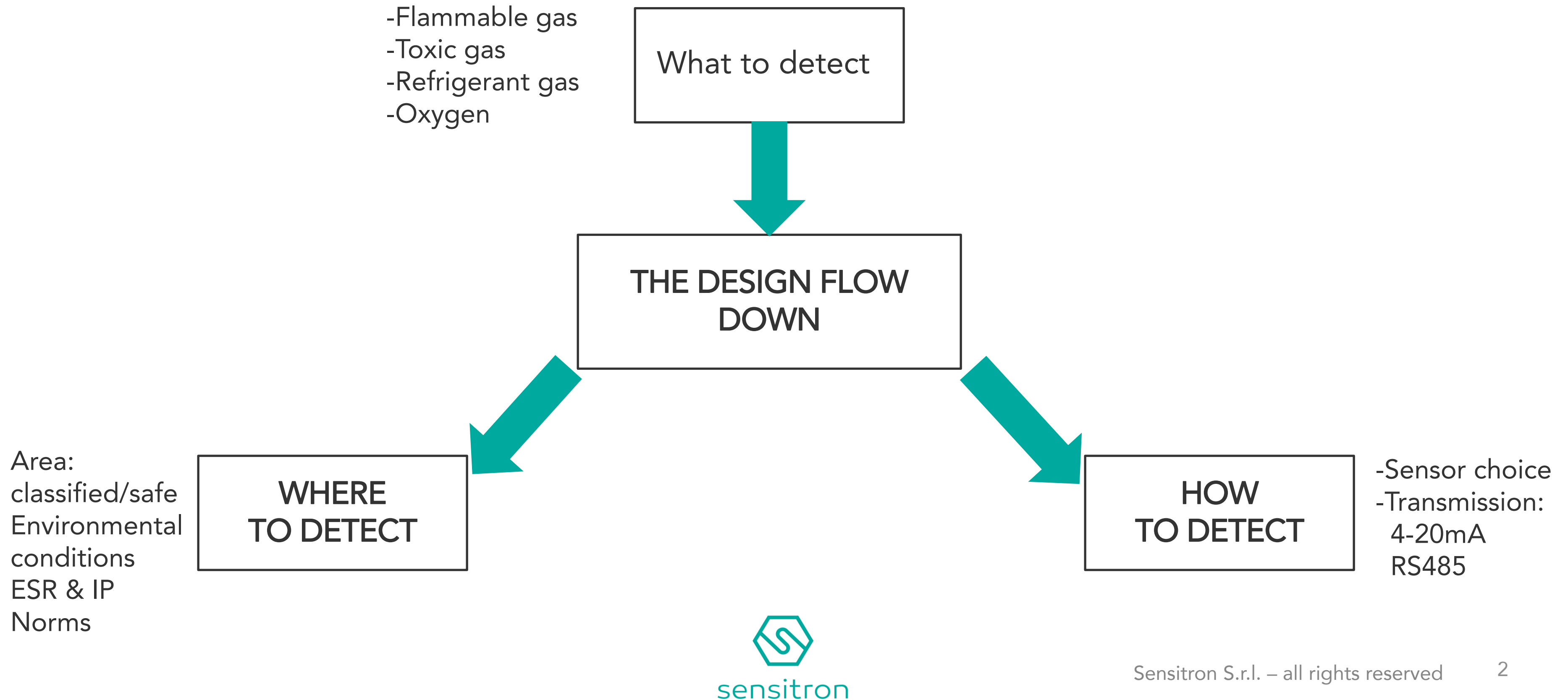


# Tutorial guide to gas detection

# How to choose the right system



# WHAT TO DETECT

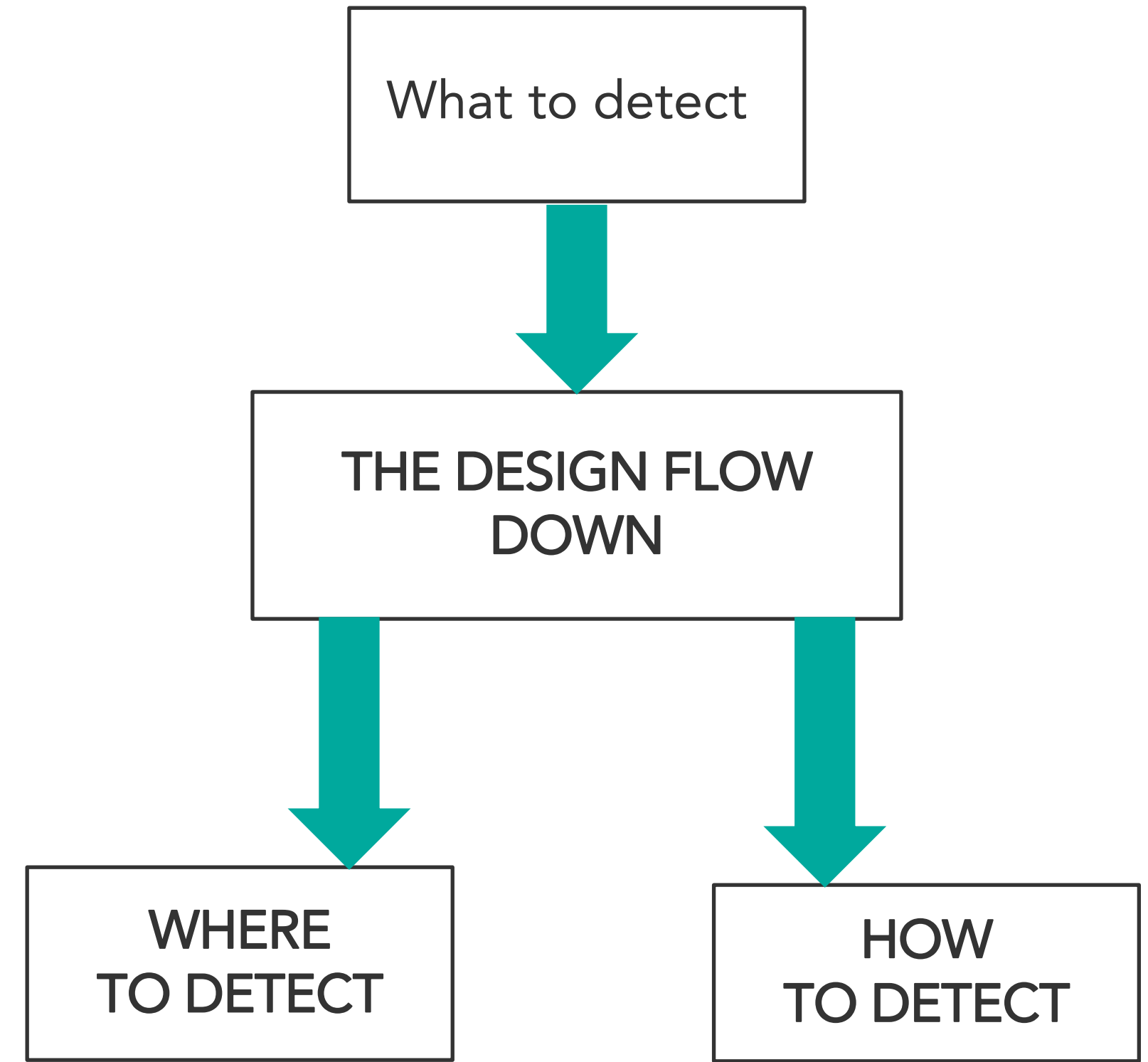
# GAS MAIN CATEGORIES

Risks related to gas mainly divide into three categories:

**FLAMMABLE:** Risk of fire or explosion  
(Methane, Butane, Propane)

**TOXIC:** Risk of poisoning (CO, H<sub>2</sub>S, Cl<sub>2</sub>)

**ASPHYXIAANT:** Risk of suffocation (O<sub>2</sub> depletion)



# FLAMMABLE GASES

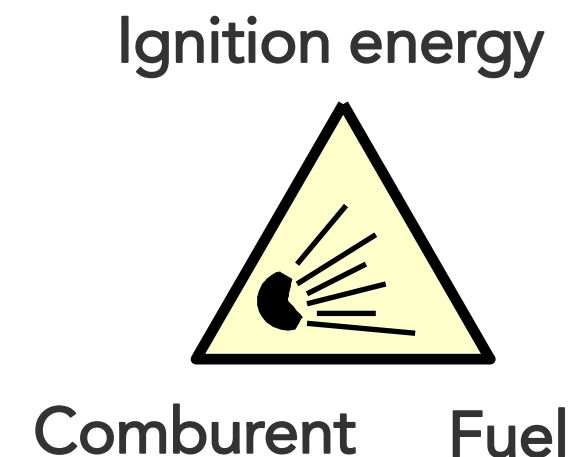
In order to arise, a thermal reaction needs the simultaneous presence, with the proper ratio, of the following three components:

The ignition energy: thermal or electrical

The fuel element: gas, dust or vapour

The comburent: oxygen or air

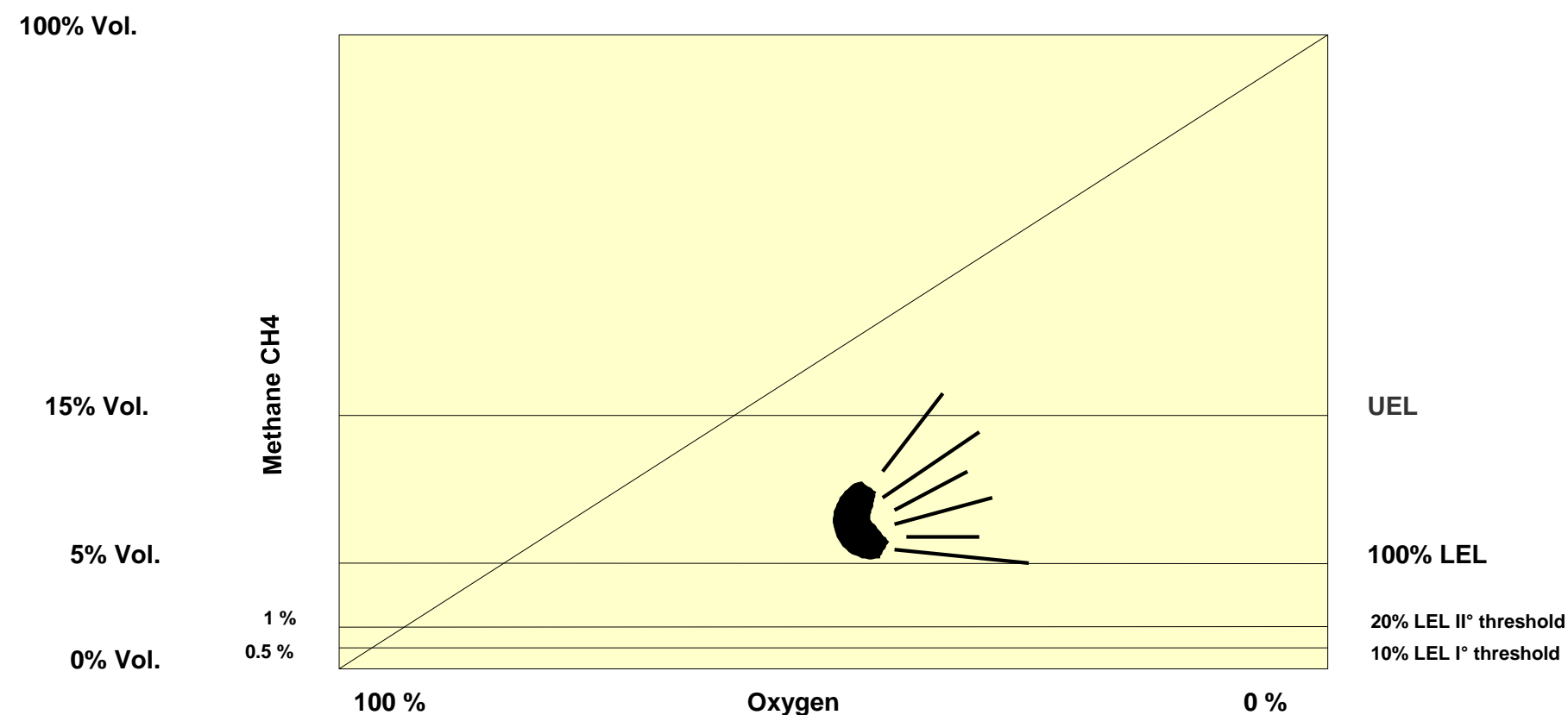
These three components constitute the explosion triangle



# FLAMMABLE LIMITS

The Lower Explosive Limit (**LEL**) or Lower Flammability Limit (**LFL**) defines the lowest concentration of a combustible in air that allows the explosion. There could be a high explosion risk even with very small gas concentrations: in fact a great part of flammable gases and vapors have the LEL figure below 5% of volume.

The Upper Explosive Limit (**UEL**) defines the maximum concentration of fuel in air that may causes explosion. Concentrations of the combustible above the UEL cannot generate explosion because of the insufficient concentration of the combustion supporter (typically Oxygen).



# FLAMMABLE LIMITS

Example of flammable limits (LFL e UEL)  
and temperatures of some common gases

GAS	FORMULA	MOLECULAR MASS	BOILING POINT °C	RELATIVE VAPOUR DENSITY	FLASH POINT °C	LFL %VOL	UEL % VOL
Acetylene	CH=CH	26	-84	0,90	gas	2,30	100
Ammonia	NH3	17	-33	0,59	gas	15	33,60
Butane	C4H10	58,1	-1	2,05	-60	1,40	9,30
Hydrogen	H2	2	-253	0,07	gas	4	77
Methane	CH4	16	161	0,55	<-188	4,4	17

# OTHER PROPERTIES OF FLAMMABLE GASES

## Ignition Temperature

The ignition point is the minimum temperature at which a compound mixed with air initiates or causes self-sustained combustion in the absence of an external source of ignition, such as a flame or spark. All devices used in hazardous areas must have a surface temperature lower than the ignition temperature. To this scope they are marked with their max surface temperature (T rating)

## Flash point

The flash point is the minimum temperature at which liquid or volatile compounds produce a sufficient concentration of vapour above it that it forms an ignitable mixture with air. This is not to be confused with the Ignition Temperature, that can be substantially different.

## Relative Density

It is the weight of gas or vapor per unit volume, compared to the weight of the same volume of air. Gases and vapors are lighter than air if their density is less than one, and heavier than air if the density is greater than one.



# TOXIC GASES

A toxic gas may be defined as a chemical compound that, when inhaled, ingested or absorbed through the skin provokes a wide range of damages, from minor irritations to death. It is possible to come in contact with these gases in different situations and it is the employer's liability to insure that no workers are exposed to concentrations exceeding the safe limits.

Commonly, the presence of toxic gases is expressed in ppm (part per million) or % v/v (percentage by volume) for O<sub>2</sub> and CO<sub>2</sub>.

Exposures to toxic gases must be calculated on the Time Weighted Average (TWA) basis, which is the medium concentration relevant to a common 8-hour workday, at which it is considered that all employee can be exposed without injuring their health.

# EXPOSURE LIMITS TO TOXIC GASES

Exposure limits to toxic gases have been established by occupational safety agencies and may vary according to local directives. They commonly refer to the short-term exposure limit (STEL) defined by the American Conference of Governmental Industrial Hygienists (ACGIH). The lower is the STEL – either expressed in ppm or mg/m<sup>3</sup> – the higher is the compound toxicity

In the **United Kingdom** the normative reference is known as COSHH (Control of Substances Hazardous to Health)

**MAK** (Maximale Arbeitsplatz Konzentration) is the system reference used in **Germany** and in some nearest countries. Its values are published by DFG and are based on experimental effects of toxic substances observed on people and animals.

