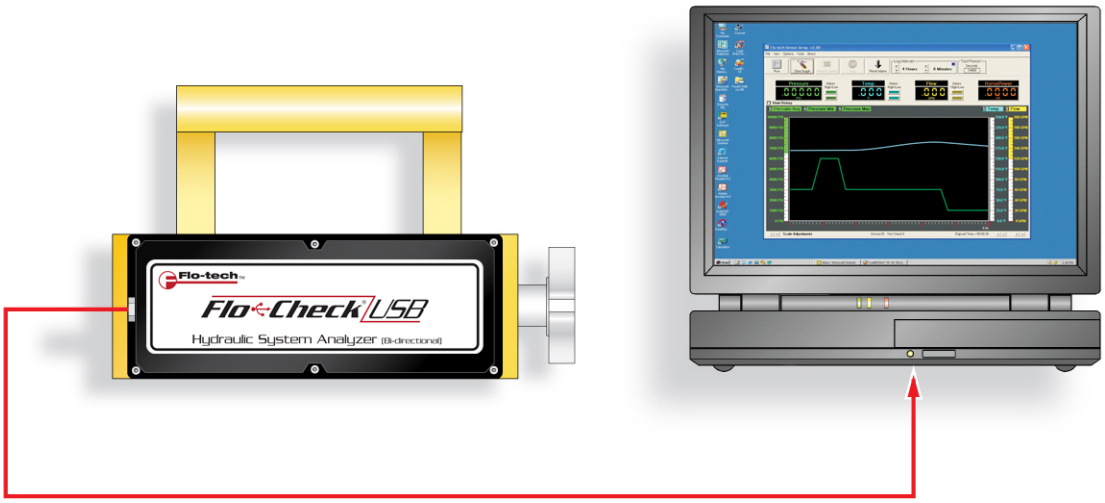
Flo-tech
Hydraulic Diagnostic Products

Portable Hydraulic Testers

USB Hydraulic System Analyzer



Badger Meter

TST-UM-02433-EN-02 (June 2022)

User Manual

CONTENTS

PRODUCT UNPACKING AND INSPECTION

Upon receipt of the product, perform the following unpacking and inspection procedures.

NOTE: If damage to the shipping container is evident upon receipt, request the carrier to be present when the product is unpacked.

1. Carefully open the shipping package, follow any instructions that may be marked on the exterior. Remove all cushioning material surrounding the product and carefully lift the product from the package.
2. Save the package and all packing material for possible use in reshipment or storage.
3. Visually inspect the product and applicable accessories for any physical damage such as scratches, loose or broken parts or any other sign of damage that may have occurred during shipment.

NOTE: If damage is found, request an inspection by the carrier's agent within 48 hours of delivery and file a claim with the carrier. A claim for equipment damage in transit is the sole responsibility of the purchaser.

OVERVIEW

The Flo-Check® USB Hydraulic System Analyzer can be used as a stationary or portable tester for both industrial and mobile hydraulic system diagnostics, and analysis of the prognostic health of a hydraulic system. It features flow, pressure and temperature sensors that are monitored by a data acquisition module. The module records the operating parameters of the system and transfers them to a laptop via the USB port.

The custom software utility is a Windows®-based application. This intuitive software configures the displayed information into user-selected engineering units and provides realtime graphics with instantaneous readings and trends for all three measurement parameters. The software permits the data to be saved as a .csv file format, for use with a spreadsheet program.

The Hydraulic System Analyzer is powered through the USB port of a PC, which makes it easy to setup and is ideal for portable applications. Interfaced to the PC application, the Hydraulic System Analyzer offers a straightforward method of monitoring system parameters, complete with data acquisition.

SPECIFICATIONS

Material

Housing	6013-T351 Anodized aluminum
Turbine Rotor	T416 Stainless steel
Rotor Supports	6061-T6 Aluminum
Seals	Viton® standard; EPR optional
Ball Bearings	440 C Stainless steel
Hub Cones	6061-T6 Aluminum alloy
Temperature Probe	T303 Stainless steel
Valve	12L14 Steel body with 303 SS seat
Spool/Sleeve	12L14 Steel
Straightening Sections	6061-T6 Aluminum
Ports	SAE Straight thread O-ring boss, female, J1926/1; BSPP ISO1179
Magnetic Pick-up	Body 12L14 Steel, electroless nickel plate
	Nut 12L14 Steel, electroless nickel plate
Electronic Case	Cold rolled steel, black zinc plate with clear seal

Table 1: Material specifications

Power

USB Power	+5V DC (supplied through USB port of a PC)
USB Voltage Tolerance	+4.6V DC min, +5.25V DC max
Current	100 mA, typ

Table 2: Power specifications

Environmental

Pressure Rating	6000 PSI (414 Bar) maximum with a 3:1 safety factor; capable of 10,000 PSI (689 Bar) transients
Operating Pressure	<6000 PSI (414 Bar, 41.4 MPa, 420 kg/cm^2); capable of 10,000 PSI (689 Bar) transients
Internal Burst Disc	7500 PSI DP
Pressure Drop	See *"Flow vs Pressure Drop Charts, ΔP Captured Using Loading Valves" on page 27*
Fluid Temperature	-40…300° F (-40…150° C)
Ambient Temperature	+32…185° F (0…85° C)
Storage Temperature	-40…185° F (-40…85° C)
Humidity	0…90%, non-condensing

Table 3: Environmental specifications

Performance

Flow	Accuracy	±1% of reading @ 32 cSt	
	Repeatability	±0.2%	
Pressure	Accuracy	±0.5% BFSL (Best Fit Straight Line)	
	Stability	±0.25% of full scale	
	Zero Offset	±2% of full scale	
	TC (Temperature Coefficent) Zero and TC Span	±1.5% of full scale	
	Response Time	0.2 milliseconds	
Temperature	Absolute Error (over range of 0…185° F)	±2.7° F (±1.5° C)	
	Nonlinearity	±0.7° F (±0.4° C)	
	Repeatability	±0.2° F (±0.1° C)	
Data Acquisition	Sample Rate	10 kHz	
	PC Screen Update/Record Rate	Flow	1 second (average 10K samples)
		Temperature	1 second (average 10K samples)
		Pressure	1 second (min, max, average 10K samples)

Table 4: Performance specifications

CALIBRATION

Testers are verified using 0.876 specific gravity, 150 SUS (32 cSt) Mobil / DTE 24 hydraulic oil. An optional 5 or 10 point calibration certificate, traceable to NIST, ISO 9001, is available from the factory. An optional 10 point calibration can be performed for increased accuracy.

Model Number Designations

Model Number	Nominal Port Size	Flow Rate
F7164 and F7165	SAE 12 or G 3/4	2.00…30.0 gpm (7.50…114 lpm)
F7160 and F7162	SAE 16 or G 1	3.00…85.0 gpm (15.0…321 lpm)
F7161 and F7163	SAE 24 or G 1-1/2	7.00…199.9 gpm (26.0…757 lpm)

Table 5: Model number designations

⚠CAUTION

READ INSTRUCTIONS THOROUGHLY BEFORE INSTALLING THE TESTER. IF YOU HAVE ANY QUESTIONS REGARDING PRODUCT INSTALLATION OR MAINTENANCE, CALL YOUR LOCAL SUPPLIER OR THE FACTORY FOR MORE INFORMATION.

General Information

The power measurements are derived from the product of flow and pressure.

$$H.P. = \frac{GPM \times PSI}{1714} \qquad H.P. = \frac{liters/min \times kg/cm^2}{456.2}$$

$$H.P. = \frac{liters/min \times Bar}{447.40} \qquad H.P. = \frac{liters/min \times MPa}{44.74}$$

$$kW = \frac{liters/min \times kg/cm^2}{611} \qquad kW = \frac{liters/min \times Bar}{600}$$

$$kW = \frac{liters/min \times MPa}{60}$$

- Make all tests at the same operating temperature to provide consistency of results. A typical operating temperature for mobile machinery is 150° F (66° C).
- Testing is easier and faster if quick disconnect couplers are used to install the Flo-Check USB Hydraulic System Analyzer.
- For complete descriptions of the following basic hydraulic tests using the Flo-Check USB Hydraulic System Analyzer, see *"Test Procedures" on page 18*:
  - ◊ "Tee" Test
  - ◊ Inline System Test
  - ◊ Control Valve and Bi-directional Hydraulic Motor Test
  - ◊ Bi-Directional Cylinder Test
  - ◊ Hydrostatic Transmission Diagnostics

⚠CAUTION

THE INFORMATION IN THIS MANUAL IS FOR GENERAL APPLICATION ONLY. FOLLOW ANY INFORMATION FURNISHED BY THE MANUFACTURER OF THE MACHINE'S HYDRAULIC COMPONENTS. SPECIFIC SYSTEMS MAY REQUIRE SPECIFIC TEST PROCEDURES.

