

Hydrogen admixture into natural gas and its effects on residential and commercial gas appliances

Gas- und Wärme-Institut Essen e.V.



– Results from the "DVGW Roadmap Gas 2050" –

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Objective

The aim of the work package "Gas applications" (Part 3) of the DVGW project "Roadmap Gas 2050" (G 201824) was to evaluate the hydrogen tolerances for various gas-fired household appliances, by increasing admixture of hydrogen in concentrations of 10 to 40 vol.% to well-defined test gases according to EN 437. The effects of H₂ admixture on the combustion behavior in terms of air excess ratios, heat load, emissions and control systems were analyzed. The focus was primarily on the aspects of safety and their performance of the appliances in the context of hydrogen admixture.

Methods

Investigated gases (based on EN 437)

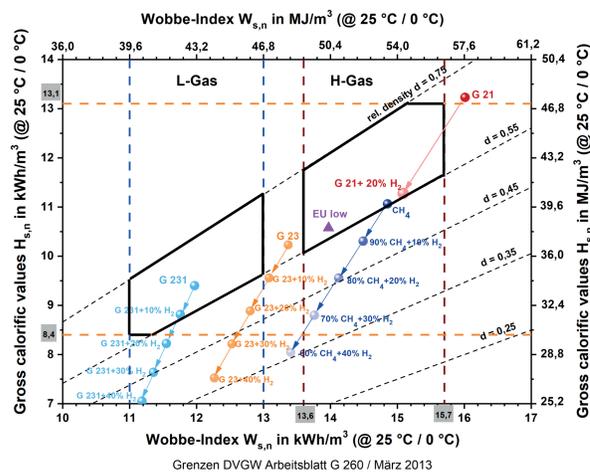
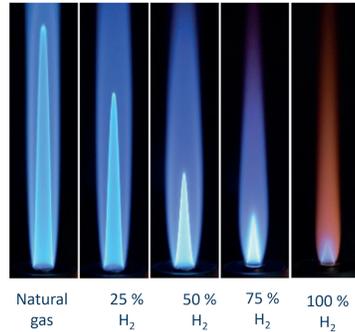


FIGURE 1: TEST GASES ACCORDING TO EN 437



LAMINAR PREMIXED BURNER WITH CONSTANT FIRING RATE AND AIR EXCESS RATIO (P = 750 W, λ = 1) SOURCE: UNIVERSITÄT DUISBURG-ESSEN



The appliances were initially tested with factory settings with G20. Then an analysis of the H₂ compatibility was carried out, increasing the H₂ content by 10 vol.% to 40 vol.% to each gas in each case. Depending on the appliance (single-stage, two-stage or modulating), the load was changed from Q_{min}/Q_{max}. All measurements were performed at water temperatures of T_{out}/T_{in} 50/30 °C.

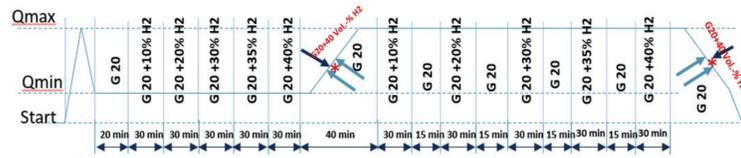


FIGURE 2: DEFINED TEST PROGRAM

Results

- CO and NO_x emissions mostly decrease with increasing H₂ content in the fuel gas, compared to combustion with natural gas or G 20
- Drop in heating performance in a range of 4 to 15 % for all temperature and load settings
- Increase in the air ratio number of 4 to 23 %, depending on the appliance type and gas composition
- Observed positive influence of hydrogen admixture on the efficiency of the gas appliances
- The appliances ignited properly and there were no safety concerns (flashback) up to 20 vol.% H₂
- Some acoustic effects (few appliances) were observed above 30 vol. % H₂ admixture

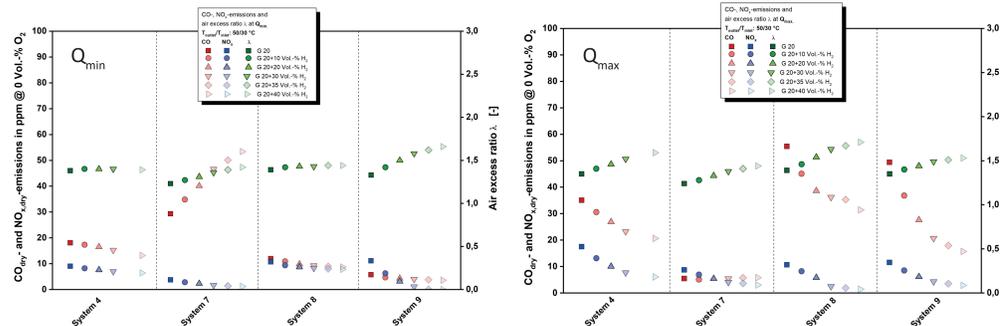


FIGURE 3: CO, NO_x EMISSIONS AND AIR EXCESS RATIOS OF CONDENSING APPLIANCES 4, 7, 8, 9 AT Q_{MIN} AND Q_{MAX} AND T_{OUT}/T_{IN} 50/30 °C FOR G20 AND G20 PLUS H₂ MIXTURES. SYSTEMS 4 AND 8 WITH COMBUSTION CONTROL, SYSTEM 9 WITH CO-SENSOR; AS THE H₂ PERCENTAGE INCREASES, THE AIR FLOW RATE IS KEPT CONSTANT OR CONTROLLED. SYSTEM 7 IS WITHOUT COMBUSTION CONTROL.

