Pneumatic Test Type Manifolds for the I-24

**Pressure Tests - Pressure Decay, Pressure Loss, Pressure Rate of Change, and Occlusion Testing with Absolute Pressure Transducer**

*Version PA, PB, PN, and PJ Single Regulator/Single Transducer Test Pneumatics*

*Figure 127 Version PA, PB, PN, and PJ Pneumatic diagram for pressure decay, pressure loss, pressure rate of loss, and occlusion tests*
Figure 128 Test Type/Manifold PA
One regulator for a pressure or vacuum decay test instrument. Limited to 100 psi tests.

Figure 129 Test Type/Manifold PB
High Flow manifold with one regulator for a pressure or vacuum decay test instrument. Limited to 200 psi tests.

Figure 130 Test Type/Manifold PJ
High pressure, high flow manifold with one regulator. 200-500 psi.

Figure 131 Test Type/Manifold PN
Low internal test volume for single pressure or vacuum decay test. Limited to 100 psig.
The most common version for leak testing is the pressure (or vacuum) decay test instrument with either one precision mechanical pressure regulator or an electronic pressure regulator. A precision mechanical regulator or electronic regulator controls the fill (evacuation) pressure for the test through a normally vented fill/exhaust valve and a normally open part isolation valve. After the fill cycle, the part isolation valve closes and then the fill/exhaust valve changes to vent the closed part isolation valve to atmosphere during the test cycle. This prevents leakage from the air source into the test pneumatics, which might hide a leak condition. At the end of the test cycle, the part isolation valve opens to exhaust the part. The normally closed calibration valve opens automatically only during the second test of the Auto Calibration routine and during Auto Setup routine in order to connect the calibrated leak standard to the test volume. There is also a manual control of the calibration valve within the SELF TEST, Open Orifice routine for calibration verification. There is a programmable digital input option to activate this isolation valve to the Leak Standard as an automated way of verify the system calibration. In AutoRun there is an option to open the Calibration Valve to add the Leak Standard for every third test.

Some applications require a fast fill capability because of the large volume of the test part. The purpose of the high flow pneumatics is to quickly get air into (or evacuate) the part for testing and exhaust (or vent) the part at the conclusion of the test. The high flow valves minimize the pre-fill and exhaust times, therefore minimizing the total cycle time. The high flow pneumatics valves have a Cv factor or flow coefficient that is approximately 5 times greater than the standard valve package.

![Timing sequence for Version PA PB, PN, or PJ pressure decay, pressure loss, and pressure rate of change tests](Figure 132)

**Occlusion (Back Pressure)**

The occlusion test is a back pressure test. The part is pressurized by activating the Fill/Exhaust Valve. At the end of the Test timer the actual test pressure is compared to the Low Limit Pressure and High Limit Pressure settings. Low Limit Pressure indicates high flow or minimum blockage or low back pressure. High Limit Pressure indicates low flow or maximum blockage or high back pressure. At the end of test, the part exhausts when the Fill/Exhaust valve deactivates.

![Timing for occlusion tests in all manifold types that offer Occlusion testing](Figure 133)
Dual Pressure Decay Testing with Absolute Pressure Transducer

**Version PC  Dual Regulator/Single Pressure Transducer Test Pneumatics**

**Figure 134** Version PC Pneumatic diagram – Sequential dual pressure decay leak rate, pressure loss, pressure rate of change, and occlusion testing (Two mechanical regulators and one absolute pressure transducer)

**Figure 135** Version PC Pneumatic manifold for two precision regulators for Dual pressure/vacuum decay leak rate, pressure loss, pressure rate of change, and occlusion tests utilizing one pressure transducer

For products requiring leak testing at two different pressures, vacuums, or combination, the Sentinel I24 instruments are configured with either one or two pressure transducers. Version PC utilizes just one absolute transducer ranged to the highest test pressure. The instrument conducts two separate pressure and/or vacuum decay tests. Two fill/exhaust valves isolate the separate precision regulators that control the two test pressures. Two leak standards with separate Leak Std isolation valves permit automatic calibration for the two different tests. This configuration can handle the combination of pressure and...
vacuum but limited to 80 psig for this type of combination. For combination tests that are only pressure tests, the high-pressure limit is 200 psig. Selectable within the part program configuration either the first or both tests can be conducted. It conducts up to two sequential leak tests using the cycle described earlier for the Version PA, PB, PJ, and PN pneumatics. See Figure 133 for Occlusion test sequencing.