- Do a preliminary check of the hydraulic system's oil supply, pump speed, oil lines and cylinder rods, as well as an external leak check, prior to installing the Flo-Check USB Hydraulic System Analyzer.

INSTALLING THE SOFTWARE

1. Close all applications you have running on your computer.
2. Insert the Flo-Check USB Hydraulic System Analyzer CD into your CD drive or download the software from *www.badgermeter.com*.
   If you have the auto-run feature enabled on your computer, the installation instructions automatically display.

NOTE: If auto-run is not enabled, use Windows Explorer to navigate to the root directory on the CD. Double-click the **setup.exe** file to begin the installation.

3. Follow the installation prompts to complete the installation.
4. After a successful installation, a message displays asking to restart the computer. Select **Yes**.

The installation creates two shortcuts on the computer; one on the desktop and the second in the *Start* > *Programs* > *Flo-Tech* Windows menu.

CONNECTING THE HYDRAULIC SYSTEM ANALYZER TO YOUR COMPUTER FOR THE FIRST TIME

The Flo-Check USB Hydraulic System Analyzer connects to your computer through a USB port. Use the cable that came with the unit or use any standard USB A Male to USB B Male cable. The initial connection is easy and uses standard drivers within Windows that do not require special driver installation.

- The Hydraulic System Analyzer interface uses the Microsoft Human Interface Driver (HID). This driver is installed with Windows operating systems that support USB.
- The first time you connect the device to your PC, your computer automatically detects it and configures the necessary drivers. No third-party device drivers need to be installed.
- The Hydraulic System Analyzer interface is plug-and-play. You can connect it to the computer before or after you install the software, and without shutting off the computer.

NOTE: Before connecting the Hydraulic System Analyzer to the computer, download and install the latest Microsoft Windows updates. For Windows XP, there is a Hotfix KB822603 that is installed to address a serious error within Windows XP and the use of USB devices.

To connect the Hydraulic System Analyzer to your computer:

1. Connect the USB cable to the Hydraulic System Analyzer and then plug the other end into a USB port on the computer.
2. The first time the Hydraulic System Analyzer is connected to the computer, several "Found New Hardware" balloons or dialogs pop up. This is normal.
3. Once the hardware has been found and installed, the last balloon or dialog states "Your new hardware is installed and ready to use." At this point, the Hydraulic System Analyzer interface has been successfully installed and can be used with the software application.

SOFTWARE OVERVIEW

The software provides a realtime graphical and digital interface for monitoring and/or recording pressure, temperature, and flow rate parameters from the Hydraulic System Analyzer. In addition to the graphical and digital displays, the main screen has a menu bar, buttons with common functions, and alarm indicators.

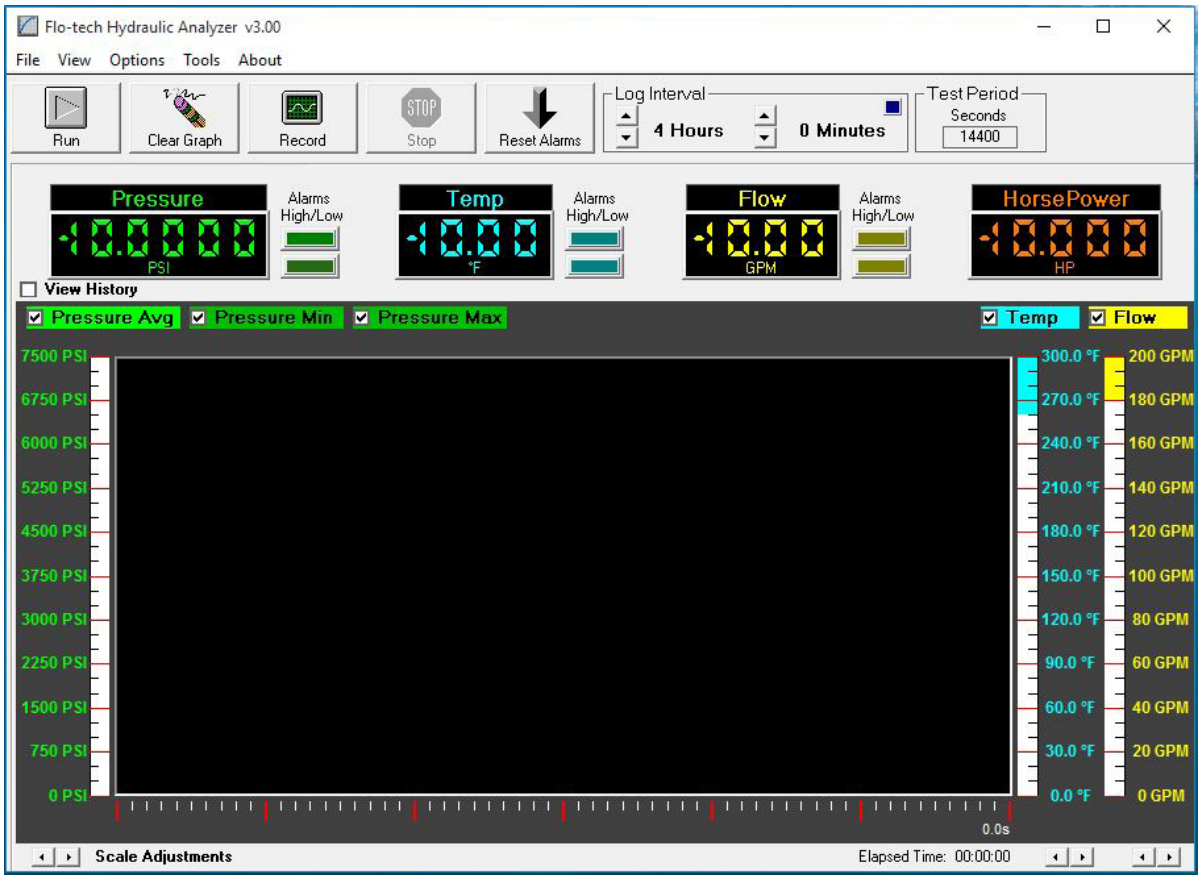


Figure 1: Flo-Check USB hydraulic system analyzer screen

Measurement (over a 1 second time period)	Color Indication	Alarm Indication	Digital Indication	Graphical Display	Record to File
Average Pressure	Green	•	•	•	•
Minimum Pressure	Dark Green			•	•
Maximum Pressure	Dark Green			•	•
Average Temperature	Blue	•	•	•	•
Average Flow Rate	Yellow	•	•	•	•
Average Power	Orange		•		•

Table 6: Measurement display and record features

RUNNING THE SOFTWARE AND VIEWING REALTIME DATA

1. Connect the USB cable from the Hydraulic System Analyzer to the computer.

NOTE: This is required before starting the software. This allows the software application to detect a connected unit.

2. Start the software application from the *Start* menu, or by double-clicking on the **Flo-tech Hydraulic System Analyzer** icon on your desktop.
3. Click **Run**.
4. Data on the digital displays and the strip-chart are updated once per second.
5. Click **Stop** to halt the collection of data.

RECORDING MEASUREMENTS TO A FILE

All measurements can be saved to a comma-separated value (.csv) file. This file type is a generic text file with the data separated by commas and can be read by many spreadsheet applications such as Excel® and Corel® Quattro Pro®. These spreadsheet programs can then re-graph and manipulate the data.

All measurements taken (see *Table 1 on page 6*) are saved once per second to the file. For example, recording for 2 minutes yields 120 points of data. Even though data points are only recorded once per second, pressure spikes and dips are captured by recording the maximum or minimum pressure during each measurement period. Therefore, the precise shape of the pressure spike is not recorded, but its *amplitude* and the *time* it occurred are both recorded.

	A	B	C	D	E	F	G	H	I	J	K
1	Device ID: Test Stand 4										
2	Serial No: 12345678										
3	Model No: USB Tester										
4	Date: 11/1/2007										
5	Time: 11:52:50 AM										
6											
7	Pressure Units: PSI										
8	Temperature Units: °F										
9	Flow Rate Units: GPM										
10											
11	Time	Seconds	P Min	P Max	P Avg	P Alarm	Temp	T Alarm	Flow	FlowAlarm	HP
12	11:52:50	2	2311	2467	2467		105.4		84.7	Low	121.9
13	11:52:51	11	3402	3510	3422		105.4		114.7		252.2
14	11:52:52	12	3910	4002	3910		105.8		116.4		265.5
15	11:52:53	13	3978	4089	4001		105.9		120.6		281.5
16	11:52:54	14	4399	5020	4399	High	107.4		126.5		324.7
17	11:52:55	15	3971	4050	4025		108.8		120.8		283.7
18	11:52:56	16	4012	4012	4012		109.5		120.8		282.8
19	11:52:57	17	4003	4003	4003		109.9		120.7		281.9
20	11:52:58	18	3827	3881	3850		110.1	High	116.2		261.0
21	11:52:59	19	3409	3409	3409		110.1	High	112.1		223.0

Figure 2: Example file

Recording a File

1. Connect the USB cable from the Hydraulic System Analyzer to the computer.

NOTE: This is required before starting the software. This allows the software application to detect a connected unit.

