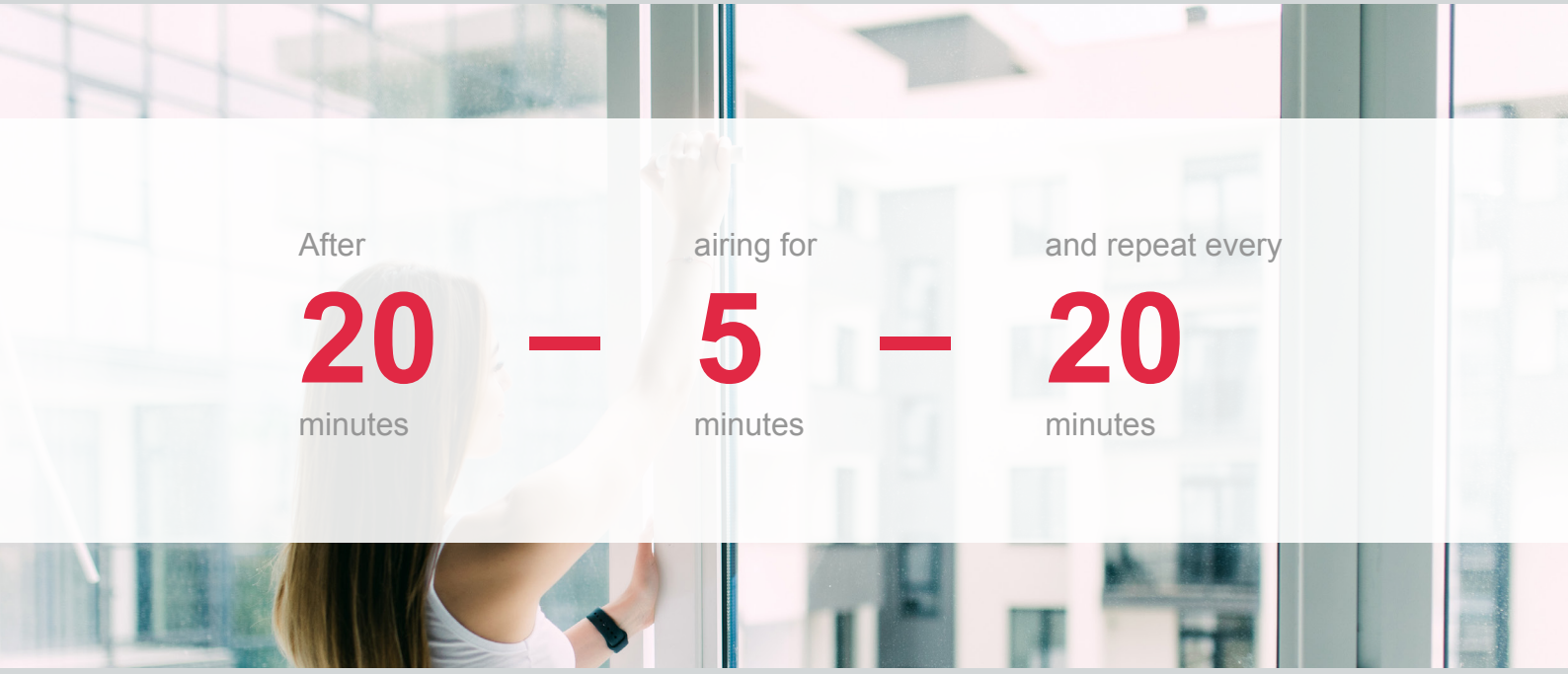
Such ventilation and air-conditioning systems are not available in many functional buildings such as schools, day-care centres or offices in Germany. Therefore, the market is currently flooded with products and solutions (for example air filter devices and indoor air quality indicators) that are supposed to support the achievement of good room air quality. However, manual ventilation will still be necessary for buildings without a ventilation system despite these helpers.

How to air properly?

Airing sounds so trivial that it is easy to think "you cannot make any mistakes". But the devil is in the details. In the past few months, we have got to know many different methods in German classrooms - from continuous ventilation in winter with students wearing thick jackets to ventilation during breaks that should be sufficient.

Ventilating as needed is usually the best method due to a variety of factors. With this type of ventilation, the ventilation interval is dynamic and is determined by indoor air quality indicators (CO_2 indicators) or permanently installed sensors in the room when a CO_2 limit is exceeded. With this method, ventilation is carried out only when and for as long as necessary. This has the least effect on people's wellbeing in the room and is at the same time the most energy-efficient.

If no indoor air quality indicators or room air sensors are available, needs-based ventilation is not possible. There are common rules of thumb for such cases that are communicated by the Federal Environment Agency. We are talking about the 20-5-20 rule: it should be ventilated every 20 minutes for 5 minutes with the windows wide open (intermittent ventilation). Creating an air draught would be ideal when windows on opposite sides can be opened. The temperature in the room only drops by a few degrees and rises again quickly after ventilation.



