NANOPARTICLE SURFACE AREA MONITOR*
MODEL 3550

OPERATION AND SERVICE MANUAL

P/N 1930076, REVISION G
FEBRUARY 2014

*US Patents 6,544,484 and 7,812,306

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NANOPARTICLE SURFACE AREA MONITOR
MODEL 3550

OPERATION AND SERVICE MANUAL

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Manual History

The following is a manual history of the Model 3550 Nanoparticle Surface Area Monitor (Part Number 1930076).

Revision	Date
A	November 2005
B	April 2006
C	April 2008
D	March 2009
E	December 2010
F	January 2011
G	February 2014

Warranty

Part Number 1930076 / Revision G / February 2014

Address TSI Incorporated / 500 Cardigan Road / Shoreview, MN 55126 / USA

E-mail Address particle@tsi.com

Limitation of Warranty and Liability
(effective June 2011)

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c. Parts repaired or replaced as a result of repair services are warranted to be free from defects in workmanship and material, under normal use, for 90 days from the date of shipment;
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Service Policy

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

Patent US Patents 6,544,484 and 7,812,306

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Safety

This section gives instructions to promote safe and proper handling of the Model 3550 Nanoparticle Surface Area Monitor.

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

To prevent problems, take these precautions:

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

C a u t i o n
If the Model 3550 is used in a manner not specified by the manufacturer, the protection provided by the equipment may be impaired.

W A R N I N G
High-voltage is accessible in several locations within this instrument. Make sure you unplug the power source before removing the cover or performing maintenance procedures.

Labels

The Nanoparticle Surface Area Monitor has six labels shown in Figures S-1, S-2 and S-3. They are described below.

1 High-Voltage Symbol Label
(interior right—on power entry module)

2 Ground Symbol Label
(interior bottom right—next to ground stud)

3 Danger, High Voltage Label
(interior left—on the charger module)

4 Serial Number Label (back of cabinet)

5 Caution, No Serviceable Parts Label (back of cabinet)

6 Customer Service Label (back of cabinet)

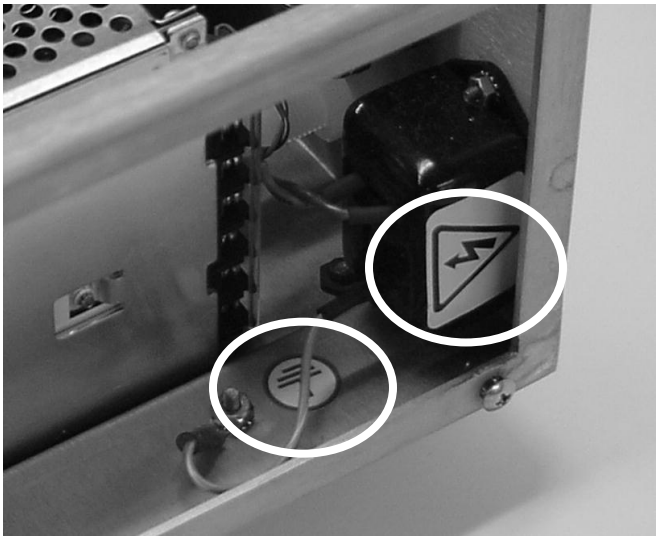

Figure S-1
Location of High Voltage Symbol Labels and Ground Label

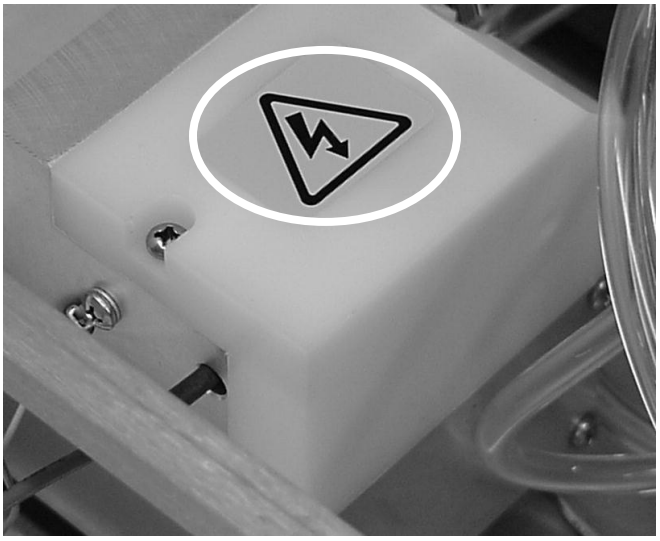

Figure S-2
Location of High Voltage Label on Charger Module

Figure S-3
Location of Serial Number and Customer Service Labels

Description of Caution Symbol

The following symbol and an appropriate caution statement are used throughout the manual and on the Model 3550 to draw attention to any steps that require you to take cautionary measures when working with the Model 3550:

Caution

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

Warning

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

Caution or Warning Symbols

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

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

About This Manual

Purpose

This is an operation and service manual for the Model 3550 Nanoparticle Surface Area Monitor.

Related Product Literature

The following TSI product manuals may be of interest.

Particle Counters

- ***Model 3007 Condensation Particle Counter Operation and Service Manual*** (part number 1930035) TSI Incorporated
- ***Model 3775 Condensation Particle Operation and Service Manual*** (part number 1980527) TSI Incorporated
- ***Model 3776 Condensation Particle Operation and Service Manual*** (part number 1980522) TSI Incorporated
- ***Model 3783 EPC ™ Environmental Particle Counter ™ Monitor Operation and Service Manual*** (part number 6003653) TSI Incorporated
- ***Model 3787 General Purpose Water-based Condensation Particle Counter Operation and Service Manual*** (part number 6003712) TSI Incorporated
- ***Model 3788 Nano Water-based Condensation Particle Counter Operation and Service Manual*** (part number 6003713) TSI Incorporated
- ***Model 3785 Water-based Condensation Particle Counter Operation and Service Manual*** (part number 1933001) TSI Incorporated
- ***Model 3786 Ultrafine Water-based Condensation Particle Counter Operation and Service Manual*** (part number 1930072) TSI Incorporated

Particle Sizers

- ***Model 3936 Scanning Mobility Particle Sizer™ (SMPS™) Spectrometer Operation and Service Manual*** (part number 1933796) TSI Incorporated
- ***Model 3034 Scanning Mobility Particle Sizer™ (SMPS™) Spectrometer Operation and Service Manual*** (part number 1980482) TSI Incorporated
- ***Model 3090 Engine Exhaust Particle Sizer™ (EEPS™) Spectrometer Operation and Service Manual*** (part number 1980494) TSI Incorporated
- ***Model 3091 Fast Mobility Particle Sizer™ (FMPS™) Spectrometer Operation and Service Manual*** (part number 1980520) TSI Incorporated

Submitting Comments

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

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CHAPTER 1

Product Overview

This chapter describes the Model 3550 Nanoparticle Surface Area Monitor*, shown in Figure 1-1, and gives an overview of how the sampler works.

Product Description

The Model 3550 Nanoparticle Surface Area Monitor measures the human lung-deposited surface area of particles (reported as $\mu m^2/cm^3$) corresponding to tracheobronchial (TB) and alveolar (A) regions of the lung. The Model 3550 provides a simple and fast solution for measuring the surface area equivalent dose in the lung.

Figure 1-1
Model 3550 Nanoparticle Surface Area Monitor

The instrument's measurement (set to measure either TB or A) matches the corresponding lung deposition of particles for a reference worker as predicted by human lung deposition model published by International Commission on Radiological Protection (ICRP, 1995; Appendix B). The deposition is calculated for a reference worker as defined in a publication by American Conference for Governmental Industrial Hygienists (ACGIH, Ed. Vincent J.H., 1999; Appendix B). The Model 3550 does not measure total surface area of particles suspended in air. Rather, it measures surface area of the fraction of these particles that deposit in TB or A region of the human respiratory tract. This measurement quantity is referred to here as "lung-deposited surface area" to differentiate it from total surface area of particles. The instrument's response is also independent of the size distribution as long as size distribution is within the specifications of the instrument (see Appendix A).

*US Patents 6,544,484 and 7,812,306

The Model 3550 can also be custom calibrated so that the instrument measurement matches a user selected lung-deposition curve (e.g., lung deposition for a child, a rat, etc.)

Applications

The Model 3550 Nanoparticle Surface Area Monitor is well-suited for measuring and monitoring workplace exposure to nanoparticles and for inhalation toxicology and epidemiology studies of nanoparticles. Nanoparticle lung-deposited surface area measurements provide a better monitoring metric to measure and quantify potential health effects of nanoparticle exposure than the mass, number or total surface area based measures.

How the Nanoparticle Surface Area Monitor Operates

The operating principle of the Model 3550 Nanoparticle Surface Area Monitor is based on diffusion charging of sampled particles, followed by detection of the aerosol using an electrometer. Aerosol enters the instrument at 2.5 L/min. The flow is split with 1 L/min passing through a filter and an ionizer, and 1.5 L/min being measured as aerosol flow.

The flows are recombined in a mixing chamber where aerosol particles are charged by diffusion. The charged aerosol passes through a trap to remove excess ions and desired amount of small particles. The voltage applied to the trap determines the amount of particles removed along with the ions. The aerosol then moves on to an aerosol electrometer for charge measurement. In the electrometer, current is passed from the particles to a conductive filter and measured by a very sensitive amplifier. A microprocessor controls the instrument flows and measures various operational parameters.

CHAPTER 2

Unpacking and Setting Up the System

Use the information in this chapter to unpack and setup the Model 3550 Nanoparticle Surface Area Monitor.

Packing List

As you unpack the shipping container, make certain the shipment is complete. Table 2-1 gives a packing list for the Model 3550.

Table 2-1
Nanoparticle Surface Area Monitor Packing List

Qty	Description	Part No.
1	Model 3550 Nanoparticle Surface Area Monitor	355000
1	Nanoparticle Surface Area Monitor accessory kit, including:	
1	Cable, 9-pin serial M-F (12 feet)	962002
1	Cable, USB to 9-pin serial (6 feet)	1102125
1	Cyclone—1 µm cut size	1030536
1	Fitting, SS Elbow ¼ Tube–¼ Tube	1601012
1	Cable, power supply	1303053*
2	Filter, Balston DFU-BX	1602230
1	Filter, wire core microfiber	1602346
1	Filter, carbon cartridge DAU	1602348
1 m (3 ft)	Tubing, Tygon ¼ OD x $\frac{1}{8}$ ID	3001220
1 m (3 ft)	Tubing, Tygon $\frac{5}{16}$ OD x $\frac{3}{16}$ ID	3001248
1	USB to RS-232 converter	1102125
1	Operation and service manual	1930076
1	Software for Nanoparticle Surface Area Monitor	390092

*Power cord listed is for U.S.A. use only.

Unpacking Instructions

The Model 3550 is shipped fully assembled. To begin using the instrument:

1. Remove the protective caps from the sample inlet (back panel) and from the pump exhaust (back panel). The caps should be saved for leak-checking use or whenever packing the instrument for shipment.
2. Attach the elbow fitting (1601012) from the accessory kit to the inlet in the back of the instrument and then insert the cyclone into the elbow fitting as shown in Figure 2-1.

   Note that the cyclone installation is optional. It will significantly extend the time that the instrument can be run without cleaning the inlet orifice by removing particles greater than 1 µm. However, it also removes some small particles. Therefore, if the instrument will be used under laboratory conditions where large particles are not present, it may be advisable to use the instrument without the cyclone.
3. Insert the appropriate power cord into the back of the instrument and turn it on using the switch next to the power entry point.

Figure 2-1
Cyclone Installed on Back Inlet of Instrument

Moving the Instrument

The Model 3550 Nanoparticle Surface Area Monitor is small and light enough that it can be easily moved by gripping the bottom of the instrument on both sides and lifting.

Mounting the Instrument

The Nanoparticle Surface Area Monitor has no special mounting requirements other than providing ventilation (see below). The cabinet has four non-marking rubber feet that give the instrument a good grip on clean, level surfaces. The rubber feet are installed in the cabinet using integrated ¼-20 UNC threaded fasteners and can be removed (by unscrewing) to allow other mounting fasteners to be used.

Note: *If the cabinet is mounted to a plate, drill holes in the plate to match the ventilation holes in the bottom of the cabinet or use standoffs to raise the bottom of the cabinet at least ½ inch (1.2 cm) above the mounting plate.*

Ventilation Requirements

The Nanoparticle Surface Area Monitor power supply is designed to be cooled by room air drawn by a fan through the vents in the bottom of the cabinet and exhausted through the back of the cabinet.

The cabinet should be installed with at least ½-inch (C-mm) clearance between the back panel and any other surface. Also, the cabinet should be set on a clean, hard surface so that air can move freely through the base of the cabinet.

Power Connection

Connect the AC power cord (supplied) to the AC POWER IN connection on the back of the Model 3550 and then into an available power outlet. It is not necessary to select the correct voltage; the instrument accepts line voltage 100 to 240 VAC, 50/60 Hz, 1A maximum single phase. The connector has a built-in on/off switch.

Notes: *Make certain the line cord is plugged into a grounded (earth grounded) power outlet. Position the Model 3550 so the power cord connector is not blocked and is easily accessible.*

The Nanoparticle Surface Area Monitor power supply contains no user-serviceable parts. If the power supply is not operating correctly, use the information in Chapter 9 to contact TSI. This instrument should not be used in a manner not specified by the manufacturer.

Toggle the on/off switch at the AC POWER IN connection to the on position to verify the instrument has power.

Connecting the Computer

Connect the serial port of an IBM-compatible computer to the SERIAL PORT connector on the back of the Model 3550 (Figure 2-2). Use the 4-meter cable provided. If your computer does not have a serial port, connect the USB port of the computer to the SERIAL PORT connector on the back of the Model 3550. Use the 1.8-meter USB to serial connector cable provided. If a longer cable is needed, use a standard IBM 9-pin, serial extension cable.

***Note**: The driver for the USB to serial connector cable on your computer must be installed before it can be used for data transfer. The cable comes with an installation software CD and owner's manual. Follow the instructions in the owner's manual to install the driver using the software.*

Figure 2-2
Location of Serial Port

Installing the Nanoparticle Surface Area Monitor Software

Install the Model 3550 Nanoparticle Surface Area Monitor software as described below.

Computer Requirements

To use this software we recommend a personal computer with the following minimum features, components, and software:

- A Pentium® 4, 2 GHz processor or higher.
- An SVGA color monitor.
- Microsoft Windows® 2000/Windows® XP or newer.
- A hard drive large enough to accommodate Windows®, the Nanoparticle Surface Area Monitor software, and data files.
- A CD-ROM drive.
- 512 MB or more of RAM.
- A mouse.
- An RS-232 serial interface port (in addition to the one that may be required for the mouse).
- A Microsoft Windows-compatible printer is optional.

Program Installation

1. Shut down (exit) all programs/applications on the Windows desktop.
2. With the computer on and Windows running, insert the Model 3550 Nanoparticle Surface Area Monitor Software CD-ROM in your CD drive. To run the **autorun.exe** from the CD:
   a. If AutoPlay is enabled on your PC, the setup program begins automatically and the introduction screen is displayed on the Windows desktop.
   b. If AutoPlay is not enabled, select **Run** from the **Start** menu and type: `D:\autorun` in the Open box and press **OK**. (D is the letter corresponding to your CD drive.)
3. Follow the instructions as the setup program runs. When installation is complete, you may be asked if you want to view the readme.htm file. You should read the readme.htm file if one is available. This file contains important information that could not be included in this manual. If you decide not to read the file immediately, you can access the file later. It will be installed in the same directory as the application.

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®Windows is a registered trademark of Microsoft Corporation.

4. When the installation program finishes, remove the CD-ROM. Store the CD-ROM in a safe place for later use.

The installation program creates a folder (directory) called “Program Files|TSI|Nanoparticle Surface Area Monitor” on your hard disk (assuming you accepted the default folder name). This folder contains the required program files and sample data files.

The setup program also creates a new item in the Start Menu called “TSI” and an icon on your desktop for the software.

***Note**: Before creating a TSI menu item, the setup program checks for an existing one. If one is present, it adds the icon only.*

CHAPTER 3

Controls, Indicators, and Connectors

Use the information in this chapter to familiarize yourself with the location and function of controls, indicators, and connectors on the Model 3550 Nanoparticle Surface Area Monitor.

This chapter is organized into two sections describing aspects of the instrument: Front Panel and Back Panel.

Front Panel

The main components of the front panel are the four push-button controls and display, and the four LED indicators.

Figure 3-1
Front of the Model 3550 Nanoparticle Surface Area Monitor

LCD Display

The front panel has a 4-digit liquid crystal display (LCD) as shown in Figure 3-2. The LCD shows the lung-deposited surface area of particles in units of square micrometers per cubic centimeter ($\mu m^2/cm^3$) corresponding to tracheobronchial (TB) or alveolar (A) region of lung, or to custom calibrated response.

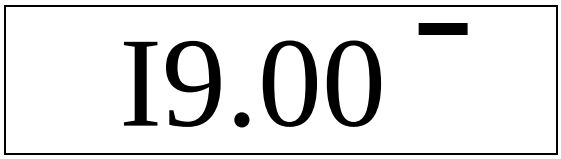

Figure 3-2
LCD Display

Control Buttons

Four control buttons control operation of the Model 3550 Nanoparticle Surface Area Monitor. Each button is briefly described below. For a more detailed description, see the Chapter 4, "Operating the Nanoparticle Surface Area Monitor."

Response	The measurement response can be configured for tracheobronchial (TB), alveolar (A) or custom calibrated deposition. Press **Response** to toggle between two measurement modes: TB or A. The bar on the right most side of LCD display indicates the current mode. No bar means custom calibrated response which can be set only through the software.
Charger	Press **Charger** to cycle through four modes of charging. The charger and trap LEDs indicate the current mode.
Zero	Press **Zero** to force the Model 3550 to perform a zero calibration. The LCD display will indicate "ZERO" for the 30 seconds that is required for a zero calibration. Note that there should be no flow (over- or under-pressure) through the instrument during a zero. ***Note*:** *The Zero button has to be held down for at least two seconds. This is to prevent an accidental reset.*
Pump	Press **Pump** to turn the internal pump off and on. The Flow Ratio and Total Flow LEDs should both be on when the pump is running and off when the pump is not running. The pump state (on/off) is remembered and restored when the power is turned off and back on. ***Note***: *When the pump is turned off, the charger is also automatically turned off to protect the charger needle from contamination build up.*

Indicator Lights

Four green status lights above the LCD display monitor instrument parameters. Each indicator is described briefly below. For a more detailed description, see the Chapter 4, "Operating the Nanoparticle Surface Area Monitor."

Charger	The Charger LED indicates that the diffusion charger is turned on or off. When the charger is first turned on (or the instrument is turned on), a few seconds of blinking is normal indicating that the charger is reaching its set point.
Trap	The Trap LED indicates that the trap is turned on or off. A blinking LED indicates that the trap is on but not at its set point.
Flow Ratio	The Flow Ratio LED indicates that the correct ratio is being maintained between the charger flow and the aerosol flow when the LED is on.
Total Flow	The Total Flow LED indicates that the total flow (pump) is on or off.

Back Panel

As shown in Figure 3-3, the back panel has a power connection and pump exhaust fitting.

AC Power Connector

The AC Power Connector accepts the line cord (supplied) to provide AC power to the instrument. See "Power Connection" in Chapter 2 for more information.

Cooling Fan

The cooling fan is located above the pump exhaust fitting. It is used to remove heat generated inside the Nanoparticle Surface Area Monitor cabinet. The fan should never be blocked or placed where it cannot exhaust warm air from the cabinet.

Figure 3-3
Back Panel of the Model 3550 Nanoparticle Surface Area Monitor

Pump Exhaust Fitting

The pump exhaust fitting on the back of the Model 3550 is a ¼-inch Swagelok®-type. This fitting can be used to connect the instrument to tubing that will carry hazardous gases to a fume hood, if desired. Note that filters are placed before and after the internal pump. Thus the pump exhaust should not normally have to be further filtered to prevent particles entering the environment.

Serial Port

The Model 3550 has a single RS-232 serial port that is used to communicate with a computer using a standard 9-pin serial cable. See Appendix D, "Using Serial Data Commands," for a detailed explanation.

Aerosol Inlet/Cyclone

The aerosol inlet samples 2.5 L/min of aerosol from ambient air or can be connected to tubing for sampling. If sampling tubing is used, it should be conductive or static dissipative to reduce particle losses. Using the cyclone will significantly extend the time that the instrument can be run without cleaning the inlet orifice by removing particles greater than 1 µm. However, it also removes some small particles. Therefore, if the instrument will be used under laboratory conditions where large particles are not present, it may be advisable to use the instrument without the cyclone (see "Cyclone" in Appendix C). See "Unpacking Instructions" in Chapter 2 for installation instructions.

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Filter Access Cover

The access cover allows the electrometer filter to be replaced without having to remove the instrument cover. See Chapter 7, “Maintenance,” for more information.

System Description

The operating principle of the Model 3550 Nanoparticle Surface Area Monitor is based on diffusion charging of sampled particles, followed by detection of the aerosol using an electrometer. Aerosol enters the instrument at 2.5 L/min. The flow is split with 1 L/min passing through a filter and an ionizer, and 1.5 L/min remaining as aerosol flow (see Figure 3-4).

The flows are recombined in a mixing chamber where aerosol particles are charged by diffusion. The charged aerosol passes through a trap to remove excess ions and desired amount of small particles. The voltage applied to the trap determines the amount of particles removed along with the ions. The aerosol then moves on to an aerosol electrometer for charge measurement. In the electrometer, current is passed from the particles to a conductive filter and measured by a very sensitive amplifier. A microprocessor controls the instrument flows and measures various operational parameters.

(continued on next page)

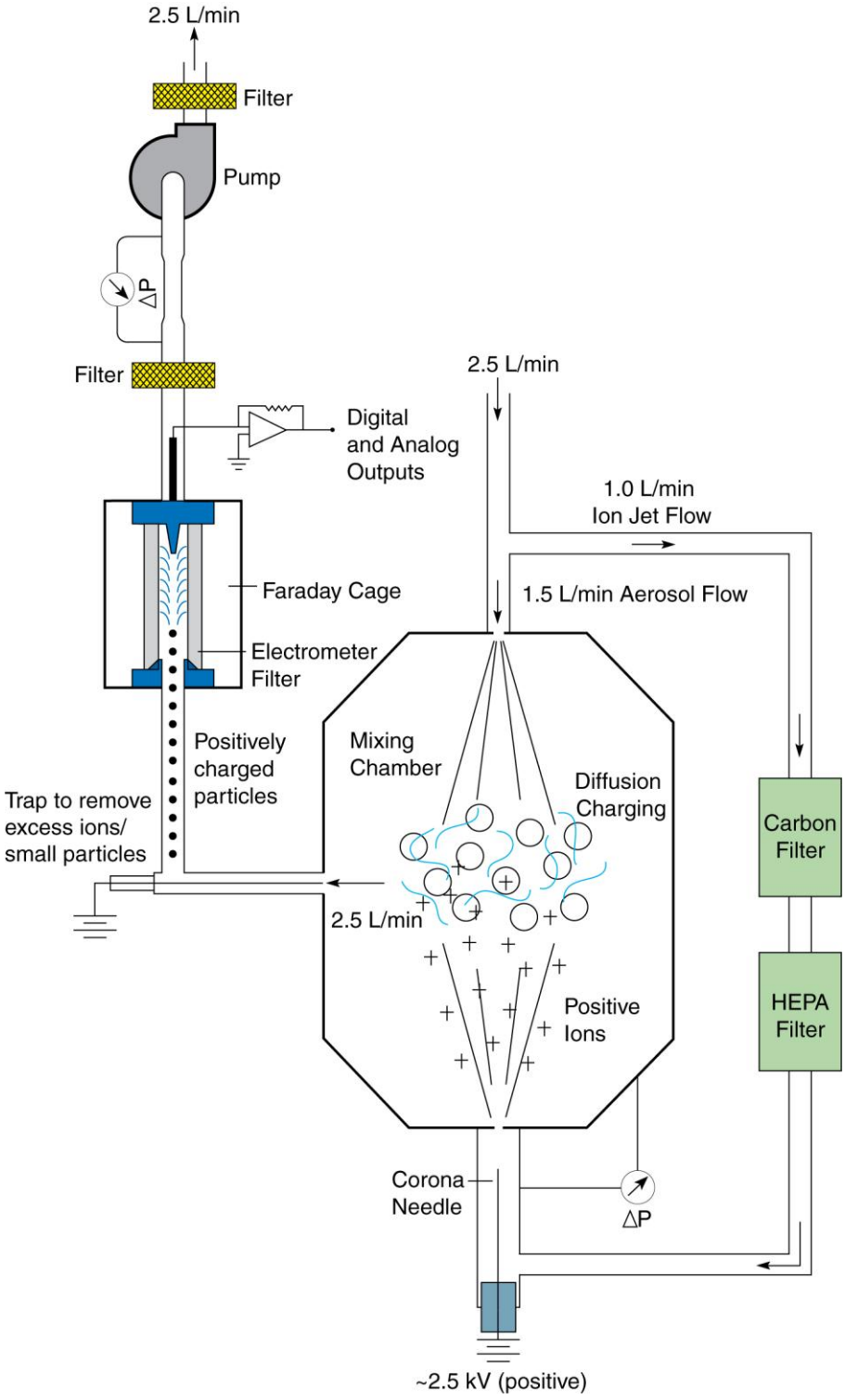

Figure 3-4
Schematic Diagram of the Nanoparticle Surface Area Monitor

CHAPTER 4

Operating the Nanoparticle Surface Area Monitor

This chapter describes how to operate the Model 3550 Nanoparticle Surface Area Monitor.

Supplying Power and Removing Power

Supply power to the Nanoparticle Surface Area Monitor by plugging the AC power cord into the power cord inlet on the back panel and then into an AC source. The power cord inlet has a switch to turn the instrument on and off without unplugging the power cord. When the instrument is powered on, it will configure itself according to the state it was in when last powered off.

