When is the air clean?

The top 12 FAQs for the topic clearance measurement

Poisonous or explosive hazardous substances are amongst the most frequent causes of accidents associated with work in confined spaces and containers.

A correctly and carefully performed clearance measurement before passing is therefore one of the most important safety measures and also essential for the risk assessment that is carried out whenever a confined space or container is entered.

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Basic knowledge and professional tips

Clearance measurement is one of the most demanding tasks that can be carried out with mobile gas detectors – this ranges from risk assessment to performing the measurement and evaluating the results. The person responsible for performing a clearance measurement must have in-depth expert knowledge about the properties of the various hazardous substances, handling of the instruments, specific features of the respective plant and much more.

Trainers at Dräger Academy know best what matters in practical application. During their seminars, they learn directly about the challenges and problems their participants encounter in practice. The most frequently asked questions in these seminars and what Dräger trainers reply is presented in the following.

1. Work is to be done in confined spaces and containers: when exactly should clearance measurements take place?

Shortly before operation – and this means: immediately before operation starts. If you decide to have lunch after having performed a clearance measurement and to release the space or container for passing without performing another clearance measurement, you could encounter a nasty surprise: Environmental factors such as temperature and ventilation can change the atmosphere immediately.

TIP

If there is the possibility that works could be interrupted or delayed after clearance measurement, position a mobile gas detector or (even better) a mobile area monitor such as the Dräger X-zone in a representative location of the container. If the atmosphere has changed and limits have been exceeded during your absence, the instrument will report alarm.

Observe the following, in particular during standstills: The preset alarm threshold does not necessarily correspond to the Workplace Exposure Limit (WEL). As working hours tend to be longer during standstills, reduction factors are often considered. These factors equalise the differences between the WEL temporal reference values and the actual working hours. A WEL refers to a total exposure time of 8 hours per day. However, usual working hours are 12 hours during plant standstills. In these cases, the alarm threshold of the gas detectors must therefore be lower than the WEL.

2. How often do function tests have to be performed?

Most manufacturers recommend to check the battery life, alarm function and display of their instruments before every use. In practice, international regulations apply as well as regulations that may vary from company to company. In Germany, for example, employer's liability insurance associations demand to check every mobile gas detector every working day. "Every working day, could be interpreted as every third shift", says Dräger Trainer Florian Mehlis. "Actually, I would not take and use a colleague's device that has already been in use for 16 hours without prior testing." The following systematic procedure has become common practice: Testing all available instruments prior to every shift and then storing them in a box which is accessible to every colleague.

By the way: Of course, an instrument may be switched off and later on again after a bump test, for example, if long distances have to be travelled to the site of work.

3. Why does a zero point adjustment have to be performed in a fresh air environment?

To determine the measurement reference point of the gas detector, it is necessary to calibrate the zero point. This ensures that the indicated values correspond to the actually existing gas concentration. To adjust the zero point correctly, calibration should be performed in an environment that really contains zero percent of the hazardous substance – ideally, in a fresh air environment.

If an instrument is used for the first time, another factor must be considered. The "original factory settings" of a gas detector are determined under very specific conditions. For example, Dräger calibrates its sensors in Lübeck, Germany, at an air pressure of 1,013.25 hP and a room temperature of 20°C. A significantly lower air

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pressure – for example at high altitudes – or an ambient temperature deviating significantly changes the physical reference points and thus can influence the measurement results.

Is your gas detector operational?

Ensure the following four steps before performing a clearance measurement:

1. Instrument testing with regard to battery life and display
2. Function testing
3. Fresh air testing
4. Leak testing of the entire system including hose and function testing of the pump

4. How can representative measuring points be determined?

If methane is to be detected and the gas sample is taken from the bottom of the container, it should become obvious to everyone that the risk of an explosion is still present. Methane is a light gas that very quickly mixes with the ambient air. The methane cloud tends to rise to the top. The gas concentration on the bottom of the container does not indicate how explosive the atmosphere is. If hydrogen sulphide is to be detected in a container, a gas sample taken from the upper part of the container is not reliable: With a molar mass of 34 g/mol, H2S is significantly heavier than air (29 g/mol) and thus sinks to the bottom. Both examples show: Measurements taken from the wrong location can in some cases lead to death.

As a rule of thumb: Light gases quickly mix with air, the volume of a cloud increases rapidly and the cloud rises to the top. Measurements in the open atmosphere should therefore be performed close to the leak. Increases in concentration take place in the upper parts of containers.

