Vector®

Operator's Manual

Uson

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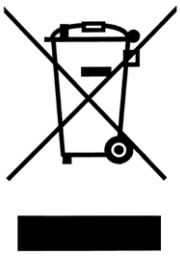


Contents

1 About This Manual

1.1 About This Manual

This manual is for the operators who will be using the Vector in the testing environment and require specific information to run tests.

The definition, setup, and configuration for these tests will have been previously established by the Vector administrator. Administrators may refer to the Vector Administrator's Manual for detailed instructions to use when creating tests.

Users with lower-level passwords may not be able to view all the areas discussed in this manual. Restricted areas are primarily used in tester configuration and set up.

Uson continually strives to improve this manual so that it may best meet the needs of our customers. To share comments or suggestions with Uson, please fill out the comments card on the last page of this manual and return it to Uson.

1.2 Symbols and Conventions

Distinctive symbols and conventions are used throughout this manual to attract the attention of readers. It is especially important to recognize warning and caution symbols associated with potentially hazardous activities.

1.2.1 Notes and Cautions

The following words and symbols, found throughout this manual, mark special messages to alert readers to specific information concerning the protection of personnel, equipment, or processes.

Notes present clarifying information or specific instructions pertinent to the immediate instruction.

Cautions indicate potentially hazardous situations which, if not avoided, may result in minor or moderate injury or damage to data or equipment.

Warnings indicate potentially hazardous situations which, if not avoided, can result in serious injury or death.

Hazardous voltage warnings indicate potentially hazardous situations which, if not avoided, can result in electrical shock, injury, or death as a result of exposure to hazardous voltage.

1.3 Setup Procedures

The Vector is normally setup under the direction of Vector administrator. Whenever directions for setting up for a test are given in this manual, it is assumed that the administrator has granted such privileges. With that in mind, this manual provides information to assist the operator when using the Vector to run test procedures.

Because each test process is unique, Uson provides a set of custom setup procedures and a pneumatic schematic with each tester. These items are packaged with the *As-Built* documentation. The custom procedures may be specific or generalized, depending on individual applications.

Read all procedures carefully.
Information in the *As-Built* documentation always takes precedence over more generalized procedures described in this manual.

1.4 Terms and Abbreviations

Acronyms and abbreviations listed in *Table 1–1* appear throughout this manual and relate either to leak testing generally, or to the Vector specifically.

Technical terms listed in *Table 1–2* may be familiar to many readers, but are listed here for reference.

Mathematical terms listed in *Table 1–3* are also included for reference.

Table 1–1: Acronyms and Abbreviations List

Abbreviation	Description
cPCI	Compact PCI, a specification of the PCI Industrial Computer Manufacturers Group
EDI	External digital input
EDI/O	External digital input/output
EDO	External digital output
EMC	Electromagnetic compatibility
EMI	Electromagnetic interference
FMEA	Failure Mode and Effects Analysis
GND	Ground
IEC	International Engineering Consortium
I/O	Input/output
IR	Infrared
LCD	Liquid crystal display
LCL	Lower control limit
LED	Light emitting diode (used for indicator lights)
LSL	Lower specification limit
LTCU	Leak Test Control Unit
MCU	Master Control Unit
NEMA	National Electrical Manufacturers Association
NIST	National Institute of Standards and Technology

Table 1–1: Acronyms and Abbreviations List (continued)

Abbreviation	Description
OIP	Operator Interface Panel
PC	Personal computer
PICMG	PCI Industrial Computer Manufacturers Group
PDA	Personal digital assistant
PLC	Programmable logic controller
RAM	Random access memory
R&R	Repeatability and reproducibility
SVGA	Super video graphics adapter
TCP/IP	Transmission Control Protocol/Internet Protocol suite of protocols
TCU	Test Control Unit
TFT	Thin film transistor
UCL	Upper control limit
UKAS	United Kingdom Accreditation Service
USB	Universal serial bus
USL	Upper specification limit
VGA	Video graphics adapter
WinXP	Microsoft Windows XP Operating System. Windows is a registered trademark of Microsoft Corporation.

Table 1–2: Technical Measurements List

Term	Definition
GB	Gigabyte
mA	Milliampere
MB	Megabyte
mSec	Milliseconds
mv	Millivolt
V AC	Volts AC

Table 1–2: Technical Measurements List

Term	Definition
V DC	Volts DC

Table 1–3: Mathematical Terms List

Term	Definition
%AC	Appraiser variation percentage relative to RF
AC	Repeatability accuracy
Cg	Gauge potential index
Cgk	Gauge potential index
Cp	Repeatability tolerance factor
Cpk	Repeatability and accuracy
R	Range or spread of results (min-max)
Std	*Standard deviation of test results*

2 Getting Started

2.1 Safety Considerations

If the equipment is used in a manner not specified in this manual, the protection provided by the equipment may be impaired.

Electrical and pneumatic (or air pressure) hazards are the two primary areas of concern when operating leak-testing equipment.

2.1.1 General Safety Guidelines: Electrical Hazards

Disconnect all voltage sources when working with internal components of Uson equipment.
Always exercise caution when working with electricity.

2.1.2 General Safety Guidelines: Pneumatic Hazards

Always wear eye protection when working with pressurized air.
Disconnect all pressure sources when working with internal components of Uson equipment.

Fixture Considerations

Fixture safety considerations vary depending on the fixture being leak tested.[1] However, the following hazards of working with pressurized systems should be given serious consideration before operating the Vector:

- High-pressure pneumatic air systems are exponentially more hazardous as the pressure increases, or as the volume of a system increases. Testing equipment subjected to consistently high-pressure ranges has an increased probability of becoming unable to permanently resist the effects of such pressure.
- Observe caution when working with nonreactive gases or liquids above their boiling points (even at lower pressures), especially when larger

1. Jackson, Charles N., Jr., Sherlock, Charles N., technical editors, and Moore, Patrick O., editor. “Safety Aspects of Leak Testing.” Nondestructive Testing Handbook, third edition: Vol. 1, Leak Testing. Columbus, OH: American Society for Nondestructive Testing (1998): p 136.

volumes of gases are involved. It is essential that relief valves, rupture disks, and pressure regulators are employed to ensure safety.

- Even at moderate pressures, pressurized systems can present a hazard in the form of pressurized air escaping from a leak or a failure. The hazard of flying particles is added when a sight glass or glass flow meter is introduced to the system. The sudden burst of a part could generate sufficient sound concussion to cause hearing damage.

2.1.3 General Safety Issues

The Vector employs an external I/O card to control mechanical and moving parts. If the machine is in an unsafe operating mode, harm to people or equipment may occur.

Perform operations, maintenance, or troubleshooting procedures only after reading and comprehending all manuals and materials supplied with the Vector.

2.2 Vector Operation

The Vector will cycle through a system boot when power is first applied. This process may take several minutes to complete. Boot status displays on the monitor as it progresses. The system is not ready until this boot status information is no longer displayed.

The Vector will then automatically start the Vector Leak and Flow Tester software. The Vector will be in either Configuration or Run Mode. The mode is determined by the position of the key interlock on the Operator Interface Panel (OIP).

If using an external keyboard, the NUM LOCK key must be OFF while in Run Mode to ensure the correct operation of the Reject lamp.

The key interlock is in the Configuration Mode position when it leaves the factory.

2.3 Navigating Vector Menus

There are seven items on the Vector tool bar:

- File
- Setup
- Run
- Service
- Tools
- Window
- Help

Table 2–1: The Vector File menu

Menu Item	Submenu Item	Purpose
File	Open File	**File/Open File** allows users to open and view log files, or to transfer them to another file folder or to a disk. Functionality varies by user access level. Users assigned lower access levels will view a standard ASCII text dialog, but will be limited to accessing the Vector log file. Those assigned higher levels will view a standalone Windows dialog providing greater file access.
	Export Database	**File/Export Database** is intended for use after test set up and configuration to back up the test configurations database at the system level. The system-level backup archives everything the operator has configured and stored. Stored data is then accessible depending on user level.
	Import Database	**File/Import Database** allows users to import test configurations at the system level.
	Password	**File/Password** opens the **Vector System LogIn/Out** dialog through which users can log on to higher access levels than Operator. Password login is only required to perform maintenance tasks, or to alter test parameters or test settings.
	Exit	**File/Exit** opens the **dialog boxes:OS Shutdown** dialog. Clicking **OK** will shut down the entire system. Clicking **Cancel** will shut down only the Vector.

Table 2–2: The Vector Setup menu

Menu Item	Submenu Item	Purpose
Setup	Sequence Setup	**Setup/Sequence Setup** opens the **Sequencer Setup** window, which is where sequence set up occurs.
	Hardware	**Setup/Hardware** opens the **Hardware Setup** window, which is where hardware configuration occurs.
	Leak Calibration	**Setup/Leak Calibration** opens the **Leak Rate Calibration** window, which is where leak rate calibration and leak rate modeling are configured.
	Communication (Only visible if this option was purchased and enabled.)	**Setup/Communications** opens the **Communication Setup** window, which is where Ethernet, Modbus, Profibus-DP, and Interbus-S preferences are set. If this option was not purchased and enabled, it is not possible to select this menu option.

Table 2–3: The Vector Run Menu

Menu Item	Submenu Item	Purpose
Run (Available only in Run Mode)	Sequence Select	**Run/Sequence Select** opens the **Sequence/ Test Select Form** window, which is where sequences and tests are selected, loaded, and run.
	Single Channel	**Run/Single Channel** opens the **Single Channel** run window, which displays testing progress and results in the Run Mode.
	Simple	**Run/Simple** opens the simple run window, which features a minimal display including LED indicators to indicate accept and reject results.
	Active Process (Only visible if this option was purchased and enabled.)	**Run/Active Process** opens one of four active process windows configured at the factory. These windows display testing progress and results in a stylized visual format simulating the mechanical processes involved in testing as they occur in real time.

TABLE 2–4: THE VECTOR SERVICE MENU

MENU ITEM	SUBMENU ITEM	PURPOSE
Service	Diagnostics (Available only in Configuration Mode)	**Service/Diagnostics** opens the **Tester Diagnostics** window, which contains seven tabs, each corresponding to a separate window displaying a diagnostic tool or tools. See Section 5.2, *Vector System Diagnostic Tools*, for detailed information on the Vector's diagnostic tools.
	Site Configuration (Available only in Configuration Mode)	**Service/Site Configuration** opens the **Site Configuration** window. Three tabs, **Site Information**, **Hardware Information**, and **Directories**, provide space for entering and storing site, hardware, and data logging information.

TABLE 2–5: THE VECTOR TOOLS MENU

MENU ITEM	SUBMENU ITEM	PURPOSE
Tools	Repeatability Trials (Available only in Run Mode)	**Tools/Repeatability Trials** opens the **Repeatability Study Configuration Setup** window, which is used to configure repeatability trials used to diagnose possible problems with the tester. See Chapter 4, *Testing*, for detailed information on this tool.
	PD Test Calc	**Tools/PD Test Calc** opens the **Pressure Decay Leak Test Calculator** window. See Section 5.6.2, *Pressure Decay Leak Test Calculator*, for detailed information on this tool.
	Virtual Leak Calc	**Tools/Virtual Leak Calc** opens the **Virtual Leak Calculator** window. See Section 5.6.3, *Virtual Leak Calculator*, for detailed information on this tool.
	Statistics	**Tools/Statistics** opens the **Statistics** window. See Section 5.6.5, *Statistics*, for detailed information on the Vector's statistical tools.

Table 2–6: The Vector Window menu

Menu Item	Submenu Item	Purpose
Window	Minimize	**Window**/**Minimize** reduces the current Vector window to a small rectangle above the Windows task bar at the bottom of the screen. To restore the window to its normal size, click the rectangle and select **Restore**.

Table 2–7: The Vector Help menu

Menu Item	Submenu Item	Purpose
Help	About	**Help**/**About** displays information about the Vector Leak and Flow Tester software.
	Vector Manual	**Help**/**Vector Manual** opens an electronic version of the Vector *Operations Manual*.

2.4 Getting Help

Uson has made every effort to provide user-friendly equipment and clear, easy-to-understand operating instructions. Nevertheless, questions may arise about the equipment or procedures. The answers to such questions may be found by using the resources described below.

2.4.1 Online Help

Help is available online:

- Press the Information option key  to view an electronic copy of the Vector *Operations Manual.*

2.4.2 Printed Documents

Read the *Vector Operator's Manual* carefully for descriptions of procedures and information to use if troubleshooting is necessary. The Vector *Installation Manual* provides detailed information on installing and preparing each Vector model for initial use, and *As-Built* documentation provides detailed customized information, including schematics.

2.4.3 Uson Service Personnel

Users may also contact the Uson technical staff for assistance. Please have the following information available for reference before calling:

- Contact information, including telephone numbers and e-mail addresses
- The Vector's model number and serial number
- Detailed information on the problem at hand, including any error message text

Contact Uson's Service Manager by phoning (281) 671-2000 between the hours of 8 a.m. and 5 p.m., CST. The Service Manager will gather information about the problem, evaluate the situation, assign a tracking number, and schedule service resources as required.

2.5 Operator Interface Panel

The Operator Interface Panel (often abbreviated as OIP) functions as the primary user interface. Through it, users can configure the tester, set up communications to external devices, and run tests. With the built-in, limited-function keyboard and mouse, users can perform any necessary data entry and menu selections. An external, full-function keyboard and mouse can be plugged in to either the USB port (recommended) or into the keyboard/mouse PS2 ports on the back panel.

There are two basic display options for the Operator Interface Panel:

- **3C**: 7-inch VGA liquid crystal display (LCD)
- **6C**: 12.1-inch super video graphics adapter (SVGA) flat panel thin film transistor (TFT) display
- Pendant-mounted remote monitor

The larger, color monitors used in the 6C and Remote Monitors allow the operator to take full advantage of the Windows environment in which large, color forms are displayed and user interaction is essential.

If an external keyboard is used, NUM LOCK must be OFF otherwise the Reject lamp may not work properly.

2.6 Introduction to Testing

Tests, such as leak tests, for example, consist of individual steps. The standard steps for a basic leak test are:

- Fill: Pressurizes the part
- Isolate: Valves close to isolate the part and prevent pressure loss
- Stabilize: Dissipation of the effects of adiabatic heating
- Test: Monitors and records the test part leak rate
- Exhaust: Vents the test part to zero pressure

Each step is controlled by test limits and other parameters that determine its behavior. Test parameters, initially installed by Uson, can be altered by the Vector administrator. The optional step editing feature allows the administrator to customize the standard test. A variety of other step types can be built into a test, depending on the test method used.

2.7 Quick Operator Instructions

The following condensed instructions summarize areas that are covered in detail in later sections of this manual.

2.7.1 Initial Startup

Connect the provided power cord to an approved voltage power source.

Connect a filtered, dry-air source to the Vector pneumatics input.

Turn on the power by using the switch located on the rear of the Vector tester electronics unit.

When power is first applied, the Vector will cycle through a system boot, which may take a few minutes to complete. The Vector will open directly to the Vector Leak and Flow Tester software in either Configuration Mode or Run Mode.

Configuration Mode: **Key switch in the horizontal position**
Run Mode: **Key switch in the vertical position**

Main power must be shut off prior to removal of any MCU, LTCU, or External I/O card.

2.7.2 Passwords

The Vector defaults to Level 5: Operator upon initial boot. Maintenance personnel can use the default passwords to access different functions within the tester and can also change the passwords. Default passwords are set at the factory, with a different password for each level of security. Complete instructions for configuring passwords are included in Chapter 2, Getting Started of the Vector Operations Manual. The default passwords are as follows:

- Access Level 2 = is
- Access Level 3 = m1
- Access Level 4 = m2

2.7.3 External Keyboard

For complex programming, Uson suggests the use of an external keyboard and mouse plugged into the USB port on the MCU board. The operator panel keyboard and mouse connections must not be removed.

2.7.4 Transducer Zero and Span

The system pressure transducers have been calibrated during system checkout. It is not necessary to recalibrate transducers upon initial tester setup.

2.7.5 Seal Leak Tests

The pneumatics shipped with the Vector tester have been checked for leak-tight integrity at the factory. The addition of tubing, a test fixture, and a test part should also be checked before performing any calibration functions. A seal leak test has been programmed and provided within the Vector tester. The seal leak test should be loaded and performed on each test channel. Refer to Chapter 5, *Diagnostics and Leak Tester Troubleshooting* for more detailed information on seal leak tests.

2.7.6 Pressure Decay Leak Rate Calibration

Calibrating the tester is an important process necessary to deliver accurate and repeatable leak rate measurements. Leak rate calibration is necessary when conducting leak tests using a pressure decay method and converting the pressure change to a leak rate. Calibration of the Vector unit is detailed in Chapter 3, *Leak Rate Calibration*.

Comp and Cal

The Comp and Cal Leak Rate Calibration method converts a pressure change to a flow based on "teaching" the system the difference between a non-leaking part and a part with a known leak rate. When using this method, a calibrated Leak Master is used as a reference.

Comp and Cal Leak Rate Calibration is a two-step process. First, the test is run with a non-leaking master part to establish the characteristic pressure change of the part and the pneumatic system. This result is referred to as the Comp value. The second test is run with a Leak Master to introduce a known leak to the master part. This process establishes pressure loss caused by a leak, and the resulting value is referred to as Cal.

Leak rate calibration is necessary for each channel and after creating a new test. Re-calibration will also be necessary after making program changes, installing a new sensor, and replacing sealing components.

Set Compensation

In the **Config** mode, open the **Leak Rate Calibration** window by clicking the **Leak Cal** button, or by selecting **Setup/Leak Calibration** from the Vector menu. Use the following procedure to run compensation:

1. Select **Leak Rate Calibration** in the **Function Select** area.
2. In the **Comp/Cal Select** area, select **Compensation**.
3. Enter a calibrated leak rate in the **Calibrated Leak Rate** field. This is the leak or flow rate to which the test will calibrate. The default unit of measure for this field is sccm.
4. Access a menu of available tests to run by clicking the arrow beside the **Select A Test** field. Click a test name to select it. The selected test name displays in the **Select A Test** field, and the **Start Comp** button below the field is enabled.
5. Start the Comp Test by clicking the **Start Comp** button.

If a calibrated leak rate has not been previously defined for the selected test, the Vector will prompt the operator to enter that information.

The test is run and test progress displays in real time in the **Comp/Cal Results** area. When testing is complete, the tester returns a Comp value in the **Comp Value** field.

After running compensation, the next step is running calibration to determine a leak rate Cal value.

Set Calibration

The procedure for running calibration is similar to the procedure for running compensation. Open the **Leak Rate Calibration** window by clicking the **Leak Cal** button, or by selecting **Setup/Leak Calibration** from the Vector menu.

Use the following procedure to run calibration:

1. Select **Leak Rate Calibration** in the **Function Select** area.
2. Select **Calibration** in the **Comp/Cal Select** area.
3. Insert the Leak Master (or the known-leak master part) into the Leak Master port (if applicable).
4. Start the Cal Test by clicking the **Start Cal** button.

The Vector runs the test and displays testing progress in real time in the **Comp/Cal Results** box. At the conclusion of the Cal Test, test sensitivity and Comp/Cal ratio are calculated and displayed in the **Sensitivity Index** field.

Concluding a Leak Test

Once the Comp and Cal values have been determined, they can be cancelled in order to rerun Comp and Cal, or they can be saved using one of two save options:

- Click the **Save** button to save the Comp and Cal values with the currently selected test. Once this option is selected, the **Repeat Comp/Cal** button displays at the bottom of the window. Click this button to rerun Comp and Cal if necessary.
- To save the values as a baseline, click the **Save As Baseline** checkbox and then click the **Save** button. Once this process is completed, the **Repeat Comp/Cal** button displays at the bottom of the window. Click this button to rerun Comp and Cal if necessary.

Comp and Cal can be run again if leaks are found, or if test parameters such as pressure or step time change. Better Comp and Cal values translate into more repeatable and faster production testing.

Leak Test Calibration Challenge

Upon completion of calibration, challenge the calibration of each test group or channel. The challenge should consist of both the leak and non-leak functions of the program.

1. Load the leak test to be challenged.
2. Select Run mode and install a known-good test part in the test fixture.
3. Install the certified leak master and start a test cycle. The end test result displayed should be the value of the leak master (e.g. 10.0 cc) ± 10% of the calibrated leak rate. The test cycle should fail and the red fail light should be on.
4. Remove the calibrated leak master and start another test cycle. The end test result should be 0.00 cc ± 10% of the calibrated leak rate. The programmed leak rate value should be the same as the calibrated orifice used. The test cycle should pass and the green pass light should be on.

2.7.7 Mass Flow Test Calibration

Comp and Cal

The Comp and Cal Leak Rate Calibration method converts a pressure change to a flow based on "teaching" the system the difference between a non-flowing part and a part with a known flow rate. When using this method, a calibrated Flow Master is used as a reference.

Comp and Cal Flow Rate Calibration is a two-step process. First, the test is run with a non-flowing master part to establish the characteristic zero flow rate of the part and the pneumatic system. This result is referred to as the Comp value. The second test is run with a Flow Master to introduce a known flow to the master part. This process establishes the actual flow rate, and the resulting value is referred to as Cal.

Flow rate calibration is necessary for each channel and after creating a new test. Re-calibration will also be necessary after making program changes, installing a new sensor, and replacing sealing components.

Set Compensation

In the Config mode, open the **Leak Rate Calibration** window by clicking the **Leak Cal** button, or by selecting Setup/Leak Calibration from the Vector menu. Use the following procedure to run compensation:

1. Select **Leak Rate Calibration** in the **Function Select** area.
2. In the **Comp/Cal Select** area, select **Compensation**.
3. Enter a calibrated flow rate in the **Calibrated Leak Rate** field. This is the flow rate to which the test will calibrate.
4. Access a menu of available tests to run by clicking the arrow beside the **Select A Test** field. Click on a test name to select it. The selected test name displays in the **Select A Test** field, and the **Start Comp** button below the field is enabled.
5. Start the Comp test by clicking the **Start Comp** button.

If a calibrated flow rate has not been previously defined for the selected test, the Vector will prompt the operator to enter that information.

The test is run and test progress displays in real time in the **Comp/Cal Results** area. When testing is complete, the tester returns a Comp value in the **Comp Value** field.

After running compensation, the next step is running calibration to determine a flow rate Cal value.

Set Calibration

The procedure for running calibration is similar to the procedure for running compensation. Open the **Leak Rate Calibration** window by clicking the **Leak Cal** button, or by selecting **Setup/Leak Calibration** from the Vector menu.

Use the following procedure to run calibration:

1. Select **Leak Rate Calibration** in the **Function Select** area.
2. Select **Calibration** in the **Comp/Cal Select** area.
3. Insert the Flow Master (or the known-flow master part) into the Flow Master port (if applicable).
4. Start the Cal test by clicking the **Start Cal** button.

The Vector runs the test and displays testing progress in real time in the **Comp/Cal Results** box. At the conclusion of the Cal test, test sensitivity and Comp/Cal ratio are calculated and displayed in the **Sensitivity Index** field.

Concluding a Flow Test

Once the Comp and Cal values have been determined, they can be cancelled in order to rerun Comp and Cal, or they can be saved using one of two save options:

- Click the **Save** button to save the Comp and Cal values with the currently selected test. Once this option is selected, the **Repeat Comp/Cal** button displays at the bottom of the window. Click this button to rerun Comp and Cal if necessary.
- To save the values as a baseline, click the **Save As Baseline** checkbox and then click the **Save** button. Once this process is completed, the **Repeat Comp/Cal** button displays at the bottom of the window. Click this button to rerun Comp and Cal if necessary.

Comp and Cal can be run again if leaks are found, or if test parameters such as pressure or step time change. Better Comp and Cal values translate into more repeatable and faster production testing.

Flow Calibration Challenge

Upon completion of calibration, challenge the calibration of each test group or channel. The challenge should consist of both the flow and non-flow functions of the program.

1. Load the Flow test to be challenged.
2. Select Run mode and install a known-good test part in the test fixture.
3. Install the certified flow master and start a test cycle. The end test result displayed should be the value of the flow master (e.g. 10.0 cc) ± 10% of the calibrated leak rate. The test cycle should fail and the red fail light should be on.
4. Remove the calibrated flow master and start another test cycle. The end test result should be 0.00 cc ± 10% of the calibrated flow rate. The programmed flow rate value should be the same as the calibrated orifice used. The test cycle should pass and the green pass light should be on.

2.7.8 Successful Leak Testing

In order to maintain a safe working environment and to conduct successful leak testing, users should read and understand the following guidelines for operating the Vector:

Table 2–8: Successful Leak Testing

Always	Never
Always back up test data on a diskette before upgrading tester software.	Never calibrate without first running and passing a Seal Leak Test.
Always disconnect power sources before removing or installing an electronic module or chassis.	Never load a test into a tester that does not have a compatible software level.
Always verify the Leak Master before calibrating the tester.	Never leak rate calibrate the tester with anything other than a non-leaking master part verified with a Seal Leak Test.
Always verify master parts, pressure gauges and Leak Masters personally before operating the tester.	Never calibrate the tester without recording all previous (known-good) compensation/calibration values.
Always calibrate the tester with a Leak Master installed.	Never compensate the tester with a Leak Master (or any other leak) installed.
Always challenge the tester after any calibration or test setup change has been performed.	Never allow inexperienced personnel to calibrate or troubleshoot leak-testing equipment.
Always back up tester data on a diskette after successful calibration and set up.	Never rely on memory; instead, document all settings and calibration information.
After making changes, always check each parameter before operating the tester.	

2.7.9 Leak-Testing Terminology

Table 2–9 lists and defines common leak-testing terminology.

Table 2–9: Leak-Testing terminology

Term	Definition
ALD	Advanced Leak Detector
ER	An electronic regulator that responds to a command through the LTCU analog output. There are two modes for this operation: open loop and closed loop.
Event	A user-defined occurrence
Limit	A user-defined boundary
Sample limits	Limit tests conducted for each sample • Sample min and max: Two limits working together as a window at the sample level. If the sample measurement value is within the window (between the minimum and maximum values) the result is true. Otherwise, it is false. • Sample threshold: A sample value is compared to a user-defined level or value. If the value is higher than the threshold, the test is true. Otherwise, it is false.
Spike limits	Two types of spike limits are defined for the Vector: • Min / max: The min and max limits (lower and upper boundaries) work together as a window. If the sample measurement value falls within the window (between the minimum and maximum values), the condition is true. If the sample measurement is outside of these limits, the condition is false. • Threshold: The threshold is a user-defined level or value. The sample measurement value is compared to a threshold value. If the sample measurement value is above the threshold value, the condition is true. If the sample measurement value is below the threshold value, the condition is false.
Step jump	A step to which the test jumps based on an accept or reject value
Step limits	Limit steps conducted at the end of a step period • Step min and max: Two limits working together as a window at the step level. If results fall within the window (between the minimum and maximum values) the result is true. Otherwise, it is false. • Step threshold limits: A value at the end of a step is compared to a user-defined level. If the value is higher than the threshold, the test is true. Otherwise, it is false.
Step termination	The end of a test step based on one of three things: time, an event, or a state.
Q-DAS Export File	An optional Vector feature that is used to create a file for use in Q-DAS quality management applications.

Notes:

3

Leak Rate Calibration

This chapter provides information on leak calibration, including the following topics:

3.1 Introduction to Leak Rate Calibration

Calibrating the test is a mandatory process necessary to deliver accurate and repeatable leak rate measurements. Before calibrating the test, ensure that all necessary hardware has been configured and calibrated. Refer to the Vector *Installation Manual* and to *As-Built* documentation for additional installation and configuration instructions.

The Vector offers the Compensation (Comp) and Calibration (Cal) method of Leak Rate Calibration.

A test using the following step types report a calculated result that requires comp and cal as part of the calculation; therefore, these require calibration:

- Classic leak
- Mass Flow
- Mass Flow w/o Comp
- Measure Change with Comp

A test using the following steps does not require calibration:

- Flow
- Measure Change

Leak Rate Calibration is necessary:

- When certain test parameters have changed
- When a new sensor is installed

leak rate calibration:Comp and Cal can be performed in each of two modes, with two options available for each mode. The Comp and Cal modes and options are:

- Configuration Mode
  - Comp and Cal by an individual test
  - Comp and Cal by all tests in sequence
- Run Mode
  - Run Time Comp and Cal option
  - Run Time Sequence Setup option

The Comp and Cal Leak Rate Calibration method converts a pressure change to a flow based on “teaching” the system the difference between a non-leaking part and a part with a known leak rate. When using this method, a calibrated Leak Master is used as a reference.

Leak Cal is not allowed at the Operator level (Level 5 password).

Comp and Cal Leak Rate Calibration is a two-step process.

1. The test is run with a non-leaking master part to establish the characteristic pressure change of the part and the pneumatic system. This result is referred to as the **Comp** value.
2. The test is run with a non-leaking master part and a calibrated Leak Master to introduce a known leak to the master part. This process establishes pressure loss caused by a known, calibrated leak, and the resulting value is referred to as **Cal**.

Step types using Comp and Cal in calculations include Classic Leak Step, Mass Flow (converted to flow rate w/ Comp Cal), Mass Flow (converted to flow rate with Cal No Comp), and Measure Change w/ Comp.

3.1.1 Leak Rate Conversion formula

The leak rate conversion formula used in the Classic Leak step type is:

$$LR_{test} = \frac{EndMeasure_{test} - Tare_{test} - Comp}{EndMeasure_{cal} - Tare_{cal} - Comp} \bullet LR_{cal}$$

Where:

Tare = Measurement at the start of the step

EndMeasure = Measurement at the end of the step

$Comp = EndMeasure_{comp} - Tare_{comp}$ = Pressure change using a non-leaking master part

$Cal = EndMeasure_{cal} - Tare_{cal} - Comp$ = Pressure loss due to adding a known leak to the master part

LR_{cal} = Leak Master Rate (user-entered value Cal Rate)

The Leak Rate Calibration method is based on the operator's desired test-result format, accuracy, and degree of repeatability.

Leak Rate Calibration is not necessary for mass flow measurements. However, it can be used to compensate for adiabatic heating effects.

3.1.2 Mass Flow Formula

The limits for the Mass Flow step are checked against the mass flow obtained at the end of the step. The Mass Flow formula is similar to Leak step except that the tare value is not used.

$$\text{Flow} = \frac{\text{EndMeasure}_{\text{test}} - \text{Comp}}{\text{Cal}} \bullet \text{LR}_{\text{cal}}$$

Where:

$\text{Comp} = \text{EndMeasure}_{\text{comp}}$

$\text{Cal} = \text{EndMeasure}_{\text{cal}} - \text{EndMeasure}_{\text{comp}}$

LR_{cal} = Leak Master Rate (user-entered value Cal Rate)

3.1.3 Mass Flow No Comp Formula

The Mass Flow No Comp calculation is the same as for Mass Flow except that the Comp value is not used.

$$\text{Flow} = \frac{\text{EndMeasure}_{\text{test}}}{\text{Cal}} \bullet \text{LR}_{\text{cal}}$$

Where:

$\text{Cal} = \text{EndMeasure}_{\text{cal}}$

LR_{cal} = Leak Master Rate (user-entered value Cal Rate)

3.1.4 Measure Change Formula

The limits for the Measure Change with Comp Step are checked against the ΔMeasure value instead of the EndMeasure value.

$$\Delta\text{Measure} = \text{EndMeasure}_{test} - \text{Tare}_{test} - \text{Comp}$$

Where:

Tare = Measurement at the start of the step

EndMeasure = Measurement at the end of the step

$$\text{Comp} = \text{EndMeasure}_{comp} - \text{Tare}_{comp}$$

3.2 Comp and Cal Leak Rate Calibration

Comp and Cal can be performed in the Config Mode or the Run Mode. In Config Mode, Comp and Cal can be run by Test or by Sequence; in Run Mode, it can be run as Run Time Comp and Cal, or by using the Run Time Sequence Setup option.

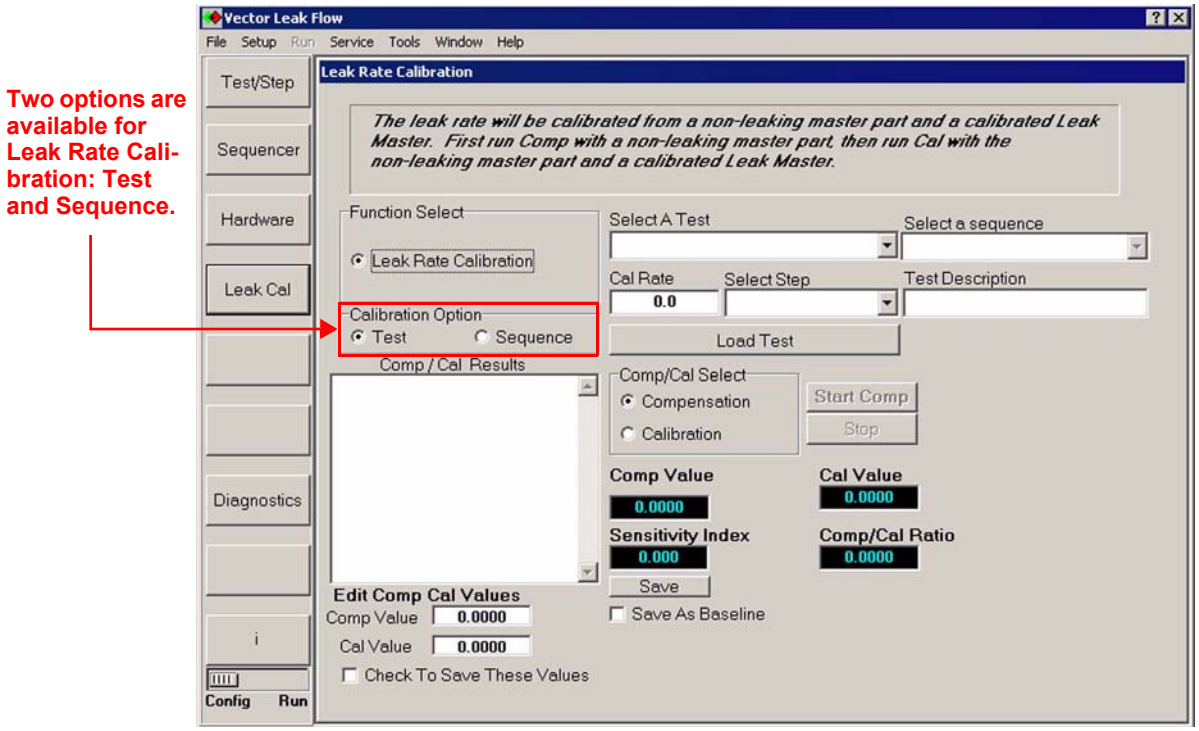
3.2.1 Comp and Cal in Config Mode

Open the **Leak Rate Calibration** window by clicking the **Leak Cal** button, or by selecting **Setup/Leak Calibration** from the Vector menu.

Comp and Cal in **Config** Mode can be run by **Test** or by **Sequence**. These two options are available in the **Calibration Option** area of the **Leak Calibration** window. **Test** is selected by default.

The two options — Test and Sequence — may yield different test results, even when the same tests are used due to *the adiabatic effect* and to the compliance of the material of the part being tested (See *"Recognizing Adiabatic Heating and Elastic Creep" on page 5-10.*) When using the Test option, a lag between tests will create conditions that are different from the conditions that exist when running tests in sequence.

Figure 3–1: Leak Rate Calibration



3.2.1.1 Config Mode Comp by Test

Before starting the test, ensure that the test part is properly set up and fixtured. Ensure that the system has no leaks, and that the test part is a non-leaking master part.

Undetected leaks will invalidate the results.

Once the test is started, air pressure will be applied.

