Particle Instruments

CertiTest® Model 3160 Automated Filter Tester

Operation and Service Manual

P/N 1930041 Revision-
May 2003

TSI®

CERTITEST® Model 3160 Automated Filter Tester

Instruction Manual

Manual History

The following is a history of the CERTITEST® Model 3160 Automated Filter Tester Operation and Service Manual, P/N 1930041.

Revision	Date
First Run	May 2003

Part Number 1930041 / Revision - / May 2003

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Safety

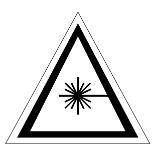
This section gives instructions to promote safe and proper operation of the Model 3160 Filter Tester, samples of warnings found in this manual, and information on labels attached to system instruments.

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.

! Caution

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.

! WARNING

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.

Radiation Safety

The Model 3080 or 3080A Electrostatic Classifier contains a Model 3077 or a Model 3077A 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).

WARNING

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

Purpose

This manual provides information necessary to operate the CERTITEST® Model 3160 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 4043 Mass Flowmeter 4000 series
- ❑ Model 220C Pressure Transducer
- ❑ Model 3077 or Model 3077A Aerosol Neutralizer

The binder also contains the following schematics and data sheets:

- ❑ 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

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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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 3160 Automated Filter Tester.

The Model 3160 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 99.999999 percent over a particle size range of .015 to .8 micron. The figure below shows the AFT 3160 filter tester in schematic form.

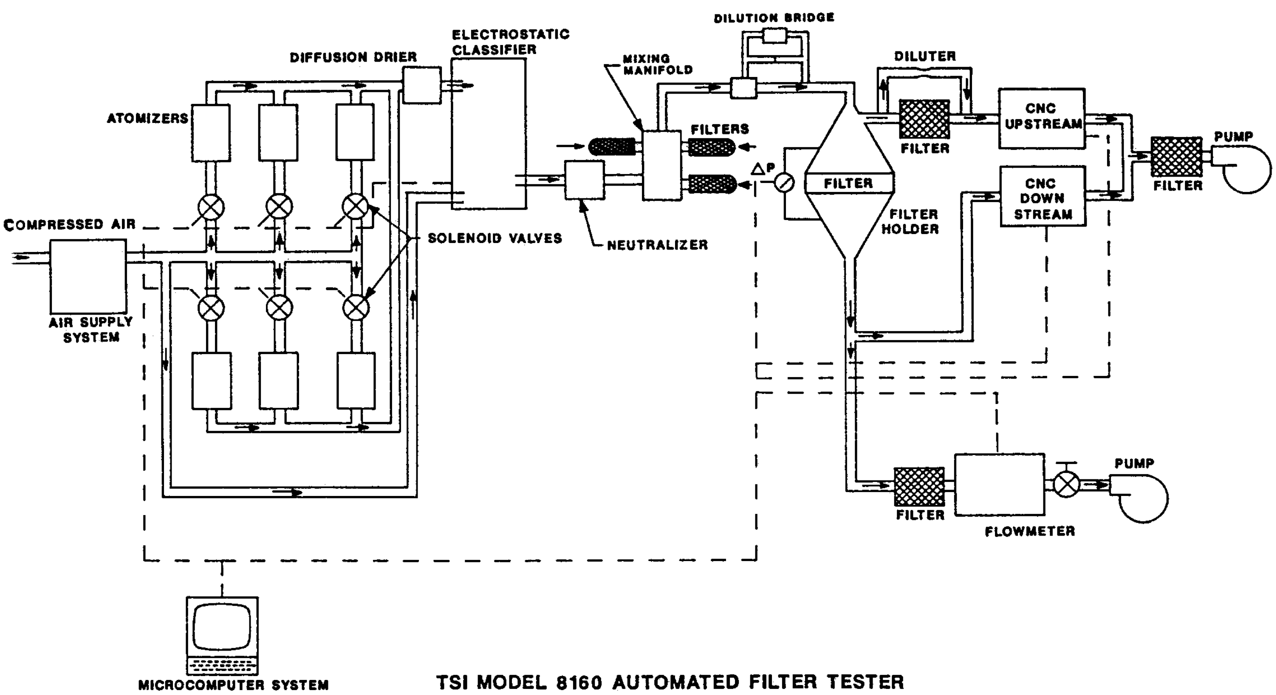

Figure 1-1
Schematic of the Model 3160 Automated Filter Tester

CHAPTER 2

Unpacking and Setting Up

Use the information in this section to unpack and set up the main components of the Model 3160 Filter Tester. The main components include the Condensation Particle Counters (CPCs), the Electrostatic Classifier, The USB hub and serial ports, the computer components, the software, and the tester itself.

Unpacking

The following instruments and accessories are included as part of the Model 3160 Automated Filter Tester.

Table 2-1
Packing List for Model 3160 Automated Filter Tester

Qty	Item	Part No.
1	Cabinet chassis	
1	TSI Model 3080 Electrostatic Classifier	3080
1	TSI Model 3081 LDMA	3081
2	TSI Model 3077 or Model 3077A Neutralizer	3077
2	TSI Model 3760A Condensation Particle Counters	3760A
1	TSI Model 3302A Diluter	3302A
1	TSI Nafion Dryer	1602338
1	Computer	1905184
1	Printer	1905185
1	Model 3160 Automated Filter Tester Manual	1930041
1	Model 3077 Aerosol Neutralizer Manual	1933077
1	AFT software disk	390103
1	Vacuum grease	1101063
1	Diffusion Dryer Filling Cap	1304017
1	Vacuum grease	1502249
6	Electrostatic Classifier filters, MSA #95302	1602011
6	HEPA capsule filters	1602051
2	MSA cartridge filters #79030	1602068
2	Filter holder gaskets	1704082
4	Filter holder O-ring 1-224	2501888
1	Printer paper	
1	Delrin Pliers	3012021
1	Model 3760A Accessory Kit	

Setting Up

Use the information in this section to set up the main components of the Model 3160 Filter Tester.

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

1	Filter holder	17	Main regulator and valve
2	Access doors	18	Dryers-Membrane, Desiccant
3	Flow meter	19	Dilution bridge
4	Power switches	20	Aerosol manifold (not shown)
5	Flow control valves	21	Pressure transducer
6	CPCs	22	Purge air filter
7	System computer	23	Vacuum pump
8	Printer	24	DC Relay-interface box
9	Drawer	25	Air supply filter
10	Filter holder controls	26	Drain bottle, salt
11	Electrostatic Classifier	27	Butanol bracket
12	Diluter	28	Kr – 85 neutralizer
13	Atomizer regulator	29	Quick Test filter
14	DOP solution bottles	30	Power strips
15	NaCl solution bottles	31	Classifier DOP purge
16	Air supply conditioner	32	USB Hub and Serial port

Figure 2-1
Front View of the Model 3160 Automated Filter Tester

Figure 2-2
Back View with Door Open

Installing the Diluter

Carefully place the Model 3302A diluter over the exhaust flow nozzle located in the top shelf behind the filter chuck. When aligned correctly, the diluter should easily slip onto the nozzle. Find the connecting hardware and connect the upstream sample line to the diluter inlet.

Figure 2-3
Diluter Installed

Installing the Condensation Particle Counters

Find and unpack the two condensation particle counters (CPCs). To install these in the Model 3160 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, serial signal cables, vacuum tubing and alcohol fill tubing are supplied for connection to the CPCs.

Place the first CPC (serial port label number 2) to the right hand side. Position it so the rubber feet fit the appropriate holes (Figure 2-4). This is the downstream CPC.

3. Find the CPC parts labeled 2. 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). Connect the other end to the tee on the vacuum pump.
4. Connect the serial cable to the serial port (2) on the back of the CPC (Figure 2-4). The other end connects to the USB serial port hub - port number 2.
5. Note the location of 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) and route to the AC power supply. Install the second CPC to the left hand side and repeat the connections described above. Connect the serial cable to the USB serial port hub - port number 1.
7. Install the sample stainless steel tubing from the outlet of the diluter to the front of the left – upstream - CPC and the stainless steel tubing from the filter chuck exit to the front of the right – downstream - CPC.
8. Connect the power cords to the AC power supply switched output number 2 (Figure 2-11).
9. Locate the CPC vacuum pump exhaust line (Figure 2–6). Vent the exhaust outside the building. This line vents the excess butanol vapor generated in the CPCs. Under no circumstances should this vapor be vented inside the building.

Caution
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.

Figure 2-4
Installing the CPCs

(1) CPC vacuum connector and vacuum tubing (2) Serial port and connector (3) Fill port (4) Drain port

Back Panel

Figure 2-5 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).

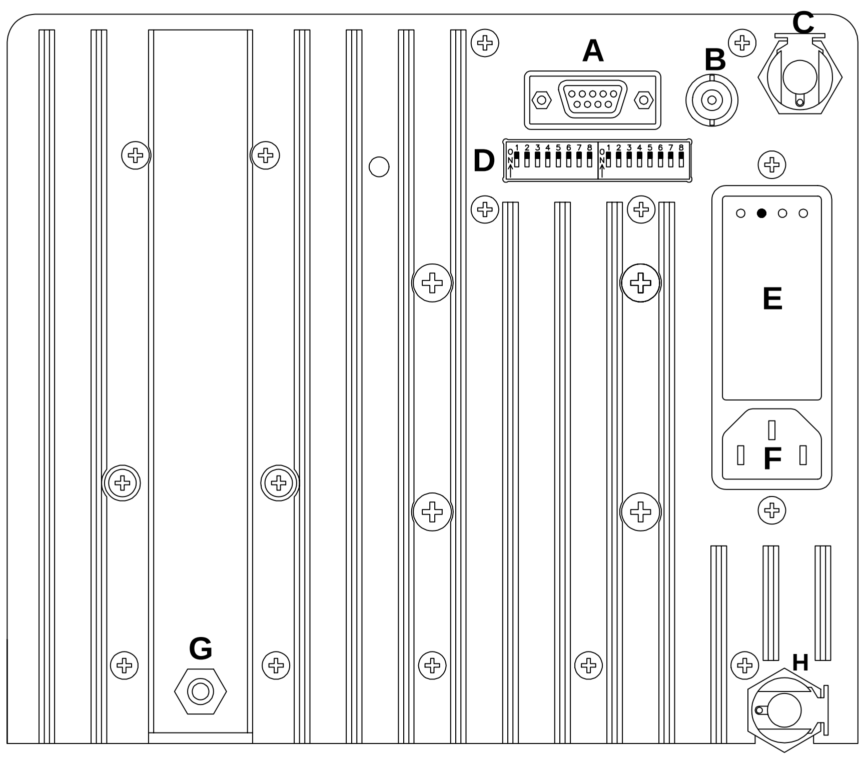

Figure 2-5
CPC Back Panel

Figure 2-6
CPCs Installed

(1) Upstream CPC (2) Downstream CPC (3) CPC vacuum pressure gauge (4) CPC Vacuum pump (5) Vacuum pump tee (6) Flowmeter filter (7) Vacuum pump exhaust line

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 into 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 2-7). The exact position of the Electrostatic Classifier will be determined by the stainless tubing which connects to it.

1. Connect the power cord and serial cable to the Electrostatic Classifier. The serial cable connects to a mating receptacle at the back of the Electrostatic Classifier. This cable is routed to the USB serial port hub - port number 3.

2. Connect the polydisperse aerosol line to the Electrostatic Classifier Aerosol Inlet. The steel polydisperse line extends from the cross connecting the membrane dryer and the DOP atomizer manifold. The Electrostatic Classifier should be shifted as necessary to make the connections with the least stress possible on the stainless steel tubing.

3. Connect the small tubing between the barbed fitting on the Aerosol Inlet tee and the Impactor High inlet on the electrostatic Classifier. The Impactor Low inlet should be open to ambient.

4. Install the second KR-85 neutralizer between the two stainless steel tubes which make up the monodisperse aerosol line. This line connects the aerosol dilution mixing manifold to the monodisperse Aerosol Outlet on the Electrostatic Classifier (Figure 2-2, item #28).

5. Plug the power cord into the IEC type power strip located adjacent to the pressure transducer (Figure 2-2 item 30).

6. Connect a section of black tubing between the Exhaust Flow and the Excess Flow ports on the side of the classifier.

7. Connect a section of black tubing between the Bypass Flow port on the classifier and the Excess Flow out port at the bottom of the long DMA column.

8. Connect a section of black tubing between the Sheath Flow port on the classifier and the Sheath Flow In port at the top of the long DMA column.

9. Connect a section of black tubing between the Polydisperse Flow port at the top of the long DMA and the Polydisperse Flow tube at the top of the classifier.

10. Connect a section of tubing between the Aerosol Inlet tee and the Large Particle flow filter.

11. Plug in the high voltage cable from the DMA to the 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 2-7
Electrostatic Classifier Installed

(1) Large Particle Test Option filter and aerosol bleed flow adjustment valve

Installing the Computer Components

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

Printer

To install the printer, follow these steps:

1. Pull the printer shelf out fully until the stops are reached.
2. Center the printer forward on the shelf.
3. Install paper in the tray under the printer platform.
4. Close the shelf carefully to make sure the printer clears the sides and top panel.
5. Connect the printer power cord to the back of the printer and plug it into the power strip adjacent to the printer shelf.
6. Connect the printer USB cable to the back of the printer and route it up to the back USB port on the computer. Alternatively, the printer USB cable can be connected to the USB hub if no second USB port is available on the computer.

Figure 2-8
Printer Installed

Computer

To install the computer, follow these steps:

1. Pull the shelf out fully until the stops are reached.
2. Center the computer forward on the shelf.
3. Connect the power cord to the computer and to the power strip behind the printer.
4. Connect the USB cable to the computer and to the USB hub.
5. To close the shelf, release the retractable catch and close.

Figure 2-9
Computer Installed

Installing the USB Hub and Serial Port Module

The Model 3160 uses USB hub and serial interface modules to connect the computer to the printer, the Data Acquisition module in the DC relay/interface box, the CPCs, flow meter and Electrostatic Classifier. These modules (Figure 2-2) are located on the shelf at the back of the Electrostatic Classifier.

Plug the Hubport power connector into the AC power strip located by the printer shelf.

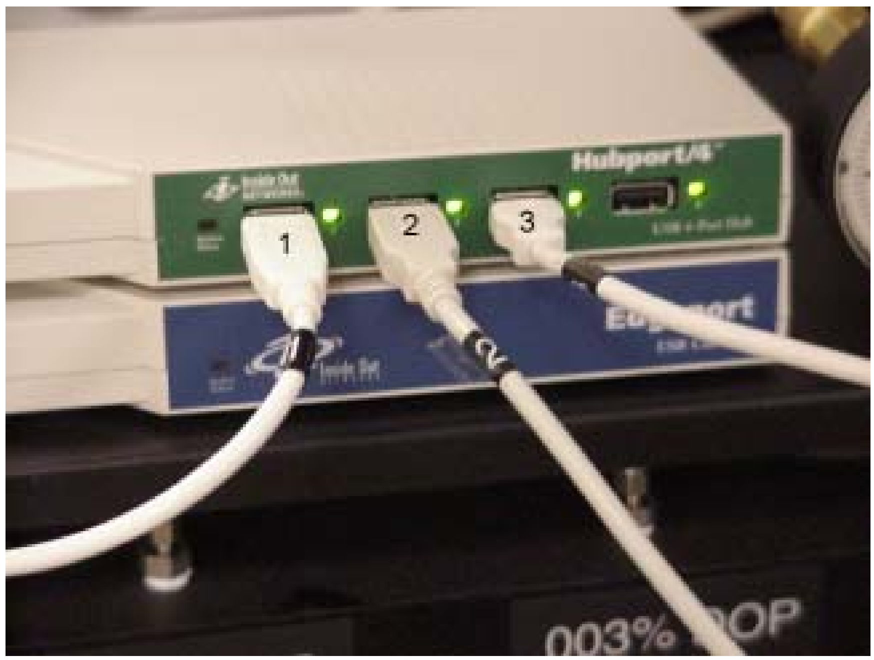

Figure 2-10
Hubport and Edgeport Serial Port Modules

AC Power

The Model 3160 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.

Line voltage is supplied to the AC power supply (Figure 2-11) located on the lower left hand chassis behind the filter flow valves. The power supply has three switched outputs, each of which can accommodate four IEC type cables. The front panel switches each control one of the switched outputs. The front panel switches are soft switches and, therefore, do not carry any appreciable current.

