



BG RCI

Berufsgenossenschaft
Rohstoffe und chemische Industrie

T 023e



Gas Detection Equipment for Explosion Protection

Use and Operation

Safe Engineering

10/2023

VISION ZERO.

ZERO ACCIDENTS – HEALTHY WORK

VISION ZERO is the vision of a world without occupational accidents and work-related illnesses. In this connection the avoidance of lethal and severe occupational accidents and illnesses is given highest priority. The goal of a comprehensive culture of risk prevention is VISION ZERO.



Further information concerning the VISION ZERO Prevention Strategy is available at: <http://visionzero.global/>

This Code of Practice particularly deals with the Golden Rule
“Identify Hazards – Control Risks”

Table of Contents

	Page
1 Area of Application.....	5
2 Terms	6
3 Selection Criteria	9
4 Specification of the Target Gas	11
5 Alarm Set Points	12
6 Oxygen Monitoring within the Scope of Explosion Protection	13
7 Fixed Gas Detection Equipment	14
7.1 Design of Fixed Gas Detection Equipment	14
7.1.1 Increased Availability	14
7.1.2 Gas Sampling.....	14
7.1.3 Installation and Design Documents.....	15
7.2 Operation of Fixed Gas Detection Equipment.....	15
7.2.1 Initial Commissioning of the Fixed Gas Detection Equipment	15
7.2.2 Operating Instructions	16
7.2.3 Alarms and Status Indications	16
7.2.4 Measures in the Event of Non-Availability.....	16
7.3 Maintenance of Fixed Gas Detection Equipment.....	16
7.3.1 Checks of the Fixed Gas Detection Equipment	17
7.3.2 Calibration and Adjustment.....	19
7.3.3 Specification of Check Intervals.....	20
7.3.4 Repair.....	21
7.3.5 Gas Detection Equipment with Automatic Self-Test Routines	21
8 Portable Gas Detection Devices.....	22
8.1 Selection of Portable Gas Detection Equipment	22
8.1.1 Power supply.....	22
8.1.2 Gas Sampling.....	22
8.1.3 Design documents	23
8.2 Operation of Portable Gas Detection Equipment.....	23
8.2.1 Initial Commissioning of the Portable Gas Detection Equipment.....	24
8.2.2 Operating Instructions	24
8.2.3 Qualification for the Use of Portable Gas Detection Equipment	24
8.3 Maintenance of Portable Gas Detection Equipment	24
8.3.1 Checks of the Portable Gas Detection Equipment.....	25
8.3.2 Calibration and Adjustment.....	26
8.3.3 Specification of Check Intervals.....	27
8.3.4 Repair.....	28
9 Transportable Gas Detection Equipment	30

10 Integration into Tests in Accordance with the Betriebssicherheitsverordnung (BetrSichV – Ordinance on Industrial Safety and Health).....	31
11 Requirements for Persons Being Charged with the Checks	33
11.1 Trained Person.....	33
11.2 Qualified Personnel.....	33
11.3 Competent Persons (Gas Detection Equipment).....	33
11.4 Specialists	34
Annex 1: Extension of the Range of Application of Gas Detection Equipment by Competent Bodies to Include Substances not Included in the EC Type-Examination of the Measuring Function	35
Annex 2: Bibliography	37
Picture credits	40

1 Area of Application

Gas detection equipment for flammable gases, whether fixed, transportable, or portable, can be used whenever there is a possibility of danger to life or property from the accumulation of flammable gas/air mixtures. Such equipment can be an aid to risk reduction by detecting the presence of flammable gases and providing appropriate audible and/or visual warnings. It can also be used to trigger specific safety measures (e.g. ventilation, plant shutdown or evacuation).

This Code of Practice gives instructions for

- > Design,
- > Initial commissioning,
- > Use,
- > Maintenance,
- > Controls,
- > Repair

of electrically operated group II devices intended for use in industrial and commercial safety applications for the detection and measurement of flammable gases and vapours or oxygen.

Note: Group II devices are suitable for potentially explosive atmospheres except for mines at risk of firedamp.

This document is a compilation of practical experience intended to assist the user. Further information can be found in the standard EN 60079-29-2¹ and the Code of Practice T 055².

It deals with gas detection systems, which may consist of

- > Gas transport to the sensor (diffusion or sampling),
- > Gas detector (with external or internal sensor),
- > Power supply,
- > Activation of connected safety equipment.

This Code of Practice applies to gas detection equipment which form a necessary part of a safety concept in accordance with

- > the Technical Rules for Industrial Safety and Health respective Technical Rules for Hazardous Substances
 - TRGS 720³
 - TRGS 721⁴
 - TRGS 722⁵
 - TRGS 723⁶ and
 - TRGS 724⁷
- > the DGUV Regel 113-001 „Explosion Protection Rules“ (EX-RL)⁸ or
- > other applicable operating regulations.

In the case of gas detection equipment for flammable gases which does not fall under this scope, application of the measures described here is also strongly recommended.

In the case of gas detection equipment, which is also used for toxic gases, the regulations of Code of Practice T 021⁹ shall also be applied.

Laws, legal ordinances, and design requirements for gas warning equipment are listed in Annex 2.

1 See Annex 2 No. 18

2 See Annex 2 No. 14

3 See Annex 2 No. 7

4 See Annex 2 No. 8

5 See Annex 2 No. 9

6 See Annex 2 No. 10

7 See Annex 2 No. 11

8 See Annex 2 No. 13

9 See Annex 2 No. 15

2 Terms

The following terms apply in this Code of Practice:

2.1 Gas Detection Equipment

Equipment for detecting of hazardous gas concentrations. In addition to the actual gas detection device, it also includes the associated power supply, possibly a sampling system, sample gas conveyance and switching contacts or signals.

2.1.1 Fixed Gas Detection Equipment

Equipment for which all parts are intended for fixed installation.

2.1.2 Transportable Gas Detection Equipment

Equipment that is not intended to be carried but can easily be moved from place to place.

2.1.3 Portable Gas Detection Equipment

Equipment that can be easily carried from place to place and used while being carried due to its design.

2.2 Flammable Gas

Gas which, when mixed with air in a certain proportion, will form an explosive gas atmosphere.

2.3 Zero Gas

Test gas that contains neither the target gas nor interfering impurities.

2.4 Test Gas

Gas mixture of known composition used to calibrate and adjust gas detection equipment.

2.5 Surrogate Test Gas

Gas/air mixture used instead of a test gas that is difficult to handle.

2.6 Calibration

Comparison of the reading of a gas detection device with a known test gas concentration, without adjustment.

2.7 Adjustment

Settings that are made to set zero and sensitivity of a gas detection device using a known zero gas or test gas.

2.8 Measuring Gas

Mixture reaching the sensor in real application. In general, it consists of air, target gas and other components.

2.9 Target Gas

Gaseous substance to be detected in the measuring gas and of which is to be warned.

2.10 Measuring Point

Location where the gas inlet of the gas detection equipment is located.

2.11 Parameter Settings

Settings of gas detection equipment necessary for its operation. These include e.g. the target gas, alarm set points and alarm configuration.

2.12 Alarm Set Point

A setting of the equipment at which the measured concentration will cause the equipment to initiate an indication, alarm or other output function.

2.13 Latching Alarm

The alarm indication remains even if the gas concentration falls below the alarm set point again. Manual acknowledgement is required to reset the alarm.

2.14 Non-latching Alarm

The alarm indication is automatically reset when the gas concentration falls below the alarm set point again.

2.15 Time of Response t_x

Time interval, between the time when an instantaneous change between clean air and test gas, or vice versa, is produced at the equipment inlet, and the time when the reading reaches a stated percentage x of the stabilized signal on the test gas.

2.16 Reaction Time

Time until a defined reaction of the gas detection equipment can be observed. This can be a particular reading or a triggered alarm. The reaction time can depend on various factors, e.g. response time of the gas detection device and the properties of gas sampling.

2.17 Leak Monitoring

Monitoring of a possible gas release point by a measuring point in the immediate vicinity.

2.18 Safety Function

The function triggered by a gas detection equipment in the event of an alarm to establish a safe state, for example visual/ acoustic alarm signal (alarm), ventilation of the endangered area, opening/closing of valves/gates (automatic switching functions) or shutdown of endangered systems or system parts (automatic triggering of emergency functions).

2.19 Explosive Limits

Explosive limits are limits of the explosive range. The lower explosive limit (LEL) or the upper explosive limit (UEL) are the lower or upper concentration limit (amount of substance) of a flammable substance in a mixture of gases, vapours, mists, or dusts with air (or another oxidizing agent) in which a flame independent of the ignition source can no longer propagate independently after ignition. The explosive limits themselves are not part of the explosive range (from TRGS 720, section 2.3 (3))¹⁰.

¹⁰ See Annex 2 No. 7

3 Selection Criteria

A gas detection equipment may only be used for such gases and vapours and in such ambient conditions (pressure, temperature, humidity) for which the gas detection equipment is suitable according to the manufacturer's specifications. The instructions in the manufacturer's instructions shall be observed.

The suitability of a gas detection equipment, including the selection and positioning of the measuring points, the measuring ranges, the alarm setpoint and the reaction time, shall be assessed with respect to the specific application in the risk assessment. If the necessary expertise is not available, the support of specialists, testing institutions or the manufacturer shall be obtained.

