

# CERTITEST<sup>®</sup> Model 8160 Automated Filter Tester

## **Instruction Manual**

*P/N 1980140, Revision D  
February 2003*

# Manual History

The following is a history of the CERTITEST® Model 8160 Automated Filter Tester Operation and Service Manual, P/N 1980140.

<b>Revision</b>	<b>Date</b>
First Run	June 1992
A	December 1993
A1	June 1998
B	October 1999
C	July 2000
D	February 2003

Revision A reflects a reformatting of the manual and changing all references of Condensation Nucleus Counter to Condensation Particle Counter.

In revision A1, TSI's area code was changed from 612 to 651.

In revision B, Chapters 2 and 3 were updated and minor changes were made throughout the manual.

In revision C, TSI's Limitation of Warranty and Liability was updated.

In revision D, TSI phone numbers and address were updated.

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(effective July 2000)

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Knowing that inoperative or defective instruments are as detrimental to TSI as they are to our customers, our service policy is designed to give prompt attention to any problems. If any malfunction is discovered, please contact your nearest sales office or representative, or call TSI at 1-800-874-2811 (USA) or (651) 490-2811.



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# Safety

This section gives instructions to promote safe and proper operation of the Model 8160 Filter Tester, samples of warnings found in this manual, and information on labels attached to system instruments.

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## Laser Safety

Condensation Particle Counters (CPC) are Class I laser-based instruments. During normal operation, you will not be exposed to laser radiation. However, you must take certain precautions or you may expose yourself to hazardous, optical radiation in the form of intense, focused, invisible light. Exposure to this light can cause blindness.

Take these precautions:

- Do **not** remove any parts from tester instruments unless you are specifically told to do so in this manual.
- Do **not** remove any instrument housing when power is applied.



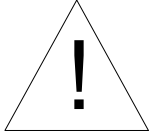
W A R N I N G
The use of controls, adjustments, or procedures other than those specified in this manual may result in exposure to hazardous optical radiation.

---

## Chemical Safety

CPCs use n-butyl alcohol (butanol) as a working fluid. Butanol is flammable. Butanol is also toxic if inhaled. Refer to a material safety data sheet on butanol and take these precautions:

- Use butanol only in a well-ventilated area.
- Butanol vapor is identified by its characteristically strong odor and can easily be detected. If you smell butanol and develop a headache, or feel faint or nauseous, leave the area at once. Ventilate the area before returning.



### C a u t i o n

Butanol is flammable. Butanol is also potentially toxic if inhaled. Use butanol only in a well-ventilated area. If you smell butanol and develop a headache, or feel faint or nauseous, leave the area at once. Ventilate the area before returning.



### W A R N I N G

Although the CPC is appropriate for monitoring inert process gases such as nitrogen or argon, it should *not* be used with hazardous gases such as hydrogen or oxygen. Using the CPC with hazardous gases may cause injury to personnel and damage to equipment.

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## Radiation Safety

The Model 3080 or 3080A Electrostatic Classifier contains a Model 3077 Aerosol Neutralizer with a Krypton-85 source. Under normal circumstances, you will not come into contact with hazardous radiation. However, take these precautions when using the Neutralizer in an Electrostatic Classifier or in another instrument:

- Do **not** remove any parts from the Electrostatic Classifier unless you are specifically told to do so in the Electrostatic Classifier manual.
- Corrosive materials can degrade materials that are a part of the Neutralizer. Do **not** operate the Classifier or other instrument with chemicals that corrode 303, 304, or 316 stainless steel, copper, silver solder, or epoxy.
- Do **not** operate the Electrostatic Classifier or other instrument in temperatures above 50°C. Temperatures above 50°C may cause the Neutralizer to leak, causing radioactive contamination.
- The Neutralizer has a half-life of 10.4 years. Keep all Neutralizer packing materials. After 10 years, TSI recommends you return the Neutralizer to the manufacturer and order a new Neutralizer.
- Install and remove the Neutralizer using directions in Electrostatic Classifier manual (if applicable).



### **W A R N I N G**

The use of controls, adjustments, or procedures other than those specified in this manual may result in exposure to hazardous radiation.

---

## **Labels**

External and internal advisory labels and identification labels are attached to the CPC, the Aerosol Neutralizer and the Electrostatic Classifier. Refer to individual product manuals for descriptions and locations of these labels.



# About This Manual

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## Purpose

This manual provides information necessary to operate the 8160 Automated Filter Tester (AFT) and should be read thoroughly. Other important documentation is contained in the large three-ring *manual binder*. The manual binder contains these separate operation manuals for individual instrumentation used in the AFT:

- Model 3760A Condensation Particle Counter
- Model 3080 Electrostatic Classifier
- Model 2012 Mass Flowmeter 2010 series
- Model 220c Pressure Transducer
- Model 3062 Diffusion Dryer
- Model 3704 Single Channel Interface Cards
- Model 3077 Aerosol Neutralizer

The binder also contains the following schematics and drawings:

- DC wiring schematic
- AC wiring schematic
- Interface card dipswitch settings
- Atomizer assembly drawing
- Filter holder schematic
- Equipment data sheets:
  - Sheet on PIAB pump and/or electric pump
  - Air logic schematic
  - Atomizer valve data sheet
  - Power supply data sheet
  - Pressure gauge data sheet

A separate manual is provided for the DASCON-1 interface card.

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## Reusing and Recycling



As part of TSI Incorporated's effort to have a minimal negative impact on the communities in which its products are manufactured and used:

- This manual has been printed on recyclable paper.
- This manual has been shipped, along with the instrument, in a reusable carton.

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## Submitting Comments

TSI values your comments and suggestions on this manual. Please use the comment sheet on the last page of this manual to send us your opinion on the manual's usability, to suggest specific improvements, or to report any technical errors.

If the comment sheet has already been used, please mail your comments on another sheet of paper to:

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# CHAPTER 1

## Product Overview

This chapter contains an introduction to the Model 8160 Automated Filter Tester.

The Model 8160 Automated Filter Tester (AFT) is an automated filter tester that measures filter efficiency and penetration versus particle size. Challenging filters or filter media with a known particle size is achieved by using atomizers and the Electrostatic Classifier to generate particles. Upstream and downstream particle detection is accomplished using two Condensation Particle Counters. The AFT is automated using a microcomputer and special software. The tester is capable of measuring efficiencies better than 99.99999 percent over a particle size range of .015 to .4 micron. The figure below shows the AFT 8160 filter tester in schematic form.

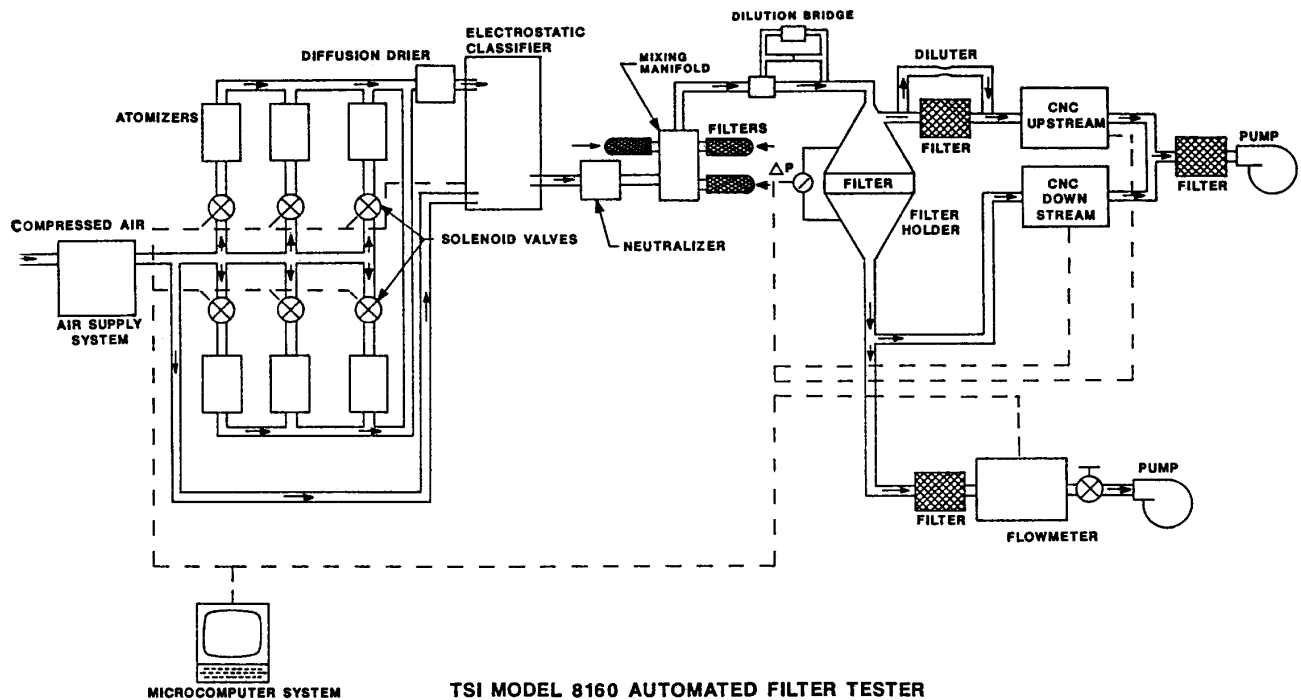


Figure 1-1  
Schematic of the Model 8160 Automated Filter Tester



## CHAPTER 2

# Unpacking and Setting Up

Use the information in this section to unpack and set up the main components of the Model 8160 Filter Tester. The main components include the Condensation Particle Counter (CPC), the Electrostatic Classifier, the interface cards and computer components, the software, and the tester itself.

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## Unpacking

The following instruments and accessories are included as part of the Model 8160 Automated Filter Tester.

**Table 2-1**  
Packing List for Model 8160 Automated Filter Tester

Qty	Item	Part No.
1	Cabinet chassis	
1	TSI Model 3080 Electrostatic Classifier	
2	TSI Model 3077 Kr-85 Neutralizer	
2	TSI Model 3760A Condensation Particle Counters	
1	TSI Model 3062 Diffusion Dryer	
1	Computer w/manual	
1	Epson printer w/manual	
1	Color monitor/keyboard	
1	Model 8160 Automated Filter Tester Manual	1980140
1	Model 3077 Aerosol Neutralizer Manual	1933077
1	Model 3704 Single-Channel Inteface Manual	1933704
1	DOS manual with disks	
1	AFT software disk	
1	Vacuum grease	1101063
1	Diffusion Dryer Filling Cap	1304017
4	Desiccant	1403002
1	Vacuum grease	1502249
6	Electrostatic Classifier filters, MSA #95302	1602011
1	Carbon capsule filter #12011	1602047
6	HEPA capsule filters	1602051
2	MSA cartridge filters #79030	1602068
5	5-amp slowblow fuse (220V)	1605041
2	Filter holder gaskets	1704082
2	Diffusion dryer O-ring 1-151	2501151
4	Filter holder O-ring 1-224	2501888
1	Printer paper	2608007
1	DASCON-Manual	
1	Diluter insertion tool	1503060
1	Delrin Pliers	3012021
1	Model 3760A Accessory Kit	

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## Setting Up

Use the information in this section to set up the main components of the Model 8160 Filter Tester.

**Table 2-2**  
Component List for Figures 2-1 and 2-2

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1 Filter holder	14 DOP solution bottles
2 Access door	15 NaCl solution bottles
3 System fuses	16 Air supply conditioner
4 Power switch	17 Main regulator and valve
5 Flow control valves	18 Desiccant dryer
6 Diffusion dryer	19 Dilution bridge
7 System computer	20 Aerosol manifold (not shown)
8 Keyboard/monitor	21 Pressure transducer
9 Printer drawer	22 Purge air filter
10 Filter holder controls	23 Vacuum pump
11 Electrostatic Classifier	24 Relay-interface box
12 Kr-85 neutralizer	25 Air supply filter
13 Atomizer regulator	26 Drain bottle, salt

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**Figure 2-1**  
Front View of the Model 8160 Automated Filter Tester



**Figure 2-2**  
Back View with Door Open

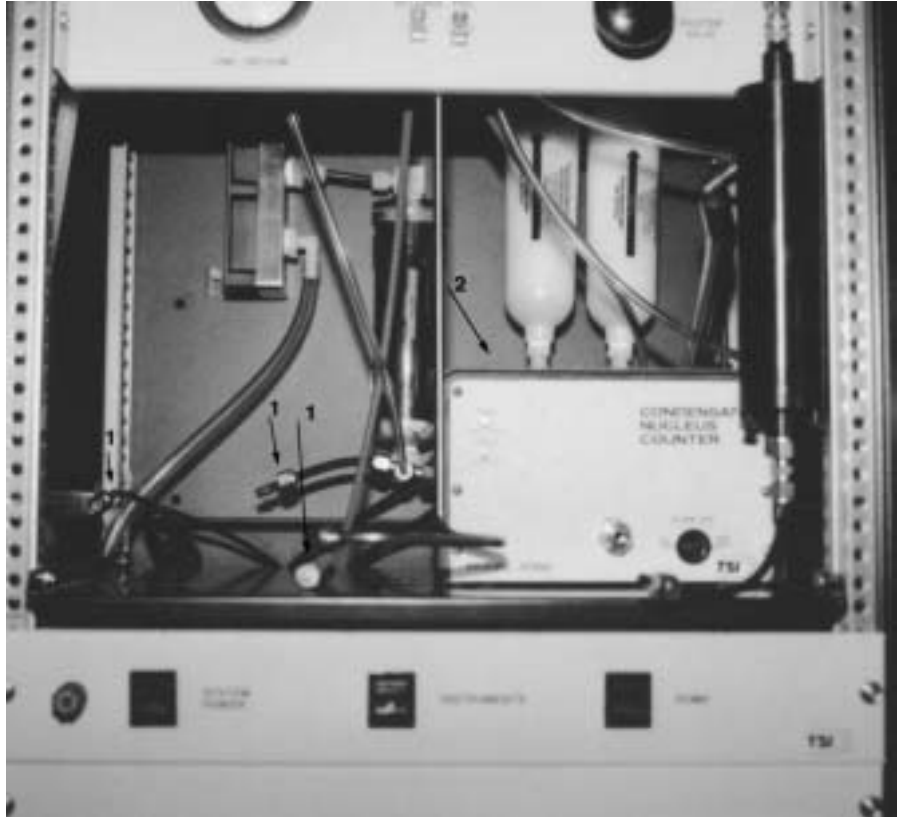
## Installing the Condensation Particle Counters

Find and unpack the two condensation particle counters (CPCs). To install these in the Model 8160 Automated Filter Tester (AFT) perform the following steps:

1. Open the clear cabinet door at the front of the AFT.
2. At the base of the cabinet is a shelf with holes to accommodate the rubber feet of each CPC. Power cords, BNC signal cables, vacuum tubing and alcohol fill tubing are present for connection to the CPCs. Cables labeled "A" should be connected to the left side CPC. Cables labeled "B" should be connected to the right CPC.