Use the following procedure to run compensation:

1. Select **Leak Rate Calibration** in the **Function Select** area.
2. Select the **Test** option in the **Calibration Option** area.
3. Access a menu of available tests to run by clicking the arrow beside the **Select A Test** field. Click on a test name to select it. The selected test name displays in the **Select A Test** field.
4. If a new Cal Rate is to be entered, select the required leak step from the **Select Step** option and enter the Cal Rate in the **Cal Rate** field.

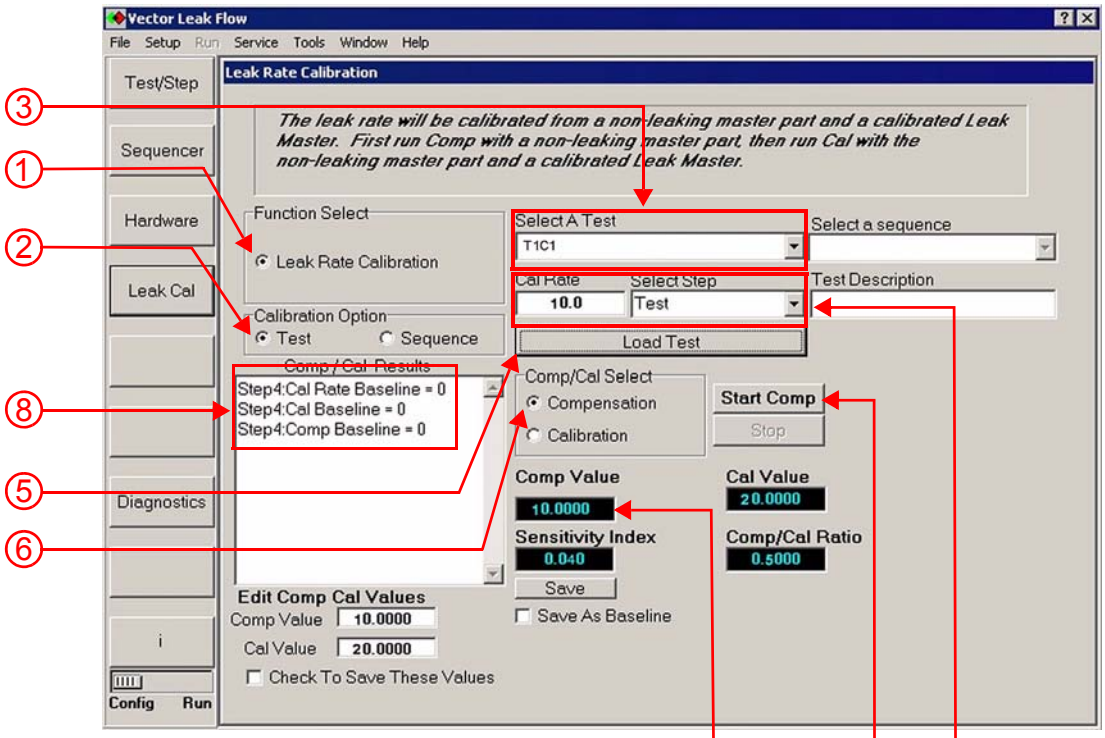
Cal Rate is used as a part of the calculation and is checked so that the calculated steps store all parameters needed as part of the final result calculation. Step types using Comp and Cal in calculations include Classic Leak Step, Mass Flow (converted to flow rate w/ Comp Cal), Mass Flow (converted to flow rate with Cal No Comp), and Measure Change w/ Comp. The other step types do not require a Cal Rate. Calculated steps must have a Cal Rate or an error message will appear.

5. Click **Load Test**, as shown in *Figure 3–2*.
   The **Start Comp** button is enabled, and the Comp/Cal baseline values for the graded step will be displayed in the **Comp/Cal Results** window.

A valid Comp value must be obtained before acquiring a Cal value.

6. In the **Comp/Cal Select** area (see *Figure 3–2*), select **Compensation** (the default setting).
7. Start the Comp Test by clicking the **Start Comp** button.
8. The test will run and test progress will be displayed in real time in the **Comp/Cal Results** area.
9. When testing is complete, the tester returns a Comp value in the **Comp Value** field. (See *Figure 3–3*.)

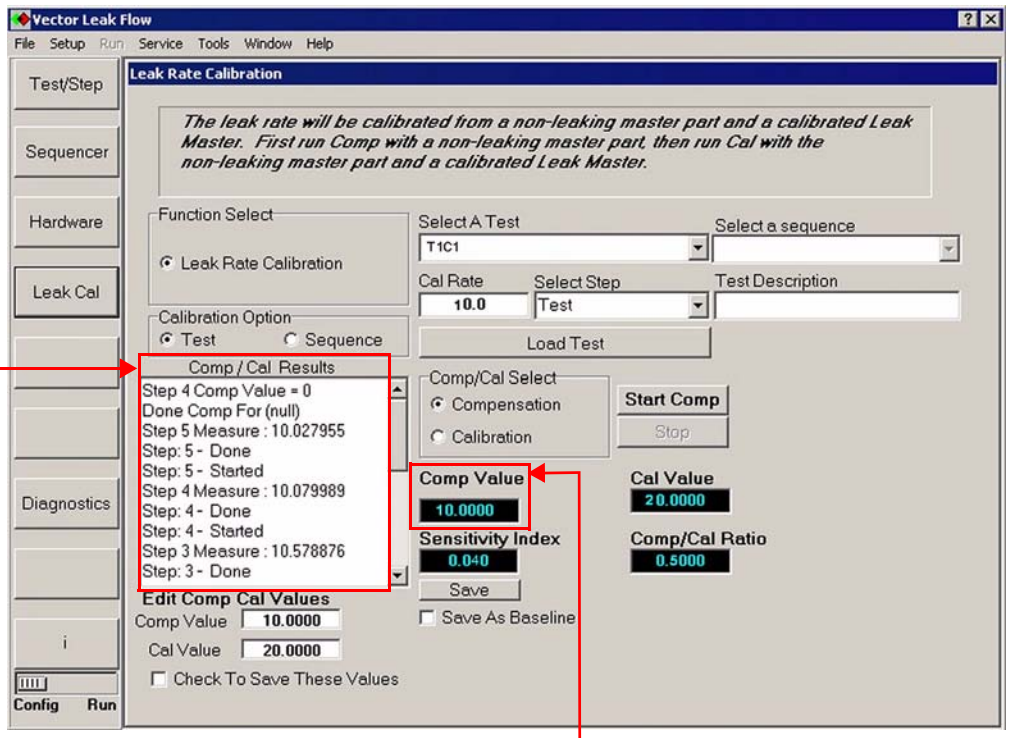
FIGURE 3–2: CONFIG MODE COMP BY TEST



1. Select Leak Rate Calibration
2. Select Test in Calibration Option
3. Select a test from the list
4. If modifying Cal Rate value, select the step and enter Cal Rate
5. Click Load Test
6. Select Compensation
7. Click the Start Comp button
8. Results for the graded step display in the Comp/Cal Results window
9. Comp Value result

Loading the test enables the Start Comp button

FIGURE 3–3: RUNNING COMP BY TEST



Test progress displays in the Comp/ Cal Results window

When the test is finished, a Comp Value displays in the Comp Value field

The sensitivity index is calculated by:

$$\text{Sensitivity} = \frac{\text{Cal Value}}{\text{Sensor Span}} \times 100\%$$

For pressure decay testing, the sensitivity calculated by the tester, which is based on span, should be at least 0.05% of full scale range of the sensor associated with this step for a high sensitivity tester (an option purchased separately), or 0.2% of full scale range of the sensor associated with this step for a low sensitivity tester. The Comp/Cal Ratio should be less than 2.0. The tester will not show good repeatability during production if these values are outside recommended ranges. See *Chapter 6, Repeatability Studies*, for information on improving repeatability.

After running Comp, the next step is running Cal to determine a leak rate Cal value.

3.2.1.2 Config Mode Cal by Test

The procedure for running calibration using the test option is similar to the procedure for running compensation.

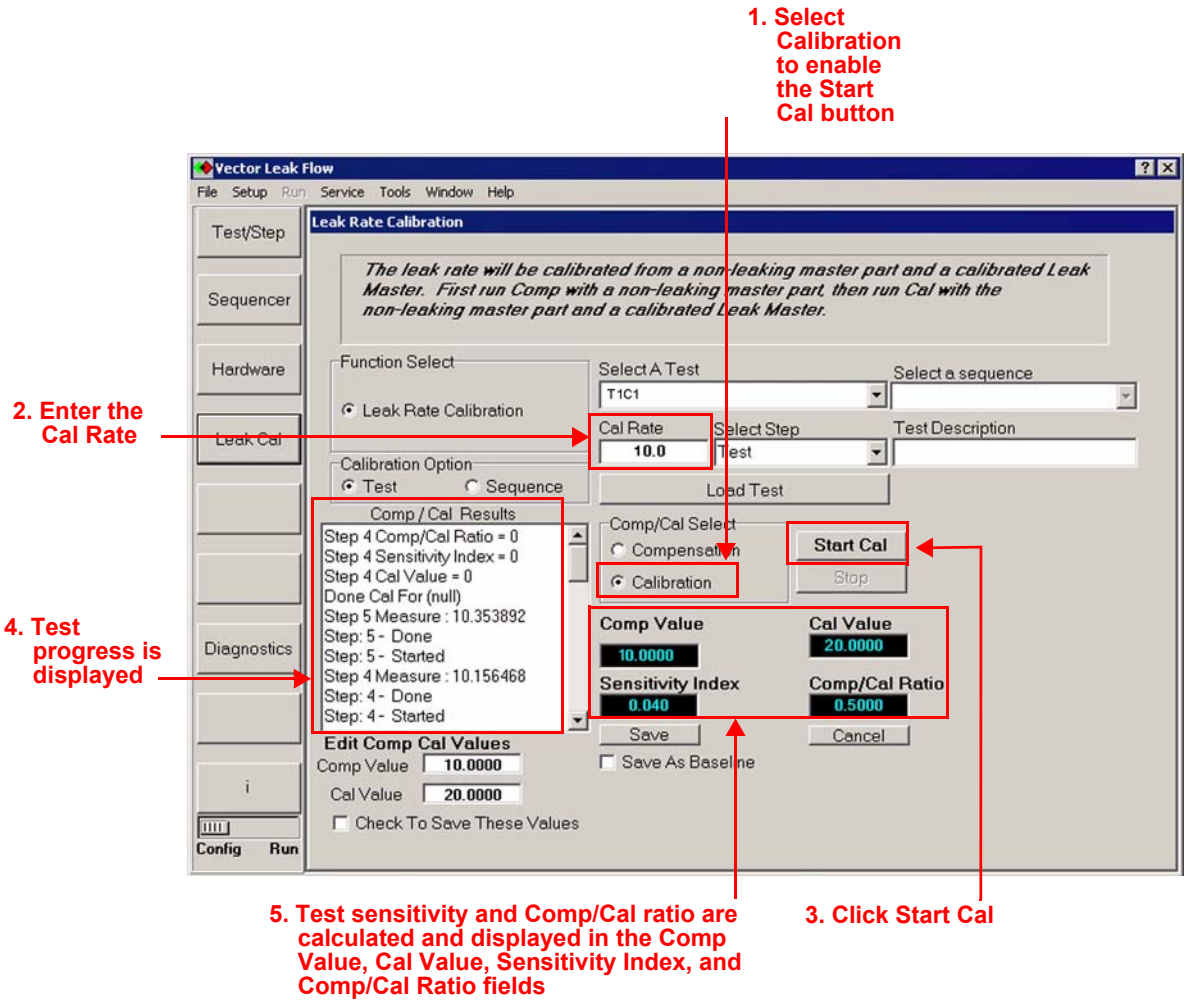
After running compensation, use the following procedure to run calibration:

1. Select **Calibration** in the **Comp/Cal Select** area. The **Start Cal** button is enabled. (See *Figure 3–5*.)
2. Insert the Leak Master (or the known-leak master part) into the Leak Master port (if applicable). This known-leak rate should match the value entered as the Cal Rate.
3. Start the Cal Test by clicking the **Start Cal** button.
4. The Vector will run the test, and the test progress will be displayed in real time in the **Comp/Cal Results** window.
5. At the conclusion of the Cal Test, test sensitivity and Comp/Cal ratio are calculated and displayed in the **Sensitivity Index** and **Comp/Cal Ratio** fields. (See *Figure 3–5*.)

If selecting the Cal option without running Comp (if Comp is needed), an error message will be displayed: "Comp should be run before Cal." (See *Figure 3–4*.)

Figure 3–4: Cal Warning Message

FIGURE 3–5: RUNNING CALIBRATION BY TEST



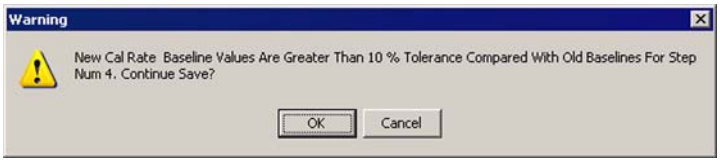
3.2.1.3 Concluding Comp/Cal by Test

Once the Comp and Cal values have been determined, they can be cancelled in order to rerun Comp and Cal, or they can be saved using one of two save options:

- Save Comp and Cal values
  Click the **Save** button to save the Comp and Cal values with the currently selected test. After saving, the **Repeat Comp/Cal** button displays at the bottom of the window. Click this button to rerun Comp and Cal if necessary.
- Save Comp and Cal values with save as baseline option
  Optionally, the Comp and Cal values can be saved for future reference. Check the **Save as Baseline** box before clicking the **Save** button to save the Comp and Cal values with the currently selected test as well as to save them as a baseline. After saving, the **Repeat Comp/Cal** button displays at the bottom of the window. Click this button to rerun Comp and Cal if necessary.

If the new baseline values saved are not within 10% of the old baseline values, a warning message will display, as shown in *Figure 3–6*.

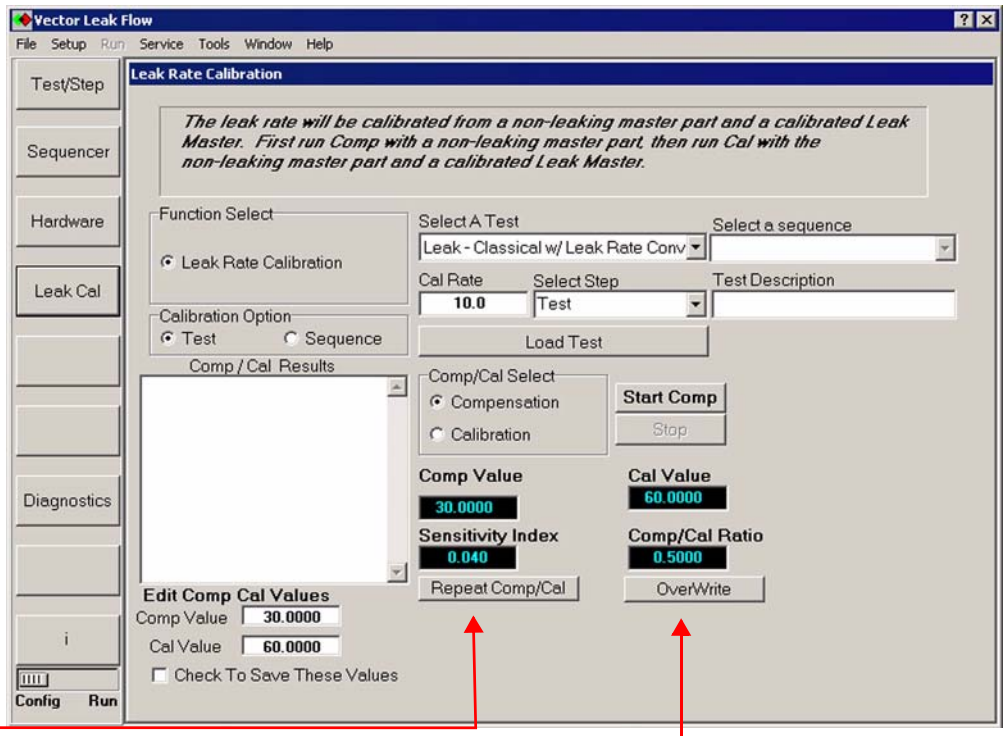
Figure 3–6: Warning message



Comp and Cal can be run again if leaks are found, or if test parameters such as pressure or step time change. Accurate Comp and Cal values translate to repeatable and fast production testing.

Comp/Cal and Cal Rate values are written to the Maintenance Log after saving. The Log can be viewed in Diagnostics. (See Section 5.2, *Vector System Diagnostic Tools*)

FIGURE 3–7: CONCLUDING A TEST



The Repeat Comp/Cal button displays after Saving the Comp/Cal values. Click Repeat Comp/Cal to rerun Comp and Cal

Click the OverWrite button to replace the Comp and cal values with the baseline values in the database.

3.2.1.4 Interpreting Comp/Cal by Test Results

Divide the Comp value by the Cal value to arrive at a Comp/Cal ratio.

$$\text{Comp/Cal Ratio} = \frac{\text{Comp Value}}{\text{Cal Value}}$$

The ratio should be less than 2.0.

Adequate values for leak sensitivity indices in pressure decay testing are:

- > 0.05% of test pressure for high sensitivity, and
- > 0.2% of test pressure for low sensitivity.

$$\text{Sensitivity} = \frac{\text{Cal Value}}{\text{Sensor Span}} \times 100\%$$

The tester may not have good repeatability if these values are outside of the recommended ranges.

To increase the sensitivity index and improve repeatability, increase the test time of the **Test Step** and rerun the compensation and calibration procedures.

To lower the Comp/Cal ratio, increase the test time of the **Stabilize Step** and rerun the compensation and calibration procedures.

3.2.1.5 Editing Comp and Cal values

Comp and Cal values can be edited without running a test. This feature may be used when:

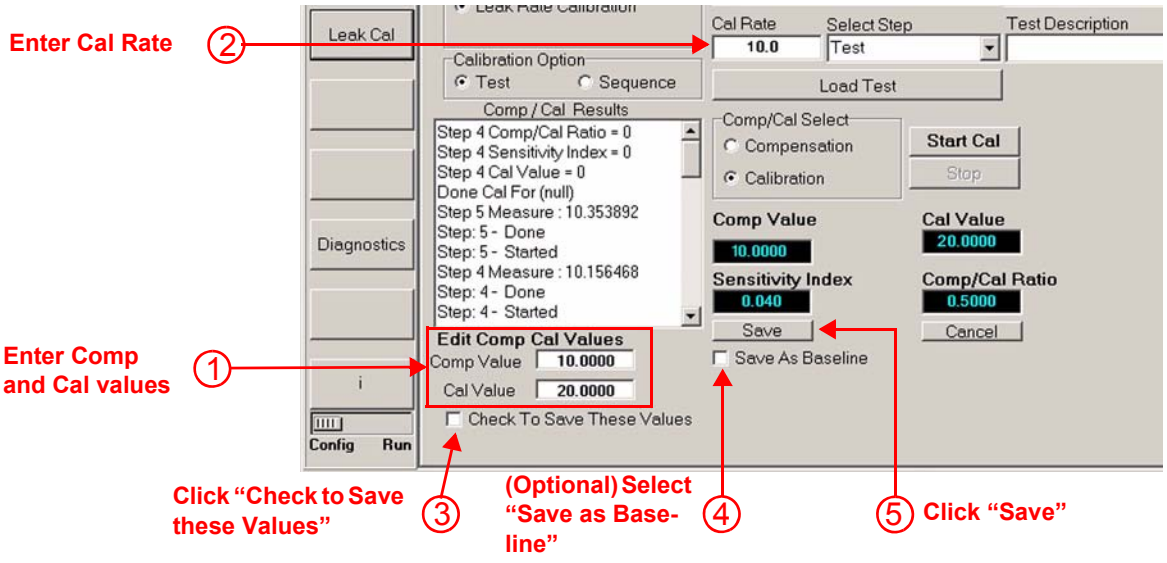
- Known good values are already available.
- The calculated values are extremely close to a more convenient number. For example, this allows rounding off 0.9999 to 1.0.

To edit the Comp and Cal values:

1. Type the Comp and Cal values in the **Comp Value** and **Cal Value** fields in the **Edit Comp Cal Values** area. (See *Figure 3–8*.)
2. Enter the correct **Cal Rate**.
3. Click the **Check to Save These Values** checkbox.
4. Optionally, check the **Save As Baseline** box to save the values also as a baseline.
5. Click **Save** (located above "Save As Baseline").

The new values will be saved with the currently selected test.

Figure 3–8: Editing Comp and Cal Values



3.2.1.6 Config Mode Comp by Sequence

Before starting the comp by sequence, ensure that the test part is a non-leaking master part and that it is properly set up and fixtured. Ensure that the system has no leaks. Once the sequence is started, air pressure will be applied.

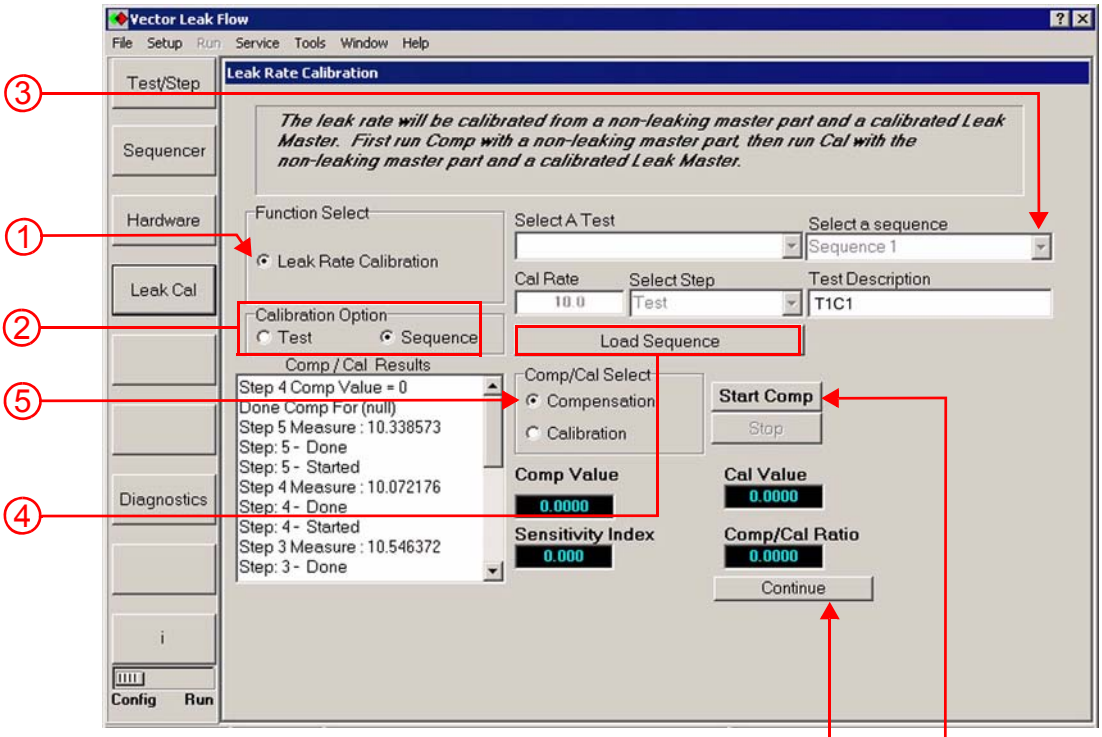
Undetected leaks will invalidate the results.

Open the **Leak Rate Calibration** window by clicking the **Leak Cal** button, or by selecting **Setup/Leak Calibration** from the Vector menu. Use the following procedure to run compensation by sequence:

1. Select **Leak Rate Calibration** in the **Function Select** area.
2. Select the **Sequence** option in the **Calibration** area.
3. Access a selection of sequences to run by clicking the arrow beside the **Select A Sequence** field. Click on a sequence name to select it. The selected sequence name displays in the **Select A Sequence** field, the name of the first test displays in the **Test Description** field, and the **Start Comp** button below the field is enabled. (See *Figure 3–9*.)

If a calibrated leak rate has not been previously defined for the selected test during the test setup process, the Vector will display an error message. All tests should have a proper Cal rate value before running a sequence Comp and Cal.

FIGURE 3–9: RUNNING COMPENSATION BY SEQUENCE



1. Select Leak Rate Calibration
2. Select Sequence (Calibration Option)
3. Select a sequence from the Select a Sequence field
4. Click Load Sequence
5. Select Compensation
6. Click Start Comp
7. Click Continue to advance to the next test in the sequence

4. Select **Load Sequence**. The first test in the sequence will display in the **Test Description** field.
5. In the **Comp/Cal Select** area (see *Figure 3–2*), select **Compensation.**
6. Start the Comp Test by clicking the **Start Comp** button. The sequence is run and test progress displays in real time in the **Comp/Cal Results** area and the tester returns a Comp value in the **Comp Value** field.

If Comp has already been run for a particular test, Cal can be run.

7. Run Comp and Cal and save to preserve the settings before clicking the **Continue** button to continue to the next test in the sequence.

Clicking on the Continue button before running Comp or Cal will bypass the test and continue to the next test.

3.2.1.7 Config Mode Cal by Sequence

After running compensation, the next step is running calibration to determine a leak rate Cal value. The procedure for running calibration is similar to the procedure for running compensation.

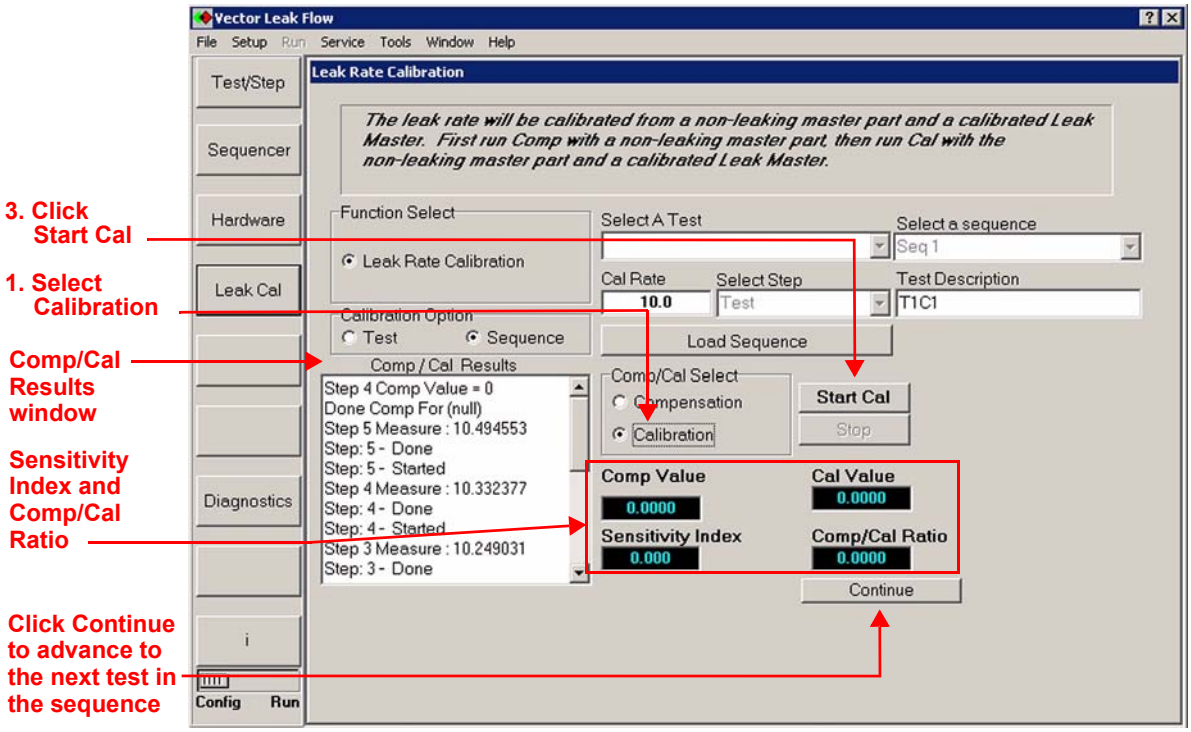
After running compensation, use the following procedure to run calibration:

1. Select **Calibration** in the **Comp/Cal Select** area.
2. Insert the Leak Master (or the known-leak master part) into the Leak Master port (if applicable).
3. Start the Cal Test by clicking the **Start Cal** button.

If selecting the Cal option without running Comp (if Comp is needed), an error message will be displayed: "Comp should be run before Cal." (See *Figure 3–4*.)

The Vector runs the test and displays testing progress in real time in the **Comp/Cal Results** box. At the conclusion of the Cal Test, test sensitivity and Comp/Cal ratio are calculated and displayed in the **Sensitivity Index** and **Comp/Cal Ratio** fields.

FIGURE 3–10: RUNNING CALIBRATION



For pressure decay testing, the sensitivity calculated by the tester, which is based on span, should be at least 0.05% of full scale range of the sensor associated with this step for a high sensitivity tester (an option purchased separately), or 0.2% of full scale range of the sensor associated with this step for a low sensitivity tester. The Comp/Cal Ratio should be less than 2.0. The tester will not show good repeatability during production if these values are outside recommended ranges. See *Chapter 6, Repeatability Studies*, for information on improving repeatability.

3.2.1.8 Concluding Comp/Cal by Sequence

Once the Comp and Cal values have been determined, they can be cancelled in order to rerun Comp and Cal, or they can be saved using one of two save options:

- Save Comp/Cal values
  Click the **Save** button to save the Comp and Cal values with the currently selected test. Once this option is selected, the **Repeat Comp/Cal** button displays at the bottom of the window. Click this button to rerun Comp and Cal if necessary.
- Save Comp and Cal values with save as baseline option
  Optionally, the Comp and Cal values can be saved for future reference. Check the **Save as Baseline** box before clicking the **Save** button to save the Comp and Cal values with the currently selected test as well as to save them as a baseline. After saving, the **Repeat Comp/Cal** button displays at the bottom of the window. Click this button to rerun Comp and Cal if necessary as shown in *Figure 3–12*.

Comp and Cal can be run again if leaks are found, or if test parameters such as pressure or step time change. Better Comp and Cal values translate to repeatable and fast production testing.

Figure 3–11: Concluding a test

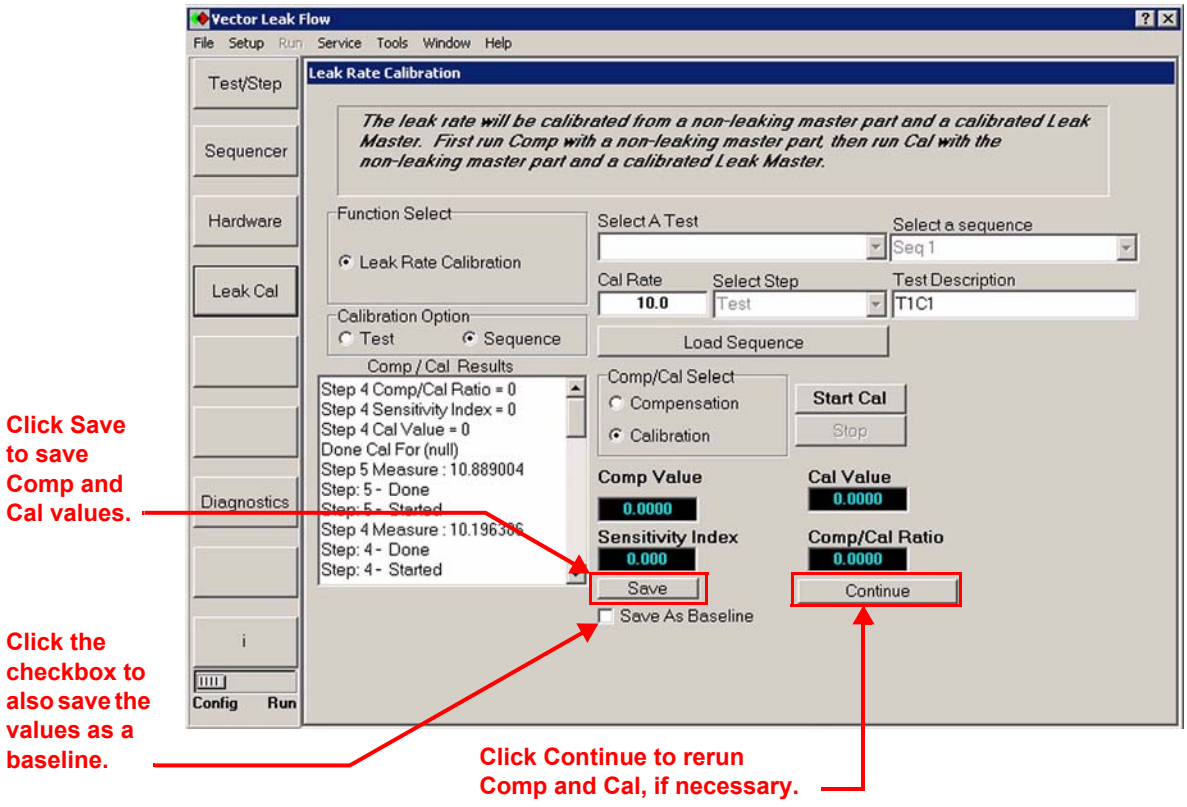
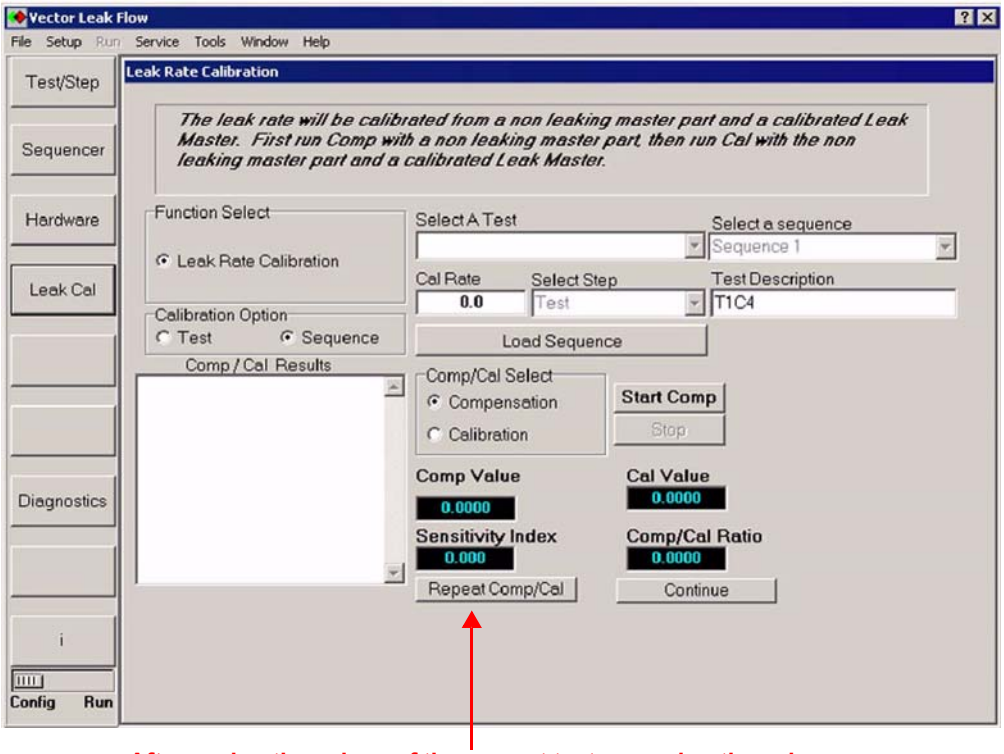


FIGURE 3–12: REPEAT COMP AND CAL



After saving the values of the current test, or saving the values as a baseline, the Repeat Comp/Cal button displays. Click this button to rerun Comp and Cal, if necessary.

3.2.1.9 Interpreting Comp/Cal by Sequence Results

Divide the Comp value by the Cal value to arrive at a Comp/Cal ratio.

$$\text{Comp/Cal Ratio} = \frac{\text{Comp Value}}{\text{Cal Value}}$$

The ratio should be less than 2.0.

