IMPACT ON CANADIAN RESIDENTAL END USE APPLIANCES WITH THE INTRODUCTION OF HYDROGEN INTO THE NATURAL GAS STREAM – AN APPLICATION

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ABSTRACT

Canada's commitment to be net-zero by 2050, combined with ATCO's own Environmental, Social and Governance goals has led ATCO to pursue hydrogen blending within the existing natural gas system to reduce CO_2 emissions while continuing to provide safe, reliable energy service to customers. Utilization of hydrogen in the distribution system is the least-cost alternative for decarbonizing the heating loads in jurisdictions like Alberta, where harsh winter climates are encountered, and low-carbon hydrogen production can be abundant. ATCO's own Fort Saskatchewan Hydrogen Blending Project began blending 5% hydrogen by volume to over 2,100 customers in the Fall of 2022 and plans to increase the blend rates to 20% hydrogen in 2023. Prior to blending, ATCO worked together with DNV to examine the impact of hydrogen blended natural gas to twelve Canadian appliances: range/stove, oven, garage heater, high and medium efficiency furnaces, conventional and on demand hot water heaters, barbeque, clothes dryer, radiant heater and two gas fireplaces. The tests were performed not only within the planned blend rates of 0-20% hydrogen but also to higher percentages to determine how much hydrogen can be blended into a system before appliance retrofits would be required. The testing was designed to get insights on safety-related combustion issues such as flash-back, burner overheating, flame detection and other performance parameters such as emissions and burner power. The experimental results indicate that the radiant heater is the most sensitive appliance for flashback, observed at 30 vol% hydrogen in natural gas. At 50% hydrogen, the range and the radiant burner of the barbeque tested were found to be sensitive to flashback. All other 9 appliances were found to be robust for flashback with no other short-term issues observed. This paper will detail the findings of ATCO and DNV's appliance testing program including results on failure mechanisms and sensitivities for each appliance.

1.0 BACKGROUND

Canada has a commitment to be net-zero by 2050. This, combined with ATCO's own Environmental, Social and Governance Goals (ES&G) has led ATCO to explore hydrogen and hydrogen blending within the existing natural gas system as a pathway to reduce CO_2 emissions and continue to provide safe, reliable energy service to customers. Blending into the distribution system allows for existing assets, including appliances, to be utilized thereby reducing the required investment to decarbonize the heating load in Alberta. ATCO's own Fort Saskatchewan Hydrogen Blending project began blending 5% hydrogen by volume to approximately 2,100 customers in the Fall of 2022 and plans to increase the blend rates to 20% hydrogen in 2023.

The combustion properties of hydrogen blends can differ from natural gases traditionally distributed, which may result in altered performance of end-use equipment [1-9]. ATCO is aiming to determine whether a mixture of hydrogen blended natural gas can be safely used to fuel existing natural gas appliances and end-use equipment. Towards this end, DNV performed an assessment and literature inventory to determine the impact of hydrogen addition on the safety and combustion performance of the different types of end-use equipment connected to ATCO Gas' network. To address the knowledge gaps identified in the assessment, 12 Canadian appliances were selected for further testing as there was either no information or conflicting information available regarding the effect of hydrogen blending on the appliance performance. ATCO utilized information gathered from a customer outreach campaign to ensure the selected appliances were reflective of what customers have in the Alberta market. Working together, ATCO and DNV selected the following appliances: a range/stove, oven, garage heater, high- and mid-efficiency furnace, conventional hot water heater, barbeque, on demand hot water heater, clothes dryer, radiant heater and two gas fireplaces.

In this paper, the test program and the test results are discussed for the selected appliances. The tests were performed not only within the planned blend rates of 0- 20 vol% hydrogen, but also extended to higher percentages of hydrogen up to the moment that malfunctioning occurred. The test program is designed to get insights in the safety related 'combustion' issues such as flash-back, burner overheating, functioning of the flame detector and other combustion performance parameters such as emissions (CO, H2 and NO_x) and changes on the burner power upon hydrogen addition.

2.0 EXPERIMENTAL APPLIANCE TYPES

12 representative domestic appliances were selected for the hydrogen blending tests. The appliance types are presented in Table 1. The combustion modes contain either fully premixed burner systems or partially premix systems. For fully premixed appliances, the air and natural gas are fully premixed before entering the burner head. The air is supplied via natural draft or via a fan placed upstream the burner (forced draft). For partially premixed appliances, the air and natural gas are partially premixed before entering the burner head and to complete the combustion, secondary air is supplied from outside via natural draft or a fan placed downstream the burner (induced draft). The combustion mode, air supply and burner type installed in the appliances are include in Table 1.

Table 1. Appliance types including combustion mode, air supply system and burner type installed.

