HIGH VOL+ Operator's Manual

Version 6 Firmware

Table of Contents

HIGH VOL+ NOTATION

Notations and Measurements: The Table below describes the measurement notion used by the HIGH VOL+ and units used to report those measurements.

Notation	Units of Measurement	Description
Qsys	CFM	System Flow Rate
Qstd	CFM	Flow Rate at Standard Conditions *Reported at 760 mmHg and 25°C*
Vstd	m^3	Volume at Standard Conditions *Reported at 760 mmHg and 25°C*
Qamb	CFM	Flow Rate at Ambient Conditions
Vamb	m^3	Volume at Ambient Conditions
Tamb	°C	Ambient Temperature
Tcjc	°C	Cold Junction Compensation Temperature (compensates Ambient Temp)
Pamb	mmHg	Ambient Pressure (Uncorrected Barometric Pressure)
Pdif	inH_2O	Differential Pressure (Orifice Pressure)
Pcal	inH_2O	Flow Calibrator Pressure

FLOW LIMITATIONS

One thing that is sometimes overlooked during sampling or during the design of an SOP is that there are limitations to what the sampler as a whole is capable of. The sampler can control the flow over a wide range of flow rates. However, it may not be capable of doing this with all filter media. For example, filter media with a high pressure drop will require more vacuum capacity from the motor. There is a tradeoff between vacuum capacity and flow rate. As the required pressure drop across the filter media increases, the maximum sustainable flow rate will decrease.   It is very important to test the filter media, capacity of the system, and expected loading of the filter media when designing an SOP. This is true for all samplers regardless of manufacturer.

If the end user observes that the sampler is consistently falling to meet the requirements of the SOP and has verified the operation of the unit without the sample media installed, they should contact the SOP writer for further instructions.

To help protect the system from runaway flow control during sampling, the unit monitors the flow rate. **If the flow rate for any reason exceeds +/- 10 percent of the set flow rate for a period of at least 2 minutes, the unit will stop the test and set the FLOW flag to indicate a problem existed during the test with the flow rate.** The FLOW flag is further described in the DATA section of this manual.

HIGH VOL+ CONNECTIONS

The descriptions of the various connections to the HIGH VOL+ control unit are described below.

"Motor"

The "Motor" power connection supplies power to the motor being controlled by the HIGH VOL+. Both Brush-Type and Brushless-Type motor are supported, but only one may be used at a time. The HIGH VOL+ will come configured to match the motor type ordered. *THE MOTOR USED WITH THE HIGH VOL+ MUST MATCH THE AC POWER BEING SUPPLIED TO THE HIGH VOL+. WHILE THE HIGH VOL+ CONTROLS THE MOTOR SPEED THROUGH THE EMBEDDED ELECTRONICS, IT CAN NOT CHANGE THE OPERATING VOLTAGE OR THE FREQUENCY OF THE INCOMING POWER THAT IS SUPPLIED TO THE MOTOR.*

"Power"

The "Power" connection supplies power to the HIGH VOL+. It should be connected to the AC power line. Operation at both 120 Volts AC and 240 Volts AC are supported. The system is designed to operate at either 50 or 60 Hz without the need to change the configuration of the unit.   However, a jumper inside the HIGH VOL+ determines the voltage on which the unit operates. *DO NOT APPLY 240-VOLT POWER TO THE HIGH VOL+ WHILE THE UNIT IS CONFIGURED FOR 120-VOLT OPERATION. THIS WILL DAMAGE THE UNIT. APPLYING 120-VOLT POWER TO THE HIGH VOL+ WHILE THE UNITS IS CONFIGURED FOR 240-VOLT OPERATION SHOULD NOT DAMAGE THE UNIT, BUT IS NOT RECOMMENDED OR SUPPORTED*.

"AutoCal" Pressure

The "AutoCal" pressure port is used to make the Pcal measurement. It should be connected to the calibrator during the AutoCal procedure.

"Ambient" Pressure

The "Ambient" pressure port is used to make the Pamb measurement. It should be left open to atmosphere so that it properly senses the ambient pressure.

"Orifice +" Pressure

The "Orifice +" pressure port is used to make one half of the Pdif measurement. It can be connect to the exhaust port on the motor to measure the back pressure of the blower. However, unlike traditional High Volume samplers, this back pressure is not used to determine the any aspect of flow. The Orifice Pressure is not utilized for any flow calculations or calibrations. However, the system does measure and log the value the value seen by this sensor.   This is provides a record similar to the Dixon chart recorder on older models. Note this pressure is only a very crude representation of the flow. It should not be used to represent the true flow of the system, because factors such as air exit temperature, humidity, ambient pressure, motor pressure drop, and filter pressure drop will affect the pressure seen by the orifice pressure sensor.

"Orifice –" Pressure

The "Orifice –" pressure port is not used by the system and should be left open to atmospheric pressure.

Flow "Probe"

The flow probe exits the control box using the same strain relief as the thermocouple used to measure ambient temperature. The flow probe is used to measure air velocity and must be installed properly in order to accurately measure the flow rate of the system. **Any time the system is moved or the flow probe adjust, the system should be calibrated.**

"Ambient" Temperature

      The Ambient Temperature thermocouple port is used to make the Tamb measurement. A Type K thermocouple must be used. The sensing tip of the thermocouple should be located so that it receives air flow while the unit is sampling and is always shield from the sun. By locating the sensor in this manner it can be used to monitor two items of importance. Most importantly, this will allow for the accurate measurement of the ambient temperature while the unit is sampling. In addition, when the unit is not sampling this allows the temperature of the filter to be approximated. This can be of importance when sampling for compounds that may changes phases (i.e. from solid to gas) due to changes in temperature. Below, is a picture showing a suitable location for the thermocouple. Note the thermocouple tip should be located so that it does not come into direct contact with any surface.
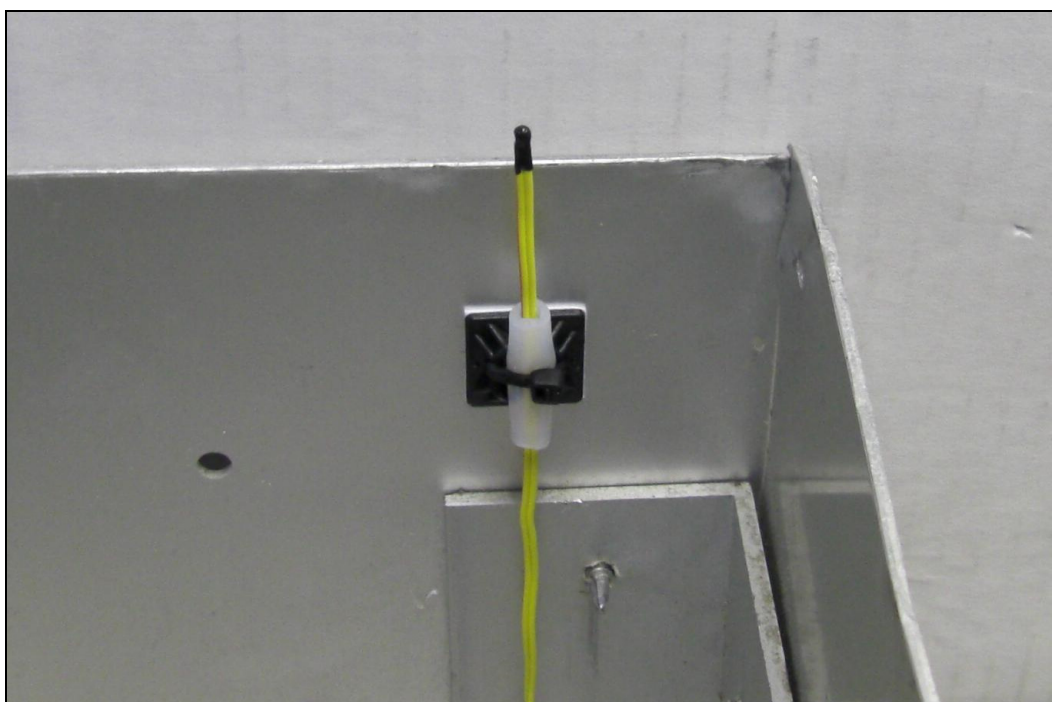
USER INTERFACE

The user interface of the HIGH VOL+ consists of the display, keypad, power status light, alert status light, and the buzzer.

User Interface: The Display

The Display is used to inform the user of the status and the configuration of the unit. When used with the Keypad, the user can configure the HIGH VOL+ operation.

User Interface: The Keypad

The Keypad is used by the user to input data into the HIGH VOL+ in order to configure the various operating parameters of the unit.

User Interface: Power Status Light

The Power Status Light indicates when power had been applied to the unit. A solid green light indicates that unit is running and receiving power. A flashing green light indicates that the motor is on.

User Interface: Alert Status Light

The Alert Status Light indicates the alert state of the unit. The unit monitors several operating parameters and alerts the user to take action when these parameters fall out of the expected range. A flashing red light indicates that a non-fatal alert has occurred. The unit will continue to operate, but may not be functioning optimally. A solid red light indicates a fatal alert has occurred. The unit will not continue to operate. To determine the source of the alert, use the INFO key on the main status screen. See INFO section of this manual for more details.

User Interface: Buzzer

The Buzzer is primarily used to provide auditory feedback when a key is pressed. In addition, the buzzer provides auditory feedback for the boot loader program used to upgrade the operating firmware of the unit. More details of this function will be provided with the release of new firmware.

