Tisch Environmental, Inc.

OPERATIONS MANUAL

TE-5170V Total Suspended Particulate VFC High Volume Air Sampler

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PREFACE

Tisch Environmental, Inc. is a third generation family owned business. The owners Wilbur J. Tisch and James P. Tisch have been involved in the High Volume Air Pollution field for the last 20 years. Started in March of 1998, they would like to welcome you to their company.

The intent of this manual is to instruct the user with unpacking, assembly, operating and calibration techniques. For information on air sampling principles, procedures and requirements please contact the local Environmental Protection Agency Office serving your area.

CONTENTS

UNPACKING

1. Shelter Box - 46" x 20" x 23"   50 lbs

TE-5170V	Anodized Aluminum Shelter with mounted 7- Day Mechanical Timer on door and Elapsed Time Indicator.

2. VFC Box - 27" x 21" x 18"   30 lbs

TE-5001-10	Gabled Roof
TE-5030	30" Water Manometer
TE-5070	VFC Blower Motor Assembly
TE-10557TSP	Volumetric Flow Controller TSP
TE-5003V	8" x 10" VFC TSP Stainless Steel Filter Holder
TE-5005-9	Filter Holder Gasket

***** Save the shipping containers and packing material for future use.**

ASSEMBLY:

a. Open shelter box and remove Anodized Aluminum Shelter.

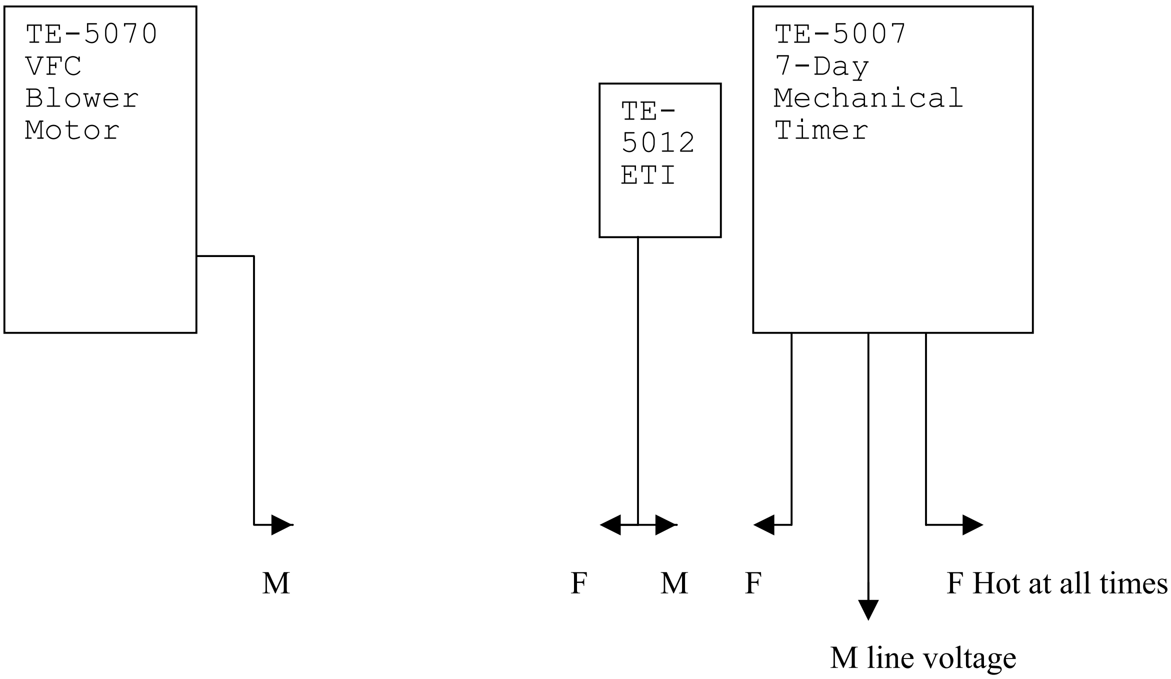
b. Open VFC box and remove 5001-10 Roof (for roof assembly see page 4), TE-5003V Filter Holder with TE-5005-9 gasket, TE-5030 30" Water Manometer, and TE-5070 VFC Blower Motor Assembly with VFC attached.

c. Screw TE-10557TSP and TE-5070 Blower Motor Assembly onto TE-5003V Filter Holder (tubing, power cord, and hole in filter holder collar to the right) make sure TE-5005-9 gasket is in place.

d. Lower Filter Holder, VFC, and Blower Motor down through top support pan on shelter.

