AS/NZS 60079.29.2:2016
IEC 60079-29-2, Ed.2.0 (2015)

AS/NZS 60079.29.2:2016

Australian/New Zealand Standard™

Explosive atmospheres

Part 29.2: Gas detectors—Selection, installation, use and maintenance of detectors for flammable gases and oxygen

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Explosive atmospheres

Part 29.2: Gas detectors—Selection, installation, use and maintenance of detectors for flammable gases and oxygen

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PREFACE

This Standard was prepared by the Joint Standards Australia/Standards New Zealand Committee EL-014, Equipment for Explosive Atmospheres, to supersede AS/NZS 60079.29.2:2008.

The objective of this Standard is to provide guidance on, and recommended practice for, the selection, installation, safe use and maintenance of electrically operated group II equipment intended for use in industrial and commercial safety applications and group I equipment in underground coal mines for the detection and measurement of flammable gases complying with the requirements of AS/NZS 60079.29.1 or AS/NZS 60079.29.4.

This Standard is identical with, and has been reproduced from IEC 60079-29-2, Ed.2.0 (2015), *Explosive atmospheres,* Part *29-2: Gas detectors—Selection, installation, use and maintenance of detectors for flammable gases and oxygen.* Changes to the Standard introduced by this edition are listed in the IEC Foreword.

As this Standard is reproduced from an International Standard, the following applies:

(a) In the source text 'this part of IEC 60079-29' should read 'this part of AS/NZS 60079.29'.

(b) A full point substitutes for a comma when referring to a decimal marker.

References to International Standards should be replaced by references to Australian or Australian/New Zealand Standards. The replacements at the time of publication are detailed in the following table but reference to the latest Australian or Australian/New Zealand Standard should be applied for any revisions after the publication of this Standard.

Reference to International Standard		*Australian/New Zealand Standard*	
IEC		AS/NZS	
60079	Explosive atmospheres	60079	Explosive atmospheres
60079-0	Part 0: Equipment—General requirements	60079.0	Part 0: Equipment—General requirements
60079-10-1	Part 10-1: Classification of areas—Explosive gas atmospheres	60079.10.1	Part 10.1: Classification of areas—Explosive gas atmospheres (IEC 60079-10-1, Ed.1.0 (2008) MOD)
60079-10-2	Part 10-2: Classification of areas—Combustible dust atmospheres	60079.10.2	Part 10.2: Classification of areas—Combustible dust atmospheres
60079-17	Part 17: Electrical installations inspection and maintenance	60079.17	Part 17: Electrical installations inspection and maintenance (IEC 60079-17, Ed.4.0 (2007) MOD)
60079-29-1	Part 29-1: Gas detectors—Performance requirements of detectors for flammable gases	60079.29.1	Part 29.1: Gas detectors—Performance requirements of detectors for flammable gases
60079-29-4	Part 29-4: Gas detectors—Performance requirements of open path detectors for flammable gases	60079.29.4	Part 29.4: Gas detectors—Performance requirements of open path detectors for flammable gases

Only normative references that have been adopted as Australian or Australian/New Zealand Standard have been listed.

The terms 'normative' and 'informative' have been used in this Standard to define the application of the annex to which they apply. A 'normative' annex is an integral part of a Standard, whereas an 'informative' annex is only for information and guidance.

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IEC FOREWORD

This edition includes the following significant changes with respect to the previous edition:

		Type		
Changes	Clause	Minor and editorial changes	Extension	Major technical changes
Addition of group 1 to scope	1		x	
Addition of Open Path Gas Detection	3, 4.6, 5.4, 6.2.3.5, 8.2, 8.6, 8.7. 8.8, 11, A4		x	
Changed “combustible” to “flammable”	Throughout	x		
Addition of specific applications	4.5		x	
Improvements to sampling systems	6.2.3.4, 8.2.3, 8.5, 11.2.2	x		

NOTE The technical changes referred to include the significance of technical changes in the revised IEC Standard, but they do not form an exhaustive list of all modifications from the previous version. More guidance may be found by referring to the Redline Version of the standard.

Explanations:

1) **Minor and editorial changes** clarification
decrease of technical requirements
minor technical change
editorial corrections

These are changes which modify requirements in an editorial or a minor technical way. They include changes of the wording to clarify technical requirements without any technical change, or a reduction in level of existing requirement.

2) **Extension** addition of technical options

These are changes which add new or modify existing technical requirements, in a way that new options are given, but without increasing requirements for equipment that was fully compliant with the previous standard. Therefore, these will not have to be considered for products in conformity with the preceding edition.

NOTE These changes represent current technological knowledge. However, these changes should not normally have an influence on equipment already placed on the market.

3) **Major technical changes** addition of technical requirements
increase of technical requirements

These are changes to technical requirements (addition, increase of the level or removal) made in a way that a product in conformity with the preceding edition will not always be able to fulfil the requirements given in the later edition. These changes have to be considered for products in conformity with the preceding edition.

NOTE These changes represent current technological knowledge. However, these changes should not normally have an influence on equipment already placed on the market.

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INTRODUCTION

Flammable gas detection equipment may be used whenever there is the possibility of a hazard to life or property caused by the accumulation of a flammable gas-air mixture. Such equipment can provide a means of reducing the hazard by detecting the presence of a flammable gas and issuing suitable audible or visual warnings. Gas detectors may also be used to initiate precautionary steps (for example plant shutdown, evacuation, and operation of fire extinguishing procedures).

Equipment may be used to monitor a gas atmosphere below the lower flammable limit in circumstances where accumulation of gas may result in a concentration of the gas/air mixture to potentially explosive levels. Performance requirements for gas detecting equipment for such purposes are set out in IEC 60079-29-1 and IEC 60079-29-4. Guidance for functional safety of fixed gas detection systems are set out in IEC 60079-29-3.

However performance capability alone cannot ensure that the use of such equipment will properly safeguard life or property where flammable gases may 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.

An additional hazard to life is the toxicity of some gases and of the vapours of all liquids except water. It is not generally appreciated that all flammable vapours are potentially toxic at concentration levels which are very small fractions of their respective lower flammable limits. Equipment covered by IEC 60079-29-1 and IEC 60079-29-4 is not specifically intended for toxic protection, and additional personal protection precautions will normally be needed where personnel could be exposed to toxic vapours.

Portable equipment covered by IEC 60079-29-1 and IEC 60079-29-2 commonly have additional detectors for specific toxic gases and also for oxygen deficiency. Users are cautioned that even mild oxygen deficiency may be due to toxic concentrations of some other gas or vapour, which may not be detectable or adequately detected by the equipment in use.

General requirements for the handbook or manual of any particular flammable gas detection equipment are specified in IEC 60079-29-1 and IEC 60079-29-4. These standards provide some necessary background knowledge on the points mentioned above.

This standard has been specifically written to cover all the functions necessary from selection to ongoing maintenance for a successful gas detection operation. Different clauses are appropriate for different tasks within this range of operations. Each clause has been written as stand-alone as far as practicable. This means that some information is repeated in different clauses but with a different emphasis.

Table 1 gives a broad suggestion as to the most relevant clauses to the typical tasks to be performed.

