Testo
White paper
Curbing the risk of infection

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Curbing the risk of infection in organisations– the impact and capabilities of state-of-the-art IAQ measuring technology.

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HVAC systems in organisations – opportunities and challenges

In organisational facilities, the requirements for monitoring IAQ parameters are particularly high. This is equally true for industries, offices, large kitchens or canteens or for the production and storage facilities. While ensuring thermal comfort levels to facilitate a good working environment and the recovery of patients, it is also particularly important to remove pollutants and ensure that employees and staffs are protected against infection.

Only a well-planned and reliably maintained HVAC system can provide optimal ambient conditions and prevent the concentration of airborne aerosols such as viruses or pollutants inside buildings. Depending on the classification of the room in question, it can simultaneously affect different IAQ parameters. These include air volume flow, degree of turbulence, pressure, humidity, temperature, CO2, sound and light. Regular comprehensive checks should be carried out on the target and actual operation of the system in terms of the relevant parameters using state-of-the-art measuring technology.

Poorly or non-maintained HVAC systems can impair the indoor climate and even increase the risk of infection. It is essential to keep this in mind, especially during times of crisis such as the global Covid-19 pandemic. In spite of the highly dynamic situation, the special HVAC requirements should be taken into account and their suitability and efficiency checked with the aid of precision measuring technology.

Professional measuring technology is also the basis for safe, reliable and standard-compliant operation of HVAC systems in extreme conditions. This is the only way for these systems to help curb the risk of infection via the ambient air and protect people.

Requirements for the inspection of HVAC systems: Guidelines and standards

Current guidelines and standards provide important and helpful information for the installation, maintenance and inspection of HVAC systems. Even if they are only considered to be recommendations, their observance significantly increases the safety, quality and efficiency of a system.

The operation of systems in healthcare facilities in Germany is governed by DIN standard 1946-4 and internationally by ANSI/ASHRAE/ASHE standard 170. Related to these are other standards such as the European DIN EN ISO 14644 (specifically for cleanrooms).

The following measurement parameters apply as minimum standards:

- Incoming air volume flow, outer air volume flow, exhaust air volume flow, overflow direction
- Air line leakage measurements
- Negative pressure in suspended ceiling cavities
- System sound pressure level
- Air filters, initial pressure loss in target volume flow
- Indoor comfort

For more detailed specifications on performance qualification, please refer to DIN EN 12599, which sets out the measuring and testing procedures in more detail. It comprehensively describes all common and special functional measurements.

In addition, DIN 1946-4 requires a hygienic acceptance test before commissioning a system built according to DIN standards. This includes documentation of all measurement locations and measuring results to enable a comparative repetition of the measurement at any time.

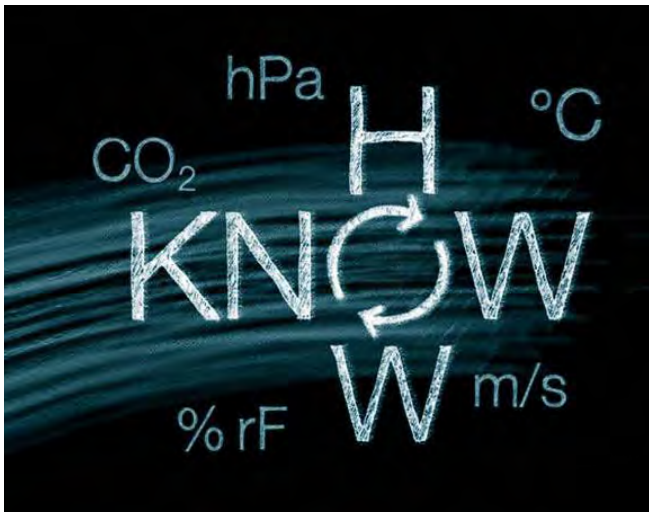
Studies show a correlation between the relative humidity and the survival time of viruses and the barrier function of the human body. At average relative humidity, viruses are inactivated much faster. In addition, people are more susceptible to infection at low relative humidity.

Sources:
https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0046789
https://www.pnas.org/content/116/22/10905

Which IAQ parameters are relevant?
Measuring technology requirements taking into account the occurrence of infections

The stricter IAQ standards in facilities pose correspondingly major challenges for the precision of measuring technology and the measuring procedure. This mainly involves determining the following parameters:

- Flow velocity, volume flow and air exchange rate
- Degree of turbulence
- Differential pressure, vacuum and overpressure
- Humidity and temperature
- CO2, sound and light.



All relevant IAQ parameters are defined in the standards and directives. The guidelines of professional associations provide information on country-specific limit values for indoor air quality, comfort and protection against infection.