Place the first CPC to the right hand side. Position it so the rubber feet fit the appropriate holes. The right CPC uses all connections labeled "B" (Figure 2-3).

3. Connect the short black nylon vacuum line to the vacuum connector on the back of the CPC. Nuts are  $\frac{9}{16}$ " (Figure 2-4).
4. Connect the BNC cable to the BNC output jack on the back of the CPC (Figure 2-4).
5. Insert the quick-connect connector to the fill port on the back of the CPC (Figure 2-4).
6. Plug the power cord into the back of the instrument (Figure 2-4). Install the second CPC to the left hand side and repeat the connections described above with all connections labeled "A".
7. Install the stainless steel sample tubing to the front of the left CPC and the black plastic tubing from the diluter to the front of the right CPC.

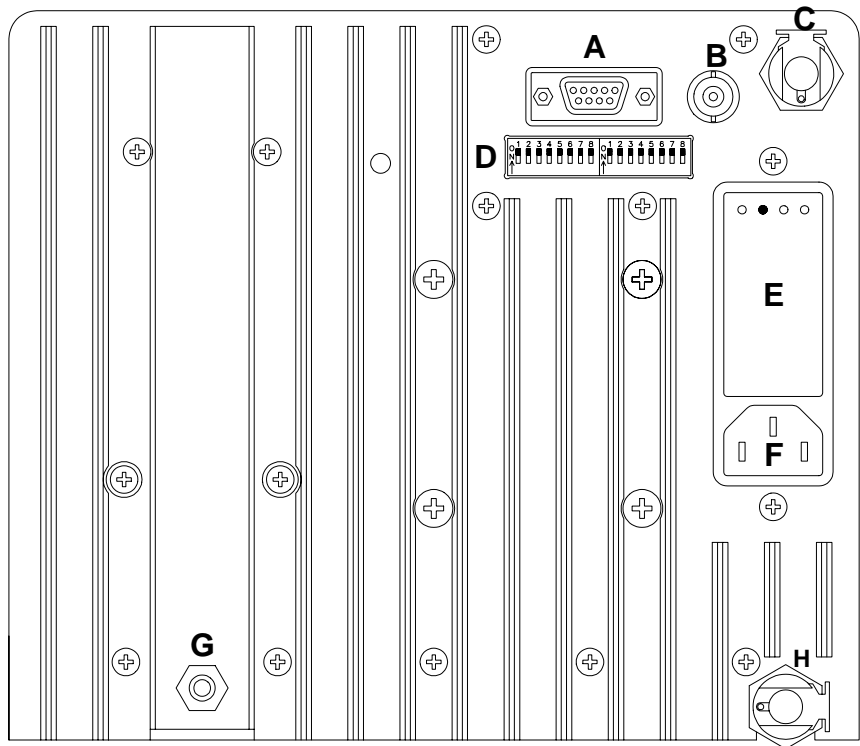


**Figure 2-3**  
Installing the Upstream CPC to Connections Marked "2"



## Back Panel

Figure 2-4 shows the back panel of the CPC. Back panel features include the COM port (A), BNC output (B), liquid fill connector (C), DIP switches (D), fuse panel (E), power cord inlet (F), vacuum connector (G), and liquid drain connector (H).



**Figure 2-4**  
CPC Back Panel



**Figure 2-5**  
CPCs Installed

## Installing the Electrostatic Classifier

The KR-85 neutralizer is shipped separately and must be installed before the Electrostatic Classifier can be used. Installation of the neutralizer in the Electrostatic Classifier is described in the Model 3080 Electrostatic Classifier manual found in the binder. Refer to that now.

The Electrostatic Classifier is installed from the front of the AFT cabinet, with the controls facing the front (Figure 2-6). The exact position of the Electrostatic Classifier will be determined by the stainless tubing which connects to it.

- 1.** Connect the power cord and BNC cable to the Electrostatic Classifier. The BNC cable connects to a mating receptacle which hangs from the back of the Electrostatic Classifier. This cable is routed from a connector on the left side of the relay/interface box (Figure 2-2).
- 2.** Connect the polydisperse aerosol line to the Electrostatic Classifier polydisperse inlet. The two steel polydisperse lines extend from the diffusion dryer on the left and from DOP atomizer manifold on the right. The Electrostatic Classifier should be shifted as necessary to make the connections with the least stress possible on the stainless tubing.
- 3.** Install the second KR-85 neutralizer between the two stainless steel tubes which make up the monodisperse aerosol line. This line connects the aerosol mixing manifold to the monodisperse aerosol outlet on the Electrostatic Classifier.

### **I M P O R T A N T**

It is critical that there are no leaks in the Electrostatic Classifier flow system. Make sure all fitting interconnections are snug.



**Figure 2-6**  
Electrostatic Classifier Installed

## Installing the Interface Cards and Computer Components

The computer system unit and computer printer are shipped separately and must be installed.



### **C a u t i o n**

To avoid damage to the circuitry, use electrostatic discharge (ESD) precautions when removing the cover of the computer:

- Use only a table top with a grounded conducting surface.
- Wear a grounded, static-discharging wrist strap

## **Interface Cards**

There are three interface cards which need to be installed in the computer system unit—if not already installed by the factory.

- 1.** Locate the Metrabyte Dascon-1 interface card and two TSI Single Channel Processor cards.
- 2.** The Single Channel Processor cards are installed first. Each card has been configured for a different I/O address. The CPC which measures upstream uses address 300H (hex) and the CPC measuring downstream uses 302H. Setting the desired addresses is done using jumpers as discussed in the Model 3704 Single Channel Processor manual in the binder. The cards are marked for upstream and downstream CPC interface.
- 3.** Remove the cover from your computer. Refer to the documentation which accompanies the computer.
- 4.** Before installing the cards touch a well grounded surface.
- 5.** Remove the downstream card from its static bag and place it in the lowest slot of the computer system unit. Place the upstream card in the next slot above.
- 6.** Remove the Metrabyte Dascon-1 interface card from its box and install in the top slot of the system unit. The dipswitch settings have been set at TSI, however, they should be verified using the schematic in the manual binder.
- 7.** Replace the cover on the system unit.

## **Printer**

To install the printer, follow these steps:

- 1.** Pull the printer drawer out fully until the stops are reached.
- 2.** Make sure the knob which adjusts the platen is removed. It is not needed.
- 3.** Center the printer forward on the drawer so it nearly touches the drawer front.
- 4.** Install paper in the tray under the printer platform.
- 5.** Bring the sheets up through the slot behind the printer and install. For specific information on paper installation refer to the printer manual.

- 6.** Close the drawer carefully to make sure the printer clears the sides and top panel.
- 7.** Connect the printer cable to the back of the printer and route it up to the shelf above.

The printer should be plugged into the power strip located at the back of the system unit shelf.



**Figure 2-7**  
Printer Installed

## Monitor and Keyboard

The monitor and keyboard are in a pullout section on the right side of the cabinet.



**Figure 2-8**  
Monitor and Keyboard

## System Unit

Make sure the system unit power switch is in the off position.

Remove the four screws securing the system computer to the cabinet (Figure 2-1). Place the system computer (with interface cards installed), on the extended keyboard drawer.

Make the following cable connections:

- Keyboard cable
- Printer cable
- Downstream CPC connector (BNC) #2
- Upstream CPC connector (BNC) #1
- 37 pin ribbon cable connector
- AC power cord
- Screw the ribbon cable connector to the back of the interface card with # 6 screws.

Once the cable connections have been made, carefully slide the computer system unit back on the shelf.

Replace the panel, moving the system unit as necessary so it fits through the panel opening.

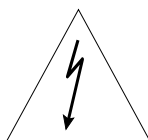
The computer shelf can be raised or lowered slightly for a better fit. Loosen the front mounting screws on the front of the shelf to accomplish this.

## AC Power

The Model 8160 has been designed for the voltage specified on the back panel. This is either 110-120 Volts, 60 Hz or 220-240 Volts, 50 Hz. The system fuse is to the left of the system power switch.

Line voltage is supplied to the junction box located on the lower left hand shelf, behind the filter flow valves. Power cables are hard wired in the box and break-out to the switches, CPCs, Electrostatic Classifier, pump, power supply and power strip. The power strip is located at the back of the computer shelf and supplies power to the computer system unit and peripherals.

Make sure the CPC and Classifier are set to the same voltage as the Tester.



### **C a u t i o n**

Only operate the tester at the voltage specified on the back panel. Attempts to operate the tester at other voltages may result in damage to the tester.



## Adding Air Supply and Aerosol Desiccant

Two silica gel desiccant air dryers are used with the AFT. The Air Supply Dryer (Figure 2-9) is used for drying the incoming supply air. The Diffusion Dryer (Figure 2-10) TSI Model 3062, is used for removing moisture from the salt aerosol. On a periodic basis the silica gel will need to be replaced in each dryer.

**Note:** *The compressed air valve must be turned off before the desiccant dryer can be disassembled.*

### Air Supply Dryer

Change the desiccant in the air supply dryer when the indicator granules turn pink. To add desiccant to the air supply dryer:

1. Press the thumb lock and rotate the top ring of the desiccator bowl.
2. Remove the bowl and add new desiccant.
3. Regenerate the old as described in the note below.
4. Replace the bowl and rotate until the thumb lock reengages. *A clean edge on the bowl necessary for bowl replacement.*

**Note:** *Used silica gel desiccant can be regenerated by heating in an oven at 300°F until the blue color reappears. Store the regenerated desiccant in an air tight container.*



**Figure 2-9**  
The Air Supply Conditioner

### **Diffusion Dryer**

When using the salt aerosol, check the silica gel desiccant in the Diffusion Dryer after every four hours of operation.

To check the desiccant:

- 1.** Drain the water from the water trap by loosening the reversed thread tap at its base.
- 2.** Remove the dryer by loosening the two fitting nuts next to the cabinet.
- 3.** Disassemble the dryer by unscrewing the end cap supporting the water trap.

4. Pour the wet silica gel into a container and examine it. If the indicator granules are still largely blue, mix up the crystals and return them to the dryer. If largely pink or white, set the silica gel aside for regeneration and add fresh desiccant. Refer to the Model 3062 Diffusion Dryer manual in the binder for more information.



**Figure 2-10**  
Aerosol Diffusion Dryer

5. Replace the diffusion dryer by reassembling and reinstalling on the cabinet side. To achieve the proper spacing of the connection fittings tighten or loosen the dryer caps, not the fittings.

## Supplying Compressed Air

The AFT requires clean, dry compressed air to operate. The air requirements are:

- 60 psi (413 kPa) line pressure and
- 70 lpm free air when an electric filter flow pump is used or 220 lpm free air when an air driven filter flow pump is used for filter flow.

Make sure the tester is off before connecting your compressed air line to the tester.

Connect the pressurized air to the compressed air inlet shown in Figure 2-11.



#### **W A R N I N G**

Always disconnect the compressed air prior to changing the air supply desiccant. High velocity air may propel the desiccant resulting in serious injury.

The Air Supply Conditioner (Figure 2-9) cleans and dries the air used with the AFT 8160. The air supply consists of a pre-filter/regulator, desiccator, and final filter assembly. If during operation, the pre-filter is filling with oil or water, or the desiccant is requiring frequent changes (every day), then the incoming air needs additional treatment to remove these contaminants.



**Figure 2-11**  
Compressed Air Inlet

## **Exhausting**

It is recommended that the exhaust from the CPC vacuum pump be routed away from the work area, especially if the space is confined. Although the CPC vacuum pump exhaust is filtered with an activated carbon capsule, butanol vapors escape.

½" ID Flexible vinyl tubing is ideal for connecting to the plastic elbow fitting on the CPC vacuum pump. The tubing can be brought out under the cabinet and exhausted outside or to a vent hood.



### **C a u t i o n**

Do *not* kink the tubing from the CPC pump exhaust. A reduction in the vacuum pressure may occur affecting the accuracy of CPC measurements.



### **C a u t i o n**

Butanol is flammable. Butanol is also potentially toxic if inhaled. Use butanol only in a well-ventilated area. If you smell butanol and develop a headache, or feel faint or nauseous, leave the area at once. Ventilate the area before returning.

## **Mixing the Aerosol Generator Solutions**

The AFT uses two sets of bottles shown in Figure 2-12. These bottles provide solutions for atomization by the aerosol generators to produce the challenge aerosols.

The upper bottles are for solutions of DOP (dioctyl pthalate) in isopropanol. The lower bottles are for solutions of NaCl (table salt) in distilled water. DOP is used when liquid particles are needed. NaCl is used for producing solid particles.