Adequate values for leak sensitivity indices in pressure decay testing are:

- > 0.2% of test pressure for testers with standard sensitivity.
- > 0.05% of test pressure for testers with the High Resolution Transducer Converter module.

$$\text{Sensitivity} = \frac{\text{Cal Value}}{\text{Sensor Span}} \times 100\%$$

The tester will not show good repeatability if these values are outside of the recommended ranges.

To improve the sensitivity index, increase the test time of the **Test Step** and rerun the compensation and calibration procedures.

To lower the Comp/Cal ratio, increase the test time of the **Stabilize Step** and rerun the compensation and calibration procedures.

3.2.2 Comp and Cal in Run Mode

In Run Mode, Comp and Cal can be performed using one of three options:

- Run Time Comp/Cal for Test
- Run Time Comp/Cal for Sequence
- Run Time Sequence Setup Option

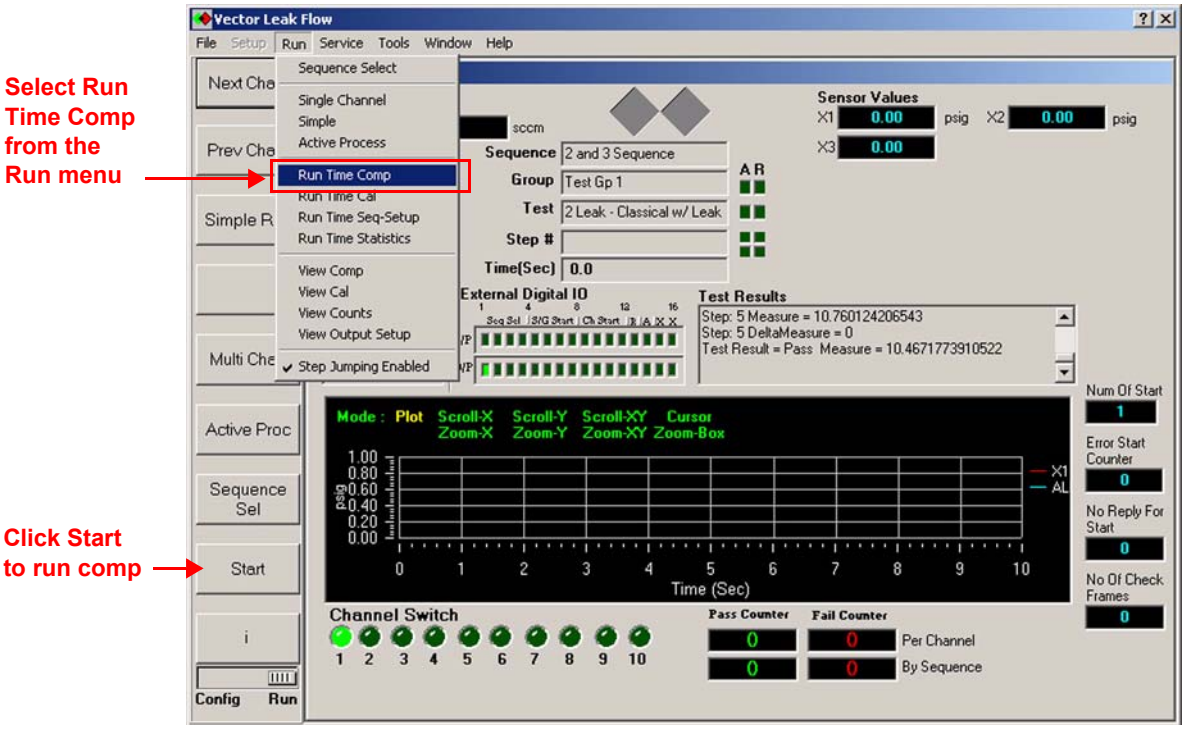
3.2.2.1 Run Time Comp/Cal

Run Time Comp and Cal for Test is performed only in the Run Mode.

Use the following procedure to perform Run Time Comp and Cal:

1. Load the desired test and select the **Run Time Comp** option from the **Run** menu at the top of the Run screen window as shown in *Figure 3–13*. The title bar will display the mode selected to run (Run Time Comp), as shown in *Figure 3–14*.

Figure 3–13: Selecting Run Time Comp

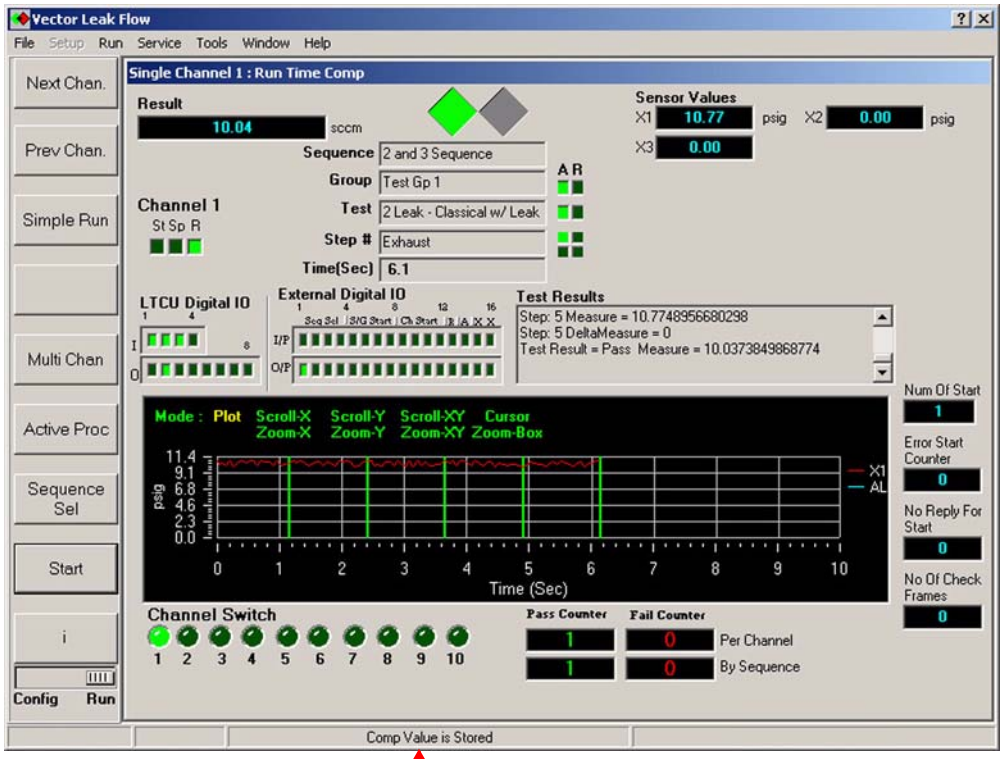


Run Time Comp and Cal operations require a password level of 4 or better. Level 5 can not access Run Time Comp and Cal.

FIGURE 3–14: RUN TIME COMP

2. Click the **Start** button located at the lower-left corner of the screen or the **Start** button on the front panel. Run Time Comp will start, and the test will run in Comp mode. At the end of the test, a message will display in the status bar, as shown in *Figure 3–15*, and the new Comp value will be automatically stored to the database.

FIGURE 3–15: MESSAGES DISPLAY IN THE STATUS BAR



3. Deselect the **Run Time Comp** option.

The option must be deselected (unchecked) before selecting another option to run. If it is not deselected, it will continue to run in Run Time Comp/Cal mode as selected.

Selecting the Run Time Cal option will automatically deselect the Run Time Comp option, and vice versa.

4. Select the **Run Time Cal** option.

A valid Cal Rate must be pre-defined for all leak steps before running Run Time Comp/Cal for test. The Cal Rate can not be set in Run Mode.

5. Click the **Start** button (at the lower-left corner of the screen) or the **Start** button on the front panel. Run Time Cal will start and the test will run in Cal mode. At the end of the test, a message will display in the status bar, and the new Cal value will be automatically stored to the database.
6. Deselect the **Run Time Cal** option.

3.2.2.2 Comp/Cal Sequence by Selection

Run Time Comp and Cal Sequence is performed only in the Run Mode.

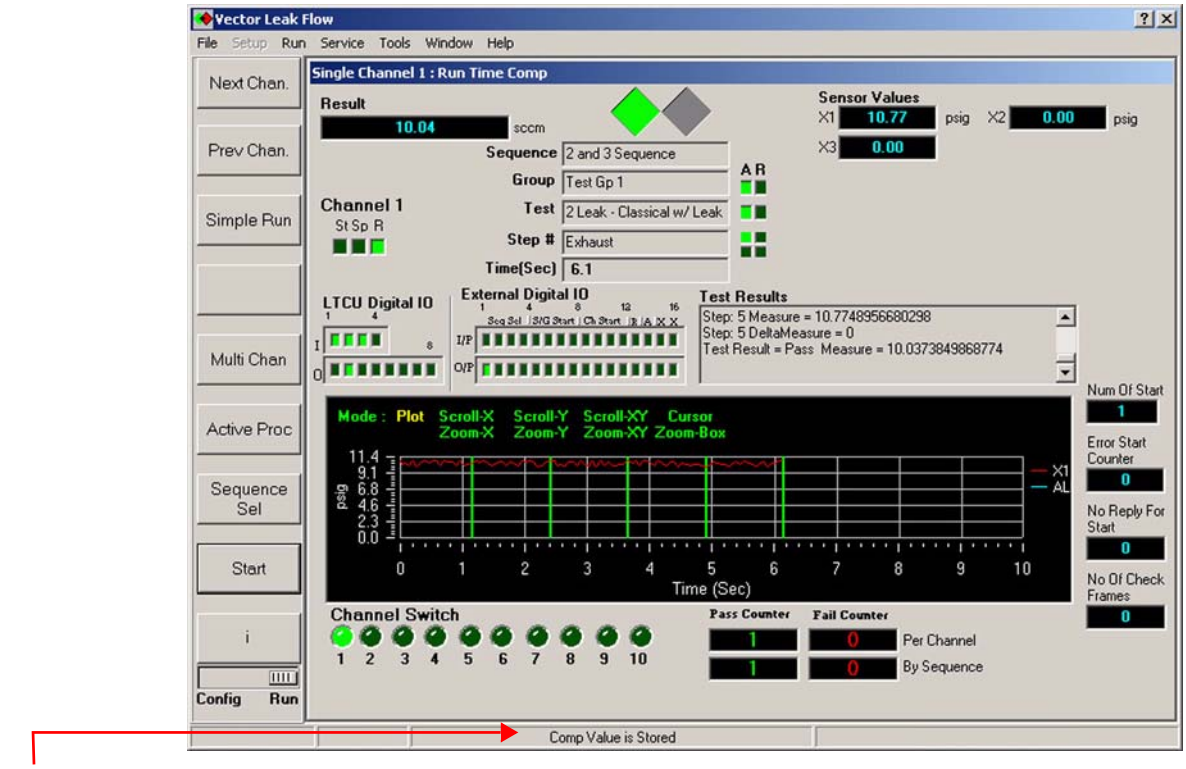
1. Load the desired sequence and select the **Run Time Comp** option from the **Run** menu at the top of the Run screen window as shown in *Figure 3–13*. The title bar will display the mode selected to run (Run Time Comp), as shown in *Figure 3–16*.

Run Time Comp and Cal operations require a password level of 4 or better. Level 5 can not access Run Time Comp and Cal.

Figure 3–16: Run Time comp

2. Click the **Start** button located at the lower-left corner of the screen or the **Start** button on the front panel. Run Time Comp will start, and the sequence will run in Comp mode. At the end of the sequence, a message will display in the status bar, as shown in *Figure 3–17*, and the new Comp value will be automatically stored to the database.

FIGURE 3–17: MESSAGES DISPLAY IN THE STATUS BAR



Messages — Comp Value is Stored or Cal Value is Stored — display in the status bar at the end of a test

3. Deselect the **Run Time Comp** option.

The option must be deselected (unchecked) before selecting another option to run. If it is not deselected, it will continue to run in Run Time Comp/Cal mode, as selected.

Selecting the Run Time Cal option will automatically deselect the Run Time Comp option, and vice versa.

4. Select the **Run Time Cal** option.

A valid Cal Rate must be pre-defined for all leak steps before running Run Time Comp/Cal for test. The Cal Rate can not be set in Run Mode.

5. Click the **Start** button (at the lower-left corner of the screen) or the **Start** button on the front panel. Run Time Cal will start and the sequence will run in Cal mode. At the end of the sequence, a message will display in the status bar, and the new Cal value will be automatically stored to the database.
6. Deselect the **Run Time Cal** option.

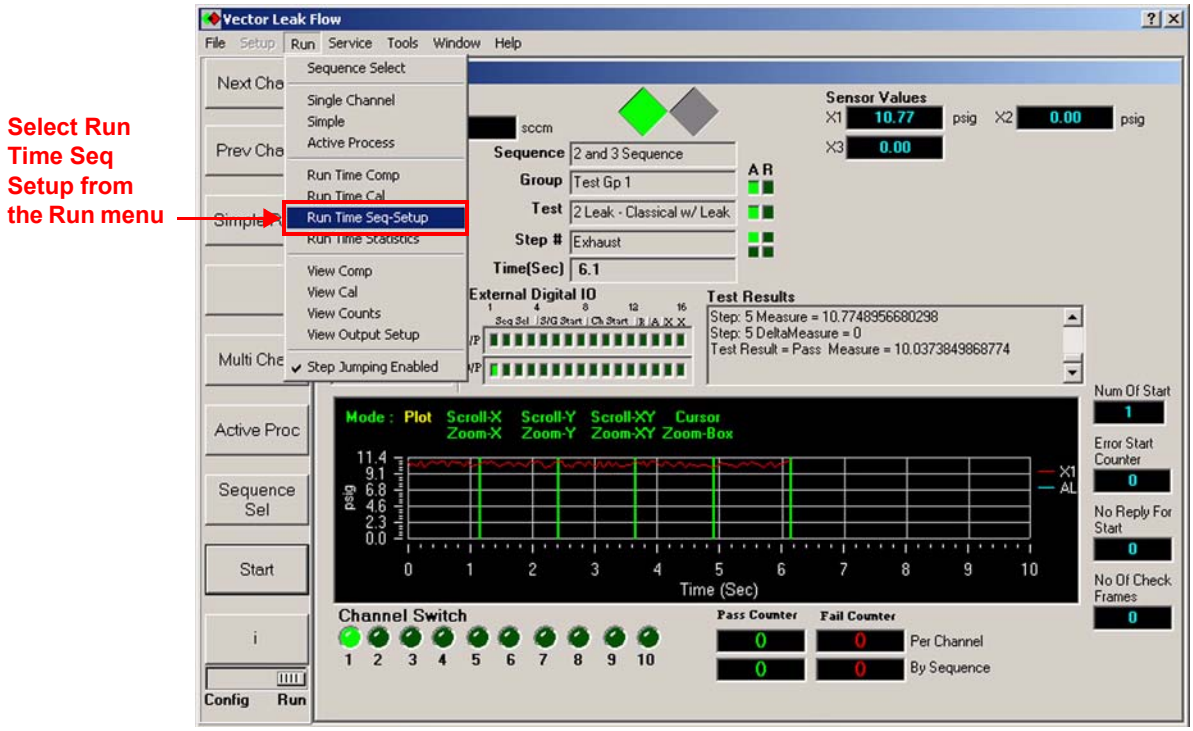
3.2.2.3 Run Time Sequence Setup

Run Time Sequence setup allows the selection of different modes (Test, Comp, and Cal) for any specific test in the sequence.

Run Time Sequence Setup requires a password level of 4 or better. Level 5 can not access Run Time Sequence Setup.

1. Select **Run Time Seq-Setup** from the **Run** menu. (See *Figure 3–18*.) The **Run Time Seq-Setup** screen will display as shown in *Figure 3–19*.

Figure 3–18: Run Time Sequence setup



2. Select any test in the grid with the mouse cursor and double-click on the test. A pop-up, as shown in *Figure 3–19*, will display three options:
    1. Test
    2. Comp
    3. Cal

3. Make a selection from the three options for the selected test by clicking with the mouse cursor. Make selections for other tests, as necessary.

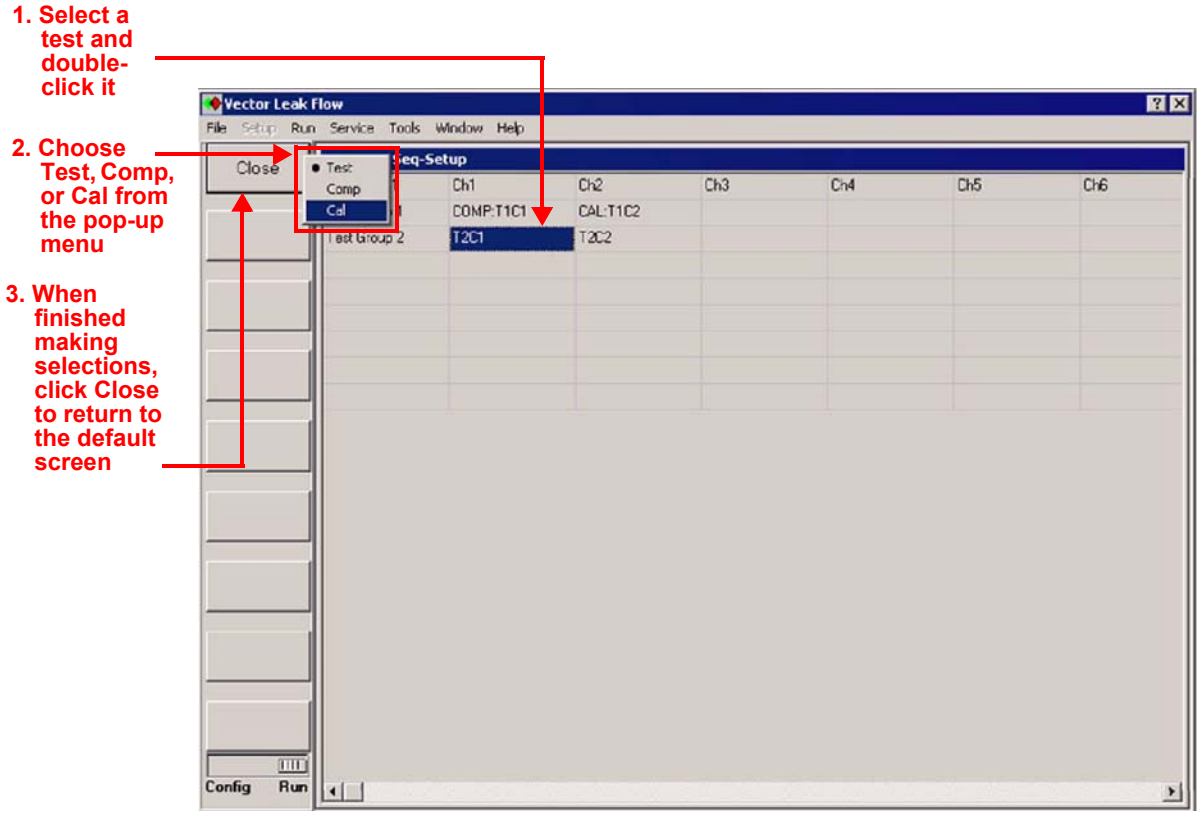
When using Run Time Seq-Setup, each of the tests in the sequence can be configured differently: one in Comp, one in Cal, and one in normal (Test) mode.

This is a one-time setup. The selections will reset to normal mode after running the sequence.

4. Select **Close** after completing selections.
5. Click the **Start** button to run the sequence. Test progress displays in real time in the **Test Results** area. (See *Figure 3–20*.) The individual test's Run Mode will be displayed as Comp or Cal in the Run screen's title bar, as shown in *Figure 3–20* and *Figure 3–21*. The new Comp and Cal values for the test will be stored to the database.

   Alternate views of test progress are available by selecting the **Multi Chan** button, the **Simple Run** button, or the **Active Proc** button. (See *Figure 3–20* and *Figure 3–21*.)

FIGURE 3–19: RUN TIME SEQ-SETUP SCREEN



If Run Time Comp or Run Time Cal is selected from the menu, the Seq-Setup option is disabled.

The Run Time Comp or the Run Time Cal option will override any defined Run Time Seq-Setup options.

FIGURE 3–20: SEQ-SETUP RESULTS

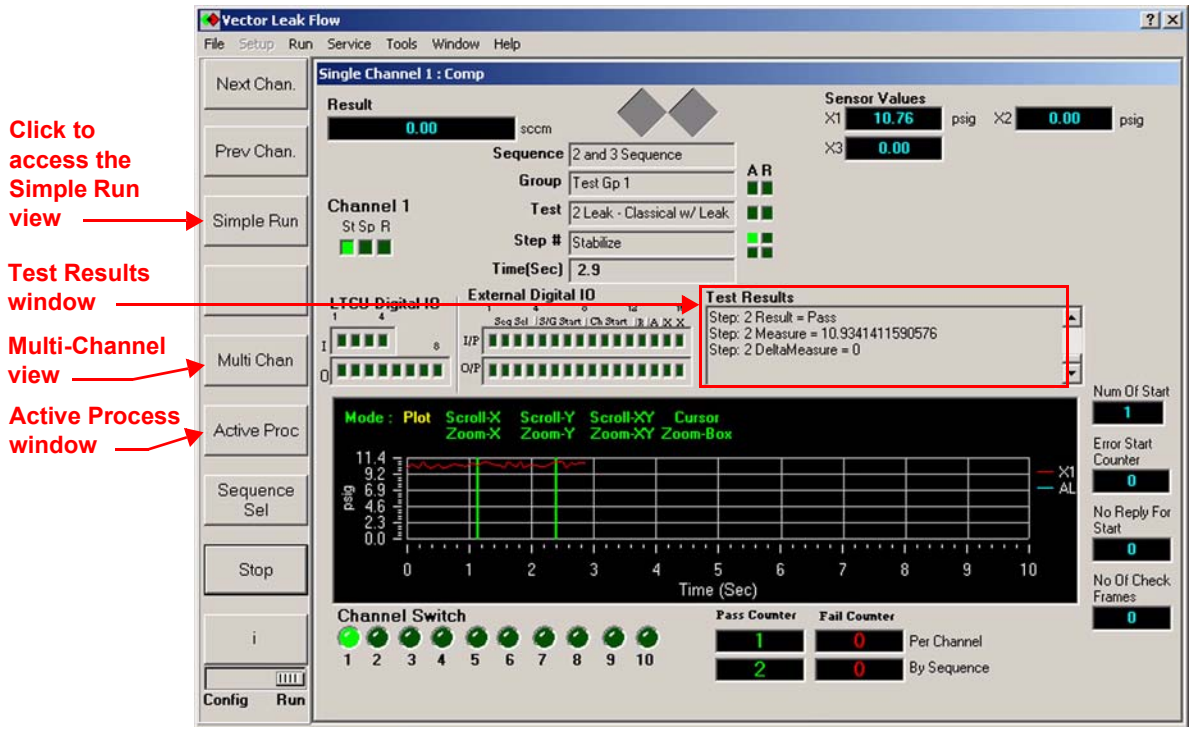
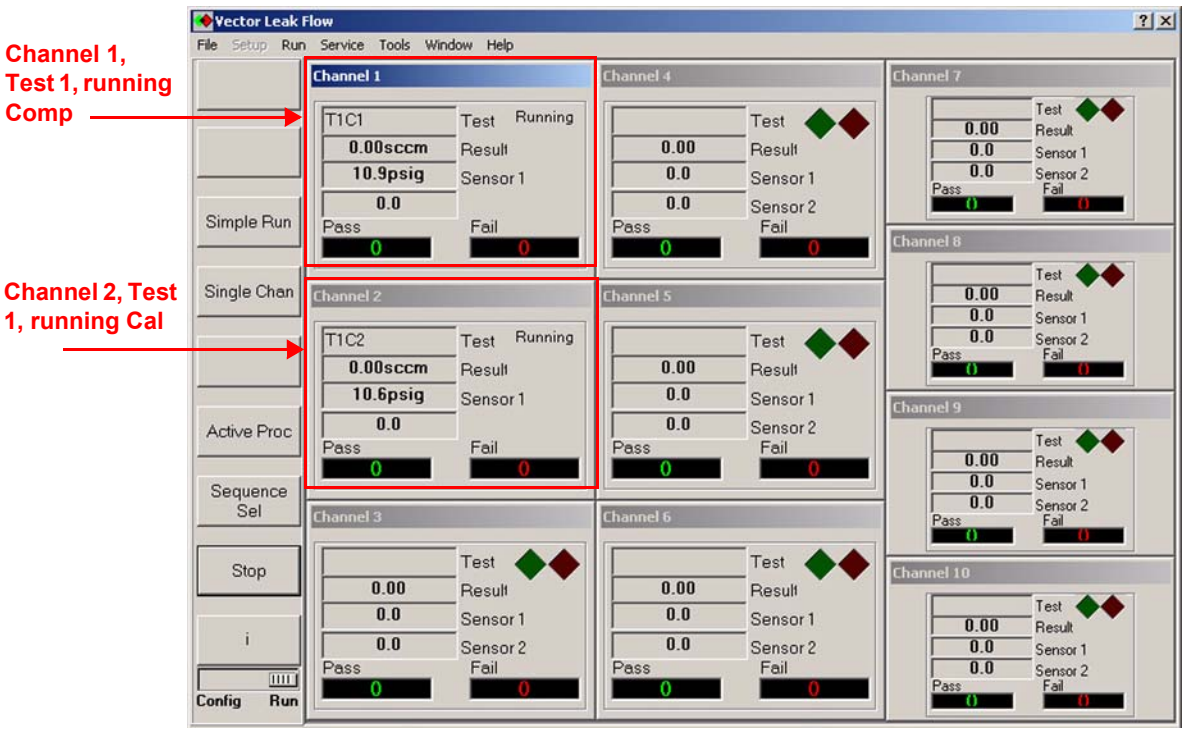


FIGURE 3–21: ALTERNATE VIEW: MULTI-CHANNEL WINDOW



Notes:

4 Testing

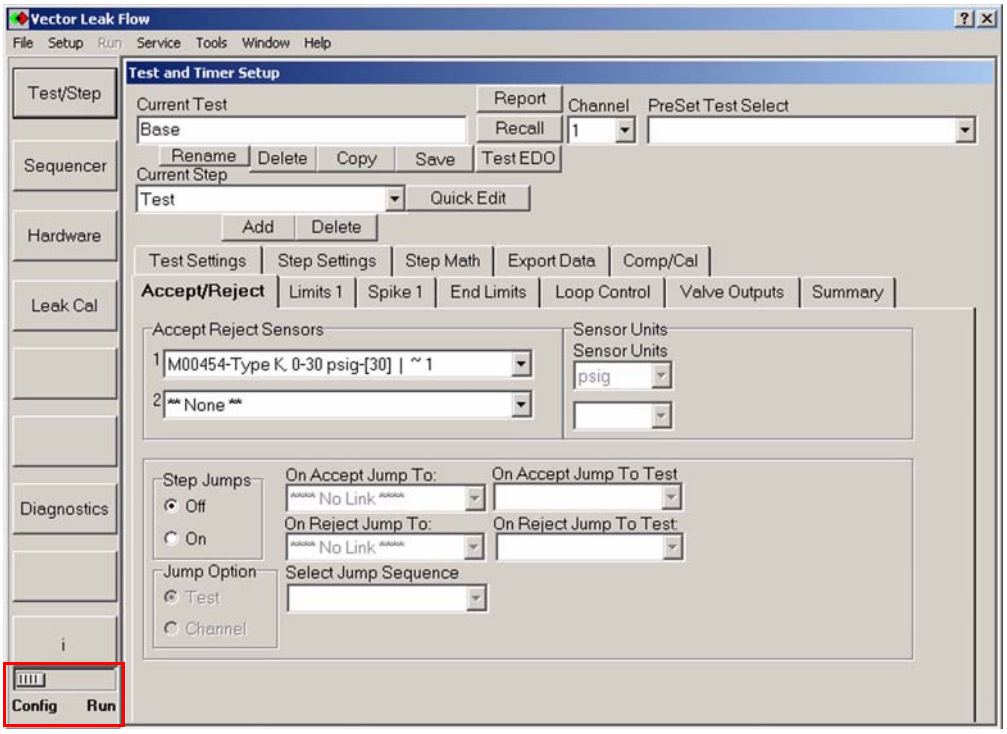
4.1 Determining the Current Mode

The Vector operates in two modes: Configuration and Run. Testing is accomplished while in Run mode. Vector's current mode is determined using either of two methods:

- Look at the toggle switch at the bottom-left corner of the main Vector window as shown in *Figure 4–1*. If the switch is not visible, the administrator has configured the Vector to hide it.
- Verify the key in the key interlock on the Operator Interface Panel (OIP) turned to the Run Mode position (this is the the vertical position), as shown in *Figure 4–2*.

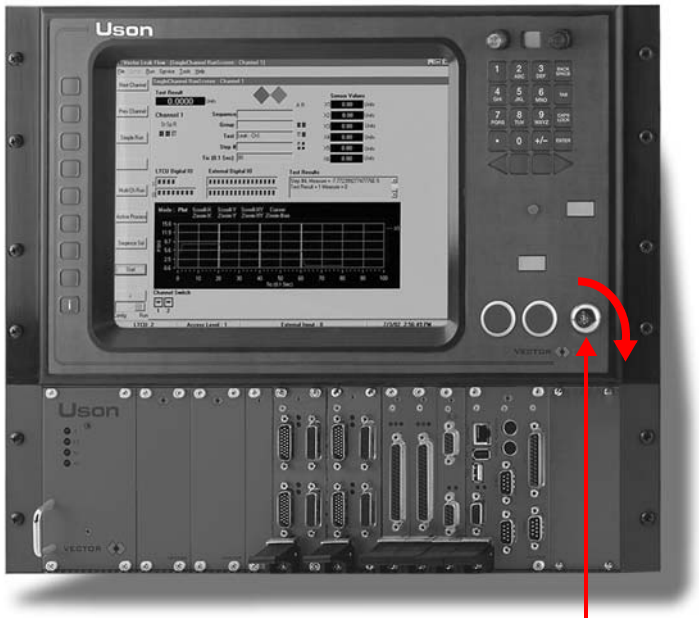
This chapter focuses on operations performed in the Run mode. Operations in Config mode are usually performed by the System Administrator or privileged operators.

Figure 4–1: Mode Toggle Switch



The toggle switch shows the current mode (if enabled)

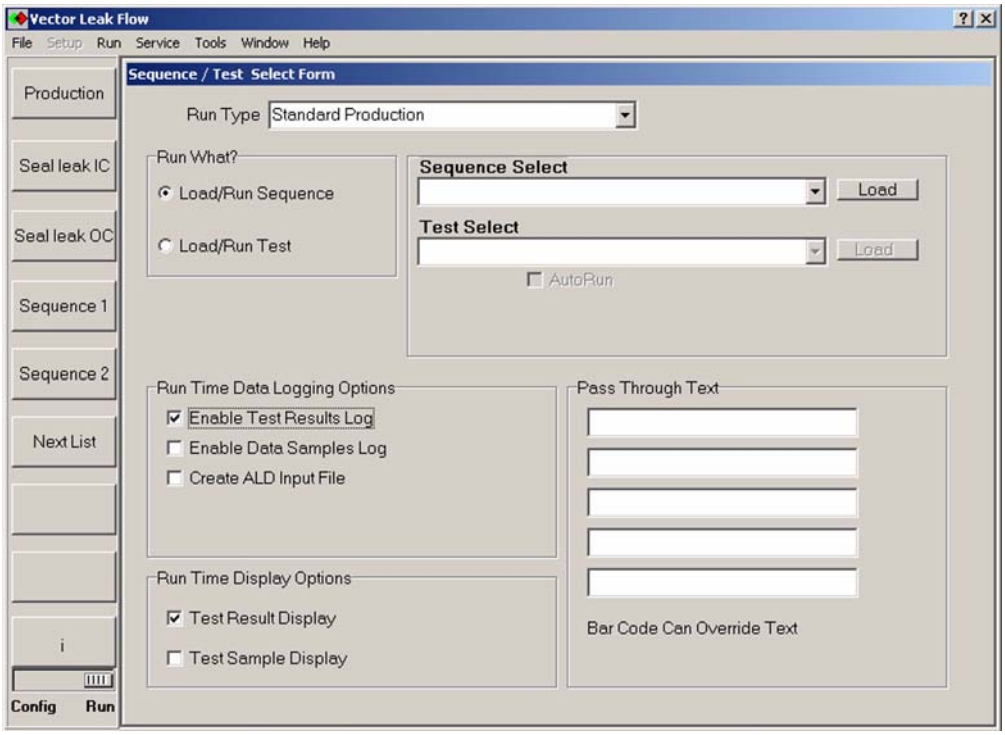
FIGURE 4–2: USING THE KEY INTERLOCK



To change from Configuration Mode to Run Mode using the key interlock, insert the key into the key interlock and turn it clockwise from the horizontal position to the vertical position, as shown

The **Sequence/Test Select Form** window opens by default when the mode is switched from Configuration to Run. This window, shown in *Figure 4–3*, is used for selecting and loading tests and sequences, for setting run time display and run time data logging options, and for entering pass through text.

Figure 4–3: Sequence/Test Select Form window



4.2 Setting Test Options

Before running tests or sequences in the Run Mode, the operator must configure several options in the **Sequence/Test Select Form** window, including:

- Selecting and loading a sequence or test
- Setting run time data logging options
- Setting run time display options
- Recording pass through text

4.2.1 Selecting and Loading a Sequence or Test

The first task to complete in the **Sequence/Test Select Form** window is to select a sequence or test in the **Run What?** area.

Selecting and Loading a Sequence

Use the following procedure (shown in *Figure 4–4*) to select and load a sequence:

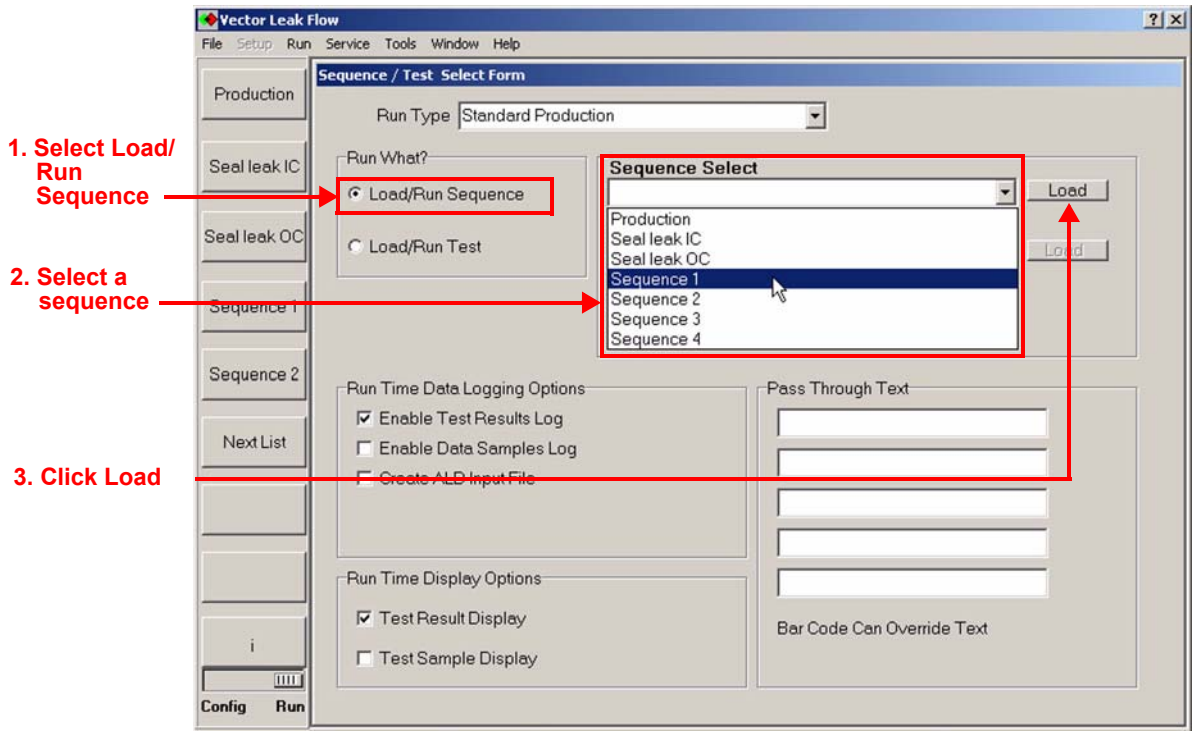
1. Select **Load/Run Sequence** in the **Run What?** area.
2. Select a sequence for the **Sequence Select** field.