Note: Requirements for a specialist are described in section 11.4. A list of (German) specialists can be found on the website www.exinfo.de under page ID: #WARM (see "4. Spezialisten").

There are many application criteria which shall be taken into consideration, but which are not all covered by this Code of Practice. The standard EN 60079-29-2¹¹ provides a comprehensive overview.

Particular attention shall be paid to:

- > Intended application (e.g., plant monitoring, clearance measurement)
- > Gases or vapours to be detected
- > Measuring ranges and measurement uncertainties
- > Environmental conditions
- > Cross sensitivities
- > Interfering gases and vapours
- > Possible damage to the sensor (e.g., due to sensor poisons or gas concentrations above the measuring range)
- > Reaction time
- > Potentially explosive atmospheres

Note: A table showing various gas detectors and corresponding measuring principles can be found in the German edition, see Code of Conduct T 023.

Particular attention shall be paid to possible interfering gases at the measuring point that could impair the function of the gas detector. This also includes an adequate oxygen concentration for the sensor function. Depending on the measuring principle, type of gas and the gas concentration at the measuring point, this effect may cause faults which can range from a steady and prolonged decrease to a sudden and sharp drop in sensitivity.

The gas detectors shall be approved and correspondingly marked for use in potentially explosive atmospheres with respect to their safety as electrical equipment based on European Directive 2014/34/EU¹².

In addition, the measuring function for the intended application shall be approved for gas detectors which perform a measuring function for explosion protection in accordance with the requirements of Directive 2014/34/EU.

In the case of gas detectors intended for a measuring function for explosion protection by the manufacturer, the EU Declaration of Conformity refers to the standards EN 60079-29-1¹³ respectively EN 50104¹⁴.

Note 1: Further information may be found in sections 4.4 and 4.5 of BG RCI Code of Practice T 055¹⁵.

¹¹ See Annex 2 No. 18

¹² See Annex 2 No. 2

¹³ See Annex 2 No. 17

¹⁴ See Annex 2 No. 19

¹⁵ See Annex 2 No. 14

Note 2: On the website www.exinfo.de at page ID: #6HY9 a list of performance tested gas detection devices is given which can be used for guidance (in German).

Note 3: Gas detectors that were placed on the market before Directive 2014/34/EU came into force may continue to be used if they complied with the requirements applicable at that time. This applies also to gas detectors which were placed on the market after Directive 2014/34/EU came into force and for which previous standards harmonized with the directive were applied.

If a gas detector meets the requirements of EN 60079-29-1 or EN 50104, the user can assume that the detector can be used for most applications and performance will not deteriorate significantly by normal changes of the ambient conditions. When measuring under non-atmospheric conditions, e.g. of process gases, the manufacturer shall be consulted.

Under the following conditions, gas detectors may be used without further testing also for gases or vapours not included in the approval of the metrological performance. This applies to detectors based on the measuring principles of catalytic combustion or flame ionization, if

- > a detector was tested for propane (C_3H_8) and a higher alkane (C_nH_{2n+2}), it can also be used for the alkanes in between (C_mH_{2m+2}) with $3 < m < n$;
- > a detector was tested for ethanol and n- or i-butanol, it can also be used for propanol's and the non-tested butanol and
- > Data on calibration and adjustment of the detector for these gases are available from the manufacturer.

For other measuring principles (based on infrared absorption, semi-conductors, and flame temperature) or other substance classes, no generally valid statement can be made based on currently available data.

Employers who have demonstrated their special know-how and the availability of suitable testing facilities to the accident insurance institution or competent authority may prove the suitability for further gases themselves. The conditions listed in Annex 1 shall be satisfied. The proof remains limited to the applications of the employer himself.

4 Specification of the Target Gas

The flammable gas to be detected on site shall be identified as target gas. The concentration is generally indicated in the unit “% LEL”. In Germany, the explosive limits of a substance shall be taken from the database CHEMSAFE¹⁶ or the freely accessible database GESTIS¹⁷.

Different flammable gases or gas mixtures may occur frequently in the monitored area. The sensors of common gas detector types are sensitive to many flammable components. It is generally not possible to determine the concentration of a single flammable gas component within a mixture of flammable gases. In such cases one component of the mixture shall be identified as target gas. Particular attention then shall be paid to the components

- > with a high-volume fraction,
- > with high vapour pressures,
- > with a low Lower Explosive Limit (LEL),
- > for which the gas detector has a low sensitivity with respect to the unit of measurement “% LEL”.

If the expertise necessary for the appropriate selection of the target gas is not available, the support of specialists¹⁸, testing institutions¹⁹ or the manufacturer shall be obtained.

The selection of a mixture as target gas is possible in individual cases only where the relative concentration ratios of the mixture components in the gaseous phase are known and are constant at the location of the measuring point. Furthermore, the Lower resp. Upper Explosive Limit of the mixture shall be known.

In cases where the components or the gas mixture are not known in advance, it is necessary to choose

- > a gas detector suitable for all components that may occur,
- > that gas as target gas for which the gas detector has the lowest sensitivity with respect to the measurement unit “% LEL”.

One example are gas detectors with the measuring principle catalytic combustion which are adjusted to the target gas non-ane for the use in emergency, e.g. by fire brigades. This example is only valid for detectors with catalytic sensors and cannot be generally applied to other measuring principles, in particular IR absorption.

¹⁶ See Annex 2 No. 21

¹⁷ See Annex 2 No. 22

¹⁸ See www.exinfo.de, page ID #WARM (“under 4. Spezialisten”)

¹⁹ See www.exinfo.de, page ID #WARM (“under 4. Spezialisten”)

5 Alarm Set Points

The alarms and the measures to be taken in case of alarm activation shall be defined specifically for each application by the employer as part of his risk assessment.

Gas detection equipment generally has a pre-alarm and a main alarm. A pre-alarm allows to take early measures before the main alarm is triggered. One example is the activation of a ventilation system that limits the increase in concentration by diluting with air. The main alarm is only triggered when these measures are not effective. The main alarm is generally latching and the pre-alarm non-latching. For latching alarms, it shall be checked in situ whether the hazardous state was eliminated before the alarm will be quitted and operation will start again.

The alarm set points of the gas detection equipment shall be set low enough to allow the corresponding protective measures to be effective early enough for the specific application in case of exceedance. On the other hand, they shall be set high enough to avoid false alarms as far as possible. Experience has shown that frequent false alarms lead to a habituation effect resulting in non-observance later.

When defining the alarm set points, one shall consider delays caused by the gas transport to the detector, the response time of the gas detector and time for the protective measure to take effect. Lowering an alarm set point will result in earlier alarm triggering.

The alarm set points are typically set between 10 % and 40 % LEL when monitoring flammable gases. Alarm set points should not be set above 40 % LEL. Using the measurement signal for process control requires special validation in the risk assessment.

The alarm set points for applications when monitoring concentrations above the Upper Explosive Limit (UEL) shall be defined from case to case. No general recommendations can be given.

6 Oxygen Monitoring within the Scope of Explosion Protection

The measurement of oxygen may be necessary when monitoring the concentration

- > in the case of displacement of oxygen by an inert gas (inertisation), or
- > to maintain inert conditions (warning of an unintentional ingress of oxygen).

For inertisation measures, the alarm set points shall be set with an adequate distance to the limiting oxygen concentration²⁰ for the respective application. If the necessary expertise is not available, then the support of specialists, testing institutions or the manufacturer shall be obtained.

Monitoring of the oxygen concentration in chemical processes is not within the scope of this Code of Practice.

Gas detection equipment designed to detect oxygen deficiency or oxygen enrichment in workplace air is in the scope of Code of Practice T 021²¹.

²⁰ Cf. section 4.3 and Annex 2 of TRGS 722, see Annex 2 No. 9

²¹ See Annex 2 No. 15

7 Fixed Gas Detection Equipment

7.1 Design of Fixed Gas Detection Equipment

Gas detection equipment shall be planned by specialists as defined in section 11.4. The recommendations in EN 60079-29-2²² and the specifications in the manufacturer's instructions shall be observed.

Gas detection equipment shall be installed and operated in such a way that unauthorized persons cannot gain access to the setting elements. Software-based devices are generally equipped with corresponding access barriers by the manufacturer. The employer shall ensure that only authorized persons have access to the corresponding codes or auxiliaries.

All components of the gas detection equipment shall be installed in such a way that they are accessible for maintenance work with reasonable effort.

7.1.1 Increased Availability

The power supply shall be dimensioned such that the unrestricted operation of the gas detection equipment and the alarm equipment is ensured.

The failure of the regular power supply shall release a status indication as defined in section 7.2.3.

To increase the availability of gas warning equipment, an uninterruptible power supply can be used to ensure the function of the gas warning equipment if the regular power supply fails. The backup power supply should maintain its function until the normal supply state is restored or the monitored area is brought into a safe state.

If parts of the alarm equipment are not covered by the backup power supply, this shall be considered when designing the safety concept.

To further increase availability, a redundant design of the gas warning equipment can be helpful.

7.1.2 Gas Sampling

Aspirated gas detection equipment shall be equipped with a flow monitor providing an indication in case of flow failure.

For discontinuous measurement, e.g. use of automatic measuring point selector switches or intermittent measuring mode, the time taken for the alarm to be triggered is prolonged by the maximum occurring cycle time.