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

Figure 2-11
AC Power Supply

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 air dryers are used with the AFT. The Air Supply Dryer (Figure 2-12) uses a silica gel desiccant for drying the incoming supply air. The Membrane Dryer (Figure 2-13), is used for removing moisture from the salt aerosol. On a periodic basis the silica gel will need to be replaced in the Air Supply dryer. The Membrane Dryer utilizes tubes made of Nafion and does not use a replaceable desiccant.

***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 desiccators 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 is 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 2-12
The Air Supply Conditioner

Membrane Dryer

The membrane dryer removes water vapor from the salt aerosol stream and transfers it to a dry gas stream that flows through the dryer in a direction opposite to the incoming aerosol flow. As the water vapor flows through the Nafion tubing, the water is absorbed by and moves through the walls of the tubing, evaporating into the surrounding counterflow dry purge air. The counterblow purge air should have a flow rate at least twice that of the incoming aerosol flow. For a typical aerosol flow of 3.8 liters per minute, the purge air flow should be at least 7.6 liters per minute.

The counterblow purge air has a brass orifice restrictor inserted in the dryer inlet. This restrictor reduces the flow to approximately 8 liters per minute.

Figure 2-13
Aerosol Membrane Dryer
(1) Relief valve (2) Membrane Dryer (3) Membrane Dryer purge air supply line and orifice restrictor (4) Classifier purge air line (5) Diluter air manifold (6) Aerosol supply manifold (7) Large particle vacuum pump air supply line

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 2-14.

WARNING
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 2-11) cleans and dries the air used with the AFT 3160. 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 2-14
Compressed Air Inlet

Exhausting

It is recommended that the exhaust from the CPC vacuum pump (Figure 2-6) be routed away from the work area, especially if the space is confined. The CPC vacuum pump exhaust is not filtered, so butanol vapors will escape if the exhaust is not confined.

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.

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

Caution
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 2-15. 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 2-15.

The concentrations of DOP are:

- Bottle 1. 0.003%
- Bottle 2. 0.03%
- Bottle 3. 0.3%

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 3 by adding 3 ml of pure DOP to 1 liter of isopropanol.
3. Make the .03% solution by removing 100 ml of the .3% solution from bottle 3 and add it to bottle 2. Fill bottle 2 with 900 ml of isopropanol. Mix thoroughly.
4. Make the .003% solution in the same way, but this time add 100 ml of the .03% solution from bottle 2 to bottle 1.
5. Fill bottle 1 by adding 900 ml of isopropanol.
6. Replace each bottle by sliding it carefully over the spiral draw tube. Screw the bottles back in until seated firmly.

Mixing the NaCl Solutions

NaCl is mixed with distilled (deionized) water in the three 1 liter bottles shown in Figure 2-15.

The NaCl concentrations are:

- ❑ Bottle 1. 0.01%
- ❑ Bottle 2. 0.1%
- ❑ Bottle 3. 1.0%

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 3 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 3 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 from bottle 2 to bottle 1.
6. Fill bottle 1 by adding 900 ml of distilled water.
7. Replace the bottles by sliding each carefully over its thin steel draw line. Screw the bottles back in until seated firmly.

Figure 2-15
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 butanol 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 2-16).
2. Locate the bottle supplied for filling the CPCs with butanol (Figure 2-16). Fill the bottle with reagent grade n-butyl alcohol (butanol).
3. Make certain that the tester air supply and pump are OFF. The Instruments Switch on the front panel should be on. Connect the butanol bottle to the CPC fill port (Figure 2-16). Open the bottle cap slightly to provide a vent when filling.

4. Press the fill button on the CPC. Watch the sight glass carefully while filling. When the liquid level reaches the fill mark in the middle of the sight glass, press the fill button to stop and 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.*

Caution
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.

Figure 2-16
Filling the CPCs with Butanol

Installing the Software

The software should be already installed on the computer upon receipt. However, in the event that the software needs to be reloaded the following steps need to be executed. The operating system is Windows based. The software used to operate the tester is CERTITEST version 1.4 or above.

1. Locate the CERTITEST software disk and follow the installation procedure. Instructions are provided to load all modules: the Data Acquisition module drivers, the USB hub and serial port drivers, and CERTITEST.

2. Install the drivers for the Data Acquisition module and the USB modules before installing CERTITEST.

3. For an upgrade to the CERTITEST software, simply copy the new CertiTest.exe into C:\Program Files\CertiTest\ after renaming the old CertiTest.exe. It should not be necessary to reload the drivers for the USB and Data Acquisition modules.

4. After installation is complete the following files should be located in C:\Windows\System:

    CertiTest.cfl
    CertiTest.ini
    CertiTest.int
    CertiTestDefault.cfg
    CertiTestNoName.cfg
    CertiTestEmptyDB.mdb
    CertiTestF.xls
    CertiTestQ.xls

Note: *CERTITEST requires that the above files be located in C:\Windows\System regardless of the current version of Windows that is installed on the computer.*

The following files are CERTITEST program files and should be located in C:\Program Files\CertiTest

CertiTest.exe	* executable code
filter.mdb	* database file
Empty filter.mdb	*empty database file
Example.cfg	* example configuration setup file
Daqx.dll	* data acquisition dll file

5. Once the files have been loaded, store the program disks in a secure location.

CHAPTER 3

Filter Tester Components

The information in this chapter describes the main components of the Model 3160 Filter Tester.

Computer/Printer

A computer is used to control AFT operation, data acquisition and data display. The computer is a laptop (Figure 2-9). The color printer is used for printouts after each test.

Condensation Particle Counters (CPCs)

Filter penetration measurements are made using two TSI Model 3760A Condensation Particle Counters (Figure 3-1). The CPC on the left (1) measures the aerosol concentration upstream of the filter and the CPC on the right (2) measures the aerosol concentration downstream of the filter. The sample flow through the CPCs is controlled by critical orifices within each instrument.

For detailed information on the Condensation Particle Counters, refer to the 3760A instrument manual.

Figure 3-1
The Condensation Particle Counters (CPCs)

Electrostatic Classifier

The Electrostatic Classifier (Figure 2-7) 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 classifier instrument instruction manual.

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. When using salt aerosol the classifier should be cleaned at least every forty hours – more often if necessary. The displayed impactor pressure measurement on the classifier will increase as the system loads. This information can be used to indicate the need to clean the classifier.

Large Particle Size Option

The particle size range can be extended to .8 microns by employing the large particle size bypass. In order to extend the aerosol challenge size presented to the filter beyond .4 microns the

Electrostatic Classifier aerosol flow and sheath flow must be reduced. This is necessary because of the limiting voltage that can be applied to the classifier. At high flow rates large particles have too much momentum and will exit the classifier before being selected. As flow is bled off through the bypass, the aerosol flow and sheath flow through the classifier are correspondingly reduced permitting larger particle sizes. Refer to the 3160 checkout sheet to obtain the flows that pertain to your unit.

Note: *When you enter a size larger than .4 microns in the Aerosol & Timing menu the software will force you to adjust the Aerosol flow in the DMA Flows menu. The sheath flow is nominally two times the aerosol flow.*

Figure 3-2
Large Particle Size Option

(1) Large Particle size bypass flow meter (2) Large Particle size filter

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 3-3) 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 circular flat 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 3-3
The Filter Holder and Diluter

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_2O (optional 0 to 200-mm H_2O), with a 2-volt output. Accuracy is specified as 0.15% of reading.

The pressure transducer power cord is plugged into the ac power supply switched output bank 2 .

Flowmeter

A TSI Model 4043 mass flow meter is located inside the Filter Tester cabinet on the center panel behind the CPCs (Figure 2-6) and is used to monitor filter flow rate. This meter produces a linear output of 0–10 volts for a measurement range of 0–200 slpm.

A manual describing the Model 4043 Flowmeter is found in the binder. The flow meter power cord is plugged into the AC power strip located behind the printer. The serial output is connected to port 4 on the USB serial port module.

Flow Adjustment Valves

The flow adjustment valves (Figure 2-1) control the flow rate through the filter holder and filter. The flow rate 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 to approximate the desired flow rate. Use the fine flow adjustment valve to adjust to the specific flow rate needed. Note that the flow meter will read 1.4 liters per minute less than the flow shown on the display. This is because 1.4 liters per minute are channeled through the downstream CPC.

Aerosol Diluter

The TSI Model 3302A Aerosol Diluter (Figure 3-3) is used to reduce the concentration of the aerosol sampled by the upstream CPC. This dilution is necessary because CPC count accuracy is lost when concentrations are too high.

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 dilution ratio. The AFT must operate with a dilution ratio of 100:1. Refer to the schematic (Figure 3-4) for assistance in understanding the diluter operation.

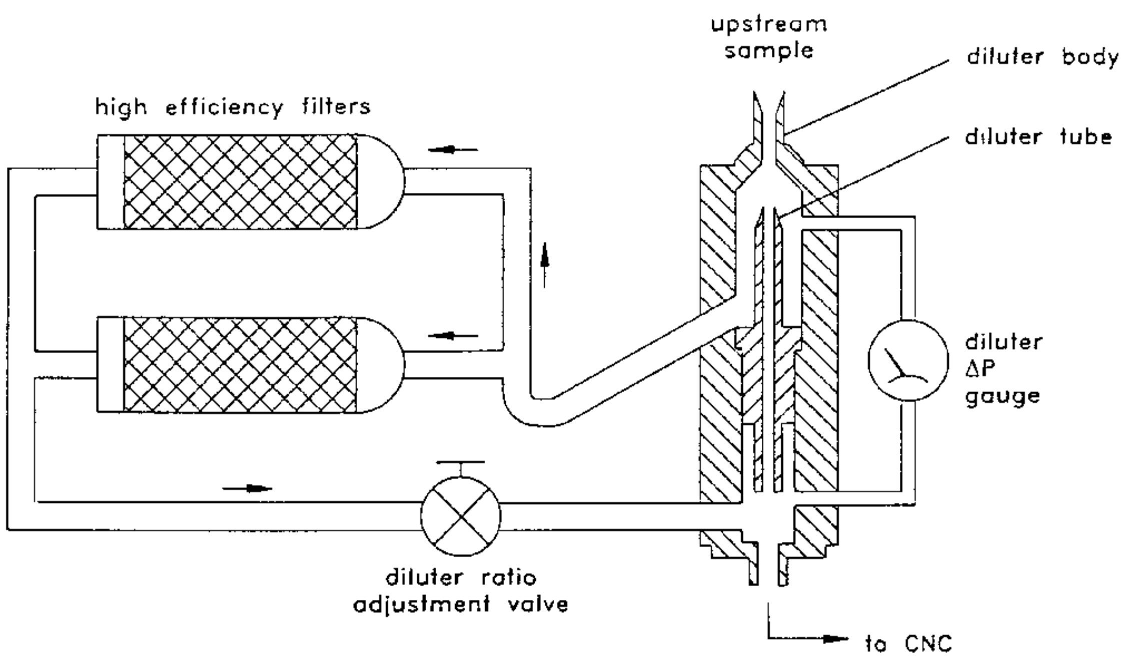

Figure 3-4
Aerosol Diluter Schematic

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 on the diluter and is used to adjust the diluter ratio to 100:1. The dilution ratio is adjusted using the aerosol diluter valve. The dilution ratio is adjusted while using the **Adjust Diluter** option in the software. Turn the valve clockwise to reduce the diluter ratio. Note that a change in the diluter flow takes a long time – 30 minutes or more - to stabilize.

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 $1/100$ 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 the 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.

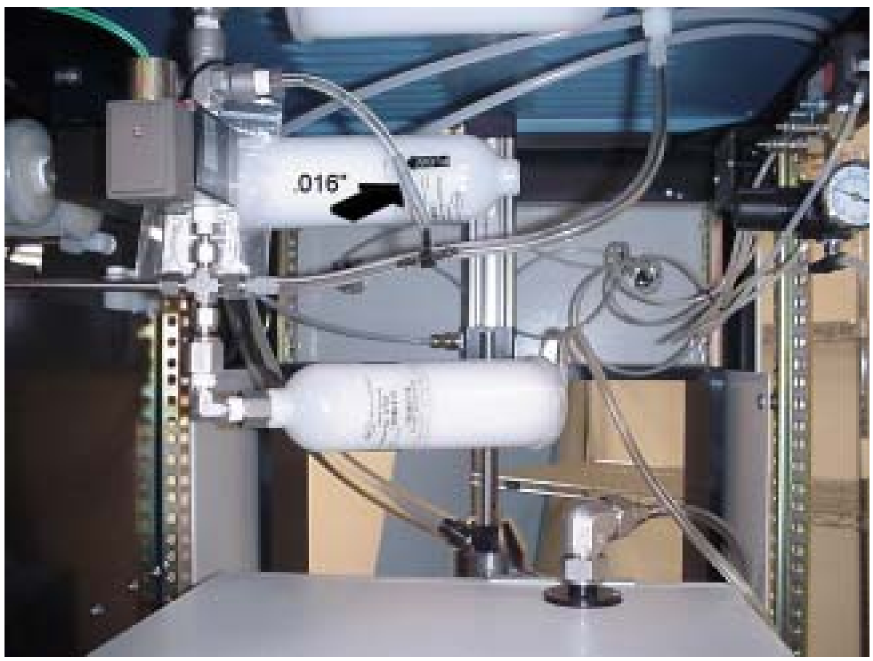

Figure 3-5
The Dilution Bridge

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.

CPC Vacuum Gauge

The CPC vacuum gauge (Figure 2-6) is located just above the flow meter inside the Filter Tester. A critical 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 2-5, 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.

Aerosol is generated when one of six solenoid valves is activated. Actuation of 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 aerosol inlet on the Electrostatic Classifier.

Aerosols from the DOP generators enter a plenum and from there are directed to the classifier inlet through stainless steel tubing. NaCl aerosols are routed through the drier prior to entering the stainless steel tubing to the classifier inlet.

The CERTITEST software denotes the minimum concentration aerosol as generator number 1. Similarly the maximum concentration aerosol is denoted as generator number 3. Labels on the aerosol valves and the DC relay/interface box reflect this numbering scheme.

Figure 3-6
Aerosol Generators

DC Relay/Interface Box

The DC relay/interface box is shown in Figure 3-7. An external power switch and plug is mounted on the lower end of the box. The power cord is plugged into the IEC power strip. Make sure the switch is set to ON and the cord is plugged in. This box contains the valve control relays, a screw terminal PC board and a 12-volt solenoid valve power supply. A data acquisition module is mounted on the PC board and is connected to the USB hub with a USB cable.

Although in the current configuration, data are transmitted serially from the CPCs, Electrostatic Classifier, and flow meter to the USB serial port module, BNC connectors are also mounted on the back of the box for CPC and Electrostatic classifier voltages, allowing independent reading of voltage signals from these transducers and also permitting utilization of older model instruments that use BNC output connectors for analog signal transmission. Flow meter and pressure transducer signal inputs are also provided on the box.

As stated previously Salt 1 refers to a 0.01 % salt concentration . DOP 1 refers to a 0.003 % DOP in alcohol concentration.

Figure 3-7a
DC Relay/Interface Box

Figure 3-7b
DC Relay/Interface Box

DC Power Supply

The AFT uses a 12-volt power supply for actuating the various solenoid valves in the tester. The power supply is mounted internally in the DC relay/interface box.

AC Power Supply

The AC power supply box is located behind the filter flow control valves on the lower left hand shelf (Figure 3-8). The tester power cord is hard wired into the ac power supply. The power supply has a manual on/off switch. AC power is routed from this box to the following locations:

- The CPCs
- The pressure transducer
- The IEC power strip for the DC relay/interface box and Electrostatic Classifier
- The power strip for the computer, printer, flow meter, and USB modules
- The vacuum pump

The power supply has three switched outputs, each of which can accommodate four IEC type cables. These in turn are controlled through the front panel switches. The front panel switches are independent of one another and may be activated independently of one another.

Switch 1 is the System Power switch on the front panel. Power is supplied from this switch to the USA connector type power strip located behind the printer. The computer, printer, USB hub module, and flow meter are connected to this power strip.

Switch 2 – Instruments on the front panel – supplies power to the two CPCs, the pressure transducer, and the IEC power strip located on the side of the chassis adjacent to the pressure transducer. The Electrostatic Classifier and the DC relay box are connected to this power strip.

Switch 3 – Pump on the front panel – supplies power to the flow vacuum pump.

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

Figure 3-8
Electrical Junction Box, Side Panel Removed

USB Hub and Serial Port Interface Modules

The CPCs, flow meter and Electrostatic Classifier all use a serial interface to transmit data. The DC relay/interface box data acquisition module and printer interface with the computer through the USB interface. The serial interface module has four ports that should be connected as follows: (1) CPC upstream, (2) CPC downstream, (3) Electrostatic Classifier and (4) flow meter. Cable 1 shown below is connected between the Hubport and the Edgeport serial port module.