Items on the Sequence Select menu are configured during the Sequence Configuration process. Sequences must be completely configured before running. See *Chapter 3, Leak Rate Calibration*, for details on sequence set up.

3. Once all sequence options have been set, click the **Load** button to load the selected sequence.

Do not click the Load button until all sequence options (data logging, display, and pass through text) have been set. Clicking the Load button automatically opens the Single Channel window. If all test options have not been set, it will be necessary to navigate back to the Sequence/Test Select Form window to complete test option set up.

FIGURE 4–4: SELECTING AND LOADING A SEQUENCE



SELECTING AND LOADING A TEST

Use the following procedure (shown in *Figure 4–5*) to select and load a test:

1. Select **Load/Run Test**.
2. Select a test for the **Test Select** field.

Items on the Test Select menu are configured during the Test Configuration process. Tests must be completely configured before running. See *Chapter 6, Test Configuration*, for details on test set up.

3. Clicking in the **Auto Run** checkbox enables the autorun feature and results in the display of two additional fields: **Time Delay**, and **Num of Trials**.

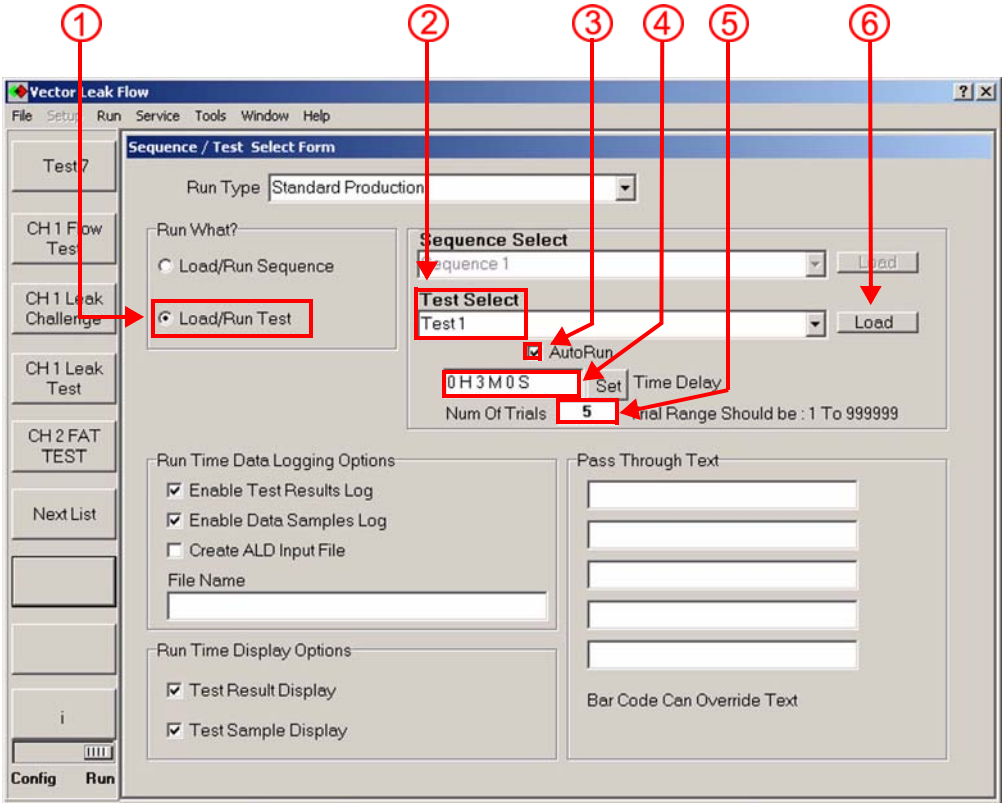
The autorun feature is typically used to run a series of tests under controlled conditions in order to verify the repeatability of the tester and its pneumatics.

4. To configure a delay period between each test, enter values for hours, minutes, and seconds in the **Time Delay** field.
5. To configure the number of times the test will be run, enter a value in the **Num of Trials** field. Once started, the tester will then run the number of tests indicated in the **Num of Trials** field, pausing between each test for the length of time indicated in the **Time Delay** field.
6. Once all test options have been set, click the **Load** button to load the selected test. The **Single Channel** window opens automatically. (See Section 4.3, *Running a Test or Sequence*, for information on running the selected test.)

Do not click the Load button until all test options (data logging, display, and pass through text) have been set. Clicking the Load button automatically opens the Single Channel window. If all test options have not been set, it will be necessary to navigate back to the Sequence/Test Select Form window to complete test option set up.

FIGURE 4–5: SELECTING AND LOADING A TEST

1. Select Load/Run Test
2. Select a test
3. Click to enable autorun
4. Enter hours, minutes, and seconds and click Set
5. Enter a number
6. Click Load



4.2.2 SETTING RUN TIME DATA LOGGING OPTIONS

Data logging options determine how test data is saved and retrieved for later use. These options are set in the **Run Time Data Logging Options** area in the **Sequence/Test Select Form** window. (See *Figure 4–6*.)

Logging options affect two categories of information: test results and data samples. When **Enable Test Results Log** is selected, data logging occurs at the test level, meaning that testing results can be stored and retrieved by test. When **Enable Data Samples Log** is selected, data logging occurs at the sample level, which means that testing results can be stored and retrieved by data sample. This makes sensor values available from every sample point in a test. Once the data logging options are set and testing data has been collected and saved, logged data can be retrieved via the **File** menu. (See Chapter 6, *Repeatability Studies*, for detailed information on data logging and retrieval.)

The Enable Test Results Log and Enable Data Samples Log options can be selected simultaneously.

Test result data is saved to Vector\log in a default format (.log) with a time stamp listing the current month, day, and year, along with the channel from which the data was collected. For example, test result data collected from Channel 1 on May 29, 2004 would be saved as May292004_Ch1.log.

Sample data is saved (in the .log file format) to Vector\log in a slightly different data format than test result data. In addition to channel information, the default sample data nomenclature reflects the hour, minute, and second the data was collected. Sample data collected from Channel 1 on May 29, 2004 would be saved by default as SampleData2_32_24PM_Ch1.log. Unlike test result data, sample data can be renamed and saved by the operator under another file name.

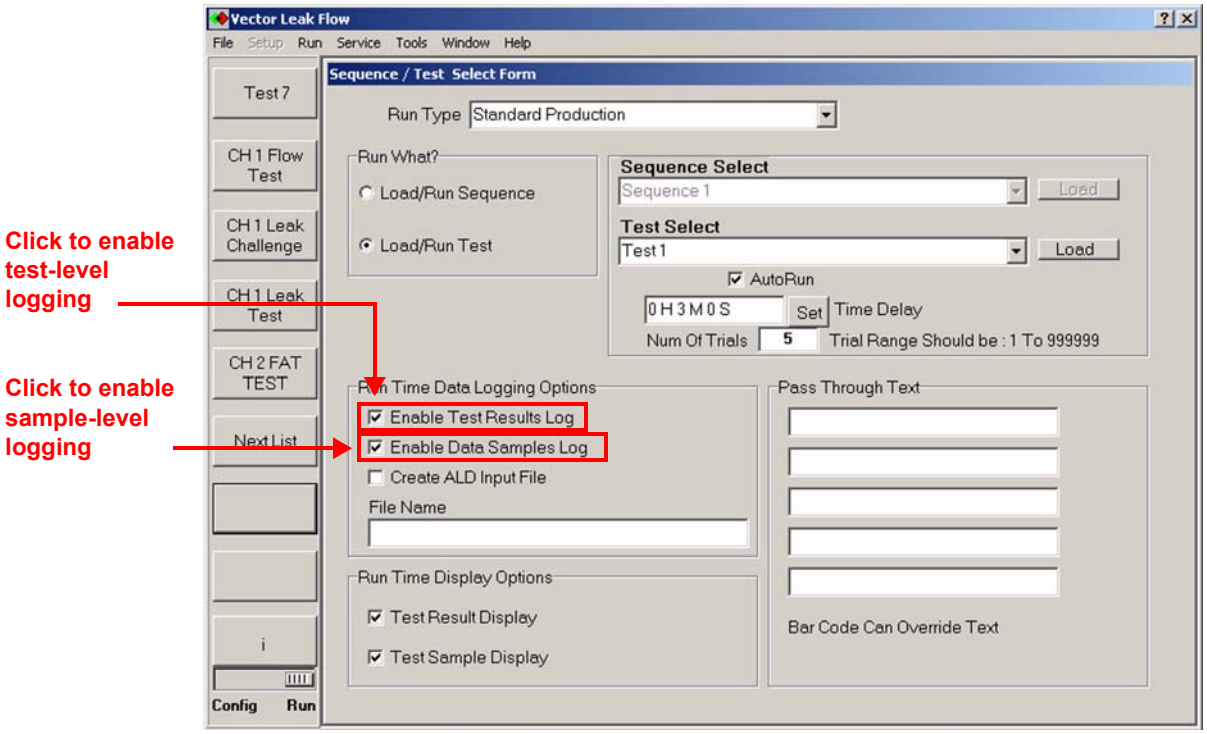
See Chapter 6, *Repeatability Studies*, for detailed information on file formatting.

Data logging options can be selected and altered from within the Single Channel window, if necessary. To view the options, right-click anywhere in the window to display an option menu. Click on any menu item to select or deselect it.

Use the following procedure (shown in *Figure 4–6*) to enable run time data logging:

1. To enable test-level logging, click the **Enable Test Results Log** checkbox.
2. To enable sample-level logging, click the **Enable Data Samples Log** checkbox.

FIGURE 4–6: SETTING RUN TIME DATA LOGGING OPTIONS



4.2.3 Setting Run Time Display Options

Run time display options determine how test data is displayed in the **Single Channel** window. Display options are set in the **Run Time Display Options** area in the **Sequence/Test Select Form** window. (See *Figure 4–7*.)

Run time display options allow the operator to display test results in two formats: test result and test sample. When selected, the **Test Result Display** option shows results for each test in the **Test Results** box in the **Single Channel** window, along with the final measurement value. Using this display format, it is possible to scroll back to view results from the previous 100 tests. The **Test Sample Display** option presents actual sensor values for every sample point within a test in the **Test Samples** box in the **Single Channel** window.

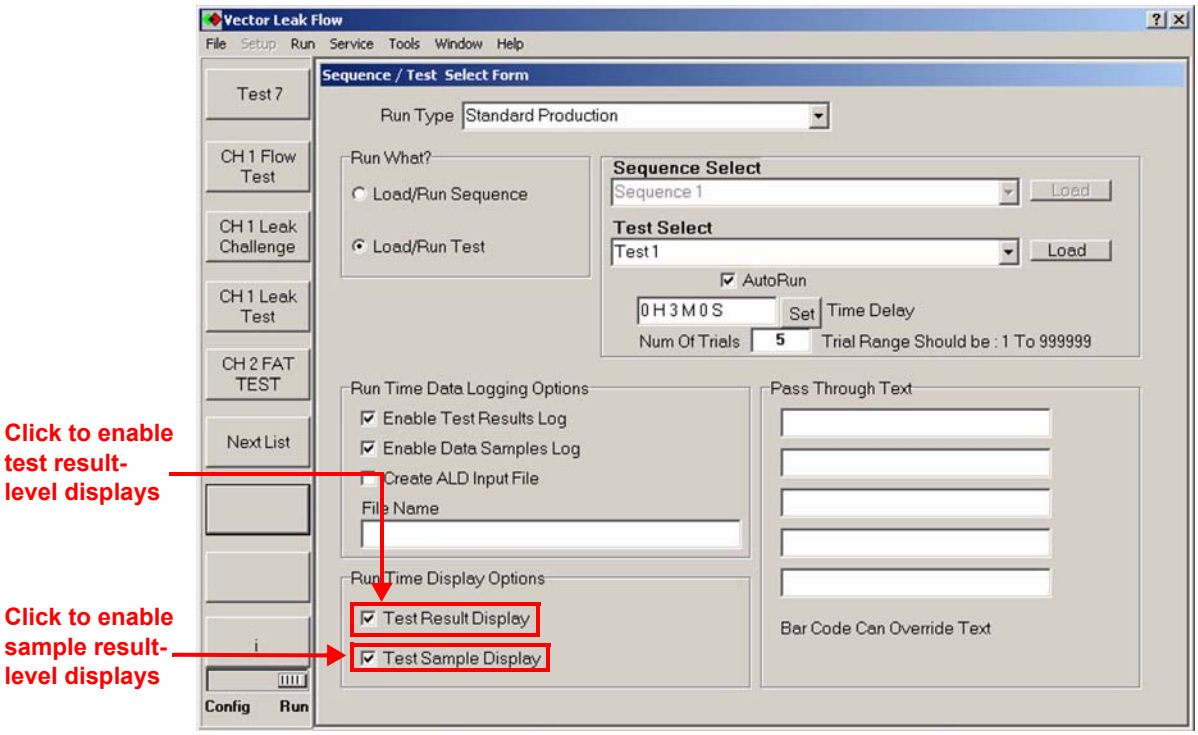
Use the following procedure to configure run time display options:

1. To enable test result-level displays, click the **Test Result Display** checkbox.
2. To enable sample result-level displays, click the **Test Sample Display** checkbox.

The Test Result Display and Test Sample Display options can be selected simultaneously.

Test options such as data logging or setting run time display can be selected or altered from within the Single Channel window, if necessary. Right-click anywhere in the window to display a menu of options. Then click an item to select or deselect it.

FIGURE 4–7: CONFIGURING RUN TIME DISPLAY OPTIONS

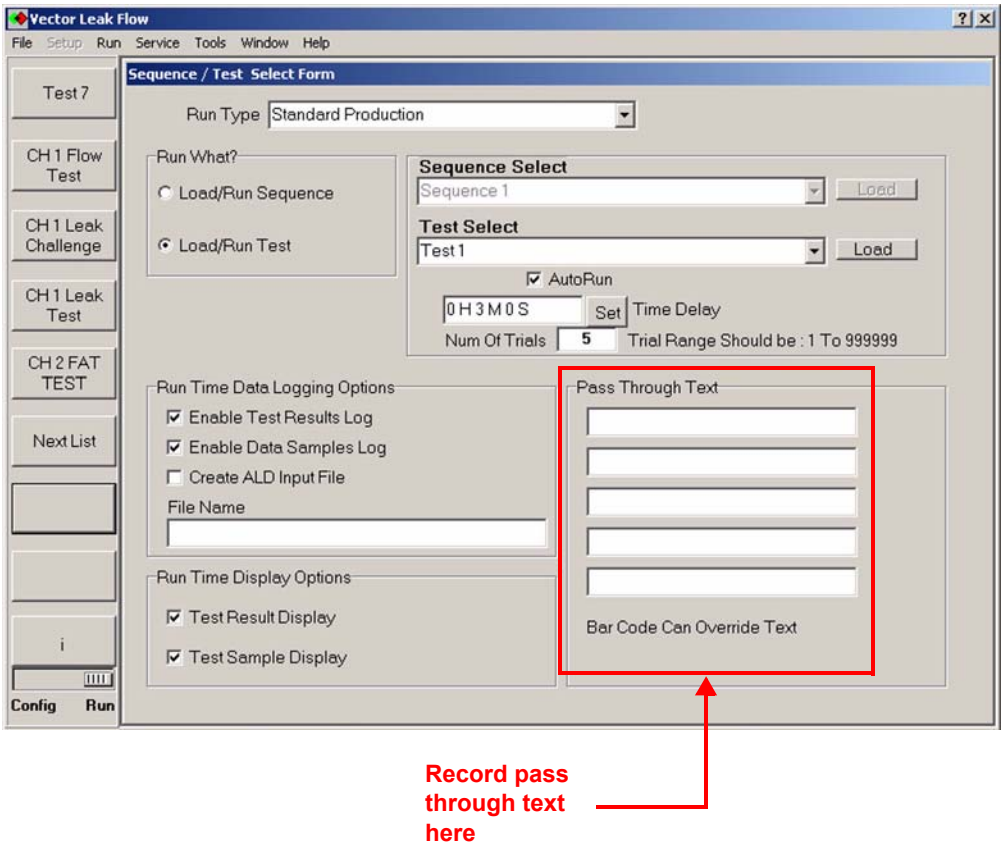


4.2.4 Recording Pass Through Text

Pass through text can include any information the operator might want to include in the log file. The text is recorded in the **Sequence/Test Select Form** window in the five fields that comprise the **Pass Through Text** area. (See *Figure 4–8*.) Text entered here displays in data sample log files and in printed files. See Chapter 6, *Repeatability Studies*, for detailed information on log file formatting.

To record pass through text, simply type it into the fields provided in the **Pass Through Text** area. The text is saved automatically when the test or sequence is loaded. Note that if the Bar Code option is installed and enabled to record pass-through text, those values may override entries in this window. A note stating "Bar Code Can Override Text" is displayed if this possibility exists.

Figure 4–8: Pass Through Text



4.3 Running a Test or Sequence

Run Mode functions occur in one of the following five windows:

- **Single Channel**
- **Simple Run**
- **Active Process**
- **Multi Channel**
- **Statistics**

If using an external keyboard, the NUM LOCK key must be OFF while in Run Mode to ensure the correct operation of the Reject lamp.

4.3.1 The Single Channel Window

The **Single Channel** window is accessible either by clicking the **Single Chan** option key or by selecting **Single Channel** from the **Run** menu. This window also opens automatically once a test or a sequence is selected and loaded successfully.

Navigating the Single Channel Window

Right-clicking in the **Single Channel** window invokes a shortcut menu the operator can use to perform several tasks. The menu is shown in *Figure 4–9*, and its selections are described in *Table 4–1*.

Figure 4–9: Single Channel Window shortcut menu

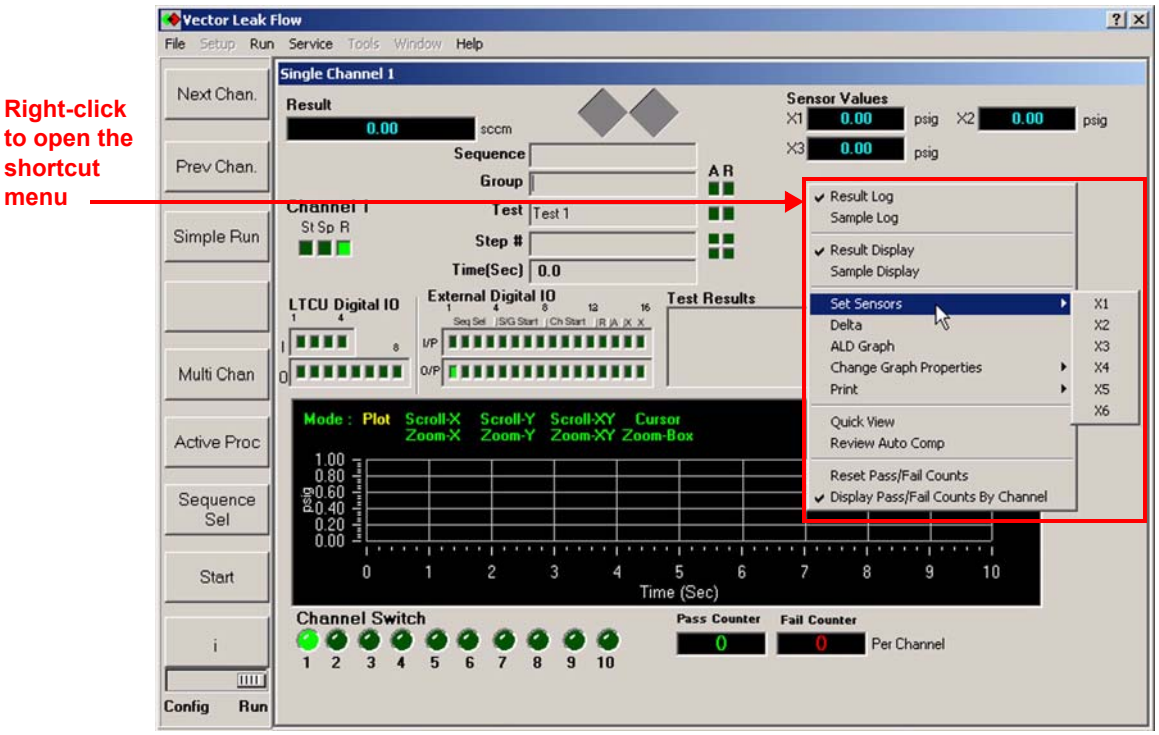


Table 4–1: Shortcut Menu Selections: Single Channel

Shortcut Menu Item	Result
ResultLog	Enables the results log. This selection is enabled by default. The results log can also be enabled in the Sequence/Test Select window in the Run Time Data Logging Options area.
SampleLog	Enables the data sample log. The sample log can also be enabled in the Sequence/Test Select window in the Run Time Data Logging Options area.
ResultDisplay	Enables test results to display in the Test Results area. This selection is enabled by default. Test results display can also be enabled in the Sequence/Test Select window in the Run Time Data Display Options area.
SampleDisplay	Enables sample results to display in the Test Samples area, which takes the place of the pass and fail counters at the bottom of the Single Channel window. Sample results display can also be enabled in the Sequence/Test Select window in the Run Time Data Display Options area.
X-1–X-6	Enables display of the selected sensor's values graphically and in the Sensor Values field. To display values for sensors that do not display by default, select a sensor in the popup window by clicking on it.
Delta	Enables display of delta (or tare) values, which show changes in measurement from the beginning to the end of a step.
Test Properties	Opens the Test Properties window, where test properties are displayed, at the conclusion of a test.
ALD Graph	Adds the Advanced Leak Detection step to the graph (if the Advanced Leak Detector is enabled on the tester).
Print Graph	Opens the Print dialog.
Reset Pass/Fail Counts	Resets the pass and fail counters (for channel and sequence).
Change Graph Properties	Enables changes to be made to the graph's X axis minimum and X axis maximum.
Modbus Review	Opens a window to allow monitoring the registers. This function is only visible on Vectors that are so equipped starting with software version 3.6.
Display Pass/Fail Counts By Channel	Enables pass and fail counters to display by channel unless the SampleDisplay option is selected.
Display Pass/Fail Counts By Sequence	Enables pass and fail counters to display by sequence unless the SampleDisplay option is selected.

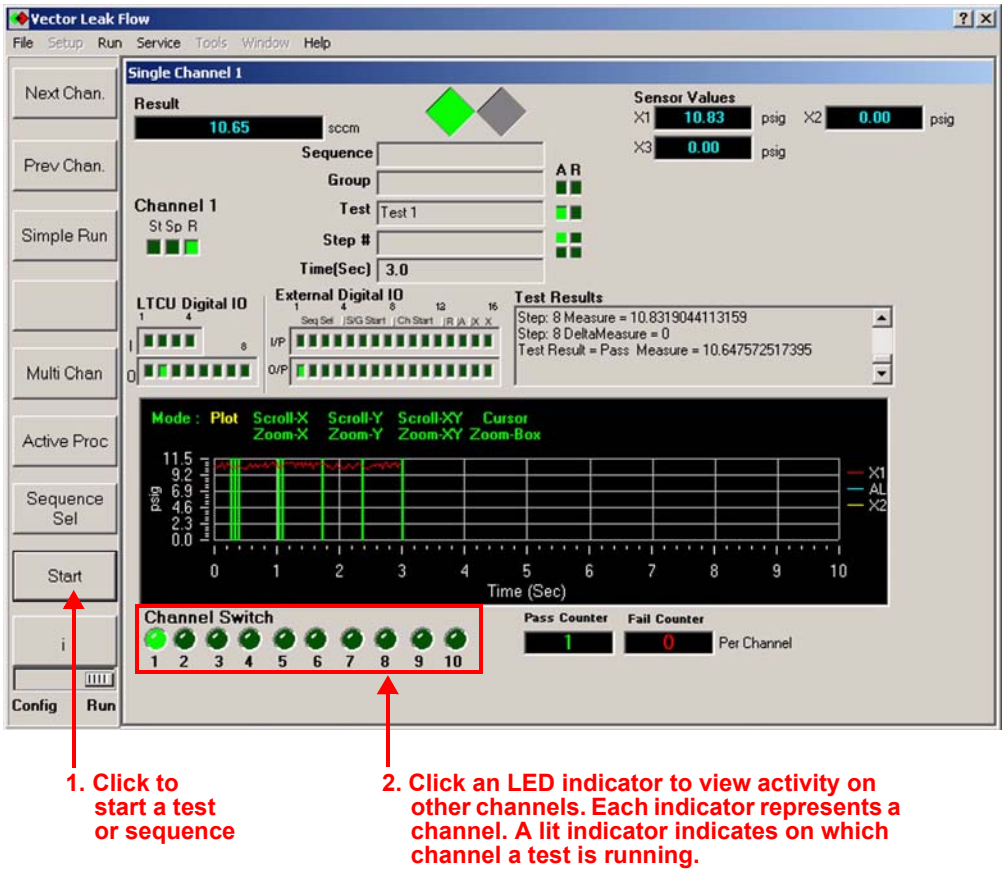
Use the following procedure to run a sequence or test in the **Single Channel** window:

1. Click the **Start** button to begin running a test or a sequence.

Test options such as data logging or setting run time display can be selected or altered from within the Single Channel window, if necessary, before running a sequence or test. Right-click anywhere in the window to display a menu of options.

2. To view activity on another channel, click the corresponding channel/LED indicator button in the lower-left portion of the window. Each of these LED indicator buttons corresponds to a channel. A ten-channel tester is shown in *Figure 4–10*.

FIGURE 4–10: RUNNING A TEST IN THE SINGLE CHANNEL WINDOW



4.3.2 Monitoring Progress in the Single Channel Window

While a test is running, progress displays in the **Single Channel** window in a variety of fields. Progress information falls into three categories:

- Tester status
- Data on the currently loaded test or sequence
- Test or sequence results

Viewing Tester Status Information in the Single Channel Window

Tester status information, shown in *Figure 4–11*, is displayed in the **Single Channel** window in the following areas:

1. LED indicators at the top-left of the window display tester status on the active channel.
   - **St**: Indicates that a start command has been received by the tester
   - **Sp**: Indicates that a stop command has been received by the tester
   - **R**: Indicates that the tester is ready
2. In the **LTCU Digital IO** area, LED indicators on the input line indicate that a command for a step terminate event has been received.
3. Also in the **LTCU Digital IO** area, LED indicators on the output line indicate that a digital output has occurred as configured in the **EDO Setup** window.

The tester's hardware outpaces the lighting of the LED indicators displayed in the Single Channel window. Therefore, the indicators should not be relied upon for timing or measurement purposes

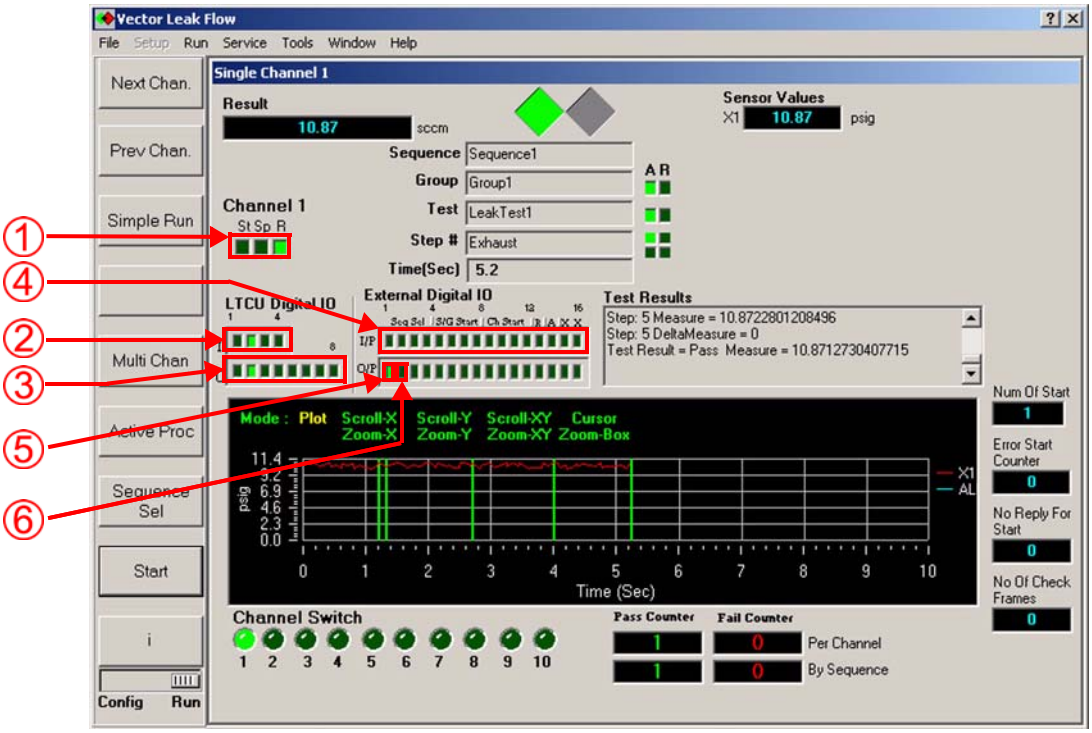
4. On the **External Digital IO** area's input line, the display is divided into seven separate display areas, each of which is configured during the EDI setup process. (See Section 8.2.5, *Assigning Unique Sequence ID Numbers*, for detailed information on EDI configuration.) The input line's display includes these elements:
   - LED indictors in the **Seq Sel** segment of the line appear lighted when a sequence select EDI input command is received
   - LED indictors in the **S/G Start** segment of the line appear lighted when a group select EDI input command is received
   - LED indictors in the **Ch Start** segment of the line appear lighted when a channel select EDI input command is received

- The LED indicator in the **R** segment of the line is illuminated when a reset command is received
- The LED indicator in the **A** segment of the line is illuminated when an abort command is received
- LED indicators in the two **X** segments of the line are not currently allocated

5. On the **External Digital IO** area's output line, the Master Ready LED indicator lights green to indicate that the tester is ready to receive an input via the I/O card. See Chapter 6, *Test Configuration*, for detailed information on test and step EDO configuration, and Chapter 3, *Leak Rate Calibration*, for detailed information on sequence and group EDO configuration.
6. Also on the **External Digital IO** area's output line, the Master A/R LED indicator lights red when a reject is received.

The output line displays in the Single Channel window's External Digital IO area only if an external I/O card has been purchased and installed.

FIGURE 4–11: TESTER STATUS INFORMATION



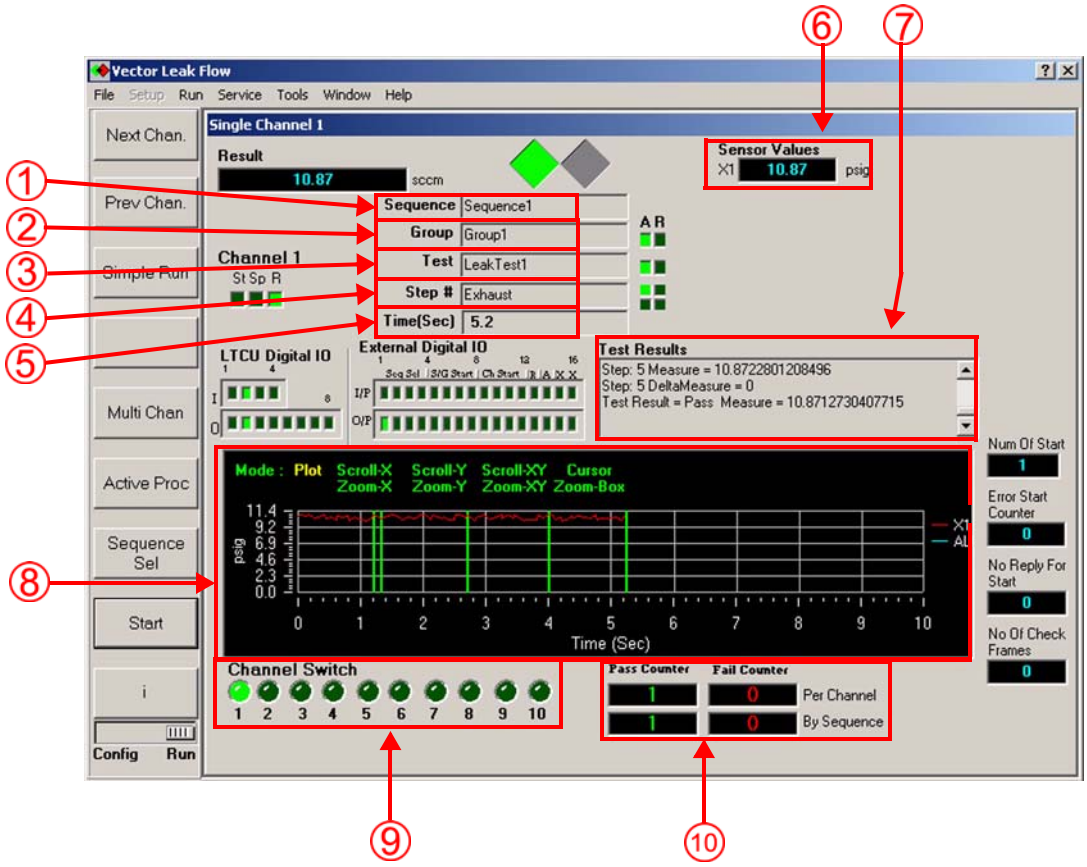
VIEWING TEST OR SEQUENCE INFORMATION IN THE SINGLE CHANNEL WINDOW

Data on the currently loaded test or sequence displays in several areas in the **Single Channel** window during a test or sequence. Displayed details, shown in *Figure 4–12*, include:

1. The **Sequence** field indicates which sequence is currently running.
2. The **Group** field indicates which group is currently running.
3. The **Test** field indicates which test is currently running.
4. The **Step #** field displays the current step.
5. The **Time (Sec)** field displays elapsed time in 0.1-second intervals.
6. The **Sensor Values** field displays sensor measurements in real time.
7. Test progress displays in the **Test Results** box in real time during testing. Arrows beside the box make it possible to scroll forward and backward through test result notes.
8. Test progress is plotted graphically in real time in the bottom portion of the **Single Channel** window while a test or sequence runs.

9. LED indicators at the bottom-left corner of the window specify on which channel the test is running. These indicators also act as switch buttons. Clicking on a button displays data from the corresponding channel. To view activity on another channel, click the corresponding channel/LED indicator button in the lower-left portion of the window. Each of these LED indicator buttons corresponds to a channel. A ten-channel tester is shown in *Figure 4–12*.
10. The pass and fail counters at the bottom of the window keep running totals of accepts and rejects in real time during testing. The top two fields show pass and fail counts by sequence. The bottom two fields show pass and fail counts for all channels and all groups.