In the **USA** Occupational Organizations are **OSHA** and **NIOSH**. As for most of the Countries, in the USA exposure limits are defined as **TLV** (Threshold Limit Value), **STEL** (Short Term Exposure Limit) and **TWA** (Time Weighted Average).

# EXPOSURE LIMITS TO TOXIC GASES

These definitions are commonly adopted:

**TLV:** (threshold limit values), limit below which toxic substances in working places generally do not provoke negative health effects.

**TLV-TWA:** (time weighted average, MAK medium), allowable medium concentration time weighted on a 8 hour workday and 40 hour workweek at which it is considered that personnel may be exposed.

**TLV-STEL:** (Short Term Exposure Limit), maximum concentration for a continuous exposure for up to 15 minutes, on condition that the TLV is not exceeded.

**TLV-C:** (Ceiling), concentration ceiling, borderline concentration, value that cannot be exceeded not even for a second.

# TOXIC RISKS: THE MOST COMMON GASES

Gas		Formula	STEL	TLV-TWA	Relative density	Molecular weight
Acido Cianidrico	Hydrogen Cyanide	HCN	-	4.7 C	$\leq 1$	27
Acido Nitrico	Nitric Acid	NHO <sub>3</sub>	4	2		
Ammoniaca	Ammonia	NH <sub>3</sub>	35	25	$< 1$	17
Anidride Carbonica	Carbon Dioxide	CO <sub>2</sub>	30000	5000	$> 1$	44
Biossido di Azoto	Nitrogen Dioxide	NO <sub>2</sub>	5	3	$> 1$	46
Biossido di Cloro	Chlorine Dioxide	CLO <sub>2</sub>	0.3	0.1	$> 1$	68
Anidride Solforosa	Sulphur Dioxide	SO <sub>2</sub>	5	2	$> 1$	64
Cloro	Chlorine	CL <sub>2</sub>	1	0.5	$> 1$	71
Acido Cloridrico	Hydrogen Chloride	HCL	-	2 C	$> 1$	36
Fluoro	Fluorine	F <sub>2</sub>	2	1	$> 1$	38
Fosfina	Phosphine	PH <sub>3</sub>	1	0.3	$> 1$	34
Idrogeno Solforato	Hydrogen Sulphide	H <sub>2</sub> S	15	10	$> 1$	34
Ossido di Azoto	Nitric Oxide	NO	-	25	$\geq 1$	30
Ossido di Carbonio	Carbon Monoxide	CO	-	25	$\leq 1$	28
Ossido di Etilene	Ethylene Oxide	C <sub>2</sub> H <sub>4</sub> O	-	1		44
Ossigeno	Oxygen	O <sub>2</sub>	-	-	-	32
Ozono	Ozone	O <sub>3</sub>		0.1	$> 1$	48

# TOXIC RISKS: MAJOR APPLICATIONS

Gas	Use/Generation
CO <sub>2</sub>	Air quality, beer cellars, food industry, cereals storage, greenhouses, incubators, mining industry, nuclear industry, oil platforms
CO	Vehicles exhaust gas, flue gases of industrial thermal process, residential and industrial heating plants, mining industry, steelworks, tunnels, underground car parks
H <sub>2</sub> S	Chemical industry, oil platforms, sewage disposal
SO <sub>2</sub>	Chemical industry, flue gases of industrial thermal process, food industry, paper mills, PCB manufacturers, steelworks
NO	Flue gases of industrial thermal process, residential and industrial heating plants, mining industry
NO <sub>2</sub>	Vehicles exhaust gas, Chemical industry, flue gases of industrial thermal process, residential and industrial heating plants
Cl <sub>2</sub>	Chemical industry, paper mills, water conditioning
HCN	Chemical industry, fumigation, semiconductor industry
HCl	Chemical industry, flue gases of industrial thermal process, PCB manufacturers, semiconductor industry, metal heat-treating.
NH <sub>3</sub>	Chemical Industry, chicken breeding, plants for fertilizers, food industry, refrigeration systems.

# OXYGEN: DEFICIENCY AND ENRICHMENT

Let's consider the air composition before introducing the concepts of Oxygen deficiency or enrichment.

Air is a mixture composed as follows:

- 78.08% NITROGEN (N<sub>2</sub>)
- 20,94% OXYGEN (O<sub>2</sub>)
- 0,93% ARGON (Ar)
- 1% WATER VAPOUR (H<sub>2</sub>O)
- 0,035% CARBON DIOXIDE (CO<sub>2</sub>)
- 0,03% OTHER GASES

# OXYGEN: DEFICIENCY AND ENRICHMENT

The normal Oxygen concentration in the air is 20,9% of its volume in dry environment. Nevertheless this level decreases during industrial manufacturing, if either Oxygen is used up by corrosion processes or similar reactions, or because it dilutes with other gases. In normal circumstances human body does not have breathing problems down to a minimum level of 19,5%.

Oxygen deficiency is one of the main causes of sudden deaths. For this reason level must be checked so that it never goes below 18-19%.

There is another aspect, not less dangerous: it concerns Oxygen enrichment in environment atmosphere. Oxygen becomes toxic at high concentrations and it enormously increases materials flammability, in particular when it exceeds 24% concentration. This happens in closed rooms during soldering operations when some leakages from the O<sub>2</sub> gas cylinder might occur.



# OXYGEN DEFICIENCY EFFECTS

% of the volume	Oxygen
19,5	Allowed oxygen minimum level
15 ... 19	Reduced capability at work. It may cause slight symptoms in people having circulatory, cardiac and pulmonary diseases
12 ... 15	It increases breathing effort, heartbeat, coordination problems, perception and discernment
10 ... 12	Breathing speed and depth increases further on, short discernment, blue lips
8 ... 10	Incapability of reasoning, weakness, unconsciousness, pale face, blue lips, nausea and vomiting
6 ... 8	8 minutes – fatal at 100%; 6 minutes – fatal at 50%; 4-5 minutes – hospitalization and treatment
4 ... 6	Coma in 40 seconds, convulsions, breath failure, death



# INERT GASES

Conventionally, noble gases and nitrogen are considered inert gases

1 H hydrogen 1.008 (1.0078, 1.0082)																	2 He helium 4.0026
3 Li lithium 6.94 (6.938, 6.947)	4 Be beryllium 9.0122											5 B boron 10.81 (10.806, 10.821)	6 C carbon 12.011 (12.009, 12.012)	7 N nitrogen 14.007 (14.005, 14.009)	8 O oxygen 15.999 (15.998, 15.999)	9 F fluorine 18.998	10 Ne neon 20.180
11 Na sodium 22.989	12 Mg magnesium 24.305 (24.304, 24.307)	21 Sc scandium 44.956	22 Ti titanium 47.867	23 V vanadium 50.942	24 Cr chromium 51.996	25 Mn manganese 54.938	26 Fe iron 55.845	27 Co cobalt 58.933	28 Ni nickel 58.693	29 Cu copper 63.546	30 Zn zinc 65.38	31 Ga gallium 69.723	32 Ge germanium 72.630	33 As arsenic 74.922	34 Se selenium 78.971	35 Br bromine 79.904 (79.901, 79.907)	36 Kr krypton 83.798
37 Rb rubidium 85.468	38 Sr strontium 87.62	39 Y yttrium 88.906	40 Zr zirconium 91.224	41 Nb niobium 92.906	42 Mo molybdenum 95.95	43 Tc technetium 98.01	44 Ru ruthenium 101.07	45 Rh rhodium 102.91	46 Pd palladium 106.42	47 Ag silver 107.87	48 Cd cadmium 112.41	49 In indium 114.82	50 Sn tin 118.71	51 Sb antimony 121.76	52 Te tellurium 127.60	53 I iodine 126.90	54 Xe xenon 131.29
55 Cs cesium 132.91	56 Ba barium 137.33	57-71 lanthanoids	72 Hf hafnium 178.49	73 Ta tantalum 180.95	74 W tungsten 183.84	75 Re rhenium 186.21	76 Os osmium 190.23	77 Ir iridium 192.22	78 Pt platinum 195.08	79 Au gold 196.97	80 Hg mercury 200.59	81 Tl thallium 204.38 (204.38, 204.39)	82 Pb lead 207.2	83 Bi bismuth 208.98	84 Po polonium	85 At astatine	86 Rn radon
87 Fr francium	88 Ra radium	89-103 actinoids	104 Rf rutherfordium	105 Db dubnium	106 Sg seaborgium	107 Bh bohrium	108 Hs hassium	109 Mt meitnerium	110 Ds darmstadtium	111 Rg roentgenium	112 Cn copernicium	113 Nh nihonium	114 Fl flerovium	115 Mc moscovium	116 Lv livermorium	117 Ts tennessine	118 Og oganesson
57 La lanthanum 138.91	58 Ce cerium 140.12	59 Pr praseodymium 140.91	60 Nd neodymium 144.24	61 Pm promethium	62 Sm samarium 150.36	63 Eu europium 151.96	64 Gd gadolinium 157.25	65 Tb terbium 158.93	66 Dy dysprosium 162.50	67 Ho holmium 164.93	68 Er erbium 167.26	69 Tm thulium 168.93	70 Yb ytterbium 173.05	71 Lu lutetium 174.97			
89 Ac actinium	90 Th thorium 232.04	91 Pa protactinium 231.04	92 U uranium 238.03	93 Np neptunium	94 Pu plutonium	95 Am americium	96 Cm curium	97 Bk berkelium	98 Cf californium	99 Es einsteinium	100 Fm fermium	101 Md mendelevium	102 No nobelium	103 Lr lawrencium			

# INERT GASES

Usually inert compounds do not need monitoring; none-the-less, whenever an inert gas may deplete the Oxygen contents, its control becomes necessary.

A few examples:

- ☐ Cry preservation of biological samples in liquefied nitrogen;
- ☐ Laboratories in which Helium, Argon and Nitrogen may be employed;
- ☐ Hospitals' NMR rooms, where possible Helium leakages from the machineries might deplete the Oxygen contents causing asphyxia.

Being «inert» these gases do not cause any reaction to gas sensors and the only way to detect their presence is by indirectly monitoring oxygen contents: the lower O<sub>2</sub>, the higher the presence of inert compounds.

# REFRIGERANT GASES

A refrigerant fluid (or simply refrigerant) has the task of optimally transferring the heat from a hot source to a cold source.

The most common refrigerants can be divided as shown in the table below:

REFRIGERANT SAFETY GROUPS		
Class 3 – Higher Flammability	A3	B3
Class 2 – Lower Flammability	A2	B2
	A2L	B2L
Class 1 – No Flame Propagation	A1	B1
	Lower Toxicity	Higher Toxicity

# REFRIGERANT GASES

There is a growing awareness and concern about the impact on the environment and climate change caused by high GWP refrigerants.

In response, the industry is developing a new class of low GWP refrigerants that in many cases has a level of flammability that needs to be monitored.

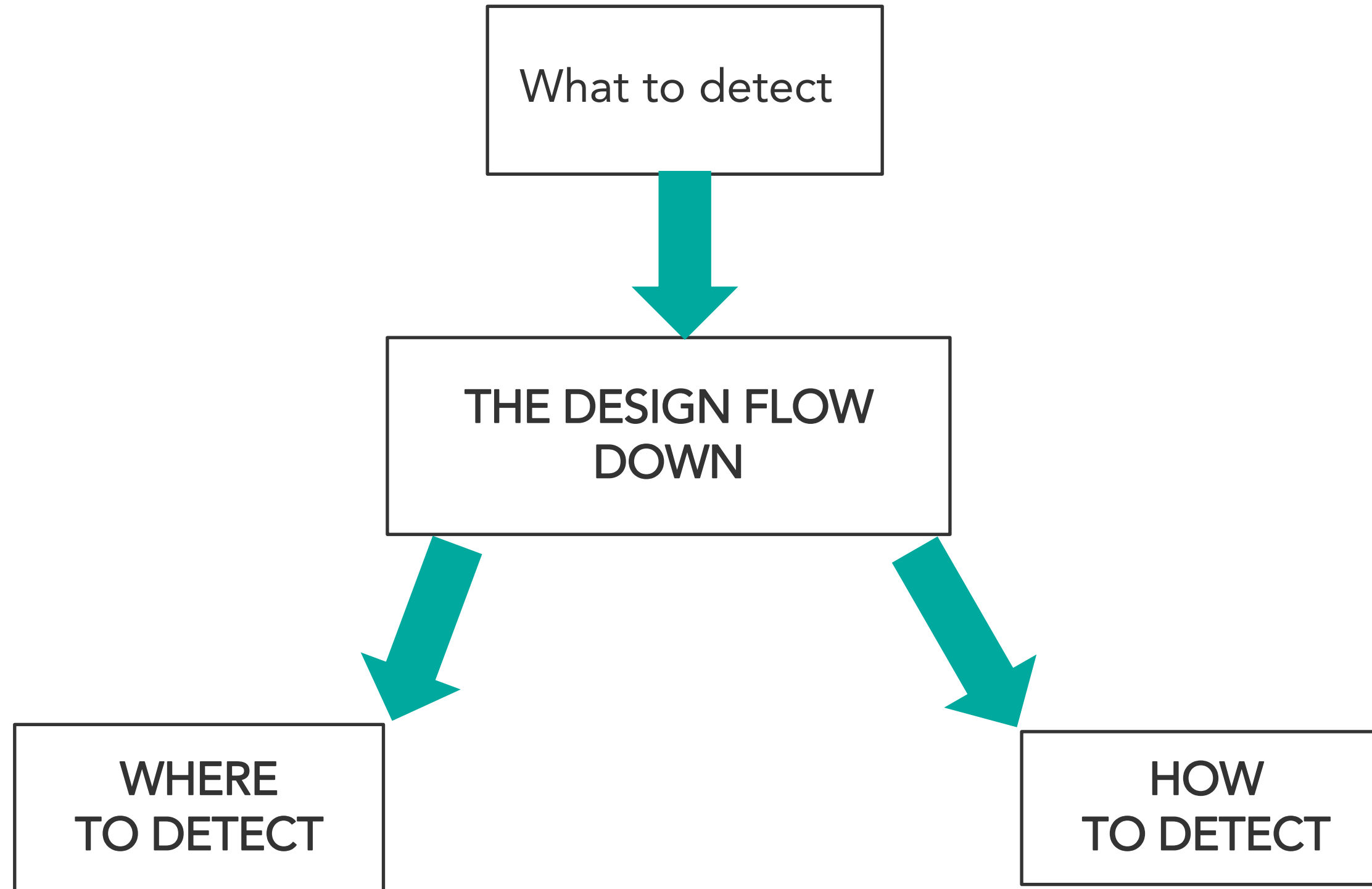
The flammability of the refrigerant is classified by ISO 817-2014 & ASHRAE 34-2016. To express the flammability properties of the new unsaturated HFCs (called HFOs) and of other refrigerants with similar properties, ISO 817-2014 regulated as a 2L a separate class, characterized by combustion speed less than or equal to 10 cm / s

Electrochemical cell technologies are used for ammonia in toxicity levels (ppm), catalytic or infrared detectors for flammable refrigerants and infrared technology detectors for ppm refrigerants.

These substances should be detected because their presence could cause environmental risks due to the high GWP, besides the fact that gas losses are expensive.