MAIN STATUS SCREEN

The main display of the HIGH VOL+ shows the operating status of the unit. If the timer is programmed to start at some time in the future, a countdown timer is shown. If the timer is currently running, a status screen is displayed with various operating parameters of the system. If the timer is not executing or set to start at some future time, a status screen is displayed describing the situation.

```
    12-01-07 12:00:01
TIMER:          NOT SET




TIMER │ DATA │ SETUP │ INFO
```

Example of the Main Display with the Timer not configured

```
    12-01-07 12:00:01
TIMER:          WAITING

STARTS IN:   00:09:59



TIMER │ DATA │ SETUP │ INFO
```

Example of the Main Display with the Timer configured to start in the future

```
    12-01-07 12:00:01
TIMER:        EXECUTING

STOPS IN:    00:04:59
MTR ETI:          0.66
CAL ETI:          0.66
USR ETI:          0.66

TIMER │ DATA │ SETUP │ INFO
```

Example of the Main Display with the Timer Operating

The Soft-Menu Function Keys

From the main display, there are four keys used to access the various information and configuration screens of the unit. The four keys are F1, F2, F3, and F4. They are called soft-menu function keys, because there functions change throughout the system. When used, the function assigned to each key is described by the bottom line of the display. While on the Main Display the functions are described by the following table:

KEY	Display Description	Extended Description
F1	TIMER	Pressing this key accesses the "TIMER" menu. The "TIMER" menu is used to setup the timer or abort the timer if it is currently running. More details on these functions are described in the "TIMER" menu section of this manual.
F2	DATA	Pressing this key accesses the "DATA" menu. The "DATA" menu is used to work with data collected by system. Data can be reviewed on the display, transfer to a memory card, or erased. More details on these functions are described in the "DATA" menu section of this manual.
F3	SETUP	Pressing this key accesses the "SETUP" menu. The "SETUP" menu is used to configure, calibrate, and diagnose the unit. More details on these functions are described in the "SETUP" menu section of this manual.
F4	INFO	Pressing this key accesses the "INFO" display. The "INFO" display show various status and operating parameters for the unit. More details on these functions are described in the "INFO" section of this manual.

STEP BY STEP GUIDE

This section of the manual serves as a quick guide providing step by step instructions to some of the most important features of the HIGH VOL+. For additional details, refer to the relevant section of this manual.

Step by Step: Installing the Gable Roof Assembly

The Gable Roof is shipped uninstalled to prevent damage that could occur in shipping and must be installed by the user when first setting up the unit.

A bag of parts is shipped tapped to the inside of the lid and contains the following:
- 5 pcs 10-24 x 1/2 pan head screws
- 5 pcs 10-24 stop nuts
- 1 pc 6-32 x 3/8 pan head screw
- 1 pc 6-32 hex nut
- 1 pc 20" chain with" S" hook
- 1 pc TE-5001-1O-9 roof back catch
- 1 pc TE-5001-1O-1O front catch
- 1 pc TE-5001-1O-11 rear lid hasp

Installation:
1. Secure TE-500l-1O-1O front catch to the shelter using 2 10-24 pan head screws with stop nuts.
2. Secure TE-5001-10-9 roof back catch to the back of shelter using 10-24 pan head screw with stop nut.
3. Secure TE-5001-1O-11 rear lid hasp inside the lid with the slotted end angled up using 2 -
   10-24 pan head screws with stop nuts.

   Note: These three items may need adjustment after the shelter lid is installed.

4. Remove 4 -10-24 x 1/2 pan head screws from the nutserts in back of shelter.
5. Attach the lid to the shelter by placing the lid hinge plates on the "OUTSIDE" of the shelter top and tighten the 4 - 10-24 x 1/2 pan head screws into the nutserts.
6. Adjust the front catch to be sure that the lid slot lowers over it when closing the lid. The rear lid hasp should align with the roof back catch when the lid is open.
7. Attach the chain and "S" hook assembly to the side of the shelter with a 6-32 pan head screw and nut.
8. The lid can now be secured in an open or closed position with the "S" hook.

Step by Step: Installing the Flow Probe

The flow probe is used to measure air velocity and must be installed properly in order to accurately measure the flow rate of the system. Any time the system is moved or the flow probe adjust, the system should be calibrated.

Install the flow probe into the side port of the funnel on the system with the scribed line on the probe aligned straight up. Be sure that the sealing washer is installed and the clamp is securely tightened as movement of the probe can cause problems with measuring and controlling the flow. The picture below shows the flow probe installed in the system.
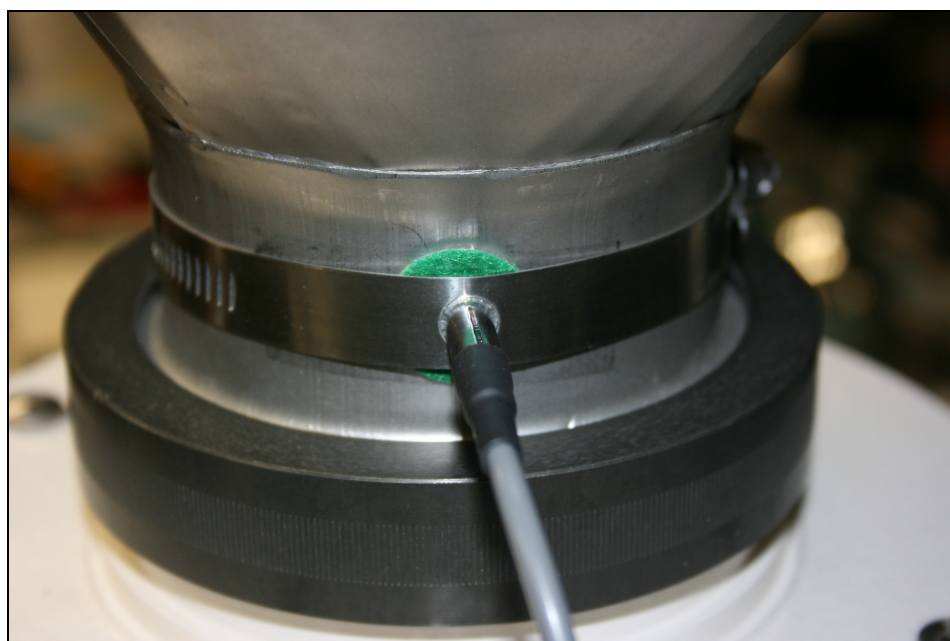
Step by Step: Setting the Date and Time

The following steps provide instructions for setting the date and time.

1. From the Main Status Screen, press "F3" key to enter the SETUP menu.
2. Scroll using the arrow keys and select the CONFIGURE menu item and press the "ENT" key.
3. Select "SET DATE" and press the "ENT" key. If adjusting date and time, the date should always be set first. If only setting the time, proceed to Step 5.
4. Using the numeric keypad enter the starting date for the timer and press the "ENT" key. The date should be entered with leading zero. For example, January 02, 2007 would be entered as 010207.
5. Select "SET TIME" and press the "ENT" key.
6. Using the numeric keypad enter the starting time for the timer and press the "ENT" key. The time should be entered with leading zeros and in 24-hour format. For

example, 1:00 PM would be entered as 1300 while 1:00 AM would be entered as 0100.

7. Press the "ESC" key to return to the previous menu. To return to the main status screen, continue pressing the "ESC" key.

Step by Step: Setting the Flow Conditions

The following steps provide instructions for setting the flow conditions which determine whether the system will control flow to maintain constant standard ("STD") or constant ambient ("AMB") conditions flow rate. This should be set in accordance with the standard operating procedures (SOP) being used. If unsure of which setting to use, select "STD" as this agrees with the older style a manual flow control unit. This should be confirmed with the SOP authors.

1. From the Main Status Screen, press "F3" key to enter the SETUP menu.
2. Scroll using the arrow keys and select the CONFIGURE menu item and press the "ENT" key.
3. Select "FLOW CONDITIONS" and press the "ENT" key.
4. Using the arrow keys select either "STD" or "AMB" to agree with the SOP and press the "ENT" key.
5. Press the "ESC" key to return to the previous menu. To return to the main status screen, continue pressing the "ESC" key.

Step by Step: Setting the Sample Flow Rate

The following steps provide instructions for setting the flow rate that the unit will operate at during sampling.

1. From the Main Status Screen, press "F3" key to enter the SETUP menu.
2. Scroll using the arrow keys and select the CONFIGURE menu item and press the "ENT" key.
3. Select "FLOW RATE" and press the "ENT" key.
4. Using the numeric keypad, enter flow rate in CFM and press the "ENT" key. This should be the flow rate specified by standard operating procedures (SOP) being used. Many SOPs use 40 CFM as the sampling flow rate. **It is important to make sure the flow rate is set to a value that can be achieved by the system with the filter media used for sampling. Failure to do this could result in premature wear of the components in the system. For example some sampling protocols may require special filter media that may have a higher pressure drop; this can limit the upper range of the flow rate that the system is capable of maintaining.**
5. Press the "ESC" key to return to the previous menu. To return to the main status screen, continue pressing the "ESC" key.

Step by Step: Calibrating the Flow

The following steps provide instructions for using the Auto Calibrate feature for flow calibration. The system comes calibrated from the factory, but the flow rate should always be calibrated anytime the system has been moved or the hotwire sensor is adjusted. For more details on calibrating the flow refer to the Calibration section of this manual.

