OPERATIONS MANUAL

TE-CD-TSP Total Suspended Particulate

Continuous Duty Motor

Volumetric Flow Controller

High Volume Air Sampler

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Model No: *TE-CD-TSP*

Welcome

We are the experts in high volume air sampling, lead sampling, lead samplers, particulate monitoring, particulate emissions, pesticide monitoring, pesticide sampling, total suspended particles, particulate sampler, Federal Reference Method PM-10, Federal Reference Method PM2.5, EPA Method TO-4A, EPA Method TO-9A, EPA Method TO-13A. TEI is a family business located in the Village of Cleves, Ohio. TEI employs skilled personnel who average over 20 years of experience each in the design, manufacture, and support of air pollution monitoring equipment. Our modern well-equipped factory, quality philosophy and experience have made TEI the supplier of choice for air pollution monitoring equipment. Now working on the fourth generation, TEI has state-of-the-art manufacturing capability and is looking into the future needs of today's environmental professionals.

Assistance

If you encounter problems or require detailed explanations, do not hesitate to contact Tisch Environmental offices by e-mail or phone.

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Introduction

EPA Standards

The following manual will instruct you in the unpacking, assemblage, operation, calibration, and usage of the corresponding Tisch Environmental product. For information on air sampling principles, procedures and requirements and to ensure compliance with government regulations please contact the local Environmental Protection Agency Office serving your area or visit www.epa.gov.

Safety Precautions

Before using Tisch Environmental products, always be sure to review the corresponding operations manuals and take all necessary safety precautions. Tisch Environmental products are to be used only for the purposes specified by operations manuals and by Tisch Environmental personnel. Tisch Environmental cannot guarantee the safe usage of its instruments in procedures that do not adhere to Tisch Environmental guidelines and standards. If you have concerns about the safety of your product or questions about safe practices, contact Tisch Environmental by phone or e-mail to speak with a representative.

Important Safety Instructions

Read and understand all instructions. Do not dispose of these instructions. Failure to follow all instruction listed in this manual may result in electric shock, fire, and/or personal injury. When using an electrical device, basic precautions must always be followed, including the precautions listed in the safety section of this manual. Never operate this unit in the presence of flammable materials or vapors are present as electrical devices may produce arcs or sparks that can cause fire or explosions. Always disconnect power supply before attempting to service or remove any components. Never immerse electrical parts in water or any other liquid. Always avoid body contact with grounded surfaces when plugging or unplugging this device is wet or dangerous conditions.

DO NOT MOVE INSTRUMENT WITH MOTOR ATTACHED

Electrical Installation

Installation must be carried out by specialized personal only, and must adhere to all local safety rules. This unit can be used for different power supply versions; before connecting this unit to the power line, always check if the voltage shown on the serial number tag corresponds to the one on your power supply. This product does use grounded plugs and wires. Grounding provides the path of least resistance for electrical currents, thereby reducing the risk of electric shock to users. This system is equipped with electrical cords with internal ground wires and a grounding plug. The plug must be plugged into a matching outlet that is properly installed and grounded in accordance with all local codes and ordinances. Do not modify the plug provided. If plug will not fit outlet, have the proper corresponding outlet installed by a professional, qualified electrician.

Do Not Abuse Cords

In the event that any electrical component of this system needs to be transported, **DO NOT** carry the unit by its power cord or unplug the unit by yanking the cord from the outlet. **Pull the plugs, not the cords**, to reduce risk of damage to unit. Keep all cords away from heat, oil, sharp objects, and moving parts.

Extension Cords

It is always advisable to use the shortest extension cord possible. Grounded units require a three-wire extension cord. As the distance from the supply outlet increases, you must use a heavier gauge extension cord. Using extension cords with inadequately sized wires results in serious changes in voltage, resulting in a loss of power and possible damage to equipment. It is recommended to only use 10-gauge extension cords for this product. Never use cords that exceed one hundred feet. Outdoor extension cords must be marked with the suffix "W-A" (or "W" in Canada) to indicate that it is suitable for outdoor usage. Always ensure that extension cords are properly wired and in good electrical condition. Always replace damaged extension cords immediately, or seek repair from qualified electricians before further use. Remember to protect extension cords from sharp objects, excessive heat, and damp or wet conditions.

Product Description

Introduction

The High Volume Air Sampler (also known as a **lead sampler**) is the recommended instrument for sampling large volumes of air for the collection of TSP (Total Suspended Particulate). The physical design of the sampler is based on aerodynamic principles that result in the collection of particles of 100 microns (Stokes Equivalent Diameter) and less. The TE-CD-TSP sampler consists of a TE-5001-CD Anodized Aluminum Shelter, TE-5001-10 Gabled Roof Assembly, TE-5070-CD Regenerative Blower Motor Assembly, TE-5003V 8"x10" Stainless Steel Filter Holder, TE-10557TSP-BL Volumetric Flow Controller, TE-5030 30" Water Manometer, TE-10618 Male Stagnation Fitting, TE-10617 bulkhead fitting, TE-VFC+ Flow recorder(USB Data Log, Elapsed Time Indicator, Digital Timer, Flow recorder, instantaneous Flow Calculations.

Applications

- Ambient air monitoring to determine suspended particulate levels relative to air quality standards.

- Impact of a specific source on ambient levels of suspended particulates by incorporating a "wind-direction-activation" modification which permits the sampler to operate only when conditions are such that a source-receptor relationship exists.

- Monitoring of enclosed environments for relatively high levels of particulate matter, particularly toxic materials.

- Monitoring of emissions from large diameter vents where physical conditions preclude the use of conventional stack-testing equipment.

Calibration Requirements

TE-CD- TSP VFC High Volume Air Sampler should be calibrated:
- Upon installation
- After any motor maintenance
- Once every quarter (three months)

Calibration Kits

The TE-5028 is the preferred method to calibrate the TE-CD-TSP TSP High Volume Air Sampler. It simulates change in the resistance by merely rotating the knob on the top of the calibrator. The infinite resolution lets the technician select the desired flow resistance. The TE-5028 calibration kit includes: carrying case, 30" slack tube water manometer, adapter plate, 3' piece of tubing, and TE-5028A orifice with flow calibration certificate. Optional electronic manometer is available.

Each TE-5028A is individually calibrated on a primary standard positive displacement device (Rootsmeter) which is directly traceable to NIST.

** It is recommended by the EPA that each calibrator should be re-calibrated annually. (1998 Code of Federal Regulations Parts 50 to 51, Appendix B to Part 50, Reference Method for the Determination of Suspended Particulate Matter in the Atmosphere, 9.2.17 page 30.)

Parts

TSP VFC Brushless Sampler System
TE-CD-TSP 110volt, 60hz

Regenerative Blower Motor
TE-5070-CD

Hose

Volumetric Flow Controller(attached to motor)
TE-10557TSP

Filter Holder
TE-5003V

30" Manometer
TE-5030

Male Stagnation Fitting with tubing
TE-10618
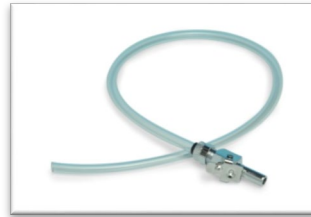
Bulkhead Fitting (attached to
aluminum shelter)
TE-10617

Gabled Roof
TE-5001-10

VFC Mounting Plate
TE-5070-FPZ-12

Motor Mounting Bracket
TE-5001-CD-3

Motor Surround
TE-5001-CD-1, Body
TE-5001-CD-2, Top
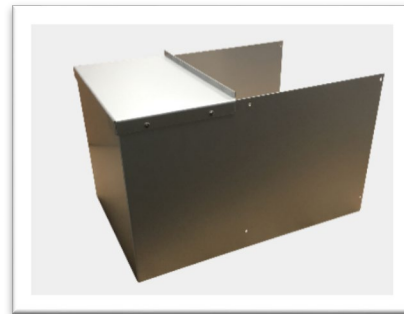
Assembly

1.) Attach The motor mounting bracket (TE-5001-CD-3) to the back of the instrument shelter using (2) ¼-20x 1" bolts and (2) ¼-20 nylock nuts.