# HOW TO DETECT

# THE SENSOR CHOICE





# GAS SENSORS- TECHNOLOGIES

For the detection of flammable gases, the following technologies are employed:

## Catalytic (Pellistor) Chemical Principle

- Fast response to gas
- Sensitive to poisoning substances
- Estimated lifetime 4 years



## Infrared Optical principle

- Selectivity
- Immune to poisoning elements
- Estimated lifetime 5 years



## POP-IR Optical principle (IR and Open Path)

- Selectivity
- Immune to poisoning elements
- Estimated lifetime 5 years
- Very fast T90



# GAS SENSORS- TECHNOLOGIES

Electrochemical cells are usually employed to guarantee a precise and accurate detection of toxic gases. Whenever, for environmental reasons, the electrochemical cells can't be employed, the MOS sensor might be considered as an alternative for H<sub>2</sub>S detection.

## Electrochemical cell

- For most of the toxic gases
- Estimated lifetime 2 years



## Solid state

### Electrochemical cell

- H<sub>2</sub> (ppm), H<sub>2</sub>S, CO
- Estimated lifetime: 2 years



## MOS

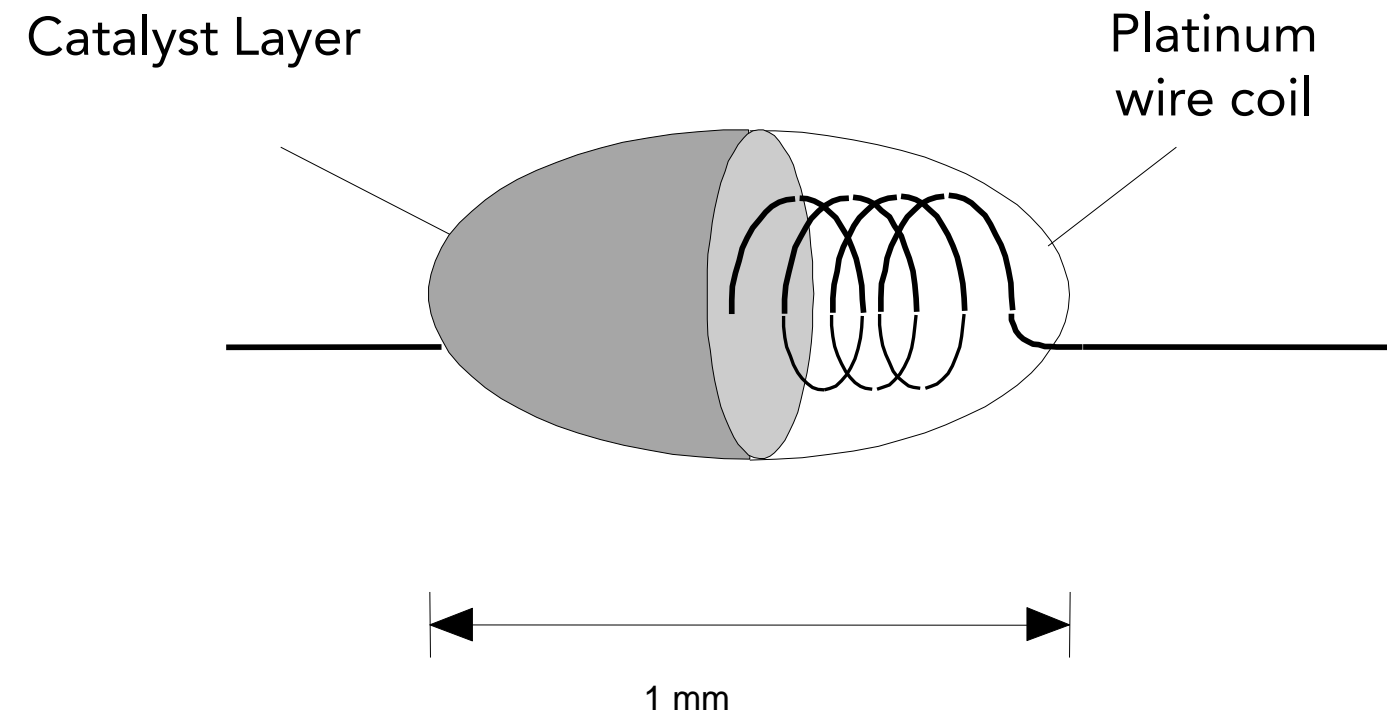
### Chemical principle

- For H<sub>2</sub>S in ppm
- Estimated lifetime 4 years

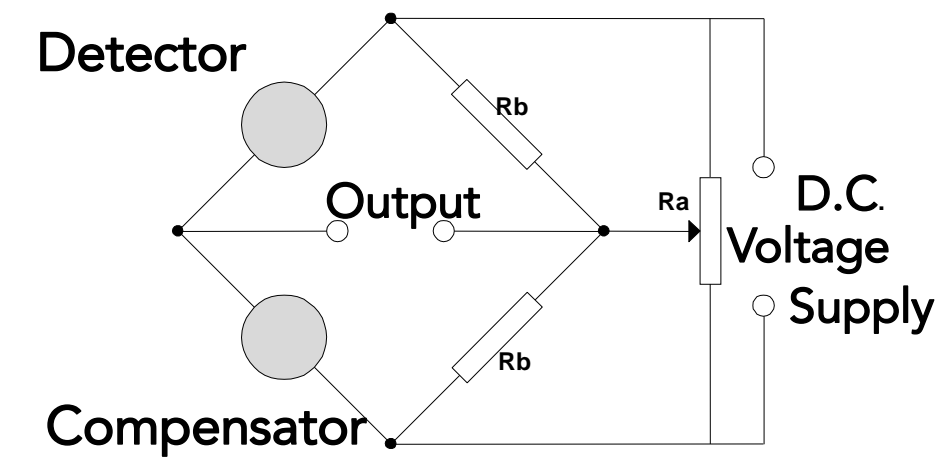




# CATALYTIC SENSORS



Catalytic Gas Sensor  
Schematic diagram



Suggested  
Operating Circuit

(doc. NEMOTO JAPAN)

# CATALYTIC SENSORS – PHYSICAL PRINCIPLE

The working principle of catalytic sensors is based on flammable gas oxidation: when a combustible gas comes in contact with the catalyst surface it is oxidised. The reaction releases heat, which causes the resistance of the wire to change.

A catalytic palletised resistor (or “Pellistor”) consists of a very fine coil of platinum wire, embedded within a ceramic pellet. On the surface of the pellet is a layer of a high surface area noble metal, which, when hot, acts as a catalyst to promote exothermic oxidation of flammable gases.

In operation, the catalyst layer is heated by passing a current throughout the underlying coil. In the presence of flammable gas the hot catalyst allows oxidation to occur in a similar chemical reaction to combustion.

Just as in combustion, the reaction releases heat, which causes the temperature of the catalyst together with its underlying pellet and coil to rise. This rise in temperature results in a change in the electrical resistance, which constitutes the signal from the sensor.

Pellistor sensors are always manufactured in pairs, the active catalysed element being supplied with an electrically matched element which contains no catalyst and is treated to ensure that no gas will oxidise on its surface. This “compensator” element is used as a reference resistance to which the sensor’s signal is compared to remove the effects of environmental factors other than the presence of a flammable gas.

# CATALYTIC SENSORS

Environmental conditions such as temperature, humidity and pressure variation, influence both of the beads (the active sensor and the reference) therefore the Wheatstone bridge will not be unbalanced. This characteristic makes it possible for the Pellistor to provide for a careful read-out also in critical environmental conditions.

Along with its capability to compensate for variations in the environmental conditions, a professional catalytic sensor offers several benefits:

linearity, meant as the linear relationship between zero and the span gas value; repeatability, defined as the percent error between the reading generated by a second application of calibration gas and the first benchmark value, compared to the range; reproducibility, intended as the possibility to get the same value, related to the same concentration and environmental conditions, on more sensors belonging to the same type and manufacturer.

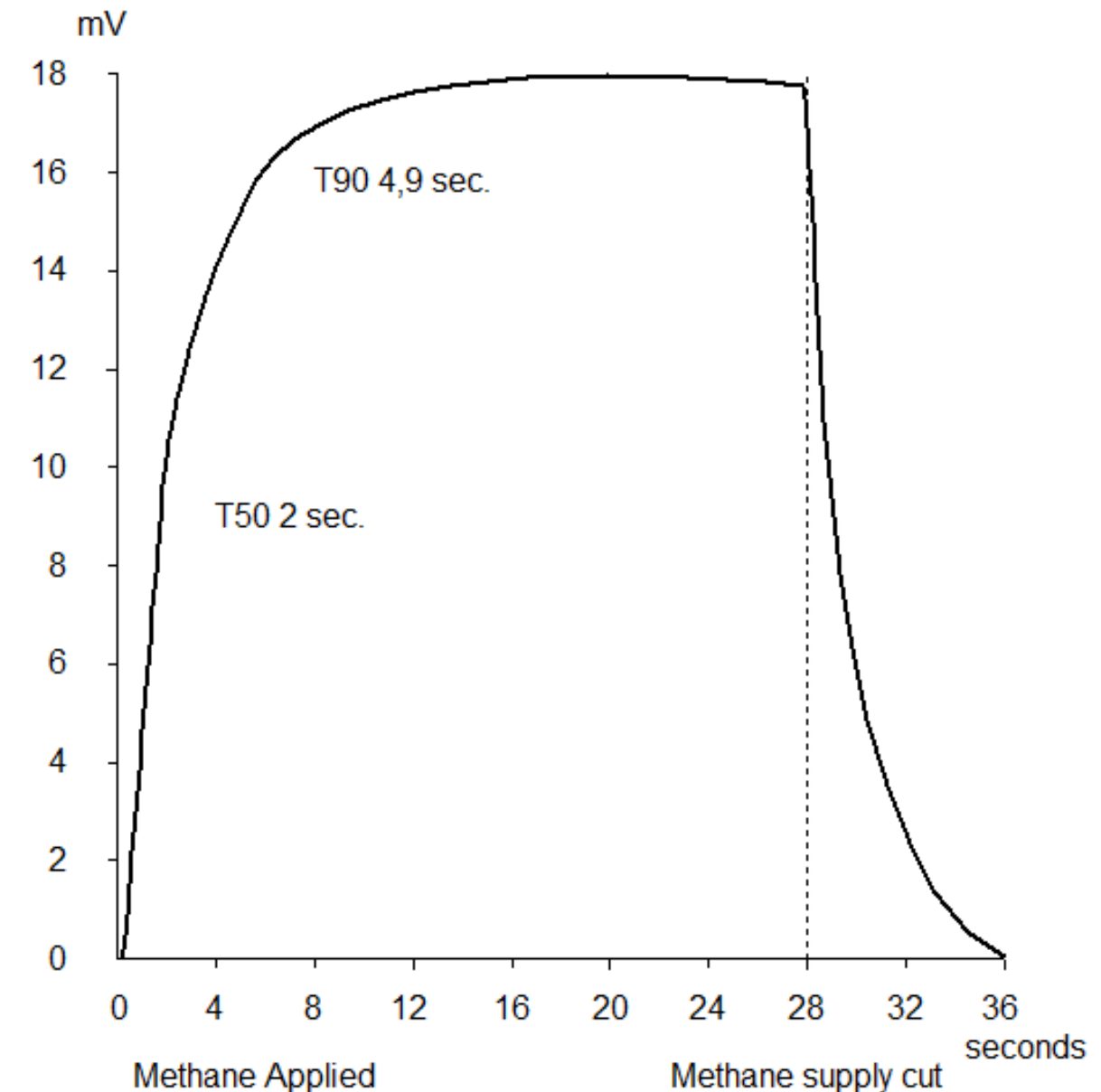


# CATALYTIC SENSORS - APPLICATIONS

The catalytic sensor is excellent for the detection of a wide range of combustible gases within the Lower Flammable Limit (LFL).

The response time depends on the gas being detected: the greatest is the gas weight or the molecular dimension the longer will be the response time.

A T90 response to methane detection is usually provided in 5-10 seconds; a slight increase occurs when the sensor is protected by a sintered filter.



(Doc. E2V)

# CATALYTIC SENSORS - RESTRICTIONS

Catalytic sensor performance may be altered by the presence of some substances. These may be divided into two categories: inhibitors and poisons.

## Inhibitors

Inhibitors cause a temporary loss of sensitivity to the sensor. Sensitivity may be partially or totally recovered after a short exposure to fresh air. The most common inhibitors are H<sub>2</sub>S, chlorine, chlorinated hydrocarbons and the halogen compounds.

## Poisons

Poisoning compounds cause a permanent reduction of the sensor sensitivity thus to damage the sensor completely. Silicon compounds and tetraethyl lead are among the most common poisons.

The presence of inhibitors or poisons is the most common cause of problems in the gas detection and it is necessary to pay attention in order to avoid any contamination.

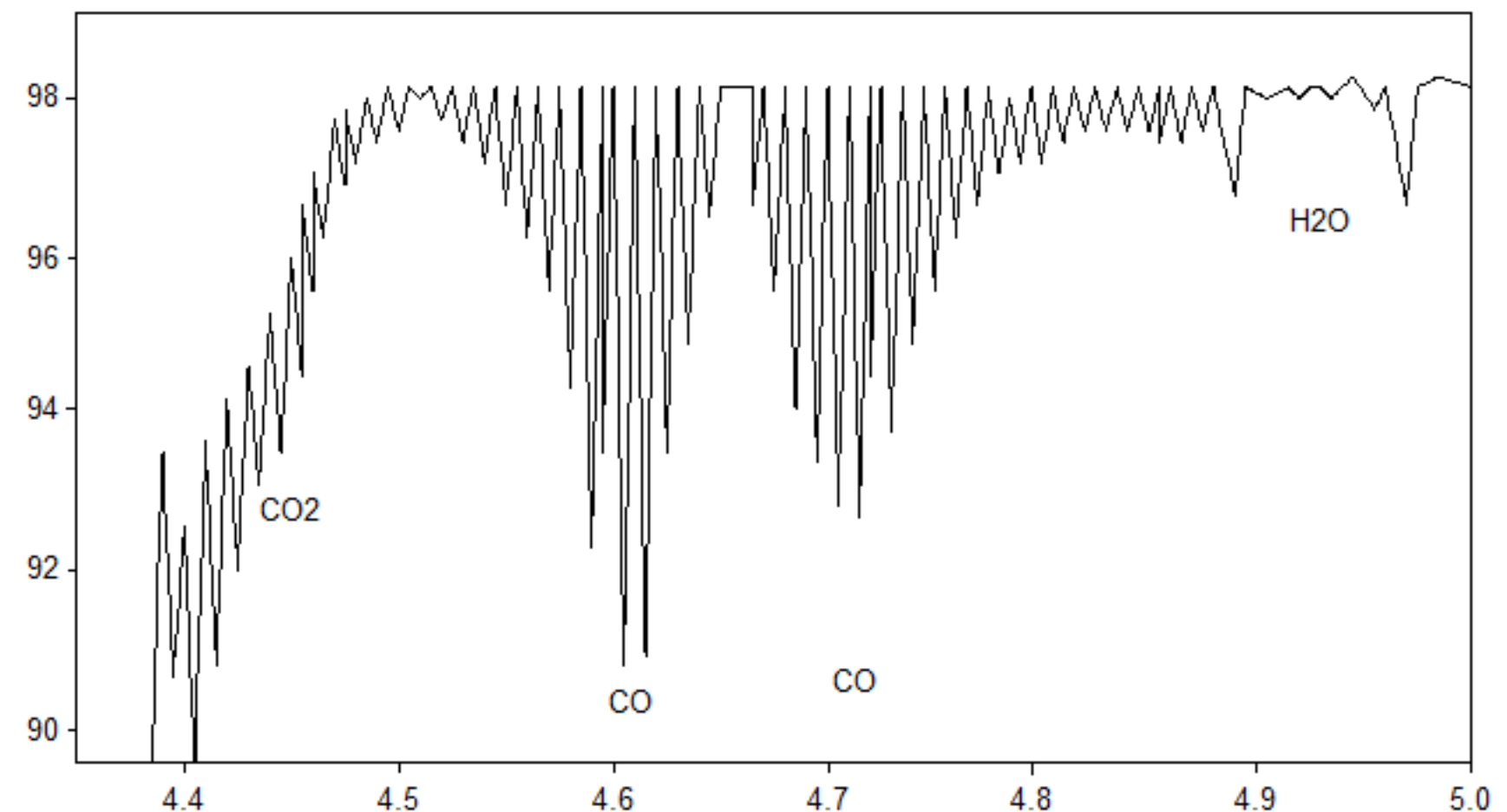
# INFRARED SENSORS

Many flammable and toxic gases have absorption bands of infrared light. Optical detectors for combustible gas detection provide an increasingly popular alternative to traditional Pellistor-based combustible gas detectors.