**Figure 136** Timing chart for Dual pressure decay leak, pressure loss, and pressure rate of change test sequences (Version PC Pneumatics) with one pressure transducer

**Version PD**  Dual Regulator/Dual Pressure Transducer Test Pneumatics

**Figure 137** Version PD Pneumatic diagram for sequential dual pressure decay, pressure loss, pressure rate of change, and occlusion tests (Two mechanical regulators and two absolute pressure transducer)
Figure 138  Version PD  Pneumatic manifold layout of Dual pressure and/or vacuum decay leak rate, pressure loss, pressure rate of change, and occlusion testing using two mechanical regulators and two absolute pressure transducers

For dual pressure, vacuum, or combination applications that require better resolution and repeatability or where the test pressures are very different, the version PD has two absolute pressure transducers. A 3-way transducer isolation valve protects each transducer during the separate leak tests. The calibration valves isolate the two calibrated leak standards for the automatic calibration sequence. This configuration can handle the combination of pressure and vacuum but is limited to 80 psig for this type of combination. For combination tests that are pressure tests only, the high-pressure limit is 200 psig. Selectable within the part program configuration either the first or both tests can be conducted. The pressure between the two sequential tests must go to atmosphere (0 psig) before the start of the second test. It conducts up to two sequential leak tests using the cycle described earlier for the Version S pneumatics and detail below. See Figure 133 for Occlusion test sequencing.

*only activated during second test of Auto Cal, third test of Auto Setup or manually via Self Test

Figure 139  Timing sequence for Dual pressure decay, pressure loss, and pressure rate of change test cycles (Version PD pneumatics) with two pressure transducers.
Differential Pressure Decay Testing

Version DG  Differential Pressure Decay Pneumatics with Single Regulator, Single Pressure Transducer, and Differential Pressure Transducer

For testing that requires the best possible resolution and repeatability, the differential pressure decay system incorporates both an absolute pressure transducer, differential pressure transducer, and calibrated leak standard integrated into a circuit with high flow valves. The normally vented fill/exhaust valve switches to fill the test part and optional external reference volume through the normally open Part Isolation and Volume Isolation valves. After filling the two volumes, the Part Isolation valve closes and the Fill/exhaust valve vents the closed Part Isolation valve to atmosphere during the stabilization and test cycle. This prevents leakage from the air source into the test pneumatics, which might hide a leak condition. Half way through the stabilization cycle the Volume Isolation valve closes to separate the part...
test volume from the reference volume for the pressure differential decay test. At the end of test the Part Isolation valve opens to exhaust the test part. The Volume Isolation valve can be optionally closed to capture the pressure between tests to reduce the charge time for large parts on the next test. The normally closed calibration valve opens automatically only during the second test of the auto calibration routine in order to connect the calibrated leak standard to the test volume. There is also manual control of the calibration valve within the SELF TEST, Open Orifice routine for calibration verification or using the optional digital input. This manifold configuration also offers direct pressure decay, pressure loss, pressure rate of loss, and occlusion testing using the valve sequences described earlier. Differential pressure decay tests can only use the Test Evaluation of FPF.

![Timing sequence for Differential pressure decay leak test cycle (Version DG pneumatics) with one pressure and one differential pressure transducer.](image)

**Volumetric Fill and Volumetric Fill + Pressure Decay**

**Version VO & VQ**  Volumetric Fill Pneumatics with Single Regulator, Reference Volume Pressure Transducer, and Test Part Pressure Transducer
Figure 142A Version VO & VQ Pneumatic diagram for Volumetric Fill + Pressure Decay Testing.

