Aerosizer User Manual

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API AEROSIZER® SPECIFICATION DATA SHEET

MODELS	Mach II and LD
MEASUREMENT RANGE	0.2 to 700 microns
PRINCIPLE OF OPERATION	Aerodynamic time-of-flight
SAMPLE RATE	Up to 100,000 particles per second
SAMPLE TIME	Selectable; usually less than one minute
CALIBRATION	None required
RESOLUTION	150 channels per decade
SOFTWARE	Proprietary, menu driven operation
RESULTS PRESENTATION	Tabular and graphical formats
DIAMETER TYPES	Geometric and aerodynamic
DISTRIBUTION TYPES	Number, surface area, and volume
PLOTTING MODES	Differential and cumulative
PLOT TYPE	Linear and logarithmic
LIGHT SOURCE	Aerosizer LD - 3 mW Laser Diode Aerosizer Mach II - 5 mW HeNe Laser
DETECTION SYSTEM	Dual photomultipliers

Power Requirements:

Aerosizer LD	90 - 264 VAC/ 1.0A - 0.5A
Aerosizer Mach II	115 V/ 2.5A 230 V 1.2A
Aerosizer Controller	115V / 3.5A 230V / 1.7A
Monitor	115V / 1.5A 230V / 0.75A
Printer	115V / 1.0A 230V / 0.5A
Vacuum Pump	115V / 11.2A 230V / 5.6A
AeroDisperser	90 - 264 VAC / 2.3A - 1.2A
Pump Unit	115V / 1.7A 230V / 0.85A
AeroDiluter	115V / 2.0A 230V / 1.0A
AeroBreather	115V / 2.0A 230V / 1.5A

1. Quick Reference guide for running the Aerosizer with Various Accessories.

1.1 Using the AeroDisperser

Installation:

Remove any other in feed devices that may be attached to the Aerosizer. If you have an AeroDiluter disconnect it from the system.

Ensure that the Large Sonic Nozzle (1.5 mm Diameter) complete with Flow Straightener is inserted in the Aerosizer. Remove the Injection Tube if it is currently in place.

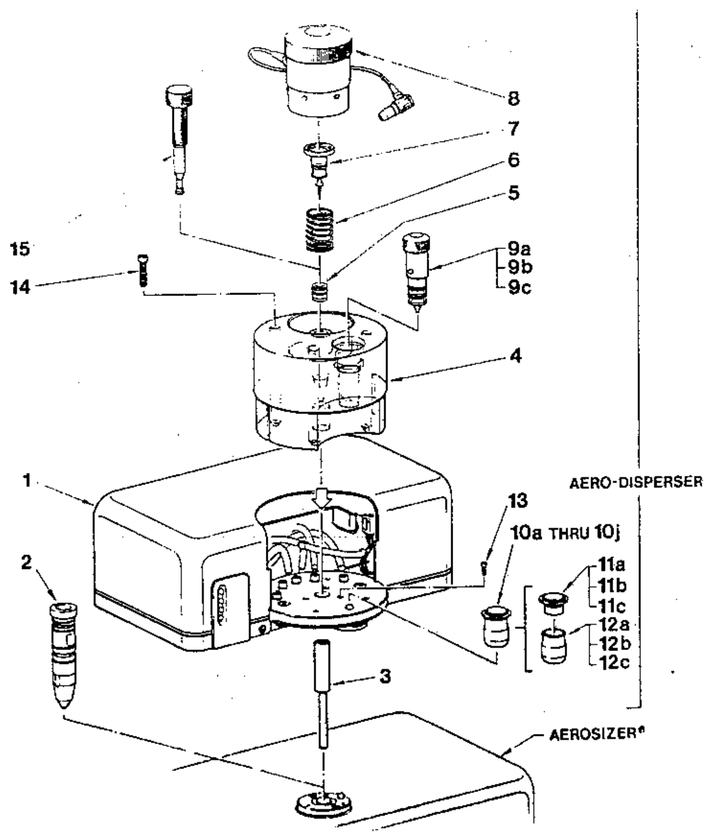


Figure 1

Remove the Dispersion Head (Item 4 Diagram) from the AeroDisperser by first disconnecting the motor connection from the back panel of the AeroDisperser (pull straight back on the collar of the connector) then using the 4 mm hex driver unscrew the four screws (Item 14 Diagram) holding down the Disperser Head. Lift the Disperser Head straight up and set it aside gently.

Place the AeroDisperser atop the Aerosizer aligning the relief in the underside with the Aerosizer inlet such that the metal plunger in the top of the Aerosizer seats in the hole in the underside of the AeroDisperser. Fasten the AeroDisperser to the Aerosizer with the three Nylon Socket Head Cap Screws (7/64 hex wrench) located in the bottom of the AeroDisperser Base.

Verify that there are O-Rings on both ends of the barrel section of the Stainless Steel Tuned Acceleration Injection tube (Item 3 Diagram) and insert it into the Aerosizer Inlet.

Install the Disperser Head on the AeroDisperser. Tighten the four screws that hold the Disperser Head to the AeroDisperser Base. Plug in the Motor connector on the back panel of the AeroDisperser, the cable should face up.

Connect the power cord to the AeroDisperser.

Connect the RS232 interface cable from COM1 of the Aerosizer controller to the RS232 port on the AeroDisperser..

Note: The AeroDisperser Pneumatic connections are color and size coded. Refer to the Interconnect Diagram for reference

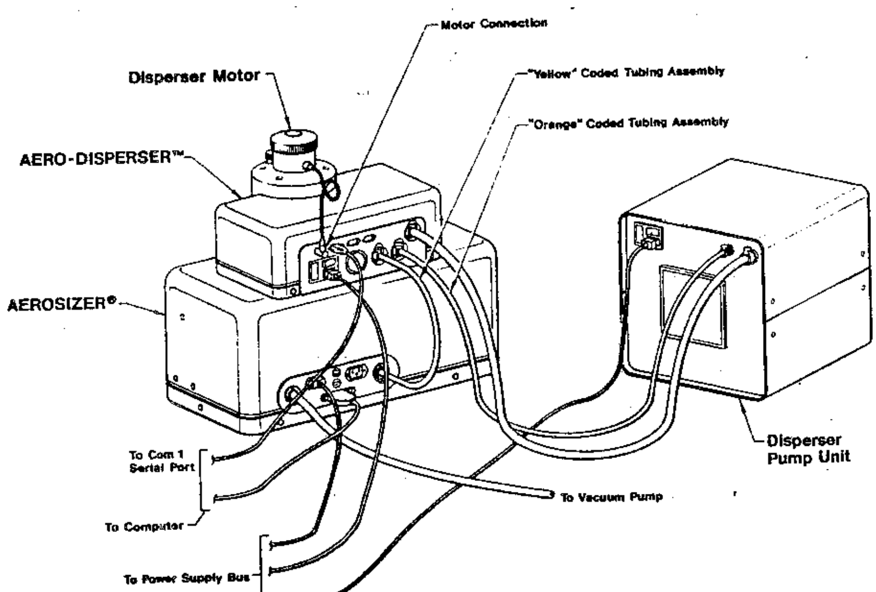


Figure 2

Connect the short small tube from the **Aerosizer Compressed Air Out** to the **AeroDisperser Compressed Air In**. The unmarked connector goes in the Aerosizer compressed air out port and the yellow connector goes to the AeroDisperser compressed air in port.

Connect the two long, tubes one small tube with orange coded connectors and one large tube with uncoded connectors from the pump unit to the AeroDisperser.

Connect power to the pump unit and switch it on. The internal pump is controlled through the small air line and should not be active at this time. You should be able to feel air flowing from the cooling fan through the filter on the front of the unit.

Boot up the Aerosizer controller. Once the Aerosizer program is up and running turn on the Aerosizer, Vacuum pump and AeroDisperser.

Go to the Setup Menu (Ctl-S from main menu) and set it up as in the following diagram.

COMMAND

F1	Return to Main Menu	
F2	Graphics Mode	IBM EPSON HPLJ DeskJet C
F3	Dual Sensitivity	OFF ON
F4	Noise Threshold(Sigmas)	6.0
F5	Sampler Purge time (Sec)	65.9
F6	PMT Voltage	850
F7	Clock Frequency	20 MHz 40 MHz
F8	Aerodiluter Present?	NO YES
F9	Mass Load. Count Eff.	1.00
F10	Sample Presentation	Pulse Jet Sampler Breather Disperser
F11	Particle Count	Absolute Relative
F12	Set Run Parameters	MANUALLY AUTOMATICALLY
Alt F1	Nozzle Type	200um 700um
Alt F2	Display Range	0.1-200um 0.5-700um
Alt F4	Baseline Offset (0-3.0)	0.1
Alt F5	Channels in Baseline	55
Alt F6	AutoSave during run?	NO YES
Alt F7	Overwrite Scans?	NO YES
Alt F8	Log Plot Resolution?	Low High

Figure 3

press F1 to return to the main menu.

Running a sample:

Calibrate the AeroDisperser by placing an empty sample cup in the AeroDisperser and seal it into place by rotating the exposed part of the thumbscrew from left to right. You need only tighten the thumbscrew until the O-Ring at the top of the sample cup is compressed.

Press F3 Sample Presentation.

The AeroDisperser should turn the pump unit on and start the calibration routine. You should hear the pump start. If the pump unit does not come on check that the power switch located above the power cord has the end labeled with a 1 depressed and that all the air lines are connected properly.

Once the calibration routine is finished Press <Enter>. The following screen should be visible:

```
              Aero-Disperser Auto Control

  Shear Force         : LOW   MED   HIGH   PEAK
  Deagglomeration     : NORMAL   HIGH
  Feed Rate           : LOW   MED   HIGH
  Pin Vibration       : OFF   ON

  Calibrate           :
  Control Mode        : AUTO   MANUAL
```

Figure 4

The operator can now set up the operating parameters for the AeroDisperser.

Shear Force

This sets the pressure drop across the gap at the dispersing pin. Increased pressure drop across the gap results in higher air speeds within the gap increasing the shear force exerted on the particles.
Low = 0.5 PSI
Med = 1.5 PSI,
High = 3.0 PSI
Peak = 4.0 PSI

Feed rate

This sets the target incremental count rate for the Aerosizer. The AeroDisperser will automatically increase or decrease the strength and duration of the air jet to try to satisfy the target feed rate selected.
Low = 1000 cts/sec
Med = 5000 cts/sec
High = 10000 cts /sec.

De agglomeration

This selects one of two preset air flow patterns within the AeroDisperser. High de agglomeration will cause the particles to be transported from the fluidized bed to the disperser pin at higher velocity resulting in grater impaction energy on the particles.

Pin Vibration

When this option is selected 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.

For an unknown powder of 150 microns or less set:

Shear Force	High
Deagglomeration	Normal
Feed Rate	Medium
Pin Vibration	On

For an unknown powder of 150 microns or greater set:

Shear Force	Low
Deagglomeration	Normal
Feed Rate	Medium
Pin Vibration	On

Release the seal on the Sample Cup by backing of the Thumbscrew that seals it in place. Rotating the exposed edge from right to left will release the seal. The sample cup may then be removed from the AeroDisperser by pulling down on the cup then sliding it out towards you.

Open up the sample cup by pulling off the cap. (Item 11 diagram)

Place a small amount of sample in the sample cup (item 12 diagram). Slide the sample cup cap into place. (Item 11 diagram)

Insert the sample cup assembly into the AeroDisperser and seal it into place by rotating the exposed part of the thumbscrew from left to right. You need only tighten the thumbscrew until the O-Ring at the top of the sample cup is compressed.

Press F2 Sample Details and enter the information you wish to have stored with the data.

Press F4 and select the sample density from the table. If it is not present you may add it to the list by pressing a small "a" and then entering the sample name and density when prompted by the software.

Press F7 to start the sample analysis.

As the sample analysis begins the feed percentage is displayed on screen in the lower right hand corner. As the feed is increased the dispersing jet is increased in both strength and duration. It will start out as a very short burst of low pressure air and will increase until it is dispersing sufficient material to satisfy the count rates set up in the Disperser menu. As the sample is consumed the jet will increase to 100%. At this point the sample run is complete.

Press F11 to complete the run and store the data.

1.2 Using The AeroSampler/AeroDryer

Setting up the Aerosizer with the AeroSampler and AeroDryer.

Ensure that the O-Rings are present in the top of the Aerosizer.

Place The AeroDryer on top of the Aerosizer. Line up the relief in the bottom of the AeroDryer with the plunger that sticks up from the Aerosizer.

Remove the Heater Cap from the AeroDryer using a 9/64" Allen wrench to unfasten the four screws fastening the cap to the dryer.

Attach the AeroDryer to the Aerosizer using a 7/64" Allen wrench to tighten the three screws down in the recessed holes in the AeroDryer. Caution: Do not over tighten the screws as this may strip the threads in the Aerosizer Sonic Nozzle Housing.

Attach the Heater Cap to the AeroDryer.

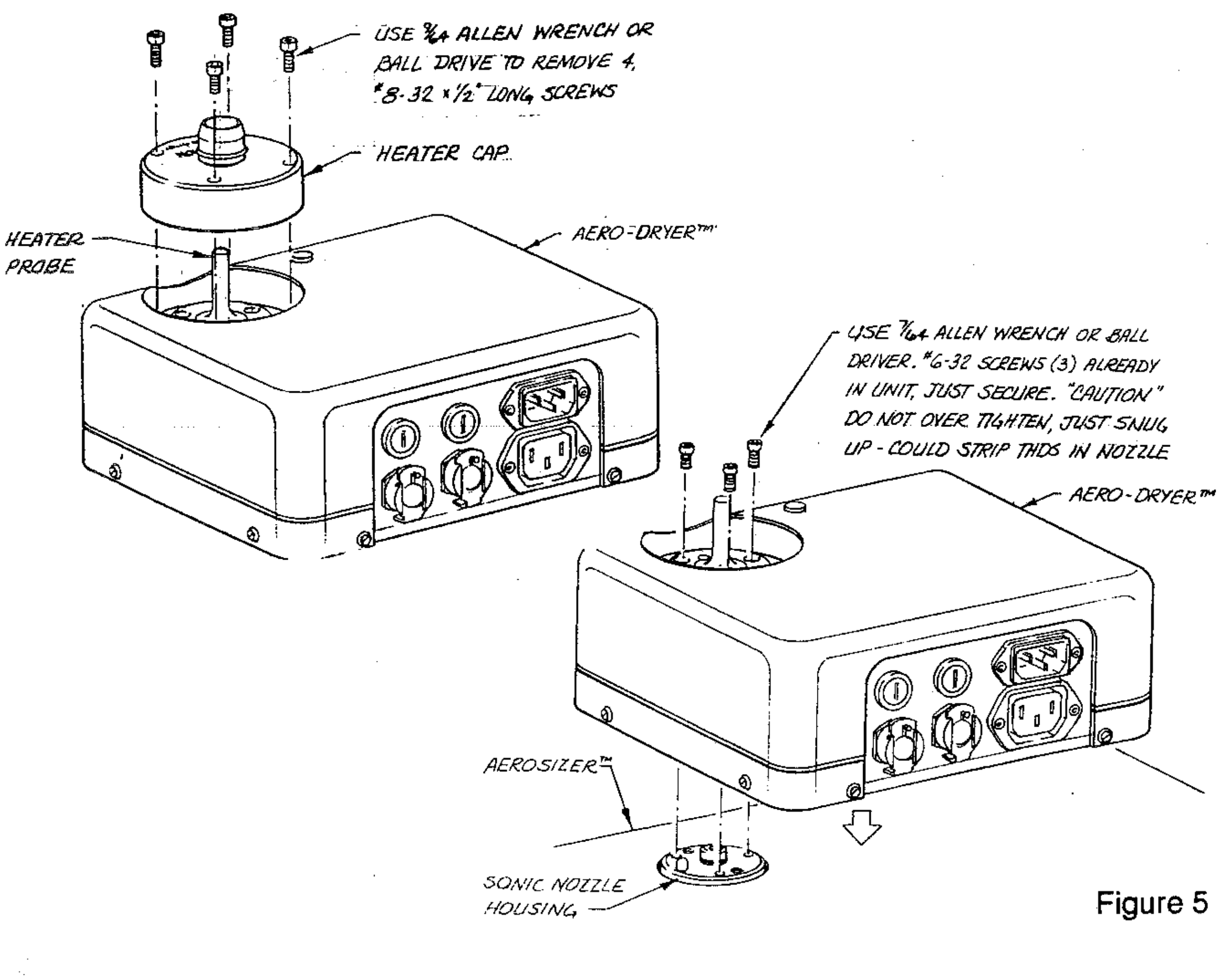


Figure 5

Connect the power cord from Aerosizer power out connector to the AeroDryer Power In.

Connect the vacuum lines to the AeroDryer. There are two possible connection arrangements. The recommended connection utilizing house vacuum when available is shown in this first illustration:

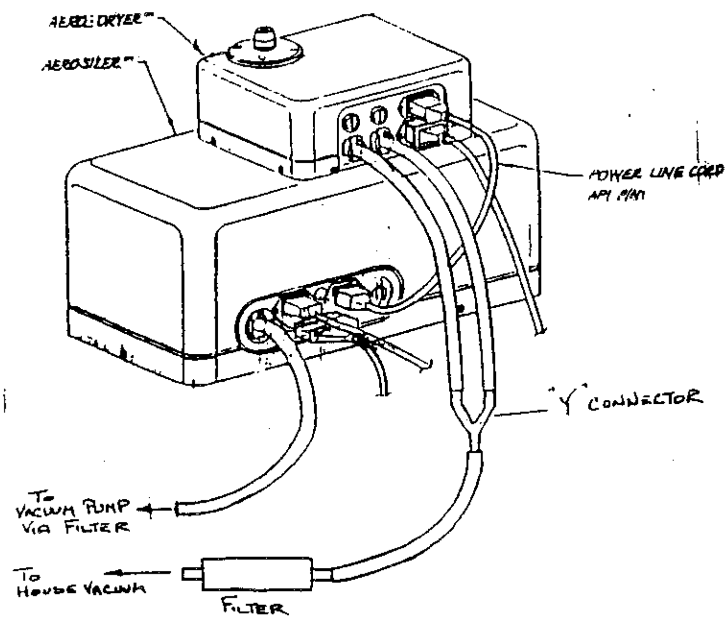


Figure 6

The second option is shown here. This option has shown a tendency to allow material to backstream though the vacuum system during the purge operation. This material backstreams into the Aerosizer Vacuum Chamber resulting in material deposition on the optical surfaces in the Chamber. This will necessitate frequent cleanings of the optics and is therefor less desirable than the first option.

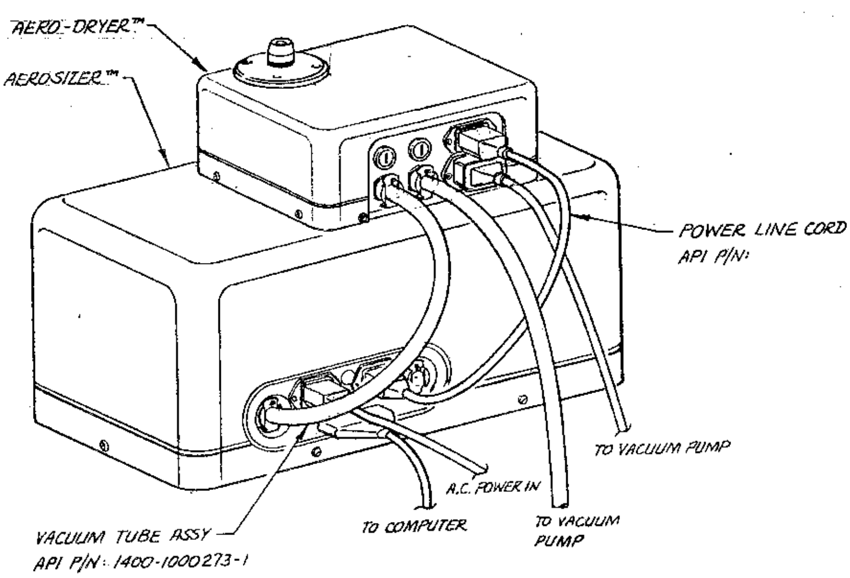


Figure 7

Install the AeroSampler onto the AeroDryer.

From the main menu Press Ctl-S to access the set-up menu as shown below:

```
COMMAND

F1     Return to Main Menu
F2     Graphics Mode                IBM   EPSON   HPLJ   DeskJet C
F3     Dual Sensitivity             OFF   ON
F4     Noise Threshold(Sigmas)        6.0
F5     Sampler Purge time (Sec)      59.9
F6     PMT Voltage                   1100
F7     Clock Frequency              20 MHz   40 MHz
F8     Aerodiluter Present?         NO   YES
F9     Mass Load. Count Eff.          1.00
F10    Sample Presentation          Pulse Jet   Sampler   Breather   Disperser
F11    Particle Count               Absolute   Relative
F12    Set Run Parameters           MANUALLY   AUTOMATICALLY
Alt F1 Nozzle Type                  200um      700um
Alt F2 Display Range                0.1-200um      0.5-700um
Alt F4 Baseline Offset (0-3.0)       0.1
Alt F5 Channels in Baseline           55
Alt F6 AutoSave during run?         NO   YES
Alt F7 Overwrite Scans?             NO   YES
Alt F8 Log Plot Resolution?         Low   High
```

Figure 8

Press F4 and set the Noise Threshold to 6.0, Press <Enter>

Press F5 and set the sampler purge time to 60 seconds. Press <Enter>

Press F6 and set the PMT Voltage to 1100 volts, Press <Enter>.

Press F10 and use the <leftarrow> or <rightarrow> to highlight the Sampler option. Press <Enter> .

Press ALT - F1 and Select the 200um nozzle

Press ALT - F2 and Select the 0.1 - 200 um display range.

Press ALT - F4 and set the Baseline Offset to 0.1, Press <Enter>.

Press ALT - F5 and set the Channels in Baseline to 55, Press <Enter>.

Press F1 to return to the Main Menu.

Press **F2** and **Enter the Sample Details**

Press **F3** to Set up the **AeroSampler Controls**

A typical set up is shown below

```
                  Aero-Sampler Control

 Automatic Purge:  OFF  ON
 Heater         :  OFF  ON
```

Figure 9

With the Heater ON the core of the AeroDryer is heated to 100 deg C to flash off any propellants

Purge ON will open a solenoid valve at the end of the run to purge the AeroSampler at the end of the run.

To change any of the settings;

press the **arrow keys** to highlight the appropriate line and press **<Enter>**.

4. Press **F4** and Select the **Density**

   Use the **<up-arrow>** and **<down-arrow>** to navigate through the list.

   Press **<enter>** to select the material at the cursor location.

   Press **a** if you need to add an item to the list.

5. Press **F6** to elect the **Display Type**

   Use the **<left-arrow>** and **<right-arrow>** to navigate **between** subblocks.
   Use the **<up-arrow>** and **<down-arrow>** to navigate **within** subblocks.

6. Press F10 for program measurements

Use the arrow keys to set up a program measurement of 30 seconds as illustrated below:

Program Measurements			
Multiple Runs	:	MANUAL	PROGRAM
Number of Runs	:		1
Nominal Run Length (sec)	:	30	
Run Spacing (sec)	:	0	

Figure 10

Actuate the MDI into the AeroSampler and press **F7** to **Start the Measurement**

Within a few seconds, you will see the particle size distribution on the screen. The distribution will at first be rough because only a few particles have been measured, but will smooth out after a larger number of particles has been measured. The run should complete after 30 seconds. (If it does not press **F11** to complete the run and verify the settings in Main menu F10 above.)