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Table 1 – Typical Tasks and Most Relevant Causes

Tasks	Definitions	Basic information properties of gas and vapours	Measuring principles	Selection of equipment	Behaviour of gas releases	Design and installation of fixed gas detection systems	Use of portable and transportable flammable gas detection equipment	Training of operational personnel	Maintenance, routine procedures General administrative control	Measuring principles (full detail) (normative)	Environmental parameters (informative)
Function (Clause)	3	4	5	6	7	8	9	10	11	Annex A	Annex B
Authorities	+	+++	+++	+	+	-	-	-	+	-	-
General management	+	+++	+++	+	+	-	-	+	+	-	+
Selection	+++	+++	+	+++	+++	+	++	-	+	+++	+++
Design engineering / management	+++	+++	+	+++	+++	+++	-	-	-	+++	+++
Installation engineering / management	+++	+++	+	++	+++	+++	-	-	-	+++	+++
Installation, technical	++	+++	++	++	++	++	-	-	-	+	++
Commissioning	+++	+++	++	+	++	+++	-	++	+	-	-
Operations management	++	+++	++	+	+	++	++	+++	+++	+	+++
Operation training	+++	+++	+	+	+	+++	+++	+++	+++	+++	+++
Servicing / Calibration	+++	+++	-	-	-	++	++	+	+++	++	++
Repair	++	+++	++	-	-	+	+	+	+++	++	-

"+++" Most appropriate

"++" Advisable

"+" Useful

"-" Not applicable

It should be noted that Clause 5 is a simplified version of Annex A.

This standard makes recommendations on how to establish maintenance and calibration intervals. In certain countries there are mandatory general or industry-specific regulations which must be followed as a minimum requirement.

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AUSTRALIAN/NEW ZEALAND STANDARD

Explosive atmospheres

Part 29.2:
Gas detectors—Selection, installation, use and maintenance of detectors for flammable gases and oxygen

1 Scope

This part of IEC 60079-29 gives guidance on, and recommended practice for, the selection, installation, safe use and maintenance of electrically operated Group II equipment intended for use in industrial and commercial safety applications and Group I equipment in underground coal mines for the detection and measurement of flammable gases complying with the requirements of IEC 60079-29-1 or IEC 60079-29-4.

This standard is applicable for oxygen measurement for the purpose of inertisation where explosion protection is provided by the exclusion of oxygen instead of measuring the flammable gases or vapours present. A similar application is measuring oxygen when inertising a goaf (mined out) area in an underground coal mine.

This standard is a compilation of practical knowledge to assist the user, and applies to equipment, instruments and systems that indicate the presence of a flammable or potentially explosive mixture of gas or vapour with air by using an electrical signal from a gas sensor to produce a meter reading, to activate a visual or audible pre-set alarm or other device, or any combination of these.

Such equipment may be used as a means of reducing the risk whenever there is the possibility of a risk to life or property specifically due to the accumulation of a flammable gas-air mixture, by providing such warnings. It may also be used to initiate specific safety precautions (e.g. plant shutdown, evacuation, fire extinguishing procedures).

This standard is applicable to fixed installations and transportable equipment. Similarly it is applicable to the safe use of portable equipment. Since much modern equipment of this type also includes oxygen deficiency detection and/or specific toxic gas sensors, some additional guidance is given for these topics.

For the purposes of this standard, except where specifically stated otherwise, flammable gases include flammable vapours.

Mists are not covered by this standard due to measurement techniques currently used.

This standard applies to Group II equipment (i.e. equipment intended for use in industrial and commercial safety applications, involving areas classified in accordance with IEC 60079-10-1) and Group I equipment.

For the purposes of this standard, equipment includes

a) fixed equipment including equipment mounted on a vehicle;

b) transportable equipment; and

c) portable equipment.

This standard is not intended to cover, but may provide useful information, for the following:

a) equipment intended only for the detection of non-flammable toxic gases;

b) equipment of laboratory or scientific type intended only for analysis or measurement purposes;

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c) equipment intended only for process control applications;

d) equipment intended for applications in explosives processing and manufacture;

e) equipment intended for the detection of a explosive atmosphere resulting from dust or mist in air.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60079-0, *Explosive atmospheres – Part 0: Equipment – General requirements*

IEC 60079-10-1:2008, *Explosive atmospheres – Part 10-1: Classification of areas – Explosive gas atmospheres*

IEC 60079-10-2, *Explosive atmospheres – Part 10-2: Classification of areas – Combustible dust atmospheres*

IEC 60079-13, *Explosive atmospheres – Part 13: Equipment protection by pressurized room "p"*

IEC 60079-17, *Explosive atmospheres – Part 17: Electrical installations inspection and maintenance*

IEC 60079-19, *Explosive atmospheres – Part 19: Equipment repair, overhaul and reclamation*

IEC 60079-29-1:2007, *Explosive atmospheres – Part 29-1: Gas detectors – Performance requirements of detectors for flammable gases*

IEC 60079-29-4, *Explosive atmospheres – Part 29-4: Gas detectors – Performance requirements of open path detectors for flammable gases*

IEC 61285, *Industrial-process control – Safety of analyser houses*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60079-0, as well as the following apply. In addition, since this is intended as a stand-alone standard, certain definitions within IEC 60079-29-1 and IEC 60079-29-4 are repeated below for the convenience of the reader.

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

3.1 Gas properties and other physics

3.1.1
ambient air
normal atmosphere surrounding the equipment

3.1.2
clean air
air which is free from gases or vapours (flammable, toxic or environmentally harmful gases) to which the equipment is sensitive or which influence the performance of the equipment

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3.1.3
concentration
amount of the gas or vapour of interest in a specified amount of the background gas or air, expressed in suitable units

Note 1 to entry: Typical units include volume fraction (v/v) (see 3.1.19); molar (moles per mole – m/m); percentage of the LFL of a particular substance; parts per million by volume (ppm); parts per billion by volume (ppb).

3.1.4
dose
total amount of substance absorbed or trapped, proportional to the concentration and the duration of exposure

3.1.5
explosive gas atmosphere
mixture with air, under normal atmospheric conditions, of flammable substances in the form of gas or vapour, which, after ignition, permits self-sustaining flame propagation

3.1.6
explosive range
range of gas or vapour mixtures with air, with concentrations between the lower and upper explosive (flammable) limits

3.1.7
firedamp
flammable mixture of gases, consisting mainly of methane, naturally occurring in a mine

3.1.8
flammable gas
gas or vapour which, when mixed with air in a certain proportion, will form an explosive atmosphere

Note 1 to entry: For the purposes of this standard, the term "flammable gas" includes flammable vapour

3.1.9
flashpoint
lowest liquid temperature at which, under certain standardized conditions, a liquid gives off vapours in a quantity such as to be capable of forming an ignitable vapour/air mixture

3.1.10
lower flammable limit
LFL
volume fraction of flammable gas or vapour in air below which an explosive gas atmosphere does not form, expressed as a percentage (see IEC 60079-20-1)

Note 1 to entry: This is also known as lower explosive limit (LEL).

3.1.11
optical radiation
ultra-violet, visible or infrared regions of the electromagnetic spectrum

3.1.12
relative density
density of gas or vapour relative to the density of air at the same pressure and at the same temperature

Note 1 to entry: Air is equal to 1,0.

