PST PROCESS SENSING TECHNOLOGIES

CO_2 – It's Effects on Health and the Environment

As a greenhouse gas, carbon dioxide, better known as CO_2, is the gas that is most responsible for the warming of the atmosphere. Moreover, at higher concentrations in the air, it is harmful to human health. However, CO_2 does have positive properties in technical applications. Here a general view.

Video CO_2

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Guidelines for healthy indoor air – Download the free poster.

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What does the WHO say?

In 2014, the World Health Organization (WHO) published new guidelines, the "WHO guidelines for indoor air quality on household fuel combustion", thereby, for the first time, setting emission targets to address the serious health risks associated with fuel combustion. The regulations also target the use of unprocessed coal and paraffin, which heavily pollute indoor air. In this way, the WHO aims to minimize the risk of fires, burns and poisoning.

Clean, sustainable sources of indoor energy play an important role in mitigating climate change, particularly by reducing substantial carbon dioxide (CO_2) emissions. The WHO recommends that governments and other agencies develop and implement a strategy to mitigate climate change, consider building energy measures and undertake assessments to maximize health and climate benefits.

What is CO_2 and where do we encounter it?

The colorless and odorless gas CO_2 – or carbon dioxide – is a natural component of the air in an average concentration of 0.04 percent. It is produced both during combustion, e.g. when driving, heating, cooking, working or flying, and in the organism of living beings as a product of cellular respiration. Carbon dioxide is an important component of the global carbon cycle, which has a wide range of applications.

In the chemical industry it is used as a raw material for syntheses, and in beverages such as beer or sparkling wine it is produced by alcoholic fermentation. In others, it is added artificially, or it is offered as mineral water containing carbon dioxide. In solid form, it is used as dry ice, e.g. for cooling food at buffets, cooling drinks, etc., or it is used as a solvent and extraction agent.

Technical use of CO_2

In the technical field, carbon dioxide is used as an extinguishing agent in hand-held fire extinguishers and automatic extinguishing systems, for example, because of its oxygen-displacing properties. Under the designation R744, it is used as a refrigerant in vehicle and stationary air-conditioning systems, in industrial refrigeration, in supermarket and transport refrigeration and in beverage vending machines. In gas-cooled nuclear reactors of the AGR (Advanced Gas-Cooled Reactor) type, CO_2 is used as a coolant, and in welding technology as a shielding gas.

CO_2 is also used in modern lasers. Such carbon dioxide lasers or CO_2 lasers are used in various industrial applications, with various powers. In the low power range (up to approx. 400 W) they are used for cutting, perforating or engraving thin, organic materials such as wood, textiles, paper or plastics. CO_2 lasers with higher power of 1 to 6 kW are used for welding, hardening or re-melting metals.

In carbon dioxide lasers, the laser gas – a mixture of nitrogen, helium and carbon dioxide – flows through the discharge tube continuously. Along with solid-state lasers, it is one of the most powerful gas lasers in industrial use. The power range extends from 10 W to around 20 kW.

CO_2 is marketed in liquid form in pressurized gas cylinders. Carbon dioxide is also being used increasingly in conjunction with an automated blasting process to produce high-purity surfaces. With its combination of mechanical, thermal and chemical properties, carbon dioxide snow, for example, can dissolve and remove various types of surface contaminants without trace.

Effects on indoor air

The effect of CO_2 on indoor air or breathing air in particular is often underestimated and neglected. In high concentrations it can be life-threatening and is therefore particularly insidious because the danger cannot be recognized without a measuring instrument.

The maximum workplace concentration for a daily exposure of eight hours per day is 0.5%. At a concentration of 1.5%, minute ventilation increases by more than 40%. In physiological and slightly increased concentrations, carbon dioxide dissolved in the blood activates the respiratory center.

In significantly higher concentrations, it first leads to respiratory depression and finally to respiratory arrest. From about 5% carbon dioxide in inhaled air, headaches and dizziness occur; at higher concentrations, accelerated heartbeat, increased blood pressure, shortness of breath and unconsciousness occur, the so-called carbon dioxide narcosis. Carbon dioxide concentrations of 8% lead to death within 30 to 60 minutes.

High carbon dioxide concentrations frequently cause accidents in wine cellars, feed silos, wells and cesspits. There, fermentation processes produce considerable amounts of carbon dioxide. For example: when 1 liter of must is fermented, about 50 liters of fermentation gas escape.

