Dräger

Explosion protection for hydrogen applications with gas detection

H2 SAFETY

01

Hydrogen

Hydrogen

Properties of Hydrogen

- smallest existing molecule
- is flammable, non-toxic and non-corrosive. It has a suffocating effect on people.
- is colourless and odorless
- is the lightest gas, rises quickly, is extremely flammable and forms an explosive atmosphere with air

	Hydrogen H_2	Methane CH_4
Density	0,08388 kg / m^3	0,7175 kg / m^3
Ignition temperature	585°C	540°C
Lower explosion limit	4 Vol.%	5 Vol.%
Upper explosion limit	77 Vol.%	14 Vol.%
Minimum ignition energy	0,02 mJ	0,28 mJ
Explosion group	IIC	IIA

02

Explosion protection standards

Explosion protection standards

Harmonized standards

Responsibility of employer	Responsibility of manufacturer
IEC / EN 1127-1: Basic concepts and methodology	IEC / EN 1127-1: Basic concepts and methodology
IEC / EN 60079-10-1: Classification of areas – explosive gas atmospheres	IEC / EN 60079-0: Equipment – General requirements
IEC / EN 60079-10-2: Classification of areas – combustible dust atmospheres	IEC / EN 60079-1: Equipment protection by flameproof enclosures “d”
IEC / EN 60079-14: Electrical installations design, selection and erection	IEC / EN 60079-7: Equipment protection by increased safety “e”
IEC / EN 60079-17: Electrical installations inspection and maintenance	IEC / EN 60079-11: Equipment protection by intrinsic safety "i"
IEC / EN 60079-19: Equipment repair, overhaul and reclamation	IEC / EN 60079-29-1: Gas detectors – Performance requirements of detectors for flammable gases
IEC / EN 60079-29-2: Gas detectors – Selection, installation, use and maintenance of detectors for flammable gases and oxygen	IEC / EN 60079-29-4: Gas detectors - Performance requirements of open path detectors for flammable gases
...	...

Explosion protection standards

Primary: prevent explosive atmospheres.

- Prevent gases to leak (gas-tight constructions)
- Remove gases quickly (ventilation systems)
- Detect gases quickly

Secondary: prevent ignition sources.

- Use ex-certified equipment only (depending on ex-zone)
- Use mechanic instead of electric equipment (e.g. valves)
- Use grounding and conductive floors

Tertiary (also referred to as "constructive"): prevent and reduce damages and effects in case of an explosion.

- Use fireproof and retardant materials/walls
- Use pressure relief valves/areas
- Mark ways for evacuation

Conclusion

Gas detection is regarded as primary explosion protection to prevent explosive atmospheres in the first place.

Explosion protection standards

Primary explosion protection – Avoidance of an explosive atmosphere

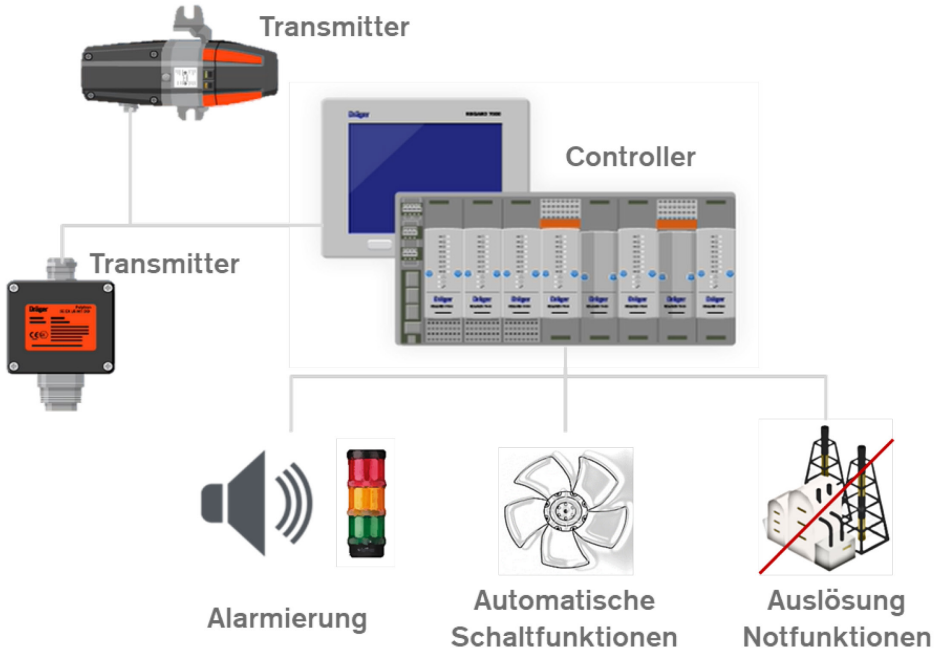
- **Prevention** of the **formation** of an explosive atmosphere **within apparatus**
  - **Concentration monitoring** – outside the explosion limits
  - **Inerting**
- **Prevention** of the **formation** of an **explosive atmosphere** in the **vicinity** of **plants** and parts of plants
  - **Leak tightness of plant parts –** constructive or constructive measures combined with organizational measures
    - Inspection and control with **portable gas warning devices** or **stationary gas warning devices** with warning function
  - **Ventilation**
    - **Dilution of the concentration** of combustible substances in air below the lower explosive limit (LEL)
    - **Prevent or limit the formation of hazardous explosive atmospheres**