Depending on their length, sampling lines delay the alarm activation. Therefore, they shall be kept as short as possible. The estimated time delay shall be considered in the risk assessment.

Parts of the sampling system which are in contact with the measuring gas shall be suitable for the operation conditions. Some gases tend to adhere (to adsorb) to surfaces, resulting in a decrease of the concentration in the measuring gas. This effect can be significant, particularly with low gas concentrations and reactive gases. Adsorbed gases or vapours can desorb later and cause a signal even though there is no longer any gas in the monitored atmosphere at that time (memory effect). The adsorption/desorption characteristics of each gas or vapour and of the sampling line shall be taken into consideration during planning and installation of the system. The material of the sampling line shall be selected so that such effects are avoided.

²² See Annex 2 No. 18

Condensation can occur in the sampling system if the measuring gas cools down or is compressed during transport. Not only water vapour but also other components contained in the gas, including the target gas itself, can condense.

Condensate can impair the sample gas transport and hence the gas supply to the sensor if the sampling line becomes clogged. On the other hand, the measured value decreases if the component to be measured is absorbed in the condensate or condenses itself. Furthermore, subsequent samples can be contaminated if the condensate evaporates again later. It may be necessary to heat the sampling line to avoid condensation. In potentially explosive atmospheres, lines and heating facilities shall comply with the applicable regulations.

A safe drainage of the sampled gas and condensate shall be ensured.

When sampling the measuring gas from a potentially explosive atmosphere, measures are necessary to prevent zone entrainment. Parts of the sampling system which are in contact with the measuring gas shall be suitable for at least the same zone from which the sample gas is drawn in. A safe drainage of the sampled gas shall be ensured. For zone separation suitable flame arresters (fittings) can be installed on the inlet side and, if necessary, also on the outlet side of the gas detection equipment (explosive decoupling). The suitability of the flame arrester as a component according to the European Directive 2014/34/EU²³ shall be approved for the respective application.

7.1.3 Installation and Design Documents

The employer shall keep the following documents in a suitable manner:

- > Manufacturer's instructions and maintenance instructions for the gas detection equipment
- > EU declaration of conformity
- > Proof of measurement and functional design to fulfill the protection objective
- > Commissioning protocol
- > Installation plans and circuit diagrams
- > Planning documents
- > Type and concentration of the test gases to be used
- > Parameter settings of the gas detection equipment
- > Modifications and extensions of the gas detection equipment

7.2 Operation of Fixed Gas Detection Equipment

The instructions and recommendations in the manufacturer's instructions shall be followed.

7.2.1 Initial Commissioning of the Fixed Gas Detection Equipment

Gas detection equipment shall be tested for proper function after installation by a competent person (gas detection equipment)²⁴. The extent of the test should – as far as possible at this moment – correspond to that of a system check as described in section 7.3.1.3. However, at least the tests described for the functional check in section 7.3.1.2 shall be performed in conjunction with the test of the switching output functions of the gas detection equipment. The results shall be recorded. The record can be used as part of a higher-level test before commissioning of the overall system by a competent person as defined in TRBS 1201 Part 1²⁵ (for plants requiring monitoring).

²³ See Annex 2 No. 18

²⁴ For the term "Competent Person (gas detection equipment)", see section 11.3.

²⁵ See Annex 2 No. 5

7.2.2 Operating Instructions

The employer shall draw up operating instructions if a gas detection equipment for explosion protection is used. It should contain at least:

- > The measures to be initiated in the event of an alarm
- > The measures to be initiated in the event of status indications
- > The measures to be initiated in the event of non-availability
- > The person(s) to be informed in the event of an alarm, a status indication or a failure of the gas detection equipment
- > The persons responsible for checks and maintenance

If emergency plans or alarm plans for the plant to be monitored do exist, the contents of the operating instructions may be integrated there.

7.2.3 Alarms and Status Indications

Alarms (pre-alarm and main alarm) and status indications (fault and maintenance) shall be transmitted to a reporting office, e.g. to a control room or any permanently manned location, where type and origin of alarms and indications shall be distinguishable. From there, appropriate measures are initiated in accordance with the operating instructions.

If an audible and a visual alarm are given at the same time, the audible alarm may be silenced while the alarm is still active.

If safety outputs (e.g. alarm activation, switching functions) of gas detection equipment are deactivated for maintenance purposes, this state shall be clearly signaled in the reporting office, to avoid remaining of the gas detection equipment in this status by mistake.

7.2.4 Measures in the Event of Non-Availability

If the whole gas detection equipment or such a number of measuring points are not available (e.g. in the event of a fault, failure, or maintenance work) that plant sections cannot be monitored adequately, appropriate measures shall be taken to ensure that safety is maintained even during the down time of the gas detection equipment. The necessary replacement measures shall be laid down in the operating instructions, depending on the operational conditions of the plant under consideration of the personnel and temporal intervention options. These include, e.g. individually or in combination:

- > Use of non-fixed gas detection equipment
- > Additional ventilation measures
- > Elimination of ignition hazards
- > Interruption of the supply of flammable gases, vapours, or liquids
- > Purging or emptying of plant section
- > Switching off plants or plant section

Regardless of the alternative measures taken, the availability of the gas detection equipment shall be restored immediately.

7.3 Maintenance of Fixed Gas Detection Equipment

The gas detection equipment shall be maintained at regular intervals to ensure the proper performance – which requires appropriate knowledge. If the employer does not have this knowledge, he shall contact the manufacturer, specialists or testing institutions that have the appropriate knowledge on the gas detection equipment installed. The specifications and recommendations in the instructions shall be observed.

The maintenance measures are divided into visual checks, functional checks and system checks which shall be carried out at regular intervals. Any faults discovered shall be remedied immediately.

The measures, their results and assessment as well as any adjustment and repair work carried out shall be documented and the records shall be stored. The records shall also be checked regularly.²⁶

Electronic documentation of the records of inspections and repairs is permitted.

7.3.1 Checks of the Fixed Gas Detection Equipment

7.3.1.1 Visual Check

The visual check includes at least the following actions²⁷:

- > Check of gas detection equipment for mechanical damage visible from the outside
- > Check of the gas inlets (e.g. for clogging due to dust or dirt)
- > Check of the sampling system (e.g. for mechanical damage, condensation of water or solvents)
- > Check of the readiness of operation, no alarm or special states activated

The check shall be carried out by a Trained Person²⁸.

The corresponding records shall contain:

- > Identification of the gas detection equipment (e.g. plant section, measuring point)
- > Confirmation that the check has been carried out
- > Faults discovered
- > Date and clear identification of the person carrying out the check

7.3.1.2 Functional Check

The functional check includes at least the following actions²⁹:

- > Visual check as described in section 7.3.1.1
- > Application of zero gas and test gas for
 - Checking and assessing the measured value (calibration) and correction of the indication (adjustment), if necessary
 - Checking and assessing the reaction time according to the specification in the manufacturer's instructions
- > For sampling systems, where installed:
 - Checking the equipment of sample gas transport, sample gas conditioning and associated monitoring devices
 - Checking flow rate
 - Checking tightness of the entire sampling system

Triggering of switching functions is not necessary at functional check.

The check shall be carried out by Qualified Personnel³⁰.

The corresponding records shall contain:

- > Identification of the gas detection equipment (e.g. plant section, measuring point)
- > Composition of the test gases used
- > Measured values at zero gas and test gas before and after calibration/adjustment

26 For an example of recordings for a fixed gas warning device and recording control of fixed gas warning devices, see www.exinfo.de, page ID #9UUN.

27 Further information can be found in section 11.2.2 a) of EN 60079-29-2, see Annex 2 No. 18.

28 For the term "Trained Person", see section 11.1.

29 Further information can be found in section 11.2.2 b) and c) of EN 60079-29-2, see Annex 2 No. 18. The term "functional check" is used differently in this standard.

30 For the term "Qualified Personnel", see section 11.2.

- > Assessment of reaction times
- > Faults discovered
- > Work carried out
- > Date and clear identification of the person carrying out the work

The functional check replaces a visual check due at the same time.

7.3.1.3 System Check

The system check includes at least the following actions³¹:

- > Functional check as described in section 7.3.1.2
- > Checking all safety functions including the triggering of switching functions (e.g., starting technical ventilation or other measures listed in the explosion protection document)
- > Checking the safety-relevant parameter settings by comparing target/actual values, including at least the measuring range, target gas, alarm set points and settings of the switching outputs
- > Checking the reporting and recording devices
- > For sampling systems, if available: additional application of test gas at the measuring point to check and evaluate the measured value display and response time

The check shall be carried out by a Competent Person (Gas Detection Equipment)³².

The corresponding records shall contain:

- > Identification of the components of the gas detection equipment (e.g. plant section, measuring point) and the associated safety devices
- > Composition of the test gases used
- > Deviations of the parameter settings from target values
- > Measured values at zero gas and test gas before and after calibration/adjustment
- > Assessment of reaction times
- > Faults discovered
- > Work carried out
- > Date and clear identification of the person carrying out the work

The system check replaces a functional check (and visual check) due at the same time.

Note: A Competent Person shall carry out the system check in close cooperation with the employer, in particular when checking the safety functions. If this is not possible due to operational reasons, interfaces shall be specified and documented where the system check ends. The system check can also be performed part by part. The employer is responsible for ensuring that the system check is performed completely within the intervals specified.

