Handbook for Dräger-Tubes and MicroTubes
22nd edition

Dräger

Technology for Life

Handbook for Dräger-Tubes and MicroTubes

22nd edition

Dräger Safety AG & Co. KGaA
Lübeck, 2026

This handbook is intended as a reference for users. All information has been compiled to the best of our knowledge, however this does not imply any liability.

The information and data provided in this handbook are subject to change and may not always reflect current standards. Always refer to the instructions for use enclosed with the products when using Dräger products.

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Introduction

A range of new developments, improvements, and changes have affected the Dräger-Tube measurement technology since the last edition. The data section on the individual Dräger-Tubes and systems has been expanded and updated. Many of the images of the Dräger-Tubes that are described there are new, as an optimized production method led to an improvement in the color depth and color contrast of the various tubes.

The design of the present 22nd edition retains the layout and structure of the previous edition.

Lübeck, February 2026 Dräger Safety AG & Co. KGaA

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1 General Section

1.2 Introduction to Gas Detection Technology

From a chemical perspective, natural, dry air is a gas mixture that consists of 78 Vol% nitrogen, 21 Vol% oxygen, 0.03 to 0.04 Vol% carbon dioxide, as well as argon, helium, and trace concentrations of other noble gases. In addition, there is water vapor, i.e., the humidity in the air. If the concentrations of the components change or a foreign gas is added, we no longer have natural air. Depending on the change in concentrations of the typical components of air or the concentration of an additional component, this can potentially impact human health.

The spectrum of additional components of air can be extremely diverse. This ranges from the pleasant scent of a nice perfume to the overpowering stench of hydrogen sulfide. Not all of these "air pollutants" pose the same hazard. The key factor is the nature of the substance, the concentration, and the exposure time as well as any synergistic effects in mixtures of certain substances. On the other hand there are also air pollutants that are not perceived by human senses, such as the colorless and odorless carbon monoxide.

So if the composition of natural air changes in any way, a check is generally required to determine what or which substance is causing this change. Even substances with distinctive odors cannot be reliably assessed as to their concentration or hazard, as the sense of smell becomes desensitized over a certain period of time. After a couple of hours, we do not even perceive the pleasant fragrance of our own perfume, while higher concentrations of hydrogen sulfide, for example, are no longer noticed by our sense of smell after a very short space of time.

Sometimes the nose is more sensitive to certain air contaminants than necessary. In such cases, substances are perceived even at concentrations so low that they do not affect health, even after extended exposure periods. These are usually solvents, some of which only have an impact at higher concentrations. In these cases, your nose is simply signaling that the air contains a component that is not usually there. Despite this, it is important to determine the nature and concentration of one or more components that are not normally contained in natural air. This is where the demand for objective gas analysis becomes apparent. Gas detection technology is required as a technical tool, as the sense of smell cannot perceive all substances and assessing concentration without a gas detector is effectively impossible. The concentration of an air-polluting gas needs to be measured to assess, together with the exposure period and other parameters such as the type of activity, whether the specific air pollutant is dangerous.

But the hazard posed by an air pollutant cannot be determined by the concentration alone. For instance, if smoking a cigarette only generated carbon monoxide, this would be much safer, as carbon monoxide is eliminated by the body with a half life of 2 hours. The greater health concern arises due to the synergistic effect of the more than 800 individual components in cigarette smoke as well as the physiological condition of the smoker.

So, to determine the potential hazard from gaseous air pollutants, we need to determine the concentration using suitable gas detectors. The kind of device to be used depends on which gases have to be measured and how often. Much to the dismay of both the user and the manufacturer, there is no universal device which measures all possible gases or vapors. The variety of substances is too wide for a single type of measuring device to measure all possible air pollutants. The more complex a substance mixture, the more complex the gas detection technology has to be. The more is known about a substance or substance mixture, the easier the measuring task.

Different detectors or measurement methods based on different principles may need to be used. The gas detector industry offers a range of devices to be used depending on the measuring task:

- Flame ionization detectors
- Photoionization detectors
- Gas chromatographs
- Infrared spectrometers
- UV-VIS photometers
- Warning devices for explosion hazards
- Dräger-Tubes
- Dräger X-act 7000 with MicroTubes
- Laboratory methods with sampling tubes or impringers
- Mass spectrometers
- Detectors with, for example, electrochemical sensors

The choice of detector or measurement method depends, among other things, on the substance and how frequently it needs to be measured. Each of the devices and methods mentioned above has its advantages and disadvantages as well as its operation limits. Just as there is no universal detector that covers all eventualities, so too is there no single gas detection method that only has advantages. When it comes to choosing the right device, Dräger Safety AG & Co. KGaA offers expert know-how to help the user solve their measuring task.


D-6491-2017
Dräger X-am 8000

For instance, photoionization and flame ionization detectors are distinguished by short response times, but do not offer any substance selectivity. Gas chromatographs and UV-VIS photometers provide extensive measurement capabilities, but are relatively expensive and require a specialist to calibrate the devices and correctly interpret the measurement results. Gas detectors such as the Dräger X-am 8000 are fitted with catalytic and electrochemical sensors. For example, these devices are used to provide a visual and acoustic warning of explosion hazards or harmful concentrations of selected substances at the workplace. However, to work correctly, the user needs to check the sensors using test gas. This is the only way to achieve a reliable and correct measurement and warning of gas hazards.

Today there are more than 220 types of short-term Dräger-Tubes and more than 500 different substances can be measured via cross-sensitivities. What's more, the easy-to-use and read Dräger-Tubes are already calibrated by the manufacturer. If Dräger-Tubes indicate negative results (substance not present), this does not rule out the presence of other hazardous substances. The tube should then be removed from use, even if a negative result is registered. Humidity, temperature, and other gases during the first measurement can influence the second measurement.
For example, if a large number of measurements of the same substance are carried out daily, a gas detector such as the Dräger Pac 6500 CO with an electrochemical sensor for measuring carbon monoxide is superior to the Dräger-Tube for economic reasons.

In the not altogether uncommon real-world case that complex substance mixtures, such as solvent mixtures, are present, there is usually only the option of using laboratory methods for gas detection. Typically, activated charcoal tubes are charged with air containing pollutant, sealed, and analyzed in a laboratory.

After sampling, the laboratory uses gas chromatography methods for analysis. Occasionally, depending on the task, this occurs in combination with mass spectrometry. These kinds of laboratory methods naturally provide a particularly high selectivity. But the required analyzers are very expensive and need to be serviced and operated by specialists.
There are different measurement methods, systems, and processes for the different areas of gas detection technology, whether this be process control or air monitoring at the workplace. The various gas detectors primarily differ in their specific measurement principle. Nowadays, for example, Dräger-Tubes are considered traditional gas detectors.

No matter which gas detector or analysis method is used, in all cases, the specific contaminant of interest must be measured directly without exception. Apart from a few exceptions in process monitoring, it is highly unlikely that concentrations of other substances will be able to be determined by differential measurement. For example, if the oxygen concentration is below the 17 Vol% limit, the oxygen measurement alone does not tell you which other substance is displacing the oxygen. Can we assume, as in the case of a very high carbon dioxide concentration, that there is "only a risk of suffocation", or could there also be an explosion hazard, for instance if methane has entered a sewer from a leaking natural gas pipeline? Other substances that may be present in the ppm or ppb range would not even be detected during the oxygen measurement. This is concerning as many occupational exposure limits are in a magnitude of 1 ppm or less, whereas contaminant concentrations even in a magnitude of 1,000 ppm can only be detected in the third decimal place using an oxygen differentiation measurement.

D-23415-2009

Dräger-Tubes

D-3205-2024

Laboratory analysis by Dräger Analytical Services.

Before any gas detection, the boundary conditions need to be determined, i.e., which substances are to be measured at what times and where, etc. This approach is particularly appropriate for workplace measurements, as this enables the targeted use of the correct method in consideration of the costs. Different approaches may be better in other situations, such as in case of accidents involving chemicals. As a general rule, more knowledge about the substance to be measured can considerably reduce the time and effort involved in gas detection. On the other hand, it is also clear that the time and effort can increase exponentially if no additional information is available.

1.2 Concentrations and their Conversion

Concentrations are indicated as the content of a substance in a reference substance. To measure contaminants in the air, the quantity of the substance is defined as a concentration related to air. An appropriate unit then needs to be selected to obtain clear and useful figures indicating concentration.

High concentrations are usually indicated in volume percent (Vol%), i.e., 1 part of a substance in 100 parts air, e.g., air is comprised of 21 Vol% oxygen, i.e., 100 parts air contain 21 parts oxygen.

For small concentrations, the unit ppm = parts per million (mL/m³) or ppb = parts per billion (µL/m³) is used. A concentration in ppm refers to 1 part of a substance in 1 million parts air (roughly equivalent to 1 sugar cube in a fuel tanker). A concentration in ppb refers to 1 part of a substance in 1 billion parts air (roughly equivalent to 5 people of the Earth's entire population).

Converting these very small concentrations to Vol% results in the simple relationship:

1 Vol% = 10,000 ppm = 10,000,000 ppb

Besides gaseous components, air can also contain "dissolved" solid or liquid substances called aerosols. As the small size of airborne droplets or particles means that there is little point in supplying volume information, the concentration of aerosols is indicated in mg/m³.

			Vol%	ppm	ppb
Vol%	=	10 L/m³ 1 cL/L	1	10^4	10^7
ppm	=	mL/m³ µL/L	10^{-4}	1	10^3
ppb	=	µL/m³ nL/L	10^{-7}	10^{-3}	1

			g/L	mg/L	mg/m³
g/L	=	10 L/m³ 1 cL/L	1	10^3	10^6
mg/L	=	mL/m³ µL/L	10^{-3}	1	10^3
mg/m³	=	µL/m³ nL/L	10^{-6}	10^{-3}	1

As every volume is related to a corresponding mass, volume concentrations of gaseous substances can be converted into mass concentrations and vice versa. However, these kinds of conversions must take place at a set temperature and pressure, as gas density is dependent on temperature and pressure. For measurements at workplaces, 20 °C and 1,013 hPa are used as the reference parameters. Conversion takes place using simple formulas.

Converting mg/m³ to ppm

$$c_{[ppm]} = \frac{\text{Molar volume}}{\text{Molar mass}} \, c$$

The molar volume of any gas is 24.1 L/mol at 20 °C and 1,013 hPa; the molar mass of the specific gas must be used in each case.

Example for acetone:

Molar volume	24.1	L/mol
Molar mass	58	g/mol
Assumed concentration	876	mg/m^3

$$c_{[ppm]} = \frac{24.1}{58} \, 876$$

Sought concentration in ppm: c = 364 ppm or mL/m^3.

Converting ppm to mg/m^3

$$c_{[mg/m_3]} = \frac{\text{Molar mass}}{\text{Molar volume}} \, c$$

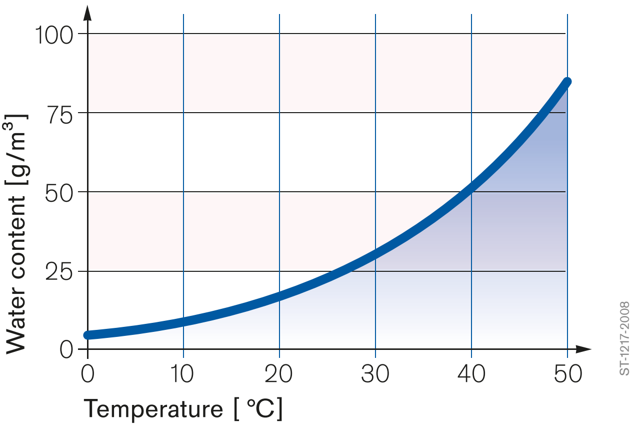
With the assumed concentration of 364 ppm, this is:

$$c_{[mg/m_3]} = \frac{58}{24.1} \, 364$$

Sought concentration in mg/m^3: c = 876 mg/m^3.

1.3 Water Vapor and Humidity

Water vapor is present everywhere in the atmosphere and is commonly called humidity. This water vapor has countless sources, after all the Earth's surface consists of two thirds water. Humans also "produce" water vapor as a metabolic product, in addition to carbon dioxide, with each breath that is exhaled.



The maximum water vapor content of the air depends on the temperature, i.e., the relative humidity must always be considered in the context of the temperature. The diagram or table can be used to convert relative humidity to absolute humidity. The conversion can also be done using a calculator:

$$Y = 3.84 \cdot 10^{-6} \cdot \vartheta^4 + 2.93 \cdot 10^{-5} \cdot \vartheta^3 + 0.014 \cdot \vartheta^2 + 0.29 \cdot \vartheta + 4.98$$

Where y = maximum absolute humidity in mg H_2O/L and ϑ = temperature in °C. This formula applies for a temperature range between 0 and 100 °C.

For example, what is the absolute humidity where ϑ = 25 °C? Using the formula, the result is y = 22.94 mg H_2O/L. The result indicates that at 25 °C, the maximum absolute humidity is 22.94 mg/L, which corresponds to a relative humidity at the same temperature of 100 %.

Every other absolute humidity at this temperature can easily be calculated, e.g., 50 % relative humidity at 25 °C equals 11.47 mg/L, etc. By contrast, if only the relative humidity and corresponding temperature are known, the absolute humidity at the given temperature is calculated using the above formula, the result of which provides the value for the absolute humidity.

When working with Dräger-Tube or MicroTube measurements, knowledge of the extent of the humidity is important, as for many components the water vapor concentration, e.g., when measuring hazardous substances at the workplace, is more than 1000 times higher than the relevant occupational exposure limit. For example, at 20 °C, 10 ppm hydrogen sulfide corresponds to 15 mg/m^3, while the humidity at the same temperature is 17.23 mg/L or g/m^3.

A general statement on the effect of humidity on the Dräger-Tube readings cannot always be made. For some tubes, such as the hydrogen sulfide tube, only a minimal amount of water vapor is required, as the indicating principle for this tube is based on an ion reaction. Due to the extraordinarily low solubility of metal sulfides, the upper limit of the humidity is not relevant for these tubes. In other types of tubes, the reaction system may be diluted if the humidity is too high. The humidity limits must therefore be observed to prevent incorrect measurements.

The permissible humidity limits are provided in the instructions for use of the Dräger-Tubes. If in doubt, also measure the humidity using Dräger-Tubes, for example.

Relative humidity in %

mg/l	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38 °C
2	29	27	26	24	23	21	20	19	18	17	16	15	14	13	12	12	11	10	10	9	9	8	8	7	7	7	6	6	6	5	5	5	5	4
3	44	41	38	36	34	32	30	28	26	25	23	22	21	19	18	17	16	15	15	14	13	12	12	11	10	10	9	9	9	8	8	7	7	7
4	59	55	51	48	45	43	40	37	35	33	31	29	28	26	25	23	22	21	19	18	17	16	15	15	14	13	12	12	11	11	10	10	9	9
5	73	68	64	60	57	53	50	47	44	41	39	37	34	32	31	29	27	26	24	23	22	20	19	18	17	16	16	15	14	13	13	12	11	11
6	88	82	77	72	68	64	60	56	53	50	47	44	41	39	37	35	33	31	29	27	26	25	23	22	21	20	19	18	17	16	15	15	14	13
7	—	96	90	84	79	74	70	65	61	58	55	51	48	45	43	40	38	36	34	32	30	29	27	26	24	23	22	21	20	19	18	17	16	15
8	—	—	—	96	91	85	80	75	70	66	62	59	55	52	49	46	44	41	39	37	35	33	31	29	28	26	25	24	23	22	20	19	18	17
9	—	—	—	—	—	96	90	84	79	74	70	66	62	58	55	52	49	46	44	41	39	37	35	33	31	30	28	26	26	24	23	22	20	20
10	—	—	—	—	—	—	—	93	88	83	78	74	69	65	61	58	55	52	48	46	43	41	39	37	35	33	31	29	29	27	26	24	23	22
11	—	—	—	—	—	—	—	—	96	91	86	81	76	71	67	64	60	57	53	50	48	45	43	40	38	36	34	32	31	30	28	27	25	24
12	—	—	—	—	—	—	—	—	—	—	94	88	83	78	74	69	66	62	58	55	52	49	46	44	42	40	37	35	34	32	31	29	27	26
13	—	—	—	—	—	—	—	—	—	—	—	96	90	84	80	75	71	67	63	60	56	53	50	48	45	43	41	38	37	35	33	32	30	28
14	—	—	—	—	—	—	—	—	—	—	—	—	97	91	86	81	77	72	68	64	61	57	54	51	49	46	44	41	40	38	36	34	32	30
15	—	—	—	—	—	—	—	—	—	—	—	—	—	97	92	87	82	77	73	69	65	61	58	55	52	49	47	44	43	41	38	37	34	33
16	—	—	—	—	—	—	—	—	—	—	—	—	—	—	98	93	87	82	78	73	70	66	62	59	56	53	50	47	46	43	41	39	36	35
17	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	98	93	88	82	78	74	70	66	62	59	56	53	50	49	46	44	41	39	37
18	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	98	93	87	83	78	73	70	66	63	59	56	53	51	49	46	44	41	39
19	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	98	92	87	83	77	74	70	66	63	60	56	54	51	49	46	43	41
20	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	97	92	87	82	77	74	70	66	63	59	57	54	51	49	45	43
21	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	96	91	86	81	77	73	69	66	62	60	57	54	51	48	46
22	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	96	90	85	81	77	73	69	65	63	59	56	54	50	48
23	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	94	89	84	80	76	72	68	66	62	59	56	52	50
24	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	98	93	88	84	79	75	71	69	65	62	58	55	52
25	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	97	92	87	82	78	74	71	68	64	61	57	54
26	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	96	91	86	81	76	74	70	67	63	59	57
27	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	94	89	84	79	77	73	69	66	61	59
28	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	97	92	87	82	80	76	72	68	64	61
29	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	96	91	85	83	78	74	71	66	63
30	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	99	94	88	86	81	77	73	68	65
Air temperature	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38 °C
100 % saturation ($mg\ H_2O/l$)	6,8	7,3	7,8	8,3	8,8	9,4	10,0	10,7	11,4	12,1	12,8	13,6	14,5	15,4	16,3	17,3	18,8	19,4	20,6	21,8	23,0	24,4	25,8	27,2	28,7	30,3	32	34	35	37	39	41	44	46

Absolute and relative humidities at different air temperatures

ST-1218-2008

1.4 Dräger VOICE Hazardous Substances Database

The Dräger VOICE hazardous substances database provides up-to-date information on over 1,600 hazardous substances, along with recommendations for measuring these hazardous substances and protecting yourself from them. There are also notes provided on the handling and use of the recommended products. Dräger VOICE starts with a search screen, which is used to access the desired hazardous substance by entering the CAS, EINECS or UN number, the chemical formula, or the substance or a synonym.

A range of continuously updated substance information can then be accessed for every selected substance:
- German and international limit values
- Various physical and chemical properties, such as molar mass, density, melting and boiling points, as well as explosive limits in air
- Markings, such as the globally harmonized system for the classification and marking of chemicals
- Synonyms

Dräger-Tubes that are recommended for detecting the selected substance are categorized as short-term and long-term tubes as well as the MicroTubes system. The following information is usually provided about the products:

- Picture and enlarged view
- Order number
- Overview of the measuring ranges of the various measuring specifications and cross-sensitivities
- Related products

The Dräger VOICE hazardous substances database is available directly online at www.draeger.com/voice.

The Dräger VOICE app

VOICE is now also available as a free app for iOS and Android – for online and offline use. The app is easy to use and provides a fast and efficient search function that lets you research up to three substances simultaneously.

1.5 Mobile Data Collection with the New Dräger-Tubes App

D-16313-2016

Dräger-Tubes app

Gas measurements with Dräger-Tubes can now be digitally documented. This is made possible using Dräger's free app for iOS and Android. This eliminates the need for laboriously entering data in hard-copy forms. Instead, this can all be done using a smartphone in just a few steps and in 17 languages: scan the tube, carry out the measurement, record the data, and send the measurement protocol by WhatsApp, email, or another messenger service.

Dräger-Tubes are used in a wide range of areas, such as in industry, by fire departments, in mining, and in shipping. Essentially, they are used whenever the concentration of a certain substance needs to be determined quickly and reliably. But the measurement results are currently still manually entered in a protocol. This involves a lot of maintenance effort, slows down processes, and may even lead to errors.

The Dräger-Tubes app now makes the entire measurement and documentation process much more convenient. The app provides great benefits, particularly when an environment needs to be cleared for safe entry. Measurement data can be transmitted to a remote safety engineer for assessment much more quickly. This engineer can then immediately make their recommendations for action.

How the app works

Before measuring, the barcode on the Dräger-Tube packaging is scanned using a smartphone. The app identifies the tube and automatically loads the relevant data into the protocol provided. This means that the person assigned to conduct the measurement only has to read the value off the tube and enter it after measurement. Photos can also be added for better documentation and additional details on the location, temperature, and humidity can be recorded.

DGT-1133-2017

App symbol

Dräger-Tubes app for iOS

Dräger-Tubes app for Android

The option of setting up a personalized user profile as well as the use of favorites lets the user access data with a single click. The time-consuming, recurrent entry of data is a thing of the past. What's more, the measured values can be graphically displayed and analyzed.

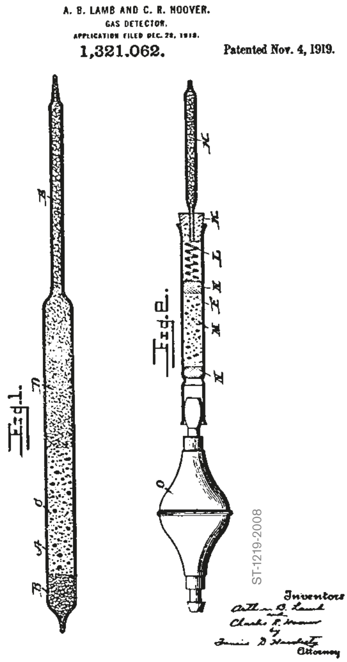
The app reliably stores all protocols in the cellular phone's memory. For comprehensive documentation, individual protocols can also be merged to form reports. The data can be quickly and easily forwarded by email, WhatsApp, or other messenger services.

2 Dräger-Tubes and their Applications

2.1 The Dräger-Tubes Measurement Technology

Today, gas detector tubes are considered a classic measurement method for gas analysis.

The first tube patent was issued in America in 1919. Two Americans, Lamb and Hoover, impregnated pumice with a mixture of iodine pentoxide and sulfuric acid, and filled the compound in glass tubes. At the time, this compound was called "Hoolamite". And so the first chemical sensor for measuring, or rather detecting, carbon monoxide was born. Before that, the coal mining sector used canaries, which were said to have a certain sensitivity to carbon monoxide. This first gas detector tube only allowed the qualitative detection of carbon monoxide, there was no such thing as quantitative measurement at the time. But the name has remained the same.



Patent drawing by Lamb and Hoover

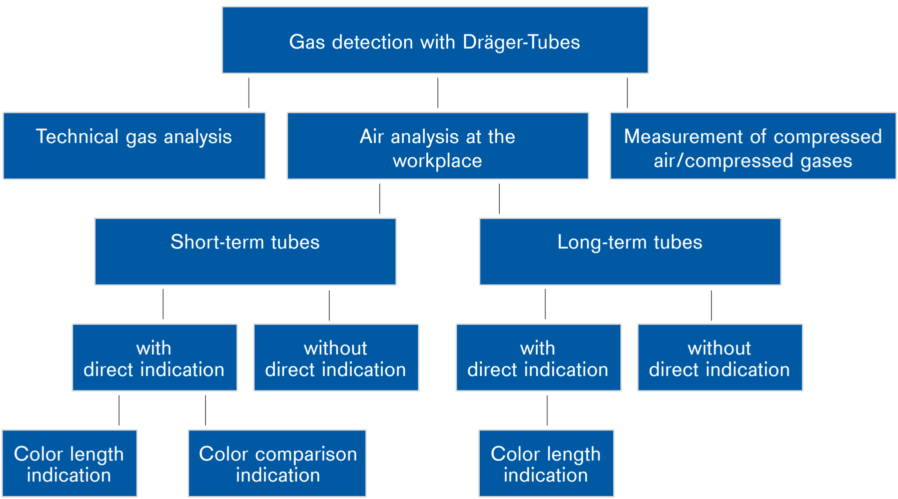
Today, the measurement accuracy and selectivity of Dräger-Tubes differ considerably from the tubes used in those times. Dräger-Tubes have been around for more than 80 years, making them a long-standing "traditional" product of Dräger Safety AG & Co. KGaA. At first glance, the basic structure has barely changed from the time of the first tube patent, but the content certainly has. So what exactly is a gas detector tube? Put simply, it is a vial that contains a chemical compound that reacts with the measured substance by changing color. In the figurative sense, the tube is a "preserved laboratory" that conducts an automatic chemical analysis. To ensure an appropriate storage time or stability of the analytics, the tips of the tube are fused at both ends. The vial therefore also provides a chemically inert packaging for the inner workings. Most Dräger-Tubes are scale tubes and

Dräger gas detector, 1950

the length of the color zone is a measure of the concentration of the measured substance.
The printed scale allows direct reading of the concentration. This makes any calibration by the user unnecessary, as the calibration is already received in the form of the scale. Of course, the length of the color is not a direct measure of concentration but, strictly speaking, is a measure of the mass reaction of the air contaminant with the compound in the Dräger-Tube. As the information that 25 mg of carbon monoxide has reacted has little practical value, calibration typically takes place in the concentration units ppm or volume percent.

The main area of application was and still is the measurement of air contaminants at workplaces in the concentration ranges of the OELs (occupational exposure limits). Falling limit values necessitate more and more sensitive Dräger-Tubes. Other possible applications, such as long-term measurements, require special Dräger-Tubes that allow measurements to be performed over many hours.
Schematically, Dräger-Tubes can be classified according to the following criteria:

Dräger-Tube Nitrogen Dioxide 2/c



The first distinction is made according to the fundamentally different areas of application:

- Air analysis at the workplace
  i.e., measurements in the range of the statutory limit values
- Technical gas analysis
  which primarily involves measurements in the range of emission concentrations, in exceptional cases also in the range of ambient air concentrations
- Measurement of compressed air/compressed gases
  Specially calibrated Dräger-Tubes and the Dräger Aerotest can be used to measure typical contaminants in compressed breathing air, e.g., CO, CO_2, water and oil content.

Further differentiations are made between short-term tubes on the one hand and long-term measurement systems on the other. Short-term tubes usually require 10 seconds to 15 minutes. Short-term tubes have a wide range of possible applications, such as measuring air contaminants in the breathing zone, checking storage tanks before entry, detecting leaks in gas pipelines, etc.

Suitable pumps for short-term tubes are:
- accuro tube pump
- X-act 5000 Basic, ex-protected, automatic tube pump

In long-term measurement systems, a distinction is made between direct indicating diffusion tubes and sampling tubes and systems. Direct indicating diffusion tubes do not require a pump for sampling. The pollutant molecules effectively move into the tube independently according to Fick's first law of diffusion. The difference in concentration between the polluted ambient air and the inside of the tube is the driving force for this flow of molecules.

The pump-free diffusion tubes are particularly suitable for personal measurements due to their wearing comfort.

Direct indicating Dräger-Tubes approach their limits of use when complex substance mixtures or components that are chemically very similar, such as methanol, ethanol, and propanol, are present. For example, a colorimetric reaction system based on iodine pentoxide cannot distinguish between aliphatic hydrocarbons and indicates the sum concentration, as the specified substances cannot be indicated separately by the reaction system. Solvents usually consist of three to five different, often very chemically similar, components. In this case, a single Dräger-Tube would not yield reliable results without any previous knowledge due to possible and probable cross-sensitivities.

In such cases, a sample should first be collected using a sampling tube, followed by an analytical determination. For example, gas chromatography or a photometric analysis technique should be used depending on the substance. Once the composition of the substance is known, it is possible to obtain corresponding information by measuring reference concentrations.

ST-1350-2004

Direct indicating diffusion tube in holder

ST-174-2004

Dräger ORSA diffusion sampler

Dräger sampling tubes contain, for example, coconut shell charcoal, different types of silica gel, or molecular sieve. Due to the sampling behavior without color change, they can also be described as Dräger-Tubes without direct indication. In addition, specially prepared Dräger samplers can be used for sampling isocyanates or aldehydes, which are analyzed using HPLC methods after sampling.

After analysis of the sampling phases, it is often possible for subsequent measurements to be performed economically using direct indicating short-term tubes for certain main components of a mixture. In order to choose the most suitable Dräger-Tube for the particular measuring task, preparing for the measurement with regard to the ambient conditions and the possible operation limits is critical. This measurement planning also ensures that interfering cross-sensitivities can be ruled out.

In any case, although the Dräger-Tube is an easy-to-use gas detector, it belongs in the hands of specialists, as only they are able to select the right measurement place and time, identify any cross-sensitivities, and correctly interpret measurement results. For all gas analysis tasks, Dräger Safety AG & Co. KGaA provides competent know-how and an extensive service offer beyond the product range. This offer includes:

- free application-related consulting and advice on measurements with Dräger-Tubes,
- the analysis of loaded sampling systems in the Dräger Analytical Services laboratory on behalf of the customer,
- carrying out measurements and sampling activities on site with subsequent analysis in the Dräger Analytical Services laboratory as a suitable external measuring service in line with TRGS 400, evaluation of the measurement results on behalf of the customer,
- advising the customer on occupational hygiene issues,
- the Dräger VOICE hazardous substances database, on the internet at www.draeger.com/voice,
- seminars on certain topics and questions.

2.2 Chemical Basics – Reaction Mechanisms

The basis of any direct indicating Dräger-Tube in all categories are the chemical reactions of the measured substance with the chemicals in the filling layers. As these reactions lead to a color change, Dräger-Tubes can also be called colorimetric chemical sensors. The substance conversion in the Dräger-Tube is approximately proportional to the mass of the reacting gas. It is usually possible to present this substance conversion quantitatively as a color length indication, otherwise the mass-dependent substance conversion is determined by the color intensity in the color comparison tubes.

The filling layers of the Dräger-Tubes use different reaction systems. A distinction is made between 14 main reaction systems, which can also be combined in some cases. For the Dräger-Tube user, the question of the selectivity of the individual tubes is of great importance. For Dräger-Tubes, the selectivity ranges from substance-selective tubes for carbon dioxide to substance group-selective tubes, e.g., for chlorinated hydrocarbons, and class-selective tubes, e.g., which indicate the class of easily oxidizable substances as a whole, such as the Polytest tube. For analytical gas measurements for the purposes of occupational hygiene, qualitative information about the presence of various substances at the workplace needs to be obtained to enable the targeted selection of Dräger-Tubes.

A classic Dräger-Tube reaction includes the reaction of iodine pentoxide under acidic conditions with carbon monoxide, for example. This is essentially a class-selective reaction for measuring easily oxidizable substances. A targeted increase in the selectivity is possible using suitable pre-layers:

$$5\ CO + I_2O_5 \xrightarrow{H_2SO_7} 5\ CO_2 + I_2$$

The hydrogen sulfide tubes work on the basis of metal salt precipitation reactions. Metal salts react with hydrogen sulfide to form metal sulfides with low solubility. This is a fast ion reaction, which is nearly independent of the volume flow through the Dräger-Tube. A minimum amount of water, i.e., humidity, is required for this reaction to occur, e.g.:

$$H_2S + Cu_2^{+} \rightarrow 2\ H^{+} + CuS$$

Nitrogen dioxide and elemental halogens react with aromatic amines to form intensely colored compounds:

$$Cl_2 + \text{o-tolidine} \rightarrow \text{orange reaction product}$$

As chlorinated hydrocarbons do not have a direct color reaction, the oxidative cleavage of the molecule is required as a first step for this compound class. This reaction takes place using potassium permanganate, for example, which forms elemental chlorine.

Carbon dioxide is measured by oxidizing hydrazine hydrate in the presence of crystal violet as the redox indicator:

$$CO_2 + N_2H_4 \rightarrow NH_2\text{–}NH\text{–}COOH$$

Due to the typically much higher concentration of carbon dioxide compared to potential cross-sensitivities, this reaction can be considered largely substance-selective. Possible interferences by hydrogen sulfide and sulfur dioxide are generally not expected, as these interferences can only occur with unusually high concentrations.

Another large group of reactions is based on pH indicators, e.g.,

$$NH_3 + \text{bromophenol blue} \rightarrow \text{blue reaction product}$$

This type of detection reaction is valid for alkaline as well as acid gases with inverted discoloration.

Compounds containing the –C≡N group are detected using multiple-stage reactions. In the case of acrylonitrile, this is additionally preceded by an oxidation step. In the next step the cyanide ion reacts with mercury chloride to form hydrochloric acid and undissociated mercury cyanide. In the last partial step of this complex reaction system, the hydrochloric acid is indicated using a pH indicator. Suitable pre-layers are once again used to ensure selective measurement. A similar reaction principle is also used in the most sensitive phosphine tube (phosphine 0.01/a). In this case, the phosphine again reacts with mercury chloride to form mercury phosphide and hydrochloric acid.

Most hydrides of the elements from group III or V of the periodic table (e.g., borane or arsine), due to their reducing properties, react with gold salts to form elemental gold. Aromatics condense under strongly acidic conditions with formaldehyde to form intensely colored quinoid compounds with different molecular structures and sizes. Both of these primary reaction partners can be measured on this basis; aromatics like benzene and xylene as well as formaldehyde. For ethylene oxide and ethylene glycol, an additional oxidation reaction is necessary, in which both substances are converted to formaldehyde.

Elemental iodine is deposited in starch molecules forming strongly colored blue inclusion compounds, during which the ready reduction to colorless iodine ions remains preserved. Due to its oxidative effect, the reaction with sulfur dioxide leads to the discoloration of these iodine complexes.

Substituted aromatic amines react relatively selectively with acetic chlorides and phosgene, where the latter can be seen as a dichloride of carbonic acid. Carbon tetrachloride is oxidized by a strong oxidation agent into phosgene, so that this type of reaction is also suitable for measuring carbon tetrachloride.

The known oxidation reaction of C=C double bonds with potassium permanganate is the basic reaction for measuring olefins. Due to the selectivity of this reaction, it is important to make sure that no other substances oxidized by permanganate are present.

Another reduction reaction of metal salts enables the measurement of ethylene and some acrylates. Molybdenum salts show an intensive color change from light yellow to deep blue when reduced from the highest oxidation stage to a lower one.

Substance-selective reactions which have not previously been mentioned include:

– ketone detection with hydrazine derivatives,
– oxidation of Ti^{3+} salts by oxygen,
– nickel detection by dimethylglyoxime.

As already mentioned, the limits of the gas detection method used must be taken into account for every analytical determination. An important selectivity requirement is knowledge of potential cross-sensitivities. As the extremely large number of chemical compounds makes it impossible to list all potential interferences, the reaction principle is stated for every individual Dräger-Tube. This allows experts to use their prior knowledge of the reaction principle to decide whether the respective Dräger-Tube is suitable for the defined measuring task. If any more detailed questions arise, contact the application consulting service provided by Dräger Safety AG & Co. KGaA.

2.3 The Dräger-Tube Measurement System

The Dräger-Tube measurement system consists of a Dräger-Tube and a Dräger tube pump. Each Dräger-Tube contains a highly-sensitive reagent system that produces accurate measurement results when the technical characteristics of the tube pump used precisely match the reaction kinetics of the reagent system in the tube. As a result, the volume and timing of the flow rate of a Dräger tube pump, i.e., the suction characteristics, must always be coordinated to the tube within small tolerances. These requirements are defined in international as well as national gas detector tube standards or norms which require or recommend the use of gas detector tubes with a matching tube pump from the same manufacturer.

Different Dräger tube pumps and Dräger-Tubes are used for the Dräger-Tube measurement system. Dräger short-term tubes and the Dräger tube pumps are matched with each other at the factory. They form a single unit. Using other pumps with Dräger short-term tubes or other short-term tubes with Dräger tube pumps can impair the proper function of the measurement system. To obtain correct measurement results with this system, each type of Dräger-Tube is calibrated in batches together with a Dräger tube pump. If short-term tubes and pumps from different manufacturers are used, there is no guarantee that the tube measurement system will perform as described in the respective instructions for use and this can lead to significant deviations in the measurement results.

Following testing and inspection by the Institut für Arbeitsschutz der Deutschen Gesetzlichen Unfallversicherung (IFA), the Dräger tube pump accuro, for example, complies with the requirements of DIN EN 17621.

Dräger tube pumps

The Dräger tube pumps can be used for short-term measurements and sampling. Short-term measurements involve the measurement of momentary concentrations, such as the detection of concentration peaks, clearance measurements, worst case considerations, etc. During sampling, the substances to be analyzed are first collected on a suitable substrate, e.g., activated carbon, silica gel etc. First, the air to be analyzed is drawn over the respective substrate – usually at a defined flow rate for a specified duration. The substances deposited on the substrate by adsorption or chemisorption are then qualitatively and quantitatively analyzed in the laboratory using analytical methods such as gas chromatography (GC), high performance liquid chromatography (HPLC), UV/VIS spectroscopy or IR spectroscopy.

The following Dräger tube pumps are available for these measurements:

- Dräger accuro, Dräger-Tube manual pump
- Dräger X-act 5000, ex-protected automatic Dräger tube pump

All Dräger tube pumps must be used in accordance with the appropriate instructions for use.

Dräger accuro tube pump

The Dräger accuro tube pump is a bellows pump. It can easily be operated with one hand and draws in 100 mL per stroke. During measurement, the pump body (bellows) is pressed together completely. This equals one "stroke". During the stroke, the air contained in the pump chamber escapes through the exhaust valve. After the bellows are released, the suction process runs automatically. The exhaust valve is closed during the opening phase of the bellows so that the gas sample flows through the connected Dräger-Tube into the pump chamber. Once the pump body has fully opened to its original position, the suction process is complete. On the Dräger accuro tube pump, the end of stroke is visible by a pressure-controlled end-of-stroke indicator located in the pump head. A scissor mechanism built into the pump bellows of the Dräger accuro tube pump ensures the parallel compression of the pump. The Dräger accuro tube pump is independent of external energy sources. As a result, there are no usage restrictions in explosion-hazard areas.

ST-2436-2003

Dräger accuro tube pump

Technical data	Dräger accuro tube pump
Application	For short-term measurements with small numbers of strokes
Design	Manually operated bellows pump, single handed operation
Number of strokes	1 - 50 strokes and higher
Stroke volume	100 mL (± 5 %)
Dimensions (H x W x D)	approx. 85 x 170 x 45 mm
Weight	approx. 250 g
Degrees of protection	(not required)
Power supply	(not required)

Dräger X-act 5000 Basic tube pump

Dräger X-act 5000 Basic is an ex-protected automatic Dräger tube pump for measuring or sampling gases, vapors, and aerosols. The Dräger X-act 5000 Basic uses a completely new pump concept. The key principle is the electronic pump control for the use of Dräger short-term tubes and for sampling with sampling tubes and systems. This pump control takes account of the special suction characteristics required for the Dräger short-term tubes.

D-0185-2019

Dräger X-act 5000 Basic

This concept significantly reduces the average measuring time for Dräger short-term tubes with higher stroke numbers compared to that of the Dräger accuro manual pump. All required parameters are entered directly during sampling. The internal pump power is designed to allow the use of extension hoses up to 30 m long.

All pump components are enclosed in a tough, corrosion-protected housing. For better corrosion protection, the pump is fitted with an internal SO_3 filter that retains sulfur trioxide vapors and aerosols for up to two years. The bright backlight of the two-part display (segment and matrix part) makes it easy to read the device settings in almost all light conditions. The Dräger-Tubes, sampling tubes and systems, as well as the accessories to be used can be easily connected.

The pump is menu-controlled and intuitive to use thanks to easy-to-follow menu instructions. After it is switched on, a start display appears and an automatic self-test is performed. After the start-up procedure, a leak test is offered. After carrying out or skipping this test, the various modes of operation are displayed. The following modes of operation are possible:

- Measurement with short-term tube
    - Air measurement
        Manual operation in air
    - Measurement in technical gases
- Sampling

The Dräger short-term tubes are calibrated for measuring substance concentrations in ambient air. For measurements in technical gases, the different viscosity of the technical gas compared to the viscosity of ambient air has to be taken into consideration. In "Measurement in technical gases" mode of operation, the necessary flow rate is adjusted by the pump. The prompt to prepare for the measurement with an additional operating step appears in the display. At the end of the measurement, the measurement result can be read directly on the tube.

The sampling preparation time is reduced by the direct entry of the flow rate and sampling time accordingly. The Dräger X-act 5000 Basic automatically adjusts the set flow rate, making any additional system calibration with an external flow meter unnecessary. The measurement starts immediately after setting the sampling time. The pump stops automatically at the end of the entered sampling time and the settings are displayed together with the elapsed time and the pumped volume.

The Dräger X-act 5000 Basic is delivered with an English language display ex-factory. The menu language can be changed in a password-protected menu. Other languages are available. Recurring modes of operation and other necessary functions can be set and selected to adapt the operation to the specific use.

Technical data	X-act 5000 Basic
Application	For short-term measurements with higher stroke numbers and for sampling with sampling tubes and systems
Design	Menu-controlled, automatic pump
Number of strokes	Adjustable, 1 – 199 strokes
Stroke volume	100 mL (± 5 %)
Dimensions (H x W x D)	approx. 175 x 230 x 108 mm
Weight	approx. 1.6 kg (without power pack)
Degrees of protection	ex-protected IP 64
Power supply	NiMH battery, T4, 7.2 V, 1500 Ah (charging time < 4 h)

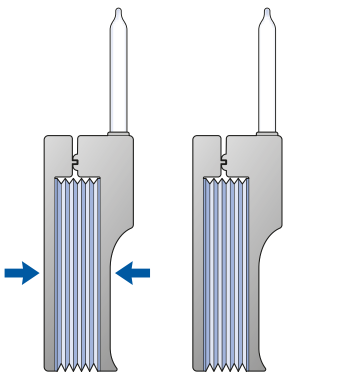
Functional integrity of Dräger tube pumps

Ensuring the functional integrity of the Dräger tube pumps used is essential in order to consistently receive correct measurement results. A check for leaks and the suction capacity should be carried out before every measurement. In addition, the Dräger tube pumps must be purged with air by a few empty strokes (without Dräger-Tube) after measurement. This purging cleans the pump of reaction products that enter the pump bellows due to the reaction in the tube.

Checking the functional integrity using the Dräger accuro by way of example

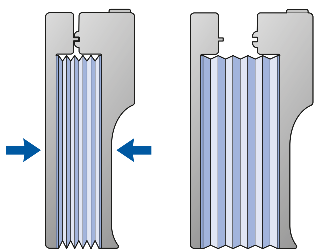
Compress the pump with unopened tube.

After releasing the pump, the position of the bellows must not change for 15 minutes.



ST-1221-2008

After removing the tube, the pump bellows must open abruptly.



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2.4 Dräger Short-Term Tubes

Short-term tubes are intended for measuring momentary concentrations. The measurement usually takes between 10 s and 15 min. The measured concentration provides the amount of the substance to be determined over the measuring time. The configuration of the short-term tubes depends on the specific measuring task, particularly the measured substance and the concentration range to be determined. Due to these specifications, the short-term tubes differ as follows:

– Tubes with one indicating layer
– Tubes with 2 scales or measuring ranges
– Tubes with one or more pre-layers plus indicating layer
– Combination of two tubes
– Tubes with connecting hose
– Tubes with reagent ampoule
– Tubes for simultaneous measurement

Tubes with 2 scales or measuring ranges

For all tube types mentioned below, a distinction can be made between tubes with one printed scale or measuring range and tubes with 2 printed scales or 2 measuring ranges. In both cases, the number of strokes (n) required for the measuring range as well as the measuring unit are printed directly on the relevant scale on the tube. Tubes with 2 scales typically have a high and low measuring range. The high measuring range requires a lower number of strokes, while the low measuring range requires a higher number of strokes.

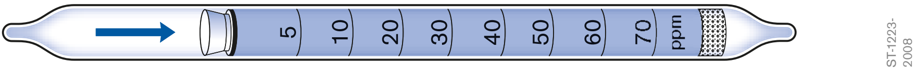
The measurement starts with the number of strokes for the high measuring range. If the result shows that a more precise evaluation is possible in the low measuring range, the necessary differential strokes are performed immediately afterwards and the measurement result – now the second scale – for the lower measuring range is evaluated.

If an evaluation in the low measuring range is not possible, the measurement result can be evaluated directly on the first scale for the high measuring range.

Short-term tubes with one indicating layer

For these tubes, the entire filling layer serves as the indicating layer.

E.g., the Dräger-Tubes Hydrazine 0.25/a, Ammonia 0.25/a



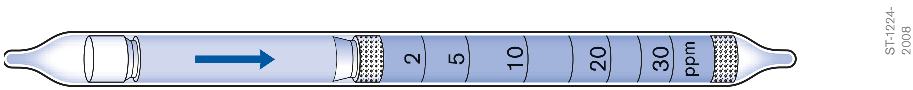
Dräger-Tubes with one indicating layer

Short-term tubes with one or more pre-layers

Two pre-layers are present here in addition to the indicating layer.
These pre-layers serve to:

adsorb moisture, or
retain interfering substances, or
convert substances to measurable substances.

E.g., Tetrahydrothiophene 1/b

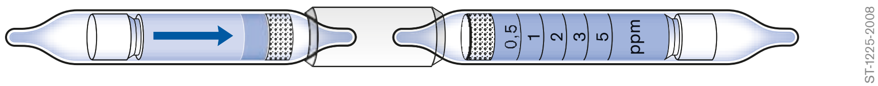


Dräger-Tubes with one pre-layer

Combination of two Dräger-Tubes

Two Dräger-Tubes, one pre-tube and one indicating tube, are connected with a shrink-fitted hose. To start the measurement, the two inner tube tips must be broken off in addition to the outer tips so that the air to be tested can be drawn through both tubes. The compound in the pre-tube fulfills a similar purpose to the pre-layer in a Dräger-Tube.

E.g., the Dräger-Tubes Halogenated Hydrocarbons 100/a, Formaldehyde 0.2/a.

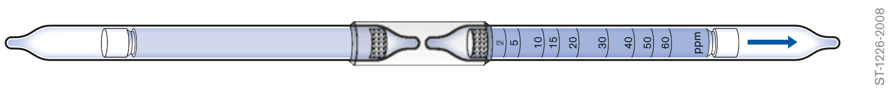


Combination of two Dräger-Tubes

Short-term tubes with connecting hose

These tubes are comprised of an indicating tube and an additional tube. After breaking off the tube tips, both tubes are connected with a hose. The additional tube is attached either before or after the indicating tube as per the instructions for use of the relevant Dräger-Tube. When it is attached after the indicating tube, the tube serves to bind reaction products generated from the conversion reaction in the indicating tube or, if it is attached before the indicating tube, it serves a similar purpose to a pre-layer in a tube.

E.g., the Dräger-Tube Tetrahydrothiophene 1/b.

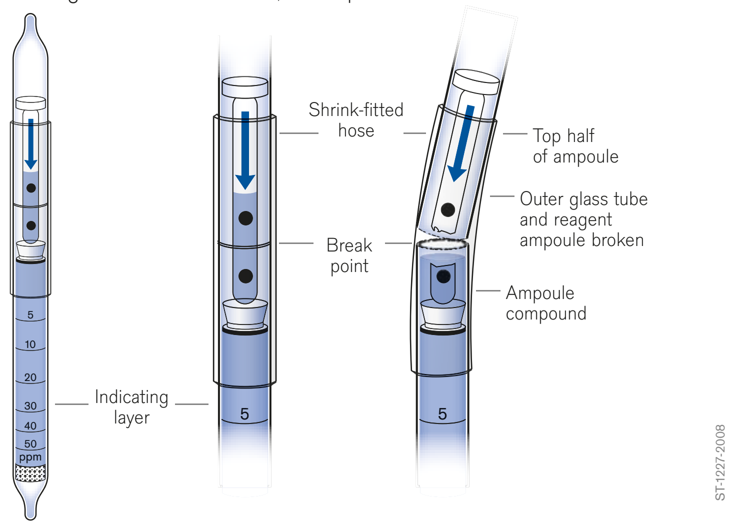


Dräger-Tube with pre-tube

Short-term tubes with reagent ampoule

As, due to chemical incompatibility, not all reagents can be contained in the filling layers, these tubes contain a reagent ampoule in addition to the indicating layer. The compound in the ampoule may be a vapor, liquid, or granular.

E.g., the Dräger-Tubes Oil Mist 1/a, Mercaptan 20/a



Dräger-Tube with additional reagent ampoule

Dräger-Tubes for simultaneous measurement

For a semi-quantitative measurement, five tubes are arranged in a rubber sleeve as a test set. The Dräger tube pump draws the air to be tested simultaneously through the tubes via an adapter. The concentrations are shown as a multiple of a limit value. As the simultaneous test set is a system solution for which special Dräger-Tubes have been developed, they cannot be exchanged with other Dräger-Tubes.

E.g., the Dräger-Tubes	Simultaneous test set I and II for inorganic fire gases, Simultaneous test set III for organic vapors.

Simultaneous test set for inorganic fire gases I

2.5 Evaluating Dräger-Tubes

The measurement result depends on the intended use of the Dräger-Tube measurement system as well as the correct reading of the concentration. Important requirements for reading the measurement result are:

– constant observation of the Dräger-Tube during measurement,
– evaluation immediately after measurement in compliance with the instructions for use,
– adequate lighting,
– light background,
– comparison with an unused Dräger-Tube.

Observing the Dräger-Tube during measurement is particularly important to ensure that, for example, any complete discoloration of the tube is detected. This complete discoloration can occur abruptly at high concentrations, in some cases even during the course of the first stroke.

Adequate lighting is also required. However, long-term exposure to direct sunlight should be avoided, as the sun's UV radiation may cause a change in the discoloration. In some cases, this type of change can occur even after an extended period of time. Dräger-Tubes should therefore always be

read immediately after measurement.

Storing the used Dräger-Tube to preserve evidence is therefore usually not useful.

A light background (white paper) is very helpful, as this allows any color change to be precisely detected and distinguished. In darkness, we advise placing the tube on the reflector of a flashlight that has been switched on. This ensures both adequate lighting and a light background.

To precisely identify a color change, the used Dräger-Tube is compared with an unused Dräger-Tube (before/after effect).

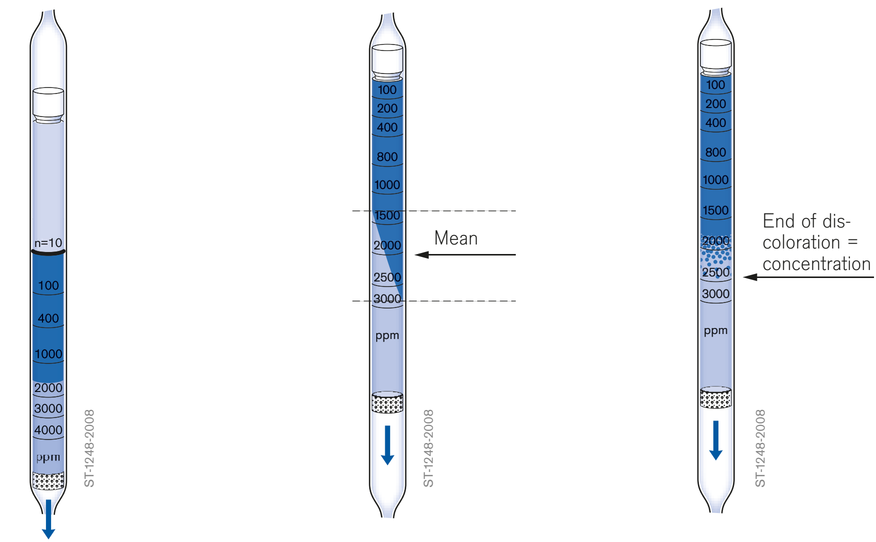
The entire visible length of the discoloration must always be read.

This is true even if different colors are present. It must be noted that the detection of a certain color is always subject to personal color perception to a certain extent. For example, it is possible that one person will call a color light brown while another calls the same color brown. These differences in personal color recognition and perception must not be overemphasized.

Three different cases can occur when evaluating scale tubes:

– the color indication ends at right angles to the tube's longitudinal axis,
– the color indication is oblique (at an angle to the tube's longitudinal axis),
– the color indication is uneven (diffuse).

If the color indication is at right angles to the tube's longitudinal axis, the concentration can be read directly off the scale (example 1). If the color indication is oblique, i.e., runs at an angle to the tube's longitudinal axis, one long and one short discoloration can be observed. In this case, the average value is taken from these indications and stated as the concentration (example 2). If the color indication is not uniform (diffuse), there is no clear, even endpoint to the discoloration. In this case, the endpoint of the discoloration is the point at which a weak discoloration is still visible (example 3).



Example 1 Example 2 Example 3

2.6 Use of Dräger-Tubes under Extreme Conditions

General information

The manufacturer normally calibrates the gas detector tubes under laboratory conditions. This means that the temperature is approximately 20 °C and the pressure and humidity of the test air do not differ significantly from normal conditions. The conditions when using the tubes in practice can be very different. Extremely high temperatures in summer and very low temperatures in winter are common. Relative humidities in excess of 95 % as well as low humidities can be encountered. At an altitude of 2000 m, the ambient pressure is roughly 20 % lower than at sea level. Higher ambient pressure can be found underground in mining; for example, at a depth of 1000 m, the ambient pressure is around 10 % above normal pressure. And when it comes to hyperbaric chambers or underwater laboratories, pressures more than ten times the normal pressure can occur depending on depth. How do the gas detector tubes behave when used in these kinds of conditions?

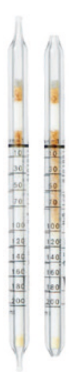
Influence of humidity on the indicating behavior of tubes

The following initial situations should be considered:

a) usual humidity, i.e., water is present as gas in the air.
b) mist, i.e., water is present in the form of fine droplets.
c) rain, i.e., large quantities of liquid water.

When measuring with gas detector tubes, liquids must be prevented from reaching the reagent layers. Open tubes therefore need to be protected from direct rain. Moisture present as gas or aerosol in the air does not affect the tube reading, provided that these tubes are designed to be "water-resistant". This statement is explained using the tubes for detecting hydrogen sulfide and the tubes for detecting carbon monoxide.

Figure 1 shows the H_2S tube. The filling consists only of the indicating layer. This indicating compound contains silica gel as the base substance (reagent substrate), which is impregnated with aqueous metal acetate solution. The pores of the silica gel therefore contain liquid water in which the reagent is dissolved. The CO tube shown in Figure 2 contains a reagent system (iodine pentoxide, sulfuric acid, and silica gel) that is highly sensitive to humidity. But the sensitivity of the reagents to water does not cause any measurement problems, as this tube contains a special filter as



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a pre-layer, which quantitatively absorbs the moisture in the test air, so that the test air that comes into contact with the reagent in the indicating layer is dry.

These two examples show that the gas detector tube configuration makes it possible to analyze air with different moisture contents without needing to use special correction factors.

Influence of ambient pressure on the indicating behavior of tubes

This topic can be answered in a few short sentences, as the reading is in fact almost directly proportional to the ambient pressure for almost all tubes. But this is not due to a change in the reaction sequence in the tube when the ambient pressure changes. Rather, the volume drawn through the tube changes depending on the pressure.

Example:
Air containing CO is analyzed in a chamber at normal pressure (1013 mbar); the tube reading is 50 ppm. The same air is then compressed by increasing the pressure with a final chamber pressure of 3040 mbar. In both cases, the tube and pump are in the chamber. The measurement at an ambient pressure of 3040 mbar shows a reading of 150 ppm (cf. also Table 1). In fact, the concentration of CO (based on ppm) has not changed as a result of the increase in pressure, there are still 50 cm^3 CO in 1 m^3 of test air. Only, the CO volume is now present under a pressure of 3040 mbar, which is also true of the test air. The actual CO concentration can be easily calculated by multiplying the reading (150 ppm) by the ratio of normal pressure to actual pressure.

Influence of rising pressure

Concentration of 50 ppm CO	
1 bar	50 ppm
2 bar	100 ppm
3 bar	150 ppm
5 bar	250 ppm

Table 1

Ambient pressure at different altitudes

2000 meters	790 mbar
1500 meters	840 mbar
1000 meters	900 mbar
500 meters	950 mbar
0 (sea level)	1013 mbar
-500 meters	1030 mbar
-1000 meters	1120 mbar

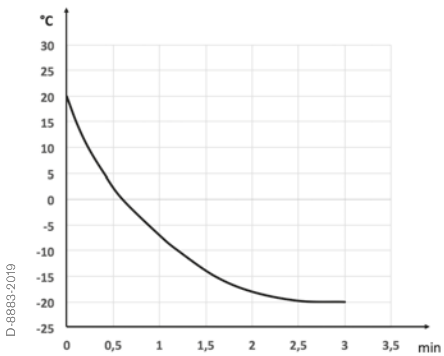
Table 2

Table 2 shows the air pressures at different altitudes (from 2000 m above sea level to 1000 m below sea level). These figures can be used to correct the reading when using gas detector tubes at altitudes that differ significantly from sea level.

$$\text{Concentration} = \text{Reading} \times \frac{1013 \text{ mbar}}{\text{Actual pressure in mbar}}$$

Eliminating the effect of temperature

When it comes to the effect of temperature on the tube reading, a distinction needs to be made between the direct influence on the reaction sequence and the dependence of the test air volume drawn through the tube on the temperature. In general, the reaction sequence is not measurably affected by the temperature in the range of 0 °C to 40 °C. The test air volume changes by about 3.5 % for every 10 °C change in temperature. This can be easily corrected using the established gas law. It is a different case when the reaction sequence in the tube is uncontrollably changed by overly high or low temperatures. Some reagent systems can freeze below 0 °C, while at temperatures above 40 °C, vaporization of the reagents can cause changes in the indicating behavior. In these cases, attempting to provide correction factors is almost impossible. But there is a very simple solution; you only need to make sure that the temperature in the tube remains within the aforementioned range of 0 to 40 °C during measurement. The temperature of the air drawn in can then be well below 0 °C or even several hundred degrees Celsius.



Testing cold ambient air

The "Testing cold ambient air" graphic shows a cooling curve recorded at an ambient temperature of minus 20 °C. The temperature was measured at the start of the tube filling layer in each case. The test lasted 3 minutes. During this time, one liter of cold air was drawn through the tube. The gas detector tube, previously at a temperature of + 20 °C, had already cooled to below 0 °C after one minute.

The Dräger "hot-pack holder" together with the hot packs allows Dräger-Tubes to be used below the temperature limits specified in the instructions for use. All Dräger short-term tubes (exception: Dräger analysis tubes) can then be used down to -20 °C.

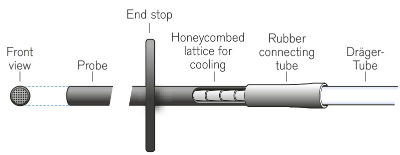

ST-58-2004

Using the hot-pack holder for Dräger-Tubes ensures that the accuracies specified in the instructions for use for Dräger-Tubes are maintained even under extreme conditions.
Typical applications include

– fire department
– industry
– military
– civil defense

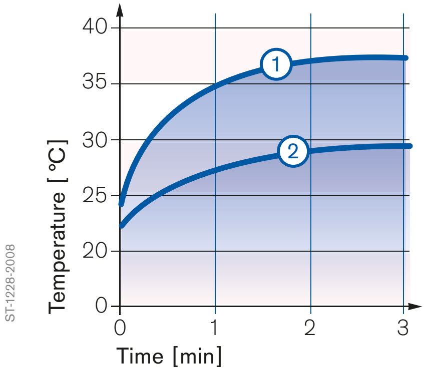
Testing hot ambient air

The tube must be cooled for measurements in hot ambient air. The hot air probe was developed for measuring hot gases. This probe must be used whenever the temperature range specified in the instructions for use (usually up to 40 °C) is exceeded. The hot air probe is designed to cool hot gases so that they can be measured directly with the Dräger-Tube measurement system. For example, at a gas temperature of 400 °C, the probe cools the gas to a temperature below 50 °C. A requirement for this cooling power is that the probe must not remain in the hot gas flow for longer than about 30 seconds. The dead air space of the probe is so small that it can be ignored during measurement.



ST-1229-2008

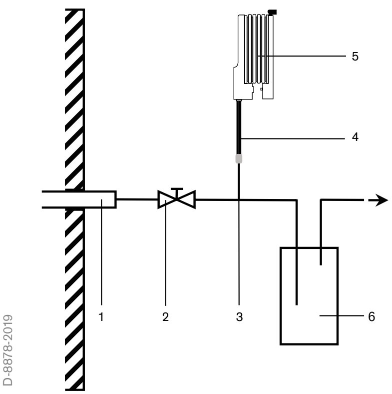
Diagram of the hot air probe



Cooling effect of the hot air probe
Gas temperature: 650 °C
Ambient temperature: 20 °C
1 L of gas was drawn in over 3 min, temperature rise in the Dräger-Tube when using
(1) one hot air probe
(2) two hot air probes

Gases under positive pressure

Even a few millibars of positive pressure lead to incorrect measurements in the gas detector tubes. The reason for this is that the valve of the pumps used together with the gas detector tubes does not seal tightly if positive pressure is present. This allows the pumped gas to flow out during the suction process so that it is lost from the volume measurement. But this problem can be solved by connecting the tube to the sampling connection with a T-piece. The gas flow is regulated so that an adequate volume of gas (at least 3 L/min) constantly flows out, but no noticeable positive pressure arises at the side port of the T-piece. This can be checked by leading the gas escaping from the T-piece through a downstream bubble counter. The figure below shows the setup of this type of sampling unit (the presence of a suitable gas vent line after the bubble counter should also be ensured).

