Particle Instruments

Aerosizer® DSP Powder Sizer

Instruction Manual

P/N 1930026
October 2002

TSI®

Errata

The following information was not included when this manual was printed.

Warm-Up Period for Aerosizer® DSP and Aero-Disperser®

The Aerosizer® and Aero-Disperser® should have a 30-minute warm-up period before performing sample measurements. Otherwise, the thermal characteristics of internal electronic components may cause a drift in the background counts detected during this time period.

"Calibration Pressure too Low, Check for Leaks" Error Message

During calibration, the Aero-Disperser® moves the Disperser Pin through its range of motion and checks the maximum pressure that is obtained. If this pressure is less than 4.0 psi, this error message may appear, even if the instrument is operating properly.

In Aerosizer® 3225 Control Software versions 8.20.02 and earlier, the minimum calibration pressure threshold is set to 4.0 psi. This threshold is too high. The Aero-Disperser® is operating properly if the pressure reported during calibration reaches at least 2.5 psi. If it does not, consult Table B-2 for typical causes and recommended corrective actions.

(This information should replace the first paragraph under the heading "Min. calibration pressure not reached" on page B-1 of the Aero-Disperser® manual.)

Special Note on the Data Acquisition Boards

The Data Acquisition Boards provided with older models of the Aerosizer® (the Mach II and LD) *cannot* work with the Aerosizer® DSP. Use only the Data Acquisition Boards that were shipped with the Aerosizer® DSP.

If the reported particle size is much smaller than expected

If the diagnostic run time on the Diagnostic Screen (accessed by pressing **<Ctl D>** from the Main Menu) is set to more than 0.1

seconds, the software may incorrectly interpret the clock speed of the low sensitivity correlator. This will cause the reported particle size to be one-third to one-half the expected size. The clock speed reported on the Diagnostic Screen should read 20/10 MHz and 40/20 MHz.

TSI.

Model 3225 Aerosizer® DSP

Instruction Manual

Manual History

The following is a manual history of the Model 3225 Aerosizer® DSP (Part Number DOC3225).

Revision	Date
Preliminary	May 1999

This manual was first published May 1999.

Part Number DOC3225 / May 1999

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Limitation of Warranty And Liability (effective April 1996)

TSI Incorporated (hereinafter referred to as "seller") warrants that this product, under normal use and service as described in this manual, shall be free from defects in workmanship and material for a period of twelve (12) months from the date of shipment to the customer. This limited warranty is subject to the following exclusions:

1. Batteries, hot wire or hot film sensors and certain other components when indicated in specifications are warranted for a period of 90 days from the date of shipment to the customer
2. With respect to any repair services rendered, seller warrants that the parts repaired or replaced will be free from defects in workmanship and material, under normal use, for a period of 90 days from the date of shipment to the customer.
3. Seller does not provide any warranty on finished goods manufactured by others. Only the original manufacturer's warranty applies.
4. Unless specifically authorized in a separate writing by the seller, seller makes no warranty with respect to, and shall have no liability in connection with, any goods which are incorporated into other products or equipment by the Buyer. All goods returned under warranty shall be at the Buyer's risk of loss, seller's factory prepaid, and will be returned at seller's risk of loss, Buyer's factory prepaid.

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The purchaser and all users are deemed to have accepted the terms of this LIMITATION OF WARRANTY AND LIABILITY, which contains the complete and exclusive limited warranty of seller. This LIMITATION OF WARRANTY AND LIABILITY may not be amended or modified nor may any of its terms be waived except by a writing signed by an authorized representative of seller.

Service Policy

Knowing that inoperative or defective instruments are as detrimental to TSI as they are to our customers, our service policy is designed to give prompt attention to any problems. If any malfunction is discovered, please contact your nearest sales office or representative, or call TSI/Particle Instrument Division—Amherst at 1-800-335-5577 (USA) or (413) 253-6966.

Safety

This section gives instructions to promote safe and proper handling of the Model 3225 Aerosizer® DSP.

There are no user-serviceable parts inside the instrument. Refer all repair and maintenance to a qualified technician. All maintenance and repair information in this manual is included for use by a qualified technician.

The Model 3225 Aerosizer® DSP is a Class I laser-based instrument. During normal operation, you will **not** be exposed to laser radiation. However, you must take certain precautions or you may expose yourself to hazardous radiation in the form of intense, focused, visible light. Exposure to this light may cause blindness.

Take these precautions:

- Do **not** remove any parts from the Aerosizer® unless you are specifically told to do so in this manual.
- Do **not** remove the Aerosizer® housing while power is supplied to the instrument.

WARNING

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

WARNING

High voltage is accessible in several locations within this instrument. Make sure you unplug the power source before removing the cover or performing maintenance procedures.

Labels

The Model 3225 has 22 labels as shown in Figures 1 through 3.

1. Warning Fire Hazard Label (back panel)
2. Danger High Voltage Label (back panel)
3. CE (European Conformity) Compliance Label (back panel)
4. Serial Number Label (back panel)
5. Laser Safety Information Label (back panel)
6. Serviceable Parts Advisory Label (back panel)

7. Ground Label (back panel)
8. Ground Label (back panel)
9. Danger Laser Radiation Label (Source Optics Tube)
10. Danger Laser Radiation Label (Source Optics Tube)
11. Danger Laser Radiation Label (Source Optics Tube)
12. Danger Laser Radiation Label (Source Optics Tube)
13. Danger Laser Radiation Label (Source Optics Tube)
14. Danger Laser Radiation Label (Source Optics Tube)
15. Danger Laser Radiation Label (Detection Optics Housing)
16. Danger Laser Radiation Label (Sonic Nozzle Housing)
17. Danger Laser Radiation Label (Sonic Nozzle Housing)
18. Danger Laser Radiation Label (Retrofocus Mirror Housing)
19. Danger Laser Radiation Label (Access Port Plug)
20. Danger Laser Radiation Label (Front Bulkhead)
21. Danger High Voltage Label (Utility PC Board)
22. Danger High Voltage Label (Utility PC Board)

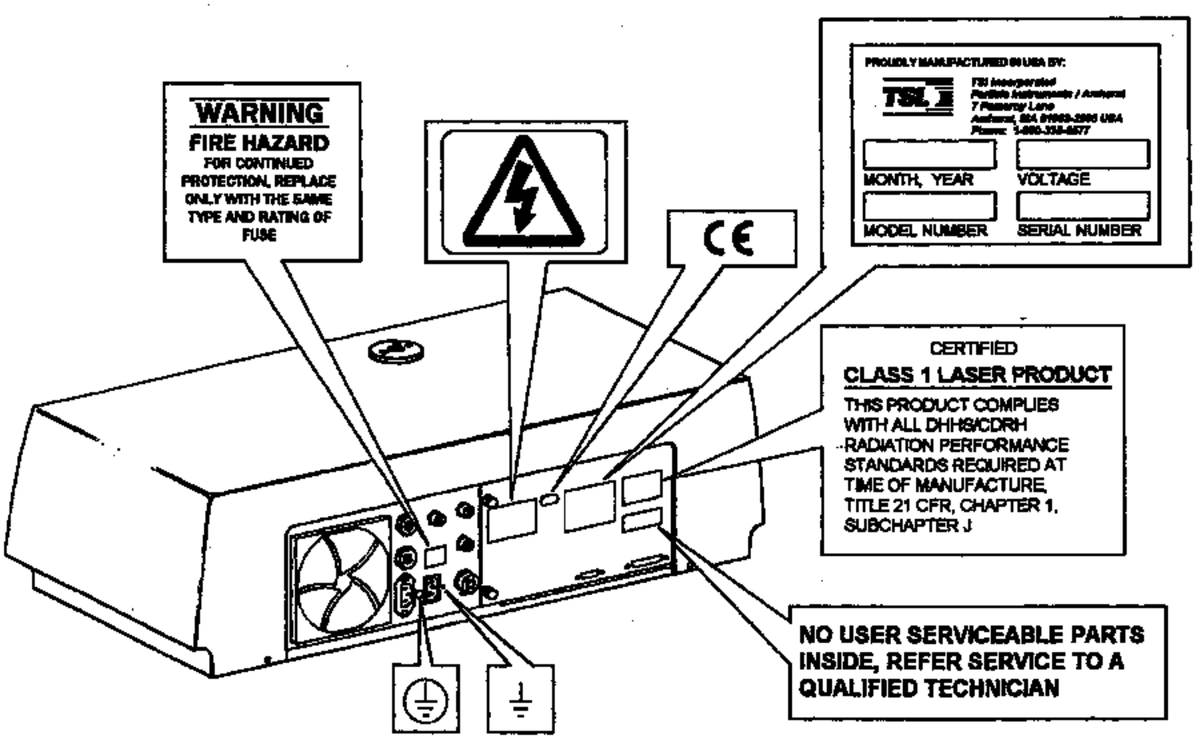
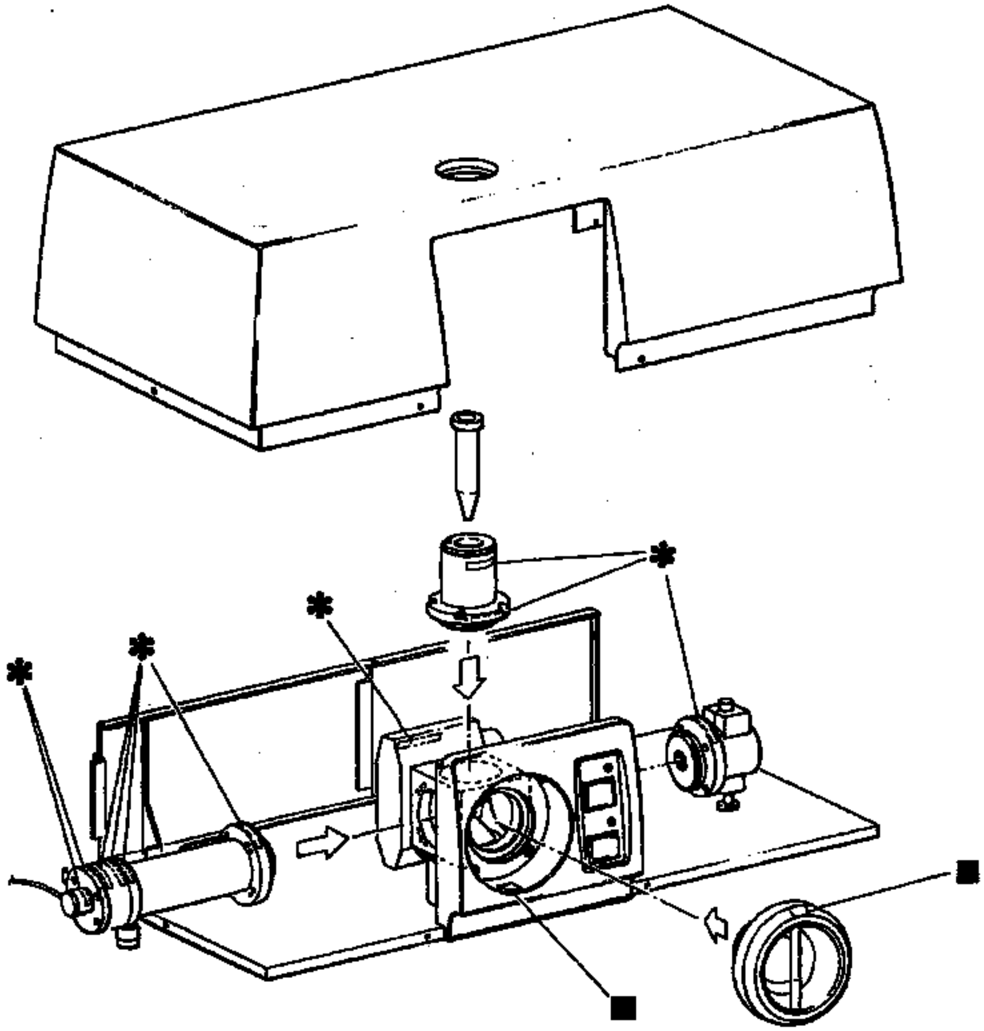


Figure 1
Location of Warning and Information Labels, Rear Panel



Above Label Located at Places Indicated With ■

Above Label Located at Places Indicated With ✱

Figure 2
Location of Warning and Information Labels, Front and Internal Components

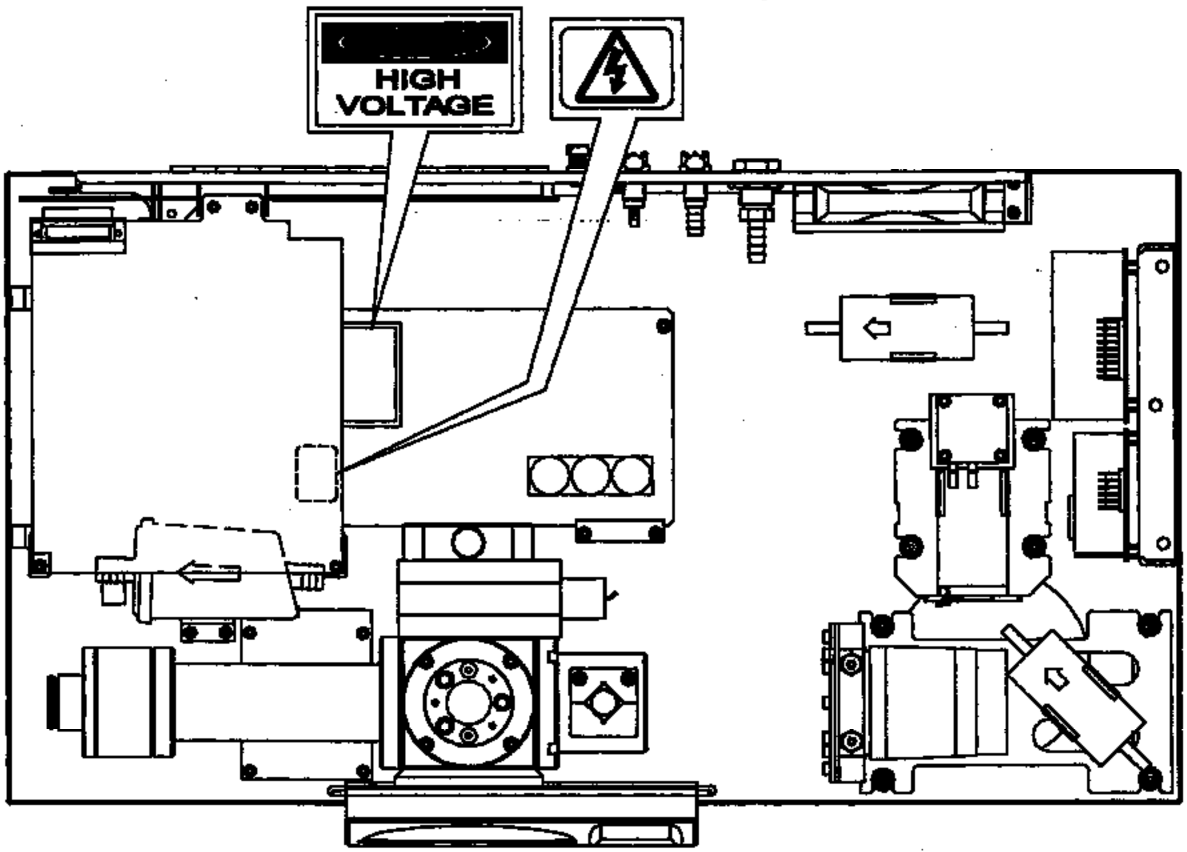


Figure 3
Location of Utility PC Board High Voltage Warning Labels

Description of Caution/Warning Symbols

The following symbols and an appropriate caution/warning statement are used throughout this manual to draw attention to any steps that require you to take cautionary measures when working with the Model 3225:

Caution

Caution
Caution means ***be careful.*** It means if you do not follow the procedures prescribed in this manual you may do something that might result in equipment damage, or you might have to take something apart and start over again. It also indicates that important information about the operation and maintenance of this instrument is included.

Warning

WARNING
Warning means that unsafe use of the instrument could result in serious injury to you or cause irrevocable damage to the instrument. Follow the procedures prescribed in this manual to use the instrument safely.

Caution or Warning Symbols

The following symbols may accompany cautions and warnings to indicate the nature and consequences of hazards:

	Warns you that uninsulated voltage within the instrument may have sufficient magnitude to cause electric shock. Therefore, it is dangerous to make any contact with any part inside the instrument.
	Warns you that the instrument contains a laser and that important information about its safe operation and maintenance is included. Therefore, you should read the manual carefully to avoid any exposure to hazardous laser radiation.
	Warns you that the instrument is susceptible to electro-static discharge (ESD) and ESD protection procedures should be followed to avoid damage.
	Indicates the connector is connected to earth ground and cabinet ground.

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Contents

Chapters

Appendices

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About This Manual

Purpose

This is an instruction manual for the operation and handling of the Model 3225 Aerosizer® DSP.

Related Product Literature

- ***Aerosizer® 3225 Control Software Manual*** (part number DOC8053 TSI Incorporated)
- ***Model 3230 Aero-Disperser® Manual*** (part number DOC3230 TSI Incorporated)
- ***Model 3276 Calibration Nebulizer™ Manual*** (part number DOC3276 TSI Incorporated)

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 uses recycled paper.
- This manual has been shipped, along with the instrument, in a reusable carton.

Getting Help

To obtain assistance with this product or to submit suggestions, please contact Particle Instruments/Amherst:

TSI Incorporated
Particle Instruments/Amherst
7 Pomeroy Lane
Amherst, MA 01002-2905 USA
Fax (413) 253-6960
Telephone: 1-800-335-5577 (USA) or (413) 253-6966
E-mail Address: amherst@tsi.com

Submitting Comments

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

If the comment sheet has already been used, send your comments to:

TSI Incorporated
Particle Instruments/Amherst
7 Pomeroy Lane
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Fax: (413) 253-6960
E-mail Address: amherst@tsi.com

CHAPTER 1

Product Overview

This chapter contains a product description of the Model 3225 Aerosizer® DSP and a brief description of how the instrument operates.

Product Description

The Model 3225 Aerosizer® DSP, shown in Figure 1-1, is a high-performance, general-purpose particle spectrometer that measures particle diameter. The Model 3225 provides size distributions for particles with geometric diameters from 0.2 to 700 micrometers.

To collect and interpret data, the Model 3225 must be connected to a computer with the Aerosizer® 3225 Control Software. A computer equipped with the necessary hardware and software is included to provide computer-controlled operation and data interpretation.

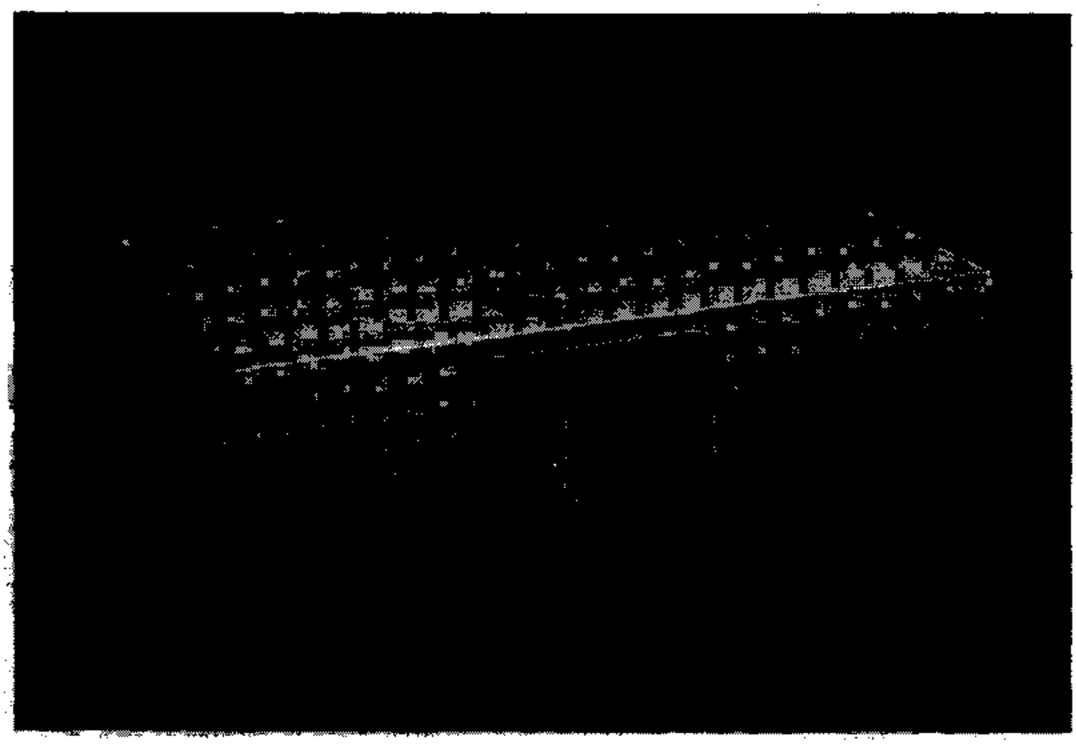

Figure 1-1
Model 3225 Aerosizer® DSP

Applications

The Model 3225 Aerosizer® DSP has application in the following areas:

- Drug-delivery studies
- Powder Sizing
- Filter and air-cleaner testing
- Basic research
- Performance evaluations of other aerodynamic devices

How the Model 3225 Aerosizer® DSP Operates

Time-of-flight particle sizing technology involves measuring the acceleration of particles in response to the accelerated flow of the sample aerosol through a nozzle. The aerodynamic size of a particle determines its rate of acceleration, with larger particles accelerating more slowly due to increased inertia. As particles exit the nozzle, the time of flight between the Model 3225's two laser beams is recorded and converted to geometric diameter using a calibration curve.

The Model 3225 uses one reflected laser to create two tightly focused laser beams. As particles pass through the laser beams, they scatter light, which is detected and converted into two distinct electronic signals by two photomultiplier tubes (PMTs). One photomultiplier detects light scattered as the particle passes through the first beam, starting a timer; the other photomultiplier detects light scattered as the particles pass through the second beam, reading the timer. The time between these two events—the time of flight—is measured with a precision of 25 nanoseconds.

Raw time-of-flight data is evaluated statistically to filter out invalid readings, such as "phantom" particles (a trigger of only the first PMT) and coincidence error (a trigger of only the second PMT).

Refer to Chapter 5, "Theory of Operation," for a detailed description.

System History

In 1988, the Aerosizer® Mach II was introduced by Amherst Process Instruments, Inc. It consisted of a sensor unit with a parallel interface to an IBM PC. The sensor unit used a small (0.75mm) nozzle and a Helium-Neon laser to detect size distributions of aerosol particles between 0.2 and 200 micrometers.

In late 1993, a version of the Aerosizer® Mach II was released using a large (1.5mm) nozzle. The large nozzle made it possible to detect size distributions for powders between 0.2 and 700 micrometers.

In early 1995, the Aerosizer® LD was released. The Aerosizer® LD used a solid-state laser diode, replacing the Helium-Neon laser. The Aerosizer® LD could be used with either the large or small nozzle to detect size distributions for powders and aerosols.

The Model 3225 Aerosizer® DSP includes a number of changes and began shipping in May 1999. It features improved digital signal processing with automatic gain control. The Model 3225 uses a large nozzle. Its larger, redesigned cabinet also contains the Disperser Pump, which was previously housed separately. In late 1998, Amherst Process Instruments became part of TSI, Inc. Particle Instrument Division. The Model 3225's new color scheme, logo, and model number designation bring it into line with the family of TSI® scientific particle instruments. The model number designation also distinguishes it from the small-nozzle Model 3220 Aerosizer® DSP.

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CHAPTER 2

Unpacking and System Setup

This chapter provides information concerning the accessories shipped with the Model 3225 Aerosizer® DSP and describes basic setup procedures.

Packing List

Note: *The Model 3225 Aerosizer® DSP and the sample feed device may have been shipped together. If this is the case, some of the accessory items shipped with the instruments are accessories to the Aerosizer® DSP; the rest are accessories to the sample feed device.*

A packing list for the Model 3225 Aerosizer® DSP is provided in the shipping box. It identifies all of the items that should have been shipped to you as the Model 3225 Aerosizer® DSP and its accessory kit. Please compare the list to the items you received. If any items are missing, notify TSI immediately.

Connecting the Model 3225 Aerosizer® DSP

The following setup is common to all applications using the Model 3225 Aerosizer® DSP. The computer components should be connected first, followed by the sensor unit and then the vacuum pump.

Connecting the Computer Components

Assemble and connect the computer, monitor, keyboard, and printer as described in their accompanying manuals. All necessary drivers and software have been installed.

Connecting the Model 3225 Sensor

The Model 3225 Aerosizer® DSP has no special mounting requirements other than the ventilation requirements (see below). The cabinet has five rubber feet that give the instrument a good grip on clean, level surfaces.

Ventilation Requirements

The Aerosizer® DSP sensor cabinet is designed to be cooled by room air drawn from the bottom and exhausted through the back of the cabinet.

The instrument should be located with at least 2 inches (50 mm) clearance between the rear bulkhead and any other surface. The sides should have at least 2 inches (50 mm) clearance between the sides of the cabinet and any other surface. Most important, the instrument should be placed on a clean, firm surface so that the exhaust air can move freely from the cabinet.

Computer Connections

The AGC cable is a computer cable with a 9-pin D-shell connector on each end—one male, one female. Insert the male end of the cable into the port marked "AGC Setup" on the Aerosizer®. Plug the female end into COM2 on the computer.

The "Y" cable is a computer cable with a 25-pin D-shell connector on one end and two connectors—a 25-pin and a 15-pin—on the other. Insert the connector on the "single" end of the cable into the mating connector on the Model 3225 labeled "COMPUTER." Insert the remaining two connectors to the mating connectors on the back of the computer (exact location of these connections will vary with computer model). Tighten the lockscrews on all computer connectors.

WARNING

Do NOT connect the "Y" cable to the "parallel port" on the computer. Serious damage to the electronics and computer components may result.

Connecting the Vacuum Pump

Place the vacuum pump according to the requirements outlined in its accompanying manual. It must be close enough for the supplied tubing connections to reach the sensor unit. Its power switch should be easily accessible to the user.

Pneumatic Connections

Using the tubing assembly with one quick-disconnect pneumatic fitting and an in-line HEPA filter (part no. 500248), insert the pneumatic fitting into the connector marked "VACUUM" on the Model 3225 rear bulkhead. Connect the remaining end of the tubing to the vacuum pump inlet. (See Figure 2-1)

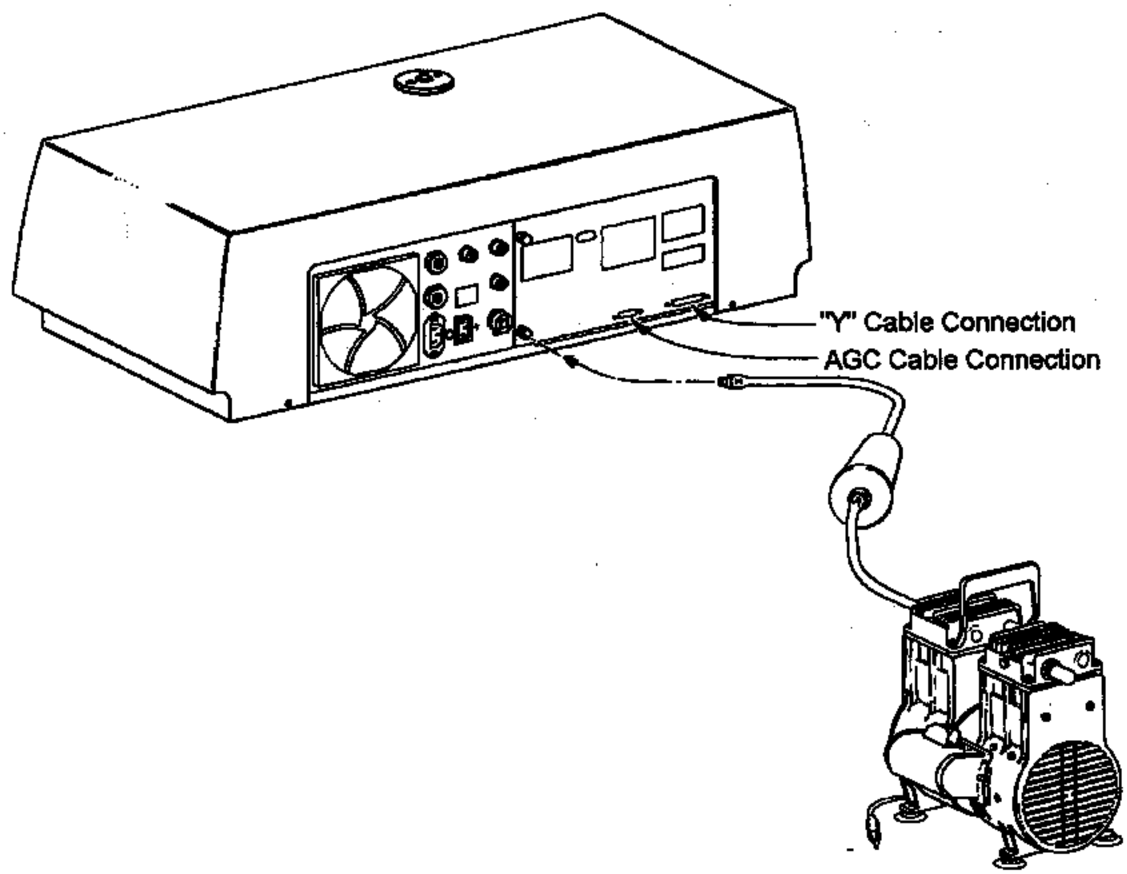

Figure 2-1
Connection of Model 3225 Aerosizer® DSP to Vacuum Pump

Power Connection

Connect the AC power cord (supplied) to the AC power in connector on the Model 3225 rear bulkhead. Plug the Model 3225, the vacuum pump, and the computer components into the outlet strip (supplied).

