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IMPACT OF HYDROGEN ON EXISTING ATEX EQUIPMENT AND ZONES

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ABOUT MARCOGAZ

Founded in 1968, Marcogaz represents 29 member organisations from 20 countries. Its mission encompasses monitoring and policy advisory activities related to the European technical regulation, standardisation and certification with respect to safety and integrity of gas systems and equipment, rational use of energy as well as environment, health and safety issues. It is registered in Brussels under number BE0877 785 464.

1. Introduction

The properties of hydrogen (H_2) are different to those of natural gas (NG). Mixtures of hydrogen and natural gas (H_2NG) have different properties than the two individual gases. This calls into question existing standards on specific safety topics applying to existing natural gas infrastructure and end uses equipment for utilizing such mixtures. The safety topic of this paper is ATEX.

2. What is ATEX?

ATEX is an abbreviation for "ATmosphere EXplosible". The EC issued two directives on this topic.

Directive 1999/92/EC of the European Parliament and of the Council of 16 December 1999 on minimum requirements for improving the safety and health protection of workers potentially at risk from explosive atmospheres (15th individual Directive within the meaning of Article 16(1) of Directive 89/391/EEC). This so-called ATEX-153 (formerly ATEX 137) Directive obliges employers to draw up and keep up to date a so-called Explosion Protection Document. This document contains the identification and assessment of the explosion risks. Furthermore, hazard zonings must be indicated as well as measures to achieve a safe working environment. Hazardous places are classified in term of zone on the basis of standard EN IEC 60079-10-1 – Explosive atmospheres – Part 10-1: Classification of areas. Categories of equipment must be used in the zones (Table 1).

Zone	Definition	Categories of equipment
Zone 0	Area in which an explosive gas atmosphere is present continuously, or for long periods, or frequently.	1
Zone 1	Area in which an explosive gas atmosphere is likely to occur occasionally in normal operation.	1 or 2
Zone 2	Area in which an explosive gas atmosphere is not likely to occur in normal operation, but, if it does occur, will exist for a short period only.	1, 2 or 3

Table 1 - ATEX classification hazardous zones

Countries issue guidelines to clarify the above definitions. In The Netherlands a long period is defined as more than 10% of the operating time. Likely to occur occasionally is defined as 0.1% -10% of the operating time. A short period is defined as less than 0.1% of the operating time.

Directive 2014/34/EC of the European Parliament and of the Council of 26 February 2014 on the harmonization of the laws of the Member States relating to equipment and protective systems intended for use in potentially explosive atmospheres (recast). This so called ATEX-114 Directive describes the minimum safety requirements for explosion-proof equipment. Currently this Directive defines two types of Equipment groups:

- Equipment group I concerns all underground (mining) installations
- Equipment group II concerns all other above-ground installations

Equipment group II is divided into 3 gas groups (see Table 2). The main difference is in the MESG (Maximum Experimental Safety Gap) for flameproof encapsulation and the MIE (Minimum Ignition Energy) for intrinsically safe circuits:

Gasgroup	MIE (uJ)	Example
IIA	>200	Methane, Propane, Kerosene
IIB	20-60	Ethylene
IIC	0-20	Hydrogen, Acetylene

Table 2 - ATEX gas groups for equipment group II

Furthermore, gas explosion-proof equipment is classified in temperature classes. Equipment classified in a certain temperature class can be used for gases with an ignition temperature higher than the temperature associated with the group (see Table 3).

Temperature class	Maximum permissible surface temperature
T1	450 °C
T2	300 °C
T3	200 °C
T4	135 °C
T5	100 °C
T6	85 °C

Table 3 - ATEX temperature class

3. Safety properties of natural gas and hydrogen

The safety properties of methane and hydrogen relevant for ATEX are (Table 4):

Property	CH_4	H_2
Gas group (ATEX)	IIA	IIC
Temperature class	T1	T1
Minimum Ignition Energy (mJ)	0,28	0,017
Ignition temperature (°C)	537 (CH_4) – 670 (L-Gas)	560
LEL-UEL (vol %)	4,4 - 17	4 - 77
Molecular weight (g/mol)	16	2
Relative density	0,55	0,07

Table 4 - Safety properties of natural gas and hydrogen

For pure hydrogen, the gas group is different compared to NG (CH_4). Mixtures of hydrogen and NG may thus belong to any gas group in between. Equipment used in a hazardous (explosion) zone must be evaluated with respect to the ATEX gas group. The temperature class does not differ. ISO/IEC 80079-20-1 chapter 5.2.4 states that methane with up to 25 % H2 is still IIA.