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3.1.13
release rate
quantity of flammable gas or vapour emitted per unit time from the source of release which itself could be a liquid surface

3.1.14
source of release
point or location from which a flammable gas, vapour or liquid may be released into the atmosphere in such a way that an explosive gas atmosphere could be formed

[SOURCE: IEC 60050-426:2008. 426-03-06, modified by removal of Note]

3.1.15
toxic gas
gas that may be harmful to human health and/or the performance of persons due to its physical or physico-chemical properties

3.1.16
upper flammable limit
UFL
volume fraction of flammable gas or vapour in air above which an explosive gas atmosphere does not form, expressed as a percentage (see IEC 60079-20-1)

Note 1 to entry: This is also known as upper explosive limit (UEL).

3.1.17
vapour
gaseous state of a substance that can reach equilibrium with its liquid or solid state in the temperature and pressure range of interest

Note 1 to entry: This is a simplification of the scientific definition, for the purposes of this standard, and merely requires that the substance is below its boiling point or sublimation point at the ambient temperature and pressure.

3.1.18
ventilation
movements of air and replacement with fresh air due to the effects of wind, temperature gradients or artificial means (for example fans or extractors)

3.1.19
volume fraction
v/v
ratio of the volume of a component gas to the volume of the gas mixture under specified conditions of temperature and pressure

Note 1 to entry: This is also known as volume ratio.

3.2 Types of equipment

3.2.1
alarm only equipment
equipment which generates an alarm signal but does not have a meter or output giving a measure of the integral concentration

3.2.2
aspirated equipment
equipment that samples the gas by drawing it to the gas sensor – for example by means of a hand-operated or electric pump

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3.2.3
continuous duty equipment
gas detecting equipment that is powered for long periods of time, but may have either continuous or intermittent sensing

3.2.4
diffusion equipment
equipment in which the transfer of gas from the atmosphere to the gas sensor takes place by random molecular movement, i.e. under conditions in which there is no aspirated flow

3.2.5
explosion protected equipment
equipment incorporating a type of explosion protection covered by the IEC 60079 series of standards

3.2.6
explosion protection
measures applied in the construction of equipment to prevent ignition of a surrounding flammable atmosphere by the equipment

3.2.7
fixed equipment
equipment that is intended to have all its parts permanently installed

3.2.8
group I equipment
equipment for mines susceptible to firedamp

3.2.9
group II equipment
electrical equipment for use in places with an explosive gas atmosphere other than mines susceptible to firedamp

3.2.10
portable equipment
spot reading or continuous duty equipment that has been designed to be readily carried from place to place and to be used while it is being carried

Note 1 to entry: A portable equipment is battery powered and includes, but is not limited to:

a) 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 (but not necessarily continuously sensing) 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 by a carrying harness; which may or may not have a hand directed probe

3.2.11
sample (sampling) system
equipment which typically draws more than one sample, conditions them as necessary, and presents them to a sensor in aspirated equipment

Note 1 to entry: This usually refers to fixed equipment where multiple samples from different detection points are presented sequentially to one or more sensors;

3.2.12
spot reading equipment
equipment intended to be used for short, intermittent or irregular periods of time as required (typically 5 min or less)

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3.2.13
transportable equipment
equipment not intended to be portable, but which can be readily moved from one place to another

3.3 Sensors and detectors

3.3.1
catalytic sensor
sensor, the operation of which depends upon the oxidation (combustion) of gases on an electrically heated catalytic element

3.3.2
electrochemical sensor
sensor, the operation of which depends upon changes of the electrical parameters of electrodes placed in an electrolyte due to redox reactions of the gas on the surface of the electrodes

3.3.3
flame ionisation detector
FID
sensor, the operation of which depends upon the ionization of the gas being detected in a hydrogen flame

3.3.4
flame temperature analyser
FTA
sensor, the operation of which depends upon the change of temperature of a flame by the gas being detected

3.3.5
infrared absorption sensor
sensor, the operation of which depends upon the absorption of infrared radiation by the gas being detected

3.3.6
paramagnetic oxygen detector
sensor, the operation of which depends upon the magnetic properties of oxygen

3.3.7
photo ionisation detector
PID
sensor, the operation of which is based on the ionisation of gaseous compounds by ultraviolet (UV) radiation

3.3.8
remote sensor
sensor that is not integral with the main body of the equipment

3.3.9
semiconductor sensor
sensor, the operation of which depends upon changes of the electrical conductance of a semi-conductor due to chemisorption of the gas being detected at its surface

3.3.10
sensor
assembly in which the sensing element is housed that may also contain associated circuit components

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3.3.11
sensing element
part of a sensor that reacts in the presence of a flammable gas mixture to produce some physical or chemical change that can be used to activate a measuring or alarm function, or both

3.3.12
single point sensor
sensor capable of detecting gas at a single point location

3.3.13
thermal conductivity sensor
sensor, the operation of which depends upon the change of heat loss by conduction of an electrically heated element located in the gas to be measured, compared with that of a similar element located in a reference gas cell

3.4 Supply of gas to instruments

3.4.1
measuring point
measurement point
location of a single sensor aspirated by diffusion or by a probe

3.4.2
point detection equipment
detection equipment located at a measurement point

Note 1 to entry: This normally refers to a complete single point sensor, rather than a sampling point, and is in contrast with open path equipment

3.4.3
sample line
means by which the gas being sampled is conveyed to the sensor including accessories

EXAMPLE Filter, water trap.

3.4.4
sampling point
point from which sample is taken in an aspirated equipment

Note 1 to entry: Typically this term is applied to fixed aspirated systems.

Note 2 to entry: Typically the equipment at this point will consist of a filter, but there may be other sample conditioning equipment as well.

3.4.5
sampling probe
separate sample line which is attached to the equipment as required, that may or may not be supplied with the equipment

Note 1 to entry: It is usually short (e.g. in the order of 1 m) and rigid (although it may be telescopic), but it may be connected by a flexible tube to the equipment.

3.5 Signals and alarms

3.5.1
alarm setpoint
fixed or adjustable setting of the equipment that is intended to pre-set the level of concentration at which the equipment will automatically initiate an indication, alarm or other output function

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3.5.2
alarm signal
audible, visual, electronic or other signal generated by the equipment when an integral concentration of gas in excess of a preset value is detected

3.5.3
continuous or quasi-continuous sensing
mode of operation in which power is applied continuously to the sensing element and readings are taken continuously or at regular and frequent intervals

3.5.4
fault signal
audible, visual, or other type of output which provides, directly or indirectly, a warning or indication that the equipment is defective or out of adjustment

3.5.5
indicating devices
means for displaying values or states in analogue or digital form

3.5.6
inhibition signal
audible, visual, or other type of output which provides, directly or indirectly, a warning or indication that normal operation has been suspended

3.5.7
intermittent sensing
mode of operation in which the power or flow to the sensor is applied intermittently according to a predetermined cycle and readings taken at the predetermined cycle

3.5.8
latching alarm
alarm which, once activated, requires a deliberate action to deactivate it

3.5.9
safety function
function (inclusive from gas sampling to signal output of the gas detection equipment) to enable the overall system to achieve a safe state.

3.6 Times, checks and equipment behaviour

3.6.1
drift
variation with time of the indication produced by the equipment under normal conditions when monitoring a fixed gas volume fraction, or, in the case of open path, a fixed concentration distribution, (including clean air) under constant ambient conditions

3.6.2
functional check
application of test gas or other means of obtaining a response from the sensor to check its function

Note 1 to entry: This may include the generation of an alarm. This check is performed without adjustments of sensitivity.

Note 2 to entry: This is also known as a “response check” or “bump test”.