7.3.1.4 Inspection of the Records

The inspection includes at least the following actions³³:

- > Checking the completeness of the maintenance records of the checks described in sections 7.3.1.1 to 7.3.1.3
- > Checking whether necessary measures identified during maintenance were carried out in due time
- > Checking if installation documents and operating instructions as described in sections 7.1.3 and 7.2.2 are complete and actual

The inspection of records shall be carried out by a Competent Person (Gas Detection Equipment)³⁴.

³¹ Further information can be found in section 11.2 d) of EN 60079-29-2, see Annex 2 No. 18.

³² For the term "Competent Person" (gas detection equipment), see section 11.3.

³³ Further information can be found in section 11.2.1 d) of EN 60079-29-2, see Annex 2 No. 18.

³⁴ For the term "Competent Person", see section 11.3.

The corresponding records shall contain:

- > Identification of the gas detection equipment (e.g. plant area, measuring point)
- > Confirmation that the inspection has been carried out
- > Inadequate records discovered
- > Date and clear identification of the person carrying out the work

Unless longer intervals are demanded by other regulations, the following applies: The records on visual checks and functional checks shall be kept until the records have been inspected. The records on the inspections of the records and system checks shall be kept for 10 years.

7.3.2 Calibration and Adjustment

The calibration with test gases is performed to check the measured value. The procedure is part of the functional check and the system check.

For diffusion sensors, the gas shall be applied via suitable accessories (e.g. test gas adapters) with the flow rate specified by the manufacturer.

Always adjust zero first, then the sensitivity. Finally, it is recommended to check zero again.

The test gas used for calibration shall in general be equivalent to the target gas. The test gas concentration should be in the middle of the measuring range, i.e. at approx. 50 % LEL, or at least above the set point of the main alarm. As far as technically possible, the test gas concentration should be known with a maximum uncertainty³⁵ of ± 5 % (relative).

If the target gas is difficult to handle as test gas, a surrogate test gas may be used. The surrogate test gas and the associated sensitivity setting value shall be specified and documented in consultation with the manufacturer of the gas detection equipment. Therefore, the sensitivity of the device for the target gas and the surrogate test gas shall be known. If only a surrogate test gas is used, it will not be possible to ensure that the sensitivity for the target gas is present permanently. During the system check, additional measures shall be taken to reveal poisoning, ageing and impairment of the gas inlet. This can be carried out, for example, with catalytic combustion sensors by qualitative control with measuring gas or control measurements with methane and hexane test gases. The procedure should be agreed upon with specialists, testing institutions or the manufacturer.

The selection of suitable gases for checking zero may be restricted by the measuring principle. The selection should be made in accordance with the manufacturer's recommendations. The use of ambient air is only possible if it is ensured that the air is free of target gas and gas for which the gas detector has a cross-sensitivity at the time of calibration.

Adjustment is only necessary if the deviation during calibration is more than ± 5 % LEL at concentrations up to 50 % LEL, and more than ± 10 % of the specified value for concentrations above 50 % LEL (see figure 1). The deviations specified here apply for gas detection equipment with a measuring range of 100 % LEL.

In the case of other measuring ranges or oxygen measurement, the permissible deviations shall be determined on a case-by-case basis. Assistance can be provided by specialists, testing institutions or the manufacturer.

³⁵ According to EN ISO 6142

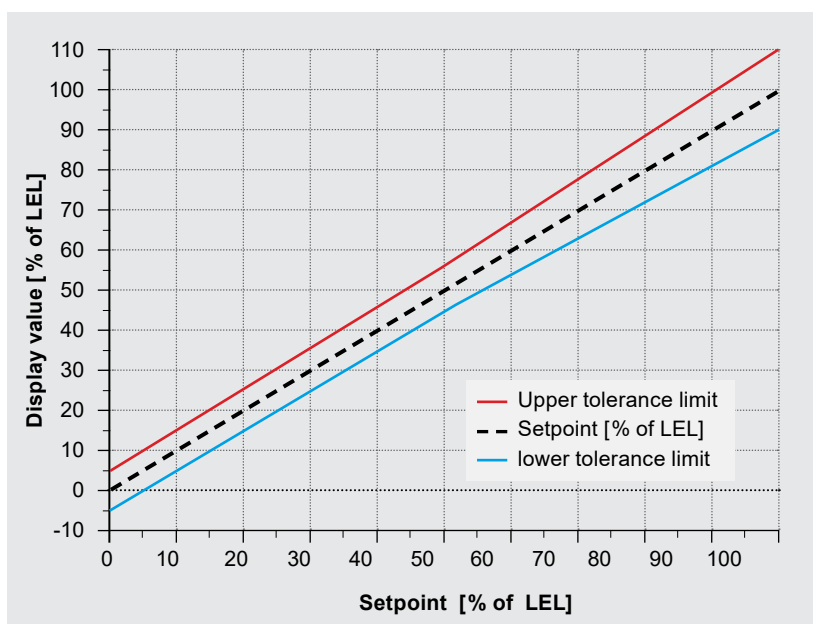


Figure 1: Tolerable deviations during calibration

7.3.3 Specification of Check Intervals

The intervals to be observed are determined as follows:

1. If sufficient experience is available for the reliability and accuracy of the measuring principle and the gas detection equipment used, the check intervals for an application under the same operating and ambient conditions can be fixed based on this experience.
2. If sufficient experience is not available for the reliability and accuracy of the measuring principle and the gas detection equipment used for the intended application, two functional checks shall be carried out at four-week intervals after commissioning. If no readjustment is required in accordance with section 7.3.2, further functional checks shall be carried out every two months. If no readjustment is required during these function checks, the maximum interval from the following table can be used.
3. If adjustment is already necessary in the first eight weeks, the function check shall be carried out at shorter intervals. Based on the experience gained, the intervals shall then be set in such a way that, as a rule, no unacceptable deterioration is to be expected between the functional checks. If the intervals become unacceptably short, it should be considered whether a more suitable measurement method can be selected.

7.3.3.1 Recommendation for the Maximum Intervals between Individual checks

Type of Check	Intervals
Visual Check	1 month
Functional Check	4 months (when using self-test routines as described in section 7.3.5: 1 year in maximum)
System Check	1 year
Inspection of Records	3 years

7.3.3.2 Fundamentals

The intervals between checks specified here apply to a wide range of common applications. If shorter or longer intervals for the checks result from the risk assessment in accordance with § 3 section 6 of the Betriebssicherheitsverordnung (BetrSichV – Ordinance on Industrial Safety and Health), these shall be used as the basis for checking the gas warning equipment.

7.3.3.3 Additional Checks

If the operating or environmental conditions change, the procedure according to number 2 of section 7.3.3 shall be applied again.

When using catalytic combustion, semiconductor or electrochemical sensors, the following applies: If the measuring range is exceeded during operation, the zero point and sensitivity may have changed permanently. In this case, the gas detection equipment shall be subjected to a function check soon afterwards, regardless of the regular interval. The function check shall then be repeated after approximately one week.

7.3.4 Repair

If a functional check proves that the sensitivity of a sensor has become so low that the required value can no longer be set or variations of climatic or operational conditions cause false alarms frequently, the sensor (or the sensing element) shall be replaced.

Note: As a rule, replacement is recommended if the residual sensitivity falls below 50 % of the initial sensitivity.

The operating and maintenance instructions apply to repairs and the replacement of parts of the gas detection equipment. For safety reasons, only original spare parts from the manufacturer of the gas detection equipment or parts specified in the operating and maintenance instructions may be used.

Note: For work that may affect the ignition protection of the electrical equipment, further requirements may need to be observed.

To carry out further repair work, a corresponding qualification is required, which can be acquired, for example, through training provided by the manufacturer of the gas detection equipment. The person carrying out this work or the employer is responsible for the proper function and condition of the gas warning equipment after repair.

After a repair, a function check or system check shall be carried out on recommissioning, depending on the type of repair.

7.3.5 Gas Detection Equipment with Automatic Self-Test Routines

For gas detection equipment with automatic self-test routines, the interval for functional checks may be extended to 1 year in maximum. The following methods are currently available:

- > Automatic calibration: At defined intervals (e.g. daily, but at least weekly), zero gas and test gas is automatically supplied to the gas detection equipment. Deviations from the required values shall be determined and assessed. It shall be ensured that an adjustment is initiated immediately when the tolerable deviations are exceeded.
- > Self-diagnosis: The method shall have been evaluated as part of the conformity assessment of the measuring performance³⁶. The following procedures are currently known:
 - Gas detection equipment with the measuring principle infrared absorption which monitors the failure of the light source and an excessive deterioration of the detector signal due to contamination, or
 - Gas detection equipment with the measuring principles flame ionization or flame temperature which monitor the flame and the flow rate of the gas sample.

³⁶ See explanations in section 2 on the application of European Directive 2014/34/EU, see Annex 2 No. 2.

8 Portable Gas Detection Devices

Portable equipment is characterized by the fact that it is carried by persons and is therefore exposed to different stresses than fixed gas detection equipment. This chapter describes the resulting requirements.