Strict requirements in terms of measuring accuracy: flow velocity, volume flow and air exchange rate

The central parameter for assessing the functionality of an HVAC system is the air volume flow. The volume flow needed for a room is determined by the required air exchange rate, the size of which depends on the function of the room. Since, in practice, flow velocity in the duct cross-section is not uniform, a single point measurement does not suffice when it comes to determining the average air velocity. Sources of interference such as dampers or elbows affect the velocity profile in the duct. For this reason, a grid measurement has to be carried out at several points in the duct.

Various standards have been established worldwide that deal with the correct measurement of flow velocities in order to meet the quality requirements for determining the volume flow. In addition to EN 12599, which is the leading standard in Germany and large parts of Europe, DIN EN 16211 and ASHRAE 111 are also worth noting in this respect. All established procedures are based on the following approach:

- The measuring points are spread across the duct cross-section in line with certain specifications depending on the duct size.
- Rectangular and round ducts are differentiated.
- The readings are averaged.

More details about flow measurement can be found in our practical guide “Air flow measurements in ducts according to DIN EN 12599”.

> Go to practical guide

Measuring technology requirements:

The specific requirement for example in the healthcare system is primarily found in the stricter limit values and the associated conflicts of objectives, which are increasingly becoming a chal-lenge in practice. One example is the conflict between the required high air exchange rates and the air turbulence caused by them:
An insufficient volume flow can be highly problematic in health care. This is because narrowly defined air exchange rates are required to ensure adequate removal of pollutants and pathogens. Insufficient volume flows can also have a negative impact on the hygiene of the system itself. If the humidified air is moved too slowly in the ducts, there is a risk of germ formation in the system. To avert this risk and/or to comply with certain standards, HVAC systems in large offices & facilities are often operated with excessive air volumes. This excess demand not only results in the fan consuming more energy and air conditioning becoming more complex (cool-ing, heating, humidification or dehumidification), thus ulti-mately increasing operating costs. Scientific studies also indicate that excessive flow velocities in sensitive areas of health care can increase the risk of infection because they create air turbulence, which in turn promotes the spread of infectious aerosols. One of the reasons for this is thought to be the ability of particles, including droplet nuclei, to stay

airborne; their reabsorption via the respiratory tract depends, among other factors, on the buoyancy forces of turbulent airflow.[1]

Above all, measuring technology for determining flow velocities and volume flows in the healthcare system must therefore support the approach required by standards and guidelines in terms of its design, functionality and precision. Sophisticated sensors help to ensure that the measuring instruments also perform measurements that meet the highest demands on measuring accuracy, e.g. for fume cupboards. This is the only way to ensure a correct calculation basis for determining volume flows in building facilities.

However, the user-friendliness of the measuring technology also plays a crucial role in the quality of the measurement results. A user interface that guides the user step by step through the measuring process helps to prevent measuring errors.

Major impact on occupational safety and infection prevention: degree of turbulence

The degree of turbulence is the measure of the fluctuations in air velocity relative to its mean value (relative standard deviation). Turbulence affects two important parameters: thermal comfort and the level of risk of infection.

The measurement of turbulence and draughts caused by air flow provides relevant information to help ensure the well-being of employees and staff in indoor environments.

More details about thermal comfort levels can be found in our practical guide “Indoor air quality and comfort level in the workplace”.

> Go to practical guide

However, turbulence measurements can also help to reduce the risk of infection, as mentioned above. In sensitive areas in particular, the turbulence must be measured to ensure the occu-pational health and safety of staff and the protection of employees against infection. Measuring the degree of turbulence provides a way of accepting and inspecting large facilities.

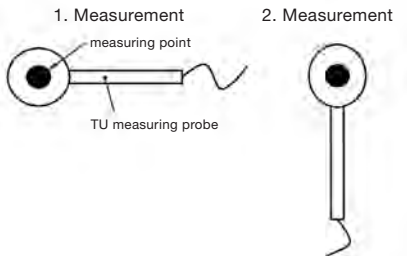
As defined in the German standard DIN 1946-4 as a measuring method for checking the protective effect of the low-turbulence displacement flow outlet in the protected zone by means of a grid measurement.

[1] English T. 2016. A brief history of healthcare ventilation, ASHRAE proceedings.

Measuring technology requirements:

As a result of strict regulations for maintaining optimum indoor air quality, the following requirements have to be met by measuring technology and accessories:

- A non-directional measuring system is to be used, with an averaging time of at least 100 s and at least 1 measured value per second.
- Probe response times at which 63% of the final values are displayed (t 63) must be <0.2 s.
- The measurement error of the velocity measuring instrument must not exceed ±0.05 m/s.
- For the second double determination, it must be possible to position the probes perpendicular to the direction of air flow on the measuring plane at 90° to the first double determination.



Arrangement of the turbulence sensors offset by 90° on the measuring plane (source: standard DIN 1946-4)

- All parameters and combinations of checked operating states must be documented in a test report with the associated test results.