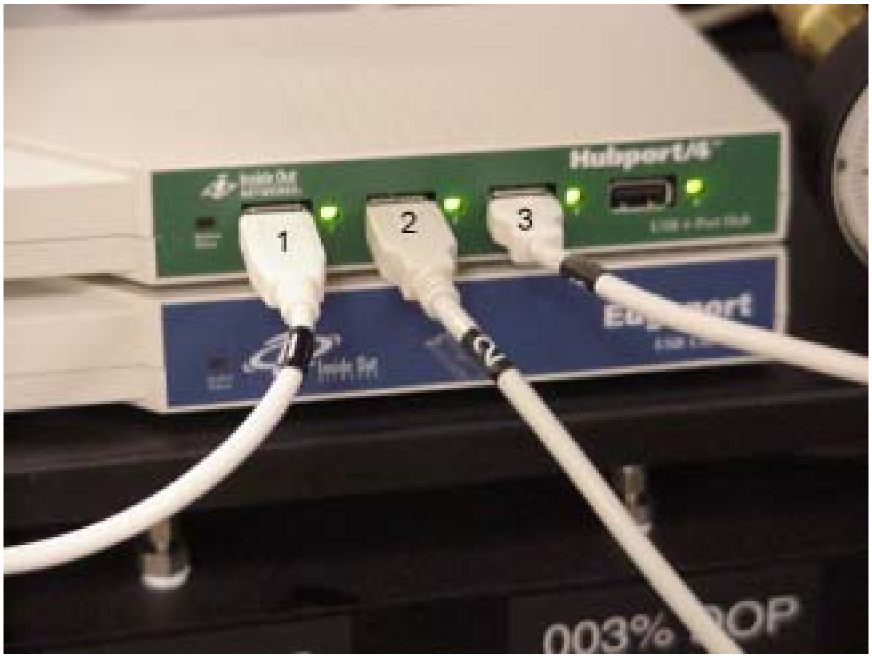

Figure 3-9
USB Hub and Serial Port Modules

(1) USB serial port hub / port modules cable (2) DC relay / interface box cable
(3) Printer cable

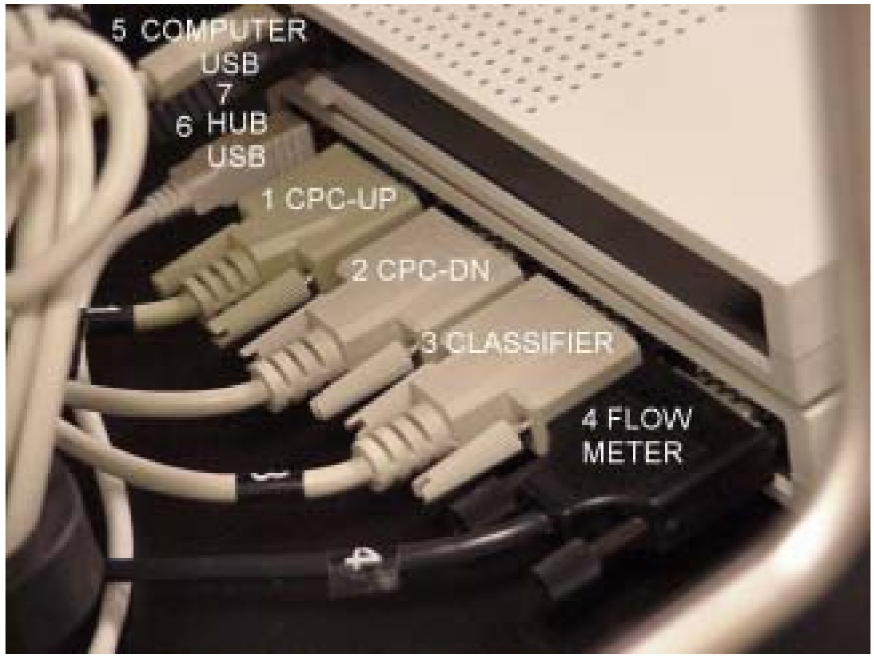

Figure 3-10
USB Hub and Serial Port Modules

(1) Upstream CPC serial port (2) Downstream CPC serial port (3) Electrostatic Classifier serial port (4) Flowmeter serial port (5) Computer USB cable (6) USB cable connecting hub to serial port module (7) Hub power cord

The computer USB cable (5) is connected to the computer and to the Hubport as shown above.

Quick Test Mode

A quick test operating mode is available for repeated testing when employing the same size aerosol. In this mode, aerosol is continuously supplied to the dilution bridge (Figure 3-5). When not testing, aerosol is routed through the Quick Test flow filter and then drawn through a small vacuum pump mounted on the center panel behind the CPC vacuum pump. This eliminates the delay to bring the aerosol to the filter. When testing in this mode only one particle size is available.

CHAPTER 4

Software Operation

The information in this chapter describes control keys and menu options for the Model 3160 Filter Tester software. Microsoft Office is provided as part of the 3160 software package. This product will need to be registered by the user. Follow the online instructions for registration. Also refer to Chapter 7, “More on the Software”, for information on particle coincidence calculations and program options.

The Program Disk

The programs used with the AFT are contained on a CD ROM labeled AFT 3160 Software. In addition to the CertiTest software, software drivers are also provided for the Data Acquisition module located inside the dc box and the USB and serial port modules.

Follow the instructions provided on the software disk to load the various drivers and CertiTest. Instructions for installing the program files are presented in the Chapter 2 section, “Installing the Software.” The drivers for the Data Acquisition module and the USB module should be loaded before installing CertiTest.

Program CertiTest.exe contains the compiled program for operating the AFT.

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.

Menu Option Selection and Screens

Menu items can be selected either with a mouse or by using keystrokes. To use keystrokes, 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:

File   Set up   Run   System Tests   Menu Style

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 selecting with a mouse, 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: File, Set up, Run, System Tests, and Menu Style. Additional information on software options is provided in Chapter 7, "More on the Software.”

File Menu

New	**Create New Database File** Use this option to create a new database file to store test results. Note the location of the database file for future reference. Database files used by CERTITEST are Microsoft Access type files (.mdb).
Open	**Filter DataBases** This option will open a new database for the current session. The database location (path) will appear in the title bar of the CERTITEST window. **Filter Sample Table** This option will allow selection of the User defined Filter Sample descriptions in the current database. **User Defined Titles Table** This option will allow selection of the User Defined Titles sample descriptions in the current database. **Test Results Table** This option selects test results from the current database for review. One may inspect General Results, Fractional Results – tabular data, and Graphs – a graph of either Efficiency or Penetration results. **Test Setup File** This option will open a test configuration file (.cfg) which contains a complete description of all test parameters required to execute a test.
Save	**Filter Sample Data** This option will save a description of the current displayed Filter Sample Data to the current selected database. **User Defined Data** This option will save a description of the current displayed User Defined Data to the current selected database. **Test Results** This option will save a description of the current displayed Test Results to the current selected database. **Test Setup as...** This option will save a description of the current Setup configuration to the selected configuration file.

(continued)

File Menu *(continued)*

Export	**Set Path for Auto-Export** Use this option to define the residence location for the Excel output file of the test results. **Export to Excel** Exports the current test results to an Excel file.
Print Results	Executes a print command to print the current displayed test results.
Exit	Terminates the current CERTITEST session.

Setup Menu

Test Configuration	**Hardware** This option is set at the factory and should not need to be changed. This screen is used to set the instruments and operating parameters of the system. See Fig. 4-5 for a description of the standard setup. The following options are for the factory default setup. Heater/Dryer: Not installed Electrostatic Classifier: Long DMA Particle Counters: 2 CPCs CPC1: 3760 CPC2: 3760 Neutralizer: Kr-85 Neutralizer Upstream Dilution: 1:100 or Measured Aerosol Generation: Multiple Sizes + Oil/Salt Switch Aerosol Dilution Bridge: Software automatically controls actuation.

(continued)

Setup Menu *(continued)*

Test Configuration	**Sample** This option brings up a screen that permits the user to input two sets of descriptions defining the test setup. See Fig. 5.6. One set is identified as User Defined Sample Descriptions. Note the presence of the check marks in the Used field. If the description is not checked it will not be displayed in the results. The other set is used to input descriptive fields defining the media under test. The information captured here is useful when reviewing old test data. Important: these descriptions must be manually saved in the database. When saved they will be assigned a database ID number. If they are not saved in the database they will not be able to be reloaded when bringing back the test results for review. ***Note***: *Exercise caution when changing databases. The description may appear on the screen but may not be saved in the database after a change or a test setup file reload. To ensure that the description is in the current database select* ***Load from Database*** *and scan through the id numbers.* **Aerosol & Timing** This screen is used to input the major parameters affecting the filter test. Up to 20 particle sizes may be input to define the test. The U/D correlation numbers default to 1.0. U/D correlation numbers are automatically calculated and input when a U/D test is selected from the Systems Test menu. They cannot be loaded manually. To execute a **Fast Test or Loading Test**, input the desired particle size to be used. Select the aerosol type: **Salt or Oil**. The Aerosol Parameters switch points should not be changed. These values are used to switch between aerosol bottles depending on the aerosol size. These switch points are based on the aerosol solution concentrations and have been optimized by the factory. Default settings are: 0.05 and 0.10 micrometers.

(continued)

Setup Menu *(continued)*

Test Configuration	**Sampling** The test sample time for each particle size is determined by the parameters set in this box. The minimum test time is determined by the input value for Minimum Sampling Time. The maximum duration of the test is dictated by either the Maximum Sampling Time input or the time to reach the Minimum Downstream Counts. If the minimum number of downstream counts is reached before the maximum sampling time has occurred the test will terminate. **Balancing** Balancing time is the time the system will take to stabilize before a test is initiated. When testing high efficiency media it is desirable to increase the Minimum Balancing Time to a value that will allow the system to achieve equilibrium before commencing a test. This is because counts will be low with high efficiency media and some residual particles may still be wending their way through the media. As with sampling, the maximum balancing time is either the Maximum Balancing Time input value or else sampling will begin when the upstream and downstream particle counters exhibit a deviation less than the percentage input for the Max. Deviation for Balancing (%) parameter.

(continued)

Setup Menu *(continued)*

Test Configuration	**DMA Flows** **DMA Parameters** This screen is where the Electrostatic Classifier flows are input. Default values are 7.2 lpm for sheath flow and 3.6 lpm for the aerosol flow. Normally at least a 2 to 1 ratio of sheath to aerosol flow is desired because this ratio dictates the width of the aerosol size distribution. The higher the ratio the narrower the distribution. See the Electrostatic Classifier manual for more details. The default flow values allow a maximum particle size of 0.4 micrometers to be selected. The test range may be extended up to a maximum of 0.8 micrometers. However, in order to reach this value the sheath and aerosol flows must be reduced to approximately 2.0 lpm and 1.0 lpm respectively. This is because at higher flow rates the classifier voltage differential is not sufficient to extract the larger particle sizes. It is desirable to maintain the 2 to 1 ratio whenever changing the sheath and aerosol flows. To determine the flows needed for a selected particle size, reduce the flows in the DMA Parameters box and then select **Calculate in Calculated Data** box. A message will indicate if the flows and particle size are compatible. ***Note:*** *When the aerosol flow is reduced the excess must be bled off. See the section detailing the operation of the Large Particle Option.* **A/D Data** This screen is informative only and no changes should be made.
Interface Configuration	No changes should be made on this screen. The parameters are set at the factory. Any changes will probably cause the software to crash.
Filter Flow Rate	Use this screen to set the flow rate. Note: the flow shown on the screen will be approximately 1.4 lpm greater than that shown on the display on the flow meter. The added flow is to compensate for the flow diverted through the downstream CPC.

(continued)

Setup Menu *(continued)*

Units	When using the default pressure transducer, 0 – 150 mm H_2O, 0 – 2 volts dc output, units id 4 (mm H_2O) should be selected. If a transducer with different parameters is used, consult the factory.
Report Language	Select language for results output.
Save Setup on Exit	If checked, √, the configuration setup will be saved to a default *.cfl file at program exit. This file will be loaded the next time CERTITEST is opened.

Run Menu

Start	**Fractional Filter Test** **Loading Test** **Quick Test** To initiate a test select one of the above options. If the desired test type is displayed on the main Window, simply click on the **Start** button to initiate a test.
Display Results	To see real time test results select this option. Alternatively, test results can also be displayed by clicking in the yellow section of the Results box on the main Window.

System Tests Menu

Dilution	**Test Mode** Input the desired particle size, then select: Adjust dilution to preselected value (1:100) or Set dilution to measured value. In the first instance the software assumes for calculation purposes that the dilution ratio is 1:100. This factor is used to compensate for the different concentrations seen by each cpc. Manually adjust the diluter to 1:100. Long stabilization times are necessary. If the second option is selected, the software stores the measured dilution value at the conclusion of the test and uses this value for calculation purposes. After setting the particle size and the desired option click **Start** and continue until the unit has stabilized. Click on the **Reset** button to rezero the Mean Dilution number. Click **ok** to terminate the test.
Up/Downstream Correlation	To perform this test remove all filters and close the filter holder. The test will be performed using the particle sizes selected in the Aerosol & Timing menu. It is recommended to have Balance times on the order of 90 to 120 seconds and Sample times of at least 60 seconds. To execute this test select **Up/Downstream Correlation**. Set the desired flow and continue. At the conclusion of the test, results will automatically be added to the particle size U/D correlation tab. To execute a filter test using the U/D correlations, select **Run > Fractional Filter Test**. The U/D correlation factors will be used to calculate penetrations taking into account the different concentrations seen by each cpc at a given particle size.
Concentration Measurement	To test, open this window and select **Start**. Test will continue until Stop. Select **Exit** to return.

(continued)

System Tests Menu *(continued)*

Serial Communication Test	This option can be used for troubleshooting if the serial communications are not responding correctly. Type a serial command in the String to Send window and click on the **Send** button.
Digital Output Status	Gives output status of various solenoids. Seems to give assumed status, not necessarily the actual state of the device.
USB Data Acquisition Test	This menu can be used to manually actuate individual aerosol generators as well as some of the flow control solenoids. The solenoids must be manually deactivated to turn off. This menu can also be used to activate the Classifier Purge. This can be used to feed clean air to the classifier if one needs to evaporate any accumulated DOP in the classifier. It is possible for DOP to accumulate in the classifier when extensive DOP testing has been performed. Note: this device must be manually turned off before beginning or resuming any testing. Inspection of the Impactor Pressure on the classifier panel will indicate when the valve is off. It generates a much higher impactor pressure than do the atomizers.
Test Flowmeter	This option returns the flow meter parameters: flow, temperature and pressure.

Menu Style Menu

Standard Menu	Limits the number of menus and submenus that are active.
Advanced Menu	Permits all menus to be viewed.