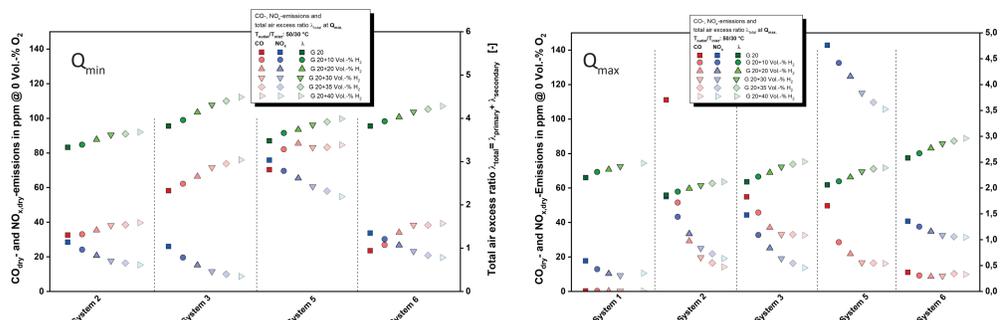


FIGURE 4: CO, NO_x EMISSIONS AND TOTAL AIR EXCESS RATIO OF LOW TEMPERATURE BOILERS WITH ATMOSPHERIC BURNERS 1, 2, 3, 5, 6 AT Q_{MIN} AND Q_{MAX} AND T_{OUT}/T_{IN} 50/30 °C FOR G20 AND G20 PLUS H₂ BLENDS.

Conclusion

The results with the tested appliances to date indicate an "H₂ readiness" of 20 vol.% and show that many existing appliances can safely be operated even with higher levels of hydrogen. An essential prerequisite

is that the appliances are in a well-maintained condition and within manufacturers specification.

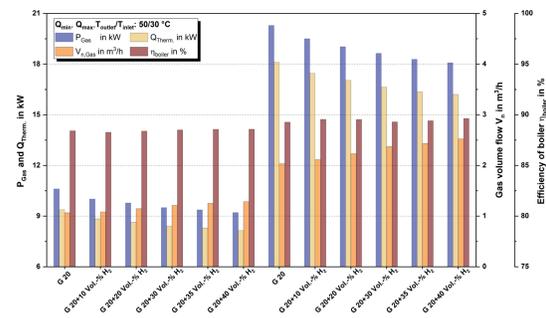


FIGURE 5: SYSTEM 5 SYSTEM DESCRIPTION: ATMOSPHERIC GAS WALL HEATER – CATEGORY B11BS – INJECTOR BURNER – MODULATING – MAX. LOAD APPROX. 20 kW – PARTIALLY PREMIXING – ROOM AIR DEPENDENT – OLD USED DEVICE THERMAL POWER OUTPUT, EFFICIENCY AND GAS VOLUME FLOW AT Q_{MIN} AND Q_{MAX} FOR G 20 AND G 20 WITH 10 - 40 VOL.% H₂; T_{OUT}/T_{IN} 50/30°C.

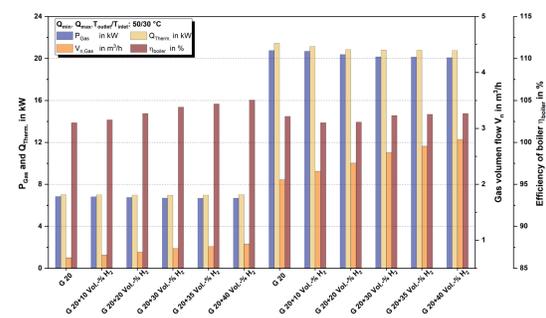


FIGURE 6: SYSTEM 8 SYSTEM DESCRIPTION: WALL-MOUNTED GAS CONDENSING COMBI BOILER – CATEGORY I2N – BURNER WITH ELECTRONIC COMBUSTION CONTROL – MODULATING – MAX. LOAD APPROX. 21 kW – FULLY PREMIXING – ROOM AIR INDEPENDENT – NEW DEVICE THERMAL POWER OUTPUT, EFFICIENCY AND GAS VOLUME FLOW AT Q_{MIN} AND Q_{MAX} FOR G 20 AND G 20 WITH 10 - 40 VOL.% H₂; T_{OUT}/T_{IN} 50/30°C.

ROADMAP GAS 2050

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References:

Roadmap Gas 2050: Bewertung der H₂-Verträglichkeit von Gasanwendungen und Gasinstallationen bis zu einer Grenze von 50 Vol.-%, Deliverable D 3.3, Teil 2 c: Häusliche Gasanwendungen Zusammenfassung der GWI-Ergebnisse. Dipl.-Ing. Eren Tali, Dr.-Ing. Frank Burmeister, Dipl.-Ing. Sabine Feldpausch-Jägers, Dr. Holger Dörr, Dipl.-Ing. Frank Erler