1. The unit should be powered on for a minimum of 30 minutes and the motor operating before performing any flow calibration. During this time, the motor should be turned on using the MTR CONTROL and MTR SETPOINT menu items in the Diagnostics Menu. MTR CONTROL should be set to FIXED and MTR SETPOINT should be set to 50. This will run the motor at 50% power. Calibration should be performed immediately after this warm up period. This warm up period allows the temperature of the electronics to equalize at operating conditions and will minimize any error due to temperature seen by the flow probe. Further information on the MTR CONTROL and MTR SETPOINT menu items can be found in the Diagnostics section of this manual.
2. Flow calibration utilizes the Pcal, Pamb, and Tamb sensors in addition to the hot wire probe. Errors in these sensors can result in difficulties or inaccuracy during the flow calibration.
3. A filter must be installed in order to calibrate the system properly. **Failure to calibrate with a filter installed can result in erroneous calibration of the flow rate.**
4. **Do NOT utilize any flow restriction plate in conjunction with the orifice. These can create flow turbulence around the probe and cause the calibration to be inaccurate.** The system will vary the speed of the motor to adjust the flow rate seen by the calibrator. This provides conditions as close as possible as to those during actual use and therefore provides for a better calibration.
5. Connect the 4' piece of tubing from calibrator to Auto Cal port on bottom of HIGH VOL+ control unit left of yellow thermo coupler wire (first pressure tap)
6. From the Main Status Screen, press "F3" key to enter the SETUP menu.
7. Scroll using the arrow keys and select the CALIBRATE menu item and press the "ENT" key.
8. Select "Qstd" and press the "ENT" key. This will enter the Qstd calibration screen. Note: Qstd calibration is always done even if operating the unit at FLOW CONDITIONS is set to AMB for ambient conditions flow control.
9. From the Qstd calibration screen, press the "F1" key to add calibration data and begin the calibration process.
10. The system will prompt "ENTER CALIBRATOR STANDARD m". Enter the value from the orifice transfer calibration worksheet for Qstd slope (m) and press the "ENT" key.
11. The system will prompt "ENTER CALIBRATOR STANDARD b". Enter the value from the orifice transfer calibration worksheet for Qstd intercept (b) and press the "ENT" key.
12. The system will prompt "ENTER HI FLOW RATE". This is the highest flow rate the system will calibrate over. The system defaults this value to +10% of the

flow rate set point. It is recommended that the user accept the default value. Press the "ENT" key to accept this value and continue. If a different HI FLOW RATE is required per the SOP, enter that value and press the "ENT" key to continue.   Consult Calibration section of this manual for additional information.

13. The system will prompt "ENTER LO FLOW RATE". This is the lowest flow rate the system will calibrate over. The system defaults this value to +10% of the flow rate set point. It is recommended that the user accept the default value. Press the "ENT" key to accept this value and continue. If a different LO FLOW RATE is required per the SOP, enter that value and press the "ENT" key to continue.   The system uses the HI and LO values to calculate the 5 target flow rates used during the flow calibration process. Consult Calibration section of this manual for additional information.

14. The motor will now turn on and the system will control the motor speed to maintain the pressure across the calibration orifice at the desired starting point.

15. The system will monitor the data being collected and automatically collect a data point once it detects the flow at that operating point is stable.

16. Once the data is collected, the system will move to the next calibration flow rate. This will continue until 5 data points have been collected. This procedure typically takes about 5 minutes, but can take longer especially under windy conditions that can cause the pressure sensor to be noisy.

17. Once 5 data points have been collected, the system will calculate the calibration values that should be used and return to the Qstd calibration screen.

18. The "R" value shown on the screen should be observed. It should be greater than 0.990. If not, repeat the calibration process. The "R" value is a measure of how well the values calculated agree with the data collected.

19. Press the "F4" key to exit the calibration screen.

20. If the calibration was satisfactory, select YES to the SAVE CALIBRATION question and press the "ENT" key.

21. Press the "ESC" key to return to the previous menu. To return to the main status screen, continue pressing the "ESC" key.

22. Remove calibration orifice and prepare unit for sampling run by installing the sample media into the filter holder.

Step by Step: Flow Rate Verification (Auditing)

Since the High Vol+ does not utilize the motor back pressure flow transfer method for calibration, a different method is required. The following steps provide instructions for one method of flow rate verification.

1. The unit should be powered on for a minimum of 30 minutes and the motor operating before performing any flow calibration. During this time, the motor should be turned on using the MTR CONTROL and MTR SETPOINT menu items in the Diagnostics Menu. MTR CONTROL should be set to FIXED and MTR SETPOINT should be set to 50. This will run the motor at 50% power. Calibration should be performed immediately after this warm up period. This warm up period allows the temperature of the electronics to equalize at operating conditions and will minimize any error due to temperature seen by the flow probe.

Further information on the MTR CONTROL and MTR SETPOINT menu items can be found in the Diagnostics section of this manual.

2. Flow control utilizes the Pamb and Tamb sensors in addition to the hot wire probe. Errors in these sensors can result in inaccurate flow control.

3. A filter must be installed in order to properly verify the flow rate. **Failure to install a filter can result in erroneous flow rate readings.**

4. **Do NOT utilize any flow restriction plate in conjunction with the orifice. These can create flow turbulence around the probe and cause the flow to be measured inaccurately.**

5. Attach the calibration orifice (or other flow reference device) to the inlet of the system.

6. From the Main Status Screen, press "F3" key to enter the SETUP menu.

7. Scroll using the arrow keys and select the DIAGNOSTICS menu item and press the "ENT" key.

8. Select MTR CONTROL from the DIAGNOSTICS menu and press the "ENT" key.

9. Select Qsys from the list of available motor control methods. This will tell the system to control the motor in the same way as it is controlled during a timer controlled run. The system will also prompt for wait conditions the flow should be controlled under (Ambient or Standard). Select the conditions to match your SOP and/or the flow measurement device being used for verification.

10. Select MTR SETPOINT from the DIAGNOSTICS menu and press the "ENT" key. The system will prompt for the desired set point. The units of measurement and the valid ranges for this field will change based on the current setting on MTR CONTROL. For Qsys, the units are in CFM.   Enter the flow rate to be verified and press the "ENT" key. Keep in mind that by default the sampler is calibrated over the range of +/- 10% of the target flow rate for the system (i.e. for 40 CFM, the valid range is 36 to 44 CFM). Attempting to verify the flow rate outside of the calibration range will very likely results in discrepancies between the system and the calibrator.

11. After pressing the "ENT" key in the last step, the motor will turn on and begin to control the flow rate. Allow the system to run for approximately 10 minutes, before continuing.

12. Using the instructions provided with the flow reference device, measure or calculate the flow and compare this to the flow rate reported by the system.

13. When finished, the motor can be turned off by exiting the DIAGNOSTICS menu or by setting the MTR CONTROL menu item to OFF.

14. If significant error is seen between the system and the reference, the following are some of the possible sources:
    a. Verify that the flow rates are in the same units of measure and at the same measurement conditions (i.e. standard or ambient). Keep in mind that EPA standard conditions are 25 degrees C and 760 mmHg. Some calibration devices may report at 0 degrees C and 760 mmHg.
    b. Check the system for leaks.
    c. Check the filter for tears. Tears can create a localized increased flow rate and affect the flow rate seen by the probe.

  d. Verify the calibration of the flow reference.
  e. Re-test using the same calibration orifice as used for calibration. If the system verifies correctly, then it is likely that either the reference device or the calibration orifice requires re-calibration.
  f. Verify the other sensors used by the flow control (and calibration) of the system. These include Tamb, Pamb, and Pcal (only used during calibration). Keep in mind that if errors were present in the readings of these sensors at the time of calibration, the calibration was probably inaccurate.

Step by Step: Setting the Timer

The following instructions provide step by step instructions for settings the timer.

1. Starting from the Main Screen, press the F1 key for "TIMER".
2. Select "DATE" and press the "ENT" key.
3. Using the numeric keypad enter the starting date for the timer and press the "ENT" key. The date should be entered with leading zero. For example, January 02, 2007 would be entered as 010207.
4. Select "TIME" and press the "ENT" key.
5. Using the numeric keypad enter the starting time for the timer and press the "ENT" key. The time should be entered with leading zeros and in 24-hour format. For example, 1:00 PM would be entered as 1300 while 1:00 AM would be entered as 0100.
6. Select "DURATION" and press the "ENT" key.
7. Using the numeric keypad enter the duration timer should run and press the "ENT" key. The duration should be entered in HHMM format with leading zeros. For example:
  0024 = 24 minutes
  2400 = 24 hours
  0240 = 2 hours 4 minutes
8. Select "REPEAT" and press the "ENT" key. Select the desired repeat frequency and press the "ENT" key. Select "NONE" if this event is not to reoccur. The most common choices are included (1 IN 1 for everyday sample, 1 IN 3 for every 3rd day sample, 1 IN 6 for six day sample, and 1 IN 7 for seven day sampling). The CUSTOM option can be used to enter a non-standard duration in accordance with specific sampling protocols.
9. Select "SAVE and EXIT" and press the "ENT" key. This will save the setting and activate the timer. The main screen will appear and the "TIMER" should now show waiting. A second line labeled "STARTS IN" will appear showing a countdown to the timer starting a sample.

Step by Step: Viewing Data on the Display

The following instructions provide step by step instruction for viewing data for a timer event.

1. Starting from the Main Screen, press the "F2" key to access the "DATA" menu.
2. Select "VIEW PAST SAMPLE" and press the "ENT" key.
3. A list showing the timer start dates and times will be displayed. Select the desired date and time and press the "ENT" key.
4. The first page of the sample data for this timer event will be displayed. The arrow keys can be used to switch to the different pages. Press the "ESC" key to exit and return to the list of available dates and times. Continue press the "ESC" key to return to the Main Screen.

Step by Step: Saving Data to the USB Memory Drive

The following instructions provide step by step instruction for saving data to the USB memory card.