High-precision measuring technology required: differential pressure, vacuum and overpressure

A pressure difference must be ensured between rooms of different room classes to prevent unwanted air exchange. An overpressure in the cleaner room ensures that no air flows back from the unclean area into the cleaner area when the doors are open. The room with the highest level of cleanli-ness itself is also accessed via personnel and material air locks where strong air currents whirl up existing particles and extract them via filter systems. Unclean rooms must in turn have a negative pressure to corridors in order to pre-vent the spread of contaminants via the air.

Measuring technology requirements:

Depending on the purity requirement of the indoor air, different HEPA (High Efficiency Particulate Air) filters are used in various facilities. When determining the differential pressure of the air supply filter, the pressure (back pressure) before the filter is compared with the pressure behind the fil-ter. The level of differential pressure is an indicator of the degree of contamination of the filter. As the measured pressures are very low, high-precision differential pressure measuring instruments must be used.

Control parameters for infection prevention: humidity and temperature

Indoor relative humidity and air temperature are established parameters in buildings when it comes to monitoring the thermal comfort of staff and employees. In recent years, the relative humidity of indoor air has increasingly become the focus of scientific research both as a control parameter and in terms of infection prevention. The correlation between the survival time of pathogens and relative humidity has been described in numerous studies.[2] Since the appearance of the coronavirus SARS-CoV-2, research efforts have intensified once again. For this new type of coronavirus, for example, it has been shown that relative humidity of over 40% at typical indoor temperatures impairs the survival of membrane-bound viruses.[3] Other studies, including those on coronaviruses, confirm that higher relative humidity also reduces the spread of the virus via indoor air. This is because larger, intact droplets containing virus particles are deposited more quickly on room surfaces. It is assumed that increased air humidity also irritates lipid-enveloped viruses, since interactions with the heads of the polar membrane can lead to conformational changes of the membrane and inactivation of the virus.

However, air humidity can also affect the immune response. Recent studies suggest that air humidity affects a person's susceptibility to viral infections and the settling of virus particles in the respiratory tract.

In accordance with the research findings, many experts recommend the use of humidifiers and a revision of the previously recommended limit values, especially for healthcare facilities.[4] This has also increased the urgency of monitoring humidity in organisational facilities by means of precision meas-urements.

Measuring technology requirements:

If the relative indoor air humidity is permanently above >80%, there is a risk of mould growth. Particularly when the HVAC system is shut down, harmful germs can spread on air filters or silencers if the dewpoint is exceeded. When balancing the optimum indoor air humidity and temperature ratio, it is therefore important to consider the respective functional range of a measuring point and to monitor the corresponding parameters without interruption.

This means that suitable measuring technology must meet several requirements:

- Be able to deliver highly accurate measurement results
- Support reproducibility of the measurement
- Enable time-defined or permanent monitoring of individual functional areas
- Ensure uninterrupted measurements and an automatic alarm function.

[2] Effects of air temperature and relative humidity on coronavirus survival on surfaces
2019 Novel Coronavirus (COVID-19) Pandemic: Built Environment Considerations to Reduce Transmission
Breathe Easy: Two basic steps to improve patient outcomes and healthcare reimbursement
Is low indoor humidity a driver for healthcare-associated infections?

[3] 2019 Novel Coronavirus (COVID-19) Pandemic: Built Environment Considerations to Reduce Transmission

[4] Breathe Easy: Two basic steps to improve patient outcomes and healthcare reimbursement

Monitoring upper limits: CO_2, sound and light

The measurement parameters carbon dioxide (CO2), sound and light minorly also have an indirect effect on the risk of infection in working facilities. The aim of monitoring these parameters is to create optimal conditions for staffs to improve the health, work and powers of concentration. Employees' comfort levels obviously need to be ensured as well.

The most important indicator of “good” indoor air quality is the concentration of carbon dioxide in the air. Too high a concentration of CO2 in indoor air leads to fatigue, lack of concentration and can even cause illness. This is why CO2 is an elementary parameter for ensuring thermal comfort, in facilities with many people working together at the same time.

In a similar way to poor indoor air quality, excessively loud ventilation systems or incorrectly adjusted light sources can also impair the performance of staffs and employees.

Measuring technology requirements:

In offices and plants in particular, optimal ambient conditions must be ensured, especially in the functional areas to reduce the risk of spread of infection. This includes precision measurement and limit monitoring of CO2, sound pressure (dB) and illuminance (lux). Consequently, mobile or stationary IAQ measur-ing technology should be equipped with appropriate probes or allow for flexible upgrade to cover these three measuring parameters.

Benefits of Testo state-of-the-art IAQ measuring technology in various sectors

High quality and accuracy

The ambient conditions in facilities must be recorded with high-precision measuring methods. It is only possible to guarantee constant and optimum ambient conditions by referring to reliable measurement data.