Type	Combustion mode	Air supply	Burner
Gas fireplace 1	Partially premix	Natural draft	Log-set
Gas fireplace 2	Partially premix	Natural draft	Log-set
Cooktop	Partially premix	Natural draft	Ring
Stovetop	Partially premix	Natural draft	Ring
Oven	Partially premix	Natural draft	Tube burner
Garage heater	Partially premix	Induced draft	In-shot
High efficiency furnace	Partially premix	Induced draft	In-shot
Mid efficiency furnace	Partially premix	Induced draft	In-shot
Hot water heater	Partially premix	Natural draft	Pancake
BBQ	Partially premix	Natural draft	Tube-, and IR burner
On demand hot water heater	Fully premix	Forced draft	Premixed burner
Clothes Dryer	Partially premix	Induced draft	Spoon burner
Radiant heater	Fully premix	Natural draft	IR burner

3.0 MEASUREMENT PROGRAM

3.1 Gas mixing facility

The gas appliances presented in Table 1 were tested in the DNV combustion laboratory in Groningen, Netherlands. The gas mixing facility contains calibrated Bronkhorst mass flow meters and flow controllers (see Fig. 1). The gas flows are controlled by the flow controllers to ensure a constant hydrogen percentage is introduced into the fuel. The flow ranges of the mass flow meters were selected to provide an accuracy of better than 5%. All fuels used in this study were supplied in cylinders with purity better than 99.99%. The fuel blends from the gas blending station are supplied to the appliances at typical household natural gas pipeline pressure in Canada (0.25 psig). The mixed gas compositions set by the gas blending unit were checked by using an Agilent 3000 Gas Chromatograph (GC). This GC uses argon as carrier gas in order to detect hydrogen in natural gas accurately.

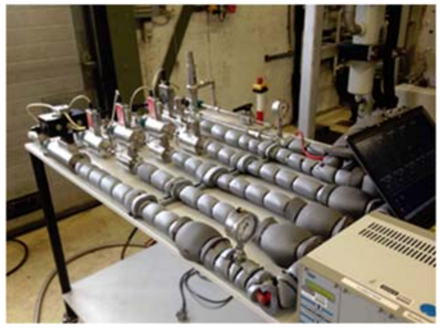

Figure 1. Gas blending equipment at DNV

3.2 Wobbe range selected for the appliance tests

During the experiments, H_2 was gradually added to CH_4 until malfunctioning of the equipment was observed. As illustrated in Figure 2, the Wobbe index will change upon hydrogen addition. The Wobbe index will decrease for hydrogen percentages up to 70-80 vol%. Since the thermal input to a gas appliance is directly proportional to the Wobbe index, the thermal input will also decrease as H_2 is added to CH_4. At H_2 percentages above 70-80 vol %, the Wobbe index begins to increase resulting in an increase in the thermal input.

Therefore, in this study two cases were studied. Case 1 is the variable Wobbe index case where hydrogen is added to methane resulting in a decrease in the Wobbe index as described above. At some point, the amount of H_2 added to CH_4 results in the Wobbe index value that is outside the historical Wobbe range (see Fig. 2). The second case is the constant Wobbe index case where hydrogen is added to a mixture of methane, ethane and propane while keeping the Wobbe index of the gas constant. While ATCO does not have contractual obligations to provide gas within a specified Wobbe range, the contractual Wobbe range of the TC Energy Mainline Tariff [10] is representative of the Wobbe range distributed to customers on the ATCO system and therefore in this study taken as an upper limit of 51.16 MJ/m^3 and as a lower limit of 47.23 MJ/m^3.

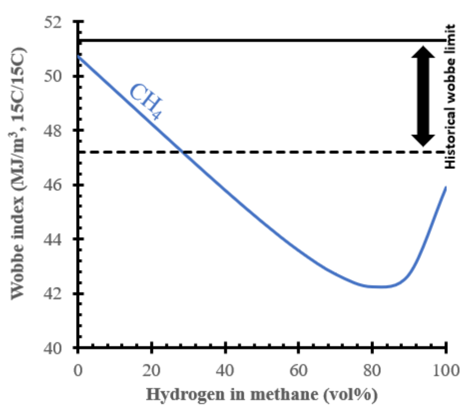

Figure 2. Effect hydrogen addition to natural gas on the Wobbe index. Historical Wobbe limits are indicated with solid (upper Wobbe limit) and dashed (lower Wobbe limit) lines.

The effect of both cases on the burning velocity is illustrated in Figure 3. For partially premixed appliances (φ>1), the effect of adding hydrogen to methane in the first case (variable Wobbe index, indicated with solid lines in Figure 3) is a shift towards stoichiometric (φ=1) conditions[1] resulting from a shift in the fuel-to-air ratio which causes an additional increase in the burning velocity as illustrated in Figure 2. In the second case, where the Wobbe index is kept constant, the change in burning velocity is smaller as compared to the variable Wobbe index case because there is no shift in fuel-to-air ratio. For partially premixed appliances, the lower end of the Wobbe index (47.23 MJ/m^3) is the worst-case scenario due to high burning velocities. For fully (lean) premixed appliances (φ<1, left hand side of Figure 3) the impact of adding hydrogen in the variable case is modest since hydrogen addition results in a shift further away from the stochiometric point resulting in lower burning velocities, while the effect of adding hydrogen in the constant Wobbe index case is much more pronounced. For fuel lean appliances the upper limit of the Wobbe index represents the highest burning velocity and is therefore considered as worst-case for appliance flashback and burner deck overheating.