Connect clear tubing from bulkhead fitting to pressure tap on side of filter holder.

ELECTRICAL HOOK-UP



The TE-5070 VFC Blower Motor male cord set plugs into the TE-5012 Elapsed Time Indicator female side.

The male side of the ETI cord set plugs into the TE-5007 7-Day Mechanical Timer timed female cord set which is on the left side of timer.

The other female cord set on timer (on the right) is hot all the time.

The male cord set of timer plugs into the line voltage.

Gabled Roof ASSEMBLY

Lid parts bag contents (taped inside of lid):

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

1. Secure TE-5001-10-10 front catch to the shelter using 2 10-24 pan head screws with stop nuts.

2. Secure TE-5001-10-9 roof back catch to the back of shelter using 10-24 pan head screw with stop nut.

3. Secure TE-5001-10-11 rear lid hasp inside the lid with the slotted end angled up using 2 - 10-24 pan head screws with stop nuts.

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

4. Remove 4 - 10-24 x 1/2 pan head screws from the nutserts in back of shelter.

5. Attach the lid to the shelter by placing the lid hinge plates on the **"OUTSIDE"** of the shelter top and tighten the 4 - 10-24 x 1/2 pan head screws into the nutserts.

6. Adjust the front catch to be sure that the lid slot lowers over it when closing the lid. The rear lid hasp should align with the roof back catch when the lid is open.

7. Attach the chain and **"S"** hook assembly to the side of the shelter with a 6-32 pan head screw and nut.

8. The lid can now be secured in an open or closed position with the **"S"** hook.

GENERAL CALIBRATION REQUIREMENTS

TE-5170V TSP VFC High Volume Air Sampler should be calibrated:

1. Upon installation

2. After any motor maintenance

3. Once every quarter (three months)

4. After 360 sampling hours

CALIBRATION KIT

The calibration kit available for the TE-5170V TSP VFC High Volume Air Sampler is the TE-5028.

The TE-5028 is the preferred method to calibrate the TE-5170V VFC 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.

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

** It is recommended that each calibrator should be re-calibrated annually for accuracy and reliablity.

CALIBRATION PROCEDURE

The following is a step by step process of the calibration of a **TE-5170V 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 **V**olumetric **F**low **C**ontrolled (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 one: 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 two: Turn on the sampler and allow it to warm up to its normal operating temperature.

Step three: 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 four:** 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 five: 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). If using the **TE-5025A (**a fixed orifice that uses load plates) orifice a longer manometer is used here as there is a possibility of great pressure difference from this port.

Step six: 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 seven: Remove the variable orifice and the top loading adapter and install a clean filter. Record the manometer reading from the side tap on the side of the sampler. This is used to calculate the operational flow rate of the sampler.

Step eight: 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 operators initials.

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 five orifice manometer readings taken during the calibration have been recorded in the column on the calibration worksheet titled Orifice H_2O. The five manometer readings taken from the side pressure tap have been recorded in the column titled Sampler "Hg.

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, m^3/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 m^3/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, m^3/min
Qa = orifice flow during calibration, m^3/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.

The line on the worksheet labeled Operational Flow Rate is where the side tap reading is recorded which is taken with no resistance plates under the calibration orifice. With this side tap reading, Pf and Po/Pa are calculated with the same equations listed above. This completes the calibration of this sampler.

Example Problems

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, m^3/min
3. H_2O = orifice manometer reading during calibration, in. H_2O
4. Ta = ambient temperature during calibration, K (K = 273 + °C)
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/.99101[Sqrt((4.15)(295/756))- 0.00656]
11. Qa = 1.009[Sqrt((4.15)(.39)) - 0.00656]
12. Qa = 1.009[Sqrt(1.6185) - 0.00656]
13. Qa = 1.009[1.2722 - 0.00656]

14. Qa = 1.009[1.26564]

15. Qa = 1.277

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(6.8/13.6)

20. Pf = 25.4(.50)

21. Pf = 12.7 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 – 12.7/756

25. Po/Pa = 1- .0167989

26. Po/Pa = .983

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 = (1.283 - 1.277)/1.277 * 100

29. % Difference = (0.006)/1.277 * 100

30. % Difference = (0.0046985) * 100

31. % Difference = .47

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 FOR DETERMINATION OF FLOW RATE

(NOTE: Individual Look Up Tables will vary.)