Note: *Make certain the line cord is plugged into a grounded power outlet. Position the Aerosizer® so the outlet strip is easily accessible.*

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CHAPTER 3

Description of the Model 3225 Aerosizer® DSP

This chapter describes the features found on the front panel, top surface, and rear bulkhead, and internal components of the Model 3225 Aerosizer® DSP. It also describes the various parts that come in the Accessory Kit.

The front panel features two status LEDs, power switches for the Aerosizer® and the Disperser Pump, and the Access Port Plug.

On the top of the Model 3225 is the Direct Feed Adapter. Under that is the Sonic Nozzle Housing, where all sample feed devices are attached.

The rear bulkhead provides power, communications, and pneumatic connections as well as a cooling air exhaust panel.

Internal components consist of the flow system, the optics system, and the signal processing electronics. It also includes a compressor pump for use with the Aero-Disperser®.

The Accessory Kit includes the Sonic Nozzle Extraction Tool and Flow Straightener Extraction Tool, along with extra fuses, o-rings, and tools and materials used to maintain the Model 3225 Aerosizer® DSP.

Front Panel

The main components of the front panel are the Access Port Plug, the power switches, and the status LEDs, as shown in Figure 3-1.

The Access Port Plug allows the user to access the detection region of the Aerosizer® for routine cleaning and maintenance. When the Access Port Plug is removed, interlock switches (white plastic plungers) disable the power to the laser. However, if the interlock switches are depressed, power to the laser may be restored.

WARNING

When the Aerosizer® sensor is ON, the detection laser is ON. To avoid exposure to hazardous laser radiation, DO NOT remove the Access Port Plug and depress the interlock switches while the Aerosizer® sensor is ON.

The upper power switch turns the Aerosizer® DSP sensor on and off. When the status LED above the power switch is lit, the unit is ON.

The lower power switch enables the Disperser Pump inside the unit to turn on and off. When the status LED above the power switch is lit, the pump power is enabled. The pump may then be turned on and off by the Aerosizer® 3225 Control Software.

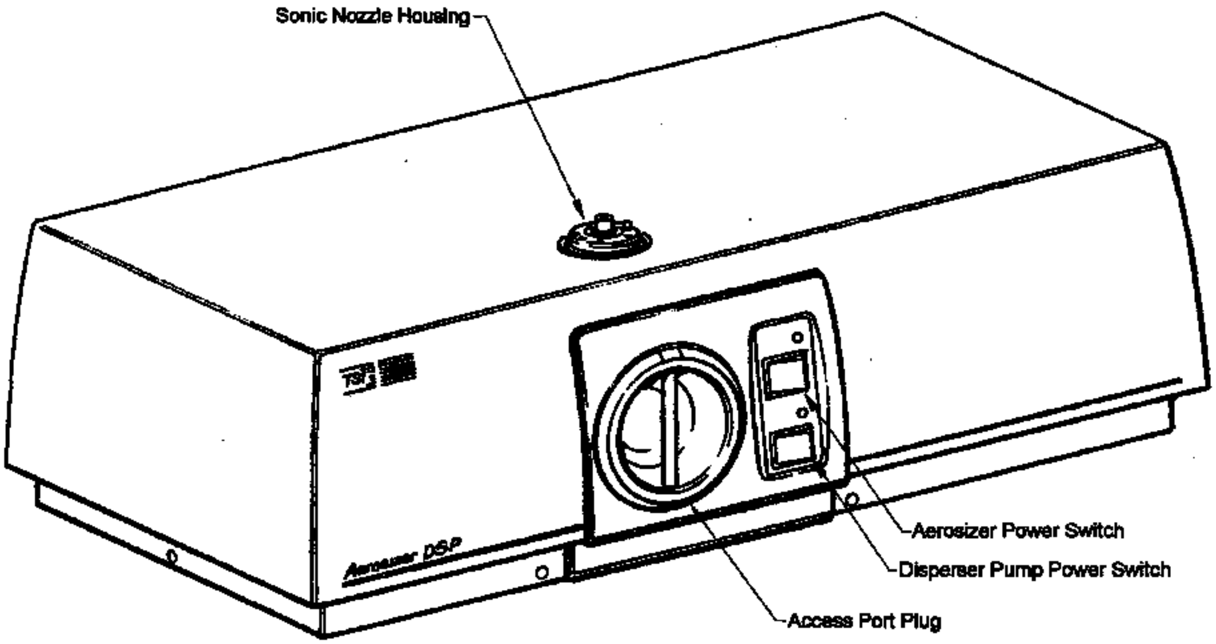

Figure 3-1
Front Panel and Top Surface of the Model 3225 Aerosizer® DSP

Top Surface

Direct Feed Adapter

The Direct Feed Adapter (shown in Figure 3-2) may be attached to the top of the Model 3225 Aerosizer® DSP. The Direct Feed Adapter is used when measuring particles that are already airborne (e.g.

natural aerosols, engine fumes, smoke). The sample may be taken directly from the atmosphere or through a 1/8" I.D. tube attached to its barbed fitting. The Direct Feed Adapter is also used with the Calibration Nebulizer™.

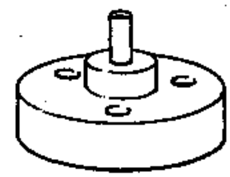

Figure 3-2
Direct Feed Adapter

To remove the Direct Feed Adapter, loosen the three screws that hold it to the Sonic Nozzle Housing. As the screws are loosened, the metal plunger underneath will be decompressed. Lift the adapter and set it aside.

Sonic Nozzle Housing

The Sonic Nozzle Housing protrudes through the top of the Aerosizer® DSP, as shown in Figure 3-1. The two white plungers are interlock switches that disable power to the laser when any sample feed device is removed. The larger, metal plunger aids in aligning (and, if necessary, grounding) any sample feed device attached to the Aerosizer®.

Two small holes fitted with o-rings provide airflow to the Aero-Dryer™, where the airflow triggers valve changes.

Injection Tube

In the center of the Sonic Nozzle Housing is the Injection Tube, shown in Figure 3-3. To remove it, grasp the top and pull up.

Figure 3-3
Injection Tube

Note: *The Model 3230 Aero-Disperser® uses a different injection tube, supplied with that instrument. The injection tube shown here is for use with all other sample feed devices.*

Sonic Nozzle

In the center of the Sonic Nozzle Housing is the Sonic Nozzle. It may be removed using the Sonic Nozzle Extraction Tool provided in the Accessory Kit. The Sonic Nozzle is shown in Figure 3-4.

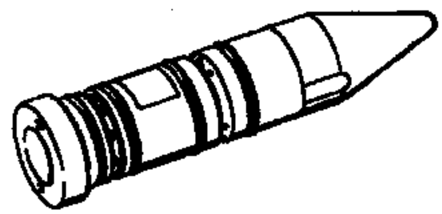

Figure 3-4
Sonic Nozzle

Flow Straightener

The Flow Straightener is inserted snugly inside the Sonic Nozzle. To remove it, use the Flow Straightener Extraction Tool (in the Accessory Kit).

Rear Bulkhead

As shown in Figure 3-5, the rear bulkhead of the Model 3225 Aerosizer® DSP allows for electrical, pneumatic, and communications connections. There is also a cooling fan with a finger guard to prevent fingers or other items from being poked into the fan.

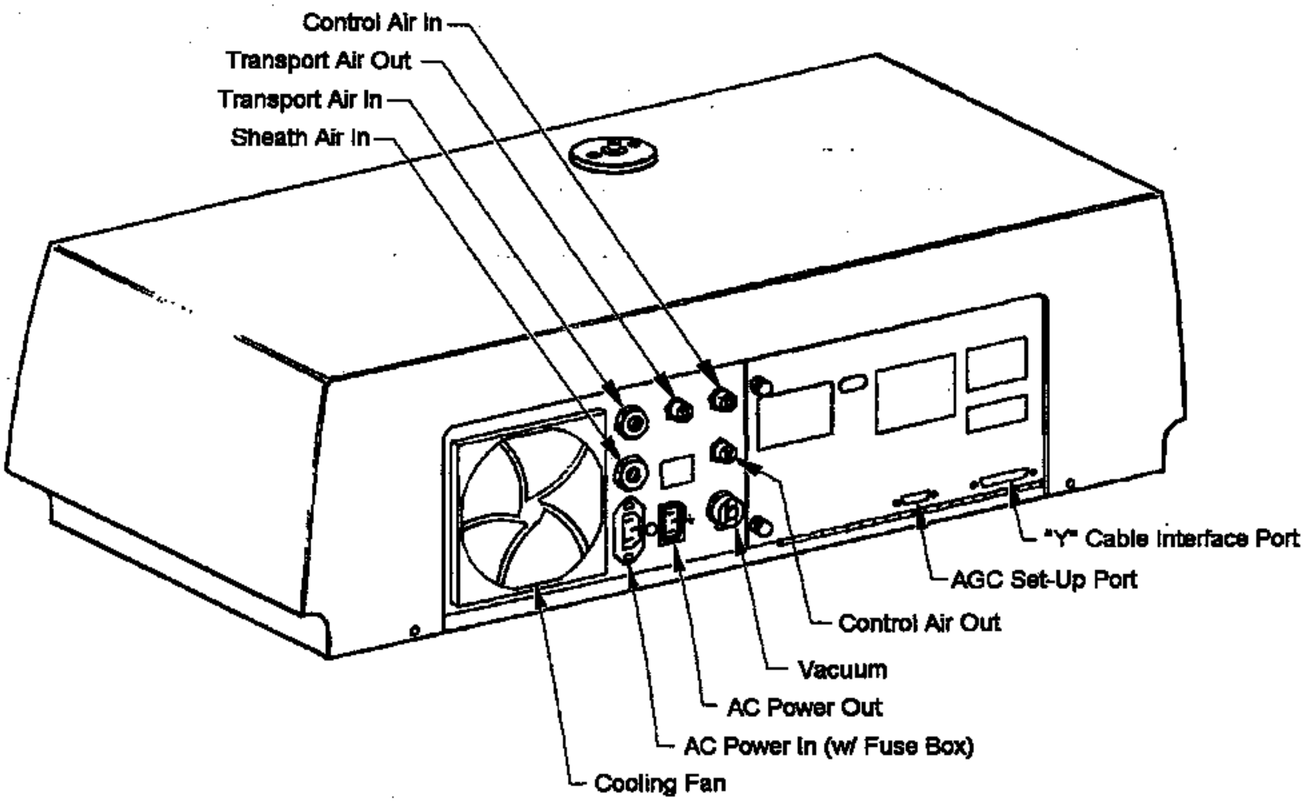

Figure 3-5
Rear Bulkhead of the Model 3225 Aerosizer® DSP

Sheath Air In

Sheath air is taken in through the "Sheath Air Inlet."

The "Sheath Air In" connector is a ¼-inch female NPT connector. The connector can be left open to draw ambient air for the sheath airflow, or it can be connected in line to provide a controlled air supply for the sheath airflow. The sheath air flowrate is computer-controlled according to the pressure conditions and should be about 16 lpm. Make certain any sheath air supply tube allows the sheath air to flow freely (check for crimps and constrictions).

If the sheath air is drawn from the environment, make certain you do not block the Sheath Air Inlet.

Transport Air In

The Transport Air Inlet supplies air to the Disperser Pump.

The "Transport Air In" connector is a ¼-inch female NPT connector. The connector can be left open to feed ambient air into the pump, or it can be connected in line to provide a controlled air supply to the pump. The pump intake flowrate is approximately 10 lpm. Make certain the Transport Air Intake tube allows the transport air to flow freely (check for crimps and constrictions).

If the transport air is taken from the ambient air, make certain you do not block the Transport Air Inlet.

Transport Air Out

The Transport Air Outlet sends air from the Disperser Pump to the Aero-Disperser®.

The "Transport Air Out" connector is a 1/8-inch CPC Quick-Disconnect fitting, coded with blue. The transport air flowrate is approximately 10 lpm. If the Disperser Pump is in use, make certain that the "Transport Air Out" tube allows the transport air to flow freely (check for crimps and constrictions).

Control Air In

The Control Air Inlet supplies air to the compressor.

The "Control Air In" connector is a 1/8-inch CPC Quick-Disconnect fitting, coded with orange. The connector can be left open to draw ambient air for the compressed air, or it can be connected in line to draw from a controlled air supply. The compressed air flow rate is approximately approximately 4 lpm. Make certain any Control Air In tube allows the control air to flow freely (check for crimps and constrictions).

If the control air is drawn from the environment, make certain you do not block the Control Air Inlet.

Control Air Out

The Control Air Outlet directs compressed air from the compressor to the sample feed device.

The "Control Air Out" connector is a 1/8-inch CPC Quick-Disconnect fitting, uncoded. The Control Air flowrate is approximately 4 lpm. If the Aero-Disperser® or Calibration Nebulizer™ is used, make certain the Control Air tube allows the compressed air to flow freely (check for crimps and constrictions).

Vacuum

The vacuum pump draws the sample aerosol from the instrument through the fitting marked "Vacuum."

The "Vacuum" connector is a ¼-inch CPC Quick-Disconnect fitting. The total flowrate is about 21 lpm. Make certain the tube leading to the vacuum pump allows the airstream to flow freely (check for crimps and constrictions).

AC Power In/Out Connectors

The AC Power In Connector accepts the line cord (supplied) to provide AC power to the Model 3225. Line voltage can be 100 to 240 Volts AC, 50-60 Hertz, single phase, 2 Amp max. Maximum power consumption is 300 Watts. The connector also houses two ~T 5.0A H/250V fuses.

The AC Power Out Connector supplies power to some of the sample feed devices associated with the Model 3225 Aerosizer® DSP. It can provide a line voltage of 85-264 Volts AC, 50-60 Hertz, single phase, and 2 Amp max. Power output is 250 Watts maximum.

Note: *Make certain the line cord is plugged into a grounded power outlet. Position the Model 3225 Aerosizer® DSP so the power cord connector is easily accessible.*

AGC Set-Up

This 9-pin D-subminiature connector port allows the Aerosizer® 3225 Control Software to communicate the signal processing parameters to the Model 3225 Aerosizer® DSP.

"Y" Cable Interface

This 25-pin D-subminiature connector allows the Aerosizer® 3225 Control Software to send non-signal processing commands and operating parameters to the Model 3225 and to receive various sensor readings and raw time-of-flight data from it.

Internal Components

The location of the functional systems and electronics of the Model 3225 Aerosizer® DSP are shown in Figure 3-6 and include:

- Laser Driver PC Board
- Utility PC Board
- AGC Board
- Interconnect PC Board
- Power Supplies
- Optical Assembly
- Valves
- Disperser Pump
- Compressor
- Filters

The only serviceable components of the Model 3225 Aerosizer® DSP are the filters, which require routine maintenance (refer to Appendix A). For a more detailed description of the internal components, refer to Chapter 5, "Theory of Operation."

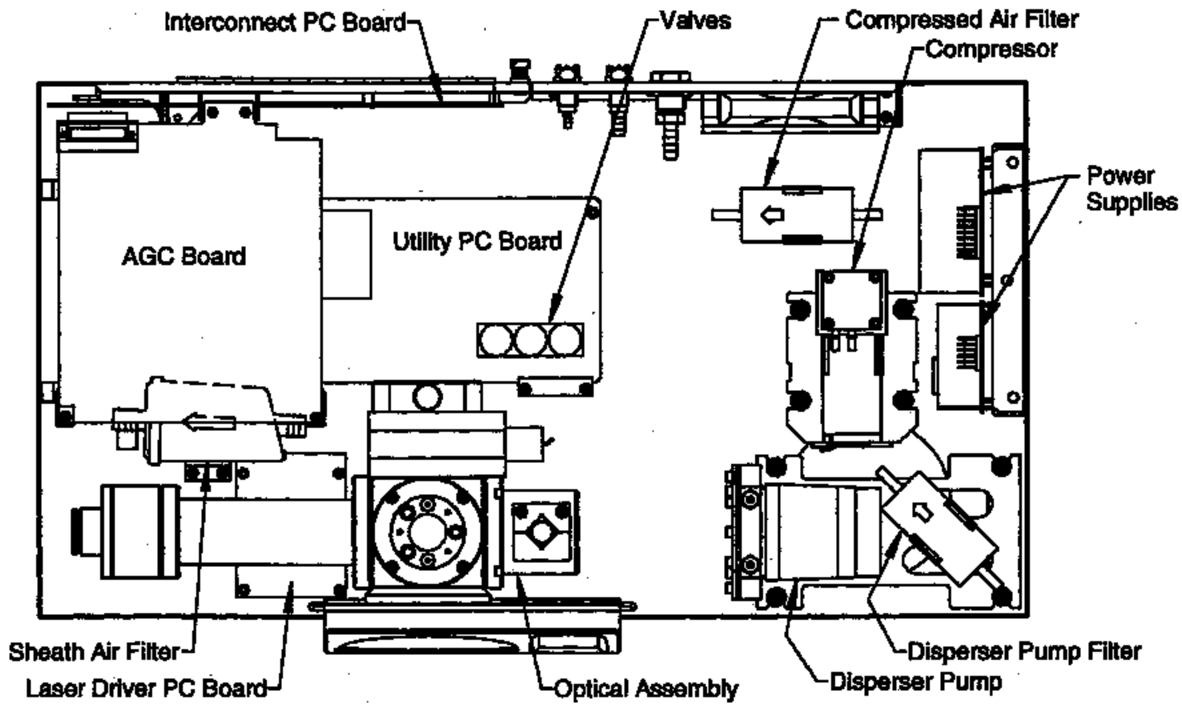

Figure 3-6
Internal Diagram of the Model 3225 Aerosizer® DSP

Accessory Kit

The items described in this section are unique to the Aerosizer® system. A complete list of items in the Aerosizer® Accessory Kit is provided in the Accessory Kit container.

Sonic Nozzle Extraction Tool

The accessory kit includes the Sonic Nozzle Extraction Tool, shown in Figure 3-7 below. The Sonic Nozzle extraction procedure is described in Chapter 2.

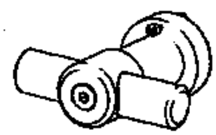

Figure 3-7
Sonic Nozzle Extraction Tool

Flow Straightener Extraction Tool

The Flow Straightener Extraction Tool is shown in Figure 3-8. The Flow Straightener extraction procedure is described in Chapter 2.

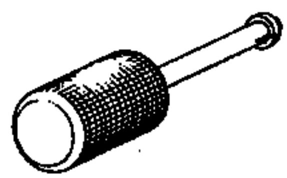

Figure 3-8
Flow Straightener Extraction Tool

CHAPTER 4

Aerosizer® DSP Operation

This chapter provides instructions for setting up and running sample measurements using the Model 3225 Aerosizer® DSP *without* a sample feed device.

Complete instructions for setting up and running sample measurements with the Model 3225 Aerosizer® DSP *and* sample feed device are provided in the sample feed device manual.

These instructions assume that the Aerosizer® and vacuum pump have been properly connected.

Getting Started

Attach the Direct Feed Adapter to the Aerosizer®. If desired, place a 1/8" I.D. hose over the barbed fitting on the adapter.

Turn on the Aerosizer® and the vacuum pump.

Turn on the computer. The software will start up, and the Main Menu will appear. Press **<Ctrl S>** to access the System Setup Screen.

System Setup Screen

The System Setup screen allows the user to set some of the operating parameters for the Aerosizer® and its control software. Table 4-1 below shows the recommended setting for each option.

Table 4-1
System Setup Options

F-key	Parameter	Recommended Setting
F2	Graphics Mode	Select printer in use
F3	Disperser Port	COM1
F4	Aerosizer Port	COM2
F5	External Control Port	COM3
F10	Sample Presentation	Cal. Neb.
Alt F6	AutoSave during run?	NO
Alt F7	Overwrite Scans?	NO
Alt F8	Log Plot Resolution?	Low

Main Menu Options

The following options should be selected *before* proceeding with a sample run.

- Press **<F2>** and enter any information to be stored with the sample data.
- Press **<F3>** and enter the desired flow pressure percentage (full scale is approximately 20 PSIG). The recommended setting is 80%.
- Press **<F4>** and select the sample material and density from the list, or add it to the list.
- Press **<F5>** and set Combine to AUTO.
- Press **<F8>** and select the desired Auto Print setting.
- Press **<F9>**. Set Automatic Save to ON. To change the current directory, move the cursor to "Data File SubDir," press **<Enter>**, and select the desired directory from the list, or add it to the list.
- Press **<F10>** and select MANUAL measurement.

Background Count Check

Press **<Ctrl D>** to access the Diagnostic Screen. Check the background counts. Clean the optics if the background counts:

- Are consistently lower than 500
- Are consistently higher than 10,000
- Show a ratio between the left and right columns of more than 5 to 1.

Performing a Sample Measurement

Make sure all options have been set from the System Setup screen and the Main Menu.

Starting the Measurement

Press **<F7>**.

A distribution will appear onscreen. It may at first appear choppy, but it will smooth out as more data is collected.

Ending the Measurement

When a sufficient amount of data has been collected, use one of the following commands:

- Press **<F11>** to complete a run and store the data.
- Press **<F1>** to abort a run.
- Press **<F7>** to restart a run.

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CHAPTER 5

Theory of Operation

The Model 3225 Aerosizer® DSP is a time-of-flight spectrometer that measures the time-of-flight of a distribution of particles in an accelerating airflow through a nozzle.

In the instrument, particles are confined to the centerline of an accelerating flow by sheath air. They then pass through two tightly focused laser beams, scattering light as they do so. This scattered light causes a pulse to be emitted from the photomultiplier tube (PMT) monitoring that laser beam. A signal from the PMT monitoring the first beam is used to start a timer, and the signal from the PMT monitoring the second beam is used to stop the timer and report the time elapsed. This time-of-flight information is sent to a computer running the Aerosizer® 3225 Control Software, where the time-of-flight to size conversion takes place.

For a discussion of the time-of-flight to size conversion, see the appendices in the Aerosizer® 3225 Control Software Manual.

Sample Flow Path

The sample flow path in the Model 3225 Aerosizer® DSP is illustrated in Figure 5-1. A vacuum pump generates the total flow from the sample feed device and through the sample chamber. The particles entering the Aerosizer® DSP may be either a dry powder or liquid aerosol, in the form of an air suspension. This suspension is drawn into the Aerosizer® inlet and forms the sample flow through the Injection Tube.

The sheath flow is filtered, and is drawn by the vacuum pump. The sheath flow pressure and the sample chamber pressure are monitored. The sheath flow confines the sample particles to the center stream and accelerates the airflow around the particles. As the particles leave the end of the Sonic Nozzle, they are at near-sonic velocity and continue to accelerate through the measurement region. Very small particles are accelerated to nearly the air velocity by the drag force between the air and the particles. Large particles experience lower acceleration because of their greater mass.

The particles' times-of-flight are then measured in the sample chamber.

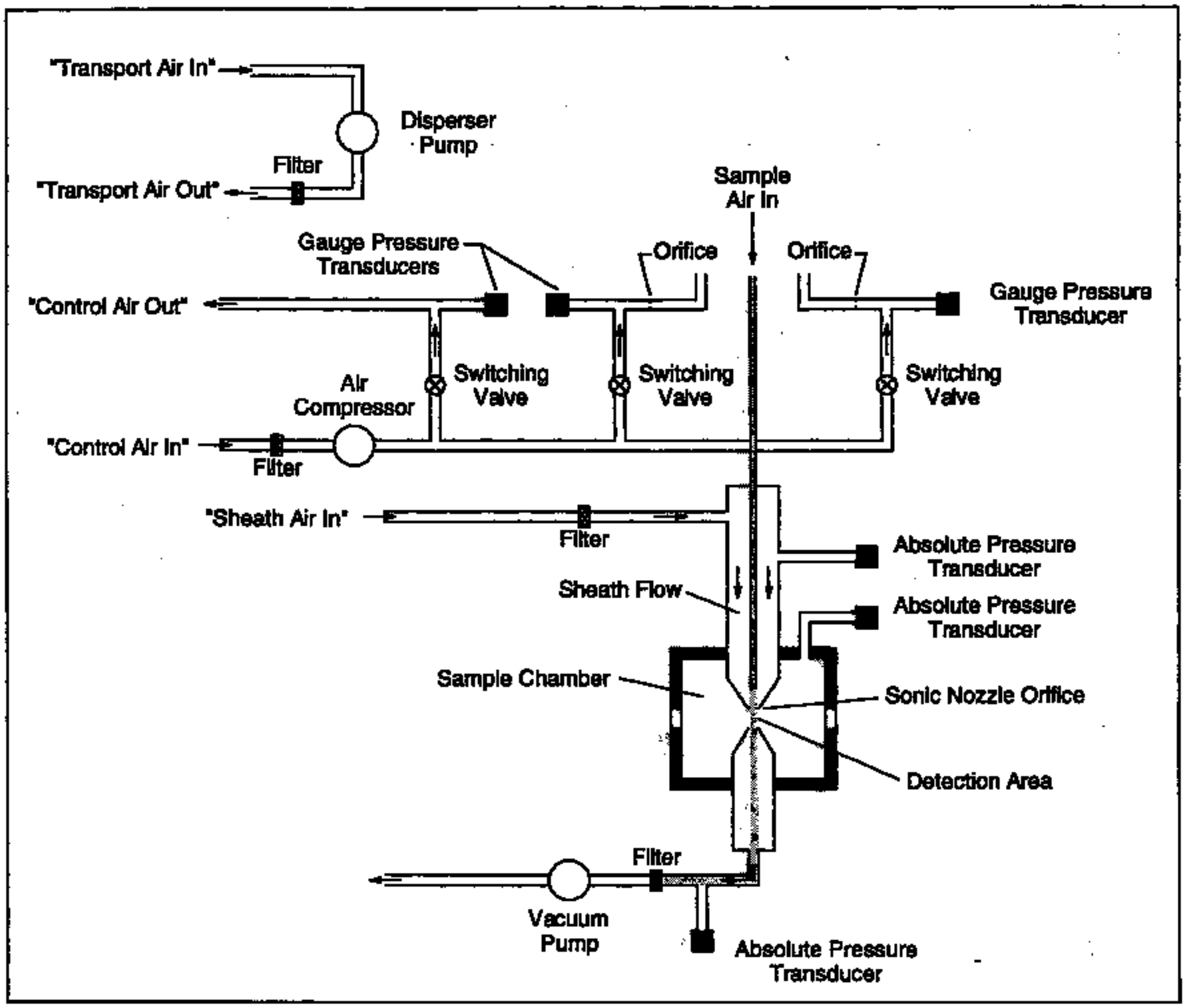

Figure 5-1
Sample Flow Path

After measurement, the particle stream exits the sample chamber. The airflow passes through a HEPA filter before entering the vacuum pump to remove any sample particles. The filtered air is then exhausted to the atmosphere.

A small compressor draws and filters room air. If the Aero-Disperser® or Calibration Nebulizer™ is used, a switching valve directs the compressed air flow to the "Control Air Out" fitting, where it is connected to the sample feed device.

In an independent system, the Disperser Pump draws room air and directs it to the "Transport Air Out" fitting, where it can be supplied to the Aero-Disperser®.

Optics Path

The optics path for the Model 3225 includes both source optics and detection optics. The source optics path is shown in Figure 5-2. The detection optics path is shown in Figure 5-3.

Source Optics

The first component in the optics path (see Figure 5-2) is the laser diode. This diode generates a 3 mW, 670-nm wavelength, collimated laser beam.