The change in burning velocity is important since it affects the position of the flame with respect to the burner surface due to the balance between the fuel/air mixture leaving the burner. When the burning velocity is increased (and the fuel/air flow leaving the burner remains unchanged) the flame moves closer to the burner surface resulting in an increase in the heat transfer to the burner (higher burner temperature) (see right side of Fig. 3). This increase in burner temperature may lead to overheating that may cause damage to the deck and a shorter life span of the appliance. If the burning velocity is increased even further, the flame can crawl into the burner until the flame is extinguished (flashback), releasing the unburned gas/air mixture into the surroundings. The burning velocity is therefore an important aspect when determining the impact of hydrogen on end use appliances.

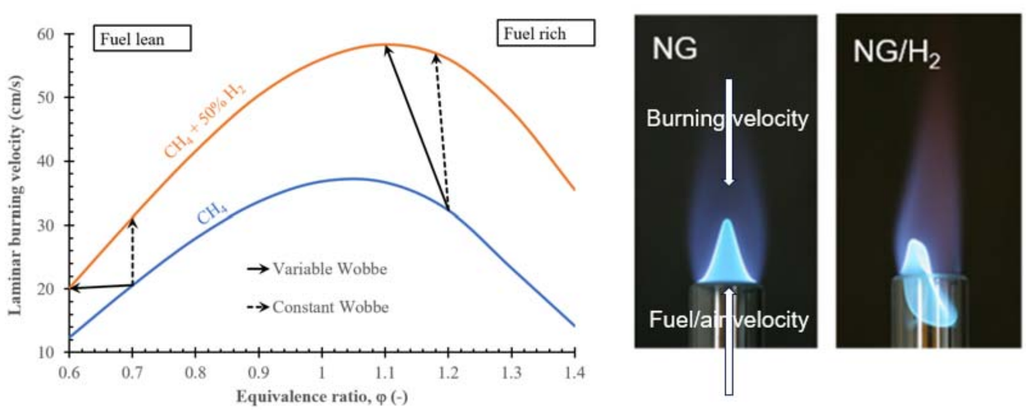

Figure 3. Illustration of effect of hydrogen addition to methane, including the shift in equivalence ratio caused by hydrogen addition.

[1] A mixture is said to be stochiometric (φ=1) when fuel and oxidizer consume each other completely. If there is an excess of fuel the mixture is called fuel rich (φ>1) and where there is an excess oxygen the mixture is called fuel lean (φ<1)

3.3 Test procedure

The performance of the appliances was tested by adding hydrogen to either methane (variable Wobbe case) or pseudo natural gas consisting of methane/ethane/propane (constant Wobbe case). All experiments were performed after 10-15 minutes of stable operation and after which the H_2 percentage was gradually increased. Under these conditions, blends containing 5, 10, 20, 30, 40, 50, 60, or 70 vol% hydrogen was used until malfunctioning of the equipment was observed. Furthermore, the performance of the appliances was also studied while abruptly changing the hydrogen content in natural gas, for example, by abruptly changing the hydrogen percentage from 0 vol% to 50 vol% hydrogen and from 50 vol% to 0 vol% hydrogen. Cold start and hot reignition with a high percentage hydrogen have also been performed and, if relevant for the appliance, tests were performed at low and high thermal load. During the cold start and hot reignition experiments, the tests were always performed with a parallel burner in operation connected to the same fuel supply line as the appliances studied to guarantee that the fuel in supply line is flowing (refreshed) and that the correct blend is used during the experiments. Additional tests were performed for the range cooktop burner such as rapid turn down and the effect of the presence of a pan on top of the cooktop burner.

To examine if the addition of hydrogen leads to burner deck overheating, several thermocouples were placed at multiple positions on burner deck and (if present) the pilot burner. As an example, Figure 4 shows the position of the thermocouples on a pancake and pilot burner of the conventional hot water heater. Experiments using burners with and without thermocouples confirmed that the test results were not influenced by the presence of the thermocouples.

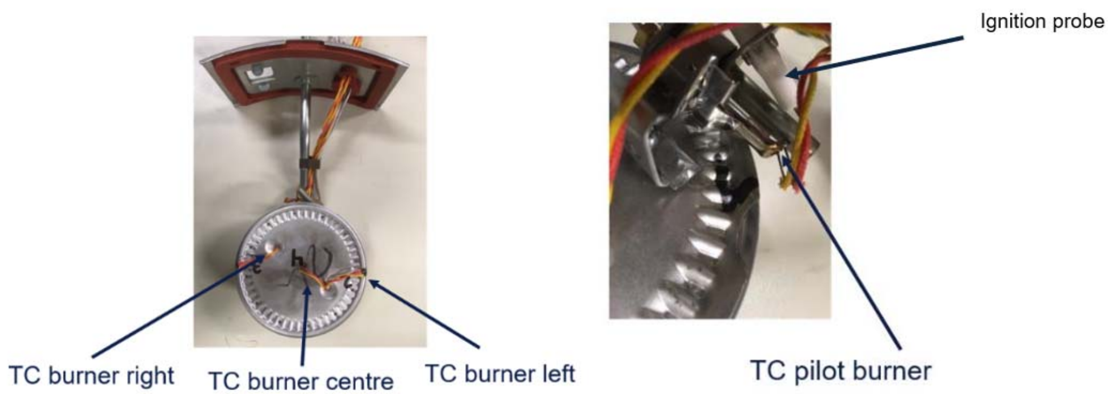

Figure 4. Pancake burner with three thermocouples.