2.) Mount the motor (TE-5070-CD) to the motor mounting bracket using (4) ¼-20x 1" bolts and (4) ¼-20 nylock nuts
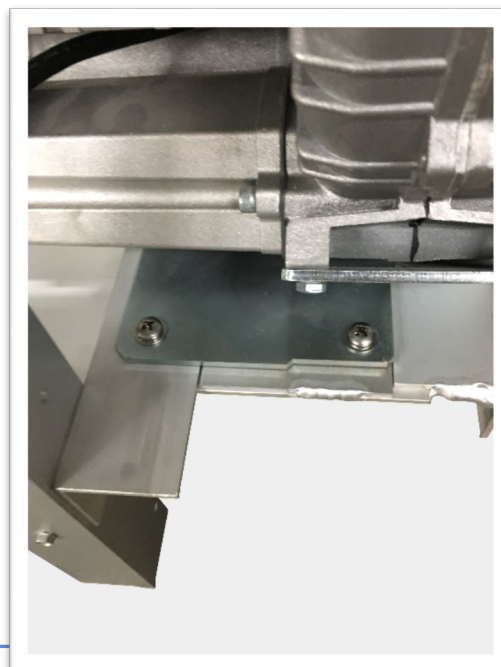
3.) Slide the motor surround around the motor ensure that the angle on the top slides underneath the lip on the shelter back. Secure the motor surround to the instrument sheltering using the (8) 10-24 Hex head screws with washers.

4.) Attach the white hose to the PVC pipe on the motor and tighten the hose clamp securely.
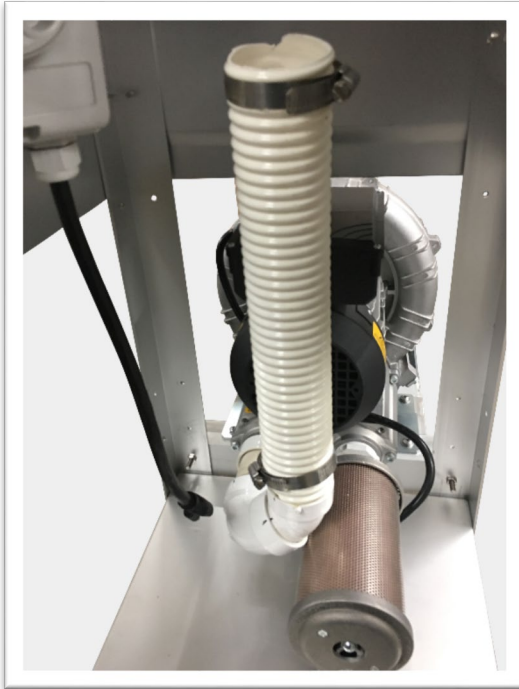
5.) Attach the filter holder to the VFC device and VFC mounting plate, ensure the filter holder gasket is inserted in between the VFC device and the filter holder. Lower the assembly through the square hole on the shelter top plate.
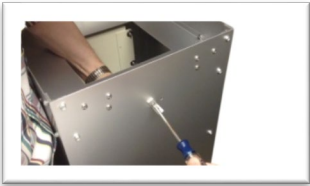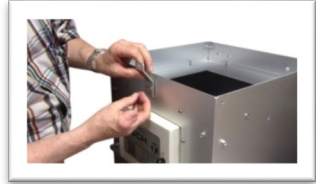
6.) Attach the Motor mounting plate to the white hose and securely tighten the hose clamp

Gabled Roof Assembly

The following steps are accompanied by pictures to aid your understanding of gabled roof assembly. **Please be aware that the pictures are standardized and may not match the equipment that you are using.** The gabled roof is used on both TSP and PUF models, and the assembly procedure is the same for both products.

Lid Hardware
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-5001-10-9 roof back catch
       1 pc TE-5001-10-10 front catch
       1 pc TE-5001-10-11 rear lid hasp	

Step 1 Secure TE-5001-10-10 front catch to the shelter using 2 10-24 pan head screws with stop nuts. *Do not tighten completely, this may need to be adjusted after final assembly*	
Step 2 Secure TE-5001-10-9 roof back catch to the back of shelter using #6-32 pan head screw with stop nut.	
Step 3 Secure TE-5001-10-11 rear lid hasp inside the lid with the slot angled up using (2) #10-24 pan head screws with stop nuts. *Do not tighten completely, this may need to be adjusted after final assembly*	

Step 4 Remove (4) #10-24 x ½" pan head screws from the rear of the shelter, attach the lid to the shelter by placing the lid hinge plates on the **"OUTSIDE"** of the shelter, line the hinges up with the (4) threaded holes in the back of the shelter. Use the (4) #10-24X ½" pan head screws that were removed preciously to attach the lid hinges to the shelter. *Tighten completely*	
Step 5 Adjust the front and rears catch to be sure that the lid slots lowers over it when closing. Tighten the roof back hasp and front catch completely.	
Step 6 Attach the chain and "S" hook assembly to the side of the shelter with a #6-32 x 3/8" pan head screw.	
Step 7 The Lid can now be secured in an open or closed position with the "S" hook.	

