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Varnostne in nadzorne naprave za gorilnike in aparate na plin in/ali tekoča goriva - Navodilo o posebnih vidikih, značilnih za vodik

Safety and control devices for burners and appliances burning gaseous and/or liquid fuels - Guidance on hydrogen specific aspects

Sicherheits- und Regeleinrichtungen für Brenner und Brennstoffgeräte für gasförmige und/oder flüssige Brennstoffe - Leitfaden zu wasserstoffspezifischen Aspekten

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27.060.01	Gorilniki in grelniki vode na splošno	Burners and boilers in general

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Safety and control devices for burners and appliances burning gaseous and/or liquid fuels - Guidance on hydrogen specific aspects

Sicherheits- und Regeleinrichtungen für Brenner und Brennstoffgeräte für gasförmige und/oder flüssige Brennstoffe - Leitfaden zu wasserstoffspezifischen Aspekten

This draft Technical Report is submitted to CEN members for Vote. It has been drawn up by the Technical Committee CEN/TC 58.

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EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

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Contents

European foreword

This document (FprCEN/TR 17924:2022) has been prepared by Technical Committee CEN/TC 58 “Safety and control devices for burners and appliances burning gaseous or liquid fuels”, the secretariat of which is held by BSI.

This document is currently submitted to the Vote on TR.

Introduction

The use of hydrogen as a renewable fuel next to biomethane is seen as a promising alternative to natural gas in the near future. As soon as the according regulations and standards are in force, the use of hydrogen can be expected on a more regular basis.

For this reason, the heating and combustion business have to provide suitable solutions based on standardized safety, construction, and performance requirements.

This document will provide a first summary of considerations regarding safety and performance aspects for safety and control devices which will in some cases require further research and which is not exhaustive.

There are ongoing research projects on the use of hydrogen as an admixture with natural gas in various percentages or as hydrogen like the European THyGA project (up to 60 vol.-% hydrogen admixture to natural gas) which results could have an influence on these first considerations.

Therefore, this document is written in preparation of future revisions of CEN/TC 58 documents and will describe findings pointing at potential changes, give the according research backgrounds and provide literature sources.

The first edition of this document includes theoretical evaluations regarding different gases, comparing their different characteristics, properties, behaviours, and their impact on the risk assessment for gas appliances. These theoretical evaluations will be complemented by laboratory measurements, which will be then included in a future revision of this document.

For the future implementation of the hydrogen in the whole value chain co-operation with other CEN/TCs is necessary like e.g. CEN/TC 234 “Gas infrastructure”, CEN/TC 109 “Central heating boilers using gaseous fuels”, and CEN/TC 131 “Gas burners using fans”.

This document up to Annex A is based on the structure of EN 13611:2019 + AC:2021, which means that clauses and subclauses including their designations are aligned to this standard.

In this document only those clauses of EN 13611:2019+AC:2021 are referred to, which may be affected by using hydrogen or hydrogen admixtures as gaseous fuel. All other clauses, which may be not affected, are not listed in this document.

1 Scope

This document is written in preparation of future revision of standards dealing with safety, design, construction, and performance requirements and testing of safety, control or regulating devices (hereafter referred to as controls) for burners and appliances burning:

- H_2NG (hydrogen in natural gas) fluctuating admixture of no more than 20 vol.-% hydrogen content; or
- hydrogen according to ISO 14687:2019, at least Type I, Grade A; or
- fluctuating admixtures to natural gas from 0 vol.-% to above 20 vol.-% hydrogen (e.g. 0 vol.-% to 10 vol.-% or 0 vol.-% to 40 vol.-%).

This document refers to controls with declared maximum inlet pressure up to and including 500 kPa and of nominal connection sizes up to and including DN 250.

The purpose of this document is to provide guidance on hydrogen specific topics, which need to be considered in the future standardization of controls covered by CEN/TC 58 documents including:

- automatic shut-off valves;
- automatic burner control systems;
- flame supervision devices;
- gas/air ratio controls;
- pressure regulators;
- manual taps;
- mechanical thermostats;
- multifunctional controls;
- pressure sensing devices;
- valve proving systems;
- automatic vent valves.