2. Start the software application by double-clicking on the **Flo-tech Hydraulic System Analyzer** icon on your desktop.
3. Click **Record**.
4. Enter a name for the file in the *filename:* text box and click **Save**.

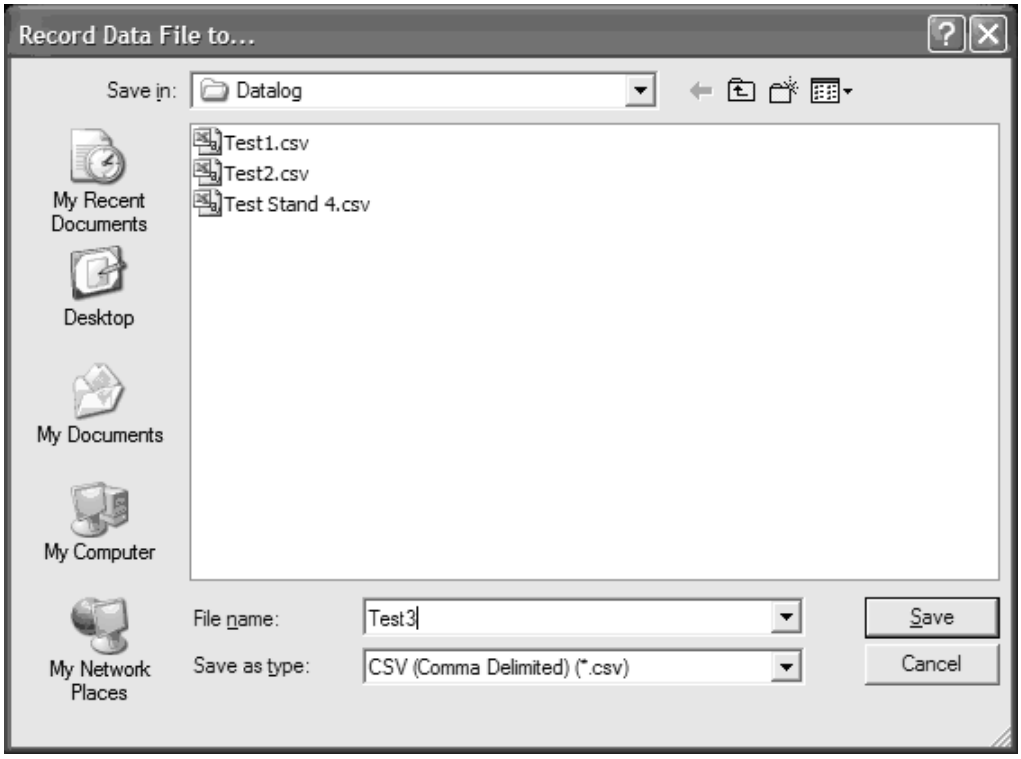


Figure 3: Select location for data file

NOTE: The default location for saving a log file for Windows XP and Windows 2000 is *C:\Documents and Settings\<user name>\My Documents\Flo-tech\Hydraulic System Analyzer\Datalog*
The default location for saving a log file for Windows Vista® is *C:\Users\<user name>\Documents\Flo-tech\Hydraulic System Analyzer\Datalog*

NOTE: If you wish to record over an existing file, double-click on the file from the list.

Data on the digital displays and the strip-chart is updated once per second. The message "Recording…" also displays under the *Run* button to indicate the software is in *Record* mode rather than *Run* mode. Data is not recorded if the file is already open by another application, such as Excel®.

5. Click **Stop** to halt the collection of data.

Recording a File While in Run Mode

1. Connect the USB cable from the Hydraulic System Analyzer to the computer.

NOTE: This is required before starting the software. This allows the software application to detect a connected unit.

2. Start the software application by double-clicking on the **Flo-tech Hydraulic System Analyzer** icon on your desktop.
3. Select **File > Record To…** to open a *Save As* dialog form.
4. Enter a name for the file in the *filename:* text box and click **Save**.
5. Click **Run** to start viewing measurements.

NOTE: The *Record* button is not grayed out. This is because the software filename and location have been set up before entering *Run* mode.

6. When ready to start recording, click **Record**. The message "Recording…" displays under the *Run* button to indicate the software has entered *Record* mode.
7. Click **Stop** to halt the collection of data.

NOTE: Once you click *Stop*, the *Record To* filename is erased from memory to avoid accidental overwriting of files. You must enter this information before each session when trying to record while in *Run* mode.

Entering Run or Record Mode

The menu disappears when entering *Run* or *Record* mode and returns when you click *Stop*. This blocks changes from being made while the software is collecting measurements. Such changes can create gaps in the collection process.

Entering the *Run* or *Record* mode also causes a blue indicator to flash in the *Log Interval* frame. This indicates the Hydraulic System Analyzer interface is running and collecting data.

Recording Modes

There are two recording modes:

- Record All Points
- Capture Points Manually

Record All Points

The *Record All Points* setting records all points in one second intervals to a .csv file until you click *Stop*.

Capture Points Manually

The *Capture Points Manually* setting lets you enter *Run* mode and use *Record* to capture points at desired intervals.

1. Select **Options > Record Mode > Capture Points Manually** from the main menu.
2. A "Save Data File as…" dialog box asks you to name the file you want to create and where to save it. Type a name in the *filename:* text box and click **Save**.
3. Click **Run** to start viewing measurements. Notice the *Record* button text has changed to *Manual Capture*.
4. Click **Manual Capture**. The message "Captured Point…" displays under the *Run* button for approximately one second to indicate the software has recorded one point to the .csv file.
5. Continue clicking **Manual Capture** to append more points to the .csv file.
6. Click **Stop** to halt the collection of data.

NOTE: Unlike the *Record All Points* mode, clicking *Stop* does not erase the .csv filename from memory. Data points are appended to the file each time you click *Stop*, so there is no danger of overwriting a .csv file.

NOTE: To capture points to a new .csv file, enter a new filename under the *File > Record To…* menu selection.

LOG INTERVAL

The *Log Interval* is used to stop the Hydraulic System Analyzer and software from running or recording data after a set period of time. To adjust the *Log Interval*, click the **Up/Down** arrows next to the log time (hours and minutes) on the main screen.

Next to the *Log Interval* setting is the *Time Period* in seconds. Since the strip-chart increments once every second, the elapsed time can be compared to the *Log Interval* in seconds. For convenience, the elapsed time is also displayed in hours and minutes on the lower right side of the software application.

The default *Log Interval* setting is 4 hours when launching the application. This is sufficient for most tests and also allows using the software without having to adjust the *Log Interval* first. If the operator doesn't need to setup a test period and each test is less than 4 hours, then the *Log Interval* setting does not need to be adjusted and can be ignored.

Click **Clear Graph** to clear the graph and reset the number of measurements that are compared to the log period. For example, if the *Log Interval* is set to 4 hours and you click *Clear Graph*, you can run another 4 hour test before timing out.

CHANGING MEASUREMENT UNITS

Set the measurement units before entering the *Run* or *Record* modes.

1. Select the menu item **Options**.
2. Select *Pressure*, *Temperature*, *Flow* or *Power* units and select the desired unit.

The digital display and strip-chart legends change to the selected unit.

Pressure	Temperature	Flow Rate	Power *
PSI	°F	GPM	HP
Bar	°C	LPM	kW
KPa	—	—	—
MPa	—	—	—
Kg/cm^2	—	—	—

* Digital Display Only

Table 7: Measurement units

USING THE GRAPH

The graph on the main screen has a strip-chart. When the software is in *Run* or *Record* mode, the strip-chart scrolls from right to left at a rate of 1 group of plots per second. The complete graph displays the last 60 plots (or 60 seconds) of data. Previous data points that scroll off the graph are saved in memory. You can view them at any time until you clear the graph or close the application.

Viewing Graph History

If the strip-chart contains more than 60 points of data, select the *View History* checkbox located on top of the upper left corner of the graph. Use the horizontal scroll bar below the graph to scroll through the data. The current incoming data is not lost while you view the history data, so you can view it while the Hydraulic System Analyzer is in *Run* or *Record* mode. When finished viewing the history data, un-check the *View History* checkbox and the graph returns to displaying the current realtime data.

Displaying and Hiding Individual Graph Plots

The top of the graph has a color coded legend for each plot. Next to each legend label is a checkbox that controls the visibility. A checked box displays the plot and an un-checked box hides the plot.

Adjusting the Graph Scales

You can adjust the scale of each plot (*Pressure*, *Temperature* and *Flow Rate*) independently so the plot displays over most of the graph height. The pressure scale is on the left side of the graph. The temperature and flow rate scales are on the right side. Under each scale is a left and right arrow used for scale adjustment. The left arrow decreases the scale and the right arrow increases the scale. You can make scale adjustments while in *Run* or *Record* mode.