1. Reference Fill Valve
2. Reference Isolation Valve
3. Part Fill / Exhaust Valve
4. Calibration Valve
5. Part Isolation Valve
6. Pressure Transducer #1
7. Pressure Transducer #2
8. Test Port
9. Reference Volume Fitting
10. Fill Inlet Fitting
11. Exhaust Fitting
12. Leak Standard

Figure 142B Version VO Pneumatic diagram for Volumetric Fill + Pressure Decay Testing.

1. Reference Fill Valve
2. Reference Isolation Valve
3. Part Fill / Exhaust Valve
4. Calibration Valve
5. Part Isolation Valve
6. Pressure Transducer #1
7. Pressure Transducer #2
8. Test Port
9. Reference Volume Fitting
10. Fill Inlet Fitting
11. Exhaust Fitting
12. Leak Standard

Figure 142C Version VQ Pneumatic diagram for Volumetric Fill + Pressure Decay Testing.

The Volumetric Fill Test type measures the ratio of the part volume to a fixed reference volume. The reference volume begins at a set initial pressure which is dumped into the test part during test. Since the pneumatic system is closed, the equilibrium pressure of the two volumes indicates the size of the part volume as a fraction of the reference volume. Two transducers are used: one to measure the initial reference volume pressure, the other to measure the part pressure before and after the volumetric fill test.
This manifold configuration also offers direct pressure decay, pressure loss, pressure rate of loss, and occlusion testing using the valve sequences described earlier.

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<th>Volumetric Fill Test Type</th>
<th>Fill Reference</th>
<th>Stabilization Reference</th>
<th>Test</th>
<th>Exhaust</th>
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<td>Reference Isolation Valve</td>
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<tr>
<td>Part Fill / Exhaust Valve</td>
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<tr>
<td>Part Isolation Valve</td>
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<td></td>
<td>Not Energized During Test</td>
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</tr>
<tr>
<td>Calibration Valve</td>
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<td></td>
<td>Not Energized During Test</td>
<td></td>
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</tbody>
</table>

<table>
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<th>Fill Reference</th>
<th>Stab. Reference</th>
<th>Vol. Fill Test</th>
<th>PD Stab.</th>
<th>PD Test</th>
<th>Exhaust</th>
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<td>Part Fill / Exhaust Valve</td>
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<td>Part Isolation Valve</td>
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<tr>
<td>Calibration Valve</td>
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</tbody>
</table>

Not Energized During Test

Figure 142D Timing sequence for Volumetric Fill and Volumetric Fill + Pressure Decay testing.

**Mass Flow Testing**

**Standard Mass Flow or Differential Mass Flow Systems**

For mass flow testing Cincinnati Test Systems offers two solutions, direct mass flow or differential mass flow tests.

Mass flow testing uses the test regulator as the reference pressure source for measuring the flow. The flow reading is directly related to the flow or leak rate of the test part. This type of flow testing relies on the stability of the regulated pressure for repeatability and part-to-part consistency.

Flow Rate = Flow Value – Flow Offset

The differential mass flow test uses a reference volume to provide a very stable reference pressure for the leak test. The measured flow reading for this test is proportional to the leak rate of the part times the ratio of the reference volume to the part + reference volume.

Leak Rate = (Flow Value – FlowM) x (Total Volume/Reference Volume)
Differential mass flow testing is better suited for measuring smaller leak rates because it is calibrated to a known leak standard. The smaller leak rates usually create small pressure changes in the test part and also the reference volume. The control of the reference pressure is extremely important for low leak rate applications. The regular mass flow test is better for high leak (flow) rate applications. These applications involve greater pressure losses due to the larger flow rates. It is easier to maintain a relatively consistent reference pressure with a regulator directly connected to the flow meter.

**Standard Mass Flow Testing with Regulator as Reference**


![Diagram](image)

**Figure 143  Version FE Manifold layout for Mass flow testing**

The mass flow pneumatic manifold, version FE, has a pressure transducer and mass flow transducer. The normally-vented Fill/exhaust valve switches to fill the test volume through the normally-open Flow Select valve. After filling the test volume to a stable pressure, the Flow Select valve switches to divert any remaining flow through the mass flow transducer. At the end of the test cycle after the final flow is measured, the Flow Select and then the Fill/exhaust valves switch to exhaust the part. There are a couple valves on this manifold that are not used for this test.