This technology has undoubted advantages such as:

- being virtually immune to temperature and humidity variations;
- being immune to poisoning;
- offering a very high selectivity.

In some circumstances, like carbon dioxide detection, the use of infrared sensor is in practice irreplaceable. IR absorption frequency or wave-length corresponds to molecular links resonance among different atoms.



(Doc. MicroParts)



# INFRARED SENSORS - PRINCIPLE

In a specific wavelength, optical sensors take the attenuation difference between a reference signal and the signal made by the light passing in the substance to survey.

A source of light gives out a ray of light that gets to an optical receiver, through a path fixed in advance and after being filtered. The source of light may be a tungsten bulb, a diode LED or a IR source.

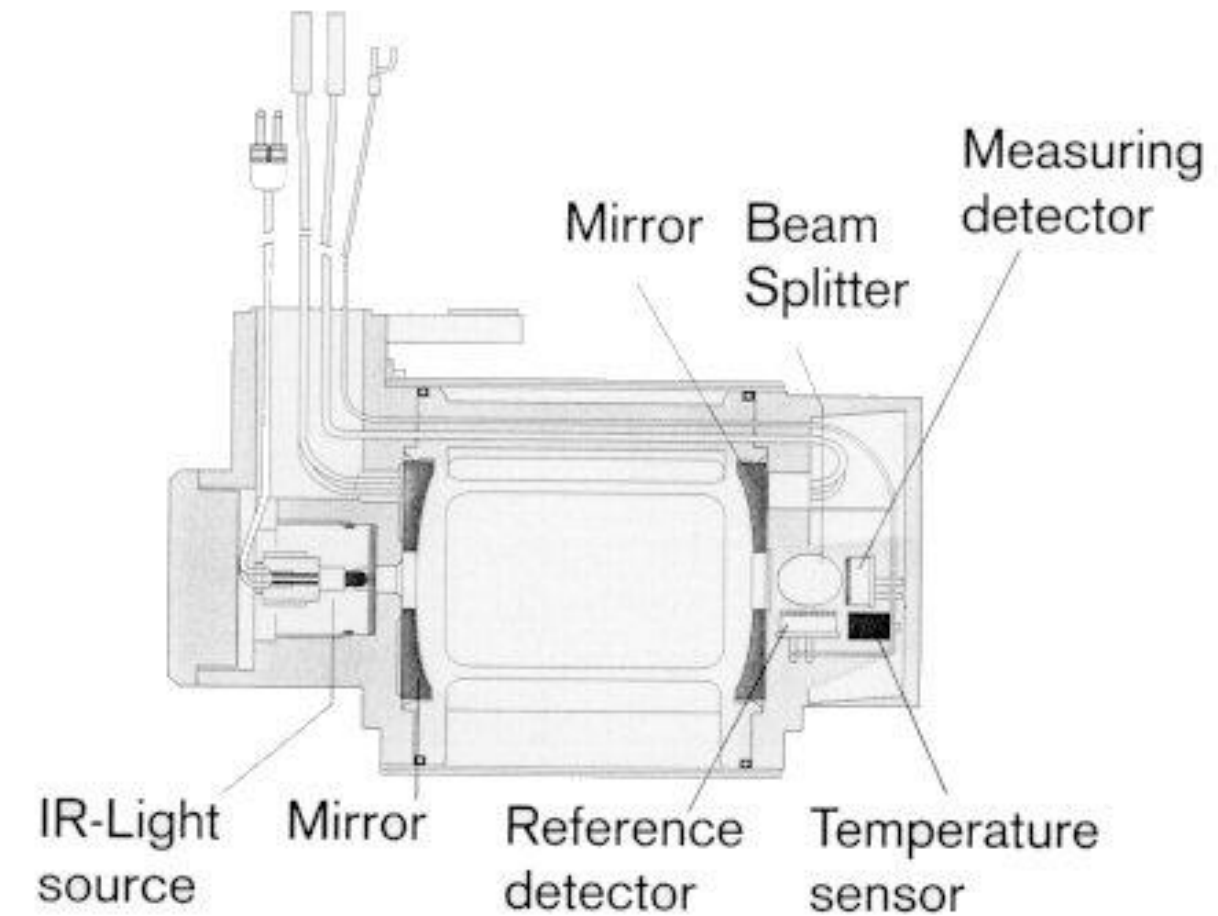
According to the type of substance to survey, the optical path will have a different length as far as to use a multireflection system made with adequate mirrors.

The sensor may be open or closed in a cuvette, with inlets and outlets for the gas or the mixture to survey.

# INFRARED SENSORS - PRINCIPLE

The source of light is usually pulsating as sensors require a modulated signal. The reference sensor is usually positioned in a IR band not influenced by the presence of the gas.

The sensor may be photovoltaic, photoconductive or pyroelectric. Some optical element may be inserted at the end of the optical path to protect the sensitive part from corrosion.



(Doc. Draeger)



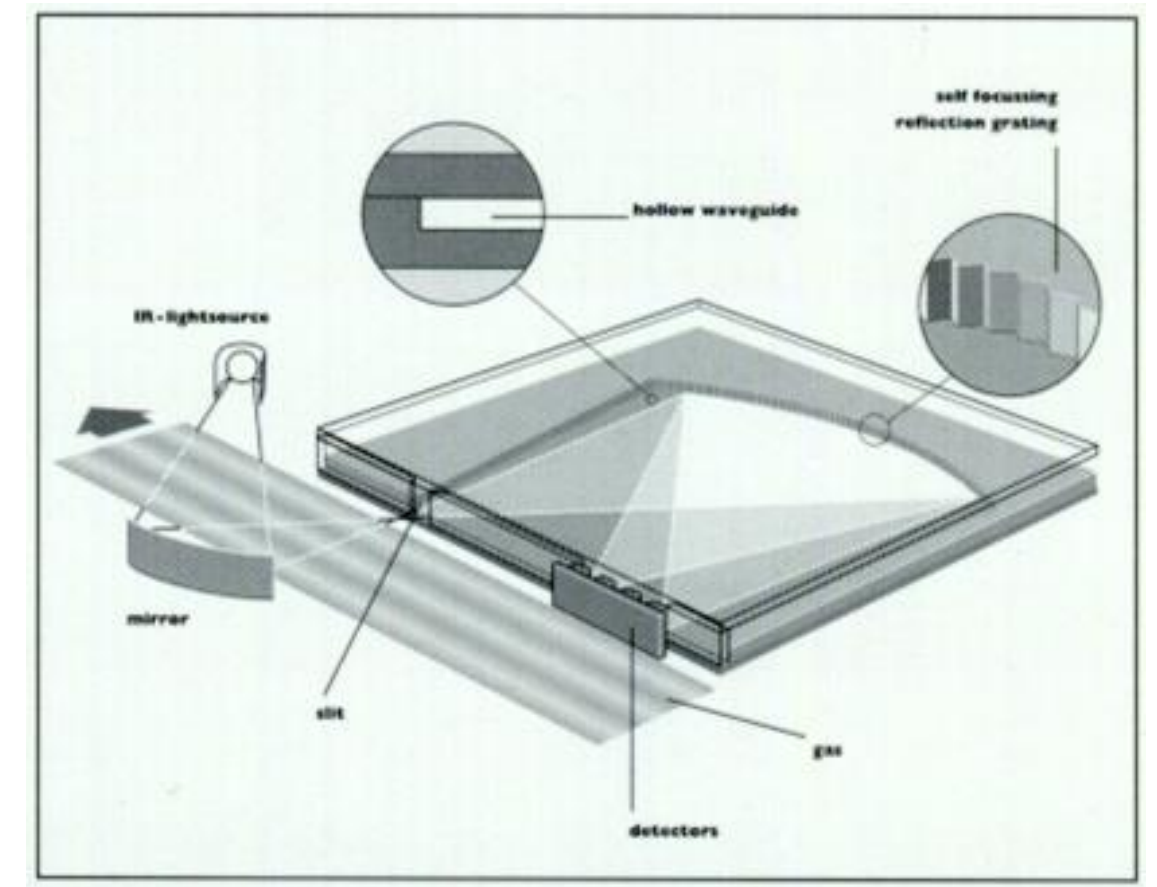
# INFRARED SENSORS - APPLICATIONS

Infrared sensors may be used to survey the most of combustible gas, except hydrogen, in every concentration range up to 100% V/V. Oxygen has no influence on the signal. By selecting adequate wavelength and optical path length, we can obtain apparatus for:

- hydrocarbons total measure
- selective measure of a single component in a mixture
- ppm measure of small parts
- measure up to 100% V/V

Sensors ranges and characteristics must be fixed on the basis of the application.

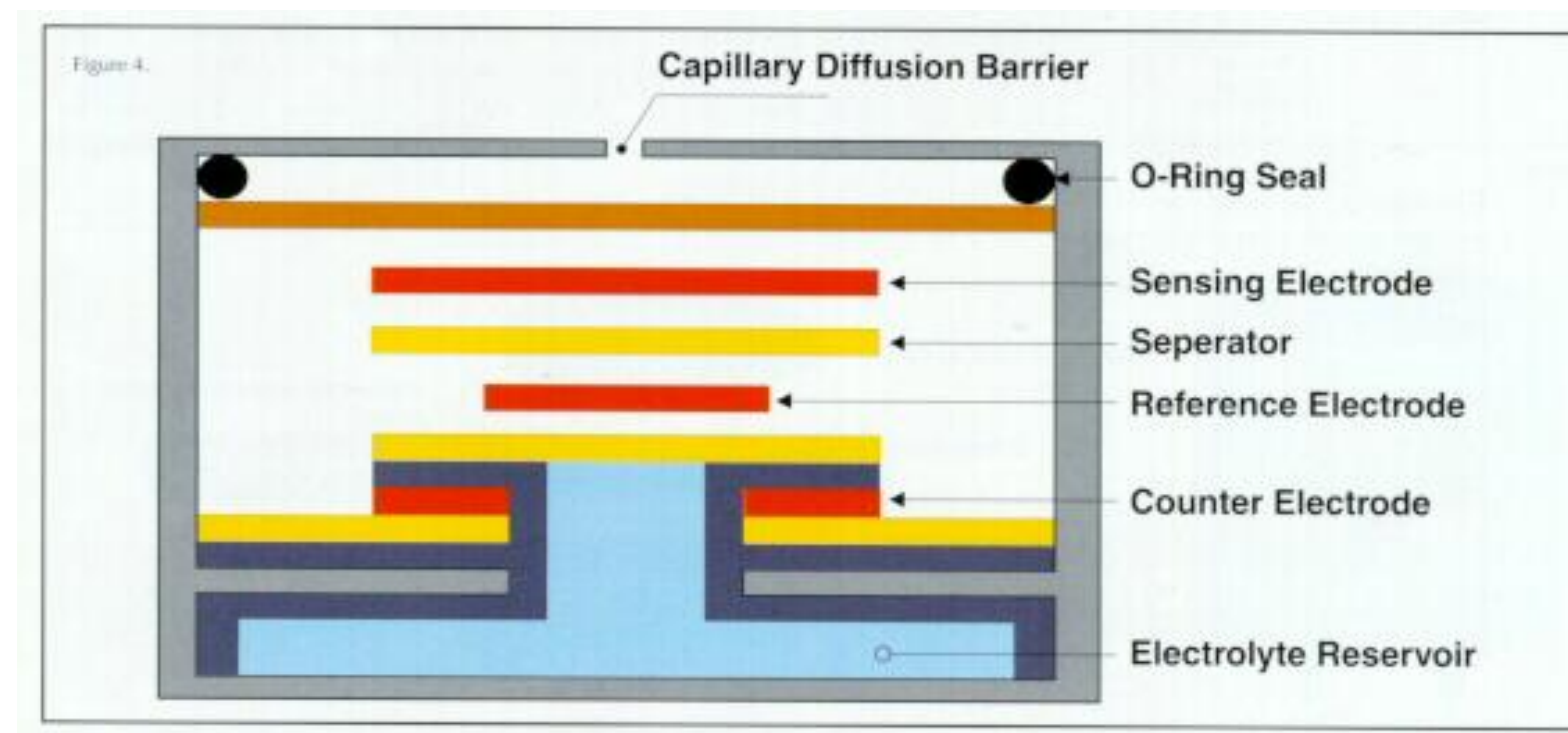
Compensation of environmental conditions, self-diagnosis and self-calibration qualify the sensor and reduce the maintenance.



# ELECTROCHEMICAL SENSORS

In its most simple form, the electrochemical sensor has two electrodes, "Sensing" and "Counter" which are divided by an electrolyte thin coat. This may be in a liquid state or in a gel state and recently also in a solid state.

The electrolyte is isolated towards the outside through a membrane permeable to gas. Gas enters in the sensor by diffusion, through the membrane, and there is an oxidization reaction (reduction that causes an electrical current directly proportional to gas concentration) if a polarization tension is applied to electrodes.



(Doc. City)

# ELECTROCHEMICAL SENSORS

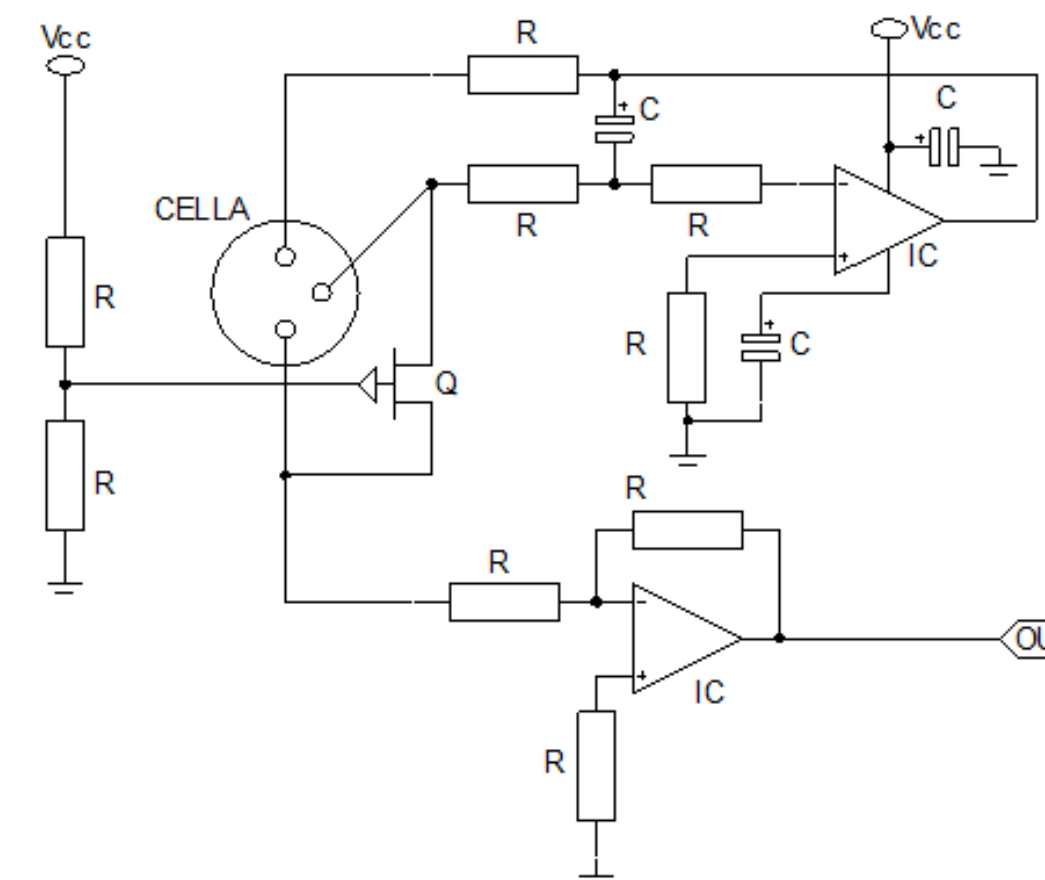
These kind of sensors need little power and they are usually linear, precise and very sensitive. It is possible to survey very few ppm and the response is generally given between 30 to 60 seconds.