Hydrogen will play an important role in the future in several energy segments and requirements and test methods need to be verified and adapted, if necessary.

The main target of this proposal is to lay the ground for defining requirements and tests for controls used for safety related functions (e.g. safety valves, automatic burner control systems, gas/air ratio controls) or regulating devices.

Summaries of subclauses to be addressed in the respective standards of each CEN/TC 58 WG are given in

- Annex A: Specific considerations to CEN/TC 58 WG 11 standards,
- Annex B: Specific considerations to CEN/TC 58 WG 12 standards,
- Annex C: Specific considerations to CEN/TC 58 WG 13 standards, and

- Annex D: Specific considerations to CEN/TC 58 WG 14 standards.

Aspects to be included for gas appliances (e.g. boilers, forced draught gas-burners, or industrial thermoprocessing equipment) covering e.g. risk standardization, certification and operation are listed in

- Annex E: Risk assessment, standardization, certification and operation of gas appliances with 20 vol.-% H_2 fluctuating admixtures, and

- Annex F: Risk assessment, standardization, certification and operation of gas appliances using hydrogen (ISO 14687:2019, Type I, Grade A).

Proposals for leakage rate requirements and tests for gas pipe work including controls (e.g. valves, regulators, pressure switches) used in gas appliances (e.g. forced draught gas-burners or industrial thermoprocessing equipment) and the impact on the installation room size are shown in Annex GG.

Considerations to be taken to stay below possible lower explosion limits in gas appliances (e.g. boilers, forced draught gas-burners, or industrial thermoprocessing equipment) and its installation rooms are shown in

- Annex H: Examples of mitigation measures in case of fracture of non-metallic parts for each combustible gas to stay below 25 % of its LEL, based on calculation, and

- Annex I: Examples of mitigation measures in case of leakages for each combustible gas to stay below 25 % of its LEL, based on calculation.

2 Normative references

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

FprEN 88-1:2022, Safety and control devices for gas burners and gas burning appliances — Part 1: Pressure regulators for inlet pressures up to and including 50 kPa

FprEN 88-2:2022, Safety and control devices for gas burners and gas burning appliances — Part 2: Pressure regulators for inlet pressures above 50 kPa up to and including 500 kPa

FprEN 88-3:2022, Safety and control devices for gas burners and gas burning appliances — Part 3: Pressure and/or flow rate regulators for inlet pressures up to and including 500 kPa, electronic types

EN 126:2012, *Multifunctional controls for gas burning appliances*

FprEN 161:2022, Automatic shut-off valves for gas burners and gas appliances

EN 377:1993, *Lubricants for applications in appliances and associated controls using combustible gases except those designed for use in industrial processes*

EN 437:2021, *Test gases - Test pressures - Appliance categories*

EN 549:2019, *Rubber materials for seals and diaphragms for gas appliances and gas equipment*

FprEN 1854:2022, Safety and control devices for burners and appliances burning gaseous and/or liquid fuels — Pressure sensing devices for gas burners and gas burning appliances

EN 13611:2019, *Safety and control devices for burners and appliances burning gaseous and/or liquid fuels - General requirements*

EN 14394:2005, *Heating boilers — Heating boilers with forced draught burners — Nominal heat output not exceeding 10 MW and maximum operating temperature of 110 °C*

ISO 14687:2019, *Hydrogen fuel quality — Product specification*

EN 16726:2015, *+ A1:2018,* Gas infrastructure — Quality of gas — Group H

3 Terms and definitions

For the purposes of this document, the terms and definitions given in EN 13611:2019 and the following apply.