Displaying Graph Gridlines

Select **View > Show Graph Gridlines** to display the horizontal graph gridlines.

Clearing the Graph

Click **Clear Graph** or select **View > Clear Graph** from the menu.

USING THE ALARMS

There are three sets of High / Low alarm indicators on the main screen that monitor pressure, temperature and flow rates. The alarm indicators flash if the current system measurements exceed the set alarm limits. The alarms continue to flash when the current system measurements return back to normal to alert you that an alarm condition occurred. You must reset the alarms manually to acknowledge the alarm condition. Upon exiting *Run* or *Record* mode, you can view all alarm events (time, value, alarm level) in another form. These alarm events are also recorded to the .csv file when in *Record* mode.

Changing Alarm Settings

1. If in the *Run* or *Record* mode, click **Stop**.
2. Select **View > Alarm Settings** from the main menu.

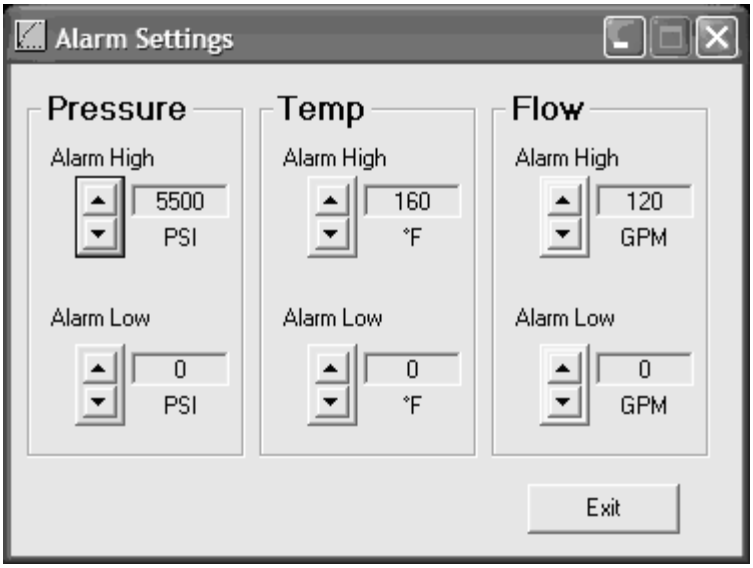


Figure 4: Alarm settings screen

3. Click the **Up/Down** arrows to adjust the level of each alarm to the desired position.
4. Click **Exit**.

The alarm level for each measurement is indicated on the strip-chart by the highlighted area shown on its associated scale. Any measurement taken inside the highlighted area triggers the alarm.

Resetting the Alarms

Click **Reset Alarms**. Alarms are reset if the alarm condition is false.

Viewing Alarm History

1. If in the *Run* or *Record* mode, click **Stop**.
2. Select **View > Alarm History** from the main menu to display the alarm events for each measurement.

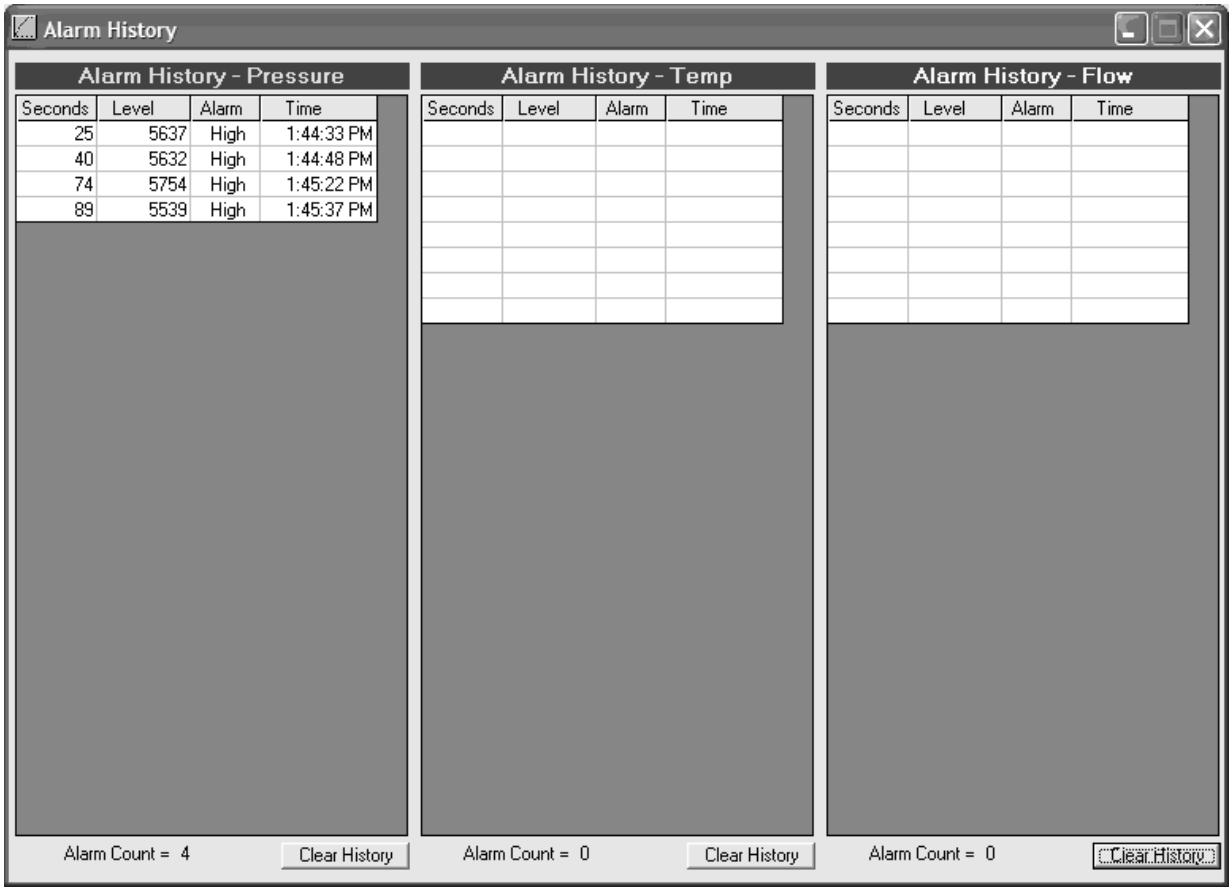


Figure 5: Alarm History screen

3. Click **Clear History** at the bottom of the form to erase captured alarms.
4. Click the red **X** in the upper right corner to exit the form.

NOTE: Alarm events are also recorded to the .csv file when in *Record* mode.

SAVING/LOADING SOFTWARE CONFIGURATIONS

You can save the current software application's settings to a configuration file that you can recall at a later time. This feature is useful for tests that use different measuring units and alarm settings. Rather than resetting each parameter, you can recall all test parameters from a file.

Saving Software Configurations

1. If in the *Run* or *Record* mode, click **Stop**.
2. Set all software parameters to desired settings.
3. Select **File > Save Setup Configuration** from the main menu.
4. A *Save Data File as…* dialog box asks you to name the configuration file and where to save it. Type a name in the *filename:* text box and click **Save**.

NOTE: The default location for saving a configuration file for Windows XP and Windows 2000 is *C:\Documents and Settings\<user name>\My Documents\Flo-tech\Hydraulic System Analyzer\Configurations*
The default location for saving a configuration file for Windows Vista® is *C:\Users\<user name>\Documents\Flo-tech\Hydraulic System Analyzer\Configurations*

Loading Software Configurations

1. If in the *Run* or *Record* mode, click **Stop**.
2. Select **File > Open Setup Configuration** from the main menu.
3. A *Select Data File to Open…* dialog box asks you to select the desired configuration file. Select a configuration file and click **Open**.

NOTE: The default location of this dialog box shows files in the following folder for Windows XP and Windows 2000 is *C:\Documents and Settings\<user name>\My Documents\Flo-tech\Hydraulic System Analyzer\Configurations*
The default location of this dialog box shows files in the following folder for Windows Vista® is *C:\Users\<user name>\Documents\Flo-tech\Hydraulic System Analyzer\Configurations*

CALIBRATION

The Hydraulic System Analyzer is calibrated at the factory, but you may need to reset zero for the pressure and flow rate sensors occasionally. Calibration parameters are stored within the electronic interface and not the PC software. When the software application is launched, it automatically reads the calibration parameters from the device. Therefore, owners of multiple units can use the same PC without worrying about calibration files.