Product solutions on the market

To what extent do indoor air quality indicators help?

Indoor air quality indicators are usually multi-sensors that measure various parameters of the room air (mostly CO_2 content, relative humidity and temperature) and provide information about the quality of the air. These helpers are often referred to as CO_2 indicators. This suggests that only the CO_2 content is measured, but does not necessarily have to be that way. In addition to the visual signal in the indicator colours

- **Red**: The room air quality is insufficient, ventilation is necessary
- **Yellow**: The room air quality is sufficient, ventilation as soon as possible is recommended
- **Green**: The room air quality is good, no ventilation is necessary,

the indoor air quality indicators usually emit warning tones when certain CO_2 limits have been exceeded. They are therefore the ideal helpers to enable needs-based ventilation and to give the room users a feeling of security as they are always informed about the room air quality. In addition to the measurement of various parameters, future-oriented indoor air quality indicators often offer additional comfort functions such as connection to central ventilation systems (ventilation and air-conditioning systems) or components of building services. This means that buildings with ventilation and air-conditioning systems can be ventilated fully automatically. Access and warnings using an app are also integrated into some models allowing an easy overview of the air quality in all rooms as well as energy-efficient ventilation if required.

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What are the benefits of using air filter devices?

In contrast to indoor air quality indicators, mobile air filter devices intervene in the indoor air climate. They clean the air of particles such as fine dust, mould spores, bacteria or viruses that become trapped in the filter mats. Special filters must be used that filter even the smallest particles. This requires the use of H13 or H14 class HEPA filters. The air filter device should be designed considering the size of the room – the larger the room, the more powerful (air throughput) the device must be. For the reliable removal of 99 % of the smallest particles from the air, the device should have an air exchange rate of six. This means that the device filters the entire room-air volume six times per hour.

Now the air is no longer polluted by tiny particles. However, the air filter devices do not influence the air quality parameters CO_2 content or relative humidity that also play a role in the well-being and the spread of the coronavirus. Here, too, only one thing helps: ventilate, ventilate, and ventilate again.

In a practical comparison: air filter devices versus indoor air quality indicators

Neither an air filter device nor an indoor air quality indicator can replace manual ventilation. Only an integrated solution with ventilation and air-conditioning systems will help. The Federal Environment Agency recommends equipping or retrofitting ventilation and air-conditioning systems in the long term also to achieve sustainable goals. Such systems solve many indoor hygiene problems in heavily frequented rooms (airborne pathogens, carbon dioxide, water vapour, odours, etc.) and thus ensure the safe operation of buildings in terms of health.

Nevertheless, air filter devices and indoor air quality indicators support safe operation especially in times of Corona. To make the choice of the right product easier, we have compared the two helpers according to various criteria. Before buying, you should be aware of the key differences, especially concerning the long-term effects.

A practical comparison: air filter devices versus indoor air quality indicators

Criteria	Air filter devices	Indoor air quality indicators
Acquisition costs	Air filter devices are many times more expensive to buy than indoor air quality indicators.	Indoor air quality indicators are low in price compared to air filter devices.
Operating cost	Significantly higher electricity costs for operation (in some cases by a factor of 10).	Low electricity costs for operation.
Ventilation measures	Ventilation is necessary despite using an air filter device. The viral load decreases, but the CO_2 concentration and the humidity can only be influenced by ventilation. As needs-based ventilation is not possible, excessive ventilation results in higher energy costs.	The indoor air quality indicator shows when and how long the room must be ventilated, thus enabling needs-based ventilation. Overall, this results in lower energy costs.
Room coverage	Depending on the size of the room, several air filter devices or more powerful devices with a higher airflow rate may be required. Common air filter devices are designed for rooms of up to 25 m².	One device is usually sufficient to monitor a room of 50 m². That corresponds to the size of an average classroom in North Rhine-Westphalia.
Maintenance	Filters must be replaced regularly under the strictest safety requirements and thus cause high maintenance efforts and costs. IMPORTANT: Filters may be full of dangerous viruses and should therefore be disposed of by qualified personnel. When a filter falls to the floor, for example, high virus loads may be released suddenly.	Indoor air quality indicators with NDIR sensors (two-beam reference measurement) do not require any maintenance. When using the single-beam reference measurement method, the measurement accuracy may decrease with the age of the infrared source and thus entail costs for recalibration.
Installation / Commissioning	Every air filter device requires an external power supply. The positioning of the device in the room (ideally in the centre of the room) is important for succeeding but may complicate the power supply.	Indoor air quality indicators can usually be operated mobile using a power bank and do not necessarily need an external power supply. The indicators should not be positioned directly in front of windows or air inlets / outlets.