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

- ISO Online browsing platform: available at https://www.iso.org/obp/ui/#home
- IEC Electropedia: available at https://www.electropedia.org/

3.1
lower explosion limit
LEL
lowest concentration of the explosion range at which an explosion can occur

[SOURCE: EN 13237:2012, 3.19.1]

3.2
hydrogen
gaseous hydrogen with a purity of at least Type I, Grade A

Note 1 to entry: Purity according to ISO 14687:2019,

3.3
hydrogen admixture
hydrogen mixed with gaseous fuels in a fluctuating percentage from 0 to a maximum value

Note 1 to entry: According to EN 16726:2015+A1:2018, Annex E

4 Classification

4.1 Classes of control

The use of hydrogen would require the categorization based on the used concentration. There will be fluctuations and variation in concentration which will be limited and will likely be described in future revisions of EN 16726:2015+A1:2018.

There are research and considerations on the use of hydrogen as an admixture with natural gas in various percentages or as hydrogen. The admixture up to 10 vol.-% hydrogen is already mentioned in EN 16726:2015+A1:2018, Annex E.

An admixture of 20 vol.-% hydrogen is considered from legal authorities and many gas appliances manufactures as a next step as well as the use of hydrogen. As a consequence, controls can be categorized as follows:

Cat NG: gaseous fuels of 2nd family according to EN 437:2021, or their admixtures with an overall hydrogen content of up to and including 20 vol.-%;

Cat Hy: gaseous fuels of 2nd family according to EN 437:2021, with an overall hydrogen content from 0 to above 20 vol.-%.

4.2 Classification of hydrogen

Hydrogen gas is currently not yet defined in EN 437:2021. Based on literature hydrogen gas properties and purity are:

Extract of PAS 4444:2020 + A1:2021:

Table 1 — Hydrogen test gas characteristics — gas dry at 15 °C and 1 013,25 mbar

Gas family	Test gases	Designation	Composition by volume	W_l **MJ/m³**	H_l **MJ/m³**	W_s **MJ/m³**	H_s **MJ/m³**	d
Gases of the fourth family								
Group Y	Reference gas	G40	H_2 = 99,9	38,67	10,2	45,88	12,1	0,0696
	Limit gases	To be defined						

Purity report from Hy4Heat: https://static1.squarespace.com/static/5b8eae345cfd799896a803f4/t/5e58ebfc9df53f4eb31f7cf8/1582885917781/WP2+Report+final.pdf

Extract of ISO 14687:2019:

Table 2 — Hydrogen and hydrogen-based fuel classification by application

Type	Grade	Category	Applications	Clause
I Gas	A	—	Gaseous hydrogen; internal combustion engines for transportation; residential/commercial combustion appliances (e.g. boilers, cookers and similar applications)	7
	B	—	Gaseous hydrogen; industrial fuel for power generation and heat generation except PEM fuel cell applications	7
	C	—	Gaseous hydrogen; aircraft and space-vehicle ground support systems except PEM fuel cell applications	7
	D[a,b]	—	Gaseous hydrogen; PEM fuel cells for road vehicles	5
	E		PEM fuel cells for stationary appliances	6
		1	Hydrogen-based fuel; high efficiency/low power applications	
		2	Hydrogen-based fuel; high power applications	
		3	Gaseous hydrogen; high power/high efficiency applications	

[a] Grade D may be used for other fuel cell applications for transportation including forklifts and other industrial trucks if agreed upon between supplier and customer.

[b] Grade D may be used for PEM fuel cell stationary appliances alternative to grade E category 3.

Table 3 — Fuel quality specification for applications other than PEM fuel cell road vehicle and stationary applications