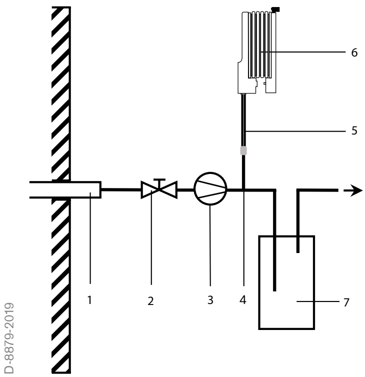


Sampling technical gases under positive pressure
1 Probe
2 Flow control valve
3 T-piece
4 Gas detector tube
5 Bellows pump
6 Bubble counter

Gases under negative pressure

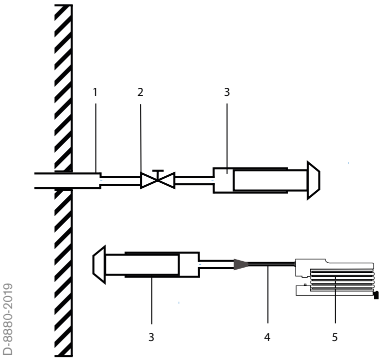
The pressure in the pipeline system can be up to 20 mbar below the ambient air pressure without affecting the suction characteristics of the tube pump. The pump valve also still works flawlessly with this pressure difference. But, if the pressure in the system is lower, a volume error can occur, as the tube pump bellows no longer open fully. Various sampling techniques have established themselves in practice under these conditions:

a) The gas under negative pressure to be tested is continuously drawn out of the gas flow with a suitable suction pump. The gas detector tube together with the tube pump is then connected to the pressure port on the suction pump via a T-piece (after the pump, the sampling technique essentially corresponds to the "Gases under positive pressure" section). But it must be ensured that the composition of the gas to be tested does not change in the suction pump (condensation or sorption losses). The requirements regarding the material properties of the pump are therefore very high.



Sampling technical
gases under negative pressure
1 Probe
2 Flow control valve
3 Suction pump (resistant to the
gas to be suctioned)
4 T-piece
5 Gas detector tube
6 Bellows pump
7 Bubble counter

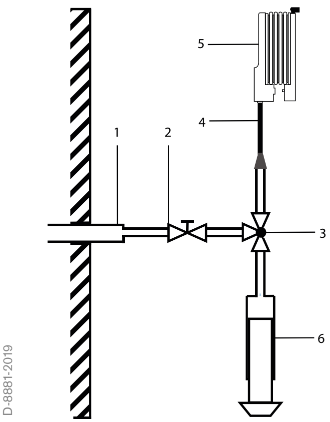
b) The gas under negative pressure to be tested is sampled using a glass plunger sampler. For testing, the gas is then drawn out of the glass plunger sampler with the tube pump. As glass plunger samplers usually have a maximum volume of 300 cm^3, but the required gas volumes can be larger, the sampling must be repeated until the prescribed total volume has been drawn through the tube.



Sampling technical
gases under negative pressure
1 Probe
2 Flow control valve
3 Glass plunger sampler
4 Gas detector tube
5 Bellows pump

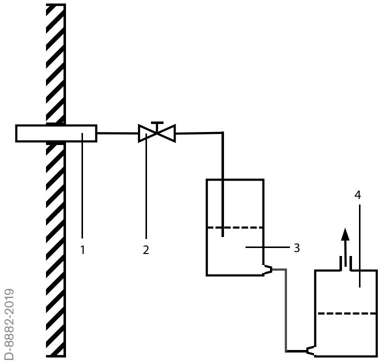
The time between sampling and continued testing must be kept short. (But this type of sampling also requires the gas sample to be drawn through the gas detector tube with the tube pump. The glass plunger sampler must not be used as the conveying pump in connection with the tube).

To avoid having to switch back and forth between the sampling point and tube with the glass plunger sampler, we recommend using a multi-way valve that you connect with the sampling point, glass plunger sampler, and tube.



Sampling technical
gases under negative pressure
1 Probe
2 Flow control valve
3 Multi-way valve
4 Gas detector tube
5 Bellows pump
6 Glass plunger sampler

c) The gas under negative pressure to be tested is collected in an aspirator. A requirement for flawless sampling is a suitable sealing liquid in which the components of the gas sample do not dissolve. After sampling is completed, the tube is connected to the aspirator and the measurement is performed. During tube measurement, the liquid level in the aspirator vessels must be set so that no positive pressure arises in the gas sample. As explained previously, a slight negative pressure has no effect.



Sampling technical gases under negative pressure
1 Probe
2 Flow control valve
3 Aspirator (the gas to be collected must not dissolve in the sealing liquid)
4 Collection vessel for sealing liquid

2.7 Extension Hose

An extension hose is used to test the air quality in sewers, shafts, tanks, or other inaccessible locations before entry. An adapter is fitted to one end of the hose, which allows the extension hose to be easily connected to the Dräger tube pump. The dimensions of the tube holder at the free end of the hose are selected so that the Dräger-Tubes can be fitted gas-tight. The extension hoses are manufactured from fuel-resistant, synthetic rubber. They are available in lengths of 1 m, 3 m, 10 m, and 15 m (30 m only in connection with Dräger X-act 5000 and X-act 5000 Basic).

2.8 Investigation of Breathing Air, Medical Gases, and Carbon Dioxide

In line with DIN EN 12021, compressed air used as breathing air must meet certain quality requirements. For instance, in an expanded state, the air must not contain more than 3.3 ppm carbon monoxide and no more than 500 ppm carbon dioxide. The moisture content in expanded air at a filling pressure of 40 to 200 bar must be less than 50 mg/m^3 and at a filling pressure of more than 300 bar it must be less than 35 mg/m^3. The permissible water content at a filling pressure of 5 to 40 bar is listed in a table in DIN EN 12021. In addition, air in an expanded state must be odorless and tasteless (this is usually ensured if the oil content is less than 0.1 mg/m^3). Moreover, the water content of the air discharged by the compressor (for filling) must not exceed 25 mg/m^3 over the entire pressure range in the expanded state (DIN EN 12021).

K-153

To check these parameters as well as to meet the intended use of the various media in the form of application-related and country-specific requirements, the medium can be qualitatively tested using the Aerotest product line. Dräger has been operating in the field of compressed air analysis for more than 100 years. The Aerotest product line enables the simultaneous measurement of contaminants in the outflowing air as well as in oxygen, nitrous oxide, and carbon dioxide. The measurements are performed with Dräger-Tubes. Using the Aerotest Simultan together with the gas detector tubes makes measurement possible in just a few minutes. The flow rate required for contaminant measurement (flow through the attached Dräger-Tubes) is ensured by a precise pressure reducer and special dosing devices. This establishes a constant flow rate independent of the compressor's primary pressure (max. 300 bar), the pressure in the ring line, or the respective residual filling pressure in the buffer cylinders. The Aerotest Simultan is compact and can be connected to conventional compressors, buffer cylinders, or ring lines without the use of any additional tools.

In 2008, measurement using impactor technology was introduced for measuring oil mists in compressed air. Impactors are generally used to collect aerosol particles, making this technology ideal for measuring oil mists.

The impactor is used in the Dräger Aerotest Simultan together with an adapter.

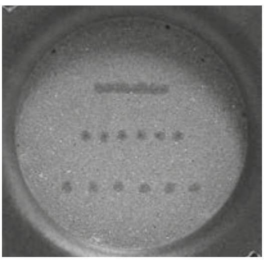
During measurement, the air to be tested flows through 20 nozzles that are arranged in the impactor and strikes a baffle plate made of ground glass at right angles. The right-angled deflection of the air in the impactor prevents the aerosol particles from following the air flow due to their inertia and they are deposited on the ground glass plate. The recesses in the ground glass are thereby filled by the oil. This eliminates the light scatter caused by the ground glass. This principle enables the visual detection of very low oil quantities.

ST-602-2008

Impactor with adapter in the Aerotest Simultan

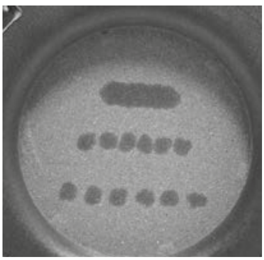
The special arrangement of the nozzles makes it possible to measure the amount of deposited oil and therefore the oil aerosol concentration in a known volume of air with good reproducibility.

The measurement result does not depend on the type of oil. But it is important to note that oil aerosols vaporize at higher temperatures and the vapor is not displayed. The measurement takes 5 minutes with a flow rate of 4 L/min, for a test volume of 20 L.



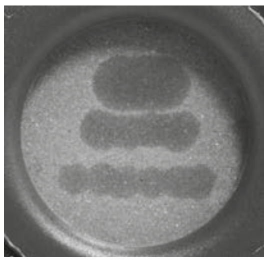
ST-1230-2008

0.1 mg/m³



ST-1231-2008

0.5 mg/m³



ST-1232-2008

1 mg/m³

Impactors with 3 different oil aerosol concentrations.

Aerotest Simultan HP, complete 6525951

For monitoring breathing air in the high-pressure range. As required by EN 12021, the breathing air quality is checked by a quantitative measurement (of the contaminants) in the outflowing compressed air within 5 minutes. The measuring device (G 5/8“ connection, DIN 477) can be connected to the high-pressure compressed air network to be tested. All components of the Aerotest Simultan HP are stored in a handy carry case.

D-5715-2022

Dräger Aerotest Simultan HP, complete

Aerotest Alpha, complete 6527150

For monitoring breathing air in the low pressure range of 3 to 15 bar. As required by DIN EN 12021, the breathing air quality is checked by a quantitative measurement (of the contaminants) in the outflowing compressed air. The measuring device (plug nipple connection) can be connected to the low pressure compressed air network to be tested. All components of the Aerotest Alpha are stored in a handy carry case.

D-5721-2022

Aerotest Alpha, complete

MultiTest med. Int., complete 6520260

For monitoring medical gases in supply systems. Contaminants in compressed air, nitrous oxide, carbon dioxide, and oxygen can be measured with the MultiTest med. Int. and the Dräger-Tubes in line with the requirements of the USP (United States Pharmacopeia) and the EUP (European Pharmacopeia). Dräger-Tubes are used for the quantitative detection of water vapor, oil, CO_2, SO_2, H_2S, NO_x, and CO as well as other contaminants in medical gases. The measuring device is connected with the various plug nipple adapters. All components of the MultiTest med. Int. measuring device are stored in a handy transport case.

D-5774-2022

Dräger MultiTest med. Int., complete

SimultanTest CO_2, complete 6526170

For monitoring carbon dioxide (CO_2) in the low pressure range of 3 bar. Carbon dioxide testing takes place via quantitative measurement (of the contaminants) in the outflowing carbon dioxide. The measuring device, plug nipple connection, can be connected to the carbon dioxide pipeline system to be tested. Dräger-Tubes are used for the quantitative detection of NH_3, NO_x, CO, SO_2, H_2S, and water vapor as well as other contaminants in carbon dioxide. All components of the SimultanTest CO_2 measuring device are stored in a handy transport case.

D-16185-2017

Dräger SimultanTest CO_2, complete

2.9 Measurement Strategy for Detecting Gas Hazards

Measurements of air contaminants that can arise from, e.g., hazardous waste sites, fires, chemical or transport accidents, present a particular challenge. In these cases, a risk assessment is made more difficult by the potential presence of a large number of different substances in the air.

Besides portable and mobile measuring devices, Dräger-Tubes or Dräger MicroTubes can be used directly on site to measure and identify gaseous substances. But the wide range of possible substances makes it impossible to detect all conceivable potential gas hazards with a single Dräger-Tube or MicroTube. Based on certain considerations and experience, recommended strategies can be developed that can significantly shorten the time taken until the initial classification of key substance groups.

Any recommended strategy is naturally, more or less, a good compromise to prevent the practical application from being complicated by growing uncertainty.

Simultaneous test sets

As part of the Dräger-Tubes measurement technology, multi-measuring devices or simultaneous test sets were developed for special applications. They each consist of five Dräger-Tubes arranged in parallel in a rubber sleeve. Two sets are currently available for measuring inorganic fire gases, one set for measuring organic vapors, and one set for measuring tolerable concentration values in line with the vfdb 10/01. For example, they are used in case of fires or accidents involving hazmat transport operations. The use of these kinds of multi-measuring devices generates significant advantages compared to measurements using the individual Dräger-Tubes or MicroTubes:

- considerable reduction of measuring time
- indication of 5 substances/substance groups and information for "cross-analyses" are available in parallel.

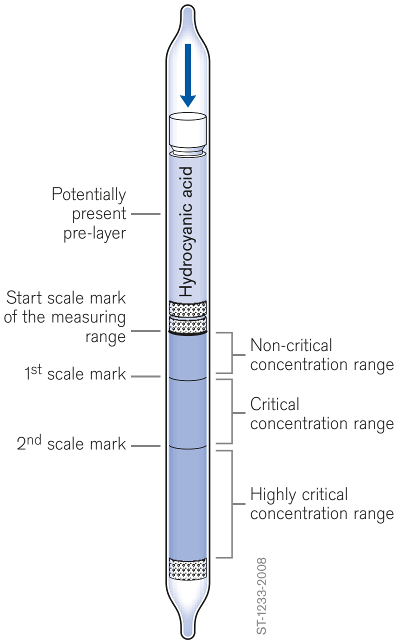
The simultaneous test sets are delivered preassembled and are connected to the Dräger tube pump with an adapter after the tube tips are opened. Due to the large standard deviations that are typically expected for measurements in practice, the tubes used here have marking rings rather than scales. These marking rings are based on the statutory limit values. The individual flow resistances of the Dräger-Tubes are precisely coordinated to ensure that the same volume of air flows through each tube during measurement. Therefore, no other Dräger-Tubes may be used.

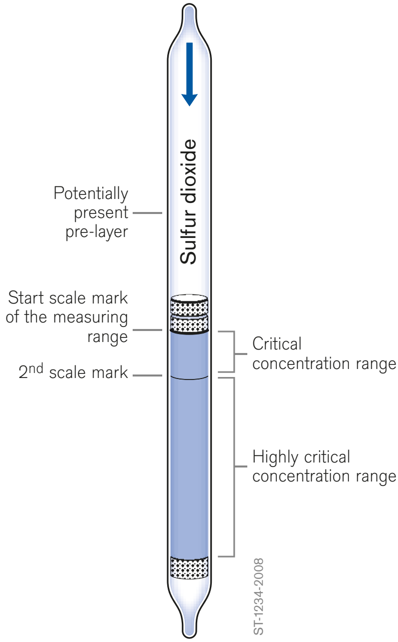
Simultaneous test sets are predominantly evaluated across three concentration ranges:

– non-critical concentration range
– critical concentration range
– highly critical concentration range

Allocation to these concentration ranges takes place by reading a color length indication.

The following figure describes the evaluation of the individual Dräger-Tubes in the simultaneous test set. There is a special feature for evaluating simultaneous test set II. In this case, the 1st scale mark is missing for the Dräger-Tubes for sulfur dioxide, chlorine, and phosgene.





Evaluating the simultaneous test sets

Whenever a critical or highly critical concentration of a gas is present, the actual concentration of this gas is subsequently measured using the corresponding Dräger-Tube.

The decision on possible measures always requires knowledge of how the gas concentration will develop over time. Moreover, the individual conditions on site always need to be taken into account for all decisions relating to measures. As a result, all decisions can only ever be made by the incident commander on site.

Measurements of fire and decomposition gases

Fire and decomposition gases occur whenever there is a fire. There is a danger that they will be present in higher concentrations during and particularly after a fire. These gases present a significant danger of intoxication for those involved as well as bystanders. The local exposure levels near the source of the fire can expand, for example, to:

- neighboring rooms
- adjacent floors
- stairwells
- neighboring buildings
- neighboring streets and squares

Two sets to carry out successive measurements are available for risk assessment and mitigation during fires.

When analyzing over 450 substances, it was noticed that 11 inorganic fire and decomposition gases are overwhelmingly present during a fire. Multi-measuring devices

- Simultaneous test set for inorganic fire gases I
- Simultaneous test set for inorganic fire gases II

2-230-92

Measurement with the simultaneous test set

were developed for ten of these fire and decomposition gases. Although Dräger simultaneous test sets I and II were developed to carry out measurements in the immediate vicinity of a fire (either during the fire or the clean-up phase), they are also very helpful for assessing the spread of the combustion and decomposition gases to other areas.

Measurements of organic vapors

Solvents or other organic vapors can occur in hazmat accidents, for example. Simultaneous test set III for organic vapors was developed for these kinds of cases. This set indicates ketones, aromatics, alcohols, aliphatic hydrocarbons, and chlorinated hydrocarbons.

Measurement strategy

Dräger-Tubes can be used as a quick decision-making tool for detecting certain gas hazards at hazardous waste sites or in case of accidents, fires, etc. A statistical evaluation of these kinds of events, at which individual contaminants could be identified, showed the presence of combustible substances and therefore the presence of an explosion hazard in 60 to 65 % of all cases. As a result, the explosion hazard needs to be detected, preferably in combination with an oxygen and carbon monoxide measurement, before Dräger-Tubes are used. For instance, the Dräger multi-gas measuring and warning devices or the Dräger X-am family (Dräger X-am 2500 to Dräger X-am 8000), which are fitted with catalytic or electrochemical sensors, can be used for this purpose.

The simultaneous test sets were developed in order to obtain information about health hazards through quick measurements in the immediate hazard area.

Besides detecting individual substances, they are also designed for group detection with targeted non-specific reaction systems. In certain cases, for example, a more detailed differentiation may already be possible by obtaining information about the presence of acidic substances.

In addition to measurement with the simultaneous test sets, which are intended as a quick decision-making aid for the detection of gas hazards, the classic, comprehensive range of Dräger-Tubes or Dräger MicroTubes is available for more accurate measurements. Where necessary, samples can be taken on site and sent off for laboratory analysis.

The combination of the Dräger X-am devices and the simultaneous test sets complement each other to create a recommended strategy. This recommended strategy represents the fundamental approach in over 85 % of all cases. The measurement results apply exclusively for the time and place of measurement (momentary concentrations). Special, individual conditions require different, specific strategies. Dräger Safety AG & Co. KGaA employees support the user with the development of these kinds of strategies.

You can also find valuable information on the
"Dräger measurement strategy for fire departments" at the following link: **www.draeger.com/Messstrategie.** This link is only available in German-speaking countries.

ST-1234-2008

The suggested approach is not exhaustive and relates to the listed substances and substance groups. For other substances or substance groups that may arise, it may be necessary to undertake additional measurements using different procedures.

The specified measuring ranges apply for 20 °C and 1013 hPa.

Dräger X-am series measurement and warning devices
(at least incl. sensor for measuring %LEL and oxygen)

Proposed measurement strategy for detecting gas hazards
(Warning of explosion hazard and oxygen deficiency or excess oxygen)

Simultaneous test set for lead substances vfdb 10/01

	Scale mark ETW-1	Scale mark ETW-4
1. Carbon monoxide	33 ppm	83 ppm
2. Hydrocyanic acid	3.5 ppm	7.1 ppm
3. Hydrochloric acid	11 ppm	22 ppm
4. Nitrous fumes	8.2 ppm	12 ppm
5. Formaldehyde	1 ppm	

Further measurements using Dräger X-act 7000 and MicroTubes			
Carbon monoxide	5	–	150 ppm
Hydrocyanic acid	2	–	50 ppm
Hydrochloric acid	1	–	25 ppm
Nitrogen dioxide	0.5	–	25 ppm
Formaldehyde	0.2	–	5 ppm

Further measurements using Dräger X-act 5000 or accuro and Dräger-Tubes			
Carbon monoxide 10/b	10	–	3000 ppm
Hydrocyanic acid 0.5/a	0.5	–	50 ppm
Hydrochloric acid/nitric acid 1/a	1	–	15 ppm
Nitrous fumes 0.2/a	0.2	–	6 ppm
Formaldehyde 0.2/a	0.2	–	5 ppm

Simultaneous test set I for inorganic fire gases

	1st scale mark	2nd scale mark
1. Acid gases	2 ppm	10 ppm
2. Hydrocyanic acid	–	9.5 ppm
3. Carbon monoxide	30 ppm	150 ppm
4. Alkaline gases	30 ppm	150 ppm
5. Nitrous fumes	–	2.5 ppm

Further measurements using Dräger X-act 7000 and MicroTubes			
Hydrochloric acid	1	–	25 ppm
Hydrocyanic acid	2	–	50 ppm
Carbon monoxide	5	–	150 ppm
Ammonia	10	–	150 ppm
Nitrogen dioxide	0.5	–	25 ppm

Further measurements using Dräger X-act 5000 or accuro and Dräger-Tubes			
Hydrochloric acid/nitric acid 1/a	1	–	15 ppm
Hydrocyanic acid 0.5/a	0.5	–	50 ppm
Carbon monoxide 10/b	10	–	3000 ppm
Ammonia 5/a	5	–	600 ppm
Nitrous fumes 0.2/a	0.2	–	6 ppm

Simultaneous test set II for inorganic fire gases

	1st scale mark	2nd scale mark
1. Sulfur dioxide	–	10 ppm
2. Chlorine	–	2.5 ppm
3. Hydrogen sulfide	5 ppm	25 ppm
4. Phosphine	–	0.3 ppm
5. Phosgene	–	0.5 ppm

Further measurements using Dräger X-act 7000 and MicroTubes			
Sulfur dioxide	0.4	–	10 ppm
Chlorine	0.2	–	10 ppm
Hydrogen sulfide	2	–	50 ppm
Phosphine	0.1	–	2.5 ppm
Phosgene	0.05	–	2 ppm

Further measurements using Dräger X-act 5000 or accuro and Dräger-Tubes			
Sulfur dioxide 0.5/a	0.5	–	25 ppm
Chlorine 0.2/a	0.2	–	30 ppm
Hydrogen sulfide 1/c	1	–	200 ppm
Phosphine 0.01/a	0.01	–	1 ppm
Phosgene 0.02/a	0.02	–	1 ppm

Simultaneous test set III for organic vapors

	1st scale mark	2nd scale mark
1. Ketones	500 ppm	2500 ppm
2. Aromatics	50 ppm	250 ppm
3. Alcohols	200 ppm	1000 ppm
4. Aliphatic HC	50 ppm	100 ppm
5. Chlorinated HC	20 ppm	100 ppm

Further measurements using Dräger X-act 7000 and MicroTubes			
Acetone	40	–	600 ppm
Benzene	10	–	250 ppm
Ethanol (Alcohol)	100	–	2500 ppm
Gasoline HC	20	–	500 ppm
Perchloroethylene	5	–	500 ppm

Further measurements using Dräger X-act 5000 or accuro and Dräger-Tubes			
Acetone 100/b	100	–	12000 ppm
Toluene 50/a	50	–	400 ppm
Ethanol 100/a	100	–	3000 ppm
Hexane 10/a	10	–	2500 ppm
Perchloroethylene 10/b	1	–	500 ppm

Dräger X-am series measurement and warning devices
(at least incl. sensor for measuring %LEL and oxygen)
(Warning of explosion hazard and oxygen deficiency or excess oxygen)

Proposed measurement strategy for detecting substances with Dräger-Tubes

Detection of various organic and some inorganic substances

Polytest

Acetone, Acetylene, Arsine, Gasoline (engine fuels), Benzene, Ethylene, Liquefied petroleum gas (propane, butane), Carbon monoxide, Monostyrene, Perchloroethylene, Carbon disulfide, Hydrogen sulfide, Natural gas (with more than 2 Vol% CO), Nitric oxide (NO), Toluene, xylene, trichloroethylene

positive

Detection of various organic substances

Ethyl Acetate 200/a

Esters of acetic acid, alcohols, ketones, benzene, toluene, gasoline hydrocarbons

positive

Detection of important aromatic hydrocarbons:

Toluene 5/b

Benzene UN no.: 1114, (Ethylbenzene, toluene, and xylene discolor the pre-layer if small amounts are present)

Detection of ketones:

Acetone 100/b

Acetone UN no.: 1090
Methyl isobutyl ketone, methyl ethyl ketone

Detection of alcohols:

Butanol 10/a

Alcohol UN no.: 1096

negative

Detection of propane, butane:

Hydrocarbons 0.1 %/c

Propane UN no. 1978

Detection of CO:

Carbon Monoxide 10/b

CO UN no. 1016

Further detection

of other substances may be necessary

positive

Detection of some halogenated hydrocarbons

Perchloroethylene 2/a

Perchloroethylene, chloroform, dichloroethylene, dichloroethane, dichloropropane, trichloroethylene, methyl bromide

Detection of phosgene:

Phosgene 0.25/c

Phosgene

negative

Detection of amines

Amine Test

Triethylamine UN no.: 1296, ethylenediamine, hydrazine, ammonia

Detection of acidic substances:

Acid Test

Hydrochloric acid
UN no. 1789,
HNO_3, Cl_2, NO_2, SO_2

Further detection

of methane, ethane, H_2, CO_2, and other substances may be necessary

ST-1234-2008

This proposed measurement strategy is not exhaustive and relates to the listed substances and substance groups. For other substances or substance groups, it may be necessary to undertake additional measurements using different procedures. The Dräger-Tubes must be used together with a Dräger tube pump.

2.10 Measurement of Fumigants

To prevent damage from animals such as insects and other disease carriers or to disinfect or sterilize rooms, enclosed spaces are flooded with toxic or asphyxiant gases.

These days, with more stringent requirements and a global transport system, fumigants have a whole host of different applications:

– Fumigation of food stores and warehouses,
– Fumigation of grain stores and freighters,
– Fumigation of containers with all types of goods during transport,
– Fumigation in the medical sector for sterilization and disinfection
– Fumigation of buildings or parts of buildings
(e.g., houses, apartments, churches, museums, etc.).

Different fumigants or other substances are used depending on the application. For example, ethylene oxide and formaldehyde are used for sterilization and disinfection in the medical sector, while ammonia is used as an auxiliary substance for neutralization.

Phosphine is used to poison insects in order to protect agricultural products such as grains, vegetables, fruits, nuts, tobacco, etc. This sector also uses inert gases such as nitrogen, carbon dioxide, or noble gases (primarily argon) to displace oxygen and asphyxiate insects.

Methyl bromide, sulfuryl fluoride, and hydrocyanic acid are used to fumigate furniture, wood products, electrical/electronic devices, etc., during transport or to fumigate buildings and rooms.

Even more adventurous procedures such as impregnating leather products with benzene have also been used. The forwarder used benzene during transport in the container in order to prevent potential mold formation on the leather due to humidity and high temperatures.

Fumigants are also used in tablet form and placed in rooms or containers. They are evenly distributed throughout the entire area to achieve their desired effectiveness. But sometimes they are only placed at a certain point, e.g., behind the door to a container or on the door side in the container. This is particularly dangerous as this causes a sudden cloud of fumigant when opening the container door or when unloading the cargo.

The concentrations of the fumigants used need to be measured to protect the persons present at the start and end of the fumigation procedure, when loading and unloading the fumigated products from transport containers, or in case of possible leaks.

This is easy if the fumigant used is known. The matching tube or Dräger MicroTube can then be specifically selected from the Dräger-Tube range by substance and measuring range.

But if the fumigant is unknown, there is also no way of knowing which Dräger-Tube should be used for measurement. This is a common issue in container transport that arises due to a lack of marking of the fumigant used or even a lack of notification of fumigation.

Fumigants are highly toxic and harmful to health in other ways. As a result, suitable measuring instruments should generally be used to check whether and which fumigants were used before opening a container. This should also always include an oxygen concentration measurement. Any inert gases that are used displace air, i.e., including the atmospheric oxygen, and create a life-threatening risk of suffocation due to oxygen deficiency. This kind of oxygen deficiency can be triggered relatively easily by leaks in individual packages in the container.

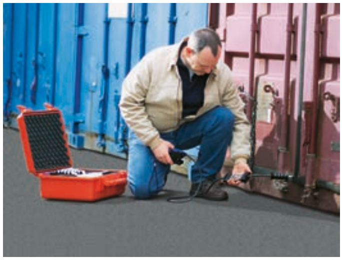
Here is a short overview of commonly used substances to give you an idea of how dangerous fumigants can be:

- Carbon dioxide
  Colorless and odorless, non-combustible gas, heavier than air, can therefore displace the atmospheric oxygen in poorly ventilated rooms and form CO_2 pools: risk of suffocation
- Phosphine
  Colorless and odorless gas: highly toxic, highly flammable
- Methyl bromide
  Colorless gas that smells slightly of chloroform: toxic, carcinogenic
- Sulfuryl fluoride
  Colorless and odorless gas, virtually inert, heavier than air: toxic, not combustible
- Hydrocyanic acid
  Colorless liquid with a typical odor of bitter almonds, boiling point 26 °C:
  highly toxic, highly explosive as a mixture with air
- Ethylene oxide
  Colorless gas with a sweet odor, heavier than air: toxic, carcinogenic, highly flammable
- Formaldehyde
  Colorless gas with a pungent odor: toxic
- Ammonia
  Colorless gas with a pungent odor: corrosive and asphyxiating, toxic, forms explosive mixture with air

Performing measurements

If the fumigant is known, the relevant Dräger-Tube is selected and the measurement performed. Depending on the determined concentration, the room can then be accessed or the container opened. If the measured concentration is still too high, it is ventilated and a new measurement performed so that the room or container can be cleared.

Fumigants should only be measured in containers when the container is still closed. To do so, the Dräger probe (order no.: 8317188) is pushed through the rubber seal on the container door. This requires the rubber seal on the container door to be lifted at the bottom point with the Dräger probe and the probe to be pushed as far into the container as possible. The Dräger-Tubes are prepared for measurement and connected to the probe. The pumps required for measurement are then carried out with the Dräger tube pump.


ST-4324-2003

Measurement at the container door


ST-4324-2003

Measurement with the probe

If the fumigant used is unknown, we recommend using the simultaneous test sets for fumigants to determine the fumigant used. The simultaneous test sets allow five fumigants to be measured simultaneously:

– Ammonia
– Methyl bromide
– Hydrocyanic acid
– Phosphine
– Formaldehyde
– or, instead of ammonia, ethylene oxide

If one or more gases are indicated by the simultaneous test set, the container is purged with air before access and the concentrations of the relevant gases are then checked again with the individual tubes.

The following additional Dräger-Tubes should be used to measure sulfuryl fluoride, ethylene oxide, and carbon dioxide:

Sulfuryl fluoride 1 / a	Measuring range	1	to	5	ppm
Ethylene oxide 1 / a	Measuring range	1	to	15	ppm
Carbon dioxide 0.1 % / a	Measuring range	0.1	to	6	Vol%

The Dräger Pac 6500 with an electrochemical sensor (measuring range 0 to 25 Vol%) is recommended for measuring oxygen. It is particularly small and handy.

If the concentration of carbon dioxide is to be measured at the same time, the Dräger X-am 8000 can be used as it has an IR CO_2 sensor (measuring range 0 to 5 or 0 to 100 Vol%). This is the best sensor for this type of CO_2 measurement. This gas detector also uses an electrochemical sensor (measuring range 0 to 25 Vol%) to measure oxygen.

Whenever performing a measurement to determine an explosion hazard, it must be noted that catalytic ex-sensors do not work in an inert atmosphere, which can arise due to the leakage of inert gases, for example. They require atmospheric oxygen for the measurement. In this case, the Dräger X-am 8000 with an infrared ex-sensor should be used.

2.11 Checking Air Flows

Detecting and localizing air flows is particularly important in some areas. The slightest flows need to be visualized in order to assess their source, direction, and speed. This particularly applies, for example,

- in underground mining
  to monitor the airflow direction, including in case of unclear ventilation;
- in industry
  to detect leaks in operating facilities, air movements in rooms, or for heating and laboratory installations;
- in ventilation technology
  to monitor and set air-conditioning systems.


2-342-93

Dräger flow tester

In addition, information about air flows is also particularly helpful if, for example, the distribution of vapor or gaseous contaminants needs to be determined in work areas. Knowledge of the airflow conditions allows suitable measuring points for the necessary concentration measurements to be determined.

Dräger Safety AG & Co. KGaA developed a flow tester for these purposes. This is a Dräger-Tube that contains a porous substrate impregnated with sulfuric acid. After opening the tube tips, air is pushed through the tube by a small blower ball.
The water vapor content in the air forms a heavily diluted sulfuric acid aerosol, which is clearly visible at the tube's outlet opening as white vapor. This smoke is carried by the air flow, as its specific gravity is effectively the same as that of air. The Dräger flow tester can be used several times and is sealed until next use with the supplied rubber caps.

Dräger Flow Check

The Dräger Flow Check is a flow tester that produces harmless fog clouds that float freely as they are coordinated with the specific gravity of air. The slightest air flows draw these fog clouds along, making them visible.

The Dräger Flow Check consists of:
– the device to generate fog and
– a cartridge or ampoule with the fog liquid.

D-7522-2019

The cartridge contains a specially developed alcohol mixture with high molecular weight. A small heating element in the head of the device heats the liquid, which then condenses to a fog when it is discharged into the ambient air. The temperature of the heating element and the quantity of the fog liquid are electronically coordinated.

Easy to use – high performance

Flow Check combines appealing device design with an ergonomic exterior shape, light weight, and optimal functionality. The device can naturally be used in any position.

ST-64-98

Dräger Flow Check

Individual, small clouds of fog are generated at the push of a button. If a continuous fog is desired, simply push and hold or lock the button. The cartridge with the fog liquid is positioned under a flap in the device handle and is effortlessly inserted in the retainer. There is enough liquid in one cartridge to continuously generate fog for about three minutes.

A rechargeable battery ensures the power supply. It is located in the handle housing and can be charged inside as well as outside the device. It can also be charged via the cigarette lighter in a vehicle using a vehicle connection cable. The charger has a fast discharge function for battery care.

2.12 Dräger Measurement Systems for Long-Term Measurements

Various direct indicating Dräger diffusion tubes are used for detecting average concentrations or time-weighted averages over several hours.

The direct indicating Dräger diffusion tubes are used as a passive system for the personal detection of average concentrations, i.e., without using a pump, over a period of one to eight hours. The measurement system is fastened to clothing at breathing height with a mount.

The contaminant molecules enter the diffusion tube based on the principle of diffusion. In Dräger diffusion tubes, the measurement result is read off the scale printed on the tube based on a color length indication. The measurement result is stated as a product of the concentration and exposure time, e.g., in ppm x h, ppm x min, Vol% x h, or mg/L x h. After the end of the measurement, the measured value read off the scale is converted to an average concentration, e.g.:

Direct indicating Dräger diffusion tubes

$$c = \frac{\text{Reading in ppm x h}}{\text{Measuring time in h}} \text{ [ppm]}$$

2.13 Expiration Date, Storage, and Disposal of Dräger-Tubes

Dräger-Tubes and MicroTubes are used for the quantitative determination of contaminants in air. A major benefit of these measurement methods is their constant readiness to be used immediately in emergencies or for routine monitoring.

This is made possible by the fact that Dräger-Tubes and MicroTubes are pre-calibrated at the factory. A scale is printed on the tubes, while, for Dräger MicroTubes, the data is stored in the RFID tag. The tubes can have different scale markings from batch to batch with the same order number within a defined tolerance range. This is due to different sensitivities of the reagent system from batch to batch. But, as a batch is always individually calibrated at the factory, this has no effect on the accuracy of the reading.
As this kind of reagent system does not have an unlimited shelf life, an expiration date is stated on the packaging. To receive a correct measurement result, the expiration date must not be exceeded.

The typical shelf life of Dräger-Tubes and MicroTubes for the customer is up to two years. A packaging box usually contains up to ten tubes with a standard label. The label displays the product name, order number, series/batch number, cold storage date, storage temperature, and the relevant expiration date of the series/batch (month and year).

Cold storage date
(only important for cold storage contract partners)

Customer storage temperature

Order number

Series/batch number

Barcode for X-act 5000
(only for pump with laser)

Shelf life date/expiration date

Manufacturer

Certificate in line with

D-5818-2022

Tube name

Measuring range

Order number

Number of tubes

Tube name

Series/batch number

QR code for Tubes app for Android

QR code for Tubes app for iOS

D-5817-2022

To ensure the trueness of the reading, Dräger-Tubes and MicroTubes should be stored in the supplied, sealed packaging at the temperature stated on the package strip (prevention of temperature and potential light influences).

The overall shelf life is determined when developing Dräger-Tubes and MicroTubes. This time is divided into a storage period at Dräger under cold storage conditions and a storage period at the customer under ambient conditions (customer storage temperature).

The customer can view the expiration date of tubes and MicroTubes on the underside of the package strip. This shows the maximum shelf life for the stated temperature range, typically room temperature.

A few Dräger-Tubes and MicroTubes also require cold storage by the customer (< 10 °C). The cold chain is therefore interrupted during transport from Dräger to the customer. As a result, a number of tubes and MicroTubes are stored at higher temperature, e.g., three days at 70 °C or 1 week at 60 °C, and monitored during the production of every series/batch. The measurement results of these pre-aged products must not differ from the results of unstored products. These tests simulate transport and long-term storage.

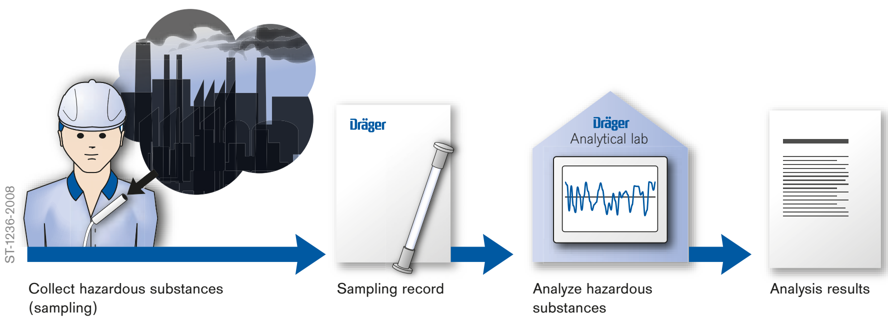
Dräger-Tubes and MicroTubes do not fall under the requirements of REACH regulation 1907/2006 for the preparation of safety data sheets, as these products do not contain hazardous ingredients. This means that no safety data sheets are necessary.
Dräger provides information about ingredients in product safety information sheets.
They can be found on the following web page: Dräger short-term tubes (www.draeger.com/sds)

Used Dräger-Tubes and MicroTubes with an expired expiration date must not be disposed of in domestic waste! They must be correctly disposed of or recycled, as the reagent system of these products contains chemicals, albeit only in extremely small amounts.

The statutory provisions, official orders, and the local conditions must be observed for the disposal of chemicals. For example, in the Federal Republic of Germany, the Circular Economy Act (KrWG) applies, which transcribes the EU Waste Framework Directive in national law. Dräger actively supports the circular economy, as by taking back and recycling our products we and our customers make an important contribution to conserving resources and sustainability. If you have any questions about recycling Dräger-Tubes, please contact us at recycling@draeger.com. Upon request, Dräger Safety AG & Co. KGaA supports users with the orderly and legally compliant disposal of Dräger products.

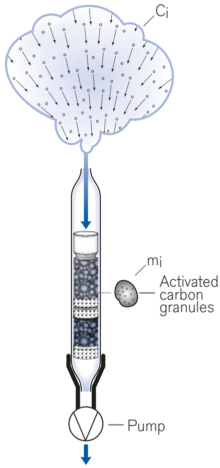
2.14 Dräger Sampling Systems

The measurement-based monitoring of hazardous substances in the air often requires considerable equipment and personal resources. This particularly applies if the measurements are carried out on site and appropriate direct indicating Dräger-Tubes are not available. Economic considerations have therefore led to a separation between sampling and analytical determination of the hazardous substances. This allows the amount of equipment required on site to be reduced to a minimum.



Air testing at the workplace by on-site sampling and subsequent laboratory analysis

Using the Dräger sampling systems, the hazardous substances contained in the air are first collected on a suitable medium by adsorption or chemisorption. The sample is then qualitatively and quantitatively examined in the laboratory using instrumental analytical methods, such as gas chromatography (GC), high performance liquid chromatography (HPLC), UV/VIS photometry, or IR spectroscopy.



Measurement principle for active sampling with Dräger activated charcoal tubes

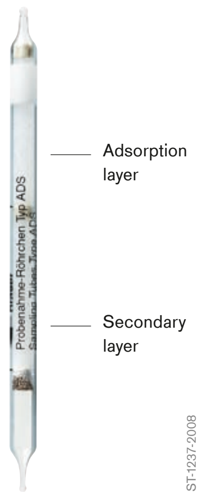
During stationary measurement, the sampling system is placed at the selected measuring site for the duration of the sampling. For personal air monitoring, the sampling system is fastened to the clothing in the breathing area.

To allow a concentration to be defined during analysis, the substance to be measured during sampling must be specifically directed at the adsorbent. This type of sampling can be active or passive.

Active sampling

During active sampling, the air to be tested is drawn through the sampling tube with a pump. The adsorbable substances contained in the air sample are deposited on the sorbent. The mass of contaminant m_i determined by the analysis and the air volume V drawn through the sampling tube make it easy to calculate the concentration c_i of the contaminant:

$$c_i = \frac{m_i}{V} \ [mg/m^3]$$



Dräger sampling tube

The sampling tube contains a collection layer and a control layer, which are analyzed separately in the laboratory. This separate analysis determines whether the total quantity of the substance to be measured was adsorbed. During sampling, the substance to be measured is first adsorbed on the collection layer. When this layer is no longer able to hold further amounts of substance, adsorption takes place on the control layer. In this case, the sampling needs to be repeated, as there is no way to be sure whether the entire amount of substance present was adsorbed. The air volume to be drawn through the sampling tube depends on the substance to be measured and the expected concentration. The volume is usually between 1 and 20 L.

As the air volume is the key reference variable for the concentration calculation following the laboratory analysis, high demands are placed on the pumps. For example, for short-term measurements, the Dräger accuro tube pump or the Dräger X-act 5000 can be used as part of the Dräger sampling system.

Sampling tubes for active sampling

Dräger-Tube	Adsorption layer	Secondary layer
Activated charcoal tube type NIOSH coconut shell charcoal	100 mg	50 mg
Activated charcoal tube type B coconut shell charcoal	300 mg	700 mg
Activated charcoal tube type G coconut shell charcoal	750 mg	250 mg
Silica gel tube type B	480 mg	1100 mg
Silica gel tube type G	1100 mg	450 mg
Sampling tube amines for aliphatic amines and dialkyl sulfates	300 mg	300 mg

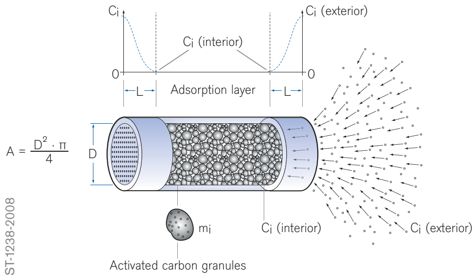
Passive sampling

Passive sampling takes place using diffusion samplers, e.g., the Dräger ORSA diffusion sampler. In contrast to active sampling, contaminant molecules are transported by diffusion processes, not by the use of a pump. In this case, the contaminant molecules from the ambient air follow a defined diffusion path and are adsorbed by the sorbent.

Fick's first law of diffusion is used to calculate the concentration:

$$\Delta c_i = \frac{m_i \cdot L}{Di \cdot t \cdot A} [mg/m^3]$$

In this formula, m_i is the mass of the substance that diffuses through the cross-sectional area A of the sampler parallel to the concentration gradient in the time t, and Δc_i is the concentration difference along the diffusion path L. Δc_i is essentially equivalent to the ambient concentration. The diffusion coefficient Di is a substance-specific variable.



Measurement principle of passive sampling with the ORSA diffusion sampler.

The diffusion samplers are fundamentally designed for sampling over an extended period to determine average concentrations. They are usually used over a period of 1 to 8 hours. In addition, the ORSA diffusion sampler can also be used for testing small concentration ranges over a period of up to 168 hours (7-day average value), e.g., for sampling perchloroethylene in living areas.

Sampling tubes for passive sampling

Diffusion sampler	Sorption layer
ORSA diffusion sampler	400 mg activated carbon made of coconut shell charcoal

2.15 Measurement of Aldehydes and Isocyanates at Workplaces

Aldehydes are commonly used for the production of synthetic resin, rubber, shoe, and adhesive products, for example. They can also be found in disinfectants, paints, lacquers, and plastics. The most important aldehydes are formaldehyde, glyoxal, glutaraldehyde, acetaldehyde, and acrolein.

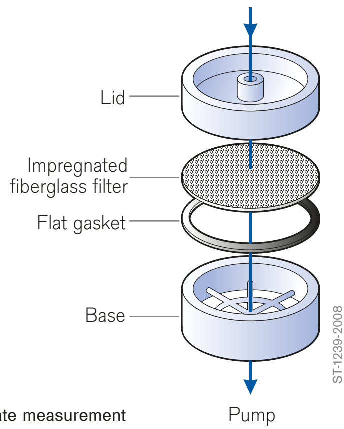
Isocyanates are of particular interest for industrial application, as they readily react with polyalcohols to form polyurethanes. Of the various high-polymer plastics, polyurethanes set themselves apart through their versatile applications, such as in lacquers, foams, elastomeric fibers, dispersions, etc. The product range of polyurethanes and therefore isocyanates as the raw material will continue to grow in future with the introduction of new technologies.

The toxicity of isocyanates, particularly the monomeric compounds, was already observed when industrial production was first established. The extended inhalation of isocyanate vapors and aerosols in concentrations that exceed the currently applicable occupational exposure limits damages the respiratory organs (isocyanate asthma).

Monitoring the occupational exposure limit for isocyanates places particularly high demands on the measurement method:

- Low limit of detection
- Insensitivity to other concomitant substances besides isocyanates in the air
- Sampling should be possible in the employee's breathing area
- Less qualified personnel should also be able to carry out sampling

Dräger Safety AG & Co. KGaA developed an aldehyde sampling set and an isocyanate sampling set for measurement.



Sampling head for isocyanate measurement

Both measurement methods are broken down into sampling and subsequent laboratory analysis. A pump draws a defined volume of air over a sampling head. The flow rate should amount to 0.1 to 1 L/min (total volume: 10 to 100 L) for aldehydes and 0.1 to 1 L/min (total volume: 20 to 100 L) for isocyanates. A coated fiberglass filter is inserted in the sampling head.

During sampling, the aldehydes react with a hydrazine compound to form a hydrazone derivative and the isocyanates react with an amine compound to form a urea derivative. After sampling, the loaded fiberglass filters must be stored in a cool place. In the laboratory, the fiberglass filters are then analyzed using high performance liquid chromatography. Immediate laboratory analysis of the fiberglass filter is required to obtain a recovery rate > 95 %.

2.16 Dräger Measurement Center for Air Testing at the Workplace

Dräger Safety AG & Co. KGaA offers a special measuring service for companies that are not able to monitor the air quality at the workplaces using an in-house measurement center. The "Dräger measurement center for air testing at the workplace" was included in the first list of suitable external measurement centers for measurements of hazardous substances in air at the workplace back in 1986. This list is issued by the Federal Ministry of Labor and Social Affairs and is published together with the Hauptverband der gewerblichen Berufsgenossenschaften (German Federation of Institutions for Statutory Accident Insurance and Prevention).

Based on the Technische Regeln für Gefahrstoffe (e.g., TRGS 402, TRGS 403, TRGS 900), concentration measurements of hazardous substances in the air at the workplace are carried out and the air quality is assessed in close collaboration with the client.

To do so, the hazardous substances present in the work area are first detected and localized. This examination is carried out together with the client and the employees working in the area, as only they are able to provide the necessary information on where and when substances are processed in the company and by whom. The determined data is then used to create a measurement plan, according to which the air testing is subsequently carried out at the workplaces to be monitored.

Both personal as well as stationary air samples are taken in the work area. The sampling extends across the entire work shift to assess the time-weighted average as well as over shorter periods to detect exposure peaks.

The qualitative and quantitative composition of the samples is analyzed in the Dräger laboratory. The high quality standard of the Dräger laboratory is ensured by ongoing internal laboratory controls and regular participation in national and international ring trials.

The results of the tests and the findings are communicated to the client in the form of a measurement report. This report provides an expert opinion and can be used as evidence, e.g., for trade inspectorates.

The Dräger measurement center for air testing at the workplace meets the requirements of the TRGS 400.

2.17 Dräger Analytical Services

The comprehensive Dräger Analytical Services is available for testing air samples taken independently with Dräger sampling systems. After taking the air sample, the sampling tube (e.g., activated charcoal tube) together with the completed sampling record and analysis order is sent to Dräger Analytical Services.

When the sample is received by the Dräger laboratory, a check takes place to determine whether

- the sampling tube is intact and sealed with the caps or the sampling system was delivered in a tightly sealed transport container,
- the sampling record contains all necessary information,
- the analysis order was clearly issued.

Any identified errors are noted in the analytical report and may require consultation with the client, e.g., in case of an incomplete sampling record. The sample is then prepared and analyzed on the basis of recognized and recommended analytical guidelines. A chemical/physical laboratory with analyzers for gas chromatography (GC), high performance liquid chromatography (HPLC), infrared spectroscopy (IR), and photometric (UV-VIS) tests is available. The personnel conducting the analyses have extensive experience in the fields of gas detection technology and instrumental analytics. The boundary conditions, such as sampling volume or duration, ambient conditions during sampling, desorption yield, or transfer rate, are then used to determine the substance concentration in the sample. The concentration is calculated using a computer-based program.

The result of the testing is transmitted to the client in the form of an analysis record. This record contains information about:

- the boundary conditions of the sampling (sampling volume, sampling duration, temperature, ambient pressure, etc.), which are taken from the associated sampling record,
- the analyzed hazardous substances and determined concentrations in mg/m^3 and mL/m^3,
- the current limit values.

The client is then able to use the analysis results and limit values to assess the air quality. This requires the results of the testing to be prepared in consideration of the data collected as part of the measurement planning and sampling.

2.18 Quality Assurance of the Dräger-Tube Measurement System

Dräger-Tubes are usually used for the quantitative determination of contaminants in air. The great benefit of the Dräger-Tube measurement system is its "constant readiness" thanks to the manufacturer calibration. Extensive manufacturer quality assurance measures are required to ensure correct calibration together with a sufficiently long shelf life.


45-915

Dräger-Tubes quality control warehouse

The development, production, and testing of Dräger-Tubes takes place within the scope of the Dräger quality system, which is set out in a separate standard. This standard includes the Dräger Quality Manual as its underlying document as well as further detailed quality standards as design instructions. This quality assurance system satisfies international requirements. Compliance with the requirements of DIN ISO 9001 has been and continues to be regularly verified by an independent test body.

This allows the life cycle of a Dräger-Tube, from the product idea to the individual development stages, series production, and subsequent product support, to be traced and monitored. This ensures a high quality standard.

Product support for the Dräger-Tubes continues even after they leave the production area. After release by Quality Assurance, several packages of every production batch are taken to a special warehouse where they are stored for up to 3 years as reference samples. Regular control measurements are carried out for every batch of Dräger-Tubes over a period of 2 years. If there are deviations from the specified calibration, recall actions are implemented as necessary.

Gas detector tube standards have been defined in various countries so that users of the Dräger-Tube measurement method can be sure that they are receiving state-of-the-art and consistent quality.

3 Dräger X-act 7000 Analysis System and Dräger MicroTubes

The innovative Dräger X-act 7000 analysis system consists of Dräger MicroTubes and the X-act 7000 optoelectronic analyzer and enables precise gas measurement in the low ppb range. It delivers exact results directly on site and replaces time-consuming and costly laboratory analyses, yet is very easy to use.

3.1 Benefits at a Glance

Sensitivity:	detects even extremely low ppb concentrations
Selectivity:	significantly reduces the number of false positive measurement results and false alarms
Versatility:	MicroTubes for the different gases and vapors
Easy to use:	insert MicroTubes, start measurement, read measurement result

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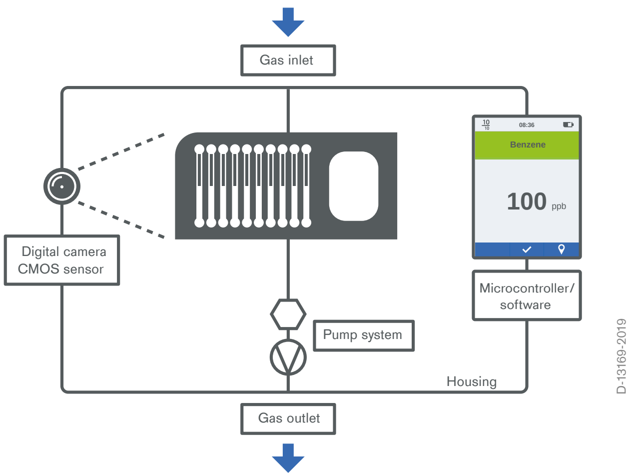
3.2 Dräger MicroTubes

Each MicroTubes set can be used to carry out 10 measurements in succession. The substance-specific reaction layers and various pre-layers in the small glass capillaries of the MicroTubes enable selective gas measurements. For example, the different layers act like a filter: They filter out other substances present at the workplace so that only the target substance flows into the measurement result. This largely eliminates cross-sensitivities and consequently reduces the number of false-positive measurement results and false alarms.

The RFID tags attached to the Dräger MicroTubes contain all calibration data that is valid for a typical period of use of one year. Calibration takes place at 20 °C and 50 % relative humidity. Possible temperature or humidity effects are stated using correction factors. This eliminates the need for complex functional tests and manual calibration, saving the user time and money. These MicroTubes are available for various hazardous substances and their number is constantly increasing.

3.3 Dräger X-act 7000

The actual analysis of the MicroTubes takes place in the X-act 7000 optoelectronic analyzer during measurement. The device opens the glass capillary in the MicroTubes and draws a constant flow through the reaction layers. This traps cross-sensitivities in the pre-layers, while the hazardous substance to be measured undergoes a chemical reaction with the reagent system, leading to a color change. This process is tracked by a high-resolution digital camera (CMOS sensor). This type of evaluation makes it possible to evaluate discolorations that are not detectable by the human eye. The speed of the color change is included in the calculation of the concentration. The result is then shown on the display. The mass flow measurement application principle means that the device is not affected by ambient pressure fluctuations.



3.4 Easy to Use

After an automatic self-test, the X-act 7000 analysis system is immediately ready to use. It is suitable for measurements with all available Dräger MicroTubes. The appropriate Dräger MicroTubes are simply inserted. The automatic motor drive carefully draws in the MicroTubes and positions them. The measurement is controlled using the 3 buttons and the 2.4-inch color display. The end of the measurement is signaled by a green LED and shown in the display. The measurement result, place, and time can be saved in the internal data logger and subsequently read out with the Dräger CC Vision software. Power is supplied by five easily replaceable batteries. The battery capacity is sufficient for more than ten hours of measurement and is shown on the display.

Suitable for tough working conditions

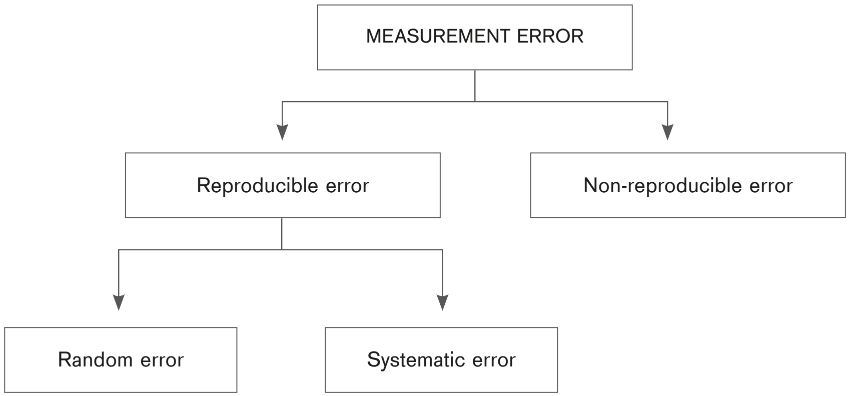
X-act 7000 is explosion-protected and certified in line with ATEX/IECEx for zone 0. The system is also protected against dust and spray water as per IP54. It satisfies the electromagnetic compatibility requirements in line with EN 61326-1.

Also suitable for pump measurements

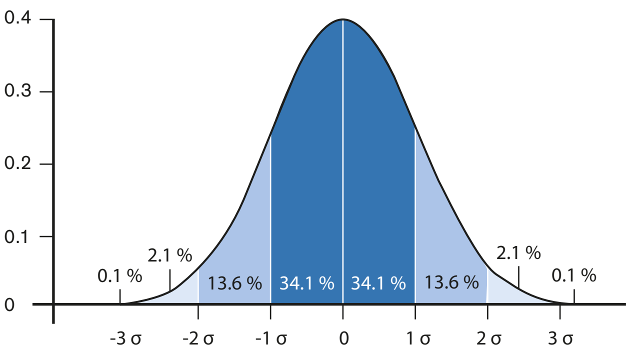
For measurements at inaccessible places, such as sewers, shafts, or tank installations, the X-act 7000 can be combined with the Dräger X-am pump. The coupler ensures a tight connection. Various probes and hoses up to 45 m long are also available.

4 Measurement Errors

The difference between the display on a detector and the correct value is referred to as measurement error. A measurement result cannot have a "zero" measurement error. The aim of every measurement system is to eliminate or at least minimize measurement errors.



There are many causes of measurement errors that can be classified as reproducible and non-reproducible errors. The latter should in fact not occur in analysis, yet remain a cause of incorrect assessments of situations. Typical examples include the use of measuring equipment that is not suitable for the analytes, or measurements at the wrong location. Reproducible errors are divided into random errors and systematic errors.



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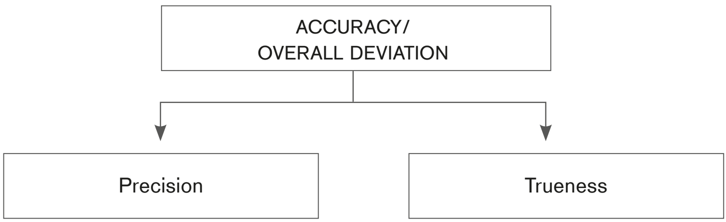
Standard deviation
Normal distribution of measurement results and their probabilities of occurrence depending on their deviation from the mean

Systematic error/trueness

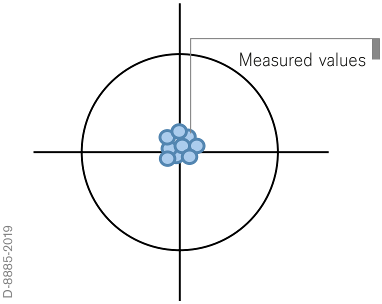
The trueness/systematic error describes the deviation of the mean of multiple measurements from the true concentration.

Accuracy/overall deviation

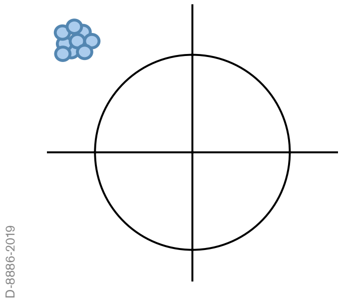
Accuracy is a general term in measurement technology and quality assurance. It is an indicator of the reproducible errors. A measuring instrument is accurate if it has a high standard of both precision and trueness. That is to say, when it allows only minor random and systematic errors.



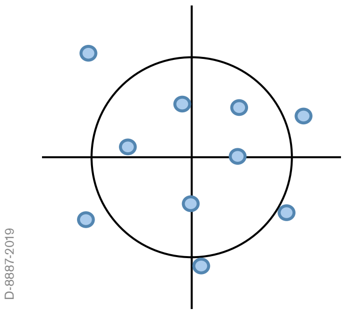
In EN 60051, the accuracy of a measuring instrument is defined as the "degree of conformity between the displayed and true value". This means that the difference between the displayed measured value and the true concentration is indicated.



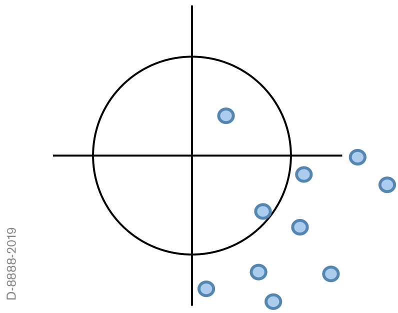
Precision good + trueness good →
Accuracy good



Precision good + trueness bad →
Accuracy bad



Precision bad + trueness good →
Accuracy bad



Precision bad + trueness bad →
Accuracy very bad

Limit of detection/limit of quantification

In analytics, a distinction is made between limit of detection and limit of quantification. The limit of detection (LOD) or lower detection limit (LDL) is the lowest measured value at which the presence of a substance can be qualitatively detected. The limit of quantification (LOQ) is the smallest concentration of an analyte that can be quantitatively detected with a defined accuracy. The limit of quantification always has at least the same accuracy as, or a higher accuracy than, the limit of detection.

4.1 Gas Detector Tubes

Random error (precision) and accuracy

The gas detector tube manufacturers provide information about the error levels in their documentation. This is defined through the relative standard deviation, as the precision usually accounts for the majority of the total measurement error (accuracy). The relative standard deviation is stated in % and relates to the mean.

Example:

Mean: 300 ppm
Standard deviation: 45 ppm
Relative standard deviation: ± 15 %

For the Dräger-Tubes, this standard deviation usually relates to the entire, specified measuring, temperature, and humidity range, in contrast to many other manufacturers.