Front Panel Controls

Response

The Response button controls the output of the display screen. Press **Response** to toggle between two measurement modes: tracheobronchial (TB) or alveolar (A). The bar on the rightmost side of LCD display indicates the current mode. No bar means custom response which can only be set through the software.

Charger

Press **Charger** to cycle through four modes of charging. The charger and trap LEDs indicate the current mode:

Mode	Charger	Trap
1	On	On
2	Off	On
3	On	Off
4	Off	Off

When the Charger LED is on, it indicates that the diffusion charger is turned on. The charger is normally required for the proper operation of the Nanoparticle Surface Area Monitor. However, there may be cases during experiments with charged particles where it is helpful to disable the charger to study the charge carried by sampled particles using the electrometer alone. When the LED is off, it indicates that the diffusion charger is turned off. The charger current is maintained by a control system. If the measured current is outside of a ±10% range, the LED will blink. When the charger is first turned on (or the instrument is turned on), a few seconds of blinking is normal.

When the Trap LED is on, it indicates that the trap is turned on. The trap is a variable-voltage electrostatic precipitator that removes excess ions generated by the charger along with desired amount of small particles. The trap is normally required for the proper operation of the Nanoparticle Surface Area Monitor. However, there may be cases during experiments with very small particles or while studying ions where it is helpful to disable the trap to study the charges carried by sampled particles using the electrometer alone.

Zero

Press **Zero** for two seconds to force the Nanoparticle Surface Area Monitor to perform a zero calibration. The LCD display will indicate “ZERO” for the 30 seconds that is required for a zero calibration.

Pump

Press **Pump** to turn the internal pump off and on. The Flow Ratio and Total Flow LEDs should both be on when the pump is running and off when the pump is not running.

When the Flow Ratio LED is on, it indicates that the correct ratio is being maintained between the charger flow and the aerosol flow. The Flow Ratio indicator should be illuminated during normal operation of the Nanoparticle Surface Area Monitor. If the flow ratio is higher than the set point, the Flow Ratio LED will blink fast (about 5 times per second). If the flow ratio is lower than the set point, the Flow Ratio LED will blink slowly (about 2 times per second). If the LED is blinking, see “Troubleshooting” in Chapter 8.

When the Total Flow LED is on, it indicates that the total sampled flow is controlled using the pump to within ±10% of the set point. The pump button toggles the pump on and off.

When the pump is turned off, the charger is automatically turned off to protect the charger needle from contamination build up.

Computer Control

Using Nanoparticle Surface Area Monitor Software

The Nanoparticle Surface Area Monitor software is shipped as an accessory to the instrument. Follow the instructions in Chapter 5, "Software Operation" to run the software.

Using Other Software

Software that allows a computer to communicate using the serial port may also be used to control and collect data from the Nanoparticle Surface Area Monitor. For example, you may develop specialized software using Microsoft® Visual Basic® or National Instruments™ LabVIEW® software. This can usually be accommodated using the serial port (RS-232) commands listed in Appendix D, "Using Serial Commands." Please note that TSI does not support third party software in any way. The command set is provided for your convenience only.

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®LabVIEW is a registered trademark of National Instruments.

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CHAPTER 5

Software Operation

This chapter provides specific information for the Model 3550 Nanoparticle Surface Area Monitor software including:

- Starting the program
- Opening an existing file
- Collecting data
- Selecting a sample to display
- Changing how data is viewed
- Selecting a data hot spot in a graph
- Zooming in and out on data in a graph
- Deleting/undeleting samples
- Printing information displayed on the desktop
- Exporting data to a file
- Arranging open windows and changing the layout
- Quitting the program
- Description of all program menus and menu items.

Start the Nanoparticle Surface Area Monitor Program

To start the program, proceed as follows:

From the Windows desktop, press the **Start** menu and select **Programs|TSI|Nanoparticle Surface Area Monitor**.

The Nanoparticle Surface Area Monitor desktop appears as shown in Figure 5-1.

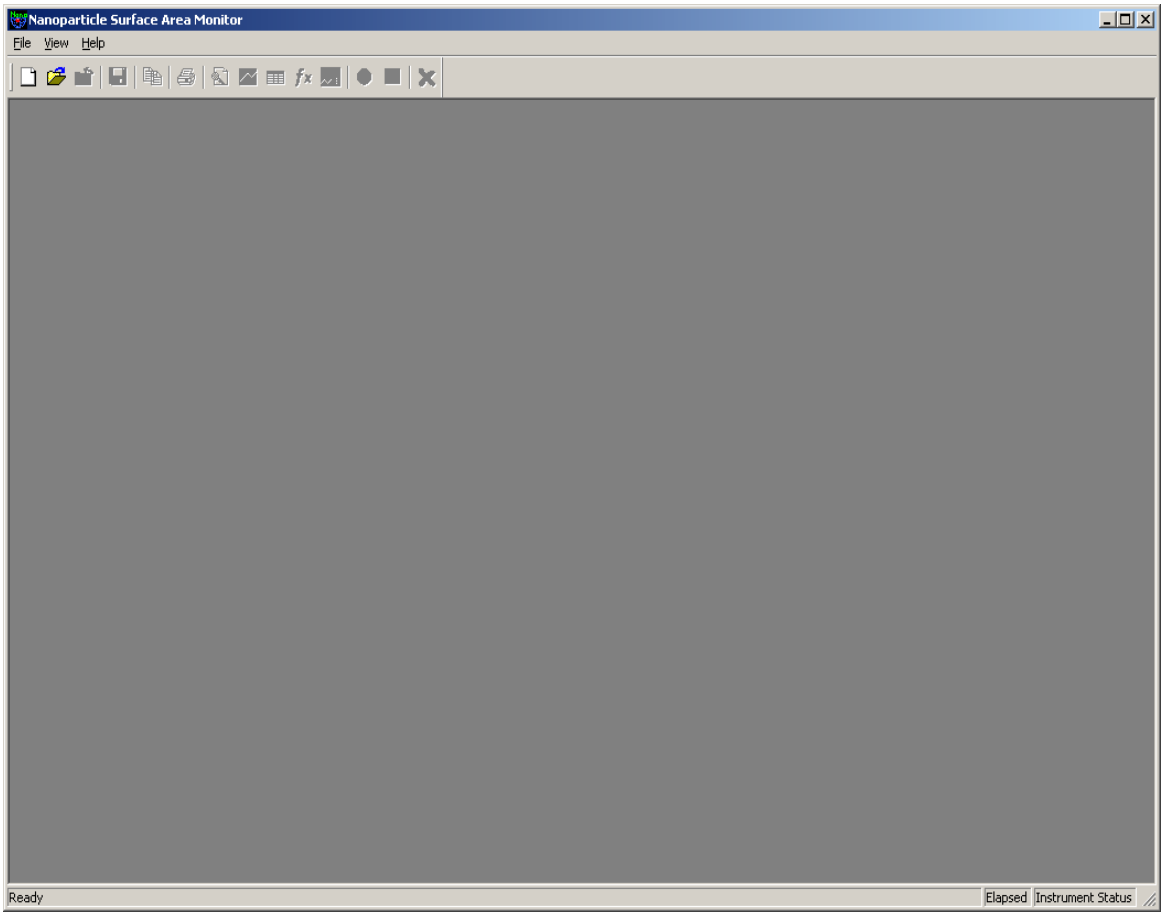


Figure 5-1
Nanoparticle Surface Area Monitor Desktop

Open an Existing File

1. Select **File|Open** or  on the toolbar.
2. When the Open file dialog box appears, it shows the files available in the default file location. The default file location is Program Files|TSI|Nanoparticle Surface Area Monitor. Example files are included with the program and are installed in the Nanoparticle Surface Area Monitor software folder when the program is installed.

   Use the mouse to highlight the file you want to open. If you store data files in a location other than the default folder, browse for the drive/directory where the data files are stored before clicking **Open**.
3. Click **Open**. The program remembers the windows that were open on the desktop when you last closed the file and reopens them when you access the file again.

Collect Data

There are two steps to collecting data.

- Open an existing file or create a new sample file
- Start data collection

Before beginning, make certain the Model 3550 is connected to the computer, the instrument is warmed up, and the software is running.

Step 1—Open an Existing File or Create a New Sample File

To open an existing file, follow the steps outlined in the previous section "Open an Existing File."

To create a new file, select **File|New** or  on the toolbar. The dialog box shown in Figure 5-2 opens on your desktop.

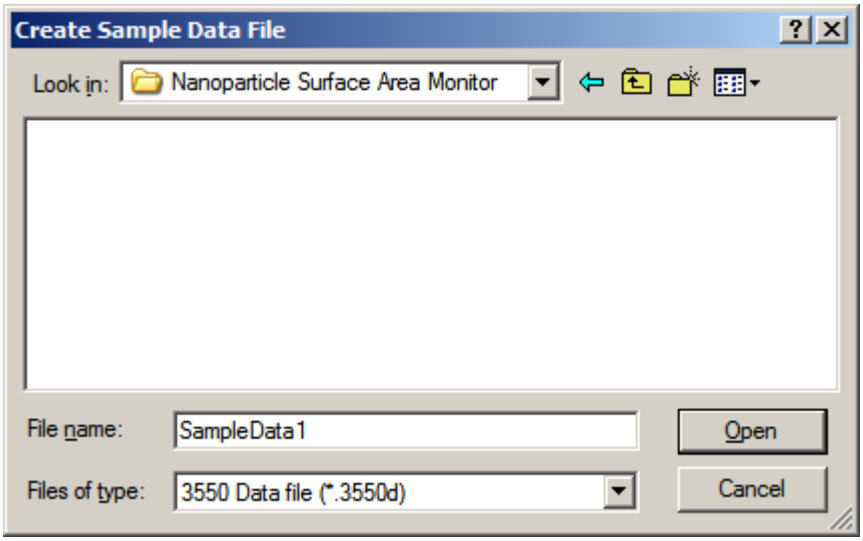


Figure 5-2
Open a New File

Select a filename (and, optionally, a location other than the default folder). The default name is "SampleData1" for the first file you open, "SampleData2" for the second file you open and so on. You can accept the default name or enter any name you choose. You do not need to enter an extension in the filename box. It will be assigned automatically (.3550d).

After entering a filename (or if you accept the default name), press the **Open** button.

After pressing the **Open** button, the computer attempts to connect to the instrument. When the connection is complete, the Samples List window opens. Other windows that were open the last time the application was closed are also opened. If this is the first time running the application, all windows are opened on the desktop. All windows are initially empty.

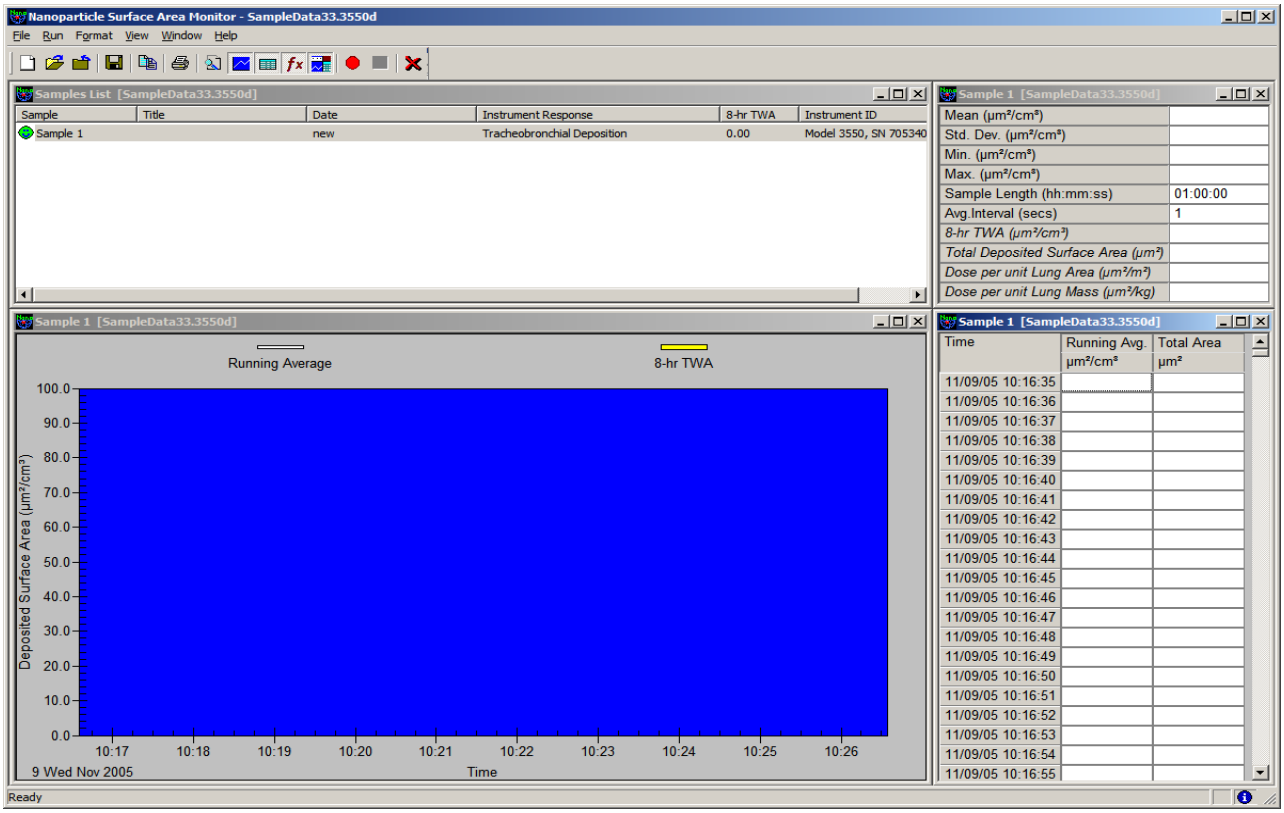


Figure 5-3
New Sample Initial Desktop

Step 2—Start Data Collection

Start sampling in one of three ways:

- Select **Run|Start Data Collection**.
- Click on the toolbar.
- Press **<F10>**.

Note: *If using an existing file, before starting a run, add a new sample by selecting **Run|Add New Sample**.*

Before starting a new sample run, you may set the properties for that sample. If you do not set sample properties before starting data collection, the defaults will be in effect. The Sample Properties dialog is described below.

As the program begins sampling, the data is displayed in the windows open on the desktop.

When the sample finishes, data for the sample is stored in the file, but the windows remain open.

To stop data collection before the selected sampling time is complete, select **Run|Stop Data Collection** or press ■ on the toolbar.

Communications Errors

If you receive the following error message (Figure 5-4) when trying to start a new sample or creating a new file, there is a communications problem between the computer and instrument (i.e., you forgot the cable connection) or you already have a connection open to the instrument, such as another instance of this application, and are attempting to open another connection.

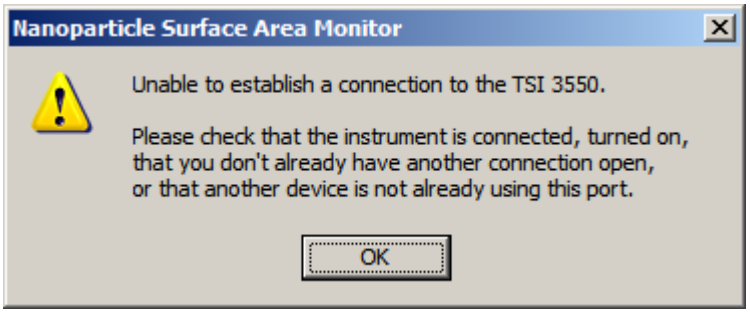


Figure 5-4
Communications Errors Dialog Box

Check the cable connection and close all files and then try to reconnect.

Note: *Most computers have only one or two active communications ports, COM1 and COM2. COM1 is most likely available for the TSI sensor connection.*

Instrument Errors

Instrument Errors may be reported while sampling. If an error is detected, a message box will open on the desktop describing the error and the time at which it occurred (Figure 5-5). Sampling will not stop. Press the close button to close this message window.

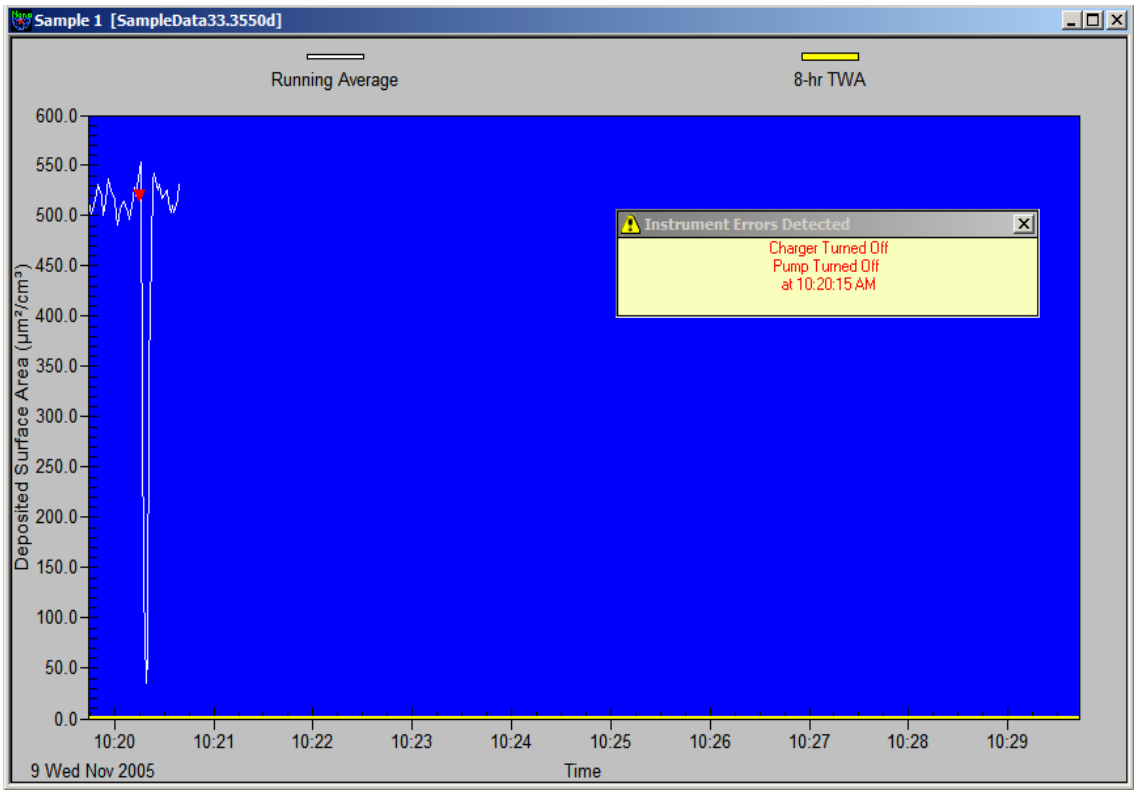


Figure 5-5
Instrument Errors Detected Dialog Box

Sample Properties for a New Sample

To configure properties for a new sample, open the Sample Properties dialog box before starting data collection by selecting **Run|Properties** or right-click on the new sample in the samples view and select **Properties**. The dialog in Figure 5-6 opens on the desktop. The Sample Properties dialog box contains three tabs: Instrument Response, Settings and Communications.

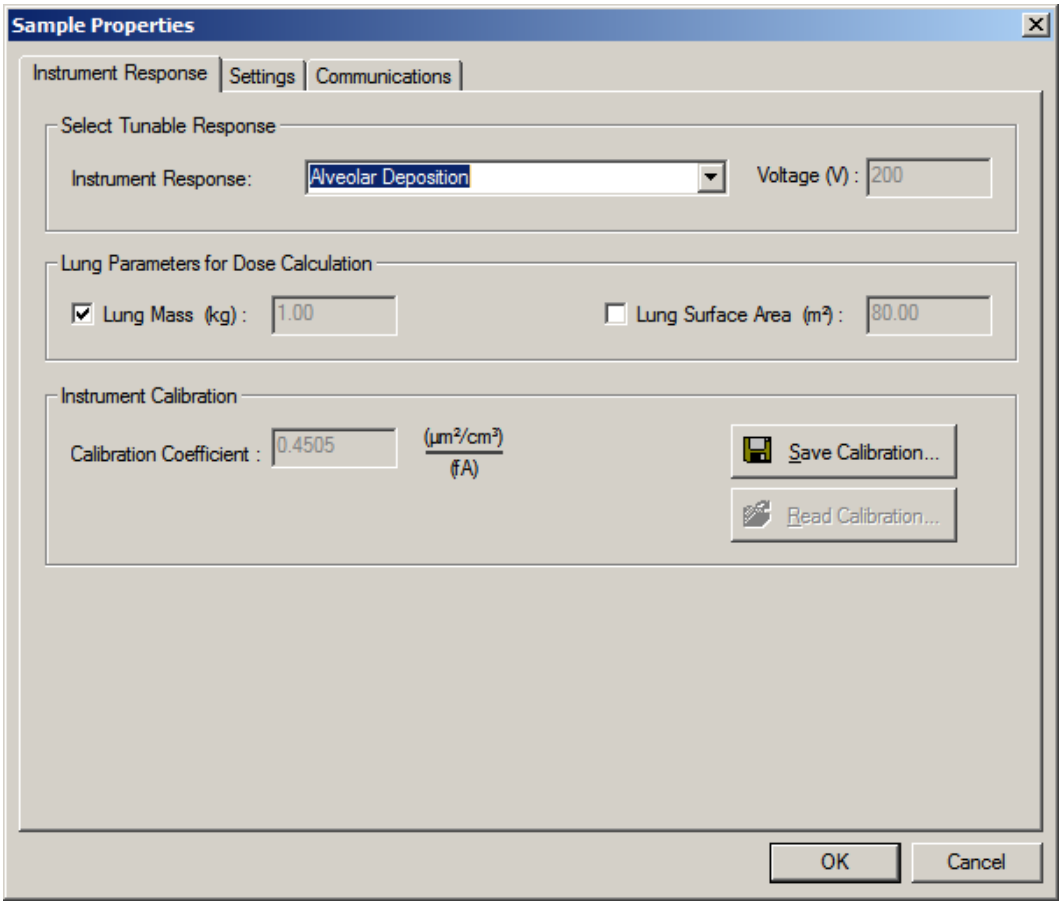


Figure 5-6
Sample Properties Dialog—Instrument Response Tab

The Instrument Response Tab

The Model 3550 can be set to measure particle deposition in tracheobronchial (TB) or alveolar (A) region of the lung of a reference worker (for details, refer to Appendix B), or to match a user selected lung-deposition curve. Information on surface area equivalent dose can also be calculated using the software. The instrument response tab provides an interface to input information to perform these functions and to read current response setting of the instrument.

Select Tunable Response

The current measurement mode is read from the 3550 and displayed here when this dialog opens. Here you may select the measurement response of the instrument to match particle deposition in the TB or A region of lung or to a custom response.

When you select either “Tracheobronchial Deposition”” or “Alveolar Deposition”,” the corresponding trap voltage is also displayed. Selecting “Trap OFF” disables the trap by setting the trap voltage to zero. Select “Custom” when you want to operate the instrument at a custom trap voltage and calibration setting (refer to Chapter 6 for information on how to determine custom trap voltage and calibration coefficient). Note that when you change the measurement mode or trap voltage, the instrument requires time to stabilize. A message box will open and the software will wait approximately 10 seconds.

Lung Parameters for Dose Calculation

The software can calculate and display the surface area equivalent dose of inhaled particles in the target region of the lung (TB or A). The surface area equivalent dose can be displayed in two ways: deposited surface area per unit lung mass ($\mu m^2/kg$) or deposited surface area per unit lung area ($\mu m^2/m^2$). For TB and A measurement modes, the default values for a reference worker’s lung mass and lung surface area as defined in a publication by ACGIH (Ed. Vincent J.H., 1999) are used for this calculation (lung mass = 1kg and lung surface area = $80 m^2$). For custom setting, if available, the values for lung mass and lung surface area for the exposed subject may be input in units of kg and m^2, respectively in the appropriate boxes. This will facilitate dose calculation by the software. The dose per unit lung mass and lung surface area are calculated by dividing the total deposited surface area by this parameter. If you choose not to display dose information then leave these boxes unchecked. The calculations will not be displayed in the statistics table (see description of statistics table later in this chapter).

Instrument Calibration

The 3550 operates by diffusion charging of sampled particles, followed by detection of the charged aerosol using an electrometer. The current signal (fA) is converted to corresponding deposited surface area measurement (μm^2) by a calibration coefficient that has units of $\mu m^2/cm^3/fA$. For TB and A measurement modes, these coefficients have been preset for your instrument and cannot be modified. Also the instrument operates at predetermined trap voltage values corresponding to the two measurement modes. If you select a “Custom” instrument response setting, you must enter a calibration coefficient and trap voltage in appropriate boxes to set the instrument response to the custom setting. This calibration coefficient and trap voltage can be determined experimentally using the custom calibration procedure described in Chapter 6.

