ADVANCED PRESSURE TECHNOLOGY

Product Note, PN 422
Pressure Regulator Across-the-seat Leak Testing

October 22, 2010

Introduction

AP Tech AP, AZ and SL Series pressure regulators have a "leakage across seat" specification published in the data sheets. The typical specification is $4x10^{-8}$ sccs helium, which applies when the regulator is in the fully closed position and tested in the forward flow direction only. Pressure regulators operate by a balance of forces. It is critical that the across-the-seat (internal) leak test method does not cause a change in the forces that would reduce the sealing force, as erroneous test data may result.

Incorrect Across-the-seat Leak Test Procedures

Customers will often attempt to leak test pressure regulators in the same manner as diaphragm valves—this is incorrect as described in the following.

Leak detector on outlet port: The standard seat leak test for components per SEMI F1-96 *Specification for Leak Integrity for High-Purity Gas Piping Systems and Components* is to connect the helium leak detector vacuum port to the component outlet port and spray (or pressurize) the component inlet port with helium. This test method results in a differential pressure across the regulator diaphragm of one atmosphere that pushes downward on the diaphragm. The resulting load works to open the regulator and can cause an across-the-seat leak. Due to the relatively large area of the diaphragm, this test method is likely to result in a rise in leak detector reading. Often the vacuum will open the regulator, preventing the leak detector from obtaining the proper vacuum pressure on the vacuum port and entering the test mode. This test method is incorrect because it has not maintained equal pressure above and below the diaphragm, upsetting the regulator balance of forces.

Leak detector on inlet port: In this test, the helium leak detector vacuum port is connected to the component inlet port and helium is sprayed (or pressurized) at the component outlet port. This test method checks the regulator in the **reverse** flow direction and AP Tech's across-the-seat leak specification only applies in the forward flow direction. This test method results in a differential pressure across the poppet of one atmosphere and the resulting load works to open the regulator and can cause an across-the-seat leak—this is especially a problem for high flow regulators with large seat diameters. This test method is incorrect because the regulator is not rated for across-the-seat leakage in the reverse flow direction and the vacuum on the inlet has upset the balance of forces across the poppet.

Regulator Across-the-seat Leak Testing for Design Validation

The standard procedure to verify the catalog data sheet specification is to place the regulator inside a bell jar as shown in Figure 1. The regulator outlet port is open to the bell jar, which is connected to the vacuum port of the helium leak detector. The regulator inlet port is connected to a helium source. The bell jar maintains equal pressure above and below the regulator diaphragm to prevent atmospheric pressure from pushing downward on the diaphragm, as the resulting load works to open the regulator and can cause an across-the-seat leak. The regulator must be placed in the fully closed position for testing. The leak detector reading at 15 seconds is corrected based on the inlet test pressure to a standard leak rate per SEMI F1-96 *Specification for Leak Integrity for High-Purity Gas Piping Systems and Components*.

The seal between the pressure regulator poppet and seat is very thin and frequently permeation of the seat material causes the leak detector reading to rise in less than 30 seconds after helium is applied. The exact time until a rise occurs varies for each model and is mostly determined by the seat material permeation rate and orifice diameter. A typical standard leak rate versus time across-the-seat leak test result is shown in Figure 2—the rise in standard leak rate represents permeation of the seat—not an actual leak path. This test was extended for 180 seconds to show permeation of the seat.