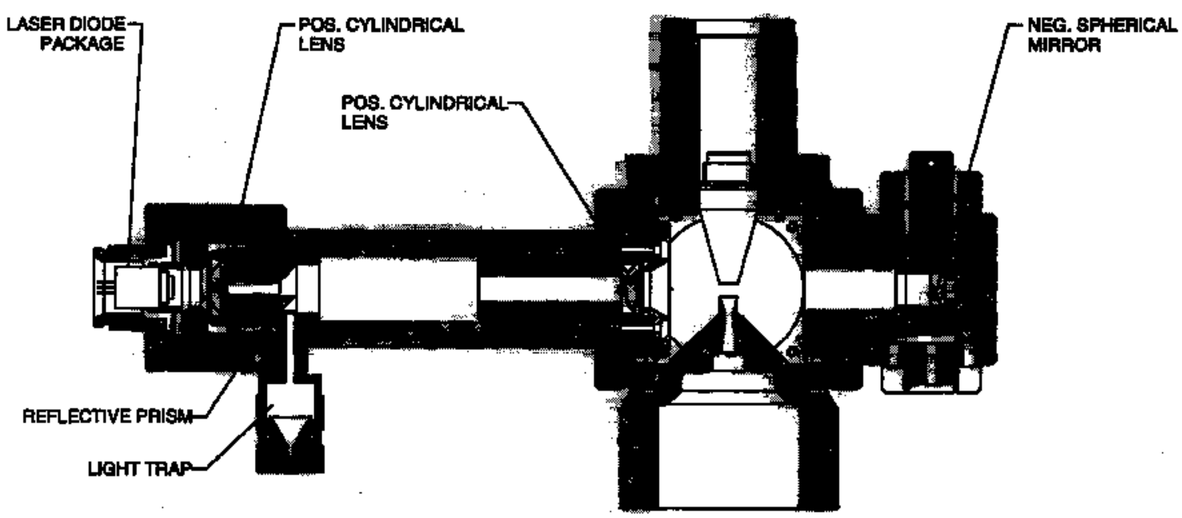

Figure 5-2
Model 3225 Source Optics Cross Section

The beam is passed through two convex, cylindrical lenses that flatten out the beam as it passes through the measurement region. The beam is then reflected off a concave, spherical mirror to generate the second, flattened beam directly above the first. The reflected beam is then passed back through the optics to a reflective prism that directs the beam into a light trap.

Detection Optics

When a sample particle crosses the source optics beams, it creates a pulse of light from each beam. Each pulse of light is passed through a convex, aspherical lens and an aperture, toward a reflective prism. The reflective prism directs each light-pulse through a biconvex spherical lens and toward the appropriate photomultiplier tube (PMT).

One PMT monitors the top laser beam; the other PMT monitors the bottom beam. The PMTs detect the light pulses from the appropriate beam and emit an electrical pulse.

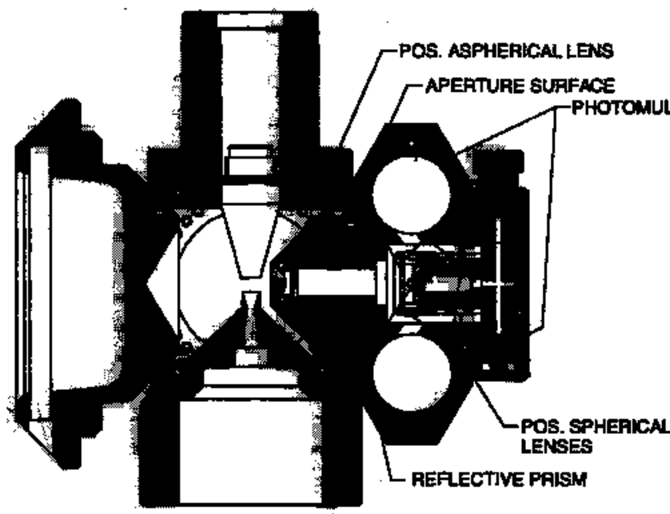

Figure 5-3
Model 3225 Detection Optics Cross Section

Signal Processing Path

The Aerosizer® DSP utilizes proprietary Digital Signal Processing to minimize false triggering of the correlator boards caused by ringing and afterpulsing of the photomultiplier tubes (PMTs). Typically, larger particles cause long, bright flashes. For such particles, the PMTs will produce commensurately long pulses, often with large overshoots and afterpulses. Look-ahead technology, coupled with a multi-level discrimination circuit, automatically sets discrimination levels based on individual pulses output by the PMTs. Analog photomultiplier pulses are first amplified and adjusted for proper offset. The resulting pulses are digitized and a look-ahead circuit determines the width and amplitude of the resulting digitized pulse. The level of a digital discrimination circuit is set accordingly. For very wide, large pulses, the discriminator level is set high enough to eliminate false triggers due to ringing or afterpulses. Conversely, for narrow pulses caused by small particles, the discriminator level will be set low enough that the smaller pulse will trigger the discriminator and be sent to the correlator boards. This technology eliminates any false triggers due to extraneous pulses, but still allows small pulses to trigger the correlators properly.

Signals are also passed from the computer to the electronics in the Model 3225 to control the valves associated with the "Control Air Out," the Disperser Pump, and the Aero-Disperser®.

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APPENDIX A

Maintenance

This section provides information about the maintenance procedures that are required for the Aerosizer® DSP and includes a suggested maintenance schedule.

Maintenance Schedule

The following table contains a schedule of approximate recommended intervals for maintenance. The conditions under which the instrument is used will greatly affect this schedule. The sample materials used will also affect the maintenance schedule—in general, smaller sample particles require more frequent cleaning of the Aerosizer's® Sonic Nozzle and optics. Use the schedule in Table A-1 as a guideline only.

Table A-1
Maintenance Schedule

Maintenance Operation	Recommended Maintenance Interval	User/Factory
Cleaning Sonic Nozzle	As needed	User
Cleaning Optics	As needed	User
Replacing Internal Compressed Air Filter	Yearly/as needed	Factory
Replacing Internal Sheath Air Filter	Yearly/as needed	Factory
Replacing Disperser Pump Filter	Yearly/as needed	Factory
Replace Fuses	As needed	User
Recalibration	Yearly	Factory

Cleaning the Sonic Nozzle

Clean the Sonic Nozzle according to the maintenance schedule and also in the following circumstances:

- The message "Nozzle Clogged" appears on the computer screen
- The flows in the instrument are too low or erratic

- A sudden, apparent degradation of the quality of the particle size distribution occurs during a measurement

To clean the Sonic Nozzle, proceed as follows:

> **WARNING**
>
> Make sure power is switched off and power cord is disconnected to avoid any exposure to hazardous laser radiation.

1. Turn the vacuum pump, computer, Model 3225 Aerosizer® DSP, and any sample feed device OFF.
2. Remove the sample feed device (including the Direct Feed Adapter, if used) from the Aerosizer® DSP.
3. Remove the Injection Tube. Be careful not to damage the tip of the Injection Tube. The tip is critical to a uniform airflow into the Sonic Nozzle. (Refer to Figure A-1)

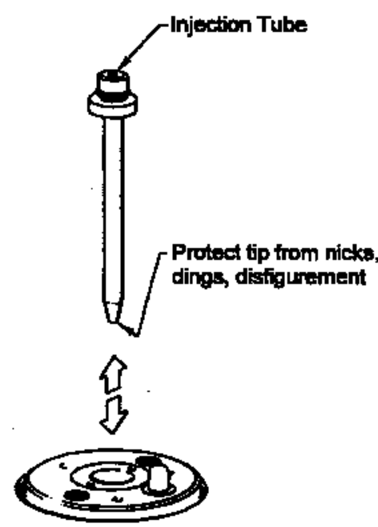

Figure A-1
Injection Tube Removal Procedure

4. Attach the Sonic Nozzle Extraction Tool to the Sonic Nozzle using the two 2-56 screws on the extraction tool. Rotate the Sonic Nozzle to break the o-ring seal. Remove the Sonic Nozzle by pulling up uniformly on the extraction tool. Remove the extraction tool from the nozzle. (Refer to Figure A-2)

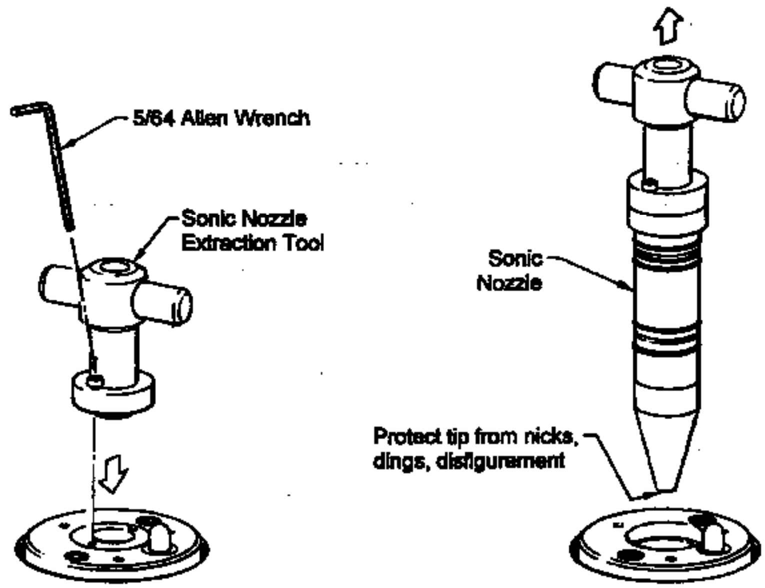

Figure A-2
Sonic Nozzle Extraction Procedure

5. Use the Flow Straightener Extraction Tool to remove the Flow Straightener from inside the Sonic Nozzle by inserting the tool through the center hole and catching the bottom edge of the Flow Straightener with the tip of the tool. Grasping the tool in one hand and the Sonic Nozzle in the other, pull out firmly. (Refer to Figure A-3)

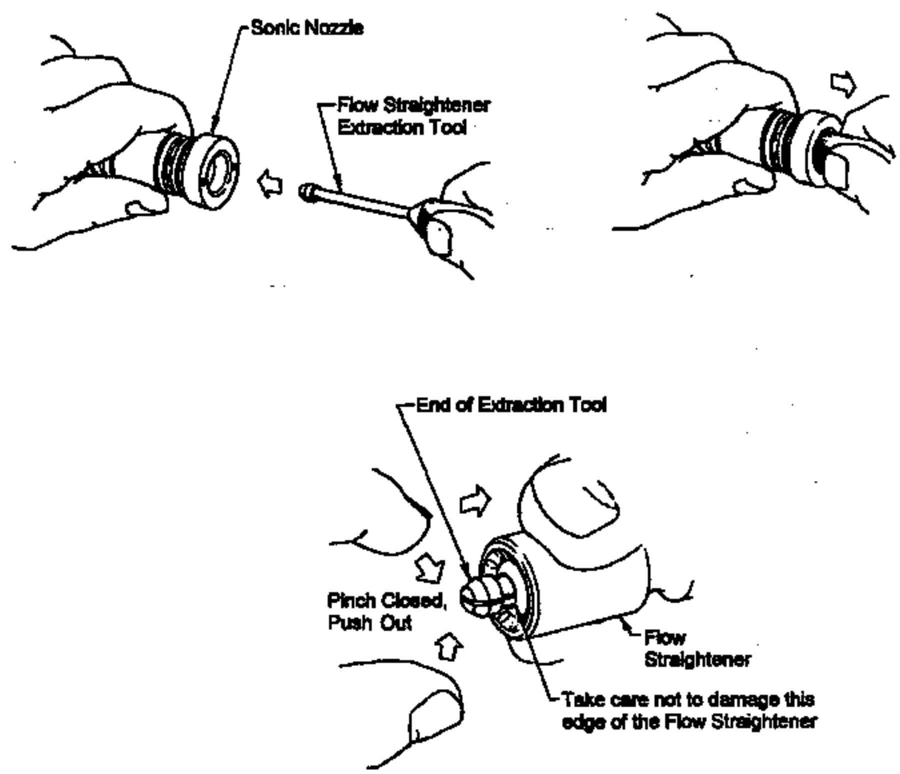

Figure A-3
Flow Straightener Extraction Procedure

6. Remove any objects in the Flow Straightener and nozzle using compressed air. Swab out the inside of the Sonic Nozzle and the nozzle tip with isopropyl alcohol.
7. If necessary, clean nozzle with soap and water. *Thoroughly* rinse and dry the nozzle.

> **Caution**
>
> Do not allow any hard objects to come in contact with the tip of the Sonic Nozzle, as even small scratches will cause serious degradation of Model 3225 Aerosizer® DSP's operation.

8. Lubricate all the o-rings on the Sonic Nozzle with a small amount of o-ring lubricant (supplied). There should be enough lubricant on the o-rings to allow the parts to fit together easily, but not so much that there are large globules present. Wiping a small amount of "o-lube" on the

inside of the top of the Sonic Nozzle, above the first ring of holes, will aid in reassembly of the parts.

9. Replace the Sonic Nozzle in the Model 3225 Aerosizer® DSP. Push the nozzle down with the Sonic Nozzle Extraction Tool.

> **Caution**
>
> Do not hold the sides of the nozzle with your fingers as you push because they may be pinched by the upper edge of the nozzle.

10. Replace the Flow Straightener in the Sonic Nozzle. Use the Flow Straightener Extraction Tool to push it in firmly. Gently remove the tool.

11. Replace the Injection Tube and the sample feed device.

Cleaning the Optics

The optics should be cleaned when operation has been degraded by sample buildup on the optics, or when the background counts on the Diagnostic Screen:

- Are consistently lower than 500
- Are consistently higher than 10,000
- Show a ratio between the left and right columns of more than 5 to 1.

To clean the optics, proceed as follows:

> **WARNING**
>
> Make sure power is switched off and power cord is disconnected to avoid any exposure to hazardous laser radiation.

1. Turn off power to the vacuum pump, the Model 3225 Aerosizer® DSP, and the sample feed device.

2. Remove the sample feed device (including the Direct Feed Adapter, if used).

3. Remove the Access Port Plug from the front of the Model 3225 by grasping the handle, rotating the plug counterclockwise, and pulling out firmly.

4. Remove the Sonic Nozzle. You may be able do this by placing your fingers on the tapered portion of the nozzle and pushing up. If this is not possible, use the Sonic Nozzle Extraction Tool provided in the Accessory Kit. (Refer to Figure A-4)

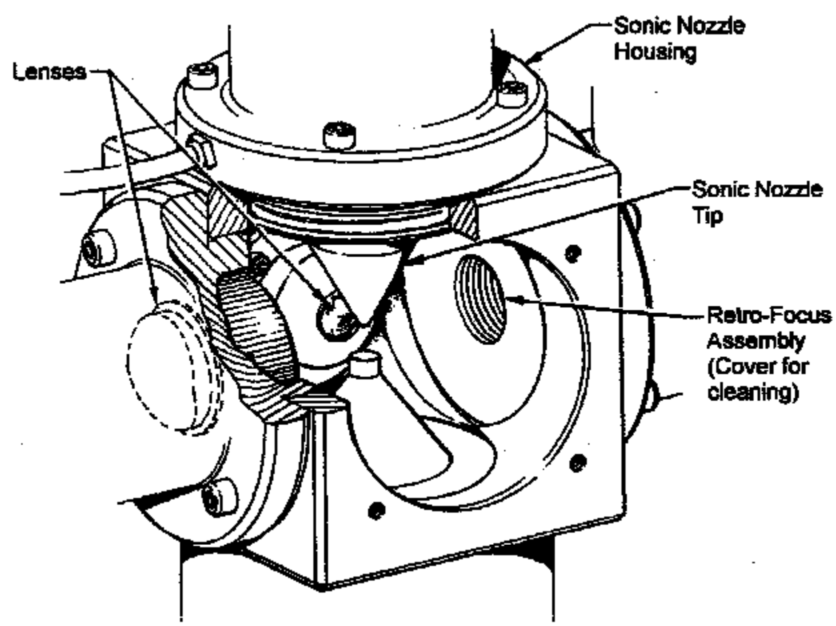

Figure A-4
Cutaway View of Sample Chamber

5. Tape over the opening to the Retro-Focus Mirror with adhesive tape.
6. Clean the sample chamber and optics by blowing out residue with compressed gas (air, nitrogen, etc...)
7. To clean the lenses with lens tissue and alcohol or acetone, cut a square of tissue paper and fold the ends up. Grasp the tissue paper swab with the forceps. (Refer to Figure A-5)

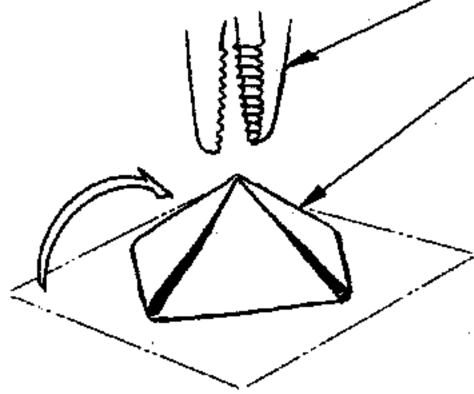

Figure A-5
Forming Tissue Paper Swab for Cleaning Optics

You should use two pieces of lens tissue, one with the alcohol to clean the lenses, and one dry piece to immediately wipe the lenses dry before the alcohol can evaporate. The cleaning should be done with a gentle, single stroke. DO NOT scrub or exert a lot of force on the lenses. It may require more than one pass to accomplish adequate cleaning. New lens tissue should be used for subsequent passes.

8. Clean the inside of the sample chamber with alcohol and lens tissue if necessary.
9. Remove the tape from the Retro-Focus Mirror opening. Replace the Access Port Plug.
10. Remove and clean the Sonic Nozzle as described in the previous section. Replace the Sonic Nozzle in the Model 3225 Aerosizer® DSP.
11. Replace the Injection Tube and the sample feed device.
12. Restore power to the system. A 20-minute warm-up period is recommended after cleaning the optics before making a measurement.

Replacing Internal Air Filters

There are three air filters internal to the Model 3225 Aerosizer® DSP. These should be replaced according to the schedule in Table A-1. The location of each filter is indicated in Figure A-6.

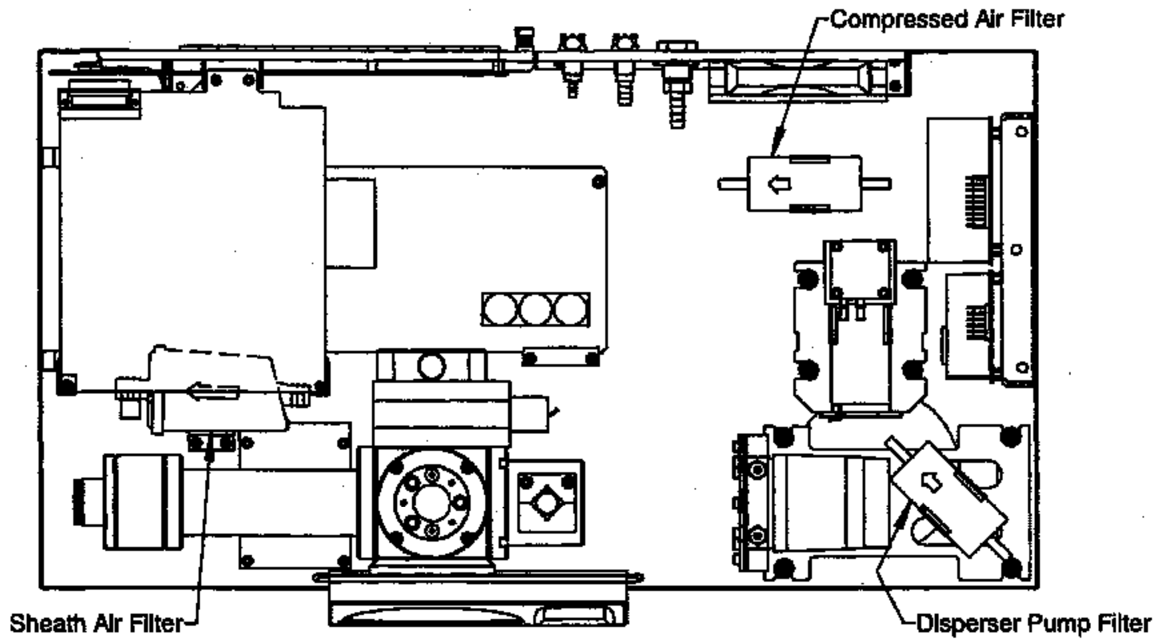

Figure A-6
Locations of Internal Air Filters

To replace the internal air filters, proceed as follows:

WARNING
Make sure power is switched off and power cord is disconnected to avoid any exposure to hazardous laser radiation.

WARNING
High voltage is accessible in several locations within this instrument. Make sure you unplug the power source before removing the cover or performing maintenance procedures.

Caution

The electronic circuits within this instrument are susceptible to electro-static discharge (ESD) damage. Use ESD precautions to avoid damage.

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

1. Turn off the vacuum pump, Model 3225 Aerosizer® DSP, and the sample feed device.
2. Remove any sample feed device (including the Direct Feed Adapter, if used).
3. Remove the six (6) screws that hold the unit's cover to the baseplate. Lift the cover straight up.
4. Replace the filter as described below:

Replacing Compressed Air Filter

To replace the compressed-air filter, slip the filter out of its retaining clip and disconnect the tubing from each end. Take note of the flow direction indicated on the new filter and reconnect the tubing to the new filter. Press the filter into the retaining clip.

Replacing Sheath Air Filter

To replace the sheath air filter, slip the filter out of its retaining clip and disconnect the tubing from each end. Take note of the flow direction indicated on the new filter and reconnect the tubing to the new filter. Press the filter into the retaining clip.

Replacing Disperser Pump Filter

To replace the Disperser Pump filter, disconnect the tubing from each end. Take note of the flow direction indicated on the new filter and reconnect the tubing to the new filter.

5. Gently lower the Model 3225 Aerosizer® DSP's cover over the instrument, taking care not to pinch any hoses inside the instrument. Make sure the holes on the cover align with the threaded holes on the instrument's baseplate. Reinsert the mounting screws.
6. Reattach all electrical and pneumatic connections. Reconnect the sample feed device.

Replacing the Fuses

The accessory kit includes two extra fuses in the event these need to be replaced. The Model 3225 Aerosizer® DSP uses two ~T5.0A H/250V fuses. To replace the fuses, proceed as follows:

1. Turn off the power to the Aerosizer® and Disperser Pump. Unplug the instrument.
2. Slide the fuse box out of its slot in the power outlet panel on the rear bulkhead. Remove the old fuses from their clips and put the new ones in their place. Slide the fuse clip back into its slot until it snaps into place.
3. Plug in the Model 3225 and turn it on.

Recalibration of the Model 3225 Aerosizer® DSP

Calibrating the Model 3225 Aerosizer® DSP is a very delicate process requiring special equipment and tools. The instrument should be returned to the factory for a recalibration.

APPENDIX B

Troubleshooting

Error Messages

Pressures within the Model 3225 Aerosizer® DSP are monitored at the sheath air inlet to the nozzle, in the vacuum chamber on the outlet side of the nozzle, and at the vacuum inlet at the back of the Aerosizer® where the vacuum line is connected. The Aerosizer® 3225 Control Software will provide error messages on the computer screen when the system detects air pressures in the system that are outside the normal range.

The following pressure-related error messages may appear. The typical causes and solutions are given for each.

Sheath Air Filter Clogged

This message may appear when the sheath air inlet pressure falls below 0.85 atmospheres. Typical causes and solutions are shown in Table B-1.

Table B-1
Causes and Solutions for "Sheath Air Filter Clogged" Error Message

Typical Causes	Solution
❑ Blocked sheath air filter	❑ Replace sheath air filter
❑ Pinched tube leading to or from the sheath air filter	❑ Adjust tubing to remove pinches
❑ Blocked sheath air inlet in rear bulkhead	❑ Unblock sheath air inlet
❑ Ambient pressure is less than 0.85 atmospheres	❑ If this is expected, call Customer Service to discuss possible solutions

Nozzle Clogged

This message may appear when the sample chamber pressure and the vacuum inlet pressure fall below 0.02 atmospheres, or if both are less than 0.05 atmospheres *and* the ration of sample chamber pressure to vacuum pressure is less than 0.7. Typical causes and solutions are shown in Table B-2.

Table B-2
Causes and Solutions for "Nozzle Clogged" Error Messages

Typical Cause	Solution
❑ Nozzle clogged by large object	❑ Clean sonic nozzle
❑ Sheath air inlet and sample inlet both blocked	❑ Unblock sheath air inlet and sample inlet

Pump Filter Clogged

This message may appear if the sample chamber pressure is between 0.07 and 0.2 atmospheres, and the vacuum inlet pressure is between 0.1 and 0.2 atmospheres. Typical causes and solutions are shown in Table B-3.

Table B-3
Causes and Solutions for "Pump Filter Clogged" Error Message

Typical Cause	Solution
❑ Clogged HEPA filter at vacuum pump	❑ Replace HEPA filter
❑ Pinched or obstructed vacuum line between vacuum pump and instrument	❑ Remove obstruction from vacuum tube or adjust position to remove pinches.
❑ Vacuum pump of insufficient pumping capacity	❑ If using the supplied vacuum pump, it may need to be returned to TSI, Inc. for service. If using another vacuum source, such as house vacuum, switch to a stronger vacuum pump.

Vacuum Pump Turned Off or Not Connected

This message may appear if the sample chamber pressure and the vacuum inlet pressure are close to atmospheric pressure, and the ratio of the two are between 0.9 and 1.1. Typical causes and solutions are shown in Table B-4.

Table B-4
Causes and Solutions for "Vacuum Pump Turned Off or Not Connected" Error Message

Typical Cause	Solution
❑ Vacuum pump turned off	❑ Turn on vacuum pump.
❑ Vacuum line not connected	❑ Connect vacuum line.
❑ Interface cable from instrument to computer not connected	❑ Connect interface ("Y") cable from instrument to computer.

Chamber Pressure Too High

This error message may appear if the sample chamber pressure and the vacuum inlet pressure are both greater than 0.2 atmospheres. Typical causes and solutions are shown in Figure B-5.

Table B-5
Causes and Solutions for "Chamber Pressure Too High" Error Message

Typical Cause	Solution
❑ Missing o-ring somewhere in system	❑ Replace o-rings where needed (Replacement o-rings are provided in Accessory Kit).
❑ Sonic Nozzle missing	❑ Insert Sonic Nozzle
❑ Access Port Plug not in place	❑ Insert or adjust Access Port Plug
❑ Interface Cable from instrument to computer not connected	❑ Connect interface ("Y") cable from instrument to computer.
❑ Vacuum line pinched or obstructed between instrument and vacuum pump	❑ Remove obstruction from vacuum tube or adjust position to remove pinches.
❑ Vacuum pump of insufficient pumping capacity	❑ If using the supplied vacuum pump, it may need to be returned to TSI, Inc. for service. If using another vacuum source, such as house vacuum, switch to a stronger vacuum pump.

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APPENDIX C

Model 3225 Specifications

The following specifications—which are subject to change—list the most important features of the Model 3225 Aerosizer® DSP.

Table C-1
Specifications of the Model 3225 Aerosizer® DSP

Measurement technique	The time-of-flight of individual particles is measured in an accelerating flow field. Processing electronics measure the time-of-flight of the particle using a dual high-speed timing processor. Raw time-of-flight data is sent to a separate computer with control and analysis software.
Particle Type	Airborne solids and non-volatile liquids
Particle Size Range	0.2 to 700 µm geometric size
Maximum Particle Concentration	900 pt/cm³ between 0.2 and 700 µm
Resolution	0.045 µm at 1.0 µm diameter. 0.45 µm at 10.0 µm diameter.
Sampling Time	User-selectable: programmable from 1 second to 9 hours, or manual.
Flow Rates	Total flow: 21.0 ± 1.0 lpm (ratio of sheath airflow to sample airflow is feedback controlled).
Flow Control	Critical orifice (choke flow)
Atmospheric Pressure Correction	None; available with Atmospheric Control Module (purchased separately)
Operating Temperature	10 to 35°C (50 to 95°F)
Operating Humidity	10 to 90% RH non-condensing
Laser Source	3 mW, 670 nm Laser Diode
Detector	Dual photomultipliers
Power	100-240 VAC, 50-60 Hz, 300 W, single phase
Communication	Proprietary interface cable
Dimensions (L, W, H)	715 mm x 395 mm x 225 mm (28 in. x 15.5 in. x 9 in.)
Weight	26.5 kg (58 lb.)
Fuse	~T 5.0A H/250V

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TSI.

Model 3230
Aero-Disperser®

Instruction Manual

Manual History

The following is a manual history of the Model 3230 Aero-Disperser® (Part Number DOC3230).

Revision	Date
Preliminary	May 1999

This manual was first published May 1999.

Part Number DOC3230 / May 1999

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Email Address amherst@tsi.com

World Wide Web Site www.aerosizer.com

Fax No. (413) 253-6960

Limitation of Warranty And Liability (effective April 1996)

TSI Incorporated (hereinafter referred to as "seller") warrants that this product, under normal use and service as described in this manual, shall be free from defects in workmanship and material for a period of twelve (12) months from the date of shipment to the customer. This limited warranty is subject to the following exclusions:

1. Batteries, hot wire or hot film sensors and certain components when indicated in specifications are warranted for a period of 90 days from the date of shipment to the customer
2. With respect to any repair services rendered, seller warrants that the parts repaired or replaced will be free from defects in workmanship and material, under normal use, for a period of 90 days from the date of shipment to the customer.
3. Seller does not provide any warranty on finished goods manufactured by others. Only the original manufacturer's warranty applies.
4. Unless specifically authorized in a separate writing by the seller, seller makes no warranty with respect to, and shall have no liability in connection with, any goods which are incorporated into other products or equipment by the Buyer. All goods returned under warranty shall be at the Buyer's risk of loss, seller's factory prepaid, and will be returned at seller's risk of loss, Buyer's factory prepaid.

The foregoing is IN LIEU OF all other warranties and is subject to the conditions and LIMITATIONS stated herein. NO OTHER EXPRESS OR IMPLIED WARRANTY OF FITNESS FOR PARTICULAR PURPOSE OR MERCHANTABILITY IS MADE.