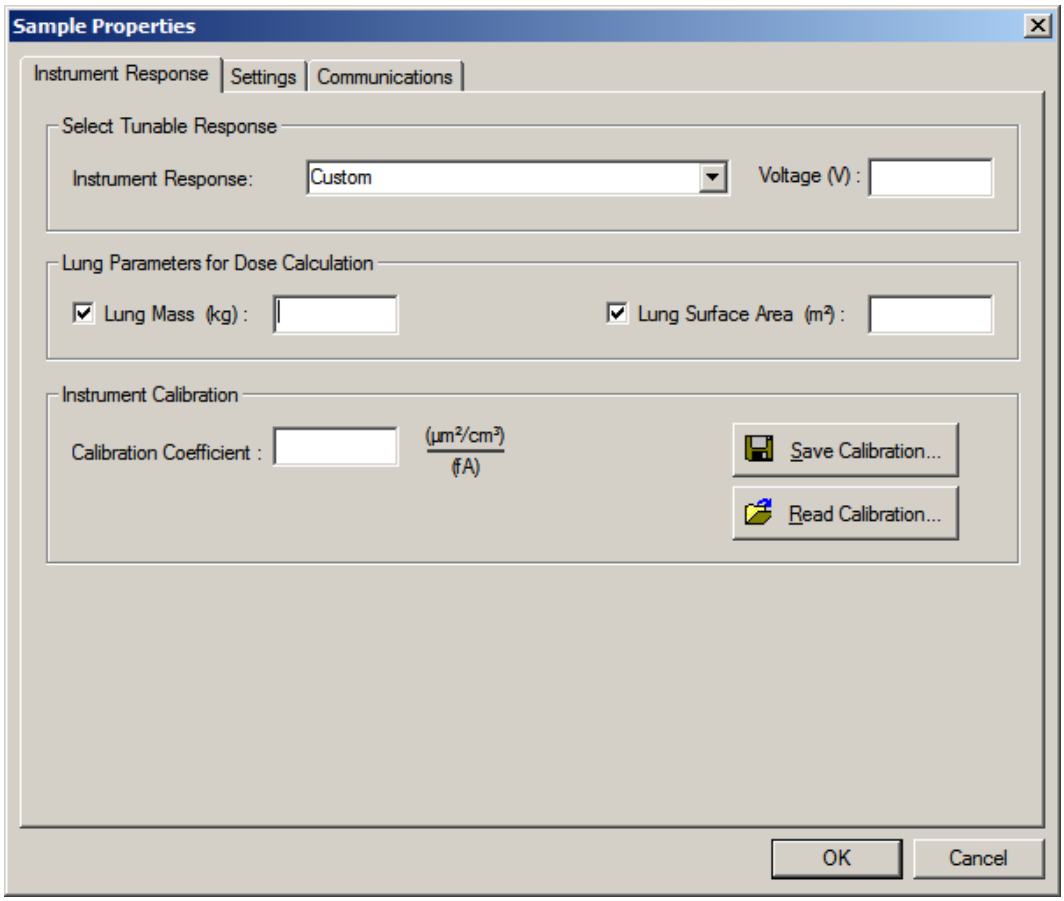


Figure 5-7
Sample Properties Dialog—Custom Instrument Response

Save Calibration…

After you have entered values for the trap voltage and the calibration coefficient, use the “Save Calibration” button to save this information for this measurement mode to a *.3550cal file. This file is a text file and is created with the extension .3550cal. Below is a sample .3550cal file which can be opened using Notepad:

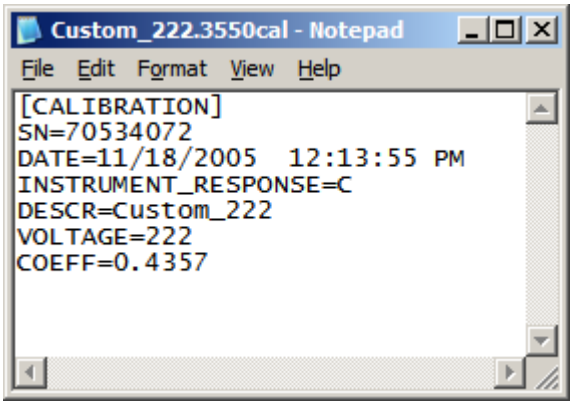


Figure 5-8
Custom Calibration File

Read Calibration…

In custom mode only, use this button to read a calibration coefficient and corresponding trap voltage from a text file previously saved using the "Save Calibration…" button.

The Settings Tab

Use the Settings tab to enter scheduling information and set other control variables for the sample.

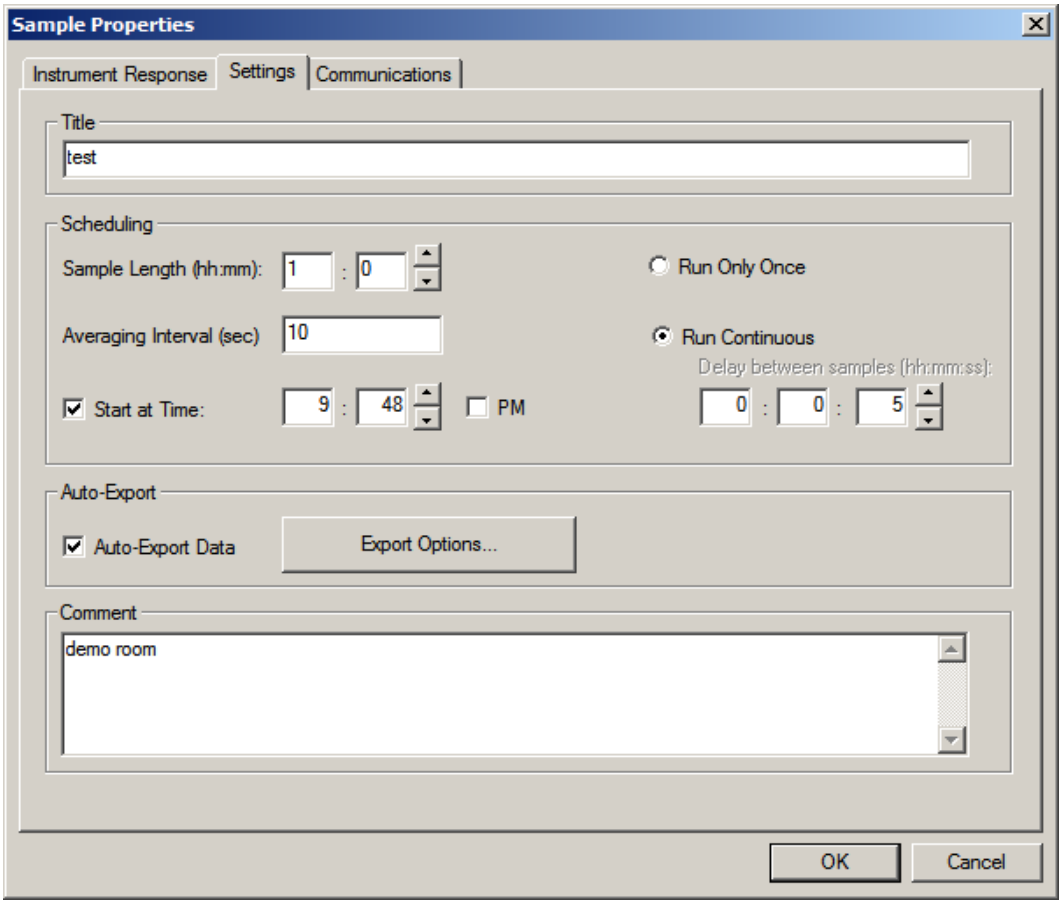


Figure 5-9
Settings Tab

Title

Enter a descriptive title for the sample. This title will appear as a heading on various windows to identify this sample. The maximum number of characters you can enter is 79.

Scheduling

Sample Length (hh:mm).	Enter a sample length by selecting the number of hours and minutes you want to collect data for this sample. The maximum value allowed is 24 hours. Remember the run can be stopped at any time by pressing the ■ button on the toolbar or select **Run|Stop Data Collection**.
Start at Time	If you do not want the sample to start immediately, you can schedule it to start at a specific time. If you select a start time, the software will go in to a "wait" state until the scheduled start time.
Averaging Interval (Sec)	This is the number of seconds of data collected that will be averaged together to make up one data point. The number of data points in a sample is equal to the Sample Length/Averaging Interval. The maximum number of data points allowed is 28,800 (8-hour sample at 1 second averaging). ***Note:*** *If this is the first sample in the file, you may change the value for the averaging interval. Otherwise, you must use the same averaging interval for all samples in the same file.*
Run Only Once or **Run Continuous**	You can also set sampling to repeat regularly (every 1 minute to 24 hours). When sampling is set up to run continuous, a new sample is created for each repetition and uses the same properties as the first sample (length, title, comment, averaging interval). The delay time between samples must be at least 5 seconds.

Note: *After completing the properties dialog box, if you selected a Start Time, the software will begin data collection for this sample immediately after you press the* ***OK*** *button. It will display "Waiting to Start…" in the status bar and the samples view will display "Start at" with the scheduled start time. If you do not select a Start Time, you must manually start data collection after closing this dialog by pressing the start data collection/record button*  *on the toolbar.*

Auto-Export

Select the **Auto Export Data** checkbox to automatically export data for the sample(s) when sampling is complete. Refer to the section "Export Data to a File" for a complete description of how to export data.

Comment

Use the Comment box to store comments about the sample run. The maximum number of characters is 255.

This information is stored with the sample data in the file and may be displayed or modified when the Properties dialog box is opened for this sample later. It is also included in the exported data output.

Communications Tab

The Communications tab, Figure 5-10, lets you view and test the communications port. You may select or highlight an available communications port and double-click to open a connection on that port. Table 5-1 describes the fields in this window.

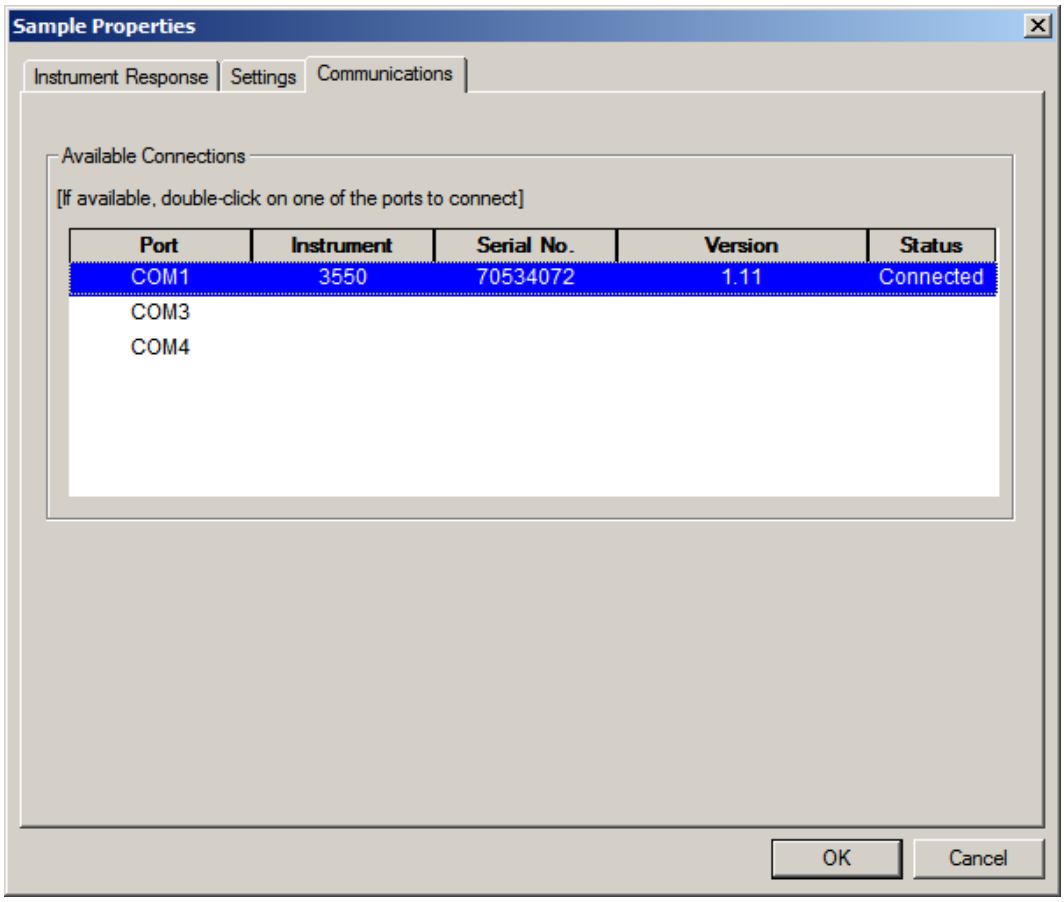


Figure 5-10
The Communications Tab of the Properties Dialog

Table 5-1
Descriptions for the Communications Tab

Property	Description
Port	Lists the ports available on your computer system and lets you select the port that is connected to the TSI sensor.
Instrument	Displays the instrument model (3550).
Serial No.	Displays the instrument serial number.
Version	Displays the instrument firmware version.
Status	Displays “Connected” if we have a connection active on this port.

Sample Properties for an Existing Sample

Use the sample properties dialog to display the properties for an existing sample by selecting or highlighting a sample in the Samples List view and selecting the **Run|Properties**… menu option or select **Properties** in the right-click popup menu. See the description of each tab above. Only certain fields may be modified for an existing sample such as the title and comment text in the **Settings** tab.

Select a Sample to Display

The Samples List view opens whenever you open a data file. To display a sample, select (highlight) the sample you wish to view from the active Samples List window by clicking on it using a mouse. This sample will be highlighted in this view and all other views on the desktop will display the data for this sample.

***Note**: The Samples List window is the controlling view for the application and is always open on the desktop. Closing this window also closes the data file.*

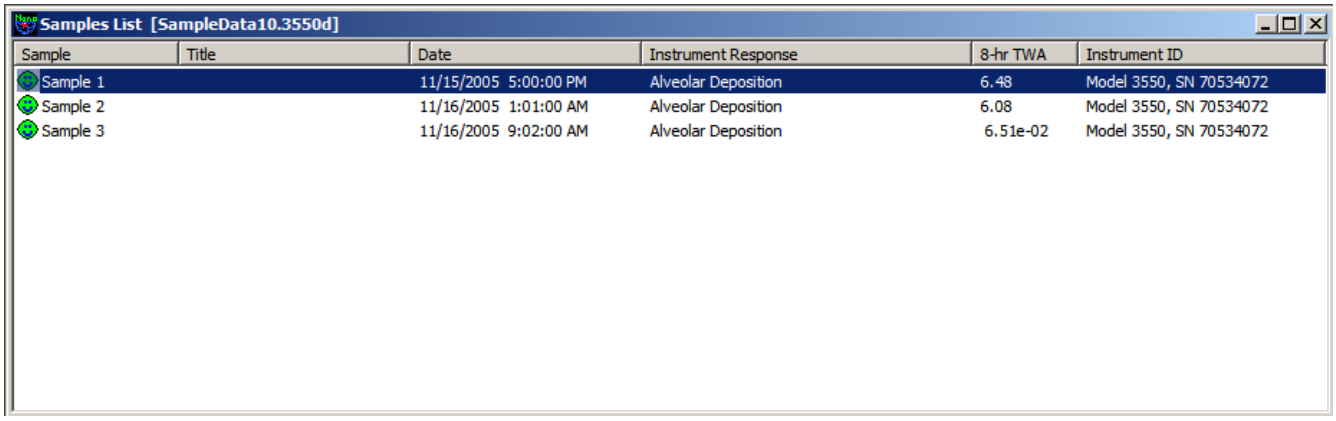


Figure 5-11
Samples List View

Graph View

This view displays the deposited surface area as a running average in units of µm²/cm³ or as a total area over time in units of µm². It also displays the calculated 8-hour Time-Weighted Average, or “8-hr TWA”, for this sample in units of µm²/cm³.

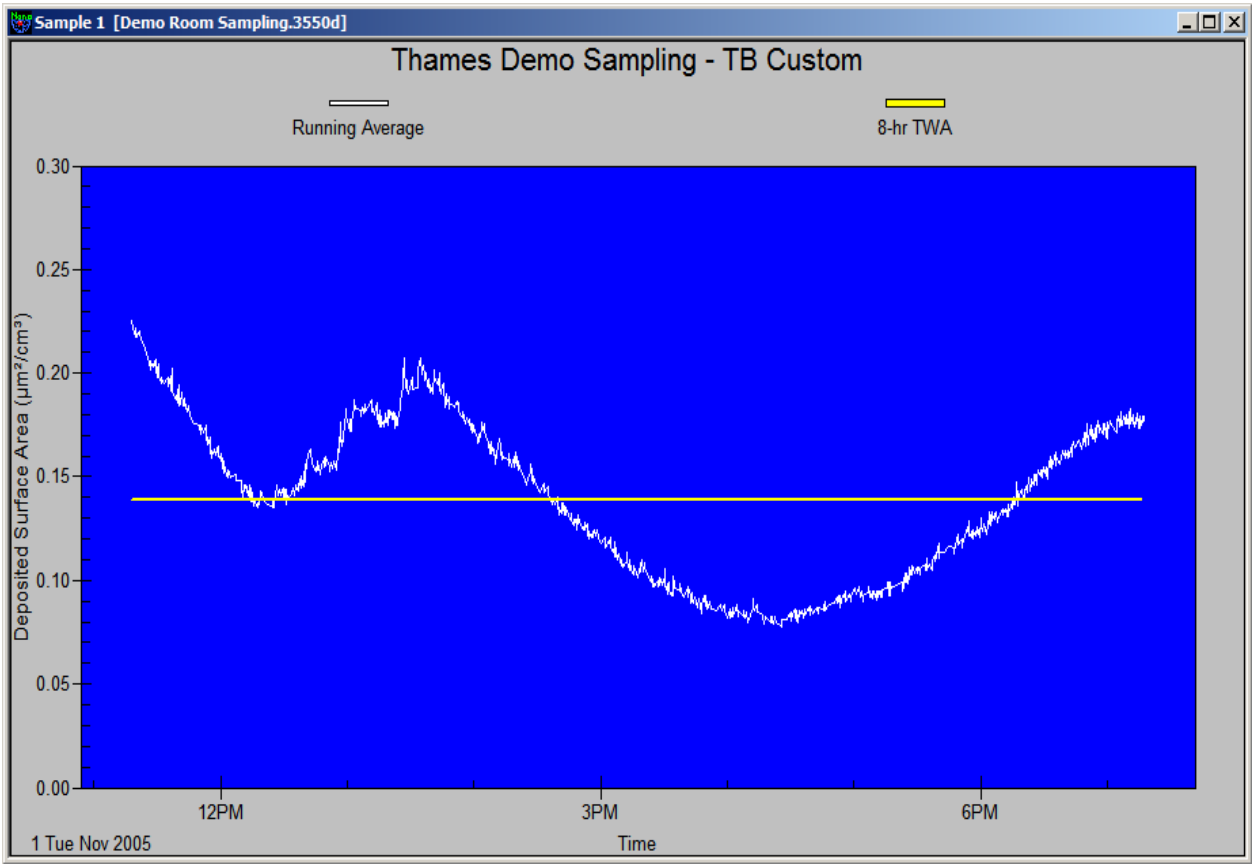


Figure 5-12
Graph View

Note: *In this application, “running average” refers to deposited surface area concentration (µm²/cm³) corresponding to a particular averaging interval. “Total area” is a cumulative quantity and refers to total deposited surface area (in units of µm²) integrated up to a particular time in the sample run. 8-hr time-weighted average refers to time weighted deposited surface area concentrations averaged for an 8-hour period. It is calculated as follows:*

$$\text{8-hr TWA} = \frac{\Sigma (Ci.Ti)}{28800}$$

Where, Ci is concentration (µm²/cm³) during averaging interval Ti (sec). The sum of all averaging intervals (Σ Ti) or the total sampling period may be less than, equal to or greater than 8 hours, however, the time weighted concentrations are always averaged for an 8-hour period (denominator in the formula is always 28800 sec or 8 hour).

Table View

The Table View displays both the deposited surface area running average (“Running Avg.”) and the total deposited surface area (“Total Area”) at each averaging interval from the start to end of the sample. You may see a more complete description of each data column by pointing to the column heading and pressing the right mouse button to display a popup menu. From this popup menu, select the item “What’s this?” and a balloon will open and display a more detailed explanation as shown in Figure 5-13.

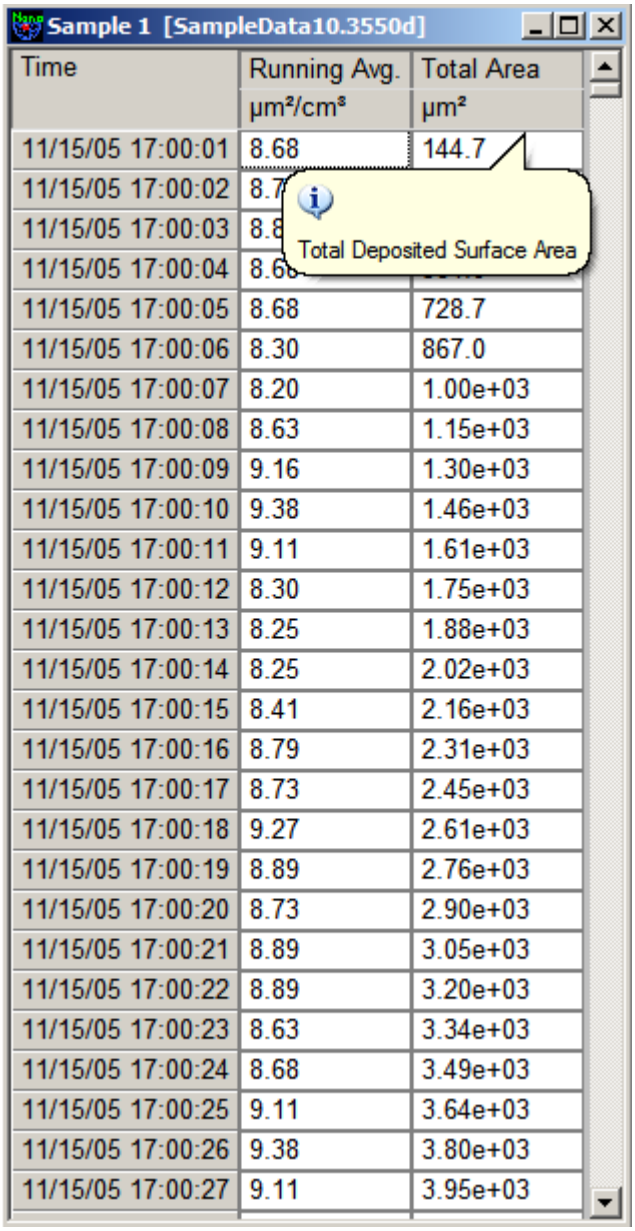


Figure 5-13
Table View

Statistics View

This view displays a summary of the statistics for the selected sample. This includes the minimum, maximum, mean, standard deviation, 8-hr TWA, sample length and averaging interval. Additionally, it displays the total deposited surface area and calculated dose per unit of lung mass and/or area. A dashed line "---" in for one of these values indicates that this calculation was not selected in the sample properties. See "Lung Parameters for Dose Calculation" description under the Sample Properties section.

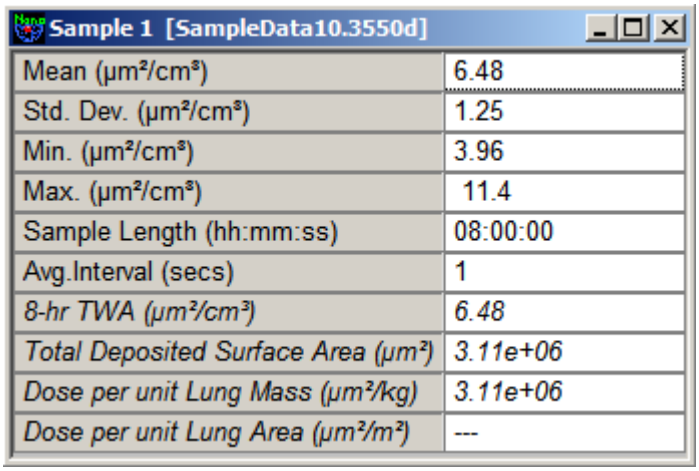


Figure 5-14
Statistics View

Change How Data is Viewed

You can change how data is viewed in the following ways:

- Display surface area as running average or as total area in the graph view
- Changing the Y-axis scale
- Enable or disable the 8-hour time weighted average in the graph
- Changing the view boundaries
- Displaying multiple samples in the graph view
- Hide or "UnHide" columns in the table

Displaying Deposited Surface Area Differently in the Graph

To display the deposited surface area data in the graph as a running average or as total area by select the option from the **Display As…** option in the graph popup menu. Open this menu using the mouse right-click button.

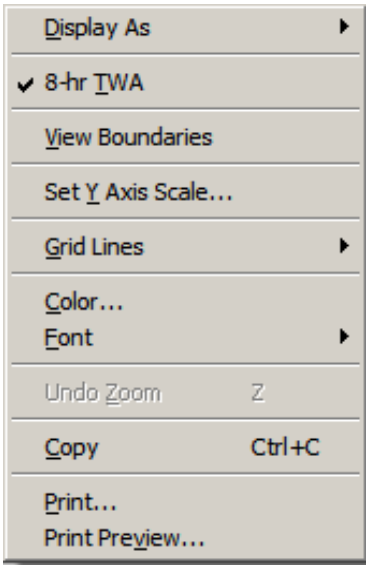


Figure 5-15
Change How Data is Viewed

Note: *Some of the items on this menu are discussed later in this chapter under the section titled "Context-Sensitive Menus".*

Displaying 8-hour Time Weighted Average

To display or to hide the 8-hour Time Weighted Average concentration of surface area measurements, select **8-hr TWA** from the right click popup menu on the Graph window.

View Boundaries

Select **View Boundaries** from the graph popup menu to enable or disable view boundaries. Once enabled, the view boundaries are drawn initially at the start and end of the sample. Using the mouse, you may click on and drag the view boundaries to "narrow-in" on a certain segment of a sample. The table view and statistics view adjust and recalculate using the view boundaries selected.

Changing the Y-axis Scale

To change the Y-axis scale of the graph, select **Set Y Axis Scale…** from the graph popup menu. The dialog box in Figure 5-16 opens. You can select either logarithmic or linear scale. By default the graphs display in linear scale. You may also select a minimum and/or maximum Y axis value or let the application determine this range for you (auto scale). Auto Scale is the default setting.

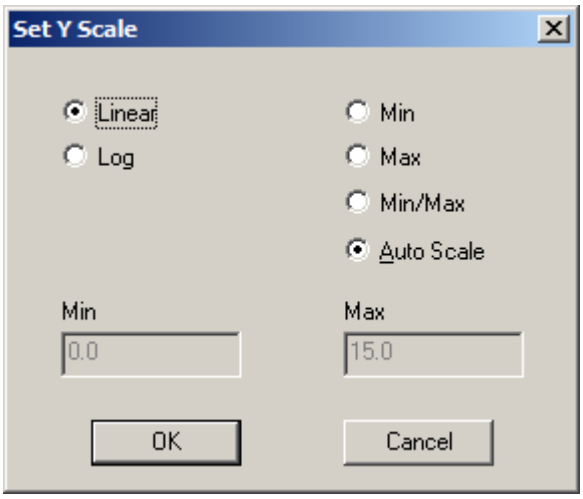


Figure 5-16
Set Y Scale

Displaying Multiple Samples in the Graph View

To select more than one sample at a time in the samples view, hold on the **Ctrl** key as you select each sample. Once you have more than one selected, open the popup menu using the right mouse button and select the **Display Selected Samples** menu option.