> ***Do not remove the memory stick while the unit is saving data.***
> ***This could cause corruption of the data and usb drive.***

1. Insert the USB memory stick into the USB port above the "POWER" status light.
2. Starting from the Main Screen, press the "F2" key to access the "DATA" menu.
3. Select the "SAVE" menu item and press the "ENT" key. This will save the data to the USB stick using the comma separated values file format (CSV) which can be viewed using Microsoft Excel or other spreadsheet programs. The format data files created by the unit are described in the DATA FORMATS section of this manual.
4. Press the "ESC" key to return to the Main Screen.

TIMER

The HIGH VOL+ controller contains a microprocessor based timer that allows for a variety of timing options including:

- Single Occurrence Timed Event
- Repeating Timed Event (ideal for 1 in X day sample operating protocols)
- Flexible Remotely Triggered Timed Event (requires optional remote trigger cable)

This section documents the possible configurations that can be used with the timer. To access the timer setup menu, press the "F1" soft-menu function key while the main status display screen is displayed. If the timer is not currently executing, the Timer Setup menu will be displayed. If the timer is currently executing, the option to the "Abort Timer" menu will be displayed.

Note: That timer event will not be started while the Timer Setup menu is displayed. For this reason it is important to always use the SAVE and EXIT menu item after the timer has been configured.

TIMER SETUP MENU: Basic Timer with Optional Repeat

The TIMER SETUP menu allows the user to configure the operation of the timer as desired to meet sampling protocols. The details of the timer setup parameters are described below.

```
        TIMER SETUP
   04-01-07 12:00:01
 ►DATE:        04-20-07
  TIME:          00:00
  DURATION:      24:00
  REPEAT:        00:00
  SAVE and EXIT
  STOP and EXIT
```

The figure above displays an example of the Timer Setup menu. For convenience, the current time and data are displayed on the second line. The details of each menu item are described below.

DATE Menu Item

The DATE menu item is used to specify the start date of the timer. The date must be entered in the MMDDYY format. Leading zeros are required (For example, to sample on January 1, 2007, enter 010107).

TIME Menu Item

The TIME menu item is used to specify the start time of the timer. The time must be entered in the HHMM format. Leading zeros are required (For example, to sample at 09:30 AM, enter 0930).

DURATION Menu Item

The DURATION menu item is used to specify the length of time the unit should sample. The duration must be entered in the HHMM format. Leading zeros are required (For example, to sample for 1 hour, enter 0100). This is the intended length of the sample. Power failures or other interruptions will not extend the sample time. For example, if the timer is set to turn on at 12:00 and run for 24 hours, but the power fails for 2 hours. The timer will stop at 12:00 the following day.

REPEAT Menu Item

The REPEAT menu item is used to specify the interval of time between sample start times. If set to zero (NONE), the repeat feature is disabled and the timer will only execute once. Several standard repeat intervals are selectable. For example, the "1 IN 3" selection will set the repeat interval for sampling every third day (a new sample would start every 72 hours). The CUSTOM selection allows for non-standard repeat intervals to be entered. When entering non-standard repeat intervals, the HHMM format must be used. Leading zeros are required (For example, to sample for 1 hour, enter 0100).

SAVE and EXIT Menu Item

The SAVE and EXIT menu item saves the current setup and returns to the Main Status Display.

STOP and EXIT Menu Item

The STOP and EXIT menu item configures the timer so that it will not operate until it is reprogrammed with valid parameters and returns to the Main Status Display.

TIMER SETUP MENU: Remote Triggering Option

The HIGH VOL+ timer also supports timer events triggered via a remote device. In order to use this feature, the unit must be configured to switch the timer into remote trigger mode and the optional remote trigger cable must be used.

Use the SETUP>CONFIGURE>TIMER MODE menu item to set the timer mode to REMOTE for remote triggering. For more details see the CONFIGURATION section of this manual.

The remote trigger cable is available in two different styles depending on how the remote device operates.

- o Style 1: Opto-Isolated Connection – This is the recommend method of connection, because it electrically isolates the remote device. This style connection requires a +5V switch signal with a current capacity of 30 mA. This style cable can also be used with contact closure type remote devices where remote power is available.

- o Style 2: Contact Closure Connection using Internal Power – This style is not recommended, because of the possible increased risk of the remote signals causing interference with the electronics. If this connection style is used, care should be taken to insure that the system is wired to not interfere with the with the HIGH VOL+ controller. It is also recommended to locate the contact closure as close as possible to the HIGH VOL+ Controller.

When in remote mode the timer has two different methods of operation.

- o Method 1: Duration Timed Mode – If the duration is set to a value other than 0, then the timer will execute a timer event that starts when the remote signal is received and last for the set duration.
- o Method 2: Remote Timed Mode – If the duration is set to a value of 0, then all timing is dependent on remote trigger signal. When the signal is active the unit will activate and operate as long as the signal is active.

```
        TIMER SETUP
   04-01-07 12:00:01
 ▶DURATION:       24:00
  SAVE and EXIT
  STOP and EXIT


```

In either mode, the unit records data just like timer mode events. Also, the remote timer mode is automatically repeating as is relies on the remote trigger on when to start.

Aborting Timer Operation

```
        ABORT TIMER?
  YES
 ▶NO
```
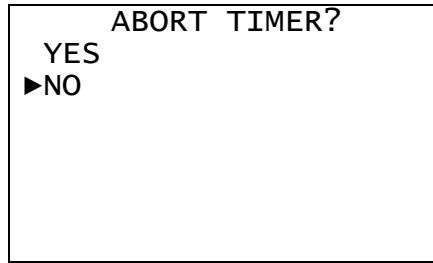
The ABORT TIMER menu (shown above) is displayed when the "F1" soft-menu function key is pressed from the main status display and the timer is currently executing. This allows the user to stop a currently executing timer event and re-configure the timer to the desired settings. Once a timer event is aborted, the timer will not execute until it has been re-programmed with a valid start time and duration. To stop a timer that has not started use the STOP and EXIT option in the TIMER SETUP menu.

DATA

The DATA menu allows the data collected by the unit to be viewed, saved to a USB memory stick, or erased.

```
              DATA
►VIEW CURRENT SAMPLE
 VIEW PAST SAMPLE
 SAVE
 ERASE
```
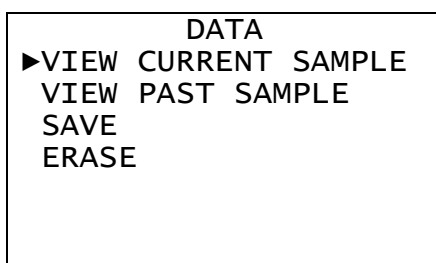
"VIEW CURRENT SAMPLE"
        The "VIEW CURRENT SAMPLE" menu item will display a summary of a currently executing timer sample. More details are provided in the Reviewing Sample Data section.

"VIEW PAST SAMPLE"
        The "VIEW PAST SAMPLE" menu item will display a list of start dates and times for past timer runs. Selecting a date and time will display the summary information collected during the execution of the timer for that start date and time. More details are provided in the Reviewing Sample Data section.

"SAVE"
        The "SAVE" menu item will save all data to a file on an inserted USB memory stick. This data may then be viewed on a PC. The file format is comma separated values with can easily be read by spreadsheet and database programs.

"ERASE"
        The "ERASE" menu item will allows for the individual logs to be erased. Because the unit automatically writes over the oldest collected data, there is normally no use of this feature. It is provided to allow the system's memory to be periodically erased to eliminate old data from being viewed or saved.

Reviewing Data

When using either the VIEW CURRENT SAMPLE or VIEW PAST SAMPLE menu items, a series of screens will be displayed that contain data collected during the timer event. Switch between screens us the UP and DOWN ARROW keys. Use the ESC key to return to the DATA menu.

```
        TIMER SETUP
   04-20-07 12:09:11
MODE: TIMER
STR:04-20-07 10:30:00
STP:04-20-07 11:30:00
DURATION:    01:00:00
REPEAT:      00:00:00
```

The first screen (shown above) displays the timer setup data. This includes the timer mode (either TIMER or REMOTE), the set start date, the set stop date, the set duration of the timed event, and the repeat interval.

```
        TIMER DATA
   04-20-07 12:09:11
MODE: TIMER
STR:04-20-07 10:30:00
STP:04-20-07 11:30:00
DURATION:    01:00:00
```

The second screen (shown above) displays the timer actual data. This includes the actual start date, the actual stop date and the actual duration. Please note that if a power failure occurs, then it is possible that the values will not match the data from the TIMER SETUP screen.

```
          FLAGS
COMPLETED:           Y
EXECUTING:           N
ABORTED:             N
EXPIRED:             N
FLOW RANGE:          N
POWERFAIL:           N
Qstd:                N
```

The third screen (shown above) displays flags associated with the timer event. The flags are described below.