![Timing Sequence Diagram](image)

**Figure 144 Timing Sequence Diagram for Mass Flow Test (Version FE Pneumatics) or Mass Flow test**
1. Pressure Select Valve
2. Fill Valve
3. Exhaust Valve
4. Part Isolation Valve
5. Flow Select Valve
6. Pressure Transducer #1
7. Mass Flow Sensor
8. Test Port
9. Air Inlet P1 & P2
10. Exhaust
11. Leak Standard

Figure 144A Manifold for Mass Flow Test (Version FE Pneumatics) or Mass Flow test

Differential Mass Flow Testing with Volume Reference


Figure 145 Version AF Manifold layout for Differential Mass flow, Mass flow, pressure decay leak rate, pressure loss, pressure rate of loss, occlusion tests plus sequential pressure decay/mass flow and mass flow/pressure decay tests.
For differential mass flow, mass flow, and pressure decay testing, the version AF pneumatic manifold has a pressure transducer, mass flow transducer, and calibrated leak standard. For Differential Mass Flow leak tests, a reference volume (supplied by the user) is attached to the test pneumatics via a Volume Isolation Valve. This reference volume provides a stable pressure source independent of plant air pressure fluctuations during the leak test. The normally-vented Fill/exhaust valve switches to fill the test part and the optional external reference volume (starting in the fill cycle if selected to isolate the reference volume between tests) through the normally open Part Isolation, Flow Select, and Volume Isolation valves. Depending the test type selected (Differential Mass Flow or Pressure decay) after filling the test part and optionally the reference volume, the Part Isolation valve closes and the Fill/exhaust valve vents the closed Part Isolation valve to atmosphere during the test cycle. This prevents leakage from the air source into the test pneumatics that might hide a leak condition. Before the end of the stabilization cycle the Flow Select valve closes to divert any remaining flow between the reference volume and the test part through the mass flow transducer. At the end of the test cycle after the final flow is measured, the Flow Select and then the Part Isolation valves open to exhaust the part and reference volume. Depending on setup, the Volume Isolation valve may close at the end of test to capture the reference pressure for the next test.

* Closes to capture air when using a large reference volume to save time cycle on next test.
** Only activated during second test of Auto Cal, third test of Auto Setup or manually via Self Test.
For pressure decay, pressure loss, and pressure rate of change tests the normally vented Fill/exhaust valve switches to fill the test part after the Volume Isolation valve closes. After filling the test part, the Part Isolation valve closes and the Fill/exhaust valve vents the closed Part Isolation valve to atmosphere during the test cycle. This prevents leakage from the air source into the test pneumatics that might hide a leak condition. At the end of the test cycle after measuring the pressure loss over the test time, the Part Isolation valve opens to exhaust the part.

*The normally closed calibration valve opens automatically only during the second test of the auto calibration routine for a pressure decay test calibration or for the differential mass flow testing, when a fixed volume reference is used as the source pressure, in order to connect the calibrated leak standard to the test volume. The leak standard is used to determine the part and/or system volume for calculating leak rate. There is also a manual control of the calibration valve within the SELF TEST, Open Orifice routine for calibration verification or by using the optional digital input for the Leak Std valve. See Figure 133 for Occlusion test sequencing.

**Figure 147 Timing Sequence Diagram Differential Mass Flow Test**

For pressure decay, pressure loss, and pressure rate of change tests the normally vented Fill/exhaust valve switches to fill the test part after the Volume Isolation valve closes. After filling the test part, the Part Isolation valve closes and the Fill/exhaust valve vents the closed Part Isolation valve to atmosphere during the test cycle. This prevents leakage from the air source into the test pneumatics that might hide a leak condition. At the end of the test cycle after measuring the pressure loss over the test time, the Part Isolation valve opens to exhaust the part.

