

PAS 4445:2025

Hydrogen-fired equipment for use in industrial and commercial (non-domestic) settings – Code of Practice



Department for
Energy Security
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Foreword

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Relationship with other publications

PAS 4445:2025 is new work, and compliments the PAS 444X series:

- PAS 4441, *Components used in hydrogen gas metering – Specification*
- PAS 4442, *Material requirements for pipework and fittings used in hydrogen gas installation – Specification*
- PAS 4443, *Assessment criteria: Ancillary valves, devices and components used in hydrogen gas installations – Specification*
- PAS 4444, *Hydrogen-fired gas appliances – Guide*

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Presentational conventions

The provisions of this document are presented in roman (i.e. upright) type. Its recommendations are expressed in sentences in which the principal auxiliary verb is "should".

Commentary, explanation and general informative material is presented in smaller italic type, and does not constitute a normative element.

Where words have alternative spellings, the preferred spelling of the *Shorter Oxford English Dictionary* is used (e.g. "organization" rather than "organisation").

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In particular, attention is drawn to the following specific regulations:

- ATEX Directive [1];
- Dangerous Substances and Explosive Atmospheres Regulations (DSEAR) 2002 [2];
- Pressure Equipment Directive (PED) [3];
- Pressure Equipment (Safety) Regulations (PE(S)R) 2016 [4];
- Machinery Directive [5]; and
- Low Voltage Directive [6].

Introduction

During the Hy4Heat programme, funded by the Department for Business, Energy and Industrial Strategy (BEIS), PAS 4444, *Hydrogen-fired gas appliances – Guide* was developed. It aimed to provide guidance for appliance developers and Certification Authorities to enable certification to the Gas Appliance Regulation for appliances using 100% hydrogen.

The Hydrogen Skills and Standards for Heat programme has since developed standards for domestic and non-domestic hydrogen gas installations, as well as associated competence frameworks and training specifications for installers. These aim to enable the existing natural gas system to be repurposed for use with 100% hydrogen downstream of the emergency control valve (ECV).

The standards developed define the required criteria to safely repurpose existing natural gas equipment for hydrogen, to design and install new hydrogen-safe pipework and appliances, and to train a workforce of competent hydrogen gas installers. The programme forms part of the DESNZ Net Zero Innovation Portfolio (NZIP).

As part of this programme, BSI have developed a series of PAS standards that codify an agreed set of principles, requirements and guidance on the functionality, safety, installation, operating and servicing requirements for hydrogen meters, pipework, fittings, and ancillary devices. So far, the standards have focussed on smaller domestic appliances. This PAS aims to address these needs for hydrogen-fired equipment which falls outside the scope of PAS 4444 and complete the Hydrogen Skills and Standards for Heat programme.

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1 Scope

This PAS provides recommendations for hydrogen-fired equipment for use in industrial and commercial (non-domestic) settings.

NOTE 1 *Attention is drawn to the Gas Appliance Regulation (GAR) [7].*

This PAS covers the safety, design, construction, testing and performance of hydrogen-fired equipment for use in industrial and commercial (non-domestic) settings which are either:

- a) manufacturer-purpose built including dual-firing;
- b) manufacturer-converted including dual-firing;
- c) retrofit-converted to use hydrogen including dual-firing; or
- d) supplied suitable for future conversion to hydrogen.

This PAS covers over 98% purity (by volume) of hydrogen.

This PAS covers pre-conversion, the conversion procedure, and post-conversion processes.

This PAS applies to gas pressure systems with a 17 mbar¹⁾ minimum and 7 bar maximum operational gas pressure measured downstream from the first stage pressure reduction.

NOTE 2 *The 7 bar limit facilitates effective gas odorization for leak detection and reduces the risk of hydrogen embrittlement or hydrogen attack in the materials.*

This PAS does not cover:

- 1) equipment for use in domestic settings;
- 2) equipment covered by PAS 4444:2020+A1;
- 3) equipment covered by other specific guidance including gas-turbines, refineries and hydro-chemical plant; or
- 4) sustainable design.

NOTE 3 *Attention is drawn to the Ecodesign and Energy Labelling Directive [8].*

This PAS is for use by original equipment manufacturers (OEMs) and designers of hydrogen-fired equipment, installers, commissioners, maintenance engineers and operators.

