Product Note, PN 448, Revision 1
Pressurized Inboard™ Helium (He) Leak Testing

January 20, 2021

Preface:

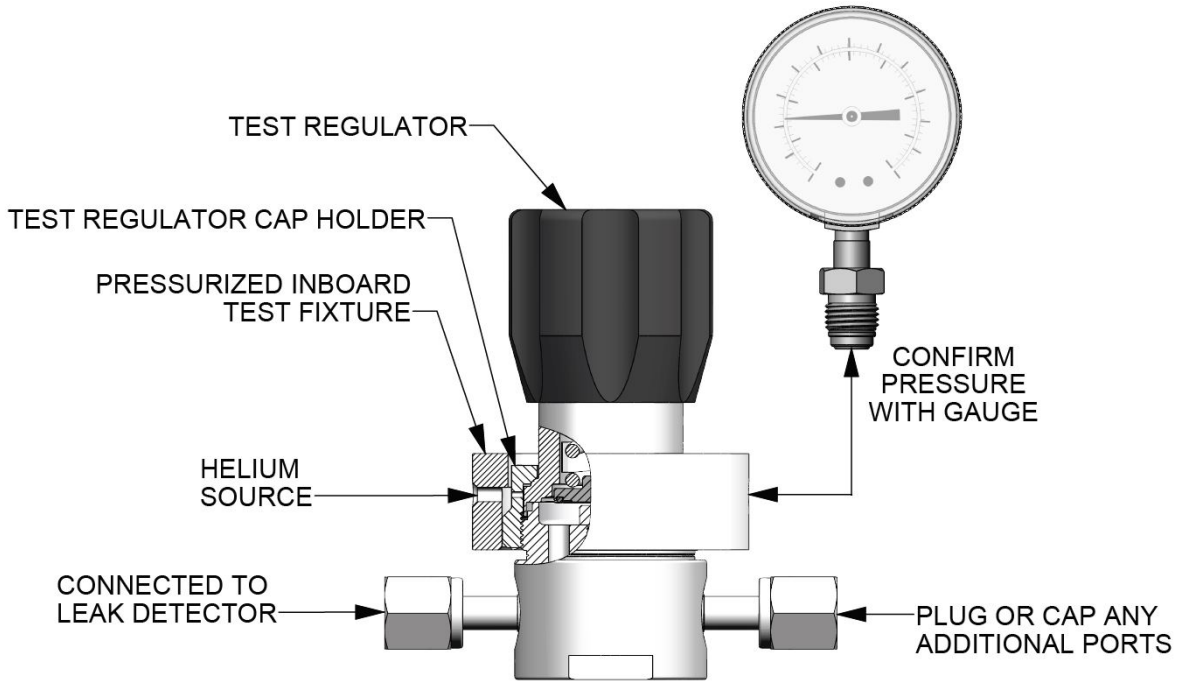
Product Note PN 442, Interpreting Leak Rates, introduction begins with the statement ‘Nothing is truly leak tight, everything leaks to some degree’. PN 442 explains the various methods of leak testing ultra high purity (UHP) components and that the leak test method and associated acceptance criteria defines a piping system’s leak integrity more than a leak rate specification. This is due to the fact that a leak may be detectible by one test method and not another with a higher sensitivity.

It is recommended that one read and understand PN 442 prior to reading this product note.

Introduction:

PN 442 provides a comparison of the various leak test methods employed for UHP gas systems today, noting the merits and downsides of each approach. AP Tech engineers have developed a hybrid test method that is patent pending. The new method combines the advantages of both inboard and outboard sniffer probe Helium (He) leak testing. Termed ‘pressurized inboard™’ (PI) the new test method is an inboard test where the He is externally pressurized rather than simply sprayed in the environment surrounding the device under test (DUT). Specifically, the diaphragm seal to the body is externally pressurized to help push He molecules through any leak path. This provides the test gas pressure differential advantage of an outboard sniffer probe test without the downside limitation of He background in the environment surrounding the DUT (leaks below background reading are not detectible). The DUT is also not internally saturated with He which can be a problem for residual He subsequent inboard He leak testing. The PI process involves a standard one (1) minute inboard test first, followed by a PI test of the diaphragm seal for one minute. The PI test is similar to a test, termed ‘bombing’, where the entire DUT is externally pressurized with He. The advantage of PI is that the general leak area can be determined, whereas this may not be possible with bombing – a leak is detected at an unknown leak point.

