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Workplace atmospheres —

Part 2:
Gas detectors — Selection, installation, use and maintenance of detectors for toxic gases and vapours

Air des lieux de travail —

Partie 2: Détecteurs de gaz — Sélection, installation, utilisation et maintenance des détecteurs de gaz et de vapeurs toxiques

This draft is submitted to a parallel vote in ISO and in IEC.

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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WORKPLACE ATMOSPHERES –

Part 2: Gas detectors –
Selection, installation, use and maintenance of detectors for toxic gases and vapours

FOREWORD

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International Standard IEC 62990-2 has been prepared IEC technical committee 31: Equipment for explosive atmospheres and ISO technical committee 146: Air quality, sub-committee 2: Workplace atmospheres.

The text of this International Standard is based on the following documents:

FDIS	Report on voting
31/XX/FDIS	31/XX/RVD

Full information on the voting for the approval of this International Standard can be found in the report on voting indicated in the above table.

This document has been drafted in accordance with the ISO/IEC Directives, Part 2.

A list of all parts in the IEC 62990, published under the general title *Workplace atmospheres*, can be found on the IEC website.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under "http://webstore.iec.ch" in the data related to the specific document. At this date, the document will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

IMPORTANT – The 'colour inside' logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.

INTRODUCTION

Toxic gas detection equipment can be used whenever there is the possibility of a hazard to life or adverse health effects caused by the accumulation of a toxic gas or vapour. Such equipment can provide a means of reducing the exposure to the hazard by detecting the presence of a toxic gas or vapour and issuing suitable audible or visual warnings. Gas detectors can also be used to initiate precautionary steps (for example, plant shutdown and evacuation).

Performance requirements for gas detection equipment for workplace atmospheres are set out in IEC 62990 series standards.

However performance capability alone cannot ensure that the use of such equipment will properly safeguard life and health where toxic gases and vapours might be present. The level of safety obtained depends heavily upon correct selection, installation, calibration and periodic maintenance of the equipment, combined with knowledge of the limitations of the detection technique required. This cannot be achieved without responsible informed management.

This document has been specifically written to cover all the functions necessary from selection to ongoing maintenance for a successful gas detection operation.

WORKPLACE ATMOSPHERES –

Part 2: Gas detectors – Selection, installation, use and maintenance of detectors for toxic gases and vapours

1 Scope

This document gives guidance on the selection, installation, use and maintenance of electrical equipment used for the measurement of toxic gases and vapours in workplace atmospheres. The primary purpose of such equipment is to ensure safety of personnel and property by providing an indication of the concentration of a toxic gas or vapour and warning of its presence.

This document is applicable to equipment whose purpose is to provide an indication, alarm or other output function to give a warning of the presence of a toxic gas or vapour in the atmosphere and in some cases to initiate automatic or manual protective actions. It is applicable to equipment in which the sensor automatically generates an electrical signal when gas is present.

For the purposes of this document, equipment includes:

a) fixed equipment;

b) transportable equipment, and

c) portable equipment.

This document is intended to cover equipment defined within IEC 62990-1, but can provide useful information for equipment not covered by that document.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60079-29-2, *Explosive atmospheres – Part 29-2: Gas detectors – Selection, installation, use and maintenance of detectors for flammable gases and oxygen*

IEC 62990-1, *Workplace atmospheres – Part 1: Gas detectors – Performance requirements of detectors for toxic gases*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 62990-1 and the following apply.

NOTE 1 Certain definitions within IEC 62990-1 are repeated below for the convenience of the reader.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at http://www.electropedia.org/
- ISO Online browsing platform: available at http://www.iso.org/obp

NOTE 2 Additional definitions applicable to explosive atmospheres can be found in Chapter 426 of the International Electrotechnical Vocabulary (IEC 60050-426).

3.1
toxic gas

gas or vapour that can be harmful to human health and/or the performance of persons due to its physical or physico-chemical properties

Note 1 to entry: For the purpose of this document, the term “toxic gas” includes “toxic vapours”.

3.2
interfering gas

any gas other than the gas to be detected, including water vapour, which affects the indication

3.3
clean air

air that is free of gases or vapours to which the sensor is sensitive or which influence the performance of the sensor

3.4
zero gas

gas recommended by the manufacturer, which is free of toxic gases and interfering and contaminating substances, the purpose of which is calibration or adjustment of the equipment zero

3.5
volume fraction

quotient of the volume of a specified component and the sum of the volumes of all components of a gas mixture before mixing, all volumes referring to the pressure and the temperature of the gas mixture

Note 1 to entry: The volume fraction and volume concentration take the same value if, at the same state conditions, the sum of the component volumes before mixing and the volume of the mixture are equal. However, because the mixing of two or more gases at the same state conditions is usually accompanied by a slight contraction or, less frequently, a slight expansion, this is not generally the case.