After completing a measurement, the computer will display the run. You can now examine the data carefully using the key strokes described in Section 2.1.1, Display manipulation.

The AeroDryer purge valve will open for the set purge length at the completion of the run. The Aerosizer program will not allow another measurement until the purge is completed.

1.3 Using the AeroBreather

Attach the Feed Adapter to the Aerosizer™. Attach the Sampling Tower and Sample Inlet Port to the Manifold Head if not already attached. Place the AeroBreather™ on top of the Aerosizer™ as indicated in the following drawing:

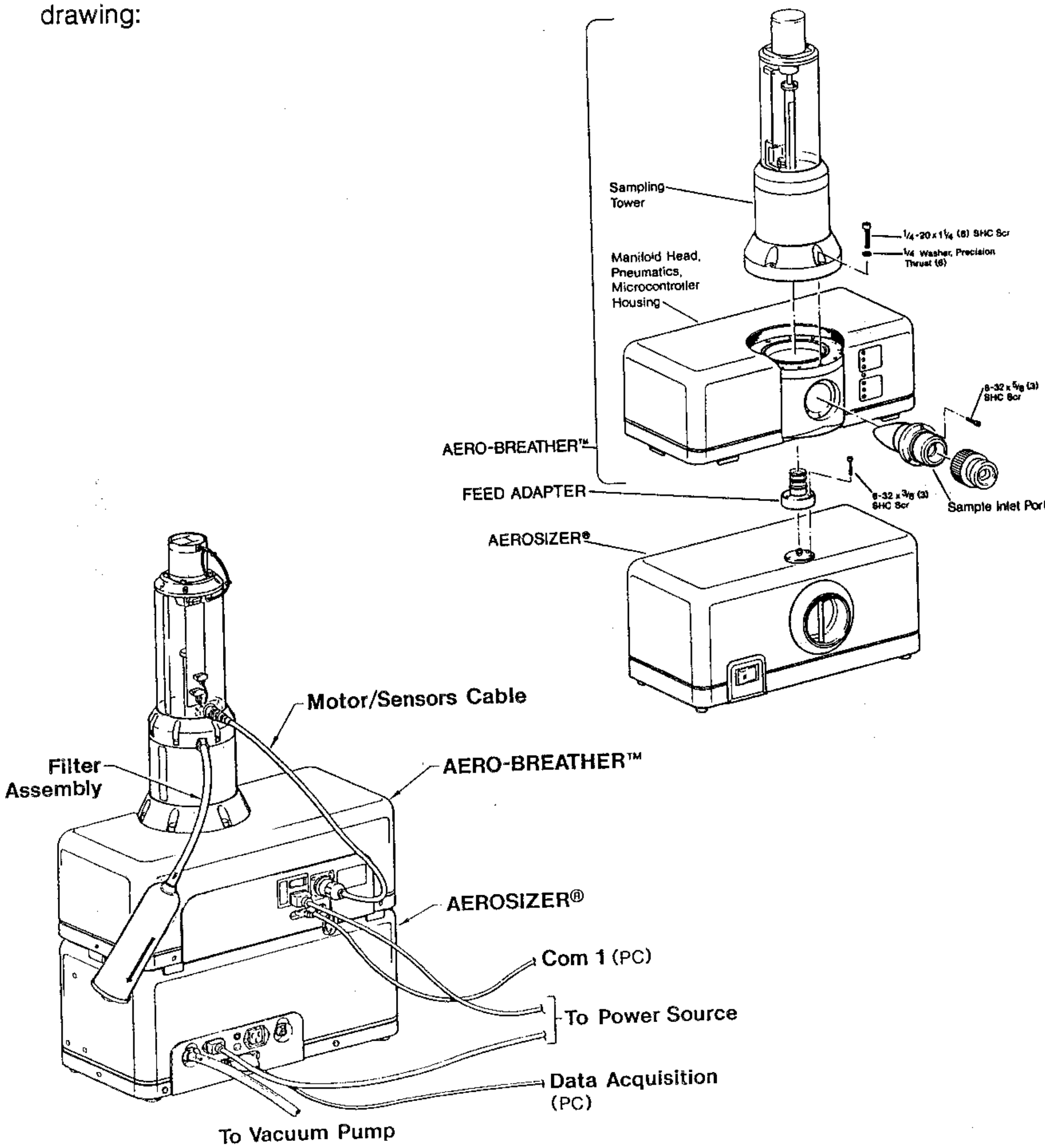


Figure 11

Connect the computer interface and power as indicated.

Power up the Computer, Aerosizer, and AeroBreather. From the main menu of the Aerosizer program go to the set-up screen by pressing CTL-S. The following screen should appear:

COMMAND

F1	Return to Main Menu	
F2	Graphics Mode	IBM EPSON HPLJ DeskJet C
F3	Dual Sensitivity	OFF ON
F4	Noise Threshold(Sigmas)	6.0
F5	Sampler Purge time (Sec)	59.9
F6	PMT Voltage	850
F7	Clock Frequency	20 MHz 40 MHz
F8	Aerodiluter Present?	NO YES
F9	Mass Load. Count Eff.	1.00
F10	Sample Presentation	Pulse Jet Sampler Breather Disperser
F11	Particle Count	Absolute Relative
F12	Set Run Parameters	MANUALLY AUTOMATICALLY
Alt F1	Nozzle Type	200um 700um
Alt F2	Display Range	0.1-200um 0.5-700um
Alt F4	Baseline Offset (0-3.0)	0.0
Alt F5	Channels in Baseline	55
Alt F6	AutoSave during run?	NO YES
Alt F7	Overwrite Scans?	NO YES
Alt F8	Log Plot Resolution?	Low High

Figure 12

Press F4 and set the Noise Threshold to 6.0, Press <Enter>

Press F6 and set the PMT Voltage to 850 volts, Press <Enter>.

Press F10 and use the <left arrow> or <right arrow> to highlight the Breather option. Press <Enter> .

Press ALT - F1 and Select the 700um nozzle

Press ALT - F2 and Select the 0.5 - 700 um display range.

Press ALT - F4 and set the Baseline Offset to 0, Press <Enter>.

Press ALT - F5 and set the Channels in Baseline to 55, Press <Enter>.

Press F1 to return to the Main Menu.

Press **F2** and **Enter the Sample Details**

Press **F3** to Set up the **AeroBreather Controls**

A typical set up is shown below

```
              Aero-Breather Control
 ------------------------------------------------
 Breath Rate (l/min)         : 60.0
 Breath Volume (l)           :  1.0
 Acceleration (l/sec^2)      : 19.0
```

Figure 13

The user can enter three parameters:

1. **Breath Rate** up to a maximum of 120 liters/minute. This will determine the maximum velocity of the piston.

2. **Breath Volume** up to a maximum of 1 liter. This determines the total distance the piston will travel.

3. **Acceleration** up to a maximum of 19 liters/sec^2. Determines the rate at which the piston will accelerate to the Breath Rate set.

To change any of the settings press the **arrow keys** to highlight the appropriate line enter the desired value and press **<Enter>**.

4. Press **F4** and Select the **Density**

   Use the **<up-arrow>** and **<down-arrow>** to navigate through the list.

   Press **<enter>** to select the material at the cursor location.

   Press **a** if you need to add an item to the list.

5. Press **F6** to elect the **Display Type**

   Use the **<left-arrow>** and **<right-arrow>** to navigate **between** subblocks.
   Use the **<up-arrow>** and **<down-arrow>** to navigate **within** subblocks.

6. Press F10 for program measurements

Use the arrow keys to set up a program measurement of 30 seconds as illustrated below:

```
              Program Measurements

Multiple Runs                 :  MANUAL  PROGRAM
Number of Runs                :             1
Nominal Run Length (sec)      :     30
Run Spacing        (sec)      :      0
```

Figure 14

Place the device in the Inlet to the AeroBreather and press **F7** to **Start the Measurement**

Within a few seconds, you will see the particle size distribution on the screen. The distribution will at first be rough because only a few particles have been measured, but will smooth out after a larger number of particles has been measured. The run should complete after 30 seconds. (If it does not press **F11** to complete the run and verify the settings in Main menu F10 above.)

The program will prompt the user to remove the device from the inlet and press a key to return the piston to the home position.

After returning the piston to the home position the computer will display the run. You can now examine the data carefully using the key strokes described in Section 2.1.1, Display manipulation.

The AeroBreather may also be used with the AeroDisperser auxiliary pump to resuspend large particles (larger than 30 microns aerodynamic diameter). To use the AeroDisperser pump with the AeroBreather:

Attach the pump activating hose (small tubing with one non color coded quick disconnect and one orange quick disconnect) from the Aerosizer Compressed Air Out to the AeroDisperser pump.

Attach the AeroDisperser Transport Air Tube (Large hose with quick disconnect fittings) to the AeroDisperser Pump. Leave other end free.

Go to F10 and set up for manual run mode.

Press F7 to initiate a run.

The AeroDisperser pump should start as data collection begins.

Monitor the count rates on screen during data collection. When the count rates have decreased to less than 1000 counts per second remove the breath activated device from the inlet to the AeroBreather and insert the free end of the AeroDisperser Transport Air Tube into the AeroBreather. Sweep the air stream around the interior of the AeroBreather. You should observe increased count rates until all the material has been resuspended and sampled through the Aerosizer.

After the material has been resuspended and sampled remove the Transport Air Tube from the AeroBreather and press F11 to store the data.

The data may now be analyzed as usual.

1.4 Using the Pulse Jet Disperser

1. **Set up** the Aerosizer to run the Pulse Jet Disperser

   Physically attach the Pulse Jet Disperser to the Aerosizer

   Set up Aerosizer program to run with the Pulse Jet Disperser. From the Main menu press

   <Ctl>-s then F**10**

   Use the **<left-arrow>** and **<right-arrow>** keys to highlight **Pulse Jet**

2. Press **F2** and **Enter the Sample Details**

3. Press **F3** to Set up the **Pulse Jet Disperser Controls**

```
                    Pulse Jet Control
---------------------------------------------------------
Disp. flow  pres.    50.0   Incr.    0.0
Disp. pulse pres.     0.0   Incr.    0.5
Nebulizer pressure    0.0   Incr.    0.0
Minimum count rate above background:   4000
Maximum count rate above background:   8000
```

Figure 15

   The figure above shows the recommended settings. To change any of the settings;

   press the **arrow keys** to highlight the appropriate line

   type in the new number, and press **<Enter>**.

4. Press **F4** and Select the **Density**

   Use the **<up-arrow>** and **<down-arrow>** to navigate through the list.

Press **<enter>** to select the material at the cursor location.

Press **a** if you need to add an item to the list.

5. Press **F6** to elect the **Display Type**

Use the **<left-arrow>** and **<right-arrow>** to navigate **between** subblocks.
Use the **<up-arrow>** and **<down-arrow>** to navigate **within** subblocks.

6. **Clean the Disperser.**

It is very important that before making a measurement all traces of the previous sample have been cleaned out of the disperser and sample cup. Section 8 describes appropriate cleaning procedures.

7. **Load the Sample**

Place some of the new sample into a clean sample cup and insert the sample cup into the disperser. The amount of sample you will need depends on the mean particle size, width of the sample size distribution, and accuracy of measurement you require. To illustrate this point, consider that a sample containing a million particles each 1 micrometer in diameter will have a volume of about 0.001 microliter, while the same number of 100 micron particles will occupy a volume of about 1 milliliter, a factor 1,000,000 times larger! After a little experimentation you will find a "reasonable" amount of sample to use for the different types of sample you encounter in operating your Aerosizer™.

8. press **F7** to **Start the Measurement**

Within a few seconds, you will see the particle size distribution on the screen. The distribution will at first be rough because only a few particles have been measured, but will smooth out after a larger number of particles has been measured. If you are in an automatic run time mode (F10, Main Menu) the measurement will be completed automatically. Otherwise you will need to complete the run manually by pressing **F11**

After completing a measurement, the computer will display the run. You can now examine the data carefully using the key strokes described in Section 2.1.1, Display manipulation.

2. SCREEN DISPLAYS AND REPORTS.

The Aerosizer software provides a variety of formats for the information to be contained in the screen displays and printed reports.

2.1. Screen Displays.

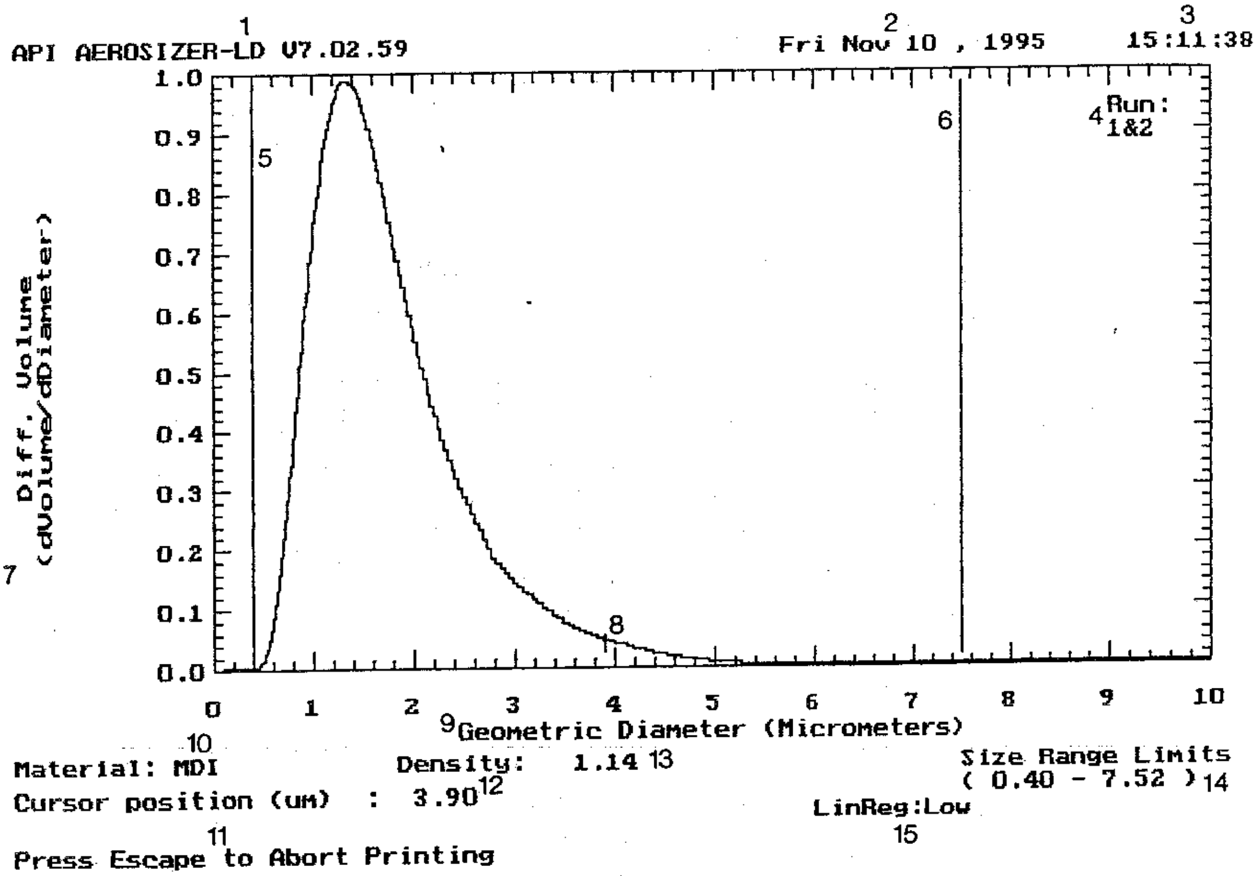


Figure 16

A typical screen display is shown in Figure 13. Each of the features of the display are numbered. The following descriptions give the significance of the corresponding feature.

1. The software version used to analyze the sample.

2. The date the data was acquired.

3. The time the data was acquired.

4. The sample run number. Both high and low sensitivity run numbers will appear with a & character between them if combine is on (example 7&8).

5. This vertical line is the upper size limit used in the statistical calculations, only data that is below this size will be used in the computation. It appears on the screen as a gray line (refer to Section 3.1.3).

6. This vertical line is the lower size limit used in the statistical calculations, only data that is above this size is used in the computation. It appears on the screen as a red line (refer to Section 3.1.3).

7. The data can be displayed on the vertical axis by number, volume, surface area or time-of-flight (refer to Section 5.2.5).

8. Cursor used to set Size Limits (F5 , F6) and set the center of display zooms, both horizontal and vertical.
(Linear display only)

9. The data can be displayed as a function of aerodynamic or geometric diameter (refer to Section 5.2.5.).

10. The sample material description is shown here.

11. Several function keys are active while displaying run(s). They are shown at the bottom of the screen. (Other keys to perform display manipulations are active as well. These keys are described in detail in Section 3.1.1) The Active Function keys are:

F1	Menu	Returns to Main Menu
F5	Low Size	Sets Lower Size Limit to the cursor position
F6	High Size	Sets Upper Size Limit to the cursor position
F7	Run	Starts a new run or continues the current run
F8	Print	Prints selected graph and tables to printer
F9	Info	Displays Run Information Section on screen
F10	Listing	Displays Size Distribution table on screen
F12	Export	Exports Selected Run Information and Size Table to spreadsheet file for further analysis

12. Cursor position in micrometers.
(Linear display only)

13. Density used to calculate the particle size distribution

14. Shows current size limits set by F5 and F6

15. Analysis configuration settings for the selected run are shown here. (If multiple runs are displayed you may toggle from run to run by using the spacebar)

2.1.1 Display Types

The displayed analysis may be changed either in the F6 dialog box from the main menu or directly while the display is on screen. The Aerosizer software will calculate either a Number, Volume, or Surface Area distribution and will also display the Time of Flight data. The distributions can be calculated as either Aerodynamic or Geometric Diameters. Plot Modes available are Histogram, Cumulative Under, and Cumulative Over on either Linear or Log Scale. Up to 5 runs may be displayed together as an overlay, A list of display options appears further on in this section.

Distribution Types

The basic measurement made by the Aerosizer counts particles by their Time of Flight. The Time of Flight distribution is collected in 2048 linearly spaced time channels. The Aerosizer program can display the raw Time of Flight data or three different types of particle size distributions: a Number distribution, a Surface Area Distribution, or a Volume Distribution. Each of these distributions is calculated from the Time of Flight distribution and assumes a spherical particle shape. The Time of Flight is converted to particle size by the Aerosizer proprietary software and placed in 500 Logarythmically spaced size bins.

The Number Distribution.

In this distribution, the number of particles in each size bin is reported with the results normalized to the bin containing the highest value. The total number of particles considered in the distribution, reported as the Sum of Channels, is determined by adding up the numbers in all of the size bins. The percentage of the total number of particles in each size bin is determined by dividing the number in each bin by the total number of particles in all bins.

The Surface Area Distribution.

This distribution displays the relative surface area for the particles in each size bin. The display is normalized to bin with the largest surface area. The Surface Area is calculated by multiplying the number of particles in each size bin by the square of the diameter at the center of that range. The percentage of the total surface area in each size bin is determined by dividing the surface area calculated for each size bin by the total surface area of all size bins.

One particle of 100 micrometers diameter has the same surface area as 10,000 particles of 1 micrometer diameter, so this distribution emphasizes the large particles more than the number distribution.

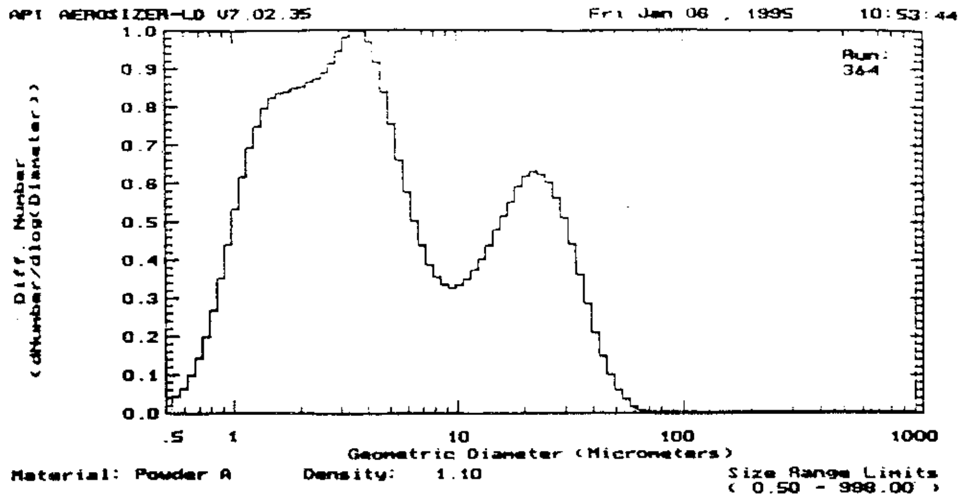
The Volume Distribution.

This distribution displays the relative volume for the particles in each size bin. The display is normalized to bin with the largest volume. The Volume is calculated by multiplying the number of particles in each size bin by the cube of the diameter at the center of that range. The percentage of the total volume in each size bin is determined by dividing the volume calculated for each size bin by the total volume of all size bins.

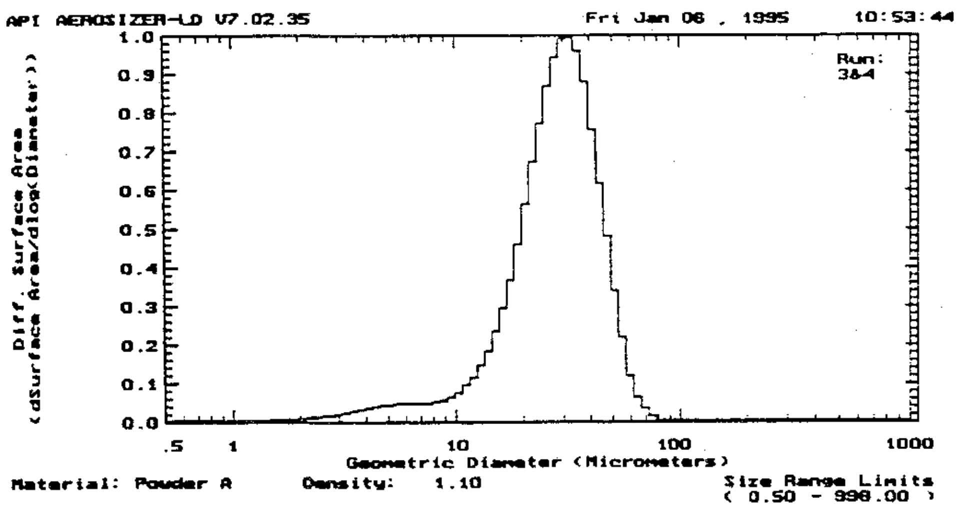
1 particle of 100 micrometers diameter has the same volume as 1,000,000 particles of 1 micrometer diameter, so this distribution emphasizes the large particles even more than the Surface Area distributions.

The following page shows the different distribution types for the same sample.