Electrochemical sensor lifetime lasts usually 2-3 years.

The lifetime depends on the gas concentration to detect and the gas background commonly present in the environment.

This type of sensor is widely used to survey toxic gases, while there are few applications for flammable gases. It is possible to detect hydrogen and CO concentrations up to LEL and oxygen concentrations to 25% of its volume. Low temperature or humidity may reduce sensor sensitivity and for this reason it is advisable to electronically offset the temperature.

Electrochemical sensors are used to survey a gas in the most specific way. Nevertheless some cross sensitivity relevant to other gases may occur without creating big disadvantages.

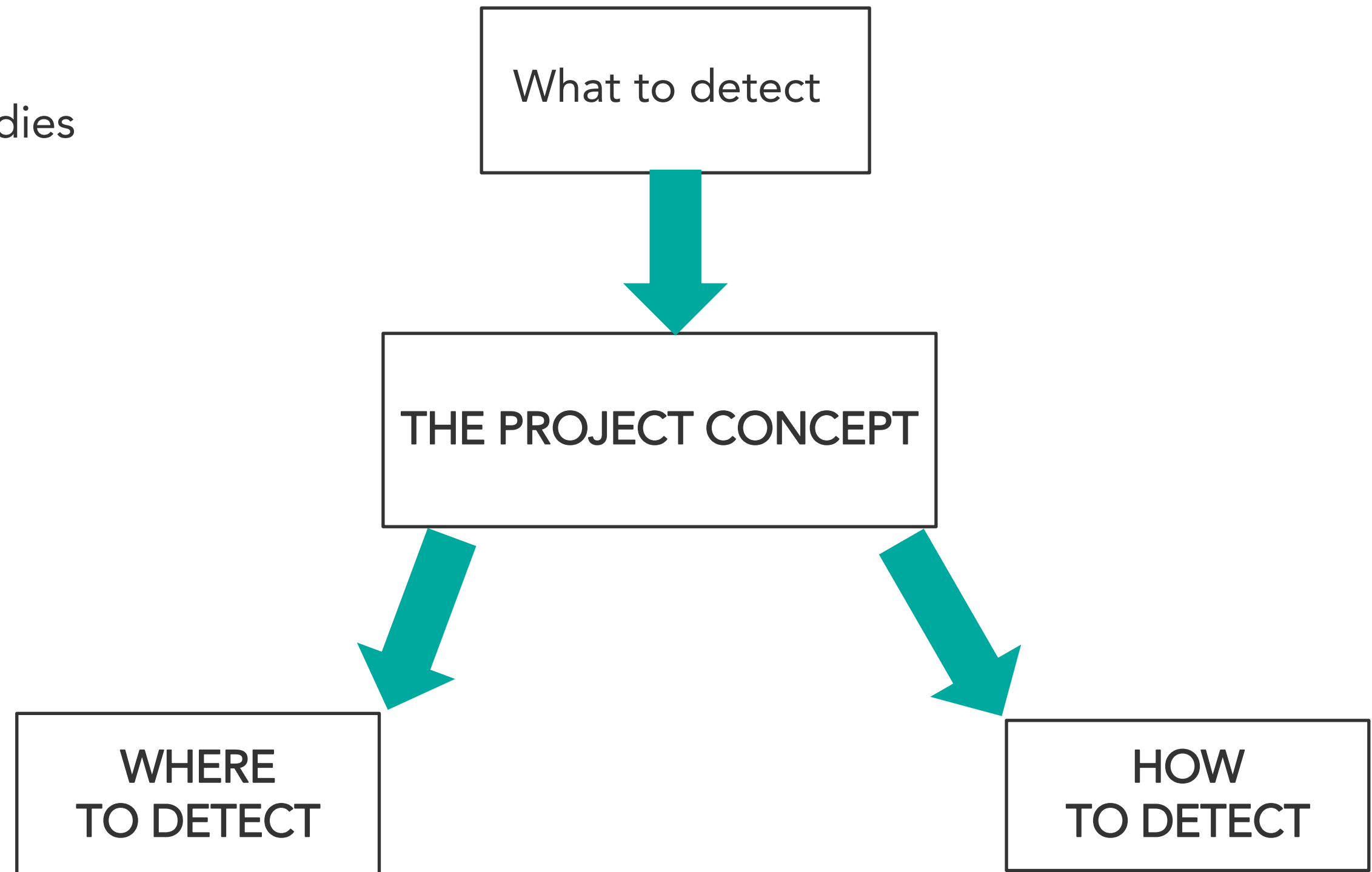


(Doc. Nemoto)

# WHERE TO DETECT

# PLACES AND SAFETY REQUIREMENTS

- The protection notion
- The norms and certification bodies
- The protection methods
- The areas classification
- The temperature classes
- The apparatus groups



Electrical Safety Requirements  
General Performance Requirements

# RISK OF GAS PRESENCE

INDUSTRY	GAS TO BE DETECTED
THERMAL PLANTS	Methane, LPG
INDUSTRIAL KITCHENS	Methane, LPG
DEPOSITS AND FILLING OF GAS CYLINDERS	GPL
LANDFILLS AND PURIFIERS	Biogas (Methane), Hydrogen Sulphide (H <sub>2</sub> S)
REFRIGERATING PLANTS	Ammonia (NH <sub>3</sub> )
REFINERIES	Methane, sulphide hydrogen
STEEL INDUSTRY	Methane, carbon monoxide (CO)
HOSPITALS	Oxygen, Nitrous oxide (N <sub>2</sub> O)
WORKSHOPS	Methane, Hydrogen, Acetylene, Oxygen, Alcohol (different)
COMBUSTIBLE DEPOSITS	Petrol Vapors, Diesel Vapors
UNDERGROUND CAR PARKS	Vapors gasoline, carbon monoxide (CO), nitrogen dioxide (NO <sub>2</sub> )
FOOD INDUSTRY	Ammonia, Carbon Dioxide, Methane
WINE CELLARS	Carbon dioxide, sulfur dioxide
DISTILLERIES	Ethyl alcohol
BEER PRODUCTION	Carbon dioxide (CO <sub>2</sub> )
POLYURETHANE PRODUCTION	Pentane
BATTERY RECHARGE	Hydrogen
EXCAVATION TUNNEL	Methane, carbon monoxide
SPRAY	Propane
STICKERS	Acetone, Benzine, heptane , hexane, metietilketone
COMPRESSION STATIONS	Methane
COSMETICS / PERFUME	Butyl acetate, ethyl acetate, isobutyl acetate , ethyl alcohol
COLORS AND PAINTS	Ethyl acetate, acetone, isopropyl alcohol, cyclohexane, heptane, toluene, xylol,
PRINT INK	Xylol, Toluene
COGENERATION	Methane, Singas (CO + H <sub>2</sub> )



# ATEX

The universally adopted standards (excluding North America) are the IEC/CENELEC and ATEX standards. The IEC (International Electrotechnical Commission) has established precise standards for equipment and for the classification of areas at risk of explosion, which constitute a standard. CENELEC (European Committee for Electrotechnical Standardization) is a standardization group which, taking the IECs as a basis, harmonizes them with all ATEX standards and with the local standards issued by member states, which are based on the ATEX directive.

**ATEX = AT**mospheres **Ex**plosibles

Since July 2003, two European directives have been approved which describe in detail the obligations of producers and users regarding the design and use of equipment in dangerous atmospheres.

LIABILITY	DIRECTIVE
PRODUCER	2014/34/CE (ex 94/9/CE)
USER/EMPLOYER	99/92/CE

# ATEX

## Differences between 2014/34/EU and 99/92/EC

Directive 2014/34/EU provides the essential requirements that products must meet to be installed in places where there is an explosion hazard due to the presence of flammable gases, vapors or mists, or combustible dusts. In particular, Directive 2014/34/EC provides the characteristics that the products must meet to be installed in places where there is an explosion hazard.

The European directive 99/92/EC, on the other hand, relates to the "minimum requirements for improving the safety and health protection of workers exposed to the risk of explosive atmospheres" and obliges the employer to adopt technical and organizational measures appropriate to the nature of the activity carried out. In particular, it will have to adopt all the necessary measures to guarantee the safety of the workers by providing the sites with appropriate controls by using appropriate technical means. In identifying the equipment and the protection systems, the selection criteria must comply with the "ATEX directive".

The criteria of the legislation have been implemented in Italy by Legislative Decree 81 of 2008.



# THE PROTECTION CONCEPT

## ELECTRICAL SAFETY

The protection concept, or protection type, is the selected method to prevent the dangerous increase of the hazard. Different methods are available and are subdivided in action categories as follows:

- a) avoid that the dangerous atmosphere reaches the ignition source
- b) avoid the generation of an ignition source
- c) avoid that an ignition effect propagates to the close atmosphere

## The Identification label (Existing Symbol)

Any protection concept has been assigned with a code composed by the symbol EX followed by a specific letter. The table shows the example:

<b>E</b>	<b>X ia</b>	<b>IIC</b>	<b>T6</b>
European approval	Protection type	Equipment group	Temperature class

# TYPE OF PROTECTION

MODE	SYMBOL	IEC	METHOD
GENERAL RULES		60079-0	
FLAME PROOF	Ex ' d b'	60079-1	Explosion enclosed
INCREASED SAFETY	Ex ' e '	60079-7	Thermal and electrical energy limited to safety levels even under worst conditions
INTRINSIC SAFETY	Ex ' ia ' / ' ib '	60079-11	

# CLASSIFICATION OF HAZARDOUS OF AREAS

In Europe, classified areas are currently referred to as **ZONES**, although it should be more correct to refer to **CATEGORIES**.

	Constant hazard	Discontinuous hazard	Sporadic hazard
EUROPE	Zone 0 (ATEX Category 1)	Zone 1 (ATEX Category 2)	Zone 2 (ATEX Category 3)
USA/CANADA	Division 1		Division 2

**ZONE 0 (CAT. 1)** An area in which an explosive gas atmosphere is present continuously or for long periods.

**ZONE 1 (CAT. 2)** An area in which an explosive gas atmosphere is likely to occur in normal operation.

**ZONE 2 (CAT. 3)** An area in which an explosive gas atmosphere is not likely to occur in normal operation and, if it does occur, it is likely to do so only infrequently and for a short period only.

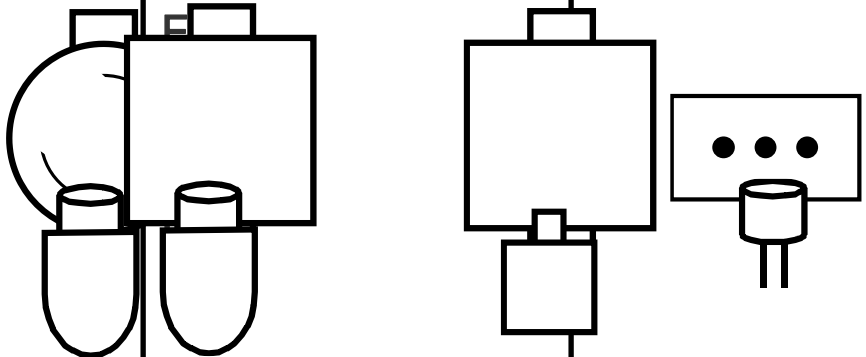
# STANDARDIZATION BODIES

AREA / REGION	ELECTRICAL PERFORMANCE REQUIREMENTS	NON ELECTRICAL REQUIREMENTS
WORLD	IEC	ISO
EUROPE	CENELEC	CEN
NATIONAL	NATIONAL STANDARDIZATION BODY	NATIONAL STANDARDIZATION BODY

# REFERENCE NORMS & AREA CLASSIFICATION

APPLICATIONS GAS TYPE		HAZARDOUS AREA		NON HAZARDOUS AREA	
		UNDERGROUND MINES	SURFACE INDUSTRIAL SITES	BUILDING, CAR PARKS & COMMERCIAL AREAS	RESIDENTIAL
FLAMMABLE GASES	ELECTRICAL SAFETY REQUIREMENTS	IEC/EN 60079-0 IEC/EN 60079-1 etc ----- -----	IEC/EN 60079-0 IEC/EN 60079-1 etc ----- -----	////////////////////	IP 42
	PERFORMANCE REQUIREMENTS	IEC/EN 60079-29-1 FOR METHANE (MANDATORY FOR ATEX)	IEC/EN 60079-29-1 (MANDATORY FOR ATEX FOR SAFETY DEVICES) (VOLUNTARY IN IEC)	IEC/EN 60079-29-1 (VOLUNTARY)	EN 50194
OXYGEN	ELECTRICAL SAFETY REQUIREMENTS	(SAME AS FLAMMABLE GASES)	(SAME AS FLAMMABLE GASES)	////////////////////	////////////////////
	PERFORMANCE REQUIREMENTS	EN 50104 (VOLUNTARY)	EN 50104 (MANDATORY FOR ATEX IN INERTISATION PLANTS)	EN 50104 (VOLUNTARY)	////////////////////
OTHER TOXIC GASES, CO2, ETC.	ELECTRICAL SAFETY REQUIREMENTS	(SAME AS FLAMMABLE GASES)	(SAME AS FLAMMABLE GASES)	////////////////////	IP 42
	PERFORMANCE REQUIREMENTS		EN 45544-1 EN 45544-2 EN 45544-3	EN 45544-1 EN 45544-2 EN 45544-3 EN 50545-1 (CAR PARKS)	EN 50291 (CO)
FOR ALL EQUIPMENT AS PART OF ANY PERFORMANCE TESTING		EN 50271 (SW&DIGITAL) (MANDATORY) EN 50402 (SIL) – (VOLUNTARY)	EN 50271 (SW&DIGITAL) (MANDATORY) EN 50402 (SIL) – (VOLUNTARY)	EN 50271 (SW&DIGITAL) (MANDATORY) EN 50402 (SIL) – (VOLUNTARY)	EN 50271 (SW&DIGITAL) (MANDATORY) EN 50402 (SIL) – (VOLUNTARY)

# REFERENCES NORMS – FLAMMABLE GASES

COMPETENCE	CLASSIFIED AREAS SC31			NON CLASSIFIED AREAS TC216	
Zone	Potentially explosive Atmospheres			Commercial	Residential Premises
<u>Electrical safety</u> ATEX Categories Gas (Dust) Zones (EN 60079-10)  Type of protection (IEC 60079-0 ... ..)	CAT 1 G (D) 0 (20)  Ex"ia" IEC 60079-11	CAT 2 G (D) 1 (21)  Ex"d" IEC 60079-1	CAT 3 G (D) 2 (22)  Ex"ed" IEC 60079-7		=  IP42 (EN50194)
	 <div>Ex e</div> <div>Ex d</div>			IP54  Ex d or Ignition test	IP54  Ignition test
<u>Product Performance</u> General Requirements	IEC 60079-29-1				EN 50194
<u>Others</u> Digital Technologies Electromagnetic Comp.	EN 50271 EN 50270				