An **area** in which an **explosive atmosphere** is **not** to be **expected** in **such quantities** that **special protective measures** are required is **considered** a **non-hazardous area** within the meaning of the present standard EN 01127.

Explosion protection standards

Gas warning devices

- Gas warning systems with alarms
  - Alarm limit so far below the explosion limit that measures from the operating instructions take effect in good time
- Gas warning systems with automatic switching functions
  - In addition to the alarm, trigger measures to prevent an explosive atmosphere (e.g., ventilation, shutting off individual system parts, Inerting)
  - Process engineering plant remains in operation
- Gas warning systems with automatic triggering of emergency functions
  - In addition to the switching functions, triggering of automatic switch-off processes (= safe shutdown of the system)



03

Classification of areas – Explosive gas atmospheres

Classification of hazardous areas

IEC / EN 60079-10-1
In areas where dangerous quantities and concentrations of flammable gas or vapour may arise, protective measures are to be applied in order to reduce the risk of explosions. This part of IEC 60079 sets out the essential criteria against which the ignition hazards can be assessed and gives guidance on the design and control parameters which can be used in order to reduce such a hazard.

Annex H (informative) Hydrogen


IEC 60079-10-1

Edition 1.0 2008-12

INTERNATIONAL STANDARD

NORME INTERNATIONALE

Explosive atmospheres –
Part 10-1: Classification of areas – Explosive gas atmospheres

Atmosphères explosives –
Partie 10-1: Classement des emplacements – Atmosphères explosives gazeuses

INTERNATIONAL ELECTROTECHNICAL COMMISSION

COMMISSION ELECTROTECHNIQUE INTERNATIONALE

PRICE CODE CODE PRIX XB

ICS 29.260.20

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Classification of hazardous areas

IEC / EN 60079-10-1

Annex H (informative) Hydrogen

H.2 The **ignition temperature** of **hydrogen** is **560 °C**. Although **very high temperatures** are required to ignite a hydrogen-air mixture, **precautions** should be taken to ensure that **hydrogen leaks** are not **exposed to any hot surfaces**.

…

H.4 **Releases** of **large volumes** of **hydrogen** are likely to accumulate in **overhead spaces**. A release of hydrogen can form **gas pockets** in **alcoves**, **eaves** and **dormers** that tend to be poorly ventilated. In contrast, relatively small openings in such spaces will permit efflux of hydrogen and may be sufficient to prevent hydrogen concentration from small volume releases.

H.5 **Releases** of hydrogen gas will generally result in a **jet directed from the release point**. Then, when the momentum is gone, the **gas plume** will assume a more **vertical upward motion** and generally disperse harmlessly in a well-ventilated area.

H.7 The **flame fronts** observed with hydrogen-air mixtures **burn less readily** when forced to burn in a **horizontal direction** and **even worse** in a **downward direction**.

