Management summary on sectioning hydrogen grids

Experts from the Dutch DSOs and Kiwa have considered how to temporarily block parts of a low-pressure hydrogen distribution grid, as requested by Netbeheer Nederland. This discussion was scoped to temporal blocking of low-pressure pipes, for the purposes of maintenance and emergency response.

The goal was to determine whether the current practice of sectioning natural gas distribution grids is also applicable for grids distributing hydrogen, or if there is a need for any additional research. Firstly, the risks of sectioning itself were considered. Secondly, the added value of sectioning in risk mitigation in emergency response was discussed.

Current field-knowledge, including national statistics on incidents and incident-investigation (period 2013-2018) on sectioning in natural gas grids, were taken as the starting point. Any incidents involving pipes made from cast iron or asbestos cement were ruled out, as these materials will not be used for any hydrogen distribution grid. Application of this on hydrogen was done with the knowledge of experts on hydrogen behavior and how it differs from natural gas.

Sectioning hydrogen distribution grids can be safely done

The consulted experts believe that sectioning a low-pressure hydrogen grid can be done as safely as is common practice for natural gas grids. This is both the case for scheduled maintenance and emergencies. It is believed that the current closing techniques (inflatable stoppers, squeezing off, closing of valves) will lead to a sufficient degree of closure of the pipes involved. Follow-up research with practical tests are to be done to confirm this. During this research a topic of discussion should be defining what a "sufficient degree of closure" is. Furthermore, it should be investigated if these temporal closing techniques can withstand a shock wave, explosion or sudden buildup of pressure due to ignition of a hydrogen mixture in the pipe.

Part of sectioning during scheduled maintenance is creating a gas-free pipe. The expert group advises the purging of hydrogen grids with nitrogen to make a pipe gas-free; this is further explained in the reports "Purging of hydrogen pipes" [1] and "Flaring and venting of hydrogen" [2], unless practical research shows that purging with nitrogen is unnecessary.

Purging with nitrogen is done to make sure that a flammable mixture can never occur within the pipe, thereby ruling out any potential ignition.

Additional measure may be necessary to respond to emergencies

Sectioning is also done in order to combat and solve emergencies. The (quick) closure of gas supply lowers the risks that come with emergencies. The consulted experts discussed whether the current closure techniques are sufficient and properly fast during an emergency. More specifically, large leakages resulting from activities near a pipe were considered. With these leakages, they will be quickly noted and the speed of application of a closure technique has a direct link to lowering the risk of a further emergency. The experts suspect that hydrogen leakages of this size pose a more profound risk as compared to natural gas.

Firstly, under the same circumstances, the chance of ignition is higher. This is because:

- the lower and higher flammability levels for hydrogen are much wider as compared to natural gas;
- the amount of leaking hydrogen is much larger as compared to natural gas;
- the gas plume is bigger, resulting in a potential ignition further away from the point of leakage.

Secondly, within the gas plume closely to the leakages, hydrogen concentration are likely to occur that could ignite with lower ignition energy as compared to natural gas. On top of that, it is believed that the results of an explosion will be more severe. An explosion as a result of hydrogen leakage in open air is very unlikely with a leakage in an open work excavation, however years of experience with natural gas grids show that, under certain circumstances, these leakages can accumulate through the soil into a confined space and explode. In The Netherlands this happened 4 times during 2013-2018 with natural gas. Hydrogen could result in more damage, due to the increased burning rate and pressure build up.

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In practice, most of the time, a fire is the only result. Hydrogen leakages may lead to a fire more often, because of the increased chances of ignition. Damage resulting from a hydrogen fire is expected to be less due to lower radiant heat. At the same time, a hydrogen-fire is less likely to be noticed as it is practically colorless.

The experts reviewed if it is possible to decrease closure time of a pipe during an emergency to further lower the risks of a fire and/or explosion. With natural gas, any ignition of leaking gas resulting from excavation damage (these cause the highest degree of leakages in the distribution grid) mostly immediately ignites. Therefore it is believed that other closure techniques are of limited added value. Only automatic closing mechanisms may help to lower the risks of a fire or explosion resulting from a hydrogen leakage. It is to be proven if this is a feasible option for distribution grids.

It seems more realistic to take measures aimed at reducing the chances of a leakage in densely populated areas, such as obligatory supervision during excavation near hydrogen-pipes, rather than attempting to mitigate the consequences of leakage.

Given the arguments above, the expert group believe the current closure techniques are safely applicable to low pressure hydrogen grids, both for scheduled maintenance and during calamities. Development of new/better closure techniques is welcomed, but not deemed necessary. Finally, the findings above should be substantiated with practical experiments.

References

[1] A. Kooiman, C. Lock and C. Pulles, "Purging of hydrogen pipes," Kiwa Technology, Apeldoorn, 2021.

[2] C. Pulles, J. d. Laat and C. Lock, "Flaring and venting of hydrogen. Research into safely and effective putting hydrogen pipes in and out of operation," Netbeheer Nederland, 2021.