Electrical Set-Up

TE-CD-TSP/TE-CD-PM10/TE-CD/PM2.5
Electrical Hook Up

Motor

RELAY
BOX

ON/OFF
SWITCH

VFC+
CONTROLLER

M   F

M   F

F
M

M-Main Power

Tubing Connections
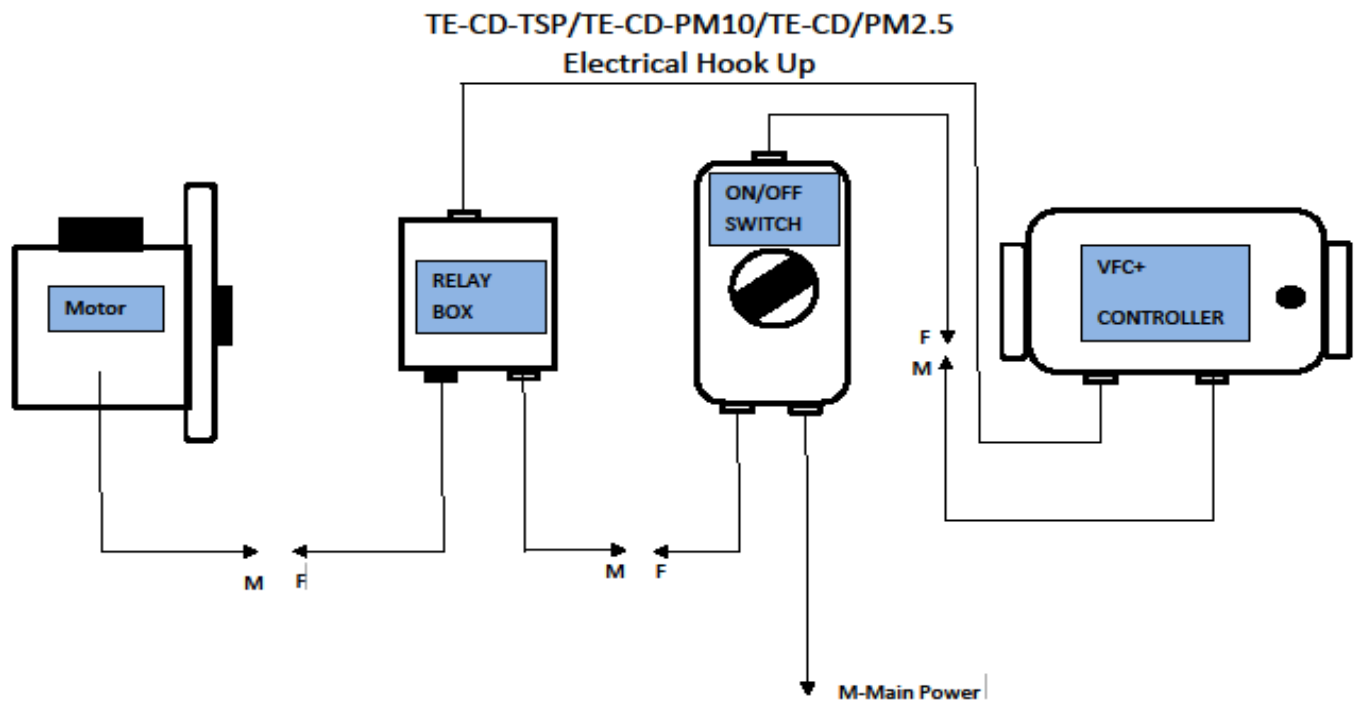
Tubing connections
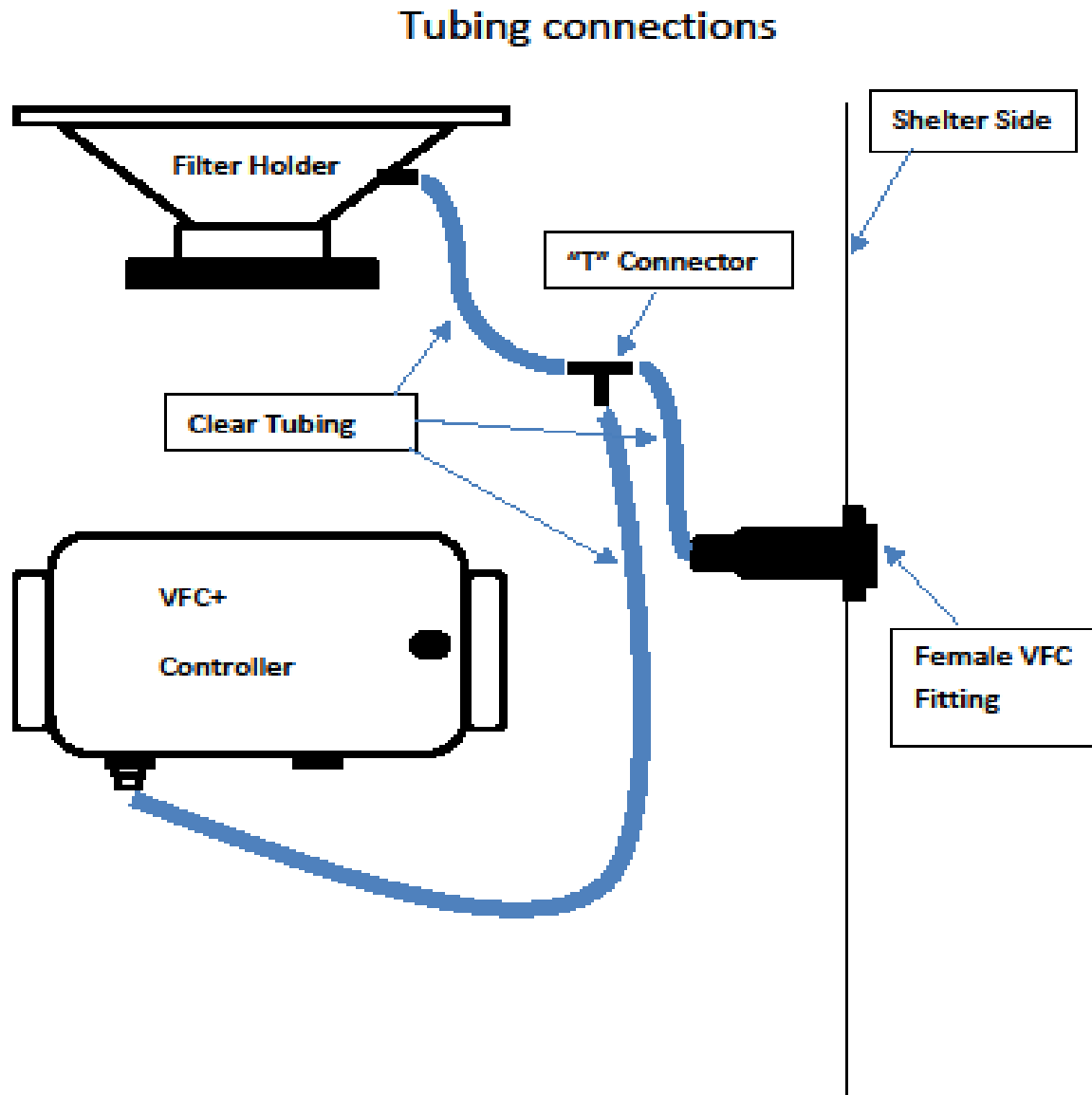
Operations

Calibration Procedure

The following is a step by step process of the calibration of a TE-CD-TSP Volumetric Flow Controlled TSP Particulate Sampling System. Following these steps are example calculations determining the calibration flow rates for the sampler. The air flow through these types of sampling systems is controlled by a Volumetric Flow Controller (VFC) or dimensional venturi device.

This calibration differs from that of a mass flow-controlled TSP sampler in that a slope and intercept does not have to be calculated to determine air flows. Also, the calibrator orifice Qactual slope and intercept from the orifice certification worksheet can be used here, unlike a mass flow-controlled TSP where Qstandard slope and intercept are used. The flows are converted from actual to standard conditions when the particulate concentrations are calculated. With a Volumetric Flow Controlled (VFC) sampler, the calibration flow rates are provided in a Flow Look Up Table that accompanies each sampler.

The attached example calibration worksheet uses a TE-5028A Variable Orifice Calibrator which uses an adjustable or variable orifice, which we recommend when calibrating a VFC.

Proceed with the following steps to begin the calibration:

Step 1: Mount the calibrator orifice and top loading adapter plate to the sampler. A sampling filter is generally not used during this procedure. Tighten the top loading adapter hold down nuts securely for this procedure to assure that no air leaks are present.

Step 2: Turn on the sampler and allow it to warm up to its normal operating temperature.

Step 3: Conduct a leak test by covering the holes on top of the orifice and pressure tap on the orifice with your hands. Listen for a high-pitched squealing sound made by escaping air. If this sound is heard, a leak is present and the top loading adapter hold-down nuts need to be re-tightened.