NUMBER DISTRIBUTION



SURFACE AREA DISTRIBUTION



VOLUME DISTRIBUTION

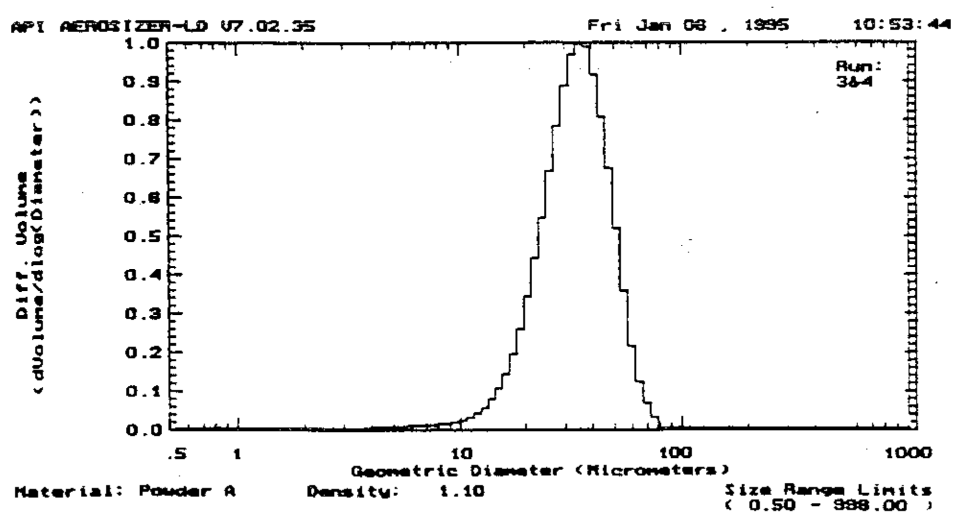


Figure 17

Diameter Type

Geometric Diameter is the equivalent spherical diameter of a particle with the same density as the measured particle that would be measured physically by either manual or optical means.

Aerodynamic Diameter 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.

Plot Mode

Histogram provides a histogram of the particle distribution by whatever distribution type and diameter type that has been selected.

Cumulative Under plots the distribution by the percentage of particles that are smaller in size than the stated size on the x-axis.

Cumulative Over plots the distribution by the percentage of particles that are greater in size than the stated size on the x-axis.

Plot Scale

Distributions may be plotted on either a Logarithmic or Linear Scale. **Log Scale** displays all the data from 0.1 to 200 microns or from 0.5 to 1000 microns depending on the Range selected. Zooms, both vertical and horizontal, are not implemented in Log Scale. **Linear Scale** displays data in a window with width from 2 to 1000 microns. Linear Scale supports all available display features.

Normalization

Individual and Group Normalization are effective when displaying more than one run. **Individual** Normalization normalizes the highest channel in each distribution to one and scales the rest of the distribution accordingly. **Group** Normalization normalizes the highest channel of all the selected runs to one and scales all the distributions accordingly.

Regularization

Regularization provides for mathematical stabilization of the transform from Time of Flight to Particle Size. You can display data on the screen at three different Regularization levels: Off, Low and High. **Off** applies no Regularization to the data and is generally used for monodisperse samples. **Low** provides a moderate amount of Regularization and is most of the time for slightly broad or unknown samples. **High** provides the maximum amount of Regularization and is used for very broad distributions whose volume distributions appear chopped on the right hand side.

Why We (and others) Apply Linear Regularization

The Aerosizer™ actually measures time-of-flight (TOF) distributions. The geometric distribution is created via a transformation from TOF to size. As in many such transformations (i.e., Laser Diffraction's converting of light intensities into sizes), the exact transformation operator may be slightly ill-conditioned yielding a mildly unstable (unsmooth) result. Laser Diffraction constrains its transformation through **Linear Regularization** (also called Phillips-Twomey, Tikhonov-Miller, constrained linear inversion). They do this by adding a stabilizing constraint into their transformation matrix prior to solving their system of equations.

What We Do

The Aerosizer™ does not perform the TOF to size transformation as a matrix operation (although it could). A matrix to convert 2048 channels of TOF into 500 channels of size would require too much memory. Therefore, the current channel by channel conversion is performed prior to the linear regularization - which is applied directly to the size distribution. To do this, an identity matrix is viewed as the transformation operator that converts 500 channels of size data into 500 channels of size data.

What Linear Regularization Does

Performing a channel-by-channel conversion of the TOF distribution into a size distribution yields a ragged-looking distribution. This is due to the instability of the conversion from 2048 channels of linearly-spaced TOF data to 500 channels of logarithmically spaced sizes. This raggedness is often magnified in viewing the volume distributions of broad samples.

If one were to take this ragged size data and evenly distribute all measured counts across the entire size domain, one would produce a perfectly smooth, yet unrealistic, distribution. The total number of counts would be conserved but all characteristics of the distribution would be erased.

Linear Regularization performs an optimization constrained by the two procedures - converting TOF to size and data smoothing - through use of minimization with Lagrangian Multipliers. It generates the optimal balance between a raw conversion and a perfectly flat distribution while conserving the total counts. Each level of Regularization (***off***, ***low*** or ***high***) applies a different Lagrangian Multiplier to the smoothness constraint in the optimization. The calculations necessary to perform the Linear Regularization reduce to an extremely simple and rapidly solved system of equations.

Which Regularization is Right for You?

Low regularization is the most commonly used configuration. However, there are certain times when either ***off*** or ***high*** are recommended. The following list should assist in determining which level to choose.

off (F) When one might expect spiky results. Examples: monodisperse samples, tight samples, calibration standards.

low (M) Most of the time while running slightly broad or unknown samples.

high (C) With very broad samples whose volume distributions appear "chopped" on the right-hand side.

Gaussian Extension

The Aerosizer™ measures the size of particles, one at a time, as they traverse a pair of laser beams. Accumulating these particle size measurements makes up a number distribution. By contrast, such techniques as sieving and diffraction analysis measure the size distribution of a group (or volume, or mass) of particles simultaneously. Accumulating these measurements yields a mass or volume distribution. Converting between these two distributions, number and volume, generates instability in the extreme sizes; converting from volume to number is highly unstable in the small particle counts and converting from number to volume is highly unstable in the large particle volume.

Many techniques of particle generation yield distributions that have a somewhat log-normal (gaussian on a logarithmic scale) shape. Additionally, a log-normal distribution maintains its gaussian shape as it is converted into any other popular logarithmically scaled size distribution.

The API utility named **Gaussian Extension** takes advantage of these facts. It fits the large sized particles in a number distribution to a log-normal curve. This guarantees that the volume distribution will also have a log-normal shape in the large particle range.

When measuring materials whose distribution is expected to be somewhat bell-curved, applying the Gaussian Extension will aid in converting a bell-shaped number distribution into a bell-shaped volume distribution. To activate this utility, type the letter **E**. To turn this function off, type **E** again. The Gaussian Extension utility can only be applied to scans using combined data and can not be applied to scans during a run.

Display Manipulation

The display type may be selected from the F6 dialog box (shown below) prior to initiating or analyzing a run.

Plot Scale	Plot Mode
Linear Logarithmic	Histogram Cumulative Under Cumulative Over
Distribution Type	**Regularization**
Number Area Volume Time of Flight	Off Low High
Diameter Type	**Normalization**
Geometric Aerodynamic	Individual Group

Figure 18

All options (with the exception of Regularization level and normalization while running) are available while displaying data by pressing certain keys. A list of active keys is provided below. Note: the commands are case sensitive so you must use upper case (capital) letters where specified and lower case (small) letters where specified.

Display Mode Action Keys

<u>**KEY**</u>	<u>**ACTION**</u>
l(lower case L)	toggles between **L**inear and Log Scale
N	displays **N**umber Distribution
S	displays **S**urface Area Distribution
V	displays **V**olume Distribution
T	displays **T**ime of Flight Distribution
A	toggles between **A**erodynamic and Geometric Diameter
D	displays Histogram **D**istribution plot
>	displays Cumulative Over plot
<	displays Cumulative Under plot
I(Uppercase i)	**I**ndividual Normalization
G	**G**roup Normalization
E	toggles Gaussian **E**xtension on and off
F	Regularization Off
M	Low Regularization
C	High Regularization
R	changes display **R**ange (toggles between 0.1-200 and 0.5-700)

Zooms and Windows

When using a linear scale, six keys are used to expand or contract the particle size graph in both axis.

<up-arrow>	changes to the next finer display range (example: changes from 0-10 micrometer range to 0-5 micrometer range).
<down-arrow>	changes to the next coarser display range (example: changes from 0-5 micrometer range to 0-10 micrometer range).
Shift <right arrow>	moves the display region to the right by 1/2 display range, keeping the display range constant (example: changes from 0-10 micrometer display to 5-15 micrometer display).
Shift <left arrow>	moves the display region to the left by 1/2 display range, keeping the display range constant. (example: changes from 10-20 micrometer display to 5-15 micrometer display).
Shift <up-arrow>	changes to the next more sensitive display height (example: changes from 0-1.0 height to 0-0.5 height). Not active during data collection.
Shift <down-arrow>	changes to the next less sensitive display height (example: changes from 0-0.5 height to 0-1.0 height). Not active during data collection.

2.1.2. The Cursor.

The portion of the display shown when using these commands is determined by the position of the cursor. The computer will always try to center the cursor on the new graph by adjusting the portion of the horizontal and vertical axes to be shown, with the axes limited in width from 2 (smallest window) to 1000 (largest window) micrometers and limited in height from 0.01 (smallest window) to 20.0 (largest window). You should always place the cursor at the center of the position of the graph that is of most interest to you. That part of the graph will then be centered on the computer screen for all horizontal and vertical scales.

The cursor is active only when examining stored or recently acquired data in the linear display mode. Four commands are used to control the cursor. They are:

<right arrow> moves the cursor to the right.

<left arrow> moves the cursor to the left.

Home moves the cursor to the left end of the graph. If you press this key twice, the region of the graph presented 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 presented will end at 200 or 1000 depending on the range selected.

The cursor position is reported at the bottom of the screen.

2.1.3. Lower and Upper Size Limits (F5, F6).

The lower and upper size limits are used to isolate specific sections of the distribution for analysis. They will limit the size range for the calculation of the Geometric Mean Diameter, Geometric Standard Deviation, and other statistical calculations. (refer to Section 2.2.1. for a description of these quantities) as well as both particle size distribution tables. The number of particles in all size bins outside the range is set to zero. The current size limits are displayed in the lower right hand portion of the screen.

To set the lower size limit, move the cursor to the desired lower limit position and

press F5.

A red vertical line will appear at the lower size limit.

To set the upper limit, move the cursor to the desired position and

press F6.

A gray vertical line will appear on the screen at the upper size limit selected. The limit lines will always appear if they are within the size range displayed.

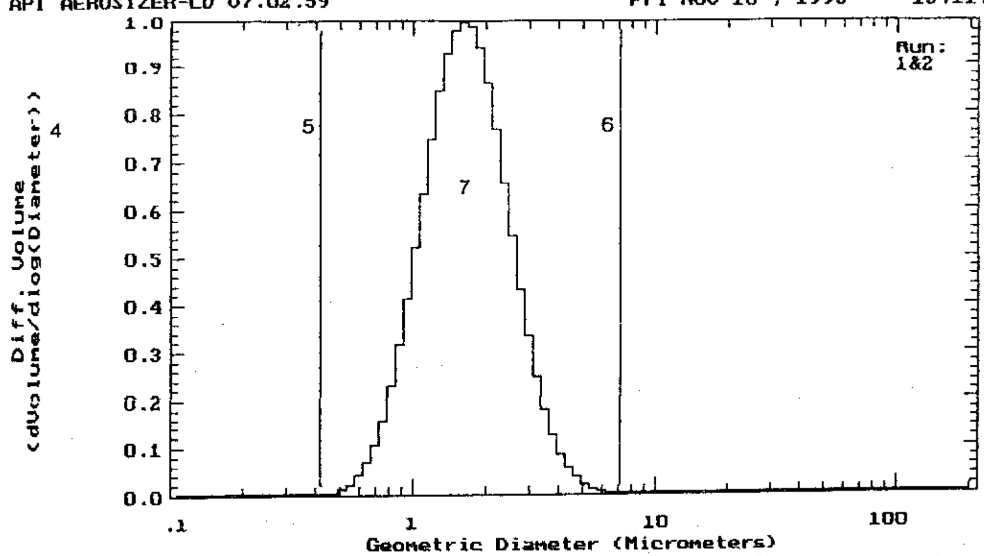
An example of how the upper and lower limits can be used to aid in analysis can be found in Application Note Number 8 which is located at the end of this manual.

2.2. Report Format.

A copy of a printed report is shown in Figure 19. Each of the important features of the report is numbered.

The contents of the text file header.api prints here. 1

API AEROSIZER-LD V7.02.59 (2) Fri Nov 10 , 1995 (3) 15:11:38



8 9

Directory: c:\api Run 1 taken on Fri Nov 10 15:11:38 1995 VOLUME DISTRIBUTION BY GEOMETRIC DIAMETER
MDI Bronchodialater 10 Regularization: Low, Gaussian Extension On
12

11

13 PARAMETERS		14 DISPERSER CONTROL		%UNDER	SIZE 15	%UNDER	SIZE
Material	: MDI	Disperser Type :	Pulse Jet	5%	0.8685	55%	1.752
Density	: 1.14	Flow Pressure :	0.0	10%	0.9971	60%	1.845
Run Length (sec)	: 67.9	Flow Increment :	0.0	15%	1.098	65%	1.946
PMT Voltage (volts)	: 1100.0	Pulse Pressure :	0.0	20%	1.186	70%	2.059
Laser Current (mA)	: 114.7	Pulse Increment:	0.0	25%	1.268	75%	2.189
Clock Freq (MHz)	: 40.0	Nebulizer Press:	0.0	30%	1.347	80%	2.343
Sum of channels	: 3674376	Nebulizer Inc :	0.0	35%	1.425	85%	2.536
Lower Size Limit	: 0.42	Low Flow Limit :	4000	40%	1.503	90%	2.802
Upper Size Limit	: 7.22	High Flow Limit:	10000	45%	1.582	95%	3.247
Nozzle Type	: 200um	SCANS 1 AND	2 COMBINED	50%	1.665		
Baseline Offset	: 0.10	BETWEEN 2.2 &	2.7 MICRONS				
Noise Filter	: 6.00						
Mean Size	: 1.670 16	D(4,3) :	1.810	Mode (Log Scale) :			1.65
Standard Deviation	: 1.493	D(3,2) :	1.543	Spec surf area:			3.41 sq meter/g

17

UPPER SIZE	% IN	LOWER SIZE	% UNDER	UPPER SIZE	% IN	LOWER SIZE	% UNDER	UPPER SIZE	% IN	LOWER SIZE	% UNDER	UPPER SIZE	% IN	LOWER SIZE	% UNDER
				100	0.0000	86	100.00	10.0	0.0000	8.6	100.00	1.00	5.3975	0.86	4.7312
				86	0.0000	74	100.00	8.6	0.0000	7.4	100.00	0.86	2.8694	0.74	1.8618
				74	0.0000	63	100.00	7.4	0.0363	6.3	99.964	0.74	1.3584	0.63	0.5034
				63	0.0000	54	100.00	6.3	0.1379	5.4	99.826	0.63	0.4160	0.54	0.0874
				54	0.0000	46	100.00	5.4	0.4332	4.6	99.393	0.54	0.0821	0.46	0.0053
				46	0.0000	40	100.00	4.6	0.9340	4.0	98.459	0.46	0.0053	0.40	0.0000
				40	0.0000	34	100.00	4.0	2.3968	3.4	96.062	0.40	0.0000	0.34	0.0000
				34	0.0000	29	100.00	3.4	4.6540	2.9	91.408	0.34	0.0000	0.29	0.0000
				29	0.0000	25	100.00	2.9	7.2429	2.5	84.165	0.29	0.0000	0.25	0.0000
				25	0.0000	22	100.00	2.5	8.7764	2.2	75.389	0.25	0.0000	0.22	0.0000
				22	0.0000	18	100.00	2.2	17.753	1.8	57.636	0.22	0.0000	0.18	0.0000
180	0.0000	160	100.00	18	0.0000	16	100.00	1.8	11.543	1.6	46.093	0.18	0.0000	0.16	0.0000
160	0.0000	140	100.00	16	0.0000	14	100.00	1.6	12.683	1.4	33.411	0.16	0.0000	0.14	0.0000
140	0.0000	120	100.00	14	0.0000	12	100.00	1.4	12.589	1.2	20.822	0.14	0.0000	0.12	0.0000
120	0.0000	100	100.00	12	0.0000	10	100.00	1.2	10.694	1.0	10.129	0.12	0.0000	0.10	0.0000

Figure 19

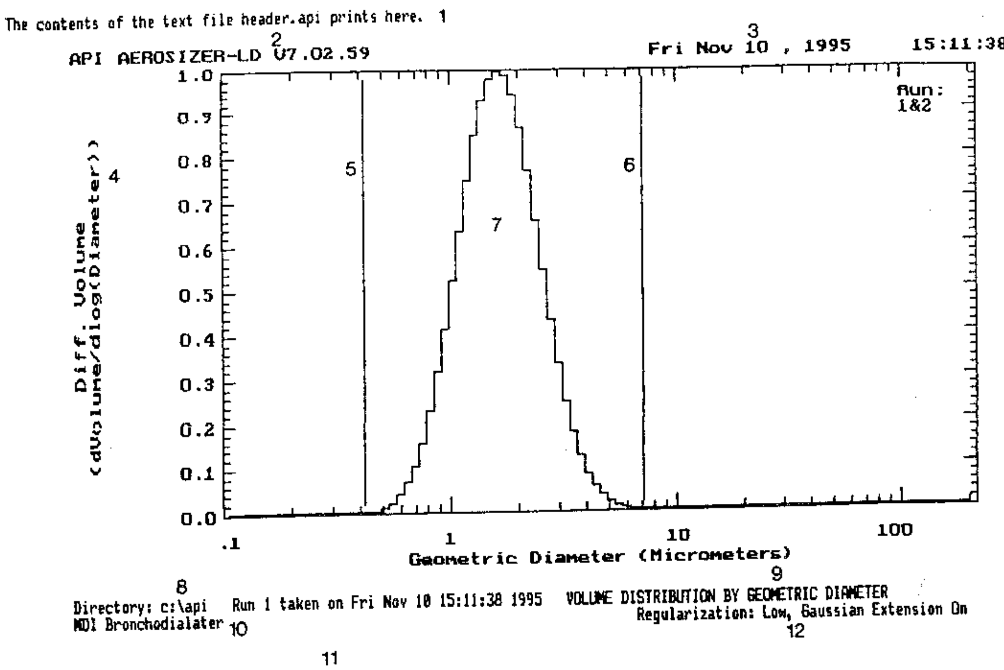


Figure 20

1. The information stored in the file header.api is printed here. This file can be edited using the DOS editor.
2. The Software version used for the analysis.

3. The Date and Time the data was acquired.

4. The distribution type and display type are indicated. The data may be displayed as a number, volume, surface area or time-of-flight distribution in histogram, cumulative under or cumulative over format. (Refer to section 4.2.5.)

5. This vertical line is the upper size limit used in the statistical calculations, only data that is below this size is used in the computation. (refer to Section 3.1.3).

6. This vertical line is the lower size limit used in the statistical calculations, only data that is above this size is used in the computation. (refer to Section 3.1.3).

7. The Graphical Display selected in display mode is printed.

8. The Data File location (disk drive and subdirectory), Run #, and date and time the run was taken are listed here. (Refer to section 4.2.8.)

9. The tabular data distribution type is stated here.

10. The sample details, entered by the user (F2 Main Menu), are printed here. (Refer to section 4.2.1.)

11. The Flow Rate and Mass Loading results when using the AeroDiluter accessory are shown in this area. The AeroDiluter is used when measuring concentrated aerosols (Refer to the Aero-Diluter Section 4.2.4).

Geometric Diameter (Micrometers)

8 9

Directory: c:\api   Run 1 taken on Fri Nov 10 15:11:38 1995   VOLUME DISTRIBUTION BY GEOMETRIC DIAMETER
MDI Bronchodialater 10   Regularization: Low, Gaussian Extension On
12

11

13 PARAMETERS		14 DISPERSER CONTROL		%UNDER	SIZE 15	%UNDER	SIZE
Material	: MDI	Disperser Type :	Pulse Jet	5%	0.8685	55%	1.752
Density	: 1.14	Flow Pressure :	0.0	10%	0.9971	60%	1.845
Run Length (sec)	: 67.9	Flow Increment :	0.0	15%	1.098	65%	1.946
PMT Voltage (volts)	: 1100.0	Pulse Pressure :	0.0	20%	1.186	70%	2.059
Laser Current (mA)	: 114.7	Pulse Increment:	0.0	25%	1.268	75%	2.189
Clock Freq (MHz)	: 40.0	Nebulizer Press:	0.0	30%	1.347	80%	2.343
Sum of channels	: 3674376	Nebulizer Inc :	0.0	35%	1.425	85%	2.536
Lower Size Limit	: 0.42	Low Flow Limit :	4000	40%	1.503	90%	2.802
Upper Size Limit	: 7.22	High Flow Limit:	10000	45%	1.582	95%	3.247
Nozzle Type	: 200um	SCANS 1 AND 2 COMBINED		50%	1.665		
Baseline Offset	: 0.10	BETWEEN 2.2 & 2.7 MICRONS					
Noise Filter	: 6.00						
Mean Size	: 1.670 16	D(4,3) :	1.810	Mode (Log Scale) :	1.65		
Standard Deviation	: 1.493	D(3,2) :	1.543	Spec surf area:	3.41 sq meter/g		

17

UPPER SIZE	% IN	LOWER SIZE	% UNDER	UPPER SIZE	% IN	LOWER SIZE	% UNDER	UPPER SIZE	% IN	LOWER SIZE	% UNDER	UPPER SIZE	% IN	LOWER SIZE	% UNDER
				100	0.0000	86	100.00	10.0	0.0000	8.6	100.00	1.00	5.3975	0.86	4.7312
				86	0.0000	74	100.00	8.6	0.0000	7.4	100.00	0.86	2.8694	0.74	1.8618
				74	0.0000	63	100.00	7.4	0.0363	6.3	99.964	0.74	1.3584	0.63	0.5034
				63	0.0000	54	100.00	6.3	0.1379	5.4	99.826	0.63	0.4160	0.54	0.0874
				54	0.0000	46	100.00	5.4	0.4332	4.6	99.393	0.54	0.0821	0.46	0.0053
				46	0.0000	40	100.00	4.6	0.9340	4.0	98.459	0.46	0.0053	0.40	0.0000
				40	0.0000	34	100.00	4.0	2.3968	3.4	96.062	0.40	0.0000	0.34	0.0000
				34	0.0000	29	100.00	3.4	4.6540	2.9	91.408	0.34	0.0000	0.29	0.0000
				29	0.0000	25	100.00	2.9	7.2429	2.5	84.165	0.29	0.0000	0.25	0.0000
				25	0.0000	22	100.00	2.5	8.7764	2.2	75.389	0.25	0.0000	0.22	0.0000
				22	0.0000	18	100.00	2.2	17.753	1.8	57.636	0.22	0.0000	0.18	0.0000
180	0.0000	160	100.00	18	0.0000	16	100.00	1.8	11.543	1.6	46.093	0.18	0.0000	0.16	0.0000
160	0.0000	140	100.00	16	0.0000	14	100.00	1.6	12.683	1.4	33.411	0.16	0.0000	0.14	0.0000
140	0.0000	120	100.00	14	0.0000	12	100.00	1.4	12.509	1.2	20.822	0.14	0.0000	0.12	0.0000
120	0.0000	100	100.00	12	0.0000	10	100.00	1.2	10.694	1.0	10.129	0.12	0.0000	0.10	0.0000

Figure 21

12. The Regularization level and use of Gaussian Extension is indicated. (Refer to section 2.1.1.)

13. This section shows the parameters for the sample run. The sample material and density, run length in seconds, the photomultiplier voltage (PMT), laser drive current (or laser intensity for Aerosizer Mach II), the data acquisition clock (20 or 40 MHz). The data acquisition clock and PMT are explained in Section 4.1.