Resetting Zero for the Pressure Transducer

1. Select **Tools > Calibration** from the main menu.

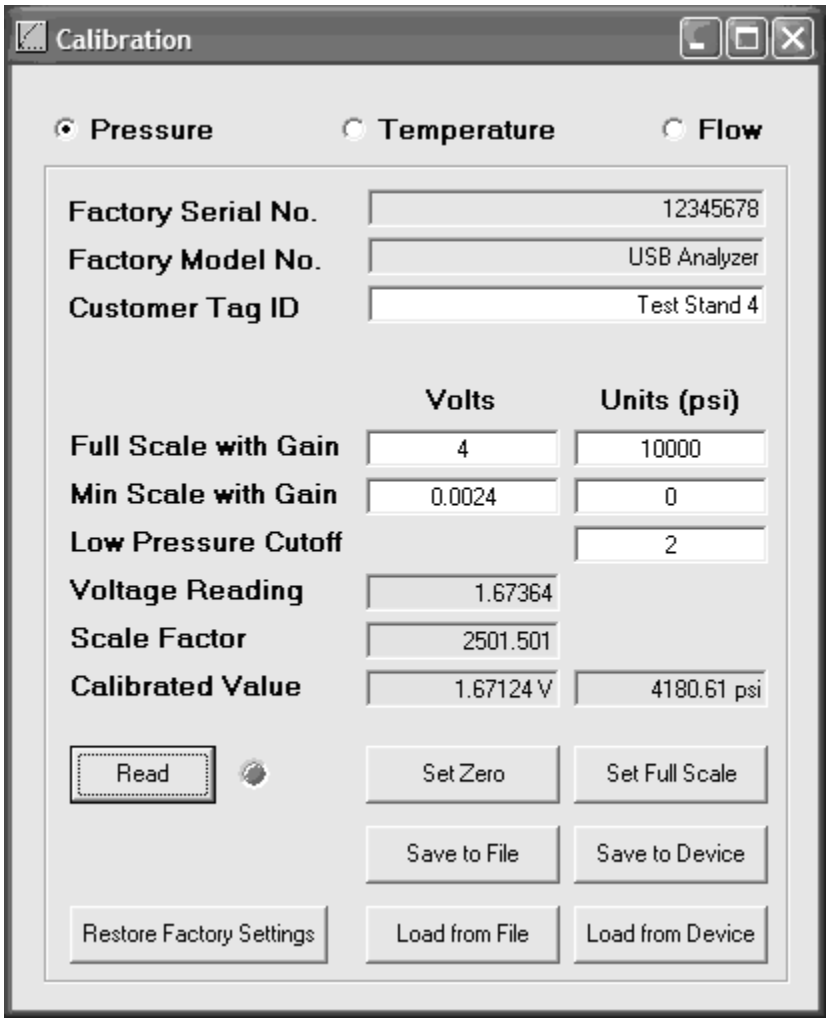


Figure 6: Calibration screen

2. Select the **Pressure** or **Flow** radio button at the top of the calibration screen.
3. Make sure the pressure/flow of the Hydraulic System Analyzer is at zero and click **Read**.
4. If the *Calibrated Value* reading under the *Units* column is not around zero, click **Set Zero** to recalibrate the sensor's zero output and write the value to the Hydraulic System Analyzer.

Resetting Factory Calibration Defaults

Click **Restore Factory Settings**.

TEST PROCEDURES

⚠ WARNING

ALL TESTERS ARE SHIPPED WITH THE LOADING VALVE IN THE CLOSED POSITION. OPEN THE LOADING VALVE FULLY BEFORE INITIATING FLOW AND TESTING OF THE HYDRAULIC CIRCUIT. TURN THE LOADING VALVE HANDLE COUNTERCLOCKWISE TO THE FULLY OPEN POSITION. FAILURE TO OPEN THE LOADING VALVE FULLY CAN RESULT IN INJURY TO PERSONNEL AND/OR DAMAGE TO THE EQUIPMENT.

⚠ CAUTION

THESE UNITS ARE NOT DESIGNED FOR HIGH PRESSURE "DEADHEAD" (LOADING VALVE FULLY CLOSED) APPLICATIONS, IN THE REVERSE DIRECTION. USAGE UNDER THIS CONDITION COULD LEAD TO LADING VALVE FAILURE. UNDER SUCH CONDITIONS, MAXIMUM OPERATING PRESSURE IS LIMITED TO 2000 PSI (138 BAR).

⚠ CAUTION

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Standard Test Conditions

1. Install the Hydraulic System Analyzer as described in one of the following test procedures:
   - ◊ *"Tee Test" on page 19*
   - ◊ *"Inline System Test" on page 20*
   - ◊ *"Control Valve and Bi-directional Hydraulic Motor Test" on page 21*
   - ◊ *"Bi-directional Cylinder Test" on page 22*
   - ◊ *"Hydrostatic Transmission Diagnostics" on page 23*
2. Open the loading valve fully by turning the handle counterclockwise.
3. Start the pump and adjust it to the rated speed.
4. To raise the system temperature, close the tester loading valve to develop a pressure somewhat below the relief valve pressure. Maintain until the desired temperature is reached.
5. Open the Hydraulic System Analyzer's loading valve fully and proceed with the required test procedure.
6. The Hydraulic System Analyzer logs flow, pressure, temperature and power readings concurrently. See *"Recording Measurements to a File" on page 10*.

Tee Test

Install a tee between the pump and control valve and connect it to the *IN* port of the Hydraulic System Analyzer. The *OUT* port of the Hydraulic System Analyzer is connected to the tank. Pumps and relief valves can be isolated from the system and checked with the *Tee Test*.

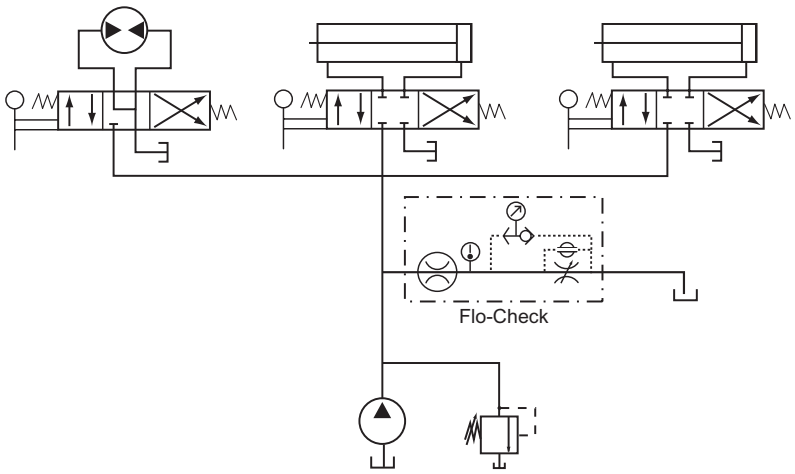


Figure 7: Tee test

⚠ WARNING

INCREASE PRESSURE SLOWLY. THE RELIEF VALVE MAY NOW BE ISOLATED FROM THE HYDRAULIC CIRCUIT, AND SYSTEM PRESSURES HIGHER THAN THE RELIEF VALVE SETTING CAN RESULT IN INJURY TO PERSONNEL AND/OR DAMAGE TO THE EQUIPMENT.

Pump Test

1. Install the Hydraulic System Analyzer in the *Tee Test* configuration and plug the line to the control valve.
2. Open the Hydraulic System Analyzer loading valve fully to read maximum pump flow at zero pressure.
3. Select **Run** and/or **Record** on the PC (see *"Recording Measurements to a File" on page 10*), then close the loading valve to increase pressure from zero pressure to rated or maximum pump pressure to determine pump condition.
4. The pump flow at rated pressure can now be checked against the pump manufacturer's specifications. A decrease in flow from zero pressure to maximum pressure indicates the pump condition. A pump that delivers a constant low flow at zero pressure and at maximum pressure suggests suction problems.

Relief Valve Test

1. Put a control valve into a power output mode with the output flow blocked, such as a cylinder at the end of its stroke or center a closed center valve.
2. Select **Run** and/or **Record** on the PC (see *"Recording Measurements to a File" on page 10*).
3. Close the Hydraulic System Analyzer loading valve while recording or viewing the pressure. Pressure increases until the relief valve opens. Record the pressure at this point. Repeat to check the relief valve adjustment.

Relief Valve in Separate Housings

1. Install the Hydraulic System Analyzer in the *Tee Test* configuration and plug the line to the control valve.
2. Select **Run** and/or **Record** on the PC (see *"Recording Measurements to a File" on page 10*).
3. Close the Hydraulic System Analyzer loading valve while recording or viewing the pressure and flow. Pressure increases until the relief valve opens. You can reference this point on the Hydraulic System Analyzer software. Repeat to check the relief valve adjustment.

Relief Valves

Often relief valves start to open before they reach their full pressure flow settings. This can be noted by comparing the pressure and flow rate readings made in a pump test. Any great decrease in flow rate from tests made in a pump test indicates a faulty relief valve.

Inline System Test

Virtually all system components can be unidirectionally tested or set in this configuration.