Testo can help you with this:

- High-precision fume cupboard probes for labs/cleanrooms with measuring accuracy of ±(0.02 m/s + 5% of m.v.)
- Turbulence probe with measuring accuracy of ±(0.03 m/s + 4% of m.v.)
- Vane probe for laminar flow measurement with ±(0.1 m/s + 1.5% of m.v.)
- Humidity probe with accuracy of <1%
- Differential pressure measurement with ±(0.3 Pa + 1% of m.v.) ±1 digit (0 to 25 hPa)
- Regular and automatic firmware updates

Sophisticated calibration concept and reliable service

Regular calibration of measuring instruments is required anywhere they are used in quality-related areas. Testo is not just a manufacturer of measuring technology, but also offers the relevant calibration services. Testo's digital probes can be calibrated independently of the measuring instrument. This means that the IAQ measuring instrument remains available and can still be used with other probes.

Maximum flexibility with an extensive modular probe concept

Testo's probe portfolio of multifunctional IAQ measuring instruments covers all relevant indoor air parameters for various industries and can be extended modularly. This means you only need one single measuring instrument for all applications!

Streamlined data management and software

Important data, such as the various measuring points and associated information and settings (e.g. duct geometry), can be created directly on the measuring instrument or with the associated software and can also be reproduced accordingly for recurring quality controls.

Intuitive user interface

The Smart-Touch technology display that even works with rubber gloves or control via the Cloud makes measurement really convenient and even more reliable and secure. The measurement data is instantly displayed in clear graphics. If mobile measuring instruments are used, such as the WLAN data logger, live data can be accessed anywhere at any time via the online app.

Comprehensive real-time documentation

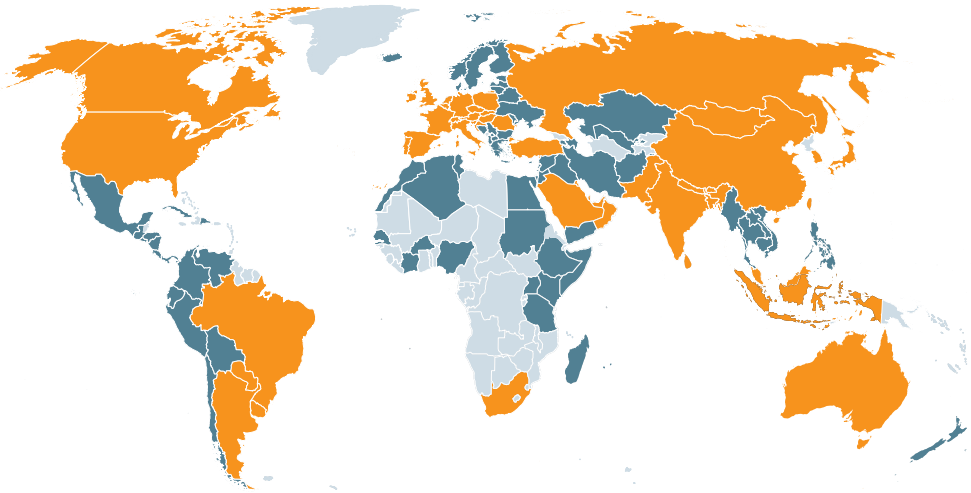
Measurement protocols are generated on the measuring device or with the software and can also be supplemented on site with photos of the measuring point or the measurement setup. These can then also be sent out directly by e-mail. With automated data monitoring using WLAN data loggers, data is automatically transferred to the Cloud at defined intervals, allowing the data to be documented and analysed in real time.

Continuous monitoring with alarm function

A WLAN data logger and cloud solution from Testo allow you to keep your eye on all critical parameters – and access them online too, anywhere and at any time. The system uses the alarm function to automatically alert you when defined limit values are exceeded.

More information at www.testo.com

About us: Introducing Testo.



Subsidiary
Retail partner

Testo, with its headquarters in Titisee-Neustadt in the Black Forest, Germany, is a world market leader in the field of portable and stationary measurement solutions. There are 3,000 employees involved in research, development, production and marketing for the high-tech company in 34 subsidiary companies all around the world.

Customers all over the world are impressed by the measuring technology expert's high-precision measuring instruments and innovative solutions for the measurement data management of the future. Testo products help save time and resources, protect the environment and human health and improve the quality of goods and services.

An average annual growth of over ten percent since the company's foundation in 1957 and a current turnover of over a quarter of a billion euro clearly demonstrate that the Black Forest and high-tech systems are a perfect match. The above-average investments in the future of the company are also a part of Testo's recipe for success. Testo invests about a tenth of annual global turnover in research and development.

More information at www.testo.com

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