THE EXCLUSIVE REMEDY OF THE USER OR PURCHASER, AND THE LIMIT OF THE LIABILITY OF SELLER FOR ANY AND ALL LOSSES, INJURIES, OR DAMAGES IN CONNECTION WITH THIS PRODUCT (INCLUDING CLAIMS BASED ON CONTRACT, NEGLIGENCE, STRICT LIABILITY, OTHER TORT, OR OTHERWISE) SHALL BE THE RETURN OF THE PRODUCT TO THE FACTORY OR DESIGNATED LOCATION AND THE REFUND OF THE PURCHASE PRICE, OR, AT THE OPTION OF SELLER, THE REPAIR OR REPLACEMENT OF THE PRODUCT. IN NO EVENT SHALL SELLER BE LIABLE FOR ANY SPECIAL, INCIDENTAL OR CONSEQUENTIAL DAMAGES. SELLER SHALL NOT BE RESPONSIBLE FOR INSTALLATION, DISMANTLING, REASSEMBLY OR REINSTALLATION COSTS OR CHARGES. NO ACTION, REGARDLESS OF FORM, MAY BE BROUGHT AGAINST THE SELLER MORE THAN ONE YEAR AFTER THE CAUSE OF ACTION HAS ACCRUED.

The purchaser and all users are deemed to have accepted the terms of this LIMITATION OF WARRANTY AND LIABILITY, which contains the complete and exclusive limited warranty of seller. This LIMITATION OF WARRANTY AND LIABILITY may not be amended or modified nor may any of its terms be waived except by a writing signed by an authorized representative of seller.

Service Policy

Knowing that inoperative or defective instruments are as detrimental to TSI as they are to our customers, our service policy is designed to give prompt attention to any problems. If any malfunction is discovered, please contact your nearest sales office or representative, or call TSI/Particle Instrument Division—Amherst at 1-800-335-5577 (USA) or (413) 253-6966.

Safety

This section gives instructions to promote safe and proper handling of the Model 3230 Aero-Disperser®.

There are no user serviceable parts inside the instrument. Refer all repair and maintenance to a qualified technician. All maintenance and repair information in this manual is included for use by a qualified technician.

WARNING
High voltage is accessible in several locations within this instrument. Make sure you unplug the power source before removing the cover or performing maintenance procedures.

Labels

The Model 3230 Aero-Disperser® has 3 labels as shown in Figure 1.

1. Serial Number Label (back panel)
2. Warning Fire Hazard Label (back panel)
3. Ground Label (back panel)

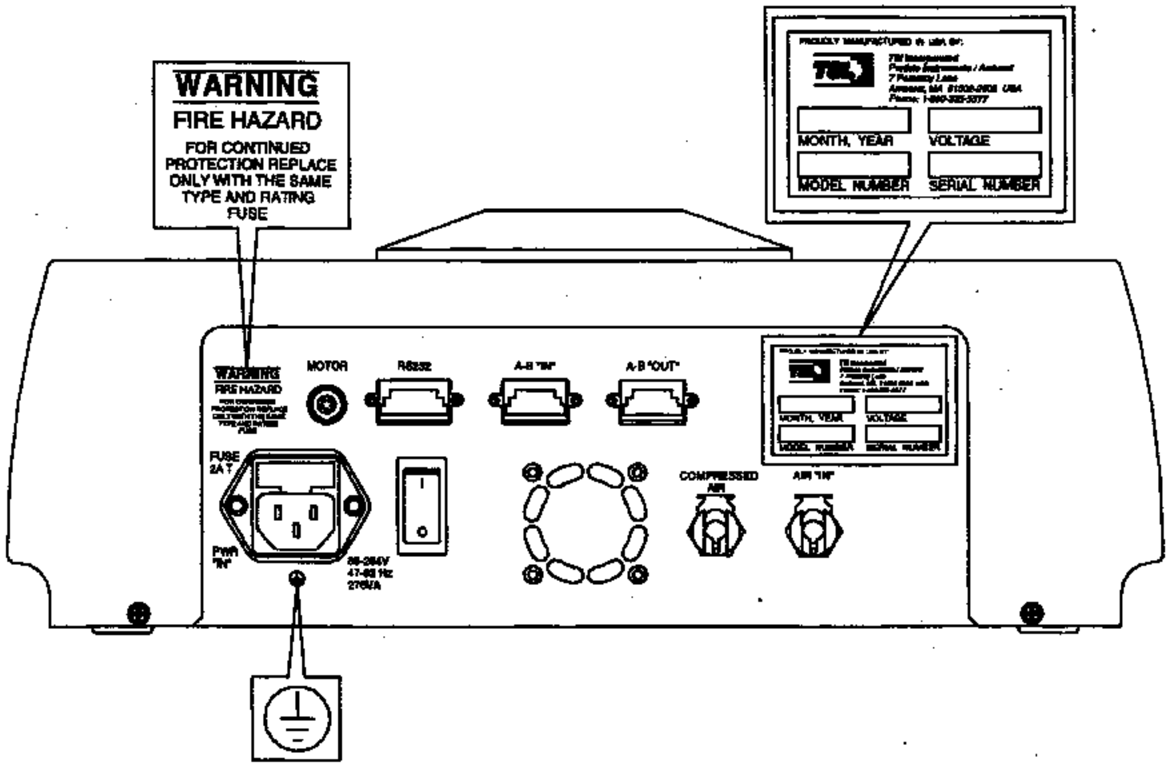

Figure 1
Location of Warning and Information Labels

Description of Caution/Warning Symbols

The following symbols and an appropriate caution/warning statement are used throughout the manual and on the Model 3230 to draw attention to any steps that require you to take cautionary measures when working with the Model 3230:

Caution

Caution
Caution means ***be careful.*** It means if you do not follow the procedures prescribed in this manual you may do something that might result in equipment damage, or you might have to take something apart and start over again. It also indicates that important information about the operation and maintenance of this instrument is included.

Warning

WARNING
Warning **means that unsafe use of the instrument could result in serious injury to you or cause irrevocable damage to the instrument. Follow the procedures prescribed in this manual to use the instrument safely.**

Caution or Warning Symbols

The following symbols may accompany cautions and warnings to indicate the nature and consequences of hazards:

	Warns you that uninsulated voltage within the instrument may have sufficient magnitude to cause electric shock. Therefore, it is dangerous to make any contact with any part inside the instrument.
	Warns you that the instrument is susceptible to electro-static discharge (ESD) and ESD protection procedures should be followed to avoid damage.
	Indicates that the connector is connected to earth ground and cabinet ground.

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Contents

Chapters

Appendices

Figures

Tables

About This Manual

Purpose

This is an instruction manual for the operation and handling of the Model 3230 Aero-Disperser®.

Related Product Literature

- ***Aerosizer® 3225 Control Software Manual*** (part number DOC8053 TSI Incorporated)
- ***Model 3225 Aerosizer® DSP Manual*** (part number DOC3225 TSI Incorporated)

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 uses recycled paper.
- This manual has been shipped, along with the instrument, in a reusable carton.

Getting Help

To obtain assistance with this product or to submit suggestions, please contact Particle Instruments/Amherst:

TSI Incorporated
Particle Instruments/Amherst
7 Pomeroy Lane
Amherst, MA 01002-2905 USA
Fax (413) 253-6960
Telephone: 1-800-335-5577 (USA) or (413) 253-6966
E-mail Address: amherst@tsi.com

Submitting Comments

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

If the comment sheet has already been used, send your comments to:

TSI Incorporated
Particle Instruments/Amherst
7 Pomeroy Lane
Amherst, MA 01002-2905
Fax: (413) 253-6960
E-mail Address: amherst@tsi.com

CHAPTER 1

Product Overview

This chapter contains a product description of the Model 3230 Aero-Disperser® and a brief description of how the instrument operates.

Product Description

The Model 3230 Aero-Disperser®, shown in Figure 1-1, is a microprocessor-controlled dry powder dispersing system. The Aero-Disperser® provides dispersion of both highly cohesive and free-flowing powders between 0.2 and 700 micrometers and delivers the dispersed sample into the Model 3225 Aerosizer® DSP.

The Model 3230 Aero-Disperser® must operate in conjunction with the Model 3225 Aerosizer® DSP. It is controlled by the Aerosizer® 3225 Control Software.

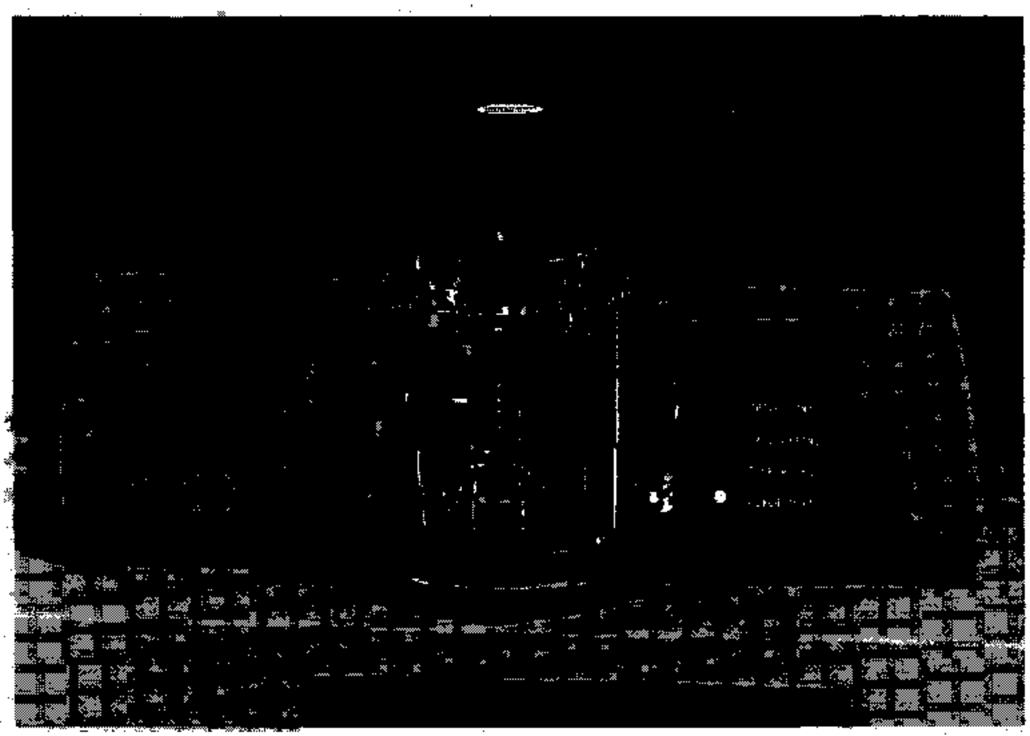

Figure 1-1
Model 3230 Aero-Disperser® (Shown with Model 3225 Aerosizer® DSP)

Applications

The Model 3230 Aero-Disperser® has application in the following areas:

- Powder sizing
- Filter and air-cleaner testing
- Basic research
- Performance evaluations of other aerodynamic devices

How the Model 3230 Aero-Disperser® Operates

In order to obtain accurate particle size distributions for cohesive and free-flowing powders, it is necessary to break up agglomerated powder into individual particles. Dry powder dispersion technology involves using high-shear airflow and impaction to break up agglomerated particles.

In the Model 3230 Aero-Disperser®, a small powder sample is dispersed from the sample cup by a pulsed jet of air. The pulsed jet fluidizes and reduces agglomerates within the sample cup. Some of this coarse aerosol is released from the sample cup into the area above the sample cup, where transport air is introduced. Material is entrained in the transport air and flows through an acceleration tube to the Disperser Pin, where agglomerates undergo further size reduction by impaction. Final de-agglomeration is accomplished by passing the aerosol through a high-shear flow field in the annular gap between the Disperser Pin and the profiled Pin-Bowl insert within the Disperser Head.

The air velocity in the high-shear flow field is a function of the position of the Disperser Pin in the Pin-Bowl and the pressure drop across the annular gap between the Disperser Pin and the Pin-Bowl. The Aero-Disperser® monitors the pressure drop across the annular gap and adjusts the pin position to maintain the necessary pressure drop. The pressure drop affects the air velocity and therefore the amount of shear force applied to the particles.

The dispersed particles are fed into the Model 3225 Aerosizer® DSP through a tuned-acceleration injection tube. The Aero-Disperser® is constantly fed back the particle count rate from the Aerosizer® and adjusts the strength and duration of the pulsed jet to provide the feed rate set by the operator.

Refer to Chapter 5, "Theory of Operation," for a detailed description.

System History

In October 1993, the Aero-Disperser® was introduced by Amherst Process Instruments, Inc. as a powder dispersion instrument for the Aerosizer® with large (1.5-mm) nozzle.

The Model 3230 Aero-Disperser® began shipping in May 1999. In late 1998, Amherst Process Instruments became part of TSI Particle Instrument Division. The Model 3230's new color scheme, logo, and model number designation bring it into line with the family of TSI scientific particle instruments. Its new cabinet design complements the cabinet of the new Model 3225 Aerosizer® DSP.

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CHAPTER 2

Unpacking and System Setup

This chapter provides information concerning the accessories shipped with the Model 3230 Aero-Disperser® and describes basic setup procedures.

Packing List

Note: *The Model 3230 Aero-Disperser® may have been shipped with the Model 3225 Aerosizer® DSP. If this is the case, some of the accessory items shipped with the instruments are accessories to the Aerosizer® DSP; the rest are accessories to the Aero-Disperser®.*

A packing list for the Model 3230 Aero-Disperser® is provided in the shipping box. It identifies all of the items that should have been shipped to you as the Model 3230 Aero-Disperser® and its accessory kit. Please compare the list to the items you received. If any items are missing, notify TSI immediately.

Attaching the Model 3230 Aero-Disperser® to the Model 3225 Aerosizer® DSP

The following instructions assume that the Model 3225 Aerosizer® DSP has already been set up, along with the vacuum pump and computer components.

Mounting the Aero-Disperser® on the Aerosizer®

1. Make sure the Aerosizer® is OFF and unplugged. Remove the direct feed adapter or any sample feed device that may be attached to the Aerosizer®.
2. Ensure that the large (1.5-mm) Sonic Nozzle and the Flow Straightener are inserted in the Aerosizer®. Remove the standard Injection Tube if it is present. Insert the Tuned-Acceleration Injection Tube into the Sonic Nozzle.
3. Make certain the power switch on the back of the Aero-Disperser® is turned OFF.

4. Disconnect the motor connection from the back panel of the Aero-Disperser® by pulling straight back on the collar of the connector.
5. Use the 4-mm ball driver to unscrew the four screws holding down the Disperser Head. Lift the Disperser Head straight up from the Aero-Disperser® and set it aside gently.
6. Place the Aero-Disperser® on top of the Aerosizer®, aligning the relief on the underside of the Aero-Disperser® with the metal plunger on the Aerosizer®.
7. Using the 7/64 hex wrench, fasten the Aero-Disperser® to the Aerosizer® with the three socket head screws located in the Aero-Disperser® base.
8. Place the Disperser Head back on the Aero-Disperser®. Tighten the four screws that hold the Disperser Head in place. Plug in the motor cable connector on the back panel of the Aero-Disperser®.

Connecting the Aero-Disperser®

The following connections are needed to run the Aero-Disperser®. Refer to Figure 2-1 for a view of the completed connections.

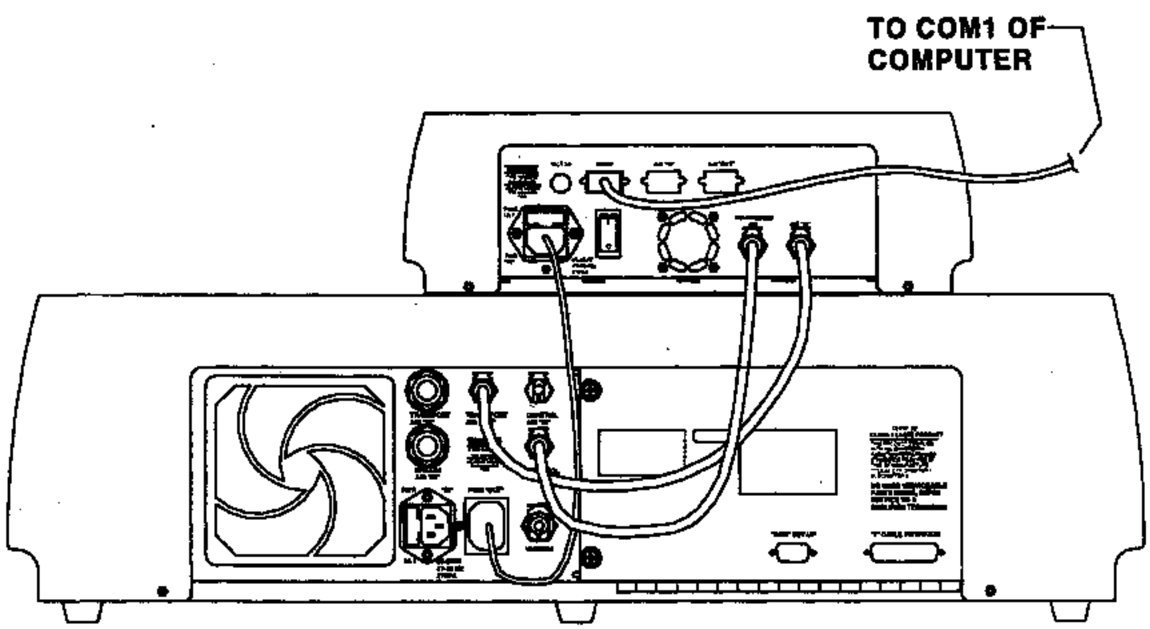

Figure 2-1
Connecting the Aero-Disperser® to the Model 3225 Aerosizer® DSP

Power Connection

Connect the power cord from the Aero-Disperser® to the "Power Out" outlet on the Aerosizer®.

Computer Connection

Connect the RS232 interface cable from COM1 of the Aerosizer® Controller computer to the RS232 port on the Aero-Disperser®.

Pneumatic Connections

- Using the 1/8" I.D. tubing assembly with two uncoded fittings, connect one end to the connector marked "Control Air Out" on the Aerosizer®. Connect the other end to the connector marked "Compressed Air" on the Aero-Disperser®.
- Using the 1/8" I.D. tubing assembly with two blue-coded fittings, from the "Transport Air" Out" connector on the Aerosizer® to the "Air In" connector on the Aero-Disperser®.

Removing the Aero-Disperser® from the Aerosizer®

1. Make sure the Aero-Disperser® is OFF and unplugged from the Model 3225 Aerosizer® DSP.
2. Disconnect the RS232 cable between the Aero-Disperser® and the Aerosizer® Controller computer. Disconnect the tubing assemblies between the Model 3225 Aerosizer® DSP and the Aero-Disperser®.
3. Unplug the motor connector on the back of the Aero-Disperser®.
4. Remove the Sample Cup from the Aero-Disperser®.
5. Use the 4-mm ball driver to loosen the four screws holding the Disperser Head onto the Aero-Disperser®. Lift the Disperser Head and set it aside gently.
6. Remove the Tuned-Acceleration Injection Tube from the Aerosizer's® Sonic Nozzle.
7. Use a 7/64 hex wrench to loosen the three screws in the Aero-Disperser® base. Lift the Aero-Disperser® off of the Aerosizer®.

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CHAPTER 3

Description of the Aero-Disperser®

This chapter describes the front, back panel, and internal components of the Model 3230 Aero-Disperser®. It also describes the parts included in the Aero-Disperser® Accessory Kit.

On the front of the Aero-Disperser® are LEDs to show ON/OFF status for four instrument functions of the Aero-Disperser®. The Disperser Head is also in the front of the instrument, containing much of the flow system by which the Aero-Disperser® operates. Beneath the Disperser Head is the base.

The back panel provides power, communications, and pneumatic connections between the Aero-Disperser® and the Aerosizer® and its controller.

The internal components of the Aero-Disperser® complete the flow system and also include the electronics that control various characteristics of the airflow.

The Aero-Disperser® Accessory Kit includes tools for maintaining the Aero-Disperser®.

Front

The clear plastic Disperser Head dominates the front of the Aero-Disperser®. The Disperser Head sits on the Aero-Disperser® base. To the right of the Disperser Head is an LED display.

Disperser Head

The user will need to disassemble and clean the Disperser Head and its internal components, and must therefore be familiar with them. The Disperser Head and its components are shown in Figure 3-1.

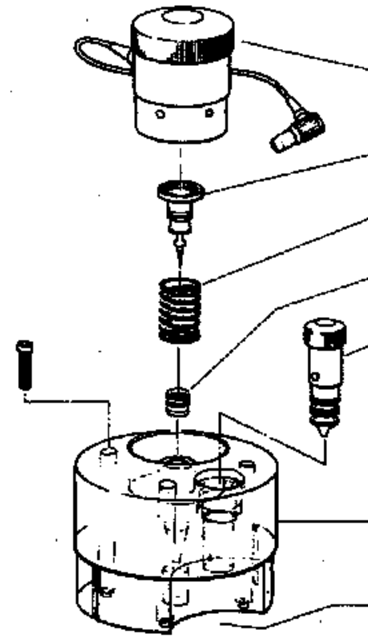

Figure 3-1
Disperser Head Components

On top of the Disperser Head is the motor assembly. It plugs into the back panel of the Aero-Disperser®, and is secured to the Disperser Head by bayonet action. Always remove the motor slowly to prevent uncontrolled ejection of the Disperser Pin, which may cause injury to the user or damage to the part.

Beneath the motor, the Disperser Pin sits on a spring. The pin's edges are sharp, fragile, and critical to the Aero-Disperser's® operation; to prevent injury to the user or damage to the part, always place it in the Disperser Pin Holder when not in place.

Inside the Disperser Head, below the Disperser Pin, is the Pin-Bowl insert. An insertion/extraction tool for the Pin-Bowl is included in the Aero-Disperser® Accessory Kit.

Above the sample cup area is the Jet. The Jet is held in the Disperser Head with a bayonet action. The tip of the Jet should be cleaned using the Jet Cleaning Tool in the Aero-Disperser® Accessory Kit, as described in Appendix A.

Four screws hold the Disperser Head to the Aero-Disperser® base. After the screws are loosened, the Disperser Head may be lifted straight up and set aside.

Aero-Disperser® Base

The base of the Aero-Disperser is shown in Figure 3-2. Its features are described below.

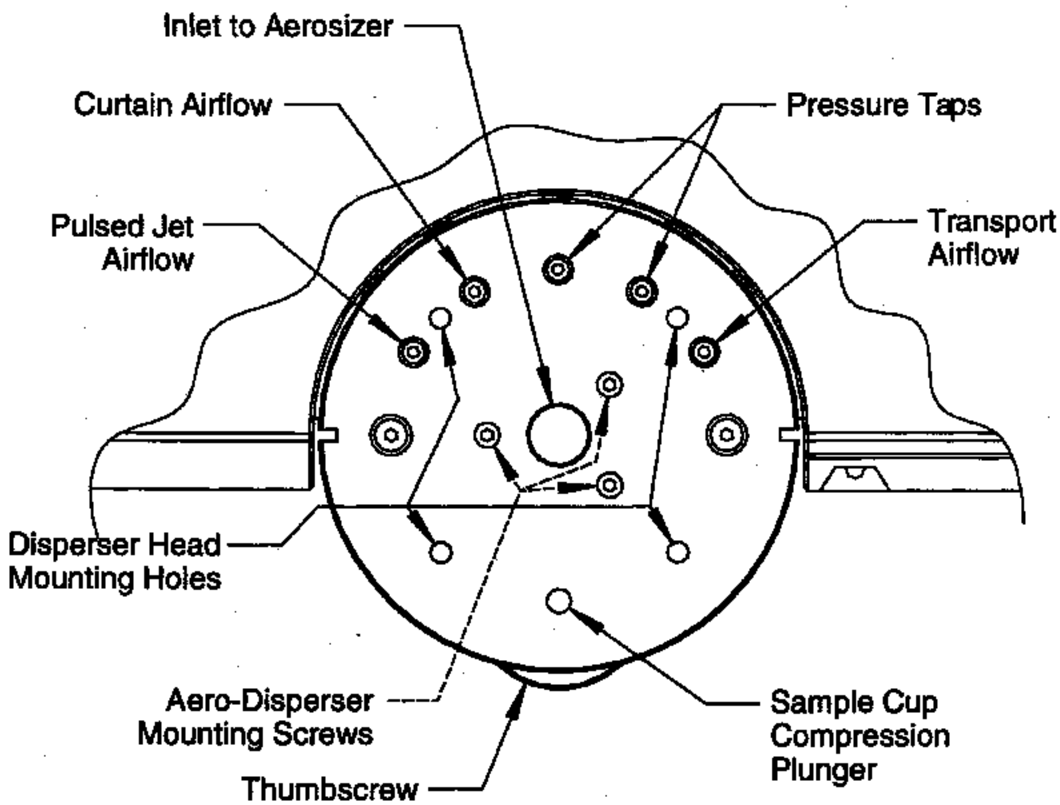

Figure 3-2
Aero-Disperser® Base

A metal plunger protrudes through the Aero-Disperser® base at its front. This plunger is used to hold the sample cup in place and to ground it electrically. The pressure the plunger exerts on the sample cup can be loosened or tightened by rotating the thumbscrew directly below. Firmly grasp the knurled edge of the thumbscrew and rotate it toward the right to tighten the screw, or to the left to loosen it.

Around the center hole that leads into the Model 3225 Aerosizer® DSP, three socket head cap screws in the base hold the Aero-Disperser® to the Aerosizer®.

There are five holes fitted with o-rings in the Aero-Disperser® base. These holes deliver airflow to various points in the Disperser Head's flow system.

LED Panel

On the front of the Aero-Disperser® is a panel with four LEDs. These LEDs indicate the current status of the instrument.

- The LED labeled **DRIVE "ON"** is lit whenever the motor on top of the Disperser Head has been actuated and is adjusting the location of the Disperser Pin.
- The LED labeled **CALIBRATING** is lit when the instrument is undergoing a calibration.
- The LED labeled **DISPERSING** is lit when the instrument is dispersing a sample.
- The LED labeled **POWER "ON"** is lit whenever power is being supplied to the instrument. This should be true whenever it is plugged into the Model 3225 Aerosizer® DSP, the "Aerosizer" power switch is ON, and the power switch on the back panel of the Aero-Disperser® is ON.

Back Panel

As shown in Figure 3-3, the back panel of the Model 3230 Aero-Disperser® allows for power, data, and pneumatic connections. The back panel also has a cooling fan with a finger guard to prevent fingers, pens, etc. from being poked into the fan.

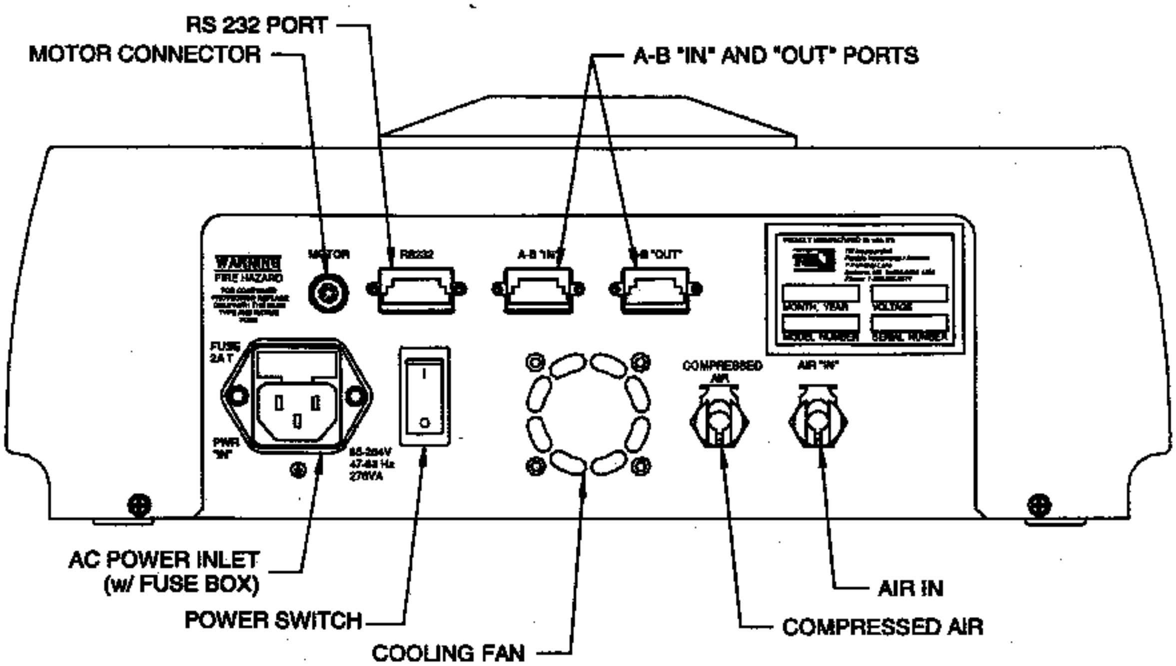

Figure 3-3
Back Panel of the Model 3230 Aero-Disperser®

AC Power Inlet

The AC Power Inlet accepts the line cord (supplied) to provide AC power to the Aero-Disperser®. Line voltage can be 100 to 240 VAC, 50-60 Hz, single phase, 2 A max. Above the AC Power inlet is a fuse compartment, housing two ~T 2.0 A H/250 fuses. Maximum power consumption is 40 Watts.