### **Mixing DOP Solutions**

DOP oil is mixed with reagent grade isopropanol (isopropyl alcohol), in the three 1 liter bottles shown in Figure 2-12.

The concentrations of DOP are:

- Bottle 1. .3%
- Bottle 2. .03%
- Bottle 3. .003%

The isopropanol purity should be <.0001% dissolved solids.

1. Remove the DOP bottles by unscrewing each. Drop the bottles down and away carefully to avoid damaging the spiral draw tubes.
2. Mix the .3% solution in bottle 1 by adding 3 ml of pure DOP to 1 liter of isopropanol. Make the .03% solution by removing 100 ml of the .3% solution from bottle 1 and add it to bottle 2.
3. Fill bottle 2 with 900 ml of isopropanol. Make the .003% solution in the same way, but this time add 100 ml of the .03% solution of bottle 2 to bottle 3.
4. Fill bottle 3 by adding 900 ml of isopropanol.
5. Replace each bottle by sliding it carefully over the spiral draw tube.

### **Mixing the NaCl Solutions**

NaCl is mixed with distilled (deionized) water in the three 1 liter bottles shown in Figure 2-12.

The NaCl concentrations are:

- Bottle 1. 1%
  - Bottle 2. 0.1%
  - Bottle 3. 0.01%
1. Remove the NaCl bottles by carefully unscrewing and dropping each down and away. Avoid damaging the thin draw tubes hanging into the bottles.
  2. Mix the 1% solution in bottle 1 by adding 10 grams NaCl to 1 liter of distilled water. Mix thoroughly by shaking or stirring.
  3. Make the .1% solution by removing 100 ml of the 1% solution from bottle 1 and add it to bottle 2.
  4. Fill bottle 2 with 900 ml of distilled water.
  5. Make the .01% solution in the same way, but this time add 100 ml of the .1% solution of bottle 2 to bottle 3.
  6. Fill bottle 3 by adding 900 ml of distilled water.
  7. Replace the bottles by sliding each carefully over its thin steel draw line.



**Figure 2-12**  
Aerosol Generator Bottles

## Filling the CPCs With Butanol

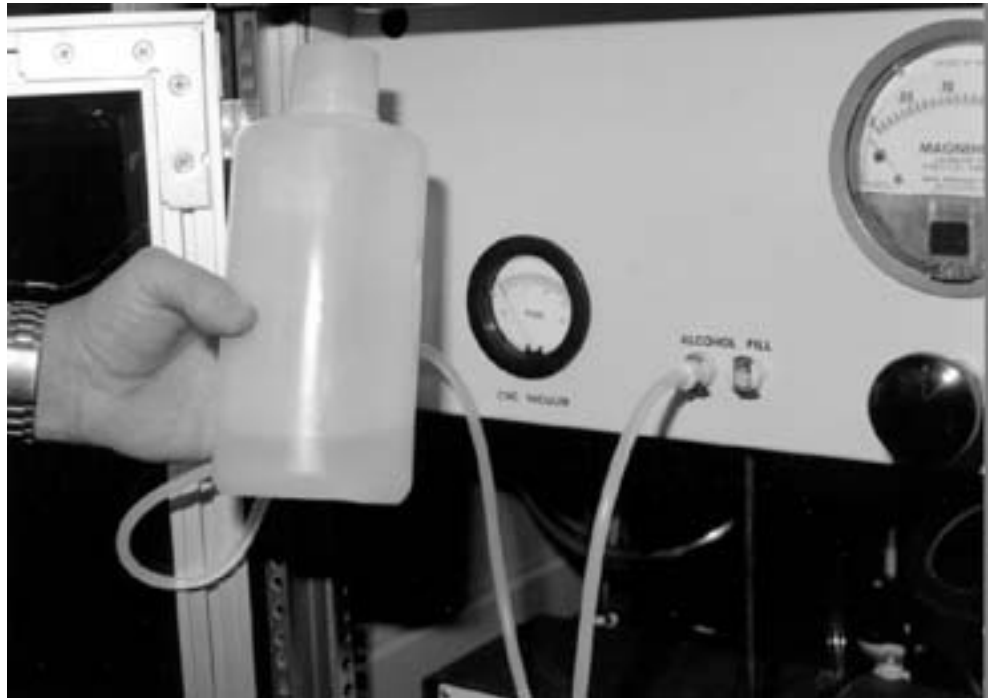
Initially, the Model 3760A Condensation Particle Counters (CPCs) should be filled with butanol to about halfway up the sight glass to the fill mark. The alcohol will need to be replenished about twice weekly.

To fill the CPCs with butanol, perform the following steps.

- 1.** Locate the two female quick-connect ports which are used for filling the CPCs with butanol (Figure 2-13). These ports are located on the gauge panel behind the front access door. The ports are connected to the CPC alcohol reservoirs by butanol resistant rubber tubing.
- 2.** Locate the bottle supplied for filling the CPCs with butanol (Figure 2-13). Fill the bottle with reagent grade n-butyl alcohol (butanol).

3. Make certain that the tester is OFF. Connect the butanol bottle to the CPC fill port (Figure 2-13). Open the bottle cap slightly to provide a vent when filling.
4. Watch the sight glass carefully while filling. When the liquid level is in the middle of the sight glass, disconnect the bottle from the fill connector.

**Note:** Do not overfill the CPC. The liquid level should not exceed the middle of the sight glass, as indicated on the CPC.



**Figure 2-13**  
Filling the CPCs with Butanol

## Installing the Software

Before Installing the Automated Filter Test software, make sure DOS has been installed on the computer hard drive (drive path C:\DOS). Instructions for installing DOS are in the manual accompanying DOS.



Turn the computer on. When the computer has finished booting insert the AFT program disk into the floppy drive (drive A:). Key in "A:" and press <Enter> to access drive a:. From drive a:, run the Setup program by typing the word SETUP, followed by pressing the <Enter> key.

The batch file SETUP.BAT will load a CONFIG.SYS file and AUTOEXEC.BAT file onto the hard drive root directory (C:\). Two new directories will also be formed; >AFT60 and >FTDATA. The directory >AFT60 will contain the operational programs. The directory >FTDATA can be used to store test data.

Once the files have been loaded, remove the program disk from drive a: Store the disk in a safe place.

From now on the AFT software will boot automatically whenever the computer is turned on. CTRL ALT DEL also starts the program if the computer is on.



## CHAPTER 3

# Filter Tester Components

The information in this chapter describes the main components of the Model 8160 Filter Tester.

---

## Computer Monitor Printer

A computer is used to control AFT operation, data acquisition and data display. The computer is rack mounted (Figure 2-1). A 13" color video monitor is used. An Epson dot matrix printer is used for printouts after each test.

---

## Computer Interface Cards

Two TSI Model 3704/7604 Single Channel Processor cards are installed in card slots in the computer. Each card is connected to a Model 3760A Condensation Particle Counter (CPC). These cards accumulate particle count data from the CPCs. When polled by the computer, these cards provide the number of particle counts and the time interval over which the counts were taken. Once polled, the card buffer is zeroed and new data begins to accumulate.

The DASCON-1 card manufactured by Metrabyte Corporation, is a multifunction I/O card. This card provides an interface with the computer to control eight 12-volt solenoid valves in the AFT. The DASCON-1 card also converts the analog voltages from the pressure and flow transducers to digital signals for the computer. This card also provides a D/A function, supplying an analog signal for controlling the rod voltage on the Electrostatic Classifier.

Manuals for these cards are included with the AFT 8160 documentation.

---

## Condensation Particle Counters (CPCs)

Filter penetration measurements are made using two TSI Model 3760A Condensation Particle Counters (Figure 3-1). The CPC on the right measures the aerosol concentration upstream of the filter and the CPC on the left measures the aerosol concentration downstream of the filter. The sample flow through the CPCs is controlled by orifices within each instrument.

For detailed information on the Condensation Particle Counters, refer to instrument manual within the manual binder.



**Figure 3-1**  
The Condensation Particle Counters (CPCs)

---

## Electrostatic Classifier

The Electrostatic Classifier Electrostatic Classifier, (Figure 2-6) produces particles of specific sizes for filter testing. The Electrostatic Classifier sorts particles by their electrical mobility from the polydisperse aerosols produced by the DOP and NaCl aerosol generators.

The standard range of particle sizes possible is between .015 and .4 micron. This particle size range depends upon the flow through the instrument and the electric field through which the particles pass. The computer software is able to vary the electric field voltage in the Electrostatic Classifier and in this way control particle size automatically during testing.

For detailed information on the Electrostatic Classifier refer to the instrument instruction manual in the binder.

---

## Electrostatic Classifier Inlet Pressure Gauge

The Electrostatic Classifier inlet pressure is monitored on the Classifier and is labeled Impactor Pressure.

Over time, the Electrostatic Classifier will accumulate aerosol particles (especially NaCl) in the filters, lines, and orifices, causing a restriction in flow through the instrument. The displayed inlet pressure measurement will inform you of the need to clean the Classifier by displaying an increasing internal pressure.

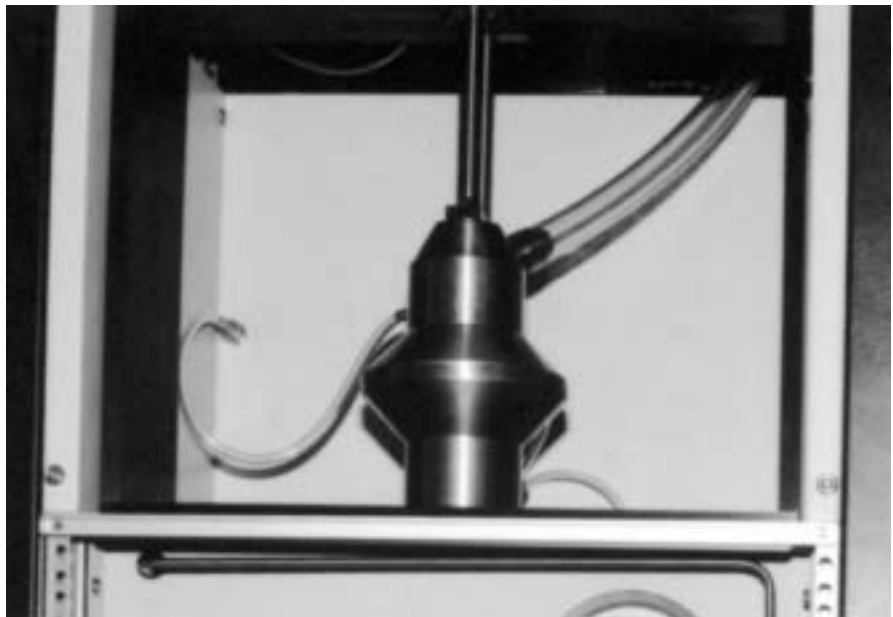
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## Filter Holder

The challenge aerosol passes from the upper filter holder to the lower filter holder. Aerosol is sampled from the upper and lower filter holders to obtain the penetration measurement.

The filter holder (Figure 3-2) has removable upper and lower attachments which can be modified or exchanged to hold filter media or filters of many different configurations. The filter holder shown has been designed to hold filter media. The upper filter holder is mounted to a non-rotating air cylinder and descends when the CLOSE keypads are pressed to clamp the filter. The CLOSE keypads must be depressed together and held for one second.

Pressing the OPEN button causes the filter holder to retract.



**Figure 3-2**  
The Filter Holder

---

## Pressure Transducer

A Model 220 Electronic Manometer is used for the measurement of filter resistance. This instrument compensates for zero drift by operating the sensor at an elevated temperature to reduce ambient temperature effects. The transducer is calibrated for use over a range of 0 to 150-mm H<sub>2</sub>O (optional 0 to 200-mm H<sub>2</sub>O), with a 2-volt output. Accuracy is specified as 0.15% of reading.

---

## Flowmeter

A TSI Model 2012 mass flowmeter is located inside the Filter Tester cabinet behind the flow control valves and is used to monitor filter flowrate. This meter produces a linear output of 0–5 volts for a measurement range of 5–150 lpm.

A manual describing the Model 2012 Flowmeter is found in the binder.

---

## Flow Adjustment Valves

The flow adjustment valves (Figure 2-1) control the flowrate through the filter holder and filter. The flowrate is displayed in real time when the Flow Set-Up option is chosen from the tester software. To adjust the flow, use the coarse valve in either the on (vertical handle position) or off (horizontal handle position) for high and low flows respectively. Use the fine flow adjustment valve to adjust to the specific flow needed.

---

## Aerosol Diluter

The aerosol diluter (Figure 3-3) is used to reduce the concentration of the aerosol sampled by the upstream CPC. This dilution is necessary because the CPC count accuracy is lost when concentrations are too high.