Classification of hazardous areas

IEC / EN 60079-10-1

Annex H (informative) Hydrogen

H.8 **Measures** to mitigate **hydrogen releases** should consider providing for **rapid rise** of the gas to atmosphere **away from structures** to help prevent possible ignition during the release. **Additional ventilation** and/or **adequate space** for **dilution** and **distribution** of the **release** may be provided internally. When **gas detection** is used as a surveillance measure, the sensors should be located **above** the **release points** and/or near the *ceiling*, **exhaust fan or exhaust duct**. The sensors require a regular **calibration** schedule, and the sensor should only be used with **hydrogen** as the calibration gas be calibrated.

04

Selection of detectors for flammable gases and oxygen – EN 60079-29-2

Selection of detectors for flammable gases and oxygen

Measuring principles

Flammable gases and vapors

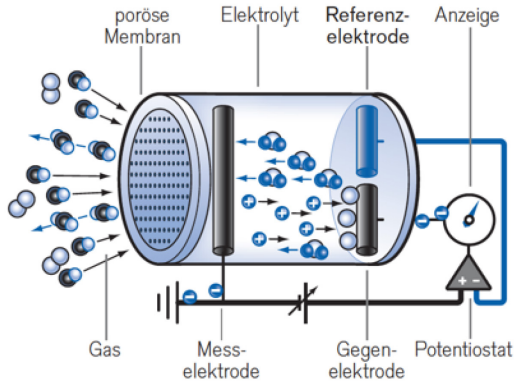
Catalytic sensor	≤ LEL
Thermal conductivity sensor	(0) up to 100%
Infrared sensor	(0) up to 100 %
Semiconductor sensor	≤ LEL
Electrochemical sensor	≤ LEL (H_2 or CO)
Flame ionization detector (FID)	≤ LEL
Flame temperature analyzer	≤ LEL
Photo ionization detector (PID)	≤ LEL

Oxygen

Electrochemical sensor	Vol. %
Paramagnetic oxygen detector	Vol. %

Alternative techniques that do not meet metrological standards (e.g., IEC 60079-29-1 or IEC 60079-29-4) should **only be considered as supplementary measurement principles.**

Selection of detectors for flammable gases and oxygen



Electrochemical sensor:

Electrochemical sensors work much like batteries

- In the presence of the target gas, a small electrical charge is chemically generated between two electrodes and displayed in the transmitter
- The signal size is proportional to the concentration

Example of a chemical reaction:

$CO + H_2O \rightarrow CO_2 + 2\,H^+ + 2e^-$

$O_2 + 4\,H^+ + 4e^- \rightarrow 2\,H_2O$

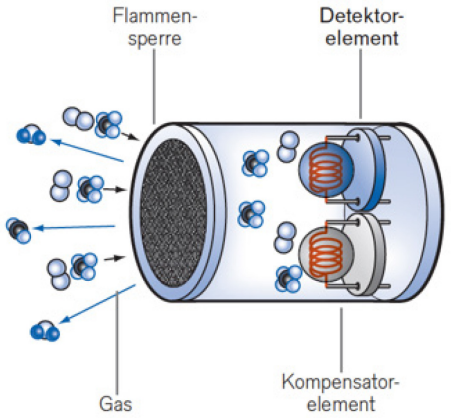
Interference, Cross-sensitivity to other gases can lead to a positive or negative signal change

Environmental influences,
Low temperature and humidity: electrolyte can dry out

–40 °C to 65 °C (–40 °F to 150 °F)
700 hPa to 1300 hPa (20.7" Hg to 38.4" Hg at 32 °F)
10 % r.h. to 95 % r.h., non condensing

Limitations,
depending on sensor type, O_2 is required for chemical reaction. No prolonged operation in O_2-free environment.

Selection of detectors for flammable gases and oxygen



$CH_4 + 2\ O_2 \rightarrow CO_2 + 2\ H_2O$ + heat of reaction

Below the LEL, flameless oxidation reaction.

