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ESTABLISHING TEST PARAMETERS for I-24

Leak Values Within LEAK routine

Low Limit *High Limit*

The Sentinel I24 instruments have two set points, low and high limits, with which to compare test results. These limit values define three regions (above high limit, between limits, and below low limit) in which to qualify the results of each test. There are five optional outputs, which are activated starting at the beginning of the exhaust cycle to indicate in which area (test passed, test failed, above high limit, between limits, and below low limit) the test results fell.

The test evaluation setup is found in the Part Configuration, Test Parameter Screen. The instrument evaluation criteria are defined by a three-letter code (PPF, PFP, PFF, FPP, FPF, and FFP). The configuration of the criteria matches the appearance of the bar graph on the display. When the part is pressurized, the bar graph goes up or to the right on the display and as pressure is lost the bar graph falls or moves to the left on the display. Small leaks cause a small loss. High Leakers have a large drop in pressure. Therefore, the bar graph moves to the right as the part is charged with pressure or evacuated for a vacuum test. If the part has a small or no leak, the bar graph will move very slowly back to the left. If the part has a large leak, it will move quickly to the left. Therefore, the Lo Lim threshold is on the right side of the graph and the Hi Lim threshold is on the left side of the graph for both pressure decay and vacuum decay testing.

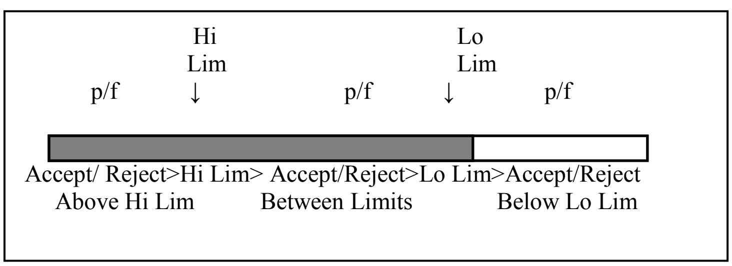

Figure 155 Bar Graph illustration

For **pressure decay leak test, pressure loss, and pressure rate of change applications**, the limits define the tolerance of air leakage allowed by the part during test. The typical configuration would have the high limit equal to the reject rate or specified tolerance of leakage, loss, or rate of change for the part. The low limit would be set at zero or a negative value (10 to 20% of reject rate or high limit value) within Part Configuration, Chapter 5.

The test evaluation criteria should be set to reject test results greater than the high limit value and accept parts between the limits. The area below the low limit is normally set to fail. It is usually desirable to alert the process when parts test significantly better than when initially calibrated so it is set to fail any value that is below the low limit.

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For **occlusion or blockage applications,** it would be desirable to check that the effective pressure when pressurizing a part is within limits of back pressure that is controlled by the flow going through a part. High flow will cause low back pressure while low flow will cause high back pressure. The Low Limit Pressure set point will be on the right side of the display and High Limit Pressure will be on the left side of the display. This is consistent with Low Lim and High Lim display for the all the other tests.

For **flow applications,** it is usual to accept values that are between a low and high limit. All values greater than the high limit and less than the low limit should be set to reject. The Low Limit flow set point is on the right while the high lim flow is on the left side.

Leak Standard (orifice)

This is the value of the leak standard located on the internal pneumatic manifold or of the calibration device located externally in the test station pneumatics or in the part. This value is used when calibrating the instrument. It must be entered before starting the Auto Cal process. The internal leak standard has a calibrated leak value printed on the stainless steel housing. There is also a printed calibration report for the leak standard included with the instrument or located in the component documentation binder if an entire machine is supplied by CTS. The flow value of the leak standard was determined at a specified pressure, which should be the test pressure for the application. If the test pressure is different, the flow value for the leak standard will be different. The calibration date is provided on the flow standard and certificate. .

Environmental Drift Correction (EDC)

The environmental drift correction routine helps to maintain the calibration of the system by continuously monitoring and calculating a correction factor for changes in the test conditions. This routine dynamically compensates for slow changes in the test environment like room temperature changes, part temperature changes, test air temperature changes, part elasticity changes, part absorption characteristics, etc. These factors influence the dynamics of how the test part reacts to the testing process and the determination of the relationship of pressure changes to leak rate. "Environmental Drift Correction" defines how wide of a band around the "Master Part Loss" value will be considered as normal variations in flow rate for a non-leaking part. The "Environmental Drift Correction (+EDC %) is based on reject rate. The instrument continuously calculates a running average of test results that fall within the band (+EDC %) about the original "Master" or No-Leak part curve. It corrects each future result by the calculated drift determined from previous test results. The drift value is calculated as shown.

$$\text{Environmental Drift Correction} = \frac{\Sigma_n \text{Flow}}{n}$$

Typical settings for "Environmental Drift Correction" are 10, 25, 50, and 90%. The sample size is set as EDC quantity (3 or greater). Flexible parts require a greater "Environmental drift correction" than rigid parts.