It might also be of interest to Notified Bodies, insurers/underwriters, and UK competent authorities.

¹⁾ 1 mbar = 0.1 kpa, 1 bar = 100 kpa.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes provisions, or limits the application, 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.

Standards publications

BS 7671, *Requirements for electrical installations – IET Wiring Regulations*

BS EN 298, *Automatic burner control systems for burners and appliances burning gaseous or liquid fuels*

BS EN 303-1:2017, *Heating boilers – Part 1: Heating boilers with forced draught burners – Terminology, general requirements, testing and marking*

BS EN 303-3:1999+A2:2004, *Heating boilers – Part 3: Gas-fired central heating boilers – Assembly comprising a boiler body and a forced draught burner*

BS EN 437, *Test gases – Test pressures – Appliance categories*

BS EN 676:2020, *Forced draught burners for gaseous fuels*

BS EN 746 (all parts), *Industrial thermoprocessing equipment*

BS EN 746-1, *Industrial thermoprocessing equipment – Part 1: Common safety requirements for industrial thermoprocessing equipment*

BS EN 746-3, *Industrial thermoprocessing equipment – Part 3: Safety requirements for the generation and use of atmosphere gases*

BS EN 746-4, *Industrial thermoprocessing equipment – Part 4: Particular safety requirements for hot dip galvanizing thermoprocessing equipment*

BS EN 746-5, *Industrial thermoprocessing equipment – Part 5: Particular safety requirements for salt bath thermoprocessing equipment*

BS EN 746-8, *Industrial thermoprocessing equipment – Part 8: Particular safety requirements for quenching equipment*

BS EN 1127-1, *Explosive atmospheres – Explosion prevention and protection – Part 1: Basic concepts and methodology*

BS EN 1749, *Classification of gas appliances according to the method of supplying combustion air and of evacuation of the combustion products (types)*

BS EN 61508 (all parts), *Functional safety of electrical/ electronic/ programmable electronic safety-related systems*

BS EN 61511 (all parts), *Functional safety – Safety instrumented systems for the process industry sector*

BS EN 10204, *Metallic products – Types of inspection documents*

BS EN 12952 (all parts), *Water-tube boilers and auxiliary installations*

BS EN 12952-15, *Water-tube boilers and auxiliary installations – Part 15: Acceptance tests*

BS EN 12953 (all parts), *Shell boilers*

BS EN 12953-7, *Shell boilers – Part 7: Requirements for firing systems for liquid and gaseous fuels for the boilers*

BS EN 12953-11, *Shell boilers – Part 11: Acceptance tests*

BS EN 16340, *Safety and control devices for burners and appliances burning gaseous or liquid fuels – Combustion product sensing devices*

BS EN 17082:2019, *Domestic and non-domestic gas-fired forced convection air heaters for space heating not exceeding a net heat input of 300 kW*

BS EN 60079-1, *Explosive atmospheres – Part 1: Equipment protection by flameproof enclosures “d”*

BS EN IEC 60079-10-1, *Explosive atmospheres – Part 10-1: Classification of areas – Explosive gas atmospheres*

BS EN IEC 60079-11, *Explosive atmospheres – Part 11: Equipment protection by intrinsic safety “i”*

BS EN ISO 12100, *Safety of machinery – General principles for design – Risk assessment and risk reduction*

BS EN ISO 13577 (all parts), *Industrial furnaces and associated processing equipment – Safety*

BS EN ISO 13577-2:2023, *Industrial furnaces and associated processing equipment – Safety – Part 2: Combustion and fuel handling systems*

BS EN ISO 80079-36, *Explosive atmospheres – Part 36: Non-electrical equipment for explosive atmospheres – Basic method and requirements*

BS EN ISO 80079-37, *Explosive atmospheres – Part 37: Non-electrical equipment for explosive atmospheres – Non-electrical type of protection constructional safety “c”, control of ignition sources “b”, liquid immersion “k”*

BS ISO 22967:2010, *Forced draught gas burners*

PAS 4442, *Material requirements for pipework and fittings used in hydrogen gas installation – Specification*

PAS 4443, *Assessment criteria: Ancillary valves, devices and components used in hydrogen gas installations – Specification*

PAS 4444:2020+A1:2021, *Hydrogen-fired gas appliances – Guide*

PD ISO/TR 15916, *Basic considerations for the safety of hydrogen systems*

PD CEN/TR 17924:2025, *Safety and control devices for burners and appliances burning gaseous and/or liquid fuels – Guidance on hydrogen specific aspects*

Other Publications

[N1] IGEM/H/1, Reference standard for low pressure hydrogen utilisation.

