Test set-up Hydrogen Dispersion in a Meter Cabinet (DNV GL, report OGNL-19-074)

Over the past 45 years, only natural gas has been supplied to the domestic gas market. Biomethane has also been added in recent years. The main components of natural gas and biomethane are the same and there was no need for a further study into possible gas leaks in meter cabinets. In the near future, hydrogen may also be added to natural gas or natural gas may even be completely replaced by hydrogen.
Hydrogen is only present at ppm level in some natural gases. Hydrogen is a very small molecule with a very low density: the density of natural gas is about 0.833 $kg/m^3(n)$, that of hydrogen is 0.09 $kg/m^3(n)$. For the integration of hydrogen in the gas network, it is important to know how the gas will disperse in the event of a leak in the meter cabinet and how high the gas concentrations can increase at different leakage rates.

A test set-up has been realized to understand dispersion of hydrogen in meter cabinets. The range of outflow rates is based on NEN7244-7 (Tests) for natural gas where leaks of up to 5 l/h are still permitted for certain network sections. The outflow rates of 10, 20 and 25 l/h represent inadmissible leakage rates but are designed to simulate a worst-case scenario. The experiments were carried out with ventilated and non-closed meter cabinets.

The measurements were carried out with gas detection sensors, which work on the basis of diffusion. Other sensors could not be used because they suck in gas and thus affect the outflow profile. The sensors are placed at a height of 50, 120, 180, 220 cm from the bottom of the cabinet. The measurements showed a relative dispersion of about 15%, which -considering the accuracy of the sensors- is more than acceptable.

The tests with the open ventilation grids show a trend that can be expected. With increasing leakage rates, the gas concentration in the cabinet increases proportionally. The gas concentration will eventually level off to around 2 vol%, for both natural gas and hydrogen. Since hydrogen is much lighter than natural gas, it was to be expected that hydrogen would rise faster, causing it to disperse faster through the upper ventilation grid. However, the tests have shown that the hydrogen concentration is comparable to the natural gas concentration at the same leakage rates.

The experiments with the closed meter cabinet show a clear trend. The sensors at 120, 180 and 220 cm show an increased gas concentration as the leakage rate rises. The hydrogen and methane concentrations are in the same order of magnitude with less variation (almost straight lines) and show no sine waves in the measurement results. The tests with the masked-off grids show a higher gas concentration, but the measured value for both gas types remains below the lower explosion limits (approx. 4 vol%).

For some tests with open ventilation grids, a kind of sine wave can be seen in the measured gas concentrations for both natural gas and hydrogen. This phenomenon cannot be explained by changes in the test setup. The meter cabinet is located indoors in a room that is not sensitive to the outside temperature. The temperature variation in the room where the meter cabinet is installed is 20±2 °C. Ventilation is present in the room but it operates continuously at low power.
One explanation could be that there is first an accumulation of gas in the cabinet, which creates extra ventilation (chimney effect) and lowers the gas concentration. If the gas concentration decreases, the extra ventilation also decreases and, after a certain period of time a stable equilibrium is re-established. If gas is then fed into the meter cabinet for a longer period of time, the gas concentration rises again. After a certain period of time, the extra ventilation increases again and this process repeats itself. This could explain the sine wave of the gas concentration in the meter cabinet. The pull of the chimney effect is less with cold air (flue gases) than with warm air (flue gases). Hot gas is lighter and rises faster. This is comparable to the difference in density between hydrogen and natural gas.

DNV GL Netherlands B.V. Energieweg 17, 9743 AN Groningen Postbus 2029, 9704 CA Groningen
Tel +31 (0)6 1528 9995 contact.gcs@dnvgl.com www.dnvgl.com Handelsregister Arnhem 09006404

To support this theory, it is recommended to perform additional tests with sensors on the outside of the cabinet, near the upper ventilation grid. This sensor should show a raised gas concentration during extra ventilation. A second theory is that there is a kind of vortex of the gases in the meter cabinet that causes these sine waves.

The above are no more than theories and should be investigated in a follow-up study, in which the gas is made visible by, for example, adding smoke and recording the gas flows with a high-speed camera.

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