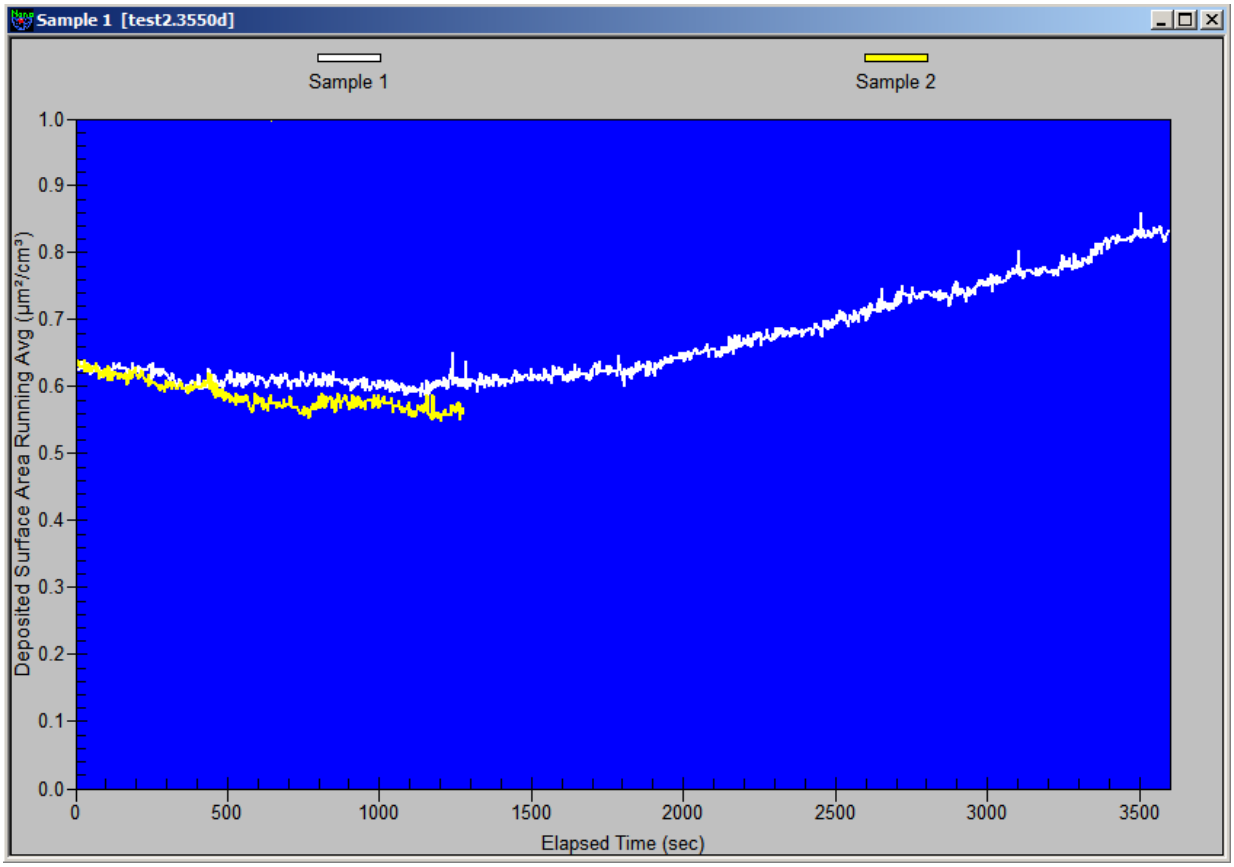


Figure 5-17
Display Selected Samples

Note in the above figure that sample 2 is shorter than sample 1. The graph will always display up to the longest sample length of the selected samples.

Note: *You may only select up to 10 samples at a time for display in this view.*

Hide or Unhide Columns in the Table View

To hide (and unhide) columns in the table view, use the mouse to right-click in the column heading of the column you want to hide or unhide.

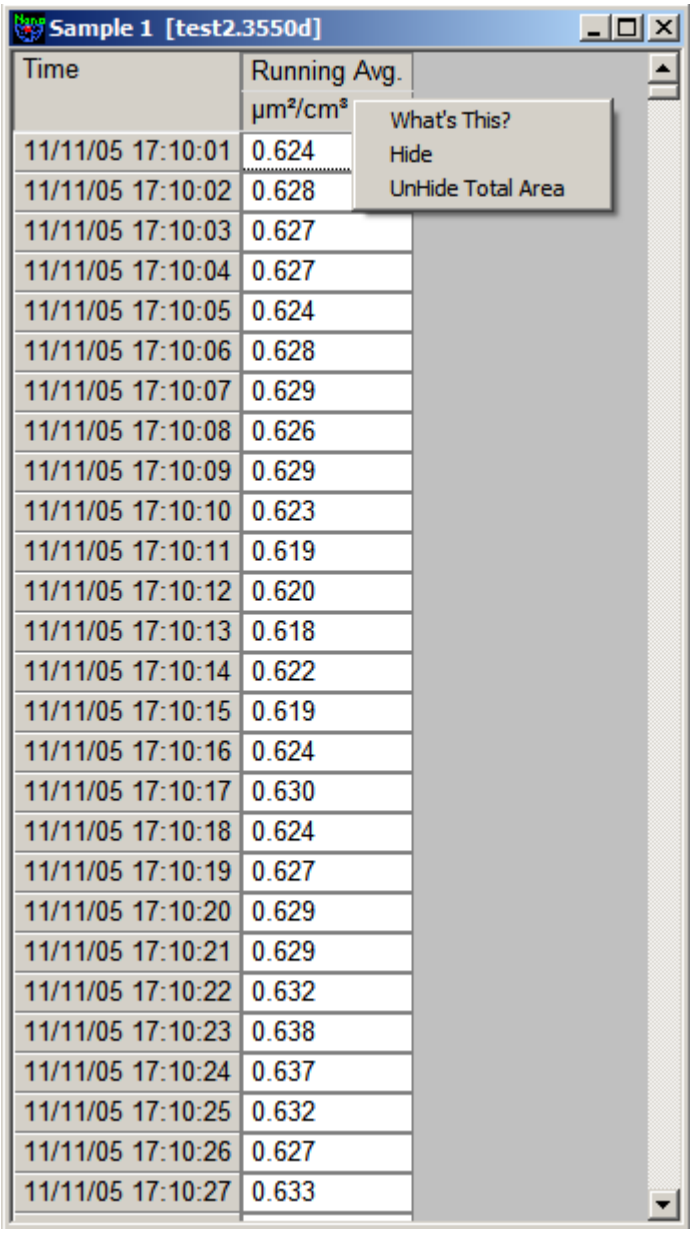


Figure 5-18
Hide or Unhide Table Columns

Besides the options discussed above, you can experiment with other views by making other windows active and selecting other options from the popup menus to see how your selections change the view of the data. Refer to "Context-Sensitive Menus" later in this chapter for a complete description.

Select a Data Hot Spot in a Graph

When a graph is open on the desktop, you can find the values of a data point as follows:

1. Position the pointer on the line or peak (depending on the type of graph that is active). The pointer becomes a pointing hand.
2. Press the left mouse button to display the values. Figure 5-19, shows how the data values would be displayed for a Graph window.

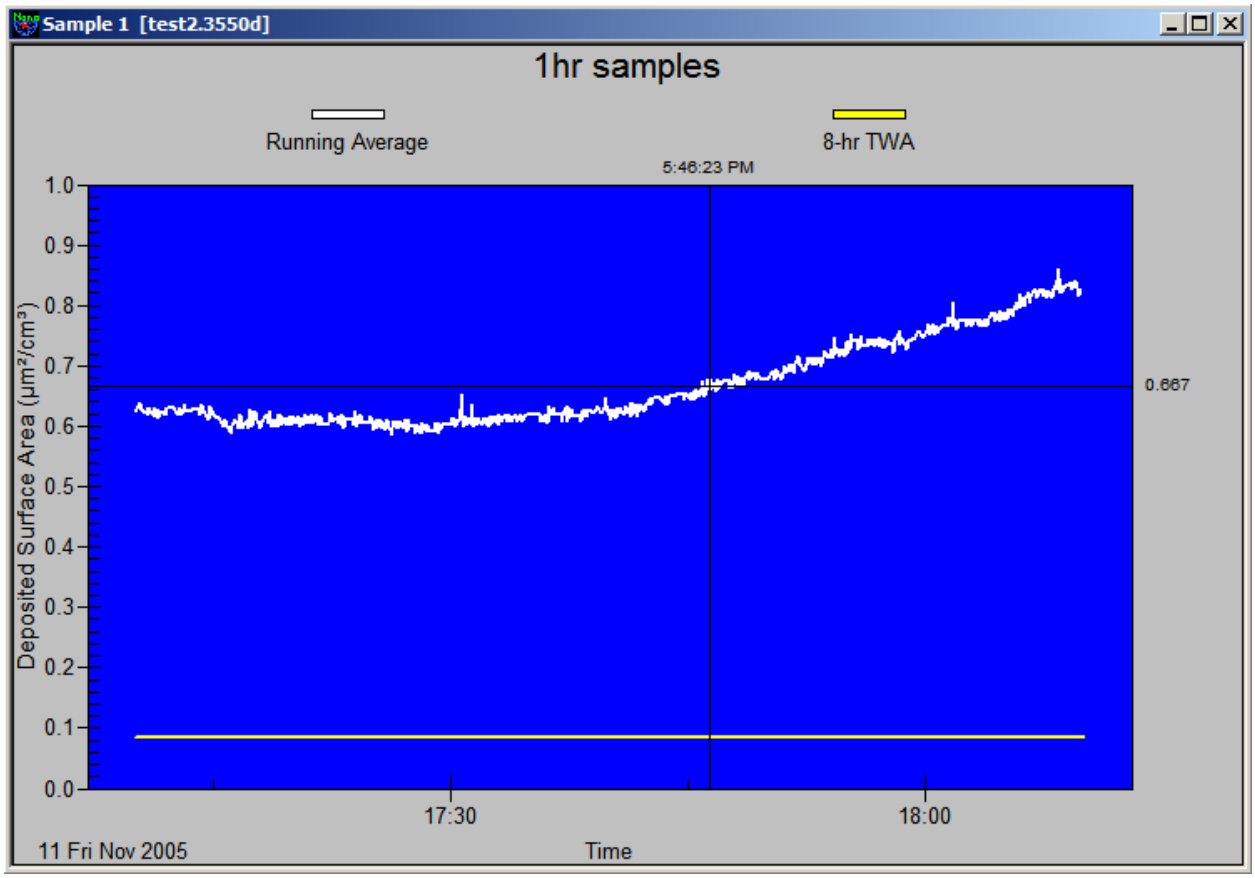


Figure 5-19
Use the Mouse to Directly View Data Values

***Note**: If an error was detected at the selected data hotspot, this information will be displayed below the Y value in the right margin of the graph.*

***Tip:** After you have a data hot spot selected, use the arrow keys to move the cursor right or left (from one value to the next), or grab the vertical bar and drag it to another location using the mouse. Refer to Appendix D for a list of other keys or key combinations you can use to navigate and perform operations without using the mouse.*

Zoom In and Out on Data in a Graph

You can zoom in on data displayed in a graph as follows:

1. Use the mouse to position the cursor (pointer) at one corner of the area you want enlarged.
2. Press down on the left mouse button and drag the mouse to the opposite corner of the data you want enlarged.
3. Release the left mouse button. The area you selected is enlarged.
4. To continue to zoom further, repeat steps 1 through 3.

To Unzoom, select **Format|Undo Zoom,** press the "z" key in the graph window, or press the button on the toolbar. The enlarged area is returned to normal view.

Delete/Undelete Samples

To delete a sample from a file, you must first mark them for deletion and either **Close** or **Save** the file. The following procedures will permanently delete samples from a file:

1. Select the sample you want to delete from the Samples List window (you can select multiple samples).
2. Select **Run|Delete Sample** or on the toolbar. The samples will be shown as "Deleted". However, they will not be permanently removed from the file until you **Close** and **Save** the file. When you close the file, you will be prompted to save your changes to the file. Answer "Yes" to permanently remove the marked samples from the file.
3. To undelete, prior to closing or saving the file, select the sample you want to undelete from the Samples List. Select **Run|Delete Sample** or press the button on the toolbar.

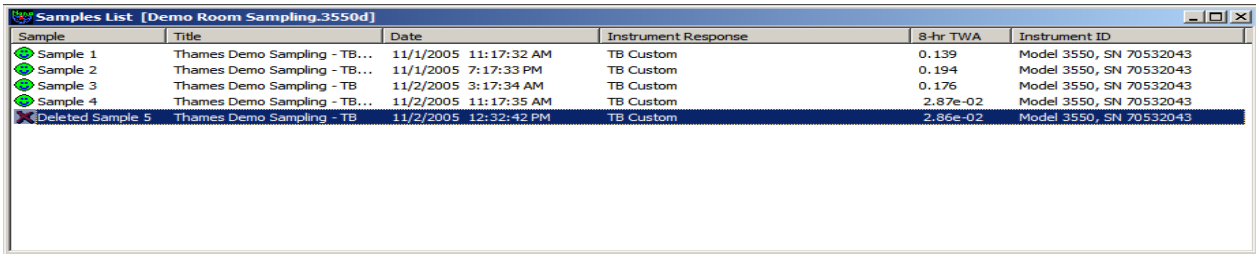


Figure 5-20
Samples View Window Showing Sample Marked for Deletion

Print Information Displayed on the Desktop

To print the information displayed in the active window on the desktop, follow these steps (you must have a printer properly installed):

1. Select **File|Print Preview** or press the  button on the toolbar. The print preview of the currently active window will be shown. The **Print Preview** option may also be accessed from the popup menu for each view.

2. Review that what you see in the print preview window is what you want to print (an example is shown in Figure 5-21), and then select **Print** from the Preview box. The contents of the window are sent to your printer.

   To immediately print a window without previewing it, select **File|Print** or  from the toolbar.

(continued on next page)

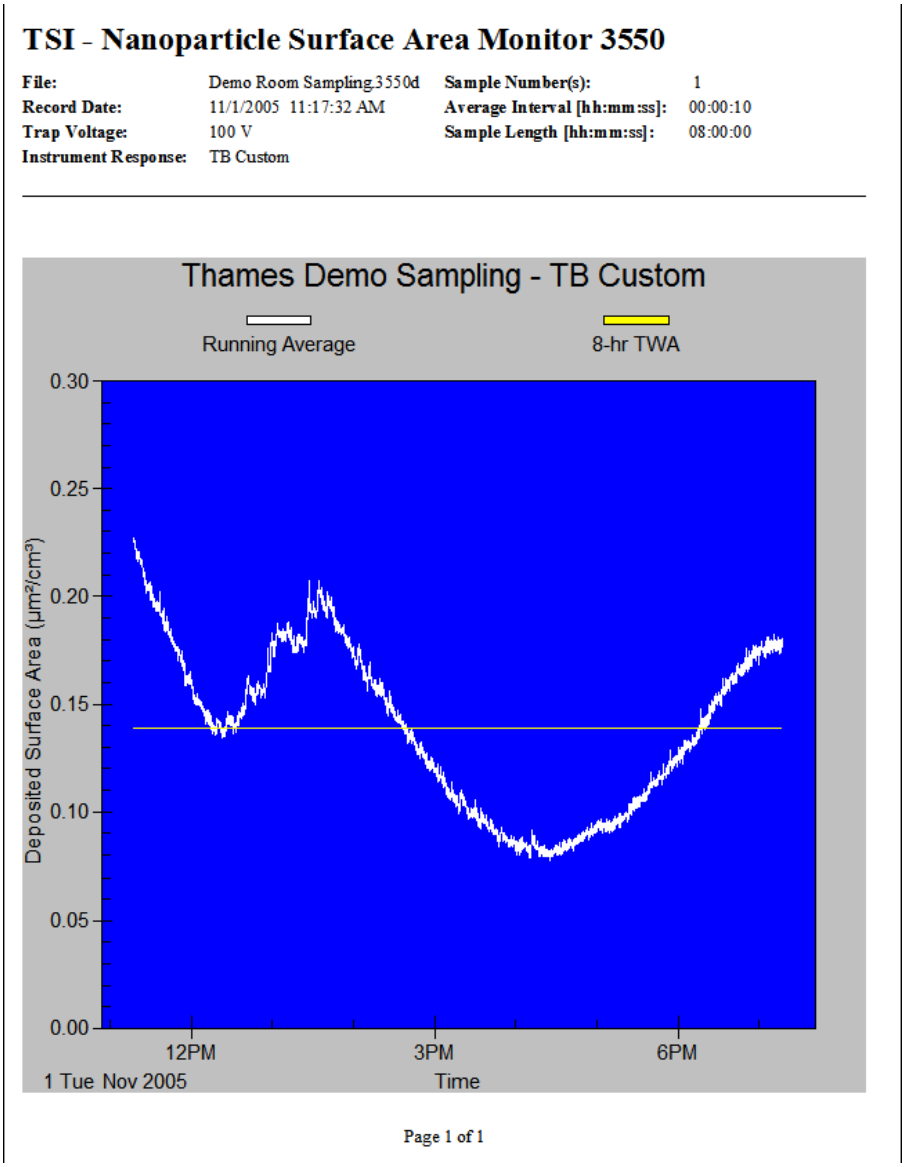


Figure 5-21
Print Preview of the Graph View

Export Data to a File

You can export data from a Nanoparticle Surface Area Monitor data file (either a single sample of the file or multiple samples of the file) for use in another program. You can export the data either manually or automatically.

To Export Data to a File Manually

To export data for existing samples to be used in another program:

1. Open the data file by selecting **File|Open** or  or <**Ctrl**><**O**>.
2. Select the sample or samples to be exported as follows:

   To export data from a single sample, select this sample in the samples view window on the desktop.

   To export data from multiple samples, select (highlight) these samples you want to export from the Samples List window.
3. Select **File|Export or** select **Export…** from the popup menu. An Export Data Options dialog box appears as shown in Figure 5-22.

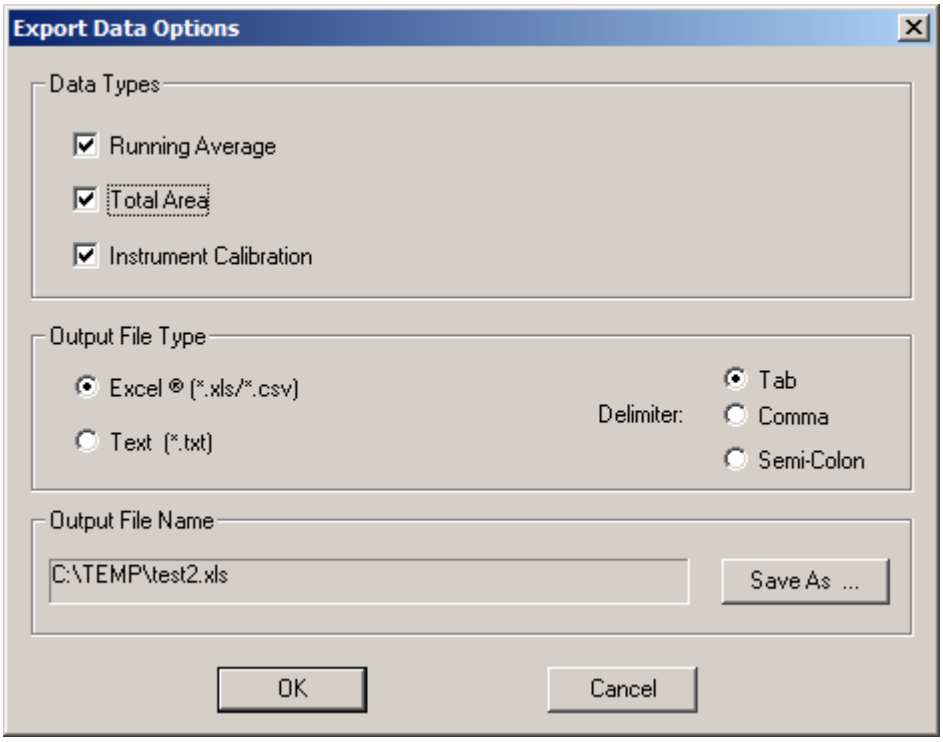


Figure 5-22
Export Data Options Dialog Box

4. Select which data you want included in the exported output under "Data Types".

5. Select the format of the file to which you want to export the data and the delimiter for the data you want to export. You can select from three delimiters: comma, tab, or semicolon. Refer to Table 5-2 for a description of the parameters.

Table 5-2
Export Data Options

Parameter	Description
File Type	
Excel	File extension will be either .xls or .csv (comma-separated-values) to be read by Microsoft® Excel® spreadsheet software.
Text	Output will be written to a text (.txt) file.
Delimiter	Delimiter used in output.
Output Filename	Name of output file for exported data.

6. Verify the default file name (and path) or press the **Save As** button to change the filename and/or location if you want to save the file to another location or provide a new filename. The extension is automatically selected when you choose a file type for exporting.
7. Press **OK**.

Figure 5-23 illustrates how an exported *.xls file is formatted for a Model 3550 Nanoparticle Surface Area Monitor.

To Automatically Export Data

To export data automatically at the end of data collection to a file for use in another program (such as Microsoft® Excel® spreadsheet software):

1. When setting up the properties for the sample, select the **Auto-Export** check box on the Settings tab. This activates the **Export Options** button on this dialog. When you press the **Export Options** button, the Export Data Options dialog shown in Figure 5-22 opens.
2. Select the format of the file to which you want to export the data and the delimiter for the data you want to export.
3. Verify the default file name (and path) or press the **Save As** button and change the filename and/or location if you want to save the file to another location or provide a new filename. The extension is automatically selected when you choose a file type for exporting.
4. Press **OK**. Data will be exported to the file at the end of the sampling.

®Microsoft and Excel are registered trademarks of Microsoft Corporation.

test2.xls

	A	B	C
1	Sample File	test2.3550d	
2	Model	3550	
3	Sample #	1	
4	Start Date	11/11/2005	
5	Start Time	17:10:00	
6	Sample Length	1:00:00	
7	Averaging Interval (secs)	1	
8	Title	1hr samples	
9	Instrument ID	SN70534072, Ver:1.11	
10	Instrument Response	Custom_125	
11	Trap Voltage (V)	125	
12	Instrument Errors	None	
13			
14	Instrument Calibration (µm²/cm³)/fA)	0.007	
15	Mean (µm²/cm³)	0.668216	
16	Min (µm²/cm³)	0.585	
17	Max (µm²/cm³)	0.86	
18	Std. Dev.(µm²/cm³)	0.0707657	
19	8-hr TWA (µm²/cm³)	0.0835269	
20	Total Deposited Surface Area (µm²)	40092.9	
21	Lung Mass (kg)	1	
22	Dose per unit lung mass (µm²/kg)	40092.933	
23	Lung Surface Area (m²)	---	
24	Dose per unit lung area (µm²/m²)	---	
25			
26	Elapsed [s]	Running Avg (µm²/cm³)	Total Area (µm²)
27	1	0.624	10.4
28	2	0.628	20.8667
29	3	0.627	31.3167
30	4	0.627	41.7667
31	5	0.624	52.1667
32	6	0.628	62.6333
33	7	0.629	73.1167
34	8	0.626	83.55
35	9	0.629	94.0333
36	10	0.623	104.417

test2

Figure 5-23
Sample Export File

Arrange Open Windows/Change Layout

When you have several windows open on the desktop it is helpful to arrange them for easier viewing.

There are two ways to arrange windows:

- The traditional Windows method.

  To arrange windows, select an item from the **Window** menu. Windows on your desktop can be arranged horizontally, vertically, or cascaded. Refer to your Windows documentation for examples and more information.

- Using the Nanoparticle Surface Area Monitor layout function.

  Select the 4-pane layout icon  from the toolbar. Windows containing Samples List, Graph, Table, and Statistics views will be displayed on the desktop. (You can also select this layout function from the **Window** menu.)

All of the program windows that are currently open on the desktop are listed at the bottom of the **Window** menu under the **Close All** item. To make a window active (and bring it to the front of all windows), select the name of the window from the list of open windows or use the corresponding toolbar icon for that window (see Table 5-3).

Table 5-3
Toolbar Icons for Different Windows

Toolbar Icon	Description
	Graph View
	Table View
	Statistics View

Quit the Program

To end the program, select **File|Exit**. All windows and files open on the desktop are closed. If you have made changes to a file, you will be prompted if you wish to save your changes.

Software Menus

This section describes the software functions available for the Nanoparticle Surface Area Monitor software. There are two types of menus you can use: desktop menus and context-sensitive or popup menus.

- Desktop menus are those menus listed at the top of the Nanoparticle Surface Area Monitor desktop. They include: **File, Run, Format, View, Window,** and **Help**.
- Popup menus are those menus that appear when you click the right mouse button when the cursor is positioned in an active window.

Nearly all menu items are available from both a desktop menu and a popup menu, though a few items are only available in one or the other. This section presents the items of the desktop menus first and then describes the menu items that are available only through the popup menus.

In addition to these menus, a toolbar, located just beneath the desktop menus, provides shortcuts to the most commonly used menu functions.

Shortcut keys (keyboard keystrokes that do not require the use of the mouse) are also available. They are described at the end of this section.

Desktop Menus

Desktop menus are listed at the top of the Nanoparticle Surface Area Monitor desktop. This section describes each of the desktop menus and the menu item available through the menu.

File Menu

The items of the **File** menu are used to open, save, and recall files and perform other program operations.