3.6.3
initial calibration
first calibration for a specific substance, measuring range and application carried out by the manufacturer before delivery, or on site, before starting the operation

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3.6.4
poisons
<for sensors>
substances which lead to temporary or permanent loss of sensitivity of the sensors

3.6.5
recalibration
calibrations carried out periodically to check and adjust the zero signal and the sensitivity of the sensor with a known calibration gas mixture without any changing of the parameters, type of gas, measuring range, specific application, which have been established by the initial calibration

3.6.6
recovery time
time interval between the time when an instantaneous decrease in gas concentration is produced at the sensor input and the time when the response reaches a stated indication

3.6.7
selectivity
response of the equipment to the gas of interest compared with the response to other gases

Note 1 to entry: If there is high selectivity to the target gas, the results will be less ambiguous and the cross-sensitivity to other gases will be low.

3.6.8
sensitivity
ratio of change produced in the equipment by a known concentration of gas or vapour

Note 1 to entry: Depending on context, this can refer to the minimum change in concentration of gas or vapour that the equipment will detect.

Note 2 to entry: High sensitivity implies that low concentrations can be measured.

3.6.9
span
reading on the normal test gas of the equipment

3.6.10
time of response
tx
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 stabilised signal on the standard test gas

Note 1 to entry: Not applicable to spot reading equipment.

3.6.11
zero gas
gas recommended by the manufacturer which is free of flammable gases, and interfering and contaminating substances, the purpose of which is calibration/adjustment of the equipment zero

3.7 Terms exclusive to open path equipment

3.7.1
albedo
proportion of incident light scattered back from a surface

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3.7.2
beam blocked signal
audible, visual or other type of output which provides, directly or indirectly, a warning or indication that the optical path is obscured or that the signal detected is too weak to enable the equipment to function normally

3.7.3
gas calibration cell
sealed enclosure with transparent ends which can be filled with test gases

3.7.4
integral concentration
mathematical integral of the gas concentration along the optical path

Note 1 to entry: It is expressed in units of concentration multiplied by distance, e.g. LFL metre for flammable gases or ppm metre for toxic gases

Note 2 to entry: 100 %LFL x 1 metre = 1 LFL metre;

10 %LFL x 10 metre = 1 LFL metre.

3.7.5
meteorological optical range
MOR
length of path in the atmosphere required to reduce the luminous flux in a collimated beam from an incandescent lamp, at a colour temperature of 2 700 K to 5 % of its original value

3.7.6
open path
optical path which traverses the area (or part of the area) in which the atmosphere is being monitored and through which gases in the atmosphere are free to move

3.7.7
optical axis
median line of the optical path

3.7.8
optical path
path traversed by optical radiation from an optical transmitter to an optical receiver

Note 1 to entry: The radiation may traverse the path once, twice or many times depending on the form taken by the instrument

3.7.9
receiver
assembly in which the optical detecting element(s) are housed and which may contain associated optical and electrical components

3.7.10
retroreflector
individual or multiple arrangement of reflecting corners of cubes arrayed so that light is reflected back parallel to its incident path

3.7.11
gas detection transmitter
fixed gas detection equipment that provide a self-conditioned electronic signal or output indication to a generally accepted industry standard (such as 4-20 mA or relay), 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

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3.7.12
transceiver
assembly in which the optical detecting element(s) and optical transmitting element(s) are housed and which may contain associated optical and electrical components

3.7.13
transmittance
fraction of luminous flux which remains in a single beam after traversing an optical path of a given length in the atmosphere

3.7.14
transmitter
assembly in which the optical transmitting element(s) are housed and which may contain associated optical and electrical components

4 Basic information on the properties, behaviour, gases and vapours, and specific applications of gas detection

4.1 Detecting gases and vapours

4.1.1 General

For the purposes of Clause 4, 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.

Effective operation of flammable gas detection equipment depends not only on its performance but also on its correct usage.

Equipment capability, and its suitability for the intended application and the user's knowledge of its limitations, both generic relating to sensor technology, and individual relating to its other design features, cannot alone ensure that its use will properly safeguard personnel, areas, or locations where flammable gases or vapours may be or are present. The level of safety obtained also depends upon the user having a basic knowledge of gas and vapour properties and phenomena.

This knowledge should enable the user to determine whether the gases are heavier or lighter than air, and whether the vapours are heavier than air or of similar density, and therefore where they may accumulate. If the direction and velocity of air movement is known, it can be seen how they may propagate. In addition, there may be physical or chemical reasons imposing limitations on a particular application, such as calibration considerations.

Consideration shall be given not only to those gases and vapours that are required to be detected, but also to those gases and vapours that are not required to be detected, but may also be present.

The effects of humidity and temperature variations may need to be evaluated, particularly when sampling lines are used, and, more importantly, if vapours other than water are involved.

Small environmental changes, such as a rise or fall in temperature, which may be ignored for most purposes, can significantly modify conditions, particularly if liquids are present and produce increased amounts of vapours, or if vapours condense as fogs or inside the equipment itself.

Failure to take these properties of gases and vapours into account at any of the stages of selection, installation, commissioning, training, operation and on-going maintenance of even the simplest of equipment can result in the production of erroneous readings. These in turn

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can lead on one hand to false alarms or incorrect action, and on the other hand to failure to alarm or failure to take any appropriate action. Such factors can unnecessarily endanger lives and property.

Some gases or vapours can cause corrosion or other deterioration to certain types of sensors. Some types of sensors have specific lifetimes. The sensitivity can change over time. This applies to certain types of sensors for toxic gases and oxygen deficiency as well as for flammable gases and vapours. This is the major reason for requiring frequent functional checks of some of the more common types of flammable gas detectors. It is usually done using a test gas or calibration gas applied in a specified way. The correct test/calibration equipment for one type of gas detection equipment may not be appropriate to another type, and some training will usually be needed.

Although a mixture that has a concentration above the upper flammable limit is not explosive, it should be realised that on dilution with air it will become explosive, and so it is advisable to consider it as explosive. It should also be noted that it will normally be toxic at much lower concentrations.

4.1.2 Safety when monitoring for flammable gases where personnel could be present

Personnel should frequently observe the reading on any gas detection apparatus when entering a potentially hazardous area. The area may already contain asphyxiates or flammable gas and the personnel may need expedient warning of this danger.

The equipment will only give a reading for the location where the reading is being taken, or the location of the end of the sampling line if a sampling line is being used. A hazardous atmosphere may be building up a few metres from the sampling point. Therefore, many gas tests shall be done all around the intended area of work to ensure that no pockets of hazardous gas or vapour are present in the work area.

If vapours are likely to be present, some of the tests should be done one or two centimetres from the floor. This might detect a small problem (e.g. a minor liquid leak) at an early stage. All nearby low spots should be tested.

The readings are only valid for the time they are taken. Circumstances change. Frequent readings are recommended, particularly if vapours (see 4.3.3) could be involved and the temperature is rising.

Where a wide range of gases and vapours could be encountered in the work area there will be a range of potential sensitivities. A low ‘alarm point’ or ‘action point’ will therefore be required.

If there is a chance of sensor ‘poisons’ (such as silicones, leaded petrol, acids, etc.) being present, the sensitivity of an equipment using catalytic or semiconductor sensors should be checked at frequent intervals.

While the atmosphere is being monitored for concentrations of flammable gases and vapours, consideration should also be given to the fact that many of these, including all vapours except water, are also toxic to personnel. Additional detectors for the specific gases and vapours and additional precautions may be needed.