Note: *The Aero-Disperser® is intended to receive its AC power from the outlet on the Model 3225 Aerosizer® DSP.*

Motor Connector

The motor connector is a five-pin Lemo bulkhead connector. It provides power and communication to the motor that sits on top of the Disperser Head.

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CHAPTER 4

Performing Sample Measurements with the Aero-Disperser®

This chapter describes how to set up and operate the Aero-Disperser® with the Model 3225 Aerosizer® DSP using the Aerosizer® 3225 Control Software.

These instructions assume that the Aero-Disperser®, Aerosizer®, vacuum pump, and computer components have all been properly connected.

For more detailed information about the options available with the Aerosizer® 3225 Control Software, see the software manual.

Getting Started

Turn on the Aerosizer®, the Disperser Pump, the vacuum pump, and the Aero-Disperser®.

Turn on the computer. The software will start up, and the Main Menu will appear. Press **<Ctrl S>** to access the System Setup Screen.

System Setup Screen

Select the following settings (Table 4-1):

Table 4-1
System Setup Screen Settings for the Aero-Disperser®

F-key	Parameter	Recommended Setting
F2	Graphics Mode	Select printer in use
F3	Disperser Port	COM1
F4	Aerosizer Port	COM2
F5	External Control Port	COM3
F10	Sample Presentation	Disperser
Alt F6	AutoSave during run?	NO
Alt F7	Overwrite Scans?	NO
Alt F8	Log Plot Resolution?	Low

Return to the Main Menu.

Main Menu Options

The following options should be selected before proceeding with a sample run.

F2—Sample Run Information

Press **<F2>** and enter any information to be stored with the sample data.

F3—Sample Presentation

The **F3** Sample Presentation dialog box is used to calibrate the Aero-Disperser® and to set various operating parameters.

Place an empty sample cup in the Aero-Disperser® and seal it in place with the thumbscrew. Turn on the Aerosizer®, Disperser Pump, vacuum pump, and Aero-Disperser®. Press **<F3>** to bring up the Sample Presentation dialog box.

The Aero-Disperser® calibration routine should begin. When the calibration routine is finished, press **<Enter>**. The following dialog box should appear (Figure 4-1):

```
                 Aero-Disperser Auto Control
  Control Mode  :                AUTO   MANUAL
  Calibrate     :
```

Figure 4-1
Aero-Disperser® Auto Control Dialog Box

The AUTO setting is the best choice for most sample materials. For calibration standards or other powders requiring special settings, select MANUAL control. The dialog box will appear as shown in Figure 4-2:

Aero-Disperser Manual Control		
Shear Force (psi)	:	0.5
Shear Tolerance	:	0.1
Feed Rate (counts)	:	5000
Feed Tolerance	:	1000
Pin Vibration	:	OFF ON
Deagglomeration	:	NORMAL HIGH
Calibrate	:	
Control Mode	:	AUTO MANUAL
Calibration Pos	:	
Max Shear (psi)	:	

Figure 4-2
Aero-Disperser® Manual Control Dialog Box

The options available with MANUAL control are described in Appendix C.

F4—Sample Density

Press **<F4>** and select the sample material and density from the list, or add it to the list.

F5—Combine/Range Options

Press **<F5>** and set Combine to AUTO.

F8—Auto Print

Press **<F8>** and select the desired Auto Print setting.

F9—Automatic Save

Press **<F9>**. Set Automatic Save to ON. To change the current directory, move the cursor to "Data File SubDir," press **<Enter>**, and select the desired directory from the list.

F10—Program Measurements

When the Aero-Disperser® is used, program measurements should be performed manually.

Press **<F10>** Program Measurements and make certain that "Multiple Runs" is set to MANUAL.

Background Count Check

Press <Ctrl D> to access the Diagnostic Screen. Check the background counts. Clean the optics if the background counts:

- Are consistently lower than 500
- Are consistently higher than 10,000
- Show a ratio between the left and right columns of more than 5 to 1.

Running a Measurement

Thoroughly clean the Disperser Head before each sample run, following the instructions given in Appendix A. Reassemble the Disperser Head components and run the Aero-Disperser® calibration routine.

Remove the cap from the sample cup. Place a small amount of sample, as shown in Figure 4-3, into the cup. Replace the cap on the sample cup.

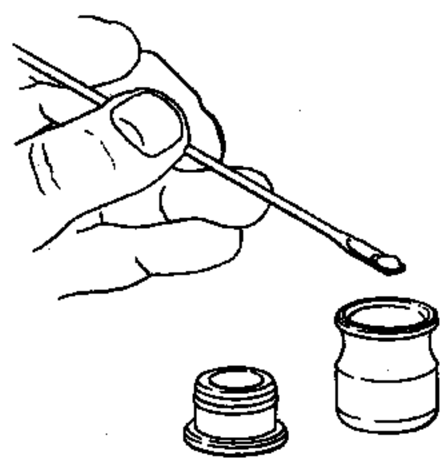

Figure 4-3
Loading a Sample into the Aero-Disperser® Sample Cup

Insert the sample cup into the Aero-Disperser® and tighten the thumbscrew until the o-ring in the top of the sample cup is compressed.

Press **<F7>** to start the measurement.

Completing a Sample Measurement

The sample measurement is complete when the feed percentage displayed in the lower-right corner of the screen reaches 100%, or approximately five (5) minutes.

- Press **<F11>** to complete the sample measurement.
- Press **<F1>** to abort a run.

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CHAPTER 5

Theory of Operation

The Model 3230 Aero-Disperser® is a microprocessor-controlled dry powder dispersing system that provides dispersion of highly cohesive as well as free-flowing powders.

In the instrument, a pulsed jet disperses the sample from the sample cup. The particles are then carried by transport air to the Disperser Pin, where they undergo further size reduction by impaction. Final de-agglomeration is accomplished by passing the aerosol through a high-shear flow field in the annular gap between the Disperser Pin and the profiled Pin-Bowl insert.

The Aero-Disperser® monitors the pressure drop across the annular gap and adjusts the Disperser Pin position to maintain the necessary pressure drop, creating the high-shear flow field. The Aero-Disperser® also monitors the count rates detected by the Model 3225 Aerosizer® DSP and adjusts the strength and duration of the pulsed jet to maintain the sample feed rate needed.

Sample Flow Path

The sample flow path in the Model 3230 Aero-Disperser® is illustrated in Figure 5-1. The compressor and the Disperser Pump inside the Model 3225 Aerosizer® DSP and the vacuum pump generate the various flows through the Aero-Disperser®.

Compressed air from the compressor in the Model 3225 Aerosizer® DSP passes through a valve to create a pulsed jet of air into the sample cup. This pulsed jet fluidizes the sample and lifts some of it out of the sample cup.

Airflow from the Disperser Pump in the Model 3225 Aerosizer® DSP is split into two streams. One is introduced directly above the sample cup as transport air, which carries the sample to the Disperser Pin. The other air stream from the Disperser Pump is introduced directly above the Disperser Pin, where it directs the sample down, toward the high-shear flow field.

The high-shear flow field is controlled by monitoring the differential pressure across the gap between the Disperser Pin and the Pin-Bowl insert. The pin's height is adjusted to maintain the desired pressure drop. The dispersed sample is carried through the tuned-acceleration injection tube and into the Model 3225 Aerosizer® DSP.

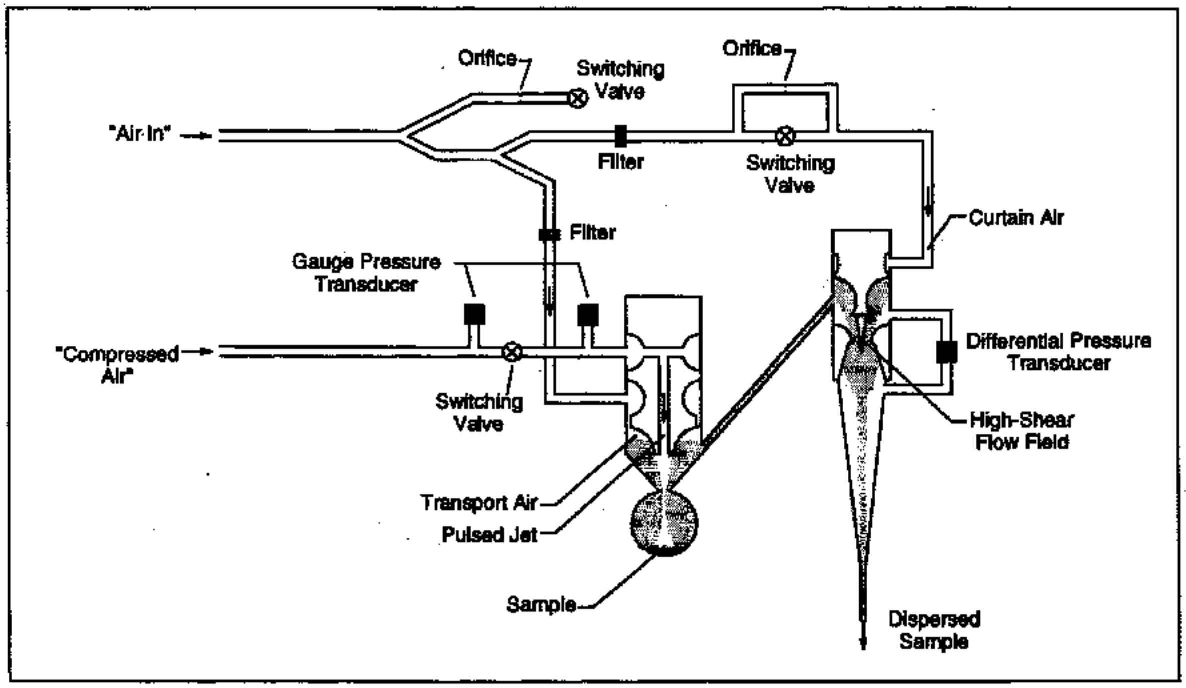

Figure 5-1
Sample Flow through the Model 3230 Aero-Disperser®

The transport air and curtain air streams are filtered before being introduced to the sample aerosol flow. This prevents any contaminants from the Disperser Pump from entering the sample flow.

APPENDIX A

Maintenance

This section provides information about the cleaning and maintenance procedures that are required for the Aero-Disperser® and includes a suggested maintenance schedule.

Maintenance Schedule

The following table contains a schedule of approximate recommended intervals for maintenance. The conditions under which the instrument is used will greatly affect this schedule. Use the schedule as a guideline only.

Table A-1
Maintenance Schedule

Maintenance Operation	**Recommended Maintenance Interval**	**User/ Factory**
Cleaning Disperser Head Components	Between sample runs	User
Cleaning Tuned-Acceleration Injection Tube	Daily/as needed	User
Replace Air Filters	Yearly/as needed	Factory
Replace Fuses	As needed	User

Cleaning the Disperser Head Components

The Disperser Head Components should be cleaned between every sample measurement to prevent cross-contamination of samples.

To clean the Disperser Head's internal components, proceed as follows:

WARNING

Make sure power is switched off and power cord is disconnected.

WARNING

TSI does not recommend the use of any solvents other than isopropyl alcohol. Other solvents, such as acetone and methanol, will have adverse affects on the materials and seals used in this instrument.

1. Switch off the power to the Aero-Disperser®, the Model 3225 Aerosizer® DSP, and the vacuum pump. Unplug the power cord from the Aero-Disperser®.
2. Remove the sample cup from the Aero-Disperser®. Open the sample cup and wipe out the inside of the cup and both sides of the sample cup cover. Blow off both parts with clean compressed gas.
3. Remove the Jet by rotating to align the captivating pins with the slots in the Disperser Head. Pull the Jet straight up. Wipe off the Jet and blow it off with compressed gas. Use the Jet Cleaning Tool to remove any particles from inside the Jet.
4. Unplug the motor assembly from the Aero-Disperser® and remove it by rotating until the captivating plungers align with the slots in the Disperser Head. Lift the motor assembly slowly. Be very careful that the Disperser Pin does not eject from the Disperser Head, as serious injury or damage may result.
5. Remove the Disperser Pin, wipe it off, and blow it clean with compressed gas. Carefully place it in the Disperser Pin Holder to prevent the pin from damage during the rest of the cleaning.
6. Use the extraction tool to remove the Pin-Bowl insert from the Disperser Head. Place the tip of the tool inside the Pin-Bowl insert and rotate the head clockwise to expand the tip. Pull the tool up to extract the Pin-Bowl insert. Wipe off the insert and blow it clean with compressed gas. Make certain that no powder is trapped in the o-ring grooves on the insert.
7. Loosen the four screws holding down the Disperser Head and remove the head. Wipe the inside of the Disperser Head with a cotton swab. Use the pipe brush provided to clean the transport tube (the angled hole from the sample cup area to the Disperser Pin area).

Caution

The Disperser Head is not intended for immersion in any type of solvent and this is not recommended.

8. Pull the Tuned-Acceleration Injection Tube out of the Aero-Disperser® base. Use a pipe brush to clean the inside of the

tube and blow it out with compressed gas. Reinsert the injection tube.

9. As the Aero-Disperser® is reassembled, all the o-rings should be checked to ensure they are present and properly lubricated. There should be a thin coating of lubricant on the o-rings, giving them a shiny appearance, and the parts should fit together easily. To lubricate any o-rings, apply a very small amount of the Super-O-Lube provided with a cotton swab.

10. Place the Pin-Bowl insert back in the Disperser Head. Make certain it is inserted with the correct orientation (o-rings closer to the top). Use the extraction tool to push it down gently until it bottoms out in the Disperser Head.

11. Place the spring on top of the Disperser Head. Place the Disperser Pin on top of the spring, with the tip inside the Disperser Head. Be very careful not to damage the pin.

12. Insert the motor assembly over the Disperser Pin and rotate it so the motor cord faces straight back. Plug the motor cord into the back panel of the Aero-Disperser®.

13. Insert the Jet into the Disperser Head and rotate it 90 degrees to secure it.

14. Reconnect the power cord from the Aero-Disperser® to the Model 3225 Aerosizer® DSP. Turn on the power to the Aerosizer®, the Disperser Pump, and the vacuum pump.

15. From the Main Menu in the Aerosizer® Control Software, press **<F3>**. If the calibration routine does not start automatically, use the arrow keys to move the cursor to "Calibrate:" and press **<Enter>**.

16. When the calibration routine is finished, the instrument is ready for use.

Replacing the Internal Filters

There are two air filters internal to the Aero-Disperser®. The filters should be replaced at least yearly and more frequently if the Aero-Disperser® is used heavily. To change the filters, proceed as follows:

1. Turn off the power to the Aero-Disperser® and unplug it from the Model 3225 Aerosizer® DSP.

2. Unplug the motor from the Aero-Disperser® and set it aside.

3. Remove the screws holding the Aero-Disperser® cover to the baseplate. Carefully remove the cover.
4. The two filters are located on the left-hand side of the instrument, as viewed from the front.
5. Replace one filter at a time to avoid incorrect tubing connections. Slide the silicone tubing off of the filters. Remove the filters from the clips and replace with the new filters.

Caution

Be very careful not to puncture the tubing while replacing the filters. Be certain that the new filters are installed in the correct flow-direction orientation.

6. Replace the Aero-Disperser® cover. Reconnect the power cord from the Aero-Disperser® to the Model 3225 Aerosizer® DSP.

Replacing the Fuses

The Aero-Disperser® Accessory Kit includes two replacement fuses of type ~T2.0A H/250V. To replace the fuses, proceed as follows:

1. Turn off the power to the Aero-Disperser® and remove the power cord from the back panel.
2. Remove the fuse box from the AC power outlet. Remove the old fuses from their clips, put the new ones in their place, and slide the fuse box into its slot until it snaps into place.
3. Plug the Aero-Disperser® back into the Model 3225 Aerosizer® DSP and turn it on.

APPENDIX B

Troubleshooting

This appendix lists potential problems relating to the Aero-Disperser® and their solutions.

Error Messages

The Aerosizer® 3225 Control Software will alert the user to possible problems with the Aero-Disperser®. These error messages are listed below with their typical causes.

The Aero-Disperser is not responding

This message appears when the Aerosizer® 3225 Control Software tries to communicate with the Aero-Disperser® through the serial port and gets no response. Table B-1 gives typical causes and the recommended corrective action.

Table B-1
Typical Causes and Recommended Solutions to Error Message "Aero-Disperser is not responding"

Typical Cause	Recommended Action
Aero-Disperser® is not connected to controller	❑ Check that the RS232 cable is connected properly from Aero-Disperser® to correct serial port on controller
Aero-Disperser® is not turned on	❑ Check that the power cord from the Aero-Disperser® to the Aerosizer® is secure. ❑ Check that the Aero-Disperser® is turned on.
The microprocessor in the Aero-Disperser® has gone out of program	❑ Turn the Aero-Disperser® off and back on with the power switch located next to the power cord. This should reset the microprocessor and cause all the front panel LEDs to illuminate briefly before returning to power-on state.

Min. calibration pressure not reached

During calibration, the Aero-Disperser® moves the Disperser Pin through its range of motion and checks the maximum pressure that is obtained. If this pressure is less than 0.5 psi, this error message will appear. The controlling factors for attaining this pressure are the gap created between the Disperser Pin and the Pin-Bowl insert in the Aero-Disperser®, and the airflow from the Disperser Pump to the Aero-Disperser®. Table B-2 gives typical causes for this condition and the recommended corrective action.

Table B-2
Typical Causes and Recommended Solutions to Error Message "Min. calibration pressure not reached"

Typical Cause	Recommended Action
Aero-Disperser® is assembled incorrectly	❑ Check that the Pin-Bowl insert is inserted in the correct orientation and is fully seated in the Disperser Head. ❑ Ensure that the four screws that hold down the Disperser Head are secure.
Sample Cup is not sealed in place during calibration	❑ Check that the Sample cup is inserted properly and that the thumbscrew is tightened completely to compress the o-ring at the top of the sample cup. ❑ Check the presence and condition of the o-rings in the sample cup.
Disperser Pump not functioning or is connected improperly	❑ The Disperser Pump should turn on at the beginning of the calibration routine. ❑ Check that the Disperser Pump power switch on the front of the Model 3225 Aerosizer® DSP is turned ON.
Missing o-rings or leaks at the base of the Disperser Head	❑ Check for the presence and condition of all the o-rings in the Aero-Disperser®. Replace any that show signs of cracking (spare o-rings are supplied in the Aero-Disperser® Accessory Kit). ❑ Apply o-ring lubricant (supplied) to the five o-rings in the Aero-Disperser® base.
Worn or damaged Disperser Pin or Pin-Bowl insert	❑ Check pin and insert for signs of damage or wear; replace Disperser Pin and/or Pin-Bowl insert

After checking all of these possible causes, from the Main Menu of the software press **<F3>**. If the calibration routine does not start automatically, move the cursor to "Calibrate:" and press **<Enter>** to force a calibration check.

Other Error Conditions

Very large powders do not flow well from the sample cup, or

Very fine powders flow too quickly from the sample cup.

The standard sample cup and cover provided with the Aero-Disperser® are "medium" sized. They work well for most sample materials. However, a shallow cup with a large opening in the cap may assist in dispersing very large particles. Similarly, a deeper cup with a smaller cap will slow down the flow of smaller particles. A supplemental sample cup/cap kit may be obtained from TSI.

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APPENDIX C

Aero-Disperser® Control Options

This appendix describes the Automatic and Manual Control settings for the Aero-Disperser®.

Aero-Disperser® Control Settings

The Aero-Disperser® may be run with Automatic Control, which uses default settings, or with Manual Control, where the user selects equipment settings. For most samples, the automatic settings for the Aero-Disperser® provide the good results. However, for some sample materials, it may be useful to select instrument settings manually.

Automatic Control

The Aero-Disperser® Automatic Control dialog box is shown in Figure C-1.

```
                    Aero-Disperser Auto Control
 Control Mode  :                        AUTO   MANUAL
 Calibrate     :
```

Figure C-1
Aero-Disperser® Automatic Control Dialog Box

AUTO control is the best selection for most sample materials. When it is selected, the software will default to the following settings:

- Shear Force: 0.5 ± 0.1 psi
- Feed Rate: 5000 ± 1000 counts
- Pin Vibration: ON
- Deagglomeration: Normal

These parameters are defined in the Manual Control section that follows.

Manual Control

To switch to Manual Control, move the cursor to MANUAL and press <**Enter**>. The Manual Control dialog box (Figure C-2) will appear.

Aero-Disperser Manual Control		
Shear Force (psi)	:	0.5
Shear Tolerance	:	0.1
Feed Rate (counts)	:	5000
Feed Tolerance	:	1000
Pin Vibration	:	OFF ON
Deagglomeration	:	NORMAL HIGH
Calibrate	:	
Control Mode	:	AUTO MANUAL
Calibration Pos	:	
Max Shear (psi)	:	

Figure C-2
Aero-Disperser® Manual Control Dialog Box

Shear Force and Shear Tolerance

The shear force entered will be the target set point for the pressure drop across the annular orifice gap between the Disperser Pin and the Pin-Bowl insert. The shear tolerance sets the tolerance band for the shear force. If the pressure drop across the orifice gap exceeds the tolerance set, the Aero-Disperser® will move the Disperser Pin up or down to increase or decrease the pressure drop to return it to within the tolerance about the target point.

Feed Rate and Feed Tolerance

Feed Rate determines the target particle count rate that is seen by the Aerosizer®. The Aerosizer® constantly feeds the Aero-Disperser® the current count rate and the Aero-Disperser® will increase or decrease the strength and duration of the jet in order to satisfy the target count rate within the tolerance band set below. **Feed Tolerance** sets the tolerance band for the Feed Rate.

Pin Vibration

When this option is ON (the default setting) the Disperser Pin is dithered slightly up and down to reduce the likelihood of deposition of material on the Disperser Pin in the annular throat region.

Deagglomeration

This selects one of two preset air flow patterns within the Aero-Disperser®. High de-agglomeration will cause the particles to be transported from the fluidized bed to the Disperser Pin at higher velocity, resulting in greater impaction energy on the particles.

Calibration Position

The software uses this block to report the results of the calibration. This value refers to the Disperser Pin's position at the point of maximum shear pressure during the calibration routine.

Max Shear

The value appearing here refers to the maximum shear pressure measured during the Aero-Disperser® calibration routine.

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APPENDIX D

Model 3230 Aero-Disperser® Specifications

The following specifications—which are subject to change—list the most important features of the Model 3230 Aero-Disperser®.

Table D-1
Specifications of the Model 3230 Aero-Disperser®

Dispersion Technique	Microprocessor-controlled pulsed-jet fluidization, impaction, and high-shear flow
Particle Type	Cohesive and free-flowing powders
Particle Size Range	0.2 to 700 µm geometric size
Sample Preparation	None required
Dispersion Time	User-selectable; concurrent with sample measurement time
Flow Rate	Approximate maximum total flow: 14.0 lpm (feedback controlled)
Flow Control	Adjustable critical orifice (choke flow)
Operating Temperature	10 to 35°C (50 to 95°F)
Operating Humidity	10 to 90% RH non-condensing
Power	100-240 VAC, 50-60 Hz, 40 W, single phase
Communications	RS232 (9-pin) port
Dimensions (L x W x H)	360 mm x 290 mm x 205 mm (14.5 in. x 11.5 in. x 8 in.)
Weight	5.5 kg (12 lb.)
Fuse	~T 2.0A H/250V

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TSI

Aerosizer® 3225 Control Software Version 8.X

Instruction Manual

Manual History

The following is a manual history of the Aerosizer® 3225 Control Software Version 8.X (Part Number DOC8053).

Revision	Date
Preliminary	May 1999

This manual was first published in May 1999.

Part Number	DOC8053 / May 1999
Copyright	
Address	TSI Incorporated / Particle Instrument Division—Amherst / 7 Pomeroy Lane / Amherst, MA 01002-2905 / USA
Email Address	amherst@tsi.com
World Wide Web Site	www.aerosizer.com
Fax No.	(413) 253-6966

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3) Seller does not provide any warranty on finished goods manufactured by others. Only the original manufacturer's warranty applies.

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Contents

Chapters

Appendices

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Tables

About This Manual

Purpose

This is an instruction manual for the operation of the Aerosizer® 3225 Control Software Version 8.X.

Related Product Literature

- ***Model 3225 Aerosizer® DSP Manual*** (part number DOC3225 TSI Incorporated)
- ***Model 3230 Aero-Disperser® Manual*** (part number DOC3230 TSI Incorporated)
- ***Model 3276 Calibration Nebulizer™ Manual*** (part number DOC3276 TSI Incorporated)

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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 uses recycled paper.
- This manual has been shipped, along with the instrument, in a reusable carton.

Getting Help

To obtain assistance with this product or to submit suggestions, please contact Particle Instruments/Amherst:

TSI Incorporated
Particle Instruments/Amherst
7 Pomeroy Lane
Amherst, MA 01002-2905 USA
Fax: (413) 253-6960
Telephone: 1-800-335-5577 (USA) or (413) 253-6966
E-mail Address: amherst@tsi.com

Submitting Comments

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

If the comment sheet has already been used, send your comments to:

TSI Incorporated
Particle Instruments/Amherst
7 Pomeroy Lane
Amherst, MA 01002-2905 USA
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E-mail Address: amherst@tsi.com

CHAPTER 1

Introduction

The Aerosizer® 3225 Control Software controls the Model 3225 Aerosizer® DSP sensor and its sample feed devices, and collects and stores the sample data in files. The software is also used to analyze, display, and print the data collected by the Aerosizer® and export the data files for use in other applications.

The Aerosizer® 3225 Control Software is installed in the Aerosizer® Controller, an IBM-compatible computer with two proprietary data acquisition boards. These proprietary boards control the Aerosizer® and sample feed device, and receive discriminated photomultiplier (PMT) signals from the Aerosizer® to generate time-of-flight data. The software then uses the time-of-flight data to calculate a particle size distribution. Output is provided as a graphical display of the size distribution as well as in tabular format. The output may be viewed onscreen and printed on a computer printer.

How This Manual is Organized

This manual describes the Aerosizer® 3225 Control Software and includes information such as:

- Requirements for loading and running the software.
- The installation procedure that loads the program onto the Aerosizer® Controller computer.
- A chapter with general information and instructions for setting up and performing sample measurements.
- A chapter with information about viewing and analyzing the Aerosizer® data.
- A Reference Information chapter that describes all program menus and menu items.
- Appendices that provide reference information not directly associated with program operation.

The Aerosizer® 3225 Control Software is designed to control the Model 3225 Aerosizer® DSP as well as a variety of sample feed devices. The control options available for the sample feed device will vary from one device to another. The Reference Information chapter includes a description of the control dialog box(es) for each sample feed device. For complete instructions, consult the user manual for that device.

The instruments that can be used with the Aerosizer® 3225 Control Software are listed below. Place a (✓) in the box below for each instrument that you use.

- ☐ Model 3225 Aerosizer® DSP
- ☐ Model 3230 Aero-Disperser®
- ☐ Model 3244 Aero-Breather®
- ☐ Model 3240 Aero-Sampler™
- ☐ Model 3242 Aero-Dryer™
- ☐ Model 3276 Calibration Nebulizer™

CHAPTER 2

Installing the Software

The Aerosizer® Controller computer has been shipped with the data acquisition boards and the Aerosizer® 3225 Control Software already installed. Instructions for setting up the computer components are contained in the manuals provided by the computer manufacturer. Instructions for setting up communications connections between the computer and the Aerosizer® and sample feed devices are found in the manuals for those instruments.

When the Aerosizer® Controller computer is booted up, it should enter directly into the Aerosizer® 3225 Control Software.

Caution

The Aerosizer® Controller computer may be used for other computing jobs when the Aerosizer® is not in use, but caution should be exercised if other plug-in boards are used, as conflicts may occur.

The following information is provided in the event that the software must be re-installed on the Aerosizer® Controller computer, or a software upgrade is installed on an existing system. If the software is being installed on a computer not provided by TSI, see the sections "Installation Requirements" and "Data Acquisition Board Installation" at the end of this chapter.

Installing the Aerosizer® 3225 Control Software

For Computers Using Windows 95 or 98

1. Exit Windows 95 or 98 to an MS/DOS prompt in the root drive (C:\).
2. If installing the Aerosizer® 3225 Control Software on a computer with a previous version of Aerosizer® software, skip to step 10.

3. At the prompt, type:

```
ATTRIB -S -R -H MSDOS.SYS
```

where S = system
R = read
H = hidden

4. Edit **MSDOS.sys** by typing

```
EDIT C:\MSDOS.SYS
```

5. Look for BootGUI value under the "options" section. It should be equal to one (1). Change the value to zero (0).
6. Exit and save file.
7. Restore old attributes to **MSDOS.sys** by typing:

```
ATTRIB +S +R +H MSDOS.SYS
```

8. Edit the **CONFIG.sys** file by typing:

```
EDIT C:\CONFIG.SYS
```

9. Add the following command after the last line:

```
DEVICE=C:\WINDOWS\COMMAND\ANSI.SYS
```

10. Edit **AUTOEXEC.bat** file by typing:

```
EDIT C:\AUTOEXEC.BAT
```

11. Add the following commands after the last line:

```
VALVEOFF.EXE
C:\WINDOWS\SMRTDRV.EXE/X 512 128 C+
CD\TSI
CLS
AERO_DSP
```

(If installing on a computer with a previous version of Aerosizer® software, change the last lines of **AUTOEXEC.bat** to those shown above.)