3.6
occupational exposure limit value

OELV

limit of the time-weighted average of the concentration of a chemical agent in the air within the breathing zone of a worker in relation to a specified reference period

Note 1 to entry: The term “limit value” is often used as a synonym for “occupational exposure limit value”, but the term “occupational exposure limit value” is preferred because there is more than one limit value (e.g., biological limit value and occupational exposure limit value).

Note 2 to entry: Occupational exposure limit values (OELVs) are often set for reference periods of 8 h, but can also be set for shorter periods or concentration excursions.

[SOURCE: ISO 18158:2016, 2.1.5.4, modified (Note 2 to entry is shortened)]

3.7
exposure (by inhalation)

situation in which a chemical agent is present in air that is inhaled by a person

3.8

time weighted average concentration
TWA concentration
concentration of gas in air averaged over a reference period

3.9

fixed equipment
equipment fastened to a support, or otherwise secured in a specific location, when energized

3.10

transportable equipment
equipment not intended to be carried by a person during operation, nor intended for fixed installation

3.11

portable equipment
equipment intended to be carried by a person during its operation

Note 1 to entry: Portable equipment is battery powered and includes, but is not limited to;

a) hand-held equipment, typically less than 1 kg, which requires use of only one hand to operate,

b) personal monitors, similar in size and mass to the hand-held equipment, that are continuously operating while they are attached to the user, and,

c) larger equipment that can be operated by the user while it is carried either by hand, by a shoulder strap or carrying harness and which might or might not have a hand directed probe.

3.12

aspirated equipment
equipment that samples the atmosphere by drawing it to the sensor

Note 1 to entry: A hand operated or electric pump is often used to draw gas to the sensor.

3.13

alarm-only equipment
equipment with an alarm but not having an indication of measured value

3.14

sensing element
part of the sensor which is sensitive to the gas or vapour to be measured

3.15

sensor
assembly in which the sensing element is housed and that can also contain associated circuit components

3.16

remote sensor
sensor that is separated from the equipment body and is connected to a gas detection control unit, gas detection transmitter

3.17

gas detection transmitter
fixed gas detection equipment that provides a conditioned electronic signal or output indication to a generally accepted industry standard (such as 4 to 20 mA), intended to be utilized with separate gas detection control units or signal processing data acquisition, central monitoring and similar systems, which typically process information from various locations and sources including, but not limited to gas detection equipment

3.18
separate gas detection control unit
equipment intended to provide display indication, alarm functions, output contacts or alarm signal outputs or any combination when operated with gas detection transmitters(s)

3.19
alarm set point
setting of the equipment at which the measured concentration will cause the equipment to initiate an indication, alarm or other output function

3.20
fault signal
audible, visible or other type of output, different from the alarm signal, permitting, directly or indirectly, a warning or indication that the equipment is not working satisfactorily

3.21
sample line
means by which the gas being sampled is conveyed to the sensor

Note 1 to entry: Accessories such as filter or water trap are often included in the sample line.

3.22
sampling probe
separate accessory sample line which is optionally attached to the equipment

Note 1 to entry: It is usually short (for example in the order of 1 m) and rigid, although it can be telescopic. In some cases it is connected by a flexible tube to the equipment.

3.23
field calibration kit
means of presenting test gas to the equipment for the purpose of calibrating, adjusting or verifying the operation of the equipment

Note 1 to entry: The field calibration kit can be used for verifying the operation of the alarms if the concentration of the test gas is above the alarm set-point.

Note 2 to entry: A mask for calibration and test is an example of a field calibration kit.