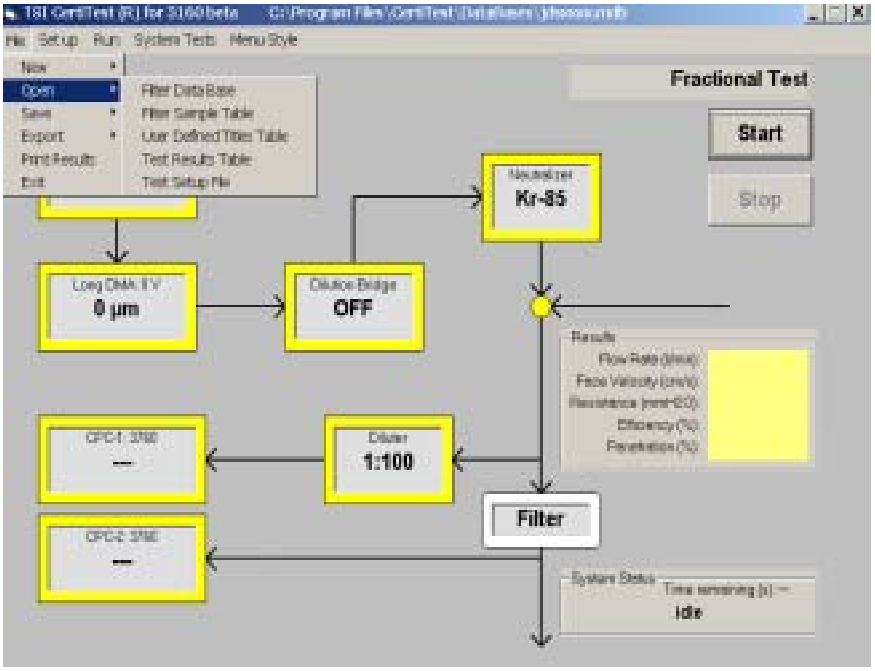

Figure 4-1
File Menu

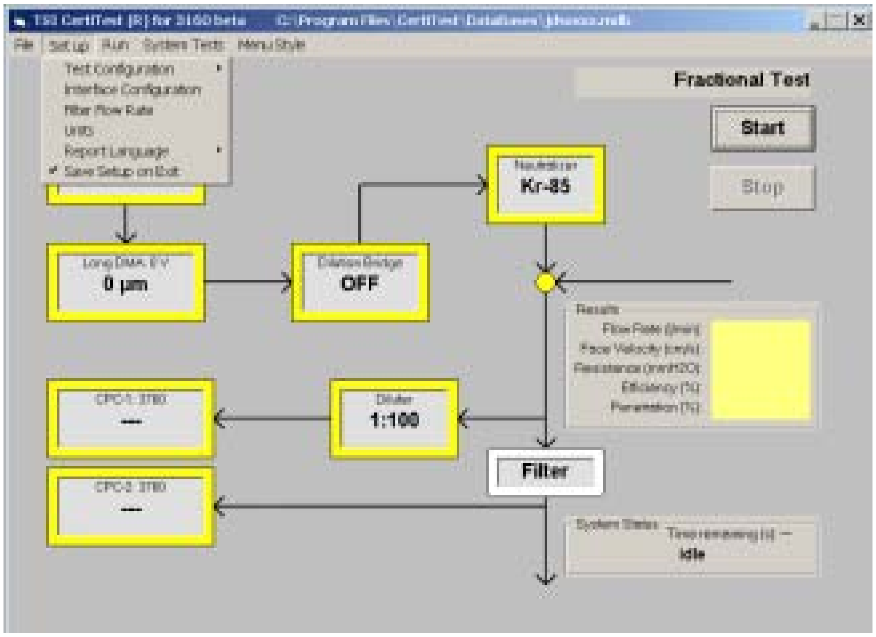

Figure 4-2
Setup Menu

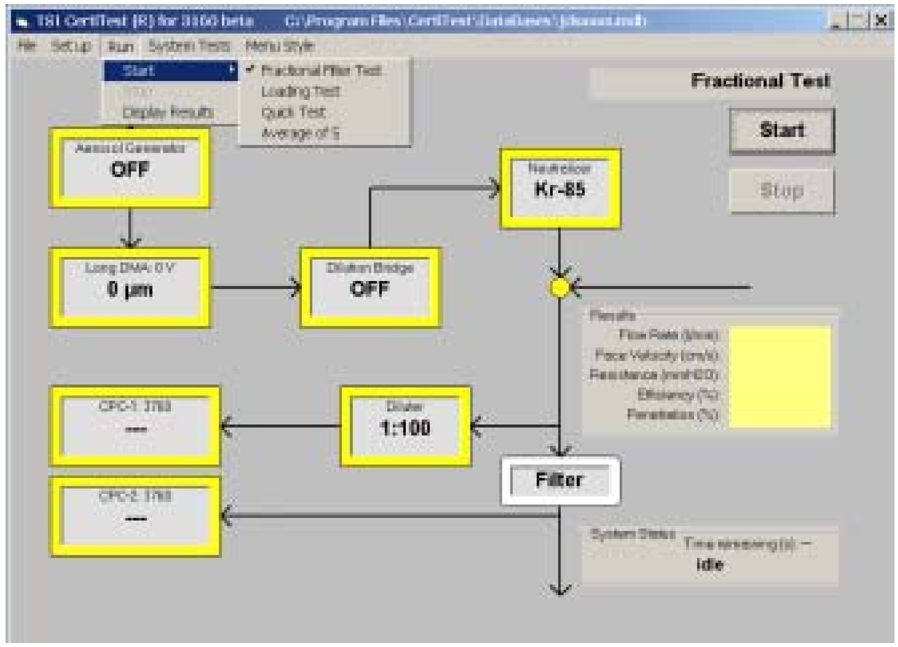

Figure 4-3
Run Menu

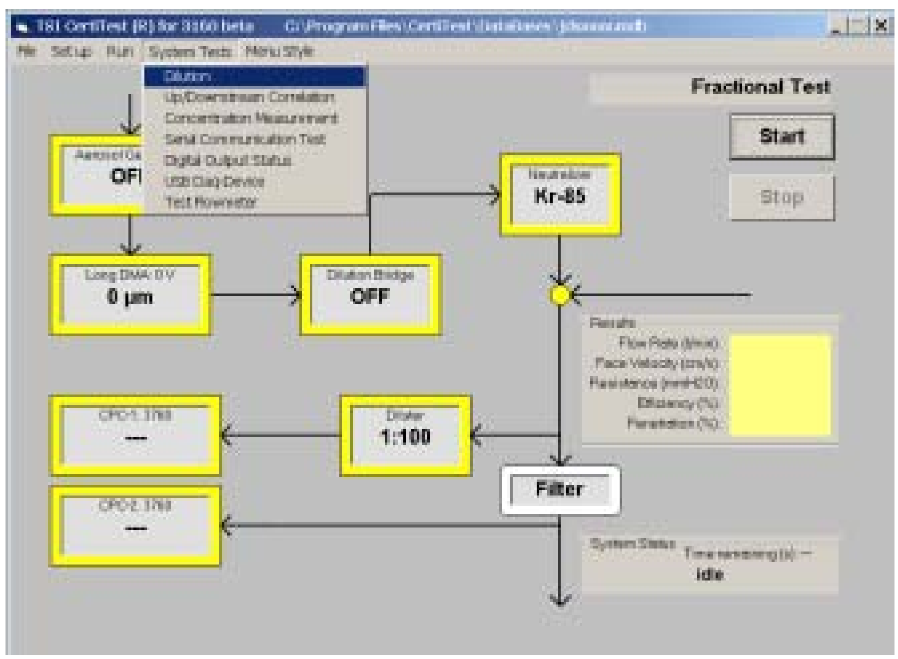

Figure 4-4
System Tests Menu

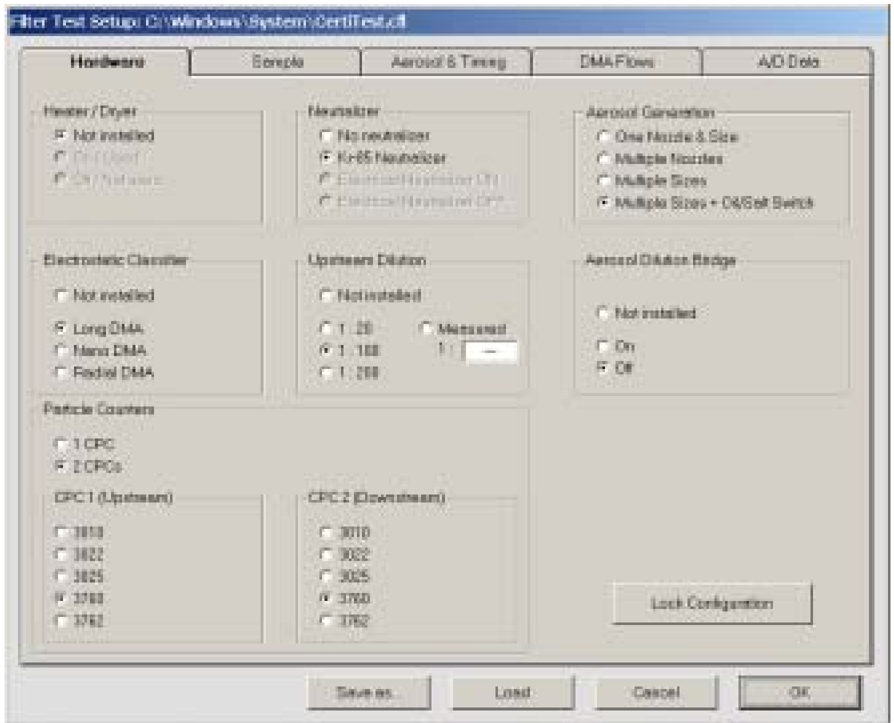

Figure 4-5
Hardware Menu

CHAPTER 5

Operating the Filter Tester

This chapter gives operating instructions for the Model 3160 Filter Tester.

Start up Procedure

Following is the start-up procedure which is followed to set up the tester and perform a test. This section assumes that the Model 3160 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. Turn on instrument power
3. Turn on pump power
4. Turn on air supply
5. Check the aerosol generators
6. Check the aerosol dryer and air supply desiccant
7. Check the CPC butanol level
8. Set main pressure regulator
9. Set aerosol generator pressure
10. Set filter holder pressure
11. Check CPC vacuum pressure
12. Warm-up Period
13. Set up the printer
14. Start the software program – CERTITEST
15. Set the diluter ratio
16. Perform a filter test

Turn on the System Power

The tester power switches are shown in Figure 2-6.

Turn the System power switch on. Turn on the Instrument and Pump switches. The Instrument power must be turned on before opening CERTITEST.

Check the Aerosol Generators

Check the solution levels in the aerosol generators. The stainless steel draw tube s 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. For long duration tests, ensure that the drain bottles are empty before initiating a test. All bottles must seal tight against the manifold to ensure proper tester operation.

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

Check the Membrane Dryer

When using salt aerosol, check the membrane dryer and make sure that air is flowing through the dryer opposite to the salt aerosol (Figure 2-13). Place your finger over the membrane dryer air outlet. Air should be exiting the outlet. The outlet air flow should be at least double the aerosol flow which is nominally 3.6 to 3.8 liters per minute. Therefore, a flow of at least 7.6 lpm should be passing through the dryer.

Check the Air Supply Desiccant

Refer to Figure 2-12 to identify the air supply desiccant holder.

Caution

Always turn the power to the Model 3160 AFT OFF before changing the desiccant. Turn OFF the air supply entering the unit at the main valve.

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 located at the back of the CPCs.
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. Open the bottle cap slightly to provide a vent when filling. Press the fill button on the CPC.

6. Watch the sight glass carefully while filling. When the liquid level is in the middle of the sight glass, press the fill button again to stop the fill. 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.

7. Ensure that the butanol bottles do not leak when they are stored inside the tester.

Figure 5-1
Filling the CPCs with Butanol

Caution

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.

Set the Main Pressure Regulator

Turn the air supply valve on (Figure 2-13). 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.

WARNING
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 *not* use excessive pressure as this may damage your filter as well as cause unnecessarily hazardous conditions.

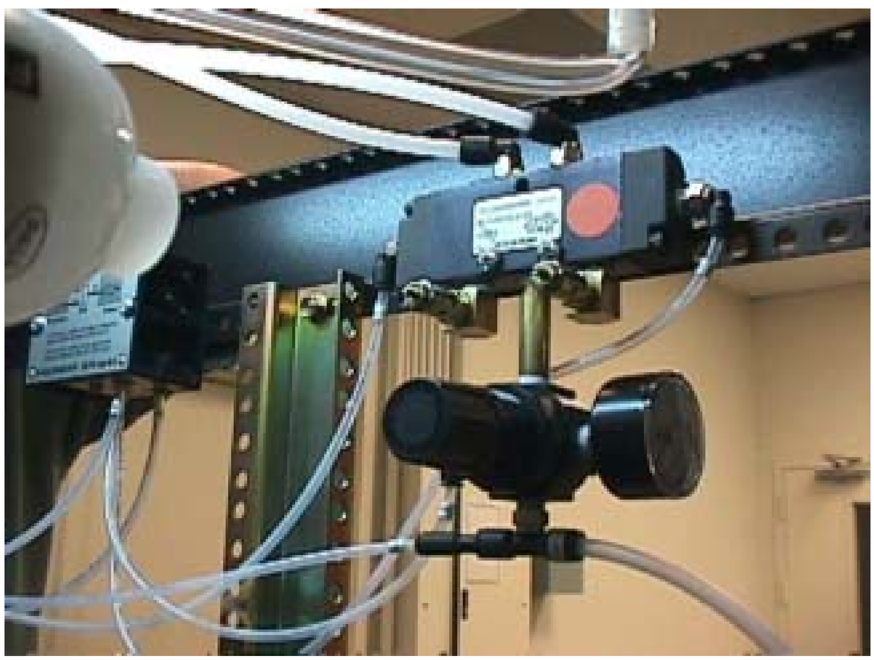

Figure 5-3
Filter Holder Pressure Regulator

Check CPC Vacuum Pressure

Check the CPC vacuum gauge (Figure 2-6). The pressure should read 8 psi or greater. This vacuum pressure is necessary to maintain 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, pump fittings, connection to the pressure gauge etc.

Warm-up Period

After the Model 3160 AFT is turned on, it requires about 15 minutes for the pressure transducer to stabilize. The CPCs require approximately 10 minutes to warm-up. The CPCs are ready for use when the TEMP lights stop blinking.

Set up the Printer

When a test is completed, test data may be sent to the printer. To avoid printer errors, the printer must be ON-LINE. Check to see that the printer is ON-LINE and has an adequate supply of paper.

Start the Software Program—CERTITEST

The software is Windows based and offers a rich array of options to tailor a test to specific requirements.

Turn on the computer. If any menus appear requesting passwords simply press **Enter**. No passwords are set at the factory. Note: the Instrument switch must be turned on before CERTITEST is started. At program initiation the software checks for the presence of the data acquisition module which is in the DC relay/interface box. If the Instruments switch is off when the program is started an error will be generated.

The CERTITEST software loads three files at program initiation. These are (1) a .cfl file which is a configuration file that loads user defined inputs to characterize a test; (2) a .int file which loads the interface configuration; and (3) a .mdb file which is a database file where all data and test results reside. The location of these files are noted in the .ini file.

1. Turn the computer on. Click on **CERTITEST** and **Open**. The window shown below should appear. If it does not appear the software cannot find the .ini file and a window will open requesting a path to the .ini file location. This window shows the location of all the files used to start the program. The input for the Operator Name window is optional. Fill in or leave blank. The name that is input here will appear on the Results outputs. Select **Start**.

Figure 5-4
CERTITEST Start Menu

2. Go to Set up > Test Configurations > Sample Description and open.

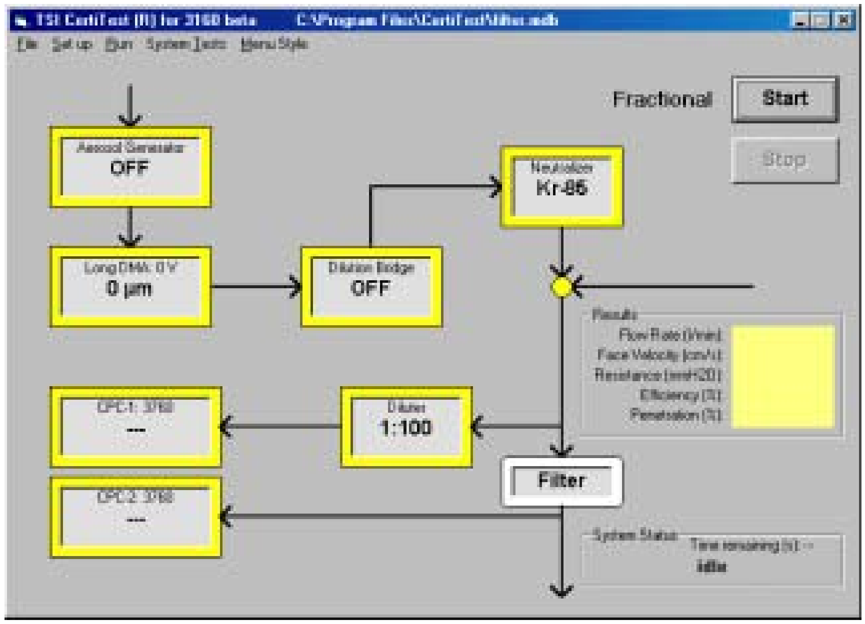

Figure 5-5
CERTITEST Main Window

3. Input descriptive text in the appropriate text boxes as shown in the example (Figure 5-6). The text box on the left contains User defined sample descriptions. The check mark in the box at the left causes these descriptions to appear on the output. Descriptive data can be saved to a database and retrieved for future input. If not saved to the database the descriptive data cannot be reloaded when reviewing old test results.

4. The Filter/Media Data shown on the right always appear in this format. Descriptive data can be input as desired. Again, these descriptions can be saved to a database for future reference.

   The Load from Database buttons can also be used to load a previously saved description.

5. The Save as... button can be employed to save the entire test description. It will be saved with a .cfg name denoting a setup configuration file which can be retrieved by executing File > Open > Test Setup File.

   Alternatively, the Load button can be used to load a previously saved configuration file.