The "Environmental Drift Correction" effectively defines how much shift can occur. This limits the routine from continuing to compensate for possible growing leaks in the seal or test pneumatics.

Pressure Values Within Test Parameters settings

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Minimum Pressure, Target Pressure, Maximum Pressure, and Target Press Window

The Target Pressure is the specified test pressure. Set the regulator to match the specified Target Pressure by using the "Set regulator" routine within the SELF TEST display function. Adjust the regulator to display the desired Target pressure. Target pressure is the control set point for the optional electronic regulator.

The Minimum Pressure must be met initially within the Pre-fill timer to start the fill cycle. The test pressure must remain within Minimum and Maximum Pressure limits about the Target Pressure to assure that the part is charged to the proper pressure or vacuum during the fill (and stabilization) timers. Failure to maintain pressure within these limits will stop the test as a Severe Leak. The Minimum and Maximum Pressures are usually set at +/-10 to 20% band about the specified Target pressure.

During the Test timer the pressure in the part must remain within the Target Press Window percentage about the Target Pressure. Failure to stay within this window during the Test timer results in a Malfunction and a test result error message of “Test Pressure Low” or “Test Pressure High”.

Master Press and Master+Leak Press

The Master Press and Master+Leak Press are the pressures measured at the mid point of the test cycle during the AutoCal routine. These pressures are used to correct the pressure loss or flow values measured in the calibration routine to the Target Pressure using the formula.

$$\text{Master Part Loss} = \frac{\text{Target Pressure}}{\text{Master Press}} \times \text{Measured Master Loss}$$

Master Part Loss (Flow), Master Flow Offset, and Master+Leak Loss (Flow)

The “Master Part Loss (Flow)” and Master Flow Offset values are measured during the first test of the AutoCal routine. They represent the pressure loss (or flow) associated with testing a Master (leak free) or “zero leak” part. The Master Flow Offset is the offset for regular mass flow tests. The “Master+Leak Loss (Flow)” value is the measured pressure loss (flow) in the second test of the AutoCal routine”. “Master+Leak Loss (Flow)” represents the pressure drop (flow) associated with a Master part that has a leak equal to the Leak Standard. **The “Master Part Loss (Flow)” and “Master+Leak Loss (Flow)” values cannot be modified after calibration. These values are adjusted for the variation of the actual pressure in test verses the Target Pressure. The Master Flow Offset can be modified.**

For pressure decay tests,

$$\text{Leak Rate} = \frac{[dP_{Part} - \text{Master Part Loss}]}{[\text{Master+Leak Loss} - \text{Master Part Loss}]} \times (\text{Leak Standard})$$

For differential mass flow tests,

$$\text{Leak Rate} = \frac{[Flow_{Part} - \text{Master Part Flow}]}{[\text{Master+Leak Flow} - \text{Master Part Flow}]} \times (\text{Leak Standard})$$

For mass flow tests,

Flow Rate = $Flow_{Part}$ – Master Flow Offset

Max Mstr+Leak Loss (Flow)

This parameter is a safety-check value used during the calibration process to make sure that the system is not calibrated with a leaking master part or fixture. Its final value should be set 2 times or less higher than Master+Leak Loss (Flow) value determined in the initial part calibration. The AutoSetup routine will automatically set this value at two times the Master+LS Loss (Flow) after optimizing the timers to conduct the leak test within the Desired Cycle Time. If you are manually determining the timers for the test, initially set this value high like 0.4 psi in order to allow error-free testing while adjusting the timers.

Low Limit Loss (Rate) and High Limit Loss (Rate)

These parameters are set as the test limits for Pressure Loss (Drop) or Pressure Rate of Change tests. The High Limit Loss or Rate is the set point that represents the test specification of *xx* Pressure Loss in *yy* seconds or *zz* loss/sec.

Low Limit Pressure and High Limit Pressure

These parameters are the back-pressure limits for the Occlusion test. Low Limit Pressure represents a high flowing part where the opening is on the high side of the tolerance band. High Limit Pressure represents a low flowing part where the opening is restrictive or on the low side of the tolerance band.

