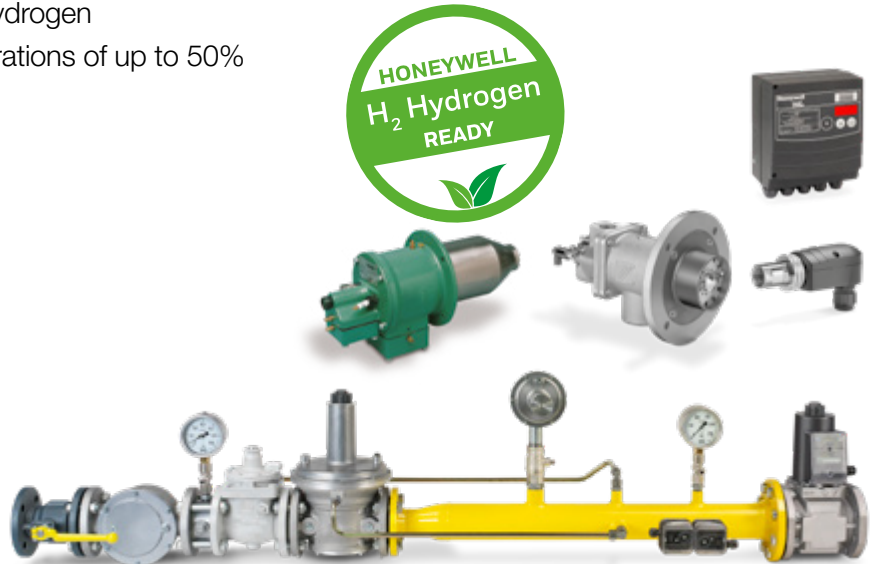


Products for hydrogen H₂

TECHNICAL INFORMATION

- Almost all controls suitable for 100% hydrogen
- Most burners can be used for concentrations of up to 50% hydrogen.
- Can be used with old plants



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1 Use of hydrogen

The importance of hydrogen as a climate-neutral fuel is on the rise.

Honeywell Thermal Solutions can supply controls and burners suitable for the use of hydrogen to generate process heat.

Hydrogen is the smallest and lightest element in the periodic table. It normally occurs in H₂ molecular form, a colourless and odourless gas. In certain chemical reactions, hydrogen temporarily occurs in atomic form as H. In this form, it features significantly higher reactivity in comparison to normal H₂ molecules. Hydrogen embrittlement caused, for example, by the ingress of atomic hydrogen into metals due to high pressures, high temperatures, vibrations and acid, cannot occur in the products featured in this Technical Information bulletin.

As a result of its low density compared to natural gas, hydrogen can escape more easily, for example at connections.

See page 5 (Hydrogen-compatible) for details of all controls and burners which are suitable for use with hydrogen.

See page 7 (Tightness) for further information about tightness.

Flame comparison for the ThermJet TJ with a rating of 213 kW, $\lambda = 1.15$



100% natural gas



Ratio of natural gas/hydrogen
40/60



Ratio of natural gas/hydrogen
20/80



100% hydrogen

2 Certification

At the current time, the Gas Appliances Regulation (GAR) (EU) 2016/426 does not provide any basis for testing with hydrogen.

However, Honeywell is working within CEN TC58 (European Technical Committee for Standardization) on adjusting the existing standards to cover H₂ as a medium (for example EN 161 for safety valves).

The current application standards ISO 13577 and EN 746 for industrial thermoprocessing equipment or EN 676 and ISO 22967 for forced draught gas burners do not contain any reference to hydrogen. However, revision discussions are currently taking place as to what additional regulations should be included for fuel gases with a high hydrogen content.

This standardization process may not be concluded until next year.

3 Hydrogen-compatible

3.1 Controls and accessories

| Type | Name | 100% H ₂ |
|------------------------------------|---|---------------------|
| Manual valves and filters | | |
| AKT | Manual valves | ✓ |
| TAS | Thermal equipment trips | ✓ |
| GFK | Gas filters | ✓ |
| Pressure regulators | | |
| J78R | Gas pressure regulators | ✓ |
| GDJ | Gas pressure regulators | ✓ |
| VGBF | Gas pressure regulators | ✓ |
| JSAV | Safety shut-off valves | ✓ |
| VSEV | Relief valve | ✓ |
| VAR | Circulation pressure control and relief regulators | ✓ |
| GIK, GIK..B | Air/gas ratio controls | ✓ |
| GIKH | Variable air/gas ratio controls | ✓ |
| Valves and butterfly valves | | |
| VAS | Gas solenoid valves | ✓ |
| VCS | Double solenoid valves | ✓ |
| VAD | Pressure regulators with solenoid valve | ✓ |
| VAG | Air/gas ratio controls with solenoid valve | ✓ |
| VAH | Flow rate regulators with solenoid valve | ✓ |
| VRH | Flow rate regulators | ✓ |
| VAV | Variable air/gas ratio controls with solenoid valve | ✓ |
| VBY | Bypass valves | ✓ |
| VMV | Fine-adjusting valves | ✓ |
| VMO | Measuring orifices | ✓ |
| VMF | Filter modules | ✓ |
| VGP | Gas solenoid valves | ✓ |
| VG | Gas solenoid valves | ✓ |
| VAN | Magnetic relief valves | ✓ |