3.24
zero indication
indication given by an equipment when exposed to zero gas in normal operating conditions

3.25
indication range
range of measured values of gas concentration over which the equipment is capable of indicating (see Figure 1)

3.26
lower limit of indication
smallest measured value within the indication range (see Figure 1)

3.27
upper limit of indication
largest measured value within the indication range (see Figure 1)

3.28
measuring range
range of measured values of gas concentration over which the accuracy of the equipment lies within specified limits (see Figure 1)

3.29
lower limit of measurement

smallest measured value within the measuring range (see Figure 1)

3.30
upper limit of measurement

largest measured value within the measuring range (see Figure 1)

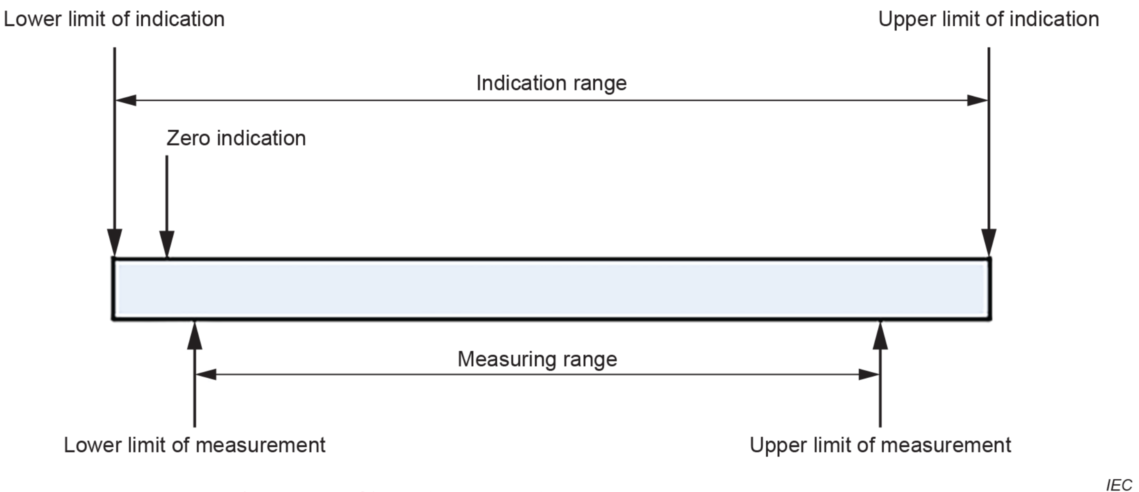

Figure 1 – Relationship between indication range and measuring range (See 6.3.1)

3.31
expanded uncertainty

U

quantity defining an interval about a result of a measurement, expected to encompass a large fraction of the distribution of values that could reasonably be attributed to the measurand

[SOURCE: ISO 18158:2016, 2.4.2.5]

3.32
zero uncertainty

quantity defining an interval about zero expected to encompass a large fraction of the distribution of values that could reasonably be attributed to the measurement in clean air

Note 1 to entry: In Figure 2 the mean value of the measured values in clean air is not equal to zero to illustrate that there can be an offset due to drift. The mean value can be above or below zero.

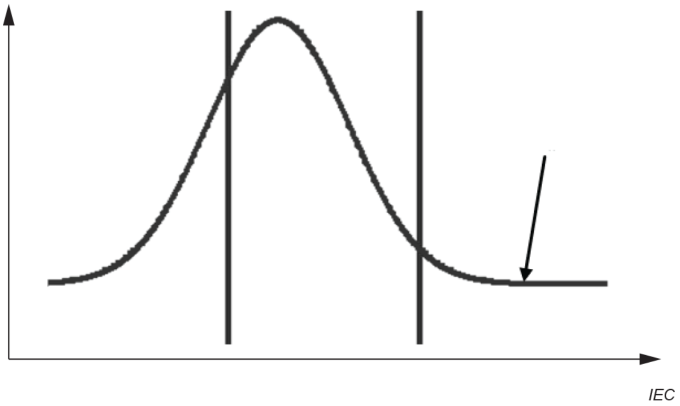

Figure 2 – Example of zero uncertainty

3.33
selectivity
degree of independence from interfering gases

3.34
averaging time
period of time for which the measuring procedure yields an averaged value

3.35
drift
variation in the equipment indication over time at any fixed gas volume fraction (including clean air) under constant ambient conditions

3.36
time of recovery
$t(x)$
time interval, with the equipment in a warmed-up condition, between the time when an instantaneous change from standard test gas to clean air is produced at the equipment inlet and the time when the indication reaches a stated percentage (x) of the initial indication

Note 1 to entry: For alarm only equipment the stated indication can be represented by the de-activation of the alarm set at a stated value.

3.37
time of response
$t(x)$
time interval, with the equipment in a warmed-up condition, between the time when an instantaneous change between clean air and the standard test gas, or vice versa, is produced at the equipment inlet, and the time when the response reaches a stated percentage (x) of the stabilized signal on the test gas

Note 1 to entry: The time of response is not applicable to spot-reading equipment.

3.38
warm-up time
time interval, with the equipment in a stated atmosphere, between the time when the equipment is switched on and the time when the indication reaches and remains within the stated tolerances

Note 1 to entry: See Figure 3.