Furthermore, calibrated gas analysers are used to measure the effect of hydrogen addition on the oxygen content and H_2, CO and NO_X emissions in the flue gas. The impact of hydrogen addition on the flame safeguarding systems is also monitored in this study. Additionally, visual changes in flame structure (e.g., size, stability, and so on) upon hydrogen addition were monitored using a camera. The addition of hydrogen may cause the flames in gas fireplaces to become less yellow/orange due to reduced soot formation resulting in a reduction in flame radiation. For this reason, radiation flux measurements were performed to investigate the effect of hydrogen addition on flame behaviour of gas fireplaces.

4.0 RESULTS

Below a summary of the results are presented where the impact of hydrogen blending is divided into safety performance related issues such as 1) flashback, 2) burner overheating and 3) emissions.

Furthermore, the impact of hydrogen blending on performance issues that are not safety related such as 4) flame detection and 5) thermal input are discussed.

4.1 Flashback

As discussed in Section 3.2, one of the risks of hydrogen addition is the occurrence of flash-back. The experimental results indicated that the radiant heater was the most sensitive appliance for flashback, which was observed at 30 vol% hydrogen for the constant Wobbe case. Up to 25 vol% H_2, no flashback was observed, and the burner deck temperature, radiation and thermal input remained the same upon hydrogen addition. However, upon increasing the hydrogen content to 30 vol% flashback was observed after 15 minutes of operation. For the cooktop range flashback was observed at 50 vol% hydrogen during rapid turndown and flashback during cold start occurred for the radiant heater of the barbeque at 50 vol% hydrogen blending. No flashback issues were observed at 40 vol% hydrogen. For the radiant heater and the BBQ infrared burner, flashback resulted in combustion inside the venturi mixing tube as shown in Figure 6. Consequently, the temperature of the venturi mixing tube (and fuel injector) increases exponentially as shown in Figure 6 which will damage the equipment. All other 9 appliances were found to be robust for flashback within the safety margin range of 0-50 vol% hydrogen.

From literature, it was found that the hot water heater and the oven are more sensitive towards flashback upon hydrogen addition. In [9] flashback was observed during ignition of an oven with a tube burner when 25 vol% hydrogen was present in natural gas. In contrast, in this study, flashback was observed at 70 vol% hydrogen when igniting the tube burner of the oven. The same authors studied the effect of hydrogen addition to natural gas for a storage tank hot water heater with a pancake burner. In [2] they observed at 10 vol% H_2, during relight of the main burner, a deflagration-like event after water was drawn for the same type of storage tank hot water heater. These effects were not observed below 10 vol% hydrogen. Interestingly, the authors observe an extreme shift in the equivalence ratio upon hydrogen addition from $\varphi=0.85$ to $\varphi=0.675$ when only 5 vol% hydrogen is present in natural gas. Based on theoretical calculations and experimental findings, an equivalence shift is expected of only $\varphi=0.85$ to $\varphi=0.82$ which might indicate to the occurrence of abnormalities in the test set-up or test procedure. In this study, flashback was observed for a storage tank hot water heater at about 70 vol% hydrogen in methane and pseudo natural gas. This result agrees with tests performed in [5] where no flashback issues were observed within the tested range of hydrogen blends between 0-30 vol% hydrogen.

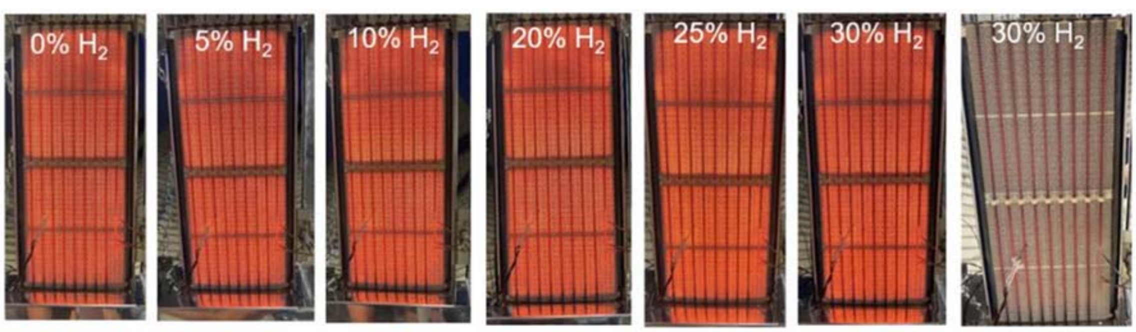

Figure 5. Images of the burner surface for different hydrogen percentages in methane for the radiant heater.

