Keeping up with Hydrogen – Understanding the dynamic of a simple leak

We covered some of the basic aspects of Fugitive Emissions testing in number 1 and 2 of our whitepaper series, and we made a few claims that show how our industry relies on technological principles that have been defined a long time ago. The use of forming gas for FE testing is a great example. Today it is innovative for our industry, after all we did not know about it, but the technology has been used for different applications for decades already. This shows a tip of the iceberg; Our products develop quicker than our methods of testing.

Let's take a quick step back into hydrogen as an example. The hydrogen industry has a clear purpose; Provide a sustainable contribution to our energy industry by allowing storage and transport of potential electric energy on a large scale. The potential would allow us to rely much more on renewable sources, whether they are located near to us or perhaps even on a different continent. This reduces our impact on the environment and will help to make energy available to every human being. To achieve these goals, we see innovations every day from a geo political level all the way down to the products necessary. The only thing we don't see changing at the same rate are; Rules, regulations, quality standards and methods of testing.

From our perspective it is absolutely essential to re-define our ways if we want our energy transition to achieve its fundamental purpose. It is not just about creating new, innovative, products that contribute. We need to innovate our methods for design, manufacturing and testing at an equal rate. Our opinion; An excellent opportunity to re-define existing industry standards and make them practical and realistic.

To contribute in our field of expertise we feel that it is absolutely instrumental to understand the principles and dynamics surrounding the concept of 'leakage'.

Let's start simple by considering a water valve in a residential building. Almost every house has a valve on the incoming waterline. It is in open position for the majority of its life and occasionally closed when you are working on the water distribution lines. Perhaps you are installing a new bathroom in your house. It's function is nowhere near as critical as a valve in chemical service in a refinery, but also this valve has to pass quality control. So let's consider how it is tested.

Step one is to determine if there are any production defects. Depending on the standard used, it is called a body or shell test. This standard integrity test proves the valve will not catastrophically fail when it enters into service in your house, and it does not leak to the environment. So, after this step in quality control, we can assume that it will not cause water damage in your house after it is properly installed. We assume that it is self-explanatory that the consequence of failure in many different applications are much more serious, or even catastrophic.

Simple concept, complex criteria. Complex? Yes, because our industry standards prescribe that valves should be tested at a certain pressure for a certain time, depending on their respective use and size. The criteria set is 'No visual leakage'. It essentially means that a human being should visually check if water appears somewhere on the valve. Great method theoretically, but there is a list of arguments why it is not practical.

For starters, the manufacturer will produce thousands of these valves, so our set of eyes might have to visually inspect hundreds of valves every day. No-one has the concentration span to do this all day, especially if the test time per valve is only 15 seconds. Automation is a great method create a higher certainty, but it is often based on the principle of pressure decay. The idea is that measured loss of pressure over time can be interpreted as a leakage. The problem with that is it's dependency on filling rate and volume of the test object. Practically, it is impossible to detect small leakages in a short time span using this method. We have plenty of experiences where valves are clearly leaking (continuously forming droplets) but the pressure in the valve seems stable.

And this brings us to an interesting misconception on pressure testing: Water is an incompressible medium, so we can immediately detect a pressure loss if one droplet of water leaks out. This is theoretically true, but in practice it is impossible to achieve 100% fill rate. This is mostly caused by the shape of the test object, but also because of air entrapped in water. The result is simple: Pressure decay is not necessarily relatable to leakage. Actually, it should even be considered that the correlation to leakage heavily depends on actual volume in the test object, meaning that every single valve model will have a unique characteristic. That is providing that every model has exactly the same volume.

Interesting alternatives would be to use Vision cameras to replace the human eye. But todays systems cannot achieve the same result. The limitation tends to come from differences in contrast between different objects. Camera's require a very repeatable image, which is hard to recreate in a manufacturing environment. And quite frankly; The cost of camera based vision systems is relatively high.

In our opinion the only method to automatically detect these leakages would be to use a tracer gas. Since it would be a consumable, it is evident that the cost of the gas should be as low as possible. Another point for forming gas.

Now, why is the example relevant? Interpretation should start by understanding where the leakage comes from. A leakage in a valve body may be very different if we compare a casted body with a forged body. The probability of porosity in a casting is much higher, and a leakage will become visible after a much longer time. It means that the method of testing for casting may be more critical compared to other materials. Another great example is a welded object. Defects could be found as porosity or a start-stop failure on the weld. The first would show as 'sweating' on the weld (if we test with water long enough), whereas the second could be a steady stream of water. Both should fail quality control, but the detectability of the leak is completely different.

To add to this, if we move back to the critical service valve in a chemical process plant, we can also see that the use of different test mediums will affect the measurability of a leakage. Typically a valve body is strength tested with water for safety reasons. A subject altogether, but it is a logical choice. However, what we often fail to realize is that water has the potential to temporarily clog defects. We tend to underestimate this effect, but the difference is enormous;

Imagine a valve with a welded process connection. The weld has a start-stop fail which is clearly visible; Even without pressure testing, purely based on a visual inspection of the valve, it would not pass quality control. If we pressurize using a tracer gas (this allows quantification of the leak) we immediately max out the range of the measuring equipment. The leakage is huge. Now, we pressure test the same valve with water. Visually, we see a stream of droplets pouring out. Measured pressure decay over 2 minutes is near to none. The valve is drained of water, dried using paper towels and left for a few hours.

End of day, the water tested valve is tested using forming gas again. Surprisingly, the measuring equipment shows a reading in the lower measuring range (10^-5 mbar l/s). A huge difference compared to the first test, which follow exactly the same procedure and parameters. Interestingly enough, if you leave the valve pressurized with forming gas for a longer period of time, you will actually see and hear that the water is pushed out at some point (about 10 minutes) and the original leak-rate reoccurs.

This may seem to be an extreme as we compare water with a viscous gas, but the same effect occurs when pressurizing an object with compressed air and then switch to a tracer gas. It simply means that method and procedure have a very important role to play to determine if a part is leaking. This is notoriously poorly documented and adopted in test standards, simply because the argumentation is based laboratory conditions. This makes our processes impractical, expensive and most importantly; They do not contribute to our industry's higher purpose.

We are strong advocates to develop quality standards and production methods at the same rate at which valves are being developed. This is the only way to ensure we achieve our fundamental purpose without creating a huge disconnection between industry and legislation. Only then will pressure testing truly add material value to a valve.

We are not a sole authority in the field of pressure testing. We do encourage anyone to join the discussion with full interest to attract wider collaboration, harmonization and standardization to achieve real solutions, accelerate growth, optimize cost and become market ready.

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