The following known causes of random errors exist for gas detector tubes (these errors cannot be avoided, but information about their size can be provided)

- Low limit of detection
- Slight fluctuations in the filling quantity and packing density of the compound in finished tubes
- Different observers evaluate the indication differently (experience, visual acuity, color perception, influence of lighting conditions)
- Slight temperature and pressure fluctuations during measurement

Systematic error/trueness

Systematic errors can almost always be minimized, for example, by good quality management, correct handling, and intelligent product design.

Examples:

– Dräger Safety AG & Co. KGaA is certified in line with DIN EN ISO 9001, guaranteeing a quality management system that is controlled and checked at regular intervals:
– Incorrect calibration: Dräger-Tubes are produced in batches, and testing and calibration is carried out separately for each produced batch. The calibration method is based on the relevant standards.
– Storage effects: Product support for the Dräger-Tubes continues even after they leave the production area. After release by Quality Assurance, several packages of every production batch are taken to a special warehouse where they are stored for up to 3 years as reference samples. Regular control measurements are carried out on each batch of the products over a period of 2 years. If there are deviations from the specified calibration, recall actions are implemented as necessary.
– Leaking pumps: Tight pump systems are a critical point for accurate measurements. The Dräger X-act 5000 or X-act 5000 Basic automatic tube pump provides the option of carrying out a leak test before every measurement series. A manual leak test of the accuro manual tube pump can be carried out very easily.
– Incorrect handling: The handling of the Dräger-Tubes is precisely described in the instructions for use enclosed in the packaging.
– Interference from cross-sensitivities, humidity, and temperatures: These interferences are largely eliminated by pre-layers in the Dräger-Tubes.

Limit of detection/limit of quantification

Dräger-Tubes usually refer to the limit of quantification directly in their name. For example: Benzene 0.25/a: The smallest concentration for which the stated standard deviation of ±15 % applies is 0.25 ppm.

4.2 Dräger X-act 7000

The innovative Dräger X-act 7000 analysis system consists of Dräger MicroTubes and an optoelectronic analyzer and enables precise gas measurement down to the low ppb range. It is very easy to use: insert Dräger MicroTubes, start measurement, read measurement result. It delivers exact results directly on site and replaces time-consuming and costly laboratory analyses.

Random errors (precision)

To reduce random errors when measuring with the X-act 7000 and MicroTubes, i.e., to obtain highly reproducible measurement results, the following points were implemented in this analysis system:

- Automatic evaluation by a CMOS chip and a modern front tracking algorithm
- 100 % check of the specification of every X-act 7000 after production
- The Dräger X-act 7000 performs a self-test before every measurement series and a leak test before every measurement with every MicroTube
- Extremely low tolerances during the production of the Dräger MicroTubes
- Regular service option

Systematic error/trueness

The following measures were implemented for the X-act 7000 in addition to the precautions already described above for the tubes in order to minimize systematic errors:

- Automatic measurement process
- Ease of use
- Dräger MicroTubes are precalibrated
- Use of pre- and filter layers to eliminate the effects of cross-sensitivities as well as humidity and temperature
- On-site analysis (no deviation due to transport or storage of the sample, as is otherwise the case with laboratory analyses)

Limit of detection/limit of quantification

This limit of detection is stated in the name of the MicroTubes.
Example:
MT Benzene 1 – 150 ppb, limit of detection = 1 ppb / full scale value: 150 ppb
In this example, the limit of quantification is 5 ppb, which is also stated in the instructions for use.

Measuring range: 5 to 150 ppb
Accuracy: 25 % (under calibration conditions)
Limit of detection: 1 ppb

Accuracy/overall deviation

The same terms and definitions as used in laboratory analytics were used for stating the measurement error. The accuracy rather than the standard deviation is stated for the MicroTubes. The accuracy stated above: ± 25 % applies for the measuring range from 5 to 150 ppb.
For example, if a concentration of 10 ppb is indicated, the "actual" concentration, assuming a normal distribution, is between 7.5 and 12.5 ppb for at least 68 % of all measurements.

ISO 20581: 2016-11 "Workplace air – General requirements for the performance of procedures for the measurement of chemical agents" requires an expanded uncertainty of measurement of min. ≤ 50 % for the measuring range from 0.5 to 2 times the limit value for short-term measurement methods. For the expanded uncertainty, the simple accuracy is multiplied by the expansion factor 2.

The following applies for the above example:
Expanded uncertainty
For MicroTubes Benzene 1 – 150 ppb → ± 50 % for the measuring range from 5 to 150 ppb

For example, if a concentration of 10 ppb is indicated, the "actual" concentration, assuming a normal distribution, is between 5 and 15 ppb for at least 95 % of all measured values. As this is an on-site analysis, the sampling is already included in the error analysis. Errors that can arise from transportation and storage, as with laboratory analytics, also do not have to be considered here.

4.3 Summary

For gas detector tubes, the standard deviation is traditionally stated as the measure for the measurement error. For most Dräger-Tubes, this relates to the entire permissible temperature and humidity range. To reflect the terminology used in laboratory analytics, the accuracy is stated for the X-act 7000. The described, comprehensive measures ensure that the accuracy of all MicroTubes is less than or equal to ± 25 %. The X-act 7000 analysis system and MicroTubes therefore meet the expanded uncertainty requirements of ± 50 %, as required in ISO 20581: 2016-11 "Workplace air – General requirements for the performance of procedures for the measurement of chemical agents". The system also enables on-site analysis, eliminating errors due to sampling, transport, and storage.

5 Overview of Dräger-Tubes and MicroTubes Measurement Systems

5.1 Dräger Tube Pumps and Systems

Dräger accuro tube pump with tube opener	6400000
Dräger accuro tube pump set	6400260
Soft-side accuro pump kit	8317186
MDG kit	8318392
Dräger accuro spare parts set	6400220
Dräger X-act 5000 Basic 3707674	
NiMH battery T4	4523520
Plug-in power supply unit	4523545
Vehicle charger 12/24 V	4523511
SO_3 filter for Dräger X-act 5000 versions	8103525
Extension hose, 1 m	6400561
Extension hose, 3 m	6400077
Extension hose, 10 m	6400078
Extension hose, 15 m	6400079
Extension hose, 30 m for Dräger X-act 5000 versions	6401175
Orange fumigation case, without contents	8317147
Hot air probe	CH00213
Bar probe 400	8317188
Tube opener TO 7000	6401200
Hot-pack holder, complete	8316130
Spare hot pack (2 pieces)	8316139
Aerotest for testing compressed air, breathing air, medical gases, and carbon dioxide:	
Dräger Aerotest Alpha, complete	6527150
Dräger MultiTest med. Int, complete	6520260
Dräger SimultanTest CO_2, complete	6526170
Dräger Aerotest Simultan HP, complete	6525951
Dräger Aerotest Simultan HP, NOx	6525975
Impactor for oil measurement in compressed air	8103560
Adapter for the impactor	8103557
Dräger X-act 7000	8610800
Dräger X-am pump	8327115
USB charging cable for X-am pump	8327102
Black transport case (empty)	8327661
PBP Set 5-AA X-act 7000 T4 =EX=*	3703133

Pre-tube holder X-act 7000	3715575
H2S pre-tube	3716630
Dräger-Tube ppb Booster Basic	3702013
Coupler X-act 7000	8610810
Dust and water filter for pump inlet	8319364
5 m hose FKM 3 mm, comp. w. adapters	8325705
10 m hose FKM 3 mm, comp. w. adapters	8325706
20 m hose FKM 3 mm, comp. w. adapters	8325707
45 m hose FKM 3 mm, comp. w. adapters	8328121
Telescopic probe 100, incl. accessories	8316530
Telescopic probe ES 150	8316533
Bar probe 90, incl. accessories	8316532
Leakage probe 70	8316531
Hose 4.76 x 1.59 mm, 3 m, Tygon, PTFE	8326980
Tygon hose with PTFE inner coating (15 m)	4594679
Hose connection set 3 mm	8327641

5.2 Dräger Short-Term Tubes

Dräger-Tube	Order no.	Measuring range [20 °C, 1013 hPa]	Measuring time [min]	Page
Acetaldehyde 100/a	6726665	100 - 1000 ppm	5	118
Acetic acid 5/a	6722101	5 - 80 ppm	30 s	119
Acetone 40/a	8103381	40 - 800 ppm	1	120
Acetone 100/b	CH22901	100 - 12000 ppm	4	121
Acid test	8101121	qualitative	3 s	122
Acrylonitrile 0.2/a	8103701	0.2 - 4 ppm	4	123
		5 - 50 ppm	1	
Alcohol 10/a	3740290	50 - 5000 ppm	3	124
		10 - 500 ppm	7.5	
Amine test	8101061	qualitative	5 s	125
Ammonia 0.25/a	8101711	0.25 - 3 ppm	1	126
Ammonia 2/a	6733231	2 - 30 ppm	1	127
Ammonia 5/a	CH20501	5 - 70 ppm	1	128
		50 - 700 ppm	10 s	
Ammonia 5/b	8101941	5 - 100 ppm	10 s	129
Ammonia 0.5 %/a	CH31901	0.5 - 10 Vol%	20 s	130
Aniline 0.5/a	6733171	0.5 - 10 ppm	4	131
Arsine 0.05/a	CH25001	0.05 - 3 ppm	6	132
Benzene 0.25/a	8103691	0.25 - 3 ppm	5	133
		3 - 10 ppm	1	
Benzene 2/a (5)	8101231	2 - 60 ppm	8	134
Benzene 5/a	6718801	5 - 40 ppm	3	135
Benzene 5/b	6728071	5 - 50 ppm	8	136
Benzene 15/a	8101741	15 - 420 ppm	4	137
Carbon dioxide 100/a	8101811	100 - 3000 ppm	4	138
Carbon dioxide 0.1 %/a	CH23501	0.5 - 6 Vol%	30 s	139
		0.1 - 1.2 Vol%	2.5	
Carbon dioxide 0.5 %/a	CH31401	0.5 - 10 Vol%	30 s	140
Carbon dioxide 1 %/a	CH25101	1 - 20 Vol%	30 s	141
Carbon dioxide 5 %/A	CH20301	5 - 60 Vol%	2	142
Carbon disulfide 3/a	8101891	3 - 95 ppm	2	143
Carbon disulfide 5/a	6728351	5 - 60 ppm	3	144
Carbon disulfide 30/a	CH23201	0.1 - 10 mg/L	1	145

Dräger-Tube	Order no.	Measuring range [20 °C, 1013 hPa]	Measuring time [min]	Page
Carbon monoxide 2/a	6733051	2 - 60 ppm	4	146
		25 - 300 ppm	1	
Carbon monoxide 5/c	CH25601	100 - 700 ppm	30 s	147
		5 - 150 ppm	150 s	
Carbon monoxide 8/a	CH19701	8 - 150 ppm	2	148
Carbon monoxide 10/b	CH20601	100 - 3000 ppm	20 s	149
		10 - 300 ppm	4	
Carbon monoxide 0.3 %/b	CH29901	0.3 - 7 Vol%	30 s	150
Carbon tetrachloride 0.1/a	8103501	0.1 - 5 ppm	2.5	151
Carbon tetrachloride 1/a (5)	8101021	1 - 15 ppm	10	152
		10 - 50 ppm	5	
Chlorine 0.2/a	CH24301	0.2 - 3 ppm	3	153
		3 - 30 ppm	30 s	
Chlorine 50/a	CH20701	50 - 500 ppm	20 s	154
Chlorine dioxide 0.025/a	8103491	0.025 - 1 ppm	7.5	155
		0.1 - 1 ppm	2.5	
Chlorobenzene 5/a (5)	6728761	5 - 200 ppm	3	156
Chloroform 2/b (5)	6728861	2 - 10 ppm	9	157
Chloroformic acid ester 0.2/b	6718601	0.2 - 10 ppm	3	158
Chloromethane 10/a	8103911	10 - 100 ppm	1.5	159
Chloropicrin 0.1/a	8103421	0.1 - 2 ppm	7.5	160
Chloroprene 5/a	6718901	5 - 60 ppm	3	161
Chromic acid 0.1/a (9)	6728681	0.1 - 0.5 mg/m^3	8	162
Cyanide 2/a	6728791	2 - 15 mg/m^3	2	163
Cyanogen chloride 0.25/a	CH19801	0.25 - 5 ppm	5	164
Cyclohexane 40/a	8103671	40 - 200 ppm	5	165
		300 - 3000 ppm	15 s	
Cyclohexylamine 2/a	6728931	2 - 30 ppm	4	166
Diethyl ether 100/a	6730501	100 - 4000 ppm	3	167
Dimethyl formamide 10/b	6718501	10 - 40 ppm	3	168
Dimethyl sulfate 0.005/c (9)	6718701	0.005 - 0.05 ppm	50	169
Dimethyl sulfide 1/a (5)	6728451	1 - 15 ppm	15	170

Dräger-Tube	Order no.	Measuring range [20 °C, 1013 hPa]		Measuring time [min]	Page
Ethanol 100/a	8103761	100 -	3000 ppm	1.5	171
Ethyl acetate 200/a	CH20201	200 -	3000 ppm	5	172
Ethylbenzene 30/a	6728381	30 -	400 ppm	2	173
Ethylene 0.1/a (5)	8101331	0.2 -	5 ppm	30	174
Ethylene 50/a	6728051	50 -	2500 ppm	6	175
Ethylene glycol 10 (5)	8101351	10 -	180 mg/m³	7	176
Ethylene oxide 1/a (5)	6728961	1 -	15 ppm	8	177
Ethylene oxide 25/a	6728241	25 -	500 ppm	6	178
Epichlorohydrin 5/c	6728111	5 -	80 ppm	8	179
Fluorine 0.1/a	8101491	0.1 -	2 ppm	5	180
Formaldehyde 0.2/a	6733081	0.5 -	5 ppm	1.5	181
		0.2 -	2.5 ppm	3	
Formaldehyde 2/a	8101751	2 -	40 ppm	30 s	182
Formic acid 1/a	6722701	1 -	15 ppm	3	183
Petroleum Hydrocarbons 10/a	8101691	10 -	300 ppm	1	184
Petroleum Hydrocarbons 100/a	6730201	100 -	2500 ppm	30 s	185
Halogenated hydrocarbons 100/a (8)	8101601	100 -	2600 ppm	1	186
Hexane 10/a	8103681	20 -	200 ppm	5	187
		300 -	2500 ppm	1	
Hydrazine 0.01/a	8103351	0.01 -	0.4 ppm	30 s	188
		0.5 -	6 ppm		
Hydrazine 0.25/a	CH31801	0.25 -	10 ppm	1	189
		0.1 -	5 ppm	2	
Hydrocarbon 2/a	8103581	2 -	24 mg/L	5	190
Hydrocarbon 0.1 %/c	8103571	0.1 -	1.3 Vol% propane	2	191
		0.1 -	1.3 Vol% butane	2	
Hydrochloric acid 0.2/a	8103481	0.2 -	3 ppm	2	192
		3 -	20 ppm	40 s	
Hydrochloric acid 1/a	CH29501	1 -	10 ppm	2	193
Hydrochloric acid 50/a	6728181	500 -	5000 ppm	30 s	194
		50 -	500 ppm	4	
Hydrochloric acid/nitric acid 1/a	8101681				195
	Hydrochloric acid	1 -	10 ppm	1.5	
	Nitric acid	1 -	15 ppm	3	

Dräger-Tube	Order no.	Measuring range [20 °C, 1013 hPa]		Measuring time [min]	Page
Hydrocyanic acid 0.5/a	8103601	0.5 -	5 ppm	2.5	196
		5 -	50 ppm	0.5	
Hydrogen 0.2 %/a	8101511	0.2 -	2.0 Vol%	1	197
Hydrogen 0.5 %/a	CH30901	0.5 -	3.0 Vol%	1	198
Hydrogen fluoride 0.5/a	8103251	0.5 -	15 ppm	2	199
		0 -	90 ppm	25 s	
Hydrogen fluoride 1.5/b	CH30301	1.5 -	15 ppm	2	200
Hydrogen peroxide 0.1/a	8101041	0.1 -	3 ppm	3	201
Hydrogen sulfide 0.2/a	8101461	0.2 -	5 ppm	5	202
Hydrogen sulfide 0.2/b	8101991	0.2 -	6 ppm	55 s	203
Hydrogen sulfide 0.5/a	6728041	0.5 -	15 ppm	6	204
		5 -	150 ppm	40 s	
Hydrogen sulfide 1/c	6719001	10 -	200 ppm	20 s	205
		1 -	20 ppm	3	
Hydrogen sulfide 1/d	8101831	10 -	200 ppm	1	206
		1 -	20 ppm	10	
Hydrogen sulfide 2/a	6728821	20 -	200 ppm	20 s	207
		2 -	20 ppm	3.5	
Hydrogen sulfide 2/b	8101961	2 -	60 ppm	30 s	208
Hydrogen sulfide 5/b	CH29801	5 -	60 ppm	4	209
Hydrogen sulfide 100/a	CH29101	100 -	2000 ppm	30 s	210
Hydrogen sulfide 0.2 %/A	CH28101	0.2 -	7 Vol%	2	211
Hydrogen sulfide 2 %/a	8101211	2 -	40 Vol%	1	212
Hydrogen sulfide + Sulfur dioxide 0.2 %/a	CH28201	0.2 -	7 Vol%	2	213
Iodine 0.1/a	8103521	1 -	5 ppm	1	214
		0.1 -	0.6 ppm	5	
		0.1 -	1.3 Vol% 1:1 mix	2	
i-propanol 50/a	8103741	50 -	4000 ppm	2.5	215
Mercaptan 0.1/a	8103281	0.1	2.5 ppm	3	216
		3 -	15 ppm	40	
Mercaptan 0.5/a	672898	0.5 -	5 ppm	5	217
Mercaptan 20/a	8101871	20 -	100 ppm	2.5	218
Mercury vapor 0.1/ b	CH23101	0.05 -	2mg/m^3	10	219

Dräger-Tube	Order no.	Measuring range [20 °C, 1013 hPa]		Measuring time [min]	Page
Methanol 20/a	8103801	20 -	50 ppm	6	220
		200 -	5000 ppm	2	
Methyl acrylate 5/a	6728161	5 -	200 ppm	5	221
Methyl bromide 0.1/a	3706301	0.1 -	5 ppm	10	222
		5 -	50 ppm	2	
Methylene chloride 20/a	8103591	20 -	200 ppm	7	223
Natural gas odorization,	8103071	3 -	15 mg/m³	3	224
tert-butyl mercaptan		1 -	10 mg/m³	5	
Natural gas test (5)	CH20001		qualitative	100 s	225
n-butanol 10/a	8103861	10 -	250 ppm	6	226
		250 -	2000 ppm	1	
Nickel tetracarbonyl 0.1/a (9)	CH19501	0.1 -	1 ppm	5	227
Nitric acid 1/a	6728311	5 -	50 ppm	2	228
		1 -	15 ppm	4	
Nitrogen dioxide 0.1/a	8103631	0.1 -	5 ppm	75 s	229
		5 -	30 ppm	15 s	
Nitrogen dioxide 2/c	6719101	5 -	100 ppm	1	230
		2 -	50 ppm	2	
Nitrous fumes 0.2/a	8103661	0.2 -	6 ppm	75 s	231
Nitrous fumes 2/a	CH31001	5 -	100 ppm	1	232
		2 -	50 ppm	2	
Nitrous fumes 20/b	3706171	20 -	500 ppm	30 s	233
Nitrous fumes 50/b	8103941	50 -	1000 ppm	120 s	234
		2000 -	4000 ppm	60 s	
Oil mist 1/a	6733031	1 -	10 mg/m³	25	235
Olefins 0.05 %/a	CH31201			5	236
	Propene	0.06 -	3.2 Vol%		
	Butylene	0.04 -	2.4 Vol%		
Oxygen 5 %/B (8)	6728081	5 -	23 Vol%	1	237
Oxygen 5 %/C	8103261	5 -	23 Vol%	1	238
Ozone 0.05/b	6733181	0.05 -	0.7 ppm	3	239
Ozone 10/a	CH21001	20 -	300 ppm	20 s	240
Pentane 100/a	6724701	100 -	1500 ppm	3	241
Perchloroethylene 0.1/a	8101551	0.5 -	4 ppm	3	242
		0.1 -	1 ppm	9	

Dräger-Tube	Order no.	Measuring range [20 °C, 1013 hPa]		Measuring time [min]	Page
Perchloroethylene 2/a	8101501	20 -	300 ppm	30 s	243
		2 -	40 ppm	3	
Phenol 1/b	8101641	1 -	20 ppm	5	244
Phosgene 0.02/a	8101521	0.02 -	1 ppm	6	245
		0.02 -	0.6 ppm	12	
Phosgene 0.25/c	CH28301	0.25 -	5 ppm	1	246
Phosphine 0.01/a	8101611	0.1 -	1 ppm	2.5	247
		0.01 -	0.3 ppm	8	
Phosphine 0.1/c	8103711	0.5 -	3 ppm	1	248
		0.1 -	1 ppm	2.5	
Phosphine 0.1/b	8103341	1 -	15 ppm	20 s	249
in acetylene		0.1 -	1 ppm	4	
Phosphine 1/a	8101801	20 -	100 ppm	2	250
		1 -	20 ppm	10	
Phosphine 25/A	8101621	200 -	10000 ppm	1.5	251
		25 -	900 ppm	13	
Phosphine 50/a	CH21201	50 -	1000 ppm	2	252
Polytest	CH28401	qualitative		1.5	253
Pyridine 5/A	6728651		5 ppm	20	254
Styrene 10/a	6723301	10 -	200 ppm	3	255
Styrene 10/b	6733141	10 -	250 ppm	3	256
Sulfur dioxide 0.1/a	6727101	0.1 -	3 ppm	20	257
Sulfur dioxide 0.5/a	6728491	1 -	25 ppm	3	258
		0.5 -	5 ppm	6	
Sulfur dioxide 1/a	CH31701	1 -	25 ppm	3	259
Sulfur dioxide 20/a	CH24201	20 -	200 ppm	3	260
Sulfur dioxide 50/b	8101531	400 -	8000 ppm	15 s	261
		50 -	500 ppm	3	
Sulfuric acid 1/a (9)	6728781	1 -	5 mg/m^3	100	262
Sulfuryl fluoride 1/a (5)	8103471	1 -	5 ppm	3	263
Tert-butyl mercaptan	8103071	3 -	15 mg/m^3	3	264
Natural gas odorization		1 -	10 mg/m^3	2.5	
Tetrahydrothiophene 1/b (5)	8101341	1 -	10 ppm	10	265
		5 -	150 ppm		
Thioether	CH25803	2 mg/m^3 Limit value		1.5	296

Dräger-Tube	Order no.	Measuring range [20 °C, 1013 hPa]	Measuring time [min]	Page
Toluene 5/b	8101661	50 - 300 ppm	2	266
		5 - 80 ppm	10	
Toluene 50/a	8101701	50 - 400 ppm	1.5	267
Toluene 100/a	8101731	100 - 1800 ppm	1.5	268
Toluene diisocyanate 0.02/A (9)	6724501	0.02 - 0.2 ppm	20	269
Trichloroethane 50/d (5)	CH21101	50 - 600 ppm	2	270
Trichloroethylene 2/a	6728541	20 - 250 ppm	1.5	271
		2 - 50 ppm	2.5	
Trichloroethylene 50/a	8101881	50 - 500 ppm	1.5	272
Triethylamine 5/a	6718401	5 - 60 ppm	3	273
Vinyl chloride 0.5/b	8101721	5 - 30 ppm	30 s	274
		0.5 - 5 ppm	3	
Vinyl chloride 100/a	CH19601	100 - 3000 ppm	4	275
Water vapor 0.1	CH23401	1 - 40 mg/L	2	276
Water vapor 0.1/a	8101321	0.1 - 1.0 mg/L	1.5	277
Water vapor 1/b	8101781	20 - 40 mg/L	20 s	278
		1 - 18 mg/L	40 s	
Water vapor 3/a	8103031	3.0 - 60lbs/mmcf	90 s	279
Xylene 10/a	6733161	10 - 400 ppm	1	280

5.3 Dräger Diffusion Tubes with Direct Indication

Dräger-Tube	Order no.	Measuring range for 1 h measurement time [20 °C, 1013 hPa]	Measuring range for 8 h measurement time [20 °C, 1013 hPa]	Page
Ammonia 20/a-D	8101301	20 - 1500 ppm	2.5 - 200 ppm	312

5.4 Dräger Sampling Tubes and Systems

Dräger-Tube	Order no.	Page
Activated charcoal tubes		
Activated charcoal tube type NIOSH (adapter required)	6728631	318
Activated charcoal tube type BIA	6733011	314
Activated charcoal tube type G	6728831	317
Activated charcoal tube type B/G	8101821	315
Silica gel tubes		
Silica gel tube type BIA	6733021	322
Silica gel tube type G	6728851	323
Sampling tube ADS for aliphatic amines and dialkyl sulfates	8101271	319
Isocyanate sampling set (including analysis) Sampling system incl. analysis e.g., for HDI, TDI, MDI, etc.	6400131	321
Aldehyde sampling set (including analysis) Sampling system incl. analysis e.g., for formaldehyde, acetaldehyde, glutaraldehyde, etc.	6400271	316
ORSA 5 ORSA pack contains: – 5 ORSA collection tubes – 5 ORSA holders – 5 sampling records – 5 shipping bags, padded, with labels for Dräger Analytical Services	6728891	320

5.5 Substance Overview for Measurement with Dräger Sampling Tubes and Systems

Substance	ORSA	Activated carbon	Silica gel	Amines	Other
Acetaldehyde					ASS
Acetone	X	X			
Acetonitrile	X	X			
Acetylene tetrachloride	X	X			
Acrolein					ASS
Acrylonitrile	X	X			
Ethyl acrylate	X	X			
Methyl acrylate	X	X			
Allyl alcohol		X			
Allyl chloride	X	X			
Formic acid			X		
Ethyl formate	X	X			
Amines (aliphatic)				X	
Aminobutane (all isomers)				X	
Cyclohexane				X	
2-aminoethanol				X	
2-aminopropane				X	
Ammonia					WB
Amyl acetate		X			
n-amyl alcohol		X			
iso-amyl alcohol		X			
Aniline			X		
Cyclohexanone	X	X			
Benzene	X	X			
Benzene	X	X			
Bis(2-chloroethyl) ether	X	X			
Lead (in dust)					P
Bromochlorotrifluoroethane	X	X			
2-bromo-2-chloro-1,1,1-trifluoroethane	X	X			
Bromodichloromethane	X	X			
Bromoethane	X	X			
Methyl bromide	X	X			
Bromoform	X	X			
1,3-butadiene	X	X			
Butanal					ASS

ASS Aldehyde sampling set, **ISS** Isocyanate sampling set, **WB** Gas wash bottle, **P** Particle filter

Substance	ORSA	Activated carbon	Silica gel	Amines	Other
Butanol (all isomers)	X	X			
2-butanone	X	X			
1-butoxy-2,3-epoxypropane		X			
2-butoxyethanol	X	X			
2-(2-butoxyethoxy)ethanol	X	X			
Butoxyethyl acetate	X	X			
Butyl acetate (all isomers)	X	X			
n-butyl acrylate	X	X			
Butyl alcohol	X	X			
Butylamine (all isomers)				X	
Butyl glycol	X	X			
p-tert.-butyl toluene	X	X			
Camphor		X			
Chlorine					WB
Chlorobenzene	X	X			
Bromochloromethane	X	X			
2-chloro-1,3-butadiene	X	X			
1-chloro-2,3-epoxypropane	X	X			
Chloroethane	X	X			
2-chlorethanol	X	X			
Chloromethane		X			
Chloromethyl		X			
Chloroform	X	X			
2-chloroprene	X	X			
3-chloropropene	X	X			
3-chloro-1-propene	X	X			
a-chlorotoluene	X	X			
2-chloro-1,1,2-trifluoroethyl (difluoromethyl) ether	X	X			
1-chloro-2,2,2-trifluoroethyl (difluoromethyl) ether	X	X			
Hydrogen chloride					WB
Chromium(III) chromate					WB/P
Chromic acid					WB/P
Chromic acid anhydride					WB/P

ASS Aldehyde sampling set, **ISS** Isocyanate sampling set, **WB** Gas wash bottle, **P** Particle filter

Substance	ORSA	Activated carbon	Silica gel	Amines	Other
Chromium trioxide					WB/P
Chromium(IV) compounds					WB/P
Cumene	X	X			
Cumol	X	X			
Cyclohexane	X	X			
Cyclohexanol		X			
Cyclohexanone	X	X			
Cyclohexene	X	X			
Cyclohexylamine				X	
Diacetone alcohol		X			
1,2-diaminoethane				X	
Chlorodibromomethane	X	X			
1,2-dibromoethane	X	X			
o-dichlorobenzene	X	X			
p-dichlorobenzene	X	X			
2,2-dichloroethyl ether	X	X			
Dichlorodifluoromethane	X	X			
1,1-dichloroethane	X	X			
1,2-dichloroethane	X	X			
1,1-dichloroethene	X	X			
1,2-dichloroethene	X	X			
1,2-dichloroethylene	X	X			
Dichlorofluoromethane	X	X			
Dichloromethane	X	X			
1,1-dichloro-1-nitroethane	X	X			
1,2-dichloropropane	X	X			
1,2-dichloro-1,1,2,2-tetrafluoroethane	X	X			
Diethylamine				X	
Diethyl ether	X	X			
Diethyl sulfate				X	
Bromodifluoromethane	X	X			
Dibromodifluoromethane	X	X			
Difluoromonochloromethane	X	X			
Diisobutyl ketone	X	X			
Toluene diisocyanate					ISS

ASS Aldehyde sampling set, **ISS** Isocyanate sampling set, **WB** Gas wash bottle, **P** Particle filter

Substance	ORSA	Activated carbon	Silica gel	Amines	Other
Diisopropyl ether	X	X			
1,2-dimethoxyethane	X	X			
Dimethylacetamide				X	
Dimethylamine				X	
N,N-dimethylaniline		X			
Dimethylbenzene	X	X			
1,3-dimethylbutyl acetate	X	X			
1,1-dimethylethylamine				X	
N,N-dimethylethylamine				X	
Dimethyl formamide				X	
2,6-dimethyl-4-heptanone	X	X			
Dimethyl sulfate				X	
1,4-dioxane	X	X			
Diphenyl ether (vapor)		X			
Diphenylmethane 4,4′-diisocyanate					ISS
4,4′-diphenylmethane diisocyanate					ISS
Dodecane	X	X			
Enflurane	X	X			
Epichlorohydrin	X	X			
1,2-epoxy-3-butoxypropane		X			
1,2-epoxypropane		X			
Epoxypropanol		X			
Acetic acid			X		
Amyl acetate (all isomers)		X			
n-butyl acetate (all isomers)	X	X			
Ethyl acetate	X	X			
Acetic acid sec-hexyl ester	X	X			
Methyl acetate	X	X			
Propyl acetate	X	X			
Vinyl acetate	X	X			
Ethanol	X	X			
Ethanolamine				X	
Ether	X	X			
2-ethoxyethanol	X	X			
2-ethoxyethyl acetate	X	X			

ASS Aldehyde sampling set, **ISS** Isocyanate sampling set, **WB** Gas wash bottle, **P** Particle filter

Substance	ORSA	Activated carbon	Silica gel	Amines	Other
1-ethoxy-2-propanol	X	X			
Ethyl acetate	X	X			
Ethyl acrylate	X	X			
Ethyl alcohol	X	X			
Ethylamine				X	
Ethylbenzene	X	X			
Ethyl bromide	X	X			
Ethyl chloride	X	X			
Ethylene bromide	X	X			
Ethylene chlorohydrin	X	X			
Ethylene chloride	X	X			
Ethylenediamine				X	
Ethylene dibromide	X	X			
Ethylene dichloride	X	X			
Ethylene glycol mono-					
butyl ether	X	X			
butyl ether acetate	X	X			
ethyl ether	X	X			
ethyl ether acetate	X	X			
methyl ether	X	X			
methyl ether acetate	X	X			
Ethylene oxide	X	X			
Ethyl ether	X	X			
Ethyl formate	X	X			
Ethylene glycol	X	X			
Ethyl glycol acetate	X	X			
Ethyl methyl ketone	X	X			
Fluorotrichloromethane		X			
Formaldehyde					ASS
Glutaraldehyde					ASS
Glycidol		X			
Halothane	X	X			
HDI					ISS
Heptane (all isomers)	X	X			
Hexachloroethane	X	X			

ASS Aldehyde sampling set, **ISS** Isocyanate sampling set, **WB** Gas wash bottle, **P** Particle filter

Substance	ORSA	Activated carbon	Silica gel	Amines	Other
1,6-hexamethylene diisocyanate					ISS
Hexamethylene diisocyanate					ISS
Hexane	X	X			
2-hexanone	X	X			
Hexone	X	X			
sec-hexyl acetate	X	X			
4-hydroxy-4-methyl-2-pentanone		X			
Iodomethane		X			
Isoamyl alcohol	X	X			
Isocyanates					ISS
Isoflurane	X	X			
Isophorone		X			
Isophorone diisocyanate					ISS
Isopropenyl benzene	X	X			
Isopropyl acetate	X	X			
Isopropyl alcohol	X	X			
Isopropylamine				X	
Isopropylbenzene	X	X			
Isopropyl ether	X	X			
Camphor		X			
Carbon disulfide	X	X			
Cresol (all isomers)			X		
MDI					ISS
Mesityl oxide	X	X			
Methanol			X		
2-methoxyethanol	X	X			
2-methoxyethyl acetate	X	X			
1-methoxy-propanol-2		X			
Dipropylene glycol monomethyl ether	X	X			
2-methoxypropyl acetate	X	X			
Methyl acetate	X	X			
Methyl acrylate	X	X			
Methyl alcohol			X		
Methylamine				X	
Methylamyl alcohol		X			

ASS Aldehyde sampling set, **ISS** Isocyanate sampling set, **WB** Gas wash bottle, **P** Particle filter

Substance	ORSA	Activated carbon	Silica gel	Amines	Other
Methyl bromide	X	X			
Methyl butyl ketone	X	X			
Methyl chloride		X			
Methyl chloroform	X	X			
Methylcyclohexane	X	X			
Methylcyclohexanol		X			
Methyl diphenyl diisocyanate					ISS
Methylene chloride	X	X			
Methyl ethyl ketone	X	X			
Methyl glycol	X	X			
Methyl glycol acetate	X	X			
5-methyl-2-hexanone	X	X			
Methyl iodide		X			
Methyl isobutyl carbinol		X			
Methyl isobutyl ketone	X	X			
Methyl methacrylate	X	X			
4-methyl-2-pentanol		X			
4-methyl-2-pentanone	X	X			
2-methyl-2-penten-4-one	X	X			
4-methyl-3-penten-2-one	X	X			
2-methyl-2-propanol	X	X			
Methyl propyl ketone	X	X			
N-methyl-2-pyrrolidone (vapor)				X	
Methyl styrene	X	X			
α-methyl styrene	X	X			
Methylvinyl benzene	X	X			
Monochlorodifluoromethane		X			
Morpholine				X	
Naphthalene		X			
Nitrobenzene			X		
1-nitropropane			X		
2-nitropropane			X		
Nitrotoluene			X		
Nonane	X	X			
Octane	X	X			

ASS Aldehyde sampling set, **ISS** Isocyanate sampling set, **WB** Gas wash bottle, **P** Particle filter

Substance	ORSA	Activated carbon	Silica gel	Amines	Other
Octyl acrylate	X	X			
Ozone					WB
Pentane (all isomers)	X	X			
n-pentanol	X	X			
2-pentanone	X	X			
Pentyl acetate		X			
Perchloroethane	X	X			
Perchloroethylene	X	X			
Phenol			X		
Phenylethylene	X	X			
alpha-pinene	X	X			
Propanal					ASS
Propanol (all isomers)	X	X			
2-propenal					ASS
2-propen-1-ol		X			
Isopropenylbenzene	X	X			
Propionaldehyde					ASS
Propyl acetate (all isomers)	X	X			
Propyl alcohol (all isomers)	X	X			
Isopropylamine				X	
Isopropylbenzene	X	X			
Propylene dichloride	X	X			
1,2-propylene oxide	X	X			
n-propyl nitrate		X			
Pyridine	X	X			
R-11		X			
R-12		X			
R-21		X			
R-112	X	X			
R-113	X	X			
R-114	X	X			
Hydrochloric acid					WB
Sulfur dioxide					WB
Carbon disulfide		X			
Hydrogen sulfide					WB

ASS Aldehyde sampling set, **ISS** Isocyanate sampling set, **WB** Gas wash bottle, **P** Particle filter

Substance	ORSA	Activated carbon	Silica gel	Amines	Other
Nitrogen dioxide					WB
Styrene	X	X			
TDI					ISS
Turpentine		X			
1,1,1,2-tetrachloro-2,2-difluoroethane	X	X			
1,1,2,2-tetrachloro-1,2-difluoroethane	X	X			
1,1,2,2-tetrachloroethane	X	X			
Tetrachloroethene	X	X			
Tetrachloroethylene	X	X			
Carbon tetrachloride	X	X			
Tetrachloromethane	X	X			
Tetrahydrofuran	X	X			
Toluene	X	X			
2,6-toluene diisocyanate					ISS
2,4-toluene diisocyanate					ISS
Toluene diisocyanate					ISS
Tribromomethane	X	X			
1,1,1-trichloroethane	X	X			
1,1,2-trichloroethane	X	X			
Trichloroethene	X	X			
Trichloroethylene	X	X			
Trichlorofluoromethane	X	X			
Trichloromethane	X	X			
1,2,3-trichloropropane	X	X			
1,1,2-trichloro-1,2,2-trifluoroethane	X	X			
Triethylamine				X	
Trifluorobromomethane	X	X			
Trimethylbenzene (all isomers)	X	X			
3,5,5-trimethyl-2-cyclohexene-1-one	X	X			
n-undecane	X	X			
Vinyl acetate	X	X			
Vinylbenzene	X	X			
Vinyl chloride		X			
Vinylidene chloride	X	X			
N-vinylpyrrolidone				X	

ASS Aldehyde sampling set, **ISS** Isocyanate sampling set, **WB** Gas wash bottle, **P** Particle filter

Substance	ORSA	Activated carbon	Silica gel	Amines	Other
Vinyl toluene	X	X			
Hydrogen peroxide					WB
Xylene (all isomers)	X	X			
Zinc chromate					WB/P

Other substances are available on request or in the Dräger VOICE hazardous substances database at: www.draeger.com/voice

ASS Aldehyde sampling set, **ISS** Isocyanate sampling set, **WB** Gas wash bottle, **P** Particle filter

5.6 Dräger MicroTubes

MicroTube	Measuring range	Order no.	Page
Acetic acid	2 - 50 ppm	8610330	327
Acetone	25 - 5000 ppm	8610470	328
Alcohol	10 - 5000 ppm	8610380	329
Ammonia	1 - 100 ppm	8610130	330
Ammonia	100 - 2500 ppm	8610020	331
Benzene	5 - 150 ppb	8610600	332
Benzene	0.15 - 10 ppm	8610030	333
Benzene	10 - 100 ppm	8610280	334
1,3-Butadiene	25 - 500 ppb	8610460	335
1,3-Butadiene	0.5 - 25 ppm	8610300	336
Carbon dioxide	200 - 50000 ppm	8610190	337
Carbon monoxide	2 - 1000 ppm	8610080	338
Chlorine	50 - 5000 ppb	8610010	339
Ethylene oxide	25 - 250 ppb	8610200	340
Ethylene oxide	0.25 - 10 ppm	8610580	341
Formaldehyde	5 - 150 ppb	8610540	342
Formaldehyde	0.15 - 3 ppm	8610100	343
Petroleum Hydrocarbons	10 - 3000 ppm	8610270	344
Hydrochloric acid	0.5 - 25 ppm	8610090	345
Hydrocyanic acid	0.5 - 50 ppm	8610520	346
Hydrogen sulfide	0.1 - 50 ppm	8610050	347
Hydrogen sulfide	100 - 2000 ppm	8610220	348

6 Data and Table Section

6.1 Dräger-Tube Measurement System

6.1.1 Notes on the Data about Dräger-Tubes

Dräger-Tubes

The name and type designation of the Dräger-Tube as well as the order number are provided.

The name of the Dräger-Tube also defines the substance that can be measured with the Dräger-Tube and to which it is calibrated. The type designation consists of numbers and letters. As a general rule, the numbers define the lower measuring range (in ppm, mg/m^3, mg/L, or Vol%). The letter following the numbers changes whenever Dräger-Tubes have been improved by a further development (e.g., the Dräger Short-Term Tube Acetone 100/b).

The additional letter D is used to identify the direct indicating Dräger diffusion tubes (e.g., the direct indicating Dräger Diffusion Tube Ammonia 20/a-D).

Measuring range

The measuring range for 20 °C and 1,013 hPa is stated for the determined standard deviation in line with DIN 1319.

The number of strokes stated for the Dräger short-term tubes or the measuring time stated for the direct indicating Dräger diffusion tubes must be observed.

Compliance with the instructions for use must also be ensured. In addition, the defined measuring range for Dräger short-term tubes applies only if the Dräger-Tubes are used together with a Dräger tube pump.

Number of strokes n

The number of strokes relating to the stated measuring range that need to be performed with a Dräger tube pump for short-term measurements are defined for the Dräger short-term tubes.

For the scale tubes, the number of strokes relates directly to the numerical values on the scale. For color comparison tubes and tubes with a marking ring, the highest and lowest number of strokes required until a certain color pattern occurs are defined.

Measuring time

For the Dräger short-term tubes, the average measuring time for the respective measuring range is stated in s or min.

Standard deviation

As a measure of the deviations of the individual measured values from their mean, the standard deviation is provided as a coefficient of variation (relative standard deviation) for the confidence interval 1 σ. At this confidence interval, 68.3 % of all possible measured values are within this standard deviation.

For example: Mean 500 ppm
Absolute standard deviation 50 ppm

$$\text{Relative standard deviation [\%]} \quad \frac{50 \times 100}{500} = 10$$

Color change

The color of the indicating layer of the unused Dräger-Tube and the expected discoloration of this indicating layer in the presence of the measured substance in the measuring range is specified. Deviations from the actual product can occur if the production process needs to be adjusted between editions of this handbook.

Permissible ambient conditions

The measuring range depends on the temperature and humidity. The permissible temperature range is stated in °C and the permissible absolute humidity in mg H_2O/L.

In addition, measurement with the Dräger-Tube measurement system calibrated at 1,013 hPa also depends on the ambient pressure. To correct for the effect of pressure, the read measured value must be multiplied by the following correction factor:

$$\text{Correction factor} = \frac{1{,}013 \text{ hPa}}{\text{Actual ambient pressure in hPa}}$$

Reaction principle

The reaction principle states the essential reaction products in simplified form.

Cross-sensitivity

Dräger-Tubes are calibrated to a specific substance. If only this substance is present during measurement, the measurement generally only depends on the measuring range or the current ambient conditions. If the measured substance as well as other substances are present, a check is required to determine the extent to which these substances influence the measurement result and whether the Dräger-Tube used provides a reliable measurement result.

The cross-sensitivity defines which other substances present during measurement affect the indicating behavior of the Dräger-Tube and the substances that have no effect on the measurement result. The effect of the cross-sensitivity has been checked for the specified substances.

Measuring range extension

Whenever the defined measuring range of a Dräger-Tube can be extended by a change in the number of strokes, the extended measuring range is stated, potentially with the necessary correction factor.

Additional notes/caution

Additional boundary conditions to be observed during the measurement are stated.

6.1.2 Data about Dräger-Tubes for Short-Term Measurements

A

Acetaldehyde 100/a

Order no. 6726665

General data

Measuring range:	100 to 1000 ppm
Number of strokes n:	20
Measuring time:	approx. 5 min
Standard deviation:	± 15 to 20 %
Color change:	orange → brown-green

Permissible ambient conditions

Temperature:	0 to 40 °C
Humidity:	3 to 15 mg H_2O/L

Reaction principle

$CH_3CHO + Cr^{VI} \rightarrow Cr^{III}$ + var. oxidation products

Cross-sensitivity

The tube does not allow differentiation if different aldehydes are present at the same time.

Ethers, ketones, esters, aromatic compounds, and benzines are also indicated, but with a different sensitivity.

ST-2-2001

Acetic Acid 5/a

Order no. 6722101

General data

Measuring range:	5 to 80 ppm
Number of strokes n:	3
Measuring time:	approx. 30 s
Standard deviation:	± 10 to 15 %
Color change:	violet-blue → yellow

Permissible ambient conditions

Temperature:	10 to 40 °C
Humidity:	less than 30 mg H_2O/L

Reaction principle

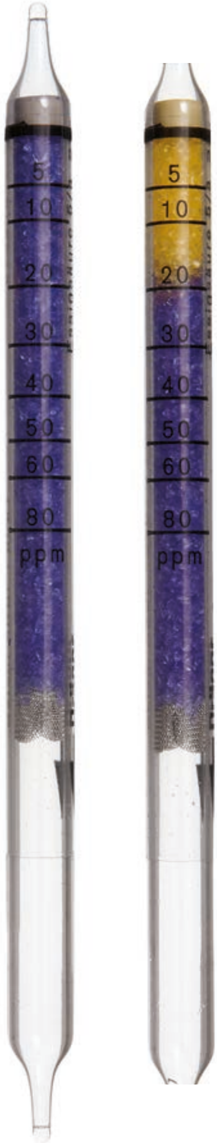
CH_3COOH + pH indicator → yellow reaction product

Cross-sensitivity

An acetic acid measurement is not possible in the presence of other acids.

Organic acids are indicated with the same color, but sometimes with different sensitivities.

Mineral acids, e.g., hydrochloric acid, are indicated with a different sensitivity and in red.



D-13305-2010

Acetone 40/a

Order no. 8103381

A

General data

Measuring range:	40 to 800 ppm
Number of strokes n:	1
Measuring time:	approx. 1 min
Standard deviation:	± 15 to 20 %
Color change:	light yellow → yellow

Permissible ambient conditions

Temperature:	5 to 40 °C
Humidity:	5 to 40 mg/L

Reaction principle

Acetone + 2,4-dinitrophenylhydrazine → yellow hydrazone

Cross-sensitivity

Other ketones are also indicated, but with different sensitivities.

Aldehydes are also indicated.

500 ppm ethyl acetate does not affect the reading.

Ammonia interferes with the indication due to a yellow-brown coloring of the indicating layer.

ST-569-2008

Acetone 100/b

Order no. CH22901

General data

Measuring range:	100 to 12000 ppm
Number of strokes n:	10
Measuring time:	approx. 4 min
Standard deviation:	± 15 to 20 %
Color change:	light yellow → yellow

Permissible ambient conditions

Temperature:	0 to 40 °C
Humidity:	5 to 20 mg H_2O/L

Reaction principle

Acetone + 2,4-dinitrophenylhydrazine → yellow hydrazone

Cross-sensitivity

Other ketones are also indicated, but with different sensitivities.

Aldehydes are also indicated, but not esters.

Ammonia affects the reading, as it discolors the indicating layer yellow-brown.

ST-567-2008

Acid Test

Order no. 8101121

General data

Measuring range:	Qualitative detection of acid gases
Number of strokes n:	1
Measuring time:	approx. 3 s
Standard deviation:	± 30 %
Color change:	violet-blue → yellow or pink-yellow

Permissible ambient conditions

Temperature:	0 to 40 °C
Humidity:	3 to 15 mg H_2O/L

Reaction principle

e.g., HCl + pH indicator → pink-yellow reaction product

Cross-sensitivity

The tube non-specifically indicates acid gases with different sensitivities and different colors. Differentiation between different acids is not possible.

ST-115-2001

Acrylonitrile 0.2/a

Order no. 8103701

General data

Measuring range:	0.2 to 4 ppm / 5 to 50 ppm
Number of strokes n:	20 / 5
Measuring time:	approx. 4 min / approx. 1 min
Standard deviation:	± 15 to 20 %
Color change:	yellow → red

Permissible ambient conditions

Temperature:	5 to 40 °C
Humidity:	1 to 25 mg H_2O/L

Reaction principle

a) CH_2=CH-CN + MnO_4 → HCN

b_1) HCN + $HgCl_2$ → HCl

b_2) HCl + methyl red → red reaction product

Cross-sensitivity

At 4 ppm acrylonitrile no affect from:

1000 ppm acetone, 20 ppm benzene, 1000 ppm ethyl acetate. In the presence of 500 ppm ethanol, 1000 ppm n-hexane, or 100 ppm toluene, acrylonitrile is indicated with lower sensitivity and the concentration cannot be determined. In the presence of 400 ppm butadiene, the indication of 4 ppm acrylonitrile is largely suppressed.

D-2149-2015

Alcohol 10/a

Order no. 3740290

A

General data

Measuring range:	500 - 5000 ppm / 10 - 500 ppm Methanol, ethanol, iso-propanol, and n-butanol
Number of strokes n:	2 / 5
Measuring time:	3 min / 7.5 min
Standard deviation:	± 10 - 25 %
Color change:	yellow → mint green

Permissible ambient conditions

Temperature:	0 - 40 °C
Temperature correction:	15 - 25 °C → none <15 °C → +10 % of the measured value per °C >25 °C → -4.5 % of the measured value per °C
Humidity:	1 – 20 mg/L

Reaction principle

Alcohol + organometallic compounds → green reaction product

Cross-sensitivity

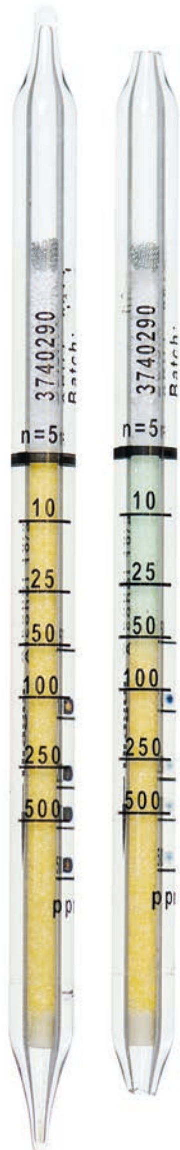
Methanol, ethanol, iso-propanol, and n-butanol are indicated with the same sensitivity.

n-propanol, 2-butanol, i-butanol, and tert-butanol are indicated with half sensitivity (indication × 2 = measured value).

The following substances are not indicated in the given concentration range:

≤ 2000 ppm acetone
≤ 10 ppm formaldehyde
≤ 50 ppm acetaldehyde
≤ 1000 ppm ethyl acetate
≤ 50 ppm diethyl ether
≤ 100 ppm dimethyl ether
≤ 1000 ppm n-hexane
≤ 100 ppm benzene
≤ 100 ppm toluene
≤ 10 ppm xylene
≤ 10 Vol% methyl bromide

Dichloromethane and chloromethane are not indicated.



D-13688-2025

Amine Test

Order no. 8101061

General data

Measuring range:	Qualitative detection of gases with an alkaline reaction
Number of strokes n:	1
Measuring time:	approx. 5 s
Standard deviation:	± 30 %
Color change:	yellow → blue

Permissible ambient conditions

Temperature:	0 to 40 °C
Humidity:	3 to 15 mg H_2O/L

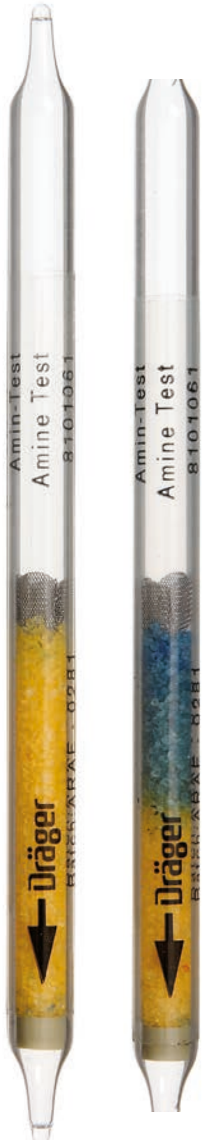
Reaction principle

Amines + pH indicator → blue reaction product

Cross-sensitivity

The tube non-specifically indicates gases with an alkaline reaction with different sensitivities.

Differentiation between different gases with an alkaline reaction is not possible.



D-13318-2010

Ammonia 0.25/a

Order no. 8101711

A

General data

Measuring range:	0.25 to 3 ppm
Number of strokes n:	10
Measuring time:	approx. 1 min
Standard deviation:	± 10 to 15 %
Color change:	yellow → blue

Permissible ambient conditions

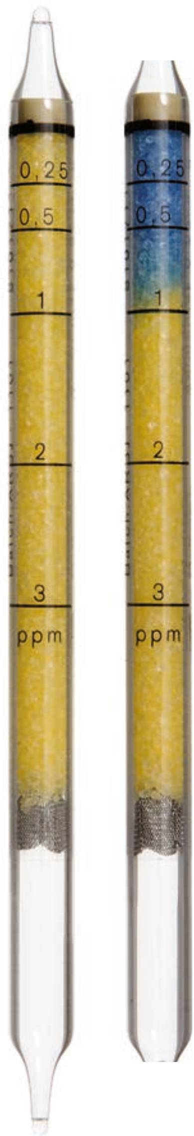
Temperature:	10 to 50 °C
Humidity:	less than 20 mg H_2O/L

Reaction principle

NH_3 + pH indicator → blue reaction product

Cross-sensitivity

Other basic substances such as organic amines are also indicated, but with different sensitivities.



D-13323-2010

Ammonia 2/a

Order no. 6733231

General data

Measuring range:	2 to 30 ppm
Number of strokes n:	5
Measuring time:	approx. 1 min
Standard deviation:	± 10 to 15 %
Color change:	yellow → blue

Permissible ambient conditions

Temperature:	10 to 50 °C
Humidity:	< 20 mg H_2O/L

Reaction principle

NH_3 + pH indicator → blue reaction product

Cross-sensitivity

Other basic substances, e.g., organic amines, are also indicated.

The indication is not affected by:

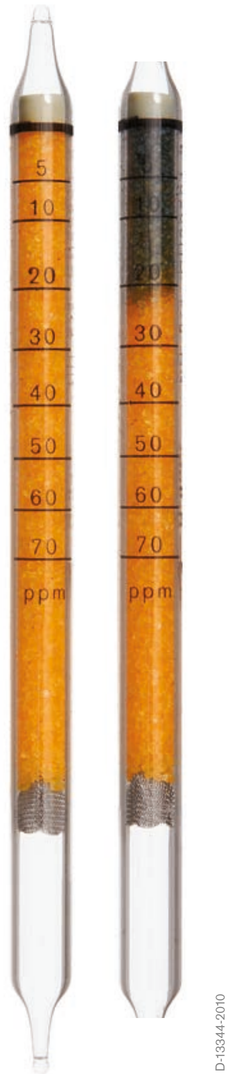
300 ppm	nitrous fumes
2000 ppm	sulfur dioxide
2000 ppm	hydrogen sulfide

D-13316-2010

Ammonia 5/a

Order no. CH20501

Measuring range:	5 to 70 ppm	/ 50 to 700 ppm
Number of strokes n:	10	/ 1
Measuring time:	approx. 60 s	/ approx. 10 s
Standard deviation:	± 10 to 15 %	
Color change:	yellow → blue	



Permissible ambient conditions

Temperature:	10 to 50 °C
Humidity:	< 20 mg H_2O/L

Reaction principle

NH_3 + pH indicator → blue reaction product

Cross-sensitivity

Other basic substances, e.g., organic amines, are also indicated.

The indication is not affected by:

300 ppm nitrous fumes
2000 ppm sulfur dioxide
2000 ppm hydrogen sulfide

Ammonia 5/b

Order no. 8101941

General data

Measuring range:	5 to 100 ppm
Number of strokes n:	1
Measuring time:	approx. 10 s
Standard deviation:	± 10 to 15 %
Color change:	yellow → blue

Permissible ambient conditions

Temperature:	10 to 50 °C
Humidity:	< 20 mg H_2O/L

Reaction principle

NH_3 + pH indicator → blue reaction product

Cross-sensitivity

Other basic substances, e.g., organic amines, are also indicated.

The indication is not affected by:

300 ppm nitrous fumes
2000 ppm sulfur dioxide
2000 ppm hydrogen sulfide

Measuring range extension

Measuring range 2.5 to 50 ppm where n=2 strokes, divide indicated scale value by 2.

D-13329-2010

Ammonia 0.5 %/a

Order no. CH31901

Measuring range:	0.5 to 10 Vol%
Number of strokes n:	1 + 1 desorption stroke in clean air
Measuring time:	approx. 20 s/stroke
Standard deviation:	± 10 to 15 %
Color change:	yellow → purple

Permissible ambient conditions

Temperature:	10 to 30 °C
Humidity:	3 to 12 mg H_2O/L

Reaction principle

NH_3 + pH indicator → blue reaction product

Cross-sensitivity

Other basic substances, e.g., organic amines, are also indicated.

Measuring range extension

Measuring range 0.05 - 1 Vol% where n = 10 strokes + 1 desorption stroke in clean air, divide indicated scale value by 10.

D-13351-2010

Aniline 0.5/a

Order no. 6733171

General data

Measuring range:	0.5 to 10 ppm
Number of strokes n:	20
Measuring time:	approx. 4 min
Standard deviation:	± 15 to 20 %
Color change:	light yellow → light green

Permissible ambient conditions

Temperature:	15 to 30 °C
Humidity:	7 to 12 mg H_2O/L

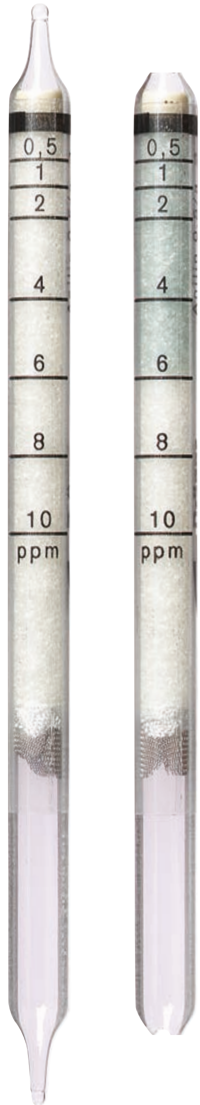
Reaction principle

$C_6H_5NH_2 + Cr^{VI} \rightarrow Cr^{III}$ + var. oxidation products

Cross-sensitivity

If methylated anilines are also present, aniline alone cannot be measured.

Ethers, ketones, esters, aromatic compounds, and benzines are also indicated, but with different sensitivities.



ST-14-2001

Arsine 0.05/a

Order no. CH25001

Measuring range:	0.05 to 3 ppm
Number of strokes n:	20
Measuring time:	approx. 6 min
Standard deviation:	± 15 to 20 %
Color change:	white → grayish-purple

Permissible ambient conditions

Temperature:	0 to 40 °C
Humidity:	max. 40 mg H_2O/L

Reaction principle

$AsH_3 + Au^{3+} \rightarrow$ Au (colloidal)

Cross-sensitivity

Phosphine and stibine are also indicated, but with different sensitivities.

Hydrogen sulfide, mercaptans, ammonia, and hydrochloric acid do not have any effect within their OEL ranges.

Carbon monoxide and sulfur dioxide also have no effect within their OEL ranges.

ST-18-2001

Benzene 0.25/a

Order no. 8103691

General data

Measuring range:	0.25 to 2 ppm	/ 2 to 10 ppm
Number of strokes n:	5	/ 1
Measuring time:	approx. 5 min	/ approx. 1 min
Standard deviation:	+ 15 %	
Color change:	light gray → dark gray to black	

Permissible ambient conditions

Temperature:	0 to 40 °C
Humidity:	< 30 mg H_2O/L

Reaction principle

Benzene Au^{3+} → dark gray to black reaction product

Cross-sensitivity

Toluene, xylene, and ethylbenzene are retained in the pre-layer up to a concentration of approx. 40 ppm with 5 strokes and 200 ppm with 1 stroke, where they cause a brown discoloration. 800 ppm n-octane with 5 strokes and 4000 ppm with 1 stroke do not discolor the indicating layer.

D-28038-2017

Benzene 2/a

Order no. 8101231

B

Measuring range:	2 to 60 ppm
Number of strokes n:	20
Measuring time:	approx. 8 min
Standard deviation:	± 10 to 15 %
Color change:	white → brown-gray

Permissible ambient conditions

Temperature:	0 to 40 °C
Humidity:	1 to 15 mg H_2O/L

Reaction principle

$C_6H_6 + I_2O_5 + H_2SO_4 \rightarrow I_2$

Cross-sensitivity

Alkylbenzenes such as toluene or xylenes do not interfere up to concentrations of 200 ppm.

It is impossible to measure benzene in the presence of gasoline hydrocarbons and carbon monoxide.

ST-184-2001

Benzene 5/a

Order no. 6718801

General data

Measuring range:	5 to 40 ppm
Number of strokes n:	15 to 2
Measuring time:	max. 3 min
Standard deviation:	± 30 %
Color change:	white → reddish brown

Permissible ambient conditions

Temperature:	0 to 40 °C
Humidity:	max. 50 mg H_2O/L

Reaction principle

$2\ C_6H_6 + HCHO \rightarrow C_6H_5\text{-}CH_2\text{-}C_6H_5 + H_2O$

$C_6H_5\text{-}CH_2\text{-}C_6H_5 + H_2SO_4 \rightarrow$ p-quinoid compound

Cross-sensitivity

Other aromatics (toluene, xylene) are retained in the pre-layer. As a result, this also changes to a reddish brown color.