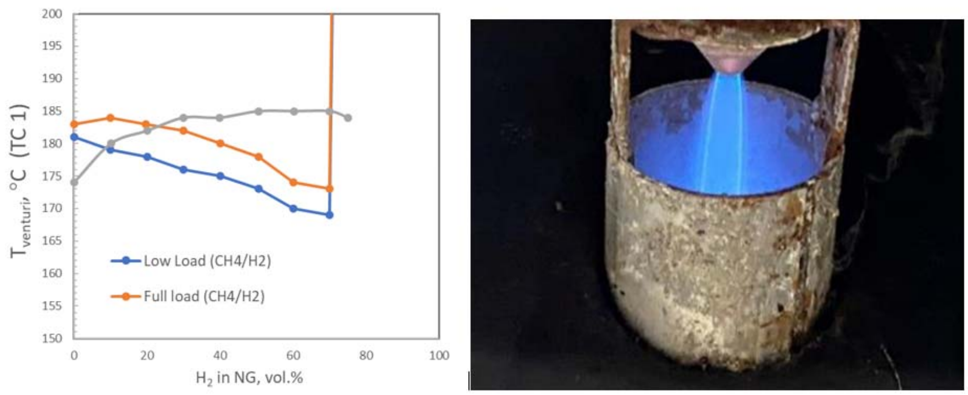

Figure 6. Temperatures measured at the venturi of the IR burner of the BBQ (left) and combustion in the venturi of the IR burner of the BBQ (right)

4.2 Effect hydrogen blending on burner deck temperature

The results obtained in this study for the 12 appliances studied showed that for both cases, increasing the hydrogen content in natural gas results in stronger stabilization of the flame on the burner deck. This effect becomes generally visible in the flame at hydrogen blends above 20 vol%. As an example, changes in flame shape upon hydrogen addition are shown in Figure 7 (left) for the cooktop studied. The results showed that the primary flames (bright inner flame cones) became shorter when the hydrogen percentage increased in natural gas. The shorter flames are direct result of the increase in the burning velocity resulting in stronger flame stabilization on the burner ports (see also Fig. 3). The stronger stabilization of the flame results in an increase in the burner deck temperature as can be seen in Figure 7 (right) where the temperatures are measured at different positions of the burner deck. As can be seen from Figure 7 (right), the increase in temperature was marginal up to 20-30 vol% hydrogen. The highest burner plate temperature and temperature increase was observed for the thermocouple on top of the burner deck near the fuel port (T3). When increasing the hydrogen percentage from 0 to 20 vol% the temperature of T3 increased by 0.5 %; a further increase to 30 vol% resulted in burner deck temperature increase of 2.5%. The temperature (T1) measured directly below the surface of the burner plate showed the lowest temperature but the highest increase upon hydrogen addition; from 0-20 vol % increases the temperature increased by 3.2% and at 30 vol%, a 6.3% temperature increase was observed.

To indicate if long term issues are to be expected due to the increase in burner deck temperature, the assumption is made that a temperature increase below 5% (based on the Kelvin scale) does not have a significant long-term impact. This rough estimate of 5% is based on the assumption that many appliances also operate on propane which typically increase the burner deck temperature by 5% (rule of thumb) compared to natural gas. Increasing the temperature above 5% may cause higher thermal stress and can ultimately result in damage (e.g., crack formation) within the lifetime of the burner. Interviews with manufacturers revealed that the long-term effects for hydrogen blends are, at present, unknown and more research is needed to address these effects on appliance integrity.

For all appliances studied, the increase of the burner deck temperature was lower than 5% for hydrogen blends between 0-20 vol% hydrogen and therefore no long-term issues of the burners are expected. Increasing the hydrogen percentage above 20 vol% increased the burner deck temperature above the defined 5% temperature increase for the cookers, high efficiency furnace, storage tank hot water heater and the clothes dryer. In contrast to the results found in this study for the oven, [9] reported that hydrogen blending results in a substantial increase in the measured burner deck temperature. For example, the presence of 10 vol% hydrogen an increase in the temperature from 169 °C to 275 °C was observed [9]. On the other hand, hydrogen blending tests up 30 vol% hydrogen in natural gas performed in [5] show similar trend in the burner deck temperature upon hydrogen addition as found in this study.