FIGURE 4–12: TEST OR SEQUENCE INFORMATION

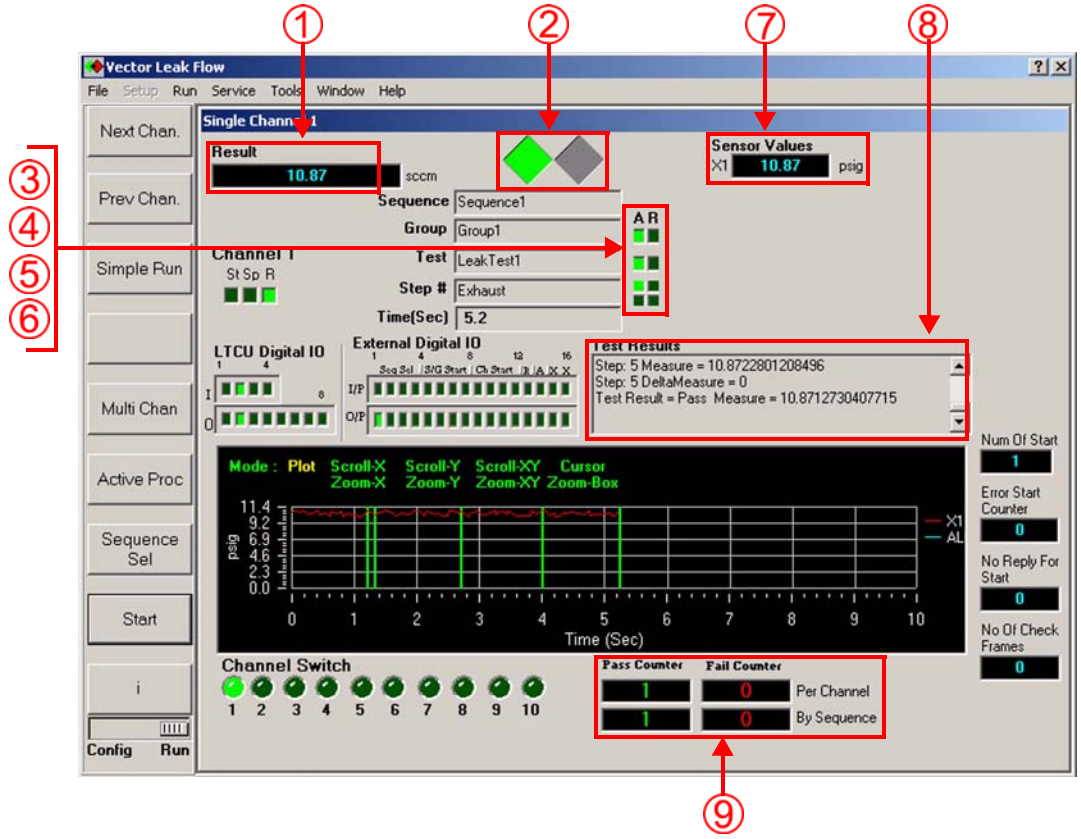


Viewing Test or Sequence Results in the Single Channel Window

At the end of a test or sequence, results are displayed in the **Single Channel** window until another test or sequence is loaded. (See *Figure 4–13*.) Results are displayed in the following areas:

1. Final test results are displayed in the **Test Results** field.
2. Diamond-shaped LED indicators at the top, center of the window provide graphical results information. A lighted green LED indicator signals an accept, while a lighted red LED indicator signals a reject.
3. LED indicators beside the **Sequence** box light green in the **A** column to indicate that a sequence has received a value of accept, or red in the **R** column to indicate a reject.
4. LED indicators beside the **Group** box light green in the **A** column to indicate that a group has received a value of accept, or red in the **R** column to indicate a reject.
5. LED indicators beside the **Test** box light green in the **A** column to indicate that a test has received a value of accept, or red in the **R** column to indicate a reject.
6. LED indicators beside the **Step** field light green in the **A** column to indicate that a step has achieved a value of accept, or red in the **R** column to indicate a reject.
7. At the end of a test or sequence, the **Sensor Values** field displays final sensor measurements. To view delta (or tare) values representing the change from the first value in a step to the current value, right-click in the window and select **Delta** from the pop-up menu.
8. Final test results display in the **Test Results** box. Arrows beside the box make it possible to scroll forward and backward through test result notes.
9. The pass counter displays a final total of accepts, and the fail counter displays a final total of rejects for each channel and sequence.

FIGURE 4–13: TEST AND SEQUENCE RESULTS



4.3.3 The Simple Run Window

The **Simple Run** window, shown in *Figure 4–14* and *Figure 4–15*, is accessible either by clicking the **Simple Run** option key, or by selecting **Simple** from the **Run** menu on the tool bar. The **Simple Run** window displays the following information:

1. Large indicator for accept (green) and reject (red) results.
2. Test name.
3. Step name.
4. Running time indicator (stops when result is achieved).
5. Numerical test result.
6. Sensor ID.
7. LED indicators at the bottom-left corner of the window specify on which channel a test is running. These indicators also act as switch buttons. To view activity on another channel, click the corresponding channel/LED indicator button in the lower-left portion of the window. Each of these LED indicator buttons corresponds to a channel. A ten-channel tester is shown in *Figure 4–14* and *Figure 4–15*.
8. Text test result.

Figure 4–14: A fail result in the Simple Run window

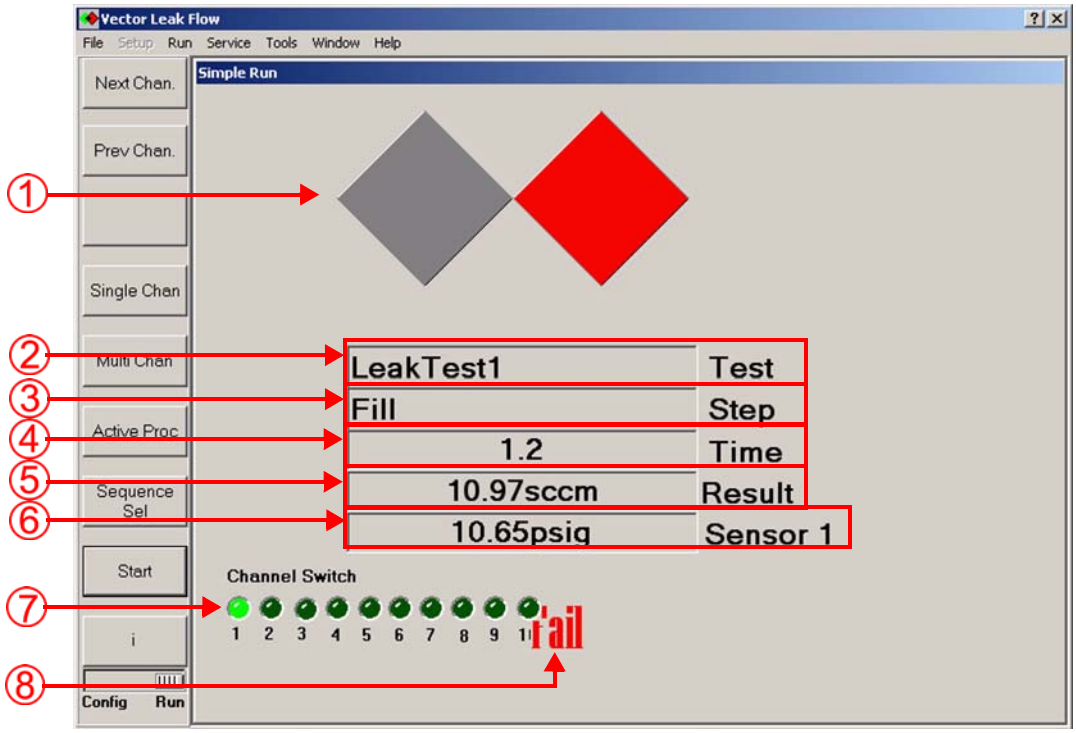
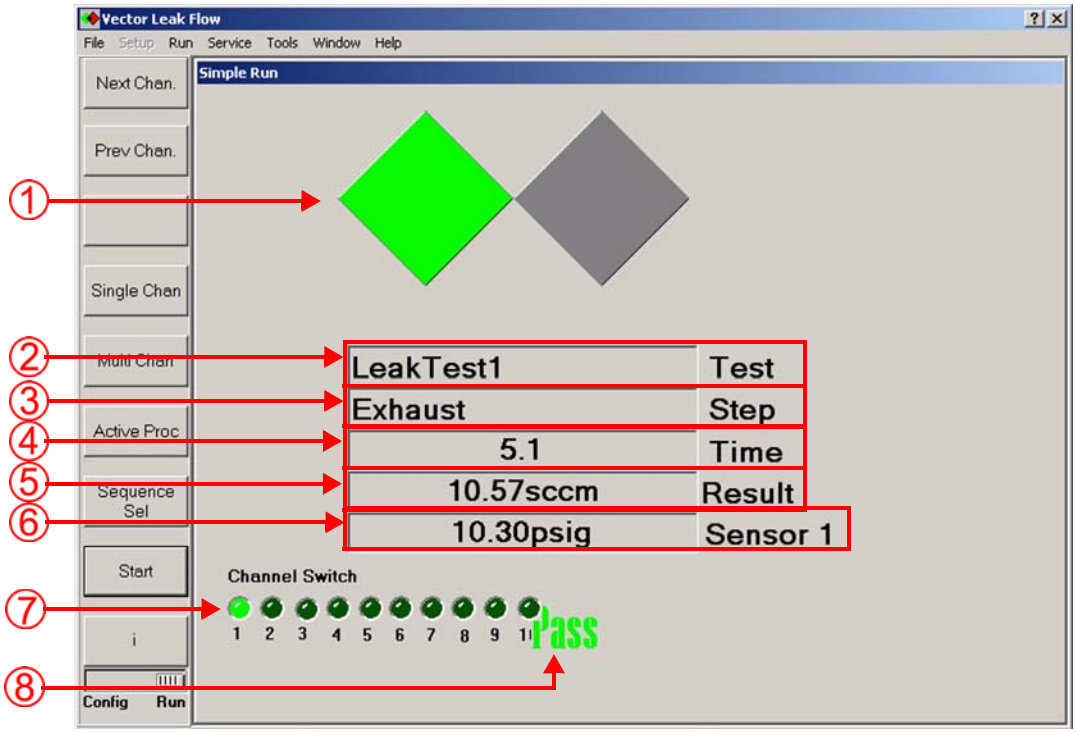


FIGURE 4–15: A PASS RESULT IN THE SIMPLE RUN WINDOW



4.3.4 The Active Process Run Screens

The Active Process screens represent hardware layout and pneumatic configurations of the test in graphical format. Current system configurations are read, and visualizations of test processes are displayed in the active process screens as they occur.

Active Process display is not a standard software feature. This option must be purchased and enabled in order to configure and use it.

There are four active process windows:

- **Standard Pressure Decay** (see *Figure 4–16*)
- **Standard Flow Test** (see *Figure 4–17*)
- **Standard Pressure Decay with Fast Fill** (see *Figure 4–18*)
- **Standard Flow with Fast Fill** (see *Figure 4–19*)

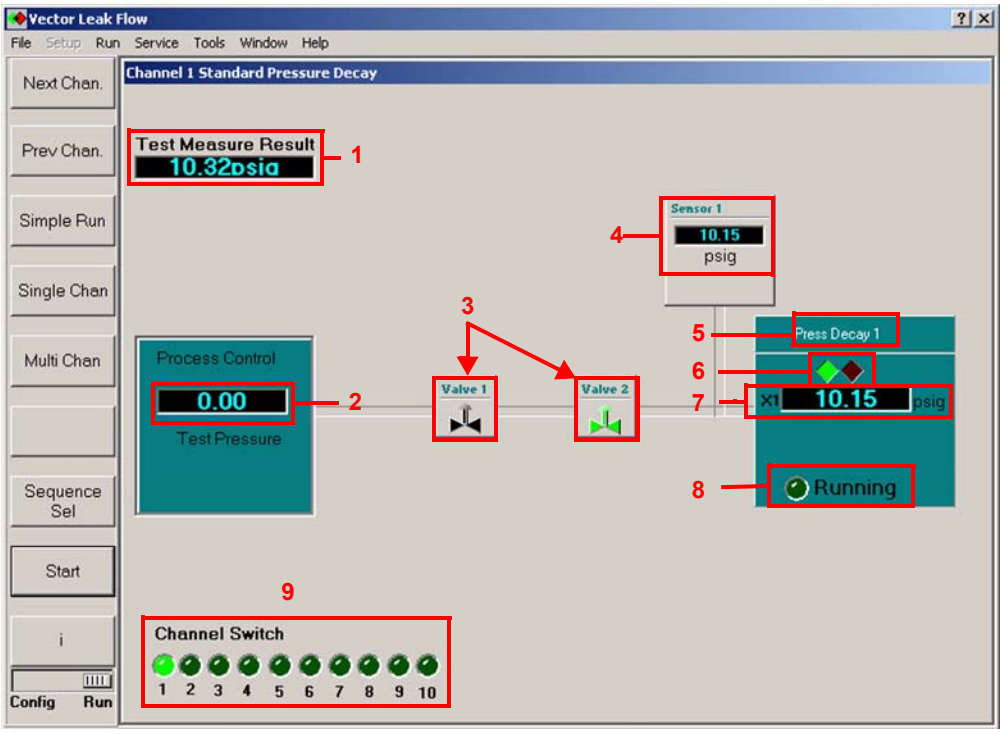
Selection of the appropriate process type for display in active process windows is made during test configuration. See Section 6.2.5, *Configuring a Test*, for instructions on selecting a process type.

Customized active process windows can be developed at the factory to represent the individualized hardware layout and pneumatic configuration of any tester.

The **Standard Pressure Decay** active process window, shown in *Figure 4–16*, displays the following information:

1. Results are displayed in the **Test Measure Result** field.
2. The **Process Control** box displays test pressure based on a regulator reading. If the regulator is manual, the window displays the pressure value input. If the regulator is electronic, the commanded pressure is displayed.
3. Valve indicators show which valves are being utilized at a particular moment. These indicators follow the protocol of red for off and green for on.
4. The **Sensor 1** box provides sensor readings in real time from sensor 1.
5. The name of the current test.
6. Pass/Fail LED indicators display test results graphically at the end of a test.
7. Sensor reading at the conclusion of a test.
8. Tester status indication.
9. LED indicators at the bottom-left corner of the window specify on which channel a test is running. These indicators also act as switch buttons. Clicking on a button displays data from the corresponding channel.

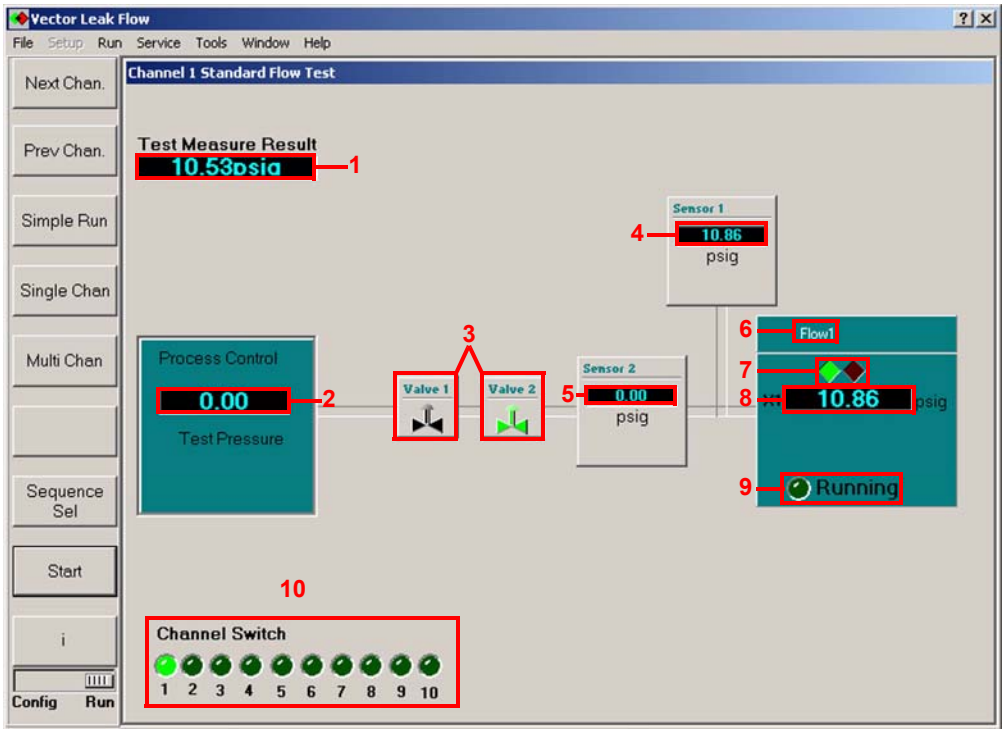
FIGURE 4–16: STANDARD PRESSURE DECAY WINDOW



The **Standard Flow Test** active process window, shown in *Figure 4–17*, displays the following information:

1. Results are displayed in the **Test Measure Result** field.
2. The **Process Control** box displays test pressure based on a regulator reading. If the regulator is manual, the window displays the pressure value input. If the regulator is electronic, the commanded pressure is displayed.
3. Valve indicators show which valves are being utilized at a particular moment. These indicators follow the protocol of red for off and green for on.
4. The **Sensor 1** box provides sensor readings in real time from sensor 1.
5. The **Sensor 2** box provides sensor readings in real time from sensor 2.
6. The name of the current test.
7. Pass/Fail LED indicators display test results graphically at the end of a test.
8. Sensor reading at the conclusion of a test.
9. Tester status indication.
10. LED indicators at the bottom-left corner of the window specify on which channel a test is running. These indicators also act as switch buttons. Clicking on a button displays data from the corresponding channel.

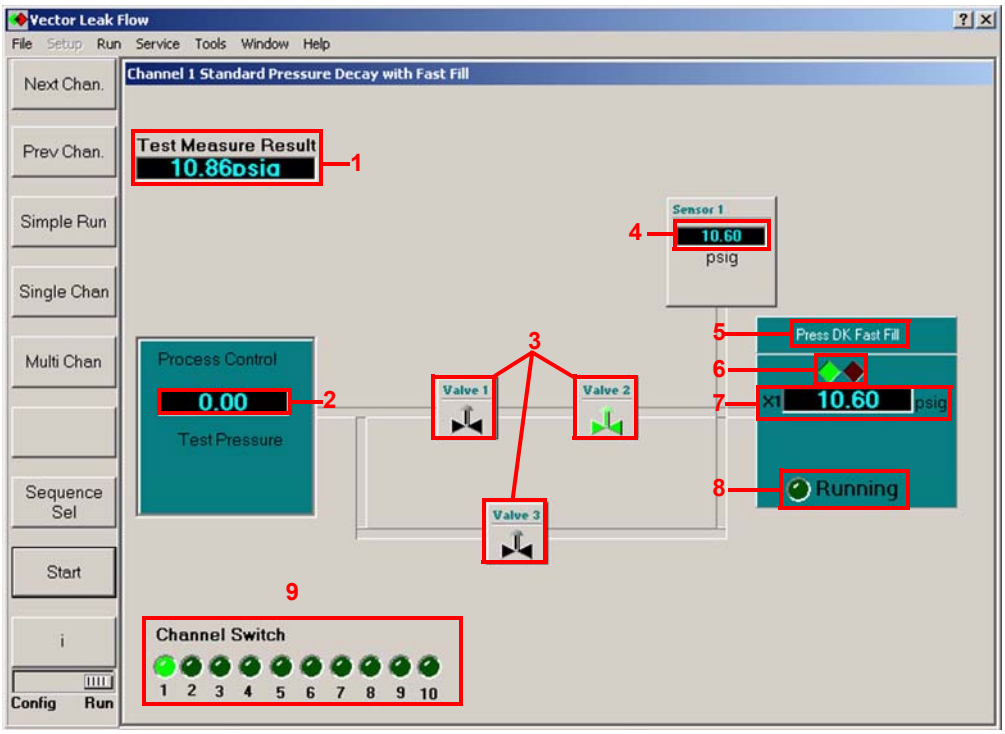
Figure 4–17: Standard Flow Test window



The **Standard Pressure Decay with Fast Fill** active process window, shown in *Figure 4–18*, displays the following information:

1. Results are displayed in the **Test Measure Result** field.
2. The **Process Control** box displays test pressure based on a regulator reading. If the regulator is manual, the window displays the pressure value input. If the regulator is electronic, the commanded pressure is displayed.
3. Valve indicators show which valves are being utilized at a particular moment. These indicators follow the protocol of red for off and green for on.
4. The **Sensor 1** box provides sensor readings in real time from sensor 1.
5. The name of the current test.
6. Pass/Fail LED indicators display test results graphically at the end of a test.
7. Sensor reading at the conclusion of a test.
8. Tester status indication.
9. LED indicators at the bottom-left corner of the window specify on which channel a test is running. These indicators also act as switch buttons. Clicking on a button displays data from the corresponding channel.

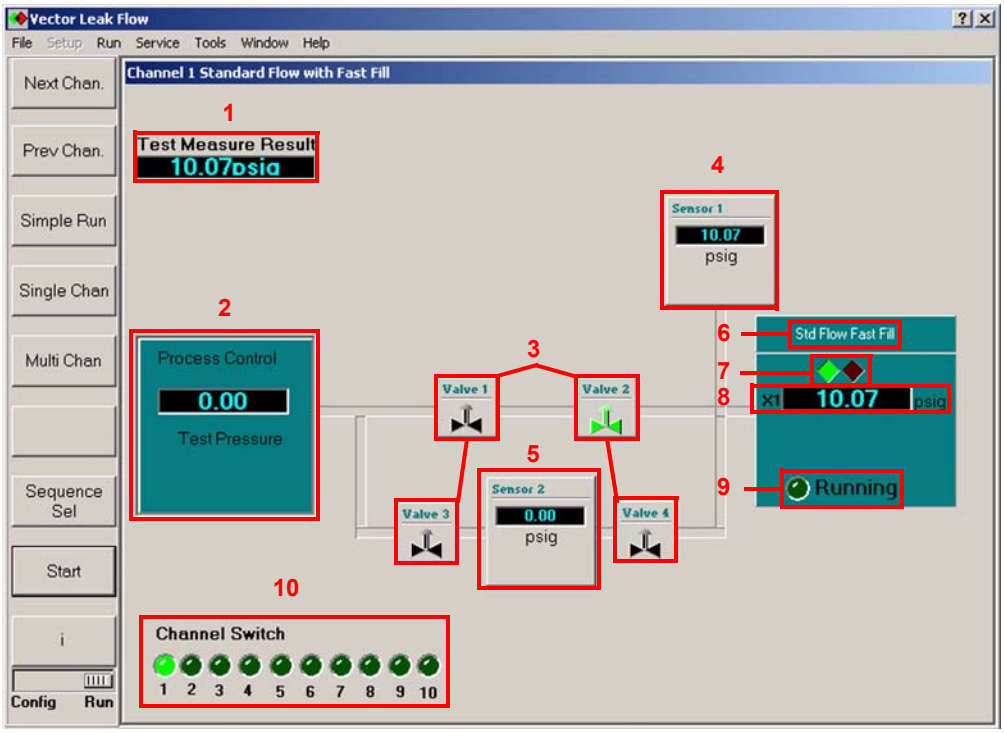
FIGURE 4–18: STANDARD PRESSURE DECAY WITH FAST FILL



The **Standard Flow with Fast Fill** active process window, shown in *Figure 4–19*, displays the following information:

1. Results are displayed in the **Test Measure Result** field.
2. The **Process Control** box displays test pressure based on a regulator reading. If the regulator is manual, the window displays the pressure value input. If the regulator is electronic, the commanded pressure is displayed.
3. Valve indicators show which valves are being utilized at a particular moment. These indicators follow the protocol of red for off and green for on.
4. The **Sensor 1** box provides sensor readings in real time from sensor 1.
5. The **Sensor 2** box provides sensor readings in real time from sensor 2.
6. The name of the current test.
7. Pass/Fail LED indicators display test results graphically at the end of a test.
8. Sensor reading at the conclusion of a test.
9. Tester status indication.
10. LED indicators at the bottom-left corner of the window specify on which channel a test is running. These indicators also act as switch buttons. Clicking on a button displays data from the corresponding channel.

Figure 4–19: Standard Flow with Fast Fill

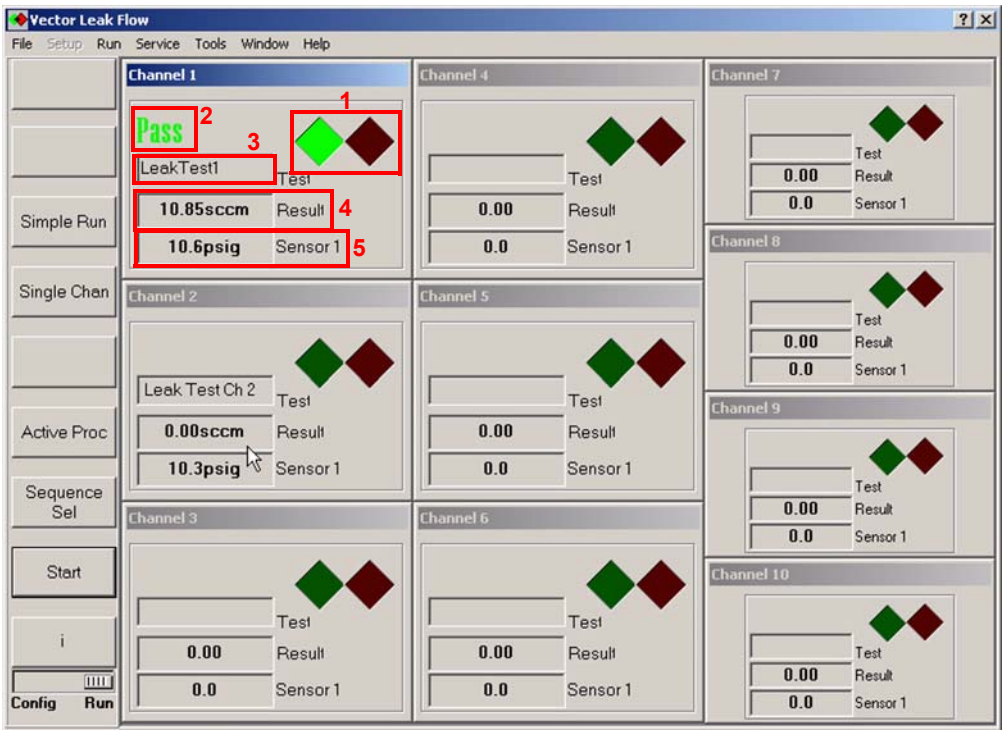


4.3.5 The Multi Channel Run Window

The **Multi Channel Run** window (shown in *Figure 4–20*) simultaneously displays testing progress and results in the Run Mode for each channel in use. The window displays the following information:

1. Pass/Fail LED indicators show test results graphically at the end of a test. The green indicator represents an accept and the red represents a reject.
2. Tester status displays graphically.
3. Test name.
4. Test result.
5. Sensor ID.

Figure 4–20: Multi Channel Run window



4.3.6 The Statistics Window

The **Statistics** window can be configured to display statistical data from tests run previously and real-time data from tests running currently. Displayed data options include X-bars, ranges, upper and lower controls, and histograms.

The Statistics feature is not a standard software feature. This option must have been purchased and enabled in order to use the window.

To access the window, select **Statistics** from the **Tools** menu. The **Statistics** window opens. The following seven tabs are displayed:

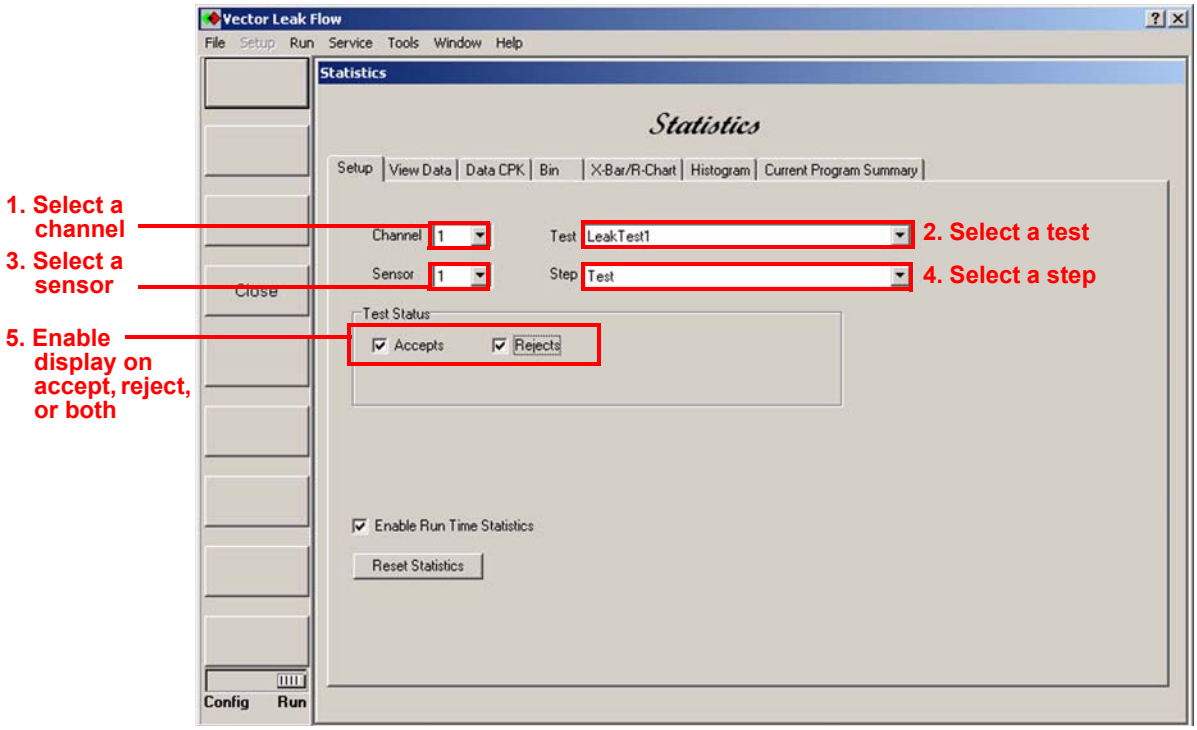
- **Setup**
- **View Data**
- **Data CPK**
- **Bin**
- **X-Bar/R-Chart**
- **Histogram**
- **Current Program Summary**

Setup Tab

The **Setup** tab displays by default when the **Statistics** window opens. (See *Figure 4–21*.) It is used to identify the channel, test, and step for which data will be displayed. Information entered in this tab dictates what information is displayed under the other six **Statistics** window tabs. Use the following procedure to enter information in the **Setup** tab:

1. Click the selector arrow beside the **Channel** field to view channels available for selection. Select a channel from the menu.
2. Click the selector arrow beside the **Test** field to view tests available for selection. Select a test from the menu.
3. Click the selector arrow beside the **Step** field to view steps available for selection. Select a step from the menu.
4. Select a sensor.
5. In the **Test Status** area, indicate whether data will be displayed for accepts, rejects, or both.
6. To clear previously displayed data, click the **Reset Statistics** button.

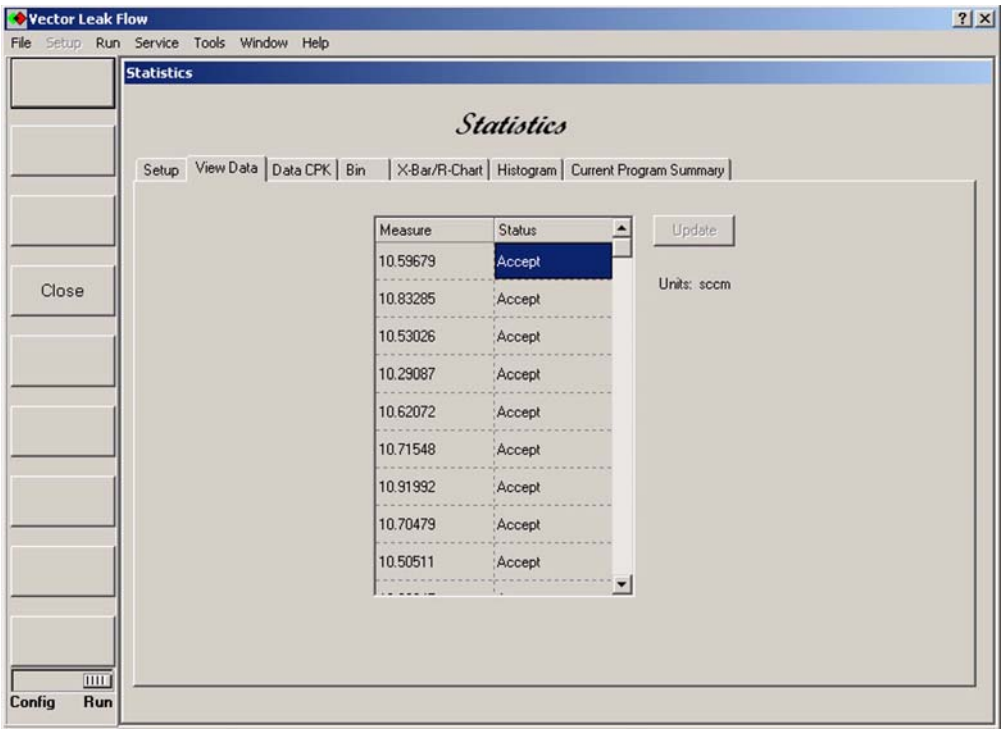
FIGURE 4–21: THE STATISTICS WINDOW AND SETUP TAB



View Data Tab

Once the required information is supplied under the **Setup** tab, the **View Data** tab displays measured values for the selected step. (See *Figure 4–22*.) Click the **Update** button to refresh the display.

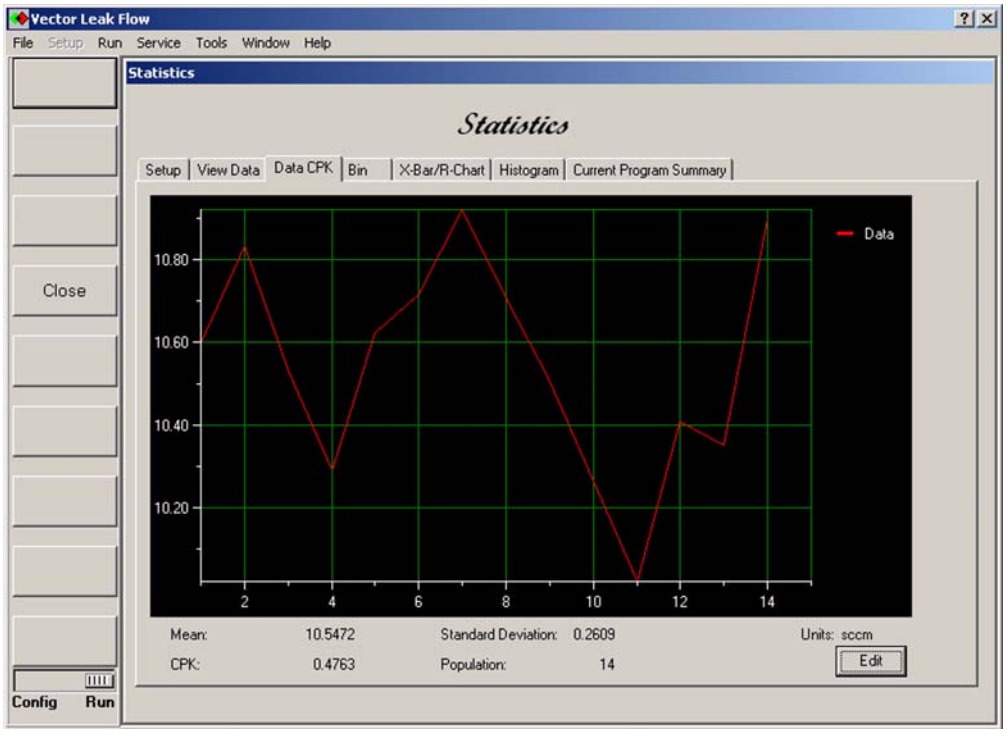
Figure 4–22: View Data measured values



Data CPK Tab

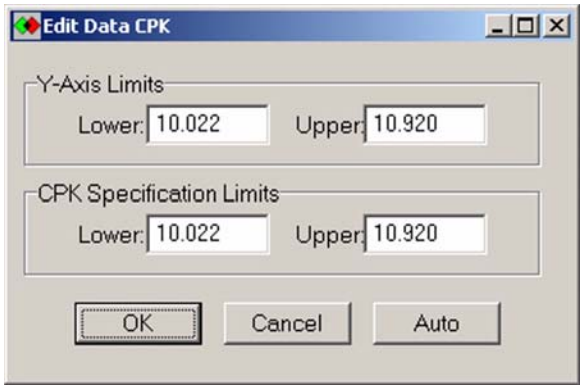
The **Data CPK** tab displays repeatability and accuracy tolerance factor data in a graphical format. (See *Figure 4–23*.) The graph plots the number of times an acceptable result was achieved during a test.