The sum of channels is the total number of particles contributing to the particle size distribution within the size range between the lower and upper size limits. The lower and upper limit values are used to limit the size range for the statistical calculations. (Section 2.1.3)

14. Disperser control settings used (F3, main menu) for the sample measurement are reported. (Refer to Section 4.2.2.)

15. This table provides numerical results showing the particle size for which the indicated percentage of the sample is smaller in size. It shows, for example, the D10%, D50% and D90% values. This table is customizable by entering values into a text file named percent.api.

16. Statistical Data is presented in this block. Calculation of the geometric mean diameter (GMD), the geometric standard deviation GSD, The DeBrouckere or Volume-weighted mean diameter D(4,3), the Sauter or Surface-weighted mean diameter D(3,2), the distribution mode and the Specific Surface Area are provided. (Refer to Section 2.2.1. for an explanation of the Statistical Calculations.)

17. This table displays the data in 50 or 165 size intervals. (see Section 4.2.11) It is used when you want to know the total percentage of the sample under a certain size or the percentage of the sample in a given size range.

2.2.1 Statistical Calculations

Geometric Mean Diameter and Geometric Standard Deviation

The Geometric Mean Diameter (GMD) and Geometric Standard Deviation (GSD) are defined by:

$$\ln(GMD) = \frac{\sum n_i \ln(D_i)}{N}$$

$$\ln(GSD)^2 = \frac{\sum n_i (\ln(D_i) - \ln(GMD))^2}{N-1}$$

where n_i is the number of particles of diameter D_i.
N is the total number of particles.

For a Surface Area Distribution replace
n_i with $s_i = n_i D_i^2$
N with $S = \sum s_i$

For a Volume Distribution replace
n_i with $v_i = n_i D_i^3$
N with $V = \sum v_i$

Often, the particle size distribution is well fitted by a log normal distribution,

$$n(D) = \frac{1}{D\sqrt{2\pi}\ln(GSD)} e^{\frac{(\ln(D_i) - \ln(GMD))^2}{2(\ln(GSD))^2}}$$

over a certain range of particle sizes. To limit the size range for the calculation of GMD and GSD, set the Lower and Upper Size Limit as described in 3.1.3.

D(4,3) and D(3,2)

The D(4,3), Volume Weighted Mean Diameter, and D(3,2), Surface Weighted Mean Diameter are described by the equation below:

$$D_{p,q} = \left[\frac{\sum n_i D_i^p}{\sum n_i D_i^q} \right]^{1/p-q}, p \neq q$$

where n_i is the number of particles of diameter D_i.

Specific Surface Area

The Specific Surface Area is the total surface area of the number of particles whose total volume equals one cubic centimeter. The specific surface area is calculated by:

$$\frac{\sum n_i D_i^2}{\sum n_i D_i^3} \left(\frac{6}{\rho_p} \right)$$

where n_i is the number of particles of diameter D_i and r_p = particle density.

Mode

The Mode is the size bin that contains the largest number.
Number Distribution mode = size bin with greatest n_i
Surface Area Distribution mode = size bin with greatest $n_i D_i^2$
Volume Distribution mode = size bin with greatest $n_i D_i^3$
Time of Flight Distribution mode = Time of Flight. bin with greatest n_i

where n_i is the number of particles and D_i.is the diameter at the center of the Size bin.

3. CONTROLLING THE AEROSIZER.

3.1. Aerosizer Commands.

The Aerosizer is controlled through a series of menus using two types of commands. There are commands used to select the action you wish to take, and commands used to manipulate sample results after completing a measurement so that the region of the size distribution of greatest interest can be examined more closely.

3.1.1. Menu Manipulation.

Each screen permits a number of actions to be taken by pressing one of the F-keys. Frequently an Action Block will appear at the bottom of a screen in response to pressing an F-key. The currently active line within an Action Block will be highlighted (the line will appear as black lettering against a white background). Many Action Blocks contain several sections. The <left-arrow> and <right-arrow> will move the active line from section to section. The <up-arrow> and <down-arrow> will move the active line within the section. To change the active line use the arrow keys on the keyboard to navigate around until the desired line is highlighted.

Then enter the required information (if appropriate) and

press <Enter>.

For some choices, a sub-screen will appear. Manipulation in the sub-screen follows the same rules as listed above.

4. MAKING A MEASUREMENT.

There are two principal steps in making a measurement. You must first provide the computer with the appropriate setup information it requires to acquire the data . This is done in the System Set-Up Mode. You must then introduce the sample into the Aerosizer

4.1 The System Set-Up Mode.

The System Set-Up Mode allows the operator to set various parameters of the instrument. Each parameter is described in detail in the following pages. The Setup Menu is accessed by pressing:

<Ctl> S.

Press both keys at the same time.

The options available are accessed by pressing the appropriate function key as shown in the Setup Menu below.

COMMAND

F1	Return to Main Menu	
F2	Graphics Mode	IBM EPSON HPLJ DeskJet C
F3	Dual Sensitivity	OFF ON
F4	Noise Threshold(Sigmas)	6.0
F5	Sampler Purge time (Sec)	59.9
F6	PMT Voltage	850
F7	Clock Frequency	20 MHz 40 MHz
F8	Aerodiluter Present?	NO YES
F9	Mass Load. Count Eff.	1.00
F10	Sample Presentation	Pulse Jet Sampler Breather Disperser
F11	Particle Count	Absolute Relative
F12	Set Run Parameters	MANUALLY AUTOMATICALLY
Alt F1	Nozzle Type	200um 700um
Alt F2	Display Range	0.1-200um 0.5-700um
Alt F4	Baseline Offset (0-3.0)	0.0
Alt F5	Channels in Baseline	55
Alt F6	AutoSave during run?	NO YES
Alt F7	Overwrite Scans?	NO YES
Alt F8	Log Plot Resolution?	Low High

Figure 22

F1 Return To Operating Menu.

You can get back to the Operating Mode by

pressing **F1**.

F2 The Graphics Mode.

You have the option of using either IBM or Epson dot matrix printer graphics modes, laserjet printer. or the HP Deskjet C color printer for printing data with the Aerosizer™. To change the present graphics mode,

press **F2**

and then press **<right arrow>** or **<left arrow>**.

F3 Dual Sensitivity.

The Aerosizer™ may be run while collecting data at two different thresholds simultaneously (dual sensitivity on) or with a single sensitivity level (dual sensitivity off) . Dual sensitivity is normally left **<u>ON</u>**. To change the mode,

press **F3**

and then press **<right arrow>** or **<left arrow>**.

F4 Noise Threshold(Sigmas)

The Noise threshold used to determine significant data when converting from Time of Flight to Particle size may be set here. A discussion of the conversion is included in Section TM-4 The Noise threshold is normally set to **<u>6</u>**. To change the noise threshold:

press **F4**

enter the desired number of thresholds and press **<enter>**

F5 Sampler Purge Time (Sec)

The duration of the Purge cycle when using an Aero-Sampler equipped with an Aero-Dryer may be varied here from 1 to 660 seconds. Typical purge time for MDI's is 60 seconds. <u>This selection is applicable only when using the Aero-Dryer.</u>

Press **F5**

enter the desired purge time and press **<enter>**

F6 Photomultiplier Voltage.

The photomultiplier voltage controls the sensitivity of the particle detection. The range is 600 to 1200 volts. A PMT voltage of 1200 volts provides maximum sensitivity and will allow detection of particles down to less than 0.5 micrometers in diameter. Elevated PMT supply voltages, however, result in increased noise pulses from the PMT's and can require a longer run time to achieve acceptable statistics to perform data analysis. The Aerosizer is normally run at one of two voltage levels:

1100 volts for samples with the majority of material under 20 microns.

850 volts for samples with the majority of material larger than 20 microns.

To change the PMT voltage

press **F6**

enter the desired voltage and press **<Enter>**.

F7 Clock Frequency (high sensitivity data only).

The basic time of flight information is obtained with a resolution of either 50 n sec or 25 n sec corresponding to a clock frequency of 20 or 40 MHz respectively. Operating at 20 MHz allows the times of flight to be measured for twice as long a period of time as can be measured at 40 MHz. The resolution will, however, be only half as great. This is only noticeable in the sub-micron range. The low sensitivity data are always taken with a clock frequency of 20 MHz. The Aerosizer can normally be run at 20 MHz for powders and at 40 MHz for Aerosols that are mostly less than 20 microns. To change the clock frequency:

press **F7**

press **<left arrow>** or **<right arrow>**

F8 Aero-Diluter Present

This will tell the Aerosizer program that the Aero-Diluter is connected to the Aerosizer. The Aero-Diluter option allows the user to enter a set sample flow rate (F5, main menu) from .1 to 2.5 liters/min. The sample flow rate and the mass loading are automatically calculated and stored for each sample run when using the Aero-Diluter accessory. The data is reported on the printout automatically when the Aero-Diluter option is ON.

press **F8**

then press **<left arrow>** or **<right arrow>** to change the Aero-Diluter option.

F9 Mass Loading Counting Efficiency.

The mass loading counting efficiency may be set to correct differences between the mass loading measured by the Aerosizer^{TM} and measured using other techniques. For example, a known reference material has a mass loading of 5 mg./cubic meter. The Aerosizer^{TM} reports the mass loading to be 4 mg./cubic meter. The mass loading counting efficiency for the material would be 80% or 0.800.

Press **F9** to

Enter the counting efficiency then press **<Enter>**

Sample Presentation

The Sample Presentation Device type is selected here. This informs the Aerosizer program to request the proper input parameters (F3 from main menu) and provide the proper control outputs. As was described in Section 2.1, there are several ways to present a sample into the Aerosizer. The Pulse Jet option is for controlling the Pulse Jet Disperser, used for free flowing dry powders, and the Calibration Nebulizer, used for aerosolizing small suspended particles. The Sampler option provides control of the AeroDryer, heater and purge unit, used in conjunction with the AeroSampler for measuring metered dose inhalers and other aerosol generating devices. The Breather option selects control of the AeroBreather accessory inspiration rate and volume to simulate breathing for evaluation of breath activated inhalers and for volumetric sampling. The Disperser option selects control of the AeroDisperser accessory for advanced dry powder dispersion of cohesive powders.

press **F10**

press **<left-arrow>** or **<right-arrow>** to select the correct accessory

F11 Particle Count.

You can print tabular data, to the screen or printer by absolute counts per print channel using the absolute option or as a percentage of the total distribution using the relative option. Both options will give you the total distribution within the upper and lower limits (set in the display) as was described in section 2.1.3.

press **F11**

press **<left-arrow>** or **<right-arrow>** to select absolute or relative count.

F12 Set Run Parameters.

This option allows you to set the parameters for the disperser controls (F3) and program measurements (F10) when a material is selected in the Density table. To change the setting

press **F12**

press **<left-arrow>** or **<right-arrow>** to highlight the desired setting.

To set up the parameters to be stored with a Density Table entry you need only do the following the first time a new sample density is entered.

Enter the parameters for F3 and F10 as normally done

then enter the density in F4.

The parameters are stored with the density.

If the manual option is selected, the F3 and F10 parameters need to be entered manually.

Alt F1 Nozzle Type

The Aerosizer can be operated in two different size range modes, 0.1-200 microns and 0.5-700 microns. Different Sonic Nozzles are required to operate in the different ranges. This command selects the proper calibration table to match the Sonic Nozzle used. To select the proper range

Press **<ALT>** and hold down while pressing **F1**

press **<left-arrow>** or **<right-arrow>** to highlight the desired setting.

ALT F2 Display Range

This command will set the display range for the size distribution on screen and on printouts. One of two size ranges 0.1- 200 um and 0.5 to 700 um is selected by the operator. To select the proper range

Press **<ALT>** and hold down while pressing **F2**

press **<left-arrow>** or **<right-arrow>** to highlight the desired setting.

ALT F4 Baseline Offset

This command sets the baseline offset parameter used in converting the Time of Flight distribution to a Particle Size Distribution. This is normally set to **0.1** See section TM-4 for a detailed description. To set the baseline offset

Press **<ALT>** and hold down while pressing **F4**

Enter the desired number of offsets and press **<enter>**.

ALT F5 Channels in Baseline

This command sets the number of channels used to determine the baseline in the Time of Flight distribution. This is normally set to **55**. See section TM-4 for a detailed description. To set the number of channels

Press **<ALT>** and hold down while pressing **F5**

Enter the desired number of channels and press **<enter>**.

ALT F6 AutoSave during run?

This command instructs the Aerosizer program to periodically save the current run during data acquisition. This protects you from losing the data should an unexpected termination of the program occur. Autosaving will periodically interrupt data acquisition during the run resulting in lower data acquisition times. This is normally set to **NO**. To select your choice

Press **<ALT>** and hold down while pressing **F6**

press **<left-arrow>** or **<right-arrow>** to highlight the desired setting.

Alt F7 Overwrite Scans?

Allows the user to overwrite previously stored data sets. This will always default to **No** on system start up to safeguard against overwriting data. Changing the setting to Yes will allow overwriting. This is normally left on **NO** to prevent lost data. (Refer to F11, Main menu)

To change the setting:

Press **<ALT>** and hold down while pressing **F7**

press **<left-arrow>** or **<right-arrow>** to highlight the desired setting.

Alt F8 Log Plot Resolution

The resolution of the log plots of data may is set to either Low (100 size bins) or High (500 size bins).

To change the setting:

Press **<ALT>** and hold down while pressing **F8**

press **<left-arrow>** or **<right-arrow>** to highlight the desired setting.

4.2. The Main Menu.

The Main Menu is shown in the figure below. The active commands are F2 through F12 and Escape. Keys F3 through F6 and F8 through F12 call up sub menu displays to the action block. You can make detailed selections in each of these displays to help you control the Aerosizer^{TM} .

```
      COMMAND

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

F3    Sample Presentation
F4    Sample Density
F5    Combine/Aero-Dilute
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)

+------------------------------+
|        Run Parameters        |
|    in F3 and F10 are set     |
|           MANUALLY           |
+------------------------------+
```

Figure 23

4.2.1 F2 Sample Details.

The Sample Details are used to identify the run for future retrieval and provide a short "narrative" about the run which will appear on printouts. Only the first line of the Sample Details is displayed when printing a run list therefor all the descriptive information (lot #, sample name, etc.) should be entered in the first line and the generic information should be entered in the second and third lines. The Sample Details block does not behave as a word processor in that it does not word wrap. If you press <enter> while in the sample details it will lose everything after the cursor position in that line. Also if you insert characters into a line any characters "pushed off" the end of the line will be lost.

To enter the Sample Details press **F2.**

Type in the description of your sample.

You may go directly to any of the other F keys once you have entered all the description (i.e. F7 to initiate a sample run, F3 to set up the disperser settings, etc.).

4.2.2. F3 Sample Presentation.

The Aerosizer program provides for user control over the different Sample Presentation Devices described in section 2.1. The F3 Action Block will be prompt for the appropriate parameters for the device selected in the system setup (Ctl-s, F10) There are currently five disperser options available for sample presentation to the Aerosizer; the Pulse Jet Disperser for dry powders, the Calibration Nebulizer for aerosolizing small suspensions, the AeroSampler with AeroDryer for propelled aerosols, the AeroBreather for breathing simulation and volumetric sampling, and the AeroDisperser for advanced dispersion of cohesive dry powders.

The F3 Action Blocks are described below according to the selection made in the system setup (Ctl-s, F10).

Pulse Jet Disperser

With the Pulse Jet Disperser selected the F3 action block allows for control of the air from the internal compressor to the dry powder disperser and the compressed air outlet used for the Calibration Nebulizer. The Pulse Jet Disperser uses two separate air pressures to control powder dispersion while the auxiliary compressed air has just one. To control the three pressures,

press F3

and the action block shown below will appear.

```
                  Pulse Jet Control

Disp. flow  pres.    50.0    Incr.    0.0
Disp. pulse pres.     0.0    Incr.    0.5
Nebulizer pressure    0.0    Incr.    0.0
Minimum count rate above background:   4000
Maximum count rate above background:   8000
```

Figure 24.

The disperser Flow Pressure and Disperser Pulse Pressure control the Pulse Jet Disperser while the Nebulizer Pressure controls the auxiliary compressed air supply available at the rear panel. Each of the numbers to be entered has a range of 0 to 100 with 100 yielding a pressure of about 20 PSIG. The air pressure will be set at zero until a measurement is started. The pressure then is increased to the Initial Pressure setting when a measurement is started and returned to zero at the completion of the measurement.

During the measurement the rate at which particles are measured is monitored and the pressures are changed if the particle rate is below the Minimum Count Rate or above the Maximum Count Rate. If the particle rate is below the Minimum Count Rate, the pressures are increased by the pressure increments entered in F3, and if the particle rate is above the Maximum Count Rate, they are decreased by a double increment. In this way, the number of particles measured each second is maintained in the range between the minimum and maximum count rates.

When the Pulse Jet Disperser is in use, the Disperser Flow Pressure controls the carrier gas pressure and is normally not incremented. The Disperser Pulse Pressure controls the jet pressure and an increase in the pressure will strengthen the jet which leads to an increase in the number of particles fed to the Aerosizer. The Disperser Pulse Pressure normally starts at zero pressure and is incremented in steps of 0.5 to increase the flow of material gradually. This helps avoid overloading the system with material which can cause deposition on the optical components within the measurement region.

The compressed air auxiliary outlet pressure is set by entering a number for Nebulizer Pressure and is usually used for the Calibration Nebulizer with a setting of 80 with an increment of 0. The delivered pressure to the Calibration Nebulizer is approximately equal to

(Set pressure / 100) x 21 PSI

It should be noted that the calibration nebulizer has a flow restricting orifice that limits the delivery to approximately 0.5 liters per minute and that these pressures may not be obtainable with other devices requiring higher flow rates.

To change any of the settings;

press **<left-arrow>** or **<right-arrow>** to highlight the appropriate line

type in the new number, and press **<Enter>**.

AeroSampler

The AeroSampler allows you to control the heating and purge cycles of the AeroSampler. The following action block will appear after pressing F3

```
                Aero-Sampler Control
 ---------------------------------------------
 Automatic Purge:  OFF  ON
 Heater         :  OFF  ON
```

Figure 25

The Aero-Dryer option is used when you want to measure the total drug contained within a metered dose actuation without any effects or presence of freon. It also provides for purging of the sample chamber through the Aerosizer vacuum system.

The heater option allows you to heat the core of the AeroDryer accessory to 100^0 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.

The Purge option allows you to 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 for the length of time set in the system setup (Ctl-S, F4) after a run (or sequence of runs if multiple runs are selected in the program measurements (F10) option).

CAUTION: ALLOW 60 MINUTES FOR THE AERO-DRYER TO COOL DOWN BEFORE TRYING TO DISCONNECT FROM THE AEROSIZER.

AeroBreather

The AeroBreather™ is a microprocessor controlled variable volume, variable rate aerosol sampling system for use exclusively with the API Aerosizer™. The AeroBreather™ utilizes a stepper motor drive to provide control over the rate and displacement of a piston in the sample chamber. This ability for control allows the user to pre select volumetric sampling parameters (displacement, acceleration, final velocity) which will define the inspiration profile. Once the sample is collected, it is analyzed by the Aerosizer™. After analysis the AeroBreather™ sample chamber is purged through the Aerosizer Vacuum system to remove any residual particulate matter to minimize cross contamination of samples. The following Action Block appears under F3 when the AeroBreather is selected in system setup (Ctl-s, F10):

Aero-Breather Control	
Breath Rate (l/min)	: 60.0
Breath Volume (l)	: 1.0
Acceleration (l/sec^2)	: 19.0

Figure 26

The user can enter three parameters:

1. **Breath Rate** up to a maximum of 120 liters/minute. This will determine the maximum velocity of the piston.

2. **Breath Volume** up to a maximum of 1 liter. This determines the total distance the piston will travel.

3. **Acceleration** up to a maximum of 19 liters/sec^2. Determines the rate at which the piston will accelerate to the Breath Rate set.

AeroDisperser

The AeroDisperser is a microprocessor controlled dry powder dispersing system that provides dispersion of highly cohesive as well as free flowing powders. The AeroDisperser allows the user to select the amount of shear force applied to the agglomerates in order to separate them down to their primary constituents. The sample is dispersed from a sample chamber within 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 will be 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 the 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" within the Disperser housing. The air velocities 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 "pin-bowl". The AeroDisperser monitors the pressure drop across the annular gap and adjusts the pin position to maintain the pressure drop specified by the operator. Varying the pressure drop will alter the air velocities and hence alter the amount of shear force applied to the particles. The AeroDisperser is constantly fed back the particle count rate from the Aerosizer and adjusts the strength and duration of the jet to provide the feed rate set by the operator. One of the following action blocks, appears after the AeroDisperser self calibrates, if the Disperser option is selected in the system setup (Ctl-s, F10):

```
COMMAND

F1     Return to Main Menu
F2     Graphics Mode                 IBM   EPSON   HPLJ   DeskJet C
F3     Dual Sensitivity              OFF   ON
F4     Noise Threshold(Sigmas)         6.0
F5     Sampler Purge time (Sec)       59.9
F6     PMT Voltage                     850
F7     Clock Frequency               20 MHz   40 MHz
F8     Aerodiluter Present?          NO   YES
F9     Mass Load. Count Eff.           1.00
F10    Sample Presentation           Pulse Jet   Sampler   Breather   Disperser
F11    Particle Count                Absolute   Relative
F12    Set Run Parameters            MANUALLY   AUTOMATICALLY
Alt F1 Nozzle Type                   200um      700um
Alt F2 Display Range                 0.1-200um      0.5-700um
Alt F4 Baseline Offset (0-3.0)         0.0
Alt F5 Channels in Baseline            55
Alt F6 AutoSave during run?          NO   YES
Alt F7 Overwrite Scans?              NO   YES
Alt F8 Log Plot Resolution?          Low   High
```

Figure 27

The AeroDisperser can be operated in two control modes, Auto and Manual. Auto Mode provides a list of preset conditions for operating the AeroDisperser. Manual Mode gives the operator direct control over the operating conditions. The AeroDisperser is normally run in Auto Mode.

AeroDisperser Auto Control Mode

```
         Aero-Disperser Auto Control

Shear Force        : LOW   MED   HIGH   PEAK
Deagglomeration    : NORMAL  HIGH
Feed Rate          : LOW   MED   HIGH
Pin Vibration      : OFF   ON

Calibrate          :
Control Mode       : AUTO   MANUAL
```

Figure 28

The operator can now set up the operating parameters for the AeroDisperser.