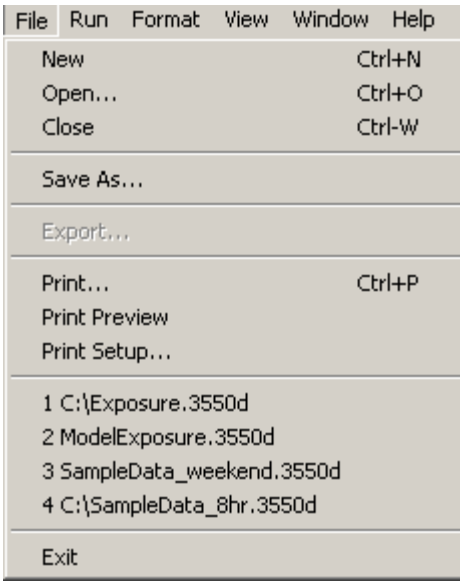


Figure 5-24
File Menu

New

Select **File|New** or or **<Ctrl><N>** to open a new file and prepare to collect sample data.

After selecting **New**, you are prompted to enter a filename. Accept the default filename or enter any filename you choose then select **OK**.

A Samples List window opens on the desktop with the filename you entered. If other windows were open at the time you last closed a file, these windows also open on the desktop. All graphs and tables are initially empty. You are ready to start collecting data. Refer to "Collect Data" earlier in this chapter for a complete description.

Open

Select **File|Open** or or **<Ctrl><O>** to open an existing file. By default, the program will look for files in the same directory location as the last file you opened or in the same directory as the Nanoparticle Surface Area Monitor program if this is the first time running the program. All files are automatically given the appropriate filename extension (.3550d). If you store data files in another directory or on another drive, you must first display the file pathname in the Open dialog box before you can select and open it.

When the file opens, a window (or windows) will open on the desktop displaying the data in this file.

You can have many files open on the desktop at the same time. Only one window; however, is the active window.

Close

Select **File|Close** or or <**Ctrl**><**W**> to close a file (and all the windows associated with it). If there are windows open on the desktop from more than one file, Close will close only those windows associated with the file whose window is currently active. If you attempt to close a file that has been changed but not saved, you will be prompted to save the changes before closing the file.

Since the Samples View is the controlling view for a file, closing this window using the button in the upper right corner also closes the file.

Save As

Select **File|Save As** or to save data to a new filename. (The file contents are duplicated to the new filename. If you want to delete the original filename later, use a program such as Windows Explorer to do so).

After selecting **Save As**, you can select a drive/directory in the file dialog box. You can use the same filename if you save the file to another drive/directory, but if you want to save the file to the same directory, you must give it a new name.

Do *not* add the filename extension. It is added automatically when you select **Save As**.

Export

Select **File|Export** to export data (either a single sample or multiple samples of a file) for use in another program. Data is exported in a delimited text file. Refer to "Export Data to a File" earlier in this chapter for information.

Print

Select **File|Print** or or <**Ctrl**><**P**> to print the active window on the desktop in a report format. To preview the output before printing it, select **File|Print Preview**.

Refer to your Windows documentation for information about the Print dialog box.

Print Preview

To avoid printing something you do not want, select **File|Print Preview** or to see what your printed output will look like before selecting **Print**.

Print Setup…

Select **File|Print Setup** to set up the printer for printing. Refer to your Windows documentation and your printer's documentation for information about setting the printer parameters.

List of Recently Accessed Files

Between the Print Setup and Exit menu items is a list of the most recently accessed data files (a maximum of four files is displayed). These are accessed from the menu by selecting **File|1**, **2**, **3**, or **4**.

The list provides a shortcut to these files so you can bypass the Open command. To open one of the files listed, use the mouse to highlight it and click the left mouse button. The file opens on the desktop.

Exit

Select **File|Exit** to end the program.

Run Menu

The items available under the Run menu are used to start, stop, and setup data collection.

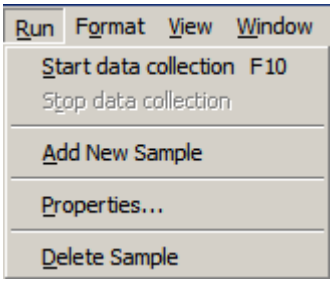


Figure 5-25
Run Menu

Start Data Collection

With a new sample selected on the desktop, select **Run|Start Data Collection** from the run menu or press the record button on the toolbar or press **<F10>** to begin collecting sample data. Samples are collected according to the sample length, scheduled time, averaging interval, and other parameters set in the tabs of the Sample Properties dialog (see earlier in this chapter).

Once you select **Start Data Collection**, sampling begins immediately. As data is collected, it is displayed in the open windows.

Note: *If a start time is set in the properties dialog, this menu item (and its associated icon) is disabled.*

Stop Data Collection

Select **Run|Stop Data Collection** or stop button on the toolbar when you want to stop collecting sample data immediately. When you select this item, sampling stops and data already collected is saved in the file.

Add New Sample

Select **Run|Add New Sample** to add a new sample for data collection in a file.

Properties…

This menu item provides a shortcut to the Properties dialog box. Refer to the description of the Properties dialog box earlier in this chapter.

Delete Sample

Select **Run|Delete Sample** or press the button on the toolbar to delete data. This is useful if you need to stop and restart a sample. Refer to the "Delete/Undelete Samples" earlier in this chapter.

Format Menu

The menu items of the Format menu let you control the fonts and colors presented in tables and graphs. It also has an option to unzoom in the graph.

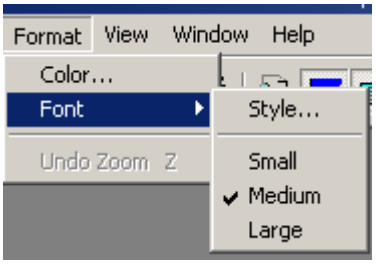
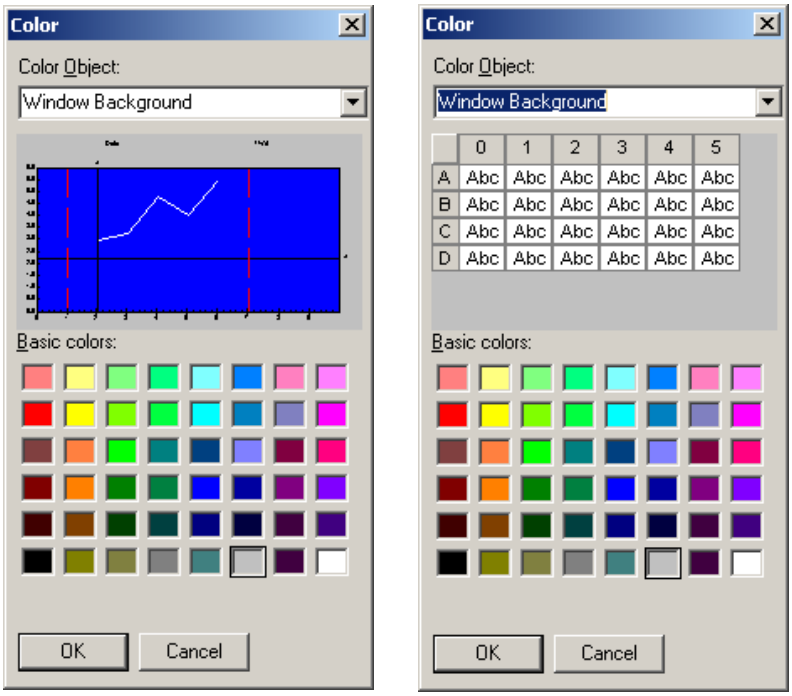


Figure 5-26
Format Menu

Color

Select **Format|Color** or press the button on the toolbar to change the colors used to display items in the active window.

When you select **Format|Color…**, the Graph Color or Table Color window opens depending on the active window on the desktop (Figure 5-27 shows both). These windows include a preview screen, a drop down list and a color palette. From the drop down list, select the name of the item you want to modify. The current color for that item is indicated in the color palette. Use the mouse to point to the new color for that item and click the left mouse button to select it. The preview screen then displays the item in the new color.



(A) **(B)**

Figure 5-27
(A) The Graph Color Dialog Box, (B) The Table Color Dialog Box

Select items from the drop down list and colors as desired. When finished, press **OK**; the colors you selected will be used from that point on in all graphs and/or tables.

The items you can select for windows containing graphs are:

- Window Background
- Plot Area Background
- Labels
- Axis
- Data
- TWA Line
- View Boundaries
- Data Hot Spot Lines

The items you can select for windows containing tables are:

- Window Background
- Cell Text
- Grid Color
- Cell Background
- Fixed Area Text

Font Style

Select the **Format|Font|Style**… menu to change the style of the text in all graphs or tables. See Figure 5-28.

You can select any font and font style available on your computer. The preview box lets you see what the text will look like before you implement it by selecting **OK**.

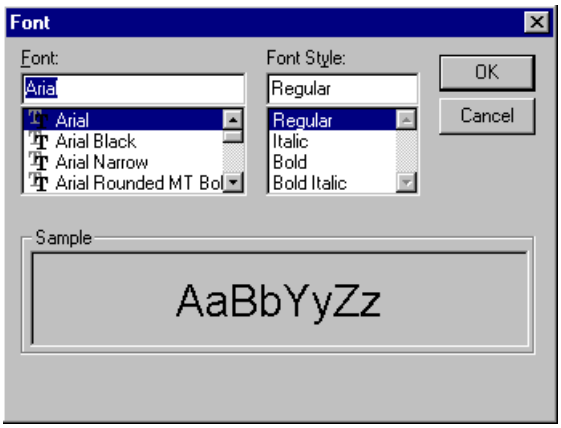


Figure 5-28
Font Dialog Box

Font Size

To change the font size, select **Format|Font|Small**, **Medium**, or **Large** (the default is Medium). To change the text size without using the menus, select the button from the toolbar. Each time you select the icon the text size changes to the next text size. (Rotation is from small to medium to large.) You can change the font size for text in all views except the Run View in which you can only change the font style.

Undo Zoom

Select the **Format|Undo Zoom**, select the **Undo Zoom** button or type Z in the graph that is currently zoomed to return the graph to its normal viewing size. Refer to the section "Zoom In and Out on Data in a Graph" earlier in this chapter.

View Menu

The View menu lets you select the windows you may open on the desktop. A checkmark next to an item indicates the item is already open. If it is not visible, look under the Windows menu to find the item and make it the active window.

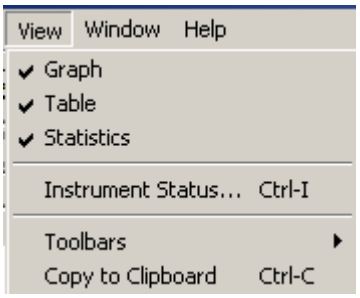


Figure 5-29
View Menu

Graph

Select **View|Graph** to open a graph view that displays the file's active sample data.

Table

Select **View|Table** to open a table view that displays the file's active sample data.

Statistics

Select **View|Statistics** to open a window of statistical information for the active sample.

Instrument Status <Ctrl><I>

Select **View|Instrument Status** to display a dialog window displaying status information for the Nanoparticle Surface Area Monitor. This menu item is available at all times. You do not need to have a data file open in order to view instrument status. When you select the Instrument Status menu item, a dialog window opens detailing the status of the instrument as in Figure 5-30. This dialog will attempt to connect to the instrument if necessary. The Instrument Status dialog reads instrument status values once per second and updates the values for each item shown. Table 5-4 describes each of the parameters and buttons on this dialog.

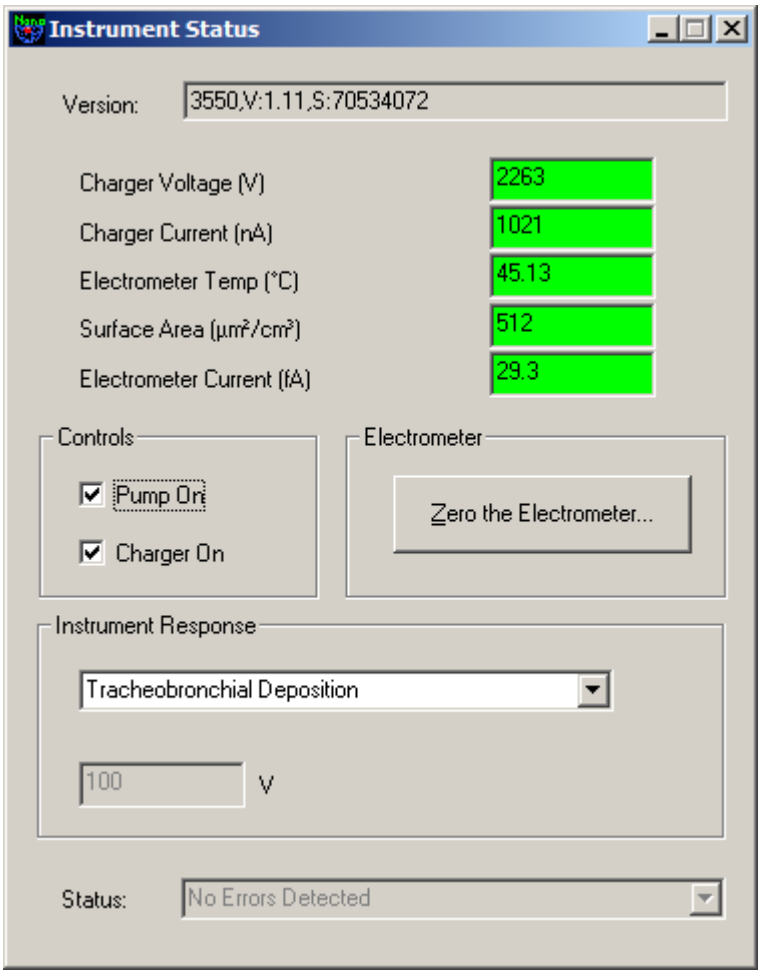


Figure 5-30
Instrument Status Dialog

Table 5-4
Instrument Status Parameters

Parameter	Description
Version	Instrument model number, firmware version and serial number are displayed.
Charger Voltage (V)	Voltage at the charger needle in volts.
Charger Current (nA)	Ion current of the charger in nano Ampere.
Electrometer Temp. (^{0} C)	Temperature of the electrometer in degree celcius.
Surface Area ($\mu m^2/cm^3$)	Surface Area of particles in square micrometers per cubic centimeter deposited in tracheobronchial (TB) or alveolar (A) region of lung.
Electrometer Current (fA)	Current of the electrometer in femto Ampere.
Controls	
Pump On	Use this to turn on/off the pump.
Charger On	Use this to turn on/off the charger.
Zero the Electrometers	Selecting this will start the process of zeroing the electrometer on the instrument (see Figure 5-31 to Figure 5-33).
Instrument Response	
Alveolar Deposition	Use this to select instrument response to alveolar deposition.
Tracheobronchial Deposition	Use this to select instrument response to tracheobronchial deposition.
Trap Off	Selecting this will turn the Trap off.
Status	Instrument status is displayed. Either “Errors Detected. Drop to View” or “No Errors Detected” are displayed.

If the background color of the charger current, charger voltage, electrometer temperature or electrometer current is green, the values are in a normal operating range. If the background color is yellow, the value is outside this range.

When the **Zero the Electrometers...** button is pressed, the following message box is displayed (Figure 5-31). To continue with the zeroing procedure, select the **Yes** button. Refer to the "Troubleshooting" section in Chapter 8 which discusses this procedure and some possible reasons for doing a zero on the instrument.

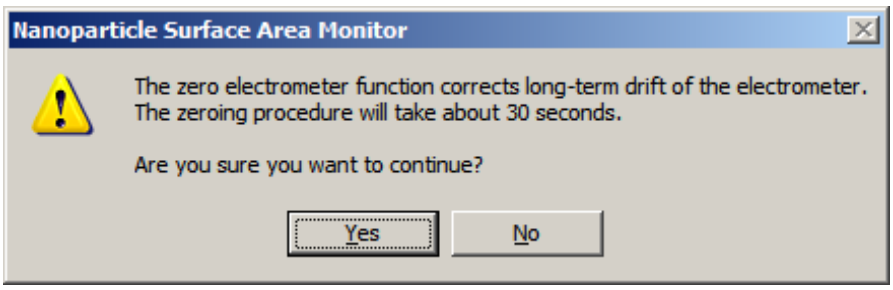


Figure 5-31
Zero Electrometer Function Dialog Box

If you answer “Yes” to continue, the zeroing procedure will start. A progress dialog will display while the zeroing is taking place. The zeroing takes approximately 30 seconds.

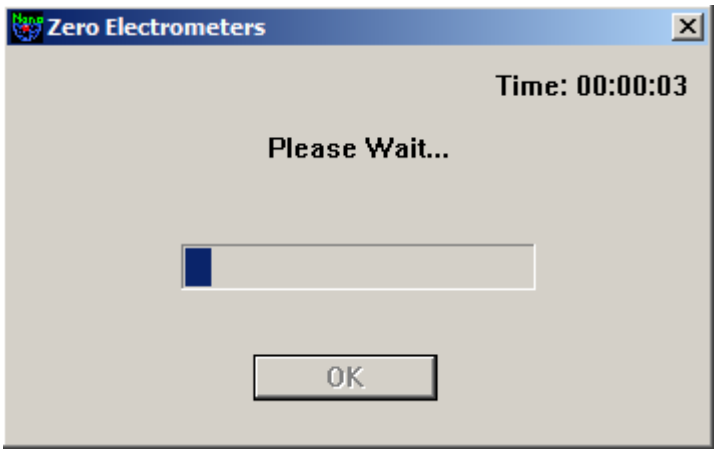


Figure 5-32
Zero Electrometers Progress Dialog

When the zeroing is complete, you will see a message window like this:

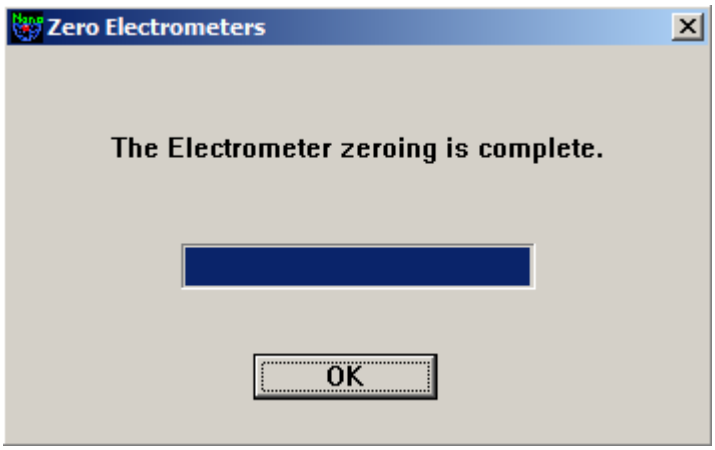


Figure 5-33
Zero Electrometers Zeroing Complete

Toolbars

Select **View|Toolbars** to display or hide the toolbars that appear on the desktop. Each toolbar is illustrated below:

Main Toolbar

Color and Font Toolbar

Graph Toolbar

By default, only the Main toolbar is displayed.

To view what each icon (tool) does, position the cursor on the icon. A balloon will appear to describe the function of the icon.

To move a toolbar, position the cursor on a gap between two icons and press and hold the left mouse button. As you move the mouse, the toolbar moves with it. When you release the mouse button, the toolbar remains where it is.

Window Menu

The Window menu items (Figure 5-34) let you select a window layout, close all windows, and open, close and arrange the windows on your desktop. Refer to your Windows documentation, if necessary, for an example of what the cascade, tile horizontal, and tile vertical commands do.

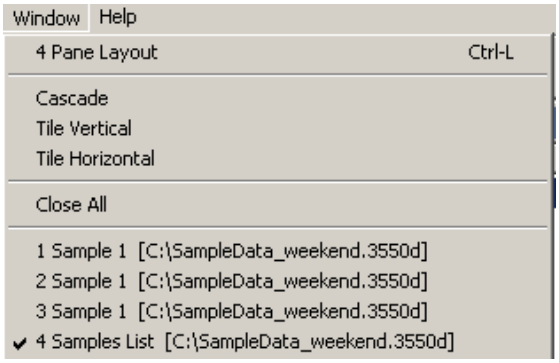


Figure 5-34
Window Menu

4 Pane Layout

This menu item and toolbar button is intended to provide a shortcut to viewing and sizing each of the windows within the bounds of the desktop in a convenient layout. It displays windows containing the Samples List, Table, Graph and Statistics views. Each window is sized so that all four panes fit on the desktop.

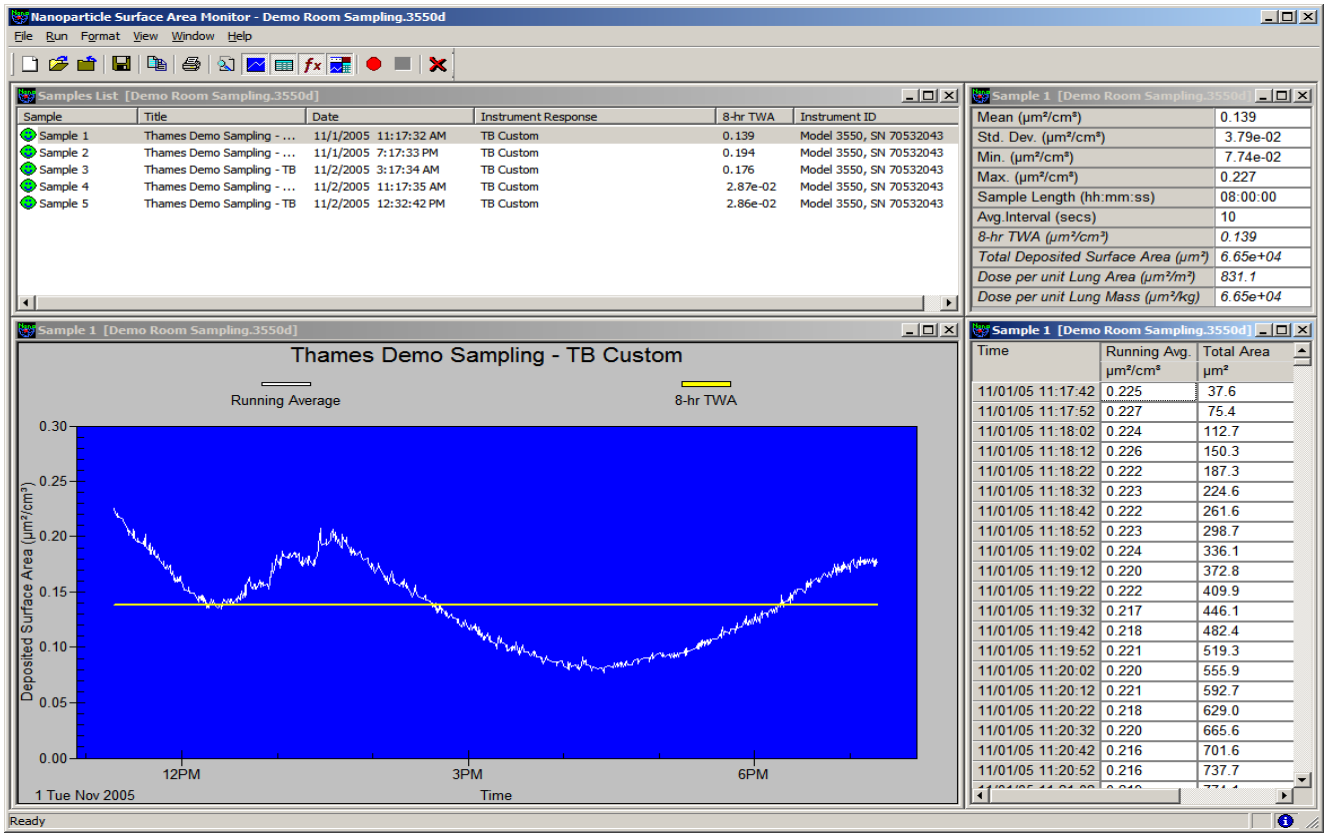


Figure 5-35
Desktop 4-Pane Layout

Help Menu

The Help menu (Figure 5-36) provides access to information about the program.

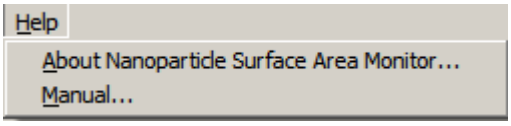


Figure 5-36
Help Menu

About Nanoparticle Surface Area Monitor Software

Select **About Nanoparticle Surface Area Monitor Software…** to see the copyright statement for the program and view the version number of the software.

Manual

Select **Manual** to open a PDF file of this manual. Adobe Acrobat must be installed on your computer to view the manual. The PDF file of the manual is searchable and printable.

Context-Sensitive Menus

To access context-sensitive menus, also called “popup menus,” click the right mouse button when the cursor is in an active window. Each window has a popup menu as shown below. The table following each popup menu describes where to find a description of that menu item.

Samples List View Popup Menu

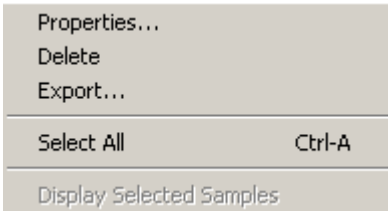


Figure 5-37
Samples List View Popup Menu

Table 5-5
Samples List View Popup Menu

Menu Item	For a description, see ...
Properties	Run Menu
Delete	Run Menu
Export	File Menu
Select All	Below
Display Selected Samples	Below

Select All

Select this option to select (highlight) all samples in the Samples List window for exporting.

Display Selected Samples

After highlighting multiple samples in the samples list, select this option to display these samples in the graph window.