Heavy gases flow on the bottom like liquids, pass obstacles or stick to them, barely mix with the ambient air and have a high range. Measurement should be performed in the flow area on the bottom.

However, the molar mass and the physical properties of the hazardous substances to be expected are only two aspects important for

defining adequate measuring points. The following aspects must also be considered:

– Type and shape of the container or confined space: Almost no tank is in a 100 percent even position. Heavy gases accumulate where the bottom is low, light gases accumulate at the highest position. Bulges, installations etc. must also be considered.

– Temperature: If gases are heated – for example, because the sun has been shining on a tank for hours – molecules begin to move faster, whereby the speed of the diffusion (mixture with the ambient air) increases.

– Ventilation: Air currents change the position and concentration of gas clouds. Also important: The container in which works are carried out, cannot always be separated from the pipelines. In this case, it must be determined whether gas can flow in and additional suitable protective measures must be taken, for example, with regard to the personal protective equipment of the staff.

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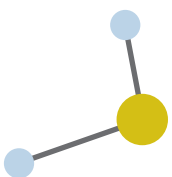
Decisive question

Is the hazardous substance to be detected heavier or lighter than air? Information on the density of the substances can be found in the safety data sheets.

5. How is it possible to determine whether a gas is heavier or lighter than air?[1]

For example, by comparing the molar mass of the compound with that of air (29 g/mol). The molar mass of the compound is calculated by the sum of the molar masses of the elements and by multiplying them by their index numbers. The relative atomic mass of each element can be found in the periodic table under the written out name of the element.



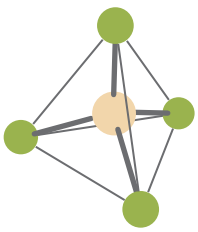
Hydrogen sulphide

$M(H_2S) = 2 \times M(H) + M(S)$

$M(H_2S) = 2 \times 1{,}01$ g/mol + 32,07 g/mol = 34,09

Result: $M(H_2S) > M(air)$

(hydrogen sulphide is heavier than air)



Methane

$M(CH_4) = M(C) + 4 \times M(H)$

$M(CH_4) = 12{,}01$g/mol + $4 \times 1{,}01$g/mol = 16,05

Result: $M(CH_4) < M(air)$

(methane is lighter than air)

6. A lack of oxygen in the atmosphere only becomes a hazard to people when the content falls below 17 percent. Why, for example, is a content of 20.5 percent already an alarming value in clearance measurement?

Because in an atmosphere with a slightly reduced oxygen content, the threshold values for explosive and hazardous substances may have already been exceeded.

Air consists of four fifths nitrogen and one fifth oxygen (the exact proportions are shown in the info box). If an inert gas is released into this mixture, not only will the oxygen content be reduced by the displacement, but also the nitrogen content – in fact, by four times. If, for example, 10 vol. % helium is released, oxygen concentration will be reduced by 2 vol. % and nitrogen concentration will be reduced by 8 vol. %.

Let us explain what this means by looking at it in reverse order: Suppose a gas detector measures an oxygen content of 20.5 vol. % in a container. The released gas has not only displaced 0.4 vol. % oxygen, but also 1.6 vol. % nitrogen – thus, a total of 2.0 vol. % of the unwanted substance is in the atmosphere. This is roughly equivalent to 20,000 ppm – a deadly concentration with regard to almost all hazardous substances.

As a rule of thumb: 5 vol. % carrier gas reduces the oxygen content by 1 vol. % in a confined space. 1 vol. % of a concentration is equivalent to 10,000 ppm.

Important

The oxygen value alone is not reliable. And an oxygen content of 20.9 percent does not mean that the air is free of hazardous substances!

1 When gas and air have the same temperature

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7. How do I convert vol. % to ppm or ppb?

Explosive gases such as methane, ethane and other hydrocarbons unfold their effect in the vol. % range. However, toxic gases (CO, Cl_2, H_2S, HCN, ...) in much lower concentrations are dangerous and are therefore measured in the ppm range.

Conversion formula
1 Vol.-% = 10.000 ppm = 10.000.000 ppb

8. Why should the carrying strap not be used for letting the gas detector down to the space or container, in which clearance measurement is to be performed?

Very simple: Because it is not possible to read the display, when the detector is hanging down from above. Sometimes people counter this argument with: If the detector let down to the container does not beep, there is no reason for an alarm and the container can be released for passing.

This is not strictly true. What if the measured value is slightly below the threshold value? If you read this result on the display, you would surely be alarmed – even if the alarm threshold were not exceeded.