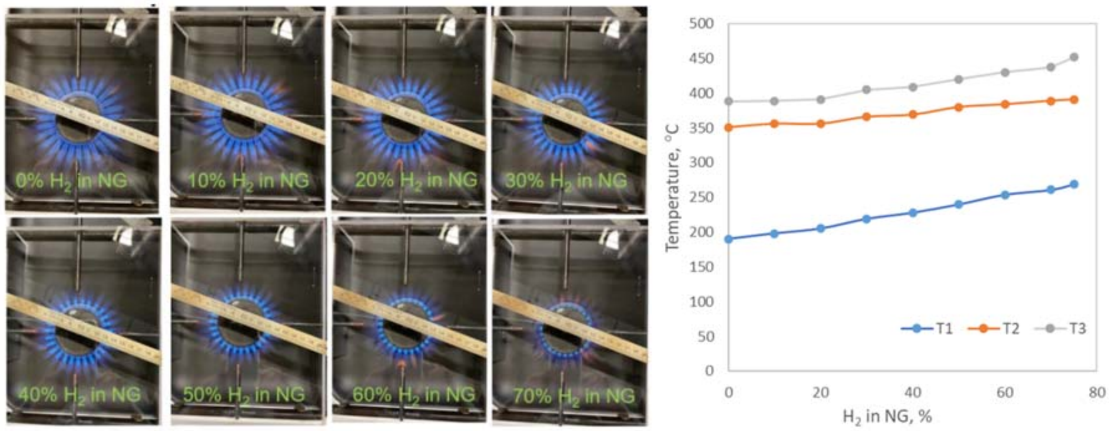

Figure 7. Effects of hydrogen addition to natural gas on the visual flame length (a) and burner plate temperature (b) for the cooktop. T1 presents the temperature reading below the burner deck, while T2 (centre) and T3 (near fuel port) presents the temperature measurement at the top of the burner deck.

4.3 Effect hydrogen blending on flame detector and ignitor

In the appliances studied several components are present such as flame detectors and ignitors. In the appliances selected, thermopiles or ionization probes are used as flame detectors. An ionization probe measures flame ions in the flame. When the measured ionization signal is zero, no flame is detected, and the safeguarding system shuts down the fuel valve automatically (fail safe). It is well known that hydrogen does not produce any ions in the flame zone. A thermopile generates a voltage signal (thermoelectric effect) when it heats up by the flame. When the thermopile system generates no voltage signal (no flame), the fuel valve will close automatically as a safety measure.

During the experiments, the thermopile and ionization signal were measured in both cases to study the impact of hydrogen addition on this flame detection system. Furthermore, the changes in the components present in the flame were visually studied with flame images taken during the experiment. As an example, Figure 8 shows that the ionization probe located in the mid efficiency furnace started to glow more brightly at 20 vol% hydrogen in the gas. Increasing to 30 vol% hydrogen resulted in an even brighter glow of the ionization probe which indicates a strong increase in the temperature of the probe as a result of the shift of the hot zone of the flame being closer to the burner deck and the position of the probe. The increase in temperature of the flame ignitor and ionization probe may result in deterioration of the lifetime of the probes. From all appliances studied, the mid efficiency furnace showed the largest sensitivity to hydrogen blending with regard to the observed visual changes in the colour of the probe. For all other appliances, no significant changes were observed. However, for hydrogen percentage between 20-30 vol% the ionization probe of the garage heater, high efficiency furnace and gas fireplace 1, and the thermopile of hot water storage tank also started to glow more brightly. It is recommended to study the long-term effect of hydrogen blending on the lifetime of these components present in the appliances to gain a better understanding of the impacts of hydrogen addition.

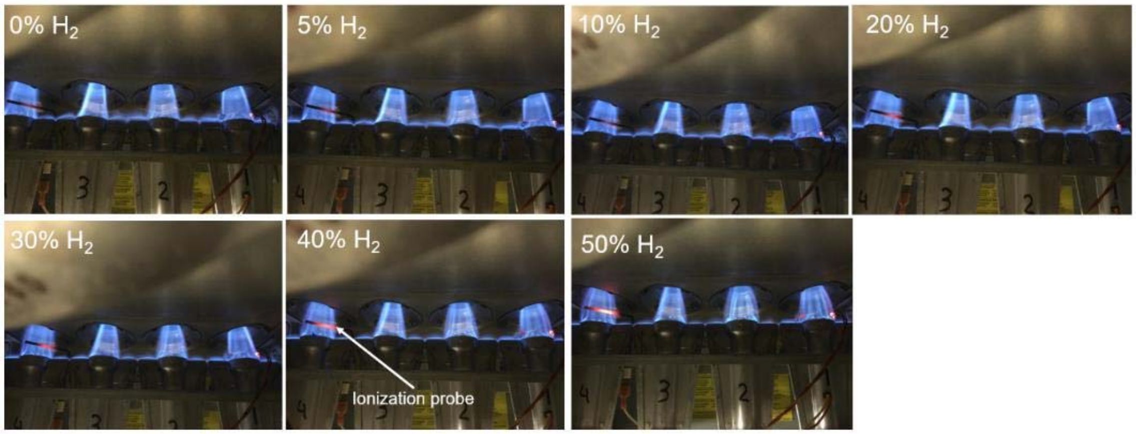

Figure 8. Effect of hydrogen blending to methane on changes in the flame structure and temperature of the ionization probe.

Although the temperature of the ionization probe increases upon hydrogen addition for the mid-efficiency furnace, no impact was observed on the measured ionization signal as shown in Figure 9 (left). With the exception of the on demand hot water heater and gas fireplace 1, no significant decrease in the ionization signal was observed between 0-30 vol % hydrogen in natural gas for the studied appliances. Figure 9 (right) shows an example of the measured ionization signal of the on demand hot water heater. Although a decrease in the ionization signal was observed the ionization signal stayed above the threshold value for all hydrogen blends studied, as was the case with the gas fireplace.