Figure 4–23: Data CPK tab



Clicking the **Edit** button permits the operator to redefine the graph axes and CPK specification limits in the **Edit Data CPK** dialog. (See *Figure 4–24*.)

FIGURE 4–24: EDIT DATA CPK DIALOG

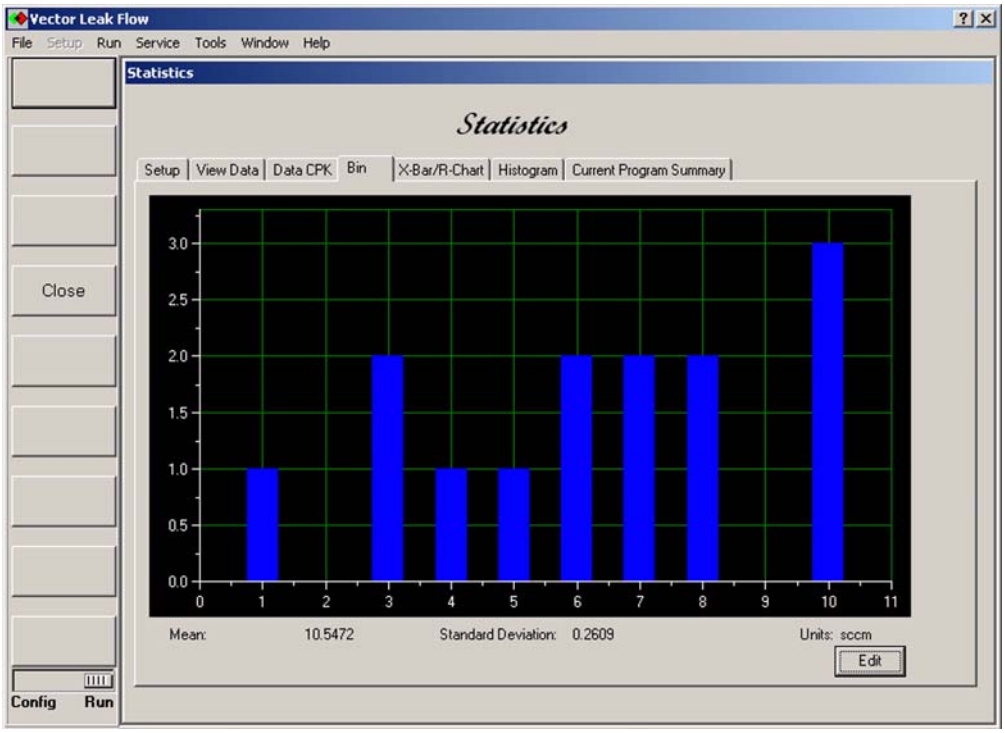


Clicking the **Auto** button in the **Edit Data CPK** dialog automatically sizes the table by adjusting the upper and lower limits of the Y-axis based on the spread of data.

Bin Tab

The bar graph under the **Bin** tab represents statistical data in a simplified histogram. (See *Figure 4–25*.) Data points represent "bins" into which statistical data from tests are classified. The percentage value represents the percentage of all data falling into a bin.

Figure 4–25: Bin tab statistical data



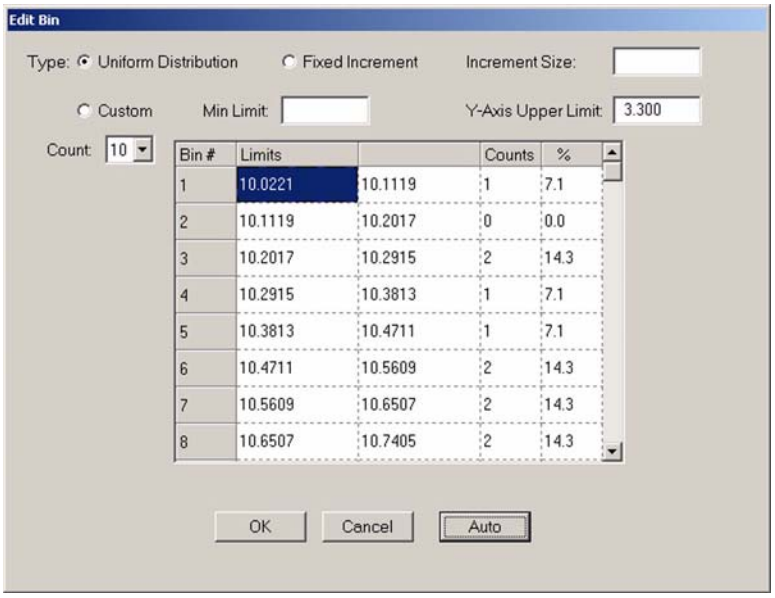
Clicking the **Edit** button in the bottom-right corner of the **Bin** tab opens the **Edit Bin** dialog (shown in *Figure 4–26*).

the operator can alter the following parameters in the **Edit Bin** dialog:

- **Type**: Select a distribution type, **Uniform Distribution** or **Custom**.
- **Increment Size**: Check **Fixed Increment** and enter an increment size.
- **Min. Limit**: If **Custom** has been selected as the distribution type, enter a minimum limit.
- **Y-Axis Upper Limit**: Enter a Y-axis upper limit.

Clicking the **Auto** button sets up the best case for data as it is returned.

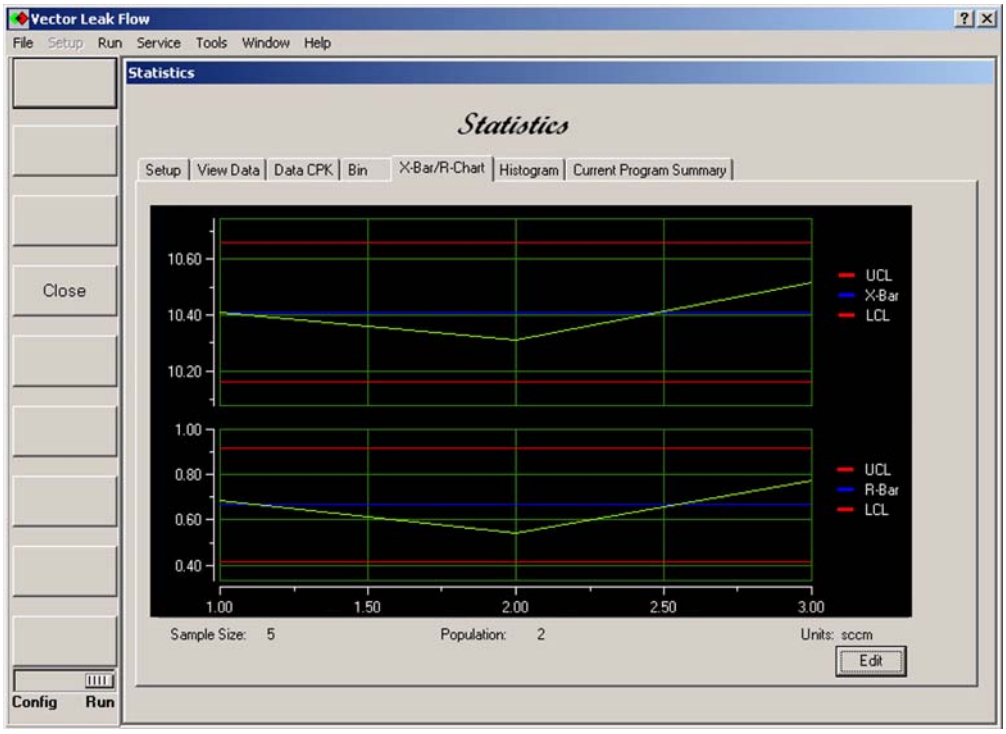
Figure 4–26: Edit Bin dialog



X-Bar/R-Chart Tab

In the **X-Bar/R-Chart** tab, the X-Bar shows an average of averages. (See *Figure 4–27*.) The R-Bar shows the range between the averages.

Figure 4–27: X-Bar/R-Chart tab



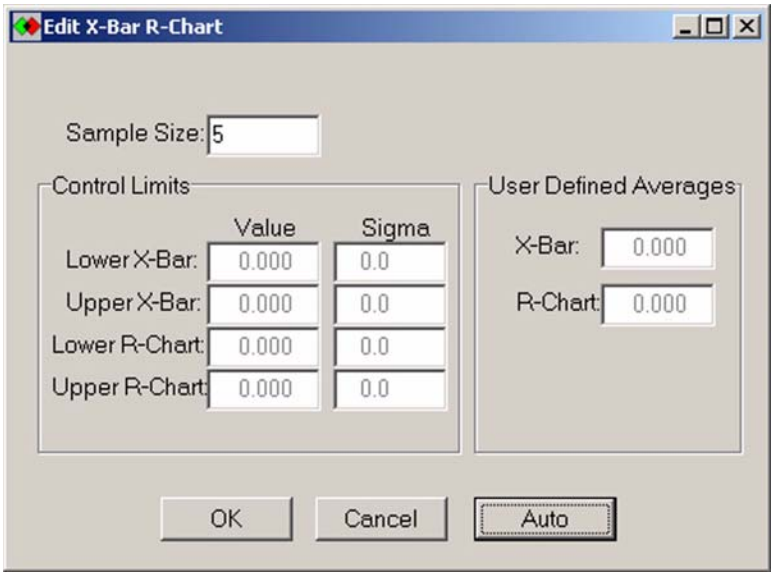
Clicking the **Edit** button in the bottom-right corner of the **X-Bar/R-Chart** tab opens the **Edit X-Bar/R-Chart** dialog, shown in *Figure 4–28*.

The operator can alter the following parameters in the **X-Bar/R-Chart** dialog:

- **Sample Size**
- **Control Limits**
- **User-Defined Averages**

Clicking the **Auto** button adjusts all of the limits and averages based on the operator-defined sample size.

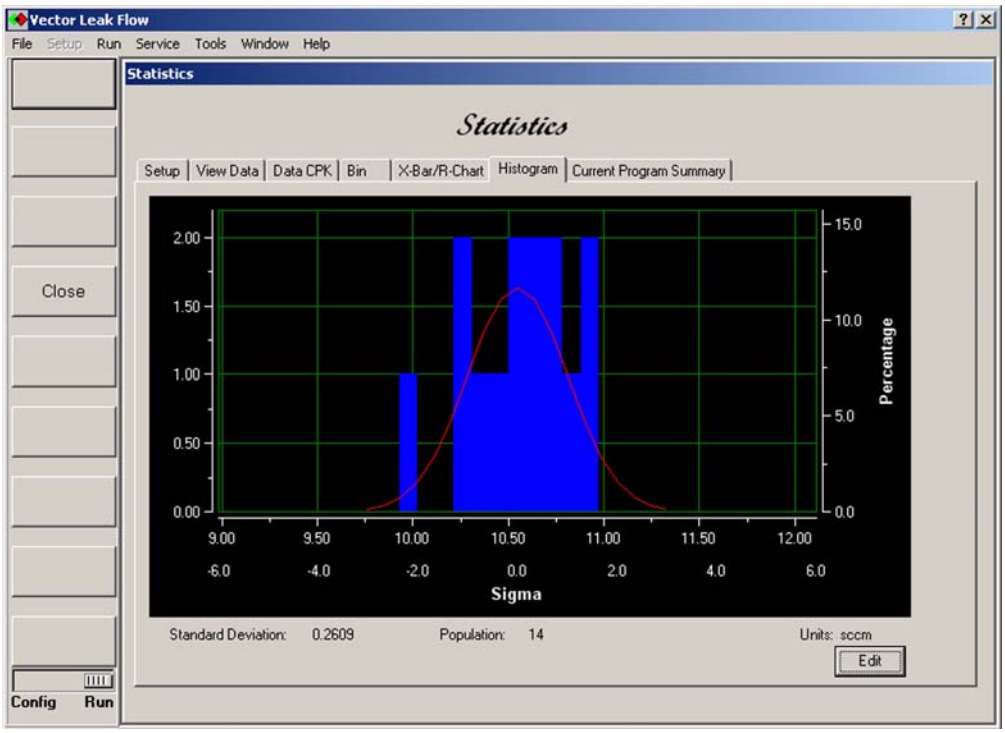
FIGURE 4–28: EDIT X-BAR R-CHART DIALOG



Histogram Tab

The **Histogram** tab shows a standard Bell curve of test results. (See *Figure 4–29*.)

Figure 4–29: Histogram tab Showing Bell curve



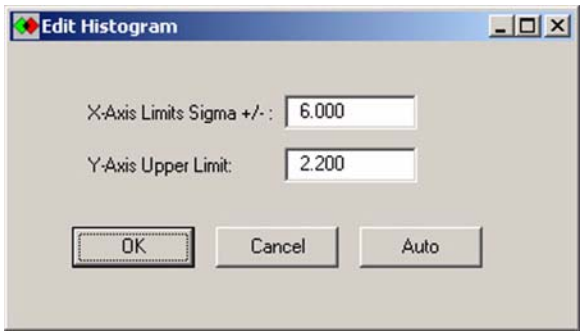
Clicking the **Edit** button in the bottom-right corner of the **Histogram** tab opens the **Edit Histogram** dialog, shown in *Figure 4–30*.

The operator can modify the following parameters in the **Edit Histogram** dialog:

- **X-Axis limits Sigma +/-**
- **Y-Axis upper limit**

Clicking the **Auto** button in the **Edit Histogram** dialog adjusts the Y-axis maximum limit automatically.

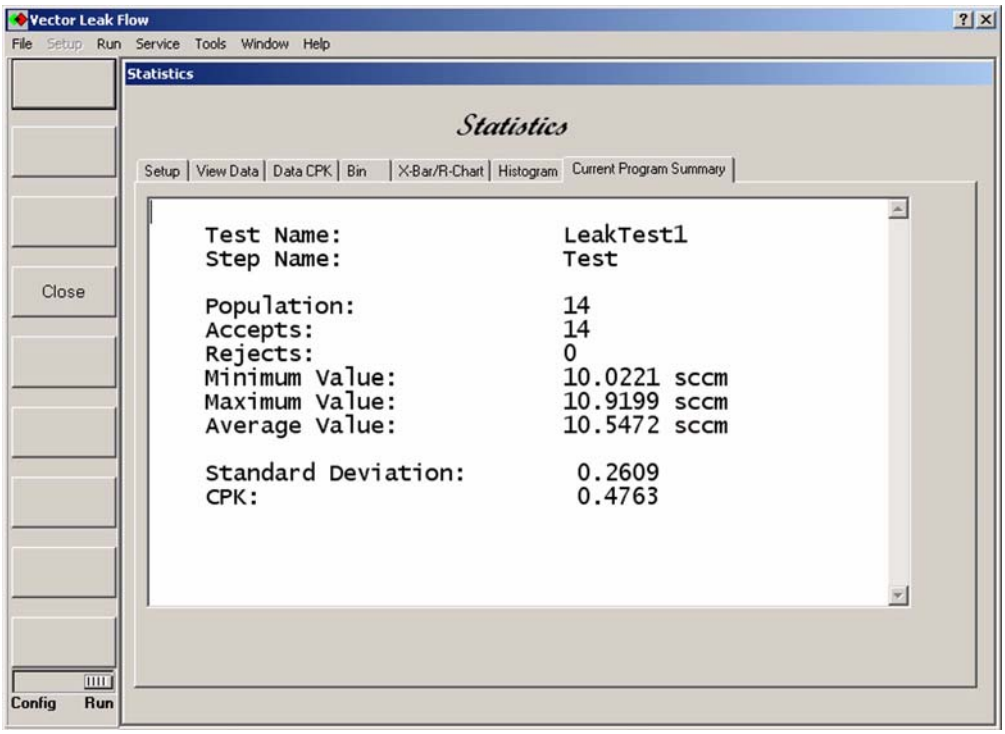
FIGURE 4–30: THE EDIT HISTOGRAM DIALOG



CURRENT PROGRAM SUMMARY TAB

The **Current Program Summary** tab (shown in *Figure 4–31*) displays a variety of summary statistical information for the currently selected test. Statistics include the number of tests run, mean, standard deviation, maximum and minimum values recorded, population, number of accepts, and number of rejects.

FIGURE 4–31: CURRENT PROGRAM SUMMARY WINDOW



5 Diagnostics and Leak Tester Troubleshooting

5.1 What to do Before Calling for Help

With any leak-testing system, technical problems can affect the reliable operation of the tester.

Many such problems are pneumatic- or fixture-related, and often these problems are easily diagnosed and corrected.

Before contacting Uson Service, read this chapter carefully.

Assistance from Uson is available for leak-testing problems. Experience has proven that many problems can easily be solved by following a systematic and disciplined troubleshooting procedure. Before calling Uson, follow the procedures described in Section 5.2, *Vector System Diagnostic Tools*, and Section 5.3, *Leak Tester Troubleshooting*.

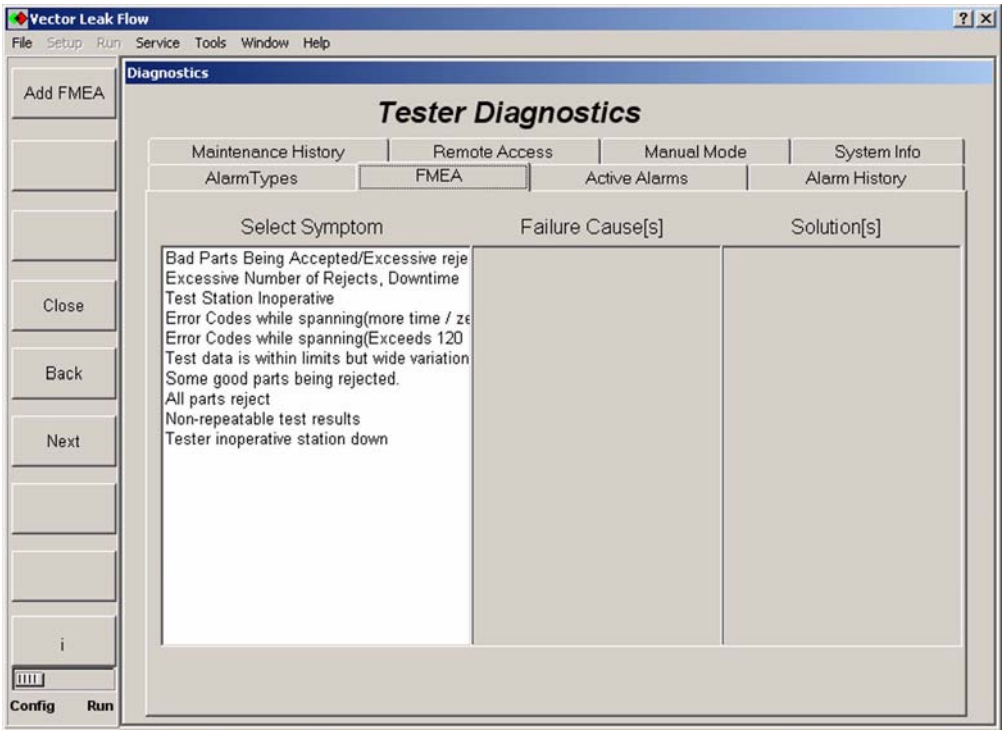
5.2 Vector System Diagnostic Tools

To access the Vector's built-in diagnostic tools, click the **Diagnostics** option key on the left edge of the main **Vector Leak Flow** window, or select **Diagnostics** from the **Service** menu. The **Tester Diagnostics** window opens. This window contains eight tabs, each corresponding to a separate window displaying a diagnostic tool or tools. The windows are:

- **Active Alarms**
- **Alarm History**
- **Alarm Types**
- **FMEA**
- **Maintenance History**
- **Manual Mode**
- **OIP Test**
- **System Info**

The Vector's diagnostic tools are accessible only in the Configure Mode.

Figure 5–1: Diagnostics Window



5.2.1 FMEA

The Vector's diagnostic tools include Failure Mode and Effects Analysis (FMEA).

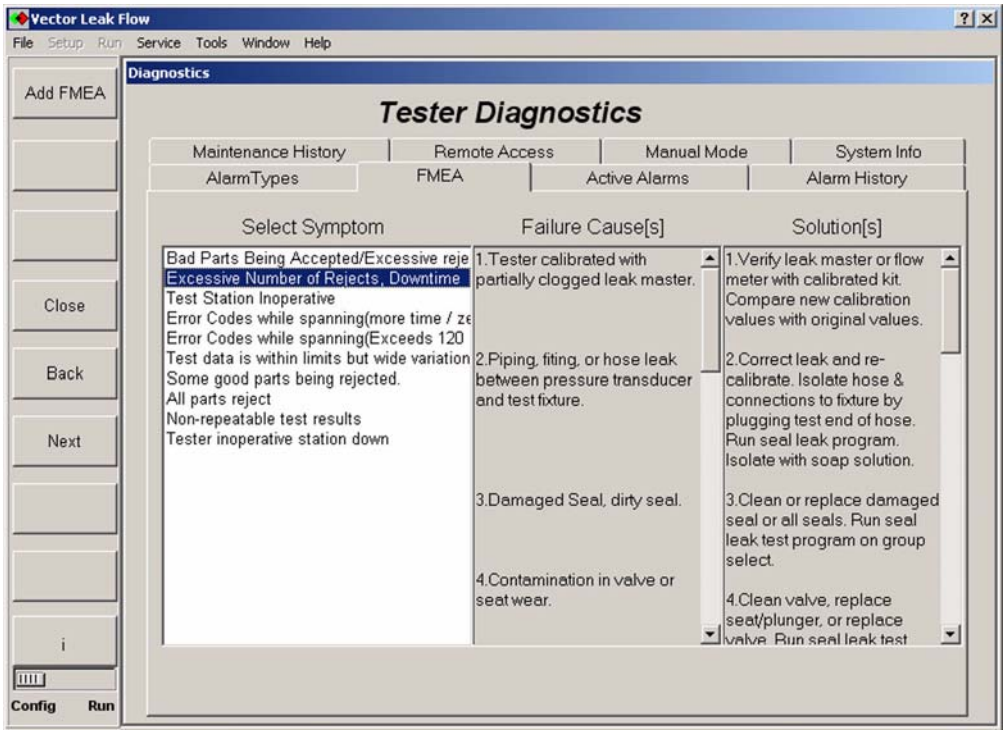
The FMEA tab in the Tester Diagnostics window displays symptoms, possible failure cause(s), and potential solutions. It is divided into three primary areas:

- **Select Symptom**: The **Select Symptom** area displays a list of tester symptoms.
- **Failure Cause(s)**: The **Failure Cause** area displays a list of possible failure causes associated with the selected symptom.
- **Solution(s)**: The **Solution** area displays a list of possible solutions for the symptom that is selected.

To view failure causes and solutions for a symptom, use the mouse pointer to click a symptom in the **Select Symptom** area. Probable causes will then display in the **Failure Causes** area, and suggested fixes will display in the **Solution** area. (See *Figure 5–2*.) The up and down arrow keys can be used to scroll through the list of symptoms and associated failure causes and solutions.

Neither the information in this manual nor the information displayed online in the FMEA window is intended to represent a full FMEA document. The information presented by Uson on this topic is a condensed version intended to help users understand probable causes for alarms.

Figure 5–2: FMEA tab



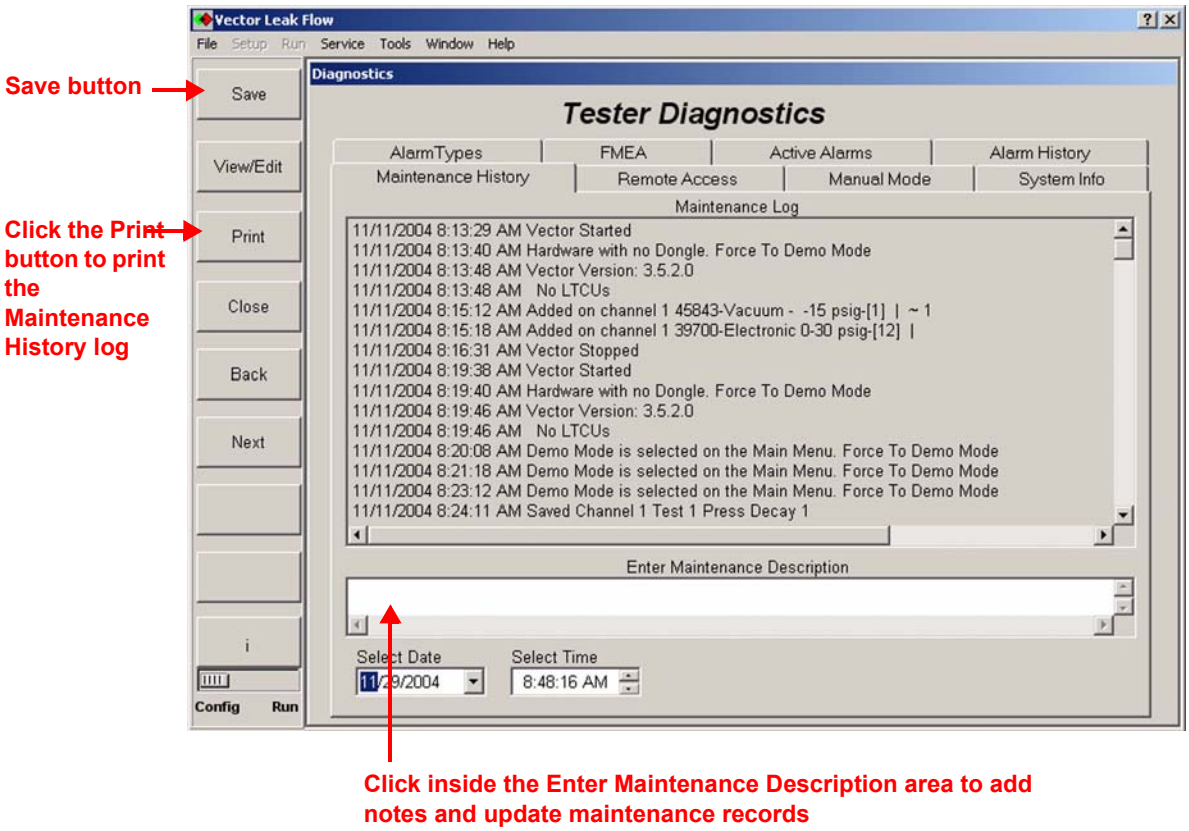
5.2.2 Maintenance History

The **Maintenance History** tab (shown in *Figure 5–3*) displays maintenance information and provides an area for the operator to update records when a maintenance task is performed. When the operator accesses the window, previously recorded maintenance information displays automatically in the **Maintenance Log** list.

To add new information to the log:

1. Click inside the **Enter Maintenance Description** area. The current day's date and the current time appear automatically in the **Select Date** and **Select Time** boxes.
2. Enter maintenance information as desired.
3. Click the **Save** button at the top-left edge of the window.

Figure 5–3: Tester Diagnostics Window: Maintenance History Tab



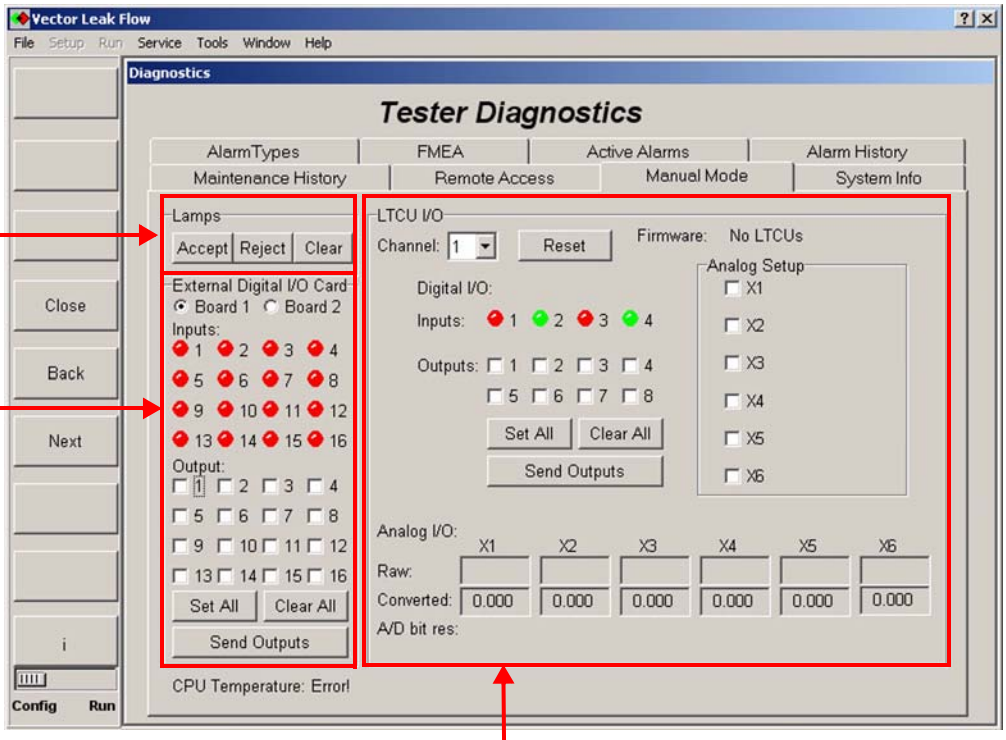
5.2.3 Checking System Hardware Using Manual Mode

The **Manual Mode** tab is divided into areas for checking the External Digital I/O card and the LTCU I/O card. External Digital I/O diagnostics are designed to diagnose problems with the accept and reject LED indicators, 16 digital inputs, and 16 digital outputs. LTCU I/O diagnostics are used to diagnose problems with four digital inputs, eight valve outputs, and six analog ports.

Checking Accept and Reject LED Indicators

To determine whether the accept and reject LED indicators on the Operator Interface Panel are functioning properly, click the **Accept** and **Reject** buttons in the top-left corner of the **Manual Mode** tab. The LED indicators should light briefly on the Operator Interface Panel. To turn off the lamps, click the **Clear** button. (See *Figure 5–4*.)

Figure 5–4: The Manual Mode tab



The Lamps section is used to check the Accept and Reject LED indicators

The External Digital I/O section is used to check the 16 digital inputs outputs

The LTCU I/O section is used to check four digital inputs, eight valve outputs, and six analog ports

Before testing External Digital Output (EDO) or LTCU Digital Output (LDO), make certain that all devices connected to outputs are configured for safe operation. Disconnect from air pressure any output device that will constitute a safety hazard when air pressure is applied during testing.

Checking Digital Inputs and Outputs

The 16 LED indicators in the top-left portion of the **Tester Diagnostics** window's **External Digital I/O Card** area correspond to inputs received by the External Digital I/O card. To determine whether there is a problem with any or all of the 16 inputs, click inside any of the numbered checkboxes at the bottom-left corner of the window (or click the **Set All** button to select all 16 inputs). The checkboxes represent output. Click the **Send Outputs** button. LED indicators corresponding to selected outputs light up to indicate that the output was sent and received, and that no problem exists. (See *Figure 5–4*.)

Checking LTCU Digital Inputs and Outputs

The LTCU I/O portion of the **Manual Mode** tab allows the operator to check four digital inputs (ordinarily these are start signals or button commands), eight valve outputs, and six analog ports.

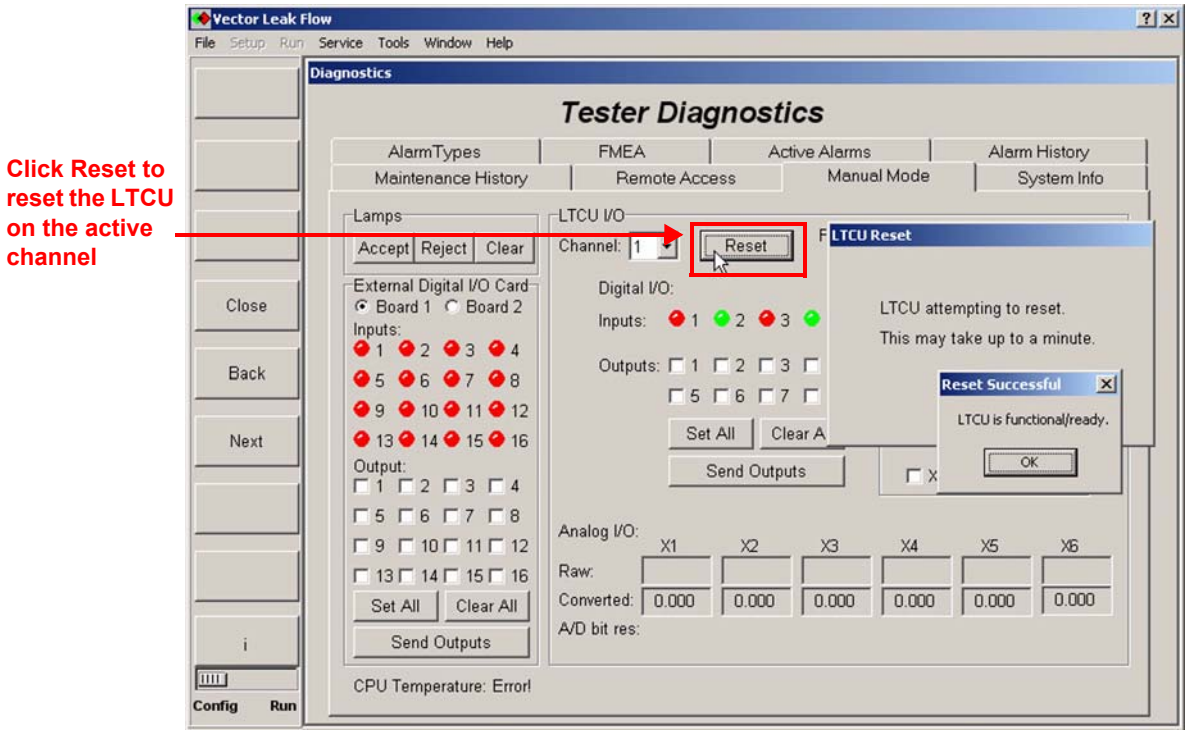
Use the following procedure to check digital inputs and outputs:

1. Select a channel for the **Channel** box. (See *Figure 5–6*.)
2. To set a valve output, click inside the numbered checkbox in the **Outputs** area corresponding to the valve to be tested. To select all eight valve outputs, click the **Set All** button.
3. Click the **Send Outputs** button, which sends a command to the LTCU to activate the LTCU outputs (usually valves).

Reinitializing LTCUs

The **Reset** button in the LTCU I/O portion of the **Manual Mode** tab can be used to reinitialize the LTCU on the currently selected channel. This might become necessary if communications are lagging, graphics appear slow, or if messages are lost. To reinitialize, click the **Reset** button. (See *Figure 5–6*.) After the system reestablishes communication with the LTCU, it will be necessary to reload the current sequence or test before attempting to run it again.