3 Terms and definitions

For the purposes of this PAS, the terms, definitions and symbols in PAS 4444:2020+A1 and the following apply.

3.1 aerated burner (premix burner)

type of burner where the gas and air are mixed prior to combustion

3.2 Category I

appliances designed exclusively for the use of gases of a single family or of a single group

3.3 Category II

appliances designed for use on gases of two families

3.4 Category III

appliances designed for use on gases of three families

3.5 combustion chamber

zone in which flame combusts and has means of radiant transfer

3.6 dual-firing

capability of a combustion system or equipment, such as a burner, boiler, or furnace, to operate using two different types of fuel

NOTE The different types of fuel are not used simultaneously.

3.7 flashback (light back)

entry of a flame into the body of the burner or further upstream (piping or gas control system)

3.8 type A

equipment not intended for connection to a flue or to a device for evacuating the combustion products to the outside of the room/plant area in which the equipment is installed

3.9 type B

equipment intended to be connected to a flue that evacuates the combustion products to the outside of the room/plant area containing the equipment

NOTE The combustion air is drawn directly from the room.

3.10 type C

equipment in which the combustion circuit (air supply, combustion chamber, heat exchanger and evacuation of combustion products) is sealed with respect to the room/plant area in which the equipment is installed

4 Gas classification

4.1 General

Gases should be classified into families and groups in accordance with BS EN 437. Gas ranges should be classified in accordance with BS EN 437.

4.2 Hydrogen gas

The values for hydrogen gas composition given in PAS 4444:2020+A1, Table 1 should be used for certification purposes until such time as limit gas compositions are agreed, defined and readily available.

NOTE 1 At time of publication, hydrogen gas is currently not defined in BS EN 437.

Table 1 – Hydrogen test gas characteristics – dry gas at 15 °C and atmospheric pressure of 1 013.25 mbar

Gas family	Test gases	Designation	Composition by volume	W_l MJ/ m ³	H_l MJ/ m ³	W_s MJ/ m ³	H_s MJ/ m ³	d
Gases of the fourth family								
Group Y	Reference gas	G40	H2 = 99.9	38.67	10.2	45.88	12.1	0.0696
	Limit gases	To be defined						
NOTE Table 1 is an extract of PAS 4444:2020+A1, Table 1.								

NOTE 2 Irrespective of the quality of manufactured hydrogen, some contamination is expected from within the gas network. PAS 4444:2020+A1, Table 2 demonstrates the limits that such contaminants are allowed to reach. This information is derived from the DNV-GL WP2 final report 10123173-FINAL PURITY, Rev. 05 [9] but does have some divergence; in particular maximum and minimum Wobbe Index have been specified to restrict possible variation in EU 2016/426 [7] thermal input.

NOTE 3 Accepting the levels of contaminants within the distributed gas provided in PAS 4444:2020+A1, Table 2, when considered holistically, the impact on the combustion process is insignificant. Further information is available under the network-led End User Safety Evidence Programme “Implications of Hydrogen Purity – End User Safety Impacts” available at https://smarter.energynetworks.org/projects/Inia_cad0084/.

NOTE 4 As the distributed gas is near-dry condition (see PAS 4444:2020+A1, Table 2 for the water dewpoint value allowed for distributed gas), wet gas grids within the UK distribution network might have a potential negative impact on the performance of hydrogen-firing equipment. Wet gas may need additional treatment at the point of reception, to ensure it has no negative effects on performance of the hydrogen firing equipment.

The effect of gas contaminants on certain types of and specific features of mechanical equipment should be monitored.

Combustion equipment should be designed to eliminate the risk of gas/air mixtures in the pipework being ignited by the equipment.

NOTE 5 Hydrogen gas pipes left depressurized for extended periods can experience air entry potentially creating a flashback into the supply pipe. If air is suspected in the line, it is good practice to purge with an inert gas (e.g. nitrogen) before restoring the hydrogen supply.