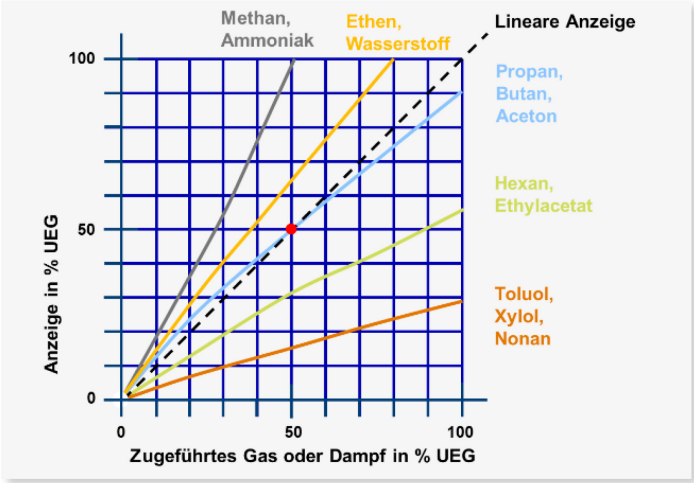
Flameproof encapsulated, with a flame barrier to the environment.

Different sensitivities, to different combustible gases.

Catalytic sensor

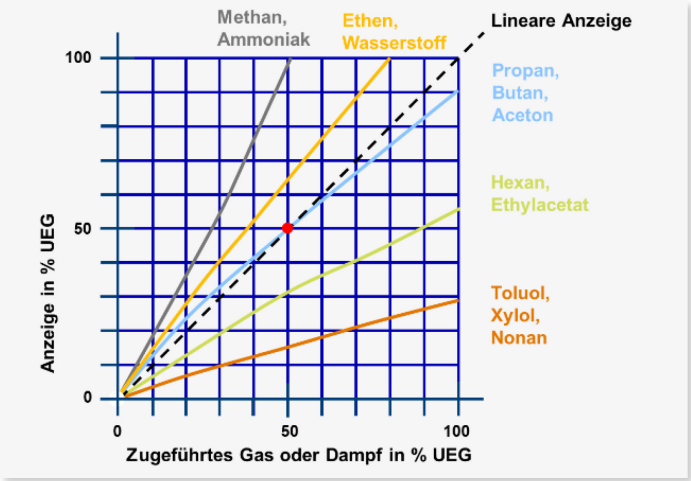
The catalytic sensor is a flameproof sensor for measuring flammable gases and vapors.

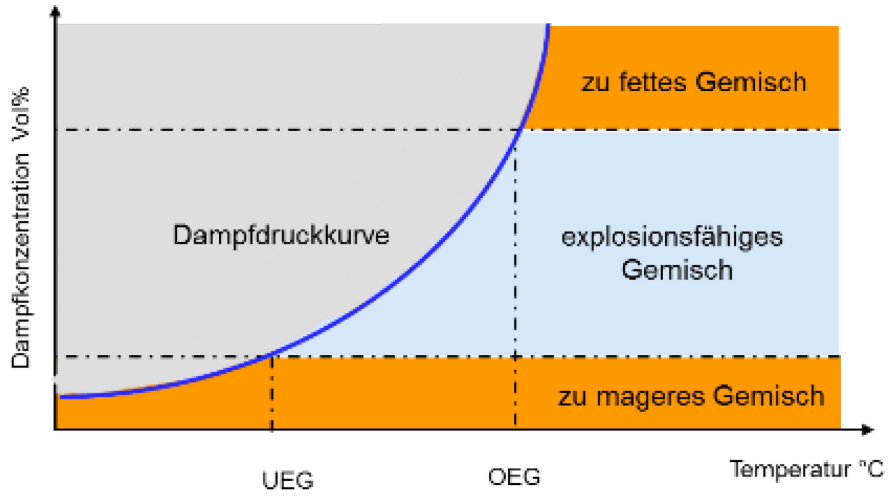
- The heat of reaction measuring principle is based on the fact that flammable gases and vapors undergo an oxidation reaction with atmospheric oxygen, even at concentrations below their LEL
- The heat of reaction released in the oxidation reaction is a measure of the gas concentration



Information and images from DrägerSensor® & Gas Detector Manual, 4th edition, 2018 Dräger Safety AG & Co. KGaA

Selection of detectors for flammable gases and oxygen





Catalytic sensors are suitable for the detection of gas/air mixtures up to the lower flammable limit (LEL)

- Response time and sensitivity depend on the individual gas to be measured.
- For gas mixtures, the sensor should be calibrated to the gas with the lowest sensitivity
- The ratio of response to different gases can change with time, particularly for methane or natural gas.