Timer Values within Part Configuration function - Timers

The purposes of the pre-fill, fill, and stabilization times are to increase the internal air pressure from atmospheric to test pressure and allow adequate time for the pressure inside the part and test pneumatics to stabilize. The effect of the fill time upon the stabilization time is discussed below.

When filling the part, the incoming air compresses the atmospheric air inside the part. This causes heat generation due to the initial air in the part being compressed suddenly (adiabatic compression). The pressure in the part will match the regulator pressure during the fill cycle using the relieving characteristics of the regulator to bleed excess pressure or supplying additional air. When the stabilization cycle begins (for pressure decay tests), the test part is isolated from the regulator and the part pressure continues to seek equilibrium in an exponential fashion. The part pressure quickly decreases at first but then slowly decays through the remaining stabilization time and into the test cycle. The amount of decay in the stabilization cycle is moderated by the amount of time spent in the fill cycle.

The pressure loss during stabilization and test is governed by the following:

- The air volume inside the part
- The test pressure
- The thermal conductivity of the part
- The temperature of the part
- The temperature of the incoming fill air
- The ambient temperature conditions
- The elasticity of the part and fixturing
- The absorption characteristics of part construction

The following factors will require a longer stabilization time:

- Larger part air volumes
- Higher test pressures
- Lower thermal conductivity parts
- Greater differences in temperature between the part and ambient air
- Flexible part walls
- Low leak rate requirements

Room temperature variation can affect the repeatability of the system but are usually minimal. This variable can be corrected by more frequent calibration or use of the Environmental Drift Correction feature in the Sentinel I24 instruments.

The fill cycle helps to stabilize the initial rise and fall of pressure in the part by leaving the regulator connected to the part until the end of the fill timer. Adequate time should be put on the fill timer so that the pressure does not drop below the minimum test pressure parameter. Because all pressure loss or flow readings are corrected for deviations from the Target Pressure, it is usually beneficial to get into stabilization quickly as long as the pressure remains above the Minimum Pressure.

The stabilization timer is the time allowed for the temperature and volume of the part to stabilize before the test starts. Enough stabilization time is required by the system so that when calibrating a good part there is not more than 0.1% loss of test pressure during the test timer cycle. Minimizing the pressure loss for a good part during calibration will improve the test repeatability.

The Sentinel I24 instrument has a pressure-streaming feature via the RS232 ports. This feature outputs the test pressure every 0.01 seconds from the start signal through the exhaust cycle. These pressure values can be recorded and plotted via HyperTerminal on most computers and a data program like MS Excel. The plotted curve may assist in setting the timers if you are manually trying to set the timers. More information about the pressure streaming values can be found on page 10-3.

The Auto Setup routine in the Sentinel I24 instrument automatically performs a series of tests to determine the optimal timer settings for Pre-fill, Fill, Stabilization, Test, Exhaust, and Relax to achieve the optimal test within Desired Cycle Time. The Auto Setup routine is addressed on the Function panel of the display keypad.

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Pre-fill Timer

The pre-fill timer serves as an initial check on the tooling and part. It establishes the maximum time allowed for the measured pressure in the part to reach the "Minimum Pressure" value. Once the pressure reaches the "Minimum Pressure", the instrument automatically moves onto the "Fill" timer. This timer is usually set at twice the normal time it takes to reach "Minimum Pressure". A Severe leak error message will occur if the pressure does not reach "Minimum Pressure" within the "Pre-fill" time. There are test failed, severe leak, and part reject outputs at the end of the test cycle and the reject lights go on. Any tooling will retract at the end of the test cycle without using STOP/RESET unless the "Retract on Reject" is set for NO.
There is a selectable digital output that goes high during this timer.

Fill Timer

To begin establishing the amount of time required for fill, set the fill timer initially at 2 seconds for small parts (less than 15 cu. in. or 250 cc. internal volume), or 5 seconds for larger parts. Set the stabilization and test timers initially to 10 seconds each.

When any change is made to the “Fill”, “Stab”, or “Test” timers, the instrument display will indicate “Calibration required” after pushing the START key. An Auto Cal routine must be successfully performed before another test can be run.