FLAG	Description
COMPLETED	Indicates that the Timer Event has been completed
EXECUTING	Indicates that the Timer Event is currently executing
ABORTED	Indicates that the Timer Event was aborted by the user
EXPIRED	Indicates that the Timer Event expired before it could be started. This can happen if the unit is without power during the entire timer event.
FLOW RANGE	Indicates that the sampling flow rates exceeded +/- 10 percent of the set flow rate for a period exceeding 2 minutes. This indicates that the system was not able to control the flow at the desired set point and the sample event was stopped for this reason. Examine the system for disconnected tubing, clogged orifices, proper sensor operation, calibration errors, and filter media requirements to determine the source of the problem.
POWERFAIL	Indicates that a power failure occurred during the Timer Event.
Qstd	Indicated that the Timer Event is using Qstd for flow control.

```
Qamb:              0.0
 AVG:             40.0
 MIN:             39.9
 MAX:             40.1
 SET:             40.0
 CV:              0.10
 VOLUME:         15.58
```

The fourth screen (shown above) displays the Qamb (ambient conditions) data including the current flow rate, average flow rate, minimum flow rate, and maximum flow rate, set flow rate, coefficient of variation, and the total volume ambient conditions volume. The coefficient of variation is a measure of stability of the flow rate during the test. The SET and CV values are only shown if the unit is set to control the flow at ambient conditions.

```
Qstd:                0
 AVG:             40.0
 MIN:             39.9
 MAX:             40.1


 VOLUME:         15.58
```

The fifth screen (shown above) displays the Qstd (standard conditions) data including the current flow rate, average flow rate, minimum flow rate, and maximum flow rate, set flow rate, coefficient of variation, and the total volume ambient conditions volume. The coefficient of variation is a measure of stability of the flow rate during the test. The SET and CV values are only shown if the unit is set to control the flow at ambient conditions.

```
Tamb:           21.1
 AVG:           22.3
 MIN:           21.6
 MAX:           22.9
Tcjc:           26.6
 AVG:           27.0
 MIN:           26.5
 MAX:           27.7
```

The sixth screen (shown above) displays the current, average, minimum, and maximum values for the ambient temperature (Tamb) and the cold-junction compensation temperature (Tcjc).

```
Pamb:            759
 AVG:            759
 MIN:            759
 MAX:            760
Pdif:           -0.0
 AVG:           51.9
 MIN:           51.2
 MAX:           52.7
```

The seventh screen (shown above) displays the current, average, minimum, and maximum values for the ambient pressure (Pamb) and the differential pressure (Pdif).

```
Pcal:           0.06
 AVG:           6.22
 MIN:           5.95
 MAX:           6.32
```

The eighth screen (shown above) displays the current, average, minimum, and maximum values for the calibration pressure (Pcal).

Saving Data

If the control unit is equipped with the optional data drive, then the data logs may be saved to the UB memory stick for later review using a PC. The data logs are stored in the CSV (comma separated values) format. In addition to saving the timer sample event logs, the units also saves a configuration log, interval log, calibration log, and power log. Further details on the data format are presented in the DATA LOG FORMATS section of this manual.

Notes on the usage of the USB data drive:
- All USB memory sticks are not created equal and some vary greatly in how well they adhere to the specifications. A USB memory stick from 64mb to 2gb is recommended.
- While it possible to save data to a memory stick used for other purpose (i.e. like a digital camera or portable drive), this is not recommended.
- Each unit records a single data file that is named with the serial number of the unit. It is therefore possible to use a single memory stick to save data from multiple units.
- If a memory stick already contains saved data from the same unit, it will be overwritten.
- If you experience errors when saving the data, it is possible that the memory stick is not compatible or has become corrupted. Memory sticks can become corrupted if they are used for purposes other than saving data from the unit or if the data saving process is interrupted. In most cases, this can be resolved by formatting the memory stick on a PC.

Erasing Data

```
             ERASE
►EVENT>
 INTERVAL LOG>
 CAL LOG>
 POWER LOG>
```

The ERASE menu (shown above) provides ability to erase the different data logs that are collected by the system. The control unit automatically overwrites the oldest data in each of the logs, so this feature does not need to be used on a routine basis. It can be used in situation where the unit has changed locations and the user no longer wishes to review the data from the other site.

SETUP

The SETUP menu allows the various operating parameters of the unit to be configured and/or monitored. Some of these parameters include the ETIs, Sensor calibrations, and general diagnostics.

```
              SETUP
  ►ETI>
   CONFIGURE>
   CALIBRATE>
   DIAGNOSTICS>
```
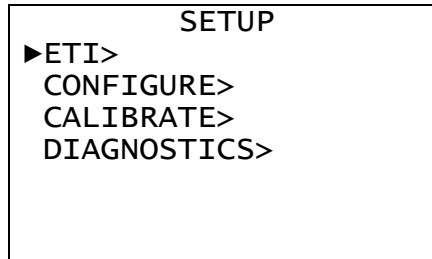
ETI Menu Item

The ETI menu item contains information and setting pertaining to the elapsed time indicator maintained by the system. For further details on the ETI's refer to the ETI section of this manual.

Configure Menu Item

The CONFIGURE menu item allows various operating parameters to be edited. This includes the setting the date and time, flow rate parameters, timer mode, and other items. For further details on the Configure menu refer to the CONFIGURATION section of this manual.

Calibrate Menu Item

The CALIBRATE menu item provide calibration function for the various sensors in the system. For more details on the CALIBRATE menu refer to the CALIBRATION section of this manual.

Diagnostics Menu Item

The DIAGNOSTICS menu item provides item that are helpful in troubleshooting and diagnosing the operation of the unit. Refer to the DIAGNOSTICS section of this manual for additional details.

ETI

The ETI menu item displays the ETI menu. The ETI menu allows the operating parameters of the units 3 ETI's to be configured.   There are two menu items for each ETI in the system. The first shows the current ETI value in hours. The second shows the point at which an alert will be triggered to notify the user of needed action. Both values are given in hours of motor operation.

```
         ETI SETUP
►MTR ETI:          200
 MTR ETI ALERT:   5000
 CAL ETI:          200
 CAL ETI ALERT:    400
 USR ETI:          200
 USR ETI ALERT:      0
```

The unit has 3 independent ETIs which can be used to track various maintenance procedures for the unit. Each ETI functions identically and is incremented any time the more is on.

ETI Designation	Use
MTR	This is the MOTOR ETI and is used to track motor lifetime and maintenance.
CAL	This is the CALIBRATION ETI and is used to track calibration schedules.
USR	This is the USER ETI and has no assigned purpose. It may be used to track other maintenance items that should be performed after some many hours of operation.

Clearing an ETI

To Clear an ETI, select the desired ETI and press the "CLEAR" key.

Setting an ETI Alert Point

To set the ETI Alert Point, select the desired ETI Alert and press enter. Then enter the ETI Alert point in hours of motor operation. To disable the ETI Alert, enter a value of 0. This will disable the ETI Alert, but the ETI will continue to increment with motor operation.

CONFIGURATION

The CONFIGURE menu (shown below) allows for various operating parameter of the unit to be configured. Details are provided below.

```
           CONFIGURE
►SET DATE:    04-20-07
 SET TIME:    12:11:18
 FLOW CONDITIONS: AMB
 FLOW RATE:        40
 LCD CONTRAST:     32
 LOG INTERVAL:      5
 TIMER MODE:    TIMER
```

Setting the Date and Time

The SET DATE and SET TIME menu items allow the battery backup real-time clock to be programmed. This clock provides the time base used for operation with the timer. The clock automatically adjusts for leap years, but does not automatically adjust for daylight savings time. If the date needs to be set, it should be set first. The date should be entered in the format MMDDYY with leading zeros. For example, January 3rd, 2007 would be entered as 010307. The time should be entered in the 24 hour format HHMM with leading zero. For example, 1:14 AM would be entered as 0114, while 1:14 PM would be entered as 13:14.

Setting the Flow Conditions

The FLOW CONDITIONS menu item selects whether the unit will operate in ambient (AMB) conditions or standard (STD) conditions flow. Standard conditions are defined to be 760 mmHg and 25°C

Setting the Flow Rate

The FLOW RATE menu item determines the operating flow rate for the system and is measured in CFM.

Setting the LCD Contrast

The LCD CONTRAST menu item controls the software contrast adjustment of the LCD. Press the ENT key with the LCD CONTRAST menu item selected to change the LCD contrast setting. Use the "+" and "-" keys to change the contrast level. The contrast level can be set between 0 and 63. Press the "ESC" key when the contrast is at the desired level. The default contrast level is 32. The LCD contrast adjustment can also be accessed by

pressing the "+" or "-" keys during the first 5 seconds the unit is turned on (while the startup screen is displayed).

Setting the Interval Log Period

The LOG INTERVAL menu item determines the time period in minutes over which the data is averaged before an entry is made in the interval data log. Setting the LOG INTERVAL to a value of 0 will disable the interval log. The default value is 5 minutes.

Setting the Timer Mode

The TIMER MODE menu item determines whether the timer operates as a normal timer or in remote trigger mode. The two choices for this menu item are "TIMER" and "REMOTE". When configured for "TIMER" operation, the unit will start sampling for a predetermined time for a set duration. When configured for "REMOTE" operation, the unit will sample when the appropriate signal is applied to the Remote input. For additional information refer to the TIMER section of this manual.

CALIBRATION

The CALIBRATE menu allow the user to calibrate the sensors used by the unit. The CALIBRATE menu (shown below) list the sensors in the system, the associated raw sensor values and the values using the current calibration. Pressing the ENT key will begin the calibration process for the selected sensor. The LOAD FACTORY CAL and LOAD DEFAULT CAL menu items will load the calibration values set at the factory or the default values from the firmware. These can be useful when tracking down calibration problems. The factory calibration values are preferred because they compensate for the normal manufacturing variations which the default firmware calibration values do not.

```
          CALIBRATE
 Qstd:(     0)      0.0
▶Tamb:(39000)     21.2
 Tcjc:(21789)     26.9
 Pamb:( 3713)      759
 Pdif:(  552)     -0.0
 Pcal:(  332)     0.01
 LOAD FACTORY CAL>
 LOAD DEFAULT CAL>
```

Important Notes on Calibration

- Sensors may be calibrated using from 1 to 5 calibration points. There are two exceptions to this. The first is the Tcjc (cold junction compensation temperature). It requires only a single point calibration. The second is the Qsys (system flow rate) which requires 5 points per EPA guidelines.
- Single point calibrations while possible, are not recommended (except for Tcjc). Single point calibrations only adjust the offset (A0) of the sensor and do not compensate for any changes in the gain (A1). If single point calibrations are used, the user should verify the gain by checking additional points against a reference.
- The ambient temperature (Tamb) is dependent on the cold junction compensation temperature (Tcjc). The cold junction compensation temperature is used to correct the voltage error introduced at the "cold junction" of the thermocouple circuit. This sensor does not normally require calibration once it leaves the factory, but if you wish to calibrate the Tcjc sensor you must locate the reference temperature probe near the thermocouple connection on the electronics.
- Flow calibration (Qsys) is dependent on other sensors in the system. It is therefore critical that they be properly calibrated or verified before calibrating the flow.
- If the unit has been powered off longer than 15 minutes, please allow 30 to 60 minutes for the electronics to warm up prior to calibrating any sensor. This is to

minimize errors that can occur while the electronics are warming up. The error is typically small, but doing this will provide optimal calibration results.