12. Exit and save file.
13. Insert the software installation disk and type:

```
A:INSTALL
```

to install Aero_dsp software on the hard disk.

14. After installation is completed, copy the **valveoff.exe** file to the root directory by typing at the c:\tsi prompt:

```
COPY VALVEOFF.EXE C:\
```

15. Remove the software installation disk and reboot.

Note: *The Aerosizer® 3225 Control Software* ***must*** *be run in DOS. It is* ***not*** *possible to collect data when running the software from a DOS prompt within Windows.*

Data Acquisition Board Installation Requirements

To use the Aerosizer® 3225 Control Software, TSI recommends using the supplied Aerosizer® Controller computer with the software and data acquisition boards already installed. To install the data acquisition boards and software on another computer system, a 100% IBM-compatible computer with the following features, components, and software is required:

- A Pentium processor
- A SVGA color monitor
- Microsoft Windows 3.X, Windows 95 or 98

Caution

The Aerosizer® 3225 Control Software cannot run on computers with Windows NT-based operating systems.

- DOS X.X or higher
- A hard drive large enough to accommodate Windows, the Aerosizer® 3225 Control Software, and data files

  Note: *The amount of disk space required depends on the number of samples you collect, the amount of information collected, and the sampling period. After you have collected a number of samples, you may want to look at the file size to estimate how much storage space you will be using. It is possible to fill a large disk drive (500 MB) in a relatively short time!*
- A 3.5-inch floppy disk drive
- 16 MB or more of random access memory (RAM)
- A keyboard
- An RS-232 serial interface port for each instrument connected (in addition to the one that may be required for a mouse)
- A printer interface port and a Microsoft-Windows compatible printer are optional.
- Two (2) full length ISA slots.

Installing the Data Acquisition Boards

The proprietary data acquisition boards use the following locations:

- I/O Locations: 300 – 311
  340 – 34E
- Memory Locations: D0000 – D07FF
  D4000 – D47FF
- Interrupt: IRQ 5

CHAPTER 3

Setting Up and Performing Sample Measurements

This chapter explains the options that must be selected by the user before performing a sample measurement with the Model 3225 Aerosizer® DSP. This is completed in two steps--the System Setup Screen, and the Sample Feed Device Control dialog box on the Main Menu.

When the software is finished loading, the Main Menu will appear onscreen.

The System Setup Screen

The System Setup screen allows the user to set parameters for the Aerosizer® and select the sample feed device used. To access the Setup Screen from the Main Menu, press **<Ctl S>**. The following screen will appear (Figure 3-1):

```
COMMAND

F1     Return to Main Menu
F2     Graphics Mode             IBM   EPSON   HPLJ   DeskJet C
F3     Disperser Port            COM1  COM2  COM3  COM4
F4     Aerosizer Port            COM1  COM2  COM3  COM4
F5     External Control Port     COM1  COM2  COM3  COM4



F10    Sample Presentation       Cal. Neb.   Sampler   Breather   Disperser





Alt F6   AutoSave during run?    NO    YES
Alt F7   Overwrite Scans?        NO    YES
Alt F8   Log Plot Resolution?    Low    High
```

Figure 3-1
System Setup Screen

From the System Setup Screen, select the Sample Presentation Device in F10. In addition, "AutoSave during run?" and "Overwrite Scans?" should both be set to NO. The options available for each parameter on the System Setup Screen are described in detail in Chapter 5.

The Main Menu

The function keys involved in setting up sample measurements are F2, F3, F4, F9, and F10. Of these, F3 and F10 settings are determined by the sample feed device being used. The F7 key begins the sample measurement.

The manual for the sample feed device in use should be consulted when setting up and performing measurements.

```
        COMMAND
                                              User-entered details to be
  F2    Sample Details                        stored with the run appear
                                              in these three lines

  F3    Sample Presentation
  F4    Sample Density
  F5    Combine/Range Settings
  F6    Display Type
  F7    Measure Sample
  F8    Automatic Print     ON    OFF
  F9    Save Options        ON    OFF
  F10   Program Measurements
  F11   Display Run(s)
  F12   Print Run(s)
```

Figure 3-2
Main Menu

F2—Sample Details

Enter any information you wish to have stored with the sample data, then press **<Esc>** or press another function key to proceed directly to another menu option.

F3—Sample Presentation

This command allows the user to select any settings necessary for the sample feed device selected in F3 of the System Setup screen. The dialog box that appears and the necessary settings will vary with each sample feed device. Refer to the user manual for that instrument for instructions and recommended settings.

F4—Sample Density

Select the sample material and its density from the sample density list (shown in Figure 3-3) by using the <↑> and <↓> keys to highlight the desired item and pressing **<Enter>**. If the material you are using is not on the list, you may add it at this time.

Sample Density	
Iron	7.86 gms/cc
Lead	11.34 gms/cc
Magnesium	1.74 gms/cc
Maleic Anhydride	1.10 gms/cc
Manganese	7.42 gms/cc
Molybdenum	9.01 gms/cc
Nickel	8.70 gms/cc
Osmium	22.50 gms/cc
Palladium	12.16 gms/cc
Glass Microspheres	2.45 gms/cc

Figure 3-3
Sample Density Dialog Box

F5—Combine/Range Settings

The Combine/Range Settings dialog box is shown in Figure 3-4. Select the measurement and display ranges that best represent the sample to be measured.

Combine			
Combine	:	OFF	AUTO
Measurement Range	:	Standard	Large
Display Range	:	0.1-200um	0.5-700um

Figure 3-4
Combine/Range Settings Dialog Box

F9—Save Options

Check to see that the "Data File SubDir" is set to the subdirectory where you want to store the sample data. If it is not, move the cursor to that line and press **<Enter>**. Select the desired subdirectory from the list by moving the cursor to that line and pressing **<Enter>**, or add a new directory to the list (see Chapter 5 for detailed instructions).

F10—Program Measurements

The Aerosizer® 3225 Control Software may be set up to perform a preset number of measurements, each lasting for a fixed period of time, with a preset waiting time between each measurement.

To set up the instrument to make a preset measurement or series of measurements, press **<F10>**.

The following dialog box will appear (Figure 3-5):

```
                 Program Measurements
 Multiple Runs                      :  MANUAL   PROGRAM
 Number of Runs                     :                1
 Nominal Run Length  (sec)          :      30
 Run Spacing         (sec)          :       0
 External Control                   :  OFF  ON
```

Figure 3-5
Program Measurements Dialog Box

A series of runs may be programmed with varying run lengths and spacing. Details for this procedure are found in Chapter 5 of this manual.

In general, MANUAL program mode is used with the Aero-Disperser® and Calibration Nebulizer™, and PROGRAM mode is used with the Aero-Sampler™ and Aero-Breather®.

CHAPTER 4

Viewing and Analyzing Data

This chapter describes the options for viewing and understanding the data collected by the Model 3225 Aerosizer® DSP. The Aerosizer® 3225 Control Software offers a variety of viewing options for the onscreen display and printed reports.

Screen Display

As a sample measurement progresses and after it is completed, the results are displayed onscreen as a graph. Other information about the run is also displayed onscreen.

During Sample Measurement

During sample measurement, the results are displayed on the computer screen as a distribution, similar to the screen shown in Figure 4-1. Each feature is numbered and described on the following page.

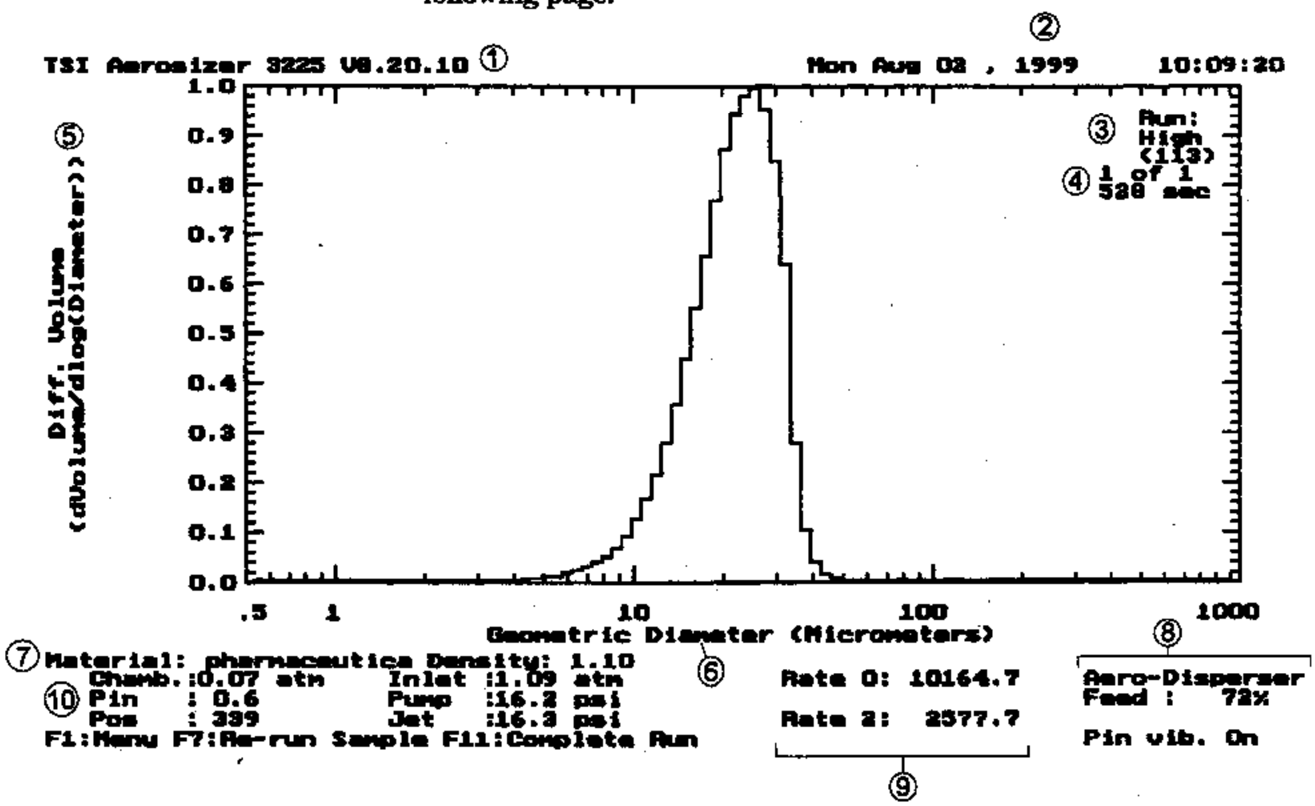


Figure 4-1
Screen Display During Sample Measurement

Each feature of the screen display is numbered and described below.

1. Software version used to analyze the sample
2. Date and time the data was acquired
3. Sample run number. During data collection, either the high-sensitivity or low-sensitivity data will be shown onscreen (not combined). The corresponding run number will be displayed in this location, along with the sensitivity level.
4. Programmed run information. The first line indicates what run in the current series of runs is currently being measured. The second line indicates, for programmed runs, how much time *remains* for the current run. For manual runs, the time shown indicates the *duration* of the current run.
5. The distribution type. Data may be displayed on the vertical axis by number, surface area, volume, or time-of-flight.
6. Diameter type. Data can be displayed as a function of geometric or aerodynamic diameter.
7. The sample material and density.
8. Feed rate information. "Aero-Disperser Feed" indicates the percentage of total possible flow from the Pulsed Jet (100% indicates a constant flow from the Jet). "Pin vib." reports whether the Disperser Pin vibration is set to ON or OFF.
9. Count rate information. If the user presses **<C>** during a sample measurement, "Rate 0" and "Rate 2" will indicate the high-sensitivity detection rate (in particles per second) for the start and stop laser beams, respectively. "Rate 1" and "Rate 3" will indicate the low-sensitivity detection rate for each beam.
10. Aero-Disperser® diagnostic information. If the user presses **<P>** during a sample measurement using the Aero-Disperser®, the following information is displayed:

    Chamb. : sample chamber pressure, atmospheres

    Pin : pressure drop across the Disperser Pin gap, psi.

    Pos. : the position of the Disperser Pin

    Inlet : the pressure at the Aerosizer® inlet, atmospheres

    Pump : the compressor pump pressure, psi

    Jet : the Pulsed Jet pressure, psi.

Completed Sample Measurement

When sample measurement is complete, the results are displayed onscreen as shown in Figure 4-2. Features not described in the previous section are numbered and described below.

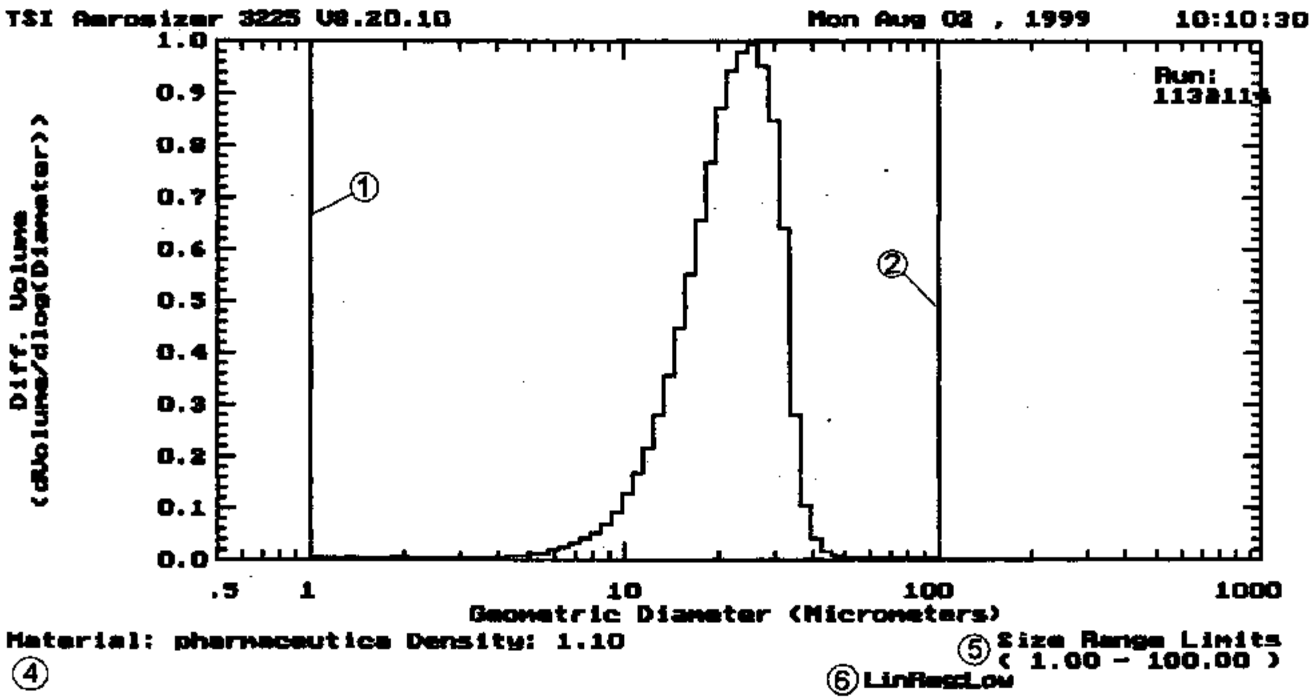


Figure 4-2
Screen Display of Sample Measurement Results

1. The lower size limit used in statistical calculations. This appears onscreen as a red line in both linear and logarithmic displays. (It may only be moved on the linear display.)
2. The upper size limit used in statistical calculations. This appears onscreen as a gray line in both linear and logarithmic displays. (It may only be moved on the linear display.)
3. (Not shown) The cursor is only visible in the linear display mode. It appears as a short, vertical line.
4. In linear display mode, the cursor location is given in micrometers at this location.
5. The size range used in statistical calculations is given in micrometers.

6. Analysis Configuration settings (Linear Regulation and Gaussian Extension) for the current run are displayed here. If more than one run is displayed, you may toggle from run to run using the spacebar.

In addition to the features described above, along the bottom of the screen is a menu of available function keys. These keys and their function are described further in Table 4-1.

Table 4-1
Active Function Keys During Data Display

Key	Label	Action
F1	Menu	Returns to Main Menu
F5	Low Size	Sets lower size limit to cursor position
F6	High Size	Sets upper size limit to cursor position
F7	Run	Starts a new run or continues current run
F8	Print	Prints selected graph and tables to printer
F9	Info	Displays Run Information table onscreen
F10	Listing	Displays Size Distribution table onscreen
F12	Export	Exports selected Run Information and Size Distribution tables to a spreadsheet file. File is named "run-xxx.prn" (where xxx is the run number) and is stored in directory c:\tsi.

The results from previously saved runs may be displayed at any time. If multiple runs are displayed, each distribution will be shown in a different color, identified by the color of the run-number label in the upper-right corner.

Display Types

A variety of display types may be used to view and analyze the sample data collected by the Aerosizer® DSP. These options are described below.

Display Range

The user may select a display range of either 0.1 to 200 microns or 0.5 to 1000 microns. This setting will not affect the size range of the data collection.

Plot Scale

The sample data collected may be plotted on either a logarithmic or linear scale.

Logarithmic Scale

A logarithmic plot will display all of the data from 0.1 to 200 microns, or from 0.5 to 1000 microns, depending on the range selected. Upper and lower limits and zooms (both horizontal and vertical) may not be implemented in logarithmic scale.

Linear Scale

A linear plot will display the data in a window with a width from 2 microns up to the full display range. When linear scale is selected, the user may change the upper or lower limits for statistical calculations, and may zoom both horizontally and vertically.

Plot Mode

The user may choose from three plot modes, depending on the type of information sought.

Histogram

This setting will plot a histogram of the particle distribution by whatever distribution type and diameter type is selected.

Cumulative Under

This setting will plot the distribution as the percentage of particles detected that were smaller than the corresponding size on the x-axis.

Cumulative Over

This setting will plot the distribution as the percentage of particles detected that were larger than the corresponding size on the x-axis.

Distribution Type

The raw data collected by the Aerosizer® DSP is a time-of-flight distribution. The Aerosizer® 3225 Control Software can display this distribution or three types of particle size distributions. Each is calculated directly from the time-of-flight data and assumes the particles have a spherical shape.

The time-of-flight data is collected in 2048 linearly spaced time channels. The Aerosizer® 3225 Control Software converts this data into size and places it in 500 logarithmically spaced size bins.

Time-of-Flight Distribution

This distribution displays the raw data collected by the Aerosizer®.

Number Distribution

This distribution displays the relative number of particles detected in each size bin. The display is normalized to the size bin with the highest number of particles (or, counts) detected.

Surface Area Distribution

This distribution displays the relative total surface area for the particles detected in each size bin. The display is normalized to the bin with the highest total surface area.

Since one particle of 100 microns diameter has the same surface area as 10,000 particles of 1micron diameter, this distribution will emphasize the large particles more than a Number Distribution.

Volume Distribution

This distribution displays the relative total volume of particles detected in each size bin. The display is normalized to the bin with the highest total volume.

Since one particle of 100 microns diameter has the same volume as 1,000,000 particles of 1micron diameter, this distribution will emphasize the large particles even more than a Surface Area Distribution.

Diameter Type

The Aerosizer® 3225 Control Software converts the time-of-flight distribution collected by the instrument into a size distribution by diameter. In order to do this, the Aerosizer® 3225 Control Software assumes that the sample particles detected are spherical. It then forms a size distribution based on either geometric diameter or aerodynamic diameter.

Geometric Diameter

The geometric diameter reported by the Aerosizer® 3225 Control Software is the equivalent spherical diameter (as measured physically by either manual or optical means) of a particle with the *same* density and time-of-flight as the measured particle.

Aerodynamic Diameter

The aerodynamic diameter reported by the software is the equivalent spherical diameter of a particle of *unit* density that would settle at the same velocity (in free air at Standard Temperature and Pressure) as the particle measured by the Aerosizer®.

Normalization

When viewing results (on the screen or in a printout) from more than one sample run, the user may wish to select individual or group normalization.

Individual Normalization

This setting will normalize the highest channel in each distribution to 1.0 and scale the rest of each distribution accordingly. This is useful when comparing results between sample runs where the comparative number of particles detected in each run is not important.

Group Normalization

This setting will compare the highest channel in each distribution and normalize only the one with the highest value to 1.0. The rest of the distributions will be scaled accordingly. This is useful when comparing sample runs where the comparative number of particles detected in each run is of interest.

Regularization

Regularization provides a mathematical stabilization for the conversion of time-of-flight to particle size. Data may be viewed at three different regularization levels.

Regularization Off

This setting applies no regularization to the data and is generally used only for monodisperse samples or calibration standards.

Low Regularization

This setting will apply a moderate amount of regularization to the data and is used most of the time for slightly broad or unknown samples.

High Regularization

This setting applies a maximum amount of regularization and should be used for very broad distributions whose volume distributions appear "chopped" on the right hand side.

Gaussian Extension

The Gaussian Extension tool provides a mathematical stabilization when viewing a volume distribution for large particles. It does this by fitting the number distribution into a log-normal (gaussian, or bell-shaped on a logarithmic scale) curve, which will maintain its log-normal shape when converted to a volume distribution.

Display Manipulation

The display type may be changed by using the **F6** Display Type dialog box from the Main Menu. It may also be changed while viewing data onscreen by using shortcut keys. In addition, when viewing data on a linear scale, the user may change upper and lower limits and zoom in on data.

The F6 Display Type Dialog Box

The Display Type dialog box is shown in Figure 4-3. It is accessed by pressing **<F6>** from the Main Menu. These settings may be selected before starting a sample run or before viewing data from a previous sample run or runs. The current options are highlighted with a bar. To change the settings, use the <↑> and <↓> keys to scroll between options, and use the <←> and <→> keys to navigate between display characteristics.

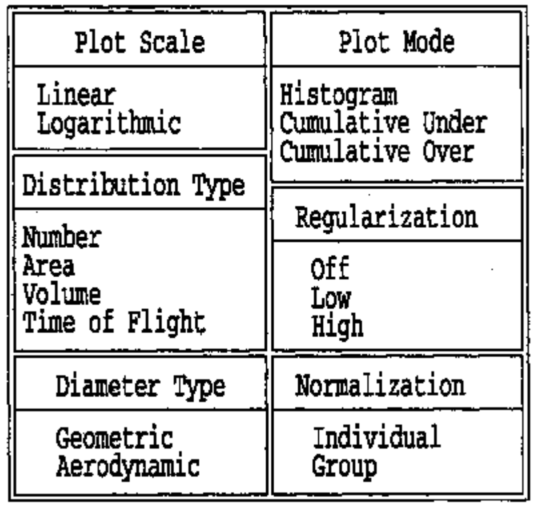


Figure 4-3
Display Type Dialog Box

Shortcut Keys

When viewing data onscreen, a number of shortcut keys may be used to change the display type. Some of these are not available while the sample is being taken. The shortcut keys are identified in Table 4-2.

Note: *The shortcut keys are case-sensitive. Be sure to use upper or lower-case letters as indicated.*

Table 4-2
Display Type Shortcut Keys

Key	Action
l	Toggles between linear and logarithmic scale
N	Displays Number distribution
S	Displays Surface Area distribution
V	Displays Volume distribution
T	Displays Time-of-Flight distribution
A	Toggles between Aerodynamic and Geometric Diameter
D	Displays Histogram distribution
>	Displays Cumulative Over plot
<	Displays Cumulative Under plot
I	Displays multiple runs with Individual normalization
G	Displays multiple runs with Group normalization
E	Toggles Gaussian Extension on and off
F	Regularization off
M	Applies Low regularization
C	Applies High regularization
R	Toggles display range between 0.1-200 microns and 0.5-1000 microns
B	During data collection, displays both high and low sensitivity data, alternately
C	During data collection, displays counts detected by high and low sensitivity sensors on each PMT
P	During data collection, displays Aero-Disperser® diagnostics: chamber pressure, inlet pressure, compressor pump pressure, pulsed jet pressure, pressure drop across Disperser Pin gap, Disperser Pin position

Zooming and Panning

When viewing a distribution graph in *linear* scale, you may use the arrow keys to zoom in or out of any portion of the graph.

Note: *When zooming in and out, the software will center the new display on the cursor's current position. Therefore, you should place the cursor on the portion of the graph that is of most interest to you.*

Table 4-3
Panning and Zooming Commands

Key(s)	Action
↑	Zooms in on the next finer horizontal display range. Smallest possible displayed range is 2.0 micrometers.
↓	Zooms out to the next coarser horizontal display range. Largest possible displayed range is 200 or 1000 micrometers (depending on range selected).
Shift →	Pans the display region to the right by ½ of the currently visible range (e.g. changes from 0-10 micrometers to 5-15 micrometers).
Shift ←	Pans the display region to the left by ½ of the currently visible range (e.g. changes from 10-20 micrometers to 5-15 micrometers).
Shift ↑	Zooms in on the next more sensitive display height (e.g. changes from 0-1.0 height to 0-0.5 height).
Shift ↓	Zooms out to the next less sensitive display height (e.g. changes from 0-0.5 height to 0-1.0 height).

The Cursor

The cursor is active when viewing data on a linear scale. It is used to select the portion of a graph for zooming. It is also used to change the upper and lower size limits used in calculations. The cursor's position is reported on the bottom of the computer screen. The following keys are used to move the cursor.

Table 4-4
Cursor Control Keys

Key	Action
←	Moves cursor to the left.
→	Moves cursor to the right.
Home	Moves cursor to the left end of the graph. If you press this key twice, the region of the graph shown will start at 0 micrometers.
End	Moves the cursor to the right end of the graph. If you press this key twice, the region of the graph shown will end at 200 or 1000 micrometers (depending on display range selected).

The cursor will move along the current distribution curve. When multiple runs are shown onscreen, you may move the cursor to another distribution curve by pressing the spacebar.

Upper and Lower Size Limits

The upper and lower size limits may be used to isolate specific regions of the distribution for analysis. Only data within these limits will be used in statistical calculations, such as mean diameter, or will appear in the particle size distribution tables. The number of particles in all size bins outside these limits will be set to zero.

If they are within the current display range on a linear graph, the upper and lower size limits are shown on the graph as vertical lines, red and gray, respectively. To move or set the upper and lower size limits, move the cursor to the desired limit position and press **<F5>** to set the lower limit or **<F6>** to set the upper limit. The limit lines will appear in the new limit locations.

Printed Reports

The Aerosizer® 3225 Control Software allows the user to print sample measurement results in a variety of formats and levels of detail. The report may include the graph, the run information, and/or the particle size table. A sample of a printed report is shown in Figure 4-4. The report shown includes the graph, the Long Info Format, and the Short Table Format (of type Size). Its features are numbered and described below.

1. The contents of file "header.tsi" print here. The user may create this text file in a word processing program and store it in the directory c:\tsi. This information will appear at the top of every report printed with a graph.
2. The software version used for the analysis.
3. The date and time the data was acquired.
4. The distribution type (number, surface area, volume, or time-of-flight).
5. The size distribution graph. The graph will be printed in the same display mode and zoom scale used onscreen.
6. The data file location (disk drive and subdirectory), run number, and date and time the run was taken.
7. Distribution type and diameter type displayed.
8. Sample details entered by the user in **F2** of the Main Menu.
9. Aerosizer® parameters used for the sample measurement.

10. Sample feed device control settings for the sample measurement. This section appears only when Info Format is set to LONG in the **F12** Display Runs dialog box.

11. Statistical summary showing the diameters at which a given percentage of the sample is measured to be smaller in size than the indicated diameter. The default table shows increments of 5%. This table may be customized by entering the percentages of interest in a text file named "percent.tsi" and located in the directory c:\tsi.

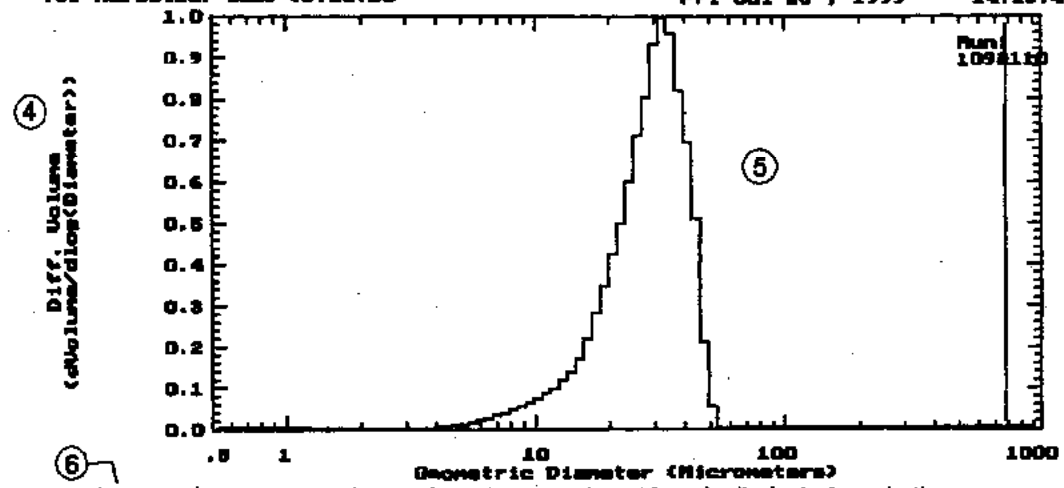
12. Statistical calculations: geometric mean diameter, geometric standard deviation, D(4,3) (DeBroukere or volume-weighted mean diameter), D(3,2) (Sauter or surface-weighted mean diameter), distribution mode, and specific surface area.

