Accurate down to one millionth of a millibar liter per second!

Leak testing high pressure valves
Testing the leakage rate of a high pressure valve of the type used in natural gas filling station pumps or in connection with hydrogen transport, for example, is a challenging task. To assure that no hydrogen can escape from the valve, it has to have a very low leakage rate of not more than $1 \cdot 10^{-6}$ mbar l/sec.
By comparison: These leakage rate ranges differ very significantly from the leakage rates that enable a bubble of air escaping under water to be seen. The maximum "bubble visibility limit" in water is in the range of ~ 10^{-3} mbar l/sec.

The path to a custom system
GSR Ventiltechnik GmbH & Co. KG specializes in the development and manufacture of high pressure valves. Pfeiffer Vacuum GmbH develops and manufactures complete helium leak detection systems. A leak testing system for high pressure valves has been developed and put into operation together with GSR Ventiltechnik.

The operating pressures in high pressure valves often range between 200 and 360 bar. And in some cases, these operating pressures are even higher. The fact that Pfeiffer Vacuum possessed a reference system served as the cornerstone for a new and challenging project. During the project design phase, it was quickly found that fully equipped systems would be meaningful for GSR. In other words: In the future, too, the aim will be to test as many different types of valves as possible with widely differing tasks; that necessitates an extremely high level of flexibility of the system to be developed.

This resulted in the following engineering requirements:
- The valves should be subjected to pressures of between 0.5 and 360 bar. Both regulation of the pressure as well as adaptation of the valve to be tested should be performed on a fully automated basis.
- A test gas recovery system with continuous measurement and follow-up regulation of the freely selectable test gas concentration, if necessary, is required. This has the following background: If the valve to be tested is charged

and then relieved after the test, around 180 liters of the helium test gas would be released during a single test cycle at a pressure of 360 bar and a potential interior valve volume of around 0.5 liter. Helium is a costly test gas because of the effort and expense involved in producing it. That makes it both economically and ecologically meaningful to recover this gas following the test. A recovery rate of up to 95 % is achieved.

- In order to assure regulation of the test pressures up to 360 bar and to avoid any potential pressure peaks, it was additionally necessary to develop a high pressure compression system for up to 500 bar, with the test gas being compressed in a special buffer tank for this purpose.
- In addition, a supplementary functional valve test was also necessary: This is performed by freely cycling the valve under a nitrogen pressure of up to 100 bar, with the pressure from the valve being able to flow off into the atmosphere. This produces a flow of up to 2.5 times the speed of sound, resulting in a high noise level that necessitates the employment of a special silencing system.

Successful testing
Following months of development work, a dual-chamber testing system was created, with these requirements being taken into consideration.
The system is designed for test pressures of up to 360 bar and can identify leaks of up to 10^{-6} mbar l/sec.
By comparison: The pressure in a container having a volume of 1 liter would rise by 1 millionth of a millibar in 1 second.

Design of the system
The internal leakage at the valve seat is first identified under vacuum conditions in the first of the two chambers, with the valve being subjected to pressure in the closed state. Any leakage is measured at the valve outlet, thus determining the valve's internal leakage rate.

In the second chamber of the testing system, the valve's so-called integral, or external, leakage rate is measured at test pressures of up to 360 bar. This identifies any leaks in the entire valve with respect to the environment.

A typical test cycle is as follows: The operator of the leak testing system receives a routing slip together with his production order. He then enters the order number and the lot size of the valves to be tested via a visualization. Next, he uses a handheld scanner to read the bar code that's printed on the routing slip. The correct test program for the type of valve in question is read into the machine's control system by means of the barcode. In addition, the test data are automatically documented on a PC.

The results of all measurements are recorded and stored. Documentation of the test results is integrated into GSR Ventiltechnik's ERP system. This enables all measured values

to be stored together with the article data. This article-related documentation can be retrieved at any time, along with the complete measured data.

Documenting technology leadership
The first step is to measure the background signal in the chamber, which is then compared with a corresponding reference value. Only if this comparison is passed does the actual measurement begin on the valve to be tested.

The operator, himself, creates the test programs that will be used in conducting the test. They stipulate, for example, the various pressure stages to which the valve is to be subjected and in which chamber, as well as how often it should be cycled.

After the valve to be tested has been put in place and confirmation has been made by means of two-handed controls, the respective chamber (depending upon the program in question) closes. The test specimen (valve) is automatically adapted and attached to the system's filling and evacuation system. Nitrogen now flows through the chamber; the valve is cycled and then filled with helium. The integral leakage rate of the valve seat and the entire valve under vacuum conditions is determined with the aid of the Pfeiffer Vacuum SmartTest helium leak detector. At the end of the test cycle, the helium is relieved into the gas recovery system.
The adaptor and chamber open, and the valve can now be removed, with the test results being appropriately stored.

The leak testing system is a meaningful investment for a midsize company like GSR Ventiltechnik, as it documents

this company's outstanding position with respect to quality assurance of its high-tech products. Even leakage rates that are far below the required limits in actual practice can be reliably indentified.

Interesting for high-tech markets of the future
The need for extreme accuracy in connection with leakage rate measurement takes on particular significance against the backdrop of future developments in valve technology. GSR Ventiltechnik specializes in the development of valves for hydrogen. This field of application is taking on increasing significance, as hydrogen will undoubtedly be playing a major role in the energy mix of the coming decades.
But hydrogen molecules are very small, and can penetrate through even the smallest leaks. That's why extremely accurate testing is a major prerequisite for being able to manufacture high-quality valves for hydrogen technology, which have to operate dependably and leak free even at pressures of up to 900 bar. With this new system, Pfeiffer Vacuum and GSR Ventiltechnik have created this prerequisite.

GSR Ventiltechnik is currently one of the few manufacturers that are able to test valves under realistic operating conditions. This means that the feasibility of ideas for developing new products can be reviewed immediately.
And the company is also excellently equipped with respect to DIN EN ISO 15848-1, which mandates helium leak testing for various valves.

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