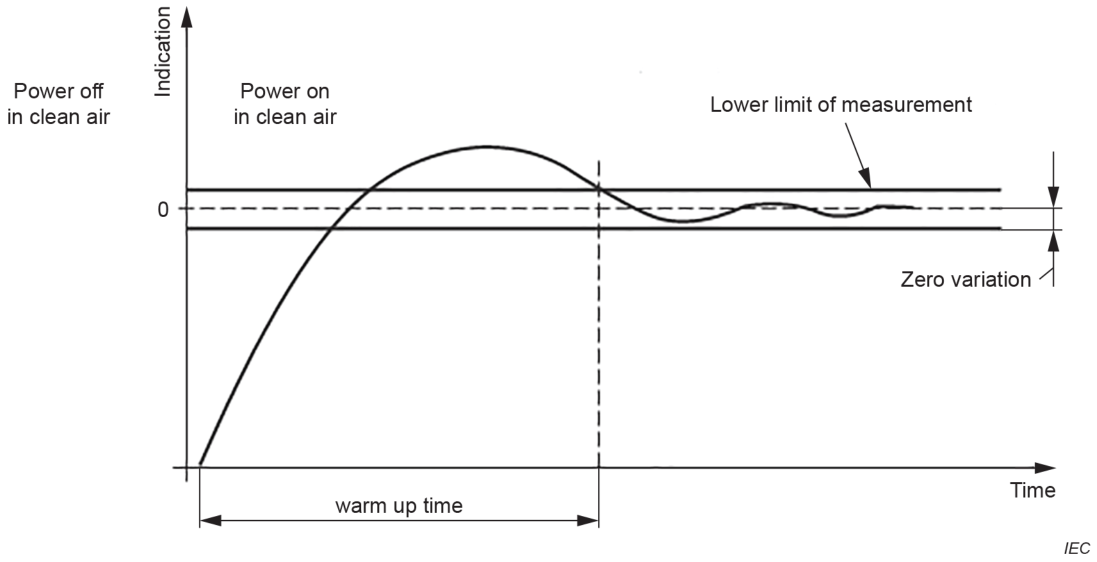

Figure 3 – Example of warm-up time in clean air

3.39
calibration
procedure which establishes the relationship between a measured value and the concentration of a test gas

Note 1 to entry: If the deviation at calibration is too high, usually an adjustment will be carried out subsequently.

3.40
adjustment
procedure carried out to minimize the deviation of the measured value from the test gas concentration

Note 1 to entry: If the equipment is adjusted to give an indication of zero in clean air, the procedure is called 'zero adjustment'.

3.41
special state
state of the equipment other than those in which monitoring of gas concentration or alarming is the intent

Note 1 to entry: Special state includes warm-up, calibration mode or fault condition.

3.42
ventilation
movement of air and its replacement with fresh air due to the effects of wind, temperature gradients, or artificial means (for example, fans or extractors)

4 Properties and detection of toxic gases and vapours

4.1 Properties and detection

A distinction is drawn between gases, which remain gaseous at typical ambient pressures and temperatures, and vapours where liquid can also exist at any relevant pressure or temperature. The following properties and behaviours of gases should be taken into account, in particular when locating detectors or deciding on a sampling strategy, in order to obtain representative indications. Failure to take proper consideration of these gas properties and behaviours can lead to failure to alarm and failure to take appropriate action or false alarms and incorrect action. It can also lead to false estimates of exposure.

Toxic gases typically become harmful at low concentrations (occupational exposure limit values typically range from parts per billion (ppb)to 1 % v/v levels). At distances far from the source of toxic gas release, the relative density of such a gas mixture is not significantly different from that of air. However, close to the source, the relative density can be significantly different, although consideration should be given to influences by the thermal effect of pressurised gas.

Gases and mixtures with relative densities between 0,8 and 1,2 should generally be considered to behave like air at ambient temperatures and are therefore capable of propagating in all directions.

High pressure leaks can generate gas clouds that propagate over significant distances from the source before mixing. This can occur for sources where the gas can be of any density.

In stagnant environments low pressure leaks can build up local high concentration pockets due to insufficient passive air movement.

Spillage of liquids can result in toxic vapour clouds that can disperse over long distances and duration and can accumulate in trenches, drains, tunnels etc. This is a result of liquid and vapour flow under gravity, cooling due to evaporation, and densities greater than air. The vapour cloud tends to stay close to the ground until well mixed with air. Nevertheless, concentrations in the breathing zone can approach harmful levels.