Due to the frequently varying operating locations and conditions, the probability of sudden damage to portable gas detection equipment is higher. Irrespective of the long-term stability of the equipment, this can result in an immediate impairment of the measuring performance. That is the reason why the extent and frequency of the checks differ from those for fixed gas detection equipment.

The use of suitable automated check and adjustment facilities is permitted.³⁷

8.1 Selection of Portable Gas Detection Equipment

The requirement to use a portable gas detection equipment is derived, for example, from a risk assessment or the application of technical regulations. The necessary selection is made before procurement and before use.

Portable gas detection equipment may only be procured after the suitability of the equipment in question for the intended protective function has been assessed by an specialist in accordance with section 11.4. Specific operating conditions and limits for the intended application shall be defined and documented so that they are available for the instruction of users.

The recommendations in EN 60079-29-2³⁸ and the information in the manufacturer's instructions shall be observed.

8.1.1 Power supply

The power supply, usually by batteries, shall be sufficient to ensure operation for the intended period of use.

When using additional batteries to extend the operating time, the conditions under which the batteries may be changed, shall be noted.

8.1.2 Gas Sampling

Portable gas detection equipment can be equipped with a pump to suck the sample gas. If a sampling equipment (e.g., hose with probe) is used for suction, it shall be checked for leaks.

The use of a sampling device leads to a delay in the measured value display depending on its volume. The volume should therefore be as low as possible. The expected delay shall be considered in the risk assessment.

All parts of the sampling system that carry sample gas shall be suitable for the operating conditions.

Some gases tend to adhere (adsorb) to surfaces, which leads to a decrease in concentration in the sample. This behavior can be particularly significant at low gas concentrations and with reactive gases. It can also happen that adsorbed gases or vapours later desorb and cause a signal even though there is no longer any gas present in the monitored atmosphere at that time (memory effect). The adsorption/desorption characteristics of each gas or vapour and the sampling system shall be considered during use. The material of the sampling system shall be selected in such a way that such effects are avoided. In addition it is recommended that the response time is checked regularly by feeding test gas to the gas inlet of the sampling system.

³⁷ See www.exinfo.de, page ID #9UUN

³⁸ See Annex 2 No. 18

Condensation can occur in the sampling system if the measuring gas cools down during transport. Not only water vapour but also other components contained in the gas, including the target gas itself, can condense.

On the one hand, the condensate can impair the sample gas transport and thus the gas supply to the sensor if the sample line becomes clogged. On the other hand, the measured value decreases if the component to be measured is absorbed in the condensate or condenses itself. Furthermore, subsequent samples can be contaminated if the condensate evaporates again later.

A safe drainage of the sampled gas and condensate shall be ensured.

When sampling the measuring gas from a potentially explosive atmosphere, it shall be ensured that the parts of the gas detection equipment that carry the measuring gas are at least suitable for the zone from which the measuring gas is extracted.

8.1.3 Design documents

The employer shall keep the following documents in a suitable manner:

- > Manufacturer's instructions and maintenance instructions for the gas warning equipment
- > EU Declaration of Conformity
- > Proof of measurement and functional design to fulfill the protection objective
- > Protocol of initial commissioning
- > Records about:
 - Application principles
 - Selection criteria
 - Type and concentration of the test gases to be used
 - Configuration and parameter settings of the gas warning equipment
 - Accessories used
 - Calibration or test station

8.2 Operation of Portable Gas Detection Equipment

When not in use, portable gas detection equipment shall be stored in accordance with the manufacturer's instructions in such a way that harmful influences (e.g., avoidance of poisoning of sensors by certain substances, temperature and humidity, low-shock and low-vibration storage) on the equipment and sensors are safely avoided. This also applies when the equipment is switched off.

The information and recommendations in the manufacturer's instructions shall be observed.

Portable gas detection equipment is used in various areas of application, for example:

- > Personal protection
- > Devices for clearance measuring
- > Working in hazardous areas

The use of portable gas detection equipment depends on the respective operational requirements. This can be regulated as follows, for example:

- > in the general or company-specific risk assessment
- > in the release procedure
- > in the relevant instructions for clearance measurement, for example in accordance with DGUV Regel 113-004

8.2.1 Initial Commissioning of the Portable Gas Detection Equipment

Before first use, the portable gas detection equipment, and accessories, e.g., test and adjustment equipment, pumps, hoses, shall be checked for proper function. The extent should correspond to that of a system check in accordance with point 8.3.1.3.

8.2.2 Operating Instructions

When using a portable gas detection equipment, the employer shall draw up operating instructions. It should contain the following points:

- > Carrying out the visual check and the display test
- > The measures to be initiated in the event of an alarm being triggered (e.g., leaving the work area)
- > The measures to be initiated in the event of status indications or failure of the equipment (e.g., stop work, replace equipment immediately in the event of a fault)
- > The persons to be notified in the event of an alarm being triggered, a status indication or a device failure
- > The group of persons responsible for checks and maintenance

8.2.3 Qualification for the Use of Portable Gas Detection Equipment

Persons who will use portable gas detection equipment shall be instructed in their proper application before use. This includes, among others:

- > Contents of the operating instructions according to section 8.2.2
- > Basic knowledge of how to use the equipment and the meaning of the display elements
- > Correct handling to fulfill the measuring task, e.g., do not wear portable gas detection equipment under clothing
- > Detecting obvious changes in the portable gas detection equipment
 - Gas inlet opening
 - Mechanical damage

The instruction shall be documented.

In addition to the above-mentioned contents, there may be special requirements for the use of portable gas detection equipment, for example the specialist knowledge for clearance measurement in accordance with DGUV Grundsatz 313-002.

8.3 Maintenance of Portable Gas Detection Equipment

The gas detection equipment shall be maintained at regular intervals to ensure the proper performance which requires appropriate knowledge. If the employer does not have this knowledge, he shall contact the manufacturer, specialists or test institution that have the necessary knowledge on the gas detection equipment installed. The specifications and recommendations in the instructions shall be observed.

The maintenance measures are divided into visual check and display test, functional checks and system checks which shall be carried out at regular intervals. Any faults discovered shall be remedied immediately.

The measures, their results and assessment as well as any adjustment and/or repair work carried out shall be documented. The records shall also be checked regularly.³⁹

Electronic documentation of the records of inspections and repairs is permitted.

³⁹ An example of recordings for a portable gas detection equipment and recording control of portable gas detection equipment, see www.exinfo.de, page ID #9UUN

8.3.1 Checks of the Portable Gas Detection Equipment

8.3.1.1 Visual Check and Display Test

They include at least the following actions⁴⁰.

Visual Check:

- > Check of the equipment and the accessories for mechanical damage.
- > Check of the gas inlets (e.g. for clogging due to dust or dirt).
- > Check of readiness of operation, no alarm or special states activated, when switched on.
- > If a pump is used: Perform tests of function and tightness including sampling accessories.

Display test:

- > Checking the charge condition of the batteries.
- > Application of suitable gas mixtures for testing the indication and alarm function: The employer shall specify a criterion for determining whether the test is passed. The response time of the equipment shall be taken into consideration. The recommendations in the manufacturer's instructions or in Code of Practice T 055 shall be observed.

Note: Simple checking of zero in ambient air does not meet the requirements of this display test.

The check shall be carried out by a Trained Person⁴¹.

The corresponding records shall contain:

- > Identification of the gas detection equipment (e.g. type, serial number)
- > Confirmation that the check has been carried out
- > Faults discovered
- > Date and clear identification of the person carrying out the work

8.3.1.2 Functional Check

The functional check includes at least the following actions⁴²:

- > Visual check as described in section 8.3.1.1
- > Application of zero gas and test gas for
 - Checking and assessing the measured value (calibration) and adjustment, if necessary
 - Checking and assessing the reaction time according to the specification in the instruction manual

The check shall be carried out by Qualified Personnel⁴³.

The corresponding records shall contain:

- > Identification of the gas detection equipment (e.g. type, serial number)
- > Composition of the test gases used
- > Measured values at zero gas and test gas before and after calibration/adjustment
- > Assessment of the reaction times
- > Faults discovered
- > Work carried out
- > Date and clear identification of the person carrying out the work

The functional check replaces a visual check and display test due at the same time.

⁴⁰ Further information can be found in section 9.2.2 a) of EN 60079-29-2, see Annex 2 No. 18. The terms "visual inspection and display test" are referred to there as "inspection and functional check".

⁴¹ For the term "Trained Person", see section 11.1.

⁴² Further information can be found in section 9.2.3 of EN 60079-29-2, see Annex 2 No. 18. The term "functional check" is used differently in this standard.

⁴³ For the term "Qualified Personnel", see section 11.2.

8.3.1.3 System Check

The system check includes at least the following actions⁴⁴:

- > Functional check as described in section 8.3.1.2
- > Checking the safety-relevant parameter settings by comparing target/actual values, including at least the measuring range, target gas, alarm set points and acceptance criterion of display test
- > If a data logger is installed: Export of the data and checking for plausibility
- > Assessing the state of the battery
- > Assessing the condition of accessories (e.g. hoses, filters)

Automated check and adjustment facilities shall be examined as part of the system check.

The check shall be carried out by a Competent Person (Gas Detection Equipment)⁴⁵.