A practical comparison: air filter devices versus indoor air quality indicators		
Criteria	**Air filter devices**	**Indoor air quality indicators**
Noise	Manufacturers of common air filter devices indicate a sound pressure level of 40 to 50 dB(A). Important: The sound pressure level is not meaningful enough. Rather note the sound power level that is closer to the actual volume of the device. When using several devices in one room, the total level must be considered. To explain: 40 dB to 60 dB are already perceived as annoying. Learning and concentration disorders are the results.	Indoor air quality indicators operate noiselessly. When limit values are exceeded, the acoustic alarms are often quite loud. They can usually be deactivated.
Future viability	Mobile air filter devices are often used as a stand-alone solution. Also in the future (after Corona), they will ensure healthier indoor air and thus reduce the risk of illness.	Indoor air quality indicators can be integrated as multi-sensors into ventilation and air-conditioning systems and thus enable a smart solution for automated and CO_2-driven ventilation control. This ensures a healthy indoor air climate for the life of the building. Energy optimisation and further cost savings are also possible.

Finding individual solutions

Both indoor air quality indicators and air filter devices have their justification and advantages as well as disadvantages as described in the direct comparison. However, neither is the miracle solution. The overall solution is a practicable combination that ensures optimal indoor air quality.

But what does such a solution look like? To provide further advice, it is necessary to know the exact conditions on-site that have a strong influence on the success of the solution used.

1 Has a central ventilation system been installed on-site?

A ventilation and air-conditioning system in the building should always be the first choice. Equipped or retrofitted with HEPA filters (H13/H14,) ventilation systems create a healthy indoor climate without manual intervention. Ideally, these systems are controlled by sensors that detect the current CO_2 content of the room air (CO_2 driven ventilation control). When exceeding limits, the supply of fresh air is increased and a healthy indoor air climate is restored. Indoor air quality indicators or CO_2 indicators can also be used as sensors to enable needs-based control at a later date. However, most buildings in Germany do not have ventilation systems installed. Therefore, the question of ventilation through open windows must be discussed.

Our proposed solution: combine a central ventilation system with an indoor air quality indicator.

2 Do the rooms to be ventilated have windows?

If no ventilation systems are installed in the building, fresh air supply should be ensured using ventilation through open windows. Intermittent ventilation or air draughts are the most efficient. An indoor air quality indicator can be installed in the room to enable manual and yet needs-based ventilation. This means that the room is only ventilated when the CO_2 limits are exceeded. The energy costs for the subsequent heating (in winter) or cooling (in summer) of the rooms are lower as ventilation is only required when and as long as necessary.

Our proposed solution: combine ventilation through open windows (intermittent ventilation or air draughts) with an indoor air quality indicator.

3 Are the rooms used by large groups of people?

If rooms are heavily frequented and by mainly large groups of people (for example in schools), adding air filter devices to needs-based ventilation with an indoor air quality indicator may be useful. The breathing of many people in a room adds plenty of aerosols to the room air. The risk of infection is further reduced with an added air filter device.

Our proposed solution: combine ventilation through open windows (intermittent ventilation or air draughts) with an indoor air quality indicator and air filter devices.

4 Do the rooms have no windows?

Large groups of people should be avoided in rooms without ventilation as it is much more difficult to ensure a healthy indoor air climate. In this situation, mobile air filter devices are the only way to reduce the viral load in the air. Indoor air quality indicators should be installed to inform the room users about the indoor air quality as the viral load grows significantly faster in closed rooms increasing the risk of infection.

Our proposed solution: reduce usage, use indoor air quality indicators and air filters.

Not all indoor air quality indicators are the same

What to look out for when buying

In the current Corona situation, the market is flooded with indoor air quality indicators or CO_2 indicators. As the products differ greatly in terms of price, functionality and quality, a few points should be considered before buying. Because “if you buy cheaply, you pay dearly” often applies.

Criteria	Description
Sensor	Always ensure a "real" CO_2 measurement. A high-quality NDIR sensor based on infrared and not a VOC sensor should be installed in the indicator. VOC sensors detect all volatile organic air components including scents from perfumes/deodorants or smells of sweat and cooking that often cause false alarms.
	Ideally, the NDIR sensor should work with the two-beam reference measurement method. This method is maintenance-free and significantly more future-proof than the single-beam reference measurement method.
	Ideally, a multi-sensor is installed that monitors the CO_2 content as well as the relative humidity and temperature. Because room air quality means much more than just the CO_2 content.
Limits & alarms	The CO_2 limits should be adjustable individually. The limit values must be adjusted depending on the room and activity levels (e.g., gym). It should also be possible to change the limits according to individual safety requirements.
	As soon as CO_2 limit values are reached, indoor air quality indicators should emit acoustic warning signals. The practice has shown that, for example in classrooms, these signals should often be deactivated.
Measuring accuracy	Products of inferior quality that often show a higher inaccuracy in CO_2 measurement should be compared before purchase and considered accordingly.
Response time	The response time of an indoor air quality indicator should be as short as possible. We recommend a response time of fewer than 2 minutes to respond as quickly as possible to changes in room air quality.
Power supply	Rooms do not always have enough power points. Therefore, it is advisable to specify operation by rechargeable batteries or power banks as a requirement.
Enclosure	As indoor air quality indicators are often used on the move, a robust, high-quality enclosure is necessary.