Table View Popup Menu

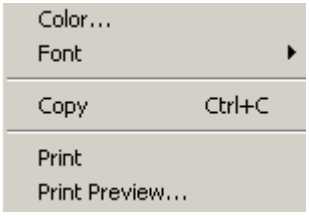


Figure 5-38
Table View Popup Menu

Table 5-6
Table View Popup Menu

Menu Item	For a description, see ...
Color	Format Menu
Font	Format Menu
Copy	View Menu
Print	File Menu
Print Preview	File Menu

Graph View Popup Menu

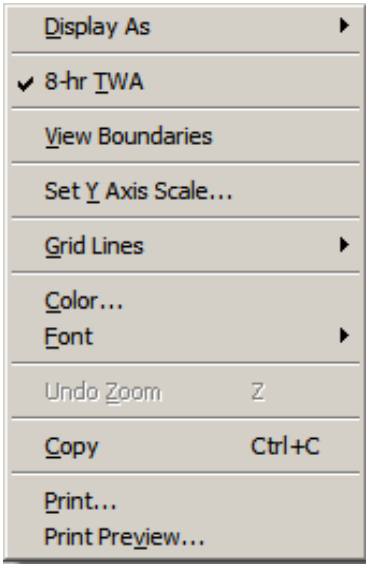


Figure 5-39
Graph View Popup Menu

Table 5-7
Graph View Popup Menu

Menu Item	For a description, see ...
Display As	Below
8-hr TWA	Below
View Boundaries	Below
Set Y Axis Scale	Below
Grid Lines	Below
Color	Format Menu

Menu Item	For a description, see ...
Font	Format Menu
Undo Zoom	Format Menu
Print	File Menu
Print Preview	File Menu

Display As

Select **Display As** and then select either **Running Average** or **Total Area** for display in the active window.

8-hr TWA

Select this option to display the 8-hr Time Weighted Average in the active window. Hide this value and graph line by unselecting this option.

View Boundaries

Select **View Boundaries** to display view boundaries in the graph window. After you select **View Boundaries**, drag view boundaries by positioning the cursor on the boundary, clicking the left mouse button, and dragging the boundary to a new location.

Set Y Axis Scale

Select **Set Y Axis Scale** to change the Y axis scale see Figure 5-16. You can select either logarithmic or linear scale. By default the graphs display in linear scale and automatically scale. To display in logarithmic scale, check the Log box.

To input custom values for a minimum and/or maximum number, select the Min or Max or Min/Max radio buttons and input values.

Grid Lines

Select **Grid Lines** to select the lines for the graph in the active window. The options are horizontal, vertical, both or none.

Statistics View Popup Menu

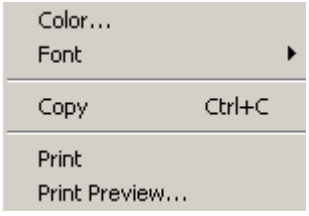


Figure 5-40
Statistics View Popup Menu

Table 5-8
Statistics View Popup Menu

Menu Item	For a description, see ...
Color	Format Menu
Font	Format Menu
Copy	View Menu
Print	File Menu
Print Preview	File Menu

Status Bar Icons

A status bar at the bottom of the desktop displays some basic information about the current session as described below.

Figure 5-41
Status Bar Icon

Table 5-9
Status Bar Icon Menu

Icon/Text	Description
Collecting Data	The first pane of the status bar indicates if the application is collecting data and will also display “Waiting to Start” if waiting to start data collection.
Elapsed	The elapsed time is updated when collecting data for a sample.
	Instrument status information. Move the mouse over the icon to view instrument status information such as whether or not there is a connection to the 3550.

Shortcut Keys

Shortcut keys and key combinations let you to perform operations using only the keyboard (no mouse required).

Key(s)	Action for Nanoparticle Surface Area Monitor Software
F1	Help; opens the help manual (PDF file)
F10	Start Data Collection
Ctrl C	Copy current view to clipboard
Ctrl I	Opens Instrument Status window
Ctrl L	Arranges windows in a 4-pane layout on the desktop
Ctrl N	Open a New document
Ctrl O	Open a document
Ctrl P	Print current view
P	Print current view
Ctrl S	Save As
Ctrl W	Close current file
Z	Undo Zoom in graph

CHAPTER 6

Custom Calibration

This chapter tells how to calibrate the Model 3550 Nanoparticle Surface Area Monitor to match a desirable lung-deposition curve.

Overview of Custom Calibration

The Model 3550 is designed to sample aerosol and give a measure of lung-deposited surface area corresponding to tracheobronchial (TB) and alveolar (A) regions of lung. Factory calibration of Model 3550 for deposition in TB and A regions is based on ICRP published human lung-deposition model for an adult male reference worker (for details see Appendix B). However, if you would like the instrument measurement to match another human lung-deposition curve derived for a different set of input parameters (e.g., for a child) or derived using another lung-deposition model (e.g., for deposition in rat lung) it may be possible to tune the instrument response by following a set of custom calibration steps.

The instrument can be calibrated by tuning the trap voltage to a value that would bring the instrument deposited surface area measurements close to those calculated by using desired lung-deposition curve for a test aerosol. To determine this trap voltage value, set the Model 3550 at an initial trap voltage setting (any value between 2 and 300 V). This can be done using the software. Set the instrument response to custom mode in Run/Properties dialog box, and enter selected trap voltage value. Leave the calibration coefficient input box blank (refer to explanation of "The Instrument Response Tab" in Chapter 5). Generate monodispersed test aerosol or size classify a polydisperse test aerosol. Test the Model 3550 response for aerosols with four or more different median particle diameters, in the size range of interest. This can be done by comparing Model 3550 measurements with near-concurrent measurements by an Ultrafine Condensation Particle Counter (TSI Model 3776 UCPC or any other CPC that measures aerosol of the size range of interest). The number concentration obtained by the CPC should be transformed into surface area concentration by multiplying the number concentration of particles in an aerosol with median diameter (D) by the formula for surface area (pi D^2). In order to convert surface area to lung-deposited surface area, multiply by the fractional deposition (a number between 0 and 1) in the lung for that diameter as predicted by lung-deposition curve. Repeat the procedure for aerosols of different median particle diameters. Measurements from 3550 could be read as current (in units of fA) using the software. Select View/Instrument status dialog box to read electrometer current (fA) values from 3550 (refer to Chapter 5). The data from CPC can

be read from the front panel and recorded using Aerosol Instrument Manager® software. The deposited surface area values obtained for different particle sizes (in units of $\mu m^2/cm^3$) should be regressed against Model 3550 current signal (fA). A high correlation and linear relationship between the two indicate that the trap voltage setting was appropriate to match the Model 3550 response to desired deposition curve. If non-linear relationship results, change the trap voltage and repeat the process iteratively until you obtain a linear response. Once a linear relationship is established, from the linear plot {with current (fA) plotted in x-axis and deposited surface area ($\mu m^2/cm^3$) plotted in y-axis} record the value of the slope in units of $\mu m^2/cm^3/fA$. This slope value is the calibration coefficient for the desired custom response. Record the calibration coefficient as well as the trap voltage value thus obtained for input into the appropriate boxes in the software properties dialog box (refer to Chapter 5, description of sample properties and instrument calibration).

***Note**: Increasing the voltage of the trap will result in decreased current signal measured by the Model 3550 for the same aerosol as the trap removes the small particles.*

Setup for Custom Calibration

Figure 6-1 depicts a suggested test setup for performing the experiments explained in previous section. This setup uses a TSI Model 3076 atomizer and TSI Model 3080 and Model 3081 Electrostatic Classifier/Long DMA for generation and size classification of the aerosol. Any other aerosol generation system could be used depending upon the particle material and particle size range of interest. It is suggested that the aerosol should be dried and neutralized prior to sampling by Model 3550 and the CPC. A diluter system consisting of HEPA filter and two valves is used to adjust the aerosol concentration. An electrostatic precipitator should be used to get rid of all charged particles. This is important since ideally the Model 3550 should not sample charged aerosol.

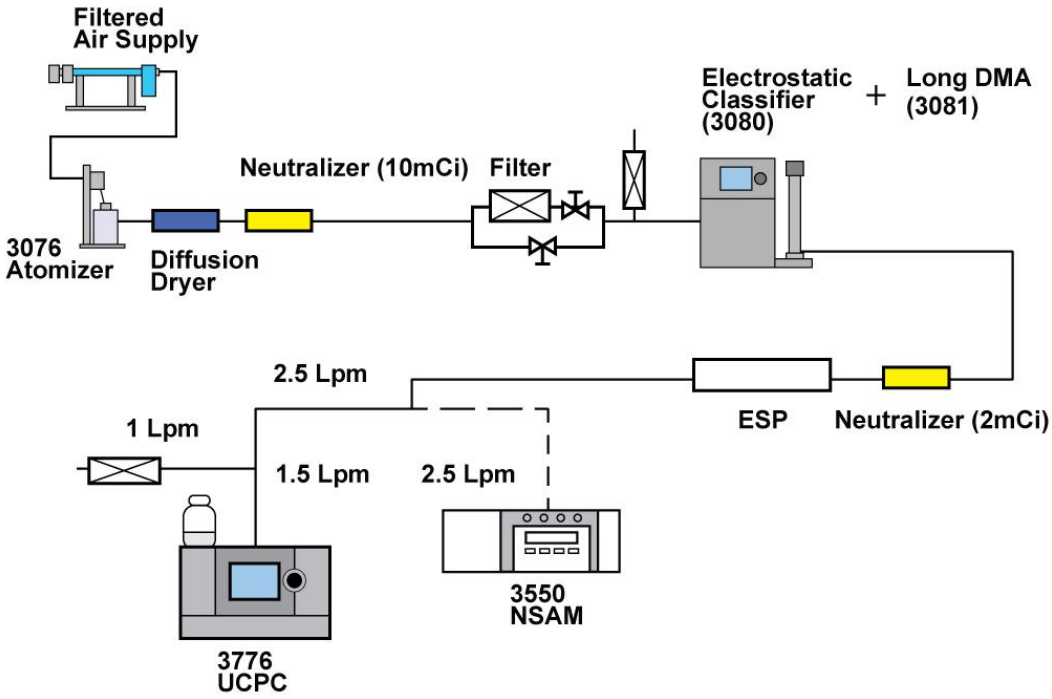


Figure 6-1
Experimental Setup for Custom Calibration

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CHAPTER 7

Maintenance

This chapter gives maintenance and service procedures for the Model 3550 Nanoparticle Surface Area Monitor.

Periodic Maintenance

Periodic cleaning of several parts of the Nanoparticle Surface Area Monitor is necessary to ensure proper performance. The service intervals depend on the aerosol concentration entering the Nanoparticle Surface Area Monitor.

Table 7-1
Maintenance Schedule

Maintenance Task	Hours of Operation
Clean the cyclone	100 to 500
Clean the inlet orifice	500 to 1000 (much more often if cyclone is not used with large particles)
Clean the charger orifice and needle	8000 (if activated carbon cartridge is replaced regularly)
Replace activated carbon cartridge	500 to 1000
Replace the charger filter	1000 to 4000
Replace the pump exhaust filter	4000 to 8000
Replace the electrometer filter	1000 to 4000
Clean the cabinet fan filter	As needed

Cleaning the Cyclone

The cyclone is provided to remove particles above 1 µm (especially fibers) from the inlet flow. This protects the inlet orifice from clogging. The cyclone can be easily cleaned (see Figure 7-1):

1. Remove the cup at the bottom of the cyclone.
2. Blow out the inside of the cup and wipe off any residue.
3. Inspect the O-ring for any damage and replace the cup.

Figure 7-1
Cleaning the Cyclone

Cleaning the Inlet Orifice

The inlet orifice is exposed to aerosol flowing through the instrument. Therefore, it is susceptible to clogging if the aerosol particle concentration is high. However, the orifice is easily cleaned. Follow the steps below to clean the orifice:

1. Turn off the instrument using the power switch on the back panel.
2. Remove the cyclone and then remove the retaining screw of the inlet (see Figure 7-2).
3. Pull the inlet straight out from the instrument.
4. Inspect the orifice using magnification to see if it is dirty.
5. If necessary, clean the orifice using warm soapy water, followed by clean water and then isopropyl alcohol and dry clean air. Re-inspect the orifice.
6. Inspect the O-rings for cuts or nicks and replace if necessary.
7. Lightly grease the O-rings if they are replaced or if they have been cleaned.

Figure 7-2
Aerosol Inlet Orifice Location

8. Re-insert the inlet into the instrument and align the retaining screw hole.
9. Insert the retaining screw.
10. Turn the instrument back on and make sure that the Flow Ratio and Total Flow LEDs are constantly lit.

Cleaning the Charger Orifice

The charger filter and activated carbon cartridge protect the charger orifice and charger needle. Normally the orifice and needle should not have to be cleaned. Cleaning either of these parts is beyond the scope of this manual. If you suspect a clogged charger orifice or dirty needle, contact TSI customer service (see Chapter 9) for further instructions.

Replacing the Activated Carbon Cartridge

WARNING

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

An activated carbon cartridge is used to remove organic vapors from the filtered air stream flowing through the charger. These vapors have been found to cause a build-up of material on the charger orifice and charger needle if they are not removed. Since it is much more difficult to clean the charger, it is a good idea to periodically replace the cartridge to prevent this buildup. Note that the charger filter (see next section) does not have to be replaced as frequently as the charcoal filter. Follow the steps below to replace the charcoal cartridge.

1. Disconnect the electric power cable.
2. Remove the cabinet cover by loosening the six (6) screws securing the cover (they do not have to be removed).
3. Locate the carbon cartridge shown in Figure 7-3 and note the direction of the flow arrow.
4. Remove the tubing from the filter by pushing it off or by cutting off the old tubing.
5. Replace the cartridge with a carbon cartridge provided in the accessory kit (TSI part number 1602348) and replace any tubing as needed.
6. Reinstall the cover.
7. Turn the instrument back on and make sure that the Flow Ratio and Total Flow LEDs are constantly lit.

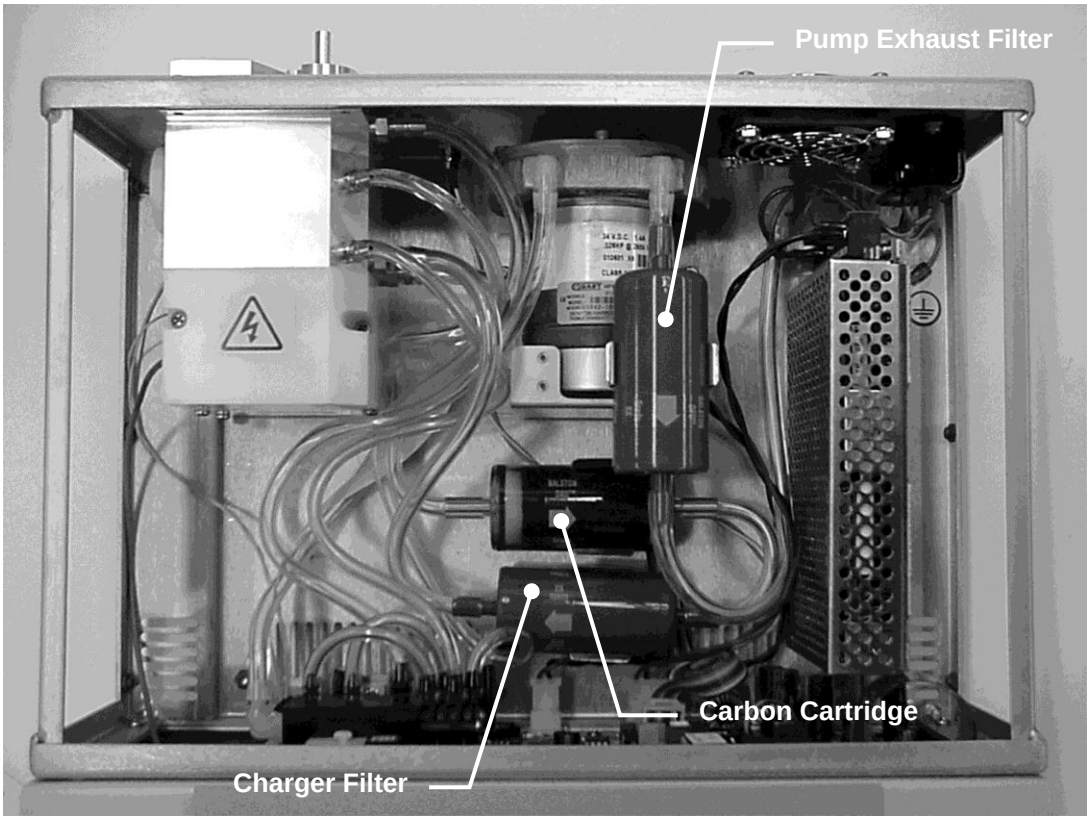

Figure 7-3
Location of Filter Cartridges

Replacing the Charger Filter

W A R N I N G

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

A capsule filter is used to filter some of the aerosol passing through the instrument for use as clean charger air. This filter will have to be replaced periodically as it collects particles and the pressure drop through the filter increases. Follow the steps below to replace the charger filter cartridge.

1. Disconnect the electric power cable.
2. Remove the cabinet cover by loosening the six (6) screws securing the cover (they do not have to be removed).
3. Locate the charger filter shown in Figure 7-3 and note the direction of the flow arrow.
4. Remove the tubing from the filter by pushing it off or by cutting off the old tubing.

5. Replace the filter with a BX filter provided in the accessory kit (TSI part number 1602230) and replace any tubing as needed.
6. Reinstall the cover.
7. Turn the instrument back on and make sure that the Flow Ratio and Total Flow LEDs are constantly lit.

Replacing the Pump Exhaust Filter

WARNING

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

A capsule filter is used to filter the exhaust from the pump (which contains carbon particles from wear of the carbon vanes in the pump). This is done to prevent contaminating the environment with instrument-generated particles. Over time the filter will become clogged with carbon particles and have to be replaced. Follow the steps below to replace the pump exhaust filter cartridge.

1. Disconnect the electric power cable.
2. Remove the cabinet cover by loosening the six (6) screws securing the cover (they do not have to be removed).
3. Locate the pump exhaust filter shown in Figure 7-3 and note the direction of the flow arrow.
4. Remove the tubing from the filter by pushing it off or by cutting off the old tubing.
5. Replace the filter with a BX filter provided in the accessory kit (TSI part number 1602230) and replace any tubing as needed.
6. Reinstall the cover.
7. Turn the instrument back on and make sure that the Flow Ratio and Total Flow LEDs are constantly lit.

Replacing the Electrometer Filter

W A R N I N G

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

C a u t i o n

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

- Wear a grounded, static-discharging wrist strap

A special filter with a wire mesh incorporated into the inner diameter is used as the collector for current in the electrometer. The wire mesh allows the current from captured particles to bleed off of the filter in a reasonable time. With use the filter will become clogged with particles from the sampled aerosol and have to be replaced. Follow the steps below to replace the electrometer filter.

1. Disconnect the electric power cable.
2. Remove the cyclone assembly.
3. Remove the electrometer chamber cover by removing the four (4) screws securing the cover shown in Figure 7-4. Be careful not to touch the plastic parts attached to the cover—this will reduce their insulating properties and increase the noise in the electrometer.

Figure 7-4
Electrometer Chamber Cover Screws

4. Locate and remove the electrometer filter by pulling it straight out.

5. Replace the filter with a wire-core filter provided in the accessory kit (TSI part number 1602346).

6. Inspect the O-rings in the cover for nicks or cuts and replace if necessary. If the insulator is dirty or has been handled (oil from fingers) it should be cleaned and wiped with methanol or isopropanol and then acetone to remove all contamination.

7. Reinstall the electrometer cover.

8. Turn the instrument back on and make sure that the Flow Ratio and Total Flow LEDs are constantly lit.

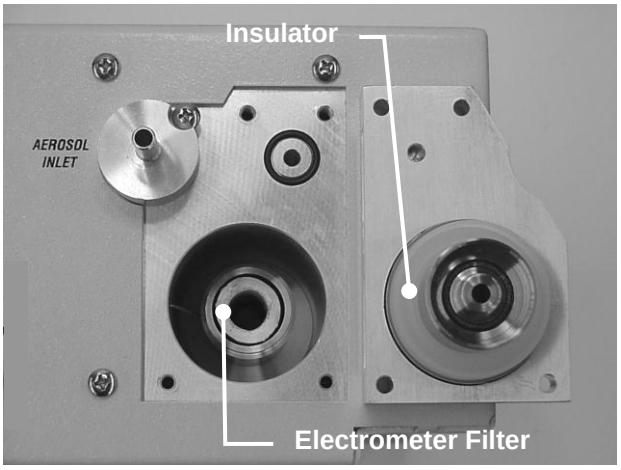

Figure 7-5
Electrometer Filter and Insulator

Cleaning the Cabinet Fan Filter

The cabinet cooling fan is mounted in the back panel and blows into the instrument to keep its interior temperature down. If operating in a dirty or dusty environment, the fan filter may accumulate debris restricting air flow. Periodically inspect the fan's filter to see if it needs cleaning, and if so follow the steps below.

1. Disconnect the electric power cable.
2. Using a flat blade screwdriver, pry off the filter housing cover as shown in Figure 7-7.
3. Pull out the filter media with your fingers.
4. Clean the filter media either with compressed air or washing with water or a mild detergent.
5. Fully dry the filter media and put it back in its housing.
6. Snap the filter housing cover back into place.

Figure 7-6
Removing the Cabinet Fan Filter for Cleaning

Replacing the EPROM

Normally the EPROM should not need to be replaced. However, updates may be required to add functions/features or to correct bugs in the firmware. In this case, EPROM replacement may be required. This service should only be performed by a qualified electronics technician observing ESD precautions.

W A R N I N G

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

C a u t i o n

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

- Wear a grounded, static-discharging wrist strap

Follow the steps below to replace the EPROM.

1. Disconnect the electric power cable.
2. Remove the cabinet cover by loosening the six (6) screws securing the cover (they do not have to be removed).
3. The Nanoparticle Surface Area Monitor uses a single EPROM chip. It should be labeled with a seven-digit part number. It is important that it goes in the correct socket with the correct orientation.
4. Locate the EPROM inside the front panel as shown in Figure 7-7 and note that the orientation notch is at the top of the EPROM chip in the figure.
5. Use the EPROM removal tool provided with the new EPROM chips to remove the old chip.
6. Remove the new EPROM from its static protection bag.
7. Install the new chip into the vacant socket by aligning the notch on the top center of the chip with the notch shown on the silkscreen.
8. Slightly insert one row of pins, and then push the chip sideways to insert the other row.
9. Once both rows of pins are slightly inserted, press the EPROM firmly the rest of the way into the socket.

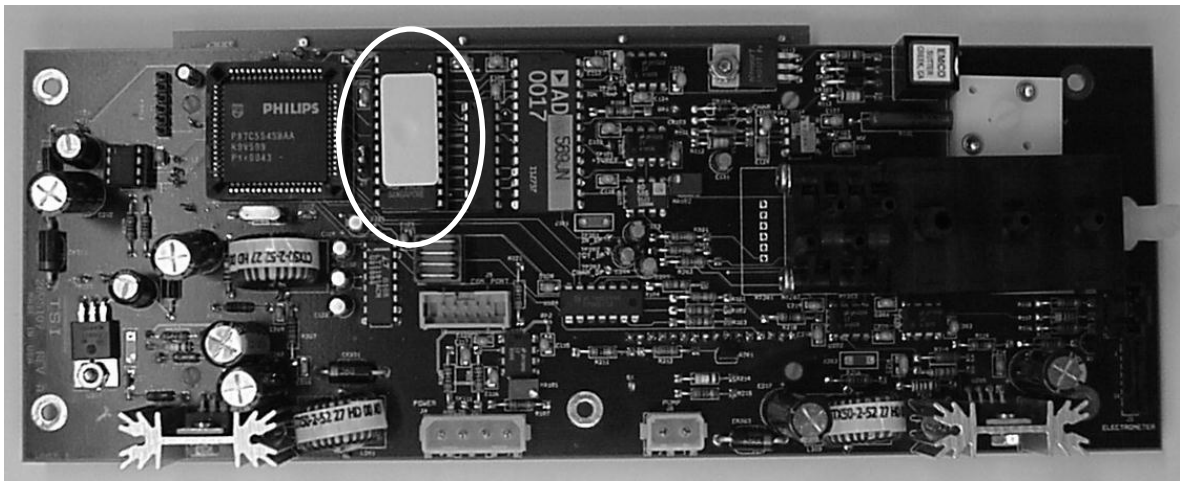

Figure 7-7
Location of the EPROM on the Main PC-Board

10. Inspect the socket to make sure that all pins are inserted into the socket.
11. Reinstall the cover.
12. Turn the instrument back on and make sure that the LED indicators and display are functioning properly.

Replacement Parts

This section contains information on replacement parts available from TSI and their part numbers.

Table 7-2
Model 3550 Nanoparticle Surface Area Monitor Replacement Parts

Part Description/Location	Part Number
Filter, carbon cartridge DAU	1602348
Filter, Balston DFU-BX	1602230
Filter, wire core micro-fiber	1602346
Tubing, Tygon ¼ OD × ⅛ ID	3001220
Tubing, Tygon 5/16 OD × 3/16 ID	3001248
Fan Filter Assembly 60 mm sq	1607039

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CHAPTER 8

Troubleshooting

This chapter tells how to troubleshoot problems with the Model 3550 Nanoparticle Surface Area Monitor.

Common Problems

The Model 3550 is designed to sample aerosol and give a measure of surface area deposited in different regions of lung. When the instrument does not seem to be operating properly, try the following troubleshooting guide:

Problem	Solution
The **Flow Ratio** LED is blinking fast (about 5 times per second).	This usually indicates that the inlet orifice is partially or completely plugged. See Chapter 7, "Cleaning the Inlet Orifice," for directions.
The **Flow Ratio** LED is blinking slowly (about 2 times per second).	This usually indicates that the charger filter is partially or completely plugged. See Chapter 7, "Replacing the Charger Filter," for directions. Another possibility is that the charger orifice has become clogged. Cleaning the charger orifice is a more involved process. Contact TSI customer support for assistance (see Chapter 9). Less likely is that the carbon cartridge is clogged. See Chapter 7, "Replacing the Activated Carbon Cartridge," for directions.
The **Total Flow** LED is blinking fast (about 5 times per second).	The instrument may be sampling from a pressure that is too high for the pump to control flow. Try connecting the pump exhaust back into the pressure source (note that in this situation, the flow reading should be independently checked).