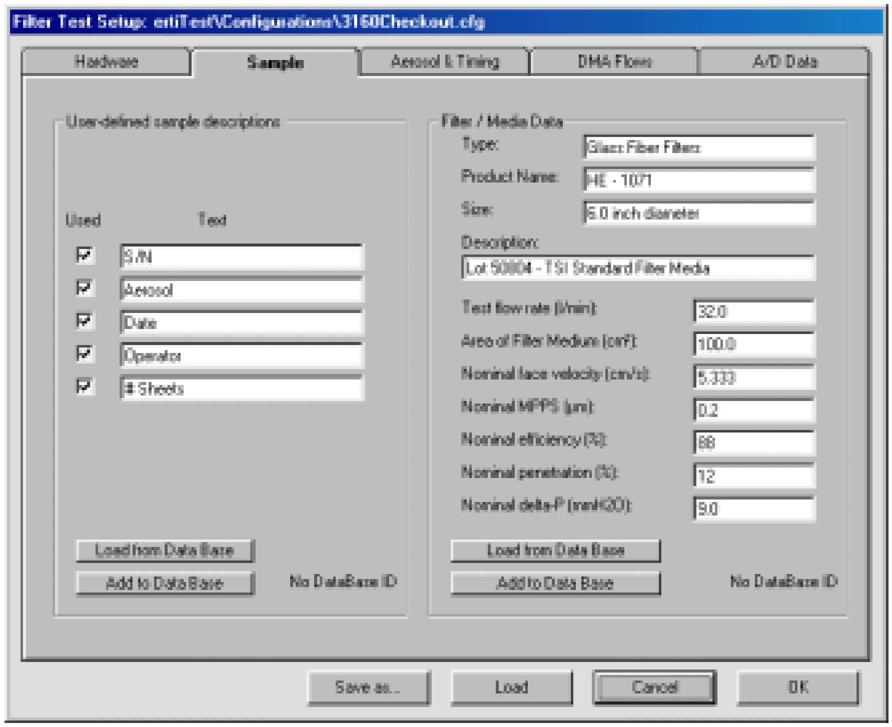

Figure 5-6
CERTITEST Sample Menu

6. Next, select the Aerosol and Timing menu and input the desired particle sizes. U/D refers to the upstream/downstream correlation. An upstream/downstream correlation test can be performed from the System Test menu to generate the U/D values. These values will be automatically input. If a U/D test is not performed a default ratio of 1.00 is used or the last saved U/D factors will be used. Up to 20 particle sizes can be selected ranging from 0.015 micrometers to 0.8 micrometers. Selection of particle sizes exceeding 0.4 micrometers requires an adjustment in classifier flow rates in the DMA Flows menu.

7. Select the aerosol type: salt or DOP. The Aerosol Parameters are used to input the aerosol switch points which control which bottle is used. These are set at the factory based on the aerosol concentrations and it is recommended that these be set to 0.05 and 0.1.

8. Set the parameters in the Sampling box. Sampling will continue until the minimum sample time or the maximum number of

counts is reached. In the event that the filter is highly efficient and the maximum number of counts is not reached, sampling will continue until the maximum time is attained.

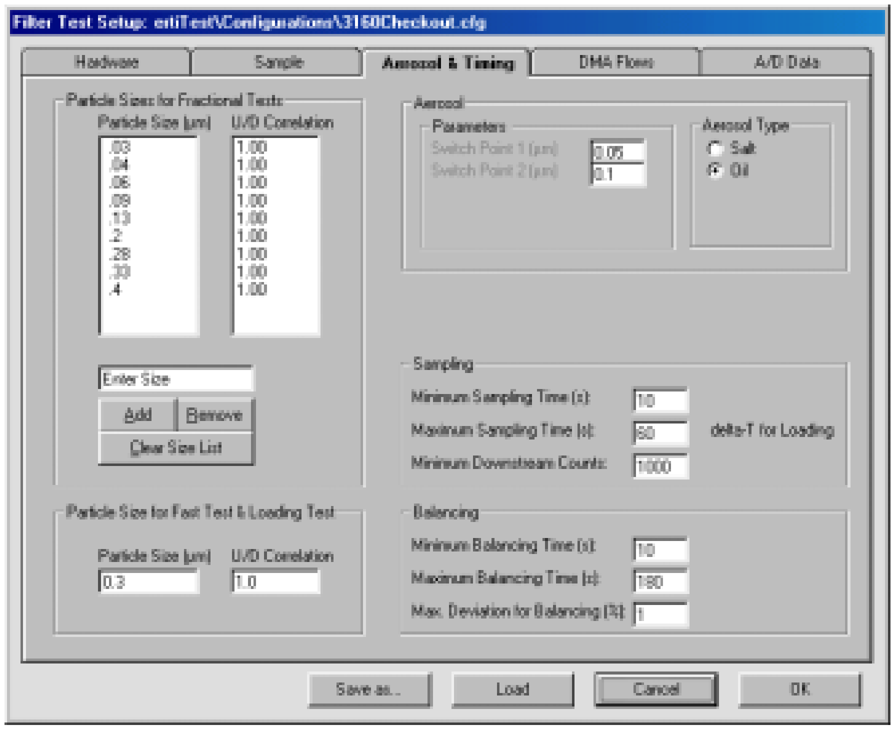

Figure 5-7
CERTITEST Aerosol and Timing Menu

9. The Balancing box parameters are used to determine the amount of time that the system checks upstream/downstream concentration ratios before initiating a test. A test will not begin until the concentration ratio is constant within the Max Deviation for Balancing in % for a set number of iterations or until the maximum balance time is reached. Conversely, the minimum balance time must be attained before sampling will begin regardless of the constancy of the ratio.

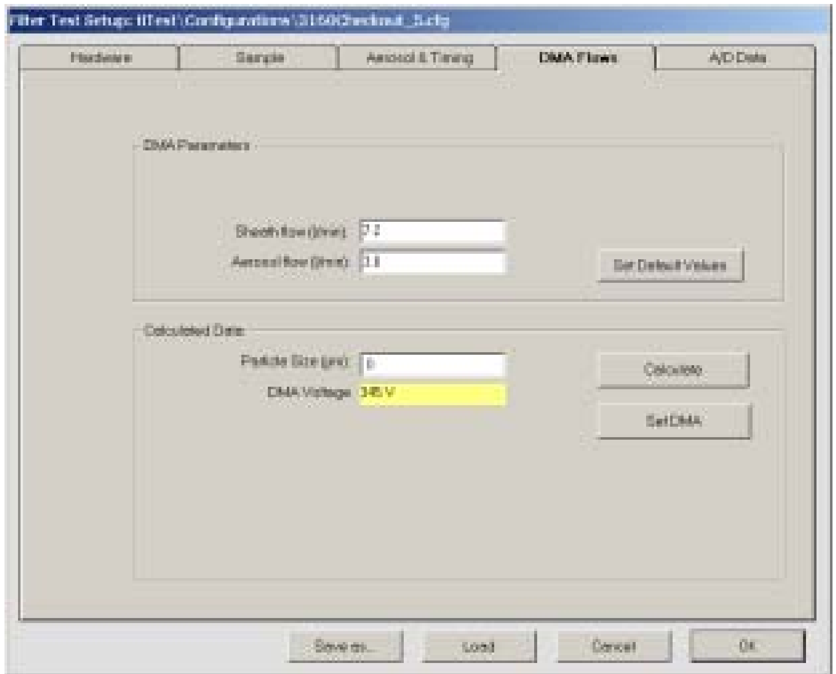

Figure 5-8
CERTITEST DMA Flows Menu

10. When testing with particle sizes 0.4 micrometers or less no changes will need to be made to the sheath flow and aerosol flow rates. However, particle sizes up to 0.8 micrometers may be selected. Particle sizes greater than 0.4 micrometers require that the sheath and aerosol flow rates be adjusted to allow the classifier to effectively select the larger particle sizes. Use this menu to modify classifier flows. It is recommended that the 2:1 sheath to aerosol ratio be maintained.

The largest particle size selected will dictate the maximum Classifier flow rates that can be accommodated and still extract the particle. Reduce the sheath and aerosol flows and hit the Calculate button. The software will generate a response noting whether or not the flow reduction is adequate.

Reductions in aerosol flow MUST be bled off in the Large Particle flow bypass; e.g., if an aerosol flow of 1.6 lpm is required, approximately 2.0 to 2.2 lpm must be channeled through the bypass. This is the difference between the atomizer flows and the flow through the Classifier. If the default classifier flows are used the bleed valve must be turned off.

Refer to the Electrostatic Classifier manual for instructions on Classifier operation.

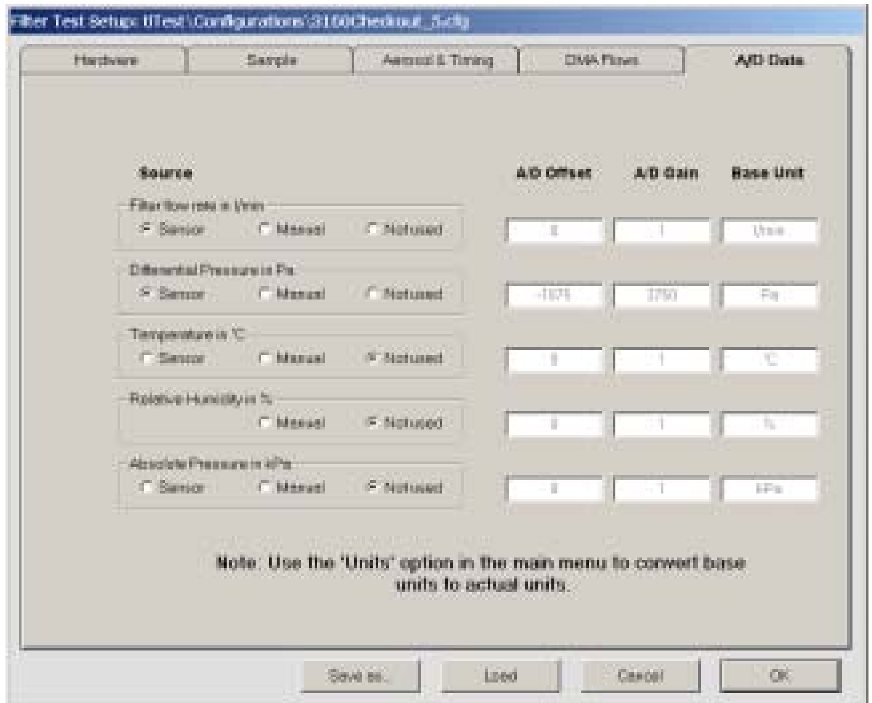

Figure 5-9
CERTITEST A/D Data Menu

11. This menu is for information purposes only. No changes should be made.

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 and in Chapter 7 of this manual.

1. Select the program option, **Adjust Diluter**.
2. Close the empty filter holder.
3. Select, Adjust Dilution to preselected value.
4. Set Dilution to 1:100
5. Select **Particle Size**. Normally, the size selected is representative of the Most Penetrating Particle Size.
6. Check the Large Particle option bleed flow. It should be set to agree with the parameters of the test. When testing with the default classifier flows, it should be off.
7. Start.
8. 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 ±2%. Note: stabilization times of 30 minutes or longer are not uncommon. Turn the diluter valve clockwise to reduce the dilution ratio.
9. Record the delta P value on the diluter gauge. This value will typically be between 0.10 and 0.15, and should be consistent with values recorded previously.
10. Alternatively, if “Set dilution to measured value” is selected, the software will use the measured dilution value at the conclusion of the test in the concentration calculations. With this option, it is not necessary to adjust the dilution to exactly 1:100.

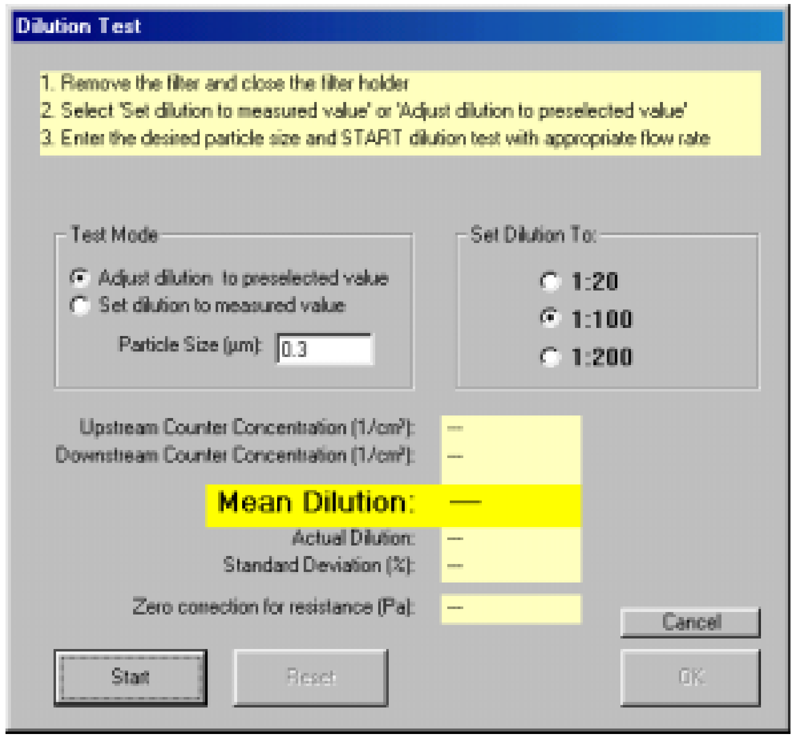

Figure 5-10
CERTITEST Dilution Test Menu

Perform 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 completed, a test: Fractional Efficiency, Loading or Quick Test can be performed.

1. First examine the test parameters by reviewing the selections from the Setup menu. Change parameters if required.
2. Turn the pump Off. Open the filter holder by pressing the OPEN button. Install the filter and press the CLOSE buttons, holding for 1 second. Turn the pump ON.
3. Initiate the test by selecting the Start option on the CERTITEST window or open the Run menu and start the test.

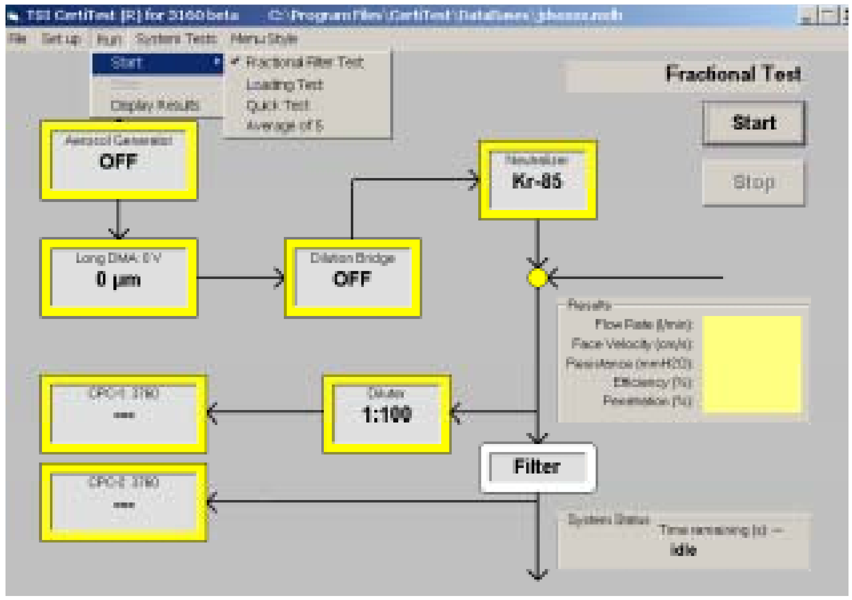

Figure 5-11
CERTITEST Run Menu

4. A screen will pop up with the selected test parameters which can be changed if desired. When satisfied with the inputs, select **ok**.