Figure 5–5: Reinitializing an LTCU

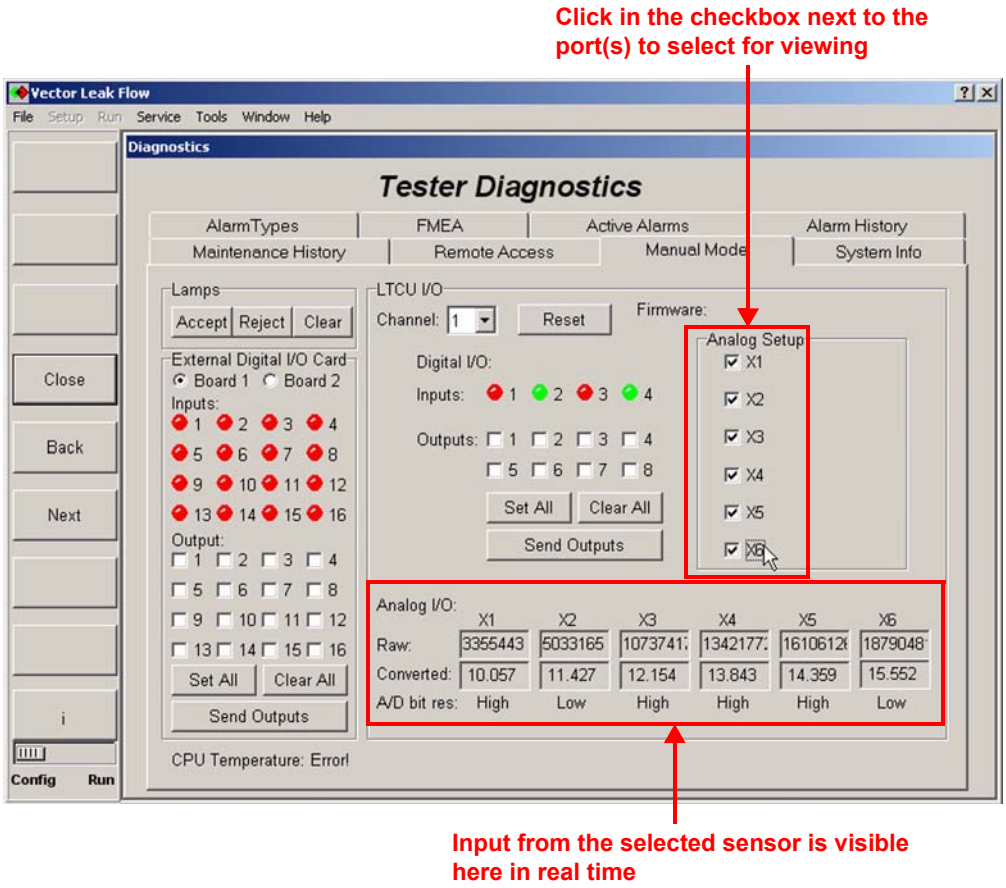


Checking LTCU Analog Inputs

The Analog Setup area in the ManualModeRun tab in the Tester Diagnostics window is used to check analog inputs and outputs. To view analog input in real time, first select an analog port (or ports) in the **Analog Setup** area by clicking in one or more of the checkboxes labeled **X1** through **X6**. (See *Figure 5–6*.) Each of these represents an analog port.

Input from the selected sensor(s) becomes visible in real time in the **Analog I/O** area at the bottom of the **Manual Mode** tab. Information in the **Raw** column represents unconverted data from the sensor(s). Information in the **Converted** column represents data converted into engineering units.

Figure 5–6: The Analog Setup area



5.3 Leak Tester Troubleshooting

Troubleshooting information in this chapter breaks down into several sections:

- Section 5.3.1, *Recognizing Adiabatic Heating and Elastic Creep*
- Section 5.3.2, *Counteracting Adiabatic Heating and Elastic Creep*
- Section 5.3.3, *Checking Master Part Leak Rate Repeatability*
- Section 5.3.4, *Checking Pneumatic, Fixture, and Master Part Integrity*
- Section 5.4, *Troubleshooting Tips*

If none of these sections helps to correct the problem, call the Uson Customer Support line for technical assistance. See Section 2.4, *Getting Help*, for information on contacting Customer Service.

The Vector's components are not field-serviceable, but are designed as removable modules, each of which can be removed and returned to the factory for maintenance.
Use caution when removing the power supply module, as internal electrical components may be exposed in the process.
Disconnect all electrical sources when working with internal components of Uson equipment.

Disconnect all pressure sources when working with components of Uson equipment.

5.3.1 Recognizing Adiabatic Heating and Elastic Creep

In most leak-testing applications, the operator must be aware of leak-testing timing considerations associated with adiabatic heating and/or elastic creep in the part. Adiabatic heating is the process of air heating during the Fill Step, while elastic creep is the process of elastomeric material yielding to pressure.

Adiabatic heating is detrimental to leak testing because it masks leaks. After the Fill Step, the air begins to cool. As the air cools, the pressure decreases. If not calibrated, this pressure loss may be misinterpreted as a leak.

Elastic creep also causes a pressure loss. After the Fill Step, elastomeric materials continue to yield to the pressure. This causes an increase in the volume of the part and thus, decreases the pressure.

Pressurizing a part causes the temperature of the air to rise. As the air temperature cools to the same temperature as the part, the pressure will drop. The adiabatic pressure drop is exponential. *Figure 5–7* shows a leak test with the effect on pressure caused by adiabatic heating.

FIGURE 5–7: ADIABATIC PRESSURE LOSS

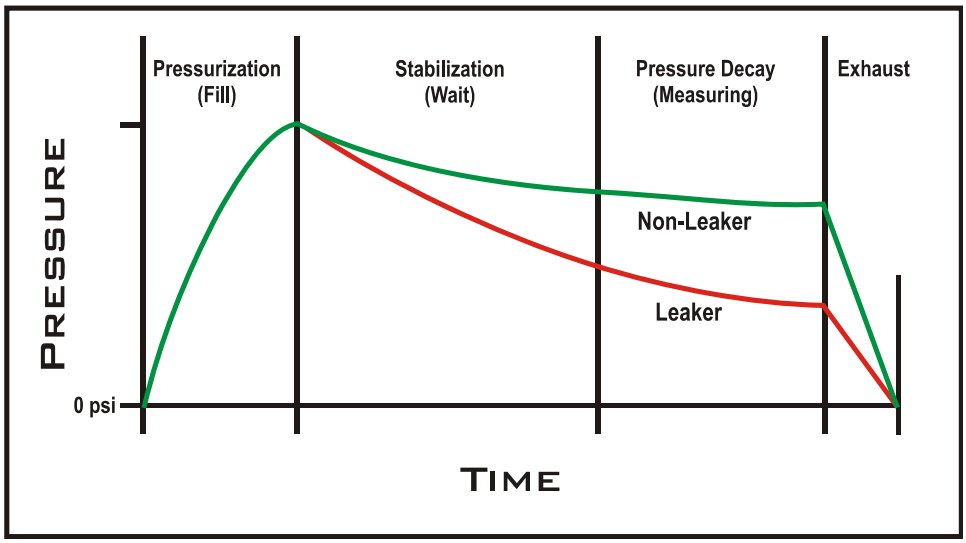
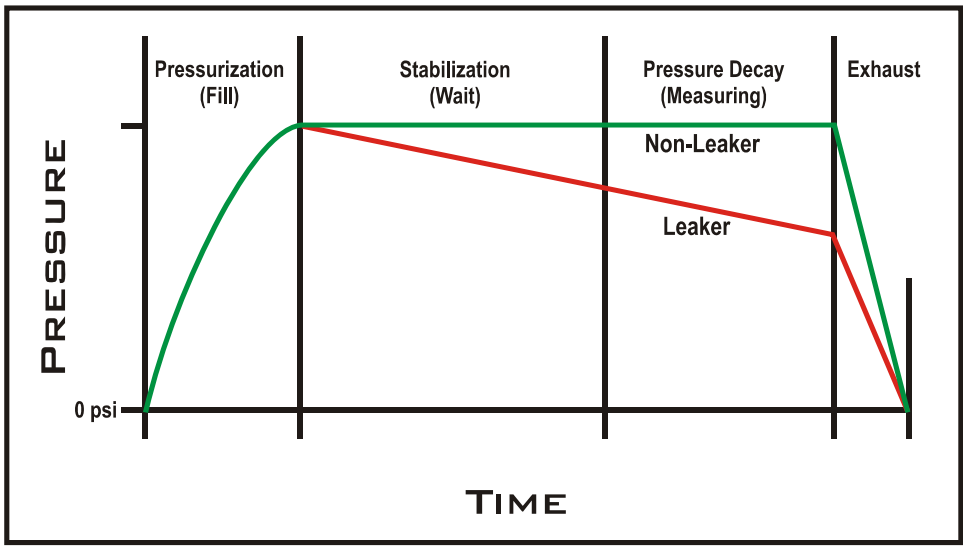


FIGURE 5–8: PRESSURE LOSS CAUSED BY A LEAK IS LINEAR



Unlike pressure loss caused by adiabatic heating, pressure loss caused by a leak is linear

The effects of adiabatic heating can interfere with accurate, fast leak testing, even to the point of masking an actual leak. These effects vary from part to part, fixture to fixture, and system to system. In general, the larger the volume, or the greater the pressure, the greater will be the effect of adiabatic heating.

5.3.2 Counteracting Adiabatic Heating and Elastic Creep

One fix for adiabatic heating or elastic creep effects is to lengthen the Stabilize Step until all of the adiabatic heating and elastic creep effects are gone. This method, however, consumes valuable time and may not be practical in a production atmosphere.

Another solution uses compensation to allow the stabilization time to be reduced within reason. Under these conditions, the shorter the stabilization, the less repeatable the leak measurement will be.

The best solution is to use the Advanced Leak Detector. This approach models the adiabatic heating effect and automatically accounts for it. This method provides the fastest test and the most repeatable results.

5.3.3 Checking Master Part Leak Rate Repeatability

Tests run with the master part should show a repeatability of plus or minus five percent, or better. If a master part does not show good repeatability, production part repeatability will be even worse.

When a problem with repeatability occurs, begin by using the following procedure to run a Repeatability Study to test leak rate repeatability:

1. Re-run Leak Rate Calibration procedures to verify proper system calibration.
2. If using the Comp/Cal Leak Rate Calibration method for pressure decay testing the following values are optimal:
   - The sensitivity calculated by the tester should be greater than 0.05% of test pressure for a high-sensitivity tester, or 0.2% of test pressure for a low-sensitivity tester.[1]
   - The Comp/Cal Ratio should be less than 2.0. The tester will not show good repeatability if these values are outside recommended ranges.
   - To improve sensitivity, increase the length of the Leak Step and rerun the compensation and calibration procedures until leak sensitivity is greater than 0.05% of test pressure for a high-sensitivity tester, or 0.2% of test pressure for a low-sensitivity tester.
   - To lower the Comp/Cal ratio, increase the length of the Stabilize Step and rerun the compensation and calibration procedures until the Comp/Cal ratio is less than 2.0.

1. High sensitivity is an option available at the time of purchase.

3. Clamp the master part and run at least 10 consecutive Master Part Leak Rate Repeatability Tests without unclamping the part, but venting between tests. Ordinarily, two minutes of venting is adequate, but this may vary based on the amount of adiabatic heating. Run the tests with the Leak Master installed, keeping the part clamped between tests.
4. The test should show a repeatability of plus or minus five percent, or better. To improve repeatability, try increasing the Stabilize and Leak Step times.

If the master part fails to produce repeatable results, see Section 5.3.4, *Checking Pneumatic, Fixture, and Master Part Integrity*. For detailed information on repeatability testing, see Chapter 6, *Repeatability Studies*. For further information on identifying the source of the problem, refer to Section 5.4, *Troubleshooting Tips*.

5.3.4 Checking Pneumatic, Fixture, and Master Part Integrity

The Seal Leak Test is the single most important tool in verifying that the pneumatic system, fixture, and master part do not leak. If a system is exhibiting a high leak rate, the first step is to run the Seal Leak Test in the following sequence:

1. Run the Seal Leak Test. If the test passes, the pneumatic system, fixture, and master part are within acceptable ranges. If the test fails, continue with Step 2.

If a Seal Leak Test is not set up for the channel, set one up by copying the test and lengthening the Fill and Stabilize Test Step times.

2. Run the Seal Leak Test three or four times consecutively without installing the Leak Master, and without unclamping or venting the part. If the Seal Leak Tests fail, but the test results improve with each test, the problem may be that more time is required to dissipate the adiabatic heating effect, or that the seals in the fixture are moving. If readings remain the same for each test, then there is a leak in the pneumatic system.

Checking Pneumatic System Integrity

Follow these steps to check the pneumatics for leaks:

1. Seal off the tester's pneumatics from the master part and fixture, if possible.
2. Run the Seal Leak Test again. If the test fails, there is a leak in the pneumatics between the transducer and the point at which the air supply is sealed off.
3. Apply a light, soapy solution such as Snoop® or Leak-Tec® to all pneumatic lines and connections, and look for bubbles. Turn on appropriate valves, or restart the Seal Leak Test, if necessary, to keep air in the lines. If no leak is found in the pneumatics system, a solenoid valve could be leaking.
4. Repair any leaks or replace faulty hoses.
5. Reconnect the master part and fixture and rerun the Seal Leak Test.
6. If the test passes, the problem has probably been corrected. Run Repeatability Tests on the master part for verification before running production tests.

If the test fails, the problem may lie with the fixture or master part.

Checking Fixture and Master Part Integrity

Follow these steps to check the master part and fixture for leaks:

1. If the Seal Leak Test passed with the master part and fixture sealed off, reconnect the part and fixture. Apply the light, soapy solution to the master part and fixture again, and repeat the process of visually inspecting for leaks while keeping pressure on the system.

To increase accuracy and speed in leak location, use the Uson 1210 Leak Locator, a rapid-detection, portable, hand-held helium detector manufactured and sold separately by Uson.

2. Repair any leaks discovered, or use a new, non-leaking part or fixture.
3. Rerun the Seal Leak Test. Pressure readings greater than + 0.002 indicate seal creep, which ordinarily occurs when a metal-to-metal connection fails when a fixture is closed. To confirm seal creep, run a Seal Creep Test (see *Running a Seal Creep Test* in this section).
4. If the test passes, the problem has probably been corrected. Run Repeatability Tests (see Chapter 6, *Repeatability Studies*) on the master part for verification before running production tests.

Running a Seal Creep Test

If the tester fails to produce repeatable results, follow these steps to run a Seal Creep Test, which will determine whether seal creep exists:

1. Adjust the step times in the Seal Creep Test to match the production test step.
2. Remove the test air supply from the regulator inlet.
3. Perform normal production leak tests on the master part and note the pressure reading at the end of each test. Pressure readings greater than + 0.002 indicate seal creep.

5.4 Troubleshooting Tips

These tips suggest probable causes and solutions for specific problems.

5.4.1 Good Parts Fail Production Tests

Table 5–1, "Good Parts Fail Production Tests," provides some ideas of things to look for when good parts fail production tests.

Table 5–1: Good Parts Fail Production Tests

Probable Cause	Solution
Leaks are occurring in the system	1. Run a Seal Leak Test. If the test fails, go to Step 2. If the test passes, see *Leak rate calibration may be off* (in this table). 2. Use a soapy water solution to locate any leaks.
Leak rate calibration may be off	1. Recalibrate the tester using the master part, with and without the Leak Master installed. 2. Compare new values with original values. If the values are the same, go to Step 3. If the values are different, see *Leak Master may be faulty or out of calibration* (in this table). 3. Run the Master Part Repeatability Test to verify the calibration.
Leak Master may be faulty or out of calibration	1. Verify the Leak Master leak rate with a calibrated flow meter or return it to Uson for verification. 2. Recalibrate the Leak Master if necessary. 3. Recalibrate the tester and run Repeatability Tests to verify repeatability.

If there are problems with repeatability, refer to *Table 5–2, "Good Parts Fail Repeatability Leak Tests,"* for additional possible causes.

5.4.2 Good Parts Fail Repeatability Leak Tests

If good parts are failing to produce repeatable results, and the possibilities in *Table 5–1, "Good Parts Fail Production Tests,"* have been ruled out, refer to *Table 5–2, "Good Parts Fail Repeatability Leak Tests,"* for possible causes and solutions.

Table 5–2: Good Parts Fail Repeatability Leak Tests

Probable Cause	Solution
Cal value is less than 0.05 percent of the transducer span	1. Increase the time of the Leak Step. 2. Recalibrate the tester.
Comp value is not between 0 and 4 times the Cal value (the Comp/Cal ratio is too high)	1. Increase the time of the Fill Step and/or the Stabilize Step. 2. Recalibrate the tester.
Part temperature varies	Keep parts at consistent temperatures.
Ambient or line air temperature varies	Control ambient or line conditions.
Line air supply contains moisture or water	1. Clean liquid traps and filters and blow out main supply. 2. Add traps if necessary.
Line air supply varies	Install local reservoir (tank) and regulator.
Test air supply varies	1. Install pre-regulator upstream. 2. Service or replace test air regulator.
Ambient pressure conditions vary	Control air pressure in room. (Close doors, windows, etc.)
Test part porosity varies	1. Notify foundry of porosity problems. 2. Increase test times for Fill and Stabilize Steps.
Parts contain water or oil residue	1. Clean and dry parts prior to testing. 2. Increase test times for Fill and Stabilize Steps.

5.4.3 Leaking Parts Pass Leak Tests

If leaking parts are passing production tests, use *Table 5–3, "Leaking Parts Pass Leak Tests,"* to identify possible causes and solutions:

Table 5–3: Leaking Parts Pass Leak Tests

Probable Cause	Solution
System calibration may be off	1. Recalibrate the tester using the master part with and without the Leak Master installed. 2. Compare new values with original values. If the values are the same, go to Step 3. If the values are different, see *Leak Master may be faulty or out of calibration* (in this table). 3. Run a Master Part Repeatability Test to verify calibration.
Leak Master may be faulty or out of calibration	1. Verify the Leak Master and replace it, if necessary. If the Leak Master is satisfactory, inspect all pneumatics, lines, ports, and valves. 2. Recalibrate the Leak Master. 3. Recalibrate and verify the tester.
Pneumatics or fixture may contain closed or clogged fill ports, manual isolation valves, pinched test lines, or faulty routing solenoid valves	Inspect all pneumatics, lines, ports, and valves.

5.4.4 Test Parts Fail to Reach Test Pressure

If test parts fail to reach test pressure, consider the possibilities in *Table 5–4, "Test Parts Fail to Reach Test Pressure."*

Table 5–4: Test Parts Fail to Reach Test Pressure

Probable Cause	Solution
Pressure regulator setting is incorrect	Correct pressure regulator setting.
Fill/vent solenoid valve is not working	Correct operation of the solenoid valve by cleaning or replacing it.
Relays for fill/vent solenoid valve are burned out	Replace the relays.
Fill and exhaust output valves are faulty	Correct output problem.
Tester is not configured correctly	1. Review the test configuration and verify that it is correct. Reconfigure the tester, if necessary. 2. Ensure that valves are being commanded properly during Fill and Exhaust Steps.

5.4.5 Excessive Number of Rejects

If the system experiences an excessive number of rejects, and the possibility of a leak has been ruled out, use *Table 5–5, "Excessive Number of Rejects,"* to determine a possible solution.

Table 5–5: Excessive Number of Rejects

Probable Cause	Solution
Production parts differ from the master part in volume, material, geometry, etc.	1. Locate a new non-leaking master part. 2. Recalibrate the tester. 3. Perform a Leak Rate Calibration.
Master part is a different temperature than production parts	1. Use different test groups for different part temperatures. 2. Condition the master part to match production parts.
Variations in test air supply exist	Clean liquid traps and filters and blow out main supply.

5.5 Contacting Uson Service

Uson Service personnel are available from 8 a.m. to 5 p.m. CST by phoning (281) 671-2000. Before calling for service assistance, it will be necessary to gather information about the tester and the service issue. Before calling, please make certain the following information is available for reference:

- Contact information, including telephone numbers and e-mail addresses
- The Vector model number and serial number
- Detailed information on the problem at hand, including any error message text

5.6 Toolbox

The Vector's toolbox, accessed through the **Tools** menu, contains five tools designed to aid the operator in diagnosing and correcting problems. These are:

- Repeatability Trials
- PD Test Calc
- Virtual Leak Calc
- Advanced Leak Detection
- Statistics

5.6.1 Repeatability Trials

Used in the Run Mode, repeatability trials:

- Provide a basis for approval of newly manufactured testers
- Are included in regular tester process control evaluations
- Assist in evaluating suspected deficiencies
- Aid in tester comparison

See Chapter 6, *Repeatability Studies*, for detailed information on Repeatability Trials.

5.6.2 Pressure Decay Leak Test Calculator

The Pressure Decay Leak Test Calculator estimates stabilization and test time required for pressure decay methods using one of three methods of calculation:

- Time Calculation
- Leak Rate Calculation
- Volume Calculation

The time calculation method derives required test time based on a known part volume, pressure, and leak rate. The leak rate calculation method derives a leak rate based on a known part volume, time, and pressure change rate. The volume calculation method derives part volume based on a known leak rate, pressure change rate, and test time.

Use the following procedure to operate the Pressure Decay Leak Test Calculator:

1. Select one from among the three methods of calculation in the **Calculation** area.

Information highlighted in yellow is automatically calculated by the Pressure Decay Leak Test Calculator.

2. Select a sensitivity level in the **Sensitivity Level** area.
3. Make a value selection from among the five options in the **Valve Selection** area.
4. Enter parameters in the **Pressure Decay Test Parameters** area and then select a unit of measurement for each.
5. Click the **Calculate** button.

Estimated step times appear automatically in the **Estimated Step Times** area, based on the information entered.

Values calculated are for estimation only. Actual values may vary.

5.6.3 Virtual Leak Calculator

The Virtual Leak Calculator calculates mass flow through a small orifice.

The Virtual Leak Calculator provides theoretical calculations of mass flow through a single orifice. Derived calculations may not be representative of actual leaks. The operator must use judgement in making comparisons between actual results and derived results.

Use the following procedure to operate the Virtual Leak Calculator:

1. Select a leak type in the **Select Type of Leak** area. (See *Figure 5–9*.)
2. Select a gas type in the **Select Type of Gas** area.
3. Select a pressure reference in the **Select Pressure Reference** area.
4. Enter a high pressure in the **High Pressure** area.
5. In the **Low Pressure** area, enter a value and a unit of measure for each of the following parameters:
   - Pressure
   - Length of Leak Path
   - Temperature of Gas
   - Leak diameter
6. In the **Mass Flow Rate** area, enter values in the **f1** and **f2** fields, and then enter a unit of measure for the **f2** field.

   Calculations for the **f1** field are based on the following formula:

$$M' = \frac{\pi d^4}{256 \eta l k_B T} m\left(P_1^2 - P_0^2\right)$$

Where:

M' = The total mass flow rate of leaking gas (in kg/s)
d = Diameter of leakage tube (in meters)
η = Dynamic viscosity of the gas
l = Length of leakage tube ($1 \cdot 10^{-3}$ meters)
k_B = Boltzmann constant ($1.38 \cdot 10^{-23}$ J molecule^{-1} K^{-1})
T = Temperature (in degrees K)
m = The mass of one gas molecule (in kg)
P_1 = Upstream pressure (in Pa)
P_0 = Downstream pressure (in Pa)

Calculations for the **f2** field are based on the following formula:

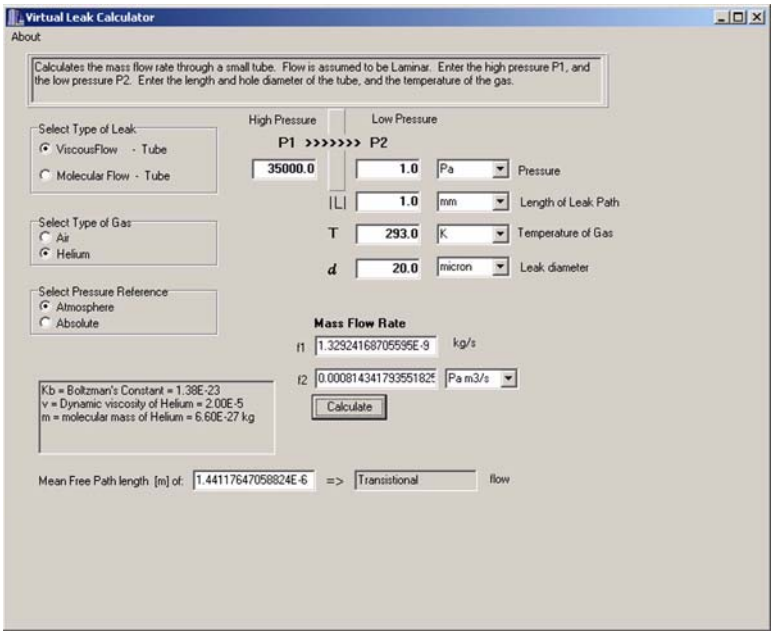
$$Q = \frac{\pi r^4}{16nl}\left(P_1^2 - P_2^2\right)$$

Where:

Q = The gas flow rate (Pa · m^3 · s^{-1})
r = Radius of the leakage tube (in meters)
l = Length of leakage tube (in meters)
n = Viscosity of the leaking gas (Pa · s)
P_1 = Upstream pressure (in Pa)
P_2 = Downstream pressure (Pa)

7. Click the **Calculate** button.

FIGURE 5–9: OPERATING THE VIRTUAL LEAK CALCULATOR



5.6.4 Advanced Leak Detection

The Advanced Leak Detector uses a sophisticated modeling approach to leak testing called Leak Rate Modeling. This method creates a precise model of the leak rate response from a series of known leaks.

5.6.5 Statistics

The **Statistics** window is a configurable form, divided into seven tabs, used to display statistical data from tests run previously and real-time data from tests running currently. Displayed data includes X bars, ranges, upper and lower controls, and histograms. For more information on statistics, see Section 4.3.6, *The Statistics Window*.

5.7 Maintenance

The Vector's components are not field-serviceable, but are designed as removable modules, each of which can be removed and returned to the factory for maintenance.

Contact Uson Service before attempting to remove any of the Vector's internal components for shipment to the factory.

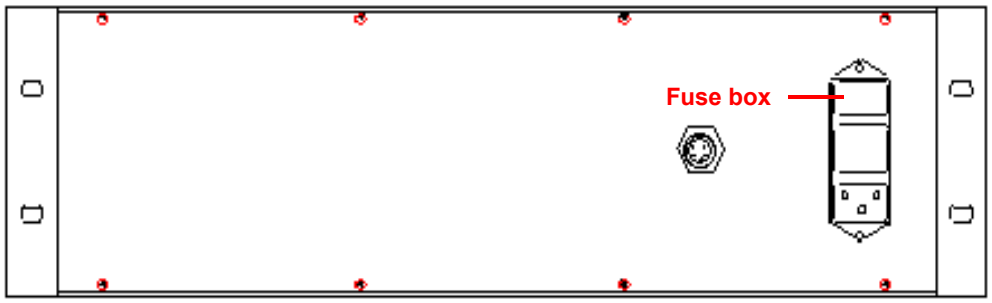
5.7.1 Fuse Replacement

If the Vector's power switch is in the "ON" position and the tester does not power up, this could indicate the need for fuse replacement. First, check to make certain that the power cord is plugged into the back of the tester and into an AC outlet. After it has been confirmed that proper power cord attachment is not the cause of the problem, use the following procedure to replace one or more fuses:

1. Disconnect the AC power cord from the back of the tester.
2. Press lightly and lift the tab on the fuse box to eject the box.
3. Insert a new 250 V fuse.
4. Replace the fuse box by sliding it in until it snaps into place.

The fuse box is accessed from the back panel of the tester above the power switch. (See *Figure 5–10*.)

FIGURE 5–10: VECTOR AC POWER ENTRY MODULE



Rear View of Chassis

The Vector's fuse box contains one 2-Amp time-delay fuse on the line side to protect the internal electronics in the event of a power failure.

Failure to disconnect the AC power cord before replacing fuses could result in exposure to hazardous voltage which could cause electric shock, injury, or death.

5.7.2 CLEANING

When working in excessively dusty or dirty environments, it may be necessary to periodically wipe the Vector's display monitor. A slightly damp, soft cloth moistened with a small amount of water or mild cleaner should be used.

Never spray water or cleaning solution directly onto the display monitor. Instead, moisten a soft, damp cloth with water or a mild cleaning solution and then apply the cloth to the display monitor.

Uson does not recommend extensive field cleaning of the Vector. If the accumulation of dust or dirt becomes so significant that it affects the operation of the tester, contact the Service Manager to make arrangements for factory service.

6 Repeatability Studies

6.1 Repeatability

Repeatability is the variation in the measurements obtained with the same equipment used several times by one operator to measure the identical characteristic on the same component. Repeatability is generally the result of conditions inherent in the system and the test part, and is a measure of the precision of the system. Tests run with a master part should show a repeatability of plus or minus five percent, or better. If a master part does not show good repeatability, production part repeatability will be unacceptable.

The objectives of repeatability testing are:

- Provide a basis for approval of newly manufactured testers
- Perform regular process control evaluations for a tester
- Evaluate suspected deficiencies
- Compare testers

6.1.1 Study Methods

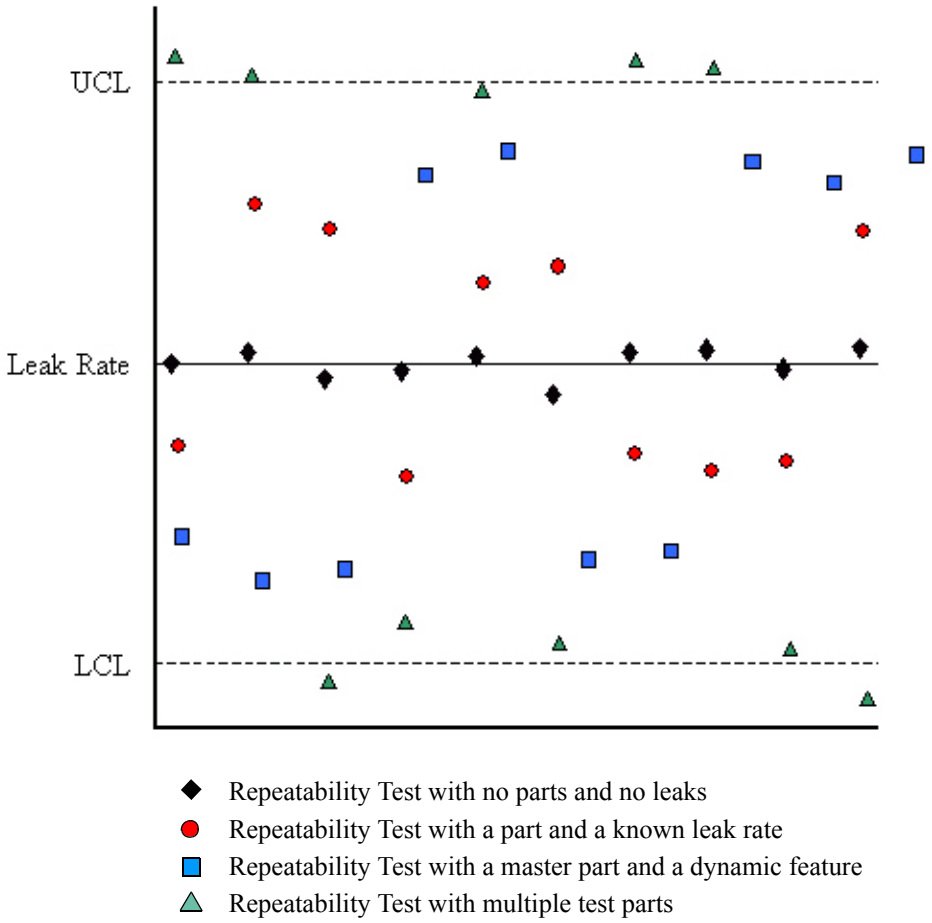
Four elements of repeatability are measured in a series of tests, collectively referred to as a Repeatability Study, to accurately determine a tester's repeatability. These four elements of repeatability are:

- Repeatability Test with no parts and no leaks
- Repeatability Test with a part and a known leak rate
- Repeatability Test with a master part and a dynamic fixture
- Repeatability Test with multiple test parts

The objective of repeatability analysis is to determine the repeatability, the accuracy, and the short-term stability of a part, and to investigate the inherent variations in the measurement system. As a rule, repeatability decreases as the degree of complexity (the number of test parts, leaks, or dynamic parts) of a test increases.

Figure 6–1 shows the results of a complete Repeatability Study.

FIGURE 6–1: REPEATABILITY DECREASES AS THE COMPLEXITY OF A STUDY INCREASES



6.2 Repeatability vs. Reproducibility

Reproducibility is the variation in the average of measurements made by different operators using the same gauge to measure identical characteristics of the same component.

Repeatability and reproducibility are sometimes referred to as Gauge R&R.

In the case of the Vector, reproducibility is not usually an issue because a machine is doing the measuring and human error is not a factor in measurements.

6.3 Formulae

The Vector's automated Repeatability Study is a Type I study, which means that measurements of the same part are repeated several times. The purpose of a Type I study is to determine the repeatability and accuracy of the measurement system.

The Vector's study employs the following formulae:

Equation 1, Standard Deviation of test results:

$$S_g = \sqrt{\frac{1}{N-1}\sum_{1}^{N}(x_i - \overline{x})^2}$$

Equation 2, Mean of test results:

$$\overline{x} = \frac{1}{N}\sum_{1}^{N} x_i$$

Equation 3, Range of test results:

$$R = x_{\max} - x_{\min}$$

Equation 4, Capability Index of Repeatability:

$$C_g = \frac{k_{cg} \cdot x_T}{6S_g}$$

Equation 5, Capability Index of Repeatability and Accuracy:

$$C_{gk} = \frac{k_{cgk} * x_T - |x - x_m|}{3S_g}$$

Equation 6, Lower and Upper Specification Limits and Control Limits:

$$LSL = x_m - x_T$$
$$USL = x_m + x_T$$
$$LCL = \overline{x} - E_2 R$$
$$UCL = \overline{x} + E_2 R$$

Equation 7, Accuracy and % Accuracy:

$$AC = \left| \overline{x} - x_m \right|$$

$$\%AC = \frac{AC}{x_m} * 100\%$$

Table 6–1: Symbol definitions and parameters for formulae used in Type I Repeatability Studies

Symbol	Description	Default value	Minimum	Maximum
%AC	System accuracy relative to the master part	—	0	100%
AC	Measure of system accuracy	—	0	—
Cg	Capability index of repeatability	>1	0	—
Cgk	Capability index of repeatability and accuracy	>1	0	—
E_2	Control limits factor	2.66	2.66	2.66
k_{cg}	Cg percentage of tolerance factor	.2	.1	.2
k_{cgk}	Cgk percentage of tolerance factor	.1	.1	.15
N	Number of tests conducted	50	0	50
S_g	Standard deviation of test results	—	0	None
$\overline{x}$	Mean value of a number of tests	—	None	None
x_i	The i^{th} test result	None	None	None
x_m	Leak Master calibrated leak rate	—	—	—
x_{min}	Minimum test result	None	None	None
x_T	Leak Master tolerance	Five percent of calibration point	0	Five percent of calibration point

6.3.1 Leak Tester Repeatability Study Types

A Repeatability Study should only be run after the system has been calibrated. A master part identical to the production part is required.

There are four stages in a Leak Tester Repeatability Study:

1. Tester Pneumatic System Repeatability Test: A test with no parts and no leaks is run. The standard deviation should be less than one percent.
2. Master Part Repeatability Study: A test with a stationary fixture and part is run. The standard deviation should be plus or minus five percent.
3. Fixture Repeatability Study: A test with a dynamic part and master part is run. The standard deviation should be plus or minus 20 percent.
4. Multiple Part Repeatability Test: Finally, a Repeatability Test with multiple test parts is run.

6.3.2 Tester Pneumatic System Repeatability Study

The Pneumatic System Repeatability Test confirms that test times and leak rate sensitivities are sufficient for good repeatability.

Isolate tester pneumatics from fixtures before running a Repeatability Study. Repeatability should be less than one percent. If it is greater than that, there is excessive pneumatic noise, and special efforts may be necessary to minimize the noise. Consult Uson for information on replicating the original factory study performed on a tester, or refer to the *As-Built* documentation shipped with the tester.