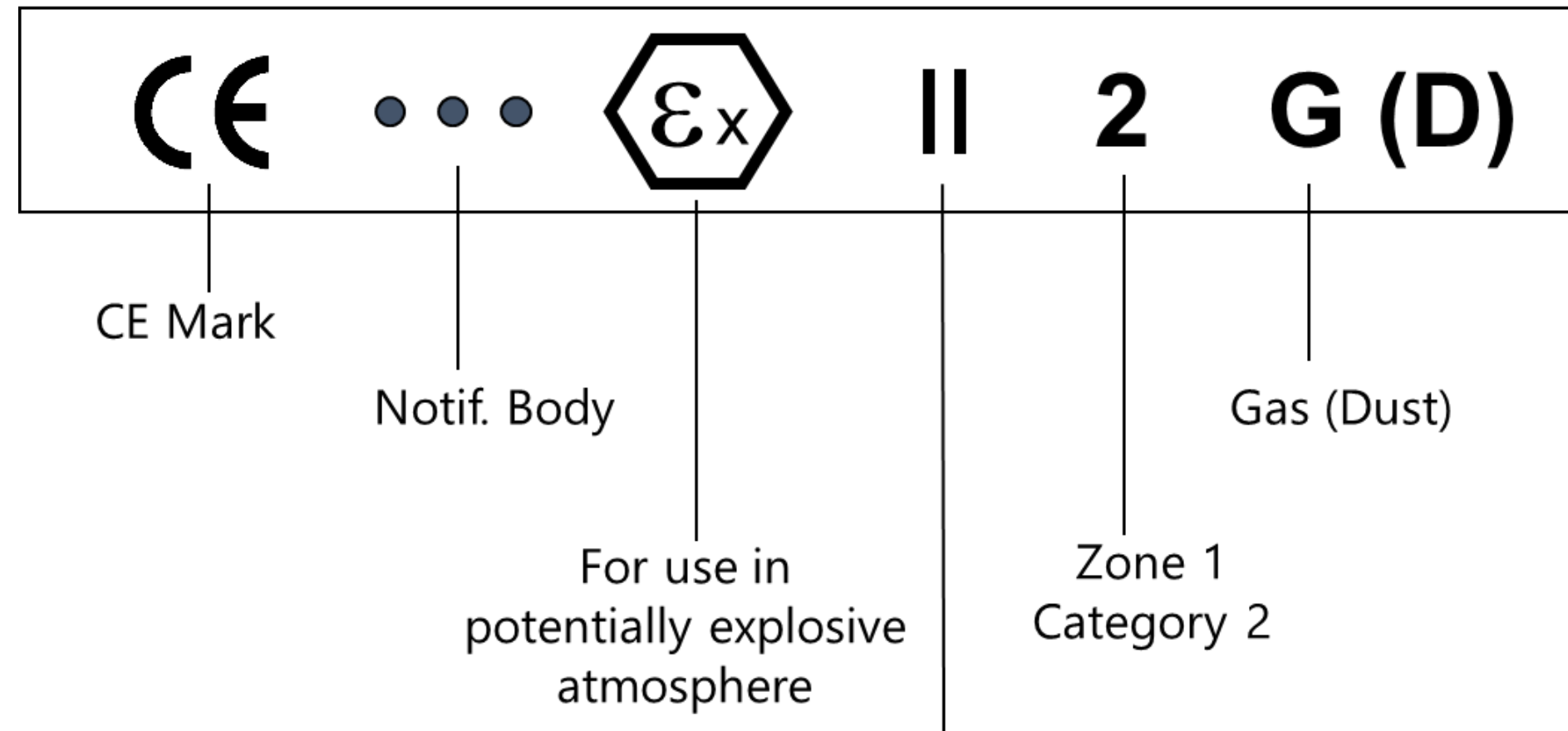
# APPARATUS CLASSIFICATION

## Directive ATEX 2014/34/EU

GROUP	EQUIPMENT CATEGORY	PRESENCE of EXPLOSIVE ATMOSPHERE	TYPE of FLAMMABLE ELEMENT	SAFETY LEVEL	PROTECTION MEANS (Failures to consider)	CORRELATION with HAZARDOUS ZONES	Example of PROTECTION TYPE
I Mines and connected surface equipment	M1	PRESENCE	Methane Dust	HIGHEST	1 Protection system (2 independent failures)	—	—
	M2	POSSIBLE PRESENCE	Methane Dust	HIGH	1 Protection Mean (1 failure in normal operations)	—	—
II Surface apparatus	1	STEADY or for long periods	Gas, Vapor, Fog, Dust	HIGHEST	2 Protection system (2 independent failures)	GAS Zone 0 DUST Zone 20	Ex ia
	2	POSSIBLE PRESENCE	Gas, Vapor, Fog, Dust	HIGH	1 Protection Mean (1 failure in normal operations)	GAS Zone 1 DUST Zone 21	Ex db
	3	LOW POSSIBILITY or for short time	Gas, Vapor, Fog, Dust	MEDIUM	Conventional Protection Mean	GAS Zone 2 DUST Zone 22	Ex ed



# LABEL IDENTIFICATION



# EN 50402 - FUNCTIONAL SAFETY

**Electrical apparatus for the detection and measurement of combustible or toxic gases or vapours or of oxygen – Requirements on the functional safety of fixed gas detection system.**

ATEX 134/34/EU directive and specific European metrological standards, detail unified performance features that gas detection apparatus have to grant, both on flammable gases, toxic gases and Oxygen, but none of these standards ever considered requirement for a fail safe function of the system.

During the last few years, users often asked for a classification of gas detection systems in safety levels according to what stated in the generic standards for “functional safety of electronic systems” EN 61508 and EN 954-1.

These Generic Standards are very “generic”, very long and very complicated, and the responsible CENELEC committee for gas detection decided to specify the requirements for functional safety of gas detection systems in a tailor made standard, the **EN 50402**, which was recently accepted by the CENELEC member states.

This standard is addressed to apparatus manufacturers. Compliance with this standard will be part of the type testing at notification bodies.

# EN 50402 - FUNCTIONAL SAFETY

This new standard is aimed to combine the concepts of the generic standards and define the requirements of a product family standard (flammable gases, toxic gases and oxygen), in order to adapt the generic requirements into specific ones for gas detection.

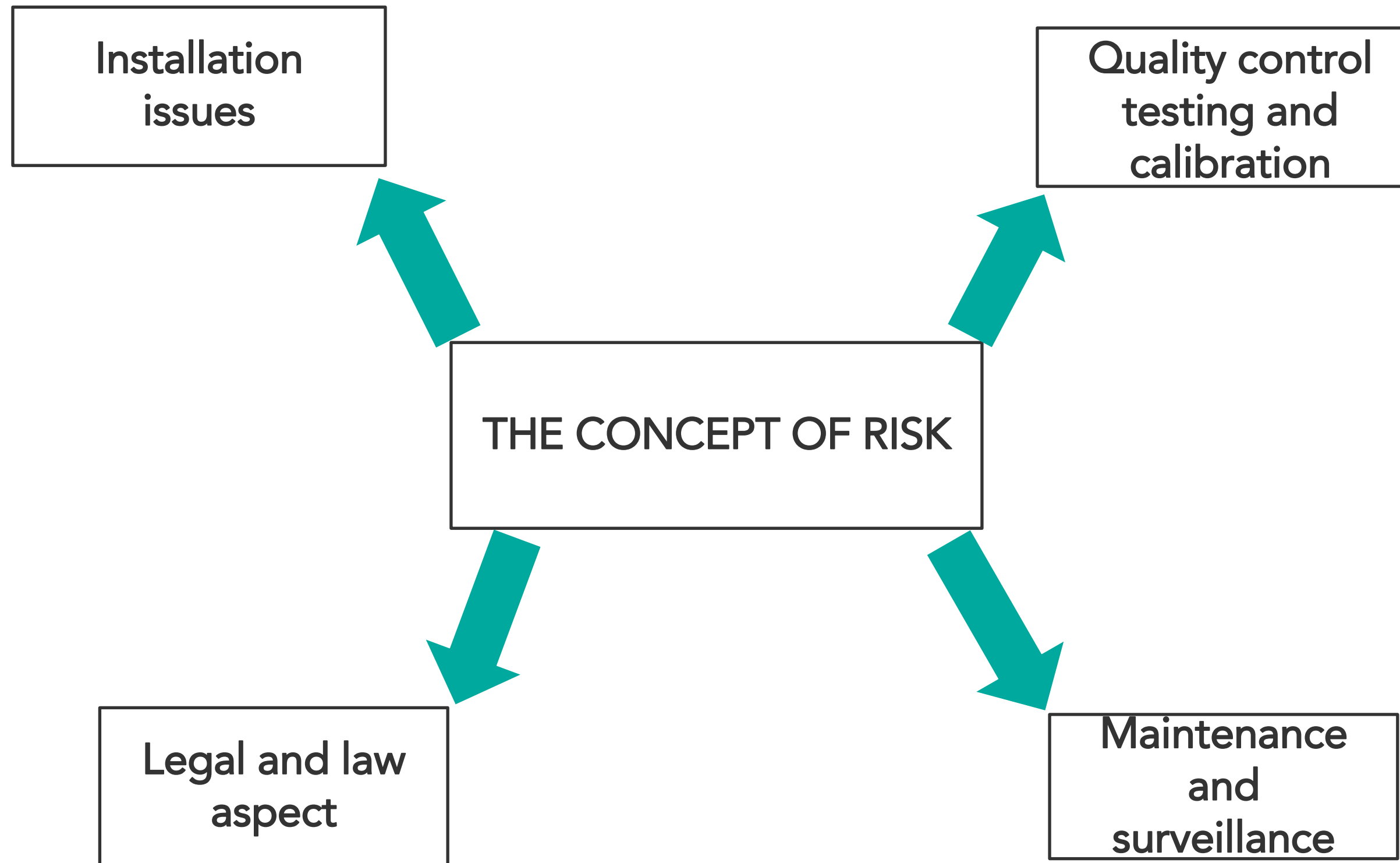
Being standard for all applications of gas detection, it offers the chance to describe a complex gas detection system for different levels of functional safety, to approve and integrate it into an overall safety system of a defined category or SIL.

The functional safety is aimed to supervise and manage the behaviour of a system in case of failures. When defining the system structure, all possible different types of failures that may occur in any part of the system are to be considered and evaluated.

Standards for functional safety specify hierarchical levels of safety from SIL 1 to SIL 4 and recommend how to avoid failures (in the development stage) and to establish fault tolerances for safety systems.

The basic approach of **EN50402** is to provide a uniform description of complex gas detection systems, independently of the strong differences in hardware due to the different manufacturers design.

To this purpose, gas detection systems have been split in “functional modules”, and for each of them the minimum requirements are detailed according to the different levels required, from SIL-C1 to SIL-C4.



# THE CONCEPT OF RISK: THE NORMS

IEC 60079-29-1

Gas detectors: Performance requirements of detectors for flammable gases

IEC 60079-29-2

Selection, installation use and maintenance of gas detectors for flammable gases and oxygen

# CHOICE OF EQUIPEMENT TO USE

## General remarks

The following principles are among those to be considered when choosing a gas detection apparatus:

- a) Which gases the apparatus must survey and the concentration values we expect to measure
- b) Which application the apparatus is installed for (such as: area monitoring, people safety, leakage detection, etc.)
- c) Decide if the apparatus must be fixed, transportable or portable.
- d) The classification of the areas according to the International standards
- e) Determine the environmental conditions that may be met in interested areas
- f) Consider all the characteristics of special apparatus that require caution in use or in result interpretation
- g) Consider temporal dependence and interactions with other safety devices
- h) Verify calibration requirements included reference and zero setting values

# CHOICE OF EQUIPEMENT TO USE

## General remarks

A gas detection and measurement system should be planned in order to let the **intervention time of the whole system to be shorter than the maximum time granted for the application**. The following elements should be considered:

- a) Delay of the gas sampling system
- b) System time response
- c) Transmission line delay
- d) Alarm and switching devices delay
- e) Auxiliary devices intervention delay (e.g. the time required by the valves to close)
- f) Leakage speed for flammable gases.



# CHOICE OF EQUIPEMENT TO USE

## General remarks

A flammable gas detection system employing catalytic sensors is unable to select different gases if present in the same environment, as catalytic sensors have a reaction to all of the flammable compounds.

Whenever more than one flammable gas is present in the area to be monitored, as a general rule, it is advised **to calibrate the sensor on the compound it results to be less sensitive to.**

A special care is to be paid to the detectors to verify their sensitivity to all of the other compounds.

# CHOICE OF EQUIPEMENT TO USE

## General remarks

An equipment for gas detection is generally used in areas classified as Zone 1 and 2 (ATEX category 2 and 3).

Equipment certified to have intrinsic safety can be employed in Zone 0 (ATEX category 1).

Gas detectors are specifically designed and intended to be used **for flammable gas detection** in air, where **about 21% oxygen content** is supposed to be present.

To identify system safety and the expected reply in anomalous oxygen conditions (enrichment or deficiency), it is recommended to consult the instruction manual or to contact the constructor in order to get the necessary advice.

# WARNING

**THE APPARATUS FOR GAS DETECTION CONSIDERED IN THE STANDARDS ARE NOT PLANNED OR CERTIFIED TO WORK IN ATMOSPHERES WITH OXYGEN ENRICHMENT OR DEFICIENCY. IN THAT CASE THEIR USE MUST BE AVOIDED.**

**For example, it is necessary to pay special attention when doing welding works with oxyacetylene in areas protected by gas detectors. Uncontrolled flames might be caused by accidentally directing an oxyacetylene gush towards a gas detector: acetylene enriched with oxygen is an extremely dangerous mixture.**

# HOW MANY DETECTORS TO INSTALL?

Once the type of detectors to be installed has been defined, it is necessary to determine how many of them are necessary. In other words it is important to define the "critical points".

The criterion to install one detector for each possible source of release is recommended by the ATEX standards but may turn out to be too expensive. In general it is wiser to evaluate the points of risk, which means those areas between a possible source of release and places where sparks, naked flames or others sources of ignition may generate.

Other areas at risk to take into consideration are those places where flammable vapours may accumulate, as trench ducts.

# DETECTORS POSITIONING

To control the average concentration of a flammable compound in the atmosphere, gas detectors location is usually not complicated; they should be placed outside the hazardous areas in a part of a hypothetical volume reached by the movements of the air passing through the hazardous areas, paying attention to the flammable gas or vapours relative density.

When ventilation is homogeneous, the quantity of gas detectors has little meaning, so far the detectors assure a continuous operation.

To control a part of a zone or specific points, gas detectors location is more complicated; they have to detect, as quickly as possible, the presence of flammable gas or vapours within the atmosphere to be controlled, therefore they should be placed between the source of release and the part of a zone, or device or electric plant.

The quantity and location of gas detectors is very important: they have to be placed taking into consideration the grades of emission, the direction of the emission, the dilution of the explosive atmosphere in the environment and are to assure a continuous operation.

# PROBLEMS CONCERNING THE GAS RELEASE

Development extension and/or speed of a flammable atmosphere is mainly influenced by chemical-physical parameters of the release. Some of these parameters concern intrinsic properties of flammable materials, others are specific of the process. To simplify, let's assume that the effect of each parameter here below is not influenced by the others (which remain steady).