Calculations shall be made for mixtures of H_2 and NG (low caloric, high caloric). For indicative purposes calculations have been made for molecular mixtures of H_2 and CH_4 regarding to the gas group (Table 5). For specific mixtures, the gas group must be determined according norm X-EN-ISO/IEC 60079-20-1 Explosive atmospheres.

Example 1:
BAM (Bundesanstalt für Materialforschung und -prüfung, Germany) investigated the explosion limits, the limiting oxygen concentrations, the maximum explosion pressures, K_G values and the MESG [BAM]: "The investigations have shown that none of the examined characteristics is affected significantly by the addition of up to 10 mol% hydrogen. The explosion ranges are increased only slightly, and the mixtures remain in explosion group IIA; as is pure natural gas. Also, the maximum explosion pressure and the rates of pressure rise of gas explosions are almost unaffected.

Comparative calculations – on the basis of gas dispersion calculations – to determine hazardous areas (explosion zones) for pure natural gas and natural gas - hydrogen mixtures with up to 10 mol% hydrogen, also revealed only minor differences within the margin of error of the calculation methods. The calculations were executed at BAM according to the free jet model from Schatzmann and with the e.Bex-Tool®, often applied by gas grid operators." [BAM]

Mixture of H_2 and CH_4	Gas group ATEX
< 25 Mol. % H_2	IIA
25 – 70 Mol. % H_2	IIB
> 70 Mol. % H_2	IIC

Table 5 - ATEX Gas group for mixtures of CH_4 and H_2 (example 1); [BAM]

4. Conclusions

Equipment with gas group IIB+H_2 is available on the market and can be suitable.
Other differences between safety properties of H_2 and CH_4 are:

- The explosion limits of hydrogen are much wider than those of methane
- The specific gravity of hydrogen is much lower than air, so that pure hydrogen released with low momentum rises about 6 times faster than methane (20 m/s)
- Due to the high rate of rise, the dilution in air is faster than that of methane under these conditions (approx. 3,8 times faster)
- The required ignition energy through sparks is much lower than that of methane in a stoichiometric mixture (27%), in outdoor air installations the required ignition energy is approximately the same because it is difficult to get the mixture above 10 vol.-% there.

Attention has to be given to prevention with respect to installations in buildings due to possible accumulation of H_2 at the ceiling. This probability is higher compared to CH_4.

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5. Glossary

ATEX	ATmosphere EXplosible
CH_4	Methane
H_2	Hydrogen
LEL	Lower Explosion Limit
L-gas	Low calorific natural gas
MESG	Maximum Experimental Safe Gap. MESG is a standardized measurement of how easily a gas flame will pass through a narrow gap bordered by heat-absorbing metal. MESG is used to classify flammable gases for the design and/or selection of electrical equipment in hazardous areas, and flame arrestor devices.
MIE	Minimum Ignition Energy
NG	Natural Gas
UEL	Upper Explosion Limit

6. References

- Directive 1999/92/EC of the European Parliament and of the Council of 16 December 1999 on minimum requirements for improving the safety and health protection of workers potentially at risk from explosive atmospheres

- Directive 2014/34/EC of the European Parliament and of the Council of 26 February 2014 on the harmonization of the laws of the Member States relating to equipment and protective systems intended for use in potentially explosive atmospheres

- EN IEC 60079-10-1 Explosive atmospheres - Part 10-1: Classification of areas - Explosive gas atmospheres.

- EN-ISO/IEC 60079-20-1 Explosive atmospheres - Part 20-1: Material characteristics for gas and vapour classification - Test methods and data.

- BAM, "Sicherheitstechnische Eigenschaften von Erdgas-Wasserstoff-Gemischen", Berlin, 2016

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