Shear Force

This sets the pressure drop across the gap at the dispersing pin. Increased pressure drop across the gap results in higher air speeds within the gap increasing the shear force exerted on the particles.
Low = 0.5 PSI
Med = 1.5 PSI,
High = 3.0 PSI
Peak = 4.0 PSI

Feed rate

This sets the target incremental count rate for the Aerosizer. The AeroDisperser will automatically increase or decrease the strength and duration of the air jet to try to satisfy the target feed rate selected.
Low = 1000 cts/sec
Med = 5000 cts/sec
High = 10000 cts /sec.

De agglomeration

This selects one of two preset air flow patterns within the AeroDisperser. 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.

Pin Vibration

When this option is selected 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.

Calibration

Selecting this item will force a re calibration of the AeroDisperser. This is useful if the AeroDisperser is inadvertently calibrated with either the vacuum pump or external pump turned off.

Control Mode

This option allows the user to switch from the Auto control mode to the manual control mode. Manual control allows the user to enter direct numbers for the shear and feed parameters and is usually only used under conditions where the normal selections will not fully disperse the powder. The manual control mode (described on the next page) may be selected here.

Manual Control Mode

The following action block will appear when the Manual Control Mode is selected for the AeroDisperser:

```
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 29

In this mode the operator can directly control the following parameters:

Shear Force (PSI):

The number entered will be the target set point for the pressure drop across the annular orifice gap between the disperser pin and the pin-bowl.

Shear Tolerance:

This sets the allowable tolerance for the pressure drop away from the target setpoint before the AeroDisperser will start making pin location adjustments. The AeroDisperser 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 (counts):

This determines the target particle count rate that is seen by the Aerosizer. The Aerosizer constantly feeds the AeroDisperser the current count rate and the AeroDisperser 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:

This sets the tolerance band for the Feed Rate as described above.

Pin Vibration

When this option is selected 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.

De agglomeration

This selects one of two preset air flow patterns within the AeroDisperser. High de agglomeration will cause the particles to be transported from the fluidized bed to the disperser pin at higher velocity resulting in grater impaction energy on the particles.

Calibration

Selecting this item will force a re calibration of the AeroDisperser. This is useful if the AeroDisperser is inadvertently calibrated with either the vacuum pump or external pump turned off.

Control Mode

This option allows the user to switch from the manual mode to the auto control mode.

4.2.3. F4 Sample Density.

The Aerosizer allows you to store the densities of the materials you use and store the Run Parameters for F3 and F10 (refer to the Run Parameters section of the System Set-Up Mode). To access the density table,

press **F4**

and you will see an action block similar to Figure 26. The list of materials and densities is stored in the computer. If the material you are measuring is already on the list, move the cursor to the proper line,

press **<Enter>**

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
Mercury	13.55 gms/cc
Mineral oil	0.92 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 30

and the proper material and density will be entered into the computer and shown on the screen below the density table.

WARNING: THE PROPER DENSITY MUST BE ENTERED INTO THE COMPUTER OR YOU WILL GET AN INCORRECT SIZE DISTRIBUTION. A COMMON CAUSE OF "STRANGE" DISTRIBUTIONS IS THE WRONG DENSITY ENTERED INTO THE COMPUTER.

Adding Items to the Density Table

If the material you are measuring is not shown on the list, you can add it to the list while in the Density List Screen by

press **a**

type in the composition name that you want to appear in the list and

press **<Enter>**

type in the materials density (specific gravity) in gm/cc

press **<Enter>**.

Deleting Items from the Density Table

To delete an item from the Density Table place the cursor on the material that is to be deleted and

press **d**

You will then be prompted for confirmation by a <D? next to the line marked for deletion.

press **Y** to delete the line or **N** if you wish to keep the line.

Associating a correlating factor with a density entry

The particle characterization technique used by the Aerosizer™ yields particle diameter measurements that, for many materials, correlates 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 which closely agrees with any other sizing techniques.

Any material in the density table can be assigned a **Correlating Factor** which is always used when that material is selected. All standard materials are initialized to have a **Correlating Factor** equal to one. This causes no additional effect on the Aerosizer™ data. Any material that has a **Correlating Factor** not equal to one will be listed in the density table with an asterisk after its density. To view or alter a material's **Correlating Factor**, place the cursor on the material of interest and type ***f***.

Customized Analysis Configuration

The Aerosizer™ software provides the user with the capability to lock specific analysis tools into a fixed configuration for all runs with a given material or for a single sample run. The analysis tools which can be locked are:

- Baseline Removal Tools - Offset, Sigmas, Channels in Baseline
- Data Fitting Tools - Gaussian Extension, Linear Regularization
- Alternative Technique Correlating Tool - Correlating Coefficient
- 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. The following will explain how to use these features.

Specific Analysis Model for a Material

To associate certain analysis tools to a specific configuration for a given material, the procedure is:

1. Type **F4** to enter the **Sample Density** window.
2. Move the cursor to the material of choice.
3. Type **f**.
4. Edit the pop-up window accordingly. Any entry set to **SYSTEM** will use the system default values from either the **SET-UP** 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.
5. Type **F1** to exit the pop-up window.
6. If any analysis tools were set to not use the system default values, an asterisk will be placed beside that material on the density list

Setting the Automatic Run Parameters

If the automatic option is selected in the System Set-Up Mode (Ctl-s, F12), the program will automatically enter the Sample Presentation (F3) and Program Measurements (F10) parameters preset by the user when an item is selected from the density table. If this option is selected, you need only do the following the first time a new sample density is entered.

First enter the parameters for F3 and F10 as normally done

then enter the density in F4.

The settings will now be stored with the entry in the Density Table.

If the manual option is selected, the F3, F4 and F10 parameters need to be entered before every sample run.

4.2.4. F5 Combine/Autodilute.

Two parameters governing the operation of the AEROSIZER^{TM} are set using F5. The first parameter allows the user to analyze sample runs using the Dual Sensitivity feature with or without blending the low and high sensitivity data together. The second parameter allows the user to operate and calibrate the Aero-Diluter accessory. To change these parameters,

press F5

and the action block will appear.

```
                 Combine/Aero-Dilute

Combine             :   OFF  MANUAL  AUTO
Lower Combine Size:                  Auto
Upper Combine Size:                  Auto

Sample Rate (l/m)  :               0.00
Aero-Dilute Cal.   :
```

Figure 31

Combine.

The Combine option is used with the Dual Sensitivity feature. The Aerosizer collects data at two sensitivities, high sensitivity for detection of small particles and low sensitivity for detection of large particles. The data from both the high and low sensitivity is combined together to provide a full distribution over the entire range of the Aerosizer. All data **below** the Lower Combine Size is from the High Sensitivity, all data **above** the Upper Combine Size is from the Low Sensitivity. Data between the Lower and Upper Combine Sizes is a mix of data from the High and Low Sensitivities. (See Appendix # 2 for a detailed description of Combine)

The Combine option pertains only to displaying and analyzing the collected data. The Aerosizer program will still collect and store raw data from both sensitivities regardless of the Combine setting. The Dual Sensitivity feature is selected in the System Set-Up Mode (Ctl-s, F3) and is normally left ON.

Selecting Combine Mode

When the Auto option is enabled the Aerosizer program will automatically select the combine points for you. Each time a data set is loaded in from the disk, it is analyzed to determine the combine sizes. The combine sizes are then stored with the run data for later use if manual combine is selected. If a run has no combine sizes stored with it and if manual combine is selected the combine size values set in the F5 dialog box are used and stored with the run.

When the Manual option is selected the Aerosizer program will combine the data at the combine points stored with the run. If it is a new run or has no combine points associated with the data set the program will use the Lower and Upper Combine Sizes that are currently displayed in the F5 sub menu.

When Off is selected the data is not combined.

Editing the Stored Combine Sizes

The combine sizes for a stored run can be edited with the standard edit data routine: Select Display Run Info in the F11 dialog box, and hit F3 when the data for the run you want to edit is displayed.

The automatic combine algorithm works by comparing the number distributions from the high and low sensitivity data, and looking for an area where the slopes and channel counts are closely matched and non-zero. A detailed explanation can be found in appendix #2

Highlight the appropriate selection to either turn combine OFF, set MANUAL combine points or AUTOmatically set combine points. When either OFF or MANUAL is selected the manual combine sizes will be displayed if AUTO is selected "auto" will be displayed.

With Combine OFF at the conclusion of a run only the High Sensitivity data will be displayed. Either the high or low sensitivity data may be displayed on the screen by selecting the appropriate run # in F11. Both low and high sensitivity data may be displayed simultaneously by entering both run numbers in F11. Please refer to section on F11 Display Runs.

To determine the matching pair of runs when using the Dual Sensitivity option, display the sample run directory in F11 or F12. A dual sensitivity run will have an asterisk next to the run number. The low sensitivity run number will be 1 greater than the high sensitivity run marked by the asterisk.

Sample Rate (l/m).

This entry controls the Aero-Diluter which regulates the mass flow of sample air through the Aerosizer. It is useful for reducing the particle loading to the Aerosizer when measuring high concentration Aerosols as are frequently found with some MDI formulations. The AeroDiluter is also used for maintaining constant flow rates for Sample probes for Isokinetic (or velocity controlled) Sampling. The AeroDiluter works with the small nozzle only.

The AeroDiluter operates by controlling the mass flow of sheath air supplied to the Aerosizer. The total flow of air through the Aerosizer nozzle remains constant at approximately 6 liters per minute because we are operating in a choke flow condition. This total flow is the combined total of the sample air and the filtered sheath air that is introduced to surround the sample air. By regulating the sheath air the sample air will necessarily be the difference between the total flow and the sheath flow.

Before the Aero-Diluter may be used with the system it must be calibrated to the Sensor Unit. Calibration is not required before each use but should be performed on a monthly basis. The Aerosizer Sensor Unit must be fitted with the Direct Feed Adapter (shipped with the unit) to correctly calibrate the Aero-Diluter. Calibration is done by highlighting the Aero-Dilute Cal line and pressing <Enter>. The user will be prompted on screen to perform the following steps for calibration of the Aero-Diluter.

Important: The AeroDiluter must be allowed to reach its' normal operating temperature before calibrating and before use. The normal warm up time for the AeroDiluter is two hours.

The Calibration procedure takes approximately three minutes.

The user is first instructed to turn the vacuum pump and AeroDiluter off and to leave the sample inlet open.. Press <enter> and the ambient pressure is measured.

Once this measurement is complete the user is prompted to turn on the vacuum pump and AeroDiluter . Block the sample inlet and press <enter>.

The program will now go through the final section of the calibration procedure. When it is complete it will prompt the user to unblock the sample inlet.

Once the Aero-Diluter has been calibrated the user may enter sample flow rates from .1 to 2.5 Liters per Minute. The Aero-Diluter will regulate the flow to match the setting. This also allows the program to do some rough mass loading calculations which can be used to provide **relative information only** on runs performed under similar conditions.

The Chart below shows the maximum Mass Loading in grams/liter for different size particles of density 1.0 grams/cc at different sample flow rates

Diameter (microns) \ Flow Rate (liters/min)	0.1	0.2	0.5	1	2	2.5
0.2	2.51E-07	1.26E-07	5.02E-08	2.51E-08	1.26E-08	1.00E-08
0.5	3.93E-06	1.96E-06	7.85E-07	3.93E-07	1.96E-07	1.57E-07
1	3.14E-05	1.57E-05	6.28E-06	3.14E-06	1.57E-06	1.26E-06
2	2.51E-04	1.26E-04	5.02E-05	2.51E-05	1.26E-05	1.00E-05
3	8.48E-04	4.24E-04	1.70E-04	8.48E-05	4.24E-05	3.39E-05
5	3.93E-03	1.96E-03	7.85E-04	3.93E-04	1.96E-04	1.57E-04
10	3.14E-02	1.57E-02	6.28E-03	3.14E-03	1.57E-03	1.26E-03
20	2.51E-01	1.26E-01	5.02E-02	2.51E-02	1.26E-02	1.00E-02
30	8.48E-01	4.24E-01	1.70E-01	8.48E-02	4.24E-02	3.39E-02
50	3.93E+00	1.96E+00	7.85E-01	3.93E-01	1.96E-01	1.57E-01
100	3.14E+01	1.57E+01	6.28E+00	3.14E+00	1.57E+00	1.26E+00

4.2.5. F6 Display Type.

The displayed analysis may be changed either in the F6 dialog box from the main menu or directly while the display is on screen. The Aerosizer software will calculate either a Number, Volume, or Surface Area distribution and will also display the Time of Flight data. The distributions can be calculated by either Aerodynamic or Geometric Diameters. Plot Modes available are Histogram, Cumulative Under, and Cumulative Over on either Linear or Log Scale.

To select the display type,

press **F6**.

The action block shown below will appear.

Plot Scale	Plot Mode
Linear Logarithmic	Histogram Cumulative Under Cumulative Over
Distribution Type	**Regularization**
Number Area Volume Time of Flight	Off Low High
Diameter Type	**Normalization**
Geometric Aerodynamic	Individual Group

Figure 32

The four arrow keys control all the display options.

Press **<left arrow>** or **<right arrow>**

to select the major blocks such as Distribution Type, Plot Mode and Plot Scale.

Press **<up-arrow>** or **<down-arrow>**

to make a selection within each of the major blocks.

Distribution Types

The basic measurement made by the Aerosizer counts particles by their Time of Flight. The Time of Flight is collected in 2048 linearly spaced channels. The Aerosizer program can display the raw Time of Flight data or three different types of particle size distributions: a Number distribution, Area Distribution, or Volume Distribution. Each of these distributions is calculated from the Time of Flight distribution and assumes a spherical particle shape. The Time of Flight is converted to particle size by the Aerosizer proprietary software and placed in 500 Logarythmically spaced size bins.

The Number Distribution.

In this distribution, the number of particles in each size bin is reported with the results normalized to the bin containing the highest value. For reporting purposes the total number of particles (Sum of Channels) is determined by adding up the numbers in all of the size bins. The percentage of the particles in each size range is determined by dividing the number in each range by the total number of particles.

The Surface Area Distribution.

This distribution displays the relative surface area for the particles in each size bin. The display is normalized to bin with the highest surface area. The Surface Area is calculated by multiplying the number of particles in each size bin by the square of the diameter at the center of that range. The percentage of the surface area in each size bin is determined by dividing the surface area calculated for each size bin by the total surface area of all size bins.

One particle of 100 micrometers diameter has the same surface area as 10,000 particles of 1 micrometer diameter, so this distribution emphasizes the large particles more than the number distribution.

The Volume Distribution.

This distribution displays the relative volume for the particles in each size bin. The display is normalized to bin with the highest volume. The Volume is calculated by multiplying the number of particles in each size bin by the cube of the diameter at the center of that range. The percentage of the volume in each size bin is determined by dividing the volume calculated for each size bin by the total volume of all size bins.

1 particle of 100 micrometers diameter has the same volume as 1,000,000 particles of 1 micrometer diameter, so this distribution emphasizes the large particles even more than the Surface Area distributions.

Diameter Type

Geometric Diameter is the equivalent spherical diameter that would be measured physically by either manual or optical means.

Aerodynamic Diameter is the equivalent spherical diameter of a particle of unit density that would settle at the same velocity in air at STANDARD TEMPERATURE AND PRESSURE as the particle measured by the Aerosizer.

Plot Scale

Distributions may be plotted on either a Logarithmic or Linear Scale. **Log Scale** displays all the data from 0.1 to 200 microns or from 0.5 to 1000 microns depending on the Range selected. Zooms, both vertical and horizontal, are not implemented in Log Scale. **Linear Scale** displays data in a window with width from 2 to 1000 microns. Linear Scale supports all available display features.

Normalization

Individual and Group Normalization are effective when displaying more than one run. **Individual** Normalization normalizes the highest channel in each distribution to one and scales the rest of the distribution accordingly. **Group** Normalization normalizes the highest channel of all the selected runs to one and scales all the distributions accordingly.

Regularization

Regularization provides for mathematical stabilization of the transform from Time of Flight to Particle Size. You can display data on the screen at three different regularization levels: Off, Low and High. **Off** applies no regularization to the data and is generally used for monodisperse samples. **Low** provides a moderate amount of regularization and is most of the time for slightly broad or unknown samples. **High** provides the maximum amount of regularization and is used for very broad distributions whose volume distributions appear chopped on the right hand side.

Why We (and others) Apply Linear Regularization

The Aerosizer™ actually measures time-of-flight (TOF) distributions. The geometric distribution is created via a transformation from TOF to size. As in many such transformations (i.e., Laser Diffraction's converting of light intensities into sizes), the exact transformation operator may be slightly ill-conditioned yielding a mildly unstable (unsmooth) result. Laser Diffraction constrains its transformation through **Linear Regularization** (also called Phillips-Twomey, Tikhonov-Miller, constrained linear inversion). They do this by adding a stabilizing constraint into their transformation matrix prior to solving their system of equations.

What We Do

The Aerosizer™ does not perform the TOF to size transformation as a matrix operation (although it could). A matrix to convert 2048 channels of TOF into 500 channels of size would require too much memory. Therefore, the current channel by channel conversion is performed prior to the linear regularization - which is applied directly to the size distribution. To do this, an identity matrix is viewed as the transformation operator that converts 500 channels of size data into 500 channels of size data.

What Linear Regularization Does

Performing a channel-by-channel conversion of the TOF distribution into a size distribution yields a ragged-looking distribution. This is due to the instability of the conversion from 2048 channels of linearly-spaced TOF data to 500 channels of logarithmically spaced sizes. This raggedness is often magnified in viewing the volume distributions of broad samples.

If one were to take this ragged size data and evenly distribute all measured counts across the entire size domain, one would produce a perfectly smooth, yet unrealistic, distribution. The total number of counts would be conserved but all characteristics of the distribution would be erased.

Linear Regularization performs an optimization constrained by the two procedures - converting TOF to size and data smoothing - through use of minimization with Lagrangian Multipliers. It generates the optimal balance between a raw conversion and a perfectly flat distribution while conserving the total counts. Each level of Regularization (***off***, ***low*** or ***high***) applies a different Lagrangian Multiplier to the smoothness constraint in the optimization. The calculations necessary to perform the Linear Regularization reduce to an extremely simple and rapidly solved system of equations.

Which Regularization is Right for You?

Low regularization is the most commonly used configuration. However, there are certain times when either ***off*** or ***high*** are recommended. The following list should assist in determining which level to choose.

off (F) When one might expect spiky results. Examples: monodisperse samples, tight samples, calibration standards.

low (M) Most of the time while running slightly broad or unknown samples.

high (C) With very broad samples whose volume distributions appear "chopped" on the right-hand side.

4.2.6. F7 Measure Sample.

Press **F7**

to make a measurement. The user can set the duration of a measurement as well as the number of measurements and the time waited between measurements using the F10 command as described in Section 5.3.10.

4.2.7. F8 Auto Print.

Press **F8**

and then

press **<left arrow>** or **<right arrow>**

to turn the automatic print function on or off. When turned on, a printed copy of the data will be made following the completion of each measurement.

4.2.8. F9 Save Options.

The AEROSIZER stores data in user defined directories . The program will allow up to 1000 data records per directory. Each directory contains a file named Aerodata.xxx which will hold 100 data records. For directories with more than 100 data records there will exist multiple aerodata files with different extensions, aerodata.xx1, aerodata.xx2 etc. File aerodata.xx1 will contain records 101 through 200, file aerodata.xx2 will contain records 201 through 300, etc. Each Dual Sensitivity run consumes two data records in the file, one for High Sensitivity data and one for Low Sensitivity data. The desired data sets can be retrieved using the Display Run option (F11). The following action block will appear when F9 is pressed:

```
              Save Options

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

c:\api

c:\api
```

Figure 32

Auto Save.

The Auto Save function is used to automatically save and store data when the measurement is completed. Auto Save should normally be left ON as there is no way to save a completed run if AutoSave is turned OFF. Highlight this line and

press **<left arrow>** or **<right arrow>**

to turn the Auto Save function ON or OFF.

Automatic Export

Automatic Export is a utility that, when activated, will *automatically* create a comma-separated spreadsheet file at the conclusion of each run. The file is stored in the current data directory with the name DDHHMMSS.PRN, where:

DD = Day of month of run

HHMMSS = Time (hour:minute:second) of day of run.

Once you set the AutoExport switch to ON, the software will automatically export the data at the conclusion of each run in the format selected on the F12 Print Run(s) screen and F6 Display Type screen.

Data File Copy To:

When you have filled the hard disk data file with 1000 runs, or want to transfer a smaller number of runs to storage, you can save the entire data file from the currently selected directory to a floppy disk. You will need a formatted disk (format the disk from DOS using the FORMAT A: or FORMAT B: command) with a minimum of 1.2 Megabytes of available space for each 100 stored records. Highlight the line Data File Copy to "A" or "B" and

press **<left arrow>** or **<right arrow>**

to select the drive you want to use in making the copy. Then

press **<Enter>**

The user will then be prompted on screen to select a save option. Pressing **<Esc>** will quit the routine. Pressing **F1** will cause the program to create a subdirectory on the floppy with the same name as the current directory and copy the file. **F2** will copy the file to the active directory on the floppy. **F3** will allow the user to specify a directory name to be used on the floppy.

Data File SubDir.

This section allows the user to select, from a list, the current data file to which runs will be stored and from which runs may be retrieved. This is also where the entries are added to and deleted from the list. Each directory can store up to 1000 data records, (500 dual sensitivity runs). To select a different Data File Subdirectory highlight the Data File SubDir line and press **<Enter>** a block similar to the one below will appear:

```
              Save Options

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

c:\api
c:\api\powderA
c:\api\powderB
c:\test3
c:\test4

c:\test4
```

Figure 33

Highlight the desired directory and press **<Enter>**.

The new directory will appear on the Data File SubDir line.

Viewing the Directory Run List

You can select a subdirectory and view the run list for this subdirectory by moving the cursor to the desired entry on the list and pressing a lowercase L, l . The list of stored data in the file will appear. This subdirectory will stay selected after you have finished viewing the list

Creating A New Directory.

To create a new directory, highlight the Data File SubDir line and

press **<Enter>**.

Type the letter **"a"**

you will be prompted for a subdirectory name. Type the name of the new directory using up to 8 letters or numbers or an underline (_). Spaces and punctuation marks are not allowed. You do not need to enter the backslash character (\). You will then be asked to select the drive for the new directory. Press the appropriate letter .

The final step in the procedure is to create the directory (if it does not exist) and write a blank data file . This marks out contiguous disk space allowing for faster data retrieval. Highlight the newly created directory and press any function key. A message indicating that the directory and/or Aerodata.xxx file does not exist will appear.

Press **Y**

to create the new directory and/or Data file.

Copy Scans.

You have the ability of copying selected runs from the aerodata file in any directory to aerodata file in any other for the purpose of combining data. This feature is useful when you wish to display runs simultaneously that were originally stored in separate data files. Follow the instructions on the screen to select the directory and data runs you want to copy from as well as the directory selected to where the data runs are copied. Highlight "Copy Scans" and

press **<Enter>**.

and the action block below will appear

```
              Save Options

 Automatic Save     :  ON    OFF
 Automatic Export   :  ON    OFF
 Data File Copy to:    A B
 Data File SubDir   :  c:\api

Source Directory :  \api
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 34

The example above would copy the runs # 1 ,2 ,and 3 from the aerodata file in the directory C:\API to runs # 36, 37 and 38 in the aerodata file in subdirectory C:\BREATHER.

