Tip of the month/No. 2

Leak Detection and Water Pressure Test, Part 1

Question:
Prior to the helium leak test, all our parts are cleaned by washing. Then, the parts are dried by flushing with compressed air. After that the products are submitted to leak testing and are completely dried in the vacuum. Despite this time-consuming preparation, leak testing of the components takes significantly longer than in previous demonstrations. Is our leak detector defective?

Answer:
The leak detector is most likely fine. Your components may not be sufficiently dry. The residual moisture in the test objects creates a certain vapor pressure. The pumping procedure can only take place at the usual speed when the water has been completely removed.

Background:
Essentially, the time response of a vacuum leak detection system depends on the volume of the test chamber and the pumping speed of the system for the helium tracer gas. The gases from the vacuum chamber are removed at the pumping system's pumping speed. If moisture is present in the chamber, the outgassing moisture film releases the vapor very slowly. This process is slower than the pumping speed. This produces a constant pressure level, which is determined by the vapor pressure of the outgassing liquid. The evaporating moisture draws energy out of the remaining liquid and the liquid continues to cool – this can even lead to the liquid freezing in the vacuum chamber. The vapor pressure decreases again, a second area of constant pressure establishes itself in the pump down curve, and the pump down process slows even further.

A blind-flanged helium leak detector quickly pumps the gas quantity present in its interior and achieves a device-specific background signal for the tracer gas. This process is illustrated in Figure 1 for the leak detector ASM Graph. The leak rate signal (red) shows a short transient, stemming from the natural helium content of the air in the leak detector.

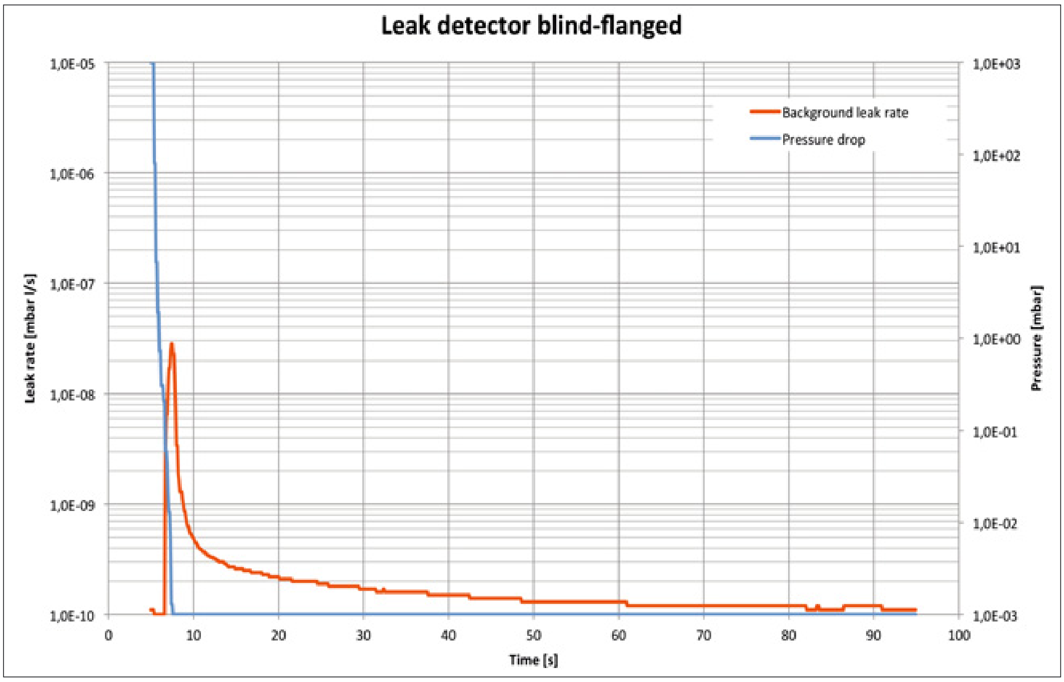

Figure 1: Pressure and leak rate signals on a blind-flanged leak detector

The larger the test object connected to the leak detector, the longer the pump down procedure will take. On the one hand, this is due to the increased volume; on the other hand to the increased surface that can now release adsorbed gas. This effect is even more pronounced if the pump down process is greatly limited by flow resistances or if a damp surface represents a rich source of gas. In Figure 2, this is illustrated with the same leak detector used in Figure 1. However, this time a supposedly dry chamber with a volume of approximately 1.5 liters was flanged on.