Constituents	Type I			Type II	Type III
(assay)	Grade A	Grade B	Grade C	Grade C	
Hydrogen fuel index[a] (minimum mole fraction, %)	98,0 %	99,90 %	99,995 %	99,995 %	99,995 %
Para-hydrogen (minimum mole fraction, %)	NS	NS	NS	95,0 %	95,0 %
Impurities (maximum content)					
Total gases	20 000 µmol/mol	1 000 µmol/mol	50 µmol/mol	50 µmol/mol	
Water (H_20) (mole fraction, %)	Non-condensing at all ambient conditions[b]	Non-condensing at all ambient conditions	[c]	[c]	
Total hydrocarbon	100 µmol/mol	Non-condensing at all ambient conditions	[c]	[c]	
Oxygen (O_2)	[b]	100 µmol/mol	[d]	[d]	
Argon (Ar)	[b]		[d]	[d]	
Nitrogen (N_2)	[b]	400 µmol/mol	[c]	[c]	
Helium (He)			39 µmol/mol	39 µmol/mol	
Carbon dioxide (CO_2)			[e]	[e]	
Carbon monoxide (CO)	1 µmol/mol		[e]	[e]	
Mercury (Hg)		0,004 µmol/mol			
Sulfur (S)	2,0 µmol/mol	10 µmol/mol			
Permanent particulates	[g]	[f]	[f]	[f]	
Density					[f]
NOTE 1 NS: Not specified.					

Constituents	Type I			Type II	Type III
(assay)	Grade A	Grade B	Grade C	Grade C	

[a] The hydrogen fuel index is determined by subtracting the “total non-hydrogen gases” expressed in mole

percent, from 100 mol percent.

[b] Combined water, oxygen, nitrogen and argon: maximum mole fraction of 1,9 %.

[c] Combined nitrogen, water and hydrocarbon: max. 9 µmol/mol.

[d] Combined oxygen and argon: max. 1 µmol/mol.

[e] Total CO_2 and CO: max. 1 µmol/mol.

[f] To be agreed between supplier and customer.

[g] The hydrogen shall not contain dust, sand, dirt, gums, oils, or other substances in an amount sufficient to

damage the fuelling station equipment or the vehicle (engine) being fuelled.

EASEE-Gas also published a common business practice about the hydrogen quality specification for dedicated hydrogen pipelines. Link: https://easee-gas.eu/latest-cbps

Furthermore, a CEN Technical Specification for the quality of hydrogen used in converted/rededicated gas systems is under preparation, which is proposing a minimum hydrogen concentration of 98 mol-% within CEN/TC 234.

5 Common properties

The intention of this document is to enable the use of the controls with hydrogen and hydrogen admixtures. Controls are already used with several fuels like biomethane or natural gas. Therefore, it is reasonable to summarize the properties of different common fuels like methane (natural gas), propane, and butane in comparison to hydrogen admixtures and hydrogen. Based on similarities and differences further conclusions, consequences, risk assessments, and impacts on materials are derived in this document.

Table 4 summarizes the properties of air (as common reference), methane (natural gas), propane, butane, hydrogen, and 20 vol.-% hydrogen admixture.

Table 4 — Gas properties

properties	unit	air	methane (CH_4)	propane (C_3H_8)	butane (isobutane) (C_4H_{10})	hydrogen (H_2)	admixture (20 vol.-% H_2, 80 vol.-% CH_4)
lower explosion limit LEL (20 °C)	[%]	—	4,4[a]	1,7[a]	1,3[a]	4,0[a]	4,2[b]
flammability temperature (air)	[°C]	—	595[a]	445[a]	460[a]	560[a]	588[c]
density ρ_{gas} (at 15 °C)	[kg/m³]	1,220[d]	0,680[d]	1,893[d]	2,527[d]	0,084[d]	0,560[d]
relative density d_V related to air	—	1	0,555[f]	1,550[f]	2,075[f]	0,069[d]	0,457[d]
dynamic viscosity η (at 15 °C)	[kg·m/s]	17,97 E-6[d]	10,87 E-6[d]	7,95 E-6[d]	7,32 E-6[d]	8,65 E-6[d]	10,98 E-6[d]
minimum air supply *AS*	[m³ air]/[m³ gas]	—	9,52[e]	23,80[e]	30,94[e]	2,38[e]	8,12[c]
calorific value H_i (inferior) (at 15 °C; 101,3 kPa)	[MJ/ m³]	—	34,02[f]	88.00[f]	116,09[f]	10,22[e]	29,27[c]
calorific value H_s (superior) (at 15 °C; 101,3 kPa)	[MJ/m³]	—	37,78[f]	95,65[f]	125,81[f]	11,97[d]	32,56[d]
Wobbe Index W_i (inferior)	[MJ/m³]	—	45,67[f]	70,69[f]	80,58[f]	38,62[d]	43,24[d]
Wobbe Index W_s (superior)	[MJ/m³]	—	50,72[f]	76,84[f]	87,33[f]	45,65[d]	48,20[d]