A range of runs may also be specified for copying by typing **run # - run #** rather than typing the individual run #'s. Please see the example below:

```
             Save Options

 Automatic Save    :  ON    OFF
 Automatic Export :  ON    OFF
 Data File Copy to:  A B
 Data File SubDir :  c:\api

Source Directory : \test
Source Disk Drive: A B C D
Run #'s to copy  : 1-6
Target Directory : \api
Target Disk Drive: A B C D
Start Copy at    : 7
GO               :
```

Figure 35

The Example above copies runs 1 through 6 from the data file C:\TEST to runs 7 through 12 in the data file C:\API.

The Example above also illustrates the prompt that appears when the second run of a dual sensitivity run pair is not selected for copying. The program will ask the user to press <Enter> if they wish to have the second run of the run pair copied (this would cause C:\TEST run 8 to be copied to C:\API run 14) or to press <Esc> if they want only the one run from the pair copied (C:\TEST run 6 copied to C:\API run 12 and marked as a single sensitivity run).

CAUTION: The Program will not protect the user from overwriting previously stored runs when copying scans.

4.2.9. F10 Program Measurements.

The Aerosizer^{TM} can be set in **PROGRAM** mode to make a preset number of measurements each lasting for a fixed period of time, with a preset waiting time between each measurement. You can set the Aerosizer^{TM} in **MANUAL** mode to continue measuring until the user completes the measurement by pressing F11. To set up the instrument to make a series of measurements,

press **F10**

and the action block below will appear.

```
                 Program Measurements

Multiple Runs                       :  MANUAL   PROGRAM
Number of Runs                      :             5
Nominal Run Length  (sec)           :     30     60     90
Run Spacing         (sec)           :     10     20
```

Figure 36

Multiple Runs.

Highlight this line and select Manual or Program. In both Modes, you can complete a run (or series of runs) by

pressing **F11**.

You can abort a run by

pressing **F1**.

You can restart a run by

pressing **F7**.

All of these actions can be taken at any time during a run.

The Program Mode allows you to make a series of runs automatically.

Number Of Runs.

You can enter up to 1000 runs (500 in the dual sensitivity mode) if you are saving the runs and the 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.

Duration (Number Of Seconds).

The Aerosizer can be set up to collect data for set run lengths while in program mode. A single run length can be entered or a series of run lengths for multiple runs. 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 (Number Of Seconds).

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 has been 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 # set in F11, Main Menu)

External Trigger

If you have purchased the External Trigger option the Aerosizer Program will display the control setup for the external trigger. The options are for the instrument to trigger on either a TTL high or a TTL low signal.

The External Trigger Option allows the data acquisition process to be remotely initiated. The Aerosizer is setup to acquire data but waits until an external signal is received before starting.

Example:
Suppose we are interested in the aerosol generated by some device at certain times after the device is started. We wish to know what the particle size distribution from the device is at three minutes after start up six minutes after startup and fifteen minutes after startup.

An Aerosol chamber is set up from which the Aerosizer is sampling. The aerosol generation device is connected to the chamber.

The Aerosizer is set to acquire data for one minute then pause for two minutes acquire a new data set for one minute pause for eight second then acquire a new data set for two minutes. External trigger mode is selected. F7 is pressed to set the Aerosizer to acquire data upon receiving the external trigger.

Device is actuated to produce aerosol cloud in chamber. Upon actuation a timer is started. At three minutes the timer sends the trigger signal to the Aerosizer.

Data accumulation begins and continues for one minute. The accumulated data is stored and the Aerosizer waits for two minutes.

During this two minutes the aerosol chamber is purged for one minute then allowed to stabilize for one minute.

At the end of the two minutes the Aerosizer starts accumulating data for one minute and then stores this data set to a new run #. The Aerosizer now waits for eight minutes.

During the eight minutes the aerosol chamber is again purged and allowed to stabilize.

At the end of the eight minutes the Aerosizer collects data for two minutes and stores this data set to a new run number.

The operator can now overlay the three data sets to observe the distributions output from the aerosol generator at the different times.

4.2.10. F11 Display Runs.

This option allows you to retrieve runs from the currently selected subdirectory for editing and to display the results on the monitor or print them in a hard copy report. You can compare results before and after a process (i.e. grinding or classifier) with the Run Calculations option. The Display Run Action Block is shown below.

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

Run Calculations		
Off	:	0
Add/Subtr Relative	:	
Add/Subtr Absolute	:	
Divide Relative	:	
Divide Absolute	:	

Figure 37

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 Section 3.

Display Run Info.

The Display Run Info option allows you to review several key parameters for a sample run as well as 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. To obtain a printed copy of the information,

press F8

and you will obtain a report similar to that below.

```
Directory              : c:\api
Run        1           : Wed Nov 22 17:23:55 1995
Material               : ambient aerosol                1.00
Run  Length (sec)      :    229.151
Pressures (atm)        :       0.9567       0.0143        0.0285
Clocks (counts)        :     4475601      1296428        634654
PMT Voltage (volts)    : 1200.00
Laser Current          : 38.7mA
Clock Freq (MHz)       :           40.0
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 38.

If you have entered more than one scan number, you can change from one run to the next by

pressing **<up-arrow>** or **<down-arrow>**.

The Edit Function.

The edit function allows you to change the density, label, material description, combine points 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 screen is shown below

```
Run      1          : Wed Nov 22 17:23:55 1995


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 39

Highlight the item you want to change and

press **<Enter>**.

Type the new material, density, or combine points and press **<Enter>**.

This will change the material or density stored in the record. The new density and combine points (if manual combine is selected, F5 from main menu) will be used to calculate particle size distributions. To change the label, move the highlight 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:

Type **F4** to access the pop-up window for analysis tool configuration.

Edit the pop-up window as desired. Any entry set to **SYSTEM** will use the system default values from either the **SET-UP** 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.

Type **F1** to exit the pop-up window.

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 stored runs within a directory are stored in data files each containing a block of 100 runs. (Note: The <left arrow> and <right arrow> keys must be used to jump from one block of 100 runs to the next 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

<up-arrow> or **<down arrow>**

To change between blocks of 100 runs press

<left arrow> or **<right arrow>**

. To obtain a printed copy of the run list, press **F8**

and you will obtain a listing similar to Figure 27.

Some of the runs show an asterisk next to the run number. This indicates that the Dual Sensitivity option was ON. The first run of a pair containing data taken at high sensitivity will be the run number displayed on the screen and the hard copy report. The low sensitivity data will have a run number greater by 1.

```
                         C:\test3\aerodata.xxx
*    3 07/12/93 22:05 Glass mic 38-45um glass, large noz, new pin
*    5 07/12/93 22:19 Glass mic 53-45um glass, large noz, new pin
*    7 07/12/93 22:35 Glass mic 53-45um glass, large noz, new pin
*    9 07/12/93 22:56 Glass mic 63-53um glass, large noz, new pin
*   11 07/12/93 23:25 Glass mic 2.1um glass, large noz, new pin,
*   13 07/12/93 23:46 Glass mic 2.1um glass, large noz, new pin,
*   15 07/13/93 00:52 Glass mic 8.1um glass, large noz, new pin,
*   17 07/13/93 01:49 Glass mic 15.5um glass, large noz, new pin,
*   19 07/13/93 02:03 Glass mic 650 um glass, large noz, new pin,
*   21 07/13/93 02:22 Glass mic 90-75um glass, large noz, new pin,
*   23 07/13/93 04:09 Glass mic 90-75um glass, small noz, reg pin
*   25 07/13/93 04:22 Glass mic 45-38um glass, small noz, reg pin
*   27 07/13/93 04:32 Glass mic 53-45um glass, small noz, reg pin
*   29 07/13/93 04:56 Glass mic 63-53um glass, small noz, reg pin
*   31 07/13/93 07:54 Glass mic 15.5um glass, small noz, reg pin
*   33 07/13/93 08:35 Glass mic 8.1um glass, small noz, reg pin
*   35 07/13/93 08:53 Glass mic 2.1um glass, small noz, reg pin
  Use up and down arrows to scroll, left and right arrows to change blocks
                  F1 for Previous Menu,     F8 to Print
```

Figure 40

Delete Run #'s.

To delete runs from the current selected directory 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 #'s separated by a space. Up to five run #'s may be entered. After entering the run #'s

press **<Enter>**

and the computer 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 is automatically indexed 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. The Aerosizer program does 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. It will show the second number of the run pair when in dual sensitivity.

Run Calculations.

The Run Calculation option is used to either add two distributions together or to compare particle size distributions before and after a process or classification procedure. There are 2 operating modes; absolute and relative.

The Absolute option adds or compares 2 runs without normalization, but the height of the distributions are weighted by the duration of the runs. It is used when comparing results to a known standard. For example, it can be used to determine the efficiency of a filter. The absolute mode is used to subtract a background measurement.

The Relative option adds or compares 2 runs after they are normalized. This option is used for comparing the relative difference of particle sizes before and after a process such as in a grinding operation to determine the effect of the process.

The run number of a measurement made before the process (or a background sample) is entered into the Run Calculation box. Up to 5 run numbers of measurements made after the process (or samples) are entered on the "Display Run #'s" line.

Operation of Run Calculations

Press F11 to access this option. Move the cursor with the <left arrow> or <right arrow> keys to highlight the Run Calculation box then move the cursor to the desired option by using the <up-arrow> and <down-arrow> keys.

To Add a run to the displayed runs enter the run number of the run you wish to add and press <enter>

To subtract a run from the displayed runs enter the run number of the run you wish to subtract preceded by a minus sign and press <enter>.

To Divide the displayed runs enter the number of the run you wish to divide by and press <enter>.

Use the **<left arrow>** or **<right arrow>** key to return to the Display Run(s) Block. Any runs selected for display will now have the selected calculation applied. Applied run calculations will be indicated on printouts by either Run X is Subtracted from Run Y or Run X is divided by Run Y. If combine is selected the run that is being subtracted from, or is dividing the displayed run will be a combined run.

4.2.11. F12 Print Runs

This option allows you to either print the sample results or export them for spreadsheet use without first displaying them on screen. This submenu also contains the setup for the format of the printout. You can specify a range of runs to be printed or exported. The action block in Figure 41 will appear when you press **F12**.

```
                    Print  Run(s)

Report with Graph :
Report - Text only:
Display Run Info  :
Print Run List    :
Spreadsheet Export:

Info Format          :   ID Only  Short  Long
Table Format         :   None  Short  Long
Table Type           :   SIZE  MESH  CUSTOM
```

Figure 41

Specifying a Range to Print or Export

To specify a range of runs, the Aerosizer program recognizes two characters, "-" (dash) and "~" (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	Specified Range
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. Printing from this option does not overlay the graphs for the selected runs but rather prints each run individually.

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 F6 Display Type.

Print Run Info

Print Run Info prints the run information as displayed in F11 Display Run Info. This provides specific information about the operating parameters used for the run.

Print Run List

Print Run List prints a complete run list for the selected data file. Dual Sensitivity runs will have the first run of the run pair displayed with an Asterisk.

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 Aerosizer program will output multiple Export Files if the range contains more than 10 run numbers. Example range specified is 1-40, export will export data from runs 1 3 5...17 19 to file run1.prn and data from runs 21 23 ....37 39 to file run21.prn. A detailed description of the data format of spread sheet export is provided in Appendix 4.

Info Format

Info Format selects the level of detail of the Statistical information and Disperser controls that is displayed on the printout and appears in the export files. ID Only will print the Run Label as entered in F2 but will not print any Statistical information or Disperser control settings. Short format will print all the statistical information and Aerosizer operating parameters but will omit the Disperser controls. Long format will print all the Statistical Information and all the Disperser controls.

Table Format

Table Format allows the user to select either None, Short or Long for the format of the printed size tables. None will cause the table to be omitted from the printout. Short format provides 50 size channels of resolution in the size table. Long format provides 165 size channels in the size table. Short and long only influence a Table Type of SIZE.

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. Selecting SIZE results in the table using either 50 or 165 logarithmically spaced sizes measured in microns. Selecting MESH results in the table using the standard sieve designations. Selecting CUSTOM results in the table using user defined sizes, in microns, or defaulting to 60 logarithmically spaced sizes.

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

a) Select **CUSTOM** for **Table Type** on the **F12 Print Runs** screen.
b) Create a text file named **"custom.api"** using a text editor or word processing program. The file must be located in the C:\API directory of your computer. Store from 2 to 61 different sizes of interest in the file **"custom.api"**. 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.api"** does not exist or has fewer than two sizes in it and **CUSTOM** is selected, the program lists 60 geometrically spaced size ranges spanning the display range.
c) Any value less than the viewed range's minimum (e.g. 0) will be read as the range's minimum.
d) Any value greater than the viewed range's maximum (e.g. 1500) will be read as the range's maximum.
e) Either display the size table (hit **F10** while viewing the graph) or print out the data.

Escape/Exit Aerosizer^{TM} Program.

The escape key serves two purposes: to erase an action block from the screen without taking any other action, or when pressed from the main menu to leave the Aerosizer^{TM} program and return to DOS. To exit the Aerosizer program press

F1

to return to the main menu, then press

<Esc>

and a prompt will appear asking for confirmation .

Press **Y**

to return to DOS.

5. MAINTENANCE.

It is important that you are aware of the following:

Caution

Use of controls or adjustments or performance of procedures other than those specified in this Manual may result in hazardous laser exposure.

Therefore, any removal of parts, other then as described in this section, should not be done by an untrained person. Where servicing contracts are in force a representative from API will perform servicing at your facility, or the unit may be returned to Amherst Process Instruments, Inc. for servicing.

Most of the routine maintenance you will perform can be done without removing the cover of the Aerosizer™.

5.1. Vacuum Pump.

Vacuum pumps made by many manufacturers are suitable for use with the Aerosizer™ . Maintenance should be performed in conformance with the separate instruction manual supplied with the vacuum pump. We suggest the use of a SV16 SOGEVAC Rotary Vane vacuum pump manufactured by Leybold, Inc.

5.2. Pump Filter (API Part # 2-7023, HEPA Filter Kit)

A filter is inserted into the vacuum line connecting the vacuum pump to the Aerosizer™ to prevent particles from entering the vacuum pump and degrading its operation. When sufficient particles have collected in the filter to significantly increase the pressure in the Aerosizer™ vacuum chamber, the warning message

Pump Filter Clogged

will appear on the screen during a measurement. Replace the filter by removing the barbed fittings from each end of the filter and screwing them into a new filter. New filters are available from API (API Part # 2-7023, HEPA Filter Kit). The Filter should be replaced yearly or more frequently if required.

5.3. Cleaning the Nozzle.

Material can deposit on the inside surfaces of the sonic nozzle during operation. This is more common with finer powders less than 10 microns. It is recommended that the sonic nozzle be cleaned on a weekly basis. The sonic nozzle may be partially blocked by a large foreign object. In severe cases, the warning message,

Nozzle Clogged

will appear on the screen during a measurement. A less severe blockage may result in a sudden apparent degradation of the quality of the particle size distribution obtained during a measurement. You may clean the Sonic Nozzle by following these steps and referring to Figure 42:

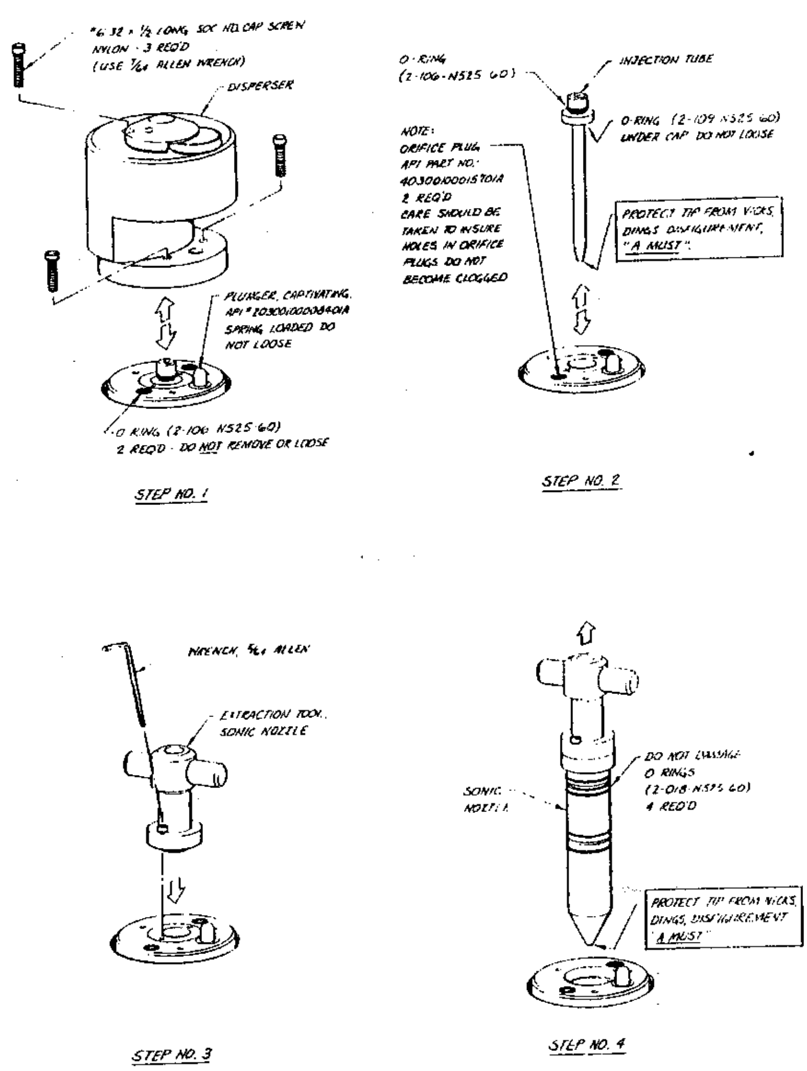


Figure 42

1. **Turn the Vacuum Pump, Computer and Aerosizer OFF.**

2. Remove the Disperser from the Aerosizer™ using a 7/64 inch Allen wrench.

3. Remove the Injection Tube. Care must be taken not to damage the tip of the Injection Tube. The tip is critical to an uniform air flow into the Sonic Nozzle.

4. Attach the Sonic Nozzle Extraction Tool (T-handle) to the Sonic Nozzle using the two 2-56 captive screws of the extraction tool.

5. Rotate the Sonic Nozzle to break the "O" ring seal. Remove the Sonic Nozzle by pulling up on the extraction tool uniformly. Remove the extraction tool from the nozzle.

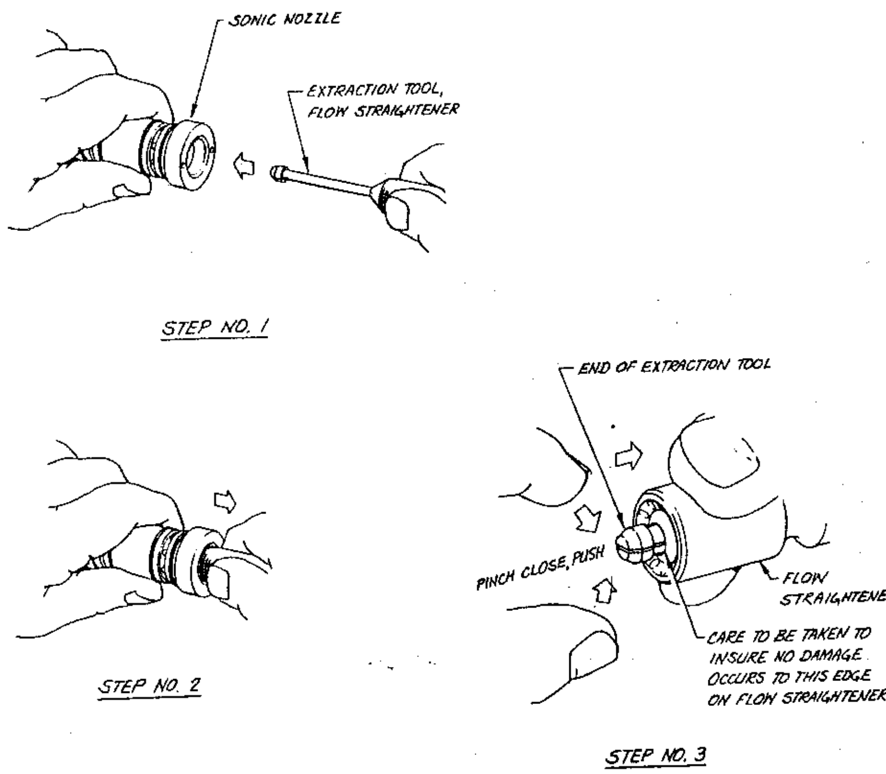


Figure 43.

5. Remove the Flow Straightener from the Sonic Nozzle using the Flow Straightener Extraction Tool (refer to Figure 43). Push the small end of the tool through the Flow Straightener until the tool end snaps into place (Step 1). Withdraw the Flow Straightener by holding the Sonic Nozzle in one hand, the tool handle in the other, and pulling apart (Step 2). This will require considerable force. Remove the tool from the Flow Straightener by pressing the two halves of the small end together while pulling the tool out of the Flow Straightener.

6. Remove any objects in the nozzle using compressed air. Swab out the inside of the sonic nozzle with isopropyl alcohol.

DO NOT ALLOW ANY HARD OBJECTS TO COME IN CONTACT WITH THE TIP OF THE NOZZLE AS EVEN SMALL SCRATCHES WILL CAUSE A SERIOUS DEGRADATION OF Aerosizer™ OPERATION.

7. Lubricate all the O-rings on the sonic nozzle and flow straightner with a small amount of O-Ring Lubricant. 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

8. Replace the Flow Straightener in the Sonic Nozzle.

9. Replace the Sonic Nozzle in the Aerosizer™ .Push the nozzle down with the Sonic Nozzle Extraction Tool.

DO NOT HOLD THE SIDES OF THE NOZZLE WITH YOUR FINGERS AS YOU PUSH BECAUSE THEY MAY BE TRAPPED BY THE UPPER EDGE OF THE NOZZLE.

10. Replace the Injection Tube and Disperser.

5.4. Replacing the Internal Air Filters (API Part # 2-7022).

Disconnect all rear panel power and air lines and remove the Disperser or direct feed connector from the top of the Aerosizer™. Remove the 6 screws at the base of the cover. The cover may then be lifted straight up.