Avoid running the sampler for longer than 30 seconds at a time with the orifice blocked. This will reduce the chance of the motor overheating. Also, never try this leak test procedure with a manometer connected to the pressure tap on the calibration orifice or the pressure tap on the side of the sampler. Liquid from either manometer could be drawn into the system and cause motor damage.

Step 4: Connect one side of a water manometer or other type of flow measurement device to the pressure tap on the side of the orifice with a rubber vacuum tube. Leave the opposite side of the manometer open to the atmosphere.

Step 5: Connect a water manometer to the quick disconnect located on the side of the aluminum outdoor shelter (this quick disconnect is connected to the pressure tap on the side of the filter holder).

Step 6: Make sure the TE-5028A orifice is all the way open (turn the black knob counter clock-wise). Record both manometer readings, the one from the orifice and the other from the side of the sampler. To read a manometer one side goes up and the other side goes down, you add both sides, this is your inches of water. Repeat this process for the other four points by adjusting the knob on the variable orifice (just a slight turn) to four different positions and taking four different readings. You should have five sets of numbers, ten numbers in all.

Step 7: Remove the variable orifice and the top loading adapter and install a clean filter. Set your timer.

Step 8: Record the ambient air temperature, the ambient barometric pressure, the sampler serial number, the orifice serial number, the orifice Qactual slope and intercept with date last certified, todays date, site location and the operator's initials.

One example calibration sheet and one blank calibration sheet are attached to this manual. To download the electronic spreadsheet, please visit www.tisch-env.com (download the TE-CD-TSP High Vol TSP VFC with G-Factor excel spreadsheet). It is highly recommended to download the electronic excel spreadsheet and use spreadsheet features to complete calculations. (If you do not have a G Factor then go to "TE-CD-TSP High Vol. TSP" excel spreadsheet on web site and then go to page 23)

G-Factor Excel Spreadsheet Instructions

The TE-CD-TSPcalibration worksheet can be found on our website at www.tisch-env.com. If you have the G Factor that accompanies each VFC, go to "TE-CD-TSPHigh Vol. TSP VFC with G-Factor", if you do not have a G Factor then go to "TE-CD-TSPHigh Vol. TSP" excel spreadsheet.

Note: Calibration orifices should be sent back to Tisch Environmental for calibration on an annual basis per US EPA Compendium Method IO-2.1 Part 7.3.2 *Sampling of Ambient Air For Total Suspened Particulate Matter (SPM) and PM$_{10}$ Using High Volume (HV) Sampler*

1. Enter the following information in the corresponding cells in the worksheet:

Site Information

Location	The location of the instrument
Date	Current Date
Tech	Technician performing the calibration
Serial #	Serial number of the instrument, Pxxxx
VFC G Factor	The g-factor of the VFC you are calibrating. This can be found on the lookup table documentation (first page of this doc) or the sticker located on the VFC.

Calibration Orifice Information

Make	The make of the orifice, typically Tisch Environmental
Model	The model number of the orifice, typically TE-5028A
Serial #	The Serial number of the calibration orifice you are using
Qa Slope (m)	The Qa slope of the calibration orifice you are using. This is found on the calibration documentation provided with the calibration orifice
Qa Int (b)	The Qa intercept of the calibration orifice you are using. This is found on the calibration documentation provided with the calibration orifice
Calibration Due Date	The date that the calibration of the orifice is due. Orifices should be calibrated on an annual basis. Call Tisch Environmental at 1-TSP-AND-PM10 to schedule a calibration.

Ambient Conditions

Temp (Deg F)	Enter the current ambient temperature at calibration, Ta in Degrees K and Ta in degrees C will be calculated by the spreadsheet

Barometric Pressure	Enter the ambient barometric pressure (Pa) inches of Hg at calibration, the Pa in mmHg will be calculated by the spreadsheet

2. Enter the calibration information by performing each calibration point and entering the following information into each corresponding row for each point:

Calibration Information

Orifice "H_2O	The pressure measured at the orifice port using a manometer. The first point should be performed with the orifice knob turned counter-clockwise or wide open, then four consecutive points turning the orifice knob clockwise (not closed) Good idea to take a few extra points here.
Sampler "H_2O	The pressure measured at the sampler side port using a manometer (clear tubing that is connect to bulk head fitting that is connected to side of filter holder)

The calibrator flow is calculated (Qa) using the formula:

$$Qa = \frac{1}{Slope} \, x \, \sqrt{"H2Ox\left(\frac{Ta}{Pa}\right) - Intercept}$$

The calculated flow in m³/min will be calculated using the g-factor formula, this flow will correspond to the flow found in the lookup table supplied with the VFC.

The percent difference will be calculated using the formula:

$$\% \, Difference = \frac{Calculated \, Flow - (Qa) \; Calibrator \, Flow}{(Qa) \; Calibrator \, Flow} \, x \, 100$$

As per stated in the method IO-2.1, % Difference calculations should be less than +-4%

3. To calculate the total air volume during the sample enter the following information:

Calculate Total Air Volume Using G-Factor

Average Temperature	Enter the average temperature of the sample throughout the sample period in Deg F. The temperature will then be calculated in Deg K
Barometric Pressure	Enter the average barometric pressure of the sample throughout the sample period in Inches of Hg. The barometric pressure in mmHg will then be calculated
Clean Filter "H_2O	Enter the clean filter pressure in inches of water prior to sampling
Dirty Filter "H_2O	Enter the dirty filter pressure in inches of water after sampling. The average sample pressure will then be calculated in mmHg
Runtime	Enter the total runtime in hours (xx.xx) of the sample

Using the g-factor formula, Po/Pa will be calculated and an average flow rate of the sample will be calculated in m^3/min. Using this information, the total sample volume will be calculated.

If you do not have a G Factor, contact Tisch Environmental.

An example of a Volumetric Flow Controlled Sampler Calibration Data Sheet has been attached with data filled in from a typical calibration. This includes the transfer standard orifice calibration relationship which was taken from the Orifice Calibration Worksheet that accompanies the calibrator orifice. The slope and intercept are taken from the Qactual section of the Orifice Calibration Worksheet.

The first step is to convert the orifice readings to the amount of actual air flow they represent using the following equation:

$$Qa = 1/m[Sqrt((H_2O)(Ta/Pa))-b]$$

where:
Qa = actual flow rate as indicated by the calibrator orifice, m3/min
H_2O = orifice manometer reading during calibration, in. H_2O
Ta = ambient temperature during calibration, K (K = 273 + °C)
Pa = ambient barometric pressure during calibration, mm Hg
m = slope of Q actual orifice calibration relationship
b = intercept of Q actual orifice calibration relationship.

Once these actual flow rates have been determined for each of the five run points, they are recorded in the column titled Qa, and are represented in cubic meters per minute. EPA guidelines state that at least

three of these calibrator flow rates should be between 1.1 to 1.7 m3/min (39 to 60 CFM). This is the acceptable operating flow rate range of the sampler. If this condition is not met, the sampler should be recalibrated. An air leak in the calibration system may be the source of this problem. In some cases, a filter may have to be in place during the calibration to meet this condition.

The sampler H_2O readings need to be converted to mm Hg and recorded in the column titled Pf. This is done using the following equation:

$$Pf = 25.4 \ (in. \ H_2O/13.6)$$

where: Pf is recorded in mm Hg
in. H_2O = sampler side pressure reading during calibration.

Po/Pa is calculated next. This is used to locate the sampler calibration air flows found in the Look Up Table. This is done using the following equation:

$$Po/Pa = 1 - Pf/Pa$$

where: Pa = ambient barometric pressure during calibration, mm Hg.