| Type | Name | 100% H ₂ |
|---|--------------------------------|---------------------|
| VK | Motorized valves | ✓ |
| BVG, BVGF | Butterfly valves for gas | ✓ |
| VFC | Linear flow controls | ✓ |
| VR4xx | Gas control blocks | ✓ |
| VRB | Gas control blocks | ✓ |
| V4730, V8730 | Gas control blocks | ✓ |
| VMU | Mixers | ✓ |
| RV | Control valves | ✓ |
| Pressure switches | | |
| DG | Gas pressure switches | ✓ |
| C6097 | Gas pressure switches | ✓ |
| C60VR | Gas pressure switches | ✓ |
| DGM, DWR | Gas pressure switches | ✓ |
| Ignition and monitoring components | | |
| UVS | UV sensors | ✓ |
| UVC 1 | UV flame detectors | ✓ |
| Accessories | | |
| KFM, RFM | Pressure gauges | ✓ |
| GEH, GEHV | Flow adjusting cocks | ✓ |
| DH | Manual cocks | ✓ |
| DMG | Electronic pressure gauge | ✓ |
| EKO | Stainless steel bellows units | ✓ |
| ES | Stainless steel flexible tubes | ✓ |
| GRS, GRSF | Non-return gas valves | ✓ |

DM, DE flow meters are suitable for 20% hydrogen.

3.2 Burners

| Type | Name | 50% H ₂ * | 30 % H ₂ |
|-------------------------|--|----------------------|---------------------|
| ZAI | Pilot burners | √ | √ |
| ZMI (C) | Pilot burners | √ | √ |
| ZKIH | Pilot burners | √ | √ |
| ZIO 40 | Pilot burners | √ | √ |
| ZT 40 | Pilot burners | √ | √ |
| ZTA | Pilot burners | √ | √ |
| ZTI | Pilot burners | √ | √ |
| BIO, BIC, BIOW, BICW | Burners | √ | √ |
| BIOA, BICA | Burners | √ | √ |
| ZIO, ZIC, ZIOW, ZICW | Burners | √ | √ |
| BIO(W), BIC(W) | With pilot burner | √ | √ |
| ZIO(W), ZIC(W) | With pilot burner | √ | √ |
| BIC..MB | Burners | | |
| BICR | Burners | √ | √ |
| GLG, GLA, GLH | Burners for bell-type annealing furnaces | √ | √ |
| ECOMAX | Self-recuperative burners | √ | √ |
| ThermJet | Burners | √ ^{**} | √ ^{**} |
| Wide Range | Burners | | √ |
| Uni-Rad-Vilvoorde | Burners | √ | √ |
| PrimeFire FH (Next Gen) | Burners | √ | √ |
| OxyTherm 300 | Burners | √ | √ |
| OxyTherm LE | Burners | √ | √ |
| PrimeFire 100 | Burners | √ | √ |
| OxyTherm FHR | Burners | √ | √ |
| OxyTherm Titan | Burners | √ ^{**} | √ ^{**} |
| NP-RG | Burners | √ ^{**} | √ ^{**} |
| LV Airflo | Burners | √ ^{**} | √ ^{**} |
| Combustifume | Burners | √ ^{**} | √ ^{**} |
| HC Airflo | Burners | √ | √ |
| OvenPak 400 | Burners | | √ ^{**} |
| OvenPak 500 | Burners | | √ |
| ValuPak II | Burners | | √ ^{**} |

| Type | Name | 50% H ₂ * | 30 % H ₂ |
|-------------|---------|----------------------|---------------------|
| UnoPak | Burners | | √ ^{**} |
| MegaFire HD | Burners | | √ ^{**} |
| Kinemax | Burners | √ | √ |

* Higher hydrogen concentration available on request

** The specified hydrogen volume can be combusted after the burner has undergone minor adjustments and after the application has been reviewed.

4 Tightness

As a result of its smaller molecular size and the changed dynamic viscosity of hydrogen (H_2), it has different leakage rates compared to methane (CH_4).

Internal and external tightness to EN 13611

Gas appliances must be tight and must comply with the leakage rates for air specified in EN 13611.

| Nominal size | Medium | Internal tightness [cm ³ /h] | External tightness [cm ³ /h] |
|----------------|--------|---|---|
| DN < 10 | Air | | ≤ 20 |
| 10 ≤ DN ≤ 25 | Air | | ≤ 40 |
| 25 ≤ DN ≤ 80 | Air | | ≤ 60 |
| 80 ≤ DN ≤ 150 | Air | ≤ 100 | ≤ 60 |
| 150 ≤ DN ≤ 250 | Air | ≤ 150 | ≤ 60 |

If less than 10% H_2 is added, the leakage rates specified in EN 13611 are satisfied.