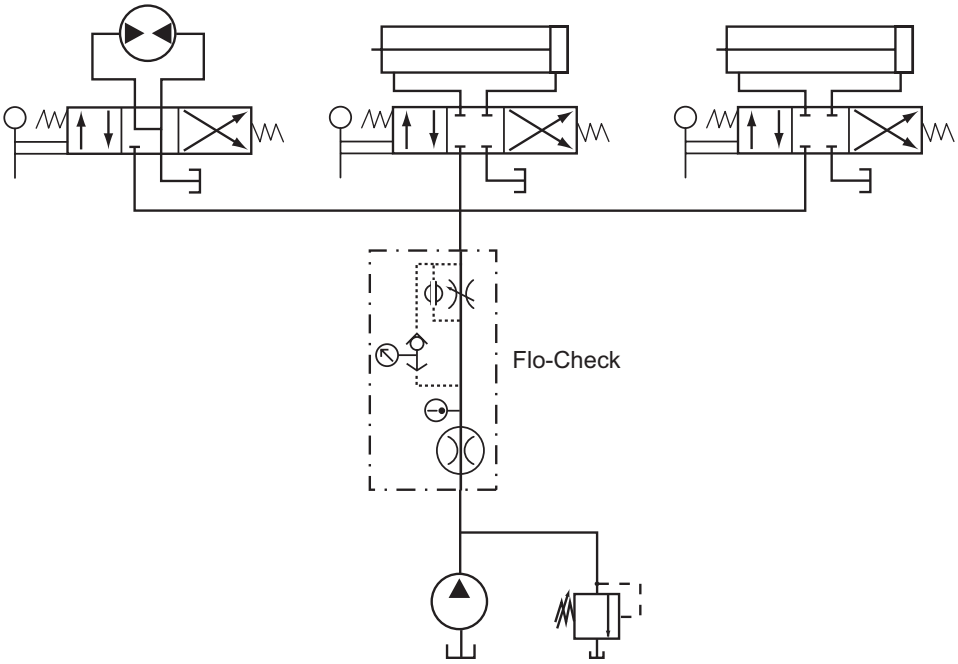


Figure 8: Inline system test

Begin by installing the Hydraulic System Analyzer between the pump and the control valves.

Pump Test

1. If the directional control valve's (DCV's) center does not allow an unrestricted flow path back to tank, see *"Pump Test"* in *"Tee Test" on page 19*.
2. Open the Hydraulic System Analyzer loading valve fully to read maximum pump flow at zero pressure.
3. Select **Run** and/or **Record** on the PC (see *"Recording Measurements to a File" on page 10*), then close the loading valve to increase pressure from zero pressure to rated or maximum pump pressure to determine pump condition.
4. The pump flow at rated pressure can now be checked against the pump manufacturer's specifications. A decrease in flow from zero pressure to maximum pressure indicates the pump condition. A pump that delivers a constant low flow at zero pressure and at maximum pressure suggests suction problems.

Relief Valve in Separate Housings

1. If the DCV's center does not allow an unrestricted flow path back to tank, see *"Pump Test"* in *"Tee Test" on page 19*.
2. Select **Run** and/or **Record** on the PC (see *"Recording Measurements to a File" on page 10*).
3. Close the Hydraulic System Analyzer loading valve while viewing or recording the pressure and flow. Pressure increases until the relief valve opens. You can reference this point on the Hydraulic System Analyzer software. Repeat to check the relief valve adjustment.

Often relief valves start to open before they reach their full pressure flow settings. This can be noted by comparing the pressure and flow rate readings made in a pump test. Any great decrease in flow rate from tests made in a pump test indicates a faulty relief valve.

Motor Test No Load

1. Open the Hydraulic System Analyzer loading valve fully to read maximum pump flow at zero pressure.
2. Select **Run** and/or **Record** on the PC (see *"Recording Measurements to a File" on page 10*).
3. Put the motor's control valve in the forward operating position. If there are multiple valves, only one control valve should be in an operating position at any one time.
4. Using a tachometer, run the motor with no load. The flow and RPM should match the manufacturer's specification. A decrease in RPM from the manufacturer's specifications indicates a loss of the motor's efficiency.

Motor Test Loaded

1. Open the Hydraulic System Analyzer loading valve fully to read maximum pump flow at zero pressure.
2. Select **Run** and/or **Record** on the PC (see *"Recording Measurements to a File" on page 10*).
3. Put the motor's control valve in the forward operating position. If there are multiple valves, only one control valve should be in an operating position at any one time.
4. Using a tachometer, run the motor while providing a load on the motor. The flow and RPM can now be checked against the motor manufacturer's specifications. A decrease in RPM from the manufacturer's specifications or the unloaded motor test indicates a loss of the motor's efficiency.

Control Valve and Bi-directional Hydraulic Motor Test

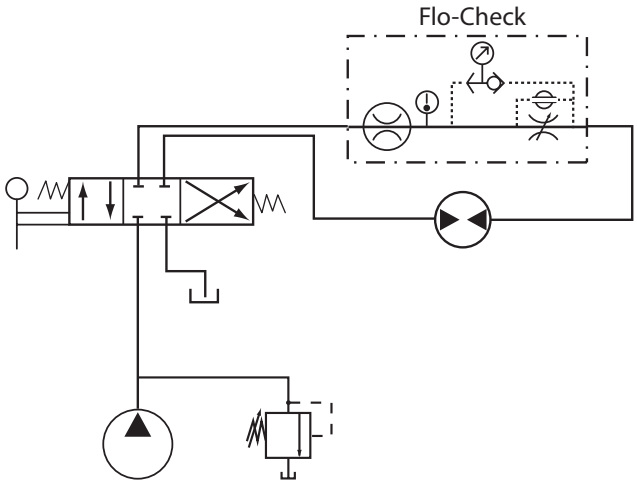


Figure 9: Control Valve and Bi-directional Hydraulic Motor Test

Motor Test No Load

1. Open the Hydraulic System Analyzer loading valve fully to read maximum pump flow at zero pressure.
2. Select **Run** and/or **Record** on the PC (see *"Recording Measurements to a File" on page 108*).
3. Put one control valve in the forward operating position. If there are multiple valves, only one control valve should be in an operating position at any one time.
4. Using a tachometer, run the motor with no load. The flow and RPM should match the manufacturer's specification. A decrease in RPM from the manufacturer's specifications indicates a loss of the motor's efficiency.

NOTE: This test can be repeated for the reverse direction.

Motor Test Loaded

1. Open the Hydraulic System Analyzer loading valve fully to read maximum pump flow at zero pressure.
2. Select **Run** and/or **Record** on the PC (see *"Recording Measurements to a File" on page 10*).
3. Put one control valve in the forward operating position. (=If there are multiple valves, only one control valve should be in an operating position at any one time.
4. Using a tachometer, run the motor while providing a load on the motor. The flow and RPM can now be checked against the motor manufacturer's specifications. A decrease in RPM from the manufacturer's specifications or the unloaded motor test indicates a loss of the motor's efficiency.

NOTE: This test can be repeated for the reverse direction.

Motor Test Simulated Load

1. Reverse the pump flow.
2. Open the Hydraulic System Analyzer loading valve fully to read maximum pump flow at zero pressure.
3. Install one or both of the following instruments on the hydraulic motor.
   a. Place a Hedland Variable Area Flow Meter[1] on the case drain and manually record the flow as you increase the load on the tester. Then compare it to the manufacturer's specifications.
   b. Place a tachometer on the motor's shaft.
4. Select **Run** and/or **Record** on the PC (see *"Recording Measurements to a File" on page 10*).
5. Increase the load on the Hydraulic System Analyzer to produce back pressure on the hydraulic motor.

⚠ WARNING

SEE MANUFACTURER'S SPECIFICATIONS FOR MAXIMUM ALLOWABLE BACK PRESSURE. IF THE MOTOR DOES NOT HAVE AN EXTERNAL DRAIN, IT CANNOT HAVE A BACK PRESSURE LOAD. FAILURE TO FOLLOW THE MANUFACTURER'S SPECIFICATIONS CAN RESULT IN INJURY TO PERSONNEL AND/OR DAMAGE TO THE EQUIPMENT.

6. The flow at rated RPM can now be checked against the motor manufacturer's specifications. A decrease in RPM and an increase of case flow with increased load indicates a loss of the motors efficiency.

NOTE: If the flow and RPM meet specifications, it could indicate a relief valve problem or DCV problem.

[1] For complete information, visit www.badgermeter.com and select Petroleum Fluids under Products / Variable Area High Pressure Flow Meters.

Directional Control Valve (DCV) Test

1. Isolate the motor from the circuit and connect the Hydraulic System Analyzer's output to the DCV's B port.
2. Select **Run** and/or **Record** on the PC (see *"Recording Measurements to a File" on page 10*).
3. Slowly close the Hydraulic System Analyzer loading valve to achieve the rated pump pressure. Repeat for all operating positions of all DCV's.

   ◊ If all components are in good operating condition, pressure and flow measurements should be the same as in the *Pump Test*.

   ◊ If a decrease in flow in any DCV position is noted, leakage is indicated.

   ◊ If the decrease in flow is the same with the control valve in all positions, it indicates the relief valve is at fault.

NOTE: This can also indicate some other leak is present in the control valve, such as a defective casting, damaged seals, or worn valve position detents, but always check the relief valve FIRST.