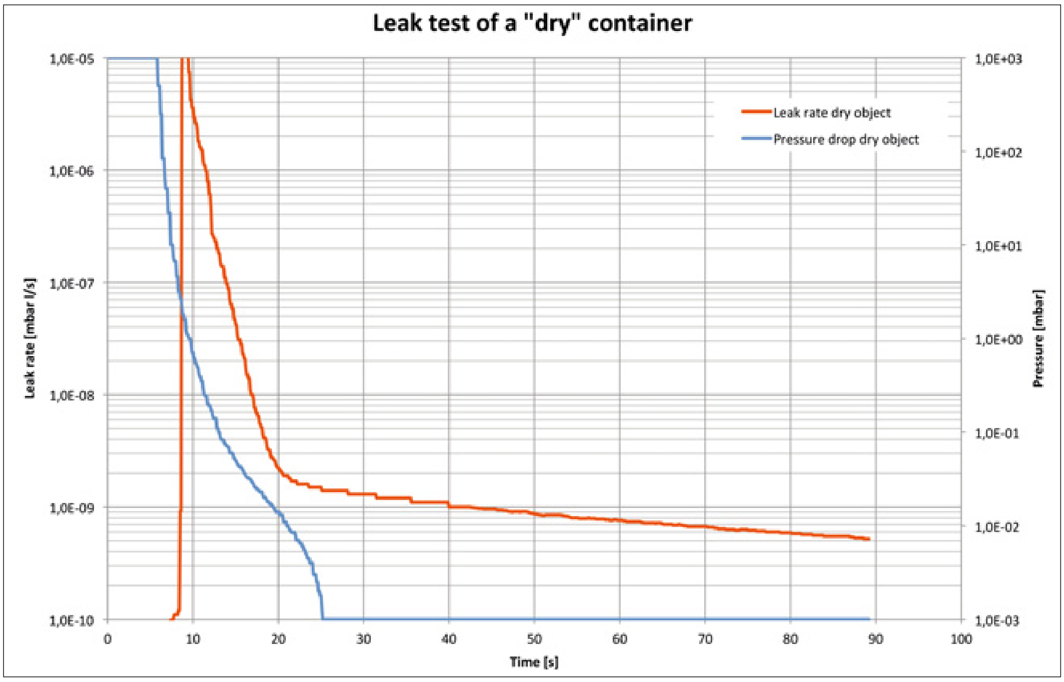

Figure 2: Pressure and leak rate signals on a “dry” chamber

The pump down curve (blue) for the pressure is less steep in this measurement than in the measurement with the blind flanged unit. The small deflection makes residual moisture a possible conclusion, although no traces of moisture can be visually determined on the chamber. The following indicators confirm the hypothesis: Within a few seconds, the helium leak rate sinks from around 10^{-5} mbar l/s over four decades to a value of 2×10^{-9} mbar l/s, but requires the same time again for a further halving of the measured value. In addition, the achievable background level within the same time is worse by a factor of 10 than for the dry, blind-flanged unit.

We have prepared the chamber with only one small drop of water for the curves illustrated in Figure 3. The pressure curve (blue) now shows two distinct ranges with a nearly constant pressure gradient. The first plateau at a pressure of about 1 mbar is the water vapor pressure; the second plateau between 0.1 and 0.01 mbar is due to the ice vapor pressure. Where the pressure curve goes into the first plateau, the helium curve (red) also flattens out. At a pressure of 0.5 mbar, the leak detector switches from gross leak to normal mode. Now, it will take 35 seconds from the start of the cycle until the leak detector achieves a background signal of 10^{-9} mbar l/s. The blind-flanged unit required just 3 seconds.