Source:

[a] IEC 80079-20-1:2017 “Explosive atmospheres — Part 20-1: Material characteristics for gas and vapour classification — Test methods and data”

[b] Scholten Dörr Wersky “Mögliche Beeinflussung von Bauteilen der Gasinstallation bei Wasserstoffanwendungen”

[c] Calculation by CEN/TC 58/WG 15/PG 1, 2022–02

[d] VDI-Wärmeatlas: 2013. 11th edition; Mason, E. A. u. S. C. Saxena: Phys. Fluids 1 (1958). 361

[e] Günter Cerbe: “Grundlagen der Gastechnik – Gasbeschaffung – Gasverteilung – Gasverwendung”

[f] EN 437:2021

Based on the common properties and research the following aspects demand further considerations with respect to subclauses of EN 13611:2019 + AC:2021:

1) leak-tightness – see 7.2

2) breather holes and housings – see 6.2.3 and 6.3.2

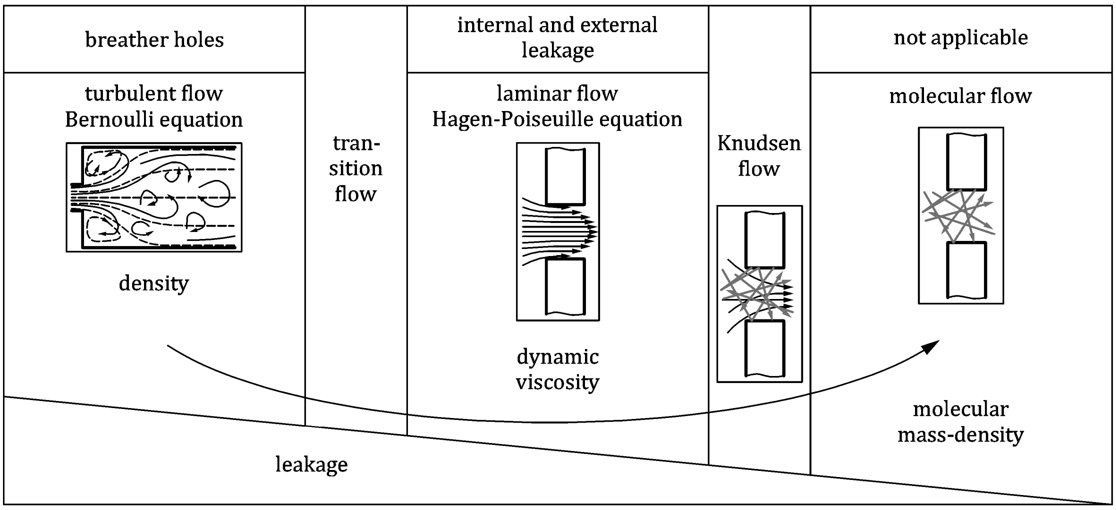
3) materials – see 6.3

4) safety aspects (risk assessment – see Annexes EE and FF)

6 General considerations regarding design and construction

6.1 Mechanical parts of the control

6.1.1 Theoretical background



To avoid too much damping on the regulator, breather holes need to have a certain minimum size. That is, the flow may turn from laminar to turbulent, because breather hole sizes are bigger than internal/external leakage hole sizes.

Figure 1 — Leakage models by theory

Figure 1 summarizes the flow characteristics which need to be taken under consideration if leakage of gaseous fuel is to be expected.

Depending on the design and the leakage rate a molecular, laminar, or turbulent flow of the gaseous fuel have to be differentiated.

Based on the common configuration of the control a molecular flow can be excluded.

Also calculations in the area between a molecular and laminar flow showed that the “Knudsen flow” is not relevant (see also Figure 2).