Problem	Solution
The **Total Flow** LED is blinking slowly (about 2 times per second).	The aerosol inlet on the back panel may be plugged or blocked. The instrument may be sampling from a vacuum that is too high for the pump to maintain flow. Try connecting the pump exhaust back into the vacuum source (note that in this situation, the flow reading should be independently checked). The pump outlet may be blocked. The electrometer filter may be plugged. See Chapter 7, "Replacing the Electrometer Filter," for directions. The pump exhaust filter may be plugged. See Chapter 7, "Replacing the Pump Exhaust Filter," for directions.
The **Charger** LED is blinking	The charger needle may be dirty or may need adjustment. Contact customer service for assistance (see Chapter 9).

If the instrument has been recently reassembled, see "Testing for Leaks" below. For situations not covered in the table above or not caused by leaks, contact customer service for assistance (see Chapter 9).

Testing for Leaks

Whenever an air leak is suspected or a significant part of the airflow system has been reassembled, perform a leak test to assure proper performance.

1. Disconnect the electric power cable.
2. Remove the cabinet cover by loosening the six (6) screws securing the cover (they do not have to be removed).
3. Locate the charger/electrometer chamber shown in Figure 8-1.
4. Remove and **label** all tubing from the chamber.
5. Using tubing from the accessory kit, connect the two top fittings together with ¼ OD × ⅛ ID tubing.
6. Using tubing from the accessory kit, connect the middle two fittings together with 5⁄16 OD × 3⁄16 ID tubing.
7. Using the inlet shipping plug, block the bottom fitting.
8. Connect a vacuum pump with valve and gauge to the aerosol inlet. When the vacuum is at 18 inHg close the valve and monitor the gauge. If the vacuum changes by more than 0.1 inHg in five (5) minutes, see "Isolating Leaks" below.
9. When the charger/electrometer chamber leak checks satisfactorily, reconnect the labeled tubing to its original state.
10. Reinstall the cover.

11. Turn the instrument back on and make sure that the instrument performs as expected. If the instrument has been significantly disassembled, it may have to be recalibrated. Contact TSI customer service for assistance (see Chapter 9).

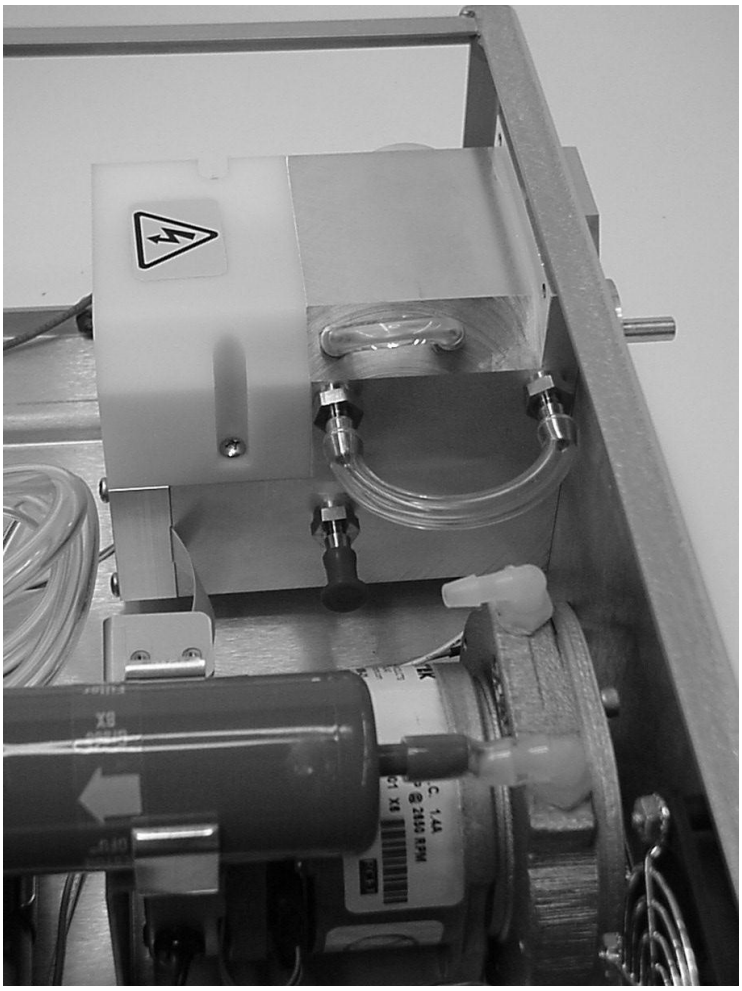

Figure 8-1
Leak Checking

Isolating Leaks

1. Isolate the leak by wetting suspected joints with clean isopropyl alcohol while the system is under vacuum. The alcohol will be drawn into a leaky joint and evaporate.
2. After isolating the leak, repair it (usually by greasing or replacing an O-ring, or by sealing a fitting).
3. Blow low-pressure clean, dry air through the repaired section to evaporate and remove any leftover alcohol.
4. If you cannot find the leak, or cannot repair the leak, please contact TSI for assistance.

CHAPTER 9

Contacting Customer Service

This chapter gives directions for contacting people at TSI Incorporated for technical information and directions for returning the Model 3550 Nanoparticle Surface Area Monitor for service.

Technical Contacts

- If you have any difficulty setting up or operating the Model 3550, or if you have technical or application questions about this system, contact an applications engineer at TSI Incorporated, 1-800-874-2811 (USA) or (651) 490-2811.

- If the Model 3550 does not operate properly, or if you are returning the instrument for service, visit our website at http://service.tsi.com or contact TSI at:

TSI Incorporated
500 Cardigan Road
Shoreview, MN 55126 USA

Phone: +1-800-874-2811 (USA) or +1 (651) 490-2811
E-mail: technical.service@tsi.com *or* particle@tsi.com

TSI GmbH
Neuköllner Strasse 4
52068 Aachen
GERMANY

Telephone: +49 241-52303-0 E-mail: tsigmbh@tsi.com
Fax: +49 241-52303-49 Web: www.tsiinc.de

TSI Instruments Ltd.
Stirling Road
Cressex Business Park
High Wycombe, Bucks
HP12 3ST
UNITED KINGDOM

Telephone: +44 (0) 149 4 459200 E-mail: tsiuk@tsi.com
Fax: +44 (0) 149 4 459700 Web: www.tsiinc.co.uk

Returning the Nanoparticle Surface Area Monitor for Service

Before returning the Model 3550 to TSI for service, visit our website at http://rma.tsi.com or call TSI at 1-800-874-2811 (USA) or 001 (651) 490-2811 for specific return instructions. Customer Service will need the following information when you call:

- The instrument model number
- The instrument serial number
- A purchase order number (unless under warranty)
- A billing address
- A shipping address

Use the original packing material to return the instrument to TSI. If you no longer have the original packing material, seal off any ports to prevent debris from entering the instrument and ensure that the display and the connectors on the instrument front and back panels are protected.

APPENDIX A

Model 3550 Specifications

The following specifications list the most important features of the Model 3550 Nanoparticle Surface Area Monitor.

Table A-1
Specifications* of the 3550 Nanoparticle Surface Area Monitor

Mode of Operation.....	Charges particles using a diffusion charger and then measures the total charge on the particles using an electrometer.
Particle Size Range	10 to 1000 nm (with 1 µm cyclone)
Measurement Accuracy (for size range 20 to 200 nm)****	TB: ±20% or 0.1 $\mu m^2/cm^3$ A: ±20% or 0.5 $\mu m^2/cm^3$
Concentration Range.....	TB: 0 to 2,500 $\mu m^2/cm^3$ A: 0 to 10,000 $\mu m^2/cm^3$
Maximum Data Rate	1 reading/sec (1 Hz)
Temperature Range.....	10 to 35°C
Pressure Range.....	700 to 1200 mbar [0.7 to 1.2 atm]
Relative Humidity Range†	0 to 80%
Front Panel Display.....	4-digit segmented LCD
Dimensions (HWD).....	13.3 cm × 38 cm × 28 cm (5.3 in. × 15 in. × 11 in.)
Weight	6.8 kg (15 lb)
Output Digital I/O	 DSUB 9-pin RS-232
Ports Aerosol Inlet ..... Pump Exhaust.....	 ¼-in. OD aluminum tube ¼-in. OD Swagelok® connection
Power Requirements.....	100 to 240 VAC, 50/60 Hz, 1A maximum
Fuse (***not*** replaceable by user).....	3.0A, 250 V, type 5 x 20 mm (internal—not replaceable by operator)

*Specifications are subject to change without notice. TSI and the TSI logo are registered trademarks of TSI Incorporated.
**Tested at TSI for NaCl particles.
†The instrument will operate optimally under the specified relative humidity conditions. The ICRP-based lung deposition model used to derive TB and A deposition curves in a reference worker (and hence the instrument's measurement for TB and A regions), does not consider the effect of humidity on particle size.

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APPENDIX B

Lung Deposition Model

This appendix gives an explanation of the lung deposition curves used for calibrating the Model 3550. The deposition curves were developed using human lung-deposition model published by International Commission on Radiological Protection (ICRP-66) (1995). The deposition curves are calculated using LUDEP Version 2.07 (2000) software. All calculations are based on a "reference worker" as defined in a publication by ACGIH (Ed. Vincent J.H,, 1999). The lung deposition curves thus derived for tracheobronchial and alveolar regions are shown in Figure B-1. The input parameters used in the model are listed in Table B-1.

Table B-1
(A) and (B) Reference Worker: Representative Values for Respiratory Anatomical and Physiological Parameters Describing an Average Healthy Worker Under Light to Moderate Physical Activity. (ACGIH, Ed. Vincent J.H., 1999). (C) Inhaled aerosol parameters.

(A) Physiological Parameters	
Subject	Adult male
Weight	70 kg
Height	175 cm
Age	20–30 years
Functional residual capacity	2200 cc
Extra-Thoracic Dead Space	50 cc
Bronchial Dead Space	49 cc
Bronchiolar Dead Space	47 cc
Tracheal Diameter	1.65 cm
First Bronchial Diameter	0.165 cm
Lung Weight	1000 g
Lung Surface Area	80 m^2
(B) Activity Related Parameters	
Activity level	Light Exercise
Activity type	Nose breathing only
Ventilation rate	1.3 cc/hr
Respiratory frequency	15.0 breaths/min
Tidal volume	1450 cc
Volumetric flow rate	725 cc/sec
Fraction breathed through nose	1.0

(C) Aerosol Parameters	
Geometric diameters	0.001 μm–0.5 μm
Geometric standard deviation	1.0
Density	1.0 g/cc
Shape factor	1.0

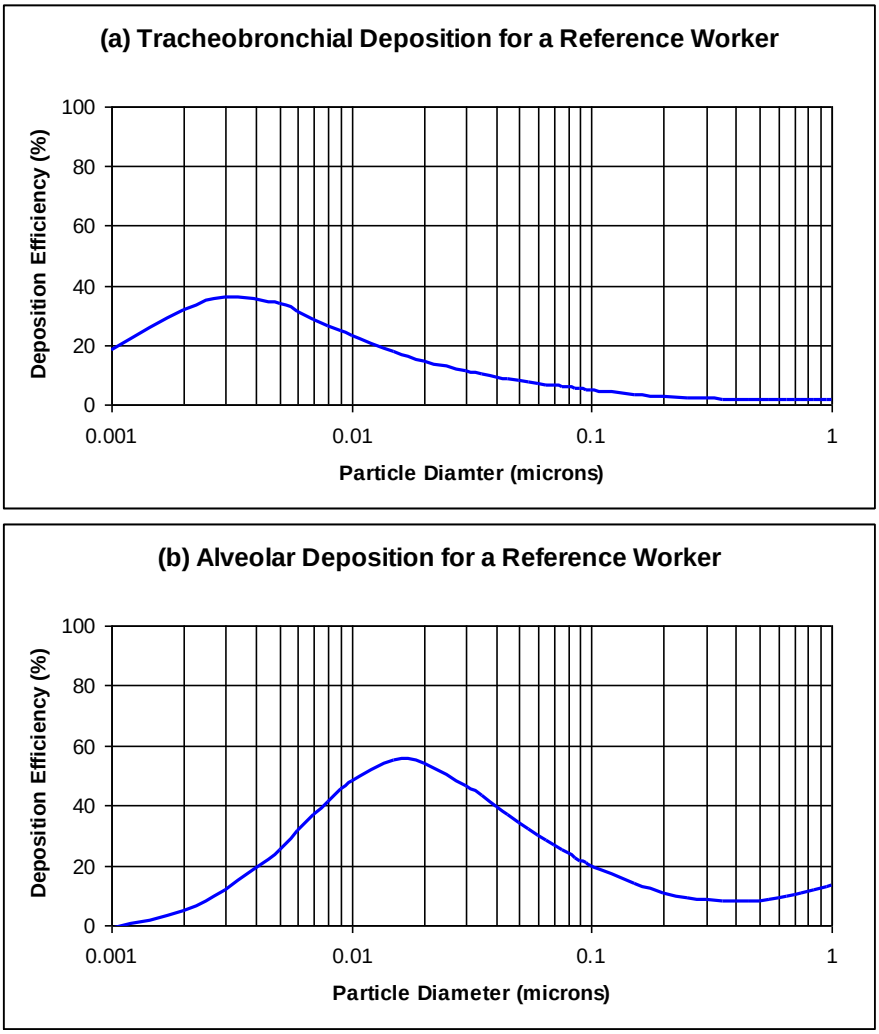

Figure B-1
Fractional Deposition of Inhaled Particles in Respiratory Tract of a Reference Worker. (a) Tracheobronchial (TB) Deposition (b) Alveolar Deposition (Source: ICRP-1995).

APPENDIX C

Theory of Operation

This appendix gives a technical explanation of the operating principles of the Model 3550 Nanoparticle Surface Area Monitor. References related to the Model 3550 are also included.

Principles of the Nanoparticle Surface Area Monitor

The Model 3550 Nanoparticle Surface Area Monitor works by charging incoming aerosol particles, then collecting the particles on an electrically-isolated, conductive filter connected to the input of a sensitive electrometer. The current measured by the electrometer is related to the surface area of particles deposited in different regions of the lung.

The basic working principle of Model 3550 is similar to the Electrical Aerosol Detector (EAD, TSI Model 3070A). Wilson et al. [2004] reported that the EAD signal is highly correlated to the calculated amount of deposited surface area in the lung. The Model 3550 features an improved design over the EAD that brings the instrument response even closer to the surface area dose corresponding to target regions of the lung.

Charger

The charging device in the Model 3550 is the "Corona-Jet" charger based on work by Medved et al. [2000]. Unipolar air ions from a corona needle-tip discharge are swept by clean air (1.0 L/min) through an orifice into a field-free mixing chamber of about 10 cc volume, forming a jet which collides with an opposing jet of the incoming aerosol (1.5 L/min). The turbulence of the two colliding jets improves the mixing of the aerosol with the unipolar ions, so that even within the residence time of about 0.25 seconds in the mixing chamber most of the aerosol has reached its limiting charge state.

Trap

A variable-voltage coaxial electrostatic precipitator in the outlet of the mixing chamber removes excess high-mobility air ions, so that they do not contribute to the current measured at the electrometer. At higher voltages it is capable of removing small particles along with the ions. Changing the voltage of the trap allows configuration of measurement response to tracheobronchial (TB) or alveolar (A) deposition. It is possible to set the trap voltage to any value between 2 V and 300 V.

Filter-Electrometer

On leaving the trap, the aerosol enters a faraday cage where the particles, and their charge, are collected on particle filter. The filter is conductive, and is electrically connected to the input of a sensitive electrometer amplifier. The electrometer's critical circuits are contained in a small enclosure placed near one end of the filter to minimize input capacitance and to maintain mechanical stiffness of the leads and thus avoid microphonics. The filter may be replaced provided proper precautions are taken to prevent electrostatic-discharge damage to the sensitive electrometer circuit.

Electrometer Circuit

The amplified signal of the electrometer circuit is digitized using a 24-bit converter. About 3.75 times per second the data are transmitted serially to the microcontroller, where the data are further reduced to 22-bit giving a resolution of 119 attoampere per bit.

Cyclone

The Model 3550 Nanoparticle Surface Area Monitor cyclone provides a way of removing a known cut size of particles from the inlet stream. A cyclone has the advantage over other methods (such as an impactor) of being able to handle high dust loading conditions over a long period of time, with a relatively small pressure drop. The cyclone provided with the Model 3550 is designed to have a d50 cut point of 1 µm at a flow rate of 2.5 L/min (see Figure C-1 below). The design is based on work by Kenny and Gussman [2000] on an extra sharp cut cyclone (ESCC).

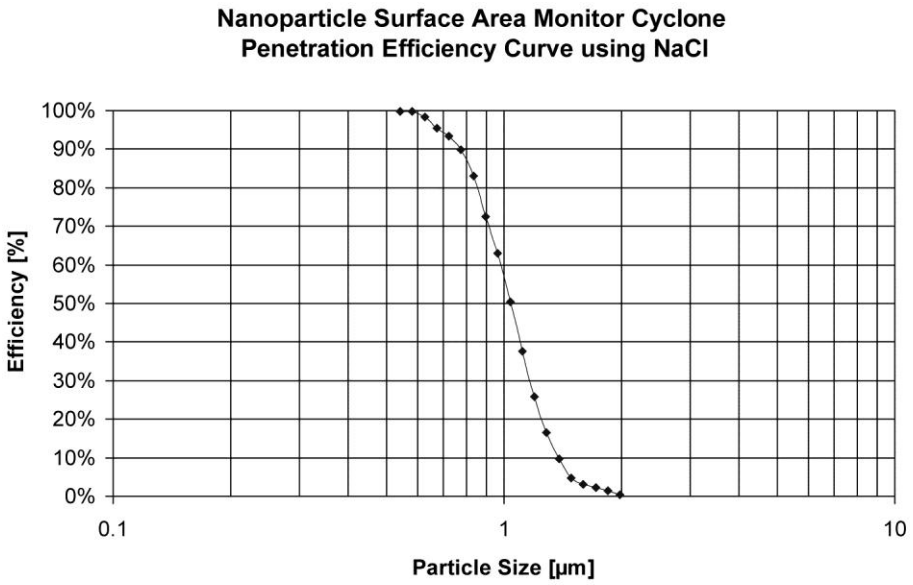

Figure C-1
Efficiency Curve of Nanoparticle Surface Area Monitor Cyclone

Selected References

The following list contains papers that apply directly to the Nanoparticle Surface Area Monitor as well as other references that may be interesting to the reader.

Fuchs, N.A. [1963] "On the Stationary Charge Distribution on Aerosol Particles in a Bipolar Ionic Atmosphere," *Geophys. Pura Appl*., **56**:185.

Han H.-S., Singh M., Osmondson B.L., and Krinke T. [2005] "A Novel Instrument for Measuring Surface Area of Particles Deposited in Different Regions of the Lung." *2005 Workshop on Generation and Health Effects of Nanoparticles*, July 2005, Karlsruhe, Germany.

Hinds, W.C. [1982] Aerosol *Technology: Properties, Behavior, and Measurement of Airborne Particles.* New York: John Wiley & Sons, Chapter 15—Electrical Properties.

International Commission on Radiological Protection (ICRP) [1995]. Human Respiratory Tract Model for Radiological protection, *ICRP publication* **66**, Elsevier, Tarrytown, NY.

Jung, H. and Kittelson, D. [2002] "Measurement of Electrical Charge on Diesel Particles," *Poster PK1-06, Abstracts of the 21st Annual AAAR Conference*, Charlotte, NC, pp. 277.

Kenny, L.C. and R.A. Gussman [2000] “A Direct Approach to the Design of Cyclones for Aerosol-Monitoring Applications,” *Journal of Aerosol Science*, **31**:1407-1420.

Lawless, P.A. [1996] “Particle Charging Bounds, Symmetry Relations, and an Analytic Charging Rate Model for the Continuum Regime,” *Journal of Aerosol Science*, **27**:191-215.

LUDEP Software, Version 2.07. James A.C., Bailey M.R., Dorrian M-D. [2000]. “Program for implementing the ICRP-66 Respiratory Tract Model.” RPB, Chilton, Didcot, OXON. OX11 0RQ UK.

Medved, A., Dorman, F., Kaufman, S.L., and Pöcher, A. [2000] “A New Corona-based Charger for Aerosol Particles,” *Journal of Aerosol Science*, **31**:S616-S617.

Pui, D.Y.H., Fruin, S., and McMurry, P.H. [1988] “Unipolar Diffusion Charging of Ultrafine Aerosols,” *Aerosol Science and Technology*, **8**(2):173-187.

Vincent J.H.(Ed.) [1999]. “Particle size-selective sampling for particulate air contaminants.” *American Conference for Governmental Industrial Hygienists (ACGIH)*, Cincinnati, OH.

Willeke, Klaus and Paul A. Baron [1993] *Aerosol Measurement: Principles Techniques and Applications.* New York: Van Nostrand Reinhold, p. 125—Electrometer.

Wilson, W.E., Han, H.-S., Stanek, J., Turner, J., Chen, D.-R., and Pui, D.Y.H. [2004] “Use of the Electrical Aerosol Detector as an Indicator for the Total Particle Surface Area Deposited in the Lung,” *paper #37, 2004 Symposium on Air Quality Measurement Methods and Technology sponsored by Air and Waste Management Association*, April 2004, Research Triangle Park, NC.

Woo, K.-S., Chen, D.-R., Pui, D.Y.H., and Wilson, W.E. [2001] “Use of Continuous Measurements of Integral Aerosol Parameters to Estimate Particle Surface Area,” *Aerosol Science and Technology*, **34**:57-65.

For more information on nanoparticle health investigations, a list of publications is shown below:

Donaldson, K., Li X.Y. and MacNee W. [1998] Ultrafine (Nanometer) Particle Mediated Lung Injury, *J. Aerosol Sci.* **29**(5/6):553-560.

Driscoll K.E. [1996] Role of inflammation in the development of rat lung tumors in response to chronic particle exposure. *Inhal. Toxicol.* **8** [suppl1]:85-98.

Driscoll K.E. Carter J.M., Howard B.W., Hassenbein D.G., Pepelko W., Baggs R.B. and Oberdörster G. [1996]. Pulmonary inflammatory, chemokine, and mutagenic responses in rats after subchronic inhalation of carbon-black. *Toxicol. Appl. Pharmacol.* **136**:372-380.

Driscoll K.E, Deyo L.C., Howard B.W., Poynter J. and Carter J.M. [1995].Characterizing mutagenesis in the hprt gene of rat alveolar epithelial-cells. *Exp. Lung Res.* **21**:941-956.

Heinrich U., Fuhst R., Rittinghausen O., Creutzenberg B., Koch W. and Levsen K. [1995] Chronic inhalation exposure of Wistar rats and two different strains of mice to diesel engine exhaust, carbon black, and titanium dioxide. *Inhal. Toxicol.* **7**:533-556.

Lam C.W., James J. T., McCluskey R. and Hunter R.L. [2004]. Pulmonary toxicity of single-wall carbon nanotubes in mice 7 and 90 days after intratracheal instillation, *Toxicol. Sci*. **77** (1):126-134.

Lee K.P. Trochimowicz J.H., Reinhardt C.F. [1985] Pulmonary response of rats exposed to titanium dioxide by inhalation for two years. *Toxicol. Appl. Pharmacol*. **79**:179-192.

Li N. Li, N., Sioutas, C., Cho, A., Schmitz, D., Misra, C., Sempf, J., Wang, M., Oberley, T., Froines J., Nel, A. [2003]. Ultrafine particulate pollutants induce oxidative stress and mitochondrial damage, *Environ. Health Persp.* **111**:455-460.

Nemmar A., Hoet P.H.M., Vanquickenborne B., Dinsdale D., Thomeer M., Hoylaerts M.F., Vanbilloen H., Mortelmans L. and Nemery B. [2002] Passage of inhaled particles into the blood circulation in humans, *Circulation* **105**:4B-414.

Nemmar A. [2001] Passage of intratracheally instilled ultrafine particles from the lung into the systemic circulation in hamster. *Am. J. Respir. Crit. Care Med.***164**:1665-1668.

Oberdörster E. [2004] Manufactured nanomaterials (Fullerenes, C-60) induce oxidative stress in the brain of juvenile largemouth bass, *Environ. Health Persp.* **112** (10):1058-1062.

Oberdörster G. [2001] Pulmonary effects of inhaled ultrafine particles. *Int. Arch. Occup. Environ. Health* **74**:1-8.

Oberdörster, G. [1996].Significance of Particle Parameters in the Evaluation of Exposure-Dose-Response Relationships of Inhaled Particles, *Particulate Sci. Technol.* **14**(2):135-151.

Oberdörster G., Gelein RM, Ferin J, Weiss B. [1995] Association of particulate air pollution and acute mortality: involvement of ultrafine particles? *Inhal. Toxicol.* **7**:1B-124.

Penttinen P, Timonen KL, Tiittanen P, Mirme A, Ruuskanen J, Pekkanen J. [2001] Number concentration and size of particles in urban air: effects on spirometric lung function in adult asthmatic subjects, *Environ. Health Persp.* **109**:319-323.

Shanbhag, A. S., Jacobs J.J., Black J., Galante J.O., Glant T.T. [1994]. Macrophage/Particle Interactions: Effect of Size, Composition and Surface Area, *J. Biomed. Mat. Res.* **28**(1):81-90.

Utell M.J. Frampton M.W. [2000]. Acute health effects of ambient air pollution: the ultrafine particle hypothesis. *J. Aerosol Med.* **13**:355-359.

Warheit D. B., Laurence B.R., Reed K.L., Roach D.H., Reynolds G.A.M. and Webb T.R. [2004] Comparative Pulmonary Toxicity Assessment of Single-wall Carbon Nanotubes in Rats, *Toxicol. Sci.* **77** (1):117-125.

APPENDIX D

Using Serial Data Commands

This appendix contains information you need if you are writing your own software for a computer or data acquisition system. Information includes:

- Pin connectors
- Baud rate
- Parity
- Command definitions and syntax
- Examples, as well as input and troubleshooting directions are also provided.