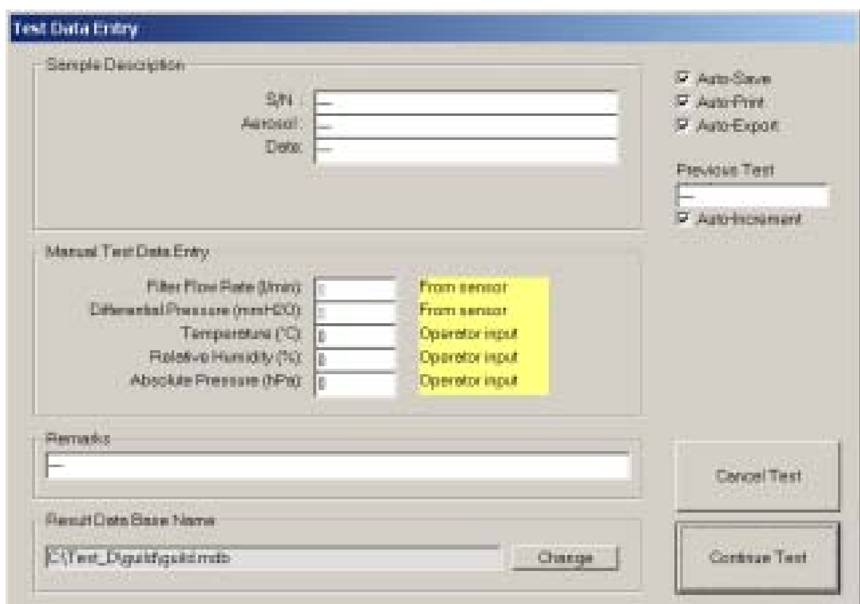

Figure 5-12
CERTITEST Test Data Entry Menu

5. A new screen will popup prompting for descriptive inputs and a test number. The Sample Description reflects the choices made on the earlier user defined sample inputs. Fill out the descriptions as desired. It is not mandatory that these fields be filled out. There is also a field for Remarks. This allows some additional descriptive input to be captured. On the right hand side are three fields with a check box for: (1) Auto-Save, (2) Auto-Print, and (3) Auto-Export. Auto_Save will automatically save the results at the conclusion of the test to the current selected database. Auto-Print will print a copy of the test results and Auto-Export will save the results in the form of an Excel file. The location of the Excel file can be set in the set path for Excel export. Otherwise a default file location will be used. The test number may be manually input each time or one can select **Auto-Increment**. If this option is selected the software will automatically increment the test number. To use these options place a check in the box adjacent to each option. The Manual Test Data Entry box has no user inputs. When satisfied with the inputs, select **Continue test** or **Cancel test**.

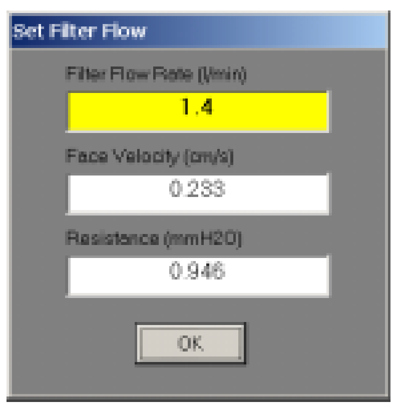

Figure 5-13
Set Filter Flow Menu

6. The tester will now open a menu to set the Filter Flowrate. Adjust the flow as necessary. Select **ok**.
7. To exit the test before it is complete press **Stop**. Data are retained and can be saved and or printed. However, the test cannot be continued once Stop is selected.
8. To perform a loading or quick test, select **Run > Start > Loading** or **Quick Test**. Only one aerosol size is used in these

tests. Setup the parameters as described previously and follow the instructions indicated on the screen.

9. The figure below shows the default Hardware menu selections. There is no reason to change these. Be sure that the correct CPC boxes are checked for your hardware configuration. The software adjusts for the flows that are pulled through different CPCs in the calculation of penetration.

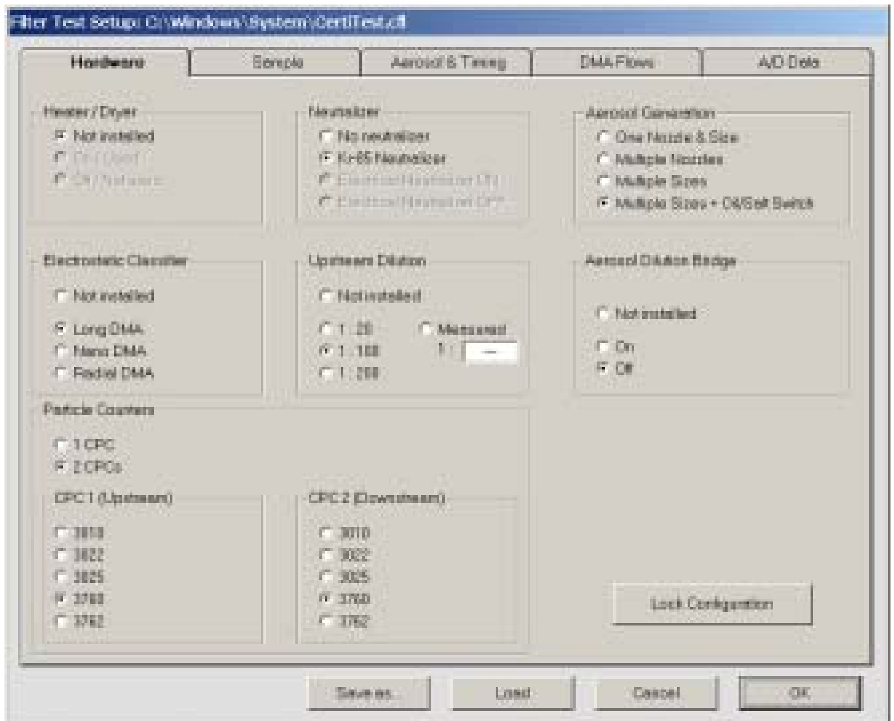

Figure 5-14
Default Hardware Menu

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 reviewing the selected parameters from the Setup menu. Change parameters as necessary.

2. Turn the pump OFF. Open the filter holder by pressing the OPEN button. The reason to turn the pump OFF is to preclude drawing contamination through the stainless steel tubing and the CPCs. Any contamination in the plumbing will affect the results for very high efficiency filters. Install the filter and press the CLOSE buttons, holding for 1 second. Turn the pump ON.

3. Initiate the test by selecting the Start option from the CERTITEST window or open the Run menu and start a test.

3. Before the test starts, a screen with input parameters is displayed allowing a last chance to change the test setup. A screen then appears requesting descriptive data to be input followed by the filter flow screen where the flow rate is set. Check the status of the bleed flow valve used in the Large Particle option. Ensure that it is closed or is set to the correct flow for the current test parameters.

4. If it is desired to utilize U/D correlation factors, a U/D test must be performed first. At the conclusion of the U/D test select **Run > Fractional Filter Test**. Do not select **Start**. Selecting Start will execute another U/D test. The U/D factors will then be used in the penetration/efficiency calculations.

5. Input any Sample descriptive data desired including comments in the Remarks window. Also, select output options for Save, Print and Excel file output and test number. Note: an Excel file can be created from old test results by loading the old test results and then selecting Export to Excel from the file menu. The database can also be changed at this time. When satisfied with the setup, Continue the test.

6. To exit the test before it is completed select **Stop**.

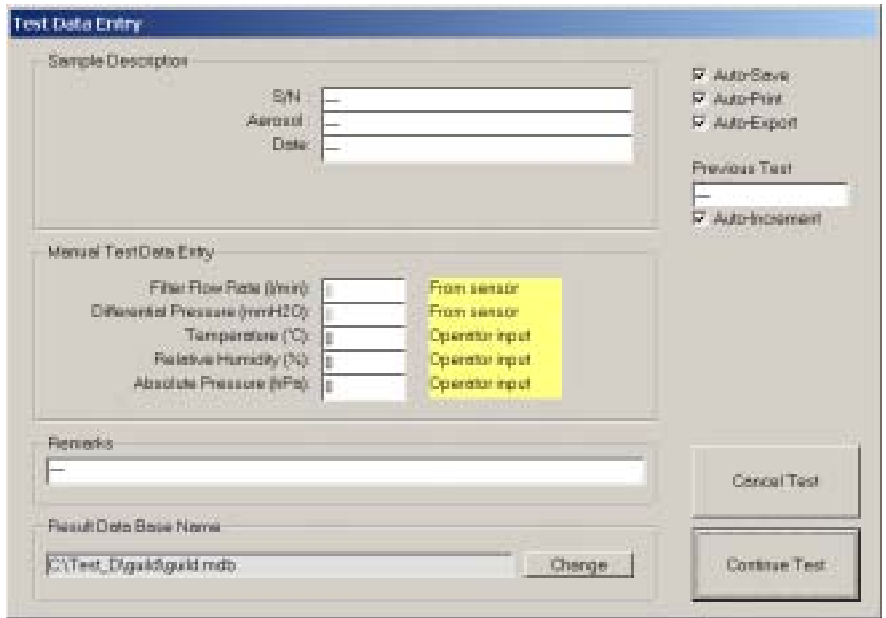

Figure 6-1
Test Data Entry Menu

Test Routine Overview

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

Before sampling begins, time is allowed for the aerosol to stabilize. The stability or balance time is input by the user on the Aerosol and Timing menu.

Once the aerosol has stabilized, the software checks for low aerosol concentration. An error message appears if a problem in aerosol generation exists. Sometimes, especially during the first test after a prolonged idle, and with high efficiency media the low aerosol concentration warning will appear. This is because it takes some time for the aerosol to wend its way through the plumbing before it arrives at the CPC. Simply wait until the concentration begins to increase. The warning message will automatically disappear.

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, balancing restarts from zero with the maximum time for the new diluted aerosol concentration to stabilize.

Note: *Clicking on the dilution bridge icon in the main Window will toggle the dilution bridge on and off.*

During the test, Condensation Particle Counter (CPC) data, filter flow rate and resistance are measured continuously and displayed on the screen. Flow and resistance readings are averaged over the entire test period. To monitor test data in real time go to Run > Display Test Results or click in the Results box shown in the Main window. Three menus appear: General Results, Fractional Results and Graphs. Toggle between these menus to view the desired data.

At the conclusion of a test, data can be manually saved and printed if the automatic selections were not made. To save results go to Run > Display Test Results > Add to Database > Add. A test ID number will be assigned to the results. Note this number for future reference. To print test results data, click on the **Print** button in the Test Results window. In the graph menu, results can be displayed in either Penetration or Efficiency format. Results will print out as Penetration or Efficiency depending on the option selected.

To exit the test before it is complete, press **Stop**. Stop causes an alert screen to be displayed – Test Stopped by Operator. Once Stop is invoked the test cannot be continued from the stop point. Data taken to this point, however, can be saved and printed. Follow the steps given above.

Test Results

Data from a filter test can be 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. Once the printer problem is corrected the data printout can be initiated manually from the Test Results software option.

Data from the last test are retained by the computer until the computer is turned off or another test is started. This “current” data can be displayed graphically from the Test Results option. A test printout is shown on the following pages. The first figure is the General Results window. The first text box shows some General Data. Text box 2 shows Sample Description data that are input in response to the user defined inputs on the Sample menu (Figure 5-6). Some summary Test Results data are given in the next text box. Last is some information regarding the Database ID’s. Pay particular attention to the ID numbers for Filter & Media, User Definitions and Units. These numbers should reflect the database numbers for these inputs. If the numbers are wrong or blank, no descriptive information will be accompany the results when reloaded from the database.

A data Fractional Results table is shown in Figure 6-3. Particle size is in micrometers. Filter Efficiency, Penetration and 95 % confidence level Penetration are given in %. Delta-P is the pressure drop across the filter in units selected by the user during Test Setup. Upstream and Downstream refer to the concentrations sampled before and after the filter, measured each second and averaged over the test interval. The number of downstream particles counted, are shown in the last column. Penetration and efficiency are presented as percents.

% Penetration = downstream concentration / upstream concentration $\times$ 100 / CF

CF = correlation factor

% Efficiency = 100 - % penetration

Correlation Factors

The correlation factor CF for each particle size is automatically computed when a U/D correlation test is executed. 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 near the particle size at which the dilution ratio is set.

To establish specific CF values, a U/D 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). A fractional efficiency test must be executed prior to the U/D test with the CFs set to 1. Before beginning this test adjust the diluter to 100 %. See the Set Diluter option.

Once the test is finished, CF values are calculated based on the test data. The CF numbers are the downstream concentration divided by the upstream concentration which is analogous to a penetration calculation with no filter. The reason these numbers differ from 1 is that the upstream CPC flow is always routed through the diluter which filters out 99 % of the upstream concentration. Since the flow is passed through a filter in the diluter the upstream concentration will vary with particle size.

CF = observed penetration

At the conclusion of the U/D correlation test, the CF numbers will automatically be input in the U/D field corresponding to the particle size. A filter may then be loaded and a filter test executed. IMPORTANT: The filter test must be started from the Run menu. Selecting Start on the Windows menu will execute another U/D test.

Note: the CF numbers will be used in subsequent filter tests until a new configuration file is loaded or the inputs are changed in the Aerosol & Timing menu, unless the current parameters are saved to a configuration file. That is, if an old configuration file is reloaded or changes are made in the Aerosol & Timing menu the U/D correlations will be lost unless they have been saved.

Low Counts

Should the number of downstream counts be zero, a count of 1 is used to compute an artificial downstream concentration. This is so that the penetration results may be plotted. Because the graphs are logarithmic, a zero value is not valid. When testing very high efficiency media this fact can lead to very strange results as presented in the graph mode. Because the concentrations leaving the classifier are different for each particle size an artificial downstream count of 1 will lead to different penetration "calculations" and the data points as plotted may exhibit very strange behavior; for example, they may be scattered all over the graph and or trend in the wrong direction. When viewing results with zero actual downstream counts one must bear in mind that the numbers are not real.

Therefore, in the case of a test with no counts at all or zero counts for some of the particle sizes, the results must be carefully reviewed and interpreted accordingly. In general, sample times for tests like this should be lengthened sufficiently to generate actual count data. Furthermore, extended balance times should also be employed to allow the media to purge itself of previous particle sizes and to come to equilibrium at the new particle size prior to initiating sampling.

Figure 6-4 shows a typical graphical representation of the test data for a Fractional Efficiency Test. The MPPS is calculated based on the graph interpolating curve or the largest data point recorded and therefore can ignore actual test results in some cases.

Figure 6-5 shows a typical general Results Summary of the test results.