Criteria	Description
Additional options	Wireless networking and the ability to integrate are very practical features of CO_2 indicators that enable integration into an existing building automation system or LoRaWAN networks in cities and municipalities. The data is often stored centrally in the cloud and is available for ventilation reports / evidence.
	Live monitoring and reporting complement the range of functions and facilitate the management of a large number of rooms. These functions are often made available in a web browser or by using an app on a smartphone.

A smart investment recommendation

Considering the challenges, we have developed and produced the DEOS SAM (**S**ensor-based **A**ir Quality **M**easurement) indoor air quality indicator – made in Germany. With our knowledge from over 54 years as a manufacturer and expert in the field of HVAC (heating, ventilation and air conditioning), we have long been concerned with the subject of indoor air quality. We know what is important. With DEOS SAM you are choosing a high-quality indoor air quality indicator with a multifunctional sensor for needs-based ventilation while reducing your energy costs at the same time. We attached great importance to the integration into smart overall systems. SAM can be integrated into existing automation systems over LoRaWAN enabling CO_2 driven ventilation control. Thanks to monitoring by app and mobile alerts when limits are exceeded, you are always well informed and can act as quickly as possible. A ventilation report helps prove optimal room ventilation for works councils or concerned parents.

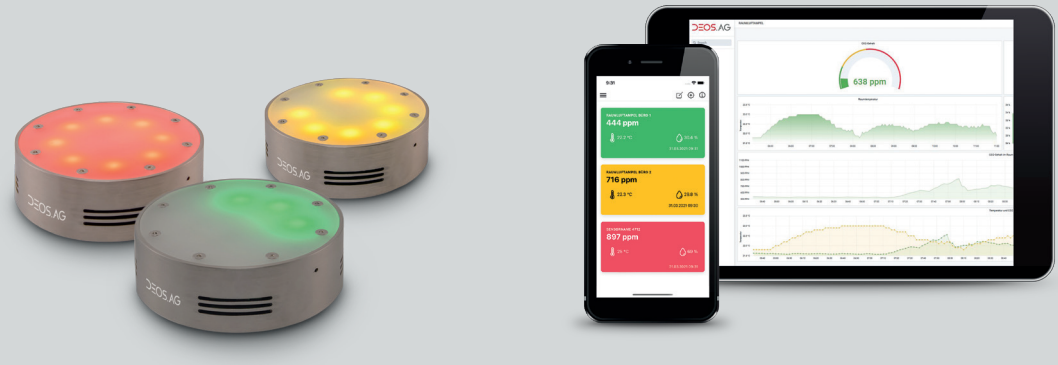

Figure: Indoor air quality indicator DEOS SAM with app for monitoring room air quality

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Summary

Both air filter devices and indoor air quality indicators have their merits. However, good and adequate ventilation is still necessary under any circumstances. Before deciding on an air filter device or an indoor air quality indicator, examine the on-site situation carefully and consider the advantages and disadvantages of each solution. Before purchasing air filter devices, weigh up the current filter and energy costs as well as the high investment costs, the filter change that must be carried out by a specialist including the costly disposal of filters and the high level of noise. Indoor air quality indicators show the correct ventilation interval. These devices also make sense because the acquisition costs are easy to plan and the subsequent operating costs are almost zero. They operate without noise, do not require maintenance and often offer clever additional functions for data storage and mobile alerts. As multi-sensors, these devices also record the data for air humidity and temperature to achieve a good room climate and energy-efficient room operation. Anyone who would like to benefit from such an investment in the long term should consider an indoor air quality indicator with an integration option.

A brief introduction to DEOS AG

Technology for intelligent buildings

As an owner-managed and internationally operating company, we have been developing and manufacturing intelligent products, solutions and services for the automation and digitisation of buildings and facilities for more than 54 years. With our passion for innovation and dedication to quality, we deliver a sustainable product portfolio that combines the fields of heating, ventilation and air conditioning into an efficient and forward-looking overall system with the help of the latest IT technology. The simple system integration of building technology plays a particularly vital role for us. Every day, our employees are committed to system partners, specialist planners, end customers as well as operators and building owners all over the world. We do this to ensure the energy-efficient and sustainable operation of buildings. For buildings that inspire.

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Find out more

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