If a flammable gas or vapour detection equipment is also equipped with high sensitivity sensors for specific toxic gases it should be realized that they may only detect these specific gases. They will not usually detect other toxic materials.

Closely allied to flammable gas monitoring is monitoring for oxygen deficiency and this is detailed in 4.4.1. Frequently this feature is added to the equipment. There are several possible reasons for an oxygen deficiency. Some of them are due to situations where a toxic

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substance is part of the cause of the deficiency, and these are of far greater concern. Again, additional detectors and precautions may be needed.

Therefore, when about to work in a hazardous area, it is advisable to specifically check on the potential toxicity of the atmosphere with the plant safety officer, industrial hygienist, or equivalent and a gas detector that covers the possible range of flammable, and toxic materials in the area should be chosen.

NOTE Different countries have different systems, and can use different values, for describing maximum safe levels of potentially toxic substances. For typical details, consult the USA's ACGIH book of TLV's (Threshold Limiting Values) and BEIs (Biological Exposure Indices), or the European Commission for the Investigation of Health Hazards of Chemical Compounds in the Work Area who publish a list of recommended TLV's. Both organisations update these publications annually. Other countries usually employ one or the other of these sets of data as a basis for their national documents, which can also be referred to.

4.2 Some common properties of gases and vapours

All gases and vapours will fully mix with all others by diffusion over time or if stirred. They will not separate out. However, some gases and vapours may react chemically with each other on mixing.

If a gas or vapour concentration is increasing in an area it is because more of that substance is being released. It is not due to settling out.

Once gases and vapours have been mixed, they will stay mixed, unless a component is removed chemically, or is absorbed (for instance on a charcoal filter). Additionally, in the case of vapours, removal can be by condensation due to increased pressure and/or falling temperature.

The density of pure gases and the effective density of vapours is proportional to their molecular mass. There is no significant change of volume on mixing gases and vapours. Therefore the density of mixtures of gases and vapours may be simply calculated from the volume fractions and molecular masses of their components. If relative density data is available, the relative density can be similarly calculated from the volume fractions and relative densities of the components.

Air has an equivalent molecular mass of approximately 29, corresponding to a relative density of 1. For instance, gases with lower molecular masses than 29 will have a relative density less than 1 and will be lighter than air.

As an example, methane with a molecular mass of 16 will be lighter than air, carbon dioxide with a molecular mass of 44 will be heavier than air. A mixture of the two, for instance a land fill gas or a mine seam gas, with approximately 53 % methane and 47 % carbon dioxide will have a similar density to air.

Mixtures of clean air with pure or mixed gases that are lighter than air, will still be lighter than air, but less so, proportionately to their volume fractions. They will tend to rise until they become so diluted with clean air that the effect becomes negligible.

Mixtures of clean air with gases or vapours that are heavier than air, will still be heavier than air, but less so. They will tend to flow into low spots; pits, trenches etc, until they become so diluted with clean air that the effect becomes negligible.

If a source of release and its surrounding air is substantially hotter than the ambient air the released mixture can rise initially, even if the relative density at the ambient temperature is greater than 1. As a rule of thumb, a temperature rise of 30 K will overcome what by calculation would be 10 % greater relative density than air. The converse applies where the release is colder than the ambient temperature.

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Because of temperature differences at release and normal turbulence, gases and mixtures with relative density between 0,8 and 1,2 generally can be considered as having a similar relative density to air, and therefore are capable of propagating in all directions.

All flammable gases and vapours will have an LFL and a UFL. The LFL and UFL are experimentally determined, and this data for many substances can be found in IEC 60079-20-1. These values cannot be predicted with any accuracy.

NOTE Because this is experimental, different countries specify different values for LFL and UFL values, which have a legal standing. As two examples:

– NFPA 30 is a publication used within the USA.

– GESTIS is a publicly available database used within Germany.

All vapours, except water vapour, are toxic to varying extents. All flammable vapours are toxic at levels well below 25 % of LFL, most are toxic below 1 % of LFL. At best, gases (except air or oxygen) are asphyxiants (i.e. their effect on personnel is only due to them diluting the oxygen content of the air). Other gases vary from mild to extreme toxicity.

NOTE An asphyxiant is a non-toxic or very mildly toxic and (mostly) inert gas which works by displacing oxygen in the lungs. A toxic gas may cause significant acute health effects even at low concentrations.

When detecting specific gases or vapours, it is necessary to be aware of the potential toxicity of other gases or vapours that might be present, but are not being detected.

4.3 The differences between detecting gases and vapours

4.3.1 General

The major practical differences between the detection of gases and the detection of vapours are outlined below.

4.3.2 Detection of gases

4.3.2.1 General

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. Basically, simple training may be adequate.

Gases may 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.

4.3.2.2 Calibration considerations

Accurate calibration requires calibration gas recommended by the manufacturer for calibration/adjustment purpose which usually contains the target gas in a known concentration with a tolerance of less than 5 % relative. For functional checking, a test gas with reduced accuracy may be used. The manufacturer's recommendations for functional checking of sensors should be followed.

Kits for routine calibration and functional checks of single point sensors, and portable and transportable equipment usually consist of a portable cylinder of a compressed gas, some form of flow control and an adapter to fit the gas detection equipment. In the case of multipoint sampling systems, larger cylinders may be used close to the central equipment, and even permanently connected for automatic calibration.

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 as balance gas. This is essential for catalytic sensors and others that require air

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as balance gas in order to operate correctly. However there are safety limits for in compressing gas mixtures that have a volume fraction of more than 50 % LFL.

The more-reactive gases tend to have longer storage life if the balance gas is specially dried nitrogen, and this is normally chosen unless it is incompatible with the sensor.

In order to calibrate open path equipment, a cell with optical windows at both ends containing a calibration gas has to be interposed in the optical path. In order to have practical dimensions for these cells, concentrations of the flammable gas are needed at volume fractions well in excess of the LFL concentrations if they use air as balance gas (see also 4.5). Fortunately the infrared detection principle permits nitrogen to be used as the balance gas, and so the calibration gas may be compressed safely.

Where more than one flammable gas (or vapour) may need to be detected, it is common to use a single calibration or test gas, and relative response data. For further details see 4.3.3.2.

For calibration gas cylinders the minimum storage temperature specified by the calibration gas manufacturer has to be followed to avoid condensation.

4.3.2.3 Propagation and sampling considerations

Gases can have a density that is lighter than air, such as hydrogen and methane. They can have approximately the same density as air, such as carbon monoxide, hydrogen sulfide, hydrogen cyanide, ethane, ethylene and acetylene; or they can have a density heavier than air such as chlorine, carbon dioxide, sulfur dioxide, LPG, propane, propylene and butane.

When sampling, at least some tests or readings should be taken in locations with the density of the gas in mind. This may also help to detect the source of release.

4.3.2.4 Toxicity considerations

Some flammable gases (specifically ammonia, hydrogen sulfide, hydrogen cyanide, carbon monoxide, methylamine and formaldehyde) are highly toxic at levels which are so low as to be undetectable by conventional flammable gas equipment, although they are listed in IEC 60079-20-1 and can be detected by such equipment at the much higher levels relevant to detection in LFL ranges. If these gases are likely to be present they will require separate and specific toxic gas sensors, and possibly other precautions, if personnel can be in the area.

