SLOVENSKI STANDARD
kSIST-TP FprCEN/TR 17924:2024

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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

Dispositifs de sécurité et de contrôle des brûleurs et des appareils brûlant des combustibles gazeux et/ou liquides - Orientations concernant les aspects spécifiques à l'hydrogène

Ta slovenski standard je istoveten z: FprCEN/TR 17924

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23.060.40	Tlačni regulatorji	Pressure regulators
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Safety and control devices for burners and appliances burning gaseous and/or liquid fuels - Guidance on hydrogen specific aspects

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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
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European foreword

This document (FprCEN/TR 17924:2024) 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 soon. 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 provides a summary of considerations regarding safety and performance aspects for safety and control devices which will in some cases require further research.

There are research projects on the use of hydrogen admixture with natural gas in various percentages or as hydrogen like the European THyGA project (up to 60 vol.-% hydrogen fluctuating admixtures to natural gas).

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.

This document includes evaluations regarding different gases, comparing their distinctive characteristics, properties, and their impact on the risk assessment for gas appliances. Theoretical evaluations are complemented by laboratory measurements.

For the future implementation of 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”, CEN/TC 131 “Gas burners using fans”, and CEN/TC 186 “Industrial thermoprocessing — Safety”.

This document up to Annex A is based on the structure of EN 13611:2019.

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

For the calculations and measurements in this document the specific admixture of 20 vol.-% hydrogen and 80 vol.-% methane is used. This admixture is already used as a typical reference in other standards.

1 Scope

This document is written in preparation of future revision of standards dealing with the general safety, design, construction, and performance requirements and testing of safety, control or regulating devices (hereafter referred to as controls) for burners and appliances burning hydrogen (see 3.2) or hydrogen admixtures (see 3.3).

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 a significant 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 document 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 assessment, standardization, certification, and operation are listed in

— Annex E: Risk assessment, standardization, certification, and operation of gas appliances with admixtures fluctuating up to 20 vol.-% hydrogen to natural gas, and

— Annex F: Risk assessment, standardization, certification, and operation of gas appliances using hydrogen referring to ISO 14687:2019, Type I, Grade A.

Proposals for leakage rate requirements and tests for gas pipework 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 G.

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 diaphragm fracture or fracture of non-metallic parts for different combustible gases to stay below 25 % of their LEL, based on measurements and calculations, and

— Annex I: Examples of mitigation measures in case of leakages for different combustible gases to stay below 25 % of their LEL, based on measurements and calculations.

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.

EN 13611:2019[1], *Safety and control devices for burners and appliances burning gaseous and/or liquid fuels — General requirements*

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 terminology databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp/

— 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 limits are given in ISO 14687:2019.

Note 2 to entry: For calculations in this document hydrogen is considered as 100 % H_2.

[1] Impacted by EN 13611:2019/AC:2021[2] Assumption for calculations for DN > 100

3.3
hydrogen admixture
hydrogen in natural gas fluctuating admixture with an overall hydrogen content from 0 to 100 vol.-%

4 Classification

4.1 Classes of control

In some standards the use of hydrogen can require a categorization based on the used concentration. There will be fluctuations and variation in concentration which will be limited and will 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.

Referring to the scope there is no further need in this document to classify controls with respect to using hydrogen admixtures or hydrogen.

4.2 Classification of hydrogen

Based on literature hydrogen gas properties and purity are:

Table 1 is an extract of PAS 4444:2020 + A1:2021, Table 1:

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

Table 2 is an extract of ISO 14687:2019, Table 1.

Table 3 is an extract of ISO 14687:2019, Table 4.

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**
	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]	

Constituents	Type I			Type II	Type III
	Grade A	Grade B	Grade C	Grade 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 NS: Not specified.

[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 cannot 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/TS 17977 for the quality of hydrogen used in converted/rededicated gas systems is available, which is proposing a minimum hydrogen concentration of 98 mol-% within certain maximum impurity concentrations.

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 a specific hydrogen admixture 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/80 vol.-% methane admixtures.