If the concentrations of toluene or xylene are too high, the entire pre-layer through to the indicating layer is discolored, in which case a benzene measurement is not possible.

Gasoline hydrocarbons, alcohols, and esters do not affect the reading.

ST-22-2001

B

Benzene 5/b

Order no. 6728071

Measuring range:	5 to 50 ppm
Number of strokes n:	20
Measuring time:	approx. 8 min
Standard deviation:	± 10 to 15 %
Color change:	white → brown-green

Permissible ambient conditions

Temperature:	0 to 40 °C
Humidity:	3 to 15 mg H_2O/L

Reaction principle

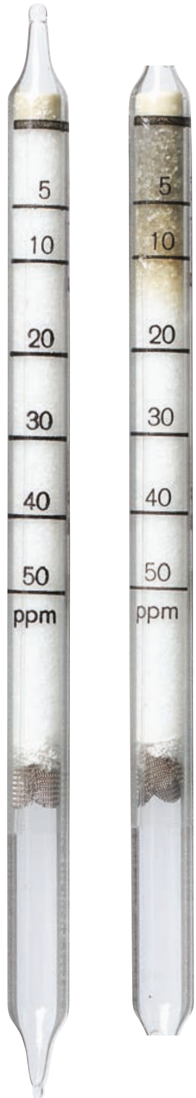
$C_6H_6 + I_2O_5 \rightarrow I_2$

Cross-sensitivity

Many gasoline hydrocarbons are also indicated, but all with different sensitivities.

Differentiation is not possible.

Other aromatics are also indicated.



ST-23-2001

Benzene 15/a

Order no. 8101741

General data

Measuring range:	15 to 420 ppm
Number of strokes n:	20 to 2
Measuring time:	max. 4 min
Standard deviation:	± 30 %
Color change:	white → reddish brown

Permissible ambient conditions

Temperature:	0 to 30 °C
Humidity:	max. 30 mg H_2O/L

Reaction principle

a) $2\ C_6H_6 + HCHO \rightarrow C_6H_5\text{-}CH_2\text{-}C_6H_5 + H_2O$

b) $C_6H_5\text{-}CH_2\text{-}C_6H_5 + H_2SO_4 \rightarrow$ p-quinoid compound

Cross-sensitivity

Other aromatics (toluene, xylene) are retained in the pre-layer. As a result, this also changes to a reddish brown color.

If the concentrations of toluene or xylene are too high, the entire pre-layer through to the indicating layer is discolored, in which case a benzene measurement is not possible.

Gasoline hydrocarbons, alcohols, and esters do not affect the reading.

ST-24-2001

Carbon Dioxide 100/a

Order no. 8101811

Measuring range:	100 to 3000 ppm
Number of strokes n:	10
Measuring time:	approx. 4 min
Standard deviation:	± 10 to 15 %
Color change:	white to light purple → violet-blue

Permissible ambient conditions

Temperature:	15 to 25 °C
Humidity:	max. 23 mg H_2O/L

Reaction principle

$CO_2 + N_2H_4 \rightarrow NH_2\text{-}NH\text{-}COOH$

Cross-sensitivity

Hydrogen sulfide and sulfur dioxide do not provide an indication in their OEL ranges.

ST-51-2001

Carbon Dioxide 0.1 %/a

Order no. CH23501

General data

Measuring range:	0.5 to 6 Vol%	/ 0.1 to 1.2 Vol%
Number of strokes n:	1	/ 5
Measuring time:	approx. 30 s	/ approx. 2.5 min
Standard deviation:	± 5 to 10 %	
Color change:	white → purple	

Permissible ambient conditions

Temperature:	0 to 30 °C
Humidity:	max. 30 mg H_2O/L

Reaction principle

CO_2 + amine → purple reaction product

Cross-sensitivity

Hydrogen sulfide and sulfur dioxide do not provide an indication in their OEL ranges.

ST-416-2008

Carbon Dioxide 0.5 %/a

Order no. CH31401

C

Measuring range:	0.5 to 10 Vol%
Number of strokes n:	1
Measuring time:	approx. 30 s
Standard deviation:	± 5 to 10 %
Color change:	white → purple

Permissible ambient conditions

Temperature:	0 to 40 °C
Humidity:	max. 50 mg H_2O/L

Reaction principle

CO_2 + amine → purple reaction product

Cross-sensitivity

Hydrogen sulfide does not provide an indication in the OEL range. Sulfur dioxide is also indicated in a comparable concentration range, but with three times less sensitivity.

ST-54-2001

Carbon Dioxide 1 %/a

Order no. CH25101

General data

Measuring range:	1 to 20 Vol%
Number of strokes n:	1
Measuring time:	approx. 30 s
Standard deviation:	± 5 to 10 %
Color change:	white → purple

Permissible ambient conditions

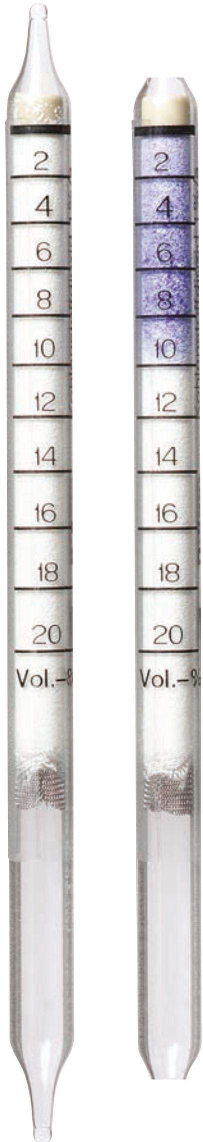
Temperature:	0 to 40 °C
Humidity:	max. 40 mg H_2O/L

Reaction principle

$CO_2 + N_2H_4 \rightarrow NH_2\text{-}NH\text{-}COOH$

Cross-sensitivity

Hydrogen sulfide does not provide an indication in the OEL range. Sulfur dioxide is also indicated in a comparable concentration range, but with three times less sensitivity.



ST-55-2001

Carbon Dioxide 5 %/A

Order no. CH20301

Measuring range:	5 to 60 Vol%
Number of strokes n:	1
Measuring time:	approx. 2 min
Standard deviation:	± 10 to 15 %
Color change:	white → purple

Permissible ambient conditions

Temperature:	0 to 40 °C
Humidity:	max. 50 mg H_2O/L

Reaction principle

$CO_2 + N_2H_4 \rightarrow NH_2\text{-}NH\text{-}COOH$

Cross-sensitivity

Hydrogen sulfide does not provide an indication in the OEL range. Sulfur dioxide is indicated with roughly half the sensitivity.

Carbon Disulfide 3/a

Order no. 8101891

General data

Measuring range:	3 to 95 ppm
Number of strokes n:	15 to 1
Measuring time:	max. 2 min
Standard deviation:	± 30 %
Color change:	light blue → yellow-green

Permissible ambient conditions

Temperature:	0 to 40 °C
Humidity:	less than 30 mg H_2O/L

Reaction principle

$2\ CS_2 + 4\ NHR_2 + Cu^{2+} \rightarrow Cu(SCSNR_2)_2 + 2\ NH_2R_2^{+}$

Cross-sensitivity

Hydrogen sulfide is retained in the pre-layer at concentrations around the OEL, so has no effect.

ST-5749-2004

Carbon Disulfide 5/a

Order no. 6728351

C

Measuring range:	5 to 60 ppm
Number of strokes n:	11
Measuring time:	approx. 3 min
Standard deviation:	± 10 to 15 %
Color change:	white → brown-green

Permissible ambient conditions

Temperature:	0 to 40 °C
Humidity:	3 to 15 mg H_2O/L

Reaction principle

$CS_2 + I_2O_5 \rightarrow I_2$

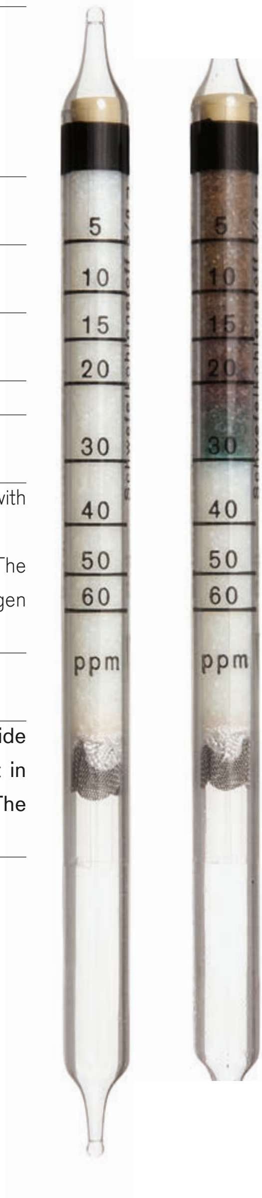
Cross-sensitivity

Aliphatic and aromatic hydrocarbons are also indicated, but with different sensitivities.

A carbon disulfide measurement is not possible in these cases. The same is true in the presence of carbon monoxide and hydrogen sulfide.

Caution

This tube must not be used in rooms in which carbon disulfide concentrations or other gases and vapors may be present in the explosion-hazard area. The indicating layer heats up. The lower explosive limit is 1 Vol% carbon disulfide.



D-13309-2010

Carbon Disulfide 30/a

Order no. CH23201

General data

Measuring range:	0.1 to 10 mg/L
Number of strokes n:	6
Measuring time:	approx. 1 min
Standard deviation:	± 15 to 20 %
Color change:	light blue → brown

Permissible ambient conditions

Temperature:	0 to 40 °C
Humidity:	< 30 mg H_2O/L

Reaction principle

$2\ CS_2 + 4\ NHR_2 + Cu^{2+} \rightarrow Cu(SCSNR_2)_2 + 2\ NH_2R_2^+$

Cross-sensitivity

A carbon disulfide measurement is not possible in the presence of hydrogen sulfide, as hydrogen sulfide colors the indicating layer light green.

D-13346-2010

Carbon Monoxide 2/a

Order no. 6733051

General data

Measuring range:	2 to 60 ppm	/ 25 to 300 ppm
Number of strokes n:	10	/ 2
Measuring time:	approx. 4 min	/ 50 s
Standard deviation:	± 10 % to 15 %	
Color change:	white → brownish pink-green	

Permissible ambient conditions

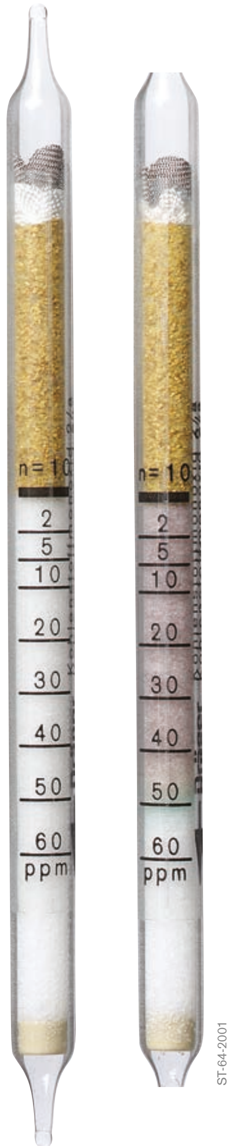
Temperature:	0 to 50 °C
Humidity:	2 to 20 mg/L

Reaction principle

$5\ CO + I_2O_5 \rightarrow I_2 + 5\ CO_2$

Cross-sensitivity

The following have no effect on the reading of 10 ppm CO:
100 ppm hydrogen sulfide,
50 ppm sulfur dioxide,
15 ppm nitrogen dioxide,
10 ppm CO + 200 ppm octane: reading approx. 30 ppm,
10 ppm CO + 40 ppm butadiene: reading approx. 15 ppm,
10 ppm CO + 30 (100) ppm benzene:
reading approx. 15 (20 - 30) ppm,
10 ppm CO + 40 ppm chloroform: reading approx. 60 ppm,
10 (60) ppm acetylene: reading approx. 5 (15) ppm.
Adding a carbon attachment tube (CH 24101) upstream allows 10 ppm CO to be measured even in the presence of 10000 ppm n-octane.



Carbon Monoxide 5/c

Order no. CH25601

General data

Measuring range:	100 to 700 ppm	/ 5 to 150 ppm
Number of strokes n:	1	/ 5
Measuring time:	approx. 30 s	/ approx. 150 s
Standard deviation:	± 10 to 15 %	
Color change:	white → brown-green	

Permissible ambient conditions

Temperature:	0 to 50 °C
Humidity:	max. 50 mg H_2O/L

Reaction principle

$$5\ CO + I_2O_5 \xrightarrow{H_2S_2O_7} I_2 + 5\ CO_2$$

Cross-sensitivity

The following have no effect on the reading of 10 ppm CO:

200 ppm n-octane

with carbon attachment tube (CH 24101) 10000 ppm

30 ppm benzene

100 ppm hydrogen sulfide

50 ppm sulfur dioxide

15 ppm nitrogen dioxide

40 ppm butadiene

10 ppm CO + 100 ppm benzene: reading approx. 20 ppm

10 ppm CO + 40 ppm chloroform: reading approx. 60 ppm

10 (60) ppm acetylene: reading 8 (20) ppm

D-5461-2014

Carbon Monoxide 8/a

C

Order no. CH19701

General data

Measuring range:	8 to 150 ppm CO in H_2
Number of strokes n:	10
Measuring time:	approx. 2 min
Standard deviation:	± 10 to 15 %
Color change:	white → light brown

Permissible ambient conditions

Temperature:	0 to 50 °C
Humidity:	less than 50 mg H_2O/L

Reaction principle

$5\ CO + I_2O_5 \rightarrow I_2 + 5\ CO_2$

Cross-sensitivity

Acetylene reacts in a similar way to carbon monoxide, but with lower sensitivity.

Benzene, halogenated hydrocarbons, and hydrogen sulfide are retained in the pre-layer. At higher concentrations of interfering hydrocarbons and halogenated hydrocarbons, a carbon attachment tube with order no. CH 24 101 should be added upstream.

Scissile halogenated hydrocarbons (e.g., trichloroethylene) at higher concentrations can form chromyl chloride in the pre-layer, which causes yellow-brown discoloration in the indicating layer.

A carbon monoxide measurement is not possible with high olefin concentrations.

Additional note

This Dräger-Tube can only be used to measure carbon monoxide in hydrogen.

Carbon Monoxide 10/b

Order no. CH20601

General data

Measuring range:	100 to 3000 ppm	/ 10 to 300 ppm
Number of strokes n:	1	/ 10
Measuring time:	approx. 20 s	/ approx. 4 min
Standard deviation:	± 10 to 15 %	
Color change:	white → brown-green	

Permissible ambient conditions

Temperature:	0 to 50 °C
Humidity:	max. 50 mg H_2O/L

Reaction principle

$$5\ CO + I_2O_5 \xrightarrow{H_2S_2O_7} I_2 + 5\ CO_2$$

Cross-sensitivity

The following have no effect on the reading of 10 ppm CO:

200 ppm n-octane

with carbon attachment tube (CH 24101) 10000 ppm

30 ppm benzene

100 ppm hydrogen sulfide

50 ppm sulfur dioxide

15 ppm nitrogen dioxide

40 ppm butadiene

10 ppm CO + 100 ppm benzene: reading approx. 30 ppm

10 ppm CO + 40 ppm chloroform: reading approx. 35 ppm

10 (60) ppm acetylene: reading 0 (70) ppm

ST-67-2001

Carbon Monoxide 0.3 %/b

Order no. CH29901

C

General data

Measuring range:	0.3 to 7 Vol%
Number of strokes n:	1
Measuring time:	approx. 30 s
Standard deviation:	± 10 to 15 %
Color change:	white → brown-green

Permissible ambient conditions

Temperature:	0 to 50 °C
Humidity:	max. 50 mg H_2O/L

Reaction principle

$$5\ CO + I_2O_5 \xrightarrow{H_2S_2O_7} I_2 + 5\ CO_2$$

Cross-sensitivity

The following have no effect on the reading of 0.3 Vol% CO:

10000 ppm n-octane,
300 ppm benzene,
500 ppm hydrogen sulfide,
500 ppm sulfur dioxide,
500 ppm nitrogen dioxide,
300 ppm butadiene,
250 ppm chloroform,
3000 ppm acetylene give a reading of 0.3 Vol%.

ST-70-2001

Carbon Tetrachloride 0.1/a

Order no. 8103501

General data

Measuring range:	0.1 to 5 ppm
Number of strokes n:	5
Measuring time:	approx. 2.5 min
Standard deviation:	± 20 to 30 %
Color change:	yellow → blue-green

Permissible ambient conditions

Temperature:	2 to 40 °C
Humidity:	1 to 40 mg/L

Reaction principle

a) $CCl_4 + H_2S_2O_7 \rightarrow COCl_2$

b) $COCl_2$ + diethylaniline + dimethylaminobenzaldehyde →
blue-green reaction product

Cross-sensitivity

Phosgene is indicated with around the same sensitivity as carbon tetrachloride.

50 ppm perchloroethylene gives a reading of approx. 1 to 2 ppm, 50 ppm trichloroethylene and 1,1,-dichloroethylene give a weak reading of < 0.1 ppm.

The indication is not affected by:

10ppm vinyl chloride

200 ppm 1,2-dichloroethylene

ST-587-2008

Carbon Tetrachloride 1/a

Order no. 8101021

C

Measuring range:	1 to 15 ppm	/ 10 to 50 ppm
Number of strokes n:	10	/ 5
Measuring time:	approx. 6 min	/ 3 min
Standard deviation:	± 15 to 20 %	
Color change:	white → yellow	

Permissible ambient conditions

Temperature:	15 to 30 °C
Humidity:	3 to 15 mg H_2O/L

Reaction principle

a) $CCl_4 + H_2S_2O_7 \rightarrow COCl_2$

b) $COCl_2$ + arom. nitro compound → yellow reaction product

Cross-sensitivity

Chloropicrin and phosgene are indicated with roughly the same sensitivity, so a carbon tetrachloride measurement is not possible in their presence.

The indication is not affected by:

1	ppm	chlorine
5	ppm	hydrochloric acid
20	ppm	methyl bromide
1000	ppm	acetone

D-13317-2010

Chlorine 0.2/a

Order no. CH24301

General data

Measuring range:	0.2 to 3 ppm	/ 3 to 30 ppm
Number of strokes n:	10	/ 1
Measuring time:	approx. 180 s	/ approx. 20 s
Standard deviation:	± 10 to 15 %	
Color change:	white → yellow-orange	

Permissible ambient conditions

Temperature:	0 to 40 °C
Humidity:	< 15 mg H_2O/L

Reaction principle

Cl_2 + o-tolidine → yellow-orange reaction product

Cross-sensitivity

Bromine is indicated with the same sensitivity, but with a paler color. Chlorine dioxide is indicated with a different sensitivity. Nitrogen dioxide is also indicated, but with a paler color and lower sensitivity.

Chlorine 50/a

Order no. CH20701

General data

Measuring range:	50 to 500 ppm
Number of strokes n:	1
Measuring time:	approx. 20 s
Standard deviation:	± 10 to 15 %
Color change:	gray-green → orange-brown

Permissible ambient conditions

Temperature:	10 to 40 °C
Humidity:	less than 40 mg H_2O/L

Reaction principle

Cl_2 + o-tolidine → orange-brown reaction product

Cross-sensitivity

Bromine is indicated with the same sensitivity, but with a larger standard deviation (± 25 to 30 %).

Chlorine dioxide and nitrogen dioxide are also indicated, but with a different sensitivity.

ST-28-2001

Chlorine Dioxide 0.025/a

Order no. 8103491

General data

Measuring range:	0.1 to 1 ppm / 0.025 to 0.1 ppm
Number of strokes n:	10 / 30
Measuring time:	approx. 2.5 min / approx. 7.5 min
Standard deviation:	± 10 to 15 %
Color change:	light gray → light green

Permissible ambient conditions

Temperature:	0 to 50 °C
Humidity:	≤ 50 mg/L

Reaction principle

a) ClO_2 + o-tolidine → light green reaction product

Cross-sensitivity

The following are not indicated:

1 ppm Cl_2

10 ppm H_2S

1 ppm SO_2

10 ppm methyl mercaptan

1 ppm bromine is not indicated with a stroke number of n = 10 at n = 30 there is a discoloration of approx. 10 mm.

D-11109-2023

Chlorobenzene 5/a

Order no. 6728761

General data

Measuring range:	5 to 200 ppm
Number of strokes n:	10
Measuring time:	approx. 3 min
Standard deviation:	± 10 to 15 %
Color change:	blue → yellow-gray

Permissible ambient conditions

Temperature:	10 to 40 °C
Humidity:	3 to 15 mg H_2O/L

Reaction principle

a) $C_6H_5Cl + Cr^{VI} \rightarrow HCl$

b) HCl + bromophenol blue → yellow-gray reaction product

Cross-sensitivity

Other chlorinated hydrocarbons are also indicated, but with different sensitivities.

Methylene chloride does not affect the indication.

Chlorine and hydrochloric acid are adsorbed in the pre-layer within their limit value ranges and have no effect at these concentrations.

D-13311-2010

Chloroform 2/b

Order no. 6728861

General data

Measuring range:	2 to 10 ppm / 20 to 80 ppm
Number of strokes n:	10 / 3
Measuring time:	approx. 9 min / approx. 3 min
Standard deviation:	± 20 to 35 %
	at 20 °C and 9 mg H_2O/L
Color change:	white → purple

Permissible ambient conditions

Temperature:	10 to 40 °C
Humidity:	1 - 18 mg H_2O/L

Reaction principle

a) $CHCl_3 + Cr^{VI} \rightarrow Cl_2$

b) Cl_2 + dimethylnaphtidin → purple reaction product

Cross-sensitivity

Other chlorinated hydrocarbons are also indicated, but with different sensitivities.

D-1135-2024

Chloroformic Acid Ester 0.2/b

Order no. 6718601

General data

Measuring range:	0.2 to 10 ppm
Number of strokes n:	20
Measuring time:	approx. 3 min
Standard deviation:	± 20 to 30 %
Color change:	white → yellow

Permissible ambient conditions

Temperature:	10 to 40 °C
Humidity:	5 to 15 mg H_2O/L

Reaction principle

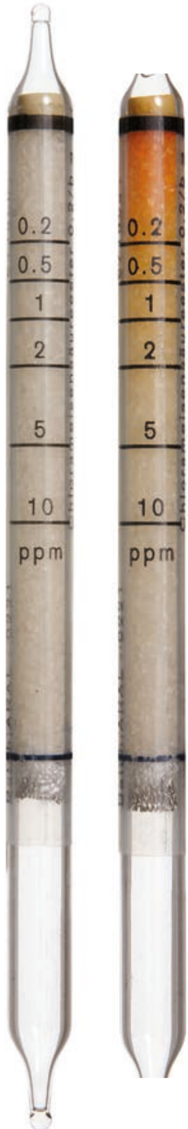
ClCOOR + 4-(4-nitrobenzyl)pyridine → yellow reaction product

Cross-sensitivity

Methyl, ethyl, and isopropyl chloroformate are indicated with roughly the same sensitivity.

Differentiation is not possible.

Gasoline hydrocarbons, aromatics, alcohols, and ketones have no effect within their limit value ranges. A chloroformic acid ester measurement is not possible in the presence of phosgene.



D-13304-2010

Chloromethane 10/a

Order no. 8103911

General data

Measuring range:	10 to 100 ppm
Number of strokes n:	8
Measuring time:	approx. 4 min
Standard deviation:	± 15 to 40 % (16 to 30 °C)
Color change:	white → blue-green

Permissible ambient conditions

Temperature:	10 to 40 °C
Humidity:	≤ 15 mg H_2O/L

Reaction principle

CH_3Cl + oxidant → Cl_2

Cl_2 + indicator → blue-green reaction product

Cross-sensitivity

Other chlorinated hydrocarbons are also indicated, but with different sensitivities.

D-1136-2024

Chloropicrin 0.1/a

Order no. 8103421

C

General data

Measuring range:	0.1 to 2 ppm
Number of strokes n:	15
Measuring time:	approx. 7.5 min
Standard deviation:	± 20 to 30 %
Color change:	yellow → blue-green

Permissible ambient conditions

Temperature:	2 to 40 °C
Humidity:	1 to 20 mg/L

Reaction principle

$CCl_3NO_2 + H_2S_2O_7 \rightarrow COCl_2$

$COCl_2$ + diethylaniline + dimethylaminobenzaldehyde → blue-green reaction product

Cross-sensitivity

The indication is not affected by:

50	ppm ammonia
10	ppm hydrocyanic acid
1	ppm ethylene oxide
1	ppm phosphine
5	ppm methyl bromide
15	ppm sulfuryl fluoride
10	ppm formaldehyde
10	ppm chloroform

D-13338-2010

Chloroprene 5/a

Order no. 6718901

General data

Measuring range:	5 to 60 ppm
Number of strokes n:	3 + 3 desorption strokes in clean air
Measuring time:	approx. 3 min
Standard deviation:	± 10 to 15 %
Color change:	purple → yellow-brown

Permissible ambient conditions

Temperature:	10 to 30 °C
Humidity:	3 to 15 mg H_2O/L

Reaction principle

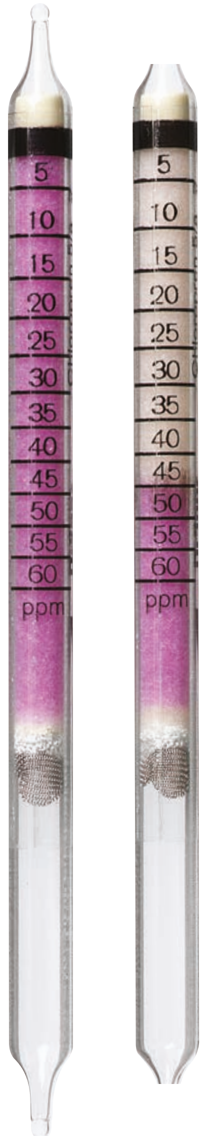
CH_2=CH-CCl=CH_2 + MnO_4^- → Mn^{IV} + var. oxidation products

Cross-sensitivity

Many organic compounds with C=C double bonds are also indicated, but all with different sensitivities.

Differentiation is not possible.

A chloroprene measurement is not possible in the presence of dialkyl sulfides.



ST-30-2001

Chromic Acid 0.1/a

Order no. 6728681

C

General data

Measuring range:	0.1 to 0.5 mg/m³ compare discoloration with color standard
Number of strokes n:	40
Measuring time:	approx. 8 min
Standard deviation:	± 50 %
Color change:	white → purple

Permissible ambient conditions

Temperature:	5 to 40 °C
Humidity:	less than 20 mg H_2O/L

Reaction principle

a) $CrO_3 + H_2SO_4 \rightarrow Cr^{VI}$

b) Cr^{VI} + diphenylcarbazide → Cr^{III} + diphenylcarbazone

Cross-sensitivity

Metal chromates such as zinc chromate or strontium chromate are indicated with roughly half the sensitivity.

Cr^{III} compounds have no effect on the reading.

Very high chromate concentrations lead to rapid bleaching of the indication; repeat the measurement with fewer strokes.

Additional notes

After carrying out the 40 strokes, the reagent ampoule must be broken and the ampoule liquid applied to the indicating layer and carefully drawn through the indicating layer with the pump.

D-11110-2023

Cyanide 2/a

Order no. 6728791

General data

Measuring range:	2 to 15 mg/m^3
Number of strokes n:	6 (+2)
Measuring time:	approx. 2.5 min
Standard deviation:	± 20 to 30 %
Color change:	yellow → red

Permissible ambient conditions

Temperature:	0 to 30 °C
Humidity:	less than 20 mg H_2O/L

Reaction principle

a) $2\ CKN + H_2SO_4 \rightarrow 2\ HCN + K_2SO_4$

b) $2\ HCN + HgCl_2 \rightarrow 2\ HCl + Hg(CN)_2$

c) HCl + methyl red → red reaction product

Cross-sensitivity

Free hydrocyanic acid is indicated even before the ampoule is broken.

Acid gases are indicated with different sensitivities.

A certain portion of the cyanides may already have reacted with the carbon dioxide in the air through hydrolysis.

A cyanide measurement in the presence of phosphine is not possible.

Additional notes

After carrying out the 6 strokes, the reagent ampoule must be broken, the ampoule liquid applied to the white separating layer, and 2 strokes of cyanide-free air carefully carried out with the pump. The indicating layer must not become moist.

D-28061-2017

Cyanogen Chloride 0.25/a

Order no. CH19801

C

General data

Measuring range:	0.25 to 5 ppm
Number of strokes n:	20 to 1
Measuring time:	max. 5 min
Standard deviation:	± 30 %
Color change:	white → pink

Permissible ambient conditions

Temperature:	5 to 40 °C
Humidity:	less than 50 mg H_2O/L

Reaction principle

a) ClCN + pyridine → glutaconaldehyde cyanamide

b) Glutaconaldehyde cyanamide + barbituric acid → pink reaction product

Cross-sensitivity

Cyanogen bromide is also indicated, but with a different sensitivity. Calibration data is not available.

Additional notes

Before measurement, the reagent ampoule must be broken and the ampoule liquid applied to the indicating layer so that it is completely saturated.

ST-402-2008

Cyclohexane 40/a

Order no. 8103671

General data

Measuring range:	40 to 200 ppm	/ 300 to 3000 ppm
Number of strokes n:	5	/ 1
Measuring time:	approx. 75 s	/ 15 s
Standard deviation:	± 15 to 20 %	
Color change:	white → brown-green	

Permissible ambient conditions

Temperature:	0 to 40 °C
Humidity:	1 to 35 mg H_2O/L

Reaction principle

$C_5H_{12} + I_2O_5 \rightarrow I_2$

Cross-sensitivity

Many gasoline hydrocarbons and aromatic compounds are also indicated, but all with different sensitivities. Differentiation is not possible. Carbon monoxide is indicated with a slightly lower sensitivity than cyclohexane.

D-28051-2017

Cyclohexylamine 2/a

Order no. 6728931

C

General data

Measuring range:	2 to 30 ppm
Number of strokes n:	10
Measuring time:	approx. 4 min
Standard deviation:	± 15 to 20 %
Color change:	yellow → blue

Permissible ambient conditions

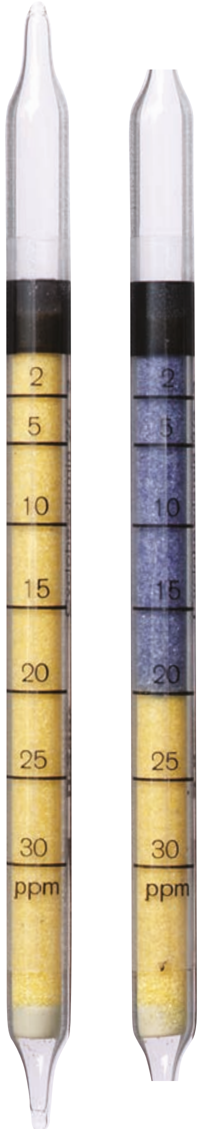
Temperature:	15 to 35 °C
Humidity:	3 to 15 mg H_2O/L

Reaction principle

$C_6H_{11}NH_2$ + pH indicator → blue reaction product

Cross-sensitivity

Other basic substances, e.g., organic amines and ammonia, are also indicated.



ST-35-2001

Diethyl Ether 100/a

Order no. 6730501

General data

Measuring range:	100 to 4000 ppm
Number of strokes n:	10
Measuring time:	approx. 3 min
Standard deviation:	± 15 to 20 %
Color change:	orange → green-brown

Permissible ambient conditions

Temperature:	15 to 40 °C
Humidity:	3 to 15 mg H_2O/L

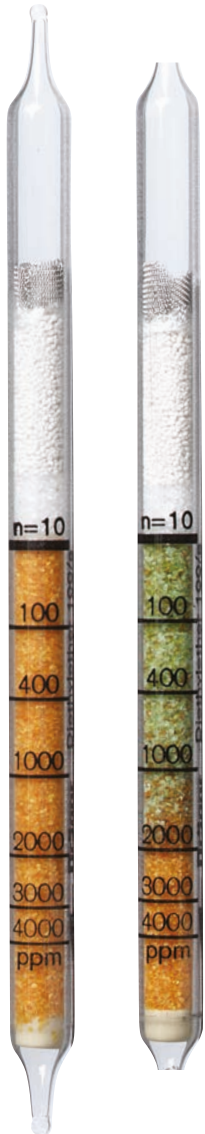
Reaction principle

$C_2H_5\text{-}O\text{-}C_2H_5 + Cr^{VI} \rightarrow Cr^{III}$ + var. oxidation products

Cross-sensitivity

Many gasoline hydrocarbons, alcohols, aromatics, and esters are also indicated, but all with different sensitivities.

Differentiation is not possible.



ST-36-2001

Dimethyl Formamide 10/b

Order no. 6718501

General data

Measuring range:	10 to 40 ppm
Number of strokes n:	10
Measuring time:	approx. 3 min
Standard deviation:	± 20 to 30 %
Color change:	yellow → gray-blue

Permissible ambient conditions

Temperature:	15 to 35 °C
Humidity:	3 to 12 mg H_2O/L

Reaction principle

a) Dimethyl formamide + NaOH → NH_3

b) NH_3 + pH indicator → gray-blue reaction product

Cross-sensitivity

Other basic substances, such as ammonia, organic amines, and hydrazine are also indicated, but with a different sensitivity.

ST-37-2001

Dimethyl sulfate 0.005/c

Order no. 6718701

General data

Measuring range:	0.005 to 0.05 ppm Compare discoloration with color standard
Number of strokes n:	200
Measuring time:	approx. 50 min
Standard deviation:	± 30 %
Color change:	white → blue

Permissible ambient conditions

Temperature:	15 to 30 °C
Humidity:	3 to 15 mg H_2O/L

Reaction principle

Dimethyl sulfate + 4-(4-nitrobenzyl)pyridine → colorless alkylation product

Colorless alkylation product → blue reaction product

Cross-sensitivity

Phosgene and chloroformic acid esters cause a yellow discoloration of the indicating layer, making a dimethyl sulfate measurement impossible. Alcohols, ketones, aromatics, and gasoline hydrocarbons have no effect in their limit value ranges.

Additional notes

After carrying out the 200 strokes, the reagent ampoule must be broken and the ampoule liquid applied to the indicating layer and carefully drawn onto the indicating layer with the pump. Wait 5 min. before evaluation. The tube must not be exposed to direct sunlight during this period.

D-11112-2023

Dimethyl Sulfide 1/a

Order no. 6728451

D

General data

Measuring range:	1 to 15 ppm
Number of strokes n:	20
Measuring time:	approx. 15 min
Standard deviation:	± 15 to 20 %
Color change:	purple → yellow-brown

Permissible ambient conditions

Temperature:	15 to 30 °C
Humidity:	less than 20 mg H_2O/L

Reaction principle

$(CH_3)_2S + KMnO_4 \rightarrow Mn^{IV}$ + var. oxidation products

Cross-sensitivity

Many organic compounds with C=C double bonds are also indicated, but all with different sensitivities. Differentiation is not possible. H_2S (hydrogen sulfide) is indicated with roughly twice the sensitivity.

The H_2S 5/b tube can be used as the filter tube. With n = 20 pump strokes, approx. 30 ppm H_2S is retained. Methyl mercaptan is indicated with twice the sensitivity.

ST-186-2001

Ethanol 100/a

Order no. 8103761

General data

Measuring range:	100 to 3000 ppm
Number of strokes n:	6
Measuring time:	approx. 1.5 min
Standard deviation:	± 5 – 20 %
Color change:	yellow → mint green

Permissible ambient conditions

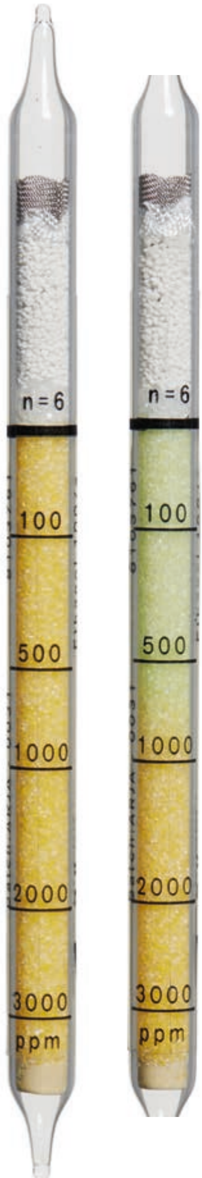
Temperature:	5 to 35 °C
Humidity:	< 20 mg H_2O/L

Reaction principle

Ethanol + organometallic compounds → green reaction product

Cross-sensitivity

Differentiation between alcohols is not possible. Methanol and tetrahydrofuran are indicated with a similar sensitivity. Higher-molecular alcohols are indicated with rapidly decreasing sensitivity. < 250 ppm acetaldehyde and < 200 ppm xylene are not indicated. Aliphatic gasoline hydrocarbons, ketones, esters, ethers, halogenated hydrocarbons, formaldehyde, benzene, and toluene are not indicated.



D-28042-2017

Ethyl Acetate 200/a

Order no. CH20201

E

General data

Measuring range:	200 to 3000 ppm
Number of strokes n:	20
Measuring time:	approx. 5 min
Standard deviation:	± 15 to 20 %
Color change:	orange → green-brown

Permissible ambient conditions

Temperature:	17 to 40 °C
Humidity:	3 to 15 mg H_2O/L

Reaction principle

$CH_3COOC_2H_5 + Cr^{VI} \rightarrow Cr^{III}$ + var. oxidation products

Cross-sensitivity

Many gasoline hydrocarbons, alcohols, aromatics, and esters are also indicated, but all with different sensitivities.

Differentiation is not possible.

ST-48-2001

Ethylbenzene 30/a

Order no. 6728381

E

General data

Measuring range:	30 to 400 ppm
Number of strokes n:	6
Measuring time:	approx. 2 min
Standard deviation:	± 10 to 15 %
Color change:	white → brown

Permissible ambient conditions

Temperature:	10 to 30 °C
Humidity:	5 to 12 mg H_2O/L

Reaction principle

$C_6H_5\text{-}C_2H_5 + I_2O_5 \rightarrow I_2$

Cross-sensitivity

Many gasoline hydrocarbons and aromatic compounds are also indicated, but all with different sensitivities.

Differentiation is not possible.

Measuring range extension

Measuring range 45 to 600 ppm where n = 4 strokes, multiply indicated scale value by 1.5.

ST-41-2001

Ethylene 0.1/a

Order no. 8101331

E

General data

Measuring range:	0.2 to 5 ppm
Number of strokes n:	20
Measuring time:	approx. 30 min
Standard deviation:	± 15 to 30 %
Color change:	light yellow → blue-gray

Permissible ambient conditions

Temperature:	10 to 40 °C
Humidity:	5 to 20 mg H_2O/L

Reaction principle

CH_2=CH_2 + Pd-molybdate complex → blue reaction product

Cross-sensitivity

Other similar compounds are indicated in addition to ethylene, e.g.:

100 ppm butadiene gives a reading of 1 ppm.
50 ppm butylene gives a reading of 1 ppm.
5 ppm propene gives a reading of 1 ppm.
20 ppm hydrogen sulfide gives a reading of 2 ppm.
25 ppm CO discolors the indicating layer light gray.

ST-5789-2004

Ethylene 50/a

Order no. 6728051

General data

Measuring range:	50 to 2500 ppm
Number of strokes n:	3
Measuring time:	approx. 6 min
Standard deviation:	± 20 to 30 %
Color change:	yellow → blue

Permissible ambient conditions

Temperature:	15 to 40 °C
Humidity:	less than 30 mg H_2O/L

Reaction principle

CH_2=CH_2 + Pd-molybdate complex → blue reaction product

Cross-sensitivity

Organic compounds with C=C double bonds are also indicated, but all with different sensitivities.

Differentiation is not possible.

In the presence of carbon monoxide, the indicating layer is discolored blue depending on the concentration of carbon monoxide and its exposure time.

Hydrogen sulfide is indicated by a black color, but with considerably lower sensitivity.

ST-43-2001

Ethylene Glycol 10

Order no. 8101351

E

General data

Measuring range:	10 to 180 mg/m^3
	corresponds to 4 to 70 ppm
Number of strokes n:	10
Measuring time:	approx. 7 min
Standard deviation:	± 20 to 30 %
Color change:	white → pink

Permissible ambient conditions

Temperature:	10 to 35 °C
Humidity:	5 to 15 mg H_2O/L

Reaction principle

a) $OH\text{-}C_2H_4\text{-}OH \rightarrow HCHO$

b) $HCHO + C_6H_4(CH_3)_2 + H_2SO_4 \rightarrow$ quinoid reaction products

Cross-sensitivity

An ethylene glycol measurement is not possible in the presence of formaldehyde and ethylene oxide, as both provide the same discoloration.

Styrene, vinyl acetate, and acetaldehyde are also indicated with a yellow-brown color.

Additional note

The reagent ampoule must be broken before measurement.

ST-198-2001

Ethylene Oxide 1/a

Order no. 6728961

General data

Measuring range:	1 to 15 ppm
Number of strokes n:	20
Measuring time:	approx. 8 min
Standard deviation:	± 20 to 30 %
Color change:	white → pink

Permissible ambient conditions

Temperature:	10 to 30 °C
Humidity:	3 to 15 mg H_2O/L

Reaction principle

a) Ethylene oxide → HCHO

b) HCHO + $C_6H_4(CH_3)_2$ + H_2SO_4 → quinoid reaction products

Cross-sensitivity

An ethylene oxide measurement is not possible in the presence of formaldehyde and ethylene glycol, as both provide the same discoloration. Styrene, vinyl acetate, and acetaldehyde are also indicated with a yellow-brown color.

Additional note

The reagent ampoule must be broken before measurement.

ST-204-2001

Ethylene Oxide 25/a

Order no. 6728241

E

General data

Measuring range:	25 to 500 ppm
Number of strokes n:	30
Measuring time:	approx. 6 min
Standard deviation:	± 20 to 30 %
Color change:	light yellow → turquoise green

Permissible ambient conditions

Temperature:	15 to 30 °C
Humidity:	3 to 15 mg H_2O/L

Reaction principle

Ethylene oxide + Cr^{VI} → Cr^{III} + var. oxidation products

Cross-sensitivity

Alcohols, esters, and aldehydes are also indicated, but with different sensitivities. Differentiation is not possible.

Propylene oxide is also indicated, but with a different sensitivity. Ethylene, ketones, and toluene do not have any effect within their OEL ranges.

ST-42-2001

Epichlorohydrin 5/c

Order no. 6728111

General data

Measuring range:	5 to 80 ppm
Number of strokes n:	20
Measuring time:	approx. 8 min
Standard deviation:	± 15 to 20 %
Color change:	light gray → yellow-orange

Permissible ambient conditions

Temperature:	10 to 40 °C
Humidity:	5 to 15 mg H_2O/L (corresponds to 50 % r.h. at 30 °C)

Reaction principle

Epichlorohydrin + Cr^{VI} → Cl_2

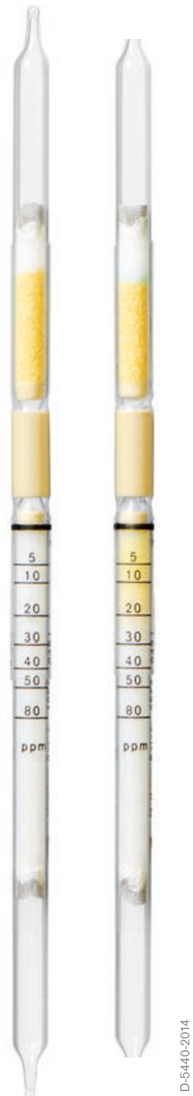
Cl_2 + o-tolidine → yellow-orange reaction product

Cross-sensitivity

Other chlorinated hydrocarbons are also indicated, but with different sensitivities.

An epichlorohydrin measurement is not possible when influenced by free halogens and halogen hydracids in their OEL ranges, as these will also be indicated.

Gasoline hydrocarbons cause the reading to be shortened.



Fluorine 0.1/a

Order no. 8101491

F

General data

Measuring range:	0.1 to 2 ppm
Number of strokes n:	20
Measuring time:	approx. 5 min
Standard deviation:	± 15 to 20 %
Color change:	white → yellow

Permissible ambient conditions

Temperature:	10 to 40 °C
Humidity:	less than 10 mg H_2O/L

Reaction principle

a) F_2 +$MgCl_2$ → Cl_2 + MgF_2

b) Cl_2 + o-tolidine → yellow reaction product

Cross-sensitivity

Nitrogen dioxide, chlorine, and chlorine dioxide are also indicated, but with different sensitivities.

Measuring range extension

Measuring range 0.05 to 1 ppm where n = 40 strokes, divide indicated scale value by 2.

D-5448-2014

Formaldehyde 0.2/a

Order no. 6733081

General data

Measuring range:	0.5 to 5 ppm	/ 0.2 to 2.5 ppm
Number of strokes n:	10	/ 20
Measuring time:	approx. 1.5 min	/ approx. 3 min
Standard deviation:	± 20 to 30 %	
Color change:	white → pink	

Permissible ambient conditions

Temperature:	10 to 40 °C
Humidity:	3 to 15 mg H_2O/L

Reaction principle

$HCHO + C_6H_4(CH_3)_2 + H_2SO_4 \rightarrow$ quinoid reaction products

Cross-sensitivity

Styrene, vinyl acetate, and acetaldehyde are also indicated with a yellow-brown color.

Acrolein, diesel fuel, and furfuryl alcohol are also indicated with a yellow-brown color.

500 ppm octane, 5 ppm nitric oxide, and 5 ppm nitrogen dioxide have no effect.

Measuring range extension

The measuring range can be extended in conjunction with the activating tube (order no. 81 01 141). Evaluation takes place on the 20-stroke scale. The indicated scale value must be divided by F:

0.1	to	1.25 ppm	with	40	strokes,	F = 2
0.05	to	0.63 ppm	with	80	strokes,	F = 4
0.04	to	0.5 ppm	with	100	strokes,	F = 5

ST-46-2001

Formaldehyde 2/a

Order no. 8101751

Measuring range:	2 to 40 ppm
Number of strokes n:	5
Measuring time:	approx. 30 s
Standard deviation:	± 20 to 30 %
Color change:	white → pink

Permissible ambient conditions

Temperature:	0 to 40 °C
Humidity:	3 to 15 mg H_2O/L

Reaction principle

$HCHO + C_6H_4(CH_3)_2 + H_2SO_4 \rightarrow$ quinoid reaction products

Cross-sensitivity

Styrene, vinyl acetate, acetaldehyde, acrolein, diesel fuel, and furfuryl alcohol are also indicated with a yellow-brown discoloration.

The indication is not affected by: 500 ppm octane, 5 ppm NO, 5 ppm NO_2

Additional note

The reagent ampoule must be broken before measurement.

ST-559-2008

Formic Acid 1/a

Order no. 6722701

General data

Measuring range:	1 to 15 ppm
Number of strokes n:	20
Measuring time:	approx. 3 min
Standard deviation:	± 10 to 15 %
Color change:	violet-blue → yellow

Permissible ambient conditions

Temperature:	10 to 50 °C
Humidity:	less than 30 mg H_2O/L

Reaction principle

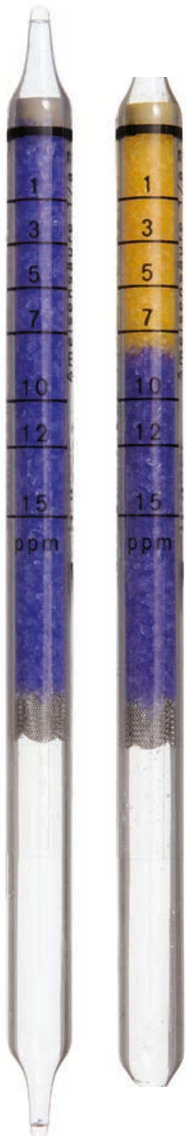
HCOOH + pH indicator → yellow reaction product

Cross-sensitivity

A formic acid measurement is not possible in the presence of other acids.

Organic acids are indicated with the same color, but sometimes with different sensitivities.

Mineral acids, e.g., hydrochloric acid, are indicated with a different sensitivity and in red.



D-13306-2010

Petroleum Hydrocarbons 10/a

Order no. 8101691

G

General data

Measuring range:	10 to 300 ppm for n-octane
Number of strokes n:	2
Measuring time:	approx. 1 min
Standard deviation:	± 25 %
Color change:	white → brown-green

Permissible ambient conditions

Temperature:	15 to 30 °C
Humidity:	1 to 20 mg H_2O/L

Reaction principle

$C_8H_{18} + I_2O_5 \rightarrow I_2$

Cross-sensitivity

Besides n-octane, other organic and inorganic compounds are also indicated.

50 ppm n-hexane gives a reading of around 70 ppm

100 ppm n-heptane gives a reading of around 150 ppm

10 ppm i-octane gives a reading of around 15 ppm

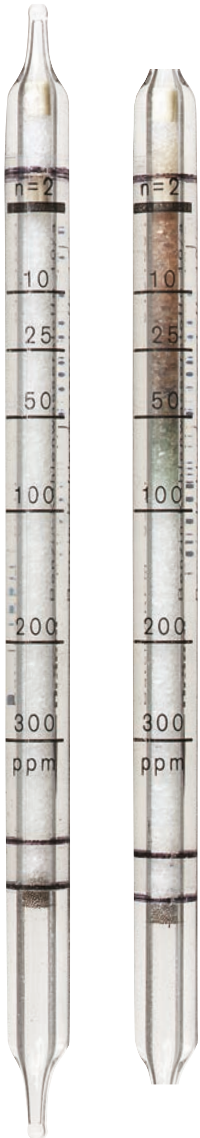
100 ppm i-octane gives a reading of around 150 ppm

200 ppm i-octane gives a reading of around 350 ppm

50 ppm n-nonane gives a reading of around 50 ppm

50 ppm perchloroethylene gives a reading of around 50 ppm

30 ppm CO gives a reading of around 20 ppm



ST-19-2001

Petroleum Hydrocarbons 100/a

Order no. 6730201

General data

Measuring range:	100 to 2500 ppm for n-octane
Number of strokes n:	2
Measuring time:	approx. 30 s
Standard deviation:	± 10 to 15 %
Color change:	white → green

Permissible ambient conditions

Temperature:	0 to 40 °C
Humidity:	< 30 mg H_2O/L

Reaction principle

$C_8H_{18} + I_2O_5 \rightarrow I_2$

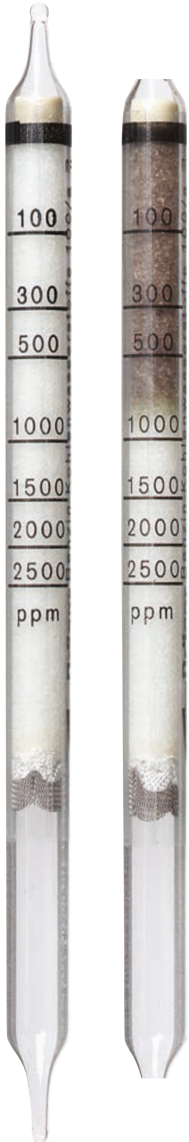
Cross-sensitivity

Many gasoline hydrocarbons are also indicated, but all with different sensitivities.

Differentiation is not possible.

Aromatic compounds are only indicated with a very low sensitivity.

Carbon monoxide is indicated in comparable concentrations with roughly half the sensitivity.



ST-20-2001

Halogenated Hydrocarbons 100/a

Order no. 8101601

H

General data

Measuring range:	200 to 2600 ppm	R 113 / R 114
	100 to 1400 ppm	R 11

The discoloration is read in mm and compared with a calibration data sheet.

Number of strokes n:	3
Measuring time:	approx. 1 min
Standard deviation:	± 30 %
Color change:	blue → yellow to gray-green

Permissible ambient conditions

Temperature:	0 to 40 °C
Humidity:	1 to 15 mg H_2O/L

Reaction principle

e.g.: a) R113 [pyrolysis] → HCl

b) HCl + pH indicator → yellow reaction product

Cross-sensitivity

Other halogenated hydrocarbons, free halogens, and halogen hydracids are also indicated.

Perchloroethylene is indicated with the same sensitivity as R 113.

Caution

The tubes heat up during measurement so must not be used in explosion-hazard areas.

If necessary, use a non-specific Ex measuring unit to qualify the use of the tubes.

ST-199-2001

Hexane 10/a

Order no. 8103681

General data

Measuring range:	10 to 200 ppm	/ 200 to 2500 ppm
Number of strokes n:	5	/ 1
Measuring time:	approx. 75 s	/ approx. 15 s
Standard deviation:	± 15 to 20 %	
Color change:	white → brown-green	

Permissible ambient conditions

Temperature:	0 to 40 °C
Humidity:	1 to 35 mg H_2O/L

Reaction principle

$C_5H_{12} + I_2O_5 \rightarrow I_2$

Cross-sensitivity

Many gasoline hydrocarbons are also indicated, but with different sensitivities.

Differentiation is not possible. Aromatic compounds are only indicated with a very low sensitivity. Carbon monoxide is indicated with a slightly lower sensitivity than n-hexane.

D-28049-2017

Hydrazine 0.01/a

Order no. 8103351

H

General data

Measuring range:	0.01 to 0.4 ppm	/ 0.5 to 6 ppm
Number of strokes n:	see tube	/ 5
Measuring time:	approx. 20 to 30 min	/ approx. 1 min
Standard deviation:	± 20 to 25 %	
Color change:	light gray (white) → brown-gray	

Permissible ambient conditions

Temperature:	10 to 30 °C
Humidity:	1 to 20 mg/L

Reaction principle

Hydrazine + silver salt → brown-gray reaction product

Cross-sensitivity

1,1-dimethylhydrazine and monomethylhydrazine are indicated with the same sensitivity (standard deviation ± 50 %).
5 ppm ammonia with 100 strokes gives a reading of approx. 0.01 ppm hydrazine. With 5 strokes, ammonia is not indicated, even at high concentrations.

*The number of strokes for the small measuring range of the tube is normally n = 100. Due to manufacturing constraints, the number of strokes for the most sensitive measuring range can be max. 150 strokes.
Please note the information on the number of strokes on the tubes.

ST-5757-2004

Hydrazine 0.25/a

Order no. CH31801

General data

Measuring range:	0.25 to 10 ppm	/ 0.1 to 5 ppm
Number of strokes n:	10	/ 20
Measuring time:	approx. 1 min	/ approx. 2 min
Standard deviation:	± 10 to 15 %	
Color change:	yellow → blue	

Permissible ambient conditions

Temperature:	10 to 50 °C
Humidity:	less than 20 mg H_2O/L

Reaction principle

N_2H_4 + pH indicator → blue reaction product

Cross-sensitivity

Other alkaline substances such as organic amines and ammonia are also indicated but with different sensitivities.

D-13350-2010

Hydrocarbon 2/a

Order no. 8103581

H

General data

Measuring range:	2 to 24 mg/L
Number of strokes n:	3
Measuring time:	max. 5 min
Standard deviation:	± 25 %
Color change:	orange → brown-green

Permissible ambient conditions

Temperature:	0 to 40 °C
Humidity:	1 to 25 mg/L

Reaction principle

$C_8H_{18} + Cr^{6+} \rightarrow Cr^{3+}$ + var. oxidation products

Cross-sensitivity

The information regarding the cross-sensitivity only applies for measurements with a maximum of 3 strokes.

- Paraffinic and aromatic hydrocarbons are indicated together. Differentiation is not possible.
- Aromatic hydrocarbons (benzene, toluene) are also indicated. Their concentration in the mixture should not exceed 20 %.
- The reading is not affected by < 1000 ppm CO.

Additional note

A maximum of 15 strokes within 1 hour can be performed for leakage measurements (qualitative measurements). However, the information regarding the cross-sensitivity only applies for measurements with a maximum of 3 strokes!

ST-14215-2008

Hydrocarbon 0.1 %/c

Order no. 8103571

General data

Measuring range:	0.1 to 1.3 Vol%	propane
	0.1 to 1.3 Vol%	butane
	0.1 to 1.3 Vol%	mix
	(mix 1:1)	
Number of strokes n:	1	
Measuring time:	max. 3 min	
Standard deviation:	± 15 %	
Color change:	orange → brown-green	

Permissible ambient conditions

Temperature:	0 to 40 °C
Humidity:	1 to 40 mg/L

Reaction principle

$C_3H_8/C_4H_{10} + Cr^{6+} \rightarrow Cr^{3+}$ + var. oxidation products.

Cross-sensitivity

The information regarding the cross-sensitivity only applies for measurements with a maximum of 1 stroke. Hydrocarbons and hydrocarbons with olefin double bonds are indicated with a different discoloration and sensitivity. The following have no effect on the reading of 0.1 Vol% propane/butane:

< 99.9	Vol%	methane
< 5	Vol%	ethane
< 1	Vol%	carbon monoxide
< 500	ppm	acetylene, ethylene

Additional note

A maximum of 15 strokes within 1 hour can be performed for leakage measurements (qualitative measurements). However, the information regarding the cross-sensitivity only applies for measurements with a maximum of 1 stroke!

ST-14216-2008

Hydrochloric Acid 0.2/a

Order no. 8103481

H

General data

Measuring range:	0.2 to 3 ppm	/ 3 to 20 ppm
Number of strokes n:	10	/ 2
Measuring time:	approx. 2 min	/ 0.4 min
Standard deviation:	± 10 to 15 %	
Color change:	blue → yellow	

Permissible ambient conditions

Temperature:	5 to 40 °C
Humidity:	≤ 15 mg/L

Reaction principle

HCl + bromophenol blue → yellow reaction product

Cross-sensitivity

The reading is not affected by 10 ppm H_2S and 2 ppm SO_2. Other acid gases are also indicated, but with different sensitivities. Chlorine discolors the indicating layer gray. The simultaneous influence of chlorine leads to higher HCl readings.

ST-561-2008

Hydrochloric Acid 1/a

Order no. CH29501

General data

Measuring range:	1 to 10 ppm
Number of strokes n:	10
Measuring time:	approx. 2 min
Standard deviation:	± 10 to 15 %
Color change:	blue → yellow

Permissible ambient conditions

Temperature:	5 to 40 °C
Humidity:	max. 15 mg H_2O/L

Reaction principle

HCl + bromophenol blue → yellow reaction product

Cross-sensitivity

Hydrogen sulfide and sulfur dioxide have no effect in their OEL ranges. A hydrochloric acid measurement is not possible in the presence of other mineral acids.

Chlorine and nitrogen dioxide are also indicated, but with different sensitivities.

ST-114-2001

Hydrochloric Acid 50/a

Order no. 6728181

H

Measuring range:	500 to 5000 ppm	/ 50 to 500 ppm
Number of strokes n:	1	/ 10
Measuring time:	approx. 30 s	/ approx. 5 min
Standard deviation:	± 10 to 15 %	
Color change:	blue → white-yellow	

Permissible ambient conditions

Temperature:	10 to 50 °C
Humidity:	max. 15 mg H_2O/L

Reaction principle

HCl + bromophenol blue → yellowish reaction product

Cross-sensitivity

Hydrogen sulfide and sulfur dioxide have no effect in their OEL ranges. A hydrochloric acid measurement is not possible in the presence of other mineral acids.

Chlorine and nitrogen dioxide are also indicated, but with different sensitivities.

ST-116-2001

Hydrochloric Acid/Nitric Acid 1/a

Order no. 8101681

General data

Measuring range:	Hydrochloric acid:	/ nitric acid:
	1 to 10 ppm	/ 1 to 15 ppm
Number of strokes n:	10	/ 20
Measuring time:	approx. 1.5 min	/ approx. 3 min
Standard deviation:	± 30 %	
Color change:	blue → yellow	

Permissible ambient conditions

Temperature: 5 to 40 °C

For HNO_3 measurements, the tube scales only apply at 20 °C. At different temperatures, multiply the measurement result by the following factor:

Temperature °C	Factor
40	0.3
30	0.4
10	2

Humidity: max. 15 mg H_2O/L

Reaction principle

HCl and/or HNO_3 + pH indicator → yellow reaction product

Cross-sensitivity

50 ppm nitrogen dioxide give roughly the same reading as 2 ppm nitric acid. 10 ppm hydrogen sulfide or 5 ppm nitrogen dioxide have no effect on the reading.

Chlorine concentrations above 1 ppm discolor the entire indicating layer yellow-green.

ST-156-2001

Hydrocyanic Acid 0.5/a

Order no. 8103601

Measuring range:	0.5 to 5 ppm	/ 5 to 50 ppm
Number of strokes n:	10	/ 2
Measuring time:	approx. 2.5 min	/ approx. 0.5 min
Standard deviation:	± 10 to 15 %	
Color change:	yellow → red	

Permissible ambient conditions

Temperature:	0 to 40 °C
Humidity:	max. 40 mg H_2O/L

Reaction principle

a) $HCN + HgCl_2 \rightarrow HCl$
b) HCl + methyl red → red reaction product

Cross-sensitivity

30 ppm hydrogen sulfide, 300 ppm ammonia, 40 ppm sulfur dioxide, 20 ppm nitrogen dioxide, as well as 1000 ppm hydrochloric acid do not affect the reading.
Hydrogen sulfide discolors the pre-layer a dark brown.
Ammonia concentrations above 300 ppm can fade the indication at the start of the layer.
Acrylonitrile up to 1000 ppm does not affect the indication.
A hydrocyanic acid measurement is not possible in the presence of phosphine.