The corresponding records shall contain:

- > Identification of the gas detection equipment (e.g. type, serial number)
- > Composition of the test gases used
- > Deviations of the parameter settings from the target values
- > Measured values at zero gas and test gas before and after calibration/adjustment
- > Assessment of the reaction times
- > Faults discovered
- > Work carried out
- > Date and clear identification of the person carrying out the work

The system check replaces a functional check (and visual check) due at the same time.

8.3.1.4 Inspection of the Records

The inspection includes at least the following actions⁴⁶:

- > Checking the completeness of the records on the checks described in sections 8.3.1.1 to 8.3.1.3.
- > Checking the implementation of the necessary measures identified during maintenance.
- > Checking that the operating instructions as described in section 8.2.2 are complete and actual.

The inspection of records shall be carried out by a Competent Person (Gas Detection Equipment)⁴⁷.

The corresponding records shall contain:

- > Identification of the gas detection equipment (e.g. type, serial number)
- > Confirmation that the inspection has been carried out
- > Inadequate records discovered
- > Date and clear identification of the person carrying out the work

8.3.2 Calibration and Adjustment

The calibration with test gases is performed to check the measured value. The procedure is part of the functional check and the system check.

⁴⁴ Further information can be found in section 9.2.3 of EN 60079-29-2, see Annex 2 No. 18.

⁴⁵ For the term "Competent Person (gas detection equipment)", see section 11.3.

⁴⁶ Further information can be found in section 11.2.3 c) of EN 60079-29-2, see Annex 2 No. 18.

⁴⁷ For the term "Competent Person", see section 11.3.

The gas is usually applied using suitable attachments (e.g., test adapters) with the volume flow rates specified by the manufacturer. Test gas shall be applied to equipment in pump mode non-pressurized in accordance with the manufacturer's specifications.

Always adjust zero first, then the sensitivity. Finally, it is recommended to check zero again.

The test gas used for calibration shall in general be equivalent to the target gas. The test gas concentration should be in the middle of the measuring range, i.e. at approx. 50 % LEL, or at least above the set point of the main alarm. As far as technically possible, the test gas concentration should be known with a maximum uncertainty of ± 5 % (relative).

If the target gas is difficult to handle as a test gas, a surrogate test gas may be used. The surrogate test gas and the associated sensitivity setting value shall be determined and documented in consultation with the manufacturer of the gas detection equipment. The sensitivity of the device for the target and surrogate test gas shall be known. If only a surrogate test gas is used, it will not be possible to ensure that the sensitivity for the target gas is present permanently. During the system check, additional measures shall be taken to reveal poisoning, ageing and impairment of the gas inlet. This can be carried out, for example, with catalytic bead sensors by qualitative control with measuring gas or control measurements with methane and hexane test gases. The procedure should be agreed upon with specialists, test institutions or the manufacturer.

Test gas mixtures with several gas components are available on the market, which are mainly intended for the calibration of multi-gas detectors. With certain devices, however, the use of the test gas mixture can lead to damage to individual sensors or to incorrect adjustment due to cross-sensitivities. Before using such test gas mixtures, it shall therefore be ensured whether the intended mixture is safe to use for the devices to be checked.

The selection of gases suitable for checking the zero point may be restricted by the measuring principle. The selection should be made in accordance with the manufacturer's recommendations. The use of ambient air is only possible if it is ensured that the air is free of target gas and gas for which the gas detector has a cross-sensitivity at the time of calibration.

Adjustment is only necessary if the deviation determined during calibration is more than ± 5 % LEL for concentrations up to ± 50 % LEL and more than ± 10 % of the target value for concentrations greater than 50 % LEL⁴⁸. The deviations specified here refer to gas warning devices with a measuring range end value of 100 % of the LEL.

In the case of other measuring ranges or oxygen measurement, the permissible deviations shall be determined on a case-by-case basis. Assistance can be provided by specialists, testing institutions or the manufacturer.

As part of every functional check, the reaction time shall be checked and compared with the maximum permissible time specified in the risk assessment. If the specified values are exceeded, either the sensor of the gas detection equipment shall be replaced or the accessories for the gas path, e.g., filters or hoses, shall be checked and repaired if necessary.

8.3.3 Specification of Check Intervals

8.3.3.1 Recommendation for the Maximum Intervals between Individual Checks

Type of check	Intervals
Visual Check and Display Test	Before each work shift. If it is foreseeable that the equipment will be used beyond the change of shift, this check can also be carried out every working day.
Functional Check	4 months
System Check	1 year
Inspection of Records	3 years

⁴⁸ See Figure 1 in section 7.3.2

8.3.3.2 Fundamentals

The visual inspection and display test shall be carried out so close to the time of use that the occurrence of a functional impairment can be reliably ruled out in the intervening time interval.

The intervals between checks specified here apply to a wide range of common applications. If shorter or longer intervals for the checks result from the risk assessment in accordance with § 3 section 6 of the Betriebssicherheitsverordnung (BetrSichV – Ordinance on Industrial Safety and Health), these shall be used as the basis for checking the gas detection equipment.

8.3.3.3 Additional Checks

After exceptional situations, e.g. dropping from heights > 1 m, ingress of humidity or measuring ranges being exceeded, a visual check and function shall be carried out immediately.

If there is a risk that damaging influences affect the equipment, e.g. contact with sensor poisons, it may be necessary to perform the display test during the working shift several times.

If the equipment has not been checked in accordance with 8.3.3.1 for more than two months, at least one function check shall be carried out before it is used again.

8.3.3.4 Check Intervals for Equipment used in Emergencies

Equipment that are used for time-critical operations by authorities and organizations with safety tasks⁴⁹ and for which a daily visual check and function test are not possible, for example because it is a volunteer fire department or a guard station that is not permanently manned, can be deviated from the daily visual check and display test as follows:

- > A visual check but no display test shall be performed before direct use.
- > After use (operation and exercise courses) a functional check⁵⁰ shall be performed instead.
- > Visual checks and display tests shall be performed every 4 weeks.

When following these procedures suitable storage of the equipment shall be ensured and corresponding specifications of the manufacturer shall be kept (e.g., avoidance of poisoning of sensors by certain substances, temperature and humidity, low-shock and low-vibration storage).

8.3.4 Repair

If a visual check or display test reveal that a target value has not been reached, the equipment shall be sent for repair.

If a functional check proves that the sensitivity of a sensor has become so low that the required value can no longer be set or variations of climatic or operational conditions cause false alarms frequently, the sensor (or the sensing element) shall be replaced.

Note: As a rule, replacement is recommended if the residual sensitivity falls below 50 % of the initial sensitivity.

The operating and maintenance instructions apply to repairs and the replacement of parts of the gas detection equipment. For safety reasons, only original spare parts from the manufacturer of the gas detection equipment or parts specified in the operating and maintenance instructions may be used.

⁴⁹ For example, fire brigade, police, rescue services, customs, aid organizations, technical relief organizations, disaster control units

⁵⁰ According to procedure 2 as per Code of Practice T 055 question 3.9

Note: For work that may affect the ignition protection of the electrical equipment, further requirements may need to be observed.

To carry out further repair work, a corresponding qualification is required, which can be acquired, for example, through training provided by the manufacturer of the gas detection equipment. The person carrying out this work or the employer is responsible for the proper function and condition of the gas warning equipment after repair.

After a repair, a function check or system check shall be carried out on recommissioning, depending on the type of repair.

9 Transportable Gas Detection Equipment

Transportable gas detection equipment operating at a fixed location like fixed gas detection equipment for a limited time shall comply for design, operation and maintenance with the rules and regulations described in section 7.

Transportable gas detection equipment operating at frequently changing locations is to be regarded as portable gas detection equipment. It shall comply with the rules and regulations described in section 8.

10 Integration into Tests in Accordance with the Betriebssicherheitsverordnung (BetrSichV – Ordinance on Industrial Safety and Health)

Gas warning equipment and detectors are considered work equipment according to § 2 (1) of the Betriebssicherheitsverordnung (BetrSichV – Ordinance of Safety and Health).

The inspections and suggested intervals described in this document assist the employer in fulfilling their responsibilities under § 3 (6) or § 4 (5) of BetrSichV and TRBS 1201 ff, particularly in establishing deadlines and personnel requirements.

Portable and transportable gas detectors, unless operated continuously at one location like stationary gas warning devices, are not considered as 'Anlagen' within the meaning of BetrSichV.

For gas warning devices, as components of monitored systems under

- > § 2 No. 30 sentence 1 of the ProdSG,

- > Annex 2 of BetrSichV or,

- > those subject to permission under § 18 (1) of BetrSichV,

the inspections described in this document do not replace the examinations of the entire system. However, they have been designed to incorporate the results into inspections according to the BetrSichV and can be used within an existing inspection concept.

If a gas warning device is used in potentially explosive areas, the requirements of Annex 2 section 3, Explosive Atmospheres, of BetrSichV apply.

The specified time intervals between inspections in this document apply to a broad range of typical cases concerning the requirements of BetrSichV. They can be used for gas warning devices or gas detectors to meet the requirements according to § 4 (4) BetrSichV, provided that no shorter or longer intervals are indicated in the risk assessment under § 3, especially § 6, BetrSichV.

The same applies, by analogy, to the defined measures and requirements for maintenance.