   ◊ If the flow readings are now higher and comparable to the other control valves, then a faulty cylinder or motor is indicated.

Bi-directional Cylinder Test

Use this setup to calculate extension times and verify force.

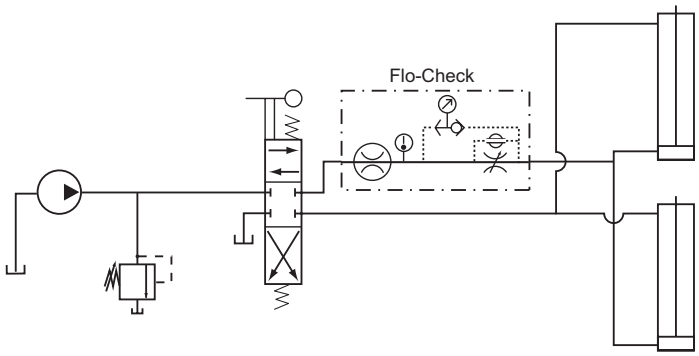


Figure 10: Bi-directional cylinder test

1. Install the Hydraulic System Analyzer on the rod or cap side of the cylinders.
2. Select **Run** and/or **Record** on the PC (see *"Recording Measurements to a File" on page 10*).
3. With the load valve fully open, the extension or retraction times can be set, verified and/or logged in the circuit. Inches per Minute = (231 × GPM) / SQ IN.
4. Force can also be checked by checking the pressure when the cylinder is at the end of its stroke.
   Force = Pressure × Area

   ◊ If all components are in good operating condition, pressure and flow measurements should be the same as in the Pump Test.

   ◊ If a decrease in flow or pressure in any control valve position is noted, leakage is indicated.

   ◊ If the decrease in flow is the same with the control valve(s) in all positions, it indicates the relief valve is at fault.

NOTE: This can also indicate some other leak is present in the control valve, such as a defective casting, damaged seals, or worn valve position detents, but always check the relief valve FIRST.

◊ If the relief valve is operating normally, see Directional Control valve (DCV) Test.

◊ A decrease in pressure at the cylinders full stroke could indicate worn piston seals.

Hydrostatic Transmission Diagnostics

Install the Hydraulic System Analyzer into the system between the pump discharge port and the inlet of the hydraulic motor.

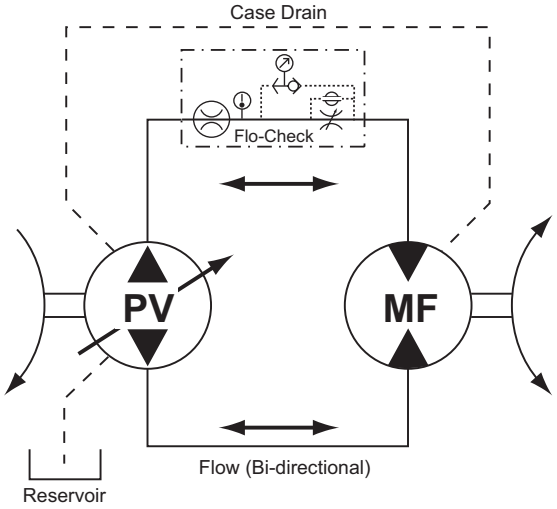


Figure 11: Hydrostatic transmission test

Pump

1. Open the Hydraulic System Analyzer loading valve fully to read maximum pump flow at zero pressure.
2. Select **Run** and/or **Record** on the PC (see *"Recording Measurements to a File" on page 10*), then close the loading valve to increase pressure from zero pressure to rated or maximum pump pressure to determine pump condition.
3. The pump flow at rated pressure can now be checked against the pump manufacturer's specifications. A decrease in flow from zero pressure to maximum pressure indicates a drop in volumetric efficiency.

Motor Test No Load

1. Open the Hydraulic System Analyzer loading valve fully to read maximum pump flow at zero pressure.
2. Select **Run** and/or **Record** on the PC (see *"Recording Measurements to a File" on page 10*).
3. Put one control valve in the forward operating position. If there are multiple valves, only one control valve should be in an operating position at any one time.
4. Using a tachometer, run the motor with no load. The flow and RPM should match the manufacturer's specification. A decrease in RPM from the manufacturer's specifications indicates a loss of the motor's efficiency.

Motor Test Loaded

1. Open the Hydraulic System Analyzer loading valve fully to read maximum pump flow at zero pressure.
2. Select **Run** and/or **Record** on the PC (see *"Recording Measurements to a File" on page 10*).
3. Put one control valve in the forward operating position. If there are multiple valves, only one control valve should be in an operating position at any one time.
4. Using a tachometer, run the motor while providing a load on the motor. The flow and RPM can now be checked against the motor manufacturer's specifications. A decrease in RPM in the manufacturer's specifications or the unloaded motor test indicates a loss of the motor's efficiency.

Motor Test Simulated Load

1. Reverse the pump flow.
2. Open the Hydraulic System Analyzer loading valve fully to read maximum pump flow at zero pressure.
3. Install one or both of the following instruments on the hydraulic motor.
   a. Place a Hedland variable area meter on the case drain and manually record the flow as you increase the load on the tester. Then compare it to the manufacturer's specifications.
   b. Place a tachometer on the motor's shaft.
4. Select **Run** and/or **Record** on the PC (see *"Recording Measurements to a File" on page 10*).
5. Increase the load on the Hydraulic System Analyzer to produce back pressure on the hydraulic motor.

⚠ WARNING

SEE MANUFACTURER'S SPECIFICATIONS FOR MAXIMUM ALLOWABLE BACK PRESSURE. IF THE MOTOR DOES NOT HAVE AN EXTERNAL DRAIN, IT CANNOT HAVE A BACK PRESSURE LOAD. FAILURE TO FOLLOW THE MANUFACTURER'S SPECIFICATIONS CAN RESULT IN INJURY TO PERSONNEL AND/OR DAMAGE TO THE EQUIPMENT.

6. The flow at rated RPM can now be checked against the motor manufacturer's specifications. A decrease in RPM and an increase of case flow with increased load indicates a loss of the motor's efficiency.

NOTE: If the motor does not have a case drain, it cannot be loaded on the discharge side.

Other Test Procedures

Case Drain

You can check the case drain flow concurrently with any of these setups using a second Hedland Variable Area Flow Meter[1]. However the motor's case drain, the pump's case drain, and the charge pump are all connected in series. This means that the charge pump flow must be factored into the case flow. Any increase in case flow would indicate a pump or motor problem.

Test Stand Calibration System

You can add the Hydraulic System Analyzer to any existing test stand for diagnostics calibration, certification and data logging of hydraulic components. You can use the Hydraulic System Analyzer for recording bi-directional flow, which makes it ideal for hydraulic motors and cylinders. Install the meter either on the supply or the return line of the test bench. However, place the meter on the supply side in case any contamination is passed through the units under test. Once the data is recorded it can be stored for future reference or printed and sent with the repaired unit.

Servo Controlled Pumps, Motors and Valves

Special procedures for testing these components may be specified. Observe the nstructions of the component and machine manufacturer.

These components may have the capability of nearly instantaneous increases of flow and/or pressure and should have a positive means of control. An example of such a control is the push-pull servo control for varying pump delivery. Attempting to manually adjust this control can result in excessive increases in flow and/or pressure. Such uncontrolled changes may cause a failure in the system and result in component damage or personal injury.

[1] For complete information, visit www.badgermeter.com and select Petroleum Fluids under Products / Variable Area High Pressure Flow Meters.

MAINTENANCE / TROUBLESHOOTING

The Flo-Check USB Hydraulic System Analyzer is designed to give years of trouble-free service. However, if trouble is suspected, a few simple checks can be made.

PC Connectivity

If there are connection issues with newer versions of Windows:

1. Make sure the unit and PC are connected with a USB A/B cable.
2. Check the cable for any signs of damage and replace, if damaged.
3. Restart the PC with the unit connected to it.
4. Run the application in *Compatibility Mode*. To do this, right-click on the software icon and click **Properties**. Under the *Compatibility* tab, check the box for **Run the program as an administrator** under the *Privilege Level* category.

NOTE: If step 4 does not work, check the box for **Run this program in compatibility mode for:** under *Compatibility Mode*. Using the activated drop-down menu, select the version of Windows that applies to your PC configuration.

Load Valve

If the valve fails to load the system, remove the valve body and check for foreign material, worn parts or seals.

Flow

The absence of any flow reading may indicate a blockage of the turbine.

1. Remove the retaining ring from the inlet port and carefully remove the turbine assembly. Remove any material that may be preventing easy rotation of the rotor.
2. Reassemble and attempt a flow reading again.
3. If the tester still fails to indicate flow, return the tester to the factory. For return procedures, see *"Return Goods Authorization" on page 27*.