- It is very important to understand the calibration process and how it affects the operation of the unit. Improperly calibrating a unit can make the unit think it is working fine while in reality it is not. For example, if the ambient temperature was incorrectly calibrated during a flow calibration, then the flow calibration will have an error in it, even after the ambient temperature calibration is correct. This may mean that the system is controlling the flow at a value of say 40 CFM, but when measured by an independent reference is only running at 36 CFM. This does not mean the unit is broken, only that the calibration is incorrect. To resolve this situation, properly calibrate the unit.

Calibrating a Sensor

The procedure for calibrating a sensor is similar regardless of what sensor is being used. The exception to this is the flow calibration which is described in detail in the Flow Calibration section.

```
SENSOR:          Tamb
POINTS: 0    R:0.0000
CURRENT:            0
    ADC:            0

A1:           32.1179
A0:           -1.2976
 ADD | REDO | EDIT | EXIT
```

The main calibration display is shown above and is common to all sensors. The SENSOR line shows the name of the sensor being calibrated. The POINTS field shows the current number of calibration point being used to determine the A1 and A0 values. The R field is an indication of how closely the calculated calibration curve matches the raw data. The R field is only valid with 3 or more data points. The closer the R value is to 1, the better the agreement between the calculated and raw data. The CURRENT and ADC values show the calibration value using the current calibration values and the raw analog to digital converter values. The A1 and A0 fields show the current gain and offset values for the sensor.

Similar to the Main Status Display, the calibration display uses the soft-menu function keys F1, F2, F3, and F4 to navigate the calibration process. Each of the soft-menu function key is described below.

Adding a Calibration Point (F1)

Pressing the F1 key (ADD) will begin the process of adding a calibration point to the data used to calibrate the sensor. Adding a calibration point involves providing the unit with a reference signal on the sensor being calibrated and then telling the unit what the value of that signal is using a reference device. The following are screen shots from a adding a calibration point to the Tamb (ambient temperature) sensor.

After pressing the F1 key, the screen below is displayed. A default reference value is automatically selected. These are provided as guidelines so that the entire calibration range of the sensors is used for the calibration. If a different value is being applied to the sensor, simply enter the correct reference value. While maintaining a constant reference value to the sensor, press the ENT key to begin data collection.

```
         ENTER
   REFERENCE VALUE:

         20.0


```

Once the ENT key is pressed, the screen below will be displayed. This screen will automatically exit and return to the main calibration screen once the system has collected a stable reading from the applied signal. If the reference signal is not sufficiently stable, this screen may be displayed for a long period of time. In these situations, the user may press the "F1" key to force the unit to collect data even if it is not being detected as stable. This may not result in an optimal calibration, but may be required in cases where the reference in not stable.

```
      ACQUIRING DATA

  TARGET:         21.5
  Tamb:           21.6
  ADC:           39301
  STABLE:          YES
  POINTS SAMPLED:    5

```

Once back at the main calibration screen, the reference value should now match the calibrated sensor value more closely. This process can be repeated to add different calibration points across the range of operation of the sensor.

Redo a Calibration Point (F2)

Pressing the F2 key (REDO) will list the current calibration points used to calibrate the sensor. Selecting one of these points allows the calibration point to be performed again. This allows the user to recover to a bad calibration point without having to redo all of the calibration points. The procedure for redoing a calibration point is identical to adding a calibration point, once the desired calibration value is selected.

Edit Calibration Constants (F3)

Pressing the F3 key (EDIT) allows the A1 (gain) and A0 (offset) calibration constants for the sensor to be manually entered. This feature is useful in trouble shooting the unit or recovering from the incorrect calibrations. Past values for A1 and A0 for each sensor can be found in the calibration log.

Exit Calibration (F4)

Pressing the F4 key (EXIT) will exit the calibration process and prompt the user save the data the sensor was calibrated. If the user chooses not to save the calibration values, the original calibration values will be restored.

Manual Flow Calibration

Manual Flow Calibration is not supported on the HIGHVOL+ systems.

Automatic Flow Calibration

When calibrating the flow, it is important to make sure that your calibration orifice is being used within its calibration range. If a calibration orifice is used below or above the range it was calibrated over, then large errors in accuracy can occur.

Flow calibration has is slightly different from the other sensors, because it is more complex to perform. To assist with this process the system performs the calculations and regression that is typically performed by the user.

1. The first set is to verify that all other sensors are accurate and working properly. The Flow Calibration depends on these sensors for measurements required by the calculations made during the flow calibration.
2. Attach the standard calibration orifice to the unit inlet and attach the calibration port of the orifice to the Pcal pressure port on the control unit.
3. **Do NOT utilize any flow restriction plates in conjunction with the orifice. These can create flow turbulence and cause the calibration to be inaccurate.** The system will vary the speed of the motor to adjust the flow rate seen by the calibrator. This provides conditions as close as possible as to those during actual use and therefore provides for a better calibration.

4. The unit should be powered on for a minimum of 30 minutes and the motor operating before performing any flow calibration. During this time, the motor should be turned on using the MTR CONTROL and MTR SETPOINT menu items in the Diagnostics Menu. MTR CONTROL should be set to FIXED and MTR SETPOINT should be set to 50. This will run the motor at 50% power. Calibration should be performed immediately after this warm up period. This warm up period allows the temperature of the electronics to equalize at operating conditions and will minimize any error due to temperature seen by the flow probe.
5. Press the F1 (ADD) soft-menu function key from the Qsys main calibration screen.
6. The unit will then prompt the user to enter the standard conditions value for the m variable of the calibration orifice. This information can be found with the calibration data provided with the orifice. The system always calibrates using standard conditions. Enter the value and press the "ENT" key to continue. The value of the last calibration orifice is displayed by default. An example screen is shown below.

```
ENTER CALIBRATOR
STANDARD m:

          2.00628


```

7. The unit will then prompt the user to enter the standard conditions value for the b variable of the calibration orifice. This information can be found with the calibration data provided with the orifice. The system always calibrates using standard conditions. Enter the value and press the "ENT" key to continue. The value of the last calibration orifice is displayed by default. An example screen is shown below.

```
ENTER CALIBRATOR
STANDARD b:

          -0.06212


```

8. The unit will then prompt the user for the HI FLOW RATE to maintain across the calibration orifice. The system defaults the HI FLOW RATE to +10% of the flow rate the unit is set to operate at. It is recommend that the user accept the default value as it will keep the calibration centered around the operating point and perform the calibration over an optimal operating range. Enter the desired HI FLOW RATE and press the "ENT" key. An example screen is shown below.

```
ENTER HI
FLOW RATE:

            44.0



```

9. The unit will then prompt the user for the LO FLOW RATE to maintain across the calibration orifice. The system defaults the LO FLOW RATE to -10% of the flow rate the unit is set to operate at. It is recommend that the user accept the default value as it will keep the calibration centered around the operating point and perform the calibration over a optimal operating range. Enter the desired LO FLOW RATE and press the "ENT" key. An example screen is shown below.

```
ENTER LO
FLOW RATE:

            36.0



```

10. The system will now turn on the motor and display a screen indicating that the system is warming up. This is a two minute (120 seconds) interval that allows the sensor reading to stabilize before any data is taken.

```
       MOTOR WARMUP
          120




```

11. Once the calibration process has started, the screen below will be displayed. As the flow becomes stable at each point, the unit will collect a data point once per second until the STABILTY counter reaches 8. If the system becomes unstable during this process, the STABILITY counter will reset and the process will begin again until all 8 data points can be gather will the system is stable. These data points are then averaged and used as one of the data point for this flow rate. If the system has difficulty becoming stable, the "F1" key can be pressed to force the system to take data and move on to the next point. This may result in a less than optimal calibration, but may be required in some situation (like calibration the system in high winds). Pressing the "ESC" key will abort the process and return to the main calibration screen.

```
ACQUIRING DATA
POINT:          1 of 5
Qcal(set):         44.0
Qcal(std):         43.9
Qsys(std):         44.0
Pdif(act):            0
Pcal(act):         5.87
STABLITY:             7
```

12. The system will repeat the process step 10 for a total of 5 times at 5 equally spaced flow rates and then perform the calculations to determine the calibration values.
13. Once the calculations are completed, the system will return to the main calibration screen and display the results. An example screen is shown below. The R value should be examined to determine how well the calibration. It should be greater than 0.990. If it is not, try calibrating again. Press the F4 (EXIT) soft-menu function key to exit the calibration process.

```
SENSOR:          Qsys
POINTS: 5    R:0.9950
CURRENT:            0
    ADC:            0

A1:           32.1179
A0:           -1.2976
 ADD  | REDO | EDIT | EXIT
```

DIAGNOSTICS

The DIAGNOSTICS menu (shown below) provides information and troubleshooting functions to help diagnose any problems that may occur. Details on the various menu items are provided below.

```
        DIAGNOSTICS
►Vpwr:(  649)     16.0
 Tcjc:(21789)     26.9
 Tamb:(39050)     21.5
 Pamb:( 3713)      759
 Pdif:(  552)     -0.0
 Pcal:(  332)     0.01
 Qcal:(    0)        0
 Qstd:(    0)        0
 MTR CONTROL:      OFF
 MTR SETPOINT        0
 REMOTE SIGNAL:    OFF
 AUX0:               0
 AUX1:               0
 AC FREQ:         60.0
 DATA DRIVE INFO
```

Vpwr

The Vpwr menu item displays the internal DC voltage being seen by the system. The number in parentheses is the raw analog to digital converter value (range of 0 - 1024), while the number to the right represents the calibrated value. The calibration is approximate and cannot be adjusted by the user. Typical calibrated value is between 14 and 18 volts.