D-5454-2014

Hydrogen 0.2 %/a

Order no. 8101511

General data

Measuring range:	0.2 to 2.0 Vol%
Number of strokes n:	1
Measuring time:	approx. 1 min
Standard deviation:	± 15 to 20 %
Color change:	green-yellow → turquoise blue

Permissible ambient conditions

Temperature:	20 to 40 °C
Humidity:	max. 50 mg H_2O/L

Reaction principle

a) $H_2 + 1/2\ O_2 \rightarrow H_2O$

b) H_2O + indicator → turquoise-blue reaction product

Cross-sensitivity

The following have no effect on the reading:

0.1 Vol%	acetylene
6 Vol%	alcohol
6 Vol%	ammonia
0.5 Vol%	carbon monoxide

Caution

The indicating layer heats up at hydrogen concentrations above 10 Vol%. The air sample must not contain additional flammable substances with an ignition temperature below 250 °C!
EXPLOSION HAZARD!
Measurement of hydrogen in air with at least 5 Vol% oxygen.

ST-169-2001

Hydrogen 0.5 %/a

Order no. CH30901

H

General data

Measuring range:	0.5 to 3.0 Vol%
Number of strokes n:	5
Measuring time:	approx. 1 min
Standard deviation:	± 10 to 15 %
Color change:	yellow-green → gray-green

Permissible ambient conditions

Temperature:	5 to 40 °C
Humidity:	less than 30 mg H_2O/L

Reaction principle

a) $H_2 + 1/2\ O_2 \rightarrow H_2O$

b) $H_2O + SeO_2 + H_2SO_4 \rightarrow$ pink reaction product

Cross-sensitivity

CO has no effect on the reading up to 1000 ppm, higher concentrations lead to minus errors.

Acetylene and alcohols react similar to hydrogen.

Caution

Do not use in explosion-hazard areas.

If necessary, use a non-specific Ex measuring unit to qualify the use of the tubes.

The catalyst layer heats up during measurement and becomes red hot at hydrogen concentrations above 3 Vol%!

Measurement of hydrogen in air with at least 5 Vol% oxygen.

ST-170-2001

Hydrogen Fluoride 0.5/a

Order no. 8103251

General data

Measuring range:	0.5 to 15 ppm	/ 10 to 90 ppm
Number of strokes n:	10	/ 2
Measuring time:	approx. 2 min	/ approx. 25 s
Standard deviation:	± 20 to 30 %	
Color change:	violet-blue → yellow	

Permissible ambient conditions

Temperature:	10 to 40 °C
Humidity:	30 to 80 %

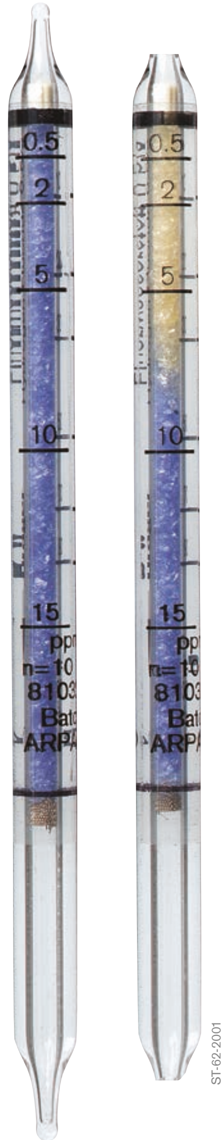
Reaction principle

HF + pH indicator → yellow reaction product

Cross-sensitivity

Mineral acids, such as hydrochloric acid or nitric acid, are also indicated.

Alkaline gases, such as ammonia, cause minus errors or can prevent an indication entirely.



Hydrogen Fluoride 1.5/b

Order no. CH30301

Measuring range:	1.5 to 15 ppm
Number of strokes n:	20
Measuring time:	approx. 2 min
Standard deviation:	± 15 to 20 %
Color change:	light blue → light pink

Permissible ambient conditions

Temperature:	15 to 30 °C
Humidity:	max. 9 mg H_2O/L

Reaction principle

HF + $Zr(OH)_4$/quinalizarin → $[ZrF_6]^{2-}$ + quinalizarin

Cross-sensitivity

Other halogen hydracids do not have any effect within their OEL ranges.

In the presence of higher humidity than shown above, hydrogen fluoride mist is generated, which cannot be quantitatively indicated by the tube, i.e., the indication is too low.

ST-63-2001

Hydrogen Peroxide 0.1/a

Order no. 8101041

General data

Measuring range:	0.1 to 3 ppm / 1 ppm
Number of strokes n:	20 / 2
Measuring time:	approx. 3 min / approx. 18 s
Standard deviation:	± 10 to 15 %
Color change:	white → brown

Permissible ambient conditions

Temperature:	10 to 25 °C
Humidity:	3 to 10 mg H_2O/L

Reaction principle

$2\ H_2O_2 + 2\ KI \rightarrow I_2 + 2\ H_2O + O_2$

Cross-sensitivity

It is impossible to measure hydrogen peroxide in the presence of nitrogen dioxide or chlorine.

Only hydrogen peroxide vapor is indicated, but not aerosols.

D-5445-2014

Hydrogen Sulfide 0.2/a

Order no. 8101461

H

General data

Measuring range:	0.2 to 5 ppm
Number of strokes n:	10
Measuring time:	approx. 5 min
Standard deviation:	± 5 to 10 %
Color change:	white → light brown

Permissible ambient conditions

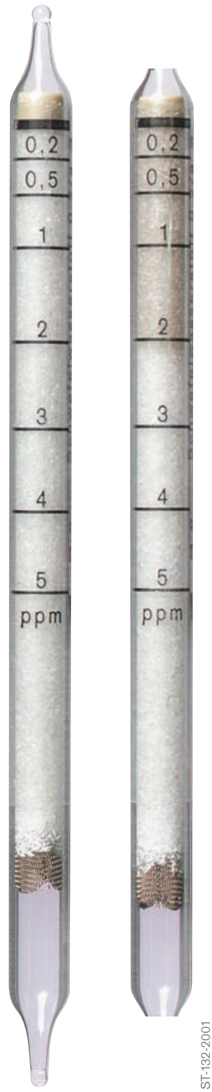
Temperature:	10 to 30 °C
Humidity:	3 to 15 mg H_2O/L

Reaction principle

$H_2S + Pb^{2+} \rightarrow PbS + 2\ H^+$

Cross-sensitivity

Sulfur dioxide and hydrochloric acid have no effect in their OEL ranges.



Hydrogen Sulfide 0.2/b

Order no. 8101991

General data

Measuring range:	0.2 to 6 ppm
Number of strokes n:	1
Measuring time:	approx. 55 s
Standard deviation:	± 15 to 20 %
Color change:	yellow → pink

Permissible ambient conditions

Temperature:	15 to 40 °C At temperatures of 0 to 10 °C, multiply the scale value by 1.5.
Relative standard deviation:	± 30 %
Humidity:	max. 20 mg H_2O/L

Reaction principle

a) $H_2S + HgCl_2 \rightarrow HgS + 2\ HCl$

b) HCl + pH indicator → pink reaction product

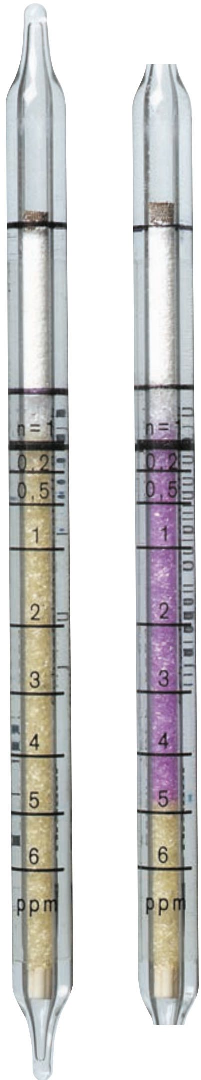
Cross-sensitivity

Sulfur dioxide has no effect on the reading up to 1000 ppm.

Mercaptans, arsine, phosphine, and nitrogen dioxide are also indicated in their OEL ranges, but with different sensitivities.

Hydrocyanic acid in the OEL range discolors the entire indicating layer light orange.

This does not affect the indication of hydrogen sulfide.



ST-127-2001

Hydrogen Sulfide 0.5/a

Order no. 6728041

H

General data

Measuring range:	0.5 to 15 ppm	/ 5 to 150 ppm
Number of strokes n:	10	/ 1
Measuring time:	approx. 6 min	/ approx. 40 s
Standard deviation:	± 5 to 10 %	
Color change:	white → light brown	

Permissible ambient conditions

Temperature:	0 to 40 °C
Humidity:	max. 30 mg H_2O/L

Reaction principle

$H_2S + Hg^{2+} \rightarrow HgS + 2\ H^+$

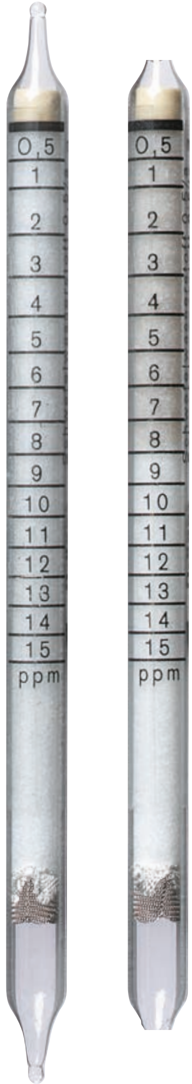
Cross-sensitivity

The indication is not affected by:

100 ppm sulfur dioxide

100 ppm hydrochloric acid

100 ppm ethyl mercaptan



ST-126-2001

Hydrogen Sulfide 1/c

Order no. 6719001

General data

Measuring range:	10 to 200 ppm	/ 1 to 20 ppm
Number of strokes n:	1	/ 10
Measuring time:	approx. 20 s	/ approx. 3 min
Standard deviation:	± 5 to 10 %	
Color change:	white → light brown	

Permissible ambient conditions

Temperature:	0 to 40 °C
Humidity:	max. 30 mg H_2O/L

Reaction principle

$H_2S + Pb^{2+} \rightarrow PbS + 2\ H^+$

Cross-sensitivity

The presence of sulfur dioxide well above its OEL at the same time results in plus errors of up to 50 %. Sulfur dioxide alone is not indicated.

ST-130-2001

Hydrogen Sulfide 1/d

Order no. 8101831

General data

Measuring range:	10 to 200 ppm	/ 1 to 20 ppm
Number of strokes n:	1	/ 10
Measuring time:	approx. 1 min	/ approx. 10 min
Standard deviation:	± 15 %	
Color change:	white → brown	

Permissible ambient conditions

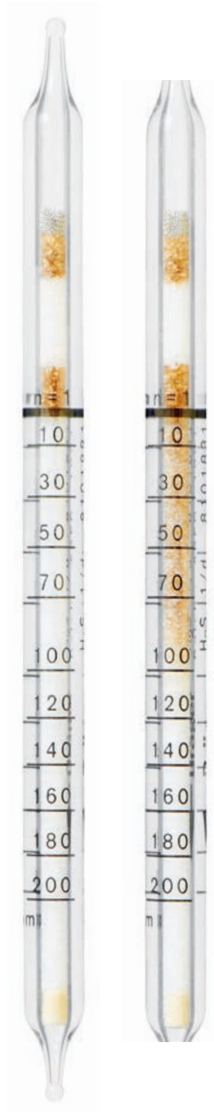
Temperature:	2 to 40 °C
Humidity:	max. 40 mg H_2O/L

Reaction principle

$H_2S + Cu^{2+} \rightarrow CuS + 2\ H^+$

Cross-sensitivity

500 ppm hydrochloric acid, 500 ppm sulfur dioxide, 500 ppm ammonia, or 100 ppm arsine do not affect the reading.
Methyl mercaptan and ethyl mercaptan discolor the entire indicating layer a weak yellow and, when mixed with hydrogen sulfide, extend the reading by around 30 %.



D-5451-2014

Hydrogen Sulfide 2/a

Order no. 6728821

General data

Measuring range:	20 to 200 ppm	/ 2 to 20 ppm
Number of strokes n:	1	/ 10
Measuring time:	approx. 20 s	/ approx. 3.5 min
Standard deviation:	± 5 to 10 %	
Color change:	white → light brown	

Permissible ambient conditions

Temperature:	0 to 40 °C
Humidity:	3 to 30 mg H_2O/L

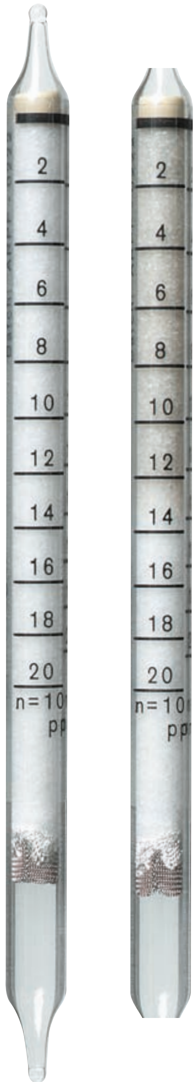
Reaction principle

$H_2S + Hg^{2+} \rightarrow HgS + 2\ H^+$

Cross-sensitivity

The indication is not affected by:

200 ppm	sulfur dioxide
100 ppm	hydrochloric acid
100 ppm	ethyl mercaptan



ST-133-2001

Hydrogen Sulfide 2/b

Order no. 8101961

H

General data

Measuring range:	2 to 60 ppm
Number of strokes n:	1
Measuring time:	approx. 30 s
Standard deviation:	± 5 to 10 %
Color change:	white → light brown

Permissible ambient conditions

Temperature:	0 to 40 °C
Humidity:	max. 20 mg H_2O/L

Reaction principle

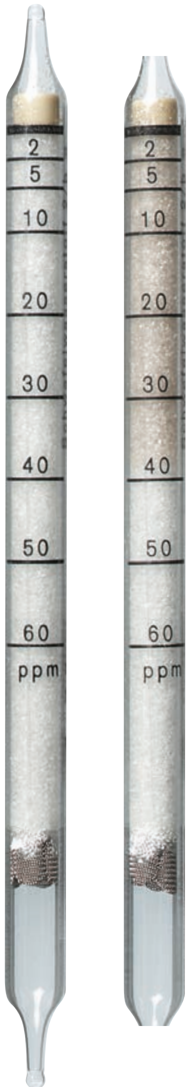
$H_2S + Pb^{2+} \rightarrow PbS + 2\ H^+$

Cross-sensitivity

Sulfur dioxide, hydrochloric acid, and mercaptan have no effect in their OEL ranges.

Measuring range extension

Measuring range 1 to 30 ppm where n = 2 strokes, divide indicated scale value by 2.



ST-128-2001

Hydrogen Sulfide 5/b

Order no. CH29801

General data

Measuring range:	5 to 60 ppm
Number of strokes n:	10
Measuring time:	approx. 4 min
Standard deviation:	± 5 to 10 %
Color change:	white → brown

Permissible ambient conditions

Temperature:	0 to 60 °C
Humidity:	less than 40 mg H_2O/L

Reaction principle

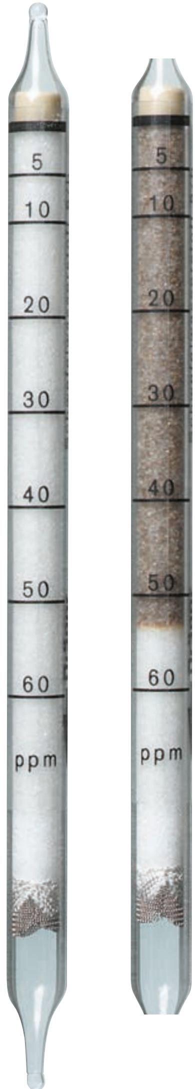
$H_2S + Pb^{2+} \rightarrow PbS + 2\ H^+$

Cross-sensitivity

The presence of sulfur dioxide at the same time results in plus errors of up to 50 %, sulfur dioxide alone is not indicated.

Measuring range extension

Measuring range 50 to 600 ppm where n = 1 stroke, multiply indicated scale value by 10.



ST-125-2001

Hydrogen Sulfide 100/a

Order no. CH29101

General data

Measuring range:	100 to 2000 ppm
Number of strokes n:	1
Measuring time:	approx. 30 s
Standard deviation:	± 5 to 10 %
Color change:	white → brown

Permissible ambient conditions

Temperature:	0 to 40 °C
Humidity:	3 to 40 mg H_2O/L

Reaction principle

$H_2S + Pb^{2+} \rightarrow PbS + 2\ H^+$

Cross-sensitivity

2000 ppm sulfur dioxide and 100 ppm nitrogen dioxide have no effect.

ST-129-2001

Hydrogen Sulfide 0.2 %/A

Order no. CH28101

General data

Measuring range:	0.2 to 7 Vol%
Number of strokes n:	1 + 2 desorption strokes in clean air
Measuring time:	approx. 2 min
Standard deviation:	± 5 to 10 %
Color change:	light blue → black

Permissible ambient conditions

Temperature:	0 to 60 °C
Humidity:	max. 40 mg H_2O/L

Reaction principle

$H_2S + Cu^{2+} \rightarrow CuS + 2\ H^+$

Cross-sensitivity

Sulfur dioxide discolors the indicating layer a yellowy color, but the hydrogen sulfide concentration can still be read.

Mercaptans affect the reading at comparable concentrations.

D-13348-2010

Hydrogen Sulfide 2 %/a

Order no. 8101211

H

General data

Measuring range:	2 to 40 Vol%
Number of strokes n:	1
Measuring time:	approx. 60 s
Standard deviation:	± 5 to 10 %
Color change:	light blue → black

Permissible ambient conditions

Temperature:	0 to 40 °C
Humidity:	3 to 20 mg H_2O/L

Reaction principle

$H_2S + Cu^{2+} \rightarrow CuS + 2\,H^+$

Cross-sensitivity

The indication is not affected by:

5000 ppm	sulfur dioxide
1000 ppm	hydrochloric acid
1000 ppm	ethyl mercaptan

D-13319-2010

H

Hydrogen Sulfide + Sulfur Dioxide 0.2 %/A

Order no. CH28201

General data

Measuring range:	0.2 to 7 Vol%
Number of strokes n:	1 + 2 desorption strokes in clean air
Measuring time:	approx. 2 min
Standard deviation:	± 5 to 10 %
Color change:	brown → light yellow

Permissible ambient conditions

Temperature:	**0 to 40 °C**
Humidity:	max. 40 mg H_2O/L

Reaction principle

$H_2S + I_2 \rightarrow 2\ HI + S_2$

$SO_2 + I_2 + 2\ H_2O \rightarrow 2\ HI + H_2SO_4$

Cross-sensitivity

All substances that can be oxidized by iodine are also indicated. A hydrogen sulfide + sulfur dioxide measurement is not possible in these cases.

Measuring range extension

Measuring range 0.02 to 0.7 Vol% where n = 10 strokes, divide measurement result by 10.

Iodine 0.1/a

Order no. 8103521

General data

Measuring range:	0.1 to 0.6 ppm / 1 to 5 ppm
Number of strokes n:	5 / 1
Measuring time:	approx. 5 min / approx. 1 min
Standard deviation:	± 15 to 20 %
Color change:	yellow → pink

Permissible ambient conditions

Temperature:	15 to 40 °C
Humidity:	≤ 20 mg/L (corresp. to 100 % r. h. at 23 °C)

Reaction principle

$I_2 + HgCl_2 \rightarrow HgI_2 + Cl_2$

Cl_2 + indicator → pink reaction product

Cross-sensitivity

Mercaptans, arsine, PH_3, and nitrogen dioxide are indicated with different sensitivities.

10 ppm hydrocyanic acid discolors the entire indicating layer light orange.

D-13339-2010

i-Propanol 50/a

Order no. 8103741

General data

Measuring range:	50 to 4000 ppm
Number of strokes n:	10
Measuring time:	approx. 2.5 min
Standard deviation:	± 5 – 20 %
Color change:	yellow → mint green

Permissible ambient conditions

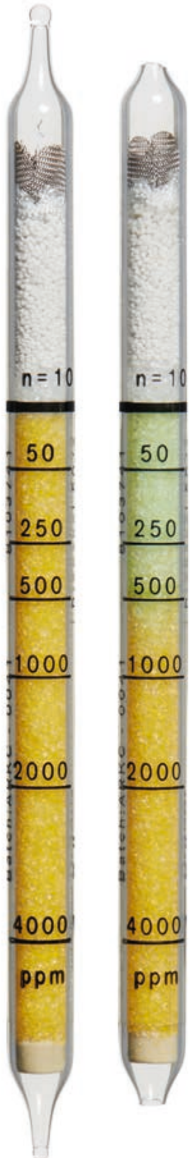
Temperature:	15 to 35 °C
Humidity:	< 20 mg H_2O/L

Reaction principle

i-propanol + organometallic compounds → green reaction product

Cross-sensitivity

Differentiation between alcohols is not possible. When measuring n-propanol with n=10 strokes, the indicated concentration must be multiplied by a factor of 3.5. Methanol is indicated with approximately twice the sensitivity, ethanol with a similar sensitivity, and tetrahydrofuran with half the sensitivity. Higher-molecular alcohols are indicated with rapidly decreasing sensitivity. < 100 ppm formaldehyde, < 250 ppm acetaldehyde, < 200 ppm toluene, < 200 ppm xylene, < 100 ppm diethyl ether, and < 1000 ppm dimethyl ether are not indicated. Aliphatic gasoline hydrocarbons, ketones, esters, halogenated hydrocarbons, and benzene are not indicated.



D-28045-2017

Mercaptan 0.1/a

Order no. 8103281

M

General data

Measuring range:	0.1 to 2.5 ppm	/ 3 to 15 ppm
Number of strokes n:	10	/ 2
Measuring time:	approx. 3 min	/ approx. 40 s
Standard deviation:	± 10 to 15 %	
Color change:	yellow → pink	

Permissible ambient conditions

Temperature:	5 to 40 °C
Humidity:	2 to 40 mg/L

Reaction principle

$2\ R\text{-}SH + HgCl_2 \rightarrow Hg(CH_3S)_2 + 2\ HCl$

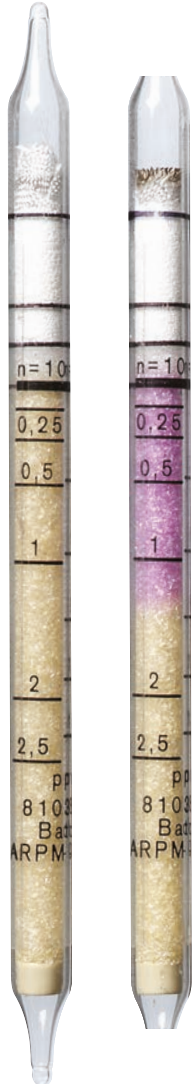
HCl + pH indicator → red reaction product

Cross-sensitivity

Propyl mercaptan and tert-butyl mercaptan are indicated, but with less sensitivity.

4 ppm ethylene, 30 ppm CO, 10 ppm tetrahydrothiophene, and 100 ppm H_2S do not affect the reading.

H_2S colors the pre-layer black.



ST-180-2001

Mercaptan 0.5/a

Order no. 6728981

General data

Measuring range:	0.5 to 5 ppm
Number of strokes n:	20
Measuring time:	approx. 5 min
Standard deviation:	± 10 to 15 %
Color change:	white → yellow

Permissible ambient conditions

Temperature:	10 to 40 °C
Humidity:	3 to 15 mg H_2O/L

Reaction principle

$2\ R\text{-}SH + Pd^{2+} \rightarrow Pd(RS)_2 + 2\ H^+$

Cross-sensitivity

Higher alkyl mercaptans (propyl and butyl mercaptan) are also indicated with roughly the same sensitivity.

The indication is not affected by:

1000	ppm	ethylene
2000	ppm	carbon monoxide
200	ppm	hydrogen sulfide

Hydrogen sulfide discolors the pre-layer black.

ST-58-2001

Mercaptan 20/a

Order no. 8101871

M

Measuring range:	20 to 100 ppm
Number of strokes n:	10
Measuring time:	approx. 2.5 min
Standard deviation:	± 10 to 15 %
Color change:	white → yellow-brown

Permissible ambient conditions

Temperature:	0 to 50 °C
Humidity:	3 to 30 mg H_2O/L

Reaction principle

a) 2 R-SH + Cu^{2+} → $Cu(RS)_2$ + 2 H^+

b) $Cu(RS)_2$ + S → yellow-brown Cu compound

Cross-sensitivity

Higher alkyl mercaptans (propyl and butyl mercaptan) are also indicated with roughly the same sensitivity.

A mercaptan measurement is not possible in the presence of hydrogen sulfide, as hydrogen sulfide is also indicated with roughly twice the sensitivity.

Additional note

After carrying out the 10 strokes, the reagent ampoule must be broken and the ampoule liquid applied to the indicating layer and carefully drawn through the indicating layer with the pump.

After carrying out the 10 strokes, wait 3 min. before evaluation.

ST-57-2001

Mercury vapor 0.1/b

Order no. CH23101

General data

Measuring range:	0.05 to 2 mg/m^3
Number of strokes n:	40 to 1
Measuring time:	max. 10 min
Standard deviation:	± 30 %
Color change:	light yellow-gray → weak orange

Permissible ambient conditions

Temperature:	0 to 40 °C
Humidity:	less than 20 mg H_2O/L

Reaction principle

Hg + CuI → Cu-Hg complex

Cross-sensitivity

Free halogens lead to significant minus errors, so a mercury measurement is not possible in the presence of halogens.
The reading is not affected by arsine, phosphine, hydrogen sulfide, ammonia, nitrogen dioxide, sulfur dioxide, and hydrazine in concentration ranges that correspond to the respective OELs.

D-5459-2014

Methanol 20/a

Order no. 8103801

General data

Measuring range:	20 to 250 ppm	/	200 to 5000 ppm
Number of strokes n:	15	/	5
Measuring time:	approx. 6 min	/	2 min
Standard deviation:	± 10 – 25 %		
Color change:	yellow → mint green		

Permissible ambient conditions

Temperature:	15 to 30 °C
Humidity:	< 15 mg H_2O/L

Reaction principle

Ethanol + organometallic compounds → green reaction product

Cross-sensitivity

Differentiation between alcohols is not possible. Higher-molecular alcohols are indicated with rapidly decreasing sensitivity. Ether and xylene are also indicated, but with different sensitivities. < 50 ppm acetaldehyde and < 50 ppm toluene are not indicated. Aliphatic gasoline hydrocarbons, ketones, esters, halogenated hydrocarbons, and benzene are not indicated.

D-28043-2017

Methyl Acrylate 5/a

Order no. 6728161

General data

Measuring range:	5 to 200 ppm
Number of strokes n:	20
Measuring time:	approx. 5 min
Standard deviation:	± 30 to 40 %
Color change:	yellow → blue

Permissible ambient conditions

Temperature:	15 to 35 °C
Humidity:	5 to 12 mg H_2O/L

Reaction principle

CH_2=CH-$COOCH_3$ + Pd-molybdate complex → blue reaction product

Cross-sensitivity

Other compounds with C=C double bonds are also indicated, but all with different sensitivities.

Differentiation is not possible.

A methyl acrylate measurement is not possible in the presence of hydrogen sulfide, hydrogen sulfide colors the indicating layer black. Carbon monoxide at higher concentrations colors the indicating layer light blue-gray.

ST-60-2001

Methyl Bromide 0.1/a

Order no. 3706301

M

General data

Measuring range:	0.1 to 5 ppm	/ 5 to 50 ppm
Number of strokes n:	10	/ 2
Measuring time:	approx. 5 min	/ approx. 1 min
Standard deviation:	± 15 to 20 %	
Color change:	light → green	

Permissible ambient conditions

Temperature:	2 to 40 °C
Humidity:	less than 40 mg/L

Reaction principle

$CH_3Br + H_2S_2O_7$ + chromate → Br_2

Br_2 + o-tolidine → green reaction product

Cross-sensitivity

Carbon tetrachloride: <2 ppm no reading. A methyl bromide measurement is not possible in the presence of perchloroethylene or trichloroethylene! Sulfuryl fluoride, phosphine, ethylene oxide, ammonia, hydrocyanic acid, chloropicrin, and formaldehyde are not indicated below their limit values. 2 ppm ethylene dibromide is indicated with approximately the same sensitivity. 0.5 ppm vinyl chloride is indicated with a reading of less than 0.1 ppm. 2 ppm 1,1-dichloroethylene is not indicated and 20 ppm 1,2 dichloroethylene is indicated with a weak reading of 3 ppm.

D-8692-2019

Methylene Chloride 20/a

Order no. 8103591

General data

Measuring range:	20 to 200 ppm
Number of strokes (n):	8
Measuring time:	approx. 7 min
Standard deviation:	± 15 % to 25 %
Color change:	yellow → red

Permissible ambient conditions

Temperature:	17 °C to 30 °C*
at 25 °C to 30 °C, multiply the reading by a factor of 0.6.	
Humidity:	3 to 25 mg/L

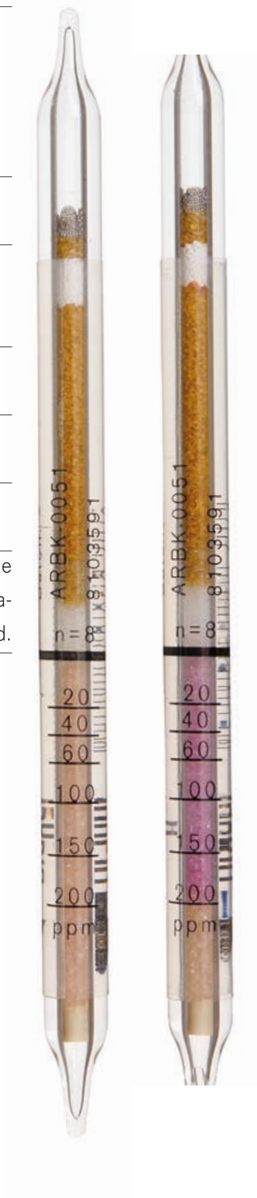
Reaction principle

CH_2Cl_2 + chromate → Cl_2

Cl_2 + amine → red reaction product

Cross-sensitivity

100 ppm n-octane and 300 ppm carbon monoxide do not affect the reading. Methylene chloride is not indicated at n-octane concentrations > 100 ppm. Other chlorinated hydrocarbons are also indicated.



D-13340-2010

Natural Gas Odorization tert-butyl mercaptan (TBM)

Order no. 8103071

General data

Measuring range:	3 to 15 mg/m^3	/ 1 to 10 mg/m^3
Number of strokes n:	3	/ 5
Measuring time:	approx. 3 min	/ approx. 5 min
Standard deviation:	± 15 to 20 %	
Color change:	yellow → pink	

Permissible ambient conditions

Temperature:	20 to 35 °C
Humidity:	≤ 15 mg/L

Reaction principle

a) R-SH + $HgCl_2$ → HgS + 2 HCl

b) HCl + pH indicator → pink reaction product

Cross-sensitivity

Hydrogen sulfide, sulfur dioxide, mercaptans, arsine, nitrogen dioxide, and phosphine are also indicated, but with different sensitivities.

Additional notes

A temperature correction needs to be applied when used below 20 °C. Refer to the information in the instructions for use.

ST-360-2008

Natural Gas Test

Order no. CH20001

General data

Measuring range:	Qualitative detection of natural gas
Number of strokes n:	5
Measuring time:	approx. 100 s
Standard deviation:	50 %
Color change:	white → brown-green to grayish-purple

Permissible ambient conditions

Temperature:	0 to 50 °C
Humidity:	max. 40 mg H_2O/L

Reaction principle

a) $CH_4 + KMnO_4 + H_2S_2O_7 \rightarrow CO$

b) $CO + I_2O_5 \rightarrow I_2 + CO_2$

Cross-sensitivity

Due to the reaction principle, a number of organic compounds are also indicated, e.g., propane, butane.

Carbon monoxide is also indicated.

Differentiation between different compounds is not possible.

ST-187-2001

n-butanol 10/a

Order no. 8103861

N

General data

Measuring range:	10 to 250 ppm / 250 to 2000 ppm
Number of strokes n:	10 / 2
Measuring time:	approx. 6 min / approx. 1 min
Standard deviation:	± 10 – 25 %
Color change:	yellow → mint green

Permissible ambient conditions

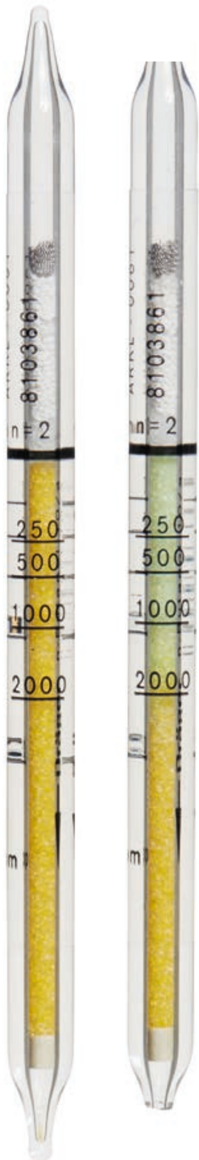
Temperature:	15 to 30 °C
Humidity:	3 – 15 mg H_2O/L

Reaction principle

n-butanol + organometallic compounds → green reaction product

Cross-sensitivity

The differentiation of other alcohols is not possible. 2-butanol is indicated with the same sensitivity. When measuring i-butanol with n=2/10 strokes, the indicated concentration must be multiplied by a factor of 0.4. When measuring tert-butanol with n=2/10 strokes, the indicated concentration must be multiplied by a factor of 3.0. Methanol is indicated with 2 (n=10) to 3 times (n=2), ethanol and iso-propanol with 1 (n=10) to 2 times (n=2) the sensitivity. Higher-molecular alcohols are indicated with rapidly decreasing sensitivity. Ethers are indicated with different sensitivities. < 25 ppm formaldehyde, < 50 ppm acetaldehyde, and < 50 ppm toluene are not indicated. Aliphatic gasoline hydrocarbons, ketones, esters, halogenated hydrocarbons, and benzene are not indicated.



D-28040-2017

Nickel Tetracarbonyl 0.1/a

Order no. CH19501

General data

Measuring range:	0.1 to 1 ppm Compare discoloration with color standard
Number of strokes n:	20
Measuring time:	approx. 5 min
Standard deviation:	± 50 %
Color change:	yellow → pink

Permissible ambient conditions

Temperature:	0 to 30 °C
Humidity:	less than 30 mg H_2O/L

Reaction principle

a) $Ni(CO)_4 + I_2 \rightarrow NiI_2 + 4\ CO$

b) NiI_2 + dimethylglyoxime → pink color complex

Cross-sensitivity

Iron pentacarbonyl is also indicated with a brownish color, but with a different sensitivity.

No nickel tetracarbonyl measurement is possible in the presence of hydrogen sulfide or sulfur dioxide, as the reading is suppressed. The indicating layer is bleached before opening the reagent ampoule.

Additional note

After carrying out the 20 strokes, the reagent ampoule must be broken and the ampoule liquid carefully drawn onto the indicating layer with the pump.

D-11118-2023

Nitric Acid 1/a

Order no. 6728311

N

General data

Measuring range:	5 to 50 ppm	/ 1 to 15 ppm
Number of strokes n:	10	/ 20
Measuring time:	approx. 2 min	/ approx. 4 min
Standard deviation:	± 10 to 15 %	
Color change:	blue → yellow	

Permissible ambient conditions

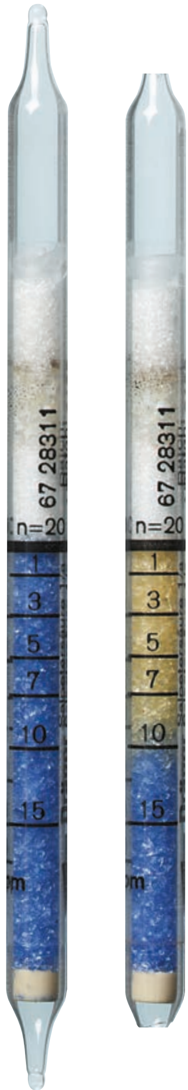
Temperature:	5 to 40 °C
Humidity:	3 to 15 mg H_2O/L

Reaction principle

HNO_3 + bromophenol blue → yellow reaction product

Cross-sensitivity

Hydrogen sulfide and nitrogen dioxide have no effect in their OEL ranges, 50 ppm nitrogen dioxide provides a reading identical to 3 ppm nitric acid. A nitric acid measurement is not possible in the presence of other mineral acids. Chlorine discolors the indicating layer gray, which makes evaluation difficult. In addition, the simultaneous presence of chlorine in the OEL range leads to slightly higher nitric acid readings.



ST-117-2001

Nitrogen Dioxide 0.1/a

Order no. 8103631

General data

Measuring range:	5 to 30 ppm	/ 0.1 to 5 ppm
	The first notch on the tube scale corresponds to 0.1 ppm.	
Number of strokes n:	1	/ 5
Measuring time:	approx. 15 s	/ approx. 75 s
Standard deviation:	± 10 to 15 %	
Color change:	gray-green → blue-gray	

Permissible ambient conditions

Temperature:	0 to 40 °C
Humidity:	< 40 mg H_2O/L

Reaction principle

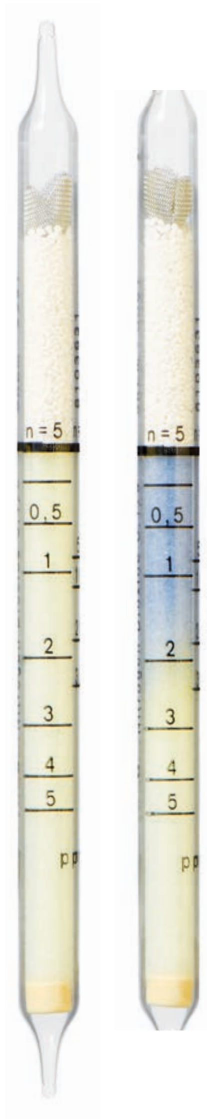
NO_2 + diphenylbenzidine → blue-gray reaction product

Cross-sensitivity

Chlorine and ozone are also indicated, but with different sensitivities.

Nitric oxide is not indicated.

Concentrations above 400 ppm cause the reading to fade.



D-5455-2014

Nitrogen Dioxide 2/c

Order no. 6719101

N

General data

Measuring range:	5 to 100 ppm	/ 2 to 50 ppm
Number of strokes n:	5	/ 10
Measuring time:	approx. 1 min	/ approx. 2 min
Standard deviation:	± 10 to 15 %	
Color change:	yellow-green → blue-gray	

Permissible ambient conditions

Temperature:	10 to 40 °C
Humidity:	max. 30 mg H_2O/L

Reaction principle

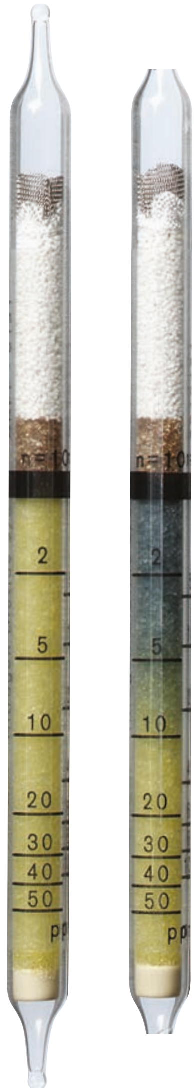
NO_2 + diphenylbenzidine → blue-gray reaction product

Cross-sensitivity

Ozone and chlorine have no effect in their OEL ranges.

Higher concentrations are indicated, but with a different sensitivity.

Nitric oxide is not indicated.



ST-140-2001

Nitrous Fumes 0.2/a

Order no. 8103661

General data

Measuring range:	0.2 to 6 ppm
Number of strokes n:	5
	The first notch on the 5-stroke tube scale corresponds to 0.2 ppm.
Measuring time:	approx. 75 s
Standard deviation:	± 10 to 15 %
Color change:	gray-green → blue-gray

Permissible ambient conditions

Temperature:	10 to 40 °C
Humidity:	3 to 40 mg H_2O/L

Reaction principle

a) NO + Ox → NO_2

b) NO_2 + diphenylbenzidine → blue-gray reaction product

Cross-sensitivity

The indicating layer may bleach at nitrogen dioxide concentrations above around 300 ppm.

Chlorine and ozone are also indicated, but with different sensitivities, and can distort the measurement result.

Nitrous Fumes 2/a

Order no. CH31001

General data

Measuring range:	5 to 100 ppm	/ 2 to 50 ppm
Number of strokes n:	5	/ 10
Measuring time:	approx. 1 min	/ approx. 2 min
Standard deviation:	± 10 to 15 %	
Color change:	yellow → blue-gray	

Permissible ambient conditions

Temperature:	10 to 30 °C
Humidity:	max. 30 mg H_2O/L

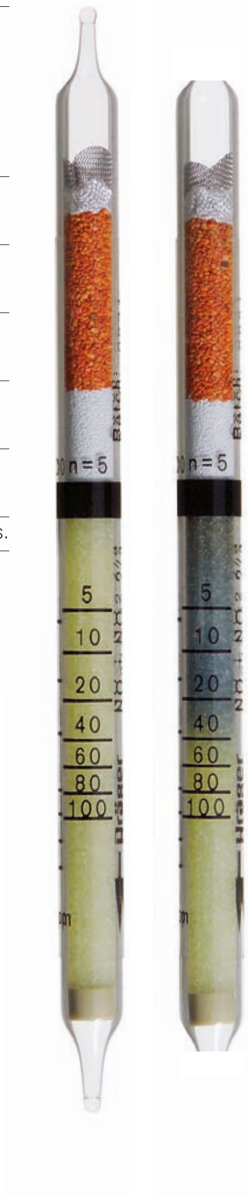
Reaction principle

a) $NO + Cr^{VI} \rightarrow NO_2$

b) NO_2 + diphenylbenzidine → blue-gray reaction product

Cross-sensitivity

Chlorine and ozone are also indicated, but with different sensitivities.



ST-583-2008

Nitrous Fumes 20/b

Order no. 3706171

General data

Measuring range:	20 to 500 ppm
Number of strokes n:	2
Measuring time:	approx. 30 s
Standard deviation:	± 10 to 15 %
Color change:	gray → orange-brown

Permissible ambient conditions

Temperature:	15 to 40 °C
Humidity:	3 to 40 mg H_2O/L

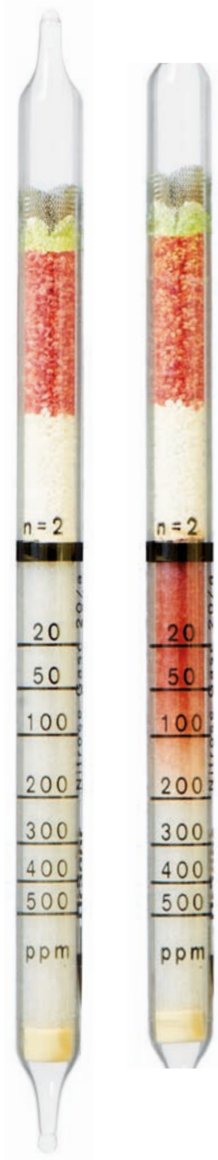
Reaction principle

a) NO + Ox → NO_2

b) NO_2 + o-tolidine → orange-brown reaction product

Cross-sensitivity

Chlorine and ozone have no effect in their OEL ranges.



D-5438-2014

Nitrous Fumes 50/b

Order no. 8103941

N

General data

Measuring range:	50 to 1000 ppm	/ 2000 to 4000 ppm
Number of strokes (n):	4	/ 2
Measuring time:	approx. 120 s	/ approx. 60 s
Standard deviation:	± 15 to 20 %	
Color change:	white → yellow-green	

Permissible ambient conditions

Temperature:	10 °C to 40 °C
Humidity:	up to 30 mg/L

Reaction principle

$NO + OX \rightarrow NO_2$

NO_2 + aromatic amine → yellow-green reaction product

Cross-sensitivity

Chlorine and ozone are also indicated, but with different sensitivities.

D-28053-2017

Oil Mist 1/a

Order no. 6733031

General data

Measuring range:	1 to 10 mg/m^3 Compare discoloration with the color standards as per the instructions for use
Number of strokes n:	100
Measuring time:	approx. 25 min
Standard deviation:	± 30 %
Color change:	white → brown

Permissible ambient conditions

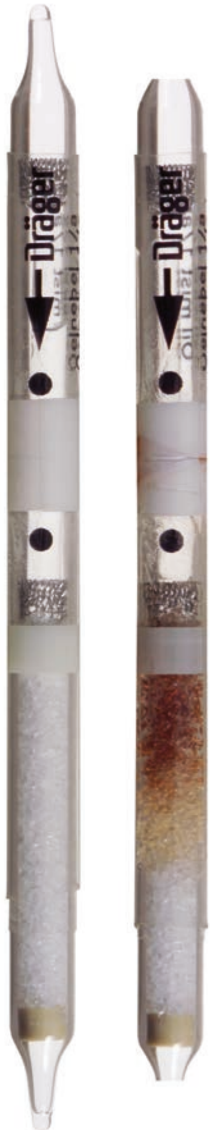
Temperature:	10 to 30 °C
Humidity:	less than 20 mg H_2O/L

Reaction principle

Oil mist + H_2SO_4 → brown reaction product

Additional note

After carrying out the 100 strokes, the reagent ampoule must be broken and the ampoule liquid carefully drawn onto the indicating layer with the pump.



ST-575-2008

Olefins 0.05 %/a

Order no. CH31201

General data

Measuring range:	0.06 to 3.2 Vol%	propene
	0.04 to 2.4 Vol%	butylene
Number of strokes n:	20 to 1	
Measuring time:	max. 5 min	
Standard deviation:	± 30 %	
Color change:	purple → light brown	

Permissible ambient conditions

Temperature:	0 to 40 °C
Humidity:	less than 30 mg H_2O/L

Reaction principle

CH_3-CH_2-CH=CH_2 + MnO_4^- → Mn^{IV} + var. oxidation products

Cross-sensitivity

Many organic compounds with C=C double bonds are also indicated, but all with different sensitivities.

Differentiation is not possible.

An olefin measurement is not possible in the presence of dialkyl sulfides.

Oxygen 5 %/B

Order no. 6728081

General data

Measuring range:	5 to 23 Vol%
Number of strokes n:	1
Measuring time:	approx. 1 min
Standard deviation:	± 5 to 10 %
Color change:	blue-black → white

Permissible ambient conditions

Temperature:	0 to 50 °C
Humidity:	3 to 20 mg/L

Reaction principle

a) O_2 + $TiCl_3$ → Ti^{IV} compound + HCl

b) Hydrochloric acid is adsorbed by silica gel

Cross-sensitivity

The reading is not affected by carbon dioxide, carbon monoxide, solvent vapors, halogenated hydrocarbons, and nitrous oxide.

Additional note

During measurement, the tubes heat up to temperatures around 100 °C and so must not be used in explosion-hazard areas. If necessary, use a non-specific Ex measuring unit to qualify the use of the tubes.

ST-5743-2004

Oxygen 5 %/C

Order no. 8103261

O

General data

Measuring range:	5 to 23 Vol%
Number of strokes n:	1
Measuring time:	approx. 1 min
Standard deviation:	± 10 to 15 %
Color change:	blue-black → white

Permissible ambient conditions

Temperature:	5 to 50 °C
Humidity:	0 to 40 mg/L

Reaction principle

$O_2 + TiCl_3 \rightarrow$ Ti compound + HCl

absorption of the HCl by silica gel

Cross-sensitivity

The reading is not affected by CO_2, solvent vapors, halogenated hydrocarbons, and nitrous oxide.

Additional note

During measurement, the tubes heat up to temperatures around 100 °C and so must not be used in explosion-hazard areas. If necessary, use a non-specific Ex measuring unit to qualify the use of the tubes.

ST-5744-2004

Ozone 0.05/b

Order no. 6733181

General data

Measuring range:	0.05 to 0.7 ppm
Number of strokes n:	10
Measuring time:	approx. 3 min
Standard deviation:	± 10 to 15 %
Color change:	light blue → white

Permissible ambient conditions

Temperature:	0 to 40 °C
Humidity:	2 to 30 mg H_2O/L

Reaction principle

O_3 + indigo → isatin

Cross-sensitivity

The indication is not affected by:

1 ppm sulfur dioxide

1 ppm chlorine

1 ppm nitrogen dioxide

Higher concentrations of chlorine and nitrogen dioxide discolor the indicating layer a diffuse white to light gray.

Measuring range extension

Measuring range 0.1 to 1.4 ppm where n = 5 strokes, multiply indicated scale value by 2.

Measuring range 0.005 to 0.07 ppm where n = 100 strokes, divide indicated scale value by 10.

ST-5750-2004

Ozone 10/a

Order no. CH21001

O

General data

Measuring range:	20 to 300 ppm
Number of strokes n:	1
Measuring time:	approx. 20 s
Standard deviation:	± 10 to 15 %
Color change:	greenish blue → yellow

Permissible ambient conditions

Temperature:	0 to 40 °C
Humidity:	2 to 30 mg H_2O/L

Reaction principle

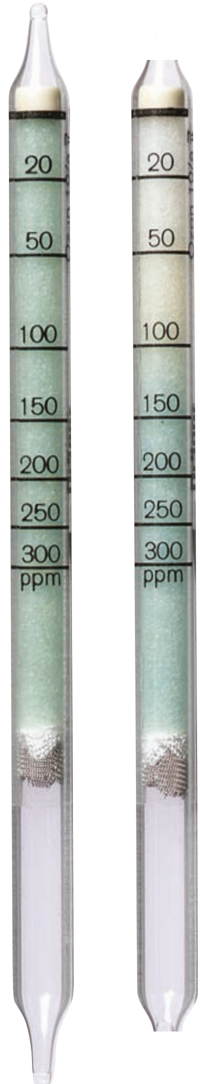
O_3 + indigo → isatin

Cross-sensitivity

The indication is not affected by:

1 ppm sulfur dioxide
1 ppm chlorine
1 ppm nitrogen dioxide

Higher concentrations of chlorine and nitrogen dioxide discolor the indicating layer a diffuse yellowy gray.



ST-138-2001

Pentane 100/a

Order no. 6724701

General data

Measuring range:	100 to 1500 ppm
Number of strokes n:	1
Measuring time:	approx. 15 s
Standard deviation:	± 15 to 20 %
Color change:	white → brown-green

Permissible ambient conditions

Temperature:	0 to 40 °C
Humidity:	1 to 40 mg H_2O/L

Reaction principle

$C_5H_{12} + I_2O_5 \rightarrow I_2$

Cross-sensitivity

Alcohols, esters, aromatics, gasoline hydrocarbons, and ethers are also indicated, but with different sensitivities.
Differentiation is not possible.

D-28047-2017

Perchloroethylene 0.1/a

Order no. 8101551

P

General data

Measuring range:	0.5 to 4 ppm	/ 0.1 to 1 ppm
Number of strokes n:	3	/ 9
Measuring time:	approx. 3 min	/ approx. 9 min
Standard deviation:	± 20 to 25 %	
Color change:	light gray → blue	

Permissible ambient conditions

Temperature:	15 to 30 °C
Humidity:	max. 30 mg H_2O/L

Reaction principle

a) $CCl_2=CCl_2 + MnO_4^- \rightarrow Cl_2$

b) Cl_2 + diphenylbenzidine → blue reaction product

At higher concentrations, a reddish zone may occur at the beginning of the indicating layer.

Cross-sensitivity

Other chlorinated hydrocarbons, free halogens, and halogen hydracids are also indicated.

Gasoline vapors cause the reading to be shortened if the following concentrations are exceeded:

40 ppm for 9 strokes or 160 ppm for 3 strokes.

ST-5751-2004

Perchloroethylene 2/a

Order no. 8101501

General data

Measuring range:	20 to 300 ppm	/ 2 to 40 ppm
Number of strokes n:	1	/ 5
Measuring time:	approx. 30 s	/ approx. 3 min
Standard deviation:	± 15 to 20 %	
Color change:	yellow → gray-blue	

Permissible ambient conditions

Temperature:	15 to 30 °C
Humidity:	less than 25 mg H_2O/L

Reaction principle

a) $CCl_2{=}CCl_2 + MnO_4^- \rightarrow Cl_2$

b) Cl_2 + diphenylbenzidine → gray-blue reaction product

At higher concentrations, a reddish zone may occur at the beginning of the indicating layer.

Cross-sensitivity

Other chlorinated hydrocarbons, free halogens, and halogen hydracids are also indicated.

Gasoline vapors cause the reading to be shortened if the following concentrations are exceeded:

50 ppm for 5 strokes or 500 ppm for 1 stroke.

ST-90-2001

Phenol 1/b

Order no. 8101641

P

General data

Measuring range:	1 to 20 ppm
Number of strokes n:	20
Measuring time:	approx. 5 min
Standard deviation:	± 10 to 15 %
Color change:	yellow → brown-gray

Permissible ambient conditions

Temperature:	10 to 30 °C
Humidity:	1 to 18 mg H_2O/L

Reaction principle

$C_6H_5OH + Ce(SO_4)_2 + H_2SO_4 \rightarrow$ brown-gray reaction product

Cross-sensitivity

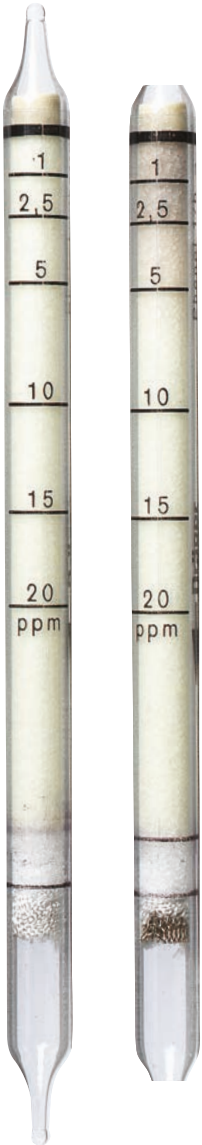
Cresols are also indicated, but with a different sensitivity. For m-cresol, multiply the reading by 0.8.

Benzene, toluene, and other aromatics without the heteroatoms are not indicated.

Aliphatic hydrocarbons and alcohols are also not indicated.

Additional note

At a temperature of 0 °C, the indicated scale value must be multiplied by 1.3, at a temperature of 40 °C by 0.8.



ST-95-2001

Phosgene 0.02/a

Order no. 8101521

P

General data

Measuring range:	0.02 to 1 ppm	/ 0.02 to 0.6 ppm
Number of strokes n:	20	/ 40
Measuring time:	approx. 6 min	/ approx. 12 min
Standard deviation:	± 10 to 15 %	
Color change:	white → red	

Permissible ambient conditions

Temperature:	0 to 40 °C
Humidity:	3 to 15 mg H_2O/L

Reaction principle

$COCl_2$ + arom. amine → red reaction product

Cross-sensitivity

Chlorine and hydrochloric acid lead to plus errors and cause the reading to fade at high concentrations.

Phosgene concentrations above 30 ppm also cause the reading to fade.

Additional note

High phosgene concentrations are not indicated!

ST-98-2001

Phosgene 0.25/c

Order no. CH28301

P

General data

Measuring range:	0.25 to 5 ppm
Number of strokes n:	5
Measuring time:	approx. 1 min
Standard deviation:	± 15 to 20 %
Color change:	yellow → blue-green

Permissible ambient conditions

Temperature:	5 to 35 °C
Humidity:	3 to 15 mg H_2O/L

Reaction principle

$COCl_2$ + diethylaniline +
dimethylaminobenzaldehyde → blue-green reaction product

Cross-sensitivity

Hydrochloric acid has no effect up to 100 ppm.
A phosgene measurement is not possible in the presence of carbonyl bromide and acetyl chloride, as both are also indicated with different sensitivities.

D-13548-2010

Phosphine 0.01/a

Order no. 8101611

General data

Measuring range:	0.1 to 1.0 ppm	/ 0.01 to 0.3 ppm
Number of strokes n:	3	/ 10
Measuring time:	approx. 2.5 min	/ approx. 8 min
Standard deviation:	± 10 to 15 %	
Color change:	yellow → red	

Permissible ambient conditions

Temperature:	2 to 40 °C
Humidity:	less than 20 mg H_2O/L

Reaction principle

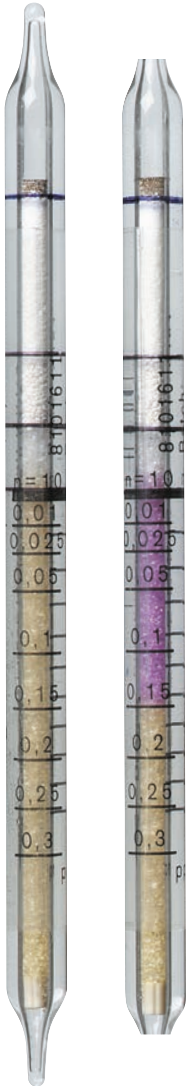
$HgCl_2 + PH_3 \rightarrow$ Hg phosphide + HCl

HCl + pH indicator → red reaction product

Cross-sensitivity

A maximum 6 ppm sulfur dioxide or 15 ppm hydrogen chloride does not affect the reading. Higher concentrations result in plus errors.

- Ammonia (> 100 ppm) results in minus errors.
- Arsine is indicated with a different sensitivity.
- Hydrogen sulfide is indicated with a different sensitivity.
- 30 ppm hydrocyanic acid does not affect the 3-stroke measurement. Minus errors of up to 50 % occur in the 10-stroke measurement.



ST-110-2001

Phosphine 0.1/c

Order no. 8103711

P

General data

Measuring range:	0.5 to 3 ppm	/ 0.1 to 1.0 ppm
Number of strokes n:	1	/ 3
Measuring time:	approx. 1 min	/ approx. 2.5 min
Standard deviation:	± 10 to 15 %	
Color change:	yellow → red	

Permissible ambient conditions

Temperature:	2 to 40 °C
Humidity:	max. 40 mg H_2O/L

Reaction principle

PH_3 + $HgCl_2$ → Hg phosphide + HCl

HCl + pH indicator → red reaction product

Cross-sensitivity

A maximum 6 ppm sulfur dioxide or 15 ppm hydrogen chloride does not affect the reading. Higher concentrations result in plus errors.

Ammonia (> 100 ppm) results in minus errors.

Arsine and hydrogen sulfide are indicated with different sensitivities.

30 ppm hydrocyanic acid has no effect.

D-21246-2015

Phosphine 0.1/b in acetylene

Order no. 8103341

General data

Measuring range:	0.1 to 1 ppm	/ 1 to 15 ppm
Number of strokes n:	10	/ 1
Measuring time:	approx. 4 min	/ approx. 20 s
Standard deviation:	± 15 to 20 %	
Color change:	yellow-orange → red violet	

Permissible ambient conditions

Temperature:	2 to 40 °C
Humidity:	less than 20 mg/L

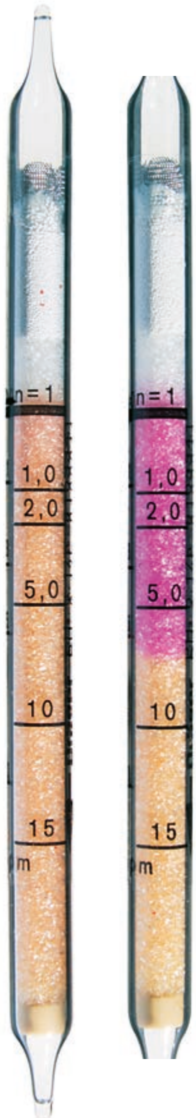
Reaction principle

PH_3 + $HgCl_2$ → Hg phosphide + HCl

HCl + pH indicator → red violet reaction product

Cross-sensitivity

Arsine and hydrogen sulfide are also indicated, but with different sensitivities.



ST-5758-2004

Phosphine 1/a

Order no. 8101801

P

General data

Measuring range:	10 to 100 ppm	/ 1 to 20 ppm
Number of strokes n:	2	/ 10
Measuring time:	approx. 2 min	/ approx. 10 min
Standard deviation:	± 15 to 20 %	
Color change:	yellow → dark brown	

Permissible ambient conditions

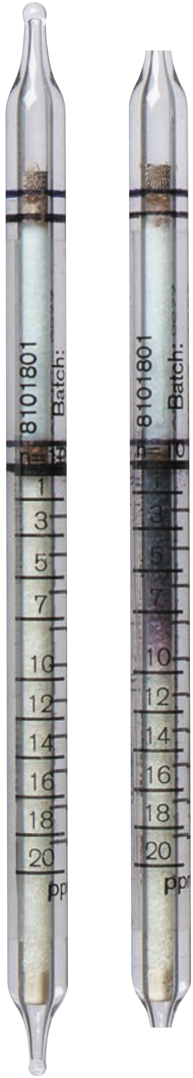
Temperature:	5 to 40 °C
Humidity:	max. 30 mg H_2O/L

Reaction principle

$PH_3 + Au^{3+} \rightarrow Au$ (colloidal)

Cross-sensitivity

Arsine and stibine are also indicated, but with lower sensitivities. Hydrogen sulfide, mercaptans, ammonia, and hydrochloric acid are retained in the pre-layer.



ST-111-2001

Phosphine 25/A

Order no. 8101621

General data

Measuring range:	200 to 10000 ppm	/ 25 to 900 ppm
Number of strokes n:	1	/ 10
Measuring time:	approx. 1.5 min	/ approx. 10 min
Standard deviation:	± 10 to 15 %	
Color change:	yellow → dark brown	

Permissible ambient conditions

Temperature:	0 to 40 °C
Humidity:	less than 30 mg H_2O/L

Reaction principle

$PH_3 + Au^{3+} \rightarrow Au$ (colloidal)

Cross-sensitivity

Arsine and stibine are also indicated, but with lower sensitivities.
Hydrogen sulfide, ammonia, hydrochloric acid, and mercaptans are retained in the pre-layer.