9. When taking a sample, how long does a hose have to be flushed, before the measurement can be carried out?

According to one rule of thumb, a typical flushing time of approx. three minutes is required for each metre of hose plus 30 seconds. According to another one, a flushing time of five minutes is required at every measuring point per 10 metres of hose.

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What matters is: The exact duration of flushing may vary depending on the measuring task and diffusion behaviour. The density of the respective gases as well as the absorption and the conductivity of the hose wall must be considered when calculating the flushing time. Their level depends among others on the hose material: Viton®[2] is chemically more resistant than vulcanised rubber, has a lower wall adhesion and is resistant to solvents.

10. Should gas detectors be used with accessories – e.g. hoses or pumps – produced by other manufacturers?

The following rule also applies for respiratory protective devices: No, never. Your Dräger gas detector would probably be compatible with a hose produced by another manufacturer. But in the event of an incident or errors, no legal warranty can be assumed for this. This is because gas detectors are only approved for combination use with certain specified accessories – these accessories are specified in the so-called "Declaration of Conformity" (in the Technical Manual).

Important

A rubber hose is not suitable for measuring hydrogen sulphide – the material lets the H_2S molecules diffuse to the outside.

11. What should be documented in the clearance measurement protocol?

The protocol must state in which space or container and at which time clearance measurement was performed – and under which conditions. Thus, the following information is essential:

- Date and time and/or time period
- Container number and measuring point at the container, if there is more than one measuring point
- Measured hazardous substances
- Responsibilities (name of the person performing the measurement, supervisor)
- The instruments used for the clearance measurement, so that they are clearly traceable later on.

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2 Viton® is a registered trademark of DuPont

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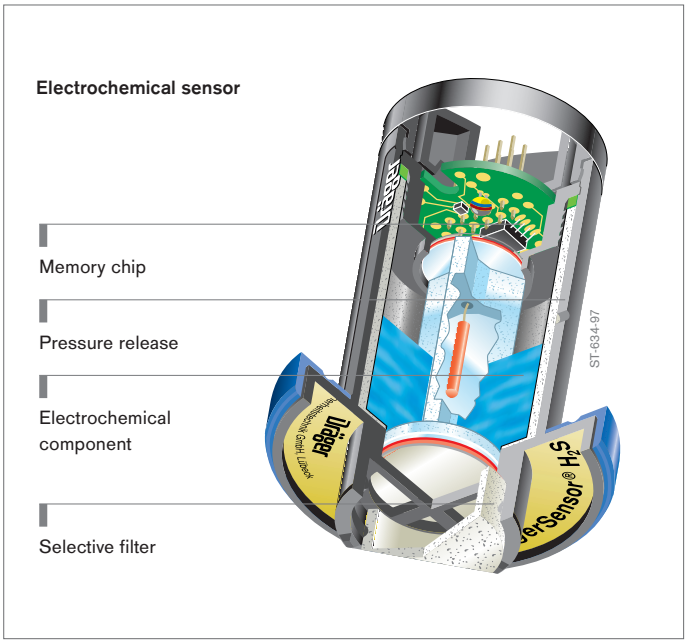
12. How do the different sensor types differ form each other?

Electrochemical sensors work in a similar way to batteries. When the target gas gets to the sensor, a small electrical charge is produced chemically between the two electrodes and is then indicated in the transmitter. The signal amplitude is proportional to the concentration.

Good to know:

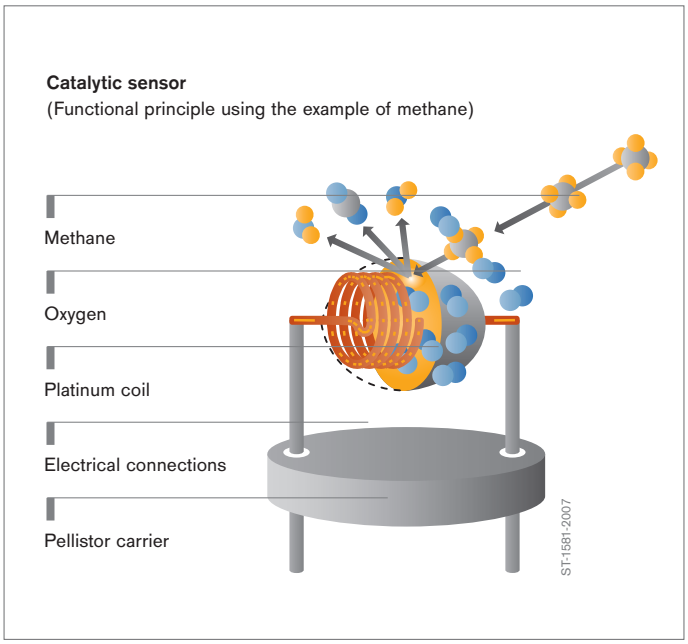
- There are electrochemical sensors for more than 100 toxic gases
- Ready for use in a temperature range from -40 to +65° Celsius
- Very robust, long service life
- Cross-sensitivities and thus false alarms can be reduced by selective filters