Using Po/Pa and the ambient temperature during the calibration, consult the Look Up Table to find the actual flow rate. Record these flows in the column titled Look Up.

Calculate the percent difference between the calibrator flow rates and the sampler flow rates using the following equation:

$$\% \ Diff. = (Look \ Up \ Flow - Qa)/Qa * 100$$

where: Look Up Flow = Flow found in Look Up Table, m3/min
Qa = orifice flow during calibration, m3/min.

The EPA guidelines state that the percent difference should be within + or - 3 or 4%. If they are greater than this a leak may have been present during calibration and the sampler should be recalibrated.

Example Calculations

The following example problems use data from the attached VFC sampler calibration worksheet.

After all the sampling site information, calibrator information, and meteorological information have been recorded on the worksheet, actual air flows need to be determined from the orifice manometer readings taken during the calibration using the following equation:

1. $Qa = 1/m[Sqrt((H_2O)(Ta/Pa))-b]$

where:

2. Qa = actual flow rate as indicated by the calibrator orifice, m3/min
3. H_2O = orifice manometer reading during calibration, in. H_2O
4. Ta = ambient temperature during calibration, K (K = 273 + ^oC)
5. Pa = ambient barometric pressure during calibration, mm Hg
6. m = slope of Q actual orifice calibration relationship
7. b = intercept of Q actual orifice calibration relationship.

Note that the ambient temperature is needed in degrees Kelvin to satisfy the Qa equation. Also, the barometric pressure needs to be reported in millimeters of mercury (if sea level barometric pressure is used it must be corrected to the site elevation). In our case the two following conversions may be needed:

8. degrees Kelvin = [5/9 (degrees Fahrenheit - 32)] + 273
9. millimeters of mercury = 25.4(inches of H_2O/13.6)

Inserting the numbers from the calibration worksheet test number one we get:

10.	Qa	=	1/.92408[Sqrt((3.8)(293/749.3))- (-0.00383)]
11.	Qa	=	1.0821573[Sqrt((3.8)(.3910316)) + 0.00383]
12.	Qa	=	1.0821573[Sqrt(1.48592) + 0.00383]
13.	Qa	=	1.0821573[1.2189831 + 0.00383]
14.	Qa	=	1.0821573[1.2228131]
15.	Qa	=	1.323

It is possible that your answers to the above calculations may vary. This is most likely due to different calculators carrying numbers to different decimal points. This should not be an area of concern as generally these variations are slight.

With Qa determined, the sampler H_2O reading needs to be converted to mm Hg using the following equation:
16. $Pf = 25.4 \, (in. \, H_2O/13.6)$

where:
17. Pf is recorded in mm Hg
18. in. H_2O = sampler side pressure reading during calibration

Inserting the numbers from the worksheet:

19. $Pf = 25.4(6.4/13.6)$
20. $Pf = 25.4(.4705882)$
21. $Pf = 11.95294$ mm Hg

Po/Pa is calculated next. This is done using the following equation:

22. $Po/Pa = 1 - Pf/Pa$
23.   where: Pa = ambient barometric pressure during calibration, mm Hg.
                   Inserting the numbers from the worksheet:
24. $Po/Pa = 1 – 11.95294/749.3$
25. $Po/Pa = 1 - .0159521$
26. $Po/Pa = .984$

Use Po/Pa and the ambient temperature during the calibration (Ta) to locate the flow for the calibration point in the Look Up table. Record this in the column titled Look Up. Calculate the percent difference using the following equation:

27.   % Difference = (Look Up flow - Qa)/Qa * 100
        Inserting the numbers from the worksheet:
28.   % Difference = (1.287 - 1.323)/1.323 * 100
29.   % Difference = (-0.036)/1.323 * 100
30.   % Difference = (-0.0272108) * 100
31.   % Difference = -2.72

It is possible that your answers to the above calculations may vary. This is most likely due to different calculators carrying numbers to different decimal points. This should not be an area of concern as generally these variations are slight.

The above calculations have to be performed for all five calibration points. Once this is done, the calibration is complete.

Use of Look-Up-Table to Determine Flow Rate

(NOTE: Individual Look-Up Tables will vary.)

1. Suppose the ambient conditions are:

   Temperature: $T_a = 20\,^{\circ}C$

   Barometric Pressure: $P_a = 749.3$ mm Hg (this must be station pressure which is not corrected to sea level)

2. Assume system is allowed to warm up for stable operation.

3. Measure filter pressure differential, P_f. This reading is the set-up reading plus pick-up reading divided by 2 for an average reading. This is taken with a differential manometer with one side of the manometer connected to the stagnation tap on the filter holder (or the Bulkhead Fitting) and the other side open to the atmosphere. Filter must be in place during this measurement.

    Assume that:

    Set-up Reading (clean filter): $P_f = 12.6$ in H_2O
    Pick-up Reading (dirty filter): $P_f = 16.0$ in H_2O

    $P_f = (12.6 + 16.0)/2 = 14.3$ in H_2O.

4. Convert $P_f =$ to same units as barometric pressure.

    $P_f = 14.3$ in H_2O / 13.61 x 25.4 = 26.687729 mm Hg

    $P_f = 26.69$ mm Hg

5. Calculate pressure ratio.

    $P_o/P_a = 1 - (P_f/P_a)$

    NOTE: P_f and P_a MUST HAVE CONSISTENT UNITS

$P_o/P_a = 1 - (26.69 / 749.3)$

$P_o/P_a = .964$

     6. Look up Flow Rate from table.

Table 1 is set up with temperature in $^{\circ}$C and the Flow Rate is read in units of m^3/min (actual, ACMM). In table 2 the temperature is in $^{\circ}$F and Flow Rate is read in ft^3/min (actual, ACFM).

     a) For the example we will use Table 1.
      Locate the temperature and pressure ratio entries nearest the conditions of:

       $T_a = 20^{\circ}$C

      $P_o/P_a = .964$

        Example: Look-Up Table for Actual Flow Rate in Units of m^3/min

           Temperature $^{\circ}$C

Po/Pa	20	22	24	26	28
0.961	1.250	1.254	1.258	1.261	1.265
0.962	1.251	1.255	1.259	1.263	1.266
0.963	1.253	1.256	1.260	1.264	1.268
0.964	1.254	1.258	1.262	1.265	1.269
0.965	1.255	1.259	1.263	1.267	1.271
0.966	1.257	1.261	1.264	1.268	1.272

     b) The reading of flow rate is:

      $Q_a = 1.254 \ m^3$/min (actual)

      If your Po/Pa number is not in look up table ie; >.979 then interpolate.

    7. Determine flow rate in terms of standard air.

$$Q_{std} = 1.254 \, m^3/\min \left(\frac{749.3 \, mm \, Hg}{760 \, mm \, Hg} \right) \left(\frac{298K}{(273 + 20) \, K} \right)$$

Q_{std} = 1.257 std m^3/min

The reading of flow rate is:

Qa = 1.260 m3/min (actual)

If your Po/Pa number is not in look up table ie; >.979 then interpolate.

8. Determine flow rate in terms of standard air.

Qstd = 1.268 std m3/min

Sampler Operation

TE-CD-TSP TSP

1. After performing calibration procedure, remove filter holder frame by loosening the four wing nuts allowing the brass bolts and washers to swing down out of the way. Shift frame to one side and remove.