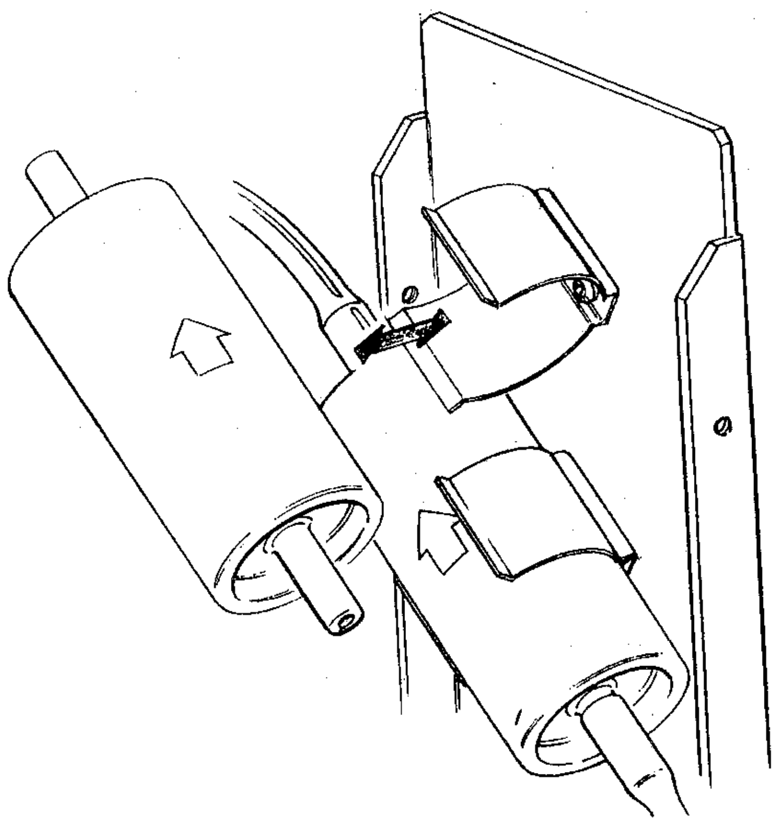


Figure 44

The Sheath Air Filter and Compressor Air Filter may be slipped out of their restraining straps and the tubing can be disconnected. It is best to replace one filter at a time to avoid errors in reconnecting the tubing. Pay particular attention to the direction of flow of the filters The new filters can be installed as shown in Figure 42. The cover may be returned to the instrument.

5.5. Cleaning the Optics and Vacuum Chamber of the AerosizerLD and Aerosizer Mach II with Access port

(Aerosizer Mach II without Access Port instructions are in section 7.5.1)

We recommend that the vacuum chamber be cleaned monthly or when operation has been degraded by sample buildup in the chamber.

Turn off the power to the Aerosizer, Vacuum Pump and Accessories.

Remove the Sample Feed Device (Direct Feed Adapter, Pulse Jet Disperser, etc.)

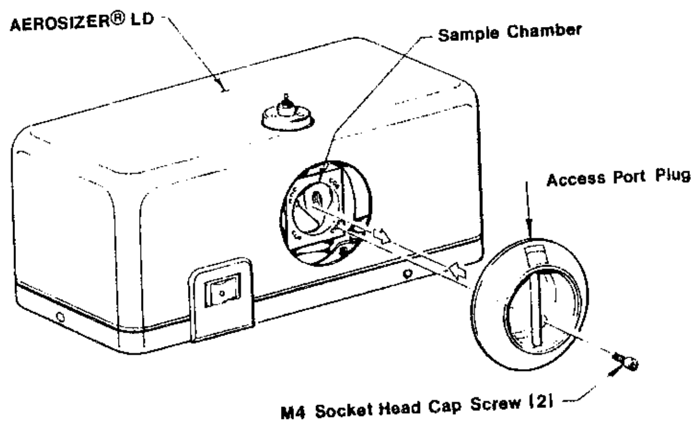


Figure 45

Remove the access port plug from the front of the Aerosizer.

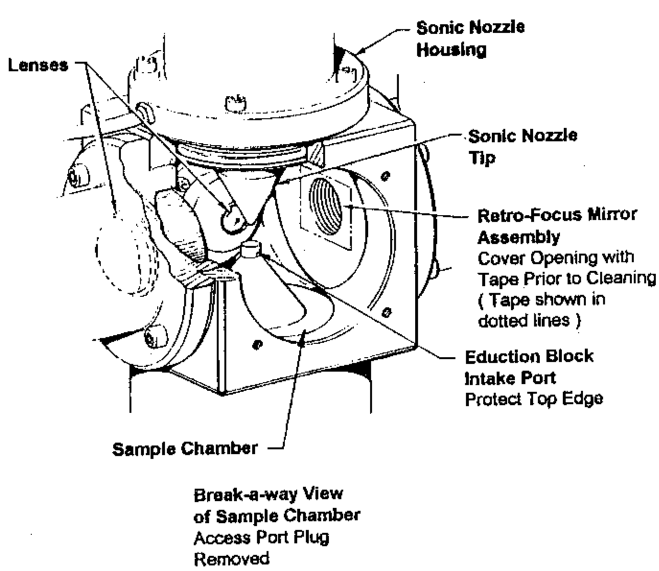


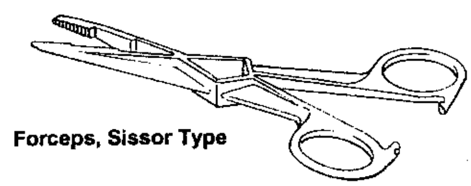
Figure 46

Remove the Sonic Nozzle. You may be able to push the sonic nozzle up by placing your fingers on the tapered portion of the nozzle and pushing. If this is not possible use the sonic nozzle extraction tool provided with the Aerosizer.

5. Tape over the opening to the Retro-Focus Mirror with Scotch Tape or an equivalent.

6 Clean the Sample Chamber and Optics by blowing out with clean compressed gas (air, nitrogen, etc.).

7 Clean the Lenses with Lens Tissue and Alcohol (or Acetone). 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 wiping action. 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.



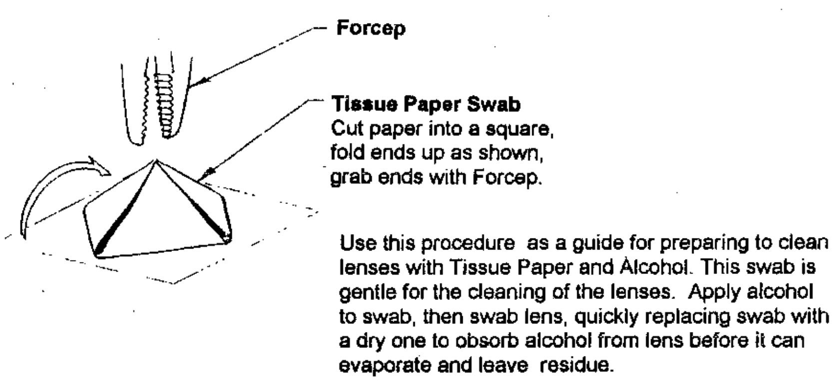


Figure 47

8. Clean the inside of the Sample Chamber with alcohol and Kimwipes if necessary.

9. **<u>Remove the tape from the Retro Focus Mirror opening.</u>**

Replace the Access Port Plug.

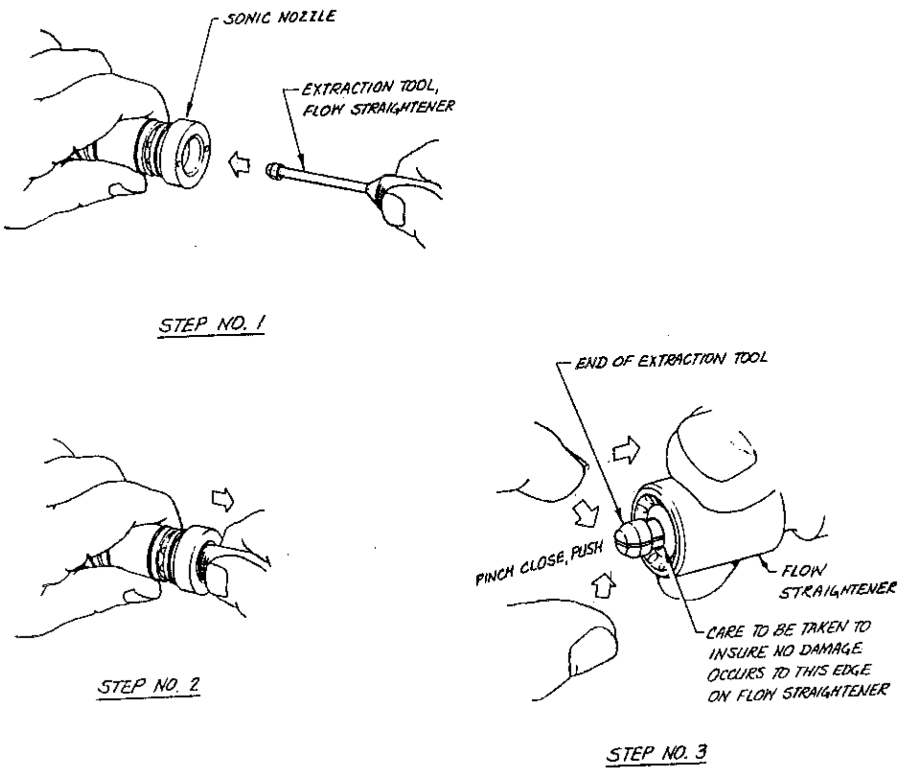


Figure 48

10. Clean and Replace the Sonic Nozzle. Remove the Flow Straightener from the Sonic Nozzle using the Flow Straightener Extraction Tool (refer to Figure). Push the small end of the tool through the Flow Straightener until the tool end snaps into place (Step 1). Withdraw the Flow Straightener by holding the Sonic Nozzle in one hand, the tool handle in the other, and pulling apart (Step 2). This will require considerable force. Remove the tool from the Flow Straightener by pressing the two halves of the small end together while pulling the tool out of the Flow Straightener.

11. Remove any objects in the nozzle using compressed air. Swab out the inside of the sonic nozzle with Isopropyl Alcohol.

Lubricate the O-rings on the flow straightner and sonic nozzle with O-Ring Lubricant if necessary. A small amount of O-Lube will keep the O-rings from sticking and provides for easy reassembly.

12. Replace the Flow Straightener in the Sonic Nozzle. The top of the Flow straightner will be approximately 1/4 " below the top of the nozzle when fully inserted.

13. Replace the Sonic Nozzle in the Aerosizer™ .Push the nozzle down with the Sonic Nozzle Extraction Tool. The top of the nozzle will be flush with the top of the housing when the nozzle is fully inserted

DO NOT HOLD THE SIDES OF THE NOZZLE WITH YOUR FINGERS AS YOU PUSH BECAUSE THEY MAY BE TRAPPED BY THE UPPER EDGE OF THE NOZZLE.

14. Replace the Sample Feed Device.

15. Restore power to the system.

A 20 minute warm up period is recommended after cleaning the optics before making measurements.

5.5.1 Optics Cleaning Instructions for Aerosizer Mach II without the Access Port

1. Remove all cables and tubes from the rear panel.

2. Remove the Sample Feed Device (Direct Feed Adapter, Pulse Jet Disperser, etc.)

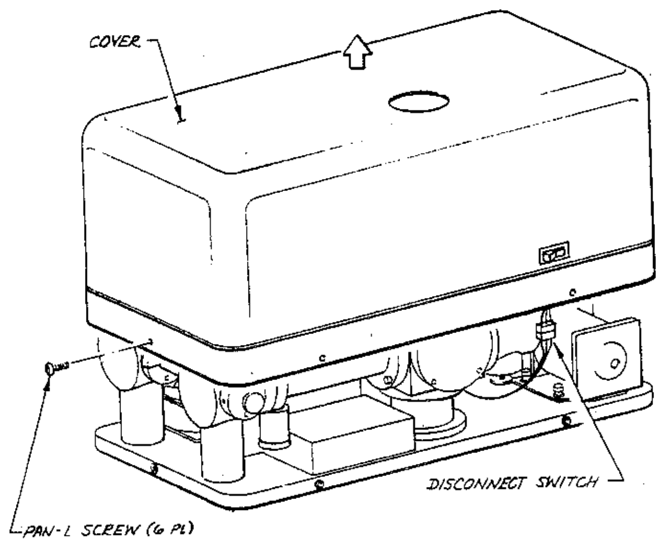


Figure 49

3. Remove the Aerosizer Cover. It may be necessary to lightly spring the cover over the rear panel of the Aerosizer. You will need to disconnect the power switch to completely remove the cover. There is a small tab on the connector that releases the locking ramp.

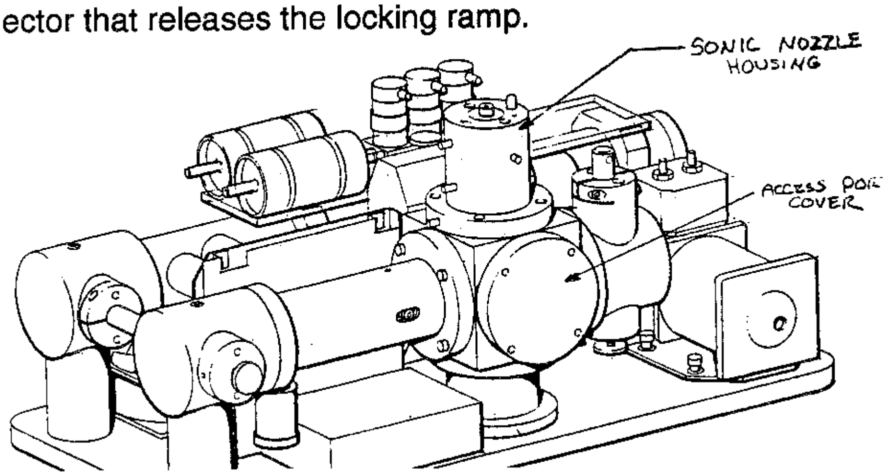


Figure 50

4. Remove the Access Port Cover and Sonic Nozzle Housing. (Use a 9/64" hex wrench to remove the four socket head cap screws that hold each part in place. It may require a little pressure to break the O-Ring seal.) Be extremely careful not to damage the sonic nozzle.

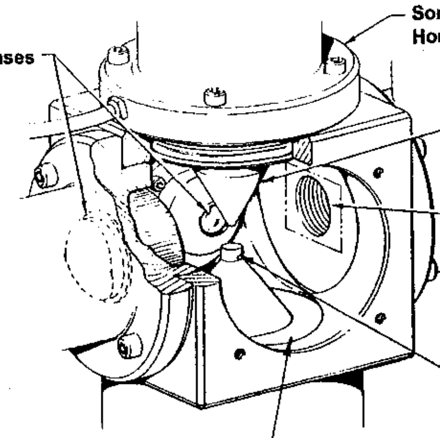


Figure 51

5. Tape over the opening to the Retro-Focus Mirror with Scotch Tape or an equivalent.

6 Clean the Sample Chamber and Optics by blowing out with clean compressed gas (air, nitrogen, etc.).

7 Clean the Lenses with Lens Tissue and Alcohol (or Acetone). **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 wiping action. 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 Kimwipes if necessary.

9. **Remove the tape from the Retro Focus Mirror opening.**

10. Clean and Replace the Sonic Nozzle Housing and Access Port Cover. The Sonic Nozzle H should be attached with the 8-32x 5/8" screws. The Access Port Cover is secured with the 8-32x1/2" screws.

11. Reinstall the cover. **Do not forget to reconnect the power switch.** The hole in the top should be guided over the sonic nozzle housing before the cutout in the back snaps into place as the cover is lowered over the Aerosizer.

A 20 minute warm up period is recommended after cleaning the optics before making measurements.

5.6 Pulse Jet Disperser Cleaning Procedures.

WARNING: API 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 OUR PRODUCTS.

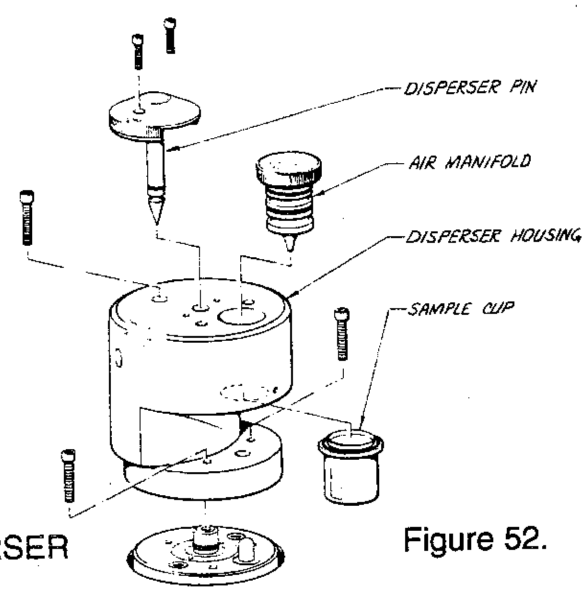
Because the Aerosizer measures particles one at a time, any particles remaining in the Disperser following a measurement may be included in the next measurement and thus contribute to errors in the new particle size distribution. It is therefore important that the Disperser be cleaned between measurements. The Disperser Pin should be removed and wiped clean a soft tissue. The Sample Air Manifold should be removed and wiped clean with a soft tissue. Swab out the inside of the Pulse Jet Disperser with a cotton swab and a small amount of Isopropyl Alcohol. Blow off the Disperser Pin and Sample Air Manifold and replace in the Pulse Jet Disperser.

Lubricate the O-rings as necessary when the Disperser Pin or Sample Air Manifold become difficult to remove.

If the Disperser develops a coating of particles that is not removed by the above methods, it may be removed from the Aerosizer™, disassembled and cleaned in an ultrasonic cleaner. This should be a part of your routine maintenance schedule.

WARNING

Do not clean the Disperser Housing, Disperser components, or Sample Cups in Acetone or other solvent. Isopropyl Alcohol may be used in limited quantity. If the Disperser requires more thorough cleaning, a mild detergent or cleaning solution such as "Glass Plus" may be used if the O-rings have been removed.



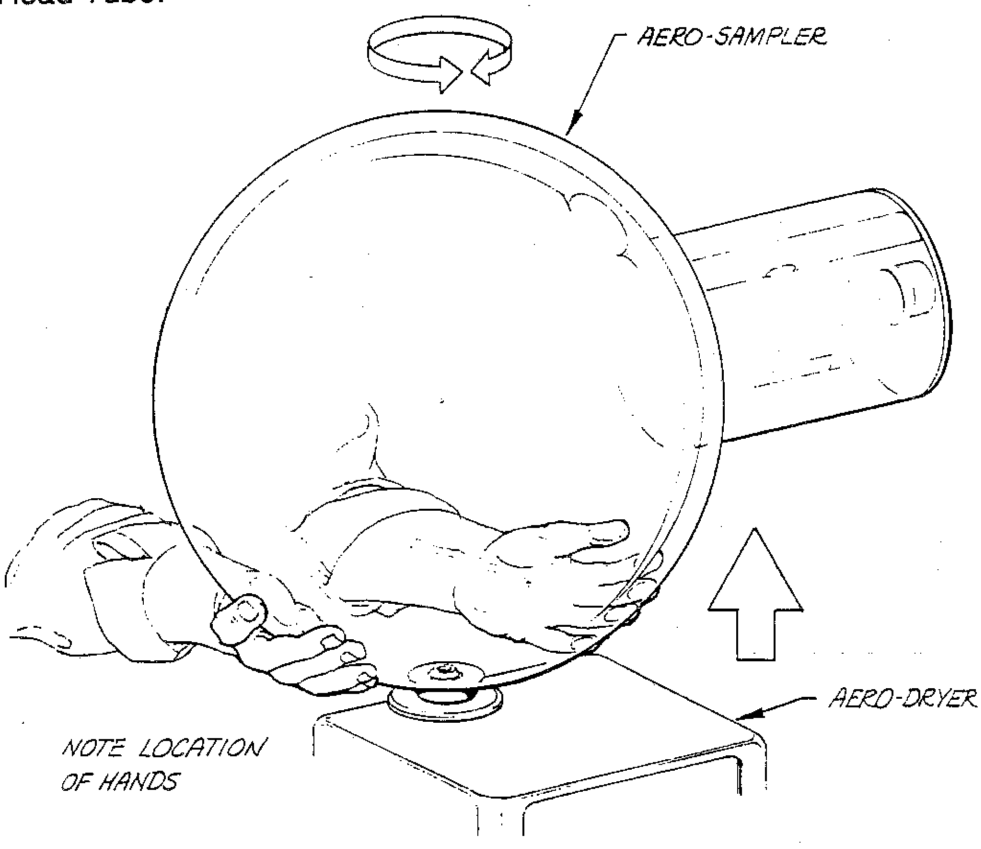
PULSE JET DISPERSER

Figure 52.

5.7 AeroSampler Cleaning Instructions

WARNING: API 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 OUR PRODUCTS.

The AeroSampler is cleaned by wiping out the inside with a commercial glass cleaner such as "Glass Plus". Isopropyl Alcohol may also be used on deposits that are not removed by the glass cleaner. The use of other solvents is not recommended as they may attack the polycarbonate and acrylic materials from which the AeroSampler is made. To access the inside of the AeroSampler either unscrew the Dynamic Head Tube or remove the end plate from the Dynamic Head Tube.



PROPER REMOVAL OF AERO-SAMPLER SPHERE FROM AERO-DRYER

WITH HANDS IN POSITION SHOWN, APPLY EVEN UPWARD PRESSURE. IF SOME RESISTANCE IS ENCOUNTERED, SLOWLY TWIST BACK AND FORTH AS YOU APPLY UPWARD PRESSURE.

Figure 53

The inside of the AeroDryer may be cleaned with a small brush or pipe cleaner. This should be done while the unit is cool. Care should be taken not to scratch the inside of the AeroDryer.

5.8 AeroBreather Cleaning Instructions

WARNING: API 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 OUR PRODUCTS.

The AeroBreather™ should be cleaned periodically as material will deposit on the interior surfaces over time. The frequency of cleaning will depend on the amount of use and type of material introduced into the sampling chamber. We recommend cleaning with a damp wipe.

Cleaning the AeroBreather Sampling Chamber

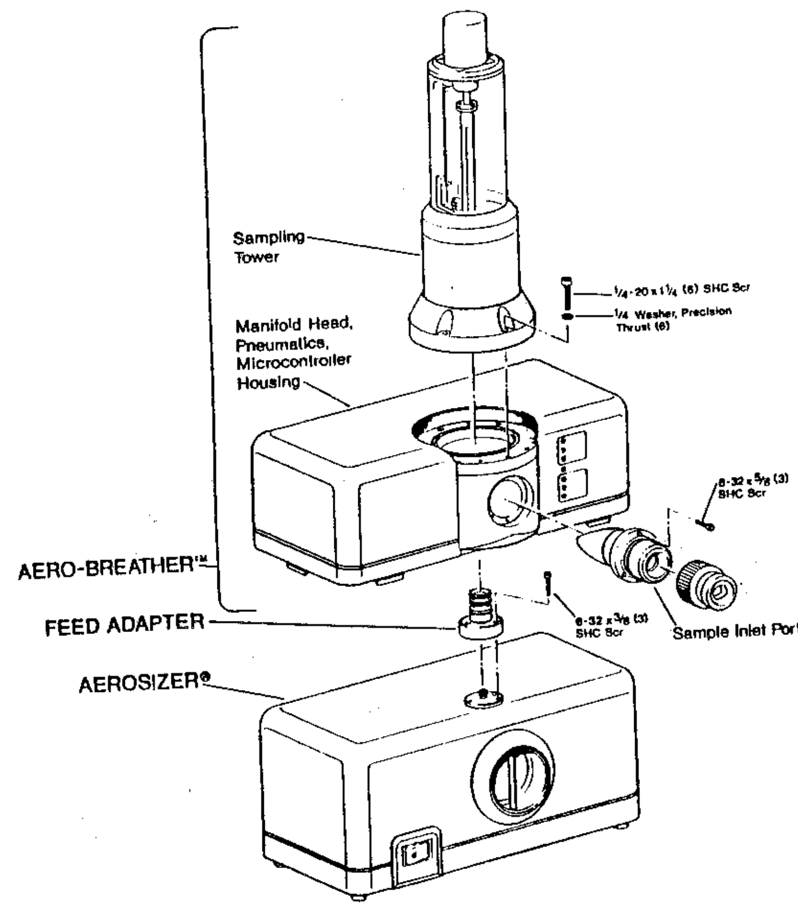


Figure 54

1. Turn off the AeroBreather™ and disconnect the power cord.

CAUTION: FAILURE TO REMOVE POWER FROM THE AEROBREATHER PRIOR TO DISCONNECTING THE CABLE TO THE SAMPLING TOWER <u>WILL</u> RESULT IN DAMAGE TO THE STEPPER MOTOR DRIVER

2. Remove the six 1/4-20 x 1 1/4 Socket Head Cap Screws holding the Sampling Tower to the Manifold Head. Disconnect the cable from the Rear Panel of the AeroBreather™. Remove the Sampling Tower and Gently push the piston to the top of its travel. Swab out the inside of the Sampling Tower with the dampened wipe.