In **catalytic sensors,** the target gas in the sensors is combusted at a heated detector element, the so-called pellistor, using a catalyst. This oxidation produces a heat of reaction that increases the electrical resistance in a second pellistor. This pellistor measures the ambient temperature – the measured value is determined by the difference between the two signals.

Good to know:

- Catalytic sensors are able to detect more than 200 flammable gases and vapours – they are however not able to differentiate between those
- They require oxygen from the ambient air for the combustion process
- Risk of intoxication from sulphurous compounds (H_2S, SO_2) and halogenated hydrocarbons
- Heavy metals, leaded petrols, substances containing silicone and long-chain polymers can cover the catalyst



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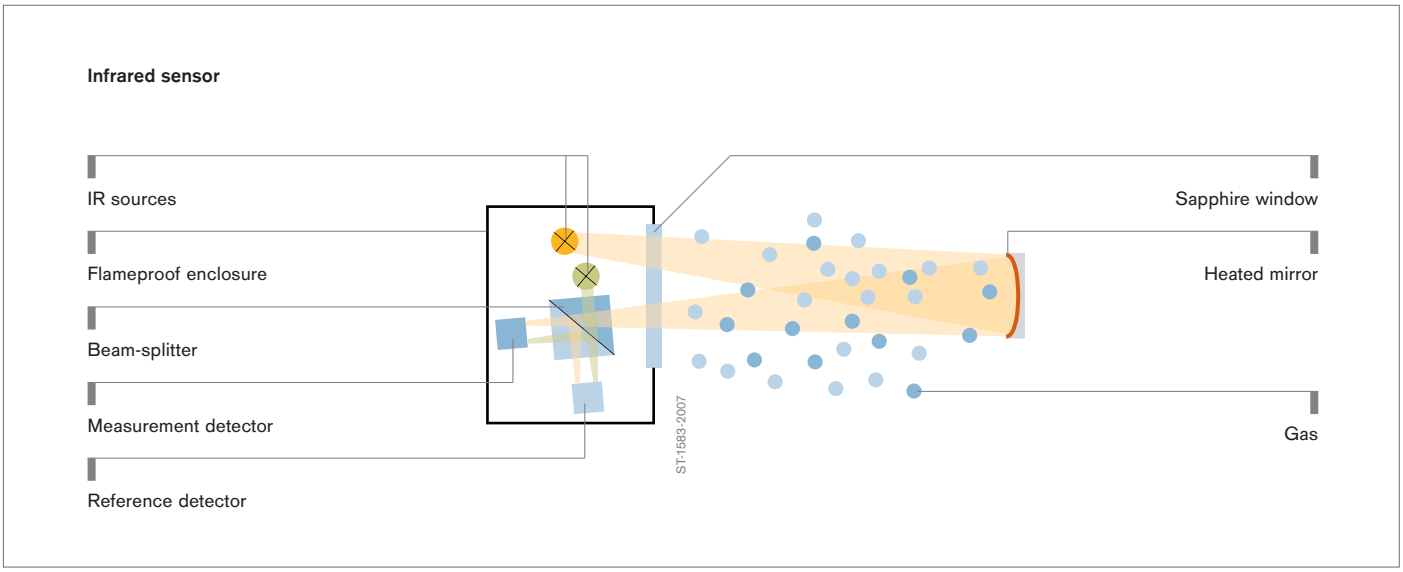
Infrared sensors make use of the fact that hydrocarbons absorb infrared radiation. This attenuation of light is detected by means of a light-sensitive pyrodetector in the sensor and is then converted into a signal by which the measured value is determined.

Good to know:

- Infrared sensors measure hydrocarbon compounds
- Wide range: concentrations from a few hundred ppm up to 100 vol. % can be measured
- No wear-out effects



Do you have further questions?

Then you are just at the right place: Dräger Academy seminars provide you with in-depth expert knowledge and all skills required for secure clearance measurements in containers and confined spaces on your plants through practical exercises.

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1 When gas and air have the same temperature

2 Viton® ist ein eingetragenes Warenzeichen von DuPont.

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