13. Size distribution table. The default table displays data in 50 or 165 logarithmically-spaced size intervals (short or long table formats, respectively). This table may be customized by entering the diameters of interest in a text file named "custom.tsi" and located in the directory c:\tsi. Then select "CUSTOM" table type in the **F12** Print Runs dialog box.

Note: *Items 1-5 appear only when the graph is printed. Items 6-8 comprise the "ID Only" Info Format. Items 6-9, 11 and 12 comprise the "Short" Info Format. Items 6-12 comprise the "Long" Info Format.*

TSI APPLICATION LAB DSP UNIT #4 (1)

TSI Aerosizer 3225 V8.20.10 (2) (3) Fri Jul 23 , 1999 14:16:47



(6) Directory: c:\test Run 109 taken on Fri Jul 23 14:16:47 1999 Volume Distribution by Geometric Diameter (7)
micronized pharmaceutical (8) Regularization: Low

(9) PARAMETERS		(10) DISPERSER CONTROL		(11) %UNDER	SIZE	%UNDER	SIZE
Material	: pharmaceutical	Disperser Type :	AeroDisperser	5%	11.69	55%	30.90
Density	: 1.10	Shear Force :	Low	10%	15.73	60%	32.14
Run Length (sec)	: 593.7	Feed rate :	High	15%	18.40	65%	33.39
Laser Current (mA)	: 43.0			20%	20.51	70%	34.74
Sum of channels	: 439740	Deagglomeration :	Normal	25%	22.35	75%	36.16
Lower Size Limit	: 0.50	Pin Vibration :	On	30%	24.01	80%	37.77
Upper Size Limit	: 770.00			35%	25.52	85%	39.64
				40%	26.93	90%	41.85
				45%	28.31	95%	44.54
		SCANS 109 AND 110 COMBINED		50%	29.63		
		BETWEEN 15.1 & 15.4 MICRONS					
(12) Mean Size	: 27.06	D(4,3) :	29.10	Mode (Log Scale) :	32.36		
Standard Deviation	: 1.517	D(3,2) :	24.33	Spec surf area:	0.224 sq meter/g		

(13)

UPPER SIZE	% IN	LOWER SIZE	% UNDER	UPPER SIZE	% IN	LOWER SIZE	% UNDER	UPPER SIZE	% IN	LOWER SIZE	% UNDER	UPPER SIZE	% IN	LOWER SIZE	% UNDER
				501	0.0000	431	100.00	50.1	6.9336	43.1	92.527	5.01	0.1445	4.31	0.1491
				431	0.0000	371	100.00	43.1	14.562	37.1	77.966	4.31	0.0736	3.71	0.0756
				371	0.0000	316	100.00	37.1	20.258	31.6	57.708	3.71	0.0373	3.16	0.0383
				316	0.0000	271	100.00	31.6	17.222	27.1	40.486	3.16	0.0174	2.71	0.0209
				271	0.0000	231	100.00	27.1	13.393	23.1	27.093	2.71	0.0094	2.31	0.0115
				231	0.0000	200	100.00	23.1	8.2684	20.0	18.824	2.31	0.0047	2.00	0.0068
				200	0.0000	170	100.00	20.0	6.6083	17.0	12.716	2.00	0.0033	1.70	0.0036
				170	0.0000	145	100.00	17.0	3.9067	14.5	8.3094	1.70	0.0018	1.45	0.0017
				145	0.0000	125	100.00	14.5	2.4129	12.5	5.8965	1.45	0.0010	1.25	0.0008
				125	0.0000	110	100.00	12.5	1.5624	11.0	4.3340	1.25	0.0004	1.10	0.0003
				110	0.0000	90.2	100.00	11.0	1.7784	9.02	2.5556	1.10	0.0003	0.90	0.0001
				90.2	0.0000	80.2	100.00	9.02	0.7623	8.02	1.7933	0.90	0.0000	0.80	0.0000
				80.2	0.0000	70.2	100.00	8.02	0.6494	7.02	1.1439	0.80	0.0000	0.70	0.0000
702	0.0000	601	100.00	70.2	0.0000	60.1	100.00	7.02	0.5057	6.01	0.6382	0.70	0.0000	0.60	0.0000
601	0.0000	501	100.00	60.1	0.5394	50.1	99.461	6.01	0.3446	5.01	0.2936	0.60	0.0000	0.50	0.0000

Figure 4-4
Printed Aerosizer® Sample Measurement Report

A printed report may be generated in three ways.

- If Automatic Print is set to ON in the Main Menu, a report will automatically print at the conclusion of the sample measurement.
- When viewing sample run data onscreen, the user may press **<F8>** to print a report. This will always include the graph as shown onscreen.
- From the Main Menu, the user may press **<F12>** to open the Print Runs dialog box and select the desired report format.

The report format selected in the **F12** Print Runs dialog box will determine the format for reports printed by any of these methods. These format options are described in detail in Chapter 5.

If more than one sample measurement run is selected to print, the printer will give a complete, separate graph and report for each run. If viewing an overlaid graph showing more than one run, the **<Print Screen>** key may be used to obtain a printed copy of that view.

Exporting Data

The Aerosizer® 3225 Control Software allows the user to export data for spreadsheet analysis. The information contained in the Run Info and Size tables selected in the **F12** Print Runs dialog box may also be exported to a file with a comma-separated values (CSV) format. This file format is easily viewed in all major spreadsheet programs.

A data export file may be created in three ways.

- Set Automatic Export to ON in the **F9** Save Options dialog box. At the end of each sample measurement, the software will create a file with the name DDHHMMSS.prn, where DD is the day of the month and HHMMSS is the time of day the sample measurement was run. The file will be stored in the same subdirectory as the raw data.
- While the sample measurement results are being viewed onscreen, press **<F12>**. The software will create a file named RUN-XXX.prn, where XXX is the run number. The file will be stored in the directory c:\tsi.

- From the Main Menu, press **<F12>** to open the Print Runs dialog box. Move the cursor to "Spreadsheet Export" and enter the run number. The software will by default create a file named RUNXXX.prn, where XXX is the three-digit run number of the run being exported. The file will be stored in the directory c:\tsi. To change the basename from the default (RUN), see instructions in Chapter 5.

CHAPTER 5

Reference Information

This chapter explains the menus displayed by the Aerosizer® 3225 Control Software and the options that can be selected or set from each.

The Aerosizer® 3225 Control Software menus control the operating parameters of the Aerosizer® and its sample feed devices, the way data is analyzed and displayed, and the way data is stored or exported.

When the software is finished loading, the Main Menu will appear onscreen.

System Setup Screen Options

The System Setup screen allows the user to set parameters for the Aerosizer® and select the sample feed device used. To access the Setup Screen from the Main Menu, press **<Ctl S>**. The following screen will appear (Figure 5-1):

```
COMMAND

F1      Return to Main Menu
F2      Graphics Mode             IBM   EPSON   HPLJ  DeskJet C
F3      Disperser Port            COM1  COM2  COM3  COM4
F4      Aerosizer Port            COM1  COM2  COM3  COM4
F5      External Control Port     COM1  COM2  COM3  COM4



F10     Sample Presentation       Cal. Neb.   Sampler   Breather    Disperser




Alt F6   AutoSave during run?   NO    YES
Alt F7   Overwrite Scans?       NO    YES
Alt F8   Log Plot Resolution?   Low     High
```

Figure 5-1
System Setup Screen

The various System Setup options are described below. To change any of the settings, press the function key corresponding to that option and use the arrow keys to highlight the desired setting, or type in the desired setting and press **<Enter>**. When all parameters have been set to the desired settings, press **<F1>** to return to the Main Menu.

F1—Return to Main Menu

Pressing **<F1>** will return the software to the Main Menu.

F2—Graphics Mode

The data gathered from the Aerosizer® can be printed on an IBM or Epson® dot matrix printer, a LaserJet printer, or the HP DeskJet C color printer. Select the printer type connected to the computer.

F3—Disperser Port

This setting assigns the computer serial port for the Aero-Disperser® when it is in use. The recommended port is COM1.

F4—Aerosizer Port

This setting assigns the computer serial port for the Aerosizer®. The recommended port is COM2.

F5—External Control Port

This setting assigns the computer serial port for the External Control option when it is used. The recommended port is COM3.

F10—Sample Presentation

The sample feed device is selected here. This tells the software to request the required operating parameters for that instrument in the **F3** dialog box from the Main Menu and provide the proper control outputs. Select the sample feed device in use.

Alt F6—AutoSave during run?

This option instructs the Aerosizer® 3225 Control Software to periodically save the data being gathered during the sample measurement. This can protect against lost data should an unexpected termination of the program occur. However, AutoSave during the sample run will interrupt data acquisition during the sample run, resulting in lower data acquisition times. For that reason, this option is normally set to NO.

Alt F7—Overwrite Scans?

When Overwrite Scans is set to YES, the user will be allowed to overwrite previously stored data sets. This setting always defaults to NO on system startup to safeguard against overwriting data.

Alt F8—Log Plot Resolution?

The resolution of logarithmic data plots may be set to Low (100 size bins) or High (500 size bins). High resolution should only be selected when a very narrow distribution is expected, such as when running calibration standards. This should normally be set to Low.

The Main Menu

The various functions on the Main Menu allow the user to set operating parameters for the sample feed device and the software analysis. The Main Menu is shown in Figure 5-2 below.

```
      COMMAND
                                                User-entered details to be
F2    Sample Details                            stored with the run appear
                                                in these three lines

F3    Sample Presentation
F4    Sample Density
F5    Combine/Range Settings
F6    Display Type
F7    Measure Sample
F8    Automatic Print    ON    OFF
F9    Save Options       ON    OFF
F10   Program Measurements
F11   Display Run(s)
F12   Print Run(s)
```

Figure 5-2
Main Menu

To access each option, press the function key specified. In most cases, a dialog box will appear. The current selection for each option will be highlighted. Use the arrow keys to highlight the desired selection, or to highlight the line where required information is to be entered.

The options available in each box are described below.

F2—Sample Details

This area, in the upper right corner of the Main Menu screen, allows the user to enter up to three lines of information to be stored with the sample data. The first line of this entry will be displayed in the run list, so any identifying information should appear in the first line.

The Sample Details block does not behave as a word processor. It does not "word wrap." If you press **<Enter>** while in the Sample Details block, it will erase everything in that line after the cursor position. If you insert characters into a line, any characters "pushed off" the end of the line will be lost.

After entering the desired information in the Sample Details block, you may press **<Esc>** or press another function key to proceed directly to another menu option.

F3—Sample Presentation

This command allows the user to select any settings necessary for the sample feed device selected in **F3** of the System Setup screen. The dialog box that appears and the necessary settings will vary with each sample feed device. The following pages contain a description of this dialog box for each sample feed device.

Aero-Disperser®

The Sample Presentation dialog box for automatic control of the Aero-Disperser® is shown in Figure 5-3.

Aero-Disperser Auto Control		
Control Mode	:	AUTO MANUAL
Calibrate	:	

Figure 5-3
Aero-Disperser® Automatic Control Dialog Box

If AUTO control is selected, the following settings are used:

- Shear Force: 0.5 ± 0.1 psi
- Feed Rate: 5000 ± 1000 counts
- Pin Vibration: ON
- Deagglomeration: Normal

If MANUAL control is selected, the dialog box will appear as shown in Figure 5-4. Its options are described below.

Aero-Disperser Manual Control		
Shear Force (psi)	:	0.5
Shear Tolerance	:	0.1
Feed Rate (counts)	:	5000
Feed Tolerance	:	1000
Pin Vibration	:	OFF ON
Deagglomeration	:	NORMAL HIGH
Calibrate	:	
Control Mode	:	AUTO MANUAL
Calibration Pos	:	
Max Shear (psi)	:	

Figure 5-4
Aero-Disperser® Manual Control Dialog Box

Shear Force and Shear Tolerance

The shear force entered will be the target set point for the pressure drop across the annular orifice gap between the Disperser Pin and the Pin-Bowl insert. The shear tolerance sets the tolerance band for the shear force. If the pressure drop across the orifice gap exceeds the tolerance set, the Aero-Disperser® will move the

Disperser Pin up or down to increase or decrease the pressure drop to return it to within the tolerance about the target point.

Feed Rate and Feed Tolerance

Feed Rate determines the target particle count rate that is seen by the Aerosizer®. The Aerosizer® constantly feeds the Aero-Disperser® the current count rate and the Aero-Disperser® will increase or decrease the strength and duration of the jet in order to satisfy the target count rate within the tolerance band set below. **Feed Tolerance** sets the tolerance band for the Feed Rate.

Pin Vibration

When this option is ON (the default setting) the Disperser Pin is dithered slightly up and down to reduce the likelihood of deposition of material on the Disperser Pin in the annular throat region.

Deagglomeration

This selects one of two preset air flow patterns within the Aero-Disperser®. High de-agglomeration will cause the particles to be transported from the fluidized bed to the Disperser Pin at higher velocity, resulting in greater impaction energy on the particles.

Calibration Position

The software uses this block to report the results of the calibration. This value refers to the Disperser Pin's position at the point of maximum shear pressure during the calibration routine.

Max Shear

The value appearing here refers to the maximum shear pressure measured during the Aero-Disperser®'s calibration routine.

Aero-Breather®

The Sample Presentation dialog box for the Aero-Breather® is shown in Figure 5-5. Its options are described below.

Aero-Breather Control			
Breath Rate (1/min)	:	60.0	
Breath Volume (1)	:	1.0	
Acceleration (1/sec^2)	:	19.0	
Purge Count	:	0	
Max Clean Concentration	:	1.0	
Auto Home & End Run	:	NO	YES

Figure 5-5
Aero-Breather® Control Dialog Box

Breath Rate

The breath rate may be entered up to 90 liters/minute. This setting determines the maximum velocity of the piston.

Breath Volume

The breath volume may be entered up to 1 liter. This setting determines the total distance the piston will travel.

Acceleration

The acceleration may be entered up to 19 liters/sec^2. This setting determines the rate at which the piston will accelerate to the Breath Rate set.

Purge Count

This feature allows the user to set the number of purge cycles executed by the Aero-Breather® after a sample intake.

Max Clean Concentration

This feature determines the maximum sample concentration at which the Aero-Breather® is considered "clean." The Aero-Breather® will continue executing purge cycles until the measured concentration meets the criteria entered.

Auto Home & End Run

If 'YES' is selected, the piston will be lowered as the sample drawn is entering the Aerosizer®. It will push down at a rate adjusted to the sample intake rate of the nozzle being used. When the piston reaches the bottom of its stroke, the sample run will end. If 'NO' is selected, the piston will remain at the top of its stroke while the sample draw is pulled into the Aerosizer® by the vacuum pump. *After* the user has pressed **<F11>** to end the run, the piston will be lowered, purging the Aero-Breather®.

Aero-Sampler™/Aero-Dryer™

The Sample Presentation dialog box for the Aero-Sampler™ and Aero-Dryer™ provides control of the Aero-Dryer™. It is shown in Figure 5-6 and its options are described below.

Aero-Sampler Control			
Automatic Purge	:	OFF	ON
Heater	:	OFF	ON
Purge Time	:	59.9	

Figure 5-6
Aero-Sampler™/Aero-Dryer™ Control Dialog Box

Automatic Purge

The Purge option will automatically use the vacuum pump to purge the sample chamber of any residual aerosol after a drug actuation. The sample is purged from the chamber after a run (or sequence of runs, if multiple runs are selected in the program measurements (**F10**) option) for the length of time set by **F4** in the System Setup.

Heater

The Heater option allows you to heat the core of the Aero-Dryer™ accessory to 100° C. This allows the freon or other carrier gas to be evaporated off the drug before a measurement takes place inside the measurement region of the Aerosizer®.

Purge Time

The duration of the purge cycle (when using the Aero-Sampler™ with the Aero-Dryer™) may be varied here from 1 to 660 seconds. Typical purge time for an MDI is 60 seconds.

Calibration Nebulizer™

The Sample Presentation dialog box for the Calibration Nebulizer™ is shown in Figure 5-7.

Calibration Nebulizer Control
Nebulizer pressure 0.0 % of full scale

Figure 5-7
Calibration Nebulizer™ Control Dialog Box

The Nebulizer pressure controls the auxiliary compressed air supply available at the rear panel of the Aerosizer®. It may be entered from 0 to 100%, with 100% yielding a pressure of about 20 PSIG.

F4—Sample Density

In order to convert the raw time-of-flight data into a particle size distribution, the density of the sample material must be selected. A list of materials and densities is stored in the computer. To access this list, press **<F4>**. A dialog box similar to Figure 5-8 will appear.

Sample Density	
Iron	7.86 gms/cc
Lead	11.34 gms/cc
Magnesium	1.74 gms/cc
Maleic Anhydride	1.10 gms/cc
Manganese	7.42 gms/cc
Molybdenum	9.01 gms/cc
Nickel	8.70 gms/cc
Osmium	22.50 gms/cc
Palladium	12.16 gms/cc
Glass Microspheres	2.45 gms/cc

Figure 5-8
Sample Density Dialog Box

To select a material and density already on the list, use the **<↑>** and **<↓>** keys to move the cursor to highlight the proper line, and press **<Enter>**. The selected material and density will be entered into the computer and shown on the screen below the density table.

Adding Items to the Sample Density Table

If the material you are using is not shown on the Sample Density list, you may add it to the list while the Sample Density list is onscreen. To do so,

1. Press '**a**'
2. Type in the composition name that you want to appear in the list and press **<Enter>**.
3. Type in the material's density (specific gravity) in grams per cubic centimeter (gms/cc) and press **<Enter>**.

Deleting Items from the Sample Density Table

To delete an item from the Sample Density Table,

1. Place the cursor on the material to be deleted

2. Press 'd'
3. The symbol <D? will appear next to the line marked for deletion, prompting for confirmation.
4. Press 'Y' to delete the list entry, or 'N' to keep it.

Customized Analysis Configuration

The Aerosizer® 3225 Control Software allows the user to lock certain analysis tools into a fixed configuration for all runs using a given material, or for a single run. The analysis tools that can be locked are:

- Data Fitting Tools—Gaussian Extension, Linear Regularization
- Data Combining Tools—Off, Manual Combine Settings, Auto Combine

Any combination of analysis tools can be locked for either a given material or a single run. To access these options from the Sample Density dialog box:

1. Use the arrow keys to highlight the sample material for which you wish to lock in a configuration.
2. Press 'f.' The following dialog box will appear (Figure 5-9):

```
          Sample Analysis Model for MATERIAL X
 Gaussian Extension          : SYSTEM OFF ON
 Linear Regularization       : SYSTEM OFF LOW HIGH
 Correlating Factor          : 1.0000
 Combine Options             : SYSTEM OFF MANUAL AUTO
    Lower Combine Size       :
    Upper Combine Size       :
```

Figure 5-9
Customized Analysis Configuration Dialog Box

Use the arrow keys to edit the dialog box according to the settings desired.

Any entry set to <u>SYSTEM</u> will use the system default values from the System Setup screen, the **F5** Combine/Range Settings screen, or the command keystrokes used while viewing plots. Any entry set to anything but <u>SYSTEM</u> will not be influenced by the system default values.

Correlating Factor

The Correlating Factor has a default value of 1. The particle characterization technique used by the Aerosizer® yields particle diameter measurements that, for many materials, correlate well with many other particle characterization techniques. However, some irregularly-shaped or partially hollow particles, as well as materials whose bulk densities are known but whose specific gravities are not known, tend to produce repeatable results on the Aerosizer® that do not correlate well with other measurement techniques. For such materials, our software provides a Correlating Factor that transforms our standard output into an output that closely agrees with any other sizing techniques. To set a Correlating Factor for the material selected, move the cursor to the Correlating Factor, enter the desired value, and press **<Enter>**.

MANUAL Combine

When the MANUAL Combine option is selected, the Aerosizer® Control Software will combine the data at the Upper and Lower Combine Sizes stored with the run. The suggested procedure for manually selecting combine sizes is found in Appendix D of this manual.

If any analysis tools were locked in for the material highlighted, or if a Correlating Factor other than 1.0 was associated with the material, an asterisk will be placed beside that material on the Sample Density list. All subsequent sample measurements taken with that sample material will automatically use the settings selected in this dialog box.

F5—Combine/Range Settings

The Aerosizer® collects data at two sensitivity levels: high sensitivity for detection of small particles, and low sensitivity for detection of large particles. The data from both the high and low sensitivity combines to provide a full distribution over the entire detection range of the Aerosizer®. All data below the Lower Combine Size is from the High Sensitivity; all data from above the Upper Combine Size is from the Low Sensitivity. Data between the Upper and Lower Combine Sizes is a mix of data from the High and Low Sensitivities. (See Appendix C for a detailed description of the Combine algorithm.)

The Combine option applies only to displaying and analyzing the collected data. The Aerosizer® will still collect and store raw data from both sensitivity levels, regardless of the Combine setting.

The user may analyze the sample runs with or without blending the low and high sensitivity data together. To change these parameters, press **<F5>**. The following dialog box will appear (Figure 5-10):

Combine/Range Settings			
Combine	:	OFF	AUTO
Measurement Range	:	Standard	Large
Display Range	:	0.1-200um	0.5-700um

Figure 5-10
Combine/Range Settings Dialog Box

Combine OFF

When Combine is set to OFF, the high and low sensitivity data is not combined. Either the high or low sensitivity data of any run may be viewed by entering the appropriate run number in the **F11** Display Runs dialog box. The low sensitivity data will have an even run number, one higher than the high sensitivity data. To view both the high and low sensitivity data simultaneously without combining them, type both run numbers in the **F11** Display Runs dialog box.

AUTO Combine

When the AUTO option is selected, the software will select the Upper and Lower Combine Sizes for you. Each time a data set is called up from the disk, it is analyzed to determine the Combine Sizes. These Combine Sizes are then stored with the run data for later use.

Measurement Range

The Measurement Range setting determines the AGC electronics settings best suited to the sample material. For sample particles in the range of 0.2 to 200 micrometers, use the "Standard" setting. For larger sample particles, in the range of 1.0 to 700 micrometers, the "Large" measurement range may be selected.

Display Range

This command will set the display range for the particle size distribution table and chart displayed onscreen and printed out. This setting affects only the display and not the data collection.

Note: *The display range may also be changed while viewing data onscreen by pressing an uppercase '**R**.'*

F6—Display Type

The Aerosizer® 3225 Control Software offers a variety of options for displaying the data collected. These may be set from the **F6** Display Type dialog box.

To select a display type from the Main Menu, press **<F6>**. The following dialog box will appear (Figure 5-11):

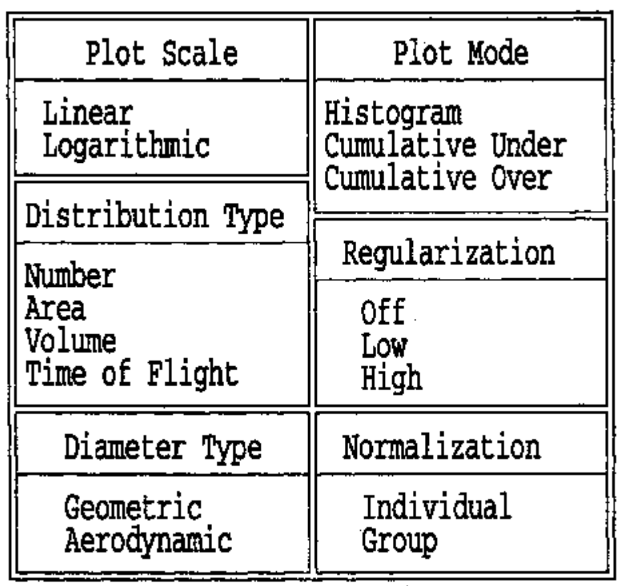


Figure 5-11
Display Type Dialog Box

Use the <→> and <←> keys (navigating clockwise and counter-clockwise) to select a major block, such as Distribution Type, Plot Scale, and Plot Mode.

Use the <↑> and <↓> keys to make a selection within each of the major blocks.

In addition to the Display Type dialog box, the display may be manipulated while it is onscreen, using shortcut keys. A complete discussion of the Display Type options and display manipulation is found in Chapter 4.

F7—Measure Sample

When all desired system parameters have been selected in the System Setup and the other Main Menu dialog boxes, the user may begin the sample measurement by pressing **<F7>**.

F8—Auto Print

The Aerosizer® 3225 Control Software may be set to automatically print a data report following the completion of each measurement. To turn this option on or off, press **<F8>** and use the arrow keys to select the desired setting.

F9—Save Options

The Aerosizer® 3225 Control Software stores data in user-defined directories. The program will allow up to 1000 data records per directory. Each directory contains a file named "AERODATA.TSX" which will hold 100 data records. For directories with more than 100 records, additional AERODATA files will be created with different extensions, e.g. "AERODATA.TS1," "AERODATA.TS2," up through "AERODATA.TS9." File "AERODATA.TS1" will contain records 101 through 200; file "AERODATA.TS2" will contain records 201 through 300, and so on. Each dual-sensitivity run uses two data records, one for high-sensitivity data and one for low-sensitivity data.

The following dialog box will appear when **<F9>** is pressed (Figure 5-12):

```
Save Options
Automatic Save      : ON   OFF
Automatic Export    : ON   OFF
Data File Copy to   : A B
Data File SubDir    : c:\tsi
Copy Scans          :
c:\tsi


c:\tsi
```

Figure 5-12
Save Options Dialog Box

Automatic Save

When Automatic Save is set to ON, the software will automatically save the data when a sample measurement is completed.

Caution
If Automatic Save is set to OFF, there is *no way* to save the data from a completed sample run. Therefore, Automatic Save should *always* be set to ON.

Automatic Export

When Automatic Export is set to ON, the software will automatically create a comma-separated spreadsheet file at the conclusion of each sample run. The file will be stored in the same directory as the sample run data (the directory listed next to "Data File SubDir" in the **F9** Save Options dialog box). The filename will be of the form DDHHMMSS.PRN, where:

- DD = day of the month on which the file was created
- HHMMSS = time (hour, minute, second) of day of the file was created.

Data File Copy To

When you have filled a directory with 1000 runs or want to transfer a number of data files to storage, you can save the entire data file from the current directory to formatted floppy disks. You will need one floppy disk with at least 1.2 megabytes of available space for each block of 100 stored runs.

To copy a data file to a floppy disk, proceed as follows:

1. In the **F9** Save Options dialog box, make sure the directory for the data file to be copied is indicated in the "Data File SubDir" line.
2. If only one data file in the directory is to be copied, make sure this is the active block in the **F11** Display Runs dialog box.
3. In the **F9** Save Options dialog box, move the cursor to the line "Data File Copy To" and highlight the floppy disk drive to which the data file will be copied. Press **<Enter>**.
4. On the screen that appears, select **<F1>** to copy only the current data file (the active block in the **F11** Display Runs dialog box), or select **<F2>** to copy the entire current subdirectory. You will need one blank, formatted disk for each data file, or block.
5. Insert the floppy disk into the drive. Select **<F1>** to copy the data file into a subdirectory with the same name as the current subdirectory, **<F2>** to copy the data file without creating a subdirectory, or **<F3>** to copy the data file into a new subdirectory on the diskette.
6. If copying multiple data files, insert a new disk and press **<F1>** when prompted.

Note: *When copying each data file, the software will scan all of the runs in the current directory, but only the runs in the data file indicated will be copied.*

Data File SubDir

This line indicates the current active subdirectory. To add, delete, or change subdirectories, move the cursor to this line and press **<Enter>**. The Save Options dialog box will resemble the one shown in Figure 5-13:

```
             Save Options
Automatic Save      : ON   OFF
Automatic Export    : ON   OFF
Data File Copy to   : A B
Data File SubDir    : c:\tsi
Copy Scans          :
c:\tsi
c:\tsi\powderA
c:\tsi\powderB
c:\test3
c:\test4
c:\test4
```

Figure 5-13
Save Options Dialog Box with Data File SubDir List

Changing Subdirectories

To change active subdirectories, move the cursor to the desired subdirectory and press **<Enter>**. The subdirectory should be highlighted in yellow and appear in the bottom of the dialog box.

Viewing the Directory Run List

To view the run list for any subdirectory, move the cursor to that line and press lowercase L, '**l**.' The list of runs stored in the data files in that directory will appear. This subdirectory will continue as the active one after you have finished viewing the list.

Creating a New Directory

To create a new directory, proceed as follows:

1. Press the lowercase '**a**' (for "add").
2. Type the name of the new subdirectory, using up to 8 letters or numbers or an underscore (_). Spaces and punctuation marks are not allowed. Do not enter the drive letter or the backslash character (\). Press **<Enter>**.
3. You will then be asked to select the drive for the new directory. Press the appropriate letter.
4. Move the cursor to the newly created directory and press any Function key.
5. A message will appear stating that the directory and/or AERODATA.TSX file does not exist and will ask whether or

not to create it. Press '**y**' to create the new directory and/or data file.