Sufficient concentration of oxygen for proper function

- Min. **10 vol.%** – for proper function
- **Warning:** With concentrations above the lower flammable limit, a catalytic sensor may erroneously indicate that the concentration of flammable gas is below the LEL
- Therefore, equipment fully complying with IEC 60079-29-1 using catalytic sensors shall have a locking over range indication to prevent erroneous readouts due to this

Selection of detectors for flammable gases and oxygen

Catalytic sensor – limitations

1

High gas concentrations

high gas concentrations can lead to longer recovery times or changes in the zero-point display or sensitivity

2

Preventing false alarms

To prevent false alarms, it is recommended that the alarm level should not be set below:

- 5% LEL for methane
- 10% LEL for propane and butane
- 20% LEL for gasoline vapors

3

Poisoning

Catalytic sensors are susceptible to poisoning by traces of several substances. This leads to an inhibition which can be permanent or temporary depending on the contaminant

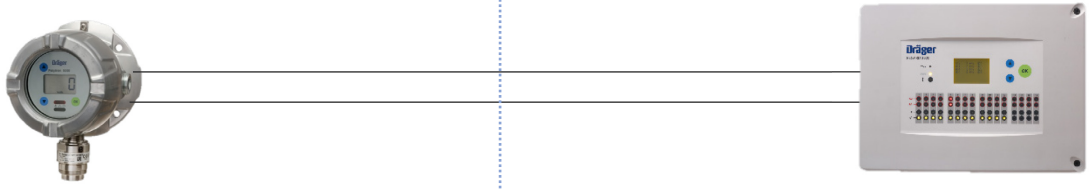
- Silicones (e.g., waterproofing, adhesives, special oils and greases, commercial cleaning agents,...);
- Sulfur compounds

05

Performance Approval – IEC / EN 60079-29-1

Performance Approval – IEC / EN 60079-29-1

Transmitter	Control unit
Requirements acc. 94/9/EC and or 2014/34/EU: – Ignition protection min. Category 2 – Safe and reliable measuring function	Requirements acc. 94/9/EC and or 2014/34/EU: – Safe and reliable measuring function
– Possible type marking acc. 94/9/EC and or 2014/34/EU: CE_{0000} Ex II 2 G – EC-/EU-Type examination certificate acc. EN 60079-0 and EN 60079-29-1/-4 required	– Possible type marking acc. 94/9/EC and or 2014/34/EU: CE_{0000} Ex II (2) G – EC-/EU-Type examination certificate acc. EN 60079-29-1 required



Ex II 2 G

Ex II (2) G

Performance Approval – IEC / EN 60079-29-1

Type examination certificate acc. EN 60079-29-1:2016

DrägerSensor PR/HT M DQ and or **PR NPT DQ** in combination with:

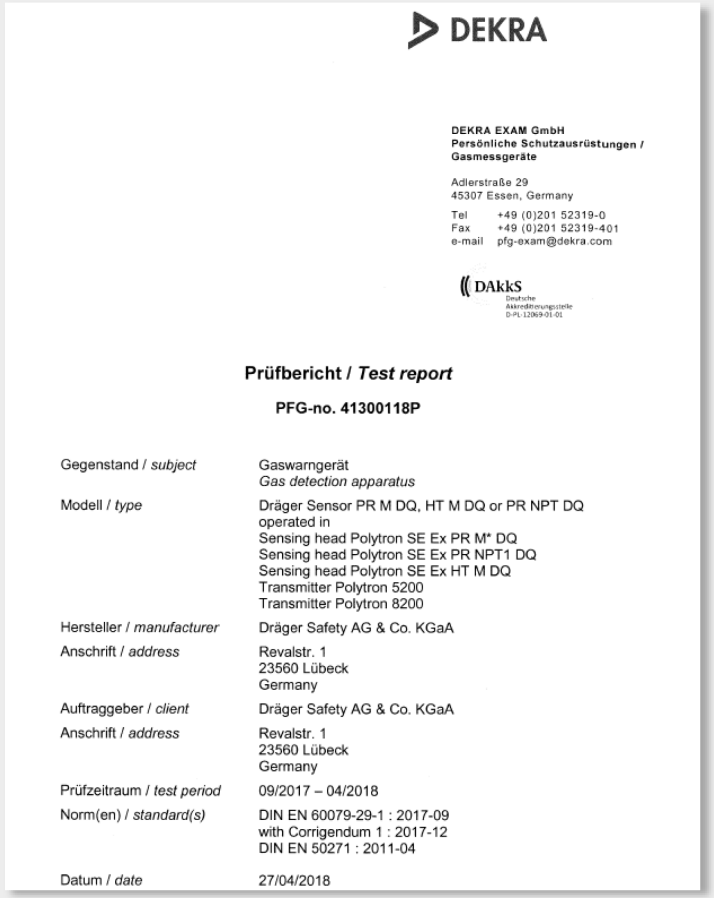
– Polytron SE Ex PR M DQ

– Polytron SE Ex PR NPT DQ

– Polytron SE Ex HT M DQ

– Polytron 5200

– Polytron 8200



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Prüfbericht / *Test report*

PFG-no. 41300118P

Gegenstand / *subject*	Gaswarngerät *Gas detection apparatus*
Modell / *type*	Dräger Sensor PR M DQ, HT M DQ or PR NPT DQ operated in Sensing head Polytron SE Ex PR M* DQ Sensing head Polytron SE Ex PR NPT1 DQ Sensing head Polytron SE Ex HT M DQ Transmitter Polytron 5200 Transmitter Polytron 8200
Hersteller / *manufacturer*	Dräger Safety AG & Co. KGaA
Anschrift / *address*	Revalstr. 1 23560 Lübeck Germany
Auftraggeber / *client*	Dräger Safety AG & Co. KGaA
Anschrift / *address*	Revalstr. 1 23560 Lübeck Germany
Prüfzeitraum / *test period*	09/2017 – 04/2018
Norm(en) / *standard(s)*	DIN EN 60079-29-1 : 2017-09 with Corrigendum 1 : 2017-12 DIN EN 50271 : 2011-04
Datum / *date*	27/04/2018

Performance Approval – IEC / EN 60079-29-1

DrägerSensor PR/HT DQ – Type examination certificate acc. EN 60079-29-1:2016

Substanz/Substance	CAS
Aceton/acetone	67-64-1
Acetylen/acetylene	74-86-2
Ammoniak/ammonia	7664-41-7
Benzin 065/095/petrol 065/095	-
Benzol/benzene	71-43-2
1,3-Butadien/1.3-butadiene	106-99-0
n-Butan/n-butane	106-97-8
n-butylacetat/n-butyl acetate	123-86-4
Diethylether/diethyl ether	60-26-7
Dimethylether/dimethly ether	115-10-6
Essigsäure/acetic acid	64-19-7
Ethanol/ethyl alcohol	64-17-5
Ethylacetat/ethly acetate	141-78-6
Ethylen (Ethen)/ethylene (ethene)	74-85-1
Ethylenoxid/ethlyene oxide	75-21-8

Substanz/Substance	CAS
n-Hexan/n-hexane	110-54-3
Methan/methane	74-82-8
Methanol/methanol	67-56-1
Methylethylketon/methyl ethyl ketone	78-93-3
Methylmethacrylat/methyl methacrylate	80-62-6
n-Nonan/n-nonane	111-84-2
n-Octan/n-octane	111-65-9
n-Pentan/n-pentane	109-66-0
Propan/propane	74-98-6
i-Propanol/i-propanol	67-63-0
Propylen (Propen)/propylene (propene)	115-07-1
Propylenoxid/propylyene oxid	75-56-9
Toluol/toluene	108-88-3
Wasserstoff/hydrogen	1333-74-0
o-Xylol/o-xylene	95-47-6

Many thanks

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