D-8693-2019

Phosphine 50/a

Order no. CH21201

P

General data

Measuring range:	50 to 1000 ppm
Number of strokes n:	3
Measuring time:	approx. 2 min
Standard deviation:	± 10 to 15 %
Color change:	yellow → brown-black

Permissible ambient conditions

Temperature:	0 to 50 °C
Humidity:	less than 40 mg H_2O/L

Reaction principle

$PH_3 + Au^{3+} \rightarrow$ Au (colloidal)

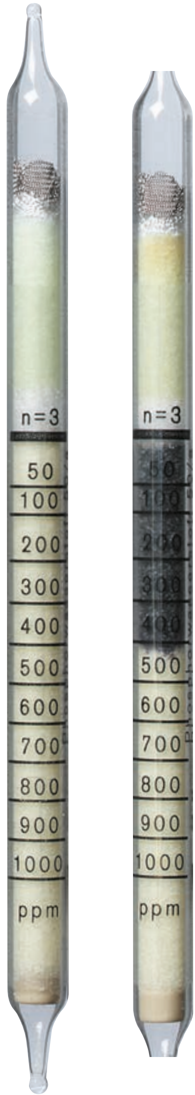
Cross-sensitivity

Arsine and stibine are also indicated, but with different sensitivities. Hydrogen sulfide, mercaptans, ammonia, and hydrochloric acid do not have any effect within their OEL ranges.

Carbon monoxide and sulfur dioxide also have no effect in their OEL ranges.

Measuring range extension

Measuring range 15 to 300 ppm where n = 10 strokes, multiply indicated scale value by 0.3.



ST-113-2001

Polytest

Order no. CH28401

General data

Measuring range:	qualitative detection of easily oxidizable substances
Number of strokes n:	5
Measuring time:	approx. 1.5 min
Color change:	white → brown, green, or purple (depending on the substance present)

Permissible ambient conditions

Temperature:	0 to 50 °C
Humidity:	max. 50 mg H_2O/L

Reaction principle

$CO + I_2O_5 \rightarrow I_2 + CO_2$

Cross-sensitivity

Based on the reaction principle, many, but not all, easily oxidizable compounds are indicated; for example, the following substances provide a clear reading:

2000 ppm acetone	10 ppm acetylene
50 ppm ethylene	1 ppm arsine
10 ppm octane	50 ppm benzene
500 ppm propane	100 ppm butane
5 ppm carbon monoxide	10 ppm styrene
1 ppm carbon disulfide	20 ppm perchloroethylene
2 ppm hydrogen sulfide	10 ppm toluene or xylene

For instance, methane, ethane, hydrogen, and carbon dioxide are not indicated.

Additional note

If there is no reading, this does not always mean that no easily oxidizable substances are present. Independent methods to qualify the use of the Dräger-Tube Polytest should be used in each specific case, particularly when combustible gases and vapors close to the lower explosive limit or toxic substances are suspected.

ST-173-2001

Pyridine 5/A

Order no. 6728651

P

Measuring range:	5 ppm
Number of strokes n:	20 5 additional strokes after opening the second reagent ampoule
Measuring time:	approx. 20 min
Standard deviation:	± 30 %
Color change:	white → brown-red

Permissible ambient conditions

Temperature:	10 to 30 °C
Humidity:	3 to 15 mg H_2O/L

Reaction principle

Pyridine + aconitic acid +
acetic anhydride → brown-red reaction product

Cross-sensitivity

Ammonia has no effect in the OEL range.

Additional note

Before measurement, the bottom reagent ampoule must be broken and the ampoule liquid applied to the indicating layer so that it is completely saturated. After carrying out the 20 strokes, break the top reagent ampoule. Gently tap to empty the powder from the ampoule.

Perform a further 5 strokes. Make sure to hold the tube upright.

ST-203-2001

Styrene 10/a

Order no. 6723301

General data

Measuring range:	10 to 200 ppm
Number of strokes n:	max. 15
Measuring time:	max. 3 min
Standard deviation:	± 15 to 20 %
Color change:	white → light yellow

Permissible ambient conditions

Temperature:	15 to 40 °C
Humidity:	less than 15 mg H_2O/L

Reaction principle

C_6H_5-CH=CH_2 + H_2SO_4 → light yellow reaction product

Cross-sensitivity

A styrene measurement is not possible in the presence of other organic substances that tend to polymerize (e.g., butadiene), as they are also indicated.

ST-5746-2004

Styrene 10/b

Order no. 6733141

S

Measuring range:	10 to 250 ppm
Number of strokes n:	20
Measuring time:	approx. 3 min
Standard deviation:	± 15 to 20 %
Color change:	white → reddish brown

Permissible ambient conditions

Temperature:	0 to 40 °C
Humidity:	3 to 15 mg H_2O/L

Reaction principle

Styrene + HCHO → reddish brown reaction product

Cross-sensitivity

Other organic compounds that also react with the formaldehyde-sulfuric acid system affect the reading.

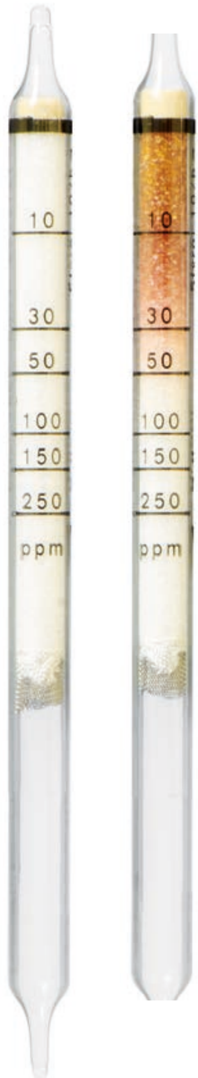
A styrene measurement is not possible in these cases. Interfering compounds include, for example, xylene(s), toluene, butadiene, ethylbenzene.

The indication is not affected by:

200 ppm methanol

500 ppm octane

400 ppm ethyl acetate



D-5443-2014

Sulfur Dioxide 0.1/a

Order no. 6727101

General data

Measuring range:	0.1 to 3 ppm
Number of strokes n:	100
Measuring time:	approx. 20 min
Standard deviation:	± 10 to 15 %
Color change:	yellow → orange

Permissible ambient conditions

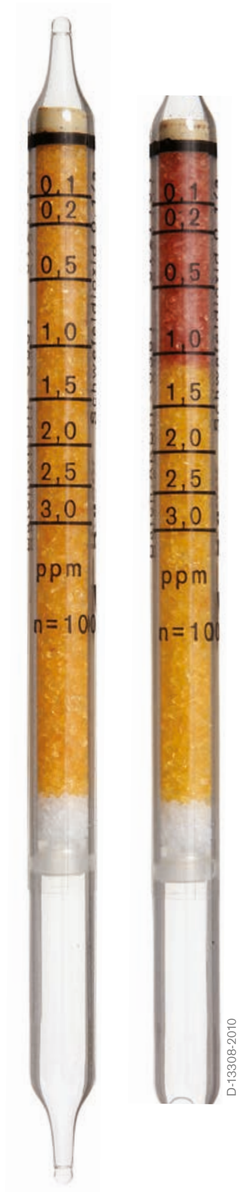
Temperature:	10 to 30 °C
Humidity:	3 to 15 mg/L

Reaction principle

SO_2 + Na_2 [$HgCl_4$] + methyl red → Na_2 [$Hg(SO_3)_2$] + 4 HCl

Cross-sensitivity

An SO_2 measurement is not possible if other acid gases are present.



D-13308-2010

Sulfur Dioxide 0.5/a

Order no. 6728491

S

General data

Measuring range:	1 to 25 ppm	/ 0.5 to 5 ppm
Number of strokes n:	10	/ 20
Measuring time:	approx. 3 min	/ approx. 6 min
Standard deviation:	± 10 to 15 %	
Color change:	gray-blue → white	

Permissible ambient conditions

Temperature:	15 to 30 °C
Humidity:	max. 20 mg H_2O/L

Reaction principle

$SO_2 + I_2 + 2\ H_2O \rightarrow H_2SO_4 + 2\ HI$

Cross-sensitivity

Measurement is not possible in the presence of H_2S.

Nitrogen dioxide shortens the reading.

ST-121-2001

Sulfur Dioxide 1/a

Order no. CH31701

General data

Measuring range:	1 to 25 ppm
Number of strokes n:	10
Measuring time:	approx. 3 min
Standard deviation:	± 10 to 15 %
Color change:	gray-blue → white

Permissible ambient conditions

Temperature:	15 to 25 °C
Humidity:	3 to 20 mg H_2O/L

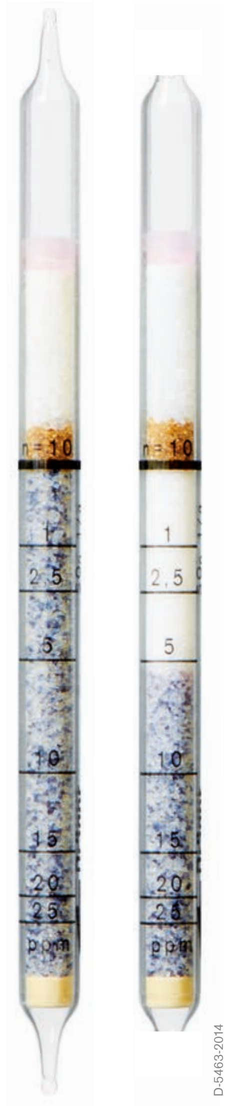
Reaction principle

$SO_2 + I_2 + 2\ H_2O \rightarrow H_2SO_4 + 2\ HI$

Cross-sensitivity

Hydrogen sulfide is retained in the pre-layer, so has no effect at concentrations around the OEL.

Nitrogen dioxide shortens the reading.



Sulfur Dioxide 20/a

S

Order no. CH24201

General data

Measuring range:	20 to 200 ppm
Number of strokes n:	10
Measuring time:	approx. 3 min
Standard deviation:	± 10 to 15 %
Color change:	brown-yellow → white

Permissible ambient conditions

Temperature:	0 to 40 °C
Humidity:	less than 30 mg H_2O/L

Reaction principle

$SO_2 + I_2 + 2\ H_2O \rightarrow H_2SO_4 + 2\ HI$

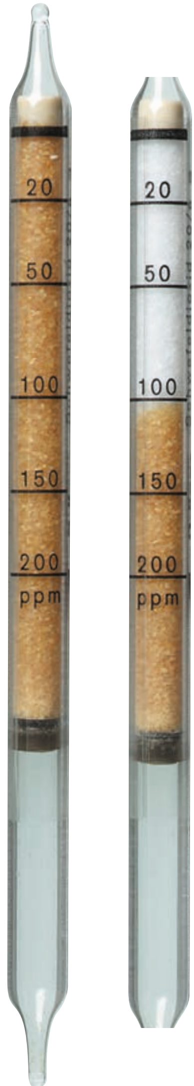
Cross-sensitivity

A sulfur dioxide measurement is not possible in the presence of hydrogen sulfide, as hydrogen sulfide is indicated with roughly the same sensitivity.

Nitrogen dioxide shortens the reading.

Measuring range extension

Measuring range 200 to 2000 ppm where n = 1 stroke, multiply the indicated value by 10. During the 1-stroke measurement, 3 desorption strokes in air free of sulfur dioxide need to be performed afterwards.



ST-123-2001

Sulfur Dioxide 50/b

Order no. 8101531

General data

Measuring range:	400 to 8000 ppm	/ 50 to 500 ppm
Number of strokes n:	1	/ 10
Measuring time:	approx. 15 s	/ approx. 3 min
Standard deviation:	± 10 to 15 %	
Color change:	blue → yellow	

Permissible ambient conditions

Temperature:	0 to 50 °C
Humidity:	1 to 15 mg H_2O/L

Reaction principle

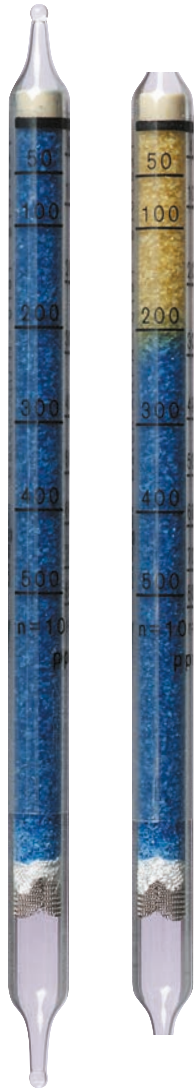
$SO_2 + IO_3^- \rightarrow H_2SO_4 + I^-$

Cross-sensitivity

Hydrochloric acid is also indicated at high concentrations.

10000 ppm hydrochloric acid corresponds to a reading of 150 ppm sulfur dioxide.

500 ppm nitric oxide or 100 ppm nitrogen dioxide have no effect.



ST-124-2001

Sulfuric Acid 1/a

Order no. 6728781

S

Measuring range:	1 to 5 mg/m^3
	Compare the discoloration with the color standard
Number of strokes n:	100
Measuring time:	approx. 100 min
Standard deviation:	± 30 %
Color change:	brown → pink-purple

Permissible ambient conditions

Temperature:	5 to 40 °C
Humidity:	less than 15 mg H_2O/L

Reaction principle

H_2SO_4 + barium chloranilate → chloranilic acid + $BaSO_4$

Cross-sensitivity

Soluble sulfates and other aerosol acids are also indicated, but with different sensitivities.

A sulfuric acid measurement is not possible in these cases.

Gaseous sulfur trioxide is not indicated, but the sulfuric acid that forms when reacting with humidity is indicated.

Additional note

After carrying out the 100 strokes, the reagent ampoule must be broken and the ampoule liquid transferred completely onto the indicating layer.

Leave for 1 min. Then use the pump (approx. 1/4 stroke) to carefully draw the liquid into the indication chamber. The measurement must then be evaluated immediately.

D-11120-2023

Sulfuryl Fluoride 1/a

Order no. 8103471

General data

Measuring range:	1 to 5 ppm
Number of strokes n:	6
Measuring time:	approx. 3 min
Standard deviation:	± 30 %
Color change:	light blue → light pink

Permissible ambient conditions

Temperature:	0 to 40 °C
Humidity:	15 to 90 % r. h.

At 0 to 10 °C, sulfuryl fluoride concentrations are indicated with roughly half the sensitivity. At 30 to 40 °C and a humidity < 30 % r. h., readings are only detectable from > 2 ppm. At 30 to 40 °C and a humidity > 75 % r. h., sulfuryl fluoride concentrations are indicated with roughly half the sensitivity.

Reaction principle

a) Sulfuryl fluoride (pyrolysis) → HF
b) HF + Zr / quinalizarin → pink reaction product

Cross-sensitivity

Fluorinated hydrocarbons are also indicated, but with different sensitivities. Ammonia and other alkaline gases can shorten or prevent the reading depending on the concentration. The following have no effect on the reading of 3 ppm sulfuryl fluoride:
2 ppm formaldehyde, 5 ppm methyl bromide, and 1 ppm phosphine. The sensitivity decreases as the oxygen concentration decreases. For example, the 3 ppm reading is very weak at 18 % oxygen.

Additional note

Do not use in explosion-hazard areas, the tube heats up. Do not touch the tubes in the region of the pre-layer during and shortly after measurement.

ST-418-2008

Tert-Butyl Mercaptan (TBM) Natural Gas Odorization

T

Order no. 8103071

General data

Measuring range:	3 to 15 mg/m³	/ 1 to 10 mg/m³
Number of strokes n:	3	/ 5
Measuring time:	approx. 3 min	/ approx. 5 min
Standard deviation:	± 15 to 20 %	
Color change:	yellow → pink	

Permissible ambient conditions

Temperature:	20 to 35 °C
Humidity:	≤ 15 mg H_2O/L

Reaction principle

a) R-SH + $HgCl_2$ → HgS + 2 HCl

b) HCl + pH indicator → pink reaction product

Cross-sensitivity

Hydrogen sulfide, sulfur dioxide, mercaptans, arsine, nitrogen dioxide, and phosphine are also indicated, but with different sensitivities.

Additional note

Temperature correction:

Temp.	0 °C	5 °C	10 °C	15 °C	20 °C
Factor	1.5	1.4	1.3	1.2	1

ST-360-2008

Tetrahydrothiophene 1/b

Order no. 8101341

General data

Measuring range:	1 to 10 ppm / 4 to 20 mg/m^3
Number of strokes n:	30
Measuring time:	in air: approx. 15 min
	in natural gas: approx. 10 min
Standard deviation:	± 15 to 20 %
Color change:	purple → yellow-brown

Permissible ambient conditions

Temperature:	0 to 35 °C
Humidity:	less than 30 mg H_2O/L

Reaction principle

THT + $KMnO_4$ → yellow-brown reaction product

Cross-sensitivity

Hydrogen sulfide is adsorbed in the pre-tube up to 10 ppm, where it leads to a brown discoloration.

A THT measurement is not possible in the presence of mercaptans.

Olefins at concentrations up to 100 ppm merely lead to a lightening of the indicating layer, but are also indicated at higher concentrations.

Methanol has no effect on the reading up to 200 ppm.

Measuring range extension

Measuring range 1.6 to 16 ppm / 6.4 to 64 mg/m^3 where n = 20 strokes, multiply indicated scale value by 1.6.

ST-206-2001

Toluene 5/b

Order no. 8101661

Measuring range:	50 to 300 ppm	/ 5 to 80 ppm
Number of strokes n:	2	/ 10
Measuring time:	approx. 2 min	/ approx. 10 min
Standard deviation:	± 10 to 15 %	
Color change:	white → light brown	

Permissible ambient conditions

Temperature:	2 to 40 °C
Humidity:	max. 20 mg H_2O/L

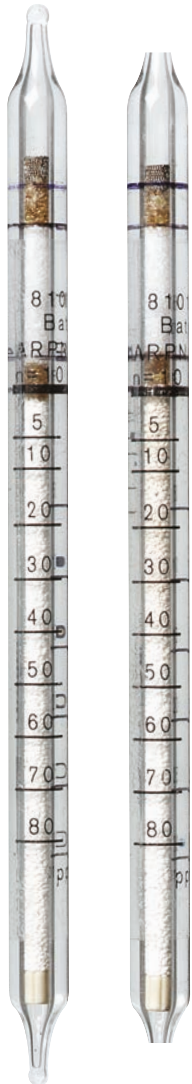
Reaction principle

Toluene + I_2O_5 + H_2SO_4 → I_2

Cross-sensitivity

10 ppm phenol, 1000 ppm acetone, 1000 ppm ethanol, and 300 ppm octane are not indicated.

Xylene (all isomers) and benzene are indicated with the same sensitivity. The discoloration for p-xylene is purple, while it is yellow-green for benzene.



ST-151-2001

Toluene 50/a

Order no. 8101701

General data

Measuring range:	50 to 400 ppm
Number of strokes n:	5
Measuring time:	approx. 1.5 min
Standard deviation:	± 10 to 15 %
Color change:	white → brown

Permissible ambient conditions

Temperature:	0 to 30 °C
Humidity:	5 to 12 mg H_2O/L

Reaction principle

Toluene + I_2O_5 + H_2SO_4 → I_2

Cross-sensitivity

Xylenes are also indicated, but with a lower sensitivity.

Benzene colors the entire indicating layer a diffuse yellow.

Gasoline hydrocarbons color the entire indicating layer a diffuse reddish-brown.

Methanol, ethanol, acetone, and ethyl acetate have no effect within their OEL ranges.

ST-152-2001

Toluene 100/a

Order no. 8101731

T

Measuring range:	100 to 1800 ppm
Number of strokes n:	10
Measuring time:	approx. 1.5 min
Standard deviation:	± 10 to 15 %
Color change:	white → brown-purple

Permissible ambient conditions

Temperature:	0 to 40 °C
Humidity:	less than 30 mg H_2O/L

Reaction principle

Toluene + SeO_2 + H_2SO_4 → brown-purple reaction product

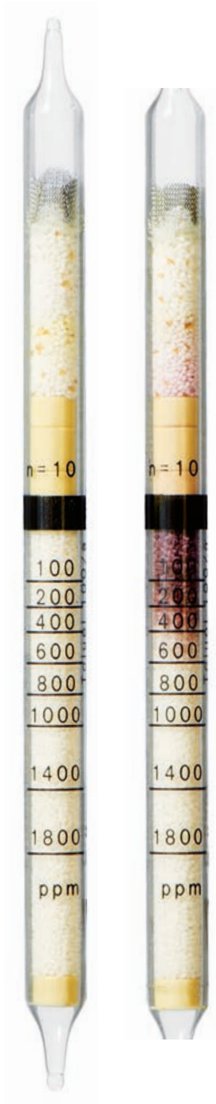
Cross-sensitivity

Xylenes are also indicated with roughly the same sensitivity, but with a violet-blue color.

Benzene colors the entire indicating layer a diffuse yellow-brown.

Gasoline hydrocarbons color the entire indicating layer a diffuse reddish-brown.

Methanol, ethanol, acetone, and ethyl acetate have no effect within their OEL ranges.



D-5450-2014

Toluene diisocyanate 0.02/A

Order no. 6724501

General data

Measuring range:	0.02 to 0.2 ppm Compare discoloration with the color comparison tube
Number of strokes n:	25
Measuring time:	approx. 20 min
Standard deviation:	± 30 %
Color change:	white → orange

Permissible ambient conditions

Temperature:	15 to 30 °C
Humidity:	less than 20 mg H_2O/L

Reaction principle

a) Pyridylpyridinium chloride + NaOH → Na-oleate of the glutaconaldehyde

b) 2,4-TDI or 2,6-TDI + HCl → arom. amine

c) Arom. amine + glutaconaldehyde → polymethine dye

Cross-sensitivity

Other isocyanates are not indicated.

The indication is not affected by:

5	ppm	aniline
10	ppm	benzylamine
5	ppm	toluene
20	ppm	benzene

Mercaptans fade the reading.

Additional notes

Before measurement, the bottom reagent ampoule must be broken and the ampoule liquid completely applied to the indicating layer so that it is colored yellow. The top reagent ampoule must then be broken and the ampoule liquid applied to the indicating layer so that the color fades again. After carrying out the 25 strokes, wait 15 min. before evaluation.

D-11122-2023

Trichloroethane 50/d

Order no. CH21101

Measuring range:	50 to 600 ppm
Number of strokes n:	2 + 3 desorption strokes in clean air
Measuring time:	approx. 1.5 min
Standard deviation:	± 10 to 15 %
Color change:	gray → brown-red

Permissible ambient conditions

Temperature:	15 to 40 °C
Humidity:	5 to 15 mg H_2O/L

Reaction principle

a) 1,1,1-trichloroethane + IO_3^- / $H_2S_2O_7$ → chlorine

b) Chlorine + o-tolidine → brown-red reaction product

Cross-sensitivity

Other chlorinated hydrocarbons are also indicated, but with different sensitivities.

The reading is too low in the presence of aromatic hydrocarbons, e.g., the reading for 200 ppm 1,1,1-trichloroethane and 200 ppm toluene is just 1/4, i.e., 50 ppm.

Trichloroethylene 2/a

Order no. 6728541

General data

Measuring range:	20 to 250 ppm	/ 2 to 50 ppm
Number of strokes n:	3	/ 5
Measuring time:	approx. 1.5 min	/ approx. 2.5 min
Standard deviation:	± 10 to 15 %	
Color change:	light gray → orange	

Permissible ambient conditions

Temperature:	10 to 40 °C
Humidity:	5 to 15 mg H_2O/L

Reaction principle

Chlorine + o-tolidine → orange reaction product

Cross-sensitivity

Other chlorinated hydrocarbons are also indicated, but with different sensitivities.

A trichloroethylene measurement is not possible in the presence of free halogens and halogen hydracids in their OEL ranges, as these are also indicated.

Gasoline hydrocarbons cause the reading to be shortened.

ST-157-2001

Trichloroethylene 50/a

Order no. 8101881

T

Measuring range:	50 to 500 ppm
Number of strokes n:	5
Measuring time:	approx. 1.5 min
Standard deviation:	± 10 to 15 %
Color change:	light gray → orange

Permissible ambient conditions

Temperature:	15 to 40 °C
Humidity:	5 to 12 mg H_2O/L

Reaction principle

a) Trichloroethylene + Cr^{VI} → chlorine

b) Chlorine + o-tolidine → orange reaction product

Cross-sensitivity

Other chlorinated hydrocarbons are also indicated, but with different sensitivities.

A trichloroethylene measurement is not possible in the presence of free halogens and halogen hydracids in their OEL ranges, as these are also indicated.

Gasoline hydrocarbons cause the reading to be shortened.

ST-154-2001

Triethylamine 5/a

Order no. 6718401

General data

Measuring range:	5 to 60 ppm
Number of strokes n:	5
Measuring time:	approx. 3 min
Standard deviation:	± 10 to 15 %
Color change:	yellow → blue

Permissible ambient conditions

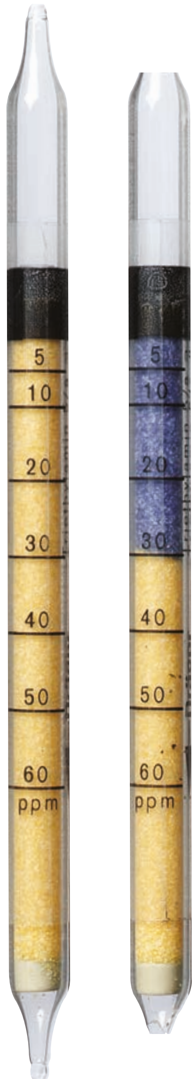
Temperature:	10 to 40 °C
Humidity:	5 to 12 mg H_2O/L

Reaction principle

$(C_2H_5)_3N$ + acid → blue reaction product

Cross-sensitivity

Other alkaline substances such as organic amines and ammonia are also indicated, but all with different sensitivities.



ST-163-2001

Vinyl Chloride 0.5/b

Order no. 8101721

V

General data

Measuring range:	5 to 30 ppm	/ 0.5 to 5 ppm
Number of strokes n:	1	/ 5
Measuring time:	approx. 30 s	/ approx. 2.5 min
Standard deviation:	± 15 to 20 %	
Color change:	white → purple	

Permissible ambient conditions

Temperature:	10 to 30 °C
Humidity:	max. 20 mg H_2O/L

Reaction principle

a) CH_2=CHCl + Cr^{VI} → Cl_2

b) Cl_2 + dimethylnaphtidin → purple reaction product

Cross-sensitivity

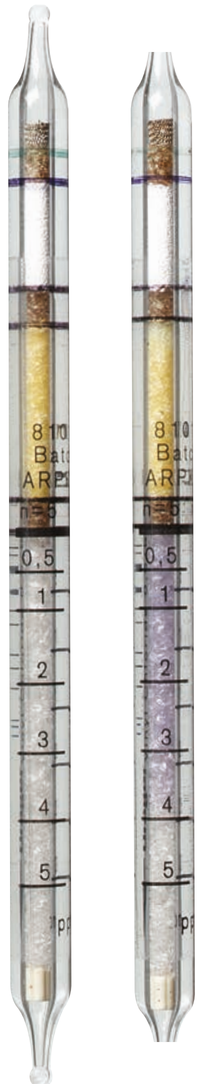
100 ppm hydrogen chloride, 20 ppm chlorine, 10 ppm carbon tetrachloride, 10 ppm chloroform, or 5 ppm perchloroethylene are not indicated.

Trichloroethylene and chlorobenzene are indicated with a lower sensitivity (5 ppm = reading of approx. 1.5 ppm).

1,1-dichloroethene is indicated with approximately the same sensitivity.

Part of the oxidation layer is consumed under the influence of vapors of organic solvents, resulting in a correspondingly lower reading. Examples:

5 ppm vinyl chloride + 100 ppm butadiene or 5 ppm vinyl chloride + 10 ppm ethylene give a reading of 0.5 ppm vinyl chloride.



ST-159-2001

Vinyl Chloride 100/a

Order no. CH19601

General data

Measuring range:	100 to 3000 ppm
Number of strokes n:	18 to 1
Measuring time:	max. 3 min
Standard deviation:	± 30 %
Color change:	purple → light brown

Permissible ambient conditions

Temperature:	0 to 40 °C
Humidity:	less than 30 mg H_2O/L

Reaction principle

$CH_2{=}CHCl + MnO_4^- \rightarrow Mn^{IV}$ + var. oxidation products

Cross-sensitivity

Many organic compounds with C=C double bonds are also indicated, but all with different sensitivities.

Differentiation is not possible.

A vinyl chloride measurement is not possible in the presence of dialkyl sulfides.

ST-161-2001

Water Vapor 0.1

Order no. CH23401

W

Measuring range:	1 to 40 mg/L
Number of strokes n:	10
Measuring time:	approx. 2 min
Standard deviation:	± 10 to 15 %
Color change:	yellow → reddish brown

Permissible ambient conditions

Temperature:	0 to 40 °C

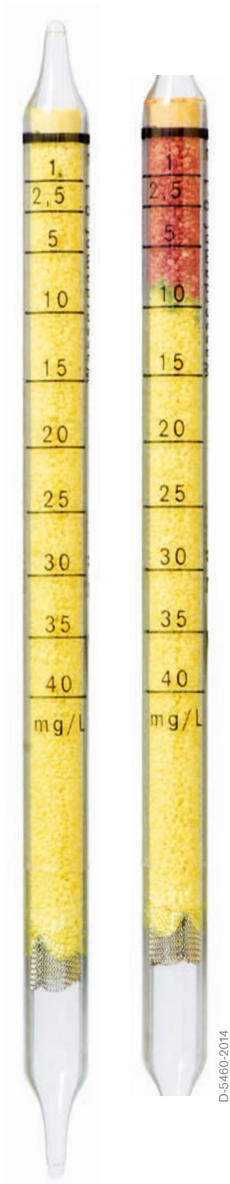
Reaction principle

$H_2O + SeO_2 + H_2SO_4 \rightarrow$ reddish brown reaction product

Cross-sensitivity

Low molecular alcohols are also indicated.

A range of other organic compounds, e.g., gasoline hydrocarbons, are also indicated.



D-5460-2014

Water Vapor 0.1/a

Order no. 8101321

General data

Measuring range:	0.1 to 1.0 mg/L
Number of strokes n:	3
Measuring time:	approx. 1.5 min
Standard deviation:	± 15 to 20 %
Color change:	yellow → blue

Permissible ambient conditions

Temperature:	0 to 30 °C

Reaction principle

$H_2O + Mg(ClO_4)_2$ → blue reaction product

Cross-sensitivity

The indication is not affected by:

1200	ppm	nitrogen dioxide
6000	ppm	sulfur dioxide
2000	ppm	ethanol
2000	ppm	acetone

As a general rule, alkaline substances can cause plus errors, while acid substances can cause minus errors.

Additional notes

The first unnumbered notch corresponds to 0.05 mg/L.

D-13320-2010

Water Vapor 1/b

Order no. 8101781

W

Measuring range:	20 to 40 mg/L	/ 1 to 18 mg/L
Number of strokes n:	1	/ 2
Measuring time:	approx. 20 s	/ approx. 40 s
Standard deviation:	± 15 to 20 %	
Color change:	yellow → turquoise blue	

Permissible ambient conditions

Temperature:	0 to 50 °C
Humidity:	up to 100 % relative humidity

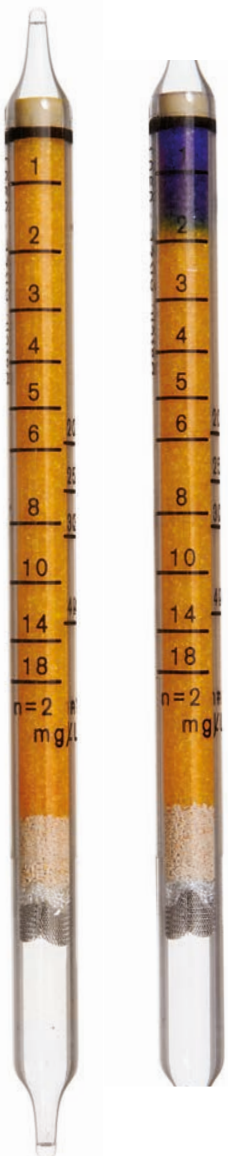
Condensation in the tube leads to measurement errors! If high relative humidity over 80 % is expected, the temperature of the tube should be at least 5 °C higher than the ambient temperature. At a relative humidity of less than 80 %, the temperature of the tube should at least equal the ambient temperature.

Reaction principle

$H_2O + Mg(ClO_4)_2 \rightarrow$ turquoise blue reaction product

Cross-sensitivity

Alkaline gases can cause plus errors.
Acid gases can cause minus errors.



D-13326-2010

Water Vapor 3/a

Order no. 8103031

General data

Measuring range:	3.0 to 60 lbs/mmcf
Number of strokes n:	3
Measuring time:	approx. 90 s
Standard deviation:	± 15 – 20 %
Color change:	yellow → blue

Permissible ambient conditions

Temperature:	0 to 30 °C

Reaction principle

H_2O + $Mg(ClO_4)_2$ → blue reaction product

Cross-sensitivity

The reading is not affected by 1200 ppm NO_2. 6000 ppm SO_2, 2000 ppm ethanol, 2000 ppm acetone, and alkaline gases can cause plus errors. Acid gases can cause minus errors.

D-28046-2017

Xylene 10/a

Order no. 6733161

General data

Measuring range:	10 to 400 ppm
Number of strokes n:	5
Measuring time:	approx. 1 min
Standard deviation:	± 20 to 30 %
Color change:	white → reddish brown

Permissible ambient conditions

Temperature:	0 to 40 °C
Humidity:	3 to 15 mg H_2O/L

Reaction principle

$C_6H_4(CH_3)_2$ + HCHO + H_2SO_4 → quinoid reaction products

Cross-sensitivity

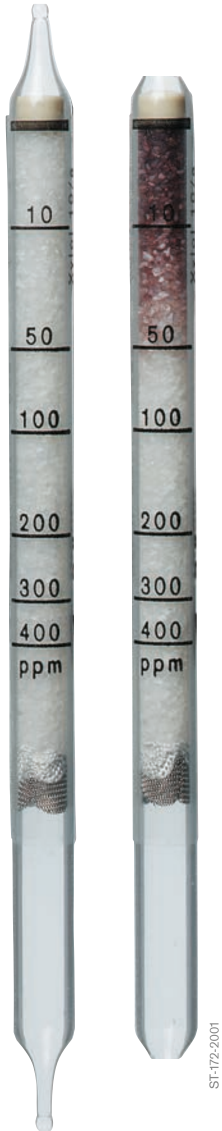
Styrene, vinyl acetate, toluene, ethylbenzene, and acetaldehyde are also indicated, but with different sensitivities.

The indication is not affected by:

500 ppm octane

200 ppm methanol

400 ppm ethyl acetate



6.1.3 Data about Dräger Simultaneous Test

Simultaneous Test Set II for Inorganic Fire Gases

Order no. 8101736

General data

Measuring range and color change

Dräger-Tubes in simultaneous test set II

	1st scale mark	2nd scale mark
1. Sulfur dioxide		
blue → white	–	10 ppm
2. Chlorine		
white → orange	–	2.5 ppm
3. Hydrogen sulfide		
white → brown	5	25 ppm
4. Phosphine		
yellow → red	–	0.3 ppm
5. Phosgene		
white → red	–	0.5 ppm

Number of strokes n:	10
Measuring time:	approx. 40 s

D-13324-2010

D-13325-2010

Permissible ambient conditions

Temperature:	10 to 30 °C
Humidity:	5 to 15 mg H_2O/L semi-quantitative measurements are also possible outside this range. Water aerosols can lead to minus errors.

Caution

The simultaneous test set was developed for the semi-quantitative simultaneous measurement of fire and decomposition gases. It is used for risk assessment and limitation by obtaining information about health risks or possible intoxication hazards around the source of a fire.

Explosion hazards cannot be detected with the simultaneous test set! Even if the simultaneous measurement provides a negative result, the presence of other dangerous gases cannot be ruled out.

Simultaneous Test Set I for Inorganic Fire Gases

Order no. 8101735

D-28054-2017

General data

Measuring range and color change

Dräger-Tubes in simultaneous test set I

	1st scale mark	2nd scale mark
1. Acid gases	Hydrochloric acid	
blue → yellow	2 ppm	10 ppm
2. Hydrocyanic acid		
yellow → red	-	9.5 ppm
3. Carbon monoxide		
white → brown-green	30 ppm	150 ppm
4. Alkaline gases	Ammonia	
yellow → blue	30 ppm	150 ppm
5. Nitrous fumes	Nitrogen dioxide	
light gray → blue-gray	-	2.5 ppm

Number of strokes n:	10
Measuring time:	approx. 40 s

D-28054-2017

Permissible ambient conditions

Temperature:	10 to 30 °C
Humidity:	5 to 15 mg H_2O/L semi-quantitative measurements are also possible outside this range. Water aerosols can lead to minus errors.

Caution

The simultaneous test set was developed for the semi-quantitative simultaneous measurement of fire and decomposition gases. It is used for risk assessment and limitation by obtaining information about health risks or possible intoxication hazards around the source of a fire.

Explosion hazards cannot be detected with the simultaneous test set! Even if the simultaneous measurement provides a negative result, the presence of other dangerous gases cannot be ruled out.

Simultaneous Test Set III for Organic Vapors

Order no. 8101770

General data

Measuring range and color change

Dräger-Tubes in simultaneous test set III

	1st scale mark	2nd scale mark
1. Ketones	Acetone	
light yellow → dark yellow	500 ppm	2500 ppm
2. Aromatics	Toluene	
white → brown	50 ppm	250 ppm
3. Alcohols	Methanol	
orange → green-brown	200 ppm	1000 ppm
4. Aliphatic hydrocarbons	n-hexane	
white → brown	50 ppm	100 ppm
5. Chlorinated hydrocarbons	Perchloroethylene	
yellow-white → gray-blue	20 ppm	100 ppm

Number of strokes n:	10
Measuring time:	approx. 2 min

D-28057-2017

D-28057-2017

Permissible ambient conditions

Temperature:	10 to 30 °C
Humidity:	5 to 15 mg H_2O/L The specified ranges for temperature and humidity apply for calibration with the original calibration substances. Semi-quantitative measurements are also possible outside this range.

Caution

The simultaneous test set was developed for the semi-quantitative simultaneous measurement of organic vapors. It is used for risk assessment and limitation by obtaining information about health risks or possible intoxication hazards.

Explosion hazards cannot be detected with the simultaneous test set! Even if the simultaneous measurement provides a negative result, the presence of other dangerous gases cannot be ruled out.

Simultaneous Test Set Lead Substances vfdb 10/01

Order no. 8103170

D-28058-2017

D-28058-2017

General data

Measuring range and color change

Dräger-Tubes in simultaneous test set

	Tolerable concentration values (ETW)	
	1st scale mark	2nd scale mark
	ETW 4	ETW 1
1. Carbon monoxide (CO) white → brown-green	33 ppm	83 ppm
2. Hydrocyanic acid (hydrogen cyanide) yellow → red	3.5 ppm	7.1 ppm
3. Hydrochloric acid (hydrogen chloride) blue → yellow	11 ppm	22 ppm
4. Nitrous fumes (nitrous oxides) light gray → blue-gray	8.2 ppm	12 ppm
5. Formaldehyde white → pink	1 ppm	

Number of strokes n:	20
Measuring time:	approx. 2 min

Permissible ambient conditions

Temperature:	5 to 30 °C
Humidity:	5 to 15 mg H_2O/L semi-quantitative measurements are also possible outside this range. Water aerosols can cause minus errors.

Caution

The simultaneous test set was developed for the semi-quantitative simultaneous measurement of fire and decomposition gases. It is used for risk assessment and limitation by obtaining information about health risks or possible intoxication hazards around the source of a fire. Explosion hazards cannot be detected with the simultaneous test set! Even if the simultaneous measurement provides a negative result, the presence of other dangerous gases cannot be ruled out.

Simultaneous Test Set Fumigation I

Order no. 8103410

General data

Measuring range and color change

Dräger-Tubes in simultaneous test set for fumigation

	Scale mark
1. Formaldehyde	
white → pink	1 ppm
2. Phosphine	
yellow → red	0.1 ppm
3. Hydrocyanic acid	
yellow → red	10 ppm
4. Methyl bromide	
greenish → brown	5 ppm
5. Ammonia	
yellow → blue	50 ppm

Number of strokes n:	50
Measuring time:	approx. 3 min

ST-342-2008

Simult_1

Permissible ambient conditions

Temperature:	10 to 30 °C
Humidity:	5 to 15 mg H_2O/L semi-quantitative measurements are also possible outside this range. Water aerosols can lead to minus errors.

Caution

The simultaneous test set was developed for the semi-quantitative simultaneous measurement of fumigants.

Explosion hazards cannot be detected with the simultaneous test set! Even if the simultaneous measurement provides a negative result, the presence of other dangerous gases cannot be ruled out.

Simultaneous Test Set Fumigation II

Order no. 8103380

General data

Measuring range and color change

	Scale mark
1. Formaldehyde	
white → pink	1 ppm
2. Phosphine	
yellow → red	0.3 ppm
3. Hydrocyanic acid	
yellow → red	10 ppm
4. Methyl bromide	
light green → brown	0.5 ppm
5. Ethylene oxide	
white → pink	1 ppm

Number of strokes n:	50
Measuring time:	approx. 4 min

ST-5786-2004

ST-5787-2004

Permissible ambient conditions

Temperature:	10 to 40 °C
Humidity:	5 to 40 mg H_2O/L

Caution

The simultaneous test set was developed for the semi-quantitative simultaneous measurement of organic vapors. It is used for risk assessment and limitation by obtaining information about health risks or possible intoxication hazards.
Explosion hazards cannot be detected with the simultaneous test set! Even if the simultaneous measurement provides a negative result, the presence of other dangerous gases cannot be ruled out.

6.1.4 Dräger-Tubes for Military Applications

CDS – Simultaneous Test Set I

Order no. 8103140

General data

Qualitative measurement of volatile substances that frequently occur in areas polluted with warfare agents.

Substance	Sensitivity
Thioether (dimethyl sulfide)	2 mg/m³
Phosgene	0.2 ppm (approx. 7 mm light green)
Hydrocyanic acid (HCN)	1 ppm
Org. arsenic compounds and arsine	0.1 ppm arsine, (3 mg/m³ org. arsenic compounds)
Organic alkaline nitrogen compounds	1 mg/m³
Number of strokes n:	50
Measuring time:	approx. 3 min

D-28059-2017

Permissible ambient conditions

Temperature:	5 ... 30 °C
Humidity:	5 to 15 mg H_2O/L

The sensitivities may change if measurements are carried out outside the specified temperature and humidity ranges. Water aerosols can cause minus errors.

D-28059-2017

Evaluating the reading: Caution! Very important.

1. Thioether

Color change: yellow → orange

Cross-sensitivity: Different thioethers are indicated; differentiation is not possible.

2. Phosgene

Color change: yellow → blue-green

Cross-sensitivity: Hydrochloric acid has no effect up to 100 ppm.

3. Hydrocyanic acid

Color change: yellow-orange → red

Cross-sensitivity: The indication is not affected by:
100 ppm hydrogen sulfide, 300 ppm ammonia, 200 ppm, sulfur dioxide, 50 ppm nitrogen dioxide, 1000 ppm acrylonitrile, and 1000 ppm hydrochloric acid color the pre-layer dark brown but have no effect on the hydrocyanic acid reading.

4. Organic arsenic compounds and arsine

Color change: light yellow → gray

Cross-sensitivity: Just like arsine, phosphine is indicated before opening the ampoule, but with a different sensitivity.

5. Organic alkaline nitrogen compounds

Color change: yellow → orange-red

Cross-sensitivity: Different nitrogen compounds are indicated, differentiation is not possible.

CDS – Simultaneous Test Set V

Order no. 8103200

General data

Qualitative measurement of volatile substances that frequently occur in areas polluted with warfare agents.

Substance	Sensitivity
Cyanogen chloride	0.25 ppm
Thioether (dimethyl sulfide)	2 mg/m^3
Phosgene	0.2 ppm (approx. 7 mm light green)
Chlorine (Cl_2)	0.2 ppm
Phosphoric acid ester	0.025 ppm dichlorvos
Number of strokes n:	50
Measuring time:	approx. 3 min

D-13335-2010

Permissible ambient conditions

Temperature:	5 ... 30 °C
Humidity:	5 to 15 mg H_2O/L

The sensitivities may change if measurements are carried out outside the specified temperature and humidity ranges. Water aerosols can cause minus errors.

D-13336-2010

Evaluating the reading: Caution! Very important.

1. Cyanogen chloride

Color change: white → pink

Cross-sensitivity: Cyanogen bromide is also indicated, but with a different sensitivity. At 0.25 ppm, the indicating layer is the same color as the comparison layer

2. Thioether

Color change: yellow → orange

Cross-sensitivity: Different thioethers are indicated; differentiation is not possible.

3. Phosgene

Color change: yellow → blue-green

Cross-sensitivity: Hydrochloric acid has no effect up to 100 ppm.

4. Chlorine

Color change: white → yellow-orange

Cross-sensitivity: Bromine and nitrogen dioxide are also indicated, but with different sensitivities.

5. Phosphoric acid ester

Color change: yellow → red (min. 1 minute)

Cross-sensitivity: Other phosphoric acid esters are also indicated, but with a different sensitivity.

Organic Arsenic Compounds and Arsine

Order no. CH26303

General data

Measuring range:	0.1 ppm arsine 3 mg org. arsenic compounds/m^3 as reading limit values
Number of strokes n:	8 to 16
Measuring time:	max. 3 min
Standard deviation:	± 50 %
Color change:	yellow → gray

Permissible ambient conditions

Temperature:	0 to 40 °C
Humidity:	less than 50 mg H_2O/L

Reaction principle

a) AsR_3 + Zn/HCl → AsH_3

b) AsH_3 + Au/Hg complex → Au (colloidal)

Cross-sensitivity

Just like arsine, phosphine is indicated before opening the ampoule, but with a different sensitivity.

Additional notes

If a gray ring appears after performing 8 strokes, arsine is present. If there is initially no reading, the reagent ampoule must be broken and the ampoule liquid applied to the indicating layer so that it is completely saturated! Then perform a further 8 strokes.

ST-17-2001

Organic Alkaline Nitrogen Compounds

Order no. CH25903

General data

Measuring range:	1 mg/m^3 as reading threshold value; 1 to 2 mm discoloration length
Number of strokes n:	8
Measuring time:	approx. 1.5 min
Standard deviation:	± 50 %
Color change:	yellow → orange-red

Permissible ambient conditions

Temperature:	0 to 40 °C
Humidity:	less than 50 mg H_2O/L

Reaction principle

$NR_3 + KBiI_4 \rightarrow$ orange-red reaction product

Cross-sensitivity

Different organic alkaline nitrogen compounds are indicated. Differentiation is not possible.

ST-77-2001

Phosphoric Acid Ester 0.05/a

Order no. 6728461

General data

Measuring range:	0.05 ppm dichlorvos
Number of strokes n:	10
Measuring time:	approx. 5 min
Standard deviation:	± 30 %
Color change:	yellow → red

ST-144-2001

Permissible ambient conditions

Temperature:	10 to 40 °C
Humidity:	3 to 18 mg H_2O/L

Reaction principle

a) $(CH_3O)_2PO_2$-CH=CCl_2 + cholinesterase → inactive enzyme, red reaction product

b_1) butyrylcholine iodide + H_2O → butyric acid

b_2) Butyric acid + phenol red → yellow reaction product

a) If phosphoric acid esters are present, the enzyme is inactivated and butyric acid is not formed, so the weakly alkaline buffer solution in the ampoule colors the indicating layer red and must be stable for 1 minute.

b) If the enzyme remains active, i.e., no phosphoric acid esters are present, the indicating layer remains yellow due to the formation of butyric acid.

Cross-sensitivity

Phosphoric acid esters other than dichlorvos are also indicated, but with a different sensitivity.

Conducting the measurement

After performing the 10 strokes, the reagent ampoule must be broken and the ampoule liquid applied to the enzyme layer using gentle back-and-forth movements. However, the following substrate layer must not become moist. Wait 1 min. Carefully draw the liquid up to the scale mark with the pump. Wait 1 min. Draw the liquid onto the indicating layer with the pump.

Thioether

Order no. CH25803

General data

Measuring range:	2 mg/m³ as reading limit value for dimethyl sulfide in the form of a ring-shaped reading
Number of strokes n:	8
Measuring time:	approx. 1.5 min
Standard deviation:	± 50 %
Color change:	yellow → orange

Permissible ambient conditions

Temperature:	0 to 40 °C
Humidity:	less than 50 mg H_2O/L

Reaction principle

R'-S-R + $AuCl_3$ + chloramide → orange reaction product

Cross-sensitivity

Various thioethers are indicated. Differentiation is not possible.

Additional notes

After carrying out the 8 strokes, the reagent ampoule must be broken and the ampoule liquid transferred completely onto the indicating layer.

ST-149-2001

6.1.5 Data about Dräger-Tubes for Use in the Dräger Aerotest

D-13316-2010

Ammonia 2/a

Order no. 6733231

General data

Use with Aerotest CO_2

Measuring range:	0.6 to 9 ppm
Test volume:	1 L
Flow rate:	0.2 L/min
Measuring time:	5 min
Standard deviation:	± 25 %
Color change:	yellow → blue

Permissible ambient conditions

Temperature:	10 to 50 °C
Humidity:	less than 20 mg H_2O/L
Pressure:	Only use for expanded gases

Reaction principle

NH_3 + pH indicator → blue reaction product

Cross-sensitivity

Other basic substances, e.g., organic amines, are also indicated.

The indication is not affected by:

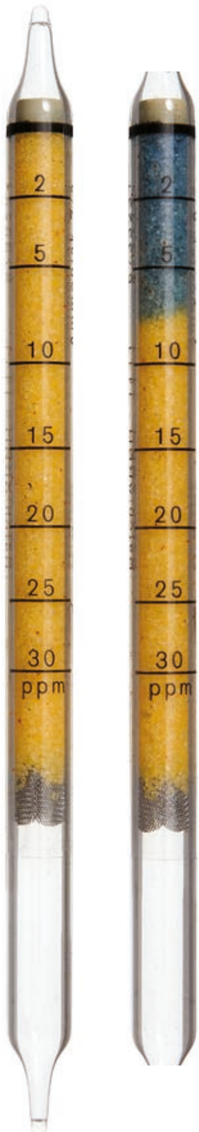
300 ppm nitrous fumes

2000 ppm sulfur dioxide

2000 ppm hydrogen sulfide

Evaluation

Scale reading x 0.3 = ppm ammonia



Impactor for Measuring Oil Mist

Order no. 8103560

General data

Use with Aerotest Alpha, MultiTest med. Int., Aerotest Simultan HP	
Measuring range:	0.1 mg/m³, 0.5 mg/m³, 1.0 mg/m³ oil mist (oil aerosols)
Test volume:	20 L
Flow rate:	4 L/min
Measuring time:	5 min
Evaluation:	Read off oil concentration as per figure

Permissible ambient conditions

Temperature:	10 to 30 °C
Humidity:	up to 60 % relative humidity
Pressure:	only use in depressurized compressed air

Measurement principle

Deflecting the air to be analyzed at right angles in the impactor causes aerosol particles to be deposited on a ground glass plate due to inertia. The aerosol particles collect in recesses in the ground glass, which eliminates the light scatter caused by the ground glass, and the aerosol particles become visible.

Cross-sensitivity

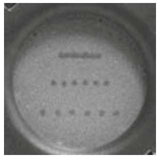
Oil aerosols are displayed irrespective of the type of oil. Please note that oil aerosols vaporize at higher temperatures and oil vapors are not displayed.

Additional notes

The impactor is used together with the adapter for the impactor (order no. 81 03 557) in the Dräger Aerotest Simultan.

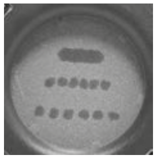
ST-357-2008

Dräger Impactor



ST-1230-2008

0.1 mg/m³



ST-1231-2008

0.5 mg/m³

ST-1232-2008

1.0 mg/m³

ST-604-2008

Adapter with impactor

ST-602-2008

Adapter in the Dräger Aerotest Simultan

Carbon Dioxide 100/a-P

Order no. 6728521

General data

Use with Aerotest Alpha, MultiTest med. Int., Aerotest Simultan HP

Measuring range:	100 to 3000 ppm
Test volume:	1 L
Flow rate:	0.2 L/min
Measuring time:	approx. 5 min
Standard deviation:	± 10 to 15 %
Color change:	white → purple

Permissible ambient conditions

Temperature:	15 to 25 °C
Humidity:	max. 23 mg H_2O/L
Pressure:	Only use for expanded gases

Reaction principle

$$CO_2 + N_2H_4 \xrightarrow{\text{Crystal violet}} NH_2\text{-}NH\text{-}COOH$$

Cross-sensitivity

Hydrogen sulfide and sulfur dioxide are not indicated in their OEL ranges.

ST-51-2001

Carbon Monoxide 2/a-P

Order no. 3735950

General data

Use with Aerotest Alpha, MultiTest med. Int., Aerotest Simultan HP, SimultanTest CO_2

Measuring range:	2 to 60 ppm
Test volume:	1 L
Flow rate:	0.2 L/min
Measuring time:	approx. 5 min
Standard deviation:	± 10 to 15 %
Color change:	white → brownish pink-green

Permissible ambient conditions

Temperature:	0 to 50 °C
Humidity:	0 to 45 mg H_2O/L
Pressure:	Only use for expanded gases

Reaction principle

$$5\ CO + I_2O_5 \xrightarrow{H_2S_2O_7} I_2 + 5\ CO_2$$

Cross-sensitivity

The following (each) have no effect on the reading of 10 ppm CO: 100 ppm hydrogen sulfide, 50 ppm sulfur dioxide, 15 ppm nitrogen dioxide, 10 ppm CO + 200 ppm
Octane: reading approx. 30 ppm, 10 ppm CO + 40 ppm
Butadiene: reading approx. 15 ppm, 10 ppm CO + 30 (100) ppm
Benzene: reading approx. 15 (20 - 30) ppm, 10 ppm CO + 40 ppm
Chloroform: reading approx. 60 ppm, 10 (60) ppm
Ethyne: reading approx. 5 (15) ppm.

D-13687-2025

Nitrous Fumes 0.2/a

Order no. 8103661

N

General data

Use with MultiTest med. Int., SimultanTest CO_2

Measuring range: 0.2 to 6 ppm	
Test volume:	in compressed air 0.5 L / in CO_2: 0.5 L
Flow rate:	in compressed air 0.2 L/min / in CO_2: 0.167 L/min
Measuring time:	in compressed air 2.5 min / in CO_2: 3 min
Standard deviation:	± 30 %
Color change:	gray-green → blue-gray

Permissible ambient conditions

Temperature:	10 to 40 °C
Humidity:	3 to 40 mg/L H_2O
Pressure:	Only use for expanded gases

Reaction principle

a) $NO + O_X \rightarrow NO_2$

b) NO_2 + diphenylbenzidine → blue-gray reaction product

Cross-sensitivity

The indicating layer may bleach at nitrogen dioxide concentrations above around 300 ppm.

Chlorine and ozone are also indicated, but with different sensitivities, and can distort the measurement result.

D-5458-2014

Oil 10/a-P

Order no. 6728371

General data

Use with Aerotest Alpha, MultiTest med. Int., Aerotest Simultan Test HP	
Measuring range:	0.1 to 1 mg/m^3
Test volume:	As per the Aerotest instructions for use
Flow rate:	As per the Aerotest instructions for use
Measuring time:	As per the Aerotest instructions for use
Standard deviation:	
Color change:	white → light beige or yellow

Permissible ambient conditions

Temperature:	10 to 30 °C
Humidity:	As per the instructions for use
Pressure:	Only use for expanded gases

Reaction principle

Oil + H_2SO_4 → beige/yellow reaction product

Cross-sensitivity

The total concentrations of mineral and synthetic aerosols (mist) and oil vapors is indicated.

Other higher-molecular organic compounds are also indicated, but with different sensitivities.

Polyethylene glycol and silicone oils are not indicated.

Additional notes

The oil tube is also suitable for analyzing the air in work areas in connection with a Dräger tube pump.

The measuring time depends on the oil used. A list of tested oils is available at www.draeger.com/voice.

ST-143-2001

Phosphine 0.1/c

Order no. 8103711

General data

Use with Aerotest SimultanTest CO_2

Measuring range:	0.1 to 1 ppm
Test volume:	0.3 L
Flow rate:	0.2 L/min
Measuring time:	1.5 min
Standard deviation:	± 10 to 15 %
Color change:	yellow → red

Permissible ambient conditions

Temperature:	2 to 40 °C
Humidity:	max. 40 mg H_2O/L
Pressure:	Only use for expanded gases

Reaction principle

$HgCL_2$ + PH_3 → Hg phosphide + HCl

HCl + pH indicator → red reaction product

Cross-sensitivity

A maximum 6 ppm sulfur dioxide or 15 ppm hydrogen chloride does not affect the reading. Higher concentrations result in plus errors. Ammonia (> 100 ppm) results in minus errors. Hydrogen sulfide and arsine are indicated with different sensitivities. 30 ppm hydrocyanic acid does not affect the reading.

D-21246-2015

Sulfur Dioxide 0.5/a

Order no. 6728491

General data

Use with MultiTest med. Int.

Measuring range:	1 to 25 ppm	/ 0.25 to 1 ppm
Test volume:	1 L	/ 2 L
Flow rate:	0.2 L/min	/ 0.2 L/min
Measuring time:	5 min	/ 10 min
Standard deviation:	± 25 %	
Color change:	gray-blue → white	

Permissible ambient conditions

Temperature:	15 to 30 °C
Humidity:	max. 20 mg H_2O/L
Pressure:	Only use for expanded gases

Reaction principle

$$SO_2 + I_2 + 2\,H_2O \xrightarrow{\text{Starch}} H_2SO_4 + 2\,HI$$

Cross-sensitivity

Measurement is not possible in the presence of H_2S.

Nitrogen dioxide shortens the reading.

Evaluation

Measuring range 1 to 25 ppm:

Scale reading (n=10) = ppm

Measuring range 0.25 to 1 ppm:

Scale reading (n=20) x 0.5 = ppm SO_2

(only valid for a scale range of 0.5 to 2 ppm)

ST-121-2001

Sulfur Dioxide 1/a

Order no. CH31701

Use with Aerotest SimultanTest CO_2	
Measuring range:	0.5 to 2 ppm
Test volume:	2 L
Flow rate:	approx. 0.2 L/min
Measuring time:	in Aerotest CO_2: 10 min
	in MultiTest (for CO_2): 12 min
Standard deviation:	± 30 %
Color change:	gray-blue → white

Permissible ambient conditions

Temperature:	15 to 25 °C
Humidity:	max. 20 mg H_2O/L
Pressure:	Only use for expanded gases

Reaction principle

$$SO_2 + I_2 + 2\ H_2O \xrightarrow{\text{Starch}} H_2SO_4 + 2\ HI$$

Cross-sensitivity

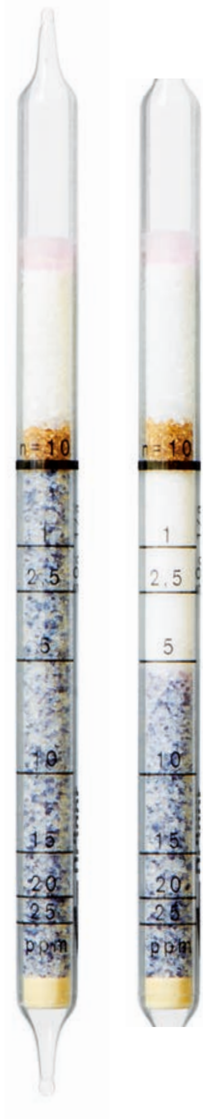
Hydrogen sulfide is retained in the pre-layer, so has no effect at concentrations around the OEL.

Nitrogen dioxide shortens the reading.

Evaluation

Scale reading (n=10) x 0.2 = ppm SO_2

(only valid for a scale range of 2.5 to 10 ppm)



D-5463-2014

S

Hydrogen Sulfide 0.2/a

Order no. 8101461

General data

Use with Aerotest SimultanTest CO_2	
Measuring range:	0.04 to 1 ppm
Test volume:	4 L
Flow rate:	0.8 L/min
Measuring time:	5 min
Standard deviation:	± 25 %
Color change:	white → light brown

Permissible ambient conditions

Temperature:	10 to 30 °C
Humidity:	max. 15 mg H_2O/L
Pressure:	Only use for expanded gases

Reaction principle

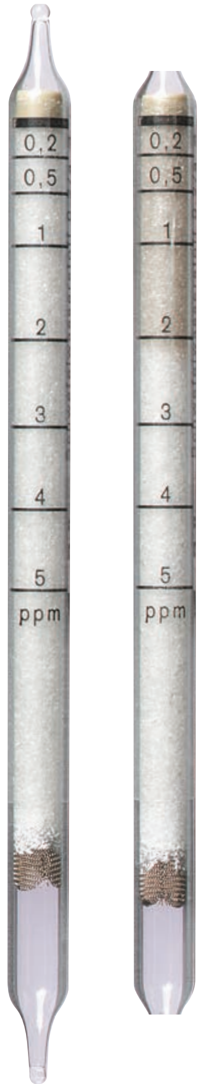
$H_2S + Pb^{2+} \rightarrow PbS + 2\ H^+$

Cross-sensitivity

Sulfur dioxide and hydrochloric acid have no effect in their OEL ranges.