Excessive CO_2 concentrations can also occur in catering establishments during the preparation of carbonated drinks. It is therefore imperative that the rooms in which the CO_2 is stored and used are monitored for prompt detection of leaks.

People often fall victim to fermentation gas poisoning because rescuers themselves inhale carbon dioxide during rescue attempts and become unconscious.
The rescue of a casualty from situations suspected of involving carbon dioxide is only possible by professional emergency workers wearing self-contained breathing apparatus.

A high carbon dioxide content becomes apparent in humans through rapid fatigue and increasing loss of concentration. In small offices and apartments where many people are present, or in classrooms and schoolrooms, these negative effects quickly become noticeable when air quality is reduced.

In order to initiate appropriate countermeasures such as an increase in the supply of fresh air, the control systems of modern ventilation and heating systems use not only measuring instruments for relative humidity and temperature (heating), but also indoor air and gas sensors, which record the CO_2 concentration as an important indicator of air quality. On the other hand, an increased CO_2 concentration can also be decisive for accelerated growth, such as with plants in greenhouses or with cells and bacteria.

CO_2 value and aerosols

Viruses and bacteria are transmitted, among other things, via aerosols. Aerosol droplets are tiny and thus so light that the gentle pressure of warm air flowing upwards is enough to keep them suspended. In dry air, droplets remain suspended in the air for longer. Aerosols are difficult to measure. Consequently, the carbon dioxide that is emitted together with the aerosols when breathing is measured. A lot of CO_2 is therefore synonymous with a high aerosol concentration.

Correct ventilation

For the best possible air exchange and efficient fresh air supply, periodic ventilation is preferable to tilted windows. The best way to do this is by cross-ventilation, opening opposite windows or doors to create a draught. Health authorities recommend opening windows fully and several times a day if possible. To avoid wasting heating energy unnecessarily, thermostats should be turned down during this time and windows should only be opened as long as necessary. The right time and the necessary duration for ventilation is indicated by the CO_2 value measured in a room.

Where and why is CO_2 monitoring essential?

Place	Solution
Indoor air, ventilation system	To achieve optimal ventilation for healthy indoor air, it is advisable to use a reliable sensor technology to measure the CO_2 concentration. It guarantees the right level of fresh air indoors.
Healthcare	Capnometry refers to a medical procedure to measure and monitor the CO_2 content of breathing air expelled from patients' lungs. These measurements lead to the most appropriate treatment for the patient. This results in a shorter recovery time for the patient.
Parking garages and tunnels	Vehicles that emit CO_2 move around in garages and tunnels. To ensure harmless air quality, good ventilation is necessary. However, continuous operation of a ventilation system is inefficient. CO_2 monitoring ensures efficient ventilation and thus healthy breathing air.
Beverage industry	Continuous measurement of the indoor air in breweries and restaurants minimizes the risk of excessive CO_2 concentrations. If the limit value is exceeded, an alarm is triggered immediately.
Transport with dry ice	Dry ice is often used as a coolant, especially in the medical sector. When it melts, the CO_2 content increases. When handling dry ice, the CO_2 content must therefore always be monitored to avoid concentrations that are hazardous to health.
Shelf life of food	The use of CO_2-controlled packaging and transport methods serves to extend the shelf life of food. This method results in less food thrown away due to short expiry dates of uncontrolled packaged products.
Poultry farming	For poultry rearing, a controlled CO_2 concentration is crucial for both breeding and animal-friendly and quick slaughter. Packaging with CO_2 ensures that the poultry meat keeps longer.
Greenhouses	CO_2 is a prerequisite for photosynthesis and thus responsible for plant growth. Effective CO_2 monitoring optimizes the growing season and increases yields. Different plants require different CO_2 concentrations to promote their development.
Ice stadiums	The CO_2 concentration in ice stadiums depends on several factors, such as the number of spectators, the type of fuel used in the ice resurfacing machine, the degree of ventilation, etc. An excessive CO_2 concentration poses a health risk to both athletes and spectators. Ventilation must therefore be measured and regulated as required.
Mushroom cultivation	The carbon dioxide content in the air is very important for growth in mushroom farms. Thanks to measurement of the CO_2 concentration, the optimal growth rate can be set. In addition, both temperature and humidity are controlled during mushroom growth, in dependence on the different growth stages.