Also it is necessary to be aware that some non-flammable gases are highly toxic, such as chlorine, sulfur dioxide, nitric oxide and nitrogen dioxide. If these gases are likely to be present they will require separate toxic gas sensors, and possibly other precautions.

Other flammable gases such as propane, butane and LPG are mildly toxic or narcotic at levels well below their LFL. Similarly non-flammable gases such as carbon dioxide and nitrous oxide are potentially toxic at levels that may not result in a significant oxygen deficiency (see 4.4.4).

4.3.2.5 Water vapour

Although this subclause relates only to detecting gases, it is not normally possible to ignore water vapour. This can produce problems in cold equipment that have been suddenly exposed to a hotter and humid atmosphere. Examples of this situation are in leaving a cold store and entering a normal atmosphere, or in leaving an air-conditioned situation and entering into a humid tropical or sub-tropical atmosphere. Water can condense in or on a sensor, causing a temporary loss of sensitivity or some other problem, until the equipment warms up and the water re-evaporates. This is particularly the case with electrochemical sensors: A very rapid drop in an oxygen reading can occur from a normal 20,8 % or 20,9 % reading to 16 % or lower, due only to a coating of water condensing onto the cold sensor membrane. The sensitivity may then only recover slowly over some minutes as the sensor warms up to ambient, and the film evaporates.

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Water vapour may also cause significant deviations of the reading of several types of sensors (see Clause 5 and Annex A).

4.3.3 Detection of vapours

4.3.3.1 General

Vapours are more difficult to understand than gases. Substances, where the liquid or solid can coexist with their gaseous state at normal or slightly abnormal temperatures and pressures are said to have vapours. Vapours behave differently than gases, and can present more problems. Where vapours are likely to be found, additional training in their properties is required.

Where a liquid is present, the rate of evaporation and the maximum volume fraction of the vapour (saturated vapour) will increase with temperature and falling pressure. The evaporation rate is dependent on the size of the surface of the liquid but 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.

The temperature at which the saturated volume fraction can reach 100 % at the prevailing pressure is the boiling point.

It is only possible to have 100 % volume fraction of a vapour at or above the boiling point at that atmospheric pressure. Below the boiling point of the liquid, the maximum possible concentration of vapour in air or other gases must be less than 100 % volume fraction.

The actual amount of vapour will be less than the amounts predicted above if clean atmosphere is being continually passed over the liquid surface, or if there has not been enough time for equilibration to be established. However this maximum amount can be achieved in an enclosed space, particularly if it has been closed for some time and the air space is slowly stirred by convection or mechanical means.

Flammable liquids have flashpoints, which are determined in a different way from LFL, but are essentially the temperatures at which their vapours can reach their LFL volume fractions in the air above their liquid surfaces, again provided that the vapour is not continuously removed by air currents.

All of these points impose limits on mixtures of vapours with gases. For any particular volume fraction of a vapour in a mixture with gas, a fall in temperature or increase in pressure will, at a certain stage, reach the saturation point, below which liquid will start to condense as a fog or liquid. When applied to water vapour this is known as the “dew point”. This term is frequently applied to other vapours. Below the dew point the composition of any vapour-gas mixture must therefore change. If this happens within the gas detection system or on the gas sensor, this can lead to falsely low readings on the condensing sample. Also, after such condensation has occurred there will be re-evaporation on returning to cleaner air which will give false high readings.

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4.3.3.2 Calibration considerations

Apart from the limitations for gas mixtures in 4.3.2.1., real restrictions on what calibration or test vapours are practical for field use are imposed by the minimum temperature at which they will be used, and the required pressure in a calibration gas or test gas cylinder.

Test kits with a stored pressure in the range 2 MPa to 3 MPa are effectively limited to around 50 % LFL for n-pentane (boiling point 36 °C), about 10 % LFL for n-hexane (boiling point 68 °C), rather less for other substances with similar boiling points, and lower values still for substances with higher boiling points.

Generally, pentane and hexane test gases are directly applicable to the petroleum industry where such vapours can be the main components. However, for other industries, it is seldom possible to make a portable or transportable calibration or test kit for use outside a laboratory that is truly representative of the vapour to be measured.

To get around this problem, responses of the equipment to different gases and vapours with reference to a particular practical test gas or vapour are determined in a laboratory. Such data is time-consuming and expensive to obtain, and for general purposes is normally only done for a particular model of equipment, not for each unit. In such cases there will be variations between different units.

Routine calibration is then effected in one of two ways:

a) to give a correct LFL readout on the calibration gas or vapour and use the relative response data directly for the substance(s) of interest (or generate the relative response in software);

b) to give an artificial LFL readout on the calibration gas or vapour so that the LFL readout will be approximately correct when exposed to the gas or vapour of interest, or to a specified range of gases or vapours.

There can also be variations in relative responses of sensors over time, particularly in the case of sensors which have a limited life, or are susceptible to “poisoning” (loss of sensitivity due to chemical action), such as electrochemical and catalytic sensors.

For instance, in the case of catalytic sensors, the response to methane will selectively deteriorate before other gases or vapours. If this happens and the equipment can be successfully re-calibrated on methane, it will over-read on all other substances, which is in the safe direction.

For this reason, in all catalytic combustion applications where methane could be involved, the use of methane test gas is recommended for functional checks and during calibration procedures, even if some other gas or vapour is the target gas. Otherwise propane, butane, pentane, or hexane calibration mixtures are usually recommended, for the reason that sensitivity to these will tend to fall before most other substances.

It should also be noted that the sensitivity of catalytic sensors to methane in LFL terms is generally higher than the sensitivity to other substances except hydrogen. Consequently, if using the technique described in a) above, the alarms should be set to a lower set point, and if using the technique described in b) the calibration reading should be set to a correspondingly higher reading than the %LFL of the methane test gas.

Hydrogen is to be used as calibration gas only for applications where hydrogen is the only target gas.

Whenever test or calibration gases other than the gas or vapour of interest are used, it is recommended that additional safety margins, lower alarm settings etc. are employed in order to compensate for the added uncertainty of relative response data due to the factors mentioned above.

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4.3.3.3 Propagation and sampling considerations

Only the vapour of water is lighter than air. There are only four vapours, three of which are flammable, with a similar density to air (methanol, hydroxylamine, hydrazine and hydrogen peroxide, the last three being uncommon).

All other vapours are more dense than air. Most are considerably more dense than air. At a point of release, unless heated, they will initially flow downwards or across level surfaces, and until they are well mixed with air they will stay close to the ground, possibly only a few centimetres deep, which is where they will present the greatest flammability problems. A severe instance of this is in the case of pits, trenches and tunnels which will tend to fill from the bottom upwards and can permit extensive propagation over hundreds of metres. This can also cause the most serious toxicity problems for personnel entering pits and tunnels.

When sampling for flammable vapours in relatively undisturbed atmospheres, some tests should be performed at very low levels, ideally within a centimetre of the floor or ground.

Once mixed with an excess of air, all vapours will be found at all levels, possibly at volume fractions well below their LFL but still presenting major toxicity problems

The vapour of a high flashpoint flammable liquid may not be detectable if the ambient temperature is well below the flashpoint. As an example, using the rule of thumb at the beginning of 4.3.3, if the ambient is 60 K below the flashpoint, it can be estimated that the vapour can only reach between 1 % and 8 % of LFL as a maximum, and then only slowly, close to the liquid, and if the vapour is not being blown away.