6.3.3 Master Part Repeatability Study

The Master Part Repeatability Study confirms that test times and leak rate sensitivities are sufficient for good repeatability. To run a Master Part Repeatability Test, begin by connecting the fixture and master part to the tester. Run the Repeatability Study with the fixture, and without unclamping the test part. If the repeatability is not plus or minus five percent or better, additional efforts are required to improve the sealing method, or test/stabilization times might require adjustment. See Chapter 5, *Diagnostics and Leak Tester Troubleshooting*, for information about improving repeatability.

6.3.4 Fixture Repeatability Study

Run a Fixture Repeatability Study with the seals configured to clamp and unclamp between tests. This will indicate the amount of test result variance created by the dynamic motion of the seals.

6.3.5 Multiple Part Repeatability Study

Run a Repeatability Study using a number of different parts to determine the part-to-part leak rate variation.

Only the end-user or product manufacturer can determine what is an acceptable degree of repeatability. A variety of influences, including operator error, environment, part irregularities, and other factors, influence repeatability.

6.4 Running a Repeatability Study

Repeatability Studies are run from the Leak Test Repeatability Study Toolkit in the Run Mode. To begin, access the **Repeatability Study Configuration Setup** window by selecting **Repeatability Trials** from the **Tools** menu on the menu bar.

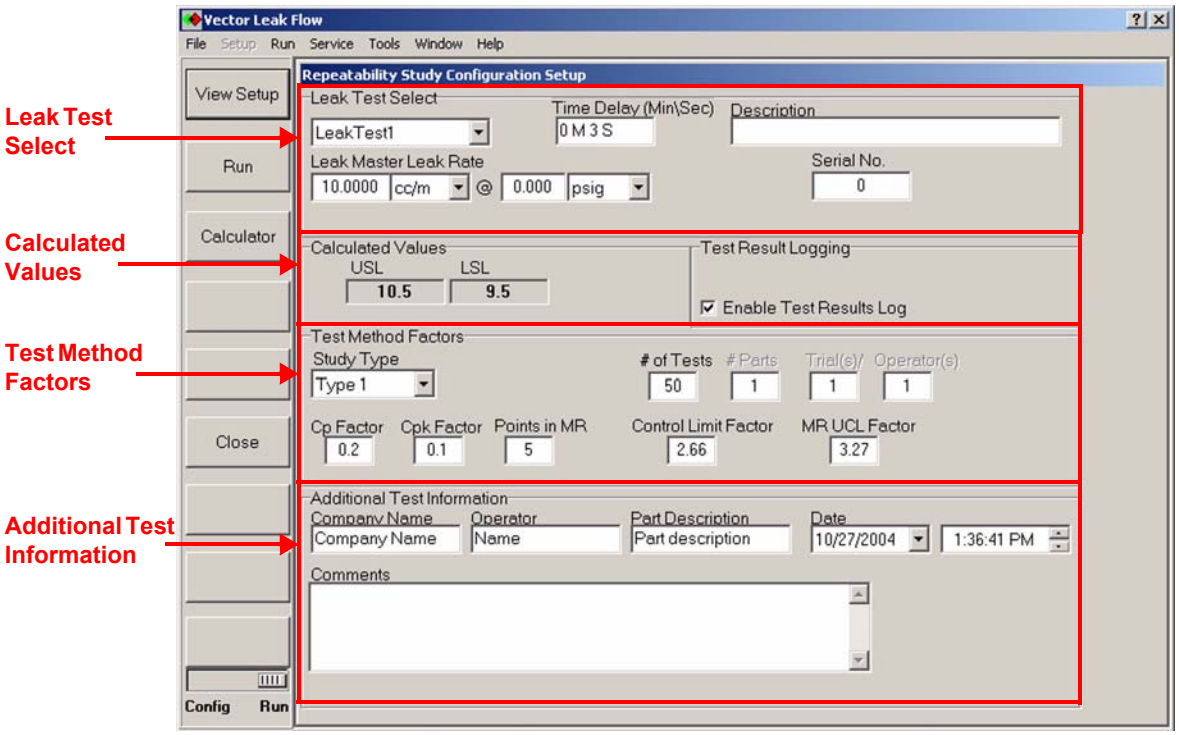
The study toolkit is divided into two windows, one for setting up the study (the **Repeatability Study Configuration Setup** window), and one (the **Repeatability Study Run** window) for running the study and reviewing the results.

Before beginning a Repeatability Study, remove from the tester any production parts or calibrated meters that might be installed.

The **Repeatability Study Configuration Setup** window is divided into four sections, each of which serves a distinct purpose. (See *Figure 6–2*.)

- **Leak Test Select**: This section is used to select a test to run, set the Leak Master leak rate, enter a time delay and a tolerance, and enter the Leak Master's serial number.
- **Calculated Values**: This area displays the upper specification limit (USL) and the lower specification limit (LSL).
- **Test Method Factors**: This section is used to select a study type, enter Cg and Cgk factors, specify points in MR, indicate the number of tests, the number of parts, the number of trials, and the number of operators, as well as enter a control limit factor and a MR UCL factor.
- **Additional Test Information**: This area provides a place to enter company name, operator name, part description, date and time, and comments.

FIGURE 6–2: THE REPEATABILITY STUDY CONFIGURATION SETUP



6.4.1 ENTERING LEAK TEST SELECTION INFORMATION

Information about the Leak Master required for this setup procedure is available on the Leak Master Certificate.

In the **Leak Test Select** portion of the window, the operator must enter information in the following fields:

- **Leak Test Select**: Use the arrow beside the field to view a list of available tests. Select a test from the list by clicking on it.
- **Time Delay (Min/Sec)**: Enter a delay period between tests in minutes and seconds.
- **Leak Master Leak Rate**: Enter the leak rate and pressure of the Leak Master to be used for the study.
- **Serial No.**: Enter the Leak Master's serial number.

6.4.2 Viewing Calculated Values

The **Calculated Values** portion of the window displays two fields of values calculated after the operator enters required information in the **Repeatability Study Configuration Setup** window (this information is saved automatically):

- **USL**: Upper specification limit based on system tolerance specifications
- **LSL**: Lower specification limit based on system tolerance specifications

6.4.3 Viewing Default Test Method Factors

Defaults include these fields:

- **Study Type**
- **# of Tests**
- **# of Parts**
- **Trials** (number of)
- **Operators** (number of)

The following defaults are based on individual study standards and will vary on a company-by-company basis. The operator should check the company's policies on Repeatability Study standards for information on the values displayed in these fields.

- **Cp Factor**
- **Cpk Factor**
- **Points in MR**
- **Control Limit Factor**
- **MR UCL Factor**

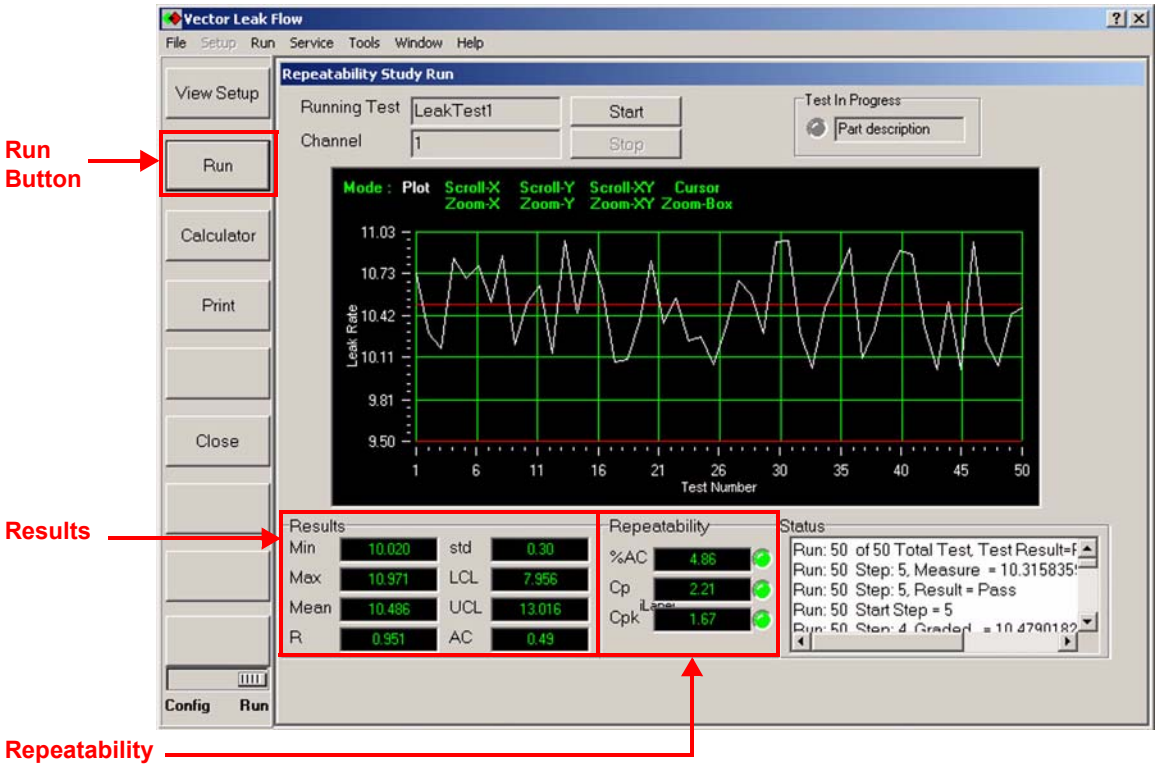
After entering all required information, click the **Run** button in the left column to open the **Repeatability Study Run** window where the test results will display. (See *Figure 6–3*) Click **Start**. The Vector runs the test and displays the following results:

- **Min**: Minimum result from among all tests
- **Max**: Maximum result from among all tests
- **Mean**: Average result
- **R**: Range (or spread) of test results (max - min)
- **Std**: Measure of the dispersion of test results
- **LCL**: Lower control limit
- **UCL**: Upper control limit
- **AC**: Repeatability Accuracy

Along with test results, the following repeatability statistics are displayed:

- **%AC**: Percentage repeatability accuracy
- **Cp**: Repeatability tolerance factor
- **Cpk**: Repeatability and accuracy factor

Figure 6–3: Repeatability Study Run



6.5 Repeatability Terms

Table *6–2* lists and defines common terms and abbreviations users might encounter in this or other leak-testing literature.

Table 6–2: Repeatability terms and abbreviations

Term	Definition
%AC	Appraiser variation (reproducibility) percentage relative to the reference figure (RF)
Accuracy (AC)	The difference between the observed average of measurements and the reference value. The reference value, also known as the accepted reference value, or master value, serves as an agreed-upon reference for measured values.
ANOVA	Analysis of variance
ARM	Average and Range Method
AV	Appraiser variation
cc/m	Cubic centimeters per minute
Cg	Gauge potential index
Cgk	Gauge capability index
EV	Equipment variation
LCL	Lower control limit
Leak rate limit	The maximum acceptable leak rate
LSL	Lower specification limit
Max (maximum value)	Maximum result from among all tests
Mean (mean value)	Average test result
Min (minimum value)	Minimum result from among all tests
R	Range of results (min - max)
R&R	Repeatability and reproducibility
RF	Reference figure, leak rate limit
Standard deviation (Std)	Measure of the dispersion of test results
Test result	Result from an individual test
UCL	Upper control limit based on system capability
USL	Upper specification limit based on system capability

7 Generating Test Reports

7.1 Reports and Data Logs

Configuration and testing information is gathered and recorded in reports and data logs. This chapter details procedures for displaying and printing test information.

Reports generated during the Configuration Mode and Run Mode include the following:

- Configuration Mode
  - System Summary Configuration Report
  - Test Parameter Report

- Run Mode
  - Test Results Log
  - Data Sample Log
  - Repeatability Report

Set up your printer in Windows before printing reports and data logs.

7.2 Reports Generated in the Configuration Mode

The reports generated during the Configuration Mode are the following:

- System Summary Configuration Report
- Test Parameter Report

This section describes these reports and the procedures for displaying and printing them.

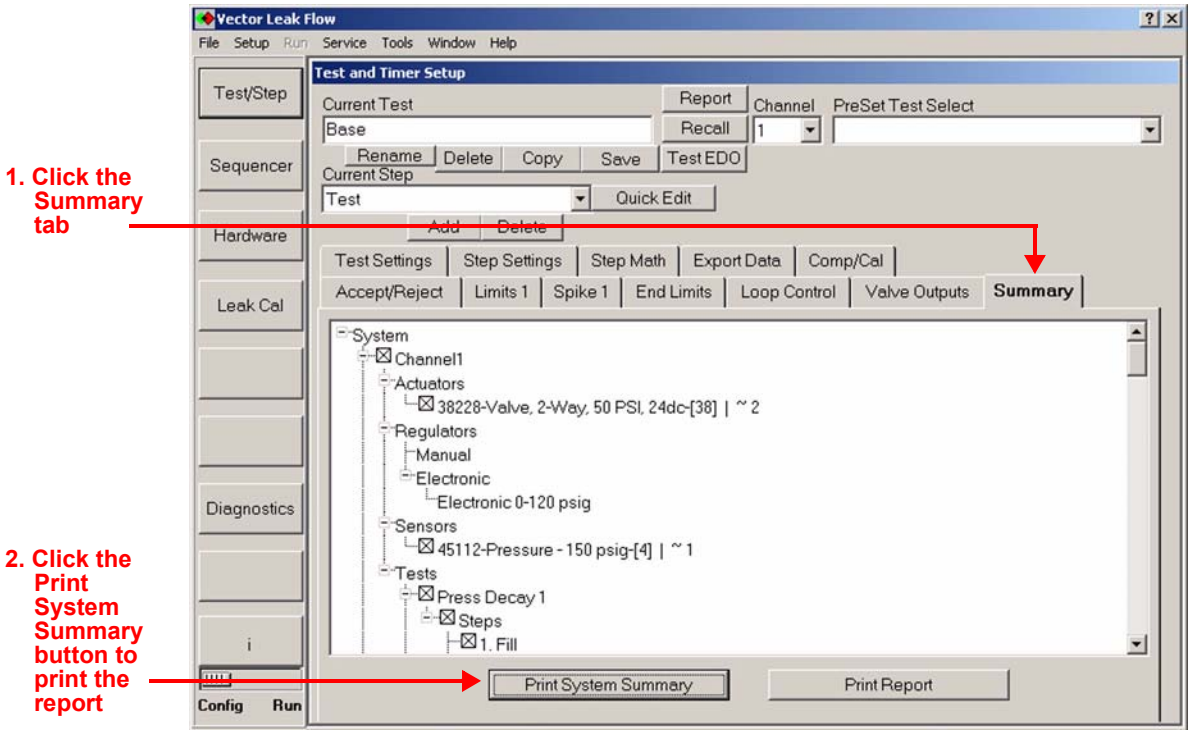
7.2.1 System Summary Configuration Report

The System Summary Configuration Report includes all parameters for a test, information on how the parameters are configured, hardware details for each channel, the number of tests configured for each channel, and test names and steps.

Use the following procedure to display and print the report:

1. In the Configuration Mode, open the **Test and Timer Setup** window and click the **Summary** tab. The System Summary Configuration Report displays.
2. Click the **Print System Summary** button to print the report. The print dialog box displays. (See *Figure 7–1*.)
3. Select a printer, enter the number of copies, and click **OK**.

Figure 7–1: The System Summary Configuration Report

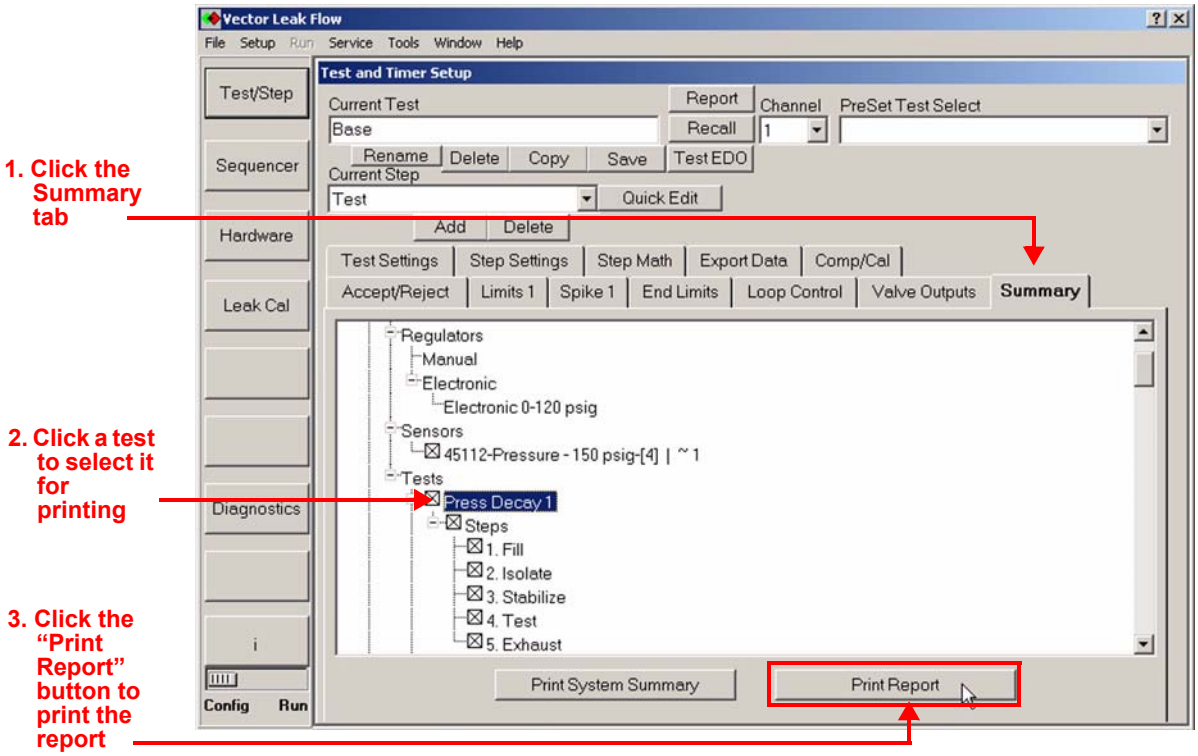


7.2.2 Test Parameter Report

The Test Parameter Report details individual tests listed in the System Summary Configuration Report. To display and print a report for a specific test:

1. In the Configuration Mode, open the **Test and Timer Setup** window and click the **Summary** tab. The System Summary Configuration Report displays. (See *Figure 7–1*.)
2. To select a test for printing, click it in the configuration tree. (See *Figure 7–2*.)
3. Click the **Print Report** button to print the report.
4. Select a printer, enter the number of copies, and click **OK**.

Figure 7–2: The Test Parameter Report



7.3 Data Logs and Reports Generated in the Run Mode

The reports generated in the Run Mode are the following:

- Test Results Log
- Data Sample Log
- Repeatability Report

This section describes the data logs and report and the procedures for displaying, printing, and saving them.

7.3.1 Test Results Log

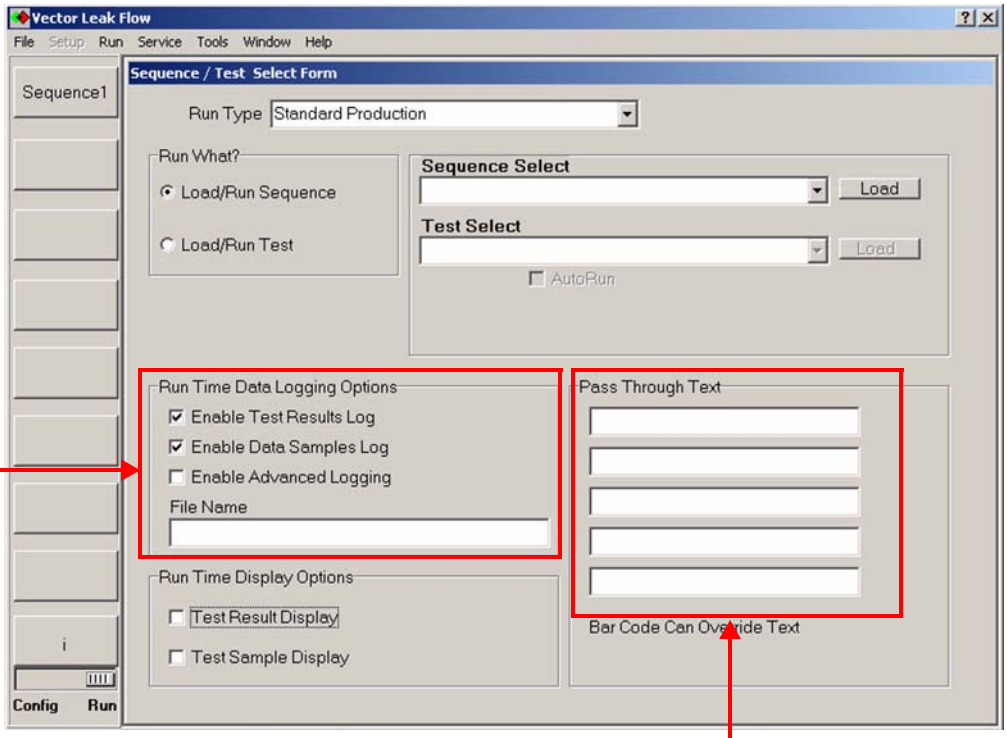
The Test Results Log records all test data results and creates a daily test log of Run Mode activity for each channel. The results for each channel are recorded in a single file.

The **Enable Test Results** option is checked by default in the **Run Time Data Logging Options** area of the **Sequence/Test Select Form.** (See *Figure 7–3*.) The default can be changed by unchecking the option or right-clicking on the window and deselecting **ResultLog** on the pop-up menu.

The right-click shortcut option is only available in the Single Channel run window.

The **Pass Through Text** area can be used to add notes that will appear at the end of each entry in the log.

FIGURE 7–3: DATA LOGGING OPTIONS



Each test result entry in the log file follows a standard format:

Date and **Time**, **Channel Number**, **Test Number**, **Step 1 Measure**, **Step 1 Result**, **Step 2 Measure**, **Step 2 Result** (through all steps), **User Pass Through** (as applicable).

The step result is numeric, with the following designations:

- 1 – "Pass"
- 2 – "Fail"
- 3 – "Stop" (Abort)

Each line is comma-delimited, with a leading and trailing space, and ends with a line feed followed by a carriage return.

The log will be given a default file name with the following format: date_channelnumber.log. By default, the log subdirectory is located on the tester's hard drive in the Vector directory, unless another location is specified.

If you configure the barcode for pass through text mode, the pass through text on the selected channel will be overridden.

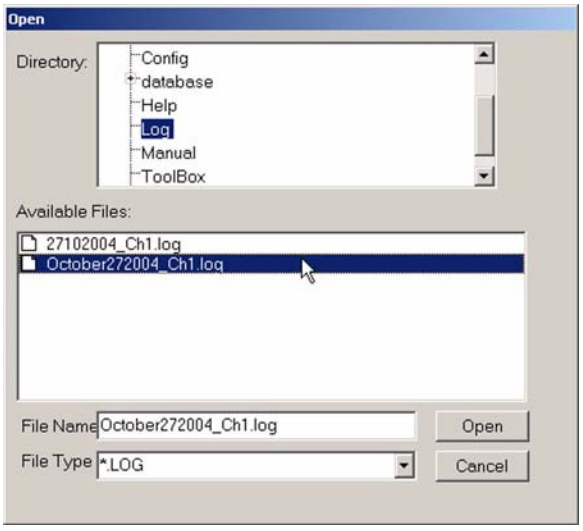
The default installation location of the Vector directory is D:\Program Files\Vector\Log.

To change the file path, click **Service/Site Configuration** on the tool bar. Click the **Directories** tab to select a drive and create a folder for storing the logs.

To display and print the Test Results Log:

1. In Run Mode, click **File** on the tool bar.
2. Click **Open File** and open the log folder.
3. Select a log file to print and then click **Open**.
4. The log opens in Notepad. Click **File** and **Print** from the menu.

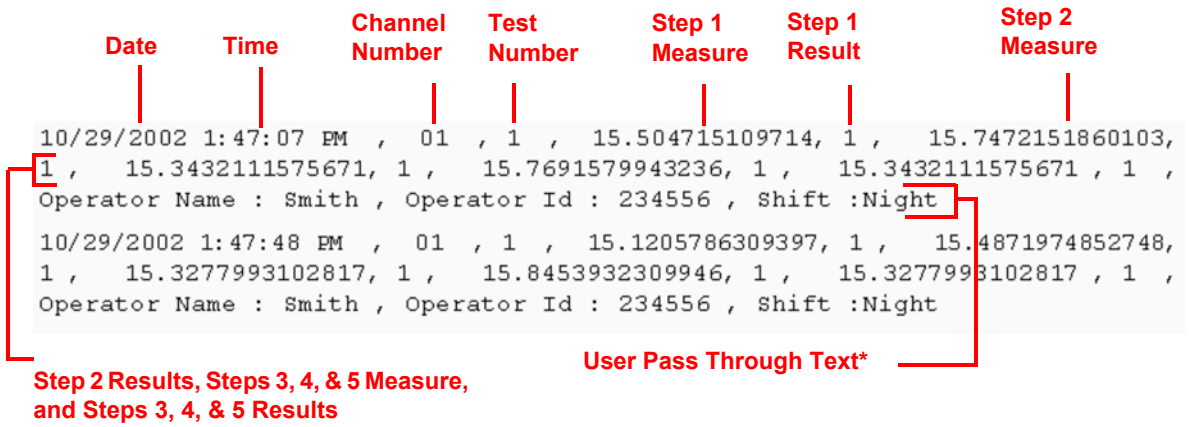
FIGURE 7–4: TEST RESULTS LOG DIRECTORY



Information is displayed in the Test Results Log in the following format: **Date and Time**, **Channel Number, Test Number, Step 1 Measure, Step 1**

Result, Step 2 Measure, Step 2 Result, Step 3 Measure, Step 3 Result, (continuing, until all step measures and results have been reported). Optional **User Pass Through Text** that has been entered will follow the step measures and results in the log. A log sample is shown in *Figure 7–5*.

FIGURE 7–5: TEST RESULTS LOG



*All User Pass Through Text is defined by the user.

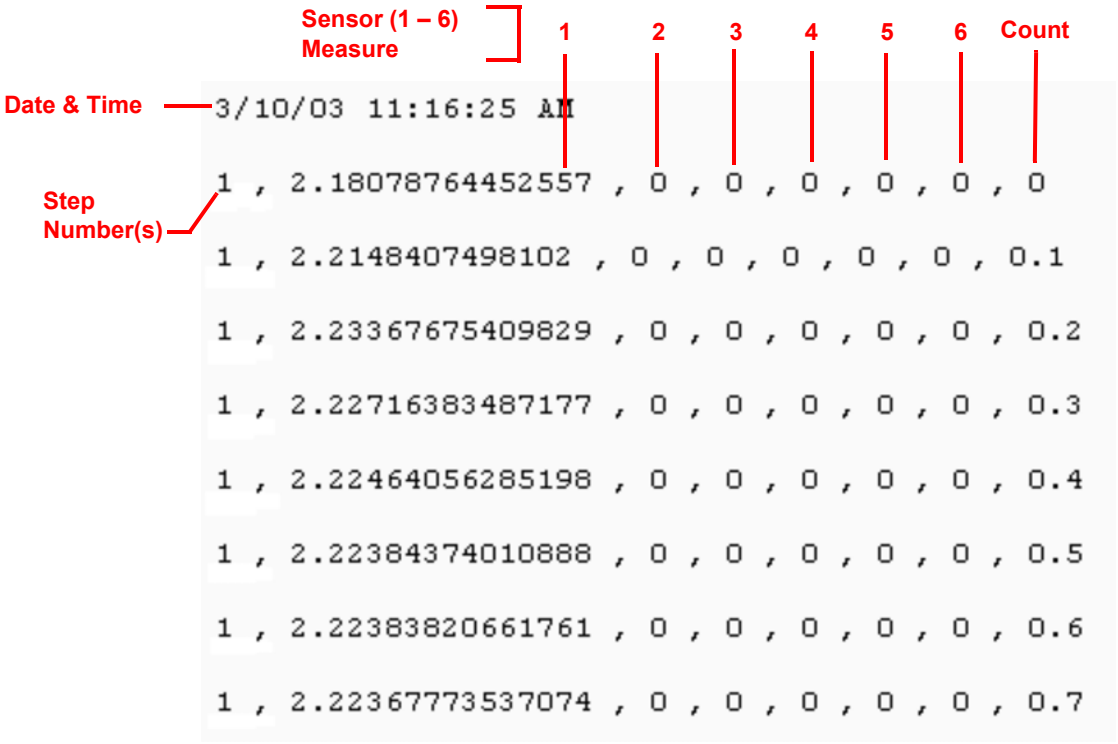
7.3.2 Data Sample Log

The Data Sample Log records actual sensor measurements for each sample period. This option is not automatically selected and therefore, must be checked in order to record this information. In the **Run Time Data Logging Options** area of the **Sequence/Test Select Form**, click **Enable Data Sample** or right-click on the window and select **SampleLog** from the pop-up menu.

The right-click shortcut option is only available in the Single Channel run window.

Information is displayed in the Data Sample Log in the following format: **Date and Time**,
Step Number, Sensor 1 Measure, Sensor 2 Measure, Sensor 3 Measure, Sensor 4 Measure, Sensor 5 Measure, Sensor 6 Measure, and **Count**. A data log sample is shown in *Figure 7–6*.

Figure 7–6: Data Sample Log



Each line is comma-delimited, with a leading and trailing space, and ends with a line feed followed by a carriage return.

The data log will be given a default file name, unless another name is specified in the **Sample FileName** field in the **Sequence/Test Select Form** window. (See *Figure 7–3*.)

The Sample FileName field is only visible when the Enable Data Sample checkbox is selected.

The default file name format is: date_hour_minute_second_channel.log.

By default, the log subdirectory is located on the tester's hard drive in the Vector directory, unless another location is specified.

The default installation location of the Vector directory is D:\Program Files\Vector\Log.

File storage will default to the log subdirectory unless another file path is specified. To change the file path, click **Service**/**Site Configuration** on the tool bar. Click the **Directories** tab to select a drive and create a folder for storing the logs.

7.3.3 Repeatability Report

The Repeatability Report details results of a Repeatability Study. Refer to Chapter 6, *Repeatability Studies*, for more information about Repeatability Trials.

Repeatability Trials is used in the Run Mode.

To display and print a Repeatability Report:

1. Select **Tools** on the tool bar and then select **Repeatability Trials** from the drop-down menu.
2. The **Repeatability Study Configuration Setup** window displays. Configure and run the Repeatability Study. For information on Repeatability Studies, refer to Chapter 6, *Repeatability Studies*.
3. After the study is complete, the **Print** button will appear on the left side of the window. Click the **Print** button or the corresponding option key. The report displays in a separate window.
4. Click the **Print** button at the bottom of the new window to print the report. The print dialog box will display.
5. Select a printer, enter the number of copies, and click **OK**.

Figure 7–7: Repeatability Report Window

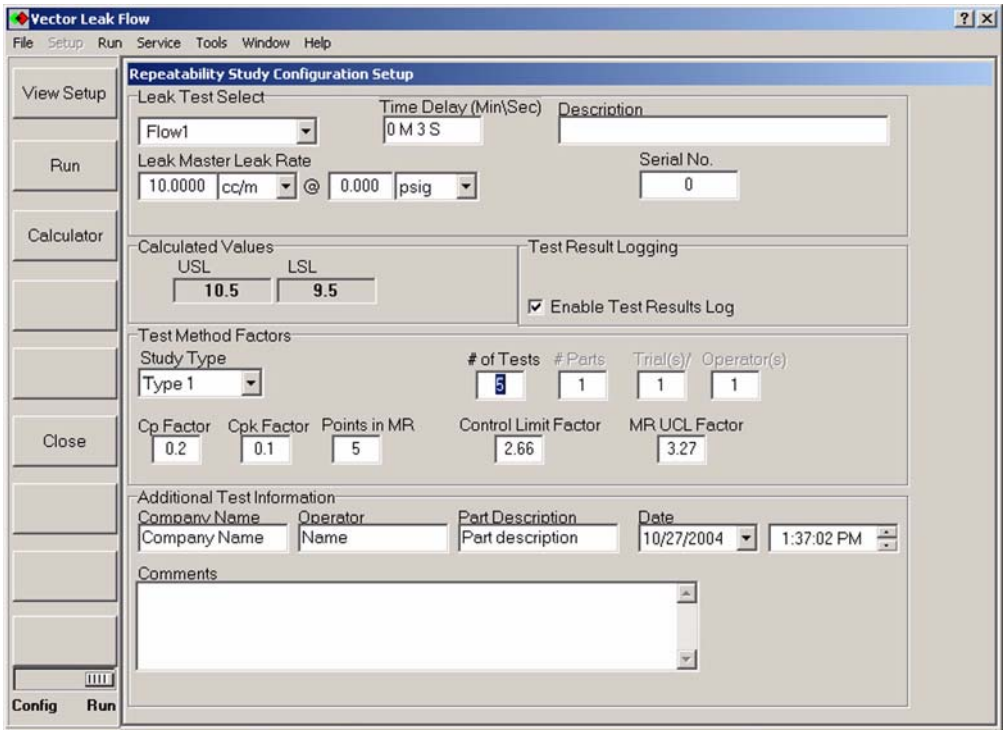
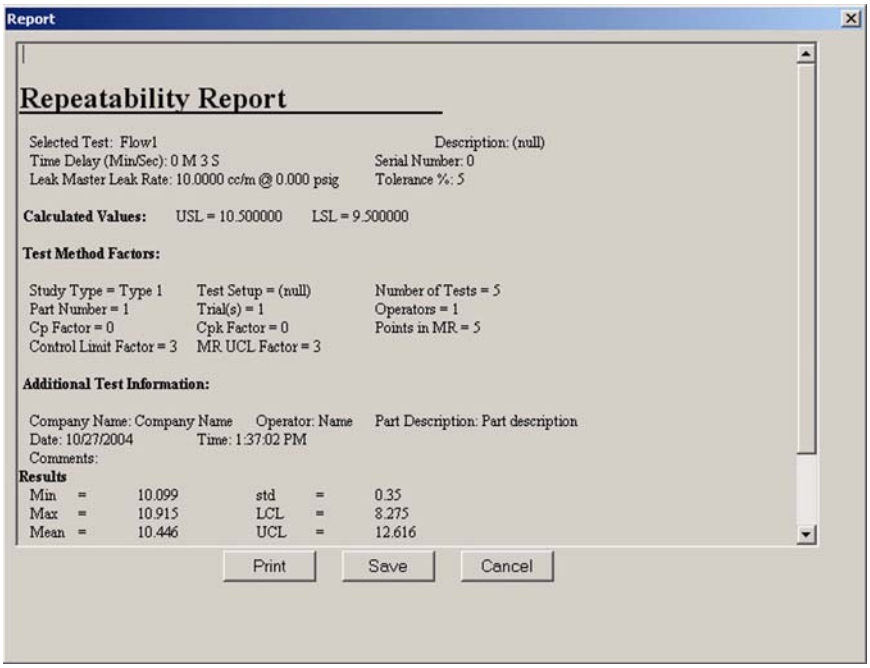


FIGURE 7–8: PRINTING A REPEATABILITY REPORT



Use the following procedure to save a Repeatability Report:

1. Click the **Save** button at the bottom of the new window. The **Save As** dialog box will appear with the default log folder selected.
2. Name the file and click the **Save As** button.

Notes:

Comments

We appreciate your taking the time to read the Vector *Operations Manual*. Please help us improve our manual by sharing your comments with us.

— Are any parts of the Vector *Operations Manual* difficult to understand?

— Are the instructions and illustrations easy to follow?

— What areas could benefit from more detailed documentation?

— What else ought to be changed?

Thank you for your comments.

Please return this form to:

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