The following drawing depicts the PI test set up:



Initial comparison testing:

One hundred (100) pressure regulators, a mix of two models and sizes, had diaphragm sealing surfaces intentionally damaged for testing purposes. The devices were inboard He leak tested, outboard bell jar He leak tested, N2 static pressure decay tested and PI He leak tested. Test duration was for one (1) minute with the exception of the N2 static test which was twenty-four (24) hours. An outboard He sniffer probe test was not conducted. Extensive production testing of a N2 static pressure decay test of devices which passed an outboard He sniffer probe test, show the long duration N2 test to be more sensitive (detecting leaks not found by the outboard He sniffer probe test).

Though intentionally damaged, only slightly more than half of the units had leaks detected by one or more of the test methods. This affirms the robustness of the seal design. Of the leaks detected, either N2 static pressure decay or PI detected leaks in almost every instance. The conclusion based upon test results was that N2 static pressure and PI testing could detect leaks not found by the other methods. An outboard bell jar test of some longer duration than one (1) minute, at least five (5) minutes and likely greater than ten (10) minutes, would be equivalent to N2 static or PI testing. However, due to He saturation that would result from longer exposure to He and other factors, outboard bell jar testing was not considered further.

Production testing:

Over two thousand (2,000) units were leak tested in production via inboard He leak testing, PI leak testing and N2 static pressure decay testing. The units were for customers who specify inboard testing in lieu of outboard He sniffer probe testing due to residual He concerns. The goal was to compare N2 static to PI testing with production units and typical failures found in the manufacturing process. The failure rate was very low, 1.45%, as expected. Of the failed units, PI detected more outboard leaks than N2 static testing. The difference is statistically insignificant relative to the total sample size, but the numbers are significant relative to total number of failed units. As with any leak test method, PI may detect leaks not found by N2 static pressure testing and the opposite may hold true too.

The following table #1 presents the test results of production testing as described:

Table 1:

Leak Test Results	**Quantity**
Total Units Tested	2,200
No Leaks Detected	2,168
Fail Inboard only (no other tests)	2
Fail Pressurized Inboard, Pass Decay	21
Fail Pressurized Inboard, Fail Decay	5
Pass Pressurized Inboard, Fail Decay	4

PI testing advantages:

Residual He: PI testing externally pressurizes the DUT with He which does not saturate the wetted area with He. The residual He from outboard testing is difficult to remove and may impede subsequent inboard testing.

Pressure differential: PI provides the higher test pressure differential advantage of outboard testing compared to traditional inboard He testing without causing residual He. Increasing the test pressure above atmospheric pressure improves the test sensitivity.

Different test method: As explained in PN 442 and herein, different test methods have different sensitivities to detect leaks. A N2 static pressure test is almost a universal test method utilized to validate a gas system’s leak integrity prior to system start up. PI testing in production followed by N2 static pressure testing upon installation assures the optimum in leak testing via two methods, not one.

Identifies leak point: Unlike N2 static pressure testing, outboard He bell jar testing and He bombing, which detect a leak but not the location of a leak, inboard He, PI and outboard He sniffer probe testing enable one to locate the general area of a leak.

Background He: Unlike He sniffer probe testing where sensitivity is limited by the background level of He in the atmosphere, the background level of He in the atmosphere is not a factor with inboard or PI testing.

Compared to N2 static pressure test: PI is not as affected by temperature change or internal volume, both of which impact N2 static pressure testing. PI also detects a leak in one (1) minute that can take overnight, sixteen to twenty-four (16 to 24) hours, with N2 static pressure testing. If a device fails the N2 static pressure test, it must be retested again to confirm that the leak was not a fitting connection.

Technician dependent: PI can be less dependent upon the skill of a technician than other test methods. Outboard He sniffer probe testing requires that the test probe be properly held and moved around test points to detect leak. N2 static pressure testing requires temperature compensation and can involve reading a gauge or transducer.

Conclusion:

PI and N2 static pressure decay testing were found to be superior production leak test methods compared to inboard He, outboard He sniffer probe and outboard bell jar testing. PI was found to be slightly better than N2 static pressure decay testing and PI has advantages over N2 static testing as explained above.