Sample Printout

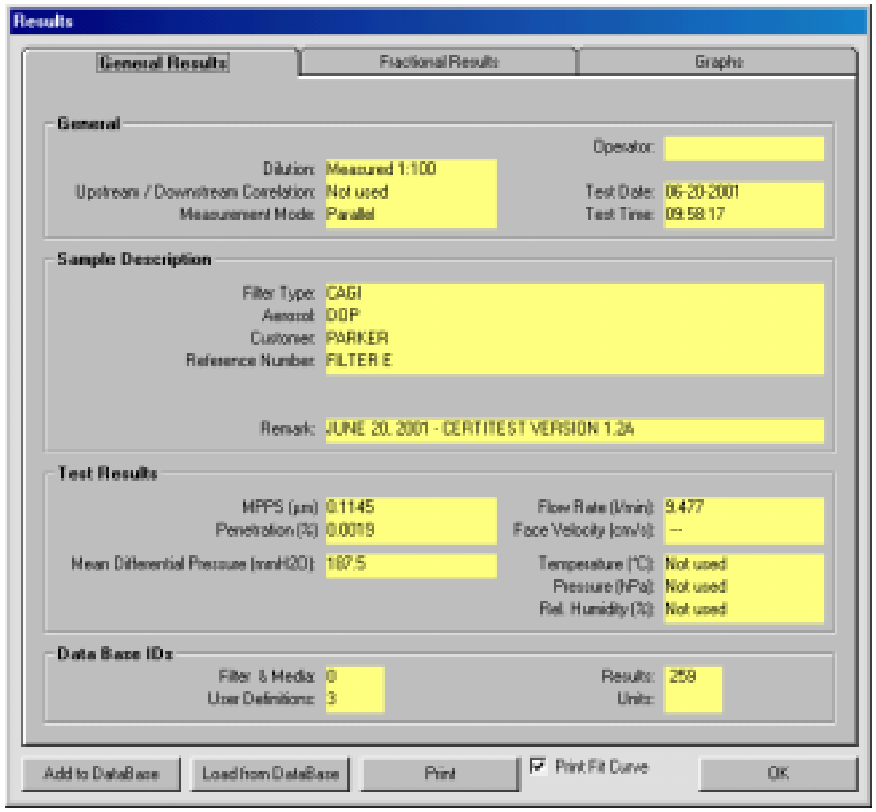

Figure 6-2
CERTITEST Test Results > General Results Window

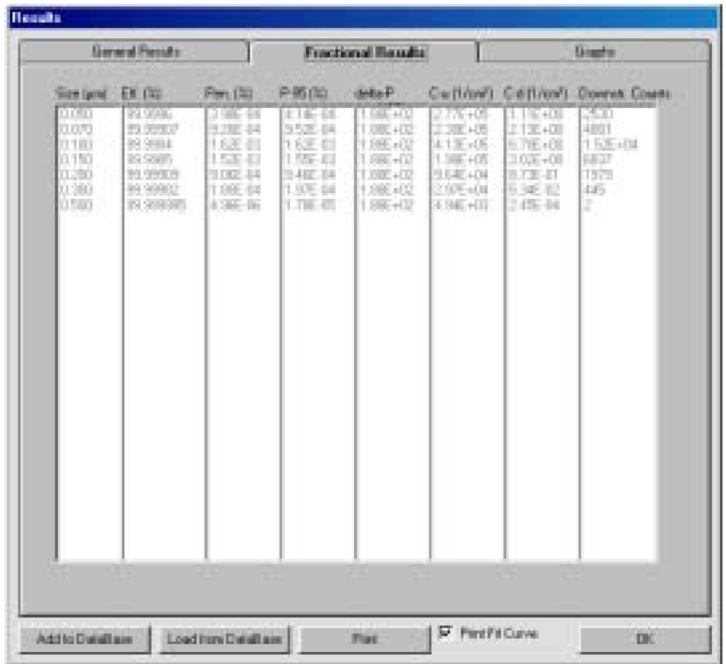

Figure 6-3
CERTITEST Test Results > Fractional Results Window

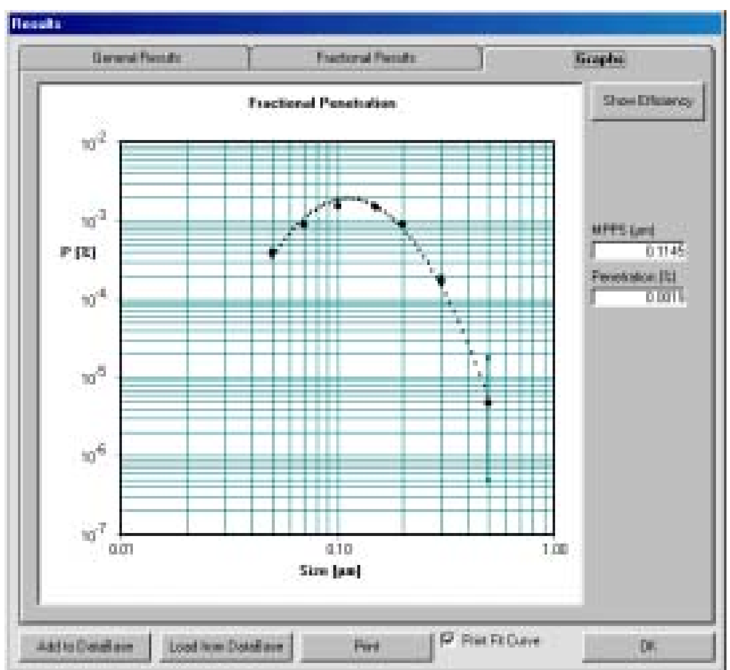

Figure 6-4
CERTITEST Test Results > Graphs Window

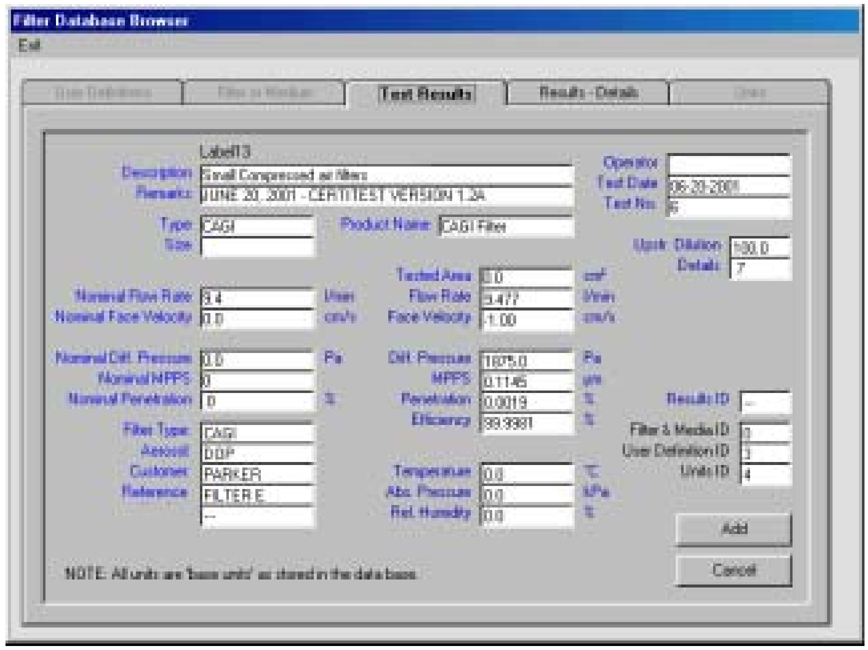

Figure 6-5
CERTITEST Test Results Window

CHAPTER 7

More on the Software

This chapter gives information on the calculation used for coincidence correction. Also refer to Chapter 4 for a description of the Model 3160 Filter Tester software menu options. Finally, some representative files used with the software are described and listed.

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:

$$Na = Ni \exp(Na\ Q\ t)$$

Na = corrected concentration
Ni = 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 Ni substituted for Na 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 10,000. 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.

CERTITEST Program Files

This section gives a brief description of some of the files used with CETITEST.

The CERTITEST software writes all data to a Microsoft Access Database. To view the database directly, open Access and open the filter database file. This file location is displayed in the main window title bar; e.g., C:\ProgramFiles\ CertiTest\ filter.mdb. Note: CERTITEST writes to an older version of Access. The Access version provided with Microsoft Office can be used to view the database but the database should NOT be converted to the new version. If it is converted, CERTITEST will no longer be able to write to the database.

Test results can also be reviewed by opening CERTITEST and then selecting Files > Open > Test Results.

A number of files are utilized by the software. A brief description of these files and their locations follow. At program initiation the first screen (Figure 5-4) shows various source files used to start a test and their usual locations.

Note: normally the software will write the current configuration to a dummy configuration file with a .cfl extension. The location of this file will be written into the .ini initialization file. In the event of a software crash some of these files can become corrupted and the software will not restart properly because it cannot read the input load files. To overcome this, manually write the default configuration file location into the CertiTest.ini file. The program should then start up properly and one can then proceed to load the desired configuration files.

It is recommended to make copies of the initialization file - *.ini, the interface file - *.int, and the configuration file - *.cfg for reference in case of a software crash. Examples of files used by the software are shown below.

CERTITEST is written in Visual Basic. The following files are the CERTITEST cabinet files.

Location - C:\Program Files\Filter Test\Install CABS

CertiT1.CAB
CertiT2.CAB
CertiT3.CAB
CertiT4.CAB
CertiT5.CAB
CertiT6.CAB
CertiT7.CAB
CertiT8.CAB
CertiT9.CAB
setup.exe
Setup.lst

The following files are CERTITEST program files.
Location - C:\Program Files\CertiTest

CertiTest.exe	* executable code
filter.mdb	* database file
Empty filter.mdb	*empty database file
Example.cfg	* example configuration setup file

The following files are CERTITEST auxiliary files.

***Note**: these files must be located in C:\Windows\System regardless of the current version of Windows installed on the computer.*

Location - C:\Windows\System

CertiTest.cfl	* configuration file saved on program exit
CertiTest.ini	* initialization file with start up information
CertiTest.int	* describes hardware configurations and interface setups
CertiTestDefault.cfg	* describes configuration with user inputs, etc.
CertiTestNoName.cfg	* used if no configuration selected
CertiTestEmptyDB.mdb	* empty database file used to create new database files
CertiTestF.xls	* Excel file
CertiTestQ.xls	* Excel file

The *.ini file gives the path to the filter database file - *.mdb, the configuration file - *.cfg or *.cfl, and the interface configuration file - *.int. A sample CertiTest.ini file would look as follows:

CertiTest.ini

"C:\Program Files\CertitTest\filter.mdb"	- database
"C:\Windows\System\CertitTest3160.cfg"	- configuration file
"C:\Windows\System\CertitTest3160.int"	- interface file
"3160"	- system descriptor
"TSI Fractional-Efficiency Filter Test"	- title

CertiTest.int: - For Serial CPC Setup

#TRUE#,#FALSE#,#FALSE#,4,5,"CPCtoCOM, CPCtoDAQ, CPCtoCPCup, Chnl CPC1, Chnl CPC2"
#TRUE#,#FALSE#,#FALSE#,6,"DMAtoCOM, DMAtoCPCup, DMAtoDAC, Chnl DMA"
#FALSE#,#FALSE#,#FALSE#,#TRUE#,6,"Dilution Bridge"
#FALSE#,#FALSE#,#FALSE#,#FALSE#,-1,"Heater"
#FALSE#,#FALSE#,#FALSE#,#FALSE#,-1,"Neutralizer"
#FALSE#,#FALSE#,#FALSE#,#FALSE#,-1,"Up/Down Switch"
#FALSE#,#FALSE#,#FALSE#,#TRUE#,0,"Aerosol Generator(s)"
#FALSE#,#FALSE#,#FALSE#,#FALSE#,0,"Analog Input"
#FALSE#,#FALSE#,#FALSE#,#TRUE#,8,"Chuck Purge Valve"
#FALSE#,#FALSE#,#FALSE#,#TRUE#,7,"Quick Test Valve"
#FALSE#,#FALSE#,#FALSE#,#TRUE#,9,"Classifier Purge Valve"
#TRUE#,7
#TRUE#
" 0","AI details"
-1,0,-1,-1,-1,-1,-1,-1
" 5","Generator details"
0,1,2,-1,3,4,5,-1
#FALSE#,#TRUE#,#FALSE#,#FALSE#,"Daq assignment"
#FALSE#,#TRUE#,#FALSE#,#TRUE#,#TRUE#,#FALSE#,"Uni/Bipolar, Single/Differential, X1/X2"
0,"CPC on 1200 baud? 1=YES"
"0.01","Delay1"
"0.01","Delay2"
"0.01","Delay3"
"0.01","Delay4"
"0","1","Flow   A/D Offset / Gain"
"-1875","3750","Resist A/D Offset / Gain"
"0","1","Temp   A/D Offset / Gain"

"0","1","Rel Hum A/D Offset / Gain"
"0","1","Abs P A/D Offset / Gain"
#FALSE#,"Print full graph for Quick Test"
"3160"

CertiTest.int: - For Analog CPC Setup

#FALSE#,#TRUE#,#FALSE#,1,2,"CPCtoCOM, CPCtoDAQ, CPCtoCPCup, Chnl CPC1, Chnl CPC2"
#TRUE#,#FALSE#,#FALSE#,6,"DMAtoCOM, DMAtoCPCup, DMAtoDAC, Chnl DMA"
#FALSE#,#FALSE#,#FALSE#,#TRUE#,6,"Dilution Bridge"
#FALSE#,#FALSE#,#FALSE#,#FALSE#,-1,"Heater"
#FALSE#,#FALSE#,#FALSE#,#FALSE#,-1,"Neutralizer"
#FALSE#,#FALSE#,#FALSE#,#FALSE#,-1,"Up/Down Switch"
#FALSE#,#FALSE#,#FALSE#,#TRUE#,0,"Aerosol Generator(s)"
#FALSE#,#FALSE#,#FALSE#,#FALSE#,0,"Analog Input"
#FALSE#,#FALSE#,#FALSE#,#TRUE#,8,"Chuck Purge Valve"
#FALSE#,#FALSE#,#FALSE#,#TRUE#,7,"Quick Test Valve"
#FALSE#,#FALSE#,#FALSE#,#TRUE#,9,"Classifier Purge Valve"
#TRUE#,7
#TRUE#
" 0","AI details"
-1,0,-1,-1,-1,-1,-1,-1
" 5","Generator details"
0,1,2,-1,3,4,5,-1
#FALSE#,#TRUE#,#FALSE#,#FALSE#,"Daq assignment"
#FALSE#,#TRUE#,#FALSE#,#TRUE#,#TRUE#,#FALSE#,"Uni/Bipolar, Single/Differential, X1/X2"
0,"CPC on 1200 baud? 1=YES"
"0.01","Delay1"
"0.01","Delay2"
"0.01","Delay3"
"0.01","Delay4"
"0","1","Flow A/D Offset / Gain"
"-1875","3750","Resist A/D Offset / Gain"
"0","1","Temp A/D Offset / Gain"
"0","1","Rel Hum A/D Offset / Gain"
"0","1","Abs P A/D Offset / Gain"
#FALSE#,"Print full graph for Quick Test"
"3160"

CertiTestDefault.cfg

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"Heater On",#FALSE#
"Heater Off",#FALSE#
"Reserved","not used"
"Reserved","not used"
"NoNeutralizer",#FALSE#
"Kr-85 Neutralizer",#TRUE#
"Electrical Neutralizer On",#FALSE#
"Electrical Neutralizer Off",#FALSE#
"Reserved","not used"
"Reserved","not used"
"No DMA",#FALSE#
"Long DMA",#TRUE#
"nano DMA",#FALSE#
"Radial DMA",#FALSE#
"Reserved","not used"
"Reserved","not used"
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"Dilution 1:100",#TRUE#
"Dilution 1:200",#FALSE#
"Dilution Measured",#FALSE#
"Dilution Value","100"
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"2 CPCs",#TRUE#
"Up 3010",#FALSE#
"Up 3022",#FALSE#
"Up 3025",#FALSE#
"Up 3760",#TRUE#
"Up 3762",#FALSE#
"Down 3010",#FALSE#
"Down 3022",#FALSE#
"Down 3025",#FALSE#
"Down 3760",#TRUE#
"Down 3762",#FALSE#
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"Delay2","0.01"
"Delay3","0.01"
"Delay4","0.01"
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"Auto Up/Down",#TRUE#
"Reserved","not used"
```

```
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"Single nozzle & size",#FALSE#
"Multiple Nozzles",#FALSE#
"Multiple Sizes",#FALSE#
"Switch Point 1","0.05"
"Switch Point 2","0.1"
"Switch Point 3","not used"
"Multiple Sizes and Salt/Oil Switch",#TRUE#
"Salt/Oil/Other",#FALSE#
#TRUE#,#FALSE#
"Other Aerosol","---"
"No Challenge Dilution",#FALSE#
"Challenge Dilution On",#FALSE#
"Challenge Dilution Off",#TRUE#
"Reserved","not used"
"Reserved","not used"
"Lock / UNlock enable","Lock Configuration"
"Password","TSI"
"Minimum sampling time","10"
"Maximum sampling time","120"
"Minimum downstream counts","1000"
"Minimum balancing time","10"
"Maximum balancing time","180"
"Maximum balancing deviation","1"
"Switching Mode Sequential",#FALSE#
"Switching Mode Alternating",#TRUE#
"Reserved","not used"
"Reserved","not used"
"DMA sheath flow","7.2"
"DMA sample flow","3.6"
"DMA particle size"," 0"
"Reserved","not used"
"Reserved","not used"
"Number of Particle Sizes",6
"Particle Size  0 and correlation"," .05","1.00"
"Particle Size  1 and correlation"," .07","1.00"
"Particle Size  2 and correlation"," .1","1.00"
"Particle Size  3 and correlation"," .15","1.00"
"Particle Size  4 and correlation"," .2","1.00"
"Particle Size  5 and correlation"," .3","1.00"
"Particle Size  6 and correlation","",""
"Particle Size  7 and correlation","",""
"Particle Size  8 and correlation","",""
"Particle Size  9 and correlation","",""
```

```
"Particle Size  10 and correlation","",""
"Particle Size  11 and correlation","",""
"Particle Size  12 and correlation","",""
"Particle Size  13 and correlation","",""
"Particle Size  14 and correlation","",""
"Particle Size  15 and correlation","",""
"Particle Size  16 and correlation","",""
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"Particle Size  19 and correlation","",""
"Particle Size  20 and correlation","",""
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"Dilution",100
"Correlation Mode",0
"Size for Loading and Fast Test","0.3"
"Correlation for Loading and Fast Test","1.0"
"Test Type"," 1"
"Menu Style",""
"Used Descriptors",0,0,0,0,0,""
"User Descriptions","","","","","",""
"Flow rate   A/D - Manual - Not used - Offset - Gain - Base
Unit",#TRUE#,#FALSE#,#FALSE#,"0","1","l/min"
"Diff Press  A/D - Manual - Not used - Offset - Gain - Base
Unit",#TRUE#,#FALSE#,#FALSE#,"-1875","3750","Pa"
"Temperature A/D - Manual - Not used - Offset - Gain - Base
Unit",#FALSE#,#FALSE#,#TRUE#,"0","1","°C"
"Rel Humidit A/D - Manual - Not used - Offset - Gain - Base
Unit",#FALSE#,#FALSE#,#TRUE#,"0","1","%"
"Abs Pressur A/D - Manual - Not used - Offset - Gain - Base
Unit",#FALSE#,#FALSE#,#TRUE#,"0","1","kPa"
"Print Fit Curve",1
"AutoPrint",0
"AutoSave",0
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"Face Velocity: Unit, Offset,Gain","cm/s",0,1
"Temperature: Unit, Offset, Gain","°C",0,1
"abs Pressure: Unit, Offset, Gain","hPa",0,10
"delta-P: Unit, Offset, Gain","Pa",0,1
"Reserve 1","---",0,1
"Reserve 2","---",0,1
"Reserve 3","---",0,1
"Type",""
"Product Name",""
"Size",""
```