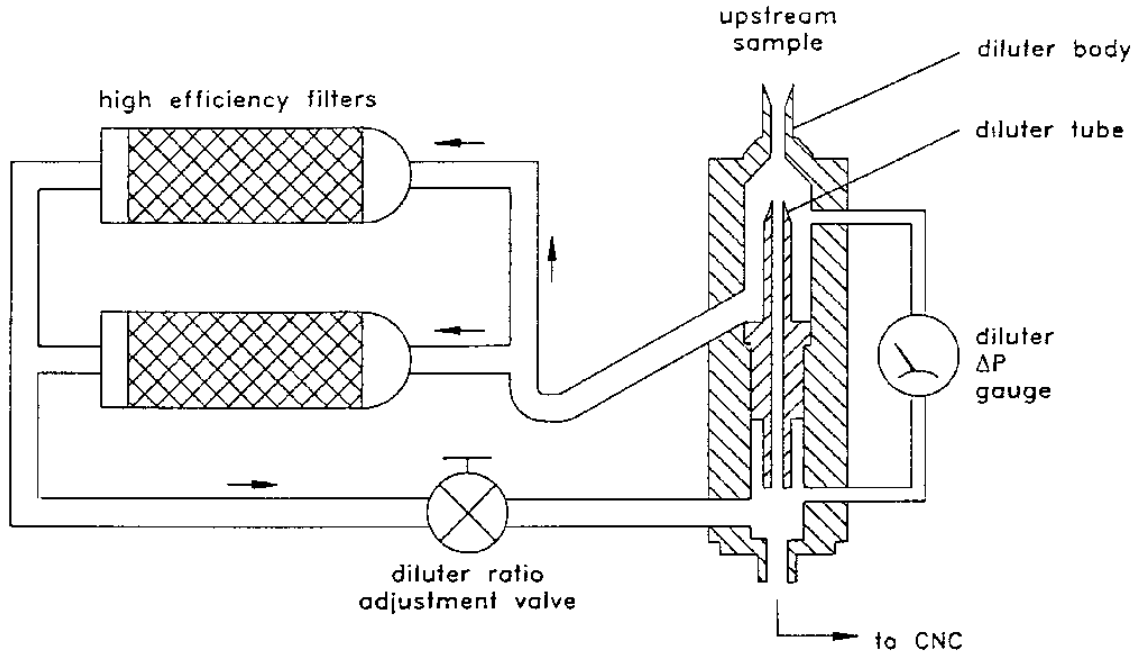


**Figure 3-3**  
The Aerosol Diluter

The upstream aerosol can have a concentration of over one million particles/cc for some particle sizes. Refer to the discussion of particle coincidence in the CPC instruction manual and in Chapter 7 of this manual.

The diluter works by splitting the aerosol sample, filtering one portion, and then remixing it with the unfiltered portion. The ratio of the portion of unfiltered aerosol to total aerosol determines how much the sample is reduced. This ratio is referred to as the diluter ratio. The AFT must operate with a diluter ratio of 100:1. Refer to the schematic (Figure 3-4) for assistance in understanding the diluter operation.





**Figure 3-4**  
Aerosol Diluter Schematic

Setting and maintaining the correct diluter ratio is an important part of AFT operation. This procedure is described in the section "Setting the Diluter Ratio," Chapter 5.

The main diluter components are the diluter valve, diluter body, diluter tube, gauge and filters.

---

## Aerosol Diluter Valve

The aerosol diluter valve (Figure 3-3) is located behind the CPC compartment door and is used to adjust the diluter ratio to 100:1. Dilution of the upstream aerosol is necessary to reduce concentration measurement errors which result from coincidence when particle concentration is too high.

The diluter works by splitting the aerosol sample, filtering one portion, and then remixing it with the unfiltered portion. The ratio of the split controls the dilution ratio. The split ratio is adjusted using the aerosol diluter valve.

The diluter ratio is adjusted while using the **Adjust Diluter** option in the software.

---

## Diluter Pressure Drop Gauge

The diluter gauge measures the pressure drop across the diluter. The flow through the center diluter tube is directly related to this pressure. The tube flow must be  $\frac{1}{100}$  of the total diluter flow to achieve the required dilution. Since the total flow is established by the CPC flow of 1.41 lpm, the diluter tube flow is .0141 lpm. As long as the CPC flow remains constant and the tube remains clean and free of damage, the pressure measured by the gauge will remain constant.

---

## Dilution Bridge

The dilution bridge is shown in Figure 3-5. This device reduces upstream concentrations when necessary to protect to downstream CPC from high concentrations. Such high concentrations occur when setting the diluter ratio (filter holder is empty) and when testing filters of high penetration (low efficiency). The dilution bridge is controlled automatically by the computer.



**Figure 3-5**  
The Dilution Bridge

The dilution bridge operates using a principal similar to the aerosol diluter described above; splitting the aerosol into two portions, filtering one portion and remixing.

A solenoid valve activates the dilution bridge in response to a command from the computer. The dilution bridge is automatically activated when the Adjust Diluter option is selected. During testing, the computer evaluates the CPC concentrations, and turns on the dilution bridge if certain criteria are met. Refer to the “Particle Coincidence” section in Chapter 7.

---

## Power On/Off Switch

The Power On/Off switch (Figure 2-1) controls the main power to the Model 8160 Filter Tester. The Instrument and Pump switches can be turned on only once the Power switch is on.

---

## CPC Vacuum Gauge

The CPC vacuum gauge is located inside the Filter Tester. An orifice within the CPC, just ahead of the outlet is used to maintain a constant CPC sample flow. In order for this to occur, the vacuum pressure measured by the gauge must remain above 8 psi. A lower value indicates a possible leak.

---

## Aerosol Generators

The aerosol generators consist of the solution supply bottles (Figure 2-12), plastic draw lines, and six atomizer heads (Figure 3-6).

Each atomizer head draws solution through a plastic draw line from its own bottle. Three generators are used for producing aerosols of NaCl, and three generators for producing aerosols of DOP. The solution concentration of DOP (in isopropanol) or NaCl (in distilled water), determines the polydisperse particle size distribution produced by the aerosol generator.

The aerosol is output when one of six solenoid valves is activated. The valve supplies pressurized air to an atomizer head. Within each atomizer head is a small orifice which forms a high velocity jet in the presence of the high pressure. A local lowering of pressure caused by the jet draws liquid from the solution bottle into the jet. The shearing action of the jet breaks the liquid into a fine aerosol mist. The aerosol follows a path to the polydisperse inlet on the Electrostatic Classifier.



**Figure 3-6**  
Aerosol Generators

---

## Relay/Interface Box

The relay/interface box is shown in Figure 2-2 (29). This compartment contains the valve control relays, a screw terminal PC board and the 12 V valve power supply. The ribbon cable from the computer runs into the box and connects to the screw terminal board. LEDs on the board light when lines are activated.

BNC connectors for the flow and pressure transducer voltages are mounted on the front of the box, allowing independent reading of voltage signals from these transducers (left is flowmeter; right is pressure transducer).

A third BNC connector is located on the left side wall of the relay/interface box. The signal from the computer which controls Electrostatic Classifier rod voltage is output here. A cable runs from this connection to a connector at the back of the Electrostatic Classifier.

---

## Power Supply

The AFT uses a 12 volt power supply for turning on the solenoid valves in the system (Figure 2-2). The power supply is mounted in the relay/interface box.

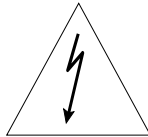
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## Electrical Junction Box

The gray electrical junction box is located behind the filter flow control valves on the lower left hand shelf (Figure 3-7). AC power is routed from this box to the following locations:

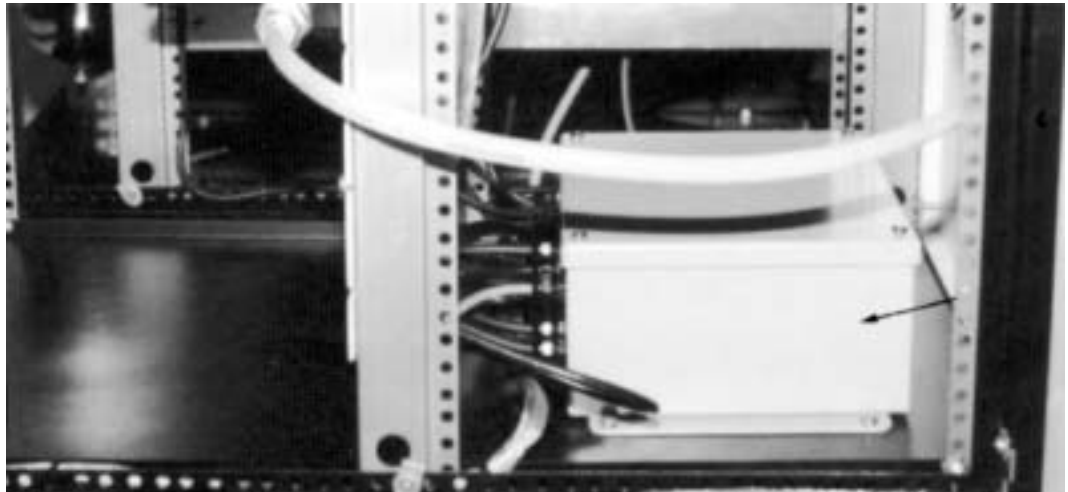
- The CPCs
- The Electrostatic Classifier
- The power supply for the valves
- The power strip for computer, monitor and printer
- The front panel switches
- The vacuum pump

A schematic of the AC power routing and junction box is included in the manual binder.



**W A R N I N G**

Do *not* do any work on this box unless the power to the tester has been disconnected.



**Figure 3-7**  
Electrical Junction Box, Side Panel Removed





# Software Operation

The information in this chapter describes control keys and menu options for the Model 8160 Filter Tester software. Also refer to Chapter 7, “More on the Software,” for information on particle coincidence calculations and program options that handle disk files.

---

## The Program Disk

The programs used with the AFT are contained on a single 3.5-inch floppy disk labeled AFT 8160 Software. The disk is found in the plastic insert at the front of the manual.

The standard disk contains the following programs:

- setup.bat
- autoexec.bat
- config.sys
- ft.exe
- aft.exe
- default.siz
- default.par
- swtchbot.fil
- datacall.wk1

**Note:** *Because of varying customer requirements, software can differ slightly from one tester to another. The key software programs ft.exe and aft.exe may have somewhat different names for identification purposes. An additional software instruction manual will accompany this different software disk, and describes options and operations which are unique to the software.*

The software programs are loaded onto the computer's hard disk drive using the batch file setup.bat. Instructions for installing the program files are presented in the Chapter 2 section, “Installing the Software.”

Programs *ft.exe* and *aft.exe* contain the compiled program for operating the AFT. File *ft.exe* contains the heading and calls the *aft.exe* program.

The files entitled *default* contain particle size and test run parameter information. The values in these files can be changed later from the software to meet specific test requirements. This is described later.

File *swtchbot.fil* tells the program which particle sizes require which bottles (that is, which solutions) to use.

The file *datacall.wk1* is an example Lotus 123<sup>®</sup> spread-sheet macro for retrieving filter test data saved to disk. Once loaded, the test data is formatted. Refer to Chapter 7 for more information on *datacall.wk1*.

---

## Keys Controlling Program Operation

The <Alt> key is used to highlight an option in the *main menu* bar. Once highlighted, a *secondary menu* is pulled down using the arrow down key, <Enter> or by pressing the designated letter.

The arrow keys are used to move from option to option when a menu is displayed. The menu option which is highlighted is activated by pressing the <Enter> key.

<Esc> is used to return to the previous menu option, or to stop a test or print out. Pressing the <Esc> key repeatedly returns you to the *main menu*.

In addition to activating menu options, the <Enter> key is used to input typed parameters such as particle sizes or filenames.

The <Tab> key is sometimes used in place of the arrow keys specifically, for the alert screen options. Alert screens contain error messages or information. Option items on alert screens are presented horizontally.

---

## Menu Option Selection and Screens

Press the <Alt> key to turn on the main menu options. Once on, select a main menu option using the left and right arrow keys.

Main menu options are:

**Setup Run Graph Data Options Exit**

Each of these is the heading for a secondary menu. The secondary menu can be displayed, once turned on, by pressing the down arrow key or by pressing the <Enter> key.

Choose an option from the secondary menu by pressing the highlighted letter of the option or by using the up and down arrow keys and the <Enter> key.

Screens appear when options are selected from the secondary menus. The screens provide information on test parameters and/or may contain menus themselves. Most screens have a title at the top, in capital letters.

---

## Menu Options

This section gives a description of the software menu options organized by the menus: Setup, Run, Data, Graph, Options, and Exit. Additional information on the software options that handle disk files is provided in Chapter 7, "More on the Software."

## Setup Menu

<b>Aerosol</b>	This option is used to select the challenge aerosol (NaCl or DOP). Use the arrow keys to select the aerosol type, then press <Enter>. Press <Esc> to exit.
<b>Particle Sizes</b>	<p>This option is used to choose particle sizes for filter testing. It is also possible to enter a correction factor for each particle size. Correction factors can be entered to compensate for size sensitive sampling biases between CPCs.</p> <p>When this option is chosen the following menu items are presented:</p> <p style="padding-left: 40px;">Enter Sizes Load File Save File Delete File</p> <p>Choose Enter sizes to examine the current particle sizes on the ENTER SIZES screen. If satisfactory, exit to the main menu via &lt;Esc&gt;.</p> <p>It is possible to <i>Add</i> new sizes or <i>Delete</i> particle sizes by selecting the appropriate option from the ENTER SIZES screen. As before, the arrow keys and &lt;Enter&gt; are used to perform the operations. If <i>Erase</i> is chosen, all particle sizes will be cleared. If <i>Cancel</i> is selected, changes made with <i>Add</i>, <i>Delete</i> or <i>Erase</i> will be ignored.</p> <p>Enter particle sizes and corrections as shown in the following example:</p> <p>Enter size: 0.085/.98</p> <p>The particle size is 0.085 microns and comes first. The correction factor is .98. This value must be separated from the particle size by a slash (/). The correction factor must be between .1 and 2. or the default "1" is used.</p> <p>Refer to the Chapter 6 section, "Test Results," for more on correction factors.</p> <p>Load File, Save File and Delete File are options that allow the manipulation of files containing particle sizes which have been entered and saved on disk. These and other disk file options are described in the "Program Options That Handle Disk Files," section in Chapter 7.</p>
<b>Flow Setup</b>	This option displays the current filter flow, pressure drop and face velocity. The data is read from the transducers and updated every second.