Making Connection

Connect the serial port of an IBM-compatible computer to the SERIAL PORT connector on the back of the Nanoparticle Surface Area Monitor (Figure D-2). Use the C-foot cable provided. If a longer cable is needed, use a standard IBM 9-pin, serial extension cable. The computer should be configured for communications settings of 9600 Baud, 7 bits, Even Parity, and 1 stop bit (7-E-1).

Pin Connectors

The Nanoparticle Surface Area Monitor has a single 9-pin, D-subminiature connector port on the back panel labeled SERIAL PORT (see Figure 3-3 and Figure D-1). This communication port is configured at the factory to work with RS-232 type devices. Table C-1 provides the signal connections.

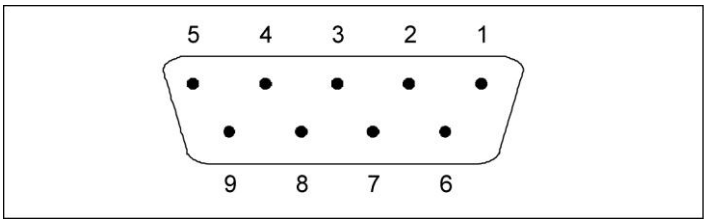

Figure D-1
SERIAL PORT Pin Designations

Table D-1
Signal Connections for RS-232 Configurations

Pin Number	RS-232 Signal
1	—
2	Transmit Output
3	Receive Input
4	—
5	GND
6	—
7	—
8	—
9	—

Figure D-2
Location of Serial Port

Baud Rate

The baud-rate setting is the rate of communication in terms of bits per second (baud). The Nanoparticle Surface Area Monitor uses a baud rate setting of 9600. For proper communications, make sure that all software used with the instrument is set at the appropriate rate.

Parity (7-Bits Even)

Parity is the additional bit that accompanies the seven data bits to confirm that they are transmitted correctly. The Nanoparticle Surface Area Monitor uses even parity as the only setting.

Commands

The Nanoparticle Surface Area Monitor uses an ASCII-based communications protocol that uses the RS-232 port of a computer to transmit commands in the form of strings.

The three types of commands are:

- Read commands, in which the Nanoparticle Surface Area Monitor sends data in response to a specific request from the computer.
- Set commands, which can set an operating parameter when used with an argument.
- Read/Set commands, which can read a parameter or current setting when used without an argument or can set an operating parameter when used with an argument.

Some things to keep in mind if you are writing your own interface software to communicate with the Nanoparticle Surface Area Monitor:

- No line-feed characters are transmitted.
- A “Set” command with no parameter echoes the current parameter setting.
- A “Set” command with parameters echoes "OK" if the parameter is accepted.
- A “Read” command returns the requested value.
- All other commands will return an "OK" if executed unless otherwise noted. The response "ERROR" will be returned if the command is not understood or it has an invalid parameter.
- Commands returning multiple parameters are separated with “,”.
- If the transmission of a command is not completed within five seconds, the serial port will timeout and reply with an "ERROR" message.

Command Quick Reference

The following tables provide a quick reference to all the serial commands. Command definitions, syntax, and examples begin after the tables. Directions for issuing commands and troubleshooting commands are provided at the end of this section.

Read Commands

RL	Read Surface Area
RCF	Read Charger Flow
RTF	Read Total Flow
RCC	Read Calibration Coefficient
RCV	Read Charger Voltage
RCI	Read Charger Current
REC	Read Electrometer Current
REOC	Read Electrometer Offset Current
RT	Read Electrometer Temperature
REB	Read Electrometer Bits
REOB	Read Electrometer Offset Bits
RAD	Read Analog Digital Converter
RV	Read Version
RE	Read Instrument Error
RS	Read Instrument Status

Read/Set Commands

SIM	Set or Read Ion Trap Mode
SIV	Set or Read Ion Trap Voltage
SCC	Set Calibration Coefficient
SRC	Set Replicate Coefficients
SCV	Set or Read Charger Voltage Mode
SP	Set or Read Pump Mode
STFS	Set or Read Total Flow Set Point
SCFS	Set or Read Charger Flow Set Point
SAV	Set or Read Averaging Mode

Set Commands

SEO	Set Electrometer Zero Offset
SUM	Set Unpolled Data Mode

Troubleshooting Input

Use Table D-2 as a troubleshooting guide.

Table D-2
Troubleshooting Serial Commands

Symptom	Possible Problem	Refer to
"Error" message after pressing <**Enter**>	An invalid command; command does not exist.	Figure D-2 in this appendix.
	An invalid parameter, which includes too many parameters or a parameter that is out-of-range.	The command showing the range and an example.
	Incorrect syntax	"Input Guidelines" in this section.
No response after pressing <**Enter**>	Serial cable	Check the cable and the cable connection. See Chapter 2, "Unpacking and Setting Up the System."
	Incorrect COM port	Check the COM port specified in the software.
	Incorrect baud rate	Software must be set at 9600 Baud, 7E1. Also check computer hardware.
	RS-232 chip on the Nanoparticle Surface Area Monitor	Contact TSI. Refer to "Contacting Customer Service."
	Nanoparticle Surface Area Monitor is locked up	Remove power from the Nanoparticle Surface Area Monitor then apply power to the instrument. If the problem continues, contact TSI.

Definitions of Read Commands

Read Surface Area

Send String	RL <CR> [2]	
Return String	x <CR> [5]	
Variable	x = Real,	0.000 <= x <= 10000
Example	Read the particle surface area in micrometer^2/cubic centimeter (e.g., 0.250 um^2/cm^3)	
Send String	RL <CR> [2]	
Return String	0.250 <CR> [5]	

Read Charger Flow

Send String	RCF <CR> [3]	
Return String	x <CR> [1-4]	
Variable	x = Unsigned Integer,	0 <= x <= 1023
Example	Read charger flow in Bit with a resolution of A-Bits (e.g., charger flow is 450)	
Send String	RCF <CR> [3]	
Return String	450 <CR> [3]	

Read Total Flow

Send String	RTF <CR> [3]	
Return String	x,y <CR> [3-8]	
Variable	x = Unsigned Integer,	0 <= x <= 1023
	y = Unsigned Char,	0 <= y <= 255
Example	Read the total flow in Bit with a resolution of A-Bits and the pump drivel level in Bit, with a resolution of 8-Bits (e.g., total flow is 650 and pump drive level is 90 Bit)	
Send String	RTF <CR> [3]	
Return String	650,90 <CR> [6]	

Read Calibration Coefficients

Command	**Read a single calibration coefficient (See SCC cmd for fuller description of calibration coefficients)**	
Send String	RCCwxy <CR> [6]	
Return String	z <CR> [1-9]	
Variable	w = Char,	w = A (Alveolar mode) w = B (Trachio Bronchial mode) w = C (Custom mode)
Variable	x = Char,	x = I (Current coefficient) x = S (Surface area coefficient)
Variable	y = Unsigned Integer,	0 <= y <= 7 (Coefficient index)
Variable	z = Unsigned Long,	z = Coefficient in atto amps if current z = Coefficient in 1000 × um^2/cc if surface area
Example	Read 3rd surface area coeff for alveolar mode (e.g., 1,000 um^2/cc)	
Send String	RCCAS2 <CR> [6]	
Return String	1000000 <CR> [9]	

Read Charger Voltage

Send String	RCV <CR> [3]	
Return String	x <CR> [1-4]	
Variable	x = Unsigned Integer,	0 <= x <= 4000
Example	Read the actual charger voltage in Volt (e.g., charger voltage is 1500 Volt)	
Send String	RCV <CR> [3]	
Return String	1500 <CR> [4]	

Read Charger Current

Send String	RCI <CR> [3]	
Return String	x,y <CR> [3-8]	
Variable	x = Unsigned Integer,	0 <= x <= 2000
	y = Unsigned Char,	0 <= y <= 255
Example	Read the actual charger current in Nano Ampere and the charger drivel level in Bit, with a resolution of 8-Bits. (e.g., charger current is 100 Nano Ampere, Charger Drive Level is 150 Bit)	
Send String	RCI <CR> [3]	
Return String	100,150 <CR> [7]	

Read Electrometer Current

Send String	REC <CR> [3]	
Return String	x <CR> [1-9]	
Variable	x = Long,	-25000000 <= x <= 425000000
Example	Read the electrometer current in Atto Ampere (e.g., 250 Atto Ampere)	
Send String	REC <CR> [3]	
Return String	250 <CR> [3]	

Read Electrometer Offset Current

Send String	REOC <CR> [4]	
Return String	x <CR> [1-9]	
Variable	x = Long,	-25000000 <= x <= 25000000
Example	Read the electrometer offset current in Atto Ampere (e.g., -10 Atto Ampere)	
Send String	RECO <CR> [4]	
Return String	-10 <CR> [3]	

Read Electrometer Temperature

Send String	RT <CR> [2]	
Return String	x <CR> [1-6]	
Variable	x = Real,	-20.00 <= x <= 60.00
Example	Read the electrometer temperature in degree Celsius (e.g. 45.00^{o}C)	
Send String	RT <CR> [2]	
Return String	45.00 <CR> [5]	

Read Electrometer Bits

Send String	REB <CR> [3]	
Return String	x <CR> [1-11]	
Variable	x = Long,	-2147483647<= x <= 2147483647
Example	Read the electrometer current in Bits with a resolution of 22-Bit (e.g., 1024)	
Send String	REB <CR> [3]	
Return String	1024 <CR> [3]	

Read Electrometer Offset Bits

Send String	REOB <CR> [4]	
Return String	x <CR> [1-7]	
Variable	x = Long,	-209715<= x <= 209715
Example	Read the electrometer offset current in Bits with a resolution of 22-Bit (e.g., -25)	
Send String	REOB <CR> [4]	
Return String	-25 <CR> [3]	

Read Analog Digital Converter

Send String	RAD <CR> [3]
Return String	CH0,CH1,CH2,CH4,CH5,CH6 <CR> [D-34]
Variable	CHx = Unsigned Integer, 0 <= x <= 999 ***Note**: Values between 1000 and 1023 are truncated to 999.*
Example	Read analog digital converter results with a resolution of 10 Bits
Send String	RAD <CR> [3]
Return String	100,100,100,100,100,100 <CR> [23]

ADC	Channel
CH0	CHARGER_V
CH1	CHARGER_I
CH2	DP_CHARGER
CH4	DP_FLOW
CH5	ION_TRAP_V (20 V)
CH6	ADJUSTABLE_ION_TRAP_V (614 = 300 V)

Read Version

Send String	RV <CR> [2]
Return String	AxBy <CR> [21 - 25]
Variable	A,B = String, x = Real, y = Unsigned Long A "3550, V:" x 0.00 <= x <= 327.68 B ", S:" y 0 <= y <= 2^32
Example	Read name, firmware version and serial number of instrument. (e.g., Name: 3550, Firmware Version: 1.00, Serial Number: 100)
Send String	RV <CR> [2]
Return String	"3550,V:1.00, S:100"<CR> [18]

(continued on next page)

Read Instrument Error

Send String	RE <CR> [2]
Return String	x <CR> [1-5]
Variable	x = Unsigned Int, B15 B14 | B13 B12 | B11 B10 | B9 B8 | B7 B6 | B5 B4 | B3 | B2 | B1 | B0
Example	Read the instrument errors (e.g., Charger flow too low, Total flow too low)
Send String	RS <CR> [2]
Return String	"640" <CR> [2] $640\|_{Decimal} = 0280\ \|_{Hexadecimal} = 0000\ \ 0010\ \ 1000\ \ 0000$

Bit Number	Status	Error
B15	Charger Current Error	0 = Charger Current Ok 1 = Charger Current too low
B14		0 = Charger Current Ok 1 = Charger Current too high
B13	Charger Voltage Error	0 = Charger Voltage Ok 1 = Charger Voltage too low
B12		0 = Charger Voltage Ok 1 = Charger Voltage too high
B11	Ion Trap Error	0 = Ion Trap Voltage Ok 1 = Ion Trap Voltage too low
B10		0 = Ion Trap Voltage Ok 1 = Ion Trap Voltage too high
B9	Charger Flow Error	0 = Charger flow Ok 1 = Charger flow too low
B8		0 = Charger flow Ok 1 = Charger flow too high
B7	Total Flow Error	0 = Total flow Ok 1 = Total flow too low
B6		0 = Total flow Ok 1 = Total flow too high
B5	Electrometer Temp Error	0 = Electrometer Ok 1 = Temperature too low
B4		0 = Electrometer Ok 1 = Temperature too high
B3	Electrometer Comm Error	0 = Communication Ok 1 = Communication Error
B2	Electr Curr Range Error	0 = With Range 1 = Out of Range
B1	Total Aerosol Length Error	0 = With Range 1 = Out of Range
B0	Not used	0 = OK

Read Instrument Status

Send String	RS <CR> [2]	
Return String	x <CR> [12]	
Variable	x = String,	x= S1 S2 S3 S4 S5 S6 S7 S8 S9 S10 S11 S12

Example	Read the instrument status
Send String	RS <CR> [2]
Return String	"111111111111" <CR> [12]

Status	Status Information	Options
S1	Charger Current Status	0 = Charger turned Off 1 = Current Ok 2 = Current too low 3 = Current too high 4 = Test mode, Charger ON
S2	Charger Voltage Status	0 = Charger turned Off 1 = Charger Voltage Ok 2 = Charger Voltage too low 3 = Charger Voltage too high 4 = Test mode, Charger ON
S3	Ion Trap Status	0 = Ion Trap turned Off 1 = Ion Trap Voltage Ok 2 = Ion Trap Voltage too low 3 = Ion Trap Voltage too high
S4	Charger Flow Status	0 = Pump turned off 1 = Charger flow Ok 2 = Charger flow too low 3 = Charger flow too high 4 = Pump test mode, Pump On
S5	Total Flow Status	0 = Pump turned Off 1 = Total flow Ok 2 = Total flow too low 3 = Total flow too high 4 = Pump test mode, Pump On
S6	Electrometer Status	0 = No Electrometer Communication 1 = Temperature Ok 2 = Temperature too low 3 = Temperature too high
S7	Surface Area Status	1 = Within Range 2 = Out of Range
S8	Electrometer Current Range Status	1 = Within Range 2 = Out of Range
S9	Ion Trap Mode	0 = Ion Trap turned off 1 = Alveolar mode 2 = Trachio Bronchial mode 3 = Custom mode
S10	Calibration Coeff, Alveolar	1 = OK 2 = Not OK S11
	Calibration Coeff, Trach-Bronch	1 = OK 2 = Not OK S12
	Calibration Coeff, Custom	1 = OK 2 = Not OK

Definitions of Set/Read Commands

Set or Read Ion Trap Mode

Command	**Read ion trap mode**	
Send String	SIM <CR> [3]	
Return String	x <CR> [1]	
Variable	x = CHAR,	x = A (Alveolar mode) x = B (Trachio Bronchial mode) x = C (Custom mode) x = F (Ion trap off)
Example	Read ion trap mode (e.g., the selected mode is alveolar)	
Send String	SIM <CR> [3]	
Return String	A <CR> [1]	

Command	**Set ion trap mode**	
Send String	SIMx <CR> [4]	
Return String	"OK" <CR> [2]	
Variable	x = CHAR,	x = A (Alveolar mode, turns on if was off) x = B (Trachio Bronchial mode, turns on if was off) x = C (Custom mode, turns on if was off) x = N (Turn on, go to previous mode, A, B or C) x = F (Turn off)
Example	Set ion trap mode (e.g., here set to alveolar)	
Send String	SIMA <CR> [4]	
Return String	"OK" <CR> [2]	

Set or Read Ion Trap Voltage

Command	**Read ion trap voltage**	
Send String	SIVx <CR> [4]	
Return String	y <CR> [1-3]	
Variable	x = CHAR,	x = A (Alveolar mode) x = B (Trachio Bronchial mode) x = C (Custom mode x = F (off)
Variable	y = Integer,	2 <= y <= 300 (if mode = A, B or C) y = 0 (if mode = F)
Example	Read ion trap voltage (e.g., alveolar voltage set point is 200V)	
Send String	SIVA <CR> [4]	
Return String	200 <CR> [3]	

Command	**Set ion trap voltage**	
Send String	SIVxy <CR> [5-7]	
Return String	"OK" <CR> [2]	
Variable	x = CHAR,	x = A (Alveolar mode voltage set point) x = B (Trachio Bronchial mode voltage set point) x = C (Custom mode voltage set point)
Variable	y = Integer,	2 <= y <= 300 (Voltage set point)
Example	Set ion trap voltage (e.g., set alveolar voltage set point to 200V)	
Send String	SIVA200 <CR> [7]	
Return String	"OK" <CR> [2]	

Set Calibration Coefficients

Command	**Send a single calibration coefficient to instrument**	
Send String	SCCwxyz <CR> [7-15]	
Return String	"OK" <CR> [2]	
Variable	w = Char,	w = A (Alveolar mode) w = B (Trachio Bronchial mode) w = C (Custom mode)
Variable	x = Char,	x = I (Current coefficient) x = S (Surface area coefficient)
Variable	y = Unsigned Integer, index)	0 <= y <= 7 (Coefficient
Variable	z = Unsigned Long,	z = Coefficient in atto amps if current z = Coefficient in 1000 × um2/cc if surface area
Example	Send 3rd surface area coeff for alveolar mode (e.g., 1,000 um^2/cc)	
Send String	SCCAS21000000 <CR> [15]	
Return String	"OK" <CR> [2] OK is returned even if the coefficient does not meet the requirements below.	

Restrictions on coefficients

Current coefficient(CI): min = 1 max = 425,000,000 (atto amp)

Surface area coefficient(CS): min = 1 max = 10,000,000 (1000 × um^2/cc)

CI_0, CS_0 must always be > 0

CI_i , CS_i (i=1-7) may be 0, but then both in the same pair must be 0

If CI_i , CS_i are both zero, then CI_k , CS_k must both be 0, for all k > i

Non zero coeff must have: $CI_i > CI_{i-1}$ (i=1-7), $CS_i > CS_{i-1}$ (i=1-7). In other words, they must be ascending and cannot be equal to the previous one.

If the coeffs for a given trap mode do not meet these restrictions, bit 10,11 or 12 of the instrument status flags (RS cmd) will be set.

Set Replicate Coefficients

Command	**Copy entire set of alveolar** or **tracheobronchial calibration coefficients and trap voltage to custom mode settings**	
Send String	SRCx <CR> [4]	
Variable	x = Char,	x = A (Clone alveolar coeff/trap voltage to custom) x = B (Clone tracheobronchial coeff/trap voltage to custom)
Return String	"OK" <CR> [2]	
Example	Overwrite custom cal coeff/trap voltage with alveolar values	
Send String	SRCA <CR> [4]	
Return String	"OK" <CR> [2]	

Set or Read Charger Mode

Command	**Read charger voltage mode**	
Send String	SCV <CR> [3]	
Return String	x <CR> [1]	
Variable	x = Integer,	x = 0 (Charger Voltage = OFF) x = 1 (Charger Voltage = ON) x = 2 (Charger in test mode)
Example	Read charger voltage mode (e.g., charger voltage is turned OFF)	
Send String	SCV <CR> [3]	
Return String	0 <CR> [1]	

Command	**Set charger voltage mode**	
Send String	SCVx <CR> [4]	
Variable	x = Integer,	x = 0 (Charger Voltage = OFF) x = 1 (Charger Voltage = ON)
Return String	"OK" <CR> [2]	
Example	Set charger status (e.g., turn charger voltage ON)	
Send String	SCV1 <CR> [4]	
Return String	"OK" <CR> [2]	

Set or Read Pump Mode

Command	**Read pump mode**	
Send String	SP <CR> [2]	
Return String	x <CR> [1]	
Variable	x = Char,	x = 0 (Pump = OFF) x = 1 (Pump = ON) x = 2 (Pump in test mode)
Example	Read pump mode (e.g., pump is OFF)	
Send String	SP <CR> [2]	
Return String	0 <CR> [1]	

Command	**Set pump mode**	
Send String	SPx <CR> [3]	
Variable	x = Char,	x = 0 (pump = OFF) x = 1 (pump = ON)
Return String	"OK" <CR> [2]	
Example	Set ion trap mode (e.g., turn pump ON)	
Send String	SP1 <CR> [3]	
Return String	"OK" <CR> [2]	

Set or Read Total Flow Set Point

Command	**Read total flow set point**	
Send String	STFS <CR> [4]	
Return String	x <CR> [1]	
Variable	x = Unsigned Integer,	0 <= x <= 1023
Example	Read charger flow set point with a resolution of A-Bits (e.g., charger flow set point = 500 [Bit])	
Send String	STFS <CR> [4]	
Return String	500 <CR> [3]	

Command	**Set total flow set point**	
Send String	STFSx <CR> [5-8]	
Variable	x = Unsigned Integer,	0 <= x <= 1023
Return String	"OK" <CR> [2]	
Example	Set total flow set point with a resolution of A-Bits (e.g., total flow set point = 620 [Bit])	
Send String	STFS620 <CR> [7]	
Return String	"OK" <CR> [2]	

Set or Read Charger Flow Set Point

Command	**Read charger flow set point**
Send String	SCFS <CR> [4]
Return String	x <CR> [1]
Variable	x = Unsigned Integer, 0 <= x <= 1023
Example	Read charger flow set point with a resolution of A-Bits (e.g., charger flow set point = 500 [Bit])
Send String	SCFS <CR> [4]
Return String	500 <CR> [3]

Command	**Set charger flow set point new**
Send String	SCFSN <CR> [5]
Return String	"OK" <CR> [2]
Example	Set charger flow set point new.
Send String	SCFSN <CR> [5]
Action	Measure current charger flow and store new charger flow set point in EEPROM
Return String	"OK" <CR> [2]

Set or Read Averaging Mode

Command	**Read averaging mode**	
Send String	SAV <CR> [3]	
Return String	x <CR> [1]	
Variable	x = Integer,	x = 0 (One second averaging) x = 1 (Three second averaging) x = 2 (Seven second averaging) x = 3 (no averaging)
Example	Read averaging mode (e.g., averaging mode is set to one second averaging) ***Note:*** *By setting the average mode the instrument calculates a running average according to the specified setting. This will affect the displayed and polled and unpolled reading via serial command as well as the update of the analog output.* The default setting is SAV0, which calculates a one-second running average.	
Send String	SAV <CR> [3]	
Return String	0 <CR> [1]	

Command	**Set averaging mode**	
Send String	SAVx <CR> [4]	
Variable	x = Integer,	x = 0 (One second averaging) x = 1 (Three second averaging) x = 2 (Seven second averaging) x = 3 (no averaging)
Return String	"OK" <CR> [2]	
Example	Set averaging mode (e.g., averaging mode is set to seven second averaging)	
Send String	SAV2 <CR> [4]	
Return String	"OK" <CR> [2]	

Definitions of Set Commands

Set Electrometer Zero Offset

Command	**Set electrometer zero offset**	
Send String	SEOx <CR> [4-12]	
Variable	x = Long,	-209715< x < 209715 (= ±25 pA)
Return String	"OK" <CR> [2]	
Example	Set electrometer offset with a resolution of 22-bits (e.g., -100 Bit)	
Send String	SEO-150 <CR> [7]	
Return String	"OK" <CR> [2]	

Command	**Set electrometer zero offset**
Send String	SEO <CR> [3]
Return String	"OK" <CR> [2]
Action	Initiate process to zero the electrometer, which will take 30 seconds to complete.

- 1 second after the command was sent, the charger will be turned OFF and the ion trap will be turned ON.
- 5 seconds after the command was sent, the pump will be turned OFF.
- 15 seconds after the command was sent, the electrical current will be measured for the next 10 seconds and the average will be stored as electrometer offset in the non-volatile EEPROM memory.
- 30 seconds after the command was sent, the pump, the charger, and the ion trap will be turned ON.

Set Unpolled Data Mode

Command	Set unpolled data mode
Send String	SUMx <CR> [4]
Variable	x = Integer, x = Integer, 0 <= x < = A
Return String	"OK" <CR> [2]
Example	Set unpolled data mode (e.g., send surface area)
Send String	SUM1 <CR> [4]
Action	Send unpolled data as specified in table below
Return String	"OK" <CR> [2]

x	Output	Update Rate	Output Format
0	Stop unpolled data transmit		
1	Surface area in micro meter squared per CC with averaging set by SAV command (resolution = 22 bit)	(~1/s)	same format as the RL command
2	Electrometer current with offset correction in Atto Ampere with averaging set by SAV command (resolution = 22 bit)	(~1/s)	same format as the REC command
3	Electrometer current with offset correction in bit with averaging set by SAV command (resolution = 22 bit)	(~1/s)	same format as the REB command
4	Electrometer current without offset correction in bit with averaging set by SAV command (resolution = 22 bit)	(~1/s)	same format as the REB command
5	Electrometer temperature in degree Celsius without averaging (resolution = 16 bit)	(~1/s)	same format as the RT command
6	Electrometer temperature in bit without averaging (resolution = 22 bit)	(~1/s)	x [1])
7	Electrometer current with offset correction in Atto Ampere with averaging set by SAV command (resolution = 22 bit)	(~3.75/s)	same format as the REC command
8	Electrometer current and temperature in bit without averaging (resolution = 22 bit)	(~3.75/s)	x,y [2])
9	Pump drive level in bit (resolution = 8 bit) and total flow pressure drop in bit (resolution = 10 bit)	(~4/s)	x, y[3])
A	Charger drive level in bit (resolution = 8 bit) and charger current in bit (resolution = 10 bit) charger voltage in bit (resolution = 10 bit)	(~4/s)	x,y,z [4])

[1]) Return String x <CR> [1-8], Variable x = Long, -4194304 <= x <= +4194304

[2]) Return String x,y <CR> [3-17], Variable x = Long, -4194304 <= x <= +4194304
y = Long, -4194304 <= y <= +4194304

[3]) Return String x,y <CR> [3-8], Variable x = UChar, 0 <= x <= 255
y = Int, 0 <= x <= 1023

[4]) Return String x,y <CR> [5-13], Variable x = UChar, 0 <= x <= 255
y = Int, 0 <= x <= 1023
y = Int, 0 <= x <= 1023

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