```
"Description",""
"Nominal Flow"," 32"
"Area"," 100"
"Nominal Efficiency","---"
"Nominal Penetration","---"
"Nominal dp"," 0"
"Nominal MPPS","---"
"Reserved","not used"
"Reserved","not used"
"Report Language"," 1"
"Data base file path and name","C:\Program
Files\CertiTest\filter.mdb"
"UserDef_ID",""
"FilterMedia_ID",""
"UnitSetNum",4
"Results_ID",""
"Resistance Zero","0.0"
"Reserved","not used"
"Reserved","not used"
"Reserved","not used"
"END"
```

This menu shows the settings for the default tester configuration. Normally, these settings should never need to be altered. Input the correct channel for the various components. The selections shown are for a new 3160 filter tester configuration using serial com port connections for the CPCs, classifier and flowmeter. For analog input, i.e. an upgrade using analog CPCs, the CPCs need to be set to DAQ and to channels 1 and 2 for up and downstream, respectively. This may vary with the unit actual settings.

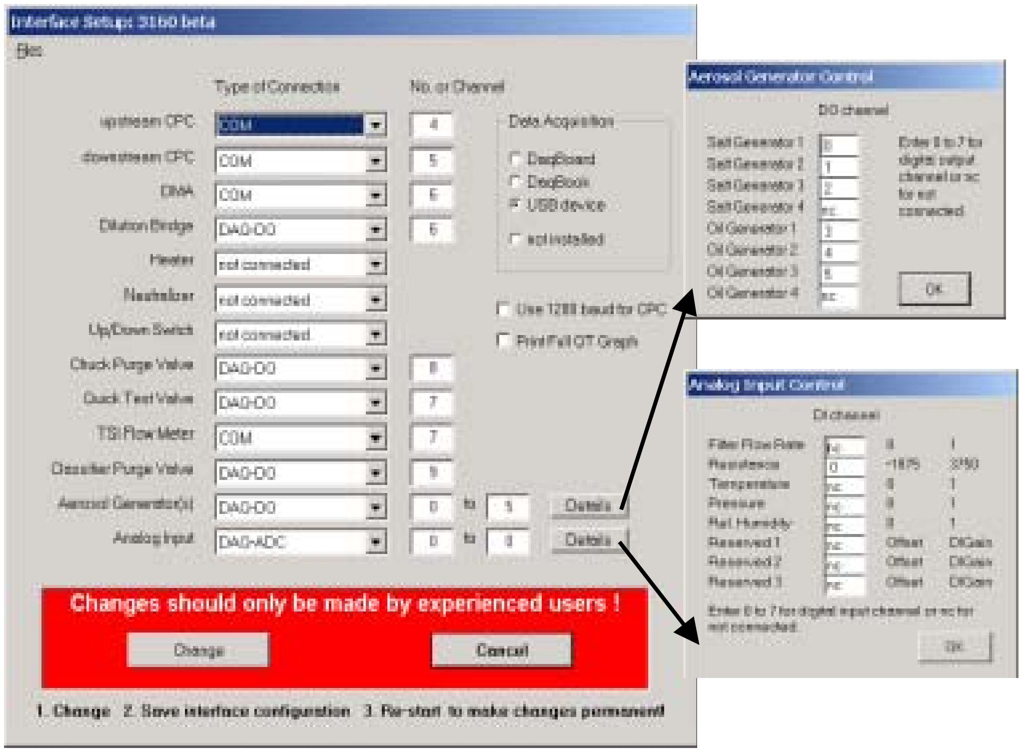

Figure 7-1
Interface Setup

CHAPTER 8
Maintenance

This chapter gives routine and special maintenance procedures for the Model 3160 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.

Description	Frequency
Filling CPCs with butanol	24 hrs
Cleaning the Electrostatic Classifier	see section below
Replace the air supply desiccant	16 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. Turn the main air supply valve OFF.

2. Locate the two female quick-connect ports located at the back of the CPCs.

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.

7. Connect the butanol bottle to the fill port. Open the bottle cap slightly to provide a vent when filling. Press the fill button on the CPC.

8. Watch the sight glass carefully while filling. When the liquid level is in the middle of the sight glass, press the fill button again to stop the fill. 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.

9. Ensure that the butanol bottles do not leak when they are stored inside the tester.

Caution
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.

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 the impactor high pressure gauge. The pressure measured is about 7 cm of H_2O when the Electrostatic Classifier is clean (and operating with a total flow of 7.6 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 serial 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 stainless tubes, power cord and serial cable are reconnected.

Replacing the Air Supply Desiccant

Refer to Figure 2-12 to identify the desiccant holder.

Caution
Always turn the power to the Model 3160 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 the Membrane Dryer

The membrane dryer should require minimal maintenance. Refer to the manual supplied with the membrane dryer.

Replacing the Air Supply Filter

The air supply filter is shown in Figure 2-12 and disassembled in Figure 8-3.

Caution

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® Air Line ULTRA FILTER® Assembly
Catalog Number 85759

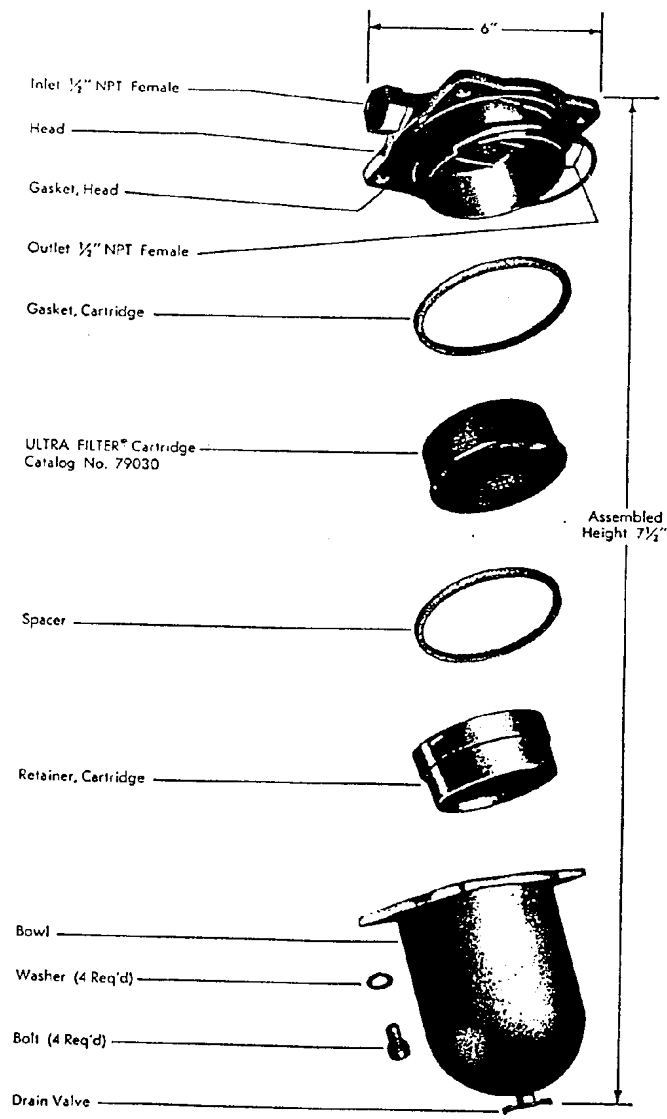

Figure 8-3
Air Supply Filter Assembly

Mixing the Aerosol Solutions

The AFT uses two sets of bottles (Figure 2-15). 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 three 1 liter bottles (Figure 2-15).

The concentrations of DOP are:

Bottle 1. 0.003%

Bottle 2. 0.03%

Bottle 3. 0.3%

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 3 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 3 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 1.
7. Fill bottle 1 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 2-15).

The NaCl concentrations are:

Bottle 1. 0.01%

Bottle 2. 0.1%

Bottle 3. 1.0%

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 3 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 3 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 1.
6. Fill bottle 1 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 2-15). 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. The bottles must be seated firmly against the manifold when reinstalled for correct filter tester operation.

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 8-4).

1. Remove the $^{9}/_{16}$” 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.*

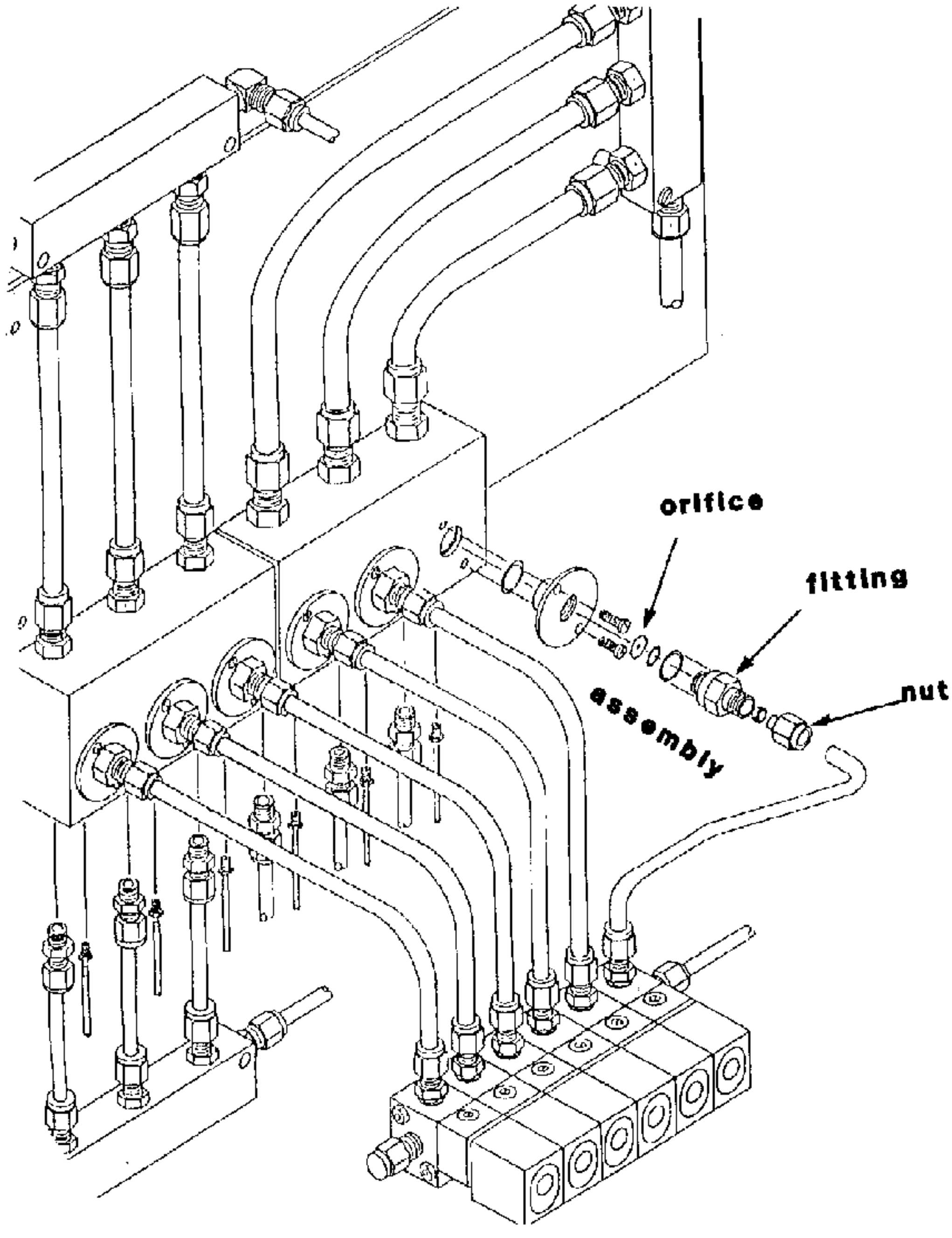

Figure 8-4
Disassembly of the Aerosol Jet

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_2O.

The downstream filter is located below the bottom filter holder just upstream of the flowmeter.

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 $^9/_{16}$-inch union nut.
2. Remove the screws holding the inlet and remove the inlet (Figure 8-5) by pulling up. Be careful not to damage the top of the diluter tube which extends into the inlet.

Figure 8-5
Diluter

3. Pull the diluter tube (Figure 8-6) straight up using the supplied plastic pliers (or similar tool).

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

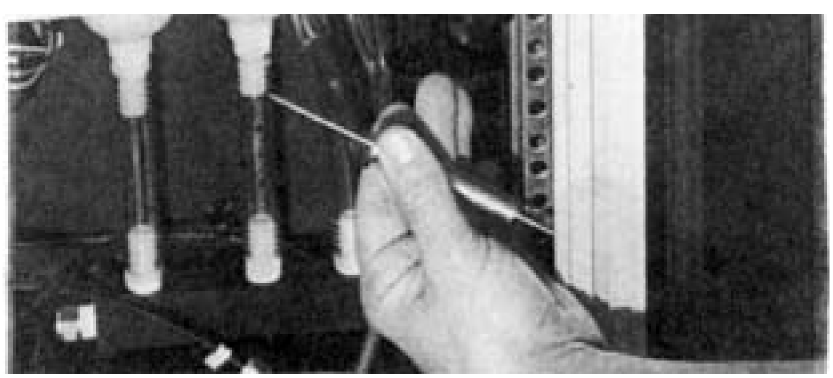

Figure 8-6
Diluter Tube Removed

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.

WARNING
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 the tapered end is pointing up.*

7. Press the diluter tube in place firmly using the insertion tool shown in Figure 8-7.
8. Replace the top and reconnect the clear tubing.

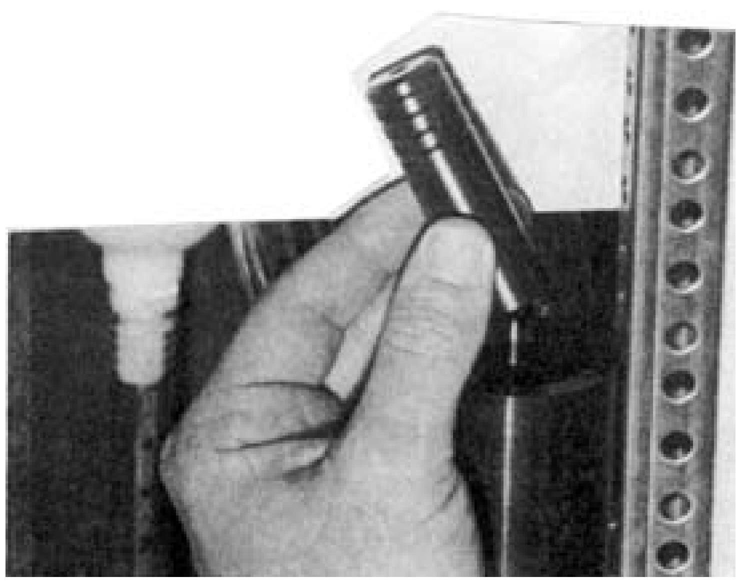

Figure 8-7
Use Insertion Tool to Press Diluter Tube in Place

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 8-5). If this occurs the filters must be replaced.

To replace the diluter filters refer to the diluter manual.

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 (item 20 Figure 2-2) 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.

Index

W–X–Y–Z

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Manual Title CERTITEST® Model 3160 Automated Filter Tester ____ P/N 1930041 Rev. --

1. Was the manual easy to understand and use?

   ❑ Yes ❑ No

   Please identify any problem area(s) ____

   ____

   ____

2. Was there any incorrect or missing information? (please explain) ________________

   ____

   ____

3. Please rate the manual according to the following features:

	Good	Adequate	Poor
Readability	❑	❑	❑
Accuracy	❑	❑	❑
Completeness (is everything there?)	❑	❑	❑
Organization (finding what you need)	❑	❑	❑
Quality and number of illustrations	❑	❑	❑
Quality and number of examples	❑	❑	❑

   Comments: ____

   ____

   ____

4. Which part(s) of this manual did you find most helpful? ______________________

   ____

   ____

5. Rate your level of experience with the product:

   ❑ Beginning ❑ Intermediate ❑ Expert

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   Company ______________________ ______________________

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