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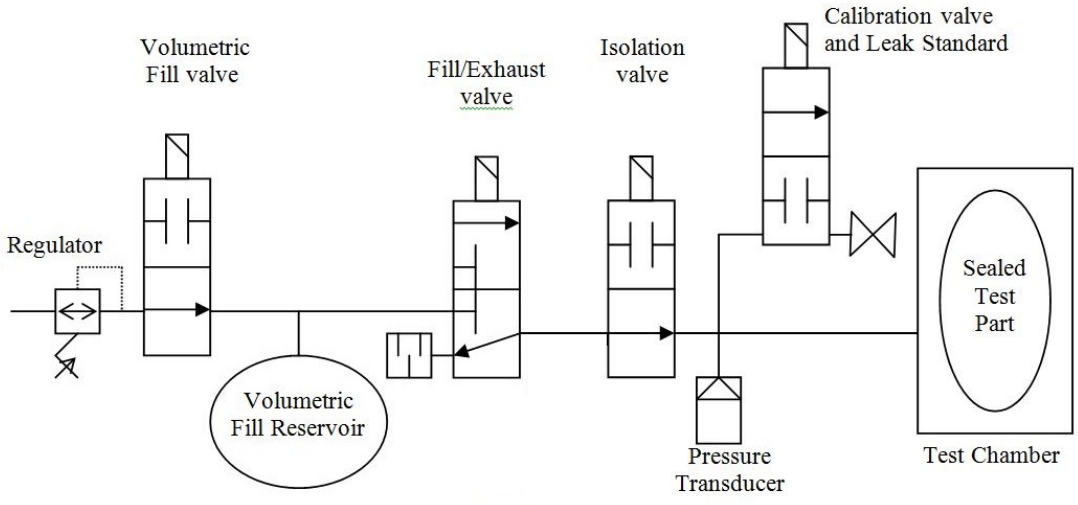
TESTING SEALED PARTS: FIXED VOLUME FILL TESTING - I21 & M24

Application: Sealed parts with no charge ports must be tested in a chamber that can be either pressurized or evacuated to create a differential pressure across the part wall. A sealed part with a severe leak cannot be tested for fine leaks because it is charged with pressure/evacuated with its test chamber. Therefore, no pressure differential is created across the part wall when the test is performed.

Solution: Because there is no way to introduce air into/evacuate a sealed part, the part must be tested in a leak-tight chamber with minimal volume around the part. The amount of volume in the chamber influences the test cycle time and the sensitivity of the leak test. To optimize both cycle time and sensitivity, it is best to use a chamber that is custom-formed to the part.

If the part has a large hole, air will quickly enter the part during the test chamber fill cycle. To detect a severe leak condition, the amount of air charged into/pulled out of, the chamber must be controlled. The test must then detect whether any air is passing quickly through the part wall. To control that volume of fill air/evacuated air, a fixed volume fill test circuit is recommended. The following pneumatic diagram shows the fixed volume fill test circuit used in the I28 volumetric fill manifold.



Concept: Before the test starts a Volumetric Fill Reservoir is pressurized/evacuated to a pressure/vacuum greater than the desired differential pressure across the test part wall. The Volumetric Fill Reservoir is isolated from the source regulator and then connected to the Test Chamber. The ratio of the Test Volume (Test Chamber volume minus Sealed Test Part volume) to the Volumetric Fill Reservoir volume determines the required charge pressure for the Volumetric Fill Reservoir. For example, if the Volumetric Fill Reservoir were equal in size to the Test Volume, then the charge pressure for the Volumetric Fill Reservoir will be two times the final desired resultant Test Chamber pressure.

I21 & M24 Fixed Volume Fill, Test Sequence:

1. The Volumetric Fill valve is normally open from the end of the Fill cycle of one test to the start of the Prefill cycle of the next test. During this time the Volumetric Fill Reservoir is pressurized/evacuated to a Preset Pressure by the source regulator.

2. At the beginning of the Prefill cycle, the Volumetric Fill valve closes and the Fill/Exhaust valve opens to charge/evacuate the Test Chamber using the fixed volume of air/vacuum in the Volumetric Fill Reservoir. The pressure between the Volumetric Fill Reservoir and the Test Chamber minus Part volume will quickly equalize based on the following formula:

$$P_1 \, x \, V_1 = P_2 \, x \, V_2$$

Where:

P_1 = Preset Pressure for the Volumetric Fill Reservoir volume
V_1 = Volumetric Fill Reservoir volume
P_2 = Resultant Test Chamber pressure after Fill/Exhaust valve is opened
V_2 = (Chamber volume – test part volume + Volumetric Fill Reservoir Volume)