2. Remove the Sample Adapter from the Sample Inlet Port. Swab out all internal surfaces of the Manifold Head, Sample inlet Port, and Sample Adapter with a dampened wipe. Reinstall the Sample Adapter.

4. Install the Sampling Tower on the Manifold Head. Attach with the six 1/4-20 x 11/4 Socket Head Cap Screws. Connect the cable to the rear panel of the AeroBreather™.

CAUTION: CONNECTING THE CABLE FROM THE SAMPLING TOWER TO THE REAR PANEL WITH THE AEROBREATHER POWERED UP WILL RESULT IN DAMAGE TO THE STEPPER MOTOR CONTROLLER.

5. Reconnect the power cord and turn on the AeroBreather™. It is now ready for a Sample Run.

Removing the Piston For Cleaning

1. It may be necessary to periodically remove the piston from within the AeroBreather to remove material that deposits within the O-Ring groove. To remove the piston the following procedures are to be followed. Part of the procedure requires that the unit be powered up. Be extremely careful not to drop any screws, washers or other metal objects into the AeroBreather as they may cause electrical short circuits resulting in damage to the unit. To remove the piston:

2. Turn the power to the AeroBreather off.

3. Remove the six 1/4-20 x 1 1/4 Socket Head Cap Screws holding the Sampling Tower to the Manifold Head. Lift the Sampling Tower off the Manifold head and lay it down atop the AeroBreather.

4. Turn the power to the AeroBreather on.

5. The next series of steps will cause the piston to be pushed out of the end of the Sample Tower. Read through the instructions completely before performing these steps.

6. From the main menu of the Aerosizer program press Ctl-D to access the diagnostic menu. Select F8 AeroBreather diagnostics.

```
API Aero-Breather Diagnostics ver 0.2

AltG: Perform sample intake cycle
AltP: Perform Purge cycle
 M   : set max rate       : 100 L/min
 A   : set acceleration : 10 L/s^2
 V   : set total volume : 1 L

 H   : Return to home position
 E   : stop motor
U/D  : Jog Up/Down
 J   : set jog speed    : 5
 Z   : Zero motor position
 C   : Start motor cycle test
+/-  : enable/disable status display
W/w  : Enable/Disable limit switches
 T   : Set limit switch thresholds
 O   : motor oscillation test
AltV: valve menu



Select option, or F1 to exit menu
```

Figure 55

7. Press small w to disable the limit switches.

8. Place your hand over the end of the Sample tower to catch the piston as it may be released from the shaft as it exits the tower.

9. Press D for down this will push the piston out the end.

10. Press E to stop the motor once the piston has exited the Tower.

11. The piston is attached to the shaft by a slide fit groove in the back side of the piston. Slide the piston in a perpendicular direction from the shaft to release it.

12. Remove the Quad Seal from the Piston.

13. Clean the Quad Seal and Piston.

14. Replace the Quad Seal on the Piston. Make sure it is seated in the groove properly.

15. Slide the piston back on to the shaft. Make certain that it is aligned with the bore of the Sampling Tower.

16. Press U to pull the piston up into the Sampling Tower.

17. Once the Piston is approximately 1-2 inches up in the tower press E to stop the Motor.

18. Press a capital W to Enable the limit switches.

19. Press D to drive the piston down.

20. The piston should stop before exiting the tower. (If it continues out the end of the tower press E to stop the motor and repeat the procedure from Step 16. Be sure that a Capital W is being entered to enable the limit switches.)

21. Press Capital Z to zero out the motor position indicator.

22. Turn off the Power to the AeroBreather

23. Position and Attach the Sampling Tower to the Manifold Head.

24. Turn the power to the AeroBreather on.

25. It is now ready for use.

5.9 AeroDisperser Cleaning Instructions

WARNING: API 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 OUR PRODUCTS.

Between sample analysis the AeroDisperser should be cleaned to prevent cross contamination of samples.

Release the seal on the Sample Cup by backing of the Thumbscrew that seals it in place. Rotating the exposed edge from right to left will release the seal. The sample cup may then be removed from the AeroDisperser by pulling down on the cup then sliding it out towards you.

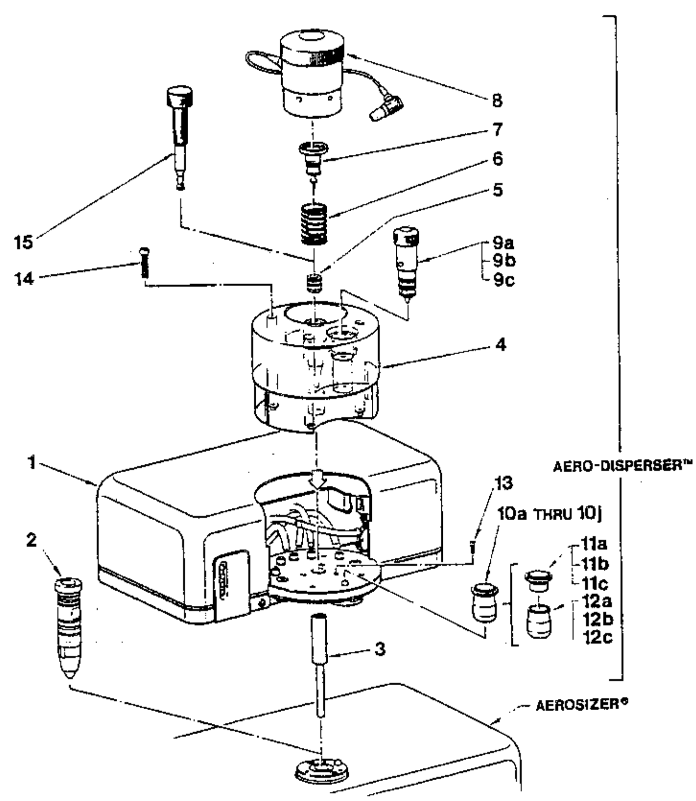


Figure 56

Open up the sample cup by pulling off the cap. (Item 11 diagram)

Wipe out the inside of the Sample Cup. Clean both sides of the Sample Cup Cap. Blow off both parts with clean compressed gas.

Remove the Jet assembly (Item 9 Diagram) by rotating to align the captivating pins with the slots. Pull the jet straight up. Wipe off the jet and blow off with compressed gas.

Remove the motor assembly (Item 8 Diagram) by rotating until the white plastic captivating plungers align with the slots in the disperser Head. Pull straight up on the Motor housing and lift it from the Disperser head slowly.. Be careful that the Disperser pin does not eject from the Disperser housing. Serious injury or damage may result. It is advisable to immediately grasp the Disperser pin as soon as the motor housing is clear of the Disperser head. If there is insufficient lubrication on the disperser pin O-ring it may hang up in the disperser head momentarily then be ejected by the force of the spring. The disperser pin is expensive and sharp and inevitably lands on its point.

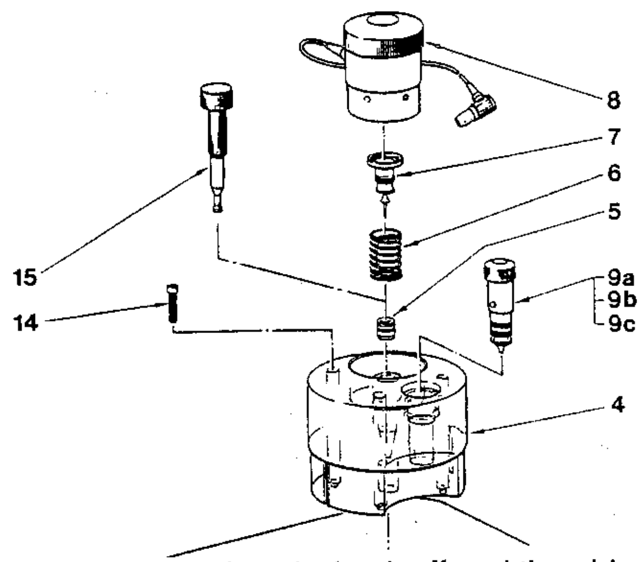


Figure 57

Remove the Disperser pin (item 7) and wipe it off and then blow it off with compressed gas. Place the Disperser pin in the Disperser Pin Holder provided with the AeroDisperser. This will protect the pin from damage during the rest of the cleaning.

Use the extraction tool (item 15) provided to remove the "Bowl" metal insert (item 5) from the disperser housing (item 4). Place the tool down into the center of the disperser housing such that it rests on the insert. While holding the bottom section of the tool stationary rotate the top of the tool in a clockwise direction. This will expand the end of the tool so that the insert may be lifted out. Pull up gently on the tool to lift out the insert. The insert may then be wiped off and blown off. Be sure to clean both sides of the insert.

Clean the inside of the Disperser housing with a cotton swab. Use the brush supplied to clean out the transport tube (angled hole within disperser housing) from the sample cup area to the disperser pin.

Reassembly

As the AeroDisperser is reassembled all O-Rings should be checked to ensure that they are present and properly lubricated. There should be a thin coating of lubricant on the -Rings giving them a shiny appearance. The parts should go together easily. If there is any significant force required to assemble the parts the O-Rings should be lubricated with the lubricant provided with the Disperser. A small amount applied with a cotton swab to create a thin film on the O-Rings is generally sufficient.

Insert the "bowl into the disperser housing. Make certain the bowl is inserted in the correct orientation (O rings closer to top). The gentle profile should be on the top side. The larger bore should be towards the bottom. Push the bowl down gently with the insertion tool until it bottoms out against the stop in the Disperser housing. The top of the insert should be below the transport tube.

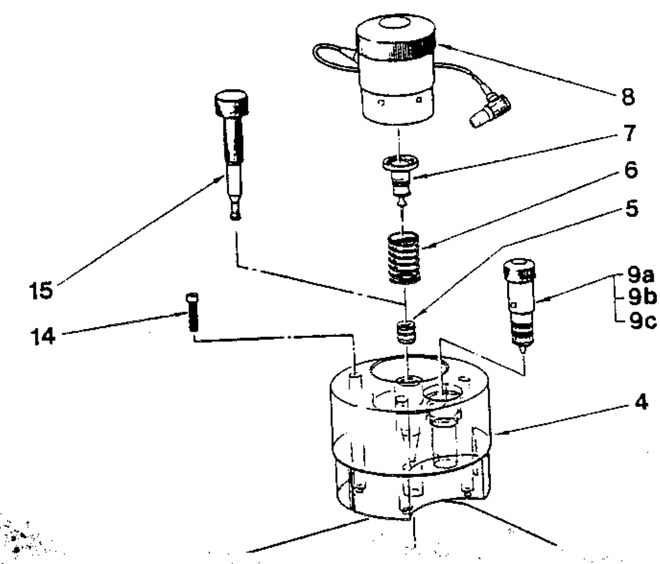


Figure 58

Place the spring (item 6) on the top of the disperser housing (item 4). The spring may be placed with either end up.

Check that the O-ring on the disperser pin is sufficiently lubricated. Place the Disperser pin (item 7) on top of the spring with the point inserted into the disperser housing. Use extreme caution not to damage the pin.

Place the Motor housing (item 8) on top of the disperser housing (item 4) and insert it by aligning the captivating plungers with the slots in the housing. Rotate the motor housing such that the cord faces straight back.

Insert the jet (item 9) into the housing. Align the pins with the slots in the disperser housing and insert it until it bottoms out on the stop in the housing. Rotate the jet 90 degrees to secure it in the housing. Failing to rotate the jet may allow it to jump out of the housing during operation resulting in damage to the jet.

The AeroDisperser is now ready to be calibrated and run with a new sample. (see Running a Sample)

Other Cleaning and Maintenance

Cleaning the injection tube

Depending on the characteristics of the material that is being run through the disperser it may be advisable to clean the injection tube between the AeroDisperser and Aerosizer between runs or some number of runs. To clean the injection tube remove the Disperser housing by unfastening the four screws attaching the housing to the base. Place the housing on top of the AeroDisperser aluminum cover. Pull the injection tube straight up. Use a pipe cleaner, small brush or twisted up wipe to clean the inside then blow it out with clean compressed gas. insert the injection tube back into the Aerosizer. Make sure O-Rings are present on both ends of the barrel section of the Injection Tube. Replace the disperser housing and fasten it to the base with the four screws.

Cleaning the Disperser housing.

The disperser housing may be cleaned by immersion in a dish detergent solution. It should be thoroughly rinsed and dried before use. The disperser housing is not intended for Immersion in any type of solvent and is not recommended.

Internal Filters (API Part # 2-7022, DFU Filter Kit)

There are two air filters internal to the AeroDisperser. These filters should be replaced at the minimum on a yearly basis and more frequently if the AeroDisperser is used heavily. To change the filters turn off the power to the AeroDisperser. Remove the Disperser Housing. Remove the aluminum cover from the AeroDisperser. The two filters are located on the left hand side of the unit as viewed from the front. API suggests that you replace one filter at a time to avoid incorrect connection of tubing during installation. Slide the Silicon Tubing off the filters. Remove the filters from the clips and replace with the new filters. Replace the Cover and Disperser Housing.

AeroDisperser Pump Filter (API Part # 2-7054)

There is one internal filter in the AeroDisperser Pump that should be changed on a yearly basis or more frequently if the AeroDisperser is operated in a dusty environment. To access the filter disconnect the power from the AeroDisperser pump. Remove the upper four screws holding the cover. Remove the cover, slip the tubing off the filter and replace it with the new filter. Replace the cover and connect the power cord.

6: Error messages.

6.1 Aerosizer Error Messages

There are several error messages that may appear on the screen when the Aerosizer™ detects air pressures in the system that are outside the normal range. Pressures within the Aerosizer 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.

ERROR MESSAGE

Sheath air filter clogged

This message occurs when the sheath air inlet pressure is below 0.85 atmospheres.

Typical causes:

Blocked sheath air filter
Pinched tube leading to or from the sheath air filter.
Blocked sheath air inlet at the rear of the Aerosizer.
Aerosizer Sample Inlet operating against pressure less than 0.85 atmospheres.

Note : This message frequently appears at the initiation of a run when the AeroDisperser is connected but goes away as data collection starts. This is normal and does not require corrective action. The AeroDisperser system is normally at a negative pressure prior to the starting of the AeroDisperser auxiliary pump and can trigger this message briefly upon startup.

Nozzle clogged

This message appears when both the chamber pressure and vacuum inlet pressure fall below 0.02 atmospheres. This message will also appear if both pressures are less than 0.05 atmospheres and the ratio of chamber pressure to vacuum inlet pressure is less than 0.7.

The Aerosizer relies on a constant gas flow through the system to create the gas jet in which the particles are accelerated. If the pathways for the gas flow upstream of the chamber become clogged the vacuum pump will pump the chamber down to lower than expected pressures.

Typical causes:

Nozzle Clogged by Large Object
Sheath Air Inlet and Sample Air Inlet Both Blocked

Pump filter clogged

This message appears when both the chamber pressure and vacuum inlet pressure are too high. If the chamber pressure is between 0.7 and 0.2 atmospheres and the vacuum inlet pressure is between 0.1 and 0.2 atmospheres this message will appear.

Typical Causes:

Clogged HEPA Filter at vacuum pump
Pinched or obstructed vacuum line between pump and Aerosizer
Vacuum Pump of insufficient pumping capacity

Vacuum pump turned off or not connected

This message will appear when both the chamber pressure and vacuum inlet pressure are close to atmosphere and the ratio of the two is between 0.9 and 1.1.

Typical Causes:

Vacuum Pump turned off
Vacuum Line not connected
Interface Cable from Aerosizer Controller to Aerosizer not connected.

Large leak somewhere in the system

This message appears when both the chamber pressure and vacuum inlet pressure are greater than 0.2 atmospheres.

Typical Causes:

Missing O-ring somewhere in system
Defective O-Ring on Quick Disconnect at vacuum inlet
Nozzle not installed
Access Port Plug Missing

Interface Cable from Aerosizer Controller to Aerosizer not connected.
Vacuum Line pinched between Aerosizer and vacuum pump
Vacuum Pump of insufficient pumping capacity

6.2 AeroBreather error messages

The AeroBreather is not responding.

This message appears when the Aerosizer Controller tries to communicate with the AeroBreather through the serial port and gets no response.

Typical Causes:

The AeroBreather is not connected
action: check that cable is connected properly from AeroBreather to correct serial port on controller
The AeroBreather is not turned on
The microprocessor in the AeroBreather has gone out of program
action: turn AeroBreather off and back on with power switch located next to power cord. This should reset the microprocessor and cause all the front panel lights to illuminate briefly before returning to power on state.

Error in sample draw

This error message appears when the number of steps required by the stepper motor to return the AeroBreather Piston to the home position is more or less than the number calculated for the sample volume entered in the sample presentation screen.

Note: this message sometimes appears when there has not really been an error in the sample draw but is triggered by the variance due to the tolerances of the optical sensors used to detect the home and end positions for the travel of the piston. It is advisable that the operator observe the motion of the piston shaft during the inspiration cycle to determine if an actual error as occurred.

Typical Causes:

Inlet restriction from inhalation device too high for selected inspiration rate.
action: lower inspiration rate or try less restrictive device
Material built up around seal on piston causing excess friction.
action: Clean AeroBreather as per instructions in section 7.8

6.3 AeroDisperser error messages

The AeroDisperser is not responding

This message appears when the Aerosizer Controller tries to communicate with the AeroDisperser through the serial port and gets no response.

Typical Causes:

The AeroDisperser is not connected
action: check that cable is connected properly from AeroDisperser to correct serial port on controller
The AeroDisperser is not turned on
The microprocessor in the AeroDisperser has gone out of program
action: turn AeroDisperser off and back on with power switch located next to power cord. This should reset the microprocessor and cause all the front panel lights to illuminate briefly before returning to power on state.

Min. calibration pressure not reached

The AeroDisperser moves the disperser pin through its range of motion and checks the maximum pressure that is obtained. If this pressure is less than 4.2 PSI this error message will appear. The controlling factors for attaining this pressure are the gap created between the disperser pin and the insert in the AeroDisperser and the flow of air from the Auxiliary pump to the AeroDisperser.

Typical Causes:

AeroDisperser is assembled incorrectly
action: check that the inset is inserted in the correct orientation and is fully seated in the housing. Also ensure that the four screws that hold the disperser head down are snug.
Sample cup is not sealed in place during calibration.
action: check that sample cup is inserted properly and that the thumbwheel is turned to the right sufficiently such that the O-ring at the top of the cup is compressed. Also check for condition and presence of O-rings in sample cup.
Make sure auxiliary pump is functioning and connected properly.
The auxiliary pump should turn on at the beginning of the calibration cycle. If it does not check that all the hoses are connected properly between the Aerosizer and AeroDisperser and auxiliary pump are connected properly. It is easy to interchange the large tube from the auxiliary pump with the one from the vacuum pump.

Missing O-rings or leaks at base of disperser head.

action: Check for presence of all O-rings in AeroDisperser. Check the condition of the O-rings and replace any that show signs of cracking or have missing section. (there are spare O-rings in the AeroDisperser accessory kit. Apply some ordinary vacuum grease (not supplied) to the five O-rings at the base of the AeroDisperser when the disperser head is removed. Replace head and recalibrate.

Worn or damaged disperser pin or insert.

action: check pin and insert for signs of damage or wear, replace disperser pin and / or insert.

Q. When I first started using my Aerosizer in Diagnostics mode at a PMT voltage of 1200V, I saw 17000 counts in the first two count rates. Now I only see 4500 counts in these channels. Is my machine broken or are my optics dirty?

A. The normal operating range for these values can vary from 2000 to 20000 counts. If the two values are similar and your measurements seem correct, there is nothing to worry about. However, if these values go out of range or the left value differs greatly from the right value or your measurements seem strange, the first thing to do is clean the optics and make sure the nozzle is clean and fully screwed together. As long as you follow the proper procedures, you can never clean too often. Remember: If in doubt, clean it out!

Q. I have no data on my graphs while viewing data which was previously collected. What is wrong and how can I fix it?

A. The Aerosizer software permits the operator to analyze data from only a portion of the total size range. Through the use of the **F5** and **F6** keys while viewing a Linear plot, the size limits can be adjusted by the operator. These limits **do not** reset automatically. Occasionally, an operator unknowingly has the limits become set such that the upper and lower size limits are equal. This causes no data to be displayed. To make this more obvious, the size limits are posted in the lower right corner of the graph screen. The quickest way to reset the limits to full range is to type **shift-R** twice.

Q. Why do I need to use Manual Combine when the Aerosizer software has an Auto-Combine tool?

A. The Auto-Combine algorithm is a minimization algorithm that finds the combine range producing the best continuity in the number distribution for a single run. The Auto-Combine algorithm **does not** utilize the data from multiple runs to find the combine range that yields the most repeatable results; only an operator using Manual Combine can do this. Additionally, the Auto-Combine algorithm is evaluated prior to applying the Gaussian Extension tool. Because of this, data sets for materials that are greatly affected by Gaussian Extension may require Manual Combine to yield ideal results with Gaussian Extension on. Finally, as with most multivariate minimization algorithms, a single run may have several combine ranges that yield equivalently smooth combined runs; the software's choice may not be the operator's choice.

Q. The AeroDisperser does not calibrate to greater than 4.0 psi. What should I do?

A. You may have a small leak in your system. First, reseat and fully tighten your sample cup. If that does not fix it, pull out the disperser pin and bowl.

Visually examine the pin for any bends on the sharp edge and make sure the bowl is curved side up (O-rings are closer to the top). Finally, make sure the disperser is properly screwed onto the Aerosizer. If none of these steps corrects the problem, call API.

Q. My disperser works okay with medium sized powders but very large powders do not seem to flow out from the sample cup. Why?
Q. My disperser works okay with medium sized powders but very fine powders seem to flow out too quickly from the sample cup. Why?
A. The standard sample cup and cap are "medium" sized. They work well for most materials. However, a shallow cup with a large cap assists in the dispersion of large particles. Similarly, a small cap with a deep cup slows down the flow of fine powders. A supplemental cap/cup kit can be obtained through API.