The following table shows the leakage rates found for 100% hydrogen (H_2):

| Nominal size | Medium | Internal tightness [cm ³ /h] | External tightness [cm ³ /h] |
|----------------|--------------------|---|---|
| DN < 10 | Hydrogen (H_2) | | ≤ 25 |
| 10 ≤ DN ≤ 25 | Hydrogen (H_2) | | ≤ 80 |
| 25 ≤ DN ≤ 80 | Hydrogen (H_2) | | ≤ 120 |
| 80 ≤ DN ≤ 150 | Hydrogen (H_2) | ≤ 200 | ≤ 120 |
| 150 ≤ DN ≤ 250 | Hydrogen (H_2) | ≤ 300 | ≤ 120 |

For an application using 100% H_2 or which involves adding more than 10% H_2 , there are no guarantees that compliance with the leakage rates specified in EN 13611 can be achieved due to the lower density and changed dynamic viscosity of hydrogen. **The suitability** of the application for

operation with mixtures of natural gas and hydrogen with a hydrogen content of ≥ 10% **must be verified by means of a risk assessment.**

Breather orifices of pressure switches and regulators to EN 13611

Breather orifices in gas appliances with diaphragms, which do not have a connector for a venting pipe, must be designed in such a way that no more than 70 dm³/h of air can escape if the diaphragm is damaged and the gas is at the highest inlet pressure. This air volume of 70 dm³/h is equivalent in the event of an accident to a leak of 100 dm³/h of natural gas (CH_4) or 270 dm³/h of hydrogen (H_2).

Flammability limits

| Gas mixture | Lower limit [% v/v] | Upper limit [% v/v] |
|-------------|---------------------|---------------------|
| H_2 | 4.0 | 77 |
| CH_4 | 4.4 | 16.5 |

The lower flammability limit is reached more quickly in applications using hydrogen.

Flow rate calculation

In the case of a “turbulent flow”, such as that caused by a breather orifice, the flow rate can be calculated using the density ratio:

Conversion factor from density ratio (reference value air):

| Medium | Density [kg/m ³] | Conversion factor |
|---------------|------------------------------|-------------------|
| Air | 1.29 | 1 |
| Natural gas H | 0.81 | 1.3 |
| H_2 | 0.09 | 3.79 |

The tightness of systems must always be tested before commissioning. In addition to the devices themselves, the thread and flange connections must also be checked.

5 Calculating the nominal size

A web app for calculating the nominal size is available at www.adlatus.org.

Enter the appropriate density for hydrogen or hydrogen-natural gas mixtures manually.

6 Project planning information

6.1 Combustion principles for adding hydrogen to natural gas

The heating value of natural gas-hydrogen mixtures falls significantly as the volume of added H₂ increases, in other words a higher flow rate is required to achieve the same thermal capacity. As a result of hydrogen's low density, the Wobbe index falls by significantly less but nevertheless the gas pressure must be up to 65% higher to achieve the same capacity. The recommended flow velocity for natural gas of 20 to 30 m/s should also be given due consideration for the addition of H₂.

The laminar flame velocity of hydrogen is significantly higher than that of natural gas. Nevertheless, the visible flame length on many burners changes very little when H₂ is added. However, the high flame velocity may cause resonance and generate noise depending on the burner design.

The demand for combustion air falls as the amount of added H₂ increases, in other words in an established system, there is no additional risk posed by excess gas due to the addition of H₂. If the burner settings are left unchanged, however, the excess air will increase by up to 45% and therefore, you should check whether the burner can still be operated stably with a higher volume of added H₂.

The adiabatic combustion temperature and the flame temperature will rise as the level of added H₂ increases. This causes the formation of thermal NO_x to increase, and an exponential increase in NO_x emissions, particularly if around 50% or more H₂ has been added, which necessitates additional action to reduce NO_x, for example by using higher excess air or selecting suitable low NO_x burners.

6.2 Conversion of existing burner systems

If 10–20 % hydrogen is added to natural gas, what is normally required is only an adjustment to the burners, particularly if they are low NO_x solutions, in which the precise adjustment of the gas/air ratio plays a vital role.

An extended gas/air ratio control must be used if the amount of added hydrogen varies.

For higher hydrogen contents, a burner suitable for that gas type must be selected.

6.3 Burner monitoring and control for hydrogen

As a result of the physical principle, flame control for pure hydrogen or hydrogen added to natural gas at a level of more than around 95% is not possible using ionization. It is only possible using UV sensors.

As a result of the significantly higher flammability limit of hydrogen compared to natural gas, you should check in each individual case whether the gas line between the shut-off valve and burner must be purged after the burner has been shut down (closing of the automatic shut-off valves). In certain circumstances, it may be possible that a flammable mixture will form between the burner and shut-off valve and flashback into the gas line will occur when the burner is restarted. In any event, shut-off valves should be placed as close to the burner as possible when hydrogen is used to minimize the danger of a potentially flammable mixture.

For more information

The Honeywell Thermal Solutions family of products includes Honeywell Combustion Safety, Eclipse, Exothermics, Hauck, Kromschöder and Maxon. To learn more about our products, visit ThermalSolutions.honeywell.com or contact your Honeywell Sales Engineer.

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