Evaluation

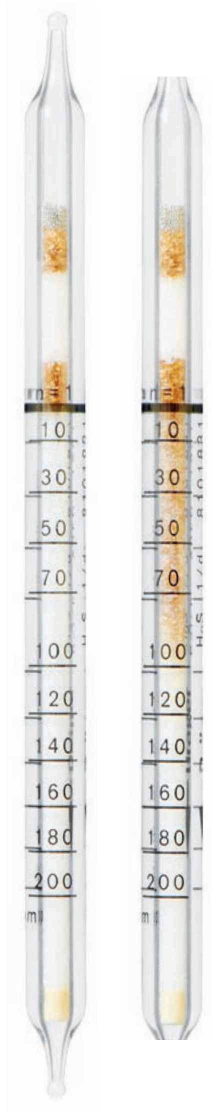
$$\frac{\text{Scale reading}}{5} = \text{ppm } H_2S$$



ST-132-2001

Hydrogen Sulfide 1/d

Order no. 8101831



D-5451-2014

General data

Use with MultiTest med. Int.	
Measuring range:	1 to 20 ppm
Test volume:	1 L
Flow rate:	0.17 L/min (CO_2)
Measuring time:	6 min
Standard deviation:	± 15 %
Color change:	white → brown

Permissible ambient conditions

Temperature:	2 to 40 °C
Humidity:	max. 40 mg H_2O/L
Pressure:	Only use for expanded gases

Reaction principle

$H_2S + Cu^{2+} \rightarrow CuS + 2\ H^+$

Cross-sensitivity

500 ppm hydrochloric acid, 500 ppm sulfur dioxide, 500 ppm ammonia, or 100 ppm arsine do not affect the reading.

Methyl mercaptan and ethyl mercaptan discolor the entire indicating layer a weak yellow and, when mixed with hydrogen sulfide, extend the reading by around 30 %.

Evaluation

Scale reading (n=10) = ppm H_2S

Water Vapor 5/a-P

Order no. 6728531

General data

Use with Aerotest SimultanTest CO_2	
Measuring range:	5 to 200 mg/m³
Test volume:	50 L
Flow rate:	2 L / 4 L/min
Measuring time:	approx. 25 min / 12.5 min
Standard deviation:	± 15 to 20 % / +25 %
Color change:	yellow → reddish brown

Permissible ambient conditions

Temperature:	0 to 40 °C
Pressure:	Only use for expanded gases

Reaction principle

$H_2O + SeO_2 + H_2SO_4$ → reddish brown reaction product

Cross-sensitivity

Alcohols and unsaturated hydrocarbons at high concentrations can cause diffuse discoloration of the indicating layer.

Measuring range extension

The following evaluation applies for other volumes:

Value read:	5	10	30	50	70	100	150	200
	mg H_2O/m^3							
25 L Vol. 12.5 min:	10	20	70	110	160	220	340	450
	mg H_2O/m^3							
100 L Vol.:	2	4	12	20	28	40	60	80
	mg H_2O/m^3							

i.e., for a test volume of 25 L, the value read off the scale of 50 mg H_2O/m^3 corresponds to a measured value of 110 mg H_2O/m^3.

Relative standard deviation:	± 25 to 30 % (25 L)
	± 20 to 25 % (100 L)

ST-565-2008

Water Vapor 20/a-P

Order no. 8103061

General data

Use with Aerotest Alpha, MultiTest med. Int., Aerotest Simultan HP

Measuring range:	20 to 250 mg H_2O/m^3 35 to 500 mg H_2O/m^3 150 to 1500 mg H_2O/m^3
Test volume:	40 L / 20 L
Flow rate:	4 L/min
Measuring time:	10 min / 5 min / 2.5 min
Standard deviation:	± 15 to 20 %
Color change:	yellow → reddish brown

Permissible ambient conditions

Temperature:	0 to 40 °C
Pressure:	Only use for expanded gases

Reaction principle

$H_2O + SeO_2 + H_2SO_4 \rightarrow$ reddish brown reaction product

Cross-sensitivity

Alcohols and unsaturated hydrocarbons at high concentrations can cause diffuse discoloration of the indicating layer.

D-13330-2010

6.1.6 Data about Direct Indicating Dräger Diffusion Tubes

Ammonia 20/a-D

Order no. 8101301

General data

Measuring range	Measuring time
20 to 1500 ppm	1 h
10 to 750 ppm	2 h
4 to 300 ppm	5 h
2.5 to 200 ppm	8 h

Standard deviation:	± 15 to 20 %
Color change:	yellow → blue

Permissible ambient conditions

Temperature:	0 to 40 °C
Humidity:	1 to 16 mg H_2O/L

Reaction principle

NH_3 + bromophenol blue → blue reaction product

Cross-sensitivity

Other compounds with alkaline reactions are also indicated, in which case an ammonia measurement is not possible.

ST-210-2001

6.1.7 Data about Dräger Sampling Tubes and Systems

Activated Charcoal Tube Type BIA

Order no. 6733011

General data

Adsorbate	Organic compounds that adsorb on activated carbon
Sorbent	Coconut shell charcoal
Collection layer	300 mg
Control layer	600 mg
Tube length	125 mm
Outer diameter	7 mm
Inner diameter	5 mm

D-13314-2010

Note on sampling

The configuration of this sampling tube was suggested by the Institute for Occupational Safety and Health of the German Social Accident Insurance (BGIA), as past experience has shown that the adsorption capacity of the collection layer is sufficient for sampling in work areas (measurements in the OEL range).
After sampling, the tube must be sealed with the enclosed polyethylene caps.

Note on analysis

The enriched volatile organic compounds are analyzed using the methods recommended by the BGIA, DFG, NIOSH, OSHA, and HSE.
Dräger Analytical Services is available for evaluating the sampling tubes and systems (further information at www.Draeger.com/Analysenservice).

Activated Charcoal Tube Type B/G

Order no. 8101821

General data

Adsorbate	Organic compounds that adsorb on activated carbon
Sorbent	Coconut shell charcoal
Collection layer	300 mg / 700 mg
Control layer	700 mg / 300 mg
Tube length	125 mm
Outer diameter	7 mm
Inner diameter	5 mm

Note on sampling

Either side of the tube can be used for measurement. As a type G tube, it is ideal for sampling organic substances that are present at high concentrations in the air sample (e.g., exhaust air measurements). For air measurements at workplaces, the tube can be used as a type B tube (measurements in the OEL range). After sampling, the tube must be sealed with the enclosed polyethylene caps and the sampling type (sampling direction), among other things, noted on the sampling record.

Note on analysis

The enriched volatile organic compounds are analyzed using the methods recommended by the BGIA, DFG, NIOSH, OSHA, and HSE.

Dräger Analytical Services is available for evaluating the sampling tubes and systems (further information at www.Draeger.com/Analysenservice).

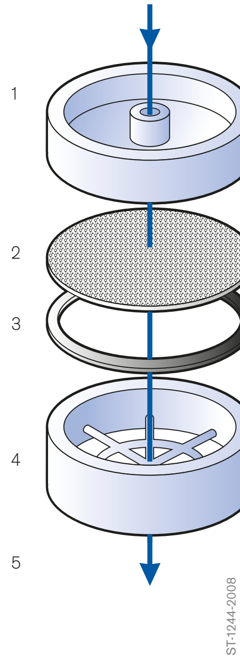
D-13327-2010

Aldehyde sampling set

Order no. 6400271

General data

Measurable substances	Aldehydes, such as Acetaldehyde Acrolein Formaldehyde Glutardialdehyde
Reaction medium	Fiberglass filter impregnated with 2,4-dinitrophenylhydrazine
Reaction product	Hydrazone derivative
Flow rate	0.1 to 1 L/min
Total volume	10 to 100 L
Storage before sampling	at 7 °C in refrigerator, max. 9 months



1 Lid
2 Impregnated fiberglass filter
3 Flat gasket
4 Base
5 Pump

Note on sampling

After sampling, the sampling head must be tightly sealed in the container, stored in a cool place, and immediately analyzed in the laboratory.

Note on analysis

The enriched volatile organic compounds are analyzed using the methods recommended by the BGIA, DFG, NIOSH, OSHA, and HSE.
Dräger Analytical Services is available for evaluating the sampling tubes and systems (further information at www.Draeger.com/Analysenservice).

Activated Charcoal Tube Type G

Order no. 6728831

General data

Adsorbate	Organic compounds that adsorb on activated carbon
Sorbent	Coconut shell charcoal
Collection layer	750 mg
Control layer	250 mg
Tube length	125 mm
Outer diameter	7 mm
Inner diameter	5 mm

Note on sampling

The large amount of activated carbon in the collection layer makes these activated charcoal tubes ideal for sampling organic substances that are present at high concentrations in the air sample. This includes, for example, exhaust air analyses to determine the emission of a hazardous substance.

After sampling, the tube must be sealed with the enclosed polyethylene caps.

Note on analysis

The enriched volatile organic compounds are analyzed using the methods recommended by the BGIA, DFG, NIOSH, OSHA, and HSE.

Dräger Analytical Services is available for evaluating the sampling tubes and systems (further information at www.Draeger.com/Analysenservice).

ST-557-2008

Activated Charcoal Tube Type NIOSH

Order no. 6728631

ST-101-2001

General data

Adsorbate	Organic compounds that adsorb on activated carbon
Sorbent	Coconut shell charcoal
Collection layer	100 mg
Control layer	50 mg
Tube length	70 mm
Outer diameter	6 mm
Inner diameter	4 mm

Note on sampling

The air to be tested must be drawn through the tube at a constant flow rate of between 0.01 and 0.2 L/min.

In its guidelines, NIOSH notes that high humidity influences the adsorption capacity of the activated carbon, which can lead to the premature breakthrough of the measuring component into the control layer.

After sampling, the tube must be sealed with the enclosed polyethylene caps.

Note on analysis

The enriched volatile organic compounds are analyzed using the methods recommended by the BGIA, DFG, NIOSH, OSHA, and HSE.

Dräger Analytical Services is available for evaluating the sampling tubes and systems (further information at www.Draeger.com/Analysenservice).

Sampling Tube Type ADS

Order no. 8101271

General data

Adsorbate	Primary, secondary, and tertiary adsorbing aliphatic amines, dialkyl sulfates, N-heterocycles
Sorbent	Special silica gel
Collection layer	300 mg
Control layer	300 mg
Tube length	125 mm
Outer diameter	7 mm
Inner diameter	5 mm

Note on sampling

When sampling, the air to be analyzed must be drawn through the tube in the direction of the printed arrow at a constant flow rate of between around 0.3 and 1 L/min.

The volume of air to be drawn through lies in the range of 1 to 100 L.

After sampling, the tube must be sealed with the enclosed poly-ethylene caps.

Note on analysis

The enriched volatile organic compounds are analyzed using the methods recommended by the BGIA, DFG, NIOSH, OSHA, and HSE.

Dräger Analytical Services is available for evaluating the sampling tubes and systems (further information at www.Draeger.com/Analysenservice).

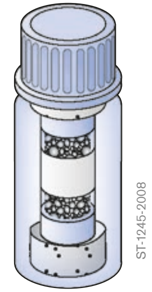
ST-1237-2008

ORSA Diffusion Sampler

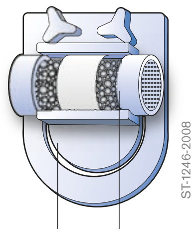
Order no. 6728891 / 6728919 / 6400365

General data

Adsorbate	Organic compounds that adsorb on activated carbon by diffusion
Sorbent	Coconut shell charcoal
Collection layer	400 mg
Adsorption capacity	Max. 10 mg, substance-dependent
Diffusion rate	1 to 4 µg/(ppmxh), substance-dependent
Collection rate	5 to 10 mL/min, substance-dependent
Response time	approx. 2 s
Measuring range	0.1 to 3 times the OEL for most organic solvents with a measuring time of 8 h
Sampling time	0.5 to 8 h for measurements in the OEL range
Diffusion cross-section	0.88 cm^2
Diffusion distance	0.5 cm
Diffusion barrier	Acetate cellulose
Device constant	0.80 cm^{-1}

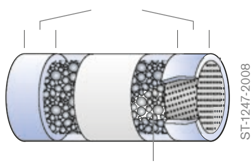


Transport cylinder with diffusion sampler



Permissible ambient conditions

Temperature	5 to 40 °C
Humidity	5 to 80 % at 20 °C
Ambient pressure	less than 1050 hPa
Air velocity	min. 1 cm/s



Note on sampling

The air sample is taken over the previously defined measuring time, which must be documented. After sampling, the sampling tube is transferred to the laboratory in the tightly sealed glass cylinder for analysis.

Note on analysis

The enriched volatile organic compounds are analyzed using the methods recommended by the BGIA, DFG, NIOSH, OSHA, and HSE.

Dräger Analytical Services is available for evaluating the sampling tubes and systems (further information at www.Draeger.com/Analysenservice).

Isocyanate Sampling Set

Order no. 6400131

General data

Measurable substances	Isocyanates, such as 2,4-toulene diisocyanate (TDI) 2,6-toulene diisocyanate (TDI) Diphenylmethane diisocyanate (MDI) Hexamethylene diisocyanate (HDI)
Reaction medium	Fiberglass filter impregnated with amine compound
Reaction product	Urea derivative
Flow rate	1 to 2 L/min
Total volume	20 to 100 L
Storage before sampling	at 7 °C in refrigerator, max. 9 months

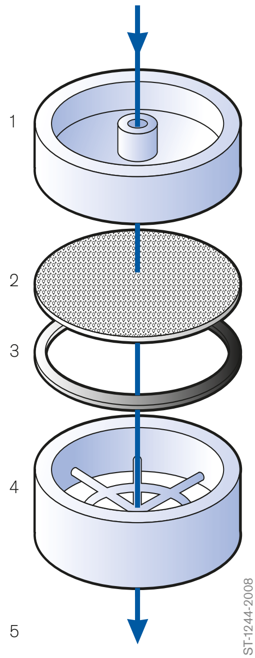
Note on sampling

After sampling, the sampling head must be tightly sealed in the container, stored in a cool place, and immediately analyzed in the laboratory.

Note on analysis

The enriched volatile organic compounds are analyzed using the methods recommended by the BGIA, DFG, NIOSH, OSHA, and HSE.

Dräger Analytical Services is available for evaluating the sampling tubes and systems (further information at www.Draeger.com/Analysenservice).



1 Lid
2 Impregnated fiberglass filter
3 Flat gasket
4 Base
5 Pump

Silica Gel Tube Type BIA

Order no. 6733021

General data

Adsorbate	Organic compounds that adsorb on silica gel
Sorbent	Silica gel
Collection layer	500 mg
Control layer	1000 mg
Tube length	125 mm
Outer diameter	7 mm
Inner diameter	5 mm

Note on sampling

The configuration of this sampling tube was suggested by the Institute for Occupational Safety and Health of the German Social Accident Insurance (BGIA), as past experience has shown that the adsorption capacity of the collection layer is sufficient for sampling organic compounds in work areas (measurements in the OEL range). If higher hazardous substance concentrations are expected, the sampling tube should be inserted into the pump in the opposite direction (opposite to the printed arrow direction, long layer at the front) (note in the sampling record!). After sampling, the tube must be sealed with the enclosed polyethylene caps.

Note on analysis

The enriched volatile organic compounds are analyzed using the methods recommended by the BGIA, DFG, NIOSH, OSHA, and HSE.

Dräger Analytical Services is available for evaluating the sampling tubes and systems (further information at www.Draeger.com/ Analysenservice).

S

Silica Gel Tube Type G

Order no. 6728851

General data

Adsorbate	Organic compounds that adsorb on silica gel
Sorbent	Silica gel
Collection layer	1100 mg
Control layer	450 mg
Tube length	125 mm
Outer diameter	7 mm
Inner diameter	5 mm

Note on sampling

The large amount of silica gel in the collection layer makes these silica gel tubes ideal for sampling organic substances that are present at high concentrations in the air sample. This includes, for example, exhaust air analyses to determine the emission of a hazardous substance. After sampling, the tube must be sealed with the enclosed polyethylene caps.

Note on analysis

The enriched volatile organic compounds are analyzed using the methods recommended by the BGIA, DFG, NIOSH, OSHA, and HSE.
Dräger Analytical Services is available for evaluating the sampling tubes and systems (further information at www.Draeger.com/Analysenservice).

D-13313-2010

6.2 Dräger X-act 7000

6.2.1 MicroTubes Descriptions

Measuring range

MicroTubes are factory-calibrated. Calibration takes place at 20 °C and 50 % r. h. Possible temperature and humidity influences are specified using correction factors.

Typical measuring time

The typical measuring time is given in minutes or seconds for selected concentrations. As the speed of measurement depends on the concentration to be measured, the measuring time is not constant. The higher the concentration to be measured, the shorter the measuring time.

Accuracy

The accuracy is given as a measure of the deviations of the individual measured values.

Permissible ambient conditions

The use of MicroTubes is partly dependent on temperature and humidity. The permissible temperature range in °C and the permissible absolute humidity in mg H_2O/L are specified.

To obtain a correct measurement result, it is possible that the concentration shown in the display needs to be corrected within the given temperature or humidity range. In this case, the relevant factors to correct the temperature and humidity are given as a percent of the measured value per °C or percent of the measured value per mg H_2O/L.

The X-act 7000 analysis system can generally be used within an air pressure range of 700 to 1,300 hPa. Pressure correction is not necessary within this range.

Cross-sensitivity

MicroTubes are calibrated for a certain substance. If only this substance is present during measurement, the measurement generally only depends on the measuring range and the current ambient conditions. If other substances are present in addition to the substance to be measured, a check is required to determine the extent to which these substances affect the measurement result and whether the MicroTube used will provide a reliable measurement result. The cross-sensitivity defines which other substances present during measurement affect the MicroTube measurement and the substances that have no effect on the measurement result. The effect of the cross-sensitivity has been checked for the specified substances.

Purging times for hose and probe measurements

The purging times provided are recommendations. They were determined using brand-new, dry, and clean hoses and probes.

Resolution

The measurement result is displayed with a different resolution depending on the measuring range.

Measured value range	Resolution
< 0.10 ppb	0.001 ppb
< 1.0 ppb	0.01 ppb
< 10.0 ppb	0.1 ppb
≥ 10 ppb	1 ppb
< 0.10 ppm	0.001 ppm
< 1.0 ppm	0.01 ppm
< 10.0 ppm	0.1 ppm
≥ 10 ppm	1 ppm
< 0.010 mg/m^3	0.0001 mg/m^3
< 0.10 mg/m^3	0.001 mg/m^3
≤ 0.25 mg/m^3	0.01 mg/m^3

6.2.2 Data about Dräger MicroTubes

Acetic Acid 2 – 50 ppm

Order no. 8610330

Measuring range:	2 to 50 ppm
Typical measuring time:	20 to 170 s
Accuracy:	± 25 % (under calibration conditions)
Permissible ambient conditions	
Temperature:	0 to 30 °C
Temperature correction:	< 20 °C: + 8 % of the measured value per °C
	> 20 °C: - 4 % of the measured value per °C
Humidity:	5 to 20 mg/L
Humidity correction:	< 10 mg/L – 2.5 % of the measured value per mg/L
	> 10 mg/L + 2.5 % of the measured value per mg/L

Cross-sensitivities

The detection of 10 ppm acetic acid is not affected by 50 ppm hydrogen peroxide. Formic acid is detected with the same sensitivity. 6 ppm peracetic acid leads to a minus error of ± 25 % for the detection of 10 ppm acetic acid.

Hose and probe measurements

The following purging time recommendations for remote measurements have been determined with a brand-new, dry, and clean hose and probes.

Hose / probe	Length in m	Purging time in min
FKM hose	5 – 20	15
FKM hose	45	not possible
PTFE-lined PVC hose	3 – 15	3
Bar probe 90 (8316532)		3
Telescopic probe ES 150 (8316533)		10
Probe set GP600 (8328667)		15

Acetone 25 – 5000 ppm

Order no. 8610470

Measuring range:	25 to 5000 ppm
Typical measuring time:	20 to 500 s
Accuracy:	± 25 % (under calibration conditions)

Permissible ambient conditions

Temperature:	0 to 30 °C
Temperature correction:	<20 °C → +5 % of the measured value per °C
	>20 °C → -3.5 % of the measured value per °C
Humidity:	1 to 30 mg/L
Humidity correction:	none

Cross-sensitivities

The detection of 500 ppm acetone is not affected by

5 ppm methanol
50 ppm ethanol
100 ppm i-propanol
50 ppm methyl ethyl ketone
150 ppm methyl isobutyl ketone

Hose and probe measurements

The following purging time recommendations for remote measurements have been determined with a brand-new, dry, and clean hose and probes.

Hose / probe	Length in m	Purging time in min
FKM hose	5 – 20	3
FKM hose	45	5
PTFE-lined PVC hose	3 – 15	3
Bar probe 90 (8316532)		2
Telescopic probe ES 150 (8316533)		2
Probe set GP600 (8328667)		2

Alcohol 10 – 5000 ppm

Order no. 8610380

Measuring range:	10 to 5000 ppm (methanol)
Typical measuring time:	approx. 20 to 450 s
Accuracy:	± 25 % (under calibration conditions)

Permissible ambient conditions

Temperature:	10 to 35 °C
Temperature correction:	<20 °C → +12 % of the measured value per °C
	>20 °C → -4.5 % of the measured value per °C
Humidity:	1 to 30 mg/L
Humidity correction:	none

Cross-sensitivities

Other alcohols are also indicated with the following sensitivities:
Ethanol with double sensitivity: Reading / 2 = ppm ethanol
(measuring range 5 - 2500 ppm)
i-propanol with the same sensitivity: Reading = ppm i-propanol
(measuring range 10 - 5000 ppm)
n-butanol with 1.5 times sensitivity: Reading / 1.5 = ppm n-butanol
(measuring range approx. 7 - 3300 ppm)

Hose and probe measurements

The following purging time recommendations for remote measurements have been determined with a brand-new, dry, and clean hose and probes.

Hose / probe	Length in m	Purging time in min
FKM hose	5 – 20	3
FKM hose	45	5
PTFE-lined PVC hose	3 – 15	4
Bar probe 90 (8316532)		3
Telescopic probe ES 150 (8316533)		2
Probe set GP600 (8328667)		3

Ammonia 1 – 100 ppm

Order no. 8610130

Measuring range:	1 to 100 ppm
Typical measuring time:	approx. 10 to 75 s
Accuracy:	± 25 % (under calibration conditions)

Permissible ambient conditions

Temperature:	0 to 40 °C
Temperature correction:	none
Humidity:	1 to 30 mg/L
Humidity correction:	none

Cross-sensitivities

With 25 ppm ammonia, no effect on the reading by:

2000 ppm sulfur dioxide

No indication with 2000 ppm sulfur dioxide.

Hose and probe measurements

The following purging time recommendations for remote measurements have been determined with a brand-new, dry, and clean hose and probes.

Hose / probe	Length in m	Purging time in min
FKM hose	5 – 20	3
FKM hose	45	5
PTFE-lined PVC hose	3 – 15	3
Bar probe 90 (8316532)		1
Telescopic probe ES 150 (8316533)		4
Probe set GP600 (8328667)		3

Ammonia 100 – 2500 ppm

Order no. 8610020

Measuring range:	100 to 2500 ppm
Typical measuring time:	approx. 3 to 45 s
Accuracy:	± 20 % (under calibration conditions)

Permissible ambient conditions

Temperature:	0 to 40 °C
Temperature correction:	none
Humidity:	1 to 40 mg/L
Humidity correction:	none

Cross-sensitivities

With 250 ppm ammonia, no effect on the reading by:

500 ppm hydrogen sulfide

No indication with 2000 ppm sulfur dioxide.

Hose and probe measurements

The following purging time recommendations for remote measurements have been determined with a brand-new, dry, and clean hose and probes.

Hose / probe	Length in m	Purging time in min
FKM hose	5 – 20	3
FKM hose	45	5
PTFE-lined PVC hose	3 – 15	3
Bar probe 90 (8316532)		2
Telescopic probe ES 150 (8316533)		2
Probe set GP600 (8328667)		3

Benzene 5 – 150 ppb

Order no. 8610600

Measuring range:	5 to 150 ppb Measurement only possible in connection with the Dräger-Tube ppb Booster Basic (3702013).
Typical measuring time:	approx. 100 to 1100 s
Accuracy:	± 25 % (under calibration conditions) < 5 ppb + 50 %

Permissible ambient conditions

Temperature:	10 to 30 °C
Temperature correction:	21 to 30 °C → none < 20 °C → + 3 % of the measured value per °C
Humidity:	1 to 25 mg/L
Humidity correction:	none

Cross-sensitivities

The detection of 25 ppb benzene is not affected by:

1.5 ppm 1,3-butadiene
50 ppb hydrogen sulfide
20 ppm n-octane
130 ppb toluene
150 ppb xylene
100 ppm cyclohexane

Hose and probe measurements

The following purging time recommendations for remote measurements have been determined with a brand-new, dry, and clean hose and probes. The additional purging time reduces the humidity range to 1 to 15 mg/L.

Hose / probe	Length in m	Purging time in min
FKM hose	5 – 20	3
FKM hose	45	5
PTFE-lined PVC hose	3 – 15	5
Bar probe 90 (8316532)		2
Telescopic probe ES 150 (8316533)		1
Probe set GP600 (8328667)		3

Benzene 0.15 – 10 ppm

Order no. 8610030

Measuring range:	0.15 to 10 ppm
Typical measuring time:	25 to 150 s
Accuracy:	± 25 % (under calibration conditions)

Permissible ambient conditions

Temperature:	0 to 30 °C
Temperature correction:	20 to 30 °C → none
	0 to 19 °C → +4 % of the measured value per °C
Humidity:	1 to 25 mg/L
Humidity correction:	none

Cross-sensitivities

The detection of 1 ppm benzene is not affected by:

1.5	ppm 1,3-butadiene
2.5	ppm hydrogen sulfide
50	ppm toluene
50	ppm xylene
800	ppm n-octane
10	ppm cyclohexane

Hose and probe measurements

The following purging time recommendations for remote measurements have been determined with a brand-new, dry, and clean hose and probes.

Hose / probe	Length in m	Purging time in min
FKM hose	5 – 20	3
FKM hose	45	5
PTFE-lined PVC hose	3 – 15	7
Bar probe 90 (8316532)		1
Telescopic probe ES 150 (8316533)		2
Probe set GP600 (8328667)		3

Benzene 10 – 100 ppm

Order no. 8610280

Measuring range:	10 to 100 ppm
Typical measuring time:	10 to 75 s
Accuracy:	± 20 % (under calibration conditions)

Permissible ambient conditions

Temperature:	0 to 35 °C
Temperature correction:	< 20 °C: + 3 % of the measured value per °C
	> 20 °C: none
Humidity:	1 – 30 mg/L
Humidity correction:	none

Cross-sensitivities

The detection of 50 ppm benzene is not affected by:

20 ppm 1,3-butadiene
150 ppm hydrogen sulfide
2500 ppm n-octane
1000 ppm toluene
2500 ppm xylene

Hose and probe measurements

The following purging time recommendations for remote measurements have been determined with a brand-new, dry, and clean hose and probes.

Hose / probe	Length in m	Purging time in min
FKM hose	5 – 20	3
FKM hose	45	5
PTFE-lined PVC hose	3 – 15	3
Bar probe 90 (8316532)		1
Telescopic probe ES 150 (8316533)		1
Probe set GP600 (8328667)		3

1,3-Butadiene 25 – 500 ppb

Order no. 8610460

Measuring range:	25 to 500 ppb Measurement only possible in connection with the Dräger-Tube ppb Booster Basic (3702013).
Typical measuring time:	approx. 200 s to 600 s
Accuracy:	± 25 % (under calibration conditions)

Permissible ambient conditions

Temperature:	0 to 40 °C
Temperature correction:	0 to 25 °C → none >25 °C → -2.5 % of the measured value per °C
Humidity:	5 to 30 mg/L
Humidity correction:	none

Cross-sensitivities

The detection of 250 ppb 1,3-butadiene is not affected by:

75	ppm benzene
50	ppm n-hexane
500	ppb hydrogen sulfide
15	ppm toluene
500	ppb white spirit

Hose and probe measurements

Hose and probe measurements are not possible with the MicroTube 1,3-butadiene 25 - 500 ppb. 1,3-butadiene is absorbed by the hose and probe material in this small concentration range.

1,3-Butadiene 0.5 – 25 ppm

Order no. 8610300

Measuring range:	0.5 to 25 ppm
Typical measuring time:	10 to 280 s
Accuracy:	± 15 % (under calibration conditions)
Permissible ambient conditions	
Temperature:	0 to 40 °C
Temperature correction:	< 20 °C → 1 % of the measured value per °C
	> 20 °C → -1 % of the measured value per °C
Humidity:	5 to 30 mg/L
Humidity correction:	< 10 °C → 8 % of the measured value per mg/L
	> 10 °C → -1 % of the measured value per mg/L

Cross-sensitivities

The detection of 2 ppm 1,3-butadiene is not affected by:

100 ppm benzene
50 ppm toluene
50 ppm n-hexane
25 ppm white spirit
5 ppm hydrogen sulfide

Hose and probe measurements

The following purging time recommendations for remote measurements have been determined with a brand-new, dry, and clean hose and probes.

Hose / probe	Length in m	Purging time in min
FKM hose	5 – 20	3
FKM hose	45	5
PTFE-lined PVC hose	3 – 15	3
Bar probe 90 (8316532)		1
Telescopic probe ES 150 (8316533)		1
Probe set GP600 (8328667)		3

Carbon Dioxide 200 – 50000 ppm

Order no. 8610190

Measuring range:	200 to 50000 ppm
Typical measuring time:	2 to 120 s
Accuracy:	± 25 % (under calibration conditions)
Permissible ambient conditions	
Temperature:	0 to 30 °C
Temperature correction:	none
Humidity:	1 to 30 mg/L
Humidity correction:	none

Cross-sensitivities

The detection of 5000 ppm carbon dioxide is not affected by:

100 ppm hydrogen sulfide

200 ppm sulfur dioxide

Hose and probe measurements

The following purging time recommendations for remote measurements have been determined with a brand-new, dry, and clean hose and probes.

Hose / probe	Length in m	Purging time in min
FKM hose	5 – 20	3
FKM hose	45	5
PTFE-lined PVC hose	3 – 15	3
Bar probe 90 (8316532)		2
Telescopic probe ES 150 (8316533)		2
Probe set GP600 (8328667)		3

Carbon Monoxide 2 – 1000 ppm

Order no. 8610080

Measuring range:	2 to 1000 ppm
Typical measuring time:	approx. 5 s to 300 s
Accuracy:	± 25 % (under calibration conditions)

Permissible ambient conditions

Temperature:	10 to 40 °C
Temperature correction:	none
Humidity:	1 to 40 mg/L
Humidity correction:	none

Cross-sensitivities

The detection of 10 ppm CO is not affected by:

1000	ppm butane
100	ppm hydrogen sulfide
1000	ppm propane
10	ppm sulfur dioxide
500	ppm n-octane
15	ppm nitrogen dioxide
2000	ppm hydrogen

Hose and probe measurements

The following purging time recommendations for remote measurements have been determined with a brand-new, dry, and clean hose and probes.

Hose / probe	Length in m	Purging time in min
FKM hose	5 – 20	3
FKM hose	45	5
TPTFE-lined PVC hose	3 – 15	3
Bar probe 90 (8316532)		2
Telescopic probe ES 150 (8316533)		2
Probe set GP600 (8328667)		3

Chlorine 50 – 5000 ppb

Order no. 8610010

Measuring range:	50 to 5000 ppb
Typical measuring time:	10 to 400 s
Accuracy:	± 25 % (under calibration conditions)

Permissible ambient conditions

Temperature:	0 to 40 °C
Temperature correction:	none
Humidity:	1 to 20 mg/L
Humidity correction:	none

Cross-sensitivities

The detection of 250 ppb chlorine is not affected by:

10 ppm hydrochloric acid

Hose and probe measurements

Hose and probe measurements are not possible with the MicroTube Chlorine 50 - 5000 ppb. Chlorine is absorbed by the hose and probe material in this small concentration range.

Ethylene Oxide 25 – 250 ppb

Order no. 8610200

Measuring range:	25 to 250 ppb
Typical measuring time:	150 to 600 s
Accuracy:	± 25 % (under calibration conditions)

Permissible ambient conditions

Temperature:	10 to 25 °C
Temperature correction:	none
Humidity:	2 to 15 mg/L
Humidity correction:	none

Cross-sensitivities

The detection of 100 ppb ethylene oxide is not affected by:

250	ppb acrolein
300	ppb formaldehyde
2500	ppb 2-chloroethanol
3000	ppb ethanol
4500	ppb iso-propanol

Hose and probe measurements

The following purging time recommendations for remote measurements have been determined with a brand-new, dry, and clean hose and probes.

Hose / probe	Length in m	Purging time in min
FKM hose	5 – 20	3
FKM hose	45	5
PTFE-lined PVC hose	3 – 15	3
Bar probe 90 (8316532)		1
Telescopic probe ES 150 (8316533)		1
Probe set GP600 (8328667)		3

Ethylene Oxide 0.25 – 10 ppm

Order no. 8610580

Measuring range:	0.25 to 10 ppm
Typical measuring time:	approx. 100 to 500 s
Accuracy:	± 25 % (under calibration conditions)
Permissible ambient conditions	
Temperature:	10 to 30 °C
Temperature correction:	none
Humidity:	1 to 25 mg/L
Humidity correction:	none

Cross-sensitivities

The detection of 1 ppm ethylene oxide is not affected by:

0.1 ppm acrolein
10 ppm formaldehyde
25 ppm iso-propanol
50 ppm ethanol

Hose and probe measurements

The following purging time recommendations for remote measurements have been determined with a brand-new, dry, and clean hose and probes.

Hose / probe	Length in m	Purging time in min
FKM hose	5 – 20	3
FKM hose	45	5
PTFE-lined PVC hose	3 – 15	3
Bar probe 90 (8316532)		1
Telescopic probe ES 150 (8316533)		1
Probe set GP600 (8328667)		3

Formaldehyde 5 – 150 ppb

Order no. 8610540

Measuring range:	5 to 150 ppb
Typical measuring time:	approx. 360 s to 960 s
Accuracy:	± 25 % (under calibration conditions)

Permissible ambient conditions

Temperature:	15 to 35 °C
Temperature correction:	none
Humidity:	4 to 18 mg/L
Humidity correction:	< 8 mg/L → +40 % of the measured value per mg/L 8 to 12 mg/L → none > 12 mg/L → -10 % of the measured value per mg/L

Cross-sensitivities

The detection of 75 ppb formaldehyde is not affected by:

0.5 ppm acrolein
10 ppm vinyl acetate
100 ppm styrene
100 ppm acetaldehyde
5 ppm propanol
1 ppm butanal

A formaldehyde measurement is not possible in the presence of SO_2.

Hose and probe measurements

The following purging time recommendations for remote measurements have been determined with a brand-new, dry, and clean hose and probes.

Hose / probe	Length in m	Purging time in min
FKM hose	5 – 20	3
FKM hose	45	5
PTFE-lined PVC hose	3	3
PTFE-lined PVC hose	15	10
Bar probe 90 (8316532)		1
Telescopic probe ES 150 (8316533)		2
Probe set GP600 (8328667)		3

Formaldehyde 0.15 – 3 ppm

Order no. 8610100

Measuring range:	0.15 to 3 ppm
Typical measuring time:	300 to 600 s
Accuracy:	± 25 % (under calibration conditions)

Permissible ambient conditions

Temperature:	0 to 40 °C
Temperature correction:	none
Humidity:	4 to 20 mg/L
Humidity correction:	< 8 mg/L → +40 % of the measured value per mg/L
	8 to 12 mg/L → none
	> 12 mg/L → -10 % of the measured value per mg/L

Cross-sensitivities

The detection of 0.6 ppm formaldehyde is not affected by:

0.25 ppm acrolein
10 ppm vinyl acetate
100 ppm styrene
50 ppm acetaldehyde
100 ppm methanol
50 ppm carbon monoxide
20 ppm propanal

A formaldehyde measurement is not possible in the presence of SO_2

Hose and probe measurements

The following purging time recommendations for remote measurements have been determined with a brand-new, dry, and clean hose and probes.

Hose / probe	Length in m	Purging time in min
FKM hose	5 – 20	3
FKM hose	45	5
PTFE-lined PVC hose	3 – 15	3
Bar probe 90 (8316532)		1
Telescopic probe ES 150 (8316533)		2
Probe set GP600 (8328667)		3

Petroleum Hydrocarbons 10 – 3000 ppm

Order no. 8610270

Measuring range:	10 to 3000 ppm cyclohexane
Typical measuring time:	10 to 360 s
Accuracy:	± 15 % (under calibration conditions)

Permissible ambient conditions

Temperature:	0 to 40 °C
Temperature correction:	< 17 °C → +5 % of the measured value per °C
	17 to 25 °C → none
	> 25 °C → -2 % of the measured value per °C
Humidity:	1 to 40 mg/L
Humidity correction:	none

Cross-sensitivities

The detection of 250 ppm cyclohexane is not affected by:

100 ppm n-hexane
250 ppm n-heptane
50 ppm n-octane
100 ppm n-nonane
100 ppm toluene
150 ppm xylene, mixed isomers

Hose and probe measurements

The following purging time recommendations for remote measurements have been determined with a brand-new, dry, and clean hose and probes.

Hose / probe	Length in m	Purging time in min
FKM hose	5 – 20	3
FKM hose	45	5
PTFE-lined PVC hose	3 – 15	3
Bar probe 90 (8316532)		1
Telescopic probe ES 150 (8316533)		2
Probe set GP600 (8328667)		3

Hydrochloric Acid 0.5 – 25 ppm

Order no. 8610090

Measuring range:	0.5 to 25 ppm
Typical measuring time:	10 to 100 s
Accuracy:	± 25 % (under calibration conditions)

Permissible ambient conditions

Temperature:	0 to 30 °C
Temperature correction:	none
Humidity:	1 to 5 mg/L
Humidity correction:	none

Cross-sensitivities

The detection of 5 ppm hydrochloric acid is not affected by:

100 ppm hydrogen sulfide

100 ppm sulfur dioxide

Hose and probe measurements

The following purging time recommendations for remote measurements have been determined with a brand-new, dry, and clean hose and probes. Hydrochloric acid is absorbed by the hose and probe material for some lengths and materials in this small concentration range.

Hose / probe	Length in m	Purging time in min
FKM hose	5	5
FKM hose	10	7
FKM hose	20	20
FKM hose	45	not possible
PTFE-lined PVC hose	3 – 15	3
Bar probe 90 (8316532)		6
Telescopic probe ES 150 (8316533)		not possible
Probe set GP600 (8328667)		5

Hydrocyanic Acid 0.5 – 50 ppm

Order no. 8610520

Measuring range:	0.5 to 50 ppm
Typical measuring time:	approx. 20 to 180 s
Accuracy:	± 15 % (under calibration conditions)

Permissible ambient conditions

Temperature:	0 to 40 °C
Temperature correction:	none
Humidity:	1 to 40 mg/L
Humidity correction:	none

Cross-sensitivities

The detection of 5 ppm hydrocyanic acid is not affected by:

200 ppm hydrochloric acid
200 ppm ammonia
25 ppm sulfur dioxide
10 ppm hydrogen sulfide

Hose and probe measurements

The following purging time recommendations for remote measurements have been determined with a brand-new, dry, and clean hose and probes. Hydrocyanic acid is absorbed by the hose and probe material for some lengths and materials in this small concentration range.

Hose / probe	Length in m	Purging time in min
FKM hose	5 – 20	3
FKM hose	45	8
PTFE-lined PVC hose	3 – 15	3
Bar probe 90 (8316532)		3
Telescopic probe ES 150 (8316533)		not possible
Probe set GP600 (8328667)		3

Hydrogen Sulfide 0.1 – 50 ppm

Order no. 8610050

Measuring range:	0.1 to 50 ppm
Typical measuring time:	5 to 350 s
Accuracy:	± 25 % (under calibration conditions)

Permissible ambient conditions

Temperature:	0 to 40 °C
Temperature correction:	none
Humidity:	1 to 40 mg/L
Humidity correction:	none

Cross-sensitivities

The detection of 1 ppm hydrogen sulfide is not affected by

100 ppm mercaptan

1 ppm sulfur dioxide

20 ppm nitrogen dioxide

Hose and probe measurements

The following purging time recommendations for remote measurements have been determined with a brand-new, dry, and clean hose and probes.

Hose / probe	Length in m	Purging time in min
FKM hose	5 – 20	3
FKM hose	45	5
PTFE-lined PVC hose	3 – 15	3
Bar probe 90 (8316532)		1
Telescopic probe ES 150 (8316533)		1
Probe set GP600 (8328667)		3

Hydrogen Sulfide 100 – 2000 ppm

Order no. 8610220

Measuring range:	100 to 2000 ppm
Typical measuring time:	15 to 180 s
Accuracy:	± 10 % (under calibration conditions)

Permissible ambient conditions

Temperature:	10 to 40 °C
Temperature correction:	none
Humidity:	1 – 40 mg/L
Humidity correction:	none

Cross-sensitivities

The detection of 250 ppm hydrogen sulfide is not affected by

25 ppm nitrogen dioxide
25 ppm sulfur dioxide
500 ppm mercaptan

Hose and probe measurements

The following purging time recommendations for remote measurements have been determined with a brand-new, dry, and clean hose and probes.

Hose / probe	Length in m	Purging time in min
FKM hose	5 – 20	3
FKM hose	45	5
PTFE-lined PVC hose	3 – 15	3
Bar probe 90 (8316532)		2
Telescopic probe ES 150 (8316533)		2
Probe set GP600 (8328667)		3

Mercaptan 50 – 6000 ppb

Order no. 8610360

Measuring range:	50 to 6000 ppb
Typical measuring time:	15 to 360 s
Accuracy:	± 25 % (under calibration conditions)

Permissible ambient conditions

Temperature:	10 to 40 °C
Temperature correction:	none
Humidity:	1 to 40 mg/L
Humidity correction:	none

Cross-sensitivities

The detection of 500 ppb mercaptan is not affected by

0.5	ppm hydrogen sulfide
15	ppm carbon monoxide
0.5	ppm ethyl mercaptan
0.5	ppm propyl mercaptan
0.5	ppm tert. butyl mercaptan

Ethyl mercaptan, propyl mercaptan, and tert. butyl mercaptan are indicated with lower sensitivities. A mercaptan detection is not possible in the presence of ethylene and tetrahydrothiophene.

Hose and probe measurements

The following purging time recommendations for remote measurements have been determined with a brand-new, dry, and clean hose and probes.

Hose / probe	Length in m	Purging time in min
FKM hose	5 – 20	4
FKM hose	45	5
PTFE-lined PVC hose	3 – 15	3
Bar probe 90 (8316532)		2
Telescopic probe ES 150 (8316533)		3
Probe set GP600 (8328667)		4

Mercury 0.005 – 0.25 mg/m³

Order no. 8610350

Measuring range:	0.005 to 0.25 mg/m³
Typical measuring time:	approx. 240 s to 1200 s
Accuracy:	± 25 % (under calibration conditions)
Permissible ambient conditions	
Temperature:	0 to 40 °C
Temperature correction:	none
Humidity:	1 to 40 mg/L
Humidity correction:	none

Cross-sensitivities

The detection of 0.025 mg/m³ mercury is not affected by:

1 Vol% methane
50 ppm benzene
200 ppm toluene
200 ppm xylene, mixed isomers

Hydrogen sulfide leads to significant plus errors. Measurement in the presence of up to 150 ppm hydrogen sulfide is only possible together with a pre-tube (3716630). A mercury measurement is not possible in the presence of hydrogen sulfide > 150 ppm.

Hose and probe measurements

The following purging time recommendations for remote measurements have been determined with a brand-new, dry, and clean hose and probes.

Hose / probe	Length in m	Purging time in min
FKM hose	5 – 20	3
FKM hose	45	5
PTFE-lined PVC hose	3 – 15	3
Bar probe 90 (8316532)		1
Telescopic probe ES 150 (8316533)		1
Probe set GP600 (8328667)		3

Methylene Chloride 10 – 500 ppm

Order no. 8610510

Measuring range:	10 to 500 ppm
Typical measuring time:	180 to 720 s
Accuracy:	± 25 % (under calibration conditions)

Permissible ambient conditions

Temperature:	10 to 40 °C
Temperature correction:	< 20 °C: + 15 % of the measured value per °C
	> 20 °C: - 4 % of the measured value per °C
Humidity:	1 to 40 mg/L
Humidity correction:	none

Cross-sensitivities

The detection of 10 ppm methylene chloride is not affected by

50	ppm hydrochloric acid
500	ppm carbon monoxide
10	ppb vinyl chloride
0.1	ppm chlorine
100	ppm n-octane
500	ppm chloromethane
10	Vol% carbon dioxide
1	ppm 1,2-dichloroethane

The detection of methylene chloride is positively influenced by perchloroethylene and trichloroethylene.

50 ppm methylene chloride + 1 ppm perchloroethylene are indicated as 170 ppm.

50 ppm methylene chloride + 1 ppm trichloroethylene are indicated as 80 ppm.

Hose and probe measurements

The following purging time recommendations for remote measurements have been determined with a brand-new, dry, and clean hose and probes.

Hose / probe	Length in m	Purging time in min
FKM hose	5 – 20	4
FKM hose	45	5
PTFE-lined PVC hose	3 – 15	5
Bar probe 90 (8316532)		1
Telescopic probe ES 150 (8316533)		2
Probe set GP600 (8328667)		4

M

Methyl Tert-Butyl Ether (MTBE) 2 – 200 ppm

Order no. 8610530

Measuring range:	2 to 200 ppm
Typical measuring time:	60 to 450 s
Accuracy:	± 25 % (under calibration conditions)

Permissible ambient conditions

Temperature:	10 to 30 °C
Temperature correction:	< 20 °C: + 12 % of the measured value per °C
	> 20 °C: - 5 % of the measured value per °C
Humidity:	1 – 30 mg/L
Humidity correction:	none

Cross-sensitivities

The detection of 50 ppm methyl tert-butyl ether (MTBE) is not affected by

150 ppm benzene
5 ppm toluene
10 ppm ethylbenzene
2 ppm xylene
100 ppm cyclohexane

Hose and probe measurements

The following purging time recommendations for remote measurements have been determined with a brand-new, dry, and clean hose and probes.

Hose / probe	Length in m	Purging time in min
FKM hose	5 – 20	3
FKM hose	45	5
TPTFE-lined PVC hose	3 – 15	3
Bar probe 90 (8316532)		2
Telescopic probe ES 150 (8316533)		2
Probe set GP600 (8328667)		2

Nitrogen Dioxide 0.25 – 25 ppm

Order no. 8610120

Measuring range:	0.25 to 25 ppm
Typical measuring time:	10 to 210 s
Accuracy:	± 20 % (under calibration conditions)
Permissible ambient conditions	
Temperature:	10 to 40 °C
Temperature correction:	none
Humidity:	1 to 30 mg/L
Humidity correction:	none

Cross-sensitivities

The detection of 1 ppm nitrogen dioxide is not affected by

0.1 ppm ozone
50 ppm sulfur dioxide
0.5 ppm chlorine

A mixture of 50 ppm sulfur dioxide and 1 ppm nitric oxide is not indicated. 1 ppm nitric oxide is not indicated.

Hose and probe measurements

The following purging time recommendations for remote measurements have been determined with a brand-new, dry, and clean hose and probes. Nitrogen dioxide is absorbed by the hose and probe material for some lengths and materials in this small concentration range.

Hose / probe	Length in m	Purging time in min
FKM hose	5 – 20	10
FKM hose	45	20
PTFE-lined PVC hose	3 – 15	3
Bar probe 90 (8316532)		2
Telescopic probe ES 150 (8316533)		not possible
Probe set GP600 (8328667)		10

Nitrous Fumes 0.25 – 50 ppm

Order no. 8610060

Measuring range:	0.25 to 50 ppm
Typical measuring time:	approx. 5 s to 120 s
Accuracy:	± 25 % (under calibration conditions)

Permissible ambient conditions

Temperature:	0 to 40 °C
Temperature correction:	none
Humidity:	1 to 30 mg/L
Humidity correction:	none

Cross-sensitivities

The detection of 1 ppm nitrous fumes is not affected by:

30 ppm sulfur dioxide
1 ppm ozone

Hose and probe measurements

The following purging time recommendations for remote measurements have been determined with a brand-new, dry, and clean hose and probes.

Hose / probe	Length in m	Purging time in min
FKM hose	5 – 20	3
FKM hose	45	5
PTFE-lined PVC hose	3 – 15	3
Bar probe 90 (8316532)		1
Telescopic probe ES 150 (8316533)		1
Probe set GP600 (8328667)		3

Ozone 10 – 1000 ppb

Order no. 8610430

Measuring range:	10 to 1000 ppb
Typical measuring time:	50 to 840 s
Accuracy:	± 20 % (under calibration conditions)
Permissible ambient conditions	
Temperature:	0 to 40 °C
Temperature correction:	none
Humidity:	1 – 30 mg/L
Humidity correction:	none

Cross-sensitivities

The detection of 250 ppb ozone is not affected by

200 ppb nitric oxide

50 ppb nitrogen dioxide

Hydrogen peroxide leads to significant plus errors, so an ozone measurement is not possible in the presence of hydrogen peroxide.

Hose and probe measurements

Hose and probe measurements are not possible with the MicroTube Ozone 10 - 1000 ppb.

Perchloroethylene 1 – 500 ppm

Order no. 8610040

Measuring range:	1 to 500 ppm
Typical measuring time:	25 to 200 s
Accuracy:	± 25 % (under calibration conditions)

Permissible ambient conditions

Temperature:	10 to 30 °C
Temperature correction:	none
Humidity:	5 to 30 mg/L
Humidity correction:	none

Cross-sensitivities

The detection of 10 ppm perchloroethylene is not affected by

50 ppm n-octane
10 ppm 1,2-dichloroethane
1 ppm vinyl chloride

Hose and probe measurements

The following purging time recommendations for remote measurements have been determined with a brand-new, dry, and clean hose and probes.

Hose / probe	Length in m	Purging time in min
FKM hose	5 – 20	3
FKM hose	45	5
PTFE-lined PVC hose	3 – 15	5
Bar probe 90 (8316532)		2
Telescopic probe ES 150 (8316533)		2
Probe set GP600 (8328667)		2

Phosgene 10 – 1000 ppb

Order no. 8610340

Measuring range:	10 to 1000 ppb
Typical measuring time:	10 to 300 s
Accuracy:	± 25 % (under calibration conditions)

Permissible ambient conditions

Temperature:	10 to 40 °C
Temperature correction:	none
Humidity:	1 to 40 mg/L
Humidity correction:	none

Cross-sensitivities

The detection of 250 ppb phosgene is not affected by

100 ppm methyl chloride

10 ppm hydrochloric acid

100 ppm carbon monoxide

Hose and probe measurements

The following purging time recommendations for remote measurements have been determined with a brand-new, dry, and clean hose and probes.

Hose / probe	Length in m	Purging time in min
FKM hose	5 – 20	20
FKM hose	45	not possible
Tygon/PTFE hose	3 – 15	5
Bar probe 90 (8316532)		10
Telescopic probe ES 150 (8316533)		not possible
Probe set GP600 (8328667)		5

Phosphine 50 – 5000 ppb

Order no. 8610400

Measuring range:	50 to 5000 ppb Measurement only possible in connection with the Dräger-Tube ppm Booster Basic (3702013).
Typical measuring time:	20 to 90 s
Accuracy:	± 25 % (under calibration conditions)
Permissible ambient conditions	
Temperature:	5 to 30 °C
Temperature correction:	none
Humidity:	1 to 25 mg/L
Humidity correction:	none

Cross-sensitivities

The detection of 200 ppb phosphine is not affected by

5000 ppb formaldehyde
5000 ppb acetylene
5000 ppb hydrochloric acid
10000 ppb methyl bromide
5000 ppb ethylene oxide
1000 ppb hydrocyanic acid

Hydrogen sulfide and ethyl mercaptan lead to plus errors; measurement in the presence of these gases is not possible.

Hose and probe measurements

Hose and probe measurements are not possible with the MicroTube Phosphine 50 – 5000 ppb. Phosphine is absorbed by the hose and probe material in this small concentration range.

Sulfur Dioxide 0.05 – 5 ppm

Order no. 8610110

Measuring range:	0.05 to 5 ppm
Typical measuring time:	20 to 480 s
Accuracy:	± 25 % (under calibration conditions)

Permissible ambient conditions

Temperature:	0 to 30 °C
Temperature correction:	none
Humidity:	1 to 20 mg/L
Humidity correction:	none

Cross-sensitivities

The detection of 0.5 ppm sulfur dioxide is not affected by:

150 ppm hydrogen sulfide
5 ppm hydrogen chloride
20 ppm nitric oxide
1 ppm sulfur dioxide and 1 ppm nitrogen dioxide indicate 4 ppm

Hose and probe measurements

The following purging time recommendations for remote measurements have been determined with a brand-new, dry, and clean hose and probes.

Hose / probe	Length in m	Purging time in min
FKM hose	5 – 20	10
FKM hose	45	20
PTFE-lined PVC hose	3 – 15	3
Bar probe 90 (8316532)		3
Telescopic probe ES 150 (8316533)		15
Probe set GP600 (8328667)		10

Toluene 10 – 1000 ppm

Order no. 8610250

Measuring range:	10 to 1000 ppm
Typical measuring time:	6 to 360 s
Accuracy:	± 20 % (under calibration conditions)

Permissible ambient conditions

Temperature:	0 to 40 °C
Temperature correction:	<10 °C → +4 % of the measured value per °C 10 to 40 °C → none
Humidity:	1 to 40 mg/L
Humidity correction:	none

Cross-sensitivities

The detection of 50 ppm toluene is not affected by:

10 ppm xylene, mixed isomers
25 ppm o-xylene
10 ppm p-xylene
300 ppm n-octane
25 ppm benzene

Hose and probe measurements

The following purging time recommendations for remote measurements have been determined with a brand-new, dry, and clean hose and probes.

Hose / probe	Length in m	Purging time in min
FKM hose	5 – 20	3
FKM hose	45	7
PTFE-lined PVC hose	3 – 15	3
Bar probe 90 (8316532)		2
Telescopic probe ES 150 (8316533)		3
Probe set GP600 (8328667)		3

Trichloroethylene 0.25 – 50 ppm

Order no. 8610320

Measuring range:	0.25 to 50 ppm
Typical measuring time:	20 to 270 s
Accuracy:	± 25 % (under calibration conditions)

Permissible ambient conditions

Temperature:	0 to 40 °C
Temperature correction:	< 20 °C: + 5.5 % of the measured value per °C
	> 20 °C: - 3.5 % of the measured value per °C
Humidity:	1 to 40 mg/L
Humidity correction:	none

Cross-sensitivities

The detection of 10 ppm trichloroethylene is not affected by:

500 ppm n-octane
5 ppm hydrochloric acid
10 ppm 1,2-dichloroethane
1 ppm vinyl chloride

0.5 ppm chlorine gives a reading of approx. 4 ppm trichloroethylene. 10 ppm methylene chloride does not give a reading. 500 ppm methylene chloride gives a reading of approx. 4 ppm trichloroethylene.

Hose and probe measurements

The following purging time recommendations for remote measurements have been determined with a brand-new, dry, and clean hose and probes.

Hose / probe	Length in m	Purging time in min
FKM hose	5 – 20	3
FKM hose	45	5
PTFE-lined PVC hose	3 – 15	3
Bar probe 90 (8316532)		2
Telescopic probe ES 150 (8316533)		2
Probe set GP600 (8328667)		3

T

Vinyl Chloride 0.1 – 10 ppm

Order no. 8610230

Measuring range:	0.1 to 10 ppm
Typical measuring time:	15 to 660 s
Accuracy:	± 20 % (under calibration conditions)

Permissible ambient conditions

Temperature:	0 to 40 °C
Temperature correction:	none
Humidity:	1 to 40 mg/L
Humidity correction:	none

Cross-sensitivities

The detection of 2 ppm vinyl chloride is not affected by

50	ppm hydrochloric acid
25	ppm chlorine
0.5	ppm trichloroethylene

Hose and probe measurements

The following purging time recommendations for remote measurements have been determined with a brand-new, dry, and clean hose and probes.

Hose / probe	Length in m	Purging time in min
FKM hose	5 – 20	3
FKM hose	45	5
PTFE-lined PVC hose	3 – 15	3
Bar probe 90 (8316532)		2
Telescopic probe ES 150 (8316533)		2
Probe set GP600 (8328667)		2

Xylene 10 – 1000 ppm

Order no. 8610260

Measuring range:	10 to 1000 ppm
Typical measuring time:	10 to 420 s
Accuracy:	± 25 % (under calibration conditions)

Permissible ambient conditions

Temperature:	0 to 40 °C
Temperature correction:	< 10 °C → +3 % of the measured value per °C
	10 to 40 °C → none
Humidity:	1 to 40 mg/L
Humidity correction:	none

Cross-sensitivities

The detection of 50 ppm xylene is not affected by:

5 ppm toluene
300 ppm n-octane
5 ppm benzene

Hose and probe measurements

The following purging time recommendations for remote measurements have been determined with a brand-new, dry, and clean hose and probes.

Hose / probe	Length in m	Purging time in min
FKM hose	5 – 20	3
FKM hose	45	20
PTFE-lined PVC hose	3 – 15	3
Bar probe 90 (8316532)		5
Telescopic probe ES 150 (8316533)		7
Probe set GP600 (8328667)		3

MicroTubes Demo

Order no. 8610290

Measuring range:	not applicable
Typical measuring time:	5 to 30 s
Accuracy:	not applicable
Permissible ambient conditions	
Temperature:	0 to 40 °C
Temperature correction:	none
Humidity:	1 to 40 mg/L
Humidity correction:	not applicable
Cross-sensitivity	not applicable
Hose and probe measurement	not applicable

6.4 Physical, Chemical, and Toxicological Data of Selected Substances

6.4.1 Explanations of the Physical, Chemical, and Toxicological Data

The table contains data and information about substances that can usually be measured using direct indicating Dräger-Tubes or MicroTubes. All information has been taken from the literature, rounded accordingly for the practical requirements, and compiled to the best of our knowledge. However, this does not imply any liability. The currency of the information, particularly the statutory limit values, is based on the OELs: August 2019, TLVs: May 2019, WELs: May 2019

Source:
Institute for Occupational Safety and Health of the German Social Accident Insurance, GESTIS – International Limit Values for Chemical Agents,
https://limitvalue.ifa.dguv.de/, August 2019

Substance name
Common names are listed in alphabetical order.

CAS number
The CAS number is an international identification number according to the Chemical Abstracts Service.

Formula
As the formula, for inorganic substances the table contains the IUPAC formula and, for organic substances, a structural formula.

Molar mass
The molar masses are shown as kg/kmol in the table.

Statutory limit values
The statutory limit values for gases, vapors, and aerosols are shown in the unit mL/m^3 (ppm) independent of the temperature and ambient pressure variables as well as in the unit mg/m^3 dependent on these variables for 20 °C and 1,013 hPa.

Occupational exposure limits in Germany
For the OELs (occupational exposure limits) applicable in Germany, the 8-hour average value for a 40-hour working week as well as the ceiling limit (short-term values and excursion factors) in line with the TRGS 900 are shown.
If no values were listed for individual substances in the TRGS 900, the values from the DFG list were used with the note "(DFG)".

Values marked with 1)

The workplace concentration corresponds to the proposed tolerance value for carcinogenic substances.

Values marked with 2)

The workplace concentration corresponds to the provisionally proposed acceptance value for carcinogenic substances.

Occupational exposure limits in the USA and Great Britain

For the TLVs (threshold limit values), the NIOSH values were used as the valid occupational exposure limits in the USA. If no values were listed for individual substances in the NIOSH list, the values from the OSHA list are used with the note "(OSHA)".

The WELs (workplace exposure limits) are the applicable occupational exposure limits in Great Britain.

[WEL in parentheses]:

The UK Advisory Committee on Toxic Substances has expressed concern that, for the limit values shown in parentheses, health may not be adequately protected because of doubts that the limit values provided are not sufficiently well-founded. These limit values were published in the UK 2002 list and its 2003 supplement, but were omitted from the list published in 2005.

For both countries, the TWA value (time-weighted average) and STEL value (short-term exposure limit) have approximately the same meaning as the OEL shift average and the OEL ceiling limit.

Values marked with "(LOQ)"

LOQ (limit of quantification) is the limit of quantification of a substance. It is the smallest concentration that can be quantitatively detected with a specified precision. Quantitative analysis results are only provided above the limit of quantification. The limit of quantification (LOQ) is always more accurate than the limit of detection.

Conversion factors

These factors aim to facilitate the quick conversion of concentrations from mL/m^3 (ppm) to mg/m^3 and vice versa.

Vapor pressure

Liquids and solids transition to their vapor phase and an equilibrium forms between the liquid or solid phase and the gaseous phase of the substance. In this context, the current saturation pressure is referred to as vapor pressure. The vapor pressure depends on the temperature. The data in the table relates to 20 °C and is provided in hPa.

Relative vapor density

The relative vapor density provides the ratio of vapor to air (air = 1) as a relative numerical value.

Solidification point

The solidification point is given in °C at 1,013 hPa.

Boiling point

The boiling point is given in °C at 1,013 hPa.

UN number

The four-digit UN number is a substance ID that is assigned to a substance or substance group by the UN Committee of Experts on the Transport of Dangerous Goods. This international marking ensures the reliable identification of the most commonly transported dangerous goods.

