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Advantages of Infrared Detection over the Electrochemical Principle when Measuring Carbon Dioxide in Manholes

Before entering sewage plant drains, landfills, overflow reservoirs, or revision works in containers, multi-gas detectors must be used to protect personnel against combustible and toxic gases. Nowadays, in sewage plants and landfills a 4 to 6-gas detector like the Polytector G750 is commonly used.

The following hazards must be monitored:

1. Combustible gas-vapor-air mixtures, to prevent an explosion.
2. Oxygen deficiency, to make sure that entering without a breathing mask is possible. Oxygen surplus, to avoid explosion hazards.
3. Hydrogen sulfide, which builds up if organic processes are carried out without oxygen. Even small concentrations of hydrogen sulfide are toxic and act as a neurotoxin.
4. Carbon dioxide (CO_2), a gas that builds up in all organic processes and, under certain geologic circumstances, even diffuses into a drain from the soil or from a balance reaction with water. The carbon dioxide (CO_2) is, contrary to most other gases, 1.5 times heavier than air and therefore builds up in badly ventilated rooms in the ground. Once it is there it is hard to remove without actively ventilating the room. Its danger lies in displacing oxygen and in its toxicity, which starts at very low CO_2 concentrations.

This explains why the TLV (Threshold Limit Value) is set so low. CO_2 exists in a concentration of 6% volume in the alveoli (small cells in the lung) and gets breathed in by the alveolus membrane of the lungs. If the CO_2 concentration in the ambient air increases, this leads to a change in CO_2 concentration in the lungs and an increase of the CO_2 amount in the blood. Therefore, ph-changes into the acidic range lead to irritation of the respiratory system. Affected organisms try to reduce the CO_2 surplus by increasing respiration. The most sensitive system is the central nervous system. Reactions to high CO_2 concentrations include depression, tiredness, and narcotic effects leading to comas.

Measuring carbon dioxide via the displacement of oxygen in air is, although often discussed, impossible. Due to the fact

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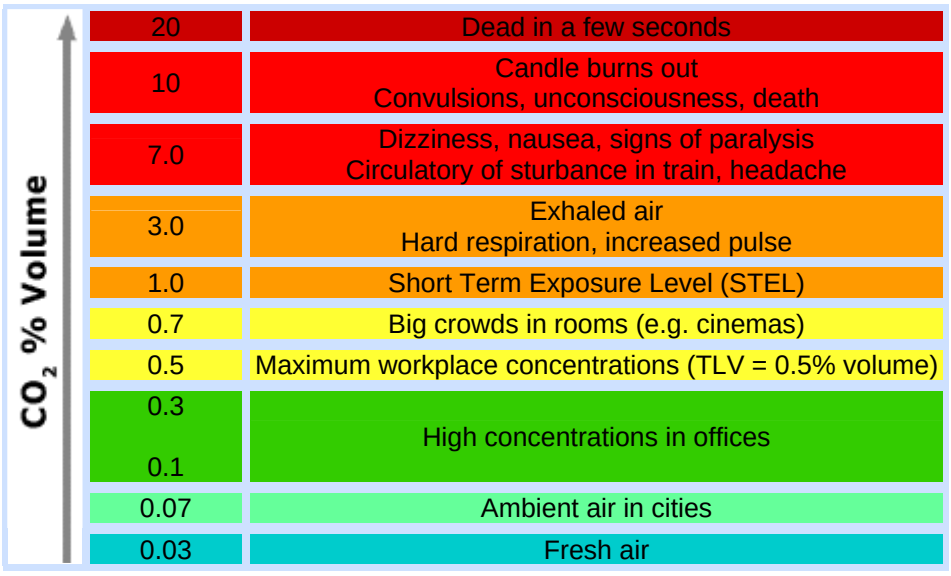
that only 1/5 of the ambient air consists of oxygen, the addition of gas only displaces 1/5 of the amount of oxygen. Most gas detectors give a first alarm for oxygen deficiency at 19% volume. This means that only at a presence of 1.9 * 5 = 9.5% volume CO_2 the first alarm would sound, and only at 19.5% volume oxygen would the main alarm be activated. At these concentrations you already face the danger of unconsciousness, death through suffocation, and paralysis of the nervous system within a few seconds.

While the detection principles for EX-, OX-, and hydrogen sulfide measurements in portable gas detectors have been in use for decades, the detection of CO2 with portable detectors has only recently become possible. You have to differentiate between two different sensor techniques for carbon dioxide measurement: electrochemical and infrared.

Effects of CO_2 in relation to concentration



Conclusion:
Nowadays, infrared sensing technology is the most appropriate for monitoring carbon dioxide (CO2) with portable instruments. The short lifetime of electrochemical sensors, the cross-sensitivity, the high follow-up costs, and the extreme drift make using an electrochemical sensor impossible not only for safety reasons, but also for economical reasons. As there is an adequate supply of multi-gas detectors that use the infrared technique, this detection principle is preferred.

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Electrochemical Sensor	Infrared Sensor
Sensor Lifetime	
1 year	More than 5 years
The electrolyte of an electrochemical CO_2 sensor decomposes after a certain time span. The lifetime of the sensor can dramatically deteriorate in the presence of CO_2 or other gases. **Manufacturer's notice:** Lifetime: 1 year, reduced by CO_2 exposure **Costs of sensor replacement (once a year)**: After the first year of operation, the electrochemical sensor is already more expensive than the IR sensor.	The infrared sensor has no mechanical parts that can wear out. Poisoning, as with electrochemical sensors, is impossible even at high gas concentrations.
Cross-sensitivity	
Electrochemical CO_2 sensors show a cross-sensitivity to many different gases: ammonia, chlorine, carbon monoxide, methanol, sulfur dioxide, nitrogen oxide, hydrogen, phosphine, and **hydrogen sulfide**. **In drains hydrogen sulfide is usually present.**	Infrared sensors measure selectively. No other gas interferes with the CO_2 measurement. Faulty alarms due to other gases are impossible. IR sensors have a comparably fast response time.
H_2S Selective Filter	
100 ppm of H_2S decreases the CO_2 measurement by 0.6% volume. A manufacturer of electrochemical sensors therefore stipulates that an H2S filter must be used. The filter only has a limited lifetime, which is reduced even more in the presence of H_2S. **Manufacturer's notice:** At 10 ppm H2S a filter has a lifetime of 15 days. **Cost per filter:** DM 71.00 The filter gets stuck to the sensor and this means that the sensor has to be torn apart to replace the filter.	No filter needed, due to the fact that H_2S does not interfere with or disturb the IR sensor. The CO_2 concentration is correctly displayed even with high amounts of H_2S.
Long-term Sensitivity Shift	
15% of the measurement value per month. According to the T031 information sheet of the BG-Chemie a calibration interval has to be chosen so as not to exceed a deviation of 5% of the measurement value. Therefore, an electrochemical CO_2 sensor needs to be calibrated every 10 days. The customer will not recognize the lack of sensitivity without checking the sensor.	Less than 0.4% of the measurement value per month. This means longer maintenance intervals and, as a result, reduced service costs.

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Pictures:
Polytector II G750 Multigas Detector

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