2. Carefully center a new filter, rougher side up, on the supporting screen. Properly align the filter on the screen so that when the frame is in position the gasket will form an airtight seal on the outer edges of the filter.

3. Secure the filter with the frame, brass bolts, and washers with sufficient pressure to avoid air leakage at the edges (make sure that the plastic washers are on top of the frame).

4. Wipe any dirt accumulation from around the filter holder with a clean cloth.

5. Close shelter lid carefully and secure with the "S" hook.

6. Prepare the Timer as instructed below.

7. At the end of the sampling period, remove the frame to expose the filter. Carefully remove the exposed filter from the supporting screen by holding it gently at the ends (not at the corners). Fold the filter lengthwise so that sample touches sample.

8. It is always a good idea to contact the lab you are dealing with to see how they may suggest you collect the filter and any other information that they may need.

VFC+ Controller
VFC+ NOTATION

Notations and Measurements: The Table below describes the measurement notion used by the VFC+ 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*
Qamb	CFM	Flow Rate 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)

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.

VFC+ CONNECTIONS

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

"Motor"

The "Motor" power connection supplies power to the motor being controlled by the VFC V+. Both Brush-Type and Brushless-Type motor are supported, but only one may be used at a time. The VFC+ will come configured to match the motor type ordered. ***THE MOTOR USED WITH THE VFC+ MUST MATCH THE AC POWER BEING SUPPLIED TO THE VFC+. THE VFC+ CONTROLS 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 VFC+. 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 VFC+ determines the voltage on which the unit operates. ***DO NOT APPLY 240-VOLT POWER TO THE VFC+ WHILE THE UNIT IS CONFIGURED FOR 120-VOLT OPERATION. THIS WILL DAMAGE THE UNIT. APPLYING 120-VOLT POWER TO THE VFC+ WHILE THE UNITS IS CONFIGURED FOR 240-VOLT OPERATION SHOULD NOT DAMAGE THE UNIT, BUT IS NOT RECOMMENDED OR SUPPORTED***.

"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.

"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.
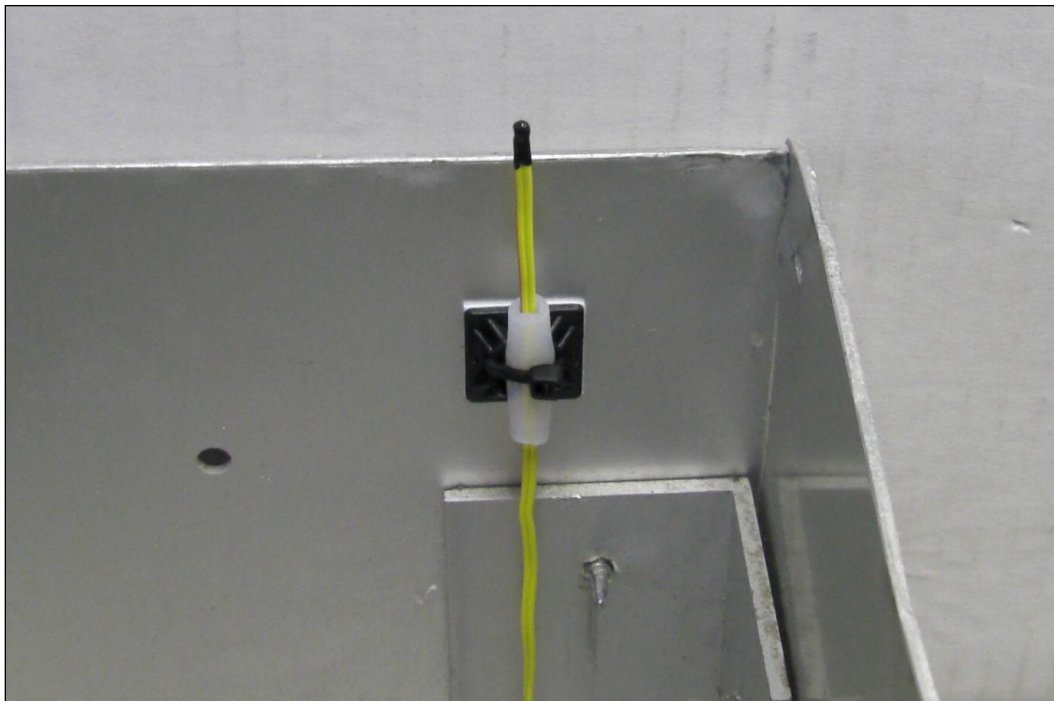
USER INTERFACE

The user interface of the VFC+ 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 VFC+ operation.

User Interface: The Keypad

The Keypad is used by the user to input data into the VFC+ 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 VFC+ 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



 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 their 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 shows 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 VFC+. For additional details, refer to the relevant section of this manual.

Step by Step: Connecting the Tubing

The VFC+ system includes three pieces of 1/8" clear vinyl tubing and a three-way barbed T-fitting.
1. One Piece of tubing will be attached to the bulkhead fitting on the inside of the aluminum shelter; the other end of this piece of tubing will be attached to the T-fitting.
2. The second piece of clear tubing will be attached to the bottom of the VFC+ controller, the other wend will be attached to the T-fitting
3. The Third piece of tubing will be connected to the T-fitting, the other end of this piece of tubing will get connected to the stagnation port on the side of the Stainless-Steel filter holder funnel.

Note: This tubing must all be connected during the sample, the VFC+ collects the pressure drop from the stagnation port to calculate the ambient flow. The tubing attached to the bulk head fitting on the side of the aluminum shelter is used for calibration (see flow calibration instructions for more information).

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 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.

Step by Step: Flow Calibration entering the G factor

Flow calibration is determined by the geometry of the specific VFC orifice. Each VFC orifice is calibrated at the factory when it is manufactured. The calibration process determines a single value that characterizes the flow properties of the orifice. This value is called the G Factor (the G factor is printed on the serial number tag on the VFC device and is also printed on the VFC device look up table). The VFC+ requires this G Factor in order to calculate the flow rate. This value is entered using the following procedure:
1. Press the 'F3' to enter the SETUP menu.
2. Press the 'ENT' key to acknowledge the warning message concerning SETUP.
3. Select the CALIBRATE menu item and press 'ENT'.
4. Select the Qamb menu item and press 'ENT'.
5. Press 'F1' to enter the G Factor.
6. The unit will prompt "ENTER G FACTOR". Enter the G Factor using the numeric keypad and press the 'ENT' key to accept the new value.
7. Press 'F4' to exit the Calibration screen.

8. Select "YES" and press 'ENTER' when the "SAVE CALIBRATION" prompt appears.
9. Press "ESC" to return to the SETUP menu.
10. Press "ESC" to exit the SETUP menu and return to the Main Status display.
11. The VFC+ will now use the entered G Factor to calculate the flow rate.

TIMER

The VFC+ 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.

