Keeping up with Hydrogen (2) – Back and forwards with Fugitive Emissions

In the first paper of this series we introduced the idea to use forming gas as an alternative method for Fugitive Emissions Testing. The idea that existing industry standards and conventional testing methods are sustainable enough to keep up with the shift to a Hydrogen industry is unrealistic. Or at least; That is our belief.

Looking at the future, we expect to see a major increase in production of hydrogen plants to allow storage and transport of energy throughout the world. Even though the go-to-technology is still open for debate, we can already see that projects are being launched for liquid hydrogen and ammonia as energy carrier. Both are potentially great solutions, and looking at Fugitive Emission (FE), they have one thing in common; FE Testing is very much a relevant topic. Hydrogen is not a new subject, and testing for Hydrogen leaks isn't either. But keep in mind that the scale at which it will be performed will increase drastically.

Looking back, we can see that FE testing has matured already in the form of industry standards. All of which are based on testing using either Helium or Methane. One of the primary examples, used on the European Continent, is ISO 15848. This standard describes Fugitive Emissions as unanticipated or spurious chemical leaks from equipment at an industrial site. These emissions may be a combination of safety risks, product and economic losses and a negative contribution to air pollution and climate change. All of these elements play a role for Hydrogen valves as well, so, intuitively, we would argue that ISO 15848 can be applied as well. The question is though; Should we?

There are a few major arguments as to why Hydrogen valves should require a different approach, and it starts with the practicality of standards. A big factor is the medium used for testing. Either Helium or Methane. Both are suitable as a tracer gas, but with consequential disadvantages. Helium has a small molecule size, is inert, non-flammable, and does not negatively affect the environment. However, the source of Helium is limited, making availability and price a huge limitation for large scale use. These factor weigh even more if we take into account that the only significant source of Helium is unlikely to grow in the coming years; Oil and Gas production. Now looking at Methane, we see that it is commonly available at a much lower price and is considered to be closer to operating conditions for a conventional valve in critical service. However, the negative element is it's characteristic of being hazardous, flammable and a direct greenhouse gas. It means that handling is much more complicated compared to Helium.

It is our opinion that Hydrogen as a tracer has at least the same potential as a solution, fewer disadvantages, a fraction of the costs and is much closer to the actual operating conditions. Especially the aspect of costs is incredibly important to give the industry a fair chance of keeping production costs reasonable without compromising on quality and integrity. In that perspective, Helium and Methane are immediately disqualified because of high cost. This argumentation becomes particularly important if we keep in mind that the conventional method of testing only in batches may not suffice for a Hydrogen valve. We believe that each Hydrogen valve should be tested for Fugitive Emission, for the sake of safety, integrity and the environment.

Our ideas may seem excessive, but if we consider the scale, different projects and potential hazards it should be a minimal requirement. Let's look back at the early days of Hydrogen at NASA, and in particular the 'Broom Test'. The Broom Test was a method to find Hydrogen leakages using a straw broom. An 'inspector' would walk past the installation with his broom and would find a leakage whenever his broom would burst into flames. Great anecdote to look back at simpler times, but unimaginable if the installation is in a residential area. Especially considering that we would allow nearly invisible flame to occur over an extremely flammable substance. The essence of the industries quality claim must be evidence and prevention. That's why we believe batch testing should not be considered as sufficient.

To be clear on the technical solution for both conventional and hydrogen FE testing; Hydrogen in a diluted form would be used as the test gas, where the hydrogen concentration will act as the tracer and a hydrogen sensor is used to measure leakages without the need for a vacuum. Such gasses are commonly available in the market as welding gasses used for stainless steel welding. Perhaps the best example is forming gas, which consists of 95% Nitrogen and 5% hydrogen. This combination is stable, not flammable and costs are only a fraction compared to Helium. Technical properties of forming gas are actually safe guarded by ISO 10156, which proves the maturity and stability of the gas on the market.

In order to compare the technical capabilities we refer back to ISO 15848. After all, this is the baseline in the industry today. In that standard we have to differentiate between leakage classes A and B and C. ISO 15848 clearly mentions that Class A is measured using a vacuum method, whereas classes B and C are measured using an atmospheric sniffer method. Interestingly enough, regardless of the contents of the standard, we know that the methodology is often not considered to be practical. Complementing standards even deviate from the ISO. Perhaps the most interesting example is allowing the bagging method as an alternative to testing in a vacuum chamber.

Obviously there are a lot of factors to keep in mind during FE testing, but we can draw some short conclusions based on the technical capability of measuring equipment for Helium and Forming gas: Allowable leak rates for class A and B are respectively 1.78*10^-7 mbarl/s and 1.78*10^-6 mbarl/s, whereas mass spectrometers and hydrogen sensors can measure respectively 1*10^-7 mbarl/s and 5*10^-7 mbarl/s in atmospheric sniffer modes.

Based on our experiences and the facts above we draw a conclusion that forming gas as a test medium is viable alternative for Helium. The only significant question would be to determine a practical conversion factor between 100% Helium and forming gas, as we know that the substances might leak at a slightly different rate. A fundamental subject, with a potentially big impact, which will be the headline of one of our upcoming whitepapers.

For now, we see that there is huge potential for this technology in the valve industry, which has already matured as a technology for the same purpose in a number of other industries; where testing of aviation fuel tanks is a great example of a critical application; whereas leak testing of food packaging show the high speed and accuracy capability in production environments. Interestingly, the first of both examples has led to conclusive research that short term injection of low concentration hydrogen do not lead to embrittlement or other negative effects on the structure of fuel tanks. However, the effect should be taken into account in the design of a specific FE testing solution. A factor in that respect is that hydrogen embrittlement only occurs at modified temperatures and high materials strains, but do note that it is 100% reversible. This suggests that testing procedures for any valve for hydrogen service could fundamentally differ from its counterpart for chemical service. Use of hydrogen during production testing should therefore provide an extra layer of guarantee that embrittlement has not been induced during the production process of the valve.

Looking at the conditions of ISO 15848 it should be taken into account that the combination of Nitrogen and Hydrogen in forming gas is not suitable for conventional cryogenic testing in the valve industry. The Nitrogen component of the gas would liquefy at -196 Degrees Celsius when cooling using Liquid Nitrogen. In those cases, it should be considered to use alternate gasses such as Helium or to evaluate alternate gas combinations with up to 5% hydrogen.

We conclude that the number of valves tested for fugitive emissions will grow exponentially in the near future. The main growth will be for hydrogen service, whether it is directly for hydrogen or indirectly in chemical forms like ammonia. To achieve the fundamental purpose of minimizing global warming, it is vital that the industry can guarantee that such valves are leak tight to the environment. This can only be achieved if production requirements and corresponding technology is developed and matured before launching the final product. The potential scale alone will require a clear vision on industry standards and methods of testing, allowable leakages and realistic forms of automation.

It is our opinion that Fugitive Emissions testing using low concentration hydrogen is ‘the’ only production testing solution to accommodate large scale production of valves for hydrogen service. Technical alternatives, such as Helium, will not be available at the required scale to keep up with the industries production needs. Implementation of Hydrogen FE testing would help the industry to effectively automate FE testing of products for hydrogen and other critical applications while maintaining a reliable quality system with a great cost balance and near to no disadvantages.