Hazard class

As per the Regulation on Combustible Liquids (VbF), the hazard classes are stated as defined in Section 3(1) "Definitions and introduction to combustible liquids": "Combustible liquids for the purposes of this Regulation are substances with a flash point, which are neither solid nor unctuous at 35 °C, have a vapor pressure of 3 bar or less at 50 °C, and belong to one of the following hazard classes:

1. Hazard class A:
   Liquids with a flash point not above 100 °C and which do not have the properties of hazard class B in terms of water solubility, namely
   Hazard class A I:
   Liquids with a flash point below 21 °C,

   Hazard class A II:
   Liquids with a flash point of 21 °C to 55 °C,

   Hazard class A III:
   Liquids with a flash point above 55 °C to 100 °C.

2. Hazard class B:
   Liquids with a flash point below 21 °C that dissolve in water at 15 °C or whose combustible liquid components dissolve in water at 15 °C. Combustible liquids in hazard class A III, which are heated to their flash point or beyond, are equivalent to the combustible liquids in hazard class A I."

Ignition temperature

The ignition temperature is the lowest temperature at which a combustible substance ignites when mixed with air. The temperature is given in °C for 1,013 hPa.

LEL (lower explosive limit)

The lower explosive limit is the lowest concentration of an explosive substance at which an explosion can occur in interaction with air. It is stated in Vol% for 20 °C and 1,013 hPa.

UEL (upper explosive limit)

The upper explosive limit is the highest concentration of an explosive substance at which an explosion can occur in interaction with air. It is stated in Vol% for 20 °C and 1,013 hPa.

Odor threshold

The information on the odor threshold is taken from literature that we consider adequately reliable. The information on odor thresholds often differs significantly in the literature. This is partly due to the subjective assessment of the odor. The numbers in the table should therefore only be considered guide values.

Note

A dash does not signify zero, it indicates that the relevant data is not available!

6.4.2 Data about Physical, Chemical and Toxicological Data of Selected Substances

		Acetaldehyde	Acetone	Acetylene	Acrolein
CAS number		[75-07-0]	[67-64-1]	[74-86-2]	[107-02-8]
Formula		H_3C-CHO	H_3C-CO-CH_3	C_2H_2	H_2C=CH-CHO
Molar mass	[kg/kmol]	44.05	58.08	26.04	56.06
OEL	ppm = [mL/m³]	50	500	–	0.09
	[mg/m³]	91	1200	–	0.2
Ceiling limit	[ppm]	50 (15 min) 100 (maximum value)	1000 (15 min)	–	0.18 (15 min)
TLV					
TWA	ppm = [mL/m³]	18 (LOQ)	250	–	0.1
	[mg/m³]	–	590	–	0.25
STEL	ppm = [mL/m³]	200 (OSHA)	–	2500	0.3 (15 min)
	[mg/m³]	360 (OSHA)	–	2662	0.8 (15 min)
WEL					
TWA	ppm = [mL/m³]	20	500	–	0.02
	[mg/m³]	37	1210	–	0.05
STEL	ppm = [mL/m³]	50	1500	–	0.05 (15 min)
	[mg/m³]	92	3620	–	0.12 (15 min)
Conversion factors					
1 mL/m³ = mg/m³		1.83	2.41	1.08	2.33
1 mg/m³ = mL/m³		0.55	0.41	0.92	0.43
Vapor pressure at 20 °C	[hPa]	1006	246	42473	295
Rel. vapor density		1.52	2.00	0.91	1.94
Solidification point	[°C]	-123	-95	-80.8	-88
Boiling point	[°C]	20	56	-83.8 subl.	52
UN number		1089	1090	1001	1092
Hazard class		B	B	–	A I
Ignition temperature	[°C]	155	535	305	215
LEL	[Vol%]	4	2.5	2.3	2.8
UEL	[Vol%]	57	14.3	100	31
Odor threshold (approx.)	ppm	0.2	100	670 mg/m³	0.1

		Acrylonitrile	Alcohol (ethanol)	Formic acid	Ammonia
CAS number		[107-13-1]	[64-17-5]	[64-18-6]	[7664-41-7]
Formula		$H_2C{=}CH\text{-}CN$	$H_3C\text{-}CH_2OH$	HCOOH	NH_3
Molar mass	[kg/kmol]	53.06	46.07	46.03	17.03
OEL	ppm = [mL/m³]	1.2 [1] 0.12 [2]	200	5	20
	[mg/m³]	2.6 [1] 0.26 [2]	380	9.5	14
Ceiling limit	[ppm]	9.6 (15 min) [1]	800 (15 min)	10 (15 min)	40 (15 min)
TLV					
TWA	ppm = [mL/m³]	1	1000	5	25
	[mg/m³]	–	1900	9	18
STEL	ppm = [mL/m³]	10 [1]	–	–	35
	[mg/m³]	–	–	–	25
WEL					
TWA	ppm = [mL/m³]	2	1000	5	25
	[mg/m³]	4.4	1920	9.6	18
STEL	ppm = [mL/m³]	–	–	–	35
	[mg/m³]	–	–	–	25
Conversion factors					
1 mL/m³ = mg/m³		2.21	1.92	1.91	0.71
1 mg/m³ = mL/m³		0.45	0.52	0.52	1.41
Vapor pressure at 20 °C	[hPa]	117	58	44.6	8574
Rel. vapor density		1.83	1.59	1.59	0.6
Solidification point	[°C]	-82	-114	8	-77.7
Boiling point	[°C]	77	78	101	-33.4
UN number		1093	1170	1779	1005
Hazard class		A I	B	–	–
Ignition temperature	[°C]	480	400	520	630
LEL	[Vol%]	2.8	3.1	10	15.4
UEL	[Vol%]	28	27.7	45.5	33.6
Odor threshold (approx.)	ppm	20	10	20	5

			Aniline	Arsenic trioxide	Arsine	Benzene
CAS number			[62-53-3]	[1327-53-3]	[7784-42-1]	[71-43-2]
Formula			C_6H_5-NH_2	As_2O_3	AsH_3	C_6H_6
Molar mass		[kg/kmol]	93.13	197.84	77.95	78.11
OEL	ppm =	[mL/m³]	2 (15 min)	–	0.005	0.6 [1)] 0.06 [2)]
		[mg/m³]	7.7 (15 min)	–	0.016	1.9 [1)] 0.2 [2)]
Ceiling limit		[ppm]	4 (15 min)	–	0.04 (15 min)	4.8 [1), 3)]
TLV						
TWA	ppm =	[mL/m³]	5 (OSHA)	–	0.05 (OSHA)	0.1
		[mg/m³]	19 (OSHA)	–	0.2 (OSHA)	0.32
STEL	ppm =	[mL/m³]	–	–	–	1 [1)]
		[mg/m³]	–	–	–	3.2
WEL						
TWA	ppm =	[mL/m³]	1	–	0.05	1
		[mg/m³]	4	–	0.16	–
STEL	ppm =	[mL/m³]	–	–	–	–
		[mg/m³]	–	–	–	–
Conversion factors						
1 mL/m³ = mg/m³			3.87	8.22	3.24	3.25
1 mg/m³ = mL/m³			0.26	0.12	0.31	0.31
Vapor pressure at 20 °C		[hPa]	0.681	0	16000	100
Rel. vapor density			3.22	3.865	2.69	2.7
Solidification point		[°C]	-6.0	313	-116.9	5.5
Boiling point		[°C]	184	460	-62.48	80.1
UN number			1547	1561	2188	1114
Hazard class			A III	–	–	A I
Ignition temperature		[°C]	630	–	285	555
LEL		[Vol%]	1.2	–	3.9	1.2
UEL		[Vol%]	11	–	77.8	8.6
Odor threshold (approx.)		ppm	0.5	–	0.2	5

		Hydrocyanic acid	Bromine	n-butane	1,3-butadiene
CAS number		[74-90-8]	[7726-95-6]	[106-97-8]	[106-99-0]
Formula		HCN	Br_2	H_3C-CH_2-CH_2-CH_3	H_2C=CH-CH=CH_2
Molar mass	[kg/kmol]	27.03	159.81	58.1	54.09
OEL	ppm = [mL/m³]	1.9 (DFG)	–	1000	2 1) 0.2 2)
	[mg/m³]	2.1 (DFG)	0.7	2400	5 1) 0.5 2)
Ceiling limit	[ppm]	3.8 (DFG)	0.7 (15 min)	4000 (15 min)	–
TLV					
TWA	ppm = [mL/m³]	10 (OSHA)	0.1	800	0.19 (LOQ)
	[mg/m³]	11 (OSHA)	0.7	1900	–
STEL	ppm = [mL/m³]	4.7	0.3 (15 min)	–	–
	[mg/m³]	5	2 (15 min)	–	–
WEL					
TWA	ppm = [mL/m³]	0.9	0.1	600	10
	[mg/m³]	1	0.66	1450	22
STEL	ppm = [mL/m³]	1.5 1)	0.2	750	–
	[mg/m³]	5 1)	1.3	1810	–
Conversion factors					
1 mL/m³ = mg/m³		1.12	6.62	2.42	2.25
1 mg/m³ = mL/m³		0.89	0.15	0.41	0.44
Vapor pressure at 20 °C	[hPa]	817	220	2100	2450
Rel. vapor density		0.93	5.52	2.08	1.93
Solidification point	[°C]	-13	-7.25	-138.29	-108.9
Boiling point	[°C]	26	59.47	-0.5	-4.5
UN number		1051	1744	1011	1010
Hazard class		–	–	–	–
Ignition temperature	[°C]	535	–	365	415
LEL	[Vol%]	5.5	–	1.4	1.4
UEL	[Vol%]	46.6	–	9.4	16.3
Odor threshold (approx.)	ppm	2	< 0.01	1.5	–

		n-butanol	1-butene	Chlorine	Chloroformic acid ethyl ester (ethyl formate)
CAS number		[71-36-3]	[106-98-9]	[7782-50-5]	[541-41-3]
Formula		$H_3C\text{-}(CH_2)_2\text{-}CH_2OH$	$H_2C{=}CH\text{-}CH_2\text{-}CH_3$	Cl_2	$Cl\text{-}CO\text{-}O\text{-}CH_2\text{-}CH_3$
Molar mass	[kg/kmol]	74.12	56.1	70.91	108.5
OEL	ppm = [mL/m³]	100	–	0.5	–
	[mg/m³]	310	–	1.5	–
Ceiling limit	[ppm]	100 (15 min)	–	0.5 (15 min)	–
TLV					
TWA	ppm = [mL/m³]	100 (OSHA)	–	–	–
	[mg/m³]	300 (OSHA)	–	–	–
STEL	ppm = [mL/m³]	50	–	0.5	–
	[mg/m³]	150	–	1.5	–
WEL					
TWA	ppm = [mL/m³]	–	–	–	1
	[mg/m³]	–	–	–	4.5
STEL	ppm = [mL/m³]	50	–	0.5	–
	[mg/m³]	154	–	1.5	–
Conversion factors					
1 mL/m³ = mg/m³		3.08	2.33	2.95	4.52
1 mg/m³ = mL/m³		0.33	0.43	0.34	0.22
Vapor pressure at 20 °C	[hPa]	7.6	2545	6776	54.6
Rel. vapor density		2.56	1.94	2.49	3.74
Solidification point	[°C]	-89	-185.35	-101.0	-81
Boiling point	[°C]	118	-6.2	-34.1	93
UN number		1120	1012	1017	1182
Hazard class		A II	–	–	500
Ignition temperature	[°C]	325	360	–	500
LEL	[Vol%]	1.4	1.5	–	3.7
UEL	[Vol%]	11.3	10.6	–	12.6
Odor threshold (approx.)	ppm	25	–	0.02	–

		Chloroformic acid methyl ester	Chlorobenzene	Cyanogen chloride	Chlorine dioxide
CAS number		[79-22-1]	[108-90-7]	[506-77-4]	[10049-04-4]
Formula		Cl-CO-O-CH_3	C_6H_5Cl	ClCN	ClO_2
Molar mass	[kg/kmol]	94.50	112.56	61.47	67.45
OEL	ppm = [mL/m³]	0.2	5	–	0.1
	[mg/m³]	0.78	23	–	0.28
Ceiling limit	[ppm]	0.4 (15 min)	10 (15 min)	–	0.1 (15 min)
TLV					
TWA	ppm = [mL/m³]	–	75 (OSHA)	–	0.1
	[mg/m³]	–	350 (OSHA)	–	0.3
STEL	ppm = [mL/m³]	–	–	0.3	0.3 (15 min)
	[mg/m³]	–	–	0.6	0.9 (15 min)
WEL					
TWA	ppm = [mL/m³]	–	1	–	0.1
	[mg/m³]	–	–	–	0.28
STEL	ppm = [mL/m³]	–	3	0.3	0.3
	[mg/m³]	–	–	0.77	0.84
Conversion factors					
1 mL/m³ = mg/m³		3.93	4.68	2.55	2.80
1 mg/m³ = mL/m³		0.26	0.21	0.39	0.36
Vapor pressure at 20 °C	[hPa]	127	11.7	1336	1400
Rel. vapor density		3.26	3.89	2.12	2.33
Solidification point	[°C]	-61	-45.1	-6.9	-59
Boiling point	[°C]	72	132.2	12.9	11
UN number		1238	1134	1589	–
Hazard class		–	A II	–	–
Ignition temperature	[°C]	475	590	–	–
LEL	[Vol%]	7.5	1.3	–	–
UEL	[Vol%]	26	11	–	–
Odor threshold (approx.)	ppm	–	0.2	1	–

		Chloroform	Chloroprene	Chloropicrin	Chromic acid
CAS number		[67-66-3]	[126-99-8]	[76-06-2]	[1333-82-0]
Formula		$CHCl_3$	$H_2C=CCl-CH=CH_2$	CCl_3NO_2	CrO_3
Molar mass	[kg/kmol]	119.38	88.54	164.38	99.9
OEL	ppm = [mL/m³]	0.5	1.4 (15 min)	0.1	–
	[mg/m³]	2.5	5.15 (15 min)	0.68	–
Ceiling limit	[ppm]	1 (15 min)	1.4 (15 min)	0.1 (15 min)	–
TLV					
TWA	ppm = [mL/m³]	–	–	0.1	–
	[mg/m³]	–	–	0.7	–
STEL	ppm = [mL/m³]	2 (15 min)	1	–	–
	[mg/m³]	9.78 (15 min)	3.6	–	–
WEL					
TWA	ppm = [mL/m³]	2	[10]	0.1	–
	[mg/m³]	9.9	[37]	0.68	–
STEL	ppm = [mL/m³]	–	–	0.3	–
	[mg/m³]	–	–	2.1	–
Conversion factors					
1 mL/m³ = mg/m³		4.962	3.68	6.82	–
1 mg/m³ = mL/m³		0.202	0.27	0.15	–
Vapor pressure at 20 °C	[hPa]	209	239	32	0
Rel. vapor density		4.12	3.06	–	–
Solidification point	[°C]	-63	-130	-64	198
Boiling point	[°C]	61	60	112	>250 decomp.
UN number		1888	1991	1580	1463
Hazard class		–	–	–	–
Ignition temperature	[°C]	982	440	–	–
LEL	[Vol%]	–	2.5	–	–
UEL	[Vol%]	–	20	–	–
Odor threshold (approx.)	ppm	200	15	–	–

		Cyclohexane	Cyclohexylamine	o-dichlorobenzene	p-dichlorobenzene
CAS number		[110-82-7]	[108-91-8]	[95-50-1]	[106-46-7]
Formula		C_6H_{12}	$C_6H_{11}NH_2$	$C_6H_4Cl_2$	$C_6H_4Cl_2$
Molar mass	[kg/kmol]	84.16	99.18	147.00	147.00
OEL	ppm = [mL/m³]	200	2	10	2
	[mg/m³]	700	8.2	61	12
Ceiling limit	[ppm]	800 (15 min)	4 (15 min)	20 (15 min)	4 (15 min)
TLV					
TWA	ppm = [mL/m³]	300	10	–	75 (OSHA)
	[mg/m³]	1050	40	–	450 (OSHA)
STEL	ppm = [mL/m³]	–	–	50	–
	[mg/m³]	–	–	300	–
WEL					
TWA	ppm = [mL/m³]	100	10	25	2
	[mg/m³]	350	41	153	12
STEL	ppm = [mL/m³]	300	–	50	10 (15 min)
	[mg/m³]	1050	–	306	60 (15 min)
Conversion factors					
1 mL/m³ = mg/m³		3.52	4.12	6.11	6.11
1 mg/m³ = mL/m³		0.28	0.24	0.16	0.16
Vapor pressure at 20 °C	[hPa]	104	13	1.3	1.7
Rel. vapor density		2.91	3.42	5.07	1.248
Solidification point	[°C]	6.6	-17.7	-18	53
Boiling point	[°C]	81	134	179	174
UN number		1145	2357	1591	1592
Hazard class		A I	–	A III	A III
Ignition temperature	[°C]	260	275	640	640
LEL	[Vol%]	1	1.14	1.7	1.7
UEL	[Vol%]	9.3	9.4	12	5.9
Odor threshold (approx.)	ppm	0.4	–	2	15

		1,3-dichloropropene	Dichlorvos	Diethyl ether	Dimethylacetamide
CAS number		[542-75-6]	[62-73-7]	[60-29-7]	[127-19-5]
Formula		$HCCl{=}CH\text{-}CH_2Cl$	$Cl_2C{=}CH\text{-}O\text{-}PO(OCH_3)_2$	$H_3C\text{-}CH_2\text{-}O\text{-}CH_2\text{-}CH_3$	$H_3C\text{-}CO\text{-}N(CH_3)_2$
Molar mass	[kg/kmol]	110.97	220.98	74.12	87.12
OEL	ppm = [mL/m³]	–	0.11	400	10
	[mg/m³]	–	1	1200	36
Ceiling limit	[ppm]	–	0.22 (15 min)	400 (15 min)	20 (15 min)
TLV					
TWA	ppm = [mL/m³]	1	–	400 (OSHA)	10
	[mg/m³]	5	1	1200 (OSHA)	35
STEL	ppm = [mL/m³]	–	–	–	–
	[mg/m³]	–	–	–	–
WEL					
TWA	ppm = [mL/m³]	–	[0.1]	100	10
	[mg/m³]	–	[0.92]	310	36
STEL	ppm = [mL/m³]	–	[0.39]	200	20
	[mg/m³]	–	[2.8]	620	72
Conversion factors					
1 mL/m³ = mg/m³		4.7	9.81	3.08	3.62
1 mg/m³ = mL/m³		0.21	0.11	0.33	0.28
Vapor pressure at 20 °C	[hPa]	37	0.016	586	3.3
Rel. vapor density		3.83	7.63	2.56	3.01
Solidification point	[°C]	-84	<60	-116	-20
Boiling point	[°C]	108	140	35	165
UN number		2047	2810	1155	–
Hazard class		A II	–	A I	–
Ignition temperature	[°C]	–	–	175	490
LEL	[Vol%]	5.3	–	1.7	1.8
UEL	[Vol%]	14.5	–	39.2	11.5
Odor threshold (approx.)	ppm	–	–	100	50

		Dimethyl formamide	Dimethyl sulfate	Dimethyl sulfide	Diphenylmethane diiso-cyanate (MDI)
CAS number		[68-12-2]	[77-78-1]	[75-18-3]	[101-68-8]
Formula		$HCO\text{-}N(CH_3)_2$	$(H_3CO)_2SO_2$	$(CH_3)_2S$	$(OCN\text{-}C_6H_4)_2CH_2$
Molar mass	[kg/kmol]	73.09	126.13	62.14	250.26
OEL	ppm = [mL/m³]	5	–	–	–
	[mg/m³]	15	–	–	0.05
Ceiling limit	[ppm]	10 (15 min)	–	–	0.05 [1) 2) 3)]
TLV					
TWA	ppm = [mL/m³]	10	0.1	–	0.005
	[mg/m³]	30	0.5	–	0.05
STEL	ppm = [mL/m³]	–	–	–	0.02 (10 min)
	[mg/m³]	–	–	–	0.2 (10 min)
WEL					
TWA	ppm = [mL/m³]	10	0.05	–	–
	[mg/m³]	30	0.26	–	–
STEL	ppm = [mL/m³]	20	–	–	–
	[mg/m³]	61	–	–	–
Conversion factors					
1 mL/m³ = mg/m³		3.04	5.24	2.58	10.40
1 mg/m³ = mL/m³		0.33	0.19	0.39	0.096
Vapor pressure at 20 °C	[hPa]	3.77	0.35	527	0.0001
Rel. vapor density		2.52	4.36	2.14	8.64
Solidification point	[°C]	-61	-32	-98.3	40
Boiling point	[°C]	153	188.5 decomp.	37	196
UN number		2265	1595	1164	2489
Hazard class		–	A III	A I	–
Ignition temperature	[°C]	440	450	215	520
LEL	[Vol%]	2.2	3.6	2.2	0.4
UEL	[Vol%]	16	23.2	19.7	–
Odor threshold (approx.)	ppm	100	–	0.001	–

			Epichlorohydrin	Acetic acid	Ethyl acetate	Ethyl acrylate
CAS number			[106-89-8]	[64-19-7]	[141-78-6]	[140-88-5]
Formula			$H_2C\text{-}O\text{-}CH\text{-}CH_2Cl$	$H_3C\text{–}COOH$	$H_3C\text{-}COOCH_2\text{-}CH_3$	$CH_2\text{-}CHCOOC_2H_5$
Molar mass		[kg/kmol]	92.53	60.05	88.11	100.12
OEL	ppm =	[mL/m³]	2 1) 0.6 2)	10	400	2
		[mg/m³]	8 1) 2.3 2)	25	730	83
Ceiling limit		[ppm]	4 (15 min) 1)	20 (15 min)	400 (15 min)	4 (15 min)
TLV						
TWA	ppm =	[mL/m³]	5 (OSHA)	10	400	25 (OSHA)
		[mg/m³]	19 (OSHA)	25	1400	100 (OSHA)
STEL	ppm =	[mL/m³]	–	15 (15 min)	–	–
		[mg/m³]	–	37 (15 min)	–	–
WEL						
TWA	ppm =	[mL/m³]	0.5	10	200	5
		[mg/m³]	1.9	25	730	21
STEL	ppm =	[mL/m³]	1.5	20 (15 min)	400	10 (15 min)
		[mg/m³]	5.8	50 (15 min)	1460	42 (15 min)
Conversion factors						
1 mL/m³ = mg/m³			3.85	2.5	3.66	4.15
1 mg/m³ = mL/m³			0.26	0.40	0.27	0.24
Vapor pressure at 20 °C		[hPa]	16	15.8	98.4	39.1
Rel. vapor density			3.2	2.07	3.04	3.45
Solidification point		[°C]	-48	17	-83	-75
Boiling point		[°C]	116	118	77	100
UN number			2023	2789	1173	1917
Hazard class			A II	–	A I	A I
Ignition temperature		[°C]	385	485	470	350
LEL		[Vol%]	2.3	6	2	1.7
UEL		[Vol%]	34.4	17	12.8	13
Odor threshold (approx.)		ppm	10	1	50	–

		Ethylbenzene	Ethylene	Ethylene dibromide	Ethylene glycol
CAS number		[100-41-4]	[74-85-1]	[106-93-4]	[107-21-1]
Formula		C_6H_5-CH_2-CH_3	H_2C-CH_2	C_2HyBr_2	H_2COHCH_2OH
Molar mass	[kg/kmol]	106.17	28.05	187.86	67.07
OEL	ppm = [mL/m³]	20	–	–	10 (as aerosol)
	[mg/m³]	88	–	–	26 (as aerosol)
Ceiling limit	[ppm]	40 (15 min)	–	–	20 (15 min) (as aerosol)
TLV					
TWA	ppm = [mL/m³]	100	–	0.045	–
	[mg/m³]	435	–	–	–
STEL	ppm = [mL/m³]	125 (15 min)	–	0.13 (15 min)	–
	[mg/m³]	545 (15 min)	–	–	–
WEL					
TWA	ppm = [mL/m³]	100	–	0.5	20
	[mg/m³]	441	–	3.9	52
STEL	ppm = [mL/m³]	125	–	–	40
	[mg/m³]	552	–	–	104
Conversion factors					
1 mL/m³ = mg/m³		4.41	1.17	7.80	2.58
1 mg/m³ = mL/m³		0.23	0.86	0.13	0.39
Vapor pressure at 20 °C	[hPa]	9.79	–	11.3	0.053
Rel. vapor density		3.66	0.97	6.49	2.14
Solidification point	[°C]	-95.0	-169.2	10	-16
Boiling point	[°C]	136	-103.8	131	197
UN number		1175	1962	1605	–
Hazard class		A I	–	–	–
Ignition temperature	[°C]	430	425	–	410
LEL	[Vol%]	1	2.4	–	3.2
UEL	[Vol%]	7.8	32.6	–	43
Odor threshold (approx.)	ppm	25	–	–	10

		Ethylene oxide	Ethyl glycol acetate	Ethyl mercaptan	Fluorine
CAS number		[75-21-8]	[111-15-9]	[75-08-1]	[7782-41-4]
Formula		$H_2C\text{-}O\text{-}CH_2$	$C_2H_5OC_2H_4OCOCH_3$	$H_3C\text{-}CH_2SH$	F_2
Molar mass	[kg/kmol]	44.05	132.16	62.1	37.99
OEL	ppm = [mL/m³]	1 [1)] 0.1 [2)]	2	0.5	1
	[mg/m³]	2 [4)] 0.2 [5)]	10.8	1.3	1.6
Ceiling limit	[ppm]	2 [1)] (15 min)	16 (15 min)	1 (15 min)	2 (15 min)
TLV					
TWA	ppm = [mL/m³]	0.1	0.5	–	0.1
	[mg/m³]	0.18	2.7	–	0.2
STEL	ppm = [mL/m³]	5 (10 min)	–	0.5	–
	[mg/m³]	9 (10 min)	–	1.3	–
WEL					
TWA	ppm = [mL/m³]	5	10	0.5	–
	[mg/m³]	9.2	55	1.3	–
STEL	ppm = [mL/m³]	–	–	2	1
	[mg/m³]	–	–	5.2	1.6
Conversion factors					
1 mL/m³ = mg/m³		1.83	5.49	2.59	1.58
1 mg/m³ = mL/m³		0.55	0.18	0.39	0.63
Vapor pressure at 20 °C	[hPa]	1442	2.67	576	–
Rel. vapor density		1.56	4.56	2.14	1.3
Solidification point	[°C]	-112.5	-61.7	-147.9	-219.6
Boiling point	[°C]	10.5	156	35	-188.2
UN number		1040	1172	2363	1045
Hazard class		–	A II	A I	–
Ignition temperature	[°C]	435	380	395	–
LEL	[Vol%]	2.6	1.2	2.8	–
UEL	[Vol%]	100	10.7	18	–
Odor threshold (approx.)	ppm	–	–	0.001	–

		Hydrogen fluoride	Formaldehyde	n-hexane	Hexamethylene diiso-cyanate (HDI)
CAS number		[7664-39-3]	[50-00-0]	[110-54-3]	[822-06-0]
Formula		HF	HCHO	$H_3C-(CH_2)_4-CH_3$	$OCN-(CH_2)_6-NCO$
Molar mass	[kg/kmol]	20.01	30.03	86.18	168.20
OEL	ppm = [mL/m³]	1	0.3 (DFG)	50	0.005 (as aerosol)
	[mg/m³]	0.83	0.37 (DFG)	180	0.035 (as aerosol)
Ceiling limit	[ppm]	2 (15 min)	0.6 (15 min)	400 (15 min)	0.005 (15 min) (as aerosol)
TLV					
TWA	ppm = [mL/m³]	3	0.016	50	–
	[mg/m³]	2.5	–	180	0.035
STEL	ppm = [mL/m³]	6 (15 min)	0.1 (15 min)	–	–
	[mg/m³]	5 (15 min)	–	–	0.14 (10 min)
WEL					
TWA	ppm = [mL/m³]	1.8	2	20	–
	[mg/m³]	1.5	2.5	72	–
STEL	ppm = [mL/m³]	3	2	–	–
	[mg/m³]	2.5	2.5	–	–
Conversion factors					
1 mL/m³ = mg/m³		0.83	1.25	3.58	6.99
1 mg/m³ = mL/m³		1.20	0.80	0.28	0.14
Vapor pressure at 20 °C	[hPa]	1000	–	160	0.014
Rel. vapor density		0.69	1.04	2.98	1.00
Solidification point	[°C]	-83.6	-117	-95	-67
Boiling point	[°C]	19.5	-19	68.7	255
UN number		1052	–	1208	2281
Hazard class		–	–	A I	–
Ignition temperature	[°C]	–	430	230	400
LEL	[Vol%]	4.75	7	1.0	0.9
UEL	[Vol%]	–	73	8.9	9.5
Odor threshold (approx.)	ppm	–	< 1	–	–

			Hydrazine	Iodine	Potassium cyanide (as CN)	Carbon dioxide
CAS number			[302-01-2]	[7553-56-2]	[151-50-8]	[124-38-9]
Formula			$H_2N\text{-}NH_2$	I_2	CKN	CO_2
Molar mass		[kg/kmol]	32.05	253.80	65.12	44.01
OEL	ppm =	[mL/m³]	0.017 [1] 0.0017 [2]	–	–	5000
		[mg/m³]	0.022 [1] 0.0022 [2]	–	5 (DFG) (as aerosol)	9100
Ceiling limit		[ppm]	0.034 [1] (15 min)	–	5 (DFG) (as aerosol)	10000 (15 min)
TLV						
TWA	ppm =	[mL/m³]	1 (OSHA)	–	–	5000
		[mg/m³]	1.3 (OSHA)	–	–	9000
STEL	ppm =	[mL/m³]	0.03 (120 min)	0.1	–	30000 (15 min)
		[mg/m³]	0.04 (120 min)	1	–	54000 (15 min)
WEL						
TWA	ppm =	[mL/m³]	0.02	–	–	5000
		[mg/m³]	0.03	–	–	9150
STEL	ppm =	[mL/m³]	0.1	0.1	–	15000
		[mg/m³]	0.13	1.1	–	27400
Conversion factors						
1 mL/m³ = mg/m³			1.33	10.52	–	1.83
1 mg/m³ = mL/m³			0.75	0.095	–	0.55
Vapor pressure at 20 °C		[hPa]	21	0.28	–	57258
Rel. vapor density			1.05	8.8	–	1.53
Solidification point		[°C]	1.54	113.6	635	–
Boiling point		[°C]	113.5	185.24	1625	-78.5 subl.
UN number			2029	3495	1680	1013
Hazard class			–	–	–	–
Ignition temperature		[°C]	270	–	–	–
LEL		[Vol%]	4.7	–	–	–
UEL		[Vol%]	100	–	–	–
Odor threshold (approx.)		ppm	3	–	–	odorless

			Carbon monoxide	Methacrylonitrile	Methanol	Methane
CAS number			[630-08-0]	[126-98-7]	[67-56-1]	[74-82-8]
Formula			CO	$H_2C{=}C(CH_3)CN$	H_3COH	CH_4
Molar mass		[kg/kmol]	28.01	67.09	32.04	16.04
OEL	ppm =	[mL/m³]	30	–	200	–
		[mg/m³]	35	–	270	–
Ceiling limit		[ppm]	60 (15 min)	–	800 (15 min)	–
TLV						
TWA	ppm =	[mL/m³]	35	1	200	–
		[mg/m³]	40	3	260	–
STEL	ppm =	[mL/m³]	200	–	250 (15 min)	–
		[mg/m³]	229	–	325 (15 min)	–
WEL						
TWA	ppm =	[mL/m³]	30	1	200	–
		[mg/m³]	35	2.8	266	–
STEL	ppm =	[mL/m³]	200	–	250	–
		[mg/m³]	232	–	333	–
Conversion factors						
1 mL/m³ = mg/m³			1.16	2.79	1.33	0.67
1 mg/m³ = mL/m³			0.86	0.36	0.75	1.50
Vapor pressure at 20 °C		[hPa]	–	86	128.6	–
Rel. vapor density			0.97	2.32	1.11	0.55
Solidification point		[°C]	-205.07	-36	-97.9	-182.47
Boiling point		[°C]	-191.5	90	65	-161.5
UN number			1016	1992	1230	1971/1972
Hazard class			–	A I	B	–
Ignition temperature		[°C]	605	465	440	595
LEL		[Vol%]	11.3	1.7	6	4.4
UEL		[Vol%]	75.6	13.2	50	17
Odor threshold (approx.)		ppm	odorless	–	5	–

		Methyl acrylate	Methyl bromide	Methylene chloride	Methyl ethyl ketone (MEK)
CAS number		[96-33-3]	[74-83-9]	[75-09-2]	[78-93-3]
Formula		$H_2C=CH-COOCH_3$	CH_3Br	CH_2Cl_2	$CH_3-CH_2-CO-CH_3$
Molar mass	[kg/kmol]	86.09	94.94	84.93	72.2
OEL	ppm = [mL/m³]	2	1	50	200
	[mg/m³]	7.1	3.9	180	600
Ceiling limit	[ppm]	4 (15 min)	2 (15 min)	100 (15 min)	200 (15 min)
TLV					
TWA	ppm = [mL/m³]	10	–	25 (OSHA)	200
	[mg/m³]	35	–	–	590
STEL	ppm = [mL/m³]	–	20 (OSHA)	125 (OSHA)	300 (15 min)
	[mg/m³]	–	80 (OSHA)	–	885 (15 min)
WEL					
TWA	ppm = [mL/m³]	5	5	100	200
	[mg/m³]	18	20	353	600
STEL	ppm = [mL/m³]	10 (15 min)	15	200 (15 min)	300
	[mg/m³]	36 (15 min)	59	706 (15 min)	899
Conversion factors					
1 mL/m³ = mg/m³		3.58	3.95	3.53	3.0
1 mg/m³ = mL/m³		0.28	0.25	0.28	0.33
Vapor pressure at 20 °C	[hPa]	91.1	1890	470	105
Rel. vapor density		2.97	3.36	2.93	2.48
Solidification point	[°C]	-75	-93.7	-96.7	-86
Boiling point	[°C]	80	4	40	80
UN number		1919	1062	1593	1193
Hazard class		A I	–	–	A I
Ignition temperature	[°C]	415	535	605	505
LEL	[Vol%]	1.95	8.6	13	1.5
UEL	[Vol%]	16.3	20	22	12.6
Odor threshold (approx.)	ppm	0.1	odorless	180	< 25

		Methyl isobutyl ketone	Methyl isothiocyanate (MITC)	Methyl methacrylate	Methyl mercaptan
CAS number		[108-10-1]	[624-83-9]	[80-62-6]	[74-93-1]
Formula		$(H_3C)_2C_2H_3$-CO-CH_3	H_3C-N=C=S	$H_2C=C(CH_3)COOCH_3$	H_3CSH
Molar mass	[kg/kmol]	100.16	73.11	100.12	48.1
OEL	ppm = [mL/m³]	20	0.01	50	0.5
	[mg/m³]	83	0.024	210	1
Ceiling limit	[ppm]	40 (15 min)	0.01	100 (15 min)	1 (15 min)
TLV					
TWA	ppm = [mL/m³]	50	0.02	100	–
	[mg/m³]	205	0.05	410	–
STEL	ppm = [mL/m³]	75 (15 min)	–	–	0.5 (15 min)
	[mg/m³]	300 (15 min)	–	–	1 (15 min)
WEL					
TWA	ppm = [mL/m³]	50	–	50	0.5
	[mg/m³]	208	–	208	1
STEL	ppm = [mL/m³]	100	–	100	–
	[mg/m³]	416	–	416	–
Conversion factors					
1 mL/m³ = mg/m³		4.16	3.04	4.16	2.0
1 mg/m³ = mL/m³		0.24	0.33	0.24	0.5
Vapor pressure at 20 °C	[hPa]	18.8	26	39.6	1700
Rel. vapor density		3.46	2.53	3.46	1.7
Solidification point	[°C]	-80.3	35	-48.2	-123
Boiling point	[°C]	115.9	119	101	6
UN number		1245	2477	1247	1064
Hazard class		A I	–	A I	–
Ignition temperature	[°C]	475	–	430	360
LEL	[Vol%]	1.2	–	1.7	4.1
UEL	[Vol%]	8	–	12.5	21
Odor threshold (approx.)	ppm	0.5	–	20	0.002

		Methyl tert-butyl ether (MTBE)	Sodium cyanide (as CN)	Nickel tetracarbonyl	Nitroglycol
CAS number		[1634-04-4]	[143-33-9]	[13463-39-3]	[628-96-6]
Formula		$C_5H_{12}O$	NaCN	$Ni(CO)_4$	$O_2N\text{-}O\text{-}(CH_2)_2\text{-}O\text{-}NO_2$
Molar mass	[kg/kmol]	88.15	49.0	170.73	152.06
OEL	ppm = [mL/m³]	50	–	–	0.01
	[mg/m³]	180	3.8 (DFG) (as aerosol)	–	0.063 1) 2)
Ceiling limit	[ppm]	75 (15 min)	3.8 (DFG) (as aerosol)	–	0.01 1) 2) 3)
TLV					
TWA	ppm = [mL/m³]	–	–	0.001	–
	[mg/m³]	–	–	0.007	–
STEL	ppm = [mL/m³]	–	–	–	–
	[mg/m³]	–	–	–	0.1
WEL					
TWA	ppm = [mL/m³]	25	–	–	[0.2]
	[mg/m³]	92	–	–	[1.3]
STEL	ppm = [mL/m³]	75	1	0.1 (as Ni)	[0.2]
	[mg/m³]	275	–	0.24 (as Ni)	[1.3]
Conversion factors					
1 mL/m³ = mg/m³		3.66	–	7.10	6.32
1 mg/m³ = mL/m³		0.27	–	0.14	0.16
Vapor pressure at 20 °C	[hPa]	268	–	425	0.053
Rel. vapor density		–	–	5.9	5.25
Solidification point	[°C]	-109	563	-25	-22.3
Boiling point	[°C]	55	1497	43	197.5
UN number		2398	1689	1259	–
Hazard class		–	–	A I	–
Ignition temperature	[°C]	435	–	35	217
LEL	[Vol%]	1.6	–	0.9	–
UEL	[Vol%]	8.4	–	–	–
Odor threshold (approx.)	ppm	–	–	0.2	–

		n-octane	Oil mist (mineral oil)	Ozone	n-pentane
CAS number		[111-65-9]	–	[10028-15-6]	[109-66-0]
Formula		C_8H_{18}	Mix	O_3	$H_3C\text{-}(CH_2)_3\text{-}CH_3$
Molar mass	[kg/kmol]	114.23	–	48.00	72.15
OEL	ppm = [mL/m³]	500	–	–	1000
	[mg/m³]	2400	–	–	3000
Ceiling limit	[ppm]	1000 (15 min)	–	–	2000 (15 min)
TLV					
TWA	ppm = [mL/m³]	75	–	0.1 (OSHA)	120
	[mg/m³]	350	5	0.2 (OSHA)	350
STEL	ppm = [mL/m³]	385 (15 min)	–	0.1	610 (15 min)
	[mg/m³]	1800 (15 min)	10	0.2	1800 (15 min)
WEL					
TWA	ppm = [mL/m³]	210	–	–	600
	[mg/m³]	1200	–	–	1800
STEL	ppm = [mL/m³]	–	–	0.2	–
	[mg/m³]	–	–	0.4	–
Conversion factors					
1 mL/m³ = mg/m³		4.75	–	2.00	3.00
1 mg/m³ = mL/m³		0.21	–	0.50	0.33
Vapor pressure at 20 °C	[hPa]	14	–	–	562
Rel. vapor density		3.95	–	1.66	2.49
Solidification point	[°C]	-57	liq.	-192.5	-129.7
Boiling point	[°C]	126	–	-111.9	36.1
UN number		1262	–	–	1265
Hazard class		A I	–	–	A I
Ignition temperature	[°C]	205	–	–	260
LEL	[Vol%]	0.8	–	–	1.4
UEL	[Vol%]	6.5	–	–	7.8
Odor threshold (approx.)	ppm	–	–	0.015	–

			Perchloroethylene	Phenol	Phosgene	Phosphine
CAS number			[127-18-4]	[108-95-2]	[75-44-5]	[7803-51-2]
Formula			$Cl_2C=CCl_2$	C_6H_5OH	$COCl_2$	PH_3
Molar mass		[kg/kmol]	165.83	94.11	98.92	34.00
OEL	ppm =	[mL/m³]	10	2 (as aerosol)	0.1	0.1
		[mg/m³]	69	8 (as aerosol)	0.41	0.14
Ceiling limit		[ppm]	20 (15 min)	4 (15 min) (as aerosol)	0.2 (15 min)	0.1 (15 min)
TLV						
TWA	ppm =	[mL/m³]	100 (OSHA)	5	0.1	0.3
		[mg/m³]	–	19	0.4	0.4
STEL	ppm =	[mL/m³]	200 (OSHA)	15.6 (as aerosol)	0.2 (15 min)	1 (15 min)
		[mg/m³]	–	60 (as aerosol)	0.8 (15 min)	1.0 (15 min)
WEL						
TWA	ppm =	[mL/m³]	20	2	0.02	0.1
		[mg/m³]	138	–	0.08	0.14
STEL	ppm =	[mL/m³]	40 (15 min)	–	0.06	0.2
		[mg/m³]	275 (15 min)	–	0.25	0.28
Conversion factors						
1 mL/m³ = mg/m³			6.89	3.91	4.11	1.41
1 mg/m³ = mL/m³			0.15	0.26	0.24	0.71
Vapor pressure at 20 °C		[hPa]	19.4	0.2	1564	34880
Rel. vapor density			5.73	3.25	3.5	1.18
Solidification point		[°C]	-22	41	-127.8	-133.8
Boiling point		[°C]	121	182	7.44	-87.8
UN number			1897	1671	1076	2199
Hazard class			–	A III	–	–
Ignition temperature		[°C]	>650	595	–	100
LEL		[Vol%]	–	1.3	–	1.6
UEL		[Vol%]	–	9.5	–	100
Odor threshold (approx.)		ppm	20	0.05	0.5	0.02

		Propane	Iso-propanol	Propene	Pyridine
CAS number		[74-98-6]	[67-63-0]	[115-07-1]	[110-86-1]
Formula		$H_3C\text{-}CH_2\text{-}CH_3$	$(H_3C)_2\text{-}CHOH$	$H_2C{=}CH\text{-}CH_3$	C_5H_5N
Molar mass	[kg/kmol]	44.1	60.1	42.1	79.10
OEL	ppm = [mL/m³]	1000	200	–	–
	[mg/m³]	1800	500	–	–
Ceiling limit	[ppm]	4000 (15 min)	400 (15 min)	–	–
TLV					
TWA	ppm = [mL/m³]	1000	400	–	5
	[mg/m³]	1800	980	–	15
STEL	ppm = [mL/m³]	–	500 (15 min)	–	–
	[mg/m³]	–	1225 (15 min)	–	–
WEL					
TWA	ppm = [mL/m³]	–	400	–	5
	[mg/m³]	–	999	–	16
STEL	ppm = [mL/m³]	–	500	–	10
	[mg/m³]	–	1250	–	33
Conversion factors					
1 mL/m³ = mg/m³		1.83	2.5	1.76	3.29
1 mg/m³ = mL/m³		0.55	0.4	0.57	0.31
Vapor pressure at 20 °C	[hPa]	8237	42.6	10140	20.5
Rel. vapor density		1.55	2.07	1.48	2.73
Solidification point	[°C]	-187.7	-88	-185.3	-42
Boiling point	[°C]	-42.1	82	-47.7	115
UN number		1978	1219	1077	1282
Hazard class		–	–	–	B
Ignition temperature	[°C]	470	425	485	550
LEL	[Vol%]	1.7	2	1.8	1.7
UEL	[Vol%]	10.8	13.4	11.2	10.6
Odor threshold (approx.)	ppm	–	1000	–	intolerable from 30 ppm

			Mercury	R 11 (Trichlorofluoromethane)	R 12 (Dichlorodifluoromethane)	R 22 (Chlorodifluoromethane)
CAS number			[7439-97-6]	[75-69-4]	[75-71-8]	[75-45-6]
Formula			Hg	$CFCl_3$	CF_2Cl_2	CHF_2Cl
Molar mass		[kg/kmol]	200.59	137.37	120.91	86.47
OEL	ppm =	[mL/m³]	–	1000	1000	–
		[mg/m³]	0.02	5700	5000	3600
Ceiling limit		[ppm]	0.16 (15 min)	2000 (15 min)	2000 (15 min)	–
TLV						
TWA	ppm =	[mL/m³]	–	–	1000	1000
		[mg/m³]	–	–	4950	3500
STEL	ppm =	[mL/m³]	–	1000	–	1250 (15 min)
		[mg/m³]	0.1	5600	–	4375 (15 min)
WEL						
TWA	ppm =	[mL/m³]	–	[1000]	[1000]	1000
		[mg/m³]	[0.025]	[5710]	[5030]	3590
STEL	ppm =	[mL/m³]	–	[1250]	[1250]	–
		[mg/m³]	–	[7140]	[6280]	–
Conversion factors						
1 mL/m³ = mg/m³			8.34	5.71	5.03	3.59
1 mg/m³ = mL/m³			0.12	0.18	0.20	0.28
Vapor pressure at 20 °C		[hPa]	0.0013	886.5	5700	9081
Rel. vapor density			6.93	4.73	4.29	3.03
Solidification point		[°C]	-38.8	-111	-157.8	-157.3
Boiling point		[°C]	356.72	23.6	-29.8	-40.9
UN number			2809	–	1028	1018
Hazard class			–	–	–	–
Ignition temperature		[°C]	–	–	–	635
LEL		[Vol%]	–	–	–	–
UEL		[Vol%]	–	–	–	–
Odor threshold (approx.)		ppm	odorless	–	–	–

		R 113 (1,1,2-trichlorotrifluoroethane)	R 114 (Cryofluorane)	R 12B1 (Chlorodifluorobromomethane)	R 13B1 (Bromotrifluoromethane)
CAS number		[76-13-1]	[76-14-2]	[353-59-3]	[75-63-8]
Formula		$F_2ClC\text{-}CFCl_2$	$F_2ClC\text{-}CF_2Cl$	CF_2ClBr	CF_3Br
Molar mass	[kg/kmol]	187.38	170.92	165.36	148.91
OEL	ppm = [mL/m³]	500	1000	–	1000
	[mg/m³]	3900	7100	–	6200
Ceiling limit	[ppm]	1000 (15 min)	8000 (15 min)	–	8000 (15 min)
TLV					
TWA	ppm = [mL/m³]	1000	1000	–	1000
	[mg/m³]	7600	7000	–	6100
STEL	ppm = [mL/m³]	1250 (15 min)	–	–	–
	[mg/m³]	9500 (15 min)	–	–	–
WEL					
TWA	ppm = [mL/m³]	[1000]	1000	–	[1000]
	[mg/m³]	[7790]	7110	–	[6190]
STEL	ppm = [mL/m³]	[1250]	1250	–	[1200]
	[mg/m³]	[9740]	8890	–	[7430]
Conversion factors					
1 mL/m³ = mg/m³		7.79	7.1	6.87	6.19
1 mg/m³ = mL/m³		0.13	0.14	0.15	0.16
Vapor pressure at 20 °C	[hPa]	364	1834	2294	14347
Rel. vapor density		6.47	6.11	5.93	5.23
Solidification point	[°C]	-35	-94.0	-160.5	-168.0
Boiling point	[°C]	47.6	3.6	-3.7	-58
UN number		–	1958	1974	1009
Hazard class		–	–	–	–
Ignition temperature	[°C]	680	–	–	–
LEL	[Vol%]	–	–	–	–
UEL	[Vol%]	–	–	–	–
Odor threshold (approx.)	ppm	–	–	–	–

		R 134a (1,1,1,2-tetrafluoroethane)	Nitric acid	Hydrochloric acid	Oxygen
CAS number		[811-97-2]	[7697-37-2]	[7647-01-0]	[7782-44-7]
Formula		$F_3C–CH_2F$	HNO_3	HCl	O_2
Molar mass	[kg/kmol]	102.03	63.01	36.46	32.00
OEL	ppm = [mL/m³]	1000	–	2	–
	[mg/m³]	4200	–	3	–
Ceiling limit	[ppm]	8000 (15 min)	1 (15 min)	4 (15 min)	–
TLV					
TWA	ppm = [mL/m³]	–	2	–	–
	[mg/m³]	–	5	–	–
STEL	ppm = [mL/m³]	–	4 (15 min)	5 (15 min)	–
	[mg/m³]	–	10 (15 min)	7 (15 min)	–
WEL					
TWA	ppm = [mL/m³]	1000	–	–	–
	[mg/m³]	4240	–	–	–
STEL	ppm = [mL/m³]	–	1	–	–
	[mg/m³]	–	2.6	–	–
Conversion factors					
1 mL/m³ = mg/m³		4.25	2.62	1.52	1.33
1 mg/m³ = mL/m³		0.33	0.38	0.66	0.75
Vapor pressure at 20 °C	[hPa]	5700	60	42560	–
Rel. vapor density		3.52	2.18	1.27	1.10
Solidification point	[°C]	-101	-41.6	-114.8	-219
Boiling point	[°C]	-26.1	121.8	-85.1	-183.0
UN number		3159	2032	1050	1072
Hazard class		–	–	–	–
Ignition temperature	[°C]	–	–	–	–
LEL	[Vol%]	–	–	–	–
UEL	[Vol%]	–	–	–	–
Odor threshold (approx.)	ppm	–	–	–	odorless

		Sulfur dioxide	Carbon disulfide	Sulfuric acid	Hydrogen sulfide
CAS number		[7446-09-5]	[75-15-0]	[7664-93-9]	[7783-06-4]
Formula		SO_2	CS_2	H_2SO_4	H_2S
Molar mass	[kg/kmol]	64.06	76.14	98.08	34.08
OEL	ppm = [mL/m³]	1	10	–	5
	[mg/m³]	2.5	30	0.1 (as aerosol)	7.1
Ceiling limit	[ppm]	1 (15 min)	20 (15 min)	0.1 (as aerosol)	10 (15 min)
TLV					
TWA	ppm = [mL/m³]	2	1	–	–
	[mg/m³]	5	3	1	–
STEL	ppm = [mL/m³]	5 (15 min)	10 (15 min)	–	10 (15 min)
	[mg/m³]	10 (15 min)	30 (15 min)	–	15 (15 min)
WEL					
TWA	ppm = [mL/m³]	0.5	10	–	5
	[mg/m³]	1.3	32	[1]	7
STEL	ppm = [mL/m³]	1 (15 min)	–	–	10
	[mg/m³]	2.7 (15 min)	–	–	14
Conversion factors					
1 mL/m³ = mg/m³		2.66	3.16	–	1.42
1 mg/m³ = mL/m³		0.37	0.32	–	0.71
Vapor pressure at 20 °C	[hPa]	3305	395	<0.001	18190
Rel. vapor density		2.26	2.64	3.4	1.19
Solidification point	[°C]	-75.5	-112	10	-85.7
Boiling point	[°C]	-10.1	46	335	-60.2
UN number		1079	1131	1830	1053
Hazard class		–	A I	–	–
Ignition temperature	[°C]	–	95	–	270
LEL	[Vol%]	–	0.6	–	4.3
UEL	[Vol%]	–	60	–	45.5
Odor threshold (approx.)	ppm	0.5	< 1	–	< 0.1

		Nitrogen dioxide	Styrene (monostyrene)	Sulfuryl fluoride	Tert-butyl mercaptan (TBM)
CAS number		[10102-44-0]	[100-42-5]	[2699-79-8]	[75-66-1]
Formula		NO_2	CH_5-CH=CH_2	SO_2F_2	$C_4H_{10}S$
Molar mass	[kg/kmol]	46.01	104.15	102.06	90.19
OEL	ppm = [mL/m³]	0.5 (DFG)	20	–	–
	[mg/m³]	0.95 (DFG)	86	10	–
Ceiling limit	[ppm]	0.5 (DFG)	40 (15 min)	–	–
TLV					
TWA	ppm = [mL/m³]	–	50	5	–
	[mg/m³]	–	215	20	–
STEL	ppm = [mL/m³]	1 (15 min)	100 (15 min)	10 (15 min)	–
	[mg/m³]	1.8 (15 min)	425 (15 min)	40 (15 min)	–
WEL					
TWA	ppm = [mL/m³]	0.5 (15 min)	100	5	–
	[mg/m³]	0.96 (15 min)	430	21	–
STEL	ppm = [mL/m³]	1 [1) 2)]	250	10	–
	[mg/m³]	1.91 [1) 2)]	1080	42	–
Conversion factors					
1 mL/m³ = mg/m³		1.91	4.33	4.23	3.74
1 mg/m³ = mL/m³		0.52	0.23	0.24	0.27
Vapor pressure at 20 °C	[hPa]	963	7.14	15500	241
Rel. vapor density		2.62	3.6	3.58	3.11
Solidification point	[°C]	-11.3	-31	-135.8	1
Boiling point	[°C]	21.1	145	-55.4	64
UN number		1067	2055	2191	2347
Hazard class		–	A II	–	–
Ignition temperature	[°C]	–	490	–	253
LEL	[Vol%]	–	0.97	–	1.3
UEL	[Vol%]	–	7.7	–	8.7
Odor threshold (approx.)	ppm	0.5	0.1	–	–

		Carbon tetrachloride	Tetrahydrothiophene	o-toluidine	Toluene
CAS number		[56-23-5]	[110-01-0]	[95-53-4]	[108-88-3]
Formula		CCl_4	$CH_2-C_3H_6-S$	$H_3C-C_6H_4-NH_2$	$C_6H_5-CH_3$
Molar mass	[kg/kmol]	153.82	88.17	107.16	92.14
OEL	ppm = [mL/m³]	0.5	50	0.1 (15 min)	50
	[mg/m³]	3.2	180	0.5 (15 min)	190
Ceiling limit	[ppm]	1 (15 min)	50 (15 min)	–	200 (15 min)
TLV					
TWA	ppm = [mL/m³]	10 (OSHA)	–	5 (OSHA)	100
	[mg/m³]	–	–	22 (OSHA)	375
STEL	ppm = [mL/m³]	2 (15 min)	–	–	150 (15 min)
	[mg/m³]	12.6 (15 min)	–	–	560 (15 min)
WEL					
TWA	ppm = [mL/m³]	1	–	0.2	50
	[mg/m³]	6.4	–	0.89	191
STEL	ppm = [mL/m³]	5 (15 min)	–	–	100
	[mg/m³]	32 (15 min)	–	–	384
Conversion factors					
1 mL/m³ = mg/m³		6.39	3.66	4.45	3.83
1 mg/m³ = mL/m³		0.16	0.27	0.23	0.26
Vapor pressure at 20 °C	[hPa]	119.4	19	0.18	29.1
Rel. vapor density		5.31	3.04	3.7	3.18
Solidification point	[°C]	-23.0	-96.2	-16.3	-95.0
Boiling point	[°C]	76.7	121	200	111
UN number		1846	2412	1708	1294
Hazard class		–	A I	A III	A I
Ignition temperature	[°C]	>982	200	480	535
LEL	[Vol%]	–	1.1	1.5	1
UEL	[Vol%]	–	12.3	7.5	7.8
Odor threshold (approx.)	ppm	70	–	0.5	< 5

		2,4-toulene diisocyanate (TDI)	2,6-toulene diisocyanate (TDI)	1,1,1-trichloroethane	1,1,2-trichloroethane
CAS number		[584-84-9]	[91-08-7]	[71-55-6]	[79-00-5]
Formula		H_3C-$C_6H_3(NCO)_2$	H_3C-$C_6H_3(NCO)_2$	H_3C-CCl_3	$ClCH_2$-$CHCl_2$
Molar mass	[kg/kmol]	174.16	174.16	133.40	133.4
OEL	ppm = [mL/m³]	0.005 (as aerosol)	0.005 (as aerosol)	200	10
	[mg/m³]	0.035 (as aerosol)	0.035 (as aerosol)	1100	55
Ceiling limit	[ppm]	0.005 (15 min) (as aerosol)	0.005 (15 min) (as aerosol)	200 (15 min)	20 (15 min)
TLV					
TWA	ppm = [mL/m³]	–	–	350 (OSHA)	10
	[mg/m³]	–	–	1900 (OSHA)	45
STEL	ppm = [mL/m³]	0.02 (OSHA)	0.02 (OSHA)	350 (15 min)	–
	[mg/m³]	0.14 (OSHA)	0.14 (OSHA)	1910 (15 min)	–
WEL					
TWA	ppm = [mL/m³]	–	–	200	10
	[mg/m³]	–	–	1100	45
STEL	ppm = [mL/m³]	–	–	400	–
	[mg/m³]	–	–	2220	–
Conversion factors					
1 mL/m³ = mg/m³		7.24	7.24	5.54	5.54
1 mg/m³ = mL/m³		0.14	0.14	0.18	0.18
Vapor pressure at 20 °C	[hPa]	0.03	0.02	133	25
Rel. vapor density		6.02	6.02	4.61	4.61
Solidification point	[°C]	21	18.3	-30	-35.5
Boiling point	[°C]	251	129	74	113.7
UN number		2078	2078	2831	–
Hazard class		–	–	–	–
Ignition temperature	[°C]	620	–	490	460
LEL	[Vol%]	0.9	9.0	8	8.4
UEL	[Vol%]	9.5	–	15.5	13.3
Odor threshold (approx.)	ppm	–	–	< 100	–

		Trichloroethylene	Triethylamine	Vinyl chloride	Water vapor
CAS number		[79-01-6]	[121-44-8]	[75-01-4]	[7732-18-5]
Formula		$ClHC=CCl_2$	$(H_3C\text{-}CH_2)_3N$	$H_2C=CHCl$	H_2O
Molar mass	[kg/kmol]	131.39	101.19	62.50	18.02
OEL	ppm = [mL/m³]	11 1) 6 2)	1	1	–
	[mg/m³]	60 1) 33 2)	4.2	2.6	–
Ceiling limit	[ppm]	88 1) (15 min)	2 (15 min)	–	–
TLV					
TWA	ppm = [mL/m³]	25	25 (OSHA)	1 (OSHA)	–
	[mg/m³]	–	100 (OSHA)	–	–
STEL	ppm = [mL/m³]	2 (1 h)	–	5 (OSHA)	–
	[mg/m³]	–	–	–	–
WEL					
TWA	ppm = [mL/m³]	100	2	3	–
	[mg/m³]	550	8	–	–
STEL	ppm = [mL/m³]	150	4	–	–
	[mg/m³]	820	17	–	–
Conversion factors					
1 mL/m³ = mg/m³		5.46	4.21	2.6	0.75
1 mg/m³ = mL/m³		0.18	0.24	0.38	1.33
Vapor pressure at 20 °C	[hPa]	77.6	69.6	3343	23
Rel. vapor density		4.53	49	2.16	0.631
Solidification point	[°C]	-86	-115	-153.7	0
Boiling point	[°C]	87	89	-13.4	100
UN number		1710	1296	1086	–
Hazard class		–	B	–	–
Ignition temperature	[°C]	410	215	415	–
LEL	[Vol%]	7.9	1.2	3.8	–
UEL	[Vol%]	100.0	8.0	31	–
Odor threshold (approx.)	ppm	20	–	–	–

			Hydrogen	Hydrogen peroxide	Xylene
CAS number			[1333-74-0]	[7722-84-1]	[1330-20-7]
Formula			H_2	H_2O_2	$C_6H_4(CH_3)_2$
Molar mass		[kg/kmol]	2.02	34.01	106.17
OEL	ppm =	[mL/m³]	–	0.5 (DFG)	100
		[mg/m³]	–	0.71 (DFG)	435
Ceiling limit		[ppm]	–	0.5 (DFG)	150 (15 min)
TLV					
TWA	ppm =	[mL/m³]	–	1	100
		[mg/m³]	–	1.4	435
STEL	ppm =	[mL/m³]	–	–	150 (15 min)
		[mg/m³]	–	–	655 (15 min)
WEL					
TWA	ppm =	[mL/m³]	–	1	50
		[mg/m³]	–	1.4	220
STEL	ppm =	[mL/m³]	–	2	100
		[mg/m³]	–	2.8	441
Conversion factors					
1 mL/m³ = mg/m³			0.084	1.41	4.41
1 mg/m³ = mL/m³			11.90	0.71	0.23
Vapor pressure at 20 °C		[hPa]	–	1.9	8...10
Rel. vapor density			0.07	1.17	3.67
Solidification point		[°C]	-259.1	-0.4	-5...13
Boiling point		[°C]	-252.8	150.2	136...140
UN number			1049	2015	1307
Hazard class			–	–	A II
Ignition temperature		[°C]	560	–	465
LEL		[Vol%]	4	–	1.7
UEL		[Vol%]	75.6	–	7.6
Odor threshold (approx.)		ppm	odorless	–	4

Corporate headquarters
Drägerwerk AG & Co. KGaA
Moislinger Allee 53–55
23558 Lübeck, Germany

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www.draeger.com/contact

Germany
Dräger Safety AG & Co. KGaA
Revalstrasse 1
23560 Lübeck
0800 882 883 0
+49 451 882-2080
info@draeger.com

Austria
Dräger Austria GmbH
Perfektastrasse 67
1230 Wien
+43 1 609 36 02
+43 1 699 62 42
office.austria@draeger.com

Switzerland
Dräger Schweiz AG
Waldeggstrasse 30
3097 Liebefeld
+41 58 748 74 74
+41 58 748 74 01
info.ch@draeger.com

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