(continued)

<b>Adjust Diluter</b>	<p>This option is used when adjusting the diluter ratio. The diluter ratio is displayed as a percent, and should read 100% when adjusted properly.</p> <p>From the ADJUST DILUTER screen, press &lt;Enter&gt; to turn on the .1 micron aerosol and begin the stability countdown. Adjustment of the diluter ratio should not begin until after the aerosol has stabilized.</p> <p>When adjusting the diluter, the filter holder must be closed and empty. The diluter gauge pressure should be set to about .13 mm H<sub>2</sub>O initially. When finished with the adjustment, record the value on the diluter gauge for future reference. This value will be between .10 and .15 mm of H<sub>2</sub>O.</p> <p>If "*****" appears as the diluter ratio, the ratio measured is outside the range one to three hundred percent. This severe out of range usually results because the filter holder has been left open or a filter is in the holder.</p>
<b>Downstream Sample</b>	<p>Two parameters affecting the downstream sample can be chosen from this screen. The test will sample downstream until, (1) the minimum number particles is counted, or (2) the maximum time for the downstream sample elapses.</p> <p>Press the &lt;Spacebar&gt; to clear the old time or count value. Input a new value and press &lt;Enter&gt;.</p> <p>Time is entered in minutes.</p> <p><b>Note:</b> <i>Ten seconds of data is taken regardless of the number of particles counted.</i></p>
<b>Classifier Flows</b>	<p>Use this option when adjusting the sheath and excess flows for the Electrostatic Classifier. When this option is chosen, an atomizer is turned on and the required sheath air and excess air flows are displayed.</p>

(continued)

<b>Test Identification</b>	<p>This screen allows you to enter specific information to identify the next test(s). This information is printed on the heading of the data sheet at the conclusion of the filter test.</p> <p>Eight fields are available for user input. The first, the heading field, allows you to alter the printout heading. The second is a field of equal length, (60 characters), and allows the entry of a test note. The final six fields provide the option to enter "labels" of up to ten characters. Before a test is run, a screen appears with each label and awaits a typed response. An example is shown below:</p> <p style="padding-left: 40px;"><i>label</i>                      <i>response</i> Filter no.                      b-1002-01</p> <p>The response can be 10 characters.</p> <p>The label and response appear on the printout following the filter test.</p>
<b>Review Parameters</b>	<p>This screen and menu provide an extensive review of all parameters affecting the filter test.</p>

## Run Menu

<b>Go</b>	<p>Starts the test. When chosen, an instruction screen, the filter flow screen, and the label response screens are displayed following repeated &lt;Enter&gt; keystrokes. F1 automatically invokes the Go command.</p>
<b>Step Through</b>	<p>This option provides a list of tasks to perform prior to the test. Using the option prevents a possible oversight such as a failure to set classifier flows.</p>

## Data Menu

<b>Set Save Status</b>	<p>From this screen, the choice is made to save data to a disk automatically after the test is complete. If the save status is turned ON, then data is saved; if the save status is OFF, no data is saved. A filename must be entered for the save status to be turned ON.</p>
------------------------	--

(continued)

<b>File Immediate</b>	<p>This option is for handling data files. Choice of this option produces the following menu screen:</p> <ul style="list-style-type: none"> <li>Load and Display</li> <li>Save Data File</li> <li>Delete Data File</li> </ul> <p>The <b>Load and Display</b> option loads a chosen data file from disk (see limitation below). The loaded data is then automatically displayed. Pressing &lt;P&gt; initiates a printout of the display.</p> <p>The <b>Save Data File</b> option immediately saves data from the last test to a disk file. If the filename already exists, then the data can be appended to the file.</p> <p>Appended data cannot be accessed through <b>Load and Display</b>. This data is accessed through data base software.</p> <p>The <b>Delete Data File</b> option frees up of disk space by allowing the elimination of data files.</p> <p>These options and other options which handle disk files are described in greater detail in Chapter 7.</p>
<b>Display</b>	<p>The current data is displayed in the test screen format; tabular and graphical information are presented together. Pressing &lt;P&gt; initiates a printout of the display.</p>

## Graph Menu

<b>Go</b>	<p>A high resolution graph of the current data is displayed when &lt;Enter&gt; is pressed.</p> <p>Pressing the arrow keys expand the graph horizontally and increase/decrease the number of decades displayed. One to four decades are possible for the display.</p> <p>Pressing the &lt;Spacebar&gt; toggles the display between percent penetration and percent efficiency.</p> <p>Pressing &lt;P&gt; initiates a printout. This printout will include the complete heading, tabular data and the chosen graph format.</p>
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## Options Menu

<b>Concentrations</b>	This option displays the CPC concentrations, filter flow and resistance. A particle size must be entered initially, followed by <Enter>. This option is most useful for trouble shooting.
<b>Parameters Files</b>	<p>The Parameter files contain all information required for running a filter test. Parameter information can be saved for later retrieval, avoiding the need to manually reenter frequently used parameters. Choice of Parameter files produces the following screen.</p> <p style="padding-left: 40px;">Load Parm. File Save Parm. File Delete Parm. File</p> <p>To select an option above, use the up-down arrow keys followed by &lt;Enter&gt;.</p> <p>These and other disk file options are described in detail in “Program Options Which Handle Disk Files” section in Chapter 7.</p>
<b>Default Drive</b>	<p>Use this option to change the default path for saving particle size files, parameter files and data files to disk. The path c:\ftdata is the default path created by the Setup batch file.</p> <p>This and other disk related options are described in detail in the “Program Options That Handle Disk Files” section in Chapter 7.</p>
<b>Temp/Press</b>	Ambient air temperature and pressure are entered here. These values are used to calculate volumetric air flow from the mass flow measured by the thermal flowmeter (TSI Model 2012). Default values are 21°C and 760 mm Hg.
<b>Cross Section</b>	The filter holder cross sectional area is entered from this option. A correct cross section is necessary for the calculation of face velocity. Press the <Spacebar> to clear the current entry. Enter a new value (in square cm) and press <Enter>.
<b>Classifier</b>	The classifier flows can be changed to extend the particle size range or improve the monodispersity of the challenge aerosol. The program is informed of any flow change from this screen. These values <i>must</i> correspond to the actual classifier flows used during AFT operation.



## Exit Menu

<b>Dos-Shell</b>	Select this option to exit to the DOS environment. To return to the filter test program type the word "exit" followed by <Enter>.
<b>Quit</b>	Use this option to leave the filter test program. All data currently residing in memory will be lost.



## CHAPTER 5

# Operating the Filter Tester

This chapter gives operating instructions for the Model 8160 Filter Tester.

---

## Start up Procedure

The following is the start-up procedure which is completed before a test can be performed. This section assumes that the Model 8160 is ready for operation (refer to “Setting Up” in Chapter 2).

Complete each procedure in the order outlined in Table 5-1 below. The instructions for each procedure are contained in the remainder of this chapter.

**Table 5-1**  
Procedure to be Completed

- 
1. Turn on system power
  2. Start the software program
  3. Check the aerosol generators
  4. Check the aerosol and air supply desiccant
  5. Check the CPC butanol level
  6. Set main pressure regulator
  7. Set aerosol generator pressure
  8. Set filter holder pressure
  9. Check CPC vacuum pressure
  10. Warm-up Period
  11. Set the diluter ratio
  12. Set classifier flows
  13. Set up the printer
  14. Performing a filter test
- 

---

## Turn on the System Power

The system power switch is shown in Figure 2-1. Before switching the system power on, make sure the instruments and pump switches are off.

Turn the system power switch on.

---

## Start the Software Program

The filter test program must be started before the instrument power switch is turned on.

1. Turn the computer on.
2. Press <Esc> when TSI logo appears.

If the AFT software program has been installed properly using the SETUP file, the filter test program boots automatically when the computer is turned on.

---

## Check the Aerosol Generators

Check the solution levels in the aerosol generators. The stainless draw lines should be well under the liquid surface. When refilling consider that the DOP solutions are consumed more rapidly than salt solutions since the liquid is not recirculated.

Refer to the “Setting Up” section in Chapter 2 or to Chapter 8, “Maintenance” for instructions on mixing aerosol generator solutions.

---

## Check the Diffusion Dryer Desiccant

When using the salt aerosol, check the silica gel desiccant in the Diffusion Dryer (Figure 2-10) after every four hours of operation.

To check the desiccant:

1. Drain the water from the water trap by loosening the reversed thread tap at its base.
2. Remove the dryer by loosening the two fitting nuts next to the cabinet.
3. Disassemble the dryer by unscrewing the end cap supporting the water trap.

4. Pour the wet silica gel into a container and examine it. If still largely blue, mix up the crystals and return them to the dryer. If largely pink or white, set the silica gel aside for regeneration and add fresh desiccant. Refer to the Model 3062 Diffusion Dryer manual in the binder for more information.
5. Replace the diffusion dryer by reassembling and reinstalling on the cabinet side. To achieve the proper spacing of the connection fittings tighten or loosen the dryer caps, not the fittings.

**Note:** *Used silica gel desiccant can be regenerated by heating in an oven at 300 degrees F until the blue color reappears. Store the regenerated desiccant in an air tight container.*

## Check the Air Supply Desiccant

Refer to Figure 2-7 to identify the air supply desiccant holder.



### C a u t i o n

Always turn the power to the Model 8160 AFT OFF before changing the desiccant.

To change desiccant:

1. Press the thumb lock and rotate the top ring on the desiccator bowl.
2. Lower the bowl to separate.
3. Pour out the used desiccant and replace with fresh.
4. Clean the top lip of the bowl and replace.
5. Rotate the top until the thumb lock reengages.

**Note:** *The used silica gel desiccant can be regenerated by heating in an oven at 300°F until the blue color reappears. Store the regenerated desiccant in an air tight container.*

---

## Check the Condensation Particle Counter Butanol Level

Check the butanol level in each CPC by looking at the sight glass (Figure 3-1). The liquid level should be visible for proper operation, and should be about in the middle of the sight glass when full. If the tester is run continuously, you can expect to add butanol about twice a week. If the CPCs need additional butanol, perform the following steps using Figure 5-1 as a reference:

- 1.** Turn the main air supply valve OFF.
- 2.** Locate the two female quick-connect ports. These ports are located on the gauge panel behind the access door on the front of the AFT.
- 3.** Locate the bottle supplied for filling the CPCs with butanol. Fill the bottle with reagent grade n-butyl alcohol (butanol).
- 4.** Note the sight glass on the front of the CPC you wish to fill.
- 5.** Connect the butanol bottle to the fill port. The Left and right ports are used to fill the left and right CPCs, respectively. Open the bottle cap slightly to provide a vent when filling.
- 6.** Watch the sight glass carefully while filling. When the liquid level is in the middle of the sight glass, disconnect the bottle from the fill connector. There is a float in each CPC which should prevent overfilling; however it should not be relied on for this purpose.



**Figure 5-1**  
Filling the CPCs with Butanol

---

## Set the Main Pressure Regulator

Turn the air supply valve on (Figure 2-9). Adjust the main pressure regulator to 60 psi.

---

## Set the Aerosol Generator Pressure

Adjust the aerosol generator regulator (Figure 5-2) to 40 psi.



**Figure 5-2**  
The Aerosol Generator Pressure Regulator

---

## Set the Filter Holder Pressure Regulator

The filter holder pressure regulator is accessed through the back door of the AFT (Figure 5-3). This regulates the clamping pressure of the filter holder. The pressure should be set to the minimum pressure required for sealing. The pressure can be set from 20 to 50 psi. Excessive pressure should not be used.



<b>W A R N I N G</b>
Keep hands away from the filter holder during operation to avoid injury. Set filter holder pressure to the minimum pressure needed to seal around your filter. Do <i>not</i> use excessive pressure as this may damage your filter as well as cause unnecessarily hazardous conditions.





**Figure 5-3**  
Filter Holder Pressure Regulator

---

## Check CPC Vacuum Pressure

Check the CPC vacuum gauge. The pressure should read 8 psi or greater. This vacuum pressure is necessary to maintain the critical flow through the CPCs.

A very small leak will affect the vacuum pressure. If the pressure is not adequate check all connections between the CPC outlet and vacuum pump, the cross fitting, the carbon filter fittings, pump fittings, connection to the pressure gauge etc.

---

## Warm-up Period

After the Model 8160 AFT is turned on, it requires about 15 minutes for the pressure transducer to stabilize. The CPCs require approximately ten minutes to warm-up. The CPCs are ready for use when their STATUS lights turn from red to green.

---

## Set the Electrostatic Classifier Flow

The Electrostatic Classifier is typically run with sheath flow set to either 7.5 lpm or 15 lpm. For normal operation 7.5 lpm flows are used. Operation with sheath and excess flows of 7.5 lpm allow an upper particle size range to .40 microns.

1. Select the Classifier Flow option from the Setup menu. An atomizer is turned on and the screen indicates the required flows.
2. Open the first panel to access the Electrostatic Classifier controls.
3. Set the sheath flow on the Electrostatic Classifier to the desired flow rate.

Refer to the Electrostatic Classifier manual for instructions on changing the sheath flow rate.

Setting the Electrostatic Classifier flows is very important. Check the flows every time the AFT is turned on and every 4 hours during operation.

---

## Set the Diluter Ratio

The diluter is used to reduce the upstream aerosol concentration by 100 times; sufficient to prevent CPC counting errors caused by particle coincidence. Coincidence is discussed in the CPC Model 3760A Instruction Manual in the binder and in Chapter 7 of this manual.

1. Select the program option, Adjust Diluter.
2. Close the empty filter holder and press <Enter> to begin 0.1 micron particle generation.
3. After the recommended wait for the particle concentration to stabilize, adjust the diluter valve to obtain 100 % on the screen display. Typical fluctuations in the reading will be about  $\pm 2\%$ .
4. Record the value on the diluter gauge. This value will be between 0.10 and 0.15, and should be consistent with values recorded previously.

---

## Set up the Printer

When a test is completed, the test data is sent to the printer. To avoid printer errors, the printer must be ON-LINE.