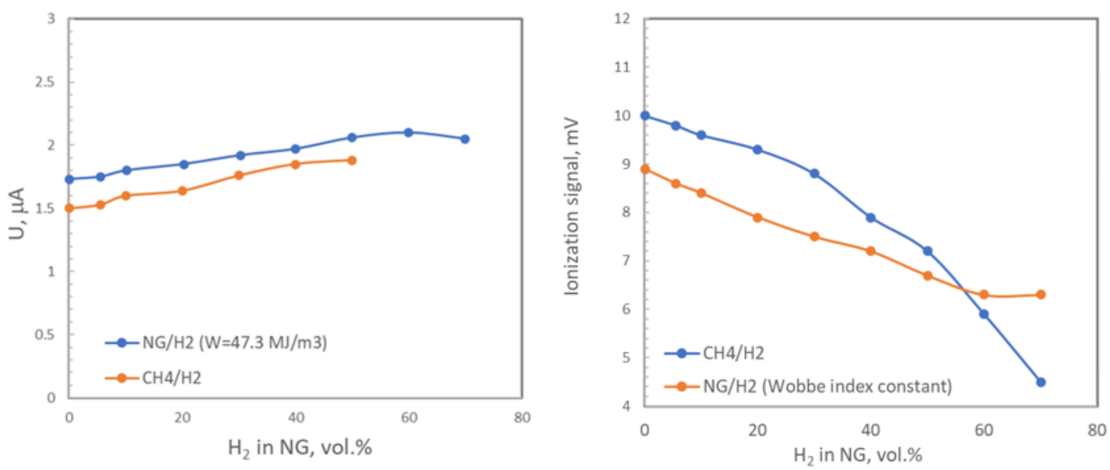

Figure 9. Measured flame detector signal for different hydrogen percentages in methane and natural gas for the mid-efficiency furnace (left) and the on demand-hot water heater (Right).

4.4 Effect hydrogen blending on emissions

For all appliances, with the exception of the cooktops due to difficulties gathering data, the CO and NO_x emissions were measured during the tests. The CO emissions measured during the experiments either remained constant or decreased upon hydrogen addition for all appliances studied. As an example, the CO emission measured in the flue of the high efficiency furnace is presented in Figure 10 (left). The measured NO_x emissions for the gas fire 1 and the conventional on demand hot water heater were found to increase (slightly) upon hydrogen addition; 5% and 10% at 30 vol% hydrogen, respectively. For the other appliances tested, the NO_x emission remained the same or was reduced upon hydrogen addition as illustrated in Figure 10 (right) for the high efficiency furnace. The NO_x emission is calculated back to oxygen free condition based on the measured oxygen concentration in the flue gas via equation 1.

$$NO_x, ppm\ (oxygen\ free) = NO_{x,abs,ppm} \frac{20.95}{20.95 - O_{2,abs,\%}} \quad (1)$$

A similar procedure was followed for the measured CO emissions.

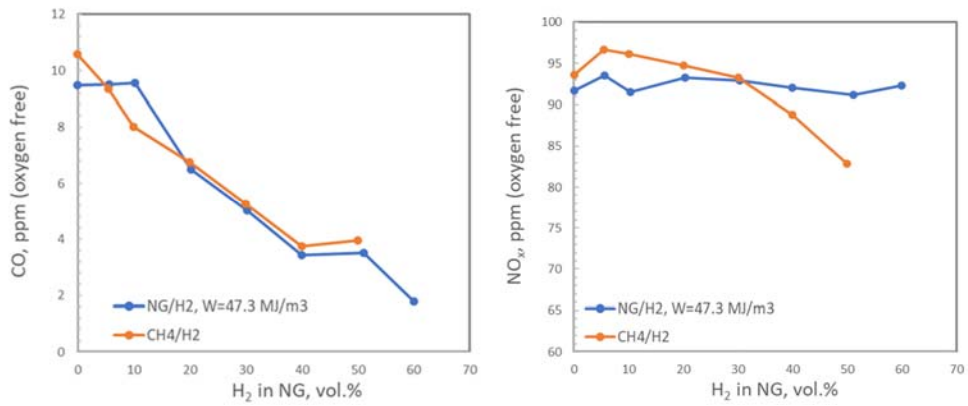

Figure 10. Effect of hydrogen blending to methane and natural on the CO emission (left) on the NO_x emission (right) in the flue gas for the high efficiency furnace .

ATCO and DNV will be studying the CO and NO_x emissions for cooktops in a separate scope of work.

4.5 Effect of hydrogen blending on other combustion performances.

As described above, upon hydrogen addition the Wobbe index (and hence thermal input) decreases. Consequently, the oxygen concentration in the flue gas (excess air) increased linearly as illustrated for the gas fireplace in Figure 11 (right). For the Wobbe constant case (47.2 MJ/m^3) the thermal input and oxygen concentration is expected to remain constant based on theory. However, a slight decrease in the thermal input and increase in oxygen concentration is observed. The deviation from ideal behaviour depends strongly upon the appliance selected, but in general the decrease in thermal input observed was slightly larger than expected based on the calculated change in the Wobbe index.