3. In the Prefill cycle the instrument monitors whether the Test Chamber pressure reaches the Minimum Test Pressure (which is set at a small percentage below the Desired Target Pressure). If the Test Part has a large hole, air will leak into/or out of the part rapidly during all of the testing phases (Prefill, Fill, Stabilization, and Test). Because no additional air is added to/evacuated from the part, the overall test volume (which might include the internal volume of the test part because of the large hole) will be bigger than the (Chamber volume – test part volume) causing the pressure to not reach the Minimum Pressure limit during Prefill or it may fall below Minimum Pressure during the Fill or Stabilization cycles. If the Test Chamber pressure falls below the Minimum pressure, the test result will be Reject as a Severe Leak. *Adequate time in the Prefill and Fill cycles is critical to allow the Volumetric Fill Reservoir and Test Chamber to equalize.*

4. The I21 or M24 instrument performs the pressure decay leak test (calibrated with a leak standard) to determine the leak rate of the Sealed Test Part. The pressure decay leak test result is compared to the settings for Low Limit Leak and High Limit Leak. The test evaluation is selected from one of the 6 following options: F/P/F, F/F/P, P/F/P, F/P/P, P/F/F, P/P/F. Based on the settings, the test result is either an Accept or Reject.

Note: All setup testing should be performed using a leak free master part in the test chamber. When setting the Minimum Pressure limit, it is helpful to test a part that has a large hole (severe leak). The resulting Test Chamber charge pressure/vacuum for this condition must fail the Minimum Pressure limit.

Example 1:
Test Chamber (TC) volume = 1000 cc
Sealed Test Part (STP) volume = 700 cc with an internal air volume (IAV) of 350 cc
Target Differential Pressure (TDP) = 6 psid
Inside the part pressure = Atmosphere (14.7 psia)
Inside the chamber pressure at start of test = Atmosphere (14.7 psia)
Required Target pressure inside the chamber = 6.0 psiv (or 8.7 psia outside the part)
Volumetric Fill Reservoir (VFR) volume and Preset (PP) pressure:

$P_1 \times V_1 + P_2 \times V_2 = P_T \times V_T$

$P_{PP} \times V_{VFR} + 14.7 \text{ psia } V_{(TC-STP)} = P_{TDP} \times V_{(VFR+TC-STP)}$

$P_{PP} \times V_{VFR} + 14.7 \text{ psia } (1000cc - 700cc) = 8.7 \text{ psia} \times (V_{VFR} + 1000cc - 700cc)$

$P_{PP} \times V_{VFR} = 8.7 \text{ psia} \times V_{VFR} + 8.7 \text{ psia} \times (1000cc - 700cc) - 14.7 \text{ psia } (1000cc-700cc)$

$P_{PP} \times V_{VFR} - 8.7 \text{ psia} \times V_{VFR} = 8.7 \text{ psia} \times 300cc - 14.7 \text{ psia } (300cc)$

$(P_{PP} - 8.7 \text{ psia}) V_{VFR} = 2610 \text{ psia cc} - 4410 \text{ psia cc} = -1800 \text{ psia cc}$

If a vacuum of 12 psiv (2.7 psia) can be achieved as the Preset Pressure in the Volumetric Fill Reservoir by the test regulator, the volume of the Volumetric Fill Reservoir should be:

$V_{VFR} = -1800 \text{ psia cc} / (P_{PP} - 8.7 \text{ psia})$

$= -1800 \text{ psia cc} / (2.7 \text{ psia} - 8.7 \text{ psia})$

$= 300 \text{ cc}$

Another example follows…

Example 2:
If the Volumetric Fill Reservoir volume is equal to the volume of the test chamber minus the part volume, the Preset Pressure needs to be evacuated to double the desired Target Differential Pressure.

In setting up this type of test, the proper Volumetric Fill Reservoir volume and Preset Pressure must be defined to achieve the desired Target Differential Pressure. The Test Part must also have enough internal volume relative the volume of the Chamber minus the overall part volume to detect a measurable difference between a Non-Leaking Part and a part with a big leak.

To determine the Minimum Pressure ($P_{MP)}$ setting calculate the final pressure in the combined volume if the internal volume of the Test Part is added to the final combined volume because it has a severe leak.

$P_{PP} \times V_{VFR} + 14.7 \text{ psia } V_{(TC\text{-}STP+IAV)=} P_{MP} \times V_{(VFR+TC\text{-}STP+\mathbf{IAV})}$
(The internal air volume (IAV) of the part is added to the final resulting volume.)

$P_{PP} \times V_{VFR} + 14.7 \text{ psia } V_{(TC\text{-}STP+IAV)} = P_{MP} \times (V_{VFR} + 1000cc - 700cc + 350cc)$

$2.7psia \times 300cc = P_{MP} \times (300cc + 1000cc - 700cc + 350cc) - 14.7psia (1000 cc - 700cc + 350cc)$

$810 \text{ psia cc} = P_{MP} \times 950cc - 14.7 \text{ psia } (750cc) = P_{MP} \times 950cc - 11025 \text{ psia cc}$

$P_{MP} = 11835psia\ cc / 950cc$

$P_{MP} = 12.46 \text{ psia} = 2.24 \text{ psiv}$

The Minimum Pressure should be set between 2.24 psiv and the desired Target Differential Pressure of 6.0 psiv. The closer the setting is to 6.0 psiv, the more sensitive the test will be for severe leaks.