Enter all the test parameters and push MONITOR. Push START to initiate a test on the master part. Observe the pressure during the fill cycle. If the fill pressure remains above the minimum test pressure for the duration of the test, reduce the fill timer by 10 to 25%. If the fill pressure dropped below the minimum test pressure, increase the fill timer. Repeat the test on the master part and observe the fill pressure to be sure it remains above the minimum test pressure. Repeat the above to determine an optimal fill time. Once the optimal fill time is set, increase the pressure regulator setting by 1/2%.
When the pressures drops below “Minimum Pressure” during the “stabilization” timer, a “Severe Leak” error message will occur. The “severe leak” and “reject” outputs will go high until the start of the next test. If there is any tooling control and it is programmed to remain clamped on reject, it will require the STOP/Reset to retract the tooling. If the pressure goes above the “Maximum Pressure” during stabilization, “Test Pressure High” error messages will occur at the end of test and the Malfunction output will go high but no test lights go on. Any tooling will retract at the end of the test cycle without using STOP/RESET unless “Retract on Reject” is set No.
There is a selectable digital output that goes high during this timer.

Stab Timer

Before setting the stabilization timer, the fill timer should be set. The optimal settings will minimize the pressure drop for a good part during test. For small parts, initially set the stabilization timer to 5 seconds and the test timer to 3 seconds. For larger parts, set the stabilization and test timers to 10 seconds. Start the test cycle on the master part and watch the pressure during stabilization and pressure loss during test. If the pressure during stabilization drops below the minimum test pressure, increase the fill timer. If the pressure loss during the test cycle is excessive (greater than 0.1% of test pressure), increase the stabilization timer. If the losses during stabilization and test are within acceptable limits, go to the next section, Test timer.
When the pressure drops below “Minimum Pressure” during the “stabilization” timer, a “Severe Leak” error message will occur. The “severe leak” and “reject” outputs will go high until the start of the next test. If there is any tooling control and it is programmed to remain clamped on reject, it will require the STOP/Reset to retract the tooling. If the pressure goes above the “Maximum Pressure” during stabilization, “Test Pressure High” error messages will occur at the end of test and the Malfunction output will go high but no test lights go on. Any tooling will retract at the end of the test cycle without using STOP/RESET unless “Retract on Reject” is set No. There is a selectable digital output that goes high during this timer.

Test Timer

With the "leak standard" value and pressure set in the Test Parameter routine and all parameters set for a test, activate the Auto Cal routine using the AUTO CAL button. At the completion of the "Auto Cal" test routine, review the "Master Part Loss" and "Master+Leak Loss" values stored in the PART CONFIG, Calib Parameter screen. The objective for setting the stabilization and test timers is to achieve a minimum difference between the "Master Loss" and the "Master+Leak Loss" values of 0.050 psi for small parts (<250 cc), 0.020 psi for medium parts, and 0.005 psi for large parts (>15,000 cc) and have the

"Master+Leak Loss" value be at least twice the "Master Loss" value. The fill and stabilization timers affect the "Master Loss" value. The test timer affects the difference between the "Master Loss" and "Master+Leak Loss" values. Adjust the timers to provide the optimal overall time cycle. There is a selectable digital output that goes high during this timer.

Exhaust timer

The purpose of the exhaust timer is to allow air to vent the part before retracting tooling. The time required depends on the test pressure and part volume. The part starts exhausting immediately after the "test" timer expires. Typical times are 1 to 3 seconds. The Exhaust output, which is activated during the exhaust timer, can be used to open an extra exhaust valve to speed up the exhaust process or divert possible dirty part air through an external valve.

Part Mark timer

There are Accept and Reject Mark outputs available to stamp a part at the end of exhaust cycle. Depending on the output(s) selected, these outputs are activated after each test, for accept parts only, or reject parts only. There is a Part Mark feedback input available to confirm to the action..

Relax timer

The relax timer is primarily used as a delay time between the first and second test within the automatic calibration routine and AutoRun routine. Sufficient delay is required so that the part can return to a virgin state before the second test. It does not affect the normal testing cycle time. It needs to be long enough to assure repeatable calibrations. Typical times range from 15 seconds to 8 minutes depending the test pressure and size/material of the part. This timer is also used as the delay time between tests when operating the instrument using "Auto Run".