Figure 1. Regulator Across-the-seat Leak Test in Bell Jar

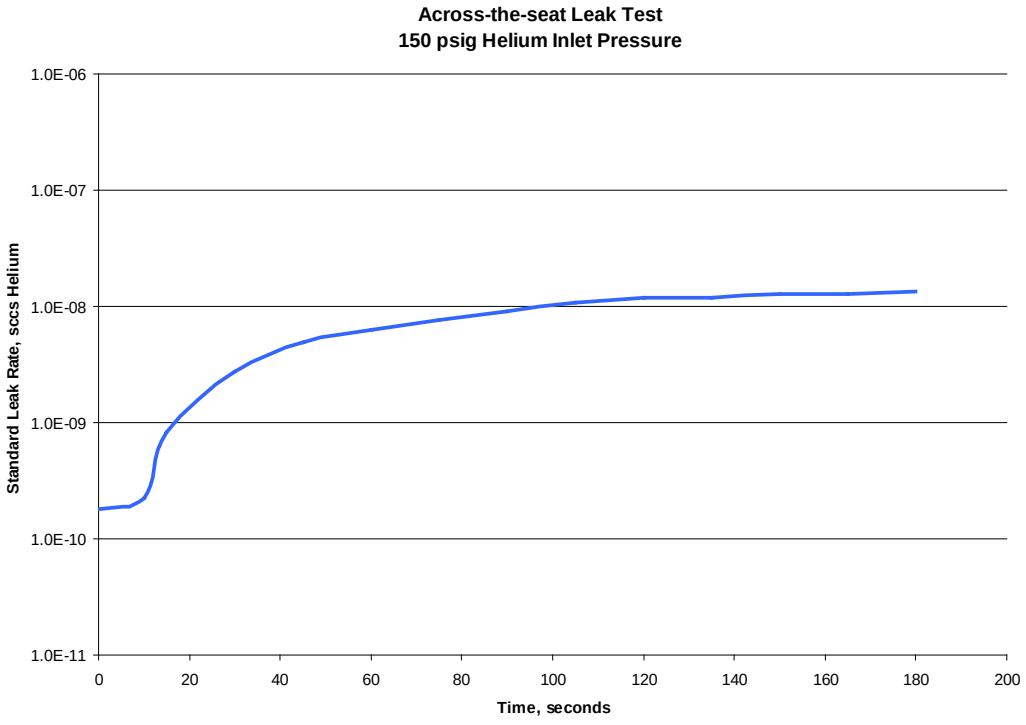

Figure 2. Across-the-seat Leak Test, Standard Leak Rate vs. Time Showing Permeation

Regulator Across-the-seat Leak Testing for Production

Bell jar helium leak testing is a slow process and not suited for production environments. For this reason, AP Tech performs a sniffer probe across-the-seat helium leak test on standard production regulators as

shown in Figure 3. Helium content in the atmosphere is approximately 5 ppm. Therefore, when used in the sniffer probe mode, most helium leak detectors can only detect leaks that are larger than $1x10^{-5}$ sccs.

The regulator is fully closed, then the inlet port is connected to a helium source. The helium leak detector sniffer probe is placed in the regulator outlet port. The inlet port is pressurized and the leak detector is monitored for any rise above background in 15 seconds. Any rise is considered a seat leak and the regulator is rejected.

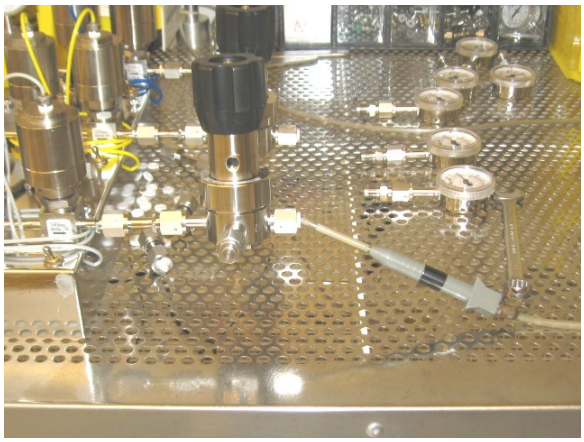

Figure 3. Regulator Across-the-seat Leak Test using Sniffer Probe

Recommended Customer Across-the-seat Leak Test

Before the regulator is installed in a system, the recommended across-the-seat leak test procedure is either the bell jar test or the sniffer probe test. If either of these leak tests is performed, then the regulator may need to be evacuated for an extended period of time (typically 24 hours minimum) to remove helium from the seat material before an inboard helium leak test can be performed.

After the regulator is installed in a gas delivery system, the across-the-seat leak test options are limited. The bell jar leak test is not possible and the sensitivity of the sniffer probe leak test is reduced because the probe may not be placed directly in the regulator outlet port. In addition, many customers perform an inboard helium leak test on the system and the introduction of helium could interfere with subsequent leak tests.

For these reasons, AP Tech recommends that a nitrogen creep test be performed in place of a helium across-the-seat leak test. The nitrogen creep test will verify that the regulator will work properly in the system and does not introduce helium that can interfere with inboard leak testing. The pressure rise will vary depending on the regulator model, test time, internal volume of the piping system on the regulator outlet and the application.

Summary

AP Tech validates the across-the-seat leak rate specification for regulators using a bell jar. Production across-the-seat leak tests are done using the leak detector in sniffer probe mode. The recommended across-the-seat leak test when the regulator is installed in a system is a nitrogen creep test.

Please consult the factory or your local distributor for further information or assistance.