Burst Discs

The burst discs are designed to rupture at a specified pressure. Testers provide protection from excessive pressure in either direction (7500 PSI differential) with two internal burst discs that, when ruptured, bypass flow around the loading valve. If rupture occurs, replace the burst discs.

⚠ WARNING

IF YOU DO NOT HAVE THE PROPER TOOLS TO ACCOMPLISH THIS TASK, RETURN THE TESTER(S) TO THE FACTORY FOR REPLACEMENT OF THE BURST DISC HOUSING AND THE BURST DISCS. INJURY TO PERSONNEL AND/OR DAMAGE TO EQUIPMENT MAY RESULT IF THE BURST DISCS ARE INSTALLED IMPROPERLY.

Gather the following tools and parts:

- 5/8 in. open-end box wrench
- ≥ 0…50 pound-inch torque wrench
- Burst disc housing
  - ◊ Housing; F5144 (1 each)
  - ◊ Ring support; F6567 (1 each)
  - ◊ O-ring, 2-015; F3137-015 (1 each)
  - ◊ Backup O-ring, 2-015; F1015-015 (1 each)
- Burst discs
  - ◊ F1614-7500 (2 each)

Internal Burst Disc Procedure

1. Position the Hydraulic System Analyzer to expose the internal burst disc housing as shown in *Figure 12*.

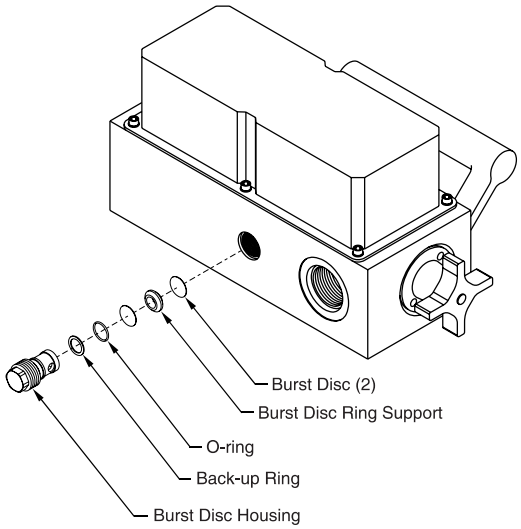


Figure 12: Burst disc replacement

2. Remove the burst disc housing from the block using a 5/ in. open-end box wrench.
3. Remove the ruptured burst discs from the burst disc housing.
4. Insert one new burst disc (F1614-7500) into the housing followed by the ring support and then the second burst disc.
5. Verify that the burst discs are seated. Be careful not to scratch the surface of the discs.
6. Insert the burst disc housing with the O-ring and backup O-ring into the port of the block and hand tighten. If required, use a new burst disc housing.
7. Set the torque wrench to 40 foot-pounds (50.8 N-m).
8. Torque the burst disc housing into the block. Torque to 40 foot-pounds (50.8 N-m).

⚠CAUTION

DO NOT OVER TORQUE THE BURST DISC HOUSING. APPLYING TOO MUCH TORQUE WILL DAMAGE THE BURST DISC AND CAUSE THE DISC TO RUPTURE PREMATURELY.

DIMENSIONS

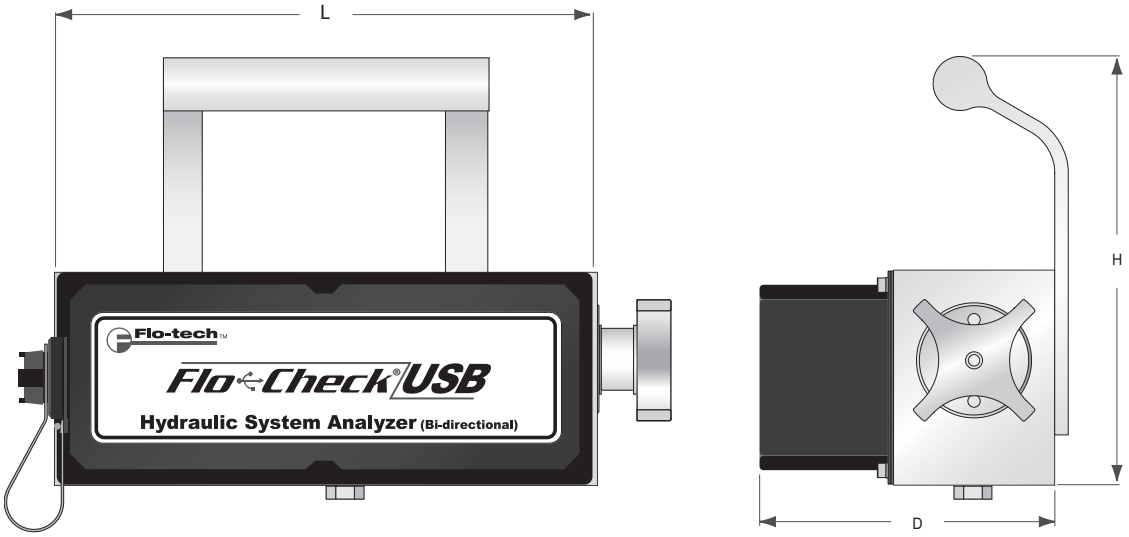


Figure 13: Dimensions

Series	Dimensions (L x D x H)		Weight
	in.	mm	lbs (kg)
F7164	11.41 × 5.70 × 7.93	289.81 × 144.78 × 201.42	17 (7.71)
F7160	11.41 × 5.70 × 7.93	289.81 × 144.78 × 201.42	17 (7.71)
F7161	12.10 × 6.20 × 7.93	307.34 × 157.48 × 201.42	20 (9.07)
F7165	11.41 × 5.70 × 7.93	289.81 × 144.78 × 201.42	17 (7.71)
F7162	11.41 × 5.70 × 7.93	289.81 × 144.78 × 201.42	17 (7.71)
F7163	12.10 × 6.20 × 7.93	307.34 × 157.48 × 201.42	20 (9.07)

FLOW VS PRESSURE DROP CHARTS, ΔP CAPTURED USING LOADING VALVES

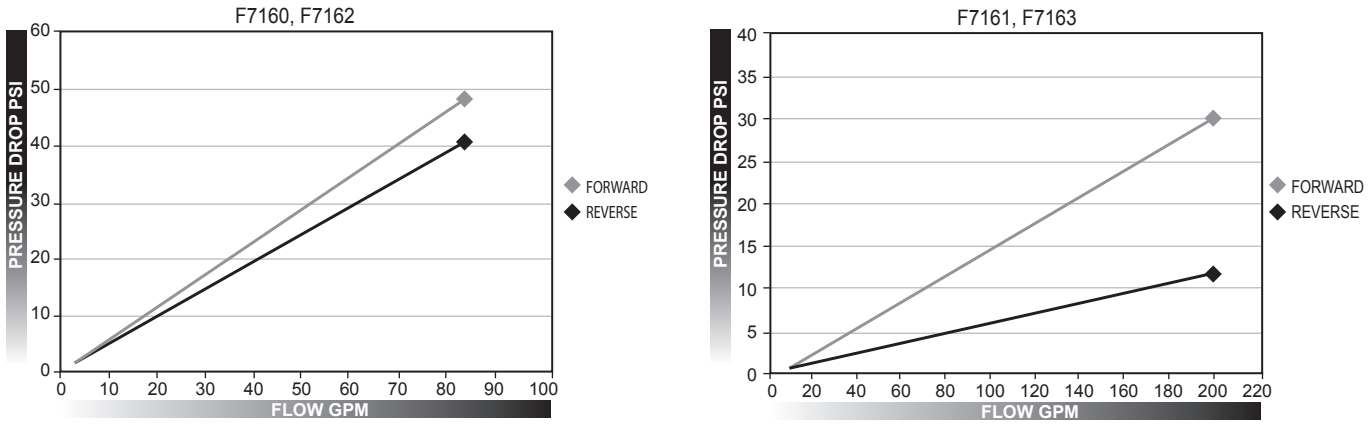


Figure 14: Flow vs pressure drop

NOTE: For Flow vs Pressure Drop information on the F7164 and F7165 models, please contact the factory.

RETURN GOODS AUTHORIZATION

When returning equipment for service, a Returned Goods Authorization (RGA) number must be obtained from our Customer Service Department. Please contact them by phone at 877-243-1010.

All returns go to the following address and must include the RGA number on the outside of the box:

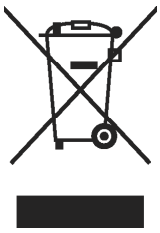
Badger Meter, Inc.

8635 Washington Avenue

Racine, WI 53406-3738 USA

Attn: RGA # xxx-xxxx

WASTE ELECTRICAL AND ELECTRONIC EQUIPMENT (WEEE) DIRECTIVE



In the European Union, this label indicates that this product should not be disposed of with household waste. It should be deposited at an appropriate facility to enable recovery and recycling.

For information on how to recycle this product responsibly in your country, please visit www.badgermeter.com.

Control. Manage. Optimize.

www.badgermeter.com