Enabling the decarbonisation of Australia's energy networks

Two Page Summary: RP1.4-05 – Performance of Type A appliances with blends of hydrogen and natural gas

Key message: A diverse range of common new and used, certified gas appliances operated safely and effectively on blends of up to 20 volume percent hydrogen with natural gas under normal gas appliance testing conditions.

Tests of new appliances with hydrogen blends

Previous work conducted by the Future Fuels CRC showed that there were no adverse consequences of operating twenty-six appliances on blends of 10 and 21.7 volume % (vol%) hydrogen with natural gas. However, to be confident of widespread adoption of 20 vol% hydrogen blending, more detailed tests with 15 appliances were performed using a blend of 31 vol% hydrogen in natural gas to provide a significant buffer above 20 vol%. These appliances were selected to include a cross-section of different appliance types commonly used throughout Australia, including space heaters, water heaters and cooking appliances.

Most of the burners operated without problems with the 31 vol% hydrogen blend with no light-back and no adverse effects on operability, efficiency, ignition, combustion, noise, emissions of carbon monoxide (CO), nitrogen dioxide (NO_2) or unburnt hydrogen. (Light-back is defined as the transfer of the flame from the burner tip or port back into the body of the burner or back to the injector.)

Notable observations were made with three appliances when operated with the 31 vol% hydrogen blend so they were then tested with blends containing lower percentages of hydrogen. One of the three was a flueless convection space heater, which lit-back inconsistently when operated with a blend of 31 vol% hydrogen and natural gas during ignition and operation. Further tests showed occasional light-back for blends with as little as 27 vol% hydrogen, but not with 26 vol% hydrogen and below. When lit-back, emissions of CO and NO_2 were both significantly above the prescribed limits, and damage to the burner was also possible, so light-back needs to be avoided.

Another notable observation was made with a cooker burner. Many cooker burners were tested but one large cooker burner with an upward facing injector lit-back when operated with 31 vol% hydrogen but only when the burner was operated at the absolute minimum flow setting. It did not light-back with lower hydrogen percentages. Once lit-back, the burner sustained this condition when turned up to the maximum rate but with an obviously different flame and louder noise. CO emissions were higher when lit-back, and damage from long-term operation in this mode is a possibility, so it is to be avoided.

The third notable observation when using the 31 vol% hydrogen blend was with an open flued wall furnace space heater which could be lit-back but only when first turning on the main burner from the pilot manually and setting the thermostat to the maximum setting. However, there were no problems with automatic relighting.

The summary from considering these three appliances is that 26 vol% hydrogen is the highest blend percentage that should be used without adjustments to appliances. In practice, since these tests could not be completely comprehensive and to allow for variation in gas blending accuracy and burner tolerances, the results show that existing Type A appliances operate safely and effectively without any modifications on a blend of up to 20 vol% hydrogen with natural gas.

Tests of used appliances with hydrogen blends

A range of second-hand appliances were tested with 10 and 22 vol% hydrogen blended in natural gas. The appliances were all operational and covered a wide range of age and in-service time with varying amounts of wear or damage, and included a range of burner types and uses. The appliances were a deep fryer, a fan-forced instantaneous water heater, a storage water heater, a flueless radiant tile space heater, a flueless convection space heater, an open-flued space heater with decorative log effect, barbeque, a domestic cooker with venturi cooktop burners and standard oven and grill burners, and a natural draught instantaneous water heater.

The addition of 10 or 22 vol% hydrogen to natural gas showed no significant effects on ignition performance or emissions from the nine second-hand appliances tested. Flame detection presented no problems with the 10 or 22 vol% hydrogen blends. For one appliance the flame ionisation rod current was tested and found to be as good for the hydrogen blends as for natural gas.

Two of the second-hand appliances (a storage water heater and a barbeque) produced light-back under normal conditions when operated on natural gas, and they also lit-back when operated with the 10 and 22 vol% blends with insignificant changes to emissions. Operating the barbeque in the lit-back condition with the 22 vol% hydrogen blend produced elevated temperatures inside the burner, compared to operating lit-back on natural gas, but did not cause damage.

These results for second-hand appliances add weight to the finding that a range of existing Type A appliances operate safety and effectively without any modifications on a blend of up to 20 volume % hydrogen with natural gas.

Flueless heaters in low oxygen environments

Flueless heaters are required to have an oxygen depletion system (ODS) that shuts off the appliance in the very rare circumstance that room oxygen concentration was to drop to 18 vol%. (Typically, there is 20.9 vol% in the atmosphere). For the ODS to operate, a heater would need to be used in a room with very limited ventilation. Tests in a sealed room showed that using 10 vol% or 22 vol% hydrogen blends delayed the operation of ODS slightly, but modelling showed that in practical rooms operation for long enough to reach 18 vol% oxygen would require unreasonably limited ventilation and result in overheating, so would be prevented by thermostat control or by the occupant. Carbon monoxide emissions were well within limits and both CO and nitrogen dioxide emission rates did not vary significantly from the ventilated cases nor from the natural gas cases.

Blending hydrogen into natural gas of varying composition

In some networks, significant levels of inert gases, such as nitrogen and carbon dioxide, are present in natural gas, so it is important to assess the effect of hydrogen in natural gas with different compositions. Previous work had identified that the appliances most likely to be problematic are the grill burner of a cooker, a fan forced instantaneous water heater and flueless convection heater, so these three were tested with a blend of 10 vol% hydrogen and 5 vol% nitrogen in methane and compared to results using both natural gas and a blend of 10 vol% hydrogen in methane. Performance and emissions of the three appliances when using the blend containing nitrogen were very similar to their performance with natural gas, including operation of the flueless heater oxygen depletion system (ODS) under vitiated conditions.

100% Hydrogen burner development

Development of 100% hydrogen burners for a cooker, a ducted space heater and a storage water heater was undertaken because of their importance in Australia. Further work is continuing.

Conclusion

For the appliances tested, which were selected to represent a broad range of the variety available in Australia, the addition of up to 20 vol% hydrogen to natural gas has little effect on appliance safety and performance.

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Authors: Doug Proud and Neil Smith

Project Team: Peter Ashman, Paul Medwell, Neil Smith, Doug Proud, Ben Crossman, Fredrick Omoarukhe – The University of Adelaide

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