Conversely, if the temperature rises, and particularly in an enclosed area, the concentration can change dramatically. Again, using the rule of thumb, the vapour concentration in an enclosed space could increase by a factor up to eight for a 30 K rise in temperature, caused, for instance, by the sun on an external tank. A previously undetected amount of vapour while the tank was cold could become very significant when it is heated up. When temperatures are rising, frequent vapour testing is necessary.

Other problems can arise with substances of high molecular mass. The higher the molecular mass is, the lower the rate of diffusion will be. This applies to non-pumped equipment where diffusion screens are used to prevent external ignition, and also within certain sensors. In particular this can adversely affect both the speed of response and the sensitivity in catalytic sensors.

Major problems also arise in vapour testing due to the possible condensation of the sample itself in the detector or its accessories: Gas detectors will only detect the gases or vapours present. They will not detect mists or condensed liquids caused as a result of the equipment, or a sample line, being markedly colder than the atmosphere being sampled.

If this happens within the gas detection system or on the gas sensor, this can lead to falsely low readings on the condensing sample. Also, after such condensation has occurred there will be re-evaporation on returning to cleaner air which will give false high readings. (see 4.3.3.1)

4.3.3.4 Toxicity considerations

All vapours except water, including all non-flammable ones, are toxic to some degree. All flammable vapours are toxic at concentrations well below LFL. Most vapours, including many commonly found in industry, are of toxic concern well below 1 % of LFL. Therefore they may be undetectable at concentrations where they are already a toxic problem if only using a flammable gas detector with a normal LFL range. Additional precautions are needed.

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4.4 Oxygen deficiency

4.4.1 General

Fixed or portable oxygen detectors are essential for work in locations such as confined spaces and underground coal mines. Portable apparatus typically combine oxygen with flammable gas sensors and frequently also with toxic sensors.

Some varieties of oxygen sensors respond to changes in pressure, and so need checking in clean air, and possibly adjusting, each time they are used and / or if there is a significant change of altitude, such as ascending a tall structure or descending in a mine shaft.

The volume fraction of oxygen in dry air is about 20,9 % v/v. A typical oxygen deficiency alarm setting is between 17,0 % to 19,5 % v/v.

Taking as an example a setting of 19,0 % v/v, the alarm should operate on a 1,9 % v/v deficiency or, put another way, a deficiency of 10 % of the original concentration. In certain circumstances (presence of toxic gases) this may not be adequate for personnel protection.

Similarly, with a setting of 19,5 % v/v, the alarm should operate on a 1,4 % v/v deficiency or, put another way, a deficiency of 7 % of the original concentration. In certain circumstances this also may not be adequate for personnel protection on its own.

In many applications the use of a combined apparatus for flammable gases and oxygen deficiency may not provide sufficient information for the operator. Oxygen deficiency may be due to the presence of a toxic gas. In this case, additional detection for toxic gases is required.

There are three basic physical and chemical mechanisms by which oxygen deficiency can occur, described in 4.4.2 to 4.4.4 with reference to the 19,5 % v/v alarm setting example above.

4.4.2 Chemical reaction of oxygen, with solid products

The main examples are the rusting of steel or the corrosion of other metals. Oxygen has simply been subtracted from the air, and a solid oxide is left. This can typically happen in confined spaces constructed of metal.

When the alarm operates at 19,5 % v/v, the atmosphere is equivalent, in physiological terms, to working at an altitude about 650 m higher than the current altitude. Normally this will not cause any health problem to personnel.

4.4.3 Chemical reaction of oxygen, with gaseous products

In the simplest case this could be the result of respiration, aerobic bacterial action (but not anaerobic action), or clean combustion. The 1,4 % reduction in oxygen content needed to set off the alarm would be accompanied by an increase in carbon dioxide level of about 0,8 %, which is fairly safe in the short term, and there would be no short-term or long-term effects on a ‘normal person’.

If, however, the oxygen deficiency was the possible result of ‘dirty’ combustion involving wood, paper, coal, oil, etc, then, even after the smoke had settled, an atmosphere with 19,5 % v/v oxygen remaining could be lethally toxic due to amounts, possibly in excess of 0,2 % v/v (2 000 parts per million), of carbon monoxide produced together with the carbon dioxide.

If the combustion had also involved plastics such as PVC, polyurethane etc, the atmosphere would be very toxic due to additional combustion products such as hydrogen chloride and hydrogen cyanide.

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4.4.4 Dilution of the air by displacement by some other gas or vapour

Detection of a gas by oxygen depletion is only recommended under very controlled conditions and is not otherwise recommended.

The 1,4 % v/v oxygen deficiency needed to cause the alarm would require an addition of 7 % v/v of the other gas or vapour. Thus the problem becomes that of knowing what gas or vapour has caused the deficiency. There are several categories:

a) Inert gases; not toxic

These are further described in the following paragraphs:If the cause of the oxygen deficiency is dilution by one of the inert gases such as nitrogen, argon, helium or neon, (or water vapour) an addition of 7 % v/v or a limited amount more of the inert gas to the atmosphere is perfectly safe. The situation is similar to that in 4.4.2.

NOTE There are areas where the volume fraction of oxygen is controlled at levels between 12 % v/v and 15 % v/v by dilution in this way, to minimise the risk of fire. These areas will be entered in some cases by personnel. If portable oxygen detectors will be used to protect the personnel the alarm levels for the devices have to be specifically adjusted in relation to the oxygen level in those areas. In such cases, for areas with low volume fractions of oxygen personnel have to pass a medical test according to national regulation before being allowed to enter such areas.

b) Flammable gases; not toxic

If the gas causing the oxygen deficiency is hydrogen, methane (natural gas) or ethane, the atmosphere would be safe to breathe for a short period but would be above the LFL, and therefore explosive. But if there was a flammable gas detector as well as the oxygen detector, it should have given an alarm well before this dangerous situation occurred.

c) Flammable gases; toxic

If the gas causing the oxygen deficiency is acetylene, ethylene, propane, LPG or butane, breathing the atmosphere would be lethal within a few seconds at least. But it would be above the LFL. So if there was a flammable sensor as well, this would alarm first.

d) Non-flammable; toxic

Oxygen deficiency measurement should never be used for the detection of toxic gases

WARNING – Oxygen detectors shall never be used to indicate displacement by CO_2.

Reliance on oxygen detectors to monitor the presence of carbon dioxide has led to fatalities.

4.5 Specific applications of gas detection

4.5.1 Gas detection as means of reducing risk of explosion

4.5.1.1 General

Flammable gas detection equipment in various combinations of operation may provide means to reduce the probability of an explosion by eliminating sources of ignition (i.e., non-explosion protected equipment that may be located in an area that may be exposed to explosive gas atmosphere) or by activating safety functions to keep flammable gas concentration below 25 % LFL.

In major accidental gas releases, an explosive gas atmosphere is likely to be present beyond the limits of an area classification; and, measures should be taken to eliminate sources of ignition within such areas.

The safety function(s) to be employed by means of gas detection and subsequent actions are:

a) the disconnection of any non-explosion protected equipment if the set alarm level is exceeded,

b) increased ventilation rate to prevent increase of gas concentration to above 25 % LFL at the equipment location,

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c) to provide a shutdown signal to the Safety System where detection of flammable gas indicates a loss of containment,

d) for rooms protected by pressurisation, closure of ventilation dampers to prevent ingress of gas. See also IEC 60079-13 regarding isolation of non-explosion protected equipment inside the room,

e) for analyser houses, a broad range of provisions as described in IEC 61285, where gas detectors are an important part.