Aborting Timer Operation

```
         ABORT TIMER?
  YES
 ►NO
```
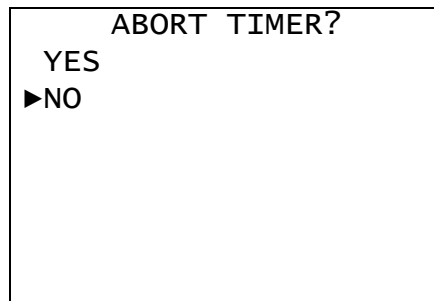
The ABORT TIMER menu (shown above) is displayed when the "F1" soft-menu function key is pressed from the main status display and the timer is currently executing. This allows the user to stop a currently executing timer event and re-configure the timer to the desired settings. Once a timer event is aborted, 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
```
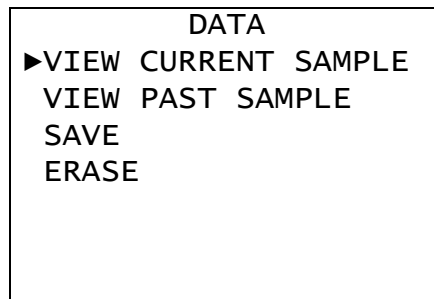
"VIEW CURRENT SAMPLE"

   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 allow 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.

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).

If the control unit is equipped with the optional data drive, then the data logs may be saved to the USB 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>
```
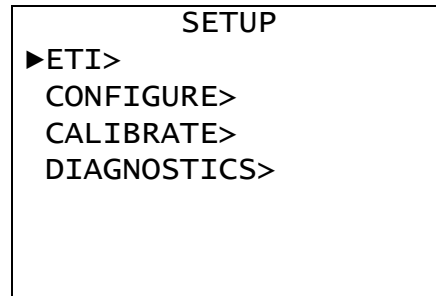
ETI Menu Item

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. For VFC+ systems changing the flow rate will not change the flow rate, the flow rate is determined by the VFC device not the VFC+ controller. This setting is only indented to be displayed on the data.csv file for reference only. CHANGING THIS WILL NOT CHANGE THE SYSTEMS FLOWRATE.

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.

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


```
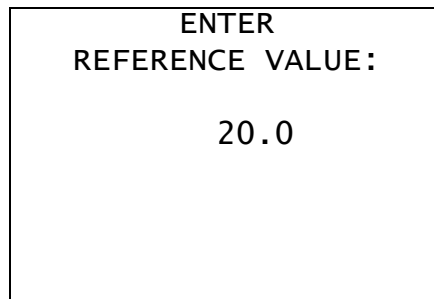
Once the ENT key is pressed, the screen below will be displayed. This screen will automatically exit and return to the main calibration screen once the system has collected a stable reading from the applied signal. If the reference signal is not sufficiently stable, this screen may be displayed for a 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.

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
 Qamb:(    0)       0.0
 MOTOR:            OFF

```

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 persists, 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 persists, 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 persists, contact technical support for further instruction.

Pdif

The Pdif menu item displays the pressure drop (across the filter) being measured by the system. **This sensor is not used in the flow control calculation on the VFC +.** 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 persists, contact technical support for further instruction.

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. This is where the Gfactor on the VFC device will be entered.

Motor

Use this function to manually toggle the motor on/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 VFC+ creates to files containing data each time the SAVE function is used. Data on the memory stick 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 VFC+ 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 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"

Troubleshooting

note: this is a general troubleshooting guide, not all problem may apply to every sampler

Problem	**Solution**
Brush Motor Won't Turn On	-Check Motor brushes(Change every 500 hours) -Check Motor(Should be replaced after 2 brush changes about 1500 hours) -Check power supply -Ensure that all electrical connections are secure -Make sure timer is on -Make sure flow controller(if applicable) is adjusted properly -Check for loose or damaged wires
Brushless Motor Won't Turn On	-Ensure that all electrical connections are secure -Make sure flow controller(if applicable) is adjusted properly -Check power supply -Make sure timer is on -Check for loose or damaged wires
Mechanical timer not working	-Make sure trippers are set properly -Make sure that trippers are not pressed against switch at start up, the timer need to rotate a few degrees before the trippers hit the switch -Check for loose or damages wires -Check power supply -Check electrical hook up diagram to ensure correct installation -Check Motor
Digital timer not working	-Check timer settings -Make sure current date and time are correct -Make sure power cords are properly connected -Check fuse on main PC board (F3) -Check Power Supply -Check Motor
Mass Flow Controller not working	-Make sure timer is on -Check Motor/Motor brushes -Make sure 8 amp breaker is not popped -Make sure flow probe is installed correctly -Check all electrical connections -Check power supply

Elapsed Time Indicator not working	-Check Power Supply -Check electrical connections
Voltage Variator with ETI not working	-Check Power Supply -Check Electrical Connections -Check Motor
Flow Rate Too Low	-Check for leaks -Check filter media placement -Ensure only one piece of filter paper is installed -Check Flow Controller -Check flow valve(TE-1000PUF samplers only) -Ensure proper voltage is being supplied -Check calibration
Chart Recorder not working	-Replace pen point -Make sure pen point is touching chart -Make sure pen point is on "0" -Make sure tubing from motor is in place -Check Power Supply -Check motor
Air Leaks	-Make sure all gaskets are in place -Make sure all connections are secure -Makes sure connections are not over tightened -Check for damaged components: Filter holder screen, gaskets, motor flanges

Maintenance and Care

A regular maintenance schedule will allow a monitoring network to operate for longer periods of time without system failure. Our customers may find that the adjustments in routine maintenance frequencies are necessary due to the operational demands on their sampler(s). We recommend that the following cleaning and maintenance activities be observed until a stable operating history of the sampler has been established.

TE-CD-TSP TSP Sampler

1. Make sure all gaskets (including motor cushion) are in good shape and that they seal properly.

2. The power cords should be checked for good connections and for cracks (replace if necessary).

    CAUTION: DO NOT allow power cord or outlets to be immersed in water!

3. Inspect the filter screen and remove any foreign deposits.

4. Inspect the filter holder frame gasket each sample period and make sure of an airtight seal.

5. Make sure elapsed time indicator is working properly.

Warranty

Instruments manufactured by Tisch Environmental, Inc. are guaranteed by warranty to be free of defects in materials and workmanship for one year after shipment from Tisch Environmental factories. The liability of Tisch Environmental, Inc. is limited to servicing or replacing any defective part of any instrument returned to the factory by the original purchaser. All service traceable to defects in original material or workmanship is considered warranty service and is performed free of charge. The expense of warranty shipping charges to and from our factory will be borne by Tisch Environmental. Service performed to rectify an instrument malfunction caused by abuse, acts of god or neglect, and service performed after the one-year warranty period will be charged to the customer at the current prices for labor, parts, and transportation. Brush-type and brushless motors will carry a warranty as far as the original manufacture will pass through its warranty to Tisch Environmental, Inc. The right is reserved to make changes in construction, design specifications, and prices without prior notice.