CO_2 guideline values

350 - 450 ppm	400 - 1200 ppm	>1000 ppm	5000 ppm (0.5 %vol)	38000 ppm (3.8 %vol)	>100000 ppm (10 %vol)
Fresh air outdoors	Indoor air	Fatigue and loss of concentration become apparent	Maximum permissible value at the workplace during an 8-hour workday	Breathing air (direct exhalation)	Nausea, vomiting, loss of consciousness and death

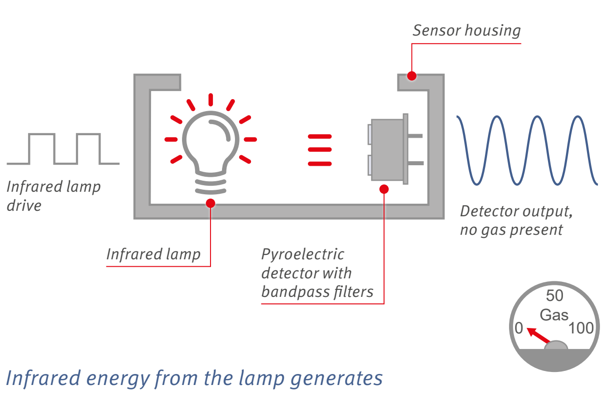
Measuring equipment for monitoring CO_2

Process Sensing Technologies offers reliable, calibrated and tested measuring instruments with different features and options for a wide range of applications: **CO_2 sensors** Dynament NDIR Standard or Dynament NDIR Platinum, SST CozIR-Blink, SST SprintIR and SST ExplorIR-M. **CO_2 transmitters** Rotronic CF1 for measuring indoor air in Minergie buildings, in ventilation ducts or in offices and other workplaces, as well as in climate chambers or incubators. **Handheld CO_2 measuring instruments** Rotronic CP11 and **CO_2 benchtop instruments** Rotronic CL11 for mobile air quality indication in rooms or for leak monitoring of filling systems. The eye-catching striking Rotronic **CO_2 Display** clearly visualizes the current CO_2 content of the indoor air as well as the point in time when new fresh air is necessary. The **CO_2 monitoring set** Rotronic RMS CCA-S-20X monitors the carbon dioxide content in incubators.

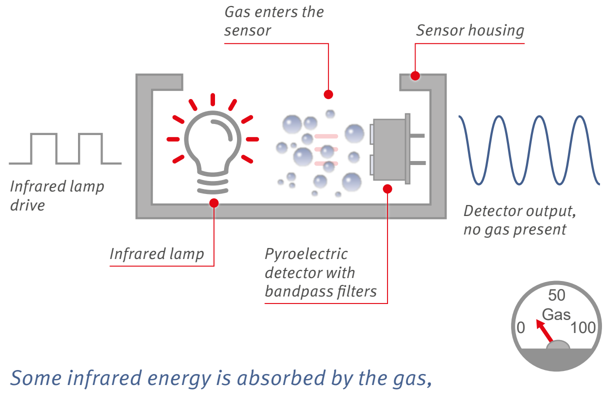
Working principle of CO_2 sensors

NDIR CO_2 sensors monitor and detect the presence of carbon dioxide based on the absorption of infrared light at a defined wavelength. An NDIR sensor consists of an infrared source, a light tube, a bandpass filter and a detector. The gas to be detected is determined by the choice of wavelength of the bandpass filter. For CO_2, the most commonly used wavelength is 4.26 µm. This wavelength is not absorbed by other commonly occurring gases or by water vapor, which greatly reduces cross-sensitivity and the influence of humidity and moisture.

In normal operation of an NDIR CO_2 sensor, the gas is pumped or diffused into the light tube. The receiving electronics then measure the absorption of the corresponding wavelength of light. The light absorption is converted into an analog or digital output signal that provides a measurement result in “parts per million (ppm)” or as a percentage volume. Put simply, the more light is absorbed, the more gas molecules are present, resulting in a lower output signal and thus a higher displayed CO_2 concentration.



Infrared energy from the lamp generates a signal at the detector.



Some infrared energy is absorbed by the gas, reducing the signal at the detector.

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