Tcjc

The Tcjc menu item displays the cold junction compensation temperature associated with the thermocouple measuring Tamb. The value in parentheses is the raw analog to digital converter (ADC) value (range of 0 - 65535), while the number to the right represents the calibrated value. An ADC value of 0 or 65535 indicates that the sensor is saturated. If this is observed, check all system connections. If the problem persist, contact technical support for further instruction.

Tamb

The Tamb menu item displays the temperature being measured by the ambient thermocouple. The value in parentheses is the raw analog to digital converter (ADC) value (range of 0 - 65535), while the number to the right represents the calibrated value. An ADC value of 0 or

65535 indicates that the sensor is saturated. If this is observed, check all system connections and examine the thermocouple for signs of damage. If the problem persist, contact technical support for further instruction.

Pamb

The Pamb menu item displays the ambient pressure (uncorrected barometric pressure) being measured by the system. The value in parentheses is the raw analog to digital converter (ADC) value (range of 0 - 4095), while the number to the right represents the calibrated value. An ADC value of 0 or 4095 indicates that the sensor is saturated. If this is observed, check all system connections. If the problem persist, contact technical support for further instruction.

Pdif

The Pdif menu item displays the differential pressure (across the Venturi orifice) being measured by the system. **This sensor is not used in the flow control calculation on the HIVOL +.** The value in parentheses is the raw analog to digital converter (ADC) value (range of 0 - 4095), while the number to the right represents the calibrated value. An ADC value of 0 or 4095 indicates that the sensor is saturated. If this is observed, check all system connections looking for kinks or cuts in the tubing. If the problem persist, contact technical support for further instruction.

Pcal

The Pcal menu item displays the pressure being measured by on the Pcal port of the system (typically used with a calibration orifice to calibrate the flow). The value in parentheses is the raw analog to digital converter (ADC) value (range of 0 - 4095), while the number to the right represents the calibrated value. An ADC value of 0 or 4095 indicates that the sensor is saturated. If this is observed, check all system connections looking for kinks or cuts in the tubing. If the problem persist, contact technical support for further instruction.

Qcal

The Qcal menu item displays the flow rate being calculated from the pressure at the Pcal port. The values displayed will be 0 unless the MTR CONTROL is set to Qcal and the associated orifice calibration values have been entered. A calibration orifice must be installed for these values to be meaningful.

Qstd (or Qamb)

The Qstd (or Qamb) menu item displays the flow rate being measured by the system. The menu item label changes between Qstd and Qamb to indicate the current flow conditions as determined by the MTR CONTROL setting.

MTR CONTROL and MTR SETPOINT

The MTR CONTROL menu item determines how the motor speed will be controlled by the system. This can be useful in trouble shooting motor / flow problems or for checking the flow rate accuracy. The following options are available:

```
MOTOR CONTROL
►OFF
 FIXED
 Qsys
 Qcal
 Pdif
 Pcal
```

OFF turn the motor off.

FIXED turns the motor on at a fixed percentage of power (between 25 and 100 percent).

Qsys controls the motor using the calibration established on the system. This can be used to audit the flow for accuracy. The user may select STD or AMB as operating conditions for flow control.

Qcal controls the motor using the flow calculated from a calibration orifice attached to the Pcal port of the system. This is an alternate method for performing flow audits. The user will be prompted to enter the calibration constants associated with the orifice attached to the system.

Pdif controls the motor by maintaining the pressure of the Pdif ports at a constant value. The Pdif ports must be connected to a Venturi orifice to used.

Pcal controls the motor by maintaining the pressure of the Pcal port at a constant value. The Pcal port must be connected to a calibration orifice to be used.

The MTR SETPOINT menu item allows the user to enter the set point associated with the MTR CONROL setting.

Diagnosing the Remote Trigger Signal

The REMOTE SIGNAL menu item displays the status of the remote trigger input. This is useful when first connecting the remote device to the unit to verify that the unit is indeed seeing the remote signal.

AUX0 and AUX1

The AUX0 and AUX1 menu items manually control the two auxiliary ports of the system. A value of 0 will turn the port off and a value of 1 will turn the port on.

Diagnosing the AC Line Frequency

The AC FREQ menu item displays the AC Line frequency measured by the unit. The unit uses this measurement in the control loop for brush type motors. If this frequency does not closely match the specification of the motor being used, then the motor will not operate correctly. In addition, this value should be fairly stable varying no more than 1 Hz. If larger variations are observed, then the power being supplied to the unit may not be stable and could result in flow instability.

Data Drive Info

The Data Drive Info screen displays information associated with the data drive on the system. The boot loader (BL) and firmware (FW) version numbers are displayed. In addition, the real time values of card detect (CD) and write protect (WP) detection switches are displayed and can be used to verify proper detection of the memory card.

```
    DATA DRIVE INFO
BL VER:          2.03
FW VER:          2.15

CD:      NOT DETECTED
WP:               OFF

```

INFO DISPLAY

The INFO screens are accessed by pressing the F4 soft-menu function key while the main status screen is displayed. In addition to basic information about the system, these screens also contain the ALERT status screens. If an ALERT condition exists then system will automatically display that screen first. Use the UP and DOWN Arrow keys to switch between screens. Press the ESC key to exit the INFO screens display.

```
┌──────────────────────────┐
│                          │
│       TISCH              │
│    ENVIRONMENTAL         │
│    01-01-07 12:34:56     │
│                          │
│                          │
└──────────────────────────┘
```

The screen above shows the manufacturer's name and the current date and time.

```
┌──────────────────────────┐
│    TISCH ENVIRONMETAL     │
│         HIVOL+            │
│      COPYRIGHT 2006       │
│     01-01-07 12:34:56     │
│                           │
│  SN:00000000              │
│   FW:04.05.0000           │
│   BL:01.02.0000           │
└──────────────────────────┘
```

This screen shows the copyright notice, current date and time, unit serial number, firmware version number, and boot loader version number.

```
┌──────────────────────────┐
│          UNITS            │
│                           │
│  Tamb, Tcjc:          C   │
│  Pamb:             mmHg   │
│  Pdif, Pcal:       inH2O  │
│  Qsys, Qcal:        CFM   │
│                           │
│                           │
└──────────────────────────┘
```

The UNITS screen shows the units of measurement associated for the values measured by the system.

```
            ALERTS 1
TIMER ERROR:          N
ETI – MOTOR:          N
ETI – CALIBRATE:      N
ETI – USER:           N
```

The ALERTS 1 screen shows the status of the alerts. ALERTS are automatically cleared when the underlying cause is resolved. For example, if the ETI – MOTOR flag is set, then service the motor and resetting the ETI using the ETI menu will clear the flag.

```
            ALERTS 2
NO ALERTS 2
```

The ALERTS 2 screen is reserved for future use and currently contains no alerts.

DATA FORMATS

The HIGH VOL+ creates to files containing data each time the SAVE function is used. Data on the memory stic is stored in the CSV (comma separated values) format readable by most spreadsheet programs. The files names are REPORT.CSV and DATA.CSV. They are stored in the following directory on the memory stick: \TISCH\DATA\SN\ (where SN is the serial number of the unit).   The REPORT.CSV file contains summary data for each sample collected in an easily readable format. The DATA.CSV file contains all data collected by the unit. The individual logs described below are appended one after the other in the DATA.CSV file. The formats of the different logs are described below.

REPORT.CSV: Format

An Example of the report format is shown below. Description of the format is provided after the example.

```
HIVOL+ SN:00000000 REPORT
RETRIEVED ON 01-08-08 AT 15:38:22

--------
Start Time (Set),12-29-07 12:35:00
Start Time (Act),12-29-07 12:35:00
Duration,01:00:00
Conditions,Standard
Flow (Set),250
Flow (Avg),250
Flow CV,0.15
Sample Volume,14.98
Avg Amb Temperature,25.5
Avg Amb Pressure,757
Flags
--------
Start Time (Set),12-29-07 14:00:00
Start Time (Act),12-29-07 14:00:00
Duration,01:23:59
Conditions,Standard
Flow (Set),250
Flow (Avg),250
Flow CV,0.22
Sample Volume,20.97
Avg Amb Temperature,26.2
Avg Amb Pressure,757
Flags,ABORTED
```

The first line of the report identifies that this unit as a HIGH VOL+ with the given serial number and that this is the REPORT format.

The second line indicates when the REPORT.CSV file was retrieved from the unit.

The "--------" line indicates the beginning of a sample record.

The "Start Time (Set)" and "Start Time (Act)" lines indicate when the unit was set to start and when it actually started, respectively. These times could be different if there was a power failure at the beginning of the test and the unit started late.

The "Duration" line indicates the actual sampling duration in Hours : Minutes : Seconds.