Quik Test

During calibration the Sentinel I24 stores the master part calibration test data and calculated High limit and Low Limit parameters. At the Quik Test Percent of the Test Timer the instrument measures the pressure loss or flow and compares the projected leak rate from this reading against the specified Quik Test Low Limit and High Limit bands. If the Projected Leak Rate is within either of these two bands, the test continues to the end of the test timer. If the instrument's projected leak rate is outside of these bands, it will stop the test, output the results according to the Test Evaluation criteria, and display the projected leak rate. Quik Test is only available for test types that have an Auto Cal procedure that requires two tests (PLR – Pressure decay, DPD – Differential pressure decay, and FLR – Differential mass flow)

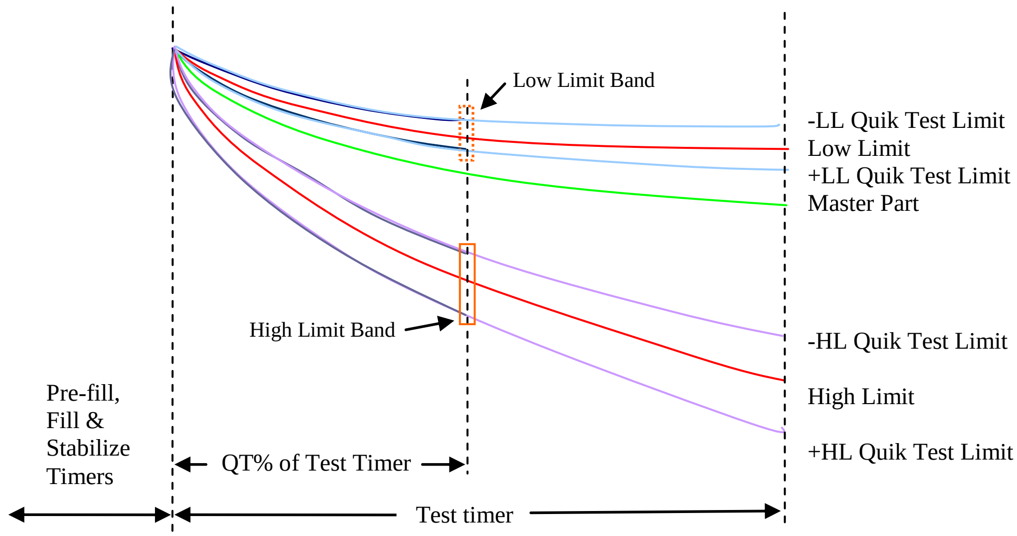

Figure 156 Graphical illustration of Quik Test

The chart above shows the Master Part curve, the Low Limit with its LL Quik Test band limit, and the High Limit with its HL Quik Test band limit. If the pressure loss or flow is within either the LL Quik Test band or HL Quik test band at the QT% of Test Timer, the test will continue and complete the entire test cycle. If the results are outside the limit bands at the QT% of Test Timer, the test will stop and the test result will reflect the Test Evaluation criteria (i.e. F/P/F for **F**ail >HL>**P**ass>LL>**F**ail). Setting narrow bands about the Low Limit and High Limit is a very aggressive approach that will greatly limit the number of tests that run to the end of the test timer. Set wider bands as a more conservative approach to Quik Test.

An initial analysis of Quik Test should be performed before actually implementing this feature by establishing the “QT% of Test Timer” at 10, 25, 50, 75, or 90% and setting “Quik Test “ to OFF. An Auto Cal must be performed after setting the "Quik Test Timer %" to measure the typical leak response curve for the test and determine the response at the Quik Test Timer%. Test production parts over a reasonable time (up to 1000 parts in various production conditions). The instrument projects a leak rate at the Quik Test Timer% and then completes the full test cycle and calculates the leak rate for the complete test. The Sentinel I24 stores up to 5000 test results that include both the actual complete test result and a projected test result based on the Quik Test measurement. By comparing the two leak rate results, a percent of error for the Quik Test feature can be calculated. If the results are satisfactory, the Quik Test feature can be implemented by setting appropriate High Limit and Low Limit Bands based on the test comparison and Enabling Quik Test. This feature will save the time difference between a full test time and the Quik Test Time for almost all of the accepted parts and most of the rejected parts. If the results are not consistent to each other, test further by increasing the Quik Test Timer %, re-calibrate the instrument, and compare the results again.

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Master calibration part

To establish times, perform calibration, or optimization test procedures you must find a master (leak free) part. If possible, this part should be marked and used as a reference whenever calibration is required.

Verify integrity of test circuit and master part

Check that the test circuit and master part are leak free. To do this, place the master part in the tooling fixture and run a test. As soon as the instrument enters the “Test” portion of the leak cycle, press the HOLD key (the display will indicate that the instrument is in HOLD.) Now watch the displayed pressure loss (flow) value. If the part and tooling are indeed leak free, the reading will eventually stabilize around a fixed value. If this does not happen, use a water and soap solution to find the leak. As an interesting experiment, grasp the brass test port with your hand. As the heat of your hand warms the metal, the pressure (flow) in the test circuit increases (the pressure loss on the display decreases).