**The greater is the release rate the faster is the development speed of flammable atmosphere. Release rate depends on the following parameters:**

- a) release source geometry
- b) release speed
- c) flammable liquid volatility
- d) liquid temperature

# PROBLEMS CONCERNING THE GAS RELEASE

## a) Geometry of the source of release

This parameter is connected to physical characteristics of the source, for example openings, flanges, etc.

## b) The speed of release

For a given source release, the release rate increases with the release speed.

In case of a product contained in process machines, the release speed is connected to the process pressure and to the release source geometry. A significant release rate combined together with a high speed will produce a vortex gush that will influence, next to the source, the way how the gas is released. The gas coming out at high speed (like a loss from a container or a pipe under pressure) will act at the beginning as a vortex gas, also far from the release source.

As the distance from the release source increases, the vortex decreases until becoming a blow and so dispersing by diffusion.



# PROBLEMS CONCERNING THE GAS RELEASE

## c) Flammable liquid volatility

This is mainly connected to vapor pressure and vaporization heat.

If vapor pressure is not known, the boiling point and the flash point may be used as a guide.

An explosive atmosphere cannot exist if the flammability point is significantly upon the maximum temperature of the flammable liquid. The lower is the flammability point the higher is the extension and/or the speed expansion of a flammable atmosphere.

Some liquids (like some halogen hydrocarbons) don't have a flash point even if they can create an explosive atmosphere. In these cases the balance temperature that corresponds to the saturated concentration at the lower flammability limit should be compared with the maximum allowable temperature.

## d) The liquid temperature

The pressure of vapor increases with the temperature, hence the rate of release increases because of the evaporation.

A liquid temperature, after releasing, might rise for instance because of a warm surface or an elevated ambient temperature.

# PROBLEMS CONCERNING THE GAS RELEASE

The lower is the LEL of the flammable gas or vapor in the air the higher will be the extension and/or the expansion rate of a flammable atmosphere. At a parity of release rate, gases having a lower LEL will reach first their flammability concentration. Both LEL and UEL change with temperature and pressure even if they are not significantly influenced by them in their limit values.

By increasing the efficiency of the ventilation the extension and/or the expansion rate of a flammable atmosphere reduces. Otherwise, obstacles that do not allow the ventilation may increase the extension and/or the expansion rate of a flammable atmosphere. However, some obstacles like obstructions, walls or ceilings may also limit the extension and/or the expansion rate of a flammable atmosphere.

# PROBLEMS CONCERNING THE GAS RELEASE

The behavior of the gas released with a negligible starting speed (for example the vapor produced by a dropping liquid) is assimilated to an ascension and depends on the relative gas density as regard to the air.

If the gas or the vapor is lighter than the air, it tends to move towards the top; on the contrary if the gas is heavier it tends to accumulate towards the ground.

The horizontal extension and/or the expansion rate of a flammable atmosphere on the ground tends to raise when the relative density increases, while the extension and/or the expansion rate of a flammable atmosphere upon the source increases when the relative density decreases.

**NOTE 1** - In practical applications, a gas or a vapor mixture having a relative density lower than 0,8 is called lighter than the air, while if it is higher than 1,2 is called heavier. For intermediate values it is necessary to consider both possibilities.

**NOTE 2** - Gas mixtures having high and low density with air will show a lower density variation and when mixed they will not separate any more: they act as if they were diluted.

# PROBLEMS CONCERNING THE GAS RELEASE

A gas temperature and/or a gas pressure before the release, that are significantly different from those of the environment, may influence the release absolute density and so the behavior next to the source.

Other parameters such as climatic condition and topography could also be taken into consideration.

In case there is a significant air motion or when the release happens in closed spaces, the release behavior will be different from what we have seen up to now and it will be described in the following points.

# DETECTORS INSTALLATION: GENERAL REMARKS

A fixed gas detection system should be installed to monitor areas where flammable gases may accidentally accumulate creating hazardous conditions.

The system must be capable to provide an acoustic or visible alarm signal (or both), to report the presence and give indication about the location of an accidental accumulation of flammable gas to allow, automatically or manually, the following actions:

- ⇒ Safe evacuation of the interested zone;
- ⇒ Activate proper fire-fighting procedures;
- ⇒ Stop up of processes or machines;
- ⇒ Ventilation control

# WARNING

DETECTORS SHOULD BE INSTALLED AT INTENDED POSITIONS CONSULTING WHO HAVE SPECIFIC KNOWLEDGE OF THE GAS DISPERSION PROBLEM AND KNOW THE PLANT SYSTEMS AND EQUIPMENT OF THE SITE TO PROTECT, TOGETHER WITH THE TECHNICAL AND SECURITY STAFF OF THE SITE.

The document that contains the adopted criteria for the detectors position selection should always be prepared in write and saved.

NOTE - For further information on the area classification and on gas dispersion refer to the IEC 60079-10.

# DETECTORS INSTALLATION

## GENERAL REMARKS

The following are some of the factors that should be considered during the selection of the most appropriate sensor location:

- a) Internal or external areas and zones;
- b) Possible sources: their location and nature (e.g. the source density, pressure, volume, temperature and distance);
- c) The chemical-physical data of gas or vapor;
- d) The presence of low volatile liquids (in this case, detectors are to be placed close to the source);
- e) The typical nature and concentration of released gases (e.g. pressurized jets, slow losses, liquid drops);
- f) The presence of turbulences and vortices;
- g) The air movement:
  - ⇒ internal: natural and forced ventilation;
  - ⇒ external: wind speed and direction;



# DETECTORS INSTALLATION

## GENERAL REMARKS

- h ) Temperature effects, the environmental plant conditions;
- i ) The number of persons in the area and their location;
- k ) The location of possible fire sources;
- l ) The position of installed detectors that should not be exposed to bumps or water during normal operations;
- m) The detectors positioning must allow easy maintenance and calibration operations;
- n) Specific architectural settings (like walls, beams or panels) that facilitate the accumulation of gas and vapor;

# DETECTORS INSTALLATION

## WHERE TO INSTALL THEM

Decisions on the detectors location are usually taken after the risk assessment, which determines the number of detectors needed.

Amongst the most important points to consider when choosing the right location we can consider what follows:

1. Sources of release
2. The gas relative density or the specific weight
3. Air currents
4. Vibrations
5. Electrical wiring
6. Ease of access for inspection and maintenance
7. Protection from water and humidity

For toxic gases, if installed in workplaces, detectors are to be located to protect human beings, therefore make sure the gas reaches the detectors before reaching workers.

E.g. Carbon Monoxide detectors should be installed at "nose" level, i.e. nearly 1.60 m from the floor. The same is also valid for Oxygen detectors, in particular when its depletion is to be monitored for the presence of inert compounds.

# DETECTORS INSTALLATION

Although detectors should be usually placed at the top to detect gas lighter than air and at the bottom for gas heavier than air, it should be also be considered that for all gases having a density between 0.8 to 1.2, it is recommended to install some detectors near the floor if the gas is only a little lighter than air, like Acetylene, and to put some detectors near the ceiling in the case the gas is only a few weighty like methyl alcohol.

Relative density of the some explosive gases (Air =1)

Acetone	2	Heptane	3,5	Pentane	2,5
Ammonia	0,6	Hexane	3	Propane	1,6
Benzene	2,8	Hydrogen	0,1	Propylene	1,5
Butane	2	Methane	0,6	Toluene	3,1
Ethane	1	Methanol	1,1	Xylene	3,7
Ethanol	1,6	MTK	2,5		
Ethylene	1	Octane	3,9		

It is important to note that among the most commonly detected explosive gases the only lighter than air are: **Hydrogen, Methane and Ammonia.**

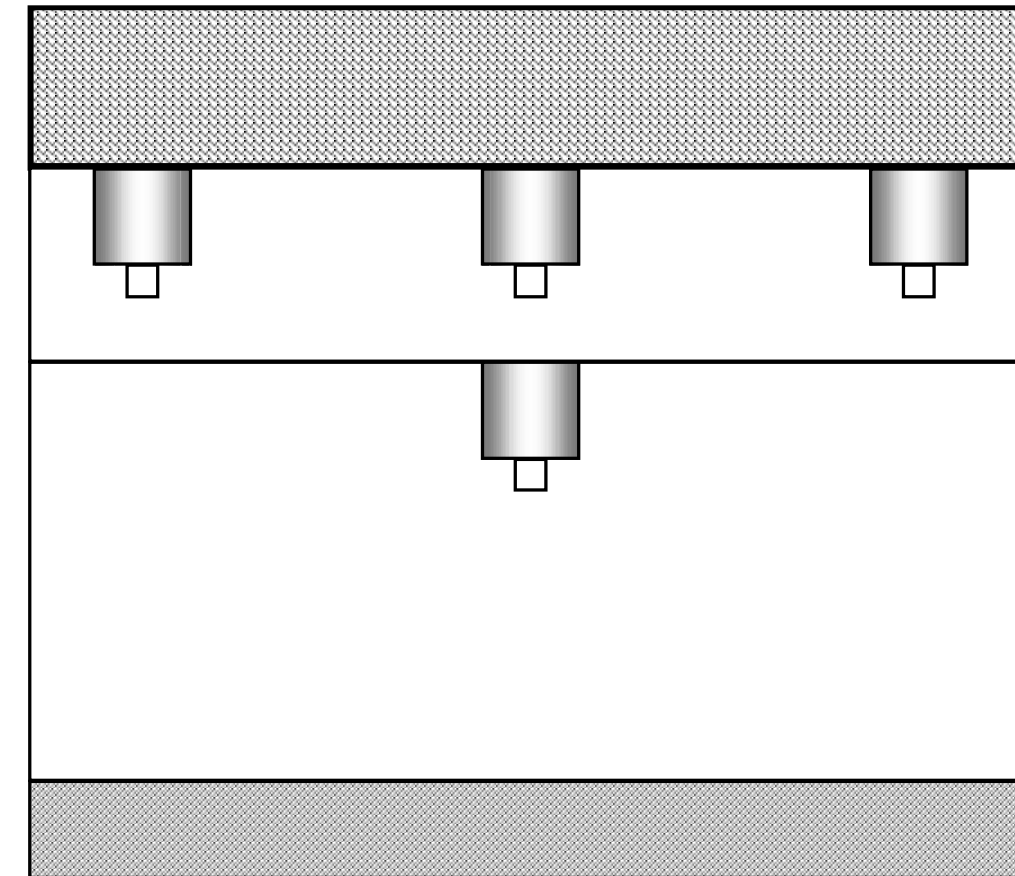
# THE LOCATION: LIGHT GASES

## Conventional areas

In areas not influenced by air flow, detectors may be installed at regular distances at near 30cm from the ceiling or along the boundary, if indoor work activities are not foreseen.

## Flat ceilings

Detectors must always be mounted on the top ceiling; in case of a lower ceiling is present in the same room some detectors must also be installed there.



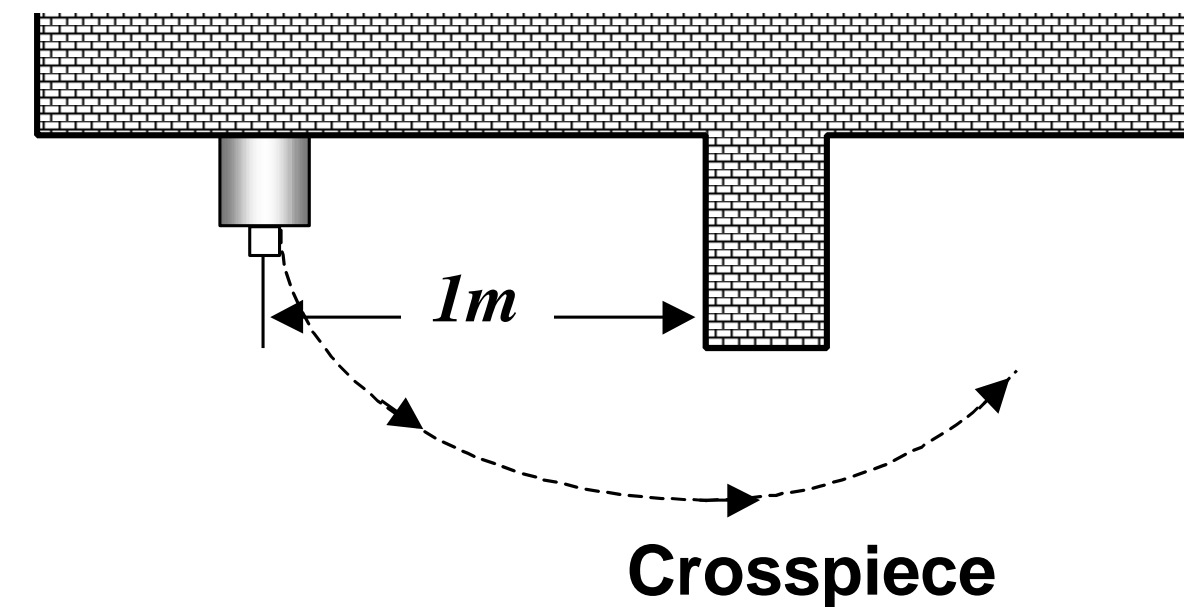
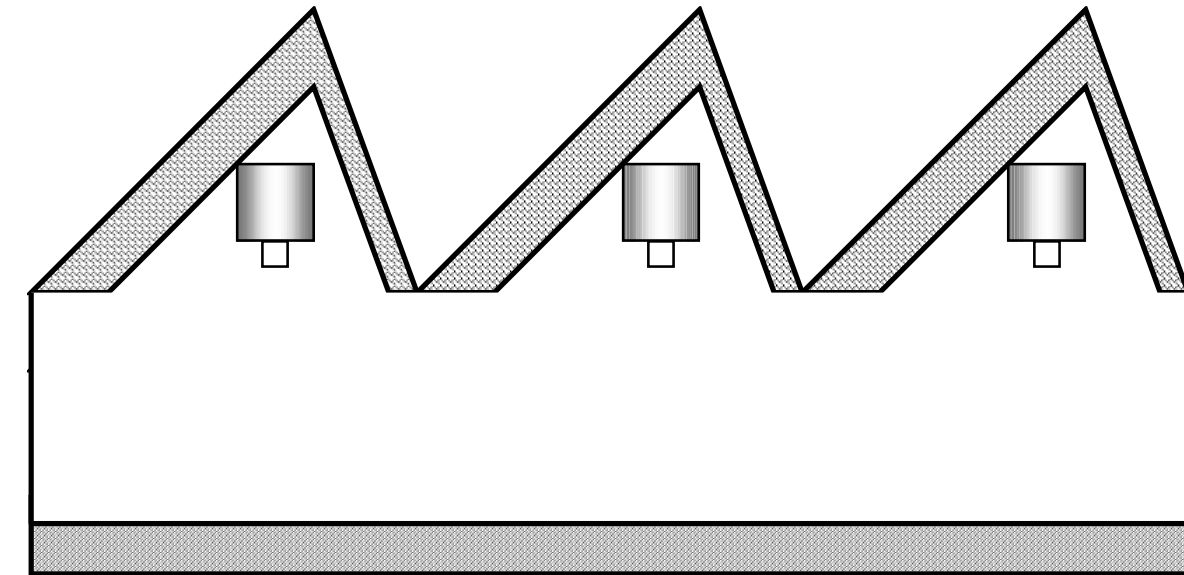
# THE LOCATION: LIGHT GASES

## Slanted ceilings

Detectors must always be placed at about 30cm from the highest available corner

## Ceiling with crosspieces

In this case, it must be considered both the height of the covered area as the crosspieces dimensions and geometry. Detectors must always be installed in the area between the crosspiece and the ceiling.