Gases and vapours fully mix with each other by diffusion over time or if stirred (for example, by convection or mechanical ventilation). Once they have been mixed, they will remain mixed, unless a component is removed chemically or is absorbed, for instance on a charcoal filter. Additionally, in the case of vapours, the concentration can be lowered by condensation due to increased pressure or reduced temperature. Some gases can react chemically with each other on mixing, for example, nitric oxide and oxygen.

The toxic component within a gas mixture follows the characteristics of the mixture, irrespective of the physical characteristics of the toxic component in pure form. The detection of H_2S for sour gas applications should be based on consideration of the characteristics of the sour gas mixture as a whole – typically dominated by methane, i.e. a “lighter than air” mixture, irrespective of the properties of pure H_2S.

Air movement by convection, mechanical ventilation or wind can have a marked effect on gas distribution. A heat source in an enclosed space, for example, can create a circular flow where the heated gas rises, runs along the ceiling which is at a lower temperature and falls as it cools, then runs along the floor back to the heat source.

Flow patterns can become very complicated and voids might well exist in which the gas can accumulate. Consequently, each workplace scenario could be different. The use of smoke tubes, mathematical modelling or scale models placed in wind tunnels can help to optimize the location of fixed detectors.

Some gases tend to stick (adsorb) on surfaces, which leads to a decrease of their concentration in air. This behaviour can be significant, especially with low gas concentrations and for reactive gases. Adsorbed gases can desorb and produce a response even when there is no gas present in the monitored air. The adsorption/desorption properties of each gas should be considered before the measurement task is undertaken. This is particularly important where sampling probes or sample lines are used to convey the gas to the equipment. The gas flow rate, temperature, length, diameter and material from which the probe or line is made are important factors.

Hygroscopic gases can form aerosols, which could be hazardous. A detector, which is only capable of measuring gas phase concentrations, will underestimate the true hazard.

4.2 The difference between detecting gases and vapours

4.2.1 Gases

4.2.1.1 Characteristics of gases

Substances that remain gaseous under the range of temperatures and pressures relevant to the gas detection application will closely follow the Gas Laws and behave predictably.

Gases can be pure, or any mixture of gases can be made, unless they react chemically. The composition of non-reacting gas mixtures does not change with temperature or pressure.

4.2.1.2 Calibration considerations

It is possible to make and store under high pressure, calibration and other test gas mixtures fully representative of the intended gas detection application. Many can be made with a dry or synthetic air background. However, the more-reactive gases tend to have longer storage life if the background is specially dried nitrogen, and this is normally chosen unless it is incompatible with the sensor.

Where a sensor is intended for use with more than one toxic gas (or vapour), the calibration gas should be the determination of worst case sensitivity combined with selected alarm threshold level. If more than one sensor is necessary to monitor multiple gases (or vapours), each sensor needs to be individually calibrated with the intended gas (or vapour) to be detected. Cross-sensitivity needs to be considered and fully understood.

4.2.1.3 Propagation and sampling considerations

Even when a pure gas is lighter or heavier by density than air, this is not a reliable means of determining propagation of a gas cloud.

The density of the gas to be detected should be taken into consideration when using sampling and diffusion equipment and when installing fixed detection equipment.

4.2.2 Vapours

4.2.2.1 Characteristics of vapours

Substances, where the liquid or solid can coexist with their gaseous state at normal or slightly abnormal temperatures and pressures are considered to be vapours. Vapours behave differently than gases and can be more difficult to detect accurately.

Where a liquid is present, the rate of evaporation will increase with temperature. Similarly, the maximum volume fraction of the vapour that can be achieved in a closed system (saturated vapour) will increase with temperature. This is dependent on the temperature and pressure and is independent of the quantity of liquid, provided there is some liquid remaining. The maximum volume fraction of the vapour is also independent of the background gas provided it is at the same temperature and pressure and is not soluble in the liquid.

The volume fraction that can be reached by the vapour at any temperature is inversely proportional to the absolute pressure. So an increase in pressure can cause condensation.

As a rule of thumb, at constant pressure, the maximum (saturated) volume fraction of any vapour will increase by a factor between 1,5 and 2,0 for each 10 K rise in liquid temperature, and will fall by a factor of 1,5 to 2,0 for every 10 K reduction.

The effect of doubling the absolute pressure has an equivalent effect to a decrease in temperature of 10 K to 17 K at constant pressure. Halving the pressure has an effect equivalent to a similar rise in temperature.