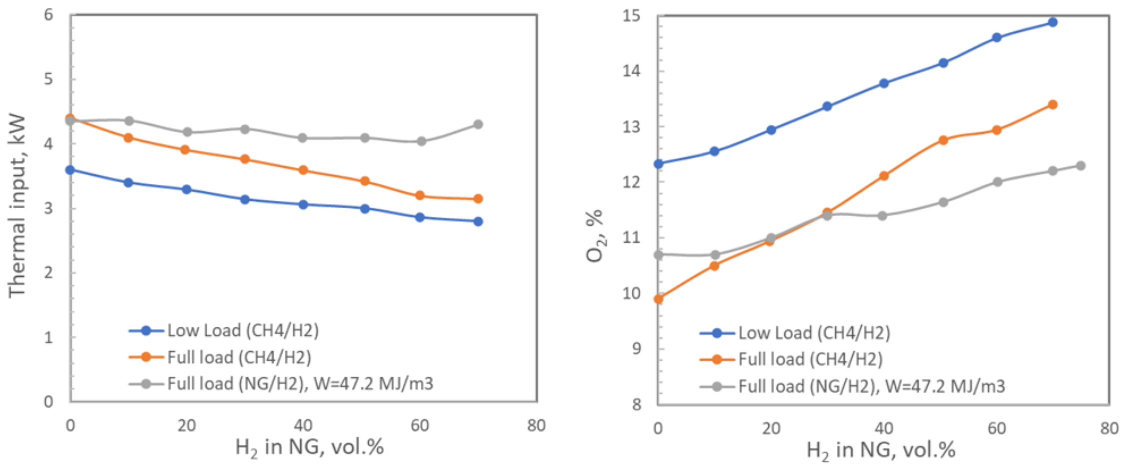

Figure 11. Changes in thermal input and oxygen concentration in the flue gas upon hydrogen addition for gas fireplace 1.

The measurements presented in Figure 12 show that the radiation flux decreased when adding hydrogen to methane (variable Wobbe index case). This can be explained by the decrease in 1) Wobbe index and thus decrease in thermal input to the burner and 2) the reduction in soot formation (produces radiation) as a result of lowering the C/H ratio and the increase in the oxygen percentage available for (complete) combustion. In contrast, the measurements at a constant Wobbe index show that the radiation flux is constant up to about 40 vol% hydrogen as a consequence of the constant heat input and minor changes in the availability of combustion air. Above about 40 vol% hydrogen a slight decrease in heat flux is observed.

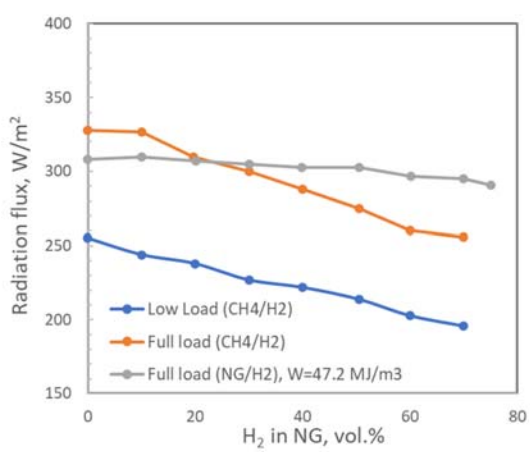

Figure 12. Measured changes in radiation flux and ionization signal upon hydrogen addition for gas fireplace 1.

5.0 CONCLUSIONS

The experimental results indicate that the radiant heater is the most sensitive appliance for flashback, which was observed at 30 vol% hydrogen. However, no performance issues were observed between 0-25 vol% for all appliances studied. Between 0-40 vol% hydrogen, the stove top and the radiant heater of the barbeque were found not to be sensitive to flashback; both appliances showed flashback at 50 vol% hydrogen. All other 9 appliances were found to be robust for flashback within the safety margin range of 0-50 vol% hydrogen. Furthermore, no other short-term issues were observed for these 9 appliances which means that between 0-50 vol% hydrogen no negative performance of the studied appliances was observed including no pollutant emission increase and proper functioning of the flame guarding safety system (flame detector).

CO emissions measured during the experiments either remained constant or decreased upon hydrogen addition for all appliances studied. The measured NO_x emissions for the gas fire 1 and the conventional on demand hot water heater were found to increase (slightly) upon hydrogen addition; 5% and 10% increase at 30 vol% hydrogen, respectively. For the other appliances tested, the NO_x emission remained the same or was reduced between 0-30 vol% hydrogen addition. For example, for the oven the NO_x reduction at 30 vol% hydrogen in methane was about 30 %.

When increasing the hydrogen content above 20 vol% hydrogen the burner deck temperature increases for some of the appliances by more than 5%. Therefore, from the experimental results DNV concludes that between 0-20 vol% hydrogen in natural gas, no safety issues are expected for the studied appliances.

To further build on these results and to address the identified knowledge gaps such as the effects of hydrogen blending on the performance of home backup generators and appliance types not yet tested, as well as the long-term effects when appliances are fuelled with hydrogen blends such as impacts to the flame ignitor, flame detection system and burner deck temperatures, ATCO is participating in a Joint Industry Project initiated by DNV. The insights gained in this study combined with the information obtained in the JIP will provide a basis to further hydrogen blending and hydrogen related standard development in Canada.

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