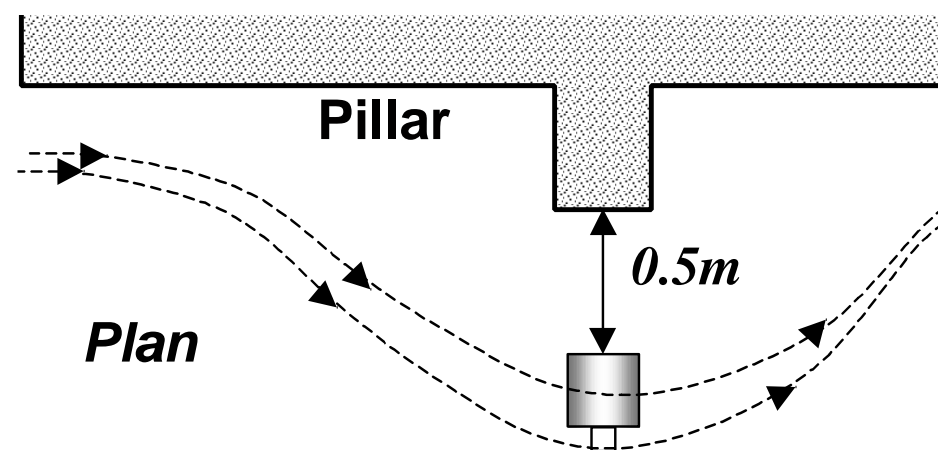


# THE LOCATION: LIGHT GASES

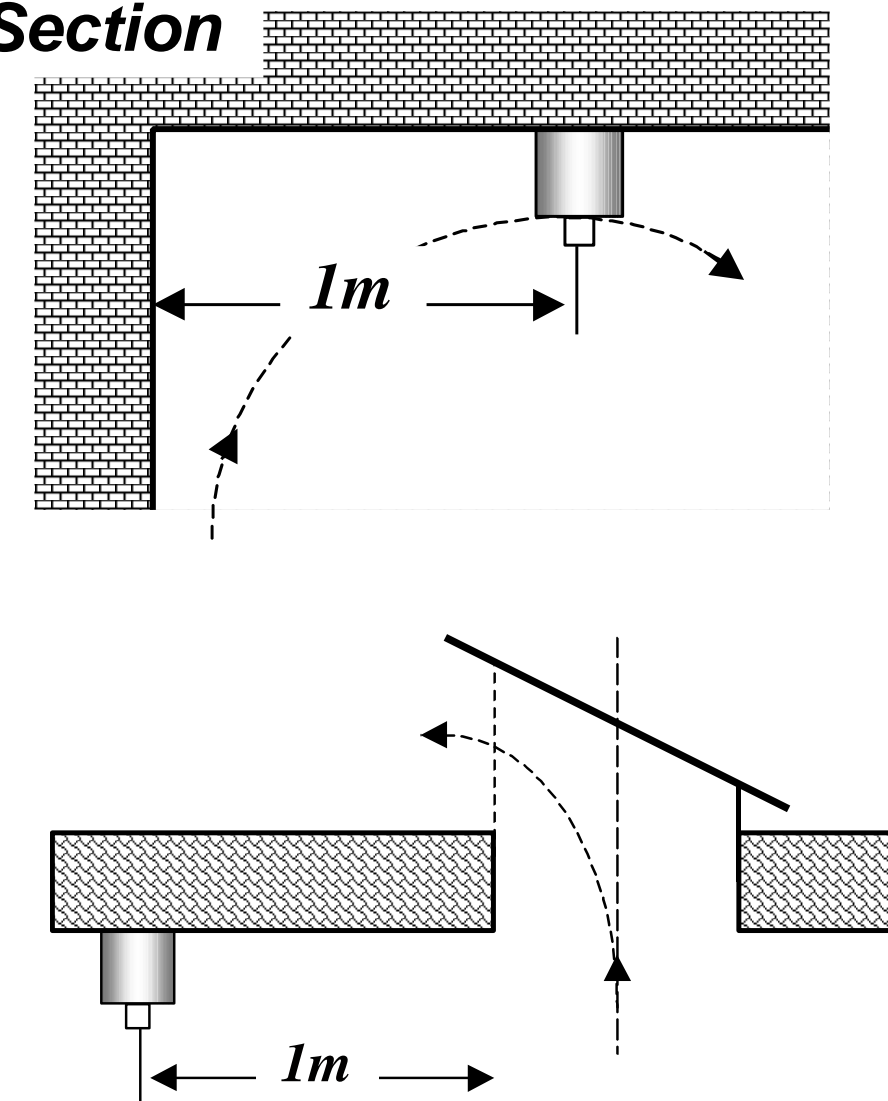
## Areas with air flow

In principle, if an air flow greater than 0.5m/s is present, as in the case of spaces with heating or air fans, some precautions must be taken to avoid placing detectors in rested zones unless the gas leakage is there expected

Smoke generators or the assistance of aeration specialists may be useful to optimise the air recirculation in the area.



## Section

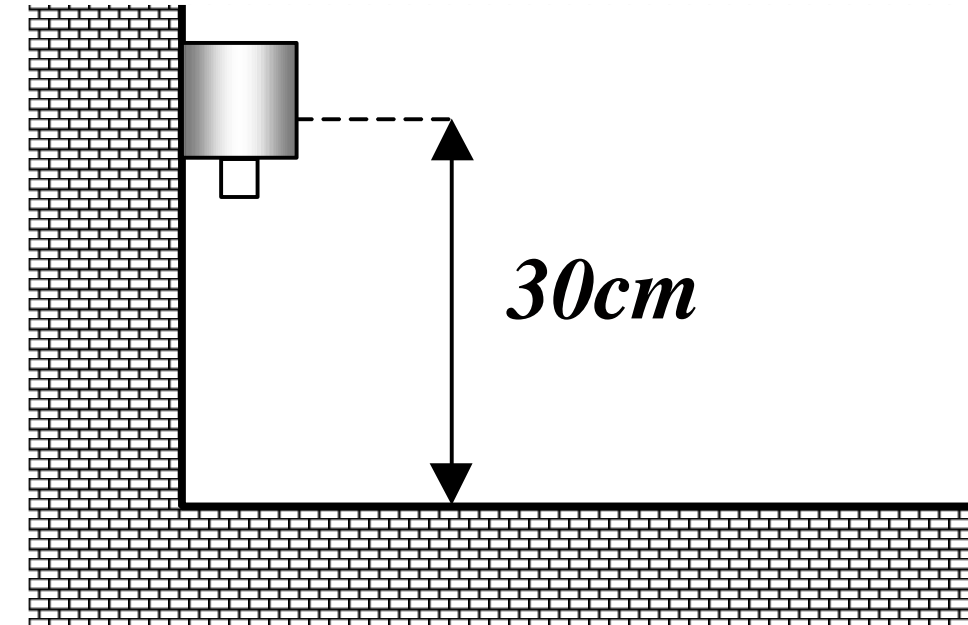


For the correct installation of gas detectors the following distance schemes should be observed.

# THE LOCATION: LIGHT GASES

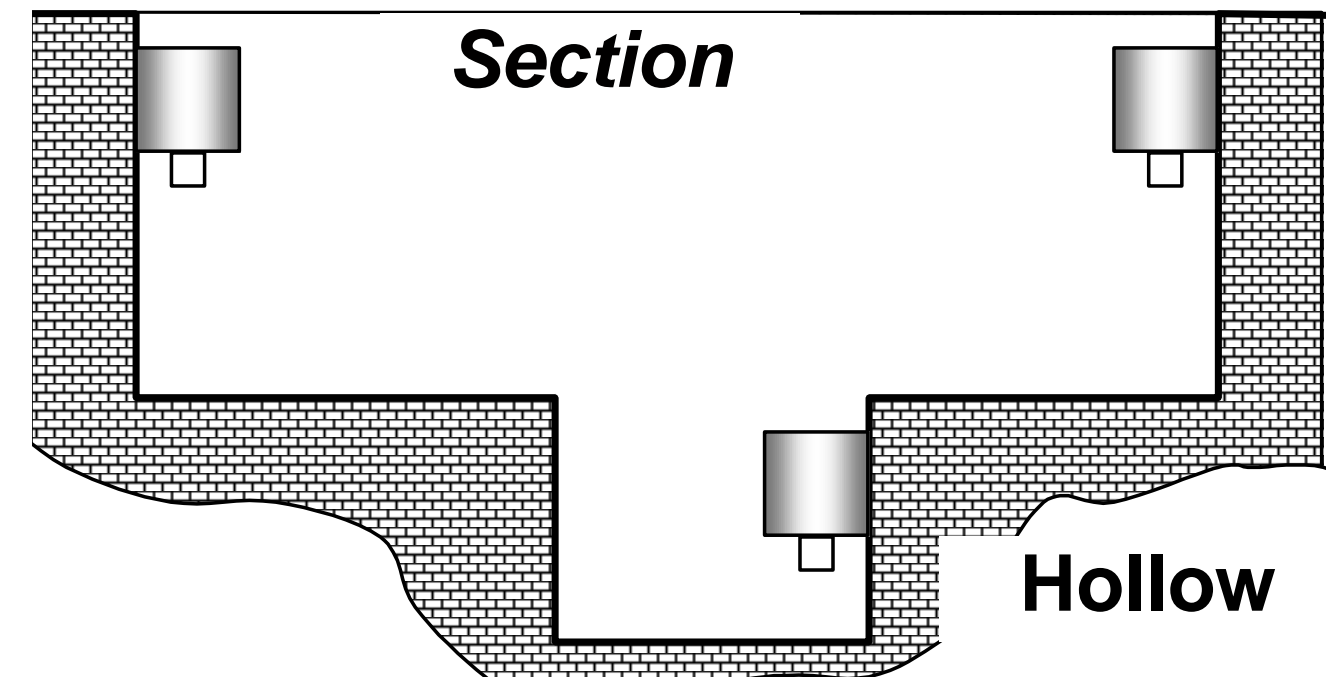
## Conventional areas

Detectors should be installed close to the floor at about 30cm from it, side mounted on the wall, on columns etc. and set in the way that at least one is installed close to the potential gas leakage



## Areas with hollows or caves

The detector must always be installed at about 30cm from the bottom of the lowest floor or depression. Additional detectors shall be installed with the same criteria in hollows or caves.



## Ventilated areas

If possible, the detector must be installed away from death zones without air circulation, unless gas leakage is expected there.



# CALIBRATION

## Calibration access

Detectors should be easily accessible to allow regular calibration, maintenance and inspection. Whenever an access to the detector is not possible, it should be considered a way to remotely calibrate it.

Nevertheless, in principle, gas detectors should be installed in a way that only authorized personnel may verify and adjust the equipment functionality.

## Alarm thresholds setting

In case the detector ranges to the LEL, alarm thresholds (the lowest if more than one threshold is available) should be as low as possible compatible with the need to avoid false alarms. Setting should be made in compliance with manufacturer specifications.

# CALIBRATION: GENERAL RULES

The equipment should:

- 1) be calibrated as per the manufacturer instructions by using recommended tools and service kit;
- 2) be verified before the installation and then verified and recalibrated periodically;
- 3) be inspected regularly to verify a possible malfunctioning, damage or other worsening;
- 4) in case of portable or transportable sensors, be verified and recalibrated before any usage;
- 5) if used for the detection of many gases, be recalibrated for the gas with the minor sensitivity.

# PLANT INSPECTION

Before a plant or apparatus is brought into service, it shall be given an initial inspection. (CEI EN 60079-17 §4.3.1)

The inspection and maintenance of installations shall be carried out only by experienced personnel, whose training has included instruction on the various types of protection and installation practices. (CEI EN 60079-17 §4.2)

# PROCEDURES FOR MAINTENANCE AND CONTROL

## Forewords

- ❑ When designing a new plant, gas detectors are to be installed as late as possible to avoid being damaged by any of the building yard activities. None the less, detectors are to be installed well before any gas or vapor may generate.
- ❑ Duly protect detectors if mounted in places in which they might suffer from mechanical damages.
- ❑ Avoid exposing detectors to polluting compounds that might damage the sensors and compromise the correct functioning (i.e. silicon compounds poison the catalytic sensors)
- ❑ The usual praxis of washing the plant environments with water jets may seriously damage the detectors if not adequately protected from water ingress and should be avoided in the areas where detectors are located.
- ❑ Before a plant is brought into service, it shall be given an initial inspection.

# PROCEDURES FOR MAINTENANCE AND CONTROL

Periodic inspections of a gas detection system ensure that the installation are maintained in a satisfactory condition.

Optimal performances for continued use will be reached with an adequate inspection program.

When it is necessary to withdraw a gas detection system or a part of it for maintenance purposes, it is fundamental not to compromise the safety of the environment (e.g. plants might be turned off declassifying the area or portable gas detectors might be employed to keep on monitoring the gas presence in the environment during maintenance operation).

The inspection and maintenance of installations shall be carried out only by experienced personnel.

Inspections shall comply with the apparatus manufacturer's instruction. Visual inspections of the system are to be considered in the inspection program.

The results of all inspections shall be recorded.

# PROCEDURES FOR MAINTENANCE AND CONTROL

To predict accurately an appropriate periodic inspection interval is not easy, but it shall be fixed taking into account the expected deterioration and the manufacturer's guidance. In any case, for gas detection systems it will be:

Each three months for systems controlling plants giving a primary grade of release

Each six months for systems controlling plants giving a secondary grade of release

Calibration inspections are to be done by using sample gas in certified gas cylinders.

If such gas cylinders are not available a reference gas suggested by the manufacturer can be used.

# CHECK – LIST EXAMPLE

Check-list for the installation of flammable gas sensors

1. Short description of the application in which the gas should be detected.

2. Report the distance between sensing locations and the control unit (if remote).

3. Specify the gas to detect and/or the vapor and its predictable composition.

Gas component*	Concentration	Remarks.

(\*) If possible report the chemical name. In case that more than one gas is specified, report if this gas and/or vapor will be present as single element or as part of a compound.



# CHECK – LIST EXAMPLE

4. Report if detection is made in standard atmosphere (21% O2) or in presence of Oxygen enrichment/reduction.

Report the expected values of oxygen in the atmosphere:

5. Report the requested measure range as LFL% for flammable gases and as ppm for toxic gases.

# CHECK – LIST EXAMPLE

6. Ambient temperature range to which the operating equipment is exposed:

From \_\_\_\_\_°C min to \_\_\_\_\_°C max

Expected nominal temperature \_\_\_\_\_°C

7. Humidity range of the atmosphere to monitor:

From \_\_\_\_\_%RH min to \_\_\_\_\_%RH max

8. Ambient pressure range of the atmosphere to monitor:

From \_\_\_\_\_ min to \_\_\_\_\_ max

9. Air speed range of the atmosphere to monitor:

From \_\_\_\_\_ min to \_\_\_\_\_ max

# CHECK – LIST EXAMPLE

10. Other conditions (presence of dust, smoke, acids, moisture etc.) Specify the factor and the amount if possible.

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11. Presence of poisoning agents: report here if the environment may contain silicon, lead or halogen composites or other materials that may influence the performance.

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# CHECK – LIST EXAMPLE

12. Classification of areas in which the detectors are installed:

Class \_\_\_\_\_Zone \_\_\_\_\_Group\_\_\_\_\_

Class \_\_\_\_\_Zone \_\_\_\_\_Group\_\_\_\_\_

Class \_\_\_\_\_Zone \_\_\_\_\_Group\_\_\_\_\_

13. Requested additional accessories:

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