This main alarm level should be at or below 20 % LFL.

In all cases of detection of flammable gas levels at or above 20 % LFL, audible and visual annunciation should be initiated.

Indication of low levels of flammable gas (with or without pre alarm) should be used to:

1) initiate troubleshooting and repair activities,

2) activate operation of a ventilation system, to increase the rate of existing ventilation to avoid the disconnection of non-explosion protected equipment, and

3) shutdown processes due to more severe gas leaks which may cause the exceeding of the main alarm level.

The equipment for the detection of flammable gas should comply with the performance requirements of IEC 60079-29-1 or IEC 60079-29-4 for the gas or vapour likely to be present in the ventilated area.

4.5.1.2 Ventilation Rates

Ventilation and air movement has two basic functions:

a) To increase the rate of dilution and promote dispersion to limit the extent of a gas hazardous area;

b) To avoid the persistence of an explosive atmosphere which may influence the type of a Zone

If the ventilation rate is calculated such that gas-air mixtures in concentrations exceeding 25 % of the LFL will not occur this high ventilation rate is the relevant means of protection. Gas detection is not mandatory but is recommended to ensure a high level of safety should the ventilation system fail.

If ventilation rates are considered as low ventilation then a combination of ventilation and gas detection is the means of protection and the recommendations provided should be followed.

All ventilation rates are to be compared with expected flammable gas leakage rates, under various conditions of operation. The relative comparison of ventilation rate to flammable gas leakage rate will determine the manner in which combination flammable gas detection equipment and ventilation should be operated.

Guidance for the assessment of ventilation efficiency and availability can be found in IEC 60079-10-1:2008, Annex B.

4.5.1.3 Gas detection in “high” ventilated areas

In this type of application the primary protection against the accumulation of flammable gas concentrations is by high ventilation. The ventilation rate is calculated such that it is ensured that significant quantities of vapour-air or gas-air mixtures in concentrations exceeding 25 % of the LFL will not occur except in the dilution area.

The ventilation rate should be calculated based on maximum leak rates expected.

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The detection of flammable gases is an additional means of protection should the ventilation system fail.

If ventilation fails (a fault condition) disconnection of non-explosion protected ignition-capable equipment should occur.

4.5.1.4 Gas detection in “medium” ventilated areas

If a maximum leak rate cannot be predicted, an adequate ventilation rate may be calculated by assuming leak rates to be expected as realistic. For those leak rates vapour-air or gas-air mixtures in concentrations exceeding 25 % LFL is controlled, resulting in a stable zone boundary, at the ventilation rate determined. However it cannot be excluded that higher leak rates may occur and then the ventilation as the only means of protection will not be sufficient.

Minimum ventilation rates and the ventilation arrangement to be considered must be sufficient to prevent accumulation of flammable gas in corners or behind equipment.

When used in conjunction with medium ventilation rates, equipment for the detection of flammable gases provides an additional level of protection in an area and does form part of the primary safety concept. Gas detection should provide means to cause increase of the ventilation rate at gas concentrations at or below 20 % LFL. If the increased ventilation fails to reduce the vapour-air or gas-air mixtures then the main alarm shall activate the safety function to disconnect all non-explosion protected equipment.

Depending on the local conditions an increase of ventilation should be started at pre-alarm levels between 5 % LFL and 20 % LFL.

If one of the means fails (gas detection or ventilation) the fault has to be indicated. Ignition-capable equipment, can be permitted to operate for a short period if immediate loss of power or automatic shutdown would result in a more hazardous situation, provided repair is initiated and the other means is working correctly.

4.5.1.5 Gas detection in low ventilated areas

Ventilation rates which are so low that they will not prevent the accumulation of flammable gas levels above 25 % LFL are considered as “low” ventilation. In case of low ventilation the degree of dilution may be so low that the classification of the area has a lower Zone number than might otherwise be applied for the grade of release (i.e. a Zone 1 hazardous area from a secondary grade source). Permanent and continuous monitoring of the gas concentration with fixed gas detectors may justify the use of equipment with a lower equipment protection level (EPL) than normally required

For such application both ventilation and gas detection are used as means of protection. Alarm levels and actions (increase of ventilation and disconnection of non-explosion protected equipment) should be the same as in 4.5.1.4.

4.5.1.6 Gas detection in ventilated areas using recirculation

Reduced outside air exchange (below determined adequate ventilation rates) may be used where recirculation of inside air is employed, provided all the following criteria are observed:

1) The area is monitored continuously by a gas detection system for flammable gases.
2) Flammable gas detection is provided in the return air of the ventilation system.
3) When the air inlet flow is reduced, the inside air distribution is maintained by the recirculation.
4) The gas detection system will stop the recirculation when exceeding the lowest alarm level (less than 20 % LFL) and increase the ventilation rate for outside air.

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5) The outside air exchange is provided at a rate that will maintain flammable gas levels below 25 % LFL.
6) At the main alarm level at or below 20 % LFL the non-explosion protected equipment shall be disconnected.
7) If the ventilation fails the fault has to be indicated but no disconnection of equipment is required, provided repair of the ventilation system is initiated and the gas detection system is working correctly.

4.5.2 Gas free work permit

4.5.2.1 General

In hazardous areas equipment that uses an acceptable method of protection that is required to be temporarily bypassed for maintenance or trouble-shooting, may be operated under a gas free work permit. The work may be performed in a hazardous area with the method of protection bypassed under the gas free work permit provided additional equipment for the detection of flammable gas is used and monitored by trained personnel.

NOTE The equipment for the detection of flammable gas can be of portable, transportable or fixed point type detection.

For the maintenance or repair work carried out in a hazardous area, any portable ignition capable devices or equipment (e.g. arc welding equipment, not suitable for the hazardous location) may be operated, according to the work permit instructions and while the equipment for the detection of flammable gas is used and monitored by trained personnel.

The additional equipment for the detection of flammable gas should be suitable for the use in the hazardous area where the work will take place (compliance with IEC 60079-0 and relevant other parts) and should comply with IEC 60079-29-1 for performance for the gas or vapour likely to be present in the working area.

4.5.2.2 Operation

Additional equipment for the detection of flammable gas used to monitor local conditions as a general indication of the presence of flammable gas at the place and time that the permitted work is being performed should be capable of and calibrated for detection of the flammable gas likely to be present in the working area during the time that the permitted work is being performed.

For maintenance and/or repair work of equipment carried out in hazardous areas where the method of protection is bypassed, the following actions should be taken:

a) All portable/transportable gas detection systems should be checked for functionality with a known concentration of flammable gas just prior to use in conjunction with a gas free permit (bump test).
b) Initial measurements should be taken to confirm the absence of any flammable gas throughout the work area.
c) Continuous monitoring should be used to confirm the continued absence of a flammable gas or vapour.
d) Monitoring equipment should be used and monitored by properly trained personnel.
e) During any maintenance activity additional and adequate operational procedures should be in place to ensure that the personnel responsible for the emergency response and actions taken when gas presence is detected is able to carry out their duties correctly.

Before the gas free work permit will be given out the points a) and b) should be carried out successfully to certify that a work location is gas free before the method of protection will be bypassed and before the introduction of sources of ignition into that work area will be allowed.

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