1. Suppose the ambient conditions are:

   Temperature: $T_a = 24\,^oC$

   Barometric Pressure: P_a = 762 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: $P_f = 14.10$ in H_2O
   Pick-up Reading: $P_f = 15.40$ in H_2O

   $P_f = (14.10 + 15.40)/2 = 14.75$ in H_2O.

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

   $P_f = 14.75$ in $H_2O / 13.61 \times 25.4 = 27.53$ mm Hg

   $P_f = 27.53$ 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

   $P_o/P_a = 1 - (27.53 / 762)$

$P_o/P_a = .964$

6. Look up Flow Rate from table.

Table 1 is set up with temperature in °C and the Flow Rate is read in units of m^3/min (actual, ACMM). In table 2 the temperature is in °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:

$T_a = 24°C$

$P_o/P_a = .964$

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

Temperature °C

Po/Pa	22	24	26	28	30
0.961	1.252	1.256	1.260	1.263	1.267
0.962	1.253	1.257	1.261	1.265	1.268
0.963	1.255	1.258	1.262	1.266	1.270
0.964	1.256	1.260	1.264	1.267	1.271
0.965	1.257	1.261	1.265	1.269	1.273
0.966	1.259	1.263	1.266	1.270	1.274

b) The reading of flow rate is:

$Q_a = 1.260\ m^3/min$ (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.

$$Q_{std} = 1.260\ m^3/\min\left(\frac{762\ mm\ Hg}{760\ mm\ Hg}\right)\left(\frac{298K}{(273+24)\ K}\right)$$

$Q_{std} = 1.268$ std m^3/min

SAMPLER OPERATION TE-5170V VFC 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. Make sure all cords are plugged into their appropriate receptacles and the clear tubing between the filter holder pressure tap and the bulkhead fitting is connected (be careful not to pinch tubing when closing door).

7. Prepare the Timer:
   a. To set the "START" time, attach a (bright) "ON" tripper to the dial face on the desired "START" time. Tighten tripper screw securely.

   b. To set the "STOP" time, attach a (dark) "OFF" tripper to the dial face on the desired "STOP" time. Tighten tripper screw securely.

   c. To set current time and day, grasp dial and rotate **clockwise only** until correct time and day appear at time pointer.

8. Manually trip timer switch on to determine if sampler is operating properly and the recorder is inking correctly.

9. Manually trip timer switch off. If the timer is set correctly you are ready to sample.

10. 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.

11. 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.

MAINTENANCE

A regular maintenance schedule will allow a monitoring network to operate for longer periods of time without system failure. Our customers may find 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-5170V VFC 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 neccesary).

   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 airtight seal.

5. Check or replace motor brushes every 500 hours.

6. Make sure elapsed time indicator is working properly.

MOTOR BRUSH REPLACEMENT TE-5170V VFC TSP (Brush part #TE-33392)

(220 Volt Brush part #TE-33378)

CAUTION: Unplug the unit from any line voltage sources before any servicing of blower motor assembly.

1. Remove the VFC device by removing the four bolts. This will expose the gasket and the TE-115923 motor.

2. Turn assembly on side, loosen the cord retainer and then push cord into housing and at the same time let motor slide out exposing the brushes.

3. Looking down at motor, there are 2 brushes, one on each side. Carefully pry the brass quick disconnect tabs (the tabs are pushed into end of brush) away from the expended brushes and toward the armature. Try to pry the tabs as far as you can without damaging the armature.

4. With a screwdriver loosen and remove brush holder clamps and release TE-33392 brushes. Carefully, pull quick disconnect tabs from expended brushes.

5. Carefully slide quick disconnect tabs into tab slot of new TE-33392 brush.

6. Push brush carbon against armature until brush housing falls into brush slot on motor.

7. Put brush holder clamps back onto brushes.

8. Make sure quick disconnect tabs are firmly seated into tab slot. Check field wires for good connections.

9. Assemble motor after brush replacement by placing housing over and down on the motor (at same time pull power cord out of housing), being careful not to pinch any motor wires beneath the motor spacer ring.

10. Secure power cord with the cord retainer cap.

11. Replace VFC device on top of motor making sure to center gasket.

****IMPORTANT**** To enhance motor life:

1. Change brushes before brush shunt touches armature.
2. Seat new brushes by applying 50% voltage for 10 to 15 minutes, the TE-5075 brush break in device allows for the 50% voltage.