Table 4 — Gas properties

properties	unit	air	methane (CH_4)	propane (C_3H_8)	butane (isobutane) (C_4H_{10})	hydrogen (H_2)	20 vol.-% H_2/80 vol.-% CH_4 admixture
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/m^3]	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[e]	1,550[e]	2,075[e]	0,069[d]	0,457[d]
dynamic viscosity η (at 15 °C)	[Pa·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[f]
minimum air supply *AS*	[m^3 air]/[m^3 gas]	—	9,52[g]	23,80[g]	30,94[g]	2,38[g]	8,12[c]
calorific value H_i (inferior) (at 15 °C; 101,3 kPa)	[MJ/m^3]	—	34,02[e]	88.00[e]	116,09[e]	10,22[g]	29,27[c]
calorific value H_s (superior) (at 15 °C; 101,3 kPa)	[MJ/m^3]	—	37,78[e]	95,65[e]	125,81[e]	11,97[d]	32,56[d]
Wobbe Index W_i (inferior)	[MJ/m^3]	—	45,67[e]	70,69[e]	80,58[e]	38,62[d]	43,24[d]
Wobbe Index W_s (superior)	[MJ/m^3]	—	50,72[e]	76,84[e]	87,33[e]	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

[e] EN 437:2021

[f] Mason, E.A., and S. C. Saxena: The Physics of Fluids, Volume 1, Number 5 (1958), pp. 361; and C. R. Wilke: The Journal of Chemical Fluids, Volume 18, Number 4 (1950), pp. 517

[g] Günter Cerbe: “Grundlagen der Gastechnik — Gasbeschaffung — Gasverteilung — Gasverwendung”

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

a) leak-tightness — see 7.1

b) breather holes and housings — see 6.1.3 and 6.2.2

c) materials — see 6.2

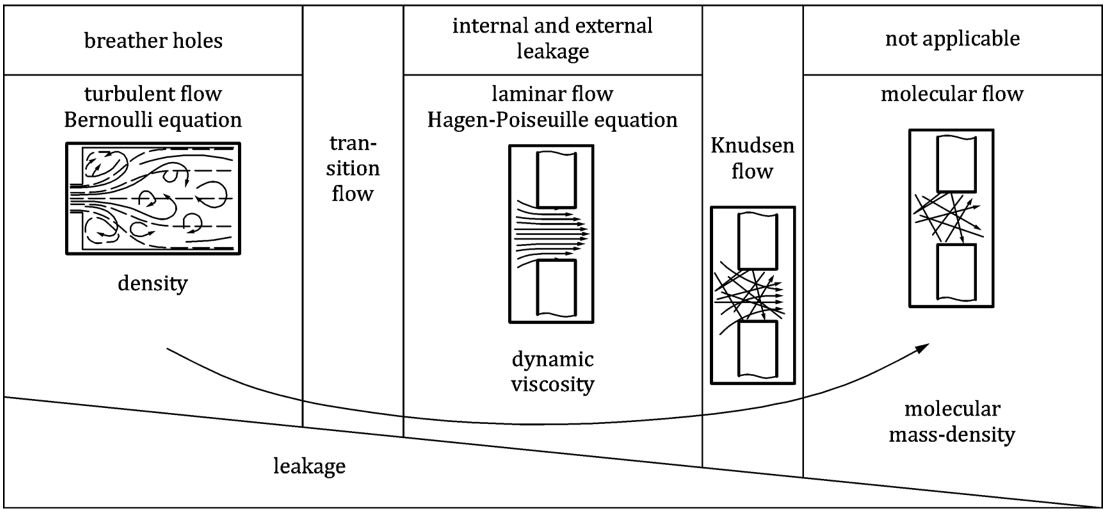
d) safety aspects (risk assessment — see Annexes E and F)

6 General considerations regarding design and construction

6.1 Mechanical parts of the control

NOTE 6.1 refers to EN 13611:2019, 6.2.

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 can 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 into 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 is differentiated.

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

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

NOTE Information regarding the modified Knudsen equation for transitional flow (between molecular and laminar) can be found in EN ISO 12807:2021, Annex B. Practical maximum leakage rates for molecular flow and minimum leakage rates for viscous laminar flow can be found in EN 1779:1999+A1:2004, 7.3.