If, when applying this document to facilities in potentially explosive areas, regular inspections are to be waived due to a general maintenance concept according to Annex 2 section 3 No. 5.4 of BetrSichV, this should be considered and documented within the risk assessment. These considerations should include the design of the stationary gas warning device. The compliance and effectiveness of the implemented measures should be assessed during inspections in accordance with Annex 2 section 3 No. 4.1 and periodically according to Annex 2 section 3 No. 5.1 of BetrSichV.

The measures specified in sections 7.3 and 8.3 fulfill, for a wide range of typical cases, the requirements of § 10 (1) of the BetrSichV regarding the maintenance of gas warning devices and gas detectors. For the expertise required by § 10 (2) concerning maintenance measures, at least the knowledge of qualified personnel according to section 11.2 shall be demonstrated.

The following table establishes the connection between this Code of Practice and the requirements of the BetrSichV for inspections.

Work Equipment General Requirements and Inspection Obligations According to BetrSichV	This Code of Practice
Risk assessment and safeguard measures § 3, especially Abs. 3, 8, and 9, § 5	Selection and design by experts see section 7.1 or 8.1
§ 14 (1) Installation conditions, effectiveness of implemented safety measures	Initial commissioning see section 7.2.1 or 8.2.1
Basic obligations of the employer § 4, (5) sentence 3	Visual inspection and display test for portable measuring devices see section 8.3.1.1
§ 14 (2) Harmful impacts	Visual inspection see section 7.3.1.1 or 8.3.1.1
	Functional test see section 7.3.1.2 or 8.3.1.2
	System check see section 7.3.1.3 or 8.3.1.3
§ 14 (3) Before commissioning after repair or replacement	Functional or system check see section 7.3.1.2/7.3.1.3 or 8.3.1.2/8.3.1.3) Note: The replacement of parts distributed by the manufacturer to customers with identical components, and their installation according to the operating and maintenance manual, does not constitute a modification within the meaning of § 10 (5) BetrSichV
§ 14 (7) documentation	Inspection of the records see section 7.3.1.4 or 8.3.1.4
Additional guidance is provided by TRBS 1123, TRBS 1201 ff, and TRBS 1203	
If the gas warning device is a component of monitored systems as defined in § 2 No. 30 sentence 1 of the ProdSG, Annex 2 of BetrSichV, or subject to permission under § 18 (1) of BetrSichV, §§ 15 to 17 of BetrSichV, if applicable, also apply in conjunction with the corresponding section or annex of BetrSichV.	

11 Requirements for Persons Being Charged with the Checks

The qualifications described below refer to the gas detection equipment used in each application. General information on the content of training is given in section 10 of EN 60079-29-2⁵¹.

11.1 Trained Person

Trained Persons who perform the visual checks as described in sections 7.3.1.1 or 8.3.1.1 shall confirm at least the following state of knowledge by training and further periodic training courses⁵²:

- > Basic knowledge of the function and design of the gas detection equipment
- > Recognition of obvious changes to the gas detection equipment
- > Knowledge of the device-specific test functions and assessment of the results

A written documentation of the state of knowledge is recommended.

11.2 Qualified Personnel

Qualified Personnel who perform functional checks as described in sections 7.3.1.2 or 8.3.1.2 shall confirm at least the following state of knowledge by training and further periodic training courses:

- > State of knowledge of Trained Persons⁵³
- > Knowledge of the instructions and maintenance manual and of the operation of the control elements
- > Basic knowledge of the measuring principle
- > Knowledge of the test gases to be used and their proper handling
- > Knowledge how to carry out calibration and adjustment
- > Knowledge of the criteria for assessment of the results of the functional checks

A written documentation of the state of knowledge is recommended.

11.3 Competent Persons (Gas Detection Equipment)

Competent Persons (Gas Detection Equipment) who perform commissioning as described in sections 7.2.1 or 8.2.1, system checks as described in sections 7.3.1.3 or 8.3.1.3 and inspection of records as described in sections 7.3.1.4 or 8.3.1.4 shall confirm at least the following state of knowledge through training and further periodic training courses⁵⁴ in addition to the general requirements specified in TRBS 1203⁵⁵ or, if used in potentially explosive atmospheres, the requirements of Annex 2 section 3 No. 3.1 BetrSichV and TRBS 1201-1.

- > State of knowledge of the Qualified Personnel⁵⁶
- > Comprehensive knowledge of the use and potential applications of gas detection equipment and gas detectors
- > Knowledge of the influences on the measuring principle – the influence of interfering gases, ambient conditions, and the detection limits of the measuring principle
- > Knowledge of influences on the measuring performance – times of response and influence of accessories such as e.g. filters, sampling lines, gas conditioning
- > Comprehensive knowledge of the operation, maintenance, and repair of the gas detection equipment

⁵¹ See Annex 2 No. 18

⁵² Recommended intervals: 2 years

⁵³ For the term "Trained Person", see section 11.1.

⁵⁴ Recommended intervals: 2 years

⁵⁵ See Annex 2 No. 6

⁵⁶ For the term "Qualified Personnel", see section 11.2.

- > General knowledge of potential applications and limits of commonly used measuring principles for the measurement of flammable gases and of oxygen
- > General knowledge of the physical and chemical properties of the substances to be monitored

A written documentation of the state of knowledge is recommended.

11.4 Specialists

Specialists are persons with technical training and recent practical experience of working in the field of gas detection technology including:

- > Comprehensive knowledge of potential applications and limits of common methods for measuring flammable gases and of oxygen
- > Knowledge of the physical and chemical properties of the substances to be monitored
- > Knowledge of gas dispersion
- > Knowledge of occupational safety and explosion protection, particularly in the assessment of hazards related to potentially explosive atmospheres
- > Knowledge of the applicable regulations
- > Continuing education

Annex 1: Extension of the Range of Application of Gas Detection Equipment by Competent Bodies to Include Substances not Included in the EC Type-Examination of the Measuring Function

1. General

Gas detection equipment for use as part of explosion protection measures shall have been tested for metrological functioning. It is necessary to ensure that the substances which could form a potentially explosive mixture with air can be detected by the gas detection equipment in the particular application. The manufacturer is responsible for the basic conformity assessment of the measuring function in accordance with Directive 2014/34/EU⁵⁷. Details are part of the equipment documentation supplied.

If a substance shall be monitored which is not part of the basic conformity assessment, a competent body can provide proof on conditions stipulated in points 2 and 3 of this Annex.

2. Requirements for the competent body

The competent body shall demonstrate fulfilment of the following requirements in written form and shall submit this documentation to the authority or responsible employers' accident insurance association on demand:

- > Detailed knowledge of the physical and chemical properties of the substances to be monitored.
- > Detailed knowledge of the function of the gas detection equipment used.
- > Special knowledge and professional experience in gas detection technology.
- > Appropriate metrological equipment.

- > Facilities for production of test gases with a precision of $\pm 5\%$ relatively to the value indicated.
- > Appropriate quality management procedures for carrying out these activities.

- > Preconditions for the demonstration of the specialist knowledge are in general:
 - The head of the competent body shall have a graduation equivalent to at least a university degree in physics, chemistry, or relevant technical discipline and several years' experience in gas detection technology for explosion protection.
 - Temporarily participating persons shall have several years' experience in testing, maintenance, or repair of gas detection equipment. The qualification of these persons should be equivalent to a qualification as laboratory technician, process control technician or mechatronics specialist.
 - The competent body itself shall have adequate knowledge of the operating conditions at the place of application. This includes knowledge of substances potentially present and the ambient conditions relevant for measurement engineering.
 - The head of the competent body shall participate in regular further training and exchanges of experience.

3. Range of extension of the application

The following limitations shall be observed:

- > The design of the gas detection equipment shall not be changed.
- > Additional components used, e.g. sampling systems, shall be included in the test.
- > The metrological functioning for a new substance shall always be demonstrated by a practical test. An assessment based on theoretical knowledge is not permitted with the exceptions of the substances indicated in s 3.

The following general procedure shall be observed during the test:

- > Recording of the calibration curve at gas concentrations of the substance between 0 % and 100 % of the measuring range in steps of approx. 20 %.
- > Measurement of the response times t_{50} and t_{90} .

⁵⁷ See Annex 2 No. 2

- > Further tests if these are necessary due to the measuring principle, substance, or application, e.g. determining the influence of pressure, temperature, and humidity.
- > Measurement of the signal-to-noise ratio (repeatability).
- > The suitability for the intended safety function shall be assessed and documented in written form by the competent body.

The results of the calibrations and adjustments during the first 16 weeks of operation shall be sent to the competent body for assessment.

Annex 2: Bibliography

Laws, ordinances, and legal text of the Accident Prevention Regulations **are binding legal standards**. Deviations require permission of the competent authority and the competent Accident Insurance Institution (e.g. Berufsgenossenschaft). Issuing a special dispensation requires compensation measures at the same safety level at least.

Deviations from the technical rules for regulations, implementation instructions for accident prevention regulations (DGUV regulations) and DGUV rules are permitted if it is documented in the risk assessment that the same level of safety can be achieved by other means.

DGUV information, information sheets and DIN/VDE standards **are non-binding legal standards**. They are regarded as important assessment standards and rules of technology from which deviations are possible if the same level of safety can be achieved by other means.

Sources of Information on the Internet

The publications of the BG RCI as well as an extensive part of the state regulations and rules and those of the statutory accident insurance institutions (around 1700 titles) are available in the BG RCI's compendium of occupational safety and health. There is a charge for using the compendium on the Internet. A free, time-limited trial access is offered.