When switching from gross leak to normal leak detector mode, the gases are fed through other channels of the valve block inside the leak detector. When the operating mode changes, the helium pumping speed of the unit also changes. In our example, the transition from the moist pumping channel in gross leak mode to a previously still dry section of the valve block in fine leak mode leads to a sudden drop in the helium curve of more than a decade.

Due to the water freezing at second 50, the vapor pressure changes and, therefore, so does the release rate of the helium dissolved in the water film – the displayed leak rate changes. The leak test is also influenced by a variety of physical processes that alter the test result or, at worst, even prevent the detection of leaks.

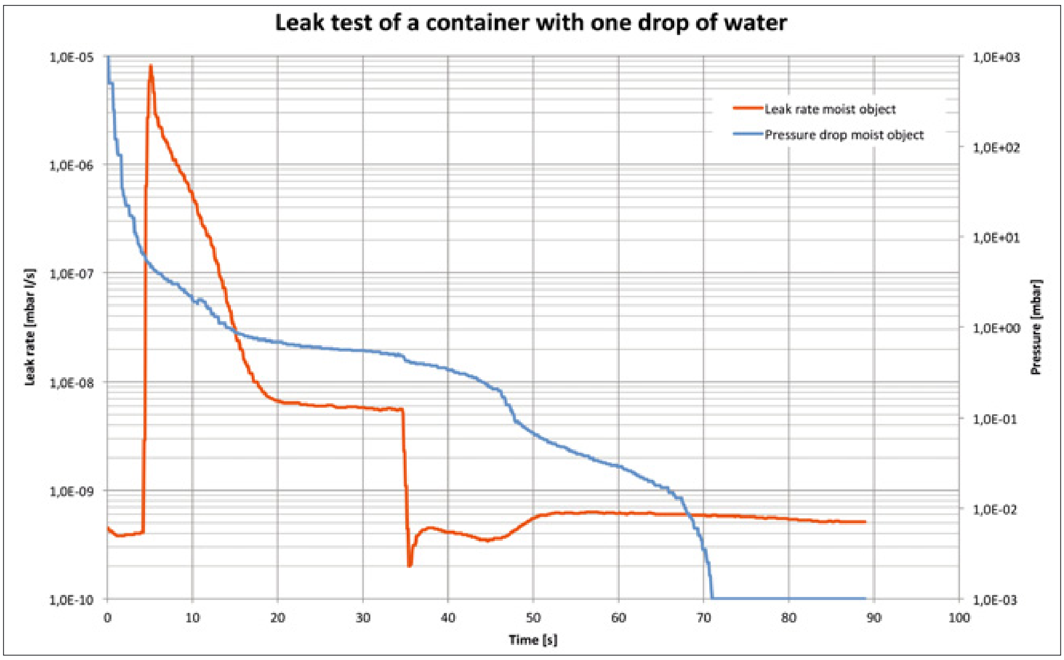

Figure 3: Pressure and leak rate signals on a "moist" chamber

The data in our example clearly show that moist specimens significantly increase the pump down time in vacuum containers and also have an influence on the results for the leakage rates obtained during the leak test.

So our tip is:
invest more time in preparing and drying the specimens well. Your results will be easier to interpret, the good/bad decision will be clear and, as a nice side effect, your leak detector will enjoy longer intervals before requiring maintenance.

We'll show you next month in the second part of this tip what happens if you do actually test moist test objects and what leakage rates you can detect at all.

Feel free to repeat the experiments described above in the practical part of our leak detection seminar. The next seminar will take place on November 7th and 8th, 2012, in Asslar. We would be delighted to welcome you to our headquarters for a visit. You can, of course, book the theoretical part of the seminar on November 7th independently of the practical part, and vice versa. And if your problem is too specific for our basic seminar, we will be happy to give you a quote for a seminar tailored to your needs, either on our premises or yours.

To seminar registration:
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