The "Conditions" line indicates whether the test and data provided are being reported at Ambient or Standard Conditions.

The "Flow (Set)" and "Flow (Avg)" lines indicate the flow rate set point and average values respectively. The values are reported in L/min with conditions as indicated by the "Conditions" line.

The "Flow CV" line provides the value for the coefficient of variation of the flow rate during the test. This is a measure of stability of the flow during the test. The closer the number is to zero the more stable the flow. This value should usually be less than 2%. If it is greater, it could indicate a pending failure of the motor, odd sites conditions (i.e. extremely gusty wind conditions), or someone tampering with the unit during sampling.

The "Sample Volume" is the total volume (reported at the value stated in the "Conditions" line) that passed through the sample media during the test. The value is reported in m^3. This value may be slightly larger than the value calculated by multiplying the duration by the average flow rate. This is because the volume is recorded from the very beginning of the test, while the average flow calculation starts after 1 minute to keep startup variation in the flow from affecting the average value. The difference is very very small and may not be noticeable on longer test.

The "Avg Amb Temperature" line reports the average ambient temperature during the sampling event. The value is reported in degrees C.

The "Avg Amb Pressure" line reports the average ambient pressure (aka true barometric pressure) and is reported in mmHg.

The "Flags" line reports any items that may be of importance in determining the validity of the data. The individual flags are separated by commas. The possible flags are POWER (which indicates a power failure or brown out occurred during the sampling), ABORTED (which indicates the sampling was aborted by user interaction with the timer), FLOW (which indicates the flow rate exceed the set flow rate by +/- 10 percent for a period greater that 2 minutes) and EXPIRED (which indicates the sampling never occurred, likely because the unit was without power for the entire test).

DATA.CSV: General Comments on the Data Record Entries

All log entries share some common entries that are best described separately. The log formats were designed so that they could be easily read in either an automated fashion or interrupted manually. In order to accomplish this, several fields that pertain to the format of each line were added at the beginning of each line.

All log entries share 3 fields in common that appear at the beginning of each line. The first field is a new record indicator that signifies that start of a new data record. This is signified by a "!". The second field is a log type identifier. This is a numeric value that indicates what type of log this record belongs to. The third field is a record type identifier. This is a numeric field that is used to indicate the format of the remaining record entry.

Each data record is terminated by a <CR><LF> (carriage return and linefeed).

DATA.CSV: Begin and End Records

Each log begins with a "Begin" record (record type 1) and end with an "End" record (record type 4). In addition, to marking the start and conclusion of each log, these records indicate the name of the log that was saved, the date and time the record was saved, the model of the unit, and the serial number of the unit.

DATA.CSV: Header Records

The second record entry of each log is a header entry (record type 2). This record entry identifies the field names for the main record entries (record type 3).

DATA.CSV: Main Records

The main data records (record type 3) for each log type follow the header record. Refer to the header record of each log type to identify what a given value represents.

DATA.CSV: System Log Example

The System Log contains information on how the system was configured at the time the log was saved. An example log is shown below.

```
!,0,1,"Begin","System Log",04-20-07 12:34:43,"HIVOL+","100-0004"
!,0,2,"Item","Value"
!,0,3,"BL VER",01.03.0000
!,0,3,"FW VER",03.03.0000
!,0,3,"MOTOR","BRUSH – 60Hz"
```

!,0,3,"LOG INTERVAL",1
!,0,3,"LCD CONTRAST",32
!,0,3,"MOTOR TYPE","BRUSHLESS"
!,0,3,"MTR ETI",1
!,0,3,"MTR ETI ALERT",0
!,0,3,"CAL ETI",1
!,0,3,"CAL ETI ALERT",0
!,0,3,"USR ETI",1
!,0,3,"USR ETI ALEART",0
!,0,4,"End","System Log",04-20-07 12:34:43,"HIVOL+","100-0004"

DATA.CSV: Event Log Example

The Event Log contains the data for each timer event. This is the same data that can be viewed using the VIEW CURRENT SAMPLE and VIEW PAST SAMPLE menu items in the DATA menu. The log entries here are shown wrapped due to space limitations. In the actual data file each record is a single line.

!,1,1,"Begin","Event Log",04-20-07 12:34:43,"HIVOL+","100-0004"
!,1,2,"Set Start","Set Stop","Set Duration","Act Start","Act Stop","Act Duration","Tamb Avg","Tamb Min","Tamb Max","Tcjc Avg","Tcjc Min","Tcjc Max","Pamb Avg","Pamb Min","Pamb Max","Pdif Avg","Pdif Min","Pdif Max","Pcal Avg","Pcal Min","Pcal Max","Qamb Avg","Qamb Min","Qamb Max","Qamb Vol","Qstd Avg","Qstd Min","Qstd Max","Qstd Vol","Q Set","Q CV","Flag: Power", "Flag: Flow Range", "Flag: Completed","Flag: Executing","Flag: Aborted","Flag: Expired","Flag: Qstd"
!,1,3,04-20-07 10:30:00,04-20-07 11:30:00,01:00:00,04-20-07 10:30:00,04-20-07 11:30:00,01:00:00,22.3,21.6,22.9,27.0,26.5,27.7,759,759,760,51.9,51.2,52.7,6.22,5.95,6.32,260,259,261,15.58,259,258,260,15.53,260,0.10,0,1,0,0,0,0,0
!,1,3,04-20-07 11:35:00,04-20-07 11:40:00,00:05:00,04-20-07 11:35:00,04-20-07 11:40:00,00:05:00,22.6,22.3,22.7,27.9,27.9,28.0,760,759,760,52.0,51.3,52.7,6.22,6.06,6.30,260,259,261,1.28,259,258,260,1.28,260,0.09,0,1,0,0,0,0,0
!,1,4,"End","Event Log",04-20-07 12:34:43,"HIVOL+","100-0004"

DATA.CSV: Interval Log Example

The Interval Log contains the period averages of the sensors as defined by the LOG INTERVAL parameter in the CONFIGURE menu. The interval log records data constantly (whether the timer is executing or not) and therefore serves as a type of site log for ambient temperature and pressure. They interval log maintains the last 4,608 entries. This equates to 16 days of data with the default 5 minute log interval.

!,2,1,"Begin","Interval Log",04-20-07 12:34:44,"HIVOL+","100-0004"
!,2,2,"Time","Tamb","Tcjc","Pamb","Pdif","Pcal","Qamb","Qstd","DAC"
!,2,3,04-20-07 10:27:00,21.6,26.5,759,-0.0,-0.01, 0, 0,0
!,2,3,04-20-07 10:28:00,21.5,26.5,759,-0.0,-0.01, 0, 0,0
!,2,3,04-20-07 10:29:00,21.4,26.6,760,-0.0,-0.01, 0, 0,0

```
!,2,3,04-20-07 10:30:00,21.4,26.6,760,-0.0,-0.01,  0,  0,0
!,2,3,04-20-07 10:31:00,21.5,26.6,760,48.8,5.87,245,244,0
!,2,3,04-20-07 10:32:00,21.6,26.6,760,51.8,6.22,260,259,0
!,2,3,04-20-07 10:33:00,21.6,26.6,760,51.8,6.24,260,259,0
!,2,3,04-20-07 10:34:00,21.7,26.6,760,51.8,6.22,260,259,0
!,2,3,04-20-07 10:35:00,21.7,26.6,760,51.8,6.23,260,259,0
!,2,4,"End","Interval Log",04-20-07 12:34:47,"HIVOL+","100-0004"
```

DATA.CSV: *Power Log Example*

The Power Log contains information on when the unit started and stopped. This is useful in identifying when power failures occurred and how long they lasted. The last 64 power failures are recorded. This can be important in determining whether a sample can be considered valid if a power failure occurred during the sampling period. The "Source" field is intended to help technical support track down any power related problems with the unit and does not contain any data relating to the actual sampling taken place.

```
!,3,1,"Begin","Power Log",04-20-07 12:34:47,"HIVOL+","100-0004"
!,3,2,"Off","On","Source"
!,3,3,04-20-07 10:19:35,04-20-07 10:19:38,130
!,3,3,04-20-07 11:48:50,04-20-07 12:02:50,16
!,3,4,"End","Power Log",04-20-07 12:34:47,"HIVOL+","100-0004"
```

DATA.CSV: *Calibration Log Example*

The "Calibration Log contains a list of the times, sensors, number of calibration points used in the calibration, the calibration gain (A1) and the calibration offset (A0) of each sensor. The last 64 calibrations are recorded. This information can be used to track how the calibration of the unit changes over time, help identify potential problem before they occur, and identify which users may need additional training in calibration a particular sensor.

```
!,4,1,"Begin","Calibration Log",04-20-07 12:34:47,"HIVOL+","100-0004"
!,4,2,"Time","Sensor","Pts","A1","A0"
!,4,3,03-02-07 20:39:29,"Tcjc",1,13.771930,0.000000
!,4,3,03-02-07 20:41:47,"Tamb",2,0.299843,-11935.423828
!,4,3,03-02-07 20:46:11,"Pamb",4,30.914890,-13626.343750
!,4,3,03-02-07 20:48:59,"Pdif",4,3.201837,-1770.477539
!,4,3,03-02-07 20:52:18,"Pcal",4,0.854666,-284.707397
!,4,3,03-02-07 20:55:23,"Pcal",5,0.857291,-287.563842
!,4,3,04-20-07 09:19:46,"Pcal",1,0.857291,-281.191467
!,4,3,04-20-07 11:48:15,"Qstd",5,32.117942,-1.297638
!,4,4,"End","Calibration Log",04-20-07 12:34:48,"HIVOL+","100-0004"
```