Assembly Drawings

TE-5003V Filter Holder Assembly

Pressure Tap
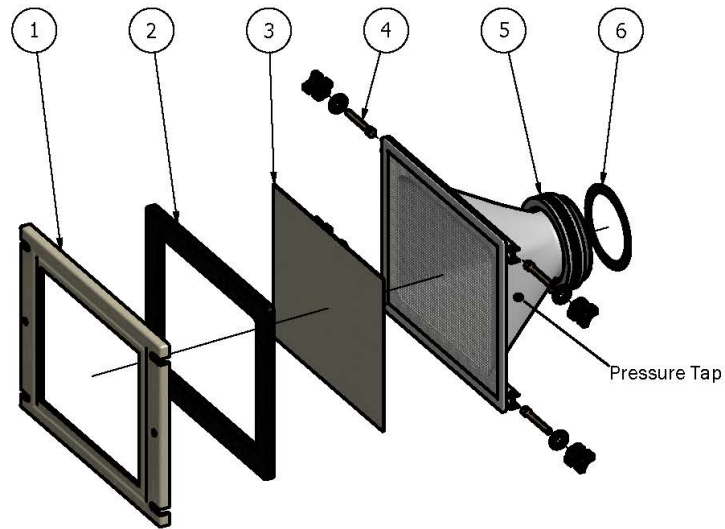
ITEM	QTY	PART NUMBER	DESCRIPTION
1	1	TE-3000-2	Hold Down Frame
2	1	TE-5018	8" x 10" Gasket
3	1	N/A	Filter Paper
4	4	TE-5003-9	Plastic Thumb Nut, Brass Bolt, Washer, and Rivet
5	1	TE-5028-9	Aluminum Threaded Ring
6	1	TE-5005-9	Filter Holder Gasket (Between Filter Holder and Blower Motor)

TE-5003V Filter Holder Assembly

Calibration Worksheets

TE-5170V Calibration Worksheet

Site Information

Location: Cleves Ohio	**Site ID:** 145	**Date:** 31-Oct-14
Sampler: TE-5170V	**Serial No:** P8644 TSP	**Tech:** Jim Tisch

Site Conditions

Temp (deg F):	68.0		
Ta (deg K):	293	**Barometric Press (in Hg):**	29.50
Ta (deg C):	20	**Pa (mm Hg):**	749

Calibration Orifice

Make: Tisch	**Qa Slope:** 0.92408
Model: TE-5028A	**Qa Intercept:** -0.00383
Serial#: 2978.00	**Calibration Due Date:** 24-Oct-15

Calibration Data

Run Number	Orifice "H2O	Qa (m3/min)	Sampler "H2O	Pf (mm Hg)	Po/Pa	Look Up (m3/min)	% Diff
1	3.80	1.323	6.40	11.944	0.984	1.287	-2.72
2	3.80	1.323	6.80	12.691	0.983	1.286	-2.80
3	3.80	1.323	7.20	13.437	0.982	1.284	-2.95
4	3.75	1.315	9.25	17.263	0.977	1.278	-2.81
5	3.75	1.315	10.20	19.036	0.975	1.275	-3.04

Calculations

Calibrator Flow (Qa) = 1/Slope*(SQRT(H20*(Ta/Pa))-Intercept)
Pressure Ratio (Po/Pa) = 1-Pf/Pa
% Difference = (Look Up Flow-Calibrator Flow)/Calibrator Flow*100

NOTE: Ensure calibration orifice has been certified within 12 months of use

Tisch Environmental 145 South Miami Ave, Cleves OH 45002 ● 877.263.7610 ● sales@tisch-env.com ● www.tisch-env.com

TE-5170V Sampler Calibration Worksheet
(Using G-Factor)

Site and Calibration Information

Site	Calibration Orifice
Location: Cleves, OH	**Make:** Tisch Environmental
Date: Oct 31, 2014	**Model:** TE-5028A
Tech.: Jim Tisch	**Serial:** 1179
Sampler: TE-5170V	**Qa Slope (m):** 0.92408
Serial #: P8644 TSP	**Qa Int (b):** -0.00383
VFC G-Factor: 0.0974264900	**Calibration due date:** 10/24/15

Ambient Conditions

Temp (deg F): 68.0	
Ta (deg K): 293	**Barometric Press (in Hg):** 29.50
Ta (deg C): 20.0	**Pa (mm Hg):** 749.3

Calibration Information

Run Number	Orifice "H2O	Qa m3/min	Sampler "H2O	Pf mm Hg	Po/Pa	Calculated m3/min	% of Diff
1	3.80	1.323	6.40	11.944	0.984	1.287	-2.72
2	3.80	1.323	6.80	12.691	0.983	1.286	-2.80
3	3.80	1.323	7.20	13.437	0.982	1.284	-2.95
4	3.75	1.315	9.25	17.263	0.977	1.277	-2.81
5	3.75	1.315	10.20	19.036	0.975	1.274	-3.04

Calculate Total Air Volume Using G-Factor

Enter Average Temperature During Sampling Duration (Deg F)	62.00
Average Temperature During Sampling Duration (Deg K)	289.67
Enter Average Barometric Pressure During Sampling Duration (In Hg)	29.40
Average Barometric Pressure During Sampling (mm Hg)	746.76
Enter Clean Filter Sampler Inches of Water	12.60
Enter Dirty Filter Sampler Inches of Water	16.00
Average Filter Sampler (mm Hg)	26.69
Enter Total Runtime in Hours (xx.xx)	23.90
Po/Pa :	0.964
Calculated Flow Rate (m3/min):	1.254
Total Flow (m3):	1797.57

Calculations

Calibrator Flow (Qa) = 1/Slope*(SQRT(H20*(Ta/Pa))-Intercept)
Pressure Ratio (Po/Pa) = 1-Pf/Pa
% Difference = (Look Up Flow-Calibrator Flow)/Calibrator Flow*100

NOTE: Ensure calibration orifice has been certified within 12 months of use

Tisch Environmental 145 South Miami Ave, Cleves OH 45002 ● 877.263.7610 ● sales@tisch-env.com ● www.tisch-env.com

Calibration Certificate

TISCH ENVIRONMENTAL, INC.
145 SOUTH MIAMI AVE
VILLAGE OF CLEVES, OH
45002
513.467.9000
877.263.7610 TOLL FREE
513.467.9009 FAX

ORIFICE TRANSFER STANDARD CERTIFICATION WORKSHEET TE-5028A

Date - Oct 24, 2014 Rootsmeter S/N   9833620   Ta (K) -   296
Operator Tisch   Orifice I.D. -   2978   Pa (mm) -   755.65

PLATE OR VDC #	VOLUME START (m3)	VOLUME STOP (m3)	DIFF VOLUME (m3)	DIFF TIME (min)	METER DIFF Hg (mm)	ORIFICE DIFF H2O (in.)
1	NA	NA	1.00	1.1880	4.5	1.50
2	NA	NA	1.00	0.9230	7.5	2.50
3	NA	NA	1.00	0.8380	9.0	3.00
4	NA	NA	1.00	0.7790	10.5	3.50
5	NA	NA	1.00	0.5860	18.0	6.00

DATA TABULATION

Vstd	(x axis) Qstd	(y axis)		Va	(x axis) Qa	(y axis)
0.9950	0.8375	1.2254		0.9940	0.8367	0.7665
0.9910	1.0737	1.5819		0.9901	1.0727	0.9896
0.9891	1.1803	1.7329		0.9881	1.1791	1.0840
0.9871	1.2671	1.8718		0.9861	1.2659	1.1709
0.9771	1.6674	2.4507		0.9761	1.6657	1.5331

Qstd slope (m)   =   1.47574   Qa   slope (m)   =   0.92408
intercept (b)   =   -0.00613   intercept (b)   =   -0.00383
coefficient (r)   =   0.99985   coefficient (r)   =   0.99985

y axis = SQRT[H2O(Pa/760)(298/Ta)]   y axis = SQRT[H2O(Ta/Pa)]

CALCULATIONS

$$Vstd = Diff.\ Vol[(Pa-Diff.\ Hg)/760](298/Ta)$$
$$Qstd = Vstd/Time$$

$$Va = Diff\ Vol\ [(Pa-Diff\ Hg)/Pa]$$
$$Qa = Va/Time$$

For subsequent flow rate calculations:

$$Qstd = 1/m\{[SQRT(H2O(Pa/760)(298/Ta))]- b\}$$
$$Qa = 1/m\{[SQRT\ H2O(Ta/Pa)]- b\}$$