**Figure 148 Timing Sequence Diagram for pressure decay, pressure loss, and pressure rate of change tests with the Version AF pneumatic manifold**

*The normally closed calibration valve opens automatically only during the second test of the auto calibration routine for a pressure decay test calibration or for the differential mass flow testing, when a fixed volume reference is used as the source pressure, in order to connect the calibrated leak standard to the test volume. The leak standard is used to determine the part and/or system volume for calculating leak rate. There is also a manual control of the calibration valve within the SELF TEST, Open Orifice routine for calibration verification or by using the optional digital input for the Leak Std valve. See Figure 133 for Occlusion test sequencing.

**Mass Flow/Pressure Decay Sequential Testing**

**NK Mass Flow/Pressure Decay Leak Rate manifold pneumatic diagram**

*Figure 149 Versions NK Manifold layout for a mass flow testing, pressure decay leak rate, pressure loss, pressure rate of change, occlusion, sequential mass flow/pressure decay, or sequential pressure decay/mass flow testing*
The mass flow portion of the pneumatic manifold has a pressure transducer and mass flow transducer. The normally-vented Fill/exhaust valve switches to fill the test volume through the normally-open Flow Select valve. After filling the test volume to a stable pressure, the Flow Select valve switches to divert any remaining flow through the mass flow transducer. At the end of the test cycle after the final flow is measured, the Flow Isolation and then the Fill/exhaust valves switch to exhaust the part. At the conclusion of the flow test, the instrument can be configured to sequentially begin a pressure decay leak rate test described below.

![Figure 150 Timing Sequence Diagram for Mass Flow Test](image)

The pressure (or vacuum) decay, pressure drop, and pressure rate of change test instrument portion of the circuit uses the same mechanical pressure regulator or an electronic pressure regulator. The regulator controls the fill (evacuation) pressure for the test through a normally vented Fill/exhaust valve and a normally open Part Isolation valve. After the fill cycle, the Part Isolation valve closes and then the Fill/exhaust valve changes to vent the closed Part Isolation valve to atmosphere during the test cycle. This prevents leakage from the air source into the test pneumatics, which might hide a leak condition. At the end of the test cycle, the Part Isolation valve opens to exhaust the part. The normally closed Calibration valve opens automatically only during the second test of the Auto Calibration routine and during Auto Setup routine in order to connect the calibrated leak standard to the test volume. There is also a manual control of the Calibration valve within the SELF TEST, Open Orifice routine for calibration verification.

![Figure 151 Timing sequence for pressure decay leak rate, pressure loss, and pressure rate of change tests](image)
NL and NM Mass Flow/Pressure Decay Leak Rate manifold pneumatic diagram

Figure 152 Versions NL an NM Manifold layouts for single and dual pressure mass flow, pressure decay leak rate, pressure loss, pressure rate of change, occlusion, sequential mass flow/pressure decay, or sequential pressure decay/mass flow testing

Figure 153 Version NM (NL) Manifold for Dual (Single) pressure Mass Flow/Pressure Decay testing
The mass flow pneumatic manifolds, version NL and NM, offer a higher flow capacity and less resistance during test when measuring flow or a leak. The manifold version NM offers the additional capability of performing a dual pressure test sequence of either mass flow, pressure decay, or combination with two mechanical regulators. This configuration has one or two sets of tandem regulators, a pressure transducer, a mass flow transducer, and a calibrated leak standard. The Pressure Select Valve (provided on the NM version only) selects the pressure regulator for the test. The normally-open exhaust valve closes and the normally-closed Fill valve opens to fill the test volume through the normally-open Flow Select and Part Isolation valves. After filling the test volume to a stable pressure, the Flow Select valve switches to divert any remaining flow through the mass flow transducer. The fill valve closes and the exhaust valve opens. At the end of the test cycle after the final flow is measured, the Flow Select valve switches back and the part exhausts through the open exhaust valve. For pressure tests the Part Isolation valve closes after the fill cycle to isolate the part test volume for the pressure test.

**Figure 154 Timing sequence for mass flow and pressure decay, pressure loss, and pressure rate of change tests**