For further information see www.kompendium-as.de.

For detailed information on BG RCI publications and media and to order, see mediencenter.bgrci.de.

Numerous leaflets, annexes, and forms from leaflets and DGUV rules as well as supplementary work aids are available free of charge in the Prevention Media Center at mediencenter.bgrci.de.

Accident prevention regulations, DGUV rules, DGUV principles and lots of DGUV information can be found on the homepage of the German Social Accident Insurance (DGUV) at publikationen.dguv.de.

1. EU Publications in the Official Journal of the European Union

Sources of supply: Bundesanzeiger-Verlag, P.O. Box 10 05 34, 50445 Cologne, Germany Free download at <http://eur-lex.europa.eu/de/index.htm> and www.exinfo.de, Page ID: #QNEM

- 1 Directive 1999/92/EC of the European Parliament and of the Council of 16 December 1999 on minimum requirements for improving the safety and health protection of workers potentially at risk from explosive atmospheres
- 2 Directive 2014/34/EU of the European Parliament and of the Council of 26 February 2014 on the harmonization of the laws of the Member States relating to equipment and protective systems intended for use in potentially explosive atmospheres (recast) (for equipment and protective systems placed on the market from 20.04.2016).

2. Laws, Ordinances, Technical Rules

Sources of supply: Bookstore

Free download at www.bundesrecht.juris.de (laws and regulations) or www.baua.de (technical rules) and www.exinfo.de, page ID: #2BC9

- 3 Ordinance on Safety and Health Protection in the Use of Work Equipment (Ordinance on Industrial Safety and Health – BetrSichV) with Technical Rules for Industrial Safety (TRBS) or Ordinance on Protection against Hazardous Substances (Ordinance on Hazardous Substances – GefStoffV) with Technical Rules for Hazardous Substances (TRGS), in particular:
- 4 TRBS 1201: Prüfungen von Arbeitsmitteln und überwachungsbedürftigen Anlagen
- 5 TRBS 1201 Teil 1: Prüfung von Anlagen in explosionsgefährdeten Bereichen
- 6 TRBS 1203: Zur Prüfung befähigte Personen
- 7 TRGS 720: Gefährliche explosionsfähige Gemische – Allgemeines
- 8 TRGS 721: Gefährliche explosionsfähige Gemische – Beurteilung der Explosionsgefährdung
- 9 TRGS 722: Vermeidung oder Einschränkung gefährlicher explosionsfähiger Atmosphäre
- 10 TRGS 723: Gefährliche explosionsfähige Gemische – Vermeidung der Entzündung gefährlicher explosionsfähiger Gemische
- 11 TRGS 724: Gefährliche explosionsfähige Gemische – Maßnahmen des konstruktiven Explosionsschutzes, welche die Auswirkung einer Explosion auf ein unbedenkliches Maß beschränken
- 12 Elfte Verordnung zum Produktsicherheitsgesetz (Explosionsschutzprodukteverordnung – 11. ProdSV) in der Fassung der Bekanntmachung vom 6. Januar 2016 zuletzt geändert durch Artikel 25 des Gesetzes vom 27. Juli 2021

3. Accident Prevention Regulations, DGUV Rules, DGUV Principles, Codes of Practice and Other Publications of Accident Insurance Institutions

Sources of supply: Carl Heymanns Verlag, Luxemburger Straße 449, 50939 Köln, www.arbeitssicherheit.de

Freier Download der Inhalte unter www.exinfo.de

- 13 DGUV Regel 113-001: Explosionsschutz-Regeln (EX-RL) – Sammlung technischer Regeln für das Vermeiden der Gefahren durch explosionsfähige Atmosphäre mit Beispielsammlung zur Einteilung explosionsgefährdeter Bereiche in Zonen

Sources of supply: Berufsgenossenschaft Rohstoffe und chemische Industrie, Postfach 10 14 80, 69004 Heidelberg, mediencenter.bgrci.de or Jedermann-Verlag GmbH, Postfach 10 31 40, 69021 Heidelberg, www.jedermann.de, verkauf@jedermann.de and at www.exinfo.de, Seiten-ID: #MAMS

Member companies of the BG RCI can obtain the following publications (down to the next source reference) free of charge in quantities commensurate with the size of the company.

- 14 Merkblatt T 055: Gaswarneinrichtungen und -geräte für den Explosionsschutz – Antworten auf häufig gestellte Fragen
- 15 Code of Practice T 021e: Gas Detection Equipment for Toxic Gases/Vapours and Oxygen – Use and Operation (DGUV Information 213-056)

4. Standards

Sources of supply: Beuth-Verlag GmbH, Burggrafenstraße 6, 10787 Berlin, www.beuth.de or VDE-Verlag GmbH, Bismarckstraße 33, 10625 Berlin, www.vde-verlag.de

- 16 EN 1127-1:2019-10: Explosive atmospheres – Explosion Prevention and protection – Part 1: Basic concepts and methodology
- 17 EN 60079-29-1:2023-09: Explosive atmospheres – Part 29-1: Gas detectors – Performance requirements of detectors for flammable gases
- 18 EN 60079-29-2:2015-12: Explosive atmospheres – Part 29-2: Gas detectors – Selection, installation, use and maintenance of detectors for flammable gases and oxygen
- 19 EN 50104:2020-08: Electrical apparatus for the detection and measurement of oxygen – Performance requirements and test methods
- 20 DIN 1319-1: 1995-01: Fundamentals of metrology – Part 1: Basic terminology

Standards are subject to regular revisions. The editions cited here were valid at editorial deadline. When using this Code of Practice, the latest editions shall be applied.

5. Other Publications and Media

- 21 CHEMSAFE database with evaluated safety parameters for the fire and explosion protection of flammable or ignitable gases, liquids and dusts. It currently contains over 3000 pure substances and mixtures. The database is a joint project of the Gesellschaft für Chemische Technik und Biotechnologie e. V. (DECHEMA e. V.), the Physikalisch-Technische Bundesanstalt (PTB) and the Bundesanstalt für Materialforschung und -prüfung (BAM). PTB offers free online access to the complete CHEMSAFE database after registration at www.chemsafe.ptb.de.
- 22 GESTIS substance database of the DGUV at www.dguv.de/ifa/stoffdatenbank with information for the safe handling of hazardous substances and other chemical substances in the workplace. It provides information on important physical and chemical data as well as special regulations on the individual substances, in particular on classification and labeling according to the GHS in accordance with the CLP Regulation. It contains information on around 8700 substances.
- 23 List of performance tested gas detection equipment: www.exinfo.de, Page ID: #6HY9

Sources of supply: Jedermann-Verlag GmbH, Postfach 10 31 40, 69021 Heidelberg, www.jedermann.de and Berufsgenossenschaft Rohstoffe und chemische Industrie, Postfach 10 14 80, 69004 Heidelberg, mediencenter.bgrci.de

- 24 Occupational safety compendium as an online database (chargeable): regulations and rules, symbol library, programs for carrying out and documenting risk assessments (GefDok Pro demo version, GefDok SME and GefDok light). Information and free, time-limited test access at www.kompendium-as.de

Source of supply: www.maurischat.eu

- 25 Kompendium zur Gasesstechnik Fassung 12/2016

Picture credits

The figures used in this Code of Practice serve for illustration only. BG RCI expressly does not intend a product recommendation.

Illustrations were kindly provided by:

Figure 1 p. 30:
ExTox Gasmess-Systeme GmbH
Max-Planck-Straße 18
59423 Unna
www.extox.de

This document concentrates on essential points of individual regulations and rules. It therefore does not list all the measures required in individual cases. In addition, the state of the art and the legal basis may have changed since the publication of this document.

This document has been carefully prepared. This does not release you from the obligation and responsibility to check the information for completeness, topicality, and correctness yourself.

The German Occupational Health and Safety Act refers to the employer, while the German Social Code VII and the accident prevention regulations of the accident insurance institutions refer to the employer. The two terms are not completely identical because employers do not necessarily have employees. In the context of this topic, this does not result in any relevant differences, so “the employer” is used.

Issue 10/2023 (revision of issue 2/2016)

© Berufsgenossenschaft Rohstoffe und chemische Industrie, Heidelberg

Reproduction, in whole or in part, only with express permission.

Berufsgenossenschaft Rohstoffe und chemische Industrie

Postfach 10 14 80
69004 Heidelberg
Kurfürsten-Anlage 62
69115 Heidelberg
www.bgrci.de

Issue 10/2023

This Code of Practice can be ordered online at
mediencenter.bgrci.de.

Do you have any questions, suggestions or criticism?
If so, please contact:

- › Berufsgenossenschaft Rohstoffe und chemische Industrie
Prävention, Grundsatzfragen und Information, Medien
Postfach 10 14 80, 69004 Heidelberg
- › E-Mail: medien@bgrci.de
- › **Do you know our Media Hotline?**
You can contact us at +49 62215108-44444 (Mon to Fri 8 AM – 2 PM CEST)
or at mediencenter@bgrci.de



Jedermann-Verlag GmbH
Postfach 10 31 40
69021 Heidelberg
Telefon 06221 1451-0
Telefax 06221 27870
www.jedermann.de
info@jedermann.de

ISBN: 978-3-86825-199-9