Deleting Directories

To delete a subdirectory, proceed as follows:

1. Move the cursor to the subdirectory you wish to delete and type the letter '**d**.'
2. The symbol "<D?>" will appear to the right of the subdirectory name. Press '**y**' to confirm deletion or '**n**' to cancel.
3. The software will warn you that all data in the subdirectory will be lost and prompt again for confirmation.

Note: *The software does not permit deletion of the current directory.*

Copy Scans

It is possible to copy selected sample runs from the AERODATA file in any directory to an AERODATA file in any other directory. This feature is useful when you wish to simultaneously display runs that were originally stored in separate directories. To copy scans (runs) from one directory to another, move the cursor to "Copy Scans" and press **<Enter>**. The Save Options dialog box will change to resemble the one shown in Figure 5-14.

```
            Save Options
 Automatic Save      : ON    OFF
 Automatic Export    : ON    OFF
 Data File Copy to   : A B
 Data File SubDir    : c:\tsi
 Copy Scans          :
Source Directory  :  \tsi
Source Disk Drive :  A B C D
Run #'s to copy   :  1 2 3
Target Directory  :  \breather
Target Disk Drive :  A B C D
Start Copy at     :  36
GO                :
```

Figure 5-14
Save Options Dialog Box with Copy Scans Expansion

The example shown above would copy run numbers 1, 2, and 3 from the file C:\TSI\AERODATA.TSX to run numbers 36, 37, and 38 in the file C:\BREATHER\AERODATA.TSX.

It is also possible to specify a range of runs to copy by typing '#-#' (the first and last run numbers to be copied, separated by a dash, with no spaces) rather than the individual run numbers.

If the second run of a dual-sensitivity run pair is not specified for copying, the software will prompt the user for clarification. Press **<Enter>** to copy the second run of the pair, or **<Esc>** to copy only the run specified and mark it as a single-sensitivity run.

Caution
When copying scans (runs), the software will *not* protect the user from overwriting previously stored runs.

F10—Program Measurements

The Aerosizer® 3225 Control Software may be set up to perform a preset number of measurements, each lasting for a fixed period of time, with a preset waiting time between each measurement.

To set up the instrument to make a series of measurements, press **<F10>**.

The following dialog box will appear (Figure 5-15):

```
                    Program Measurements
 Multiple Runs                  :  MANUAL   PROGRAM
 Number of Runs                 :              1
 Nominal Run Length   (sec)    :     30
 Run Spacing          (sec)    :      0
 External Control               :  OFF  ON
```

Figure 5-15
Program Measurements Dialog Box

Multiple Runs

In <u>MANUAL</u> mode, the Aerosizer® will continue measuring a sample until the user terminates the measurement. In <u>PROGRAM</u> mode, the Aerosizer® can be set up to make a preset number of measurements, each lasting for a fixed period of time, with a preset waiting time between each measurement. In both modes, the following commands may be used at any time during a run:

- Press **<F11>** to complete a run or series of runs, and store the data.
- Press **<F1>** to abort a run.
- Press **<F7>** to restart a run.

Number of Runs

You can program up to 1000 runs (500 in the dual-sensitivity sample measurements) if you are saving the runs and the first run label is set at 1. This is the maximum number of runs that can be stored in a subdirectory. You can select up to 10,000 runs at a time if you want to print *but not save* the results.

Nominal Run Length (sec)

The Aerosizer® can be set up to collect data for set run lengths while in PROGRAM mode. A single run length, or a series of run lengths for multiple runs, can be entered. The program will start with the first run length in the series and cycle through the series until the requested number of runs has been completed. The maximum run length is 10,000 seconds (2.75 hours).

Run Spacing (sec)

You can program the Aerosizer® to wait from 0 to 10,000 seconds (2.75 hours) between runs. Run spacing can also be entered as either a single number or a series of numbers. The program will start with the first run spacing number in the series and cycle through the list until the requested number of runs is completed.

Example:

Number of Runs	5
Nominal Run length	30 60 90
Run Spacing	20 40

After **<F7>** is pressed to start, the following sequence will occur:

- Data is collected for 30 seconds, run is stored to Run # X
- Aerosizer® waits 20 seconds
- Data is collected for 60 seconds, run is stored to Run # X+2
- Aerosizer® waits for 40 seconds

- Data is collected for 90 seconds, run is stored to Run # X+4
- Aerosizer® waits 20 seconds
- Data is collected for 30 seconds, run is stored to Run # X+6
- Aerosizer® waits for 40 seconds
- Data is collected for 60 seconds, run is stored to Run # X+8

(X is the reset run number, set in **F11** from the Main Menu)

External Control

This command enables external control of the Aerosizer®. This option may be purchased separately. If this option has been purchased, see the documentation that accompanied it for information.

F11—Display Runs

The Display Runs dialog box allows the user to view previously stored runs in graphic and tabular format, to view the run list for the current subdirectory, and to delete individual runs.

The Run Calculations options allow you to add, subtract, or divide two runs. This may be useful for comparing the results of runs, such as runs taken before and after a process has been performed on the sample material.

The Display Runs dialog box is shown in Figure 5-16.

```
                  Display Run(s)
 Display Run #s       :     1
 Display Run Info     :     1
 Display Run List     :
 Delete Run #s        :
 Reset Run Number     :         59
 (Last Run Number)    :         58
```

Figure 5-16
Display Runs Dialog Box

Display Run Numbers

Highlight the first line, type in up to 5 run numbers separated by a space, and press **<Enter>**.

The measurements you have selected will be plotted on the computer screen. Each measurement will be in a different color, with the color of each graph corresponding to the color of the run number in the graph header. Display type can be manipulated as described in Chapter 4.

Display Run Info

The Display Run Info option allows you to review several key parameters for a sample run as well as to edit some of the information stored with the run. Move the cursor to the "Display Run Info" line, then type one to five run numbers separated by spaces, and press **<Enter>**.

The information concerning that run will be shown on the screen, such as is shown in Figure 5-17.

```
Directory              : c:\tsi
Run      1             : Tue Dec 22 17:23:55 1998
Material               : ambient aerosol              1.00
Run Length (sec)       :    229.151
Pressures (atm)        :      0.9567        0.0143        0.0285
Clocks (counts)        :     4475601       1296428        634654
Laser Current          : 38.7 mA
Sum of channels        :          6882
Lower Combine Size     :           2.0
Upper Combine Size     :           4.0
Flow Max/Min (l/min)   :         2.078         2.078



Trial Run with no aerosol generated



↑↓ to browse, F1 for Previous Menu, F3 to Edit Scan, F8 to Print
```

Figure 5-17
Display Run Info Screen

To obtain a printed copy of the information, press **<F8>**.

If you have entered more than one scan (run) number, you can change from one run to the next by pressing the **<↑>** or **<↓>.**

Editing Scans

The edit function allows you to change the density, label, material description, combine sizes, and analysis parameters used for any run. While you Display Run Info for the appropriate run, press **<F3>** to edit the information associated with that run. The Edit Scan screen is shown in Figure 5-18:

```
Run      1           : Tue Dec 22 17:23:55 1998


Material            : ambient aerosol
Density             : 1.00

Lower combine size : 2.0
Upper combine size : 4.0
Label     : Trial Run with no aerosol generated








↑↓ to select, F1 to Previous Menu, F4 to Edit Analysis Configuration
```

Figure 5-18
Edit Scan Screen

To change the material or density, use the arrow keys to highlight the item you want to change and press **<Enter>**. Type the new material or density and press **<Enter>.**

Note: *Changing the sample material will* not *cause the software to update the sample density or the Specific Analysis Model settings to match those for the new sample material.*

Entering a new sample density will change the parameters stored in the record. The new density will be used to calculate particle size distributions.

To change the label (information entered under **F2** from the Main Menu), move the cursor down to the label and press **<Enter>**. After editing you must press **<Esc>** to accept the new label.

The Specific Analysis Model for the run may also be edited. To edit the model:

1. Press **<F4>** to access the dialog box for analysis tool configuration.
2. Edit the block as desired. Any entry set to SYSTEM will use the system default values from the System Setup screen, the **F5** (Combine) screen, or the command keystrokes used while viewing plots. The default value for the Correlating Coefficient is 1. Any entry set to anything but SYSTEM will not be influenced by the system default values.
3. Type **<F1>** to exit the dialog box.

If any analysis tools were set to not use the system default values, a warning statement will be written in the Display Run Info window.

Display Run List

Selecting this option will display a list of the measurements in the current directory. The list will show the measurement numbers, date and time each measurement was made, the material measured, and the first line of the run label. The runs stored within a directory are stored in data files; each data file contains a block of 100 runs. To display the list, highlight Display Run List and press **<Enter>**.

To scroll within the current block of 100 runs, press the <↑> or <↓> keys. To change between blocks of 100 runs, press the <←> or <→> keys.

To obtain a printed copy of the current block's run list, press **<F8>**, and you will obtain a listing similar to Figure 5-19.

```
                    D I R E C T O R Y
                     of c:\workshop
                 Wed Apr 14 14:54:22 1999

*  3 12/22/98 22:05 Glass mic 38-45um glass
*  5 12/22/98 22:19 Glass mic 53-45um glass
*  7 12/22/98 22:35 Glass mic 53-45um glass
*  9 12/22/98 22:56 Glass mic 63-53um glass
* 11 12/22/98 23:25 Glass mic 2.1um glass
* 13 12/22/98 22:46 Glass mic 2.1um glass
* 15 12/23/98 00:52 Glass mic 8.1um glass
* 17 12/23/98 01:49 Glass mic 15.5um glass
* 19 12/23/98 02:03 Glass mic 650 um glass
* 21 12/23/98 02:22 Glass mic 90-75um glass
* 23 12/23/98 04:09 Glass mic 90-75um glass
* 25 12/23/98 04:22 Glass mic 45-38um glass
* 27 12/23/98 04:32 Glass mic 53-45um glass
* 29 12/23/98 04:56 Glass mic 63-53um glass
* 31 12/23/98 07:54 Glass mic 15.5um glass
* 33 12/23/98 08:35 Glass mic 8.1um glass
* 35 12/23/98 08:53 Glass mic 2.1um glass
```

Figure 5-19
Typical Run List

Only the odd (high-sensitivity) run numbers will be displayed. The asterisk to the left of the number indicates that there is also a low-sensitivity run associated with that run. The low sensitivity data will have a run number greater by 1.

Delete Run #'s

To delete runs from the current selected directory, proceed as follows:

1. Highlight the "Delete Run #'s" line and type in the run numbers of the scan(s) you wish to delete. To delete more than one run at a time you may enter multiple run numbers separated by a space. Up to five runs may be entered.
2. After entering the run numbers, press **<Enter>**.
3. The software will ask you if you really want to delete those runs. Press 'Y' to confirm or 'N' to abort.

Reset Run Number

This number shows the location where the next run will be stored. The reset run number automatically indexes by two whenever a run is saved. Care should be taken to ensure that the program is not going to overwrite any previously stored data that is of value.

Caution

If "Overwrite Scans?" is set to YES in the Setup Screen, the Aerosizer® program will **NOT** protect the operator from overwriting data, nor are there any warnings given.

Last Run Number

This number shows the location of the last stored run.

F12 –Print Runs

This option allows you to either print the sample results or export them to a spreadsheet file without first displaying them on screen. This submenu also contains the setup for the format of the printout. You can specify a list or range of runs in the current directory to be printed or exported. The following dialog box (Figure 5-20) will appear when you press **<F12>**:

```
                      Print  Runs
Report with Graph      :
Report - Text only     :
Display Run Info       :
Print Run List         :
Spreadsheet Export     :
Export Base Name       :
Info Format            :  ID Only  Short  Long
Table Format           :  None  Short  Long
Table Type             :  SIZE  MESH  CUSTOM
Particle Count         :  Absolute  Relative
```

Figure 5-20
Print Runs Dialog Box

Specifying a Range to Print or Export

To specify a range of runs, the Aerosizer® program recognizes two characters, a "-" (dash) and a "~" (tilde). Run numbers separated by a dash will specify a range that includes *every other* run number, starting with the first run number up to the end run number. Run numbers separated by a tilde will specify a range that includes *all* run numbers from the first run number to the end run number.

Ranges must always be specified in ascending order. Individual run numbers may be entered in random order. Ranges may also be combined with single run numbers and other ranges.

Examples:

Input from user	Resulting Range Printed or Exported
1-10	1 3 5 7 9
1~10	1 2 3 4 5 6 7 8 9 10
1 23 35-39	1 23 35 37 39
23 1 7~100	23 1 7 8 9 10...97 98 99 100

Report with Graph

Report with Graph will print the Graph, Statistical Information and Run Table in the currently selected format for each of the run numbers entered. A list or range of runs printed with this command will produce a *separate* graph and table for each run specified, *not* an overlaid graph.

Report - Text only

Report - Text only will print the Statistical Information and Run Table for each of the run numbers entered without printing the graphs. The tables will be for the distribution type specified in the F6 Display Type dialog box.

Display Run Info

Display Run Info provides an onscreen display of specific information about the operating parameters used for the sample run. This screen is also accessible from the Display Run Info command in the **F11** Display Runs dialog box (Figure 3-12).

Print Run List

Print Run List prints a complete run list for the selected data file. An asterisk will appear next to the first run number of a dual-sensitivity run pair.

Spreadsheet Export

Spreadsheet Export will output a file in Comma Separated Value (CSV) format that contains all the information contained in the Statistical Information and Run Tables as specified in the setup section described below. Up to 10 run tables will be contained in each data file. The default filename will be labeled 'RUNXXX.PRN' where 'XXX' is the first run number in the range exported. The file will be stored in the directory C:\TSI.

The Aerosizer® program will output multiple Export files if the range contains more than 10 run numbers. For example, if the range specified is 1-40, the Spreadsheet Export command will export data from runs 1 3 5...17 19 to file 'RUN001.PRN' and data from runs 21 23...37 39 to file 'RUN021.PRN.'

A detailed description of the data format of spreadsheet export is provided in Appendix.

Export Base Name

Export Base Name displays and allows the user to set the filename to be used when exporting run data. The default base name will appear on this line as 'RUN%03d.PRN' (the characters "%03d" tell the software to insert the 3-digit run number in that location). This will create Export files of the format 'RUNXXX.PRN' where 'XXX' is the first run number in the series.

The user may wish to specify a particular base name for an Export file. Highlight the "Export Base Name" line. Type 'BASENAME%03d.PRN' and press **<Enter>**. The software will create an empty file labeled 'BASENAME001.PRN' in the directory C:\TSI.

The user may now enter the run numbers for export as described above. Data will be exported to a file labeled 'BASENAMEXXX.PRN' where 'XXX' is the first run number in the series. If run 1 is specified to be exported, the software will state that 'BASENAME001.PRN' already exists and ask whether or not to overwrite. If you are certain that no data was previously stored under this base name, press **'y'** to overwrite the empty file with the run data.

Info Format

Info Format selects the level of detail of the statistical information and Sample Presentation control information that is displayed on the printout and appears in the export files.

ID Only

ID Only will print the Run Label as entered in **F2** but will not print any statistical information or Sample Presentation control settings (set in **F3** of Main Menu).

Short

Short format will print all the statistical information and Aerosizer® operating parameters but will omit the Sample Presentation control settings.

Long

Long format will print all the statistical information and all the Sample Presentation control settings.

Table Format

Table Format allows the user to select either None, Short or Long for the format of the printed size tables.

None

None will cause the table to be omitted from the printout.

Short

Short format provides 50 size channels of resolution in the size table.

Long

Long format provides 165 size channels in the size table.

Note: *The Table Format option will only affect tables of the type SIZE (see below).*

Table Type

Table Type allows the user to select whether their In/Under tables display the particle sizes in microns or expressed by mesh size as per standard sieve designation.

SIZE

If SIZE is selected, the table will use either 50 or 165 logarithmically spaced sizes, measured in microns.

MESH

If MESH is selected, the table will use the standard sieve designations.

CUSTOM

If CUSTOM is selected, the table will use the sizes specified in the file 'CUSTOM.TSI' or default to 60 logarithmically spaced sizes.

To create a customized In/Under table containing only your desired sizes ranges:

1. Select CUSTOM for Table Type on the F12 Print Runs screen.
2. Create a text file named 'CUSTOM.TSI' using a text editor or word processing program. The file must be located in the C:\TSI directory of your computer. Store from 2 to 61 different sizes of interest in the file 'CUSTOM.TSI.' Put one number per line; decimal points are allowed, but do not use commas or other punctuation marks. The program will sort the list of numbers in descending order to create the size bins for the table. Duplicates of the same number are ignored.

If 'CUSTOM.TSI' does not exist (or if it has fewer than two sizes in it) and CUSTOM is selected, the program will list 60 geometrically spaced size ranges spanning the display range. Any value less than the viewed range's minimum will be read as the range's minimum. Any value greater than the viewed range's maximum will be read as the range's maximum.

Particle Count

Data may be presented to the screen or printer by several tabulation methods. All of these methods will give the total distribution within the upper and lower limits chosen.

Absolute Particle Count

If Absolute is selected, the data table will show data as the *absolute* number of particles detected in each size range.

Relative Particle Count

If Relative is selected, the data table will show what *percentage* of the total detected distribution was detected in each size range.

Escape/Exit Aerosizer® Program

The **<Escape>** key serves two purposes: to remove a dialog box from the screen without taking any other action, or, when pressed from the Main Menu, to leave the Aerosizer® program and return to DOS. To exit the Aerosizer® program, press **<F1>** to return to the main menu, if needed. Then press **<Esc>.**

A prompt will appear asking for confirmation. Press **'Y'** to return to DOS.

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APPENDIX A

Troubleshooting

This chapter addresses problems you may encounter when collecting or analyzing data with the Aerosizer® 3225 Control Software.

The Aerosizer® 3225 Control Software also provides the user with a number of instrument-related error messages to inform the user of a problem with the instrument setup. These error messages and the suggested corrective actions are discussed in the instrument manuals.

Data Collection Errors

"Scan XXX already exists. Press Esc to continue."

This message may appear immediately after pressing **<F7>** to begin a sample measurement. The software is trying to collect new data and place it in a file location that already contains data. This may occur after viewing previously collected data stored in another directory or in another block (of 100 runs).

When the **<Esc>** key is pressed, the new run will be aborted. From the Main Menu, press **<F11>**. Check the "Reset run number."

The sample run is proceeding but no data appears in the graph onscreen

There are several possible reasons that data may not appear onscreen. *Before assuming there is an error in sample feed, check the following:*

Data collected is outside of the current viewing range

Check the following settings:

- Press the <↓> key to zoom out to the full range.
- Press 'R' to change size range. Pressing this twice will also reset the upper and lower size limits to the range limits.

High-sensitivity noise is creating a false reading

At times, high-sensitivity noise can create a "peak" in a low diameter range. If this imaginary peak is sufficiently high, the normalization process can make it difficult to see the actual size distribution onscreen.

- When viewing a full range of data, if there is an unexpected "spike" in the histogram in the low range, move the cursor just past it and press **<F5>** to set the lower size limit.

There is an error in supplying sample to the Aerosizer®

Before terminating the sample measurement, try the following:

- Make sure all tubing is connected properly and unpinched.
- If using the Aero-Disperser®, gently tap the side of the sample cup to dislodge or loosen any clumps.
- Visually check the system for trapped sample material.

If it is necessary to terminate the measurement, try to determine the cause of the error condition before another attempt. Check the injection tube and sonic nozzle for clogs or trapped sample material.

Data Display Errors

Previously collected data does not appear on graph when viewing

The upper and lower size limits may be changed when viewing data on a linear scale. These limits do not reset automatically when viewing a different sample run. The upper and lower limits may be set to the same size, or they may be set to sizes out of the range of the sample you are currently trying to view. The current limits are listed in the lower right corner of the screen.

APPENDIX B

Converting Time-of-Flight to Particle Size

The Model 3225 Aerosizer® DSP collects time-of-flight data to create a distribution. The Aerosizer® 3225 Control Software converts this raw time-of-flight data to a particle size distribution.

The general procedure for this conversion may be described as follows:

1. Locate and subtract baseline
2. Remove peaks created by system noise
3. Convert time-of-flight to diameter
4. (If requested by user) convert size distribution by number to size distribution by surface area or volume.

This process is described in greater detail in this appendix.

Baseline Removal

The Aerosizer® system measures and records the time between each start-beam crossing and every following stop-beam crossing for 100 microseconds (µsec). One of these times will be the correct time-of-flight for the particle that triggered the start-beam, and the others will be randomly distributed. The number of randomly-distributed times depends on the feed rate of the particles. If the system is run at a very low count rate, no other particles will pass cross the beam during the 100 µsec. If particles come through the system more frequently, the true time-of-flight data will have randomly distributed counts added to it. These random counts will appear as a constant number (with statistical fluctuations) added to each time channel.

Finding the Baseline Region

The software program begins to scan for a baseline after the first peak in the time-of-flight data. It scans a window across the data, computing the total number of counts in the window at each possible location. The location where the window has the lowest total counts is selected as the baseline region.

Computing the Baseline Value

The software program finds the mean (average) number of counts for all of the channels in the baseline region. The baseline value is set to this mean value.

Subtracting the Baseline

The software program subtracts the baseline value from every channel in the time-of-flight distribution. If the result of that subtraction is negative, the channel is set to zero.

Noise Peak Filtering

The next step is to remove statistically insignificant fluctuations from the data. The software program determines a threshold which a peak must exceed in order to be considered valid. If any value in the peak exceeds the threshold, the entire peak is kept; otherwise, the entire peak is rejected.

Computing the Noise Threshold

The noise threshold is computed by taking the standard deviation of the channel counts in the baseline region around the mean channel count in that region. This is then multiplied by a noise threshold factor to determine the threshold.

Isolating Peaks

The software scans across the data to isolate peaks to evaluate for statistical significance. A peak is defined as a region with one or more non-zero channels bounded by two channels with zero counts.

Evaluating Peaks for Acceptance and Rejection

For each peak identified by the software, the maximum channel in the peak is compared to the threshold value. If the maximum value in the peak is below the threshold, all of the channels in the peak are set to zero. If the maximum value in the peak exceeds the threshold, all of the channels in the peak remain unchanged.

The data has now been reduced to a particle number versus time-of-flight distribution. This distribution may now be converted to particle size.

Time-of-Flight to Diameter Conversion

Once a number versus time-of-flight distribution has been created, it must be converted to a particle size (diameter) distribution. The time-of-flight (TOF) data is stored in 2048 linearly spaced channels. The software program converts this distribution into 500 logarithmically spaced size channels.

Mapping TOF Channels to Size Channels

Depending on the measurement range selected, the program creates 500 logarithmically spaced diameter bins.

Based on the calibration curves for the instrument, and on the sample density entered by the user, the program computes a list of 501 times-of-flight that correspond to the edges of the diameter bins.

Reducing Data from 2048 TOF Channels to 500 Size Bins

For each size bin, the program sums all of the TOF channels that fall between its upper and lower times-of-flight to create the total count for that size bin.

Converting to a Size Distribution by Surface Area or Volume

Rather than view a size distribution by number of *counts* per size bin, the user may prefer to view a distribution by total *surface area* or *volume* per size bin. If this is the case, the value assigned to each size bin is calculated as follows:

Surface Area

$$S_i = n_i * D_i^2$$

Volume

$$V_i = n_i * D_i^3$$

Where:

n_i = channel count for channel i
D_i = diameter at geometric center of channel i.

APPENDIX C

Combining High and Low Sensitivity

The Aerosizer® collects time-of-flight data simultaneously in two data acquisition sections. The high-sensitivity section is optimized to detect small particles, and the low sensitivity section is optimized to detect larger particles. In order to get an overall size distribution, it is necessary to combine the data sets from these two sections into a single distribution. The size where the transition is made between sensitivities is affected by several factors, so the Combine size must be adjusted to match the associated data sets. This can be done for most sample materials using the software's Automatic Combine setting. When necessary, the user may manually select the Combine region.

Factors Affecting Combine Size

The appropriate Combine size is determined by the low sensitivity detection threshold. This size is affected by the following factors:

Light-Scattering Efficiency

Different materials scatter light with varying efficiency, depending on the particle size and the refractive index of the material. This will affect the smallest size particle detectable by the low sensitivity for a given material.

Sample Deposition on Detection Optics

When the detection optics become coated with a thin film of sample material, the amount of scattered light that arrives at the PMTs is reduced. If the optics are only slightly coated, the sensitivity of the instrument may be reduced without rendering it unusable. In this case, the size range detectable by the low sensitivity will decrease.

Automatic Combine Algorithm

The software scans the high- and low-sensitivity time-of-flight data to determine the Combine Size. For sizes smaller than the Combine Size, the high sensitivity data is used. For sizes larger than the Combine Size, the low sensitivity data is used.

Determining the Combine Size

The auto-combine algorithm selects a size at which to combine the data from the low and high sensitivity channels based on how well the time-of-flight channel counts of the two curves match. This evaluation takes place after the baseline removal and noise peak filtering are applied to the time-of-flight data.

Set Allowable Combine Region

The software sets the upper limit for the allowable combine region to the size corresponding to a 15 microsecond time-of-flight. The lower limit for the allowable combine region is determined by examining the high-sensitivity data to find the size channel with the highest counts below the combine region's upper limit.

Scan for Combine Size

The software scans across the allowable Combine region, looking for the first channel where the low-sensitivity data has higher counts than the high-sensitivity data. The particle size for this time-of-flight channel is set as the Combine Size. If no such point is found, the software forces the sensitivities to combine at a size corresponding to a 15 microsecond time-of-flight.

Manually Selecting the Combine Region

The automatic combine algorithm will give the best results for most sample materials. For certain sample materials, the user may prefer to manually select a Combine region. This process is described below.

1. Turn Combine to <u>OFF</u> in the **F5** Combine/Range Options dialog box.
2. From the **F6** Display Type dialog box, select: <u>Linear</u> Scale, <u>Number</u> Distribution, <u>Group</u> Normalization
3. From the **F11** Display Runs dialog box, enter the run numbers for the low- and high-sensitivity runs to be combined, separated by a space. (The low-sensitivity data set will have an even run number, one higher than the high-sensitivity data set.)
4. Zoom in both the X and Y axes in the expected combine region.

5. Look for a region on both curves with matching slopes and matching height
6. Note the upper and lower sizes for this range—these are the Upper and Lower Combine Sizes.
7. Return to the Main Menu.
8. From the **F4** Sample Density list, press **'f'** to access the Customized Analysis Configuration dialog box, and set Combine to MANUAL. If you want to apply these Combine Sizes to all subsequent runs using this sample material, you may then enter the combine sizes in the appropriate spaces.
9. From the **F11** Display Runs dialog box, select Display Run Info for the first (high-sensitivity) run. Press **<F3>** to edit the scan.
10. Enter the new Combine Sizes. Press **<F1>** to return to the Main Menu.
11. From the **F11** Display Runs dialog box, display the combined data by entering the high-sensitivity run number. The software will display the combined data.

The software will now combine the high and low-sensitivity data in the user-specified region. Data below the Lower Combine Size will be all high-sensitivity data. Data above the Upper Combine Size will be all low-sensitivity data. Within the Combine Region, data will be a mix of high- and low-sensitivity data.

The Upper and Lower Combine Sizes entered for this run will be stored with the sample run and used every time it is viewed.

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APPENDIX D
Statistical Calculations

The reports created by the Aerosizer® 3225 Control Software include a number of statistical calculations. The formulae used to calculate these values are provided in table D-1 below.

Table D-1
Statistical Calculations

Equation Name	**Formula**	**Notes**
Total counts in channel i	n_i	
Total counts for all channels	$N = \Sigma n_i$	
Geometric Mean Diameter GMD	$\ln(GMD) := \frac{\sum_i \left(n_i \cdot \ln(D_i)\right)}{N}$	**For Surface Area distribution,** replace n_i with $s_i = n_i D_i^2$ N with $S = \Sigma s_i$
Geometric Standard Deviation GSD	$\ln(GSD) := \frac{\sum_i \left[n_i \cdot \left(\ln(D_i) - \ln(GMD)\right)^2\right]}{N - 1}$	**For Volume distribution,** replace n_i with $v_i = n_i D_i^3$ N with $V = \Sigma v_i$
Volume Weighted Mean Diameter D(4,3)	$D(p,q) := \left[\frac{\sum_i \left[n_i \cdot D_i^p\right]}{\sum_i \left[n_i \cdot D_i^q\right]}\right]^{\frac{1}{p-q}}$	$p \neq q$
Surface Weighted Mean Diameter D(3,2)		
Specific Surface Area SSA	$SSA := \left[\frac{\sum_i \left[n_i \cdot D_i^2\right]}{\sum_i \left[n_i \cdot D_i^3\right]} \cdot \frac{6}{\rho_p}\right]$	ρ_p = sample density entered by user
Mode = number of counts in:	Size bin with highest n_i	For distribution by number
	Size bin with highest $n_i D_i^2$	For distribution by surface area
	Size bin with highest $n_i D_i^3$	For distribution by volume
	Time-of-flight bin with highest n_i	For time-of-flight distribution

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