To insure that the printouts do not cross page perforations, the top of form must be set properly. Setting top-of-form is simple using the FX-850. First, press the ON-LINE button so the on-line light is off. Advance the paper with a Form Feed and neatly tear the paper at nearest perforation. Press the LOAD-EJECT button. The paper will feed back, and the printer beeps. Press the LOAD-EJECT button again. The paper advances and sets the form automatically. Press the ON-LINE button again. It is normal for the ON-LINE light to blink.

Loss of top of form occurs if an <Esc> is pressed while printing. Should this occur, repeat the procedures above.

---

## Performing a Filter Test

Testing with the AFT is described in detail in the next chapter, Testing and Test Results.

Once the preceding start-up operations have been done, a test can be performed.

1. First examine the test parameters by selecting the Review Parameters options from the Setup menu. Change parameters if required.
2. Open the filter holder by pressing the OPEN button. Turn the pump OFF. Install the filter and press the CLOSE buttons, holding for 1 second.
3. Initiate the test by selecting the Go option from the Run menu or press the <F1> key.
4. Before the test starts, an instruction screen and the filter flow screen are displayed -after pressing <Enter> twice. The label screen appears if labels have been entered earlier from the Test Identification option. Press <Enter> after responding to labels.
5. To exit the test before it is complete press <Esc>. <Esc> causes an alert screen to be displayed with the following options:

**Stop Test   Continue   Abort**

Use the <Tab> key to choose between these options. Stop Test completes the test at this point. If data has been taken it will be printed and retained. Continue will cause a return to the test routine. Abort will cause a return to the main menu, data will be lost.

## CHAPTER 6

# Testing and Test Results

This chapter assumes that the reader is familiar with the basic use of the software. If not, please read Chapter 4, "Software Operation."

---

## Starting the Test

Before a filter test is started complete the setup procedures in Chapters 2 and 5.

1. Examine the test parameters by selecting the Review Parameters options from the Setup menu. Change parameters if required.
2. Open the filter holder by pressing the OPEN button. Turn the pump OFF. Install the filter and press the CLOSE buttons, holding for 1 second.
3. Initiate the test by selecting the Go option from the Run menu or press the <F1> key.
4. Before the test starts, an instruction screen and the filter flow screen are displayed. The label screen appears if labels have been entered earlier from the Test Identification option. Press <Enter> after responding to labels.
5. To exit the test before it is complete press <Esc>.

---

## Test Routine Overview

Once the test is started, the test program turns on an atomizer and sets the Electrostatic Classifier rod voltage. The software calculates the rod voltage based upon the sheath flow, excess flow and particle size.

Before sampling begins, time is allowed for the aerosol to stabilize. The stability time depends upon the aerosol (DOP or NaCl). Seventy seconds of delay is allowed whenever a new NaCl bottle is turned on, 200 seconds of delay if a new DOP bottle is turned on. Stability time is reduced to 40 seconds for both NaCl and DOP when the bottle is reused for the next particle size.

Once the aerosol has stabilized, the software checks for low aerosol concentration. An error message appears if a problem in aerosol generation exists.

The software determines if the *dilution bridge* should be turned on before sampling begins. This determination is based upon the criteria discussed in the Particle coincidence section of the following chapter. If the dilution bridge is turned on, an additional few seconds are allowed for the new aerosol concentration to stabilize.

During the test, Condensation Particle Counter (CPC) data, filter flowrate and resistance are measured each second and displayed on the screen. The current CPC data is presented and updated in light green, as each particle size is finished the CPC measurements are averaged and displayed in gray. Flow and resistance readings are averaged over the entire test period.

When the test is complete the data is automatically printed. If the printer is off or disconnected a print error occurs. Press <Esc> to return to the main menu. All data is retained. Once the printer error is corrected, print the data using the Graph option.

To exit the test before it is complete press <Esc>. <Esc> causes an alert screen to be displayed with the following options:

**Stop Test Continue Abort**

Use the <Tab> key to choose between these options. Stop Test completes the test at this point. If data has been taken it is printed and retained. Continue causes a return to the test routine. Abort causes a return to the main menu and data is lost.

---

## Test Results

Data from a filter test is printed at the end of the test. Should a print error occur, such as having the printer off or off-line, an error message is displayed. Pressing the <Esc> returns the program to the main menu. Once the printer problem is corrected the data printout can be initiated manually from the Graph software option.

Data from the last test is retained by the computer until the computer is turned off or another test is started. This “current” data can be displayed graphically from the Graph option or in the test screen format by selecting *Display* from the Data option.

The test printout is shown on the following page. The first line contains the heading, the second an optional note. The type of challenge aerosol, date, time, face velocity, flowrate, and resistance are presented as lines three through five on the printout. Lines six through eight are for the six label-response fields discussed in “Test Identification” under the “Setup Menu” section of Chapter 4.

Following the heading items, a data table is presented. Particle size is in microns. Upstream and Downstream refer to the concentrations sampled before and after the filter, measured each second and averaged over the test interval. Exception; if the downstream counts are fewer than 100, then the number of particles counted, rather than concentration is given as the downstream measurement. Unlike the concentration data, which is presented in scientific notation, the particle counts are presented in standard form. Penetration and efficiency are presented as percents.

$\% \text{ Penetration} = \frac{\text{downstream concentration}}{\text{upstream concentration}} \times 100 \times \text{CF}$

CF = correction factor

$\% \text{ Efficiency} = 100 - \% \text{ penetration}$

## Correction Factors

The correction factor value CF is entered when the particle sizes are entered. It is possible (but not required) to establish and enter a different CF for each particle size. The CF numbers compensate for differences in counting between CPCs. This difference is normally quite small and can be considered to be 1 (the default value) in most cases.

To establish specific CF values, a filter test must be performed with an empty filter holder, at the particle sizes of interest. The initial CF's used during this test must be one (/1). Before beginning adjust the diluter to 100 % using the .1 micron particle size aerosol (see the *Set Diluter* option).

Once the test is finished, CF values are calculated based on the test data.

$$CF = 100/\text{observed penetration}$$

Reenter the particle sizes with these new CF values. Note: these CF values are applicable only if in the future the diluter is adjusted using the .1 micron aerosol.

## Low Counts

Should the number of counts be less than the minimum number of downstream counts (entered in the software *Downstream sample* option), an asterisk appears ahead of the penetration data in the table.

Lastly, a graph of penetration versus particle size is displayed. The log-log graph presents three decades of penetration or efficiency. The graph scaling is automatic, with the most penetrating size appearing in the topmost decade for penetration and the bottom decade for efficiency.

In some cases, data may exceed three decades. If this occurs the graph data can be reprinted with a fourth decade using the Graph main menu option.



## Test Screen Printout

During a test, the screen displays a simple heading, tabular data and a graph. Current data can be printed in this graph-tabular format using *Display* from the Data option. Select Data, then *Display*. When the data is on the screen press <P>.

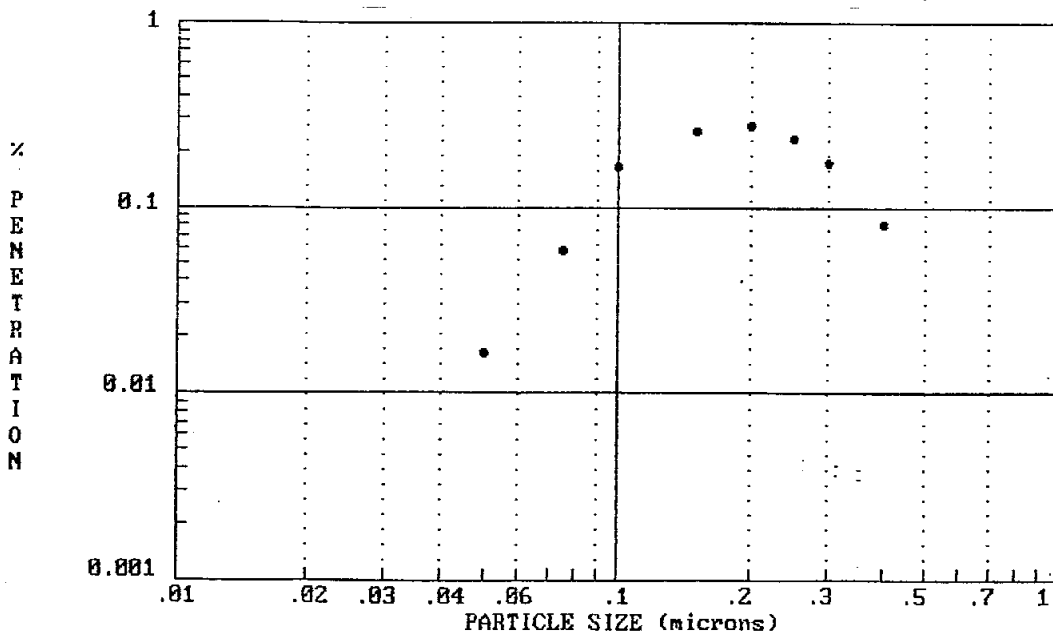
## Sample Printout

### AFT 8160 AUTOMATED FILTER TESTER

NOTE:

AEROSOL: DOP	FACE VEL...: 5.32 cm/sec.
DATE...: 08-11-1991	FLOW RATE...: 31.90 lpm
TIME/RT: 13:51:22 / 12.8 min.	RESISTANCE...: 31.99 mm H2O

PARTICLE SIZE (microns)	UPSTREAM (#/cc)	DOWNSTREAM (#/cc or cnts)	PENETRATION %	EFFICIENCY %
0.050	1.21E+05	2.00E+01	0.0165017	99.983
0.075	1.12E+05	6.46E+01	0.0578598	99.942
0.100	3.46E+05	5.73E+02	0.1653960	99.835
0.150	1.97E+05	5.03E+02	0.2554926	99.745
0.200	9.75E+04	2.69E+02	0.2758615	99.724
0.250	4.77E+04	1.12E+02	0.2351858	99.765
0.300	2.35E+04	4.07E+01	0.1732614	99.827
0.400	5.91E+03	4.81E+00	0.0813841	99.919



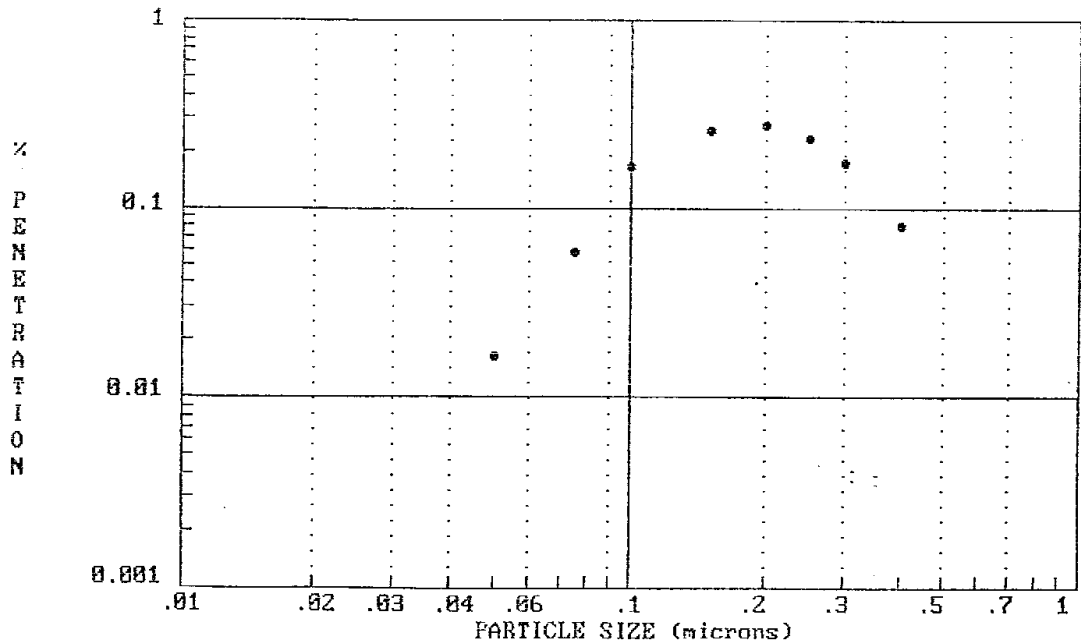
## Sample Printout

### AFT 8160 AUTOMATED FILTER TESTER

NOTE:

AEROSOL: DOP	FACE VEL...: 5.32 cm/sec.
DATE...: 08-11-1991	FLOW RATE...: 31.90 lpm
TIME/RT: 13:51:22 / 12.8 min.	RESISTANCE...: 31.99 mm H2O

PARTICLE SIZE (microns)	UPSTREAM (#/cc)	DOWNSTREAM (#/cc or cnts)	PENETRATION %	EFFICIENCY %
0.050	1.21E+05	2.00E+01	0.0165017	99.983
0.075	1.12E+05	6.46E+01	0.0578598	99.942
0.100	3.46E+05	5.73E+02	0.1653960	99.835
0.150	1.97E+05	5.03E+02	0.2554926	99.745
0.200	9.75E+04	2.69E+02	0.2758615	99.724
0.250	4.77E+04	1.12E+02	0.2351858	99.765
0.300	2.35E+04	4.07E+01	0.1732614	99.827
0.400	5.91E+03	4.81E+00	0.0813841	99.919



# More on the Software

This chapter gives information on the calculation used for coincidence correction as well as the software options that handle disk files. Also refer to Chapter 4 for a description of the Model 8160 Filter Tester software menu options.

---

## Particle Coincidence

The software performs a mathematical coincidence correction on all CPC data. Coincidence occurs when two or more particles are in the CPCs “viewing volume” at the same time and are counted as one particle. The likelihood of this happening increases with increasing particle concentrations. The correction formula is based upon statistical probability and is used in the program as follows:

$$N_a = N_i \exp(-N_i Q t)$$

$N_a$  = corrected concentration

$N_i$  = indicated concentration (particles/cc)

$Q$  = CPC flow (23.58 cc/sec)

$t$  = .25 microseconds is the effective time each particle spends in the viewing volume

The formula is used with  $N_i$  substituted for  $N_a$  in the equation.

The effectiveness of the formula as applied in the software is limited and count accuracy is quickly lost above thirty thousand particles/cc. For this reason, the diluter and dilution bridge components are needed to keep the actual concentrations low enough to maintain good CPC count accuracy.

The software turns the dilution bridge on automatically when using the **Adjust Diluter** option. When testing, the dilution bridge is turned on if the upstream concentration is greater than 100,000 (particles/cc) and the downstream is greater than 1000 or if the upstream is between 10,000 and 100,000 and the downstream is greater than 5000. This dilution bridge criteria was based on a knowledge of aerosol concentrations produced by the aerosol generators and test data of coincidence effects at high concentrations. The dilution bridge will not be used if the filter tested has a penetration of less than one percent.

---

## Program Options That Handle Disk Files

This section gives program options for handling disk files.

### Load, Save, Delete

Size files, Parameter files and Data files can be saved, loaded, or deleted from disk using options in the software.

To access the files select the *Particle Sizes* option from Setup, the *Parameters* option from Options or the *File-immediate* option from Data.

Also see "Set Save Status" below.

When an option above is chosen, a screen appears which allows the selection of Load, Save or Delete. Once chosen, a new screen awaits the entry of a filename. The filename can contain a path as the example below:

*c:\dir1\dir2\Filename*

The directory(s) and filename are limited to 23 characters total.

If no path is included, the default path is used.

After the file is typed and <Enter> pressed the Load, Save, or Delete operation will be initiated. An alert screen appears when saving or deleting files, or if an error occurs.

### DIRECTORY

From each Load File, Save File or Delete File screen it is possible to choose and view a directory for the presence of files. Prior to selecting DIRECTORY using the down arrow key, enter a path as in the example below:

*c:\ftdata\*

The directory name must be followed by "\".

Select DIRECTORY using the arrow keys, followed by <Enter>. If no directory is specified, the default directory is displayed.

A cursor in the directory window can be moved using the up and down arrows to select a file from the list of files. By pressing <Enter> the highlighted file is installed as the input file (no typing necessary). Pressing <Enter> again performs the Load, Save, or Delete operation using that filename.

## Set Save Status

This option is chosen from the Data menu. The Set Save Status screen is used to set up a path and filename into which test data is saved automatically after a test. The mechanics of entering the filename and using the DIRECTORY are the same as those described above.

To save data automatically turn the SAVE STATUS ON. Test data continues to append to the designated filename as long as SAVE STATUS remains ON.

## Lotus Macro

The file *datacall.wk1* is a short program which loads data files into Lotus 123<sup>®</sup>. The program is written in the Lotus macro language as an example.

Load the datacall program into Lotus 123 and press the <Alt> key and the letter C. Enter a path and filename as requested.

The *datacall.prn* program retrieves a file with data from as many as twenty tests. Data is *imported* as *numbers* from the disk into consecutive cells in column A of the spreadsheet. Once loaded the data is transposed horizontally by the macro. Data is loaded in the following order:

Test note; labels 1 - 6; date; time; pressure ; flow; particle size 1; upstream concentration; downstream concentration; downstream counts; penetration data; efficiency data; particle size 2; .....

Once the data is loaded it can be manipulated and saved again. The datacall.prn program is protected with the +r DOS attribute so it can not be written over.

The macro starts at GB.40.

# CHAPTER 8

## Maintenance

This chapter gives routine and special maintenance procedures for the Model 8160 Filter Tester.

---

### Maintenance Schedule

The following schedule should be used as a guide for required maintenance. Actual maintenance times will vary depending on system usage.

<b>Description</b>	<b>Frequency</b>
Filling CPCs with butanol .....	24 hrs
Cleaning the Electrostatic Classifier .....	see section below
Replace the air supply desiccant .....	16 hrs
Inspect/Replace the Diffusion Dryer desiccant..	16 hrs
Replace the carbon exhaust filter .....	100 hrs
Replace the air supply filter .....	6 mo.
Replace the downstream filter .....	yearly
Mixing the aerosol solutions .....	as necessary

### Nonroutine Maintenance Items

The following maintenance items are performed on an “as necessary” basis.

- Cleaning the atomizer orifice
- Replacing the dilution bridge orifice
- Replacing the downstream filter
- Cleaning the diluter tube
- Replacing the diluter filters
- Dilution bridge filter
- Manifold filters

---

## Filling the Condensation Particle Counters with Butanol

Check the CPCs' butanol level regularly. When full, the butanol level is about half way up the sight glass as marked. The CPCs will operate properly as long as butanol is visible. If running the CPC continuously, the alcohol will need to be replenished about twice weekly.

To fill the CPCs with butanol, perform the following steps using Figure 8-1 as a reference:

- 1.** Locate the two female quick-connect ports which are used for filling the CPCs with butanol. These ports are located on the gauge panel behind the door on the lower front of the AFT. These ports are connected to the CPC alcohol reservoirs.
- 2.** Locate the bottle supplied for filling the CPCs with butanol.
- 3.** Fill the supplied bottle with reagent grade n-butyl alcohol (butanol).
- 4.** Make certain that the tester is OFF.
- 5.** Note the sight glass on the front of the CPC you wish to fill.
- 6.** Connect the butanol bottle to the fill port for the CPC you wish to fill. Open the bottle cap slightly to provide a vent when filling.
- 7.** Watch the sight glass carefully while filling. When the liquid level is in the middle of the sight glass, disconnect the bottle from the fill connector. Do *not* overfill.





**Figure 8-1**  
Filling the CPC with Butanol

---

## Cleaning the Electrostatic Classifier

The Electrostatic Classifier requires cleaning when small orifices at the base of the high voltage rod become plugged with NaCl. DOP does not plug these orifices and has this important advantage over the use of NaCl. Filters, valves and aerosol transport lines also become clogged over time and require cleaning.

To help determine if the Electrostatic Classifier is becoming plugged, the inlet pressure is measured using a pressure gauge (Figure 2-2). The pressure measured is about 10 cm of H<sub>2</sub>O when the Electrostatic Classifier is clean (and operating with a total flow of 11.25 lpm; 2:1 ratio). As it starts to clog this value increases rapidly. If the pressure exceeds 30 cm cleaning is required.

To clean the Electrostatic Classifier, remove the Electrostatic Classifier from the AFT cabinet.

1. Disconnect the polydisperse, monodisperse, and sheath air lines.
2. Disconnect the BNC and power cables.
3. Lift the Electrostatic Classifier off the shelf and place it on a clean work surface.
4. Refer to the Electrostatic Classifier manual for specific cleaning instructions.
5. When the cleaning process is complete, reinstall the Electrostatic Classifier in the AFT cabinet, making sure the three stainless tubes, power cord and BNC are reconnected.

---

## Replacing the Air Supply Desiccant

Refer to Figure 2-9 to identify the desiccant holder.



<b>C a u t i o n</b>
Always turn the power to the Model 8160 AFT OFF before changing the desiccant.

To change desiccant:

1. Press the thumb lock and rotate the top ring on the desiccator bowl.
2. Lower the bowl to separate.
3. Pour out the used desiccant and replace with fresh.
4. Clean the top lip of the bowl and replace.
5. Rotate the top until the thumb lock reengages.

**Note:** *The used silica gel desiccant can be regenerated by heating in an oven at 300°F until the blue color reappears. Store the regenerated desiccant in an air tight container.*



**Figure 8-2**  
Dilution Bridge Showing Orifice

---

## Inspecting/Replacing the Diffusion Dryer Desiccant

When using the salt aerosol, check the silica gel desiccant in the Diffusion Dryer after every four hours of operation.

To check the desiccant:

1. Drain the water from the water trap by loosening the reversed thread tap at its base.

2. Remove the dryer by loosening the two fitting nuts next to the cabinet.
3. Disassemble the dryer by unscrewing the end cap supporting the water trap.
4. Pour the wet silica gel into a container and examine it. If still largely blue, mix up the crystals and return them to the dryer. If largely pink or white, set the silica gel aside for regeneration and add fresh desiccant. Refer to the Model 3062 Diffusion Dryer manual in the binder for more information.
5. Replace the diffusion dryer by reassembling and reinstalling on the cabinet side. To achieve the proper spacing of the connection fittings tighten or loosen the dryer caps, not the fittings.

**Note:** *Used silica gel desiccant can be regenerated by heating in an oven at 300°F until the blue color reappears. Store the regenerated desiccant in an air tight container.*

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## Replacing the Carbon Exhaust Filter

The carbon filter removes butanol from the exhaust of the CPC's. It is only moderately helpful and should not be relied on entirely to protect the work place from butanol vapor. If not vented, (see the "Exhausting" section of Chapter 2), strong butanol vapors become evident when the carbon capsule is no longer effective and requires replacement. If properly vented, the need for carbon capsule replacement will be diminished or eliminated. Replacement depends on whether the carbon loads sufficiently to cause a vacuum flow resistance and loss of CPC vacuum pressure, (see the "CPC Vacuum Gauge" section of Chapter 3).

1. Use a wrench to disconnect the nuts from the plastic fittings on the carbon capsule (Figure 8-3.)



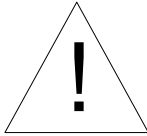
**Figure 8-3**  
Replacing the CPC Carbon Filter

- 2.** Remove the filter from the clamps.
- 3.** Remove the plastic fittings from the ends of the used filter and install on a new filter.
- 4.** Press the new filter into the clamps (arrow up) and reconnect the nuts. Be careful not to cross thread the plastic fittings.

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## Replacing the Air Supply Filter

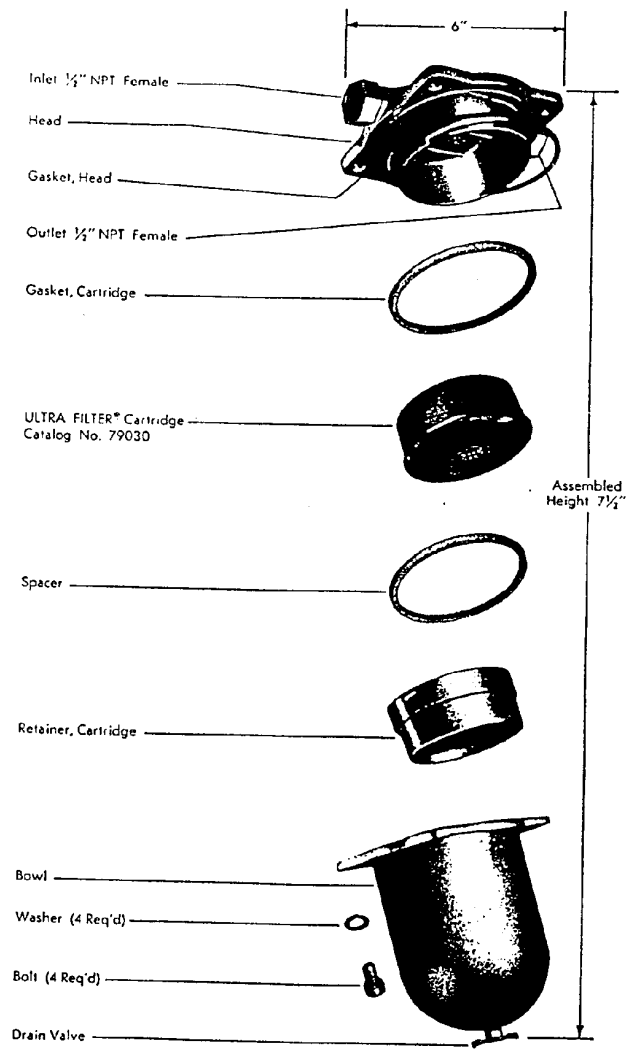
The air supply filter is shown in Figure 2-9 and disassembled in Figure 8-4.



<b>C a u t i o n</b>
Before replacing the air supply filter, turn the power to the AFT off.

1. After turning the power to the AFT off, remove the wing nuts that hold the filter cover (bowl) in place.
2. Lower the bowl and clean with a cloth.
3. Unscrew the filter holder from the filter and remove the filter from the holder. Do not lose the two gaskets that seal the filter.
4. Throw out the older filter cartridge before taking out the new one.
5. Wipe the inside of the filter holder with a dry cloth.
6. Install the new cartridge.
7. Attach the four bolts with the wing nuts facing up.

M-S-A<sup>®</sup> Air Line ULTRA FILTER<sup>®</sup> Assembly  
 Catalog Number 85759



**Figure 8-4**  
 Air Supply Filter Assembly

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## Mixing the Aerosol Solutions

The AFT uses two sets of bottles (Figure 2-12). These bottles provide solutions for atomization by the aerosol generators to produce the challenge aerosols.

The upper bottles are for solutions of DOP (dioctyl phthalate) in isopropanol. The lower bottles are for solutions of NaCl (table salt) in distilled water. DOP is used when liquid particles are needed. NaCl is used for producing solid particles.

### Mixing DOP Solutions

DOP oil is mixed with reagent grade isopropanol (isopropyl alcohol), in three 1 liter bottles (Figure 2-12).

The concentrations of DOP are:

- Bottle 1. .3%
- Bottle 2. .03%
- Bottle 3. .003%

The isopropanol purity should be <.0001% dissolved solids.

1. Remove the DOP bottles by unscrewing each.
2. Drop the bottles down and away carefully to avoid damaging the spiral draw tubes.
3. Mix the .3% solution in bottle 1 by adding 3 ml of pure DOP to 1 liter of isopropanol.
4. Make the .03% solution by removing 100 ml of the .3% solution from bottle 1 and add it to bottle 2.
5. Fill bottle 2 with 900 ml of isopropanol.
6. Make the .003% solution in the same way, but this time add 100 ml of the .03% solution of bottle 2 to bottle 3.
7. Fill bottle 3 by adding 900 ml of isopropanol.
8. Replace each bottle by sliding it carefully over the spiral draw tube.



## Mixing the NaCl Solutions

NaCl is mixed with distilled (deionized) water in three 1 liter bottles (Figure 2-12).

The NaCl concentrations are:

Bottle 1. 1%

Bottle 2. 0.1%

Bottle 3. 0.01%

1. Remove the NaCl bottles by carefully unscrewing and dropping each down and away. Avoid damaging the thin draw tubes hanging into the bottles.
2. Mix the 1% solution in bottle 1 by adding 10 grams NaCl to 1 liter of distilled water. Mix thoroughly by shaking or stirring.
3. Make the .1% solution by removing 100 ml of the 1% solution from bottle 1 and add it to bottle 2.
4. Fill bottle 2 with 900 ml of distilled water.
5. Make the .01% solution in the same way, but this time add 100 ml of the .1% solution of bottle 2 to bottle 3.
6. Fill bottle 3 by adding 900 ml of distilled water.
7. Replace the bottles by sliding each carefully over its thin steel draw line.

---

## Empty Aerosol Generator Drain Bottles

Two bottles are used to collect excess generator solution during generator operation. The excess or “drain” bottle for DOP/isopropanol is located on the right side of the bottle rack (Figure 2-12). The NaCl solution drain bottle is located on the left side of the NaCl bottle rack. Empty these bottles frequently. The aerosol generators will not operate properly if the bottles are full. The bottles are removed by turning counterclockwise. Drain bottles must be replaced before operating the system.

---

## Cleaning the Atomizer Orifice

The atomizer orifice disk is mounted in the atomizer head. It is platinum, approximately 1 cm in diameter with a centered orifice approximately .013 inches in diameter. Because of its small size the orifice will plug if a speck of solid material gets into it. Keeping the solutions and bottles clean is the best way to prevent plugging.

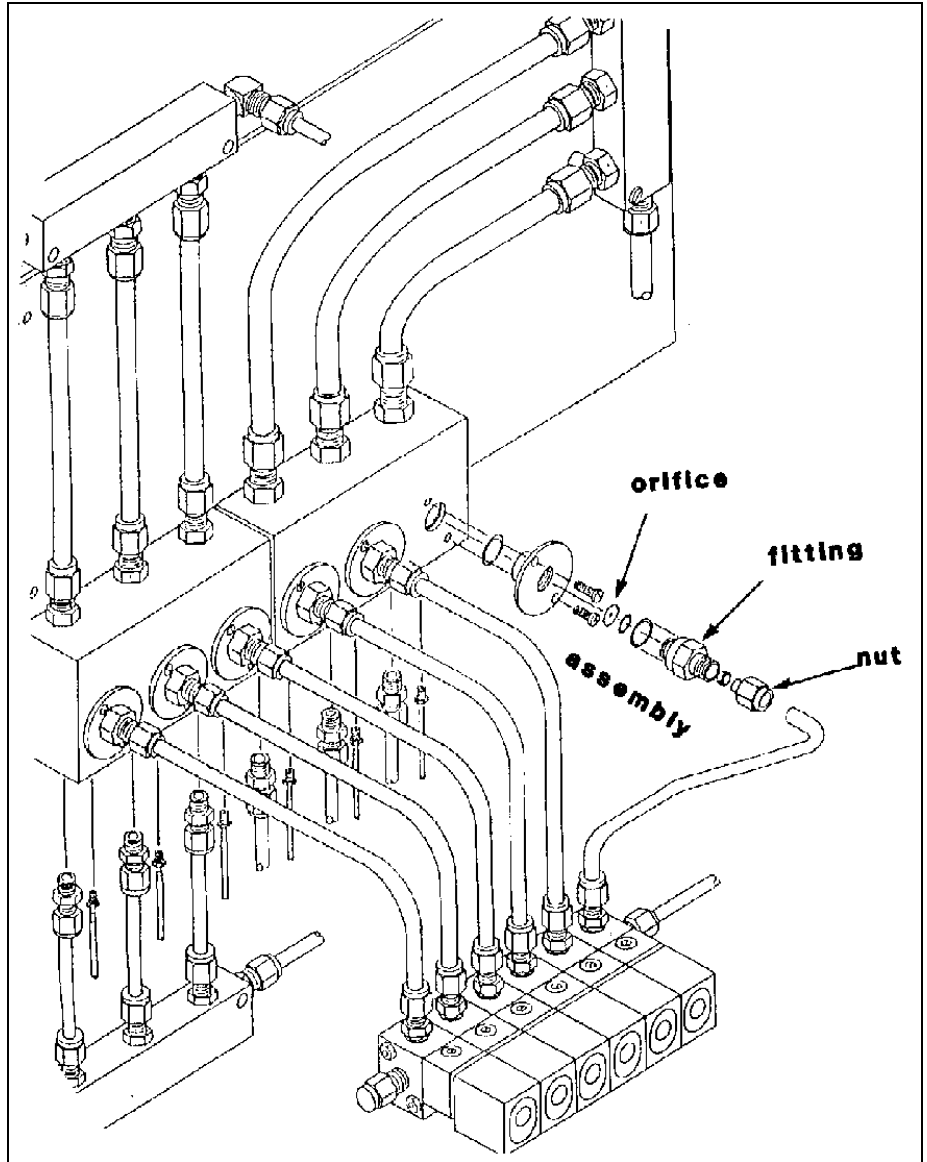
A plugged orifice causes a low output concentration. The computer software checks for low aerosol concentration and causes a “low aerosol concentration” message in this case.

**Note:** *Low aerosol concentration can be caused by insufficient atomizer pressure or low solution levels too. Check these before assuming an orifice problem.*

The orifice must be removed for cleaning (Figure 8-5).

1. Remove the  $\frac{9}{16}$ ” plastic nut which holds the tubing to the generator head.
2. Loosen the plastic fitting slightly.
3. Remove the two screws holding the orifice assembly. Pull this assembly out.
4. Back out the loosened fitting ensuring the orifice disk does not pop out.
5. Remove the orifice carefully by tipping.
6. Using a tweezers, dip the orifice repeatedly in isopropanol and water, and let dry.
7. Examine the orifice by holding to the light. If visibly clean, then replace by reversing the removal steps.

**Note:** *When reassembling, be very careful not to cross thread the plastic threads.*



**Figure 8-5**  
Disassembly of the Aerosol Jet

---

## Replacing the Dilution Bridge Orifice

The gray plastic .016" orifice used with the dilution bridge (Figure 3-5), may plug with NaCl over time. This will be apparent by a significant lowering of particle concentration when the dilution bridge is activated. Replace the orifice if plugged. Clean the contaminated orifice with water for reuse.

---

## Replacing the Downstream Filter

The downstream filter protects the flowmeter from contamination by the challenge aerosol. This filter is normally only exposed to very low concentrations and may never need replacement. If it does, it becomes evident because the filter flow will be restricted -100 lpm flow cannot be achieved at a filter resistance of 150 mm H<sub>2</sub>O.

The downstream filter is located below the bottom filter holder, behind the diluter panel. Remove the left side panel of the Filter Tester to reach this filter. The panel is removed by removing two screws located midway up the tester. Locate the screws from the inside, looking through circular cutouts on the vertical rails.

---

## Cleaning the Diluter Tube

The diluter tube is cleaned as needed. If DOP aerosol is used cleaning may not be necessary at all. If salt is used, the end of the tube may accumulate sufficient particle matter to cause a restriction. An increase in the pressure measured by the diluter pressure gauge after the diluter setup is complete, indicates that the tube may need to be cleaned.

To clean the diluter tube, perform the following operations:

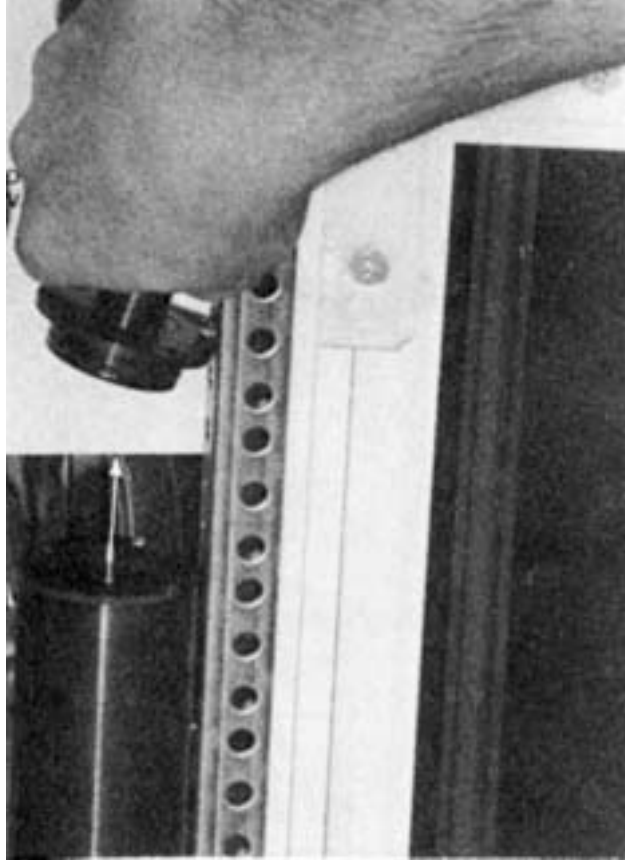
1. Remove the stainless tube from the top of the diluter by loosening the <sup>9</sup>/<sub>16</sub>-inch union nut.
2. Remove the screws holding the inlet and remove the inlet (Figure 8-6) by pulling up. Be careful not to damage the top of the diluter tube which extends into the inlet.



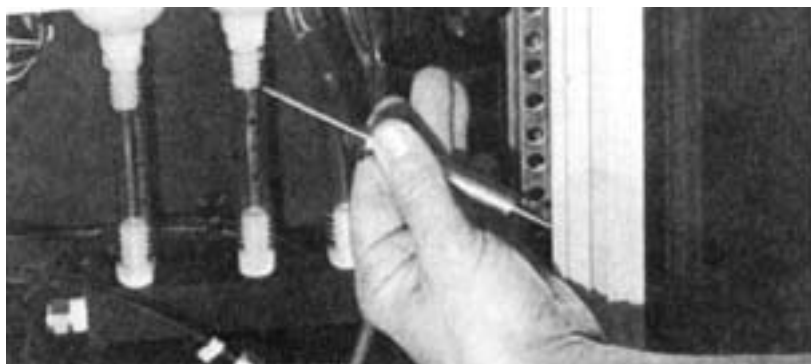
**Figure 8-6**  
Diluter Location

- 3.** Pull the diluter tube (Figure 8-7) straight up using the supplied plastic pliers (or similar tool).

**Note:** Avoid scratching, crimping, or bending the tube.

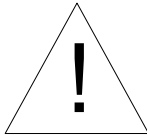


**Figure 8-7**  
Diluter Tube Should be Pulled Straight Up



**Figure 8-8**  
Diluter With Inlet and Diluter Tube Removed

4. Rinse the diluter tube with water to remove salt accumulation or isopropanol to remove oil. Examine the inlet carefully for blockage. Peer through the tube while looking at a light source to detect blockage. Use compressed air to dislodge contamination and dry the tube before replacing.



### W A R N I N G

To avoid eye injury, do *not* place diluter tube above eye level when examining it.

5. Reapply a small amount of the vacuum grease to the O-rings of the diluter tube.
6. Reinsert the diluter tube into the diluter body.  
**Note:** *The diluter tube should be placed in the diluter body so that tapered end is pointing up.*
7. Press the diluter tube in place firmly using the insertion tool shown in Figure 8-9.
8. Replace the top and reconnect the clear tubing.



**Figure 8-9**  
Use Insertion Tool to Press Diluter Tube in Place

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## Replacing the Diluter Filters

If the filters become sufficiently contaminated, it will be impossible to reduce the penetration to 100% in Setup mode. This is because the diluter valve is no longer controlling the ratio of filter flow to diluter tube flow; the pressure drop through the filters has become too great (refer to Figure 3-4). If this occurs the filters must be replaced.

To replace the diluter filters, perform the following steps.

1. Remove the diluter filters by separating the clear flex tubing from the barbed fittings mounted to the inlet and outlet of the filters (Figure 8-10).
2. Remove the barbed fittings from the old filters and retain.
3. Place the barbed fittings on the new filters and replace with the flow direction arrows pointed up.



**Figure 8-10**  
Diluter Filters



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## Dilution Bridge Filter

The dilution bridge is shown in Figure 3-5. This filter is subjected to a low flow of aerosol, and only when the dilution bridge is activated. This high capacity filter may last almost indefinitely.

An increase in restriction in this filter results in a lowering of the effective dilution.

To replace:

1. Disconnect the tubing from the tube stub at the back of the filter capsule.
2. Turn the capsule counterclockwise to remove it.
3. Remove the plastic fitting from the old filter and place it on the new.
4. Add a small amount of thread compound to the mating threads and replace the filter capsule.
5. Reconnect the tubing by pushing over the fitting tube stub.

---

## Manifold Filters

The manifold filters are connected to the mixing manifold at the top of the tester. Make up air enters the manifold through these filters. Since the make up air is generally very low in particle concentration the manifold filters can be expected to last almost indefinitely.

To replace, grasp each capsule body and turn it counterclockwise. Replace with clean filters.



# Reader's Comments

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Manual Title CERTITEST® Model 8160 Automated Filter Tester P/N 1980140 